DISPERSED, DISGUISED, AND DEGRADABLE

The Implications of the Fighting in Ukraine for Future U.S.-Involved Conflicts

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About This Report

In this report, we fill a gap in existing literature on the Russia-Ukraine war by identifying novel and notable observations about the warfighting and assessing their relevance to hypothetical future wars involving the United States and near-peer adversaries. To do so, we closely examined the tactical and operational levels of the fighting in Ukraine to make our observations. Then, we evaluated whether and how these observations might translate to two potential U.S.-involved conflict scenarios: a North Atlantic Treaty Organization (NATO)-Russia conflict in Eastern Europe and a U.S.-People's Republic of China conflict in the Indo-Pacific. In this report, we review this work, highlight the implications of our observations, and provide recommendations for the U.S. Department of the Air Force, U.S. Department of Defense, and U.S. government policymakers.

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- Alisa Laufer, Howard J. Shatz, and Omar Danaf, *Implications of Russia's War on Ukraine for the U.S. and Allied Defense Industrial Bases*, RAND Corporation, RR-A3141-3, 2025
- Howard Wang and Brett Zakheim, *China's Lessons from the Russia-Ukraine War: Perceived New Strategic Opportunities and an Emerging Model of Hybrid Warfare*, RAND Corporation, RR-A3141-4, 2025
- Alexandra T. Evans, Krystyna Marcinek, and Omar Danaf, *Will Europe Rebuild or Divide? The Strategic Implications of the Russo-Ukraine War for Europe's Future*, RAND Corporation, RR-A3141-5, 2025.

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Summary

Issue

What insights does the Russia-Ukraine war offer about the current (and future) character of warfare? Are certain tactical and operational dynamics observed in Ukraine unique, or do they presage broader shifts that could shape future wars between advanced military powers? In this report, we assess whether tactical and operational insights gleaned from the fighting in Ukraine might apply to hypothetical near-future wars between the United States and near-peer adversaries. By understanding how the wars of tomorrow could differ from the war being fought in Ukraine today, U.S. policymakers can better inform decisions related to military acquisition, force design, and force employment.

Approach

We applied an inductive approach to understanding the warfighting implications of the conflict in Ukraine. We began this approach by identifying novel or notable aspects at the tactical and operational levels of warfare, and then we evaluated whether and how these aspects might translate to two potential future U.S.-involved conflict scenarios: a North Atlantic Treaty Organization (NATO)–Russia conflict in Eastern Europe and a U.S.–People's Republic of China conflict in the Indo-Pacific. Lastly, we identified broader tactical, operational, and strategic implications for U.S. policymakers. Although the ongoing war in Ukraine is but one data point in the broader study of modern armed conflict, it can nevertheless offer a valuable glimpse into challenges that could define—and complicate—future military operations.

Key Findings

- **The delivery of mass is changing**: Although mass has been delivered in Ukraine primarily as artillery, future U.S.-involved conflicts might advantage different systems. Large volumes of uncrewed aircraft systems (UASs) could provide an additional solution to problems that were previously restricted to the domain of long-range precision fires. Given their low cost, UASs could also offer a sustainable complement to artillery in protracted conflicts.
- **The distinction between cruise missiles and one-way attack (OWA) UASs is blurring**: Although cruise missiles currently deliver larger payloads at faster speeds than OWA UASs, drones offer a unique value in their ability to loiter—and to do so at low cost. Technological advances will likely enhance the size, weight, power, and autonomy of UASs, thereby blurring the distinction between these two classes of weapons. Consequently, future warfighters might regard cruise missiles and drones as points along the same continuum and employ one or the other depending on the requirements of a given mission.

- **Offensive operations are confronting enhanced challenges**: Offense-defense balances can change quickly, but the Russia-Ukraine war has demonstrated a set of enhanced challenges that are likely to stress future attackers when air superiority is unachievable. These challenges arise from persistent surveillance and greater battlefield transparency, advances in capabilities to disrupt command and control, and the integration of surveillance and long-range fires to enhance the effectiveness of traditional area defense and denial measures, such as minefields.
- **Protraction requires adaptation**: Long wars demand a different set of replaceable, cost-effective capabilities that can be fielded and employed quickly. Battlefield outcomes could be dictated by production decisions at home, including those taken in advance.
- **The need to seek external support to sustain protracted conflict is not a question of "if" but "how much"**: External support is essential for waging and sustaining high-intensity wars. States with more-limited domestic production capabilities would need to seek out such support sooner, but the incentives to do so will remain for all states. Such support could help future warfighters sustain or better adapt to protracted, high-intensity conflict using capabilities that allies or partners could provide. Of course, the value of preventing or interrupting such transfers would be proportionately important for these states' opponents.
- **Competency matters as much as, if not more than, technology**: The fighting in Ukraine has demonstrated the continued importance of tactical proficiency, sound operational planning, and coherent strategy. These intangible factors are also among the most challenging characteristics to assess in the absence of war, meaning military analysts must develop better analytic techniques for measuring them in peacetime.
- **Air superiority is critical**: Many of the dilemmas highlighted in Ukraine arise from the inability of either combatant to establish air superiority. Although a similar struggle could arise in the Indo-Pacific, a NATO-Russia war would likely see Western air forces control the skies, given the West's technological overmatch and Russia's evident airpower deficiencies.

Key Recommendations

For U.S. Air Forces in Europe–Air Forces Africa, the U.S. Air Force, and the U.S. Space Force:

- **Invest in the development of affordable, extended-range munitions.** The resilience of Ukrainian air defenses has pushed Russia to develop longer-range, low-cost munitions that can be fired from relative sanctuary. The United States might face similar challenges in a future conflict but lacks comparably affordable options that can be produced in large volumes.
- **Continue development of proliferated satellite constellations and hybrid space architectures.** The resilience of commercial satellite constellations supporting Ukrainian operations has highlighted the value of distributed approaches to space capabilities and the operational capability of commercial space providers.

For the U.S. Department of Defense (DoD):

- **Prioritize the development and integration of high-volume kinetic counter-UAS capabilities.** U.S. adversaries are likely to develop large volumes of UASs for attack missions,

as Russia has in Ukraine. Although electronic warfare could provide a partial counter to some types of UASs in some circumstances, others might require kinetic responses, particularly if adversaries develop UASs with greater autonomy.

- **Accelerate large-scale investments in and integration of OWA UASs and uncrewed surface vehicles.** Uncrewed aircraft and naval systems have proven effective in overwhelming advanced anti-access/area denial capabilities. Although DoD has begun to acquire and field greater quantities of these systems, many steps remain before they can be employed at scale and to their full combat potential.
- **Evaluate the utility and robustness of concepts for sensing and targeting enemy surface forces in highly contested environments.** Large numbers of small uncrewed aircraft systems (sUASs) are capable of locating, identifying, tracking, and targeting hostile forces in the absence of air superiority. DoD has taken steps to expand the number of units equipped with sUASs, but additional effort is required to develop associated tactics, techniques, and procedures to ensure operator proficiency in integrating data from these systems into timely operations.
- **Emphasize decentralized decisionmaking in exercises and training.** Improvements in persistent surveillance and precision strike capabilities are likely to increase the demand for dispersed operations. Although the United States already benefits from enabling forces to make some tactical and operational decisions without centralized direction, this agility could become more important in conflicts against authoritarian opponents that would be challenged to replicate the U.S. culture of flexibility and risk-taking.
- **Evaluate the potential for uncrewed systems to enhance the effectiveness of naval minefields.** Persistent surveillance and loitering munitions have sharply increased the difficulty of clearing operations in Ukraine. Additional analysis is required to determine whether uncrewed underwater systems can be used to challenge minesweeping and enhance the effectiveness of naval mines for area denial in a maritime-centric theater.
- **Identify priority munition systems for scaled-up, rapid production in the event of a protracted conflict.** U.S. and allied efforts to supply Ukraine with munitions to combat Russia's attritional way of warfare have stressed their collective defense industrial bases. Because the United States might face similar challenges and trade-offs in a future protracted conflict, DoD should begin identifying and prioritizing the production of particularly critical munitions today.

For the U.S. government:

- **Sustain and focus defense industrial base investments to build capacity for priority munition systems needed for protracted conflict.** The U.S. government has taken steps to strengthen the industrial base, but congressional opposition has stymied efforts to use multiyear procurement authorities to create the demand signals required to promote long-term expansions in production capacity.
- **Plan to deny U.S. and allied commercial space assets to adversaries.** Russia has successfully leveraged Western commercial space assets to support combat operations despite intense and far-reaching sanctions. The U.S. government should investigate diplomatic, commercial, and intelligence efforts to prevent such exploitation by U.S. adversaries in a future conflict.

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Chapter 1

Introduction

This research was completed in November 2024. It has not been subsequently revised.

Russia's full-scale invasion of Ukraine in February 2022 sparked what has become one of the deadliest and most destructive wars in recent decades. The intensity of the fighting and the resources expended by both Russian and Ukrainian forces have created immense incentives for military adaptation and innovation. The Russia-Ukraine war is the first protracted, high-intensity interstate war of the information era, and participants in and observers of the conflict have seen the demonstration and large-scale adoption of many capabilities for the first time, including small uncrewed aircraft systems (sUASs) and proliferated space-based communications.[1] Nevertheless, the war has also highlighted the surprising persistence of several less-sophisticated legacy systems, such as tanks, unguided tube artillery, and even mines.[2]

How Russia and Ukraine have fought to date has been a product of their capabilities and the specific characteristics of the battlefield. Although wars frequently demonstrate novel capabilities or emerging trends that could play key roles later, one cannot assume that all aspects of the current fighting will manifest themselves in future conflicts. Many of these capabilities and trends could be relevant only because of the peculiarity of today's battlefield and the specific abilities of these two combatants. For example, the United States differs greatly from Ukraine in its military capabilities, and the geography of future conflicts in which the United States might find itself embroiled could differ substantially from the steppes of Eastern Europe. Observing what has occurred in Ukraine is important, but understanding the implications for U.S. military planners and warfighters requires evaluating how future U.S.-involved conflicts might differ from the war in Ukraine and how those differences might affect the capabilities and concepts of operations that have been demonstrated over the past two years.

How Wars Drive Military Adaptations

Wars between states—particularly protracted, high-intensity conflicts, such as the Russia-Ukraine war, that involve the commitment of significant resources—have the capacity to reshape how

[1] On the large-scale use of uncrewed aircraft systems (UASs), see Stacie Pettyjohn, *Evolution Not Revolution: Drone Warfare in Russia's 2022 Invasion of Ukraine*, Center for a New American Security, February 8, 2024. On proliferated satellite communications (SATCOM) architectures, see Frank Wolfe, "Saltzman: Proliferated LEO Shows Mettle in Ukraine," *Defense Daily*, October 18, 2023.

[2] For the enduring importance of conventional armor, artillery, and mines, see Stephen Biddle, "Back in the Trenches: Why New Technology Hasn't Revolutionized Warfare in Ukraine," *Foreign Affairs*, Vol. 102, No. 5, September/October 2023; and David Johnson, "The Tank Is Dead: Long Live the Javelin, the Switchblade, the . . . ?" *War on the Rocks*, April 18, 2022.

states fight by providing both the opportunity and the pressure to use and adapt novel capabilities. In peacetime, military organizations strive to solve hypothetical operational challenges through continuous innovation, whether by developing new technologies, refining operational concepts, or effecting reorganization. But the battlefield invariably reveals faults in prewar assumptions and presents new or unforeseeable information.[3] To succeed or even survive, militaries must adapt to both the realities of the battlefield they confront and any changes in the operating environment that arise as their opponent evolves.[4] In short, militaries must innovate and adapt simultaneously during wartime.[5]

Wars reveal new information about the effectiveness of novel or emerging technologies and concepts and can also spur changes in how foreign observers prepare to fight future conflicts. Through direct observation and postconflict investigations of foreign wars, states historically have sought to institutionalize lessons from prior wars by adjusting their acquisition strategy or developing operational concepts to respond to revealed dilemmas.[6] For instance, Chinese military analysts have sought to compensate for the People's Liberation Army's (PLA's) limited combat experience by studying foreign wars to identify best practices and discern changes in warfare.[7] Analysis of U.S. operations during the Persian Gulf War inspired adaptations in Chinese tactical, operational, and strategic concepts and spurred an emphasis on information technology that has remained a centerpiece of Chinese military thinking to date.[8]

How military organizations react to wars varies among countries and across time. Accurately identifying and effectively institutionalizing insights from a conflict is a fraught process, and the historical record is littered with cases in which states have overlooked, misinterpreted, or misapplied lessons from foreign conflicts.[9] Distinguishing between events that are fortuitous or contingent on specific circumstances and those that are indicative of a more generalizable trend is intrinsically difficult. Reflecting on European militaries' failure to anticipate the significance of trench warfare prior to World War I, one historian notes, "experts tended to read into the experiences [of previous wars] very much what they wanted to find."[10] Even close observers with access to similar information might

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[3] As one historian has written, in peacetime "there is always time available to think through problems . . . [but not] an interactive, adaptive opponent who is trying to kill us. In the case of war, on the other hand, there is little time, but there is the feedback of combat results" (Williamson Murray, *Military Adaptation in War: With Fear of Change*, Cambridge University Press, 2011, p. 2).

[4] David Barno and Nora Bensahel, *Adaptation Under Fire: How Militaries Change in Wartime*, Oxford University Press, 2020.

[5] Martijn van der Vorm, "The Crucible of War: What Do We Know About Military Adaptation?" *Journal of Advanced Military Studies*, Vol. 12, No. 1, Spring 2021, p. 197. For a similar argument, see Murray, 2011, pp. 1–2.

[6] For a study of how the U.S. military has sought to learn from direct observation and postconflict examinations of other states' wars, see Brent L. Sterling, *Other People's Wars: The U.S. Military and the Challenge of Learning from Foreign Conflicts*, Georgetown University Press, 2021.

[7] For a survey of Chinese learning from foreign wars, see Andrew Scobell, David Lai, and Roy Kamphausen, eds., *Chinese Lessons from Other Peoples' Wars*, Strategic Studies Institute, U.S. Army War College, November 2011.

[8] Dean Cheng, "Chinese Lessons from the Gulf Wars," in Andrew Scobell, David Lai, and Roy Kamphausen, eds., *Chinese Lessons from Other Peoples' Wars*, Strategic Studies Institute, U.S. Army War College, November 2011.

[9] For a historical survey of military futurists' attempts to predict warfare's evolution, see Lawrence Freedman, *The Future of War: A History*, Public Affairs, 2019. For discussion of mislearning based on historical cases, see Alexandra T. Evans, *Alternative Futures Following a Great Power War:* Vol. 2, *Supporting Material on Historical Great Power Wars*, RAND Corporation, RR-A591-2, 2023; and David C. Gompert, Hans Binnendijk, and Bonny Lin, *Blinders, Blunders, and Wars: What America and China Can Learn*, RAND Corporation, RR-768-RC, 2014.

[10] Michael Howard, "Men Against Fire: Expectations of War in 1914," *International Security*, Vol. 9, No. 1, Summer 1984, p. 53.

explain the course of a war differently or draw differing conclusions about its implications for future fighting. The increasing pace of technological change has made this task even more complex.[11]

Nonetheless, it is likely that certain attributes of the Russia-Ukraine war will both foreshadow characteristics of later conflicts and inform the behavior of future belligerents because these attributes demonstrate the operational value of new technologies and operating concepts and underline dilemmas that are likely to reoccur. A detailed assessment of how the characteristics of the fighting in Ukraine should inform U.S. military planning for future high-intensity warfare is therefore essential.

Building on Prior Assessments of Warfighting Implications from Ukraine

More than two years after Russia's full-scale invasion of Ukraine, many have sought to discern lessons from how the war is being fought.[12] These efforts have ranged from the abstract to the highly specific, either attempting to identify trends across different domains of warfare or focusing more heavily on changes in one specific area and their potential implications. At the more general level, high-profile reviews in the popular press have identified such trends as the increased importance of UASs and persistent surveillance.[13] More-specialized analysts—most notably those at the Royal United Services Institute—have produced a series of reports highlighting what they believe can and should be learned from the fighting in Ukraine, including detailed illustrations of how new technologies and evolving operational concepts have reshaped small-unit tactics.[14] Others have produced in-depth assessments of how such capabilities as UASs, fires, and ground maneuvers have shaped—and been shaped by—battlefield dynamics in Ukraine.[15] All of these assessments are an important part of the base on which this report is built.

Where the existing literature is not as well developed—and where this report holds unique value—is in assessing how the potential changes to warfighting observed in Ukraine could or could not translate to potential future conflicts, including those that might involve the United States.

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[11] Murray, 2011; Barno and Bensahel, 2020, p. 3.

[12] For example, see "Warfare After Ukraine: Battlefield Lessons," *The Economist*, July 8, 2023; Stephen M. Walt, "The Top 5 Lessons from Year One of Ukraine's War," *Foreign Policy*, February 9, 2023; Constanze Stelzenmüller, Fiona Hill, Steven Pifer, James Goldgeier, Tara Varma, Aslı Aydıntaşbaş, Patricia M. Kim, Suzanne Maloney, Tanvi Madan, Bruce Jones, et al., "Lessons from Ukraine: Brookings Scholars Assess Vladimir Putin's Assault, Ukraine's Resistance, and the World's Response After One Year of War," Brookings, February 24, 2023; and Peter W. Singer, "One Year In: What Are the Lessons from Ukraine for the Future of War?" *Defense One*, February 22, 2023.

[13] "Warfare After Ukraine: Battlefield Lessons," 2023; Alex Horton, "What the Pentagon Has Learned from Two Years of War in Ukraine," *Washington Post*, February 22, 2024.

[14] Mykhaylo Zabrodskyi, Jack Watling, Oleksandr V. Danylyuk, and Nick Reynolds, *Preliminary Lessons in Conventional Warfighting from Russia's Invasion of Ukraine: February–July 2022*, Royal United Services Institute, November 30, 2022; Jack Watling, Oleksandr V. Danylyuk, and Nick Reynolds, *Preliminary Lessons from Russia's Unconventional Operations During the Russo-Ukrainian War, February 2022–February 2023*, special report, Royal United Services Institute, March 29, 2023; Jack Watling and Nick Reynolds, *Stormbreak: Fighting Through Russian Defences in Ukraine's 2023 Offensive*, special report, Royal United Services Institute, September 4, 2023b; Stephen Biddle, "Ukraine and the Future of Offensive Maneuver," *War on the Rocks*, November 22, 2022.

[15] Pettyjohn, 2024; Sam Cranny-Evans, "Russia's Artillery War in Ukraine: Challenges and Innovations," commentary, Royal United Services Institute, August 9, 2023.

Although some past research has attempted to identify potential implications of the fighting in Ukraine for conflicts in the Indo-Pacific or European theaters that might directly involve the United States, it has tended to be rather preliminary in nature.[16] This report, alternatively, offers a more novel contribution by detailing the relevance of individual capabilities and concepts of operations observed in Ukraine to future conflicts between the United States and its two most capable adversaries, the Russian Federation and the People's Republic of China (PRC).

Research Approach

We examined three research questions:

1. What tactical- or operational-level observations about the fighting in the Russia-Ukraine war have been novel or notable compared with prior conflicts?
2. To what extent are these novel or notable observations likely to be relevant to a hypothetical conflict involving the United States and either Russia or China?
3. How can the U.S. Department of the Air Force (DAF), the U.S. Department of Defense (DoD), and U.S. policymakers in other organizations incorporate these insights into their planning?

To answer these questions, we took an inductive approach, starting with tactical and operational observations from Ukraine. We then evaluated whether and how these observations might translate to potential future U.S.-involved conflicts and identified the broader implications for U.S. policymakers. Specifically, we conducted an extensive review of publicly available sources, such as news accounts, think tank analyses, government reports, and social media posts.[17] We supplemented this literature review with discussions with U.S. government officials and nongovernmental subject-matter experts who have closely followed the conflict to date. The research was completed in November 2024 and has not been subsequently revised. Our discussions with U.S. government officials and nongovernmental subject-matter experts occurred between October 2023 and April 2024.

This research led us to develop several observations about the fighting in Ukraine at the tactical and operational levels. Although any account of a war as lengthy and complex as the one in Ukraine is undoubtedly incomplete, we focused these observations on phenomena that we assessed to be especially *novel* or *notable*. This means that the observed capability or behavior has not been seen previously in high-intensity interstate wars and/or was not generally anticipated before the war began.

This focus meant that we excluded from our analysis several important aspects of the fighting in Ukraine that have been widely commented on elsewhere and particularly those that emphasized continuity with prior conflicts or prewar expectations. Perhaps most notably, the central role of artillery in the fighting in Ukraine has been widely cited as a point of continuity with conflicts dating

[16] Michael Kofman, "NATO Should Avoid Learning the Wrong Lessons from Russia's Blunder in Ukraine," *The Economist*, June 7, 2022; M. Taylor Fravel, "China's Potential Lessons from Ukraine for Conflict over Taiwan," *Washington Quarterly*, Vol. 46, No. 3, Fall 2023.

[17] Russian and Ukrainian sources (e.g., *Military Review*, *Ukrainska Pravda*) were consulted in this report, but their English versions are cited because they did not substantively differ from the original reporting in each respective language.

back to at least the 19th and early 20th centuries.[18] The challenges to the survivability of rotary-wing attack aircraft, which have been acute in Ukraine, have been remarked on since the proliferation of man-portable air defense systems (MANPADS) in the latter half of the 20th century.[19] Similarly, the initial phases of the war prompted significant debate over the continued relevance of tanks, with some analysts suggesting that heavy Russian losses indicated the systems were now obsolete.[20] However, later phases of the conflict demonstrated the continued importance of tanks for protective mobile firepower, akin to their use in prior conflicts.[21] Other factors that are clearly critical to explaining the conflict, such as Ukrainian success with information operations and the high degree of Ukrainian popular and elite commitment to winning the war, reflect topics that were widely studied before the war and whose importance had been clearly demonstrated in earlier conflicts.[22]

Furthermore, we focused our analysis on identifying overall potential changes in the tactical and operational character of warfare stemming from the conflict as a whole rather than how specific belligerents or foreign observers have learned from different phases or battles of the war. There is a rich analysis to be done tracing precisely how Ukrainian and Russian conduct has evolved in response to battlefield pressures, and in Chapter 2, we highlight moments when key implications arose as the result of discrete changes. However, we did not attempt to anticipate how the conflict in Ukraine could still evolve, and we limited ourselves to describing the most-novel and most-notable observations to date.

Having identified these novel and notable observations in Chapter 2, we then assessed the relevance of each to potential future conflicts between North Atlantic Treaty Organization (NATO) members and Russia and between the United States and China. To do so, we evaluated the extent to which the capabilities or concepts demonstrated in Ukraine might be relevant to the operational and tactical challenges the combatants would likely face in our hypothetical scenarios. We considered the possibility that future combatants could attempt to replicate the use of certain capabilities or concepts demonstrated in Ukraine, as well as the possibility of further modifications or adaptations that could prove consequential. We also considered whether differences between the two scenarios could render

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[18] Cranny-Evans, 2023; Jeff Kinard, *Artillery: An Illustrated History of Its Impact*, Bloomsbury Publishing, 2007; Fred K. Vigman, "The Theoretical Evaluation of Artillery After World War I," *Military Affairs*, Vol. 16, No. 3, Autumn 1952.

[19] Carlo Kopp, "Are Helicopters Vulnerable?" *Australian Aviation*, March 2005.

[20] For examples of this debate, see Johnson, 2022; Ed Cumming, "Is This the End of the Tank?" *The Telegraph*, March 14, 2022; Phillips Payson O'Brien, "War Will Never Be This Bulky Again," *The Atlantic*, May 26, 2022; and Rob Lee, "The Tank Is Not Obsolete, and Other Observations About the Future of Combat," *War on the Rocks*, September 6, 2022.

[21] Curtis A. Buzzard, Thomas M. Feltey, John M. Nimmons, Austin T. Schwartz, and Robert S. Cameron, "The Tank Is Dead . . . Long Live the Tank: The Persistent Value of Armored Combined Arms Teams in the 21st Century," *Military Review*, November-December 2023; Antony Beevor, "They Said Tanks Were Obsolete. Now, Ukraine Can't Get Enough of Them," *Washington Post*, February 21, 2023; Biddle, 2023; David Axe, "Tanks Remain Kings of the Battlefield. Drones Have Not Made Them Obsolete," *The Telegraph*, February 28, 2024b.

[22] Ben Connable, Michael J. McNerney, William Marcellino, Aaron B. Frank, Henry Hargrove, Marek N. Posard, S. Rebecca Zimmerman, Natasha Lander, Jasen J. Castillo, and James Sladden, *Will to Fight: Analyzing, Modeling, and Simulating the Will to Fight of Military Units*, RAND Corporation, RR-2341-A, 2018; Michael J. McNerney, Ben Connable, S. Rebecca Zimmerman, Natasha Lander, Marek N. Posard, Jasen J. Castillo, Dan Madden, Ilana Blum, Aaron B. Frank, Benjamin J. Fernandes, In Hyo Seol, Christopher Paul, and Andrew Parasiliti, *National Will to Fight: Why Some States Keep Fighting and Others Don't*, RAND Corporation, RR-2477-A, 2018; Miriam Matthews, Alyssa Demus, Elina Treyger, Marek N. Posard, Hilary Reininger, and Christopher Paul, *Understanding and Defending Against Russia's Malign and Subversive Information Efforts in Europe*, RAND Corporation, RR-3160-EUCOM, 2021.

these capabilities and concepts less impactful than they have proven in Ukraine. For example, sUASs have contributed to the surprising effectiveness of minefields in Ukraine by inhibiting clearing operations (as we discuss in more detail in Chapter 2). Although a future U.S.-China conflict would be unlikely to involve substantial ground combat, at least in its initial phases, we considered whether sUASs or similar capabilities could make naval mines more effective than conventional wisdom currently anticipates.

Next, we reviewed our assessments for their broader implications for U.S. policymaking. We further assessed these implications as potentially conditional based on factors that could still shift during the remainder of the conflict. For example, our assessments do not highlight any changes in the character of warfare related to nuclear weapon use because these weapons have not been used in the conflict, nor in any other conflict since 1945. If that condition should change and Russia were to use nuclear weapons in the conflict, it could have a wide variety of downstream effects on the character of warfighting and on the implications we have highlighted. We discuss our approach to dealing with this uncertainty regarding changes that might still occur during the war in greater detail in Chapter 1 of the summary volume of this series of reports.[23]

Finally, these implications and the foregoing analysis subsequently inform a series of recommendations for the DAF, DoD, and the U.S. government. In these recommendations, we suggest how the U.S. military can adapt to changes in the character of warfare and better prepare for the future.

Report Organization

In Chapter 2, we provide a summary of the most-novel and most-notable observations related to the conduct of the war in Ukraine at the tactical and operational levels. What has been most surprising about the capabilities that both sides have demonstrated or the way in which they have been employed? In Chapter 3, we evaluate these observations for their relevance to a potential future conflict between NATO and Russia.

In the latter half of this report, we continue to explore key questions: Are dynamics observed in Ukraine likely to translate to future conflict? If so, will they manifest themselves as imitations or adaptations from the current war? Chapter 4 provides a parallel analysis of how observations from Ukraine could be relevant to a potential U.S.-China conflict in the Indo-Pacific. Chapter 5 concludes by highlighting important trends from across these analyses, noting where they might be conditional based on factors that could still plausibly shift during the war and drawing implications and recommendations for the DAF, DoD, and other U.S. policymakers.

[23] Bryan Frederick, Alexandra T. Evans, Mark Hvizda, Alisa Laufer, Howard Wang, Samuel Charap, Krystyna Marcinek, Howard J. Shatz, Khrystyna Holynska, David A. Ochmanek, Omar Danaf, Brett Zakheim, and Kristen Gunness, *The Consequences of the Russia-Ukraine War*, RAND Corporation, RR-A3141-1, 2025.

Chapter 2

Novel and Notable Warfighting Observations from Ukraine at the Tactical and Operational Levels

The conduct of the war in Ukraine could indicate broader changes in the character of warfare.[24] Whereas late-twentieth century conflicts underscored the importance of precision weaponry and skilled combined-arms maneuver, the Russia-Ukraine war has revived debate about the utility of firepower, mass, and attritional concepts of operation.[25] At the same time, the conflict has emphasized new or evolving technologies, such as UASs and distributed space-based communications. In this chapter, we take an inductive approach to addressing this juxtaposition and delve into the specific conduct of the war in Ukraine at the tactical and operational levels to identify novel and notable observations about how the war has been fought to date. In subsequent chapters of this report, we build on these observations to assess whether the fighting in Ukraine could be indicative of how future wars involving the United States could be fought.

Identifying Novel and Notable Observations from the Fighting in Ukraine

To focus the scope of our analysis, we detail only those observations from the Russia-Ukraine war that we deem to be particularly novel or notable, and we focus on operational and tactical dynamics rather than strategic choices or policy decisions. *Novel* observations refer to phenomena that have not been witnessed in other high-intensity interstate wars of the 21st century. For example, the widespread use of sUASs for intelligence, surveillance, and reconnaissance (ISR) and strike missions represents a development wholly unseen in previous large-scale conventional wars between peer adversaries. *Notable* observations are those that might not have been expected or anticipated prior to February 2022 but have had substantial effects on the conduct and course of the war. The inability of the Russian Aerospace Forces (VKS) to establish comprehensive air superiority is an example of a

[24] On the distinction between the constant nature of war versus the changing character of war, see Mark A. Milley, "Strategic Inflection Point: The Most Historically Significant and Fundamental Change in the Character of War Is Happening Now—While the Future Is Clouded in Mist and Uncertainty," *Joint Force Quarterly*, No. 110, July 2023; and Gerard Roncolato, "The Character of War Is Constantly Changing," *Proceedings*, U.S. Naval Institute, Vol. 148/5/1,431, May 2022.

[25] See, for example, Andrew A. Michta, "Mass Still Matters: What the U.S. Military Should Learn from Ukraine," *New Atlanticist*, Atlantic Council, October 3, 2023; Franz-Stefan Gady and Michael Kofman, "Making Attrition Work: A Viable Theory of Victory for Ukraine," *Survival: Global Politics and Strategy*, Vol. 66, No. 1, February–March 2024; and Alex Vershinin, "The Attritional Art of War: Lessons from the Russian War on Ukraine," Royal United Services Institute, March 18, 2024.

notable observation that merits further explanation. Of course, some observations from the war—such as the criticality of mass and artillery support in ground operations—are certainly not groundbreaking. Many of these observations were well understood before the current conflict, and the fighting in Ukraine has underscored their continued relevance. In this chapter, we focus on what has likely changed about the character of warfare rather than what appears to have remained consistent.

Throughout this report, we draw our observations from a wealth of publicly available primary and secondary sources. Although videos and first-person battlefield accounts posted to social media have emerged as hallmark features in the coverage of contemporary conflicts, press reporting continues to provide more-reliable accounts. Additionally, many academic institutions and think tanks have published outstanding research related to the conflict, some of which has been derived from field work in Ukraine. With the variety of source material available, the Russia-Ukraine war has produced a greater volume of publicly available information about its conduct than any war in recent memory.[26] The challenge in studying the fighting, however, lies in identifying how this abundance of detail translates into more-generalizable insights about how modern warfighting has potentially changed.

By examining tactical and operational aspects of the fighting in Ukraine in this chapter, we establish a foundation from which we and other stakeholders can conduct a wider, strategic-level assessment of the war's implications. In the next two chapters, we assess the relevance of trends observed in Ukraine to potential future conflicts elsewhere in the world. In Chapter 5, we compare what has occurred in the current conflict with what might unfold in these future fights to assess strategic-level implications for U.S. policy.

Observing Tactical and Operational Attributes of the Russia-Ukraine War

This section summarizes eight novel or notable observations drawn from the fighting in Ukraine at the tactical and operational levels of warfare. Because some aspects of one observation could echo certain warfighting dynamics in another, these observations are not fully distinct. Neither are they exhaustive. As discussed in Chapter 1, others have highlighted different ways in which the war could reveal important new trends. Our work does not necessarily disagree with those analyses—each of which has its own specific scoping conditions. Instead, we identify the observations at the tactical and operational levels that are most likely to represent a new dynamic in high-intensity interstate warfare.

[26] See, for example, Seth G. Jones, "Russia's Ill-Fated Invasion of Ukraine: Lessons in Modern Warfare," brief, Center for Strategic and International Studies, June 1, 2022; Justin Bronk, Nick Reynolds, and Jack Watling, *The Russian Air War and Ukrainian Requirements for Air Defence*, special report, Royal United Services Institute, November 7, 2022; Zabrodskyi et al., 2022; Justin Bronk, *Russian Combat Air Strengths and Limitations: Lessons from Ukraine*, Center for Naval Analysis, IOP-2023-U-035263-Final, April 2023; Jack Watling and Nick Reynolds, *Meatgrinder: Russian Tactics in the Second Year of Its Invasion of Ukraine*, special report, Royal United Services Institute, May 19, 2023a; "Warfare After Ukraine: Battlefield Lessons," 2023; and "In Ukraine, A War of Incremental Gains as Counteroffensive Stalls," *Washington Post*, December 4, 2023.

Observation 1: The Pairing of Persistent Surveillance Capabilities with Precision Fires Has Created a New and Unresolved Dilemma for Offensive Operations

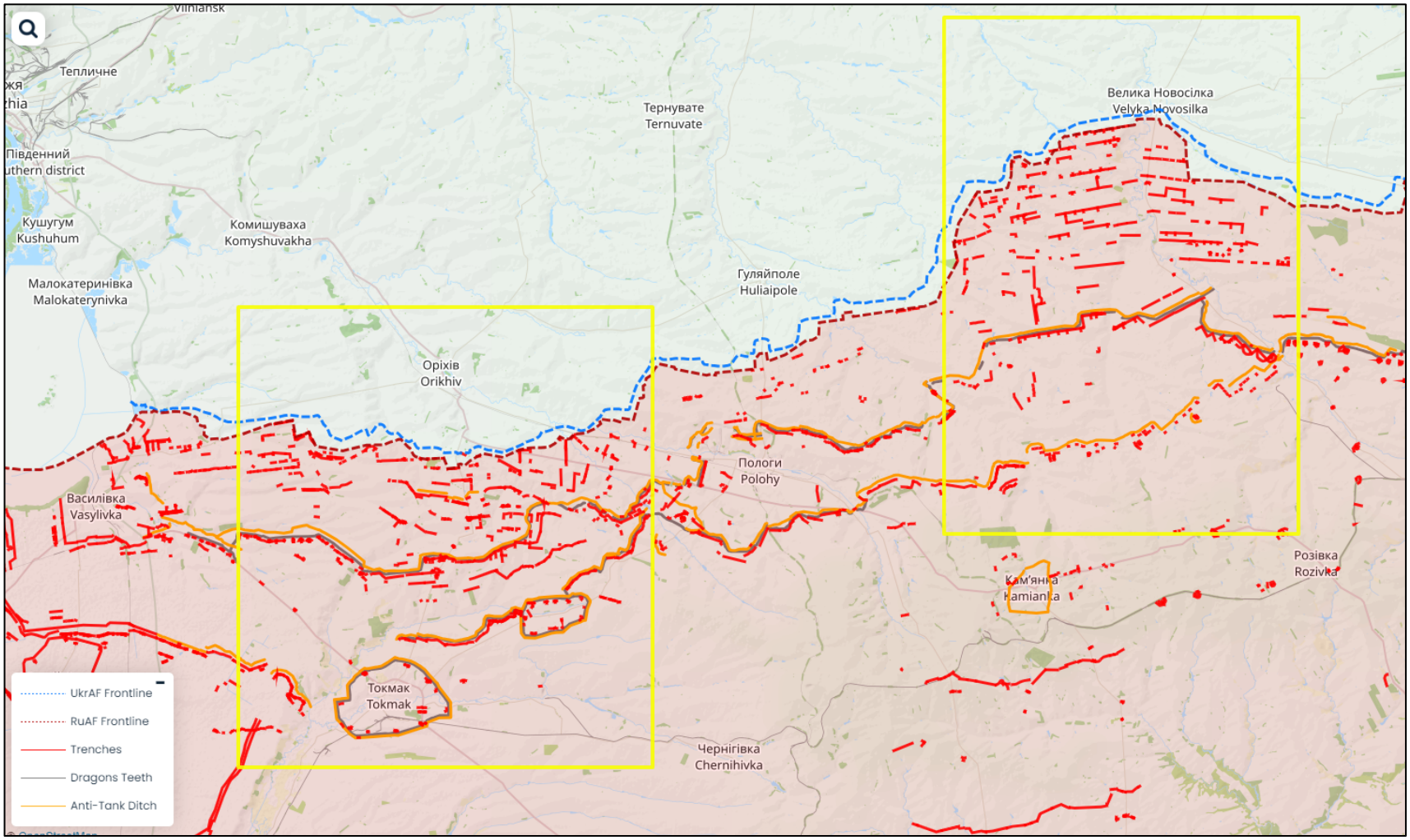
Throughout the Russia-Ukraine war, attacking forces have had to reconcile the need to remain dispersed, decentralized, and survivable with the requirement to mass quickly for coordinated offensive breakthroughs. This balance has been difficult to maintain because defending forces have dramatically complicated offensive maneuver by pairing persistent surveillance capabilities with highly responsive precision fires. During the war's opening weeks, for example, Russian forces' deficient communications and cultural aversion to delegating command authority drove many brigade commanders to the front line so that they could more effectively manage the massing of their disparate battalion tactical groups (BTGs) for offensive operations.[27] As a result of this "officer's reconnaissance" and ill-advised decisions to replace defective military communications with unsecure civilian cell phones, dozens of exposed Russian commanders were killed by opportunistic Ukrainian targeting and precision fires early in the war.[28] This dynamic has affected both sides in the conflict. Russian defenders anticipated Ukrainian assaults during the 2023 counteroffensive in occupied Zaporizhzhia (Figure 2.1) and prepared for it by blanketing their defensive network with UASs, mines, and artillery emplacements.[29] These capabilities allowed the defenders to observe, canalize, and consequently disrupt Ukrainian vehicles massing in preparation for large, mechanized attacks.

[27] Pavel Baev, *Russia's War in Ukraine: Misleading Doctrine, Misguided Strategy*, *Études de L'Ifri*, No. 40, French Institute of International Relations, October 2022, p. 17; Robert Dalsjö, Michael Jonsson, and Johan Norberg, "A Brutal Examination: Russian Military Capability in Light of the Ukraine War," *Survival: Global Politics and Strategy*, Vol. 64, No. 3, June-July 2022, p. 11; Andrew S. Bowen, *Russia's War in Ukraine: Military and Intelligence Aspects*, Congressional Research Service, R47068, September 14, 2023, p. 6; Julian E. Barnes, Helene Cooper, and Eric Schmitt, "U.S. Intelligence Is Helping Ukraine Kill Russian Generals, Officials Say," *New York Times*, May 4, 2022.

[28] Jeff Schogol, "Why Russian Generals Keep Getting Killed in Ukraine," *Task and Purpose*, March 23, 2022a.

[29] See Watling and Reynolds, 2023b.

Figure 2.1. Map of Russian Defensive Fortifications Along the Tokmak and Velyka Novosilka Axes of Southern Ukraine as of June 2023



SOURCE: Provided by the Black Bird Group. Used with permission.
NOTE: Red shading indicates Russian-occupied territory. The yellow boxes indicate Ukraine's main axes of advance (the Tokmak axis and the Velyka Novosilka axis). Dragon's teeth are concrete anti-tank obstacles. RuAF = Russian Armed Forces, UkrAF = Ukrainian Armed Forces.

Both Russian and Ukrainian forces have adapted to the marriage of persistent surveillance capabilities with precision fires by dispersing and decentralizing their attacks. Since its early mistakes, the Russian military has reverted to conducting smaller, less complex assaults, potentially learning from the early successes of PMC [Private Military Company] Wagner.[30] With more freedom of action and looser rules of engagement than regular forces bound to the traditional Russian chain of command, some Wagner mercenary units operated with higher proficiency throughout eastern Ukraine in early 2023.[31] Similarly, Ukraine eventually adapted to the initial failures of its 2023 counteroffensive by decentralizing its attacks, although doing so sacrificed its potential to achieve a large-scale breakthrough of Russian lines.[32] A similar fate befell Russia's own attempt at massed mechanized offensive maneuver during its initial effort to capture Avdiivka in October 2023.[33] Although Russian and Ukrainian forces have enjoyed tactical successes on offense by adapting to the risks of centralization, they have done so at the cost of successfully coordinating decisive, large-scale operations.

Observation 2: Air Defenses Have Been Resilient Against Manned Aircraft but Have Been Less Effective Against UASs

Throughout the Russia-Ukraine war, ground-based air defenses (GBADs) have proven highly effective in denying air control and destroying manned aircraft, but they have performed inconsistently against low-cost, expendable UASs. In the opening hours of the conflict, Russia attempted to achieve VKS air superiority by suppressing fixed Ukrainian surface-to-air missile (SAM) sites with massive barrages of cruise and ballistic missiles. Ukraine's legacy Soviet SAMs survived this initial strike by dispersing and moving continuously to complicate Russian targeting.[34] Once they returned to action, Ukrainian mobile air defenses began to attrit VKS jets operating at high altitudes. Russian pilots adapted by flying below the SAMs' radar horizons, but this tactic exposed them to MANPADS fire from Ukrainian ground forces. As a result, Ukraine's layered approach to air defense largely prevented the VKS from attempting fixed-wing sorties beyond the line of contact after April 2022.[35] Severely outranged by modernized Russian GBADs and fighters armed with advanced air-to-air missiles, Ukrainian aircraft similarly abstained from crossing the front line shortly after the war's chaotic start.

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[30] Tim Lister, Frederik Pleitgen, and Victoria Butenko, "Deadly and Disposable: Wagner's Brutal Tactics in Ukraine Revealed by Intelligence Report," CNN, January 26, 2023.

[31] Lister, Pleitgen, and Butenko, 2023; Patrick Tucker, "Senior White House Official: Wagner Mercenaries More 'Aggressive' Than Russian Military," *Defense One*, January 4, 2023a; Tatarigami_UA, "1/17 You don't hear as much about the advancement of regular russian brigades . . ." post on the X platform, February 21, 2023. @Tatarigami_UA is an anonymous but well-regarded commentator on the Russia-Ukraine war.

[32] "In Ukraine, A War of Incremental Gains as Counteroffensive Stalls," 2023; "Is Ukraine's Offensive Stalling?" *The Economist*, July 25, 2023.

[33] Although Russian forces ultimately captured Avdiivka in February 2024, they encountered astounding losses during their initial mechanized assault on the city in October 2023. Marcus Walker, "Tired Ukrainian Troops Fight to Hold Back Russian Offensive: 'They Come Like Zombies,'" *Wall Street Journal*, November 21, 2023; "In Ukraine, A War of Incremental Gains as Counteroffensive Stalls," 2023.

[34] See Bronk, Reynolds, and Watling, 2022; and Bronk, 2023.

[35] Zabrodskyi et al., 2022, p. 20; Bronk, Reynolds, and Watling, 2022, p. 1; Bronk, 2023, p. 8.

By early 2023, the VKS began to respond to the threat posed by Ukraine's dispersed, mobile SAM capabilities by employing an air-launched stand-off weapon that could be fired from a greater distance: the Unified Gliding and Correction Module (UMPK). This innovation converts a traditional gravity bomb into a guided, longer-range munition that can be launched from the safety of friendly airspace.[36] The UMPK proved to be an important factor in blunting Ukraine's 2023 counteroffensive, particularly because of the Ukrainian Armed Forces' (UAF) lack of short-range air defenses capable of intercepting it.[37] Nevertheless, Ukraine recently offset this Russian development with a purely tactical innovation. Ukrainian forces have begun to covertly position long-range SAMs (such as the MIM-104 Patriot) near the front line, enabling them to threaten the airspace deep behind the Russian forward line of troops (FLOT) where attacking jets typically release their UMPKs.[38] Once they fire, these maneuverable systems quickly reposition to avoid counterfire. At least twice between December 2023 and February 2024, highly proficient Ukrainian air defense teams successfully downed multiple Russian aircraft in a single day by applying these so-called *SAMbush* tactics, thereby demonstrating the enduring lethality of legacy air defenses when practicing deception, dispersion, and evasion.[39]

Despite their proficiency against manned aircraft, both Russian and Ukrainian GBADs have displayed notable deficiencies in their ability to counter UASs. On multiple occasions since the start of the war, Ukrainian attack drones have penetrated Russia's integrated air defense system (IADS) and have struck highly sensitive targets in the Russian interior, including in Moscow. Systems ranging in technical complexity from the explosives-laden Soviet-era Tu-141 Strizh target drone to the cutting-edge UJ-26 Bober deep-attack drone have scored multiple successes against Russian air defenses, although this success could also be attributable to the inherent difficulty of interdicting small, low-flying threats or poor Russian air defense proficiency.[40] For their part, Russian forces have employed Iranian-produced Shahed-series one-way attack (OWA) UASs as both a complement to and substitute for cruise and ballistic missile strikes.[41] By launching swarms of attack drones against Ukrainian critical infrastructure, Moscow has attempted to exhaust Kyiv's scarce, Western-supplied

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[36] For a detailed description of the UMPK, see Sergio Miller, "'An Extremely Big Threat': Russian Glide Bombs Make Their Debut in the War," *Wavell Room*, April 17, 2023.

[37] Thomas Newdick and Tyler Rogoway, "Ukraine's Armor Appears to Have a Russian Attack Helicopter Problem," *War Zone*, June 15, 2023.

[38] Julian E. Barnes and Marc Santora, "Ukraine's Creative Use of Weapons Carries Promise and Risk," *New York Times*, February 8, 2024.

[39] David Axe, "'Minus Three Russian Bombers.' Ukraine Set Another Deadly Missile-Ambush—And Shot Down a Trio of High-Tech Su-34s," *Forbes*, December 22, 2023b; David Axe, "Sukhoi Massacre: Ukraine Has Shot Down Six of Russia's Best Jets in Just Three Days," *Forbes*, February 19, 2024a; Kateryna Stepanenko, Riley Bailey, Angelica Evans, Karolina Hird, George Barros, and Frederick W. Kagan, "Russian Offensive Campaign Assessment," Institute for the Study of War, December 22, 2023; Vitaly Shevchenko, "Ukraine War: Ukraine Reports Jump in Number of Downed Russian Planes," BBC News, February 28, 2024.

[40] Christiaan Triebert, Haley Willis, Yelyzaveta Kovtun, and Alexander Cardia, "Ukraine's Other Counteroffensive: Drone Attacks on Russian Soil," *New York Times*, July 31, 2023; Steve Rosenberg and Jaroslav Lukiv, "Ukraine War: Drone Attack on Russian Bomber Base Leaves Three Dead," BBC News, December 26, 2022.

[41] When in service with the Russian Federation Armed Forces, the Shahed-131 is known as the *Geran-1* and the Shahed-136 is called the *Geran-2*. This report continues to refer to these weapons by their Shahed designations because they are used much more commonly in public media sources. See Defense Intelligence Agency, *Iranian UAVs in Ukraine: A Visual Comparison*, DIA_F_24L1I_G, August 7, 2023.

air defense interceptors. With a single Shahed-131 or Shahed-136 costing an estimated $20,000 to $30,000 and Western interceptors pricing between $450,000 (for the Infrared Imaging System Tail/Thrust Vector-Controlled, or IRIS-T) to $3.7 million (for the Patriot Advanced Capability-3, or PAC-3), these drones present Russia with a notable cost-exchange advantage—even if Moscow is paying Tehran more than six times the drones' production cost, as alleged by Ukrainian hackers.[42] Dispersed and highly mobile air defenses operated by skilled crews have proven instrumental to denying manned aircraft from establishing air control, but their utility as competent and cost-efficient counter-uncrewed aircraft system (C-UAS) weapons in Ukraine has been much more limited.

Observation 3: Dumb (Unguided) and Smart (Precision) Artillery Systems Have Been Complements, Not Substitutes

Traditional cannon and rocket artillery has played a central role in the Russia-Ukraine war since its outset. In February and March 2022, Ukrainian forces successfully defended Kyiv by leveraging heavy artillery to prevent Russian forces from consolidating outside the capital—most famously at Hostomel Airport.[43] The Russians later exploited their own firepower advantages at Sievierodonetsk and Lysychansk in spring 2022 and Bakhmut throughout winter 2023 by pulverizing Ukrainian fortifications with relentless barrages and then capturing the residual rubble with light infantry.[44] Ukraine's Zaporizhzhia counteroffensive in summer 2023 further underscored the war's emphasis on artillery. Russian fires pummeled Ukrainian maneuver units as they massed in preparation to attack, which compelled Kyiv to pause ground operations until Russia's guns could be suppressed.[45] Thus, traditional artillery has proven decisive in the war because of its ability to paralyze defenders and disrupt attackers. Both Ukraine's and Russia's efforts to secure millions of artillery shells and rockets from third parties underscores the supreme importance that each has ascribed to fires dominance.

Although the significance of massed artillery is not a novel insight, the war in Ukraine has specifically revealed that firepower alone is insufficient for securing victory on the modern battlefield. Precision weapons—including OWA UASs—have fundamentally altered warfare at both the tactical and operational levels. Regarding the former, UASs have become integral to all types of fire missions. The pairing of reconnaissance UASs with precision munitions has dramatically expedited kill chains and raised new questions about the survivability of towed or low-mobility artillery systems.[46] Counter-

[42] Pettyjohn, 2024, pp. 32–36; Missile Defense Advocacy Alliance, "Missile Interceptors by Cost," webpage, updated February 2024; Ukrainian Military Center, "The Cost of Shahed-136 for Russia Has Been Reported," February 6, 2024.

[43] Paul Sonne, Isabelle Khurshudyan, Serhiy Morgunov, and Kostiantyn Khudov, "Battle for Kyiv: Ukrainian Valor, Russian Blunders Combined to Save the Capital," *Washington Post*, August 24, 2022; Liam Collins, Michael Kofman, and John Spencer, "The Battle of Hostomel Airport: A Key Moment in Russia's Defeat in Kyiv," *War on the Rocks*, August 10, 2023.

[44] Zabrodskyi et al., 2022, p. 42; Joshua Yaffa, "The Fight to Survive Russia's Onslaught in Eastern Ukraine," *New Yorker*, June 7, 2022; Matthew Luxmoore, "Ukraine Says Russia Is Using 'Scorched Earth' Tactics in Bakhmut," *Wall Street Journal*, April 10, 2023.

[45] Michael Kofman and Rob Lee, "Perseverance and Adaptation: Ukraine's Counteroffensive at Three Months," *War on the Rocks*, September 4, 2023.

[46] Jack Watling and Nick Reynolds, *Ukraine at War: Paving the Road from Survival to Victory*, special report, Royal United Services Institute, July 4, 2022, p. 7; Cranny-Evans, 2023; Michael Peck, "For 250 Years, US Troops Could Tow Their Cannons Around the Battlefield. The War in Ukraine Shows They Won't Have That Luxury in the Future," *Business Insider*, October 31, 2023; Ashley Roque, "Towed Artillery Has Reached 'End of the Effectiveness,' Army Four-Star Declares," *Breaking Defense*, March 27, 2024.

battery fire has also experienced a remarkable transformation with the emergence of OWA and first-person view (FPV) UASs. These weapons are capable of locating, targeting, and engaging individual gun crews even when they are operating from dispersed and hidden sites, as is often the case in Ukraine.[47] At the operational level, Ukraine's acquisition of Western long-range strike systems, such as the M142 High-Mobility Artillery Rocket System (HIMARS) and the Storm Shadow air-launched cruise missile, has compelled the Russian military to reconsider and reorganize its highly centralized logistical system.[48] Ukraine's effective employment of these weapons has also triggered debate about the viability of legacy command-and-control (C2) structures given the destruction of Russian command posts and muster areas tens of kilometers behind the front line.[49] In short, the ongoing war has highlighted the value of maintaining a robust and complementary mix of massed and precision fires.

Observation 4: Employing and Countering Uncrewed Systems Has Become a Battlefield Priority

Beyond frustrating modern air defenses and expediting the coordination of tactical fires, UASs have also reshaped traditional ground maneuver across the Ukrainian theater. Infantry platoons and squads on both sides of the front line now rely on FPV UASs and quadcopters to maintain local situational awareness and track enemy movements. While defenders use sUASs to observe the attackers' route of advance and complicate their ability to overcome obstacles, attackers employ them as organic precision-strike assets to clear trenches and destroy fortified positions.[50] This offsetting interaction has contributed to the stalemated, positional warfare now endemic to the fighting in Ukraine.[51] Given the apparent democratization of ISR and precision-strike capabilities to the lowest maneuver echelons, both Russian and Ukrainian troops have adopted extensive countermeasures to break the stalemate. Electronic warfare (EW) systems now checker the FLOT, which could be saturated with as many as 25 drones at any time.[52] So-called *cope cages* (improvised armor sheets welded or bolted to the top of tanks)[53] and fishing net covers for artillery pieces represent additional

[47] Watling and Reynolds, 2023a, p. 12; Cranny-Evans, 2023; "How Cheap Drones Are Transforming Warfare in Ukraine," *The Economist*, February 5, 2024.

[48] "Warfare After Ukraine: Battlefield Lessons," 2023; Kofman and Lee, 2023.

[49] Milford Beagle, Jason C. Slider, and Matthew R. Arrol, "The Graveyard of Command Posts: What Chornobaivka Should Teach Us About Command and Control in Large-Scale Combat Operations," *Military Review*, May–June 2023; Dmitri Minic, *What Does the Russian Army Think About Its War in Ukraine? Criticisms, Recommendations, Adaptations*, French Institute of International Relations, September 21, 2023, p. 17; Zabrodskyi et al., 2022, p. 53; Steve Brown, "Second Ukrainian Strike on Congregating Russian Troops in 48 Hours Reportedly Kills 60," *Kyiv Post*, February 22, 2024.

[50] Pettyjohn, 2024, pp. 3–4; Alex Horton and Serhii Korolchuk, "In Ukraine, Explosive DIY Drones Give an Intimate View of Killing," *Washington Post*, October 4, 2023b.

[51] Valerii Zaluzhnyi, "Modern Positional Warfare and How to Win It," *The Economist*, November 1, 2023.

[52] Watling and Reynolds, 2023b, p. 23.

[53] David Axe, "Cope Cages Come to Israel as IDF Tanks Get Extra Drone Armor," *Forbes*, October 16, 2023a.

defensive innovations that have become commonplace on an increasingly lethal battlefield inundated with uncrewed technology.[54]

Aircraft are not the only uncrewed systems changing the face of battle in Ukraine. Lacking conventional naval power capable of challenging the Russian Navy (VMF), Ukraine has developed a highly effective fleet of uncrewed surface vessels (USVs) to contest Moscow's dominance of the Black Sea. Indigenously produced weapons, such as the Sea Baby and Maritime Autonomous Guard Uncrewed Robotic Apparatus V-type (MAGURA V5), have enabled Ukrainian forces to sink several key Russian warships, threaten the Kerch Strait Bridge, and attack Crimean ports.[55] As a result, the VMF has lost nearly one-third of the Black Sea Fleet since the start of the invasion and has been forced to withdraw some of its surviving assets east of Crimea.[56] Just as Kyiv has employed uncrewed aircraft as an asymmetric substitute for the Ukrainian Air Force's lack of traditional deep-strike capabilities, it has effectively leveraged uncrewed sea drones to offset its maritime deficiencies and loosen the VMF's grip on the Black Sea region. Uncrewed systems have thus become central to both Russia's and Ukraine's war efforts given their asymmetric ability to upset the balance on the front line.

Observation 5: Attritable Systems Have Sustained Protraction

After two years of high-intensity warfare, Russia and Ukraine have lost thousands of soldiers and platforms while expending immense quantities of munitions. Both nations have turned to international partners to sustain their exhaustive campaigns, but even these sources are finite. Consequently, the rapid production of low-cost, attritable platforms and munitions has become an essential factor enabling the protraction of the Russia-Ukraine war.

Expendable drones have become synonymous with the attritional contest in Ukraine. Because drones have armed even the smallest tactical units with ISR and strike capabilities previously reserved for higher-echelon formations, both militaries now prioritize their destruction. One recent report estimates that Ukrainian forces lose a staggering 10,000 drones per month.[57] As evidence of the importance of these attritable systems, both Moscow and Kyiv have recently announced ambitious programs to ensure domestic drone production.[58] These efforts will decrease each nation's reliance on commercial systems, ensure long-term access to drone technology, and guarantee a continued ability to resist each other.

Additionally, expendable systems prolong combat operations by serving as substitutes for exquisite but expensive and scarce weapons. Russia's use of Shahed-series OWA UASs as an analog

[54] Edward Perov, "From Fishing Nets to Netting: How Ukrainians Are Trying to Protect Themselves from Our 'Lancets,'" *Military Review*, August 27, 2023.

[55] Nick Paton Walsh, Victoria Butenko, and Florence Davey-Attlee, "The Moment Ukraine Used an Experimental Drone to Attack a Russian Bridge," CNN, August 15, 2023; H. I. Sutton, "USVs at Work in the Black Sea," *Proceedings*, U.S. Naval Institute, Vol. 148/12/1,438, December 2022.

[56] Victoria Butenko, Christian Edwards, and Alex Stambaugh, "Ukraine Says It Has Sunk Another Warship, Disabling a Third of Russia's Black Sea Fleet," CNN, February 14, 2024; Thomas Grove and Jared Malsin, "Russia Withdraws Black Sea Fleet Vessels from Crimea Base After Ukrainian Attacks," *Wall Street Journal*, October 4, 2023.

[57] Watling and Reynolds, 2023a, p. 18.

[58] Ian Lovett, "Low on Ammo, Ukraine Tries to Build a Million Explosive Drones," *Wall Street Journal*, February 3, 2024; David Hambling, "Russian Volunteer Group Claims to Make 1,000 FPV Kamikaze Drones a Day," *Forbes*, December 5, 2023.

for cruise and ballistic missiles provides the clearest example of this point. With the cost of a single 3M-14 Kalibr sea-launched cruise missile estimated between $1 million and $6.5 million, Russia can acquire many more drones than cruise missiles, even when accounting for their inflated Iranian price of $193,000 per 6,000-unit batch.[59] Recent reporting confirms that Shaheds are more readily available than Kalibrs, revealing that Russia likely produces 500 of the former but just 40 of the latter in a single month.[60] In other words, Shaheds offer Russia an alternative, long-range strike capability that can be used in place of legacy missiles or, at a minimum, as a stopgap until additional high-end munitions can be manufactured. Similarly, Ukraine has used sea drones as an apparent substitute for scarce R-360 Neptune and RGM-84 Harpoon anti-ship cruise missiles in its highly successful campaign against Russia's Black Sea Fleet.

Observation 6: Smart Devices Have Been Powerful Civilian Tools and Military Targets

Smart devices have demonstrated the potential to revolutionize the scale and speed of intelligence collection, analysis, and dissemination in warfare. Ukraine has modified the *Diia* government services app to enable civilians to support intelligence and combat operations with direct reporting and imagery, while Ukrainian military units now use the Delta app to build a real-time common operational picture.[61] Despite their promise, however, app-enabled smart devices have also created new vulnerabilities for modern militaries. Russian soldiers using stolen Ukrainian cell phones to coordinate maneuvers—mainly because of defects with their own military-grade systems—or to call home to their families have been subjected to Ukrainian eavesdropping and targeting.[62] The latter point was exemplified in a devastating Ukrainian rocket attack against a Russian barracks in Makiivka, Ukraine, on December 31, 2022, which Moscow later blamed on its soldiers' unbridled cell phone use.[63] As reports of smartphone-induced targeting have notably decreased since the Makiivka strike, both Russian and Ukrainian forces have evidently learned to balance the benefits of these devices against their nontrivial risks.

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[59] Howard J. Shatz and Clint Reach, *The Cost of the Ukraine War for Russia*, RAND Corporation, RR-A2421-1, 2023, p. 30; Yuriy Tarasovskyi [Юрій Тарасовський] and Konstantin Gnenny [Костянтин Гненний], "Russia Spent About $620 Million on Shelling Ukraine on January 2, Forbes Estimates" ["Росія витратила на обстріл України 2 січня близько $620 млн. Оцінка Forbes"], *Forbes*, January 2, 2024; Ukrainian Military Center, 2024.

[60] Tetiana Lozovenko, "Russia Steps Up Production of Kalibr and Kh-101 Missiles by 3–4 Times—Ukrainian Defence Intelligence," *Ukrainska Pravda*, June 23, 2023; Yehven Rudenko [Євген Руденко], Nazariy Mazylyuk [Назарій Мазилюк], and Yehven Buderatskyi [Євген Будерацький], "'Zirkon,' 'Shahed Y,' and Other Toys of Putin. Kyiv Experts Showed the Insides of Air Weapons of the Russian Federation" ["'Циркон,' 'Шахед Ы,' Та Інші Іграшки Путіна. Київські Експерти Показали Нутрощі Повітряної Зброї РФ"], *Ukrainska Pravda*, February 23, 2024.

[61] Jerry England, "Integration of the Ukrainian Tech Sector for Civil Defense," *Red Diamond*, Winter 2023; Lukasz Olejnik, "Smartphones Blur the Line Between Civilian and Combatant," *Wired*, June 6, 2022; Grace Jones, Janet Egan, and Eric Rosenbach, "Advancing in Adversity: Ukraine's Battlefield Technologies and Lessons for the U.S.," policy brief, Belfer Center for Science and International Affairs, Harvard Kennedy School, July 31, 2023.

[62] Kevin Freese, "Smart Phones Playing Prominent Role in Russia-Ukraine War," *Red Diamond*, Vol. 14, No. 2, Summer 2023; Jeff Schogol, "Russian Troops Are Proving That Cell Phones in War Zones Are a Very Bad Idea," *Task and Purpose*, May 13, 2022b.

[63] Rhoda Kwan, "Russia Blames Its Soldiers' Cellphone Use for Missile Strike That Killed Dozens," *NBC News*, January 4, 2023.

Observation 7: Constant Adaptation Has Been Required for Effective Electronic Warfare

To counter the proliferation of uncrewed persistent surveillance assets, Russian and Ukrainian forces have embraced new EW assets and tactics. Moscow's forces have been especially active in the electromagnetic spectrum in recent months despite their inability to use jammers effectively during the opening phase of the war.[64] Specifically, they have adapted to Ukraine's pervasive use of ISR and strike sUASs by deploying large numbers of tactical radiofrequency and Global Positioning System (GPS) jammers near the FLOT.[65] Ukrainian forces have leveraged their own EW assets to down hostile drones, but the Russians have recently equipped their Lancet-3M loitering munitions with an autonomous terminal attack capability to counteract them.[66] The continuous move-countermove cycle that defines the interaction of EW systems and uncrewed assets has progressed at a stunning pace over the past two years and appears set to continue for the duration of hostilities.

Observation 8: Commercial Actors Have Enabled States with Limited Native Assets to Access Sophisticated and Resilient Space Capabilities

In the space domain, the Russia-Ukraine war has underscored the growing prominence of commercial actors and the inherent dual-use nature of space-based assets. Starlink satellite internet terminals supplied by the West have enabled Ukrainian society to maintain connectivity despite the disruption of Ukraine's telecommunications infrastructure.[67] Starlink has also been heavily exploited for military purposes. Ukrainian forces now rely extensively on Starlink for distributed communications and have attempted to use it to coordinate a long-range drone attack on at least one occasion.[68] Apparently unable to effectively disrupt SpaceX's proliferated Starlink satellite architecture, Russia has recently chosen to adopt the network for its own military purposes.[69] Kyiv has noted the difficulty of countering Moscow's acquisition of Starlink terminals, given that they are widely available for purchase.[70] Moreover, any efforts on behalf of SpaceX to disable Russian Starlink access along the front line in occupied Ukraine could affect the connectivity of UAF terminals operating within their immediate proximity.[71]

Commercial remote sensing is another key space-based capability influencing the conflict in Ukraine. Prior to Russia's full-scale invasion, commercial firms released high-resolution imagery of

[64] Bronk, Reynolds, and Watling, 2022, p. 13; Zabrodskyi et al., 2022, p. 49.

[65] Watling and Reynolds, 2023b, p. 17; see also, Watling and Reynolds, 2022; and Samuel Bendett and Jeffrey Edmonds, *Russian Military Autonomy in Ukraine: Four Months In*, Center for Naval Analyses, DOP-2022-U-032953-Final, July 2022.

[66] Francis Farrell, "How Russia's Homegrown Lancet Drone Became So Feared in Ukraine," *Kyiv Independent*, November 8, 2023.

[67] Alex Horton and Serhii Korolchuk, "Whatever the Fuss over Elon Musk, Starlink Is Utterly Essential in Ukraine," *Washington Post*, September 18, 2023a.

[68] Horton and Korolchuk, 2023a; Victoria Kim, Richard Pérez-Peña, and Andrew E. Kramer, "Elon Musk Refused to Enable Ukraine Drone Attack on Russian Fleet," *New York Times*, September 8, 2023.

[69] James Marson and Thomas Grove, "Russia Using Thousands of Musk's Starlink Systems in War, Ukrainian General Says," *Wall Street Journal*, February 15, 2024.

[70] Marson and Grove, 2024.

[71] Sam Skove, "Russia Is Using SpaceX's Starlink Satellite Devices in Ukraine, Sources Say," *Defense One*, February 9, 2024.

Russian military encampments in Belarus to discredit the Kremlin's claim that its troops were simply conducting "exercises" near the Ukrainian border.[72] Recognizing the power of commercial imagery and lacking its own military satellites, Ukraine has leased a remote sensing capability from a commercial provider. This Finnish ICEYE satellite—as well as commercial imagery provided in Western aid packages—has enabled Ukraine to monitor Russian troop movements and even collect evidence of Russian war crimes in Mariupol and Bucha.[73] Russian forces might have also acquired commercial imagery through third parties, with unnamed Ukrainian officials alleging that Moscow has used imagery from Western firms to refine the precision of its long-range missile strikes.[74] In short, commercial capabilities have enabled Ukraine to compete with Russia in a domain once reserved explicitly for spacefaring powers, while also allowing the Kremlin to compensate for its own space deficiencies.[75]

Conclusion

Russia's full-scale invasion of Ukraine has offered the 21st century its first glimpse of protracted, high-intensity conventional warfare. While the fighting in Ukraine has presented useful insight into warfare's changing character, it has also renewed interest in certain aspects of combat not seen since World War I. Table 2.1 summarizes several novel observations from the ongoing conflict at the tactical and operational levels as well as notable ones that share striking connections to wars of the past.

Table 2.1. Observations of Novel and Notable Features of the Fighting in Ukraine

	Observation	Driving Factors
1	The pairing of persistent surveillance capabilities with precision fires has created a new and unresolved dilemma for offensive operations	• Proliferation of persistent surveillance capabilities • Advances in technology required for rapid data fusion • Proliferation of highly responsive long-range precision fires • Necessity of massing and concentration to achieve offensive breakthrough against fortified defenses
2	Air defenses have been resilient against manned aircraft but have been less effective against UASs	• Effectiveness of dispersion, CCD, and evasion TTPs • Creation of layered air defense networks with GBADs and MANPADS • Effectiveness of low-cost OWA UASs and limitations of current C-UAS capabilities

[72] Jacob Knutson, "Satellite Images Show Increased Russian Military Buildup near Ukraine," *Axios*, February 11, 2022.

[73] Brendan Cole, "Ukraine's 'People's Satellite' Helping Expose Russian Equipment: Kyiv," *Newsweek*, November 26, 2022; Jamie Johnson, "How Maxar Is Helping Beat the Russians with Its Four Eyes in the Sky," *The Telegraph*, June 8, 2022; Malachy Browne, David Botti, and Haley Willis, "Satellite Images Show Bodies Lay in Bucha for Weeks, Despite Russian Claims," *New York Times*, April 6, 2022.

[74] Graeme Wood, "A Suspicious Pattern Alarming the Ukrainian Military," *The Atlantic*, March 18, 2024.

[75] United States Geospatial Intelligence Foundation, "GEOINT Lessons Being Learned from the Russian-Ukrainian War," February 22, 2024.

Observation		Driving Factors
3	Dumb (unguided) and smart (precision) artillery systems have been complements, not substitutes	• Massive, legacy stockpiles of munitions and additional infusions from external actors • Liberal rules of engagement and fire discipline (particularly for Russia) • Proliferation of persistent surveillance capabilities • Proliferation of highly responsive long-range precision fires
4	Employing and countering uncrewed systems has become a battlefield priority	• Distribution of persistent ISR and strike capabilities to small units via uncrewed systems • Effectiveness of low-cost OWA UASs and limitations of C-UAS capabilities • Effectiveness of low-cost USVs and limitations of C-USV capabilities • Favorable cost-exchange ratio of small uncrewed systems relative to other systems
5	Attritable systems have sustained protraction	• Resource-intensive and highly attritional fighting • Availability of large volumes of low-cost UASs • Production limitations of exquisite systems
6	Smart devices have been powerful civilian tools and military targets	• Proliferation of smart devices, apps, and connectivity • Vulnerability of smart devices to detection and tracking • Poor OPSEC (particularly for Russia)
7	Constant adaptation has been required for effective EW	• Need for exquisite ISR and strike for some military operations • Effectiveness of FPV UAS and GPS for enabling precision strike at scale • Proliferation of low-cost, effective jammers • Experimentation with autonomy and other counter-EW innovations
8	Commercial actors have enabled states with limited native assets to access sophisticated and resilient space capabilities	• Proliferation of commercial space companies and capabilities • Development of resilient satellite constellations • Widespread availability of commercial imagery

NOTE: CCD = camouflage, concealment, and deception; C-USV = counter-uncrewed surface vessel; OPSEC = operational security; TTP = tactic, technique, and procedure

In the following chapters, we assess the extent to which the war in Ukraine could indicate technological or military innovation changes that could shape future battlefields and might affect the United States' approach to warfighting as it prepares for potential conflicts with either Russia or China. Which tactical and operational dynamics of the current war are likely to apply to these potential future conflicts? How might the United States, its allies, and even its adversaries learn from and adapt to their own interpretations of the combat in Ukraine? How might different geographic, political, and strategic circumstances affect their efforts to do so? We explore these questions in more detail in Chapters 3 and 4.

Chapter 3

Implications for a Potential Future NATO-Russia War

Novel and notable aspects of contemporary wars may not necessarily manifest themselves in future conflicts. Extrapolating lessons from recent conflicts is such a fraught exercise that "fighting the last war" has become a shorthand in both military and nonmilitary circles for misinterpretations of the operational and strategic environments.[76] As discussed in Chapter 2, the novel and notable features that we have observed from the Russia-Ukraine war are driven by numerous factors that may or may not apply to other conflicts.

In this chapter, we assess the likely relevance of these observations to a hypothetical future conflict between NATO and Russia. To do so, we analyze the observations highlighted in Chapter 2 to understand whether the important factors that underpin each one are likely to differ in such a conflict. We also investigate how other factors not observed in Ukraine might alter the way in which either NATO or Russia could attempt to solve various tactical and operational challenges. In Chapter 3, we conduct a similar analysis for a potential U.S.-PRC conflict in the Indo-Pacific. By assessing the likely relevance of the novel or notable observations from the fighting in Ukraine to these hypothetical conflicts, we lay the groundwork to identify which of these observations should alter DAF, DoD, or U.S. government planning and investments and in what manner.

Envisioning a Future NATO-Russia War

A full-scale war between NATO and Russia would likely bear little resemblance to the "special military operation" in Ukraine, especially since the Putin regime originally designed, resourced, and executed its 2022 invasion as if it were a lesser armed action.[77] Although the Russian state's commitment to the ongoing conflict has increased dramatically, an attack on the nuclear-armed, multinational NATO alliance would probably differ from the current war in terms of its planning and execution. In what Russia's *Military Doctrine* might describe as a regional or large-scale war, the Kremlin would probably not abide by many of the constraints that have governed its operations in Ukraine. Given the geopolitical stakes involved, we would expect it to mobilize its military, economy,

[76] See, for example, Peter Spiegel, "How America Found Itself Fighting the Last War—Again," *Financial Times*, August 18, 2021; and J. E. Kaufmann and H. W. Kaufmann, *Fortress France: The Maginot Line and French Defenses in World War II*, Stackpole Books, 2007.

[77] At the time of this writing, the Kremlin continues to refer to its combat operations in Ukraine as a "special military operation." Watling, Danylyuk, and Reynolds, 2023, p. 4; Zabrodskyi et al., 2022, pp. 7–8; Vladimir V. Putin, *On the Historical Unity of Russians and Ukrainians*, Presidential Library of the Russian Federation, July 12, 2021.

and society to their maximum potential. Should a clash with NATO be perceived as an existential threat to the regime, Russian leaders might also consider the employment of nuclear weapons.[78]

For the purposes of this report, the precise geopolitical details concerning a potential war between NATO and Russia are less relevant to us than the discussion of how such a war would actually be conducted. Definitive statements about the conclusion of the current war in Ukraine or the Russian military's reconstitution potential are similarly less pertinent given the aims of this analysis. Nevertheless, any hypothetical conflict requires some strategic-level scoping assumptions so that policymakers can examine it more fruitfully from tactical and operational perspectives.

For our purposes, then, we settled on a set of assumptions that would likely be most useful for U.S. military planners to consider for a potential future NATO-Russia conflict. We included assumptions that the conflict is highly stressing for both Russia and NATO and would involve high stakes for both sides, creating incentives to adapt under pressure such that their capabilities in the conflict may not be limited to those presently fielded. From this perspective, shorter, less-intense conflicts may inform military adaptations but are less influential than longer, costlier wars. We also assumed that the conflict would be precipitated by a Russian attack on NATO, rather than vice versa, given the former's history of armed aggression against its neighbors and the importance of planning for this risk for NATO military planners. In sum, our assumptions are as follows:

- The fighting between NATO and Russia occurs after an attempted Russian invasion of a NATO member state. Russia seizes some NATO territory, which the United States and its allies subsequently seek to reclaim. The war does not include NATO efforts to seize Russian territory.
- The fighting escalates quickly to a high-intensity conventional conflict. Although it is conducted under the shadow of potential nuclear escalation, it does not involve the actual use of tactical or strategic nuclear weapons.
- Russia commits sufficient troops and resources such that protracted, resource-intensive combat operations and NATO mobilization are required for victory.

Of course, these assumptions may or may not hold in an actual NATO-Russia war. A true conflict of this intensity could plausibly escalate into a nuclear war, especially if Russian forces suffer unsustainable losses or NATO actions threaten the integrity of the Russian state.[79] However, we have chosen these assumptions because they allow us to examine a plausible, stressing future conflict for which key observations from the Russia-Ukraine war may be relevant.

Relevance of Observations from the Russia-Ukraine War

To explore whether certain dynamics observed during the Russia-Ukraine war might shape a future NATO-Russia conflict, we assessed whether the operational challenges that both sides have been attempting to solve in Ukraine would likely occur in a future European fight. If so, we considered

[78] Russia Strategic Initiative, *Russian Military Doctrine: RSI Primer*, Spring 2022, p. 26.

[79] Mary Beth D. Nikitin, *Russia's Nuclear Weapons: Doctrine, Forces, and Modernization*, Congressional Research Service, R45861, Version 16, April 21, 2022, pp. 7–8; "Putin Warns Again That Russia Is Ready to Use Nuclear Weapons If Its Sovereignty Is Threatened," Associated Press, March 13, 2024.

how NATO and Russia would likely attempt to address these challenges, and whether their likely approaches would be similar or would differ from those observed in the Russia-Ukraine war.

Relevance of Observation 1: Persistent Surveillance Capabilities and Precision Fires Would Initially Challenge Offensive Operations for Either Force Until NATO Gains Air Control

In a hypothetical conflict between NATO and Russia, persistent surveillance capabilities and highly precise long-range strike systems could complicate offensive operations in a manner resembling the current stalemate in Ukraine. At the strategic level, NATO would surely apply its experience from the crisis along Ukraine's borders in early 2022 to detect concerning or suspicious Russian military exercises and equipment deployments near its eastern flank. It could leverage high-resolution satellite imagery and social media analysis from its constituent militaries and commercial firms to observe Russian military activity. The additional indication and warning time generated by these capabilities would allow NATO's blunt layer forces to fortify their defenses in anticipation of an imminent Russian advance.

Assuming the initial Russian invasion seizes some NATO territory, the Alliance would be compelled to counterattack and eliminate Russian lodgments. However, Russia's persistent surveillance capabilities could enable Moscow to disrupt NATO preparations for a counteroffensive and reduce the Alliance's ability to obscure the timing and magnitude of its counterattack. The Kremlin does possess space-based sensing capabilities and both the Ministry of Defense and PMC Wagner have allegedly purchased commercial satellite imagery for military applications.[80] Russia also fields highly capable special operations forces, reconnaissance units, and human intelligence networks to offset some of its technical intelligence-collection limitations.[81] These assets could be deployed covertly throughout Europe to observe and report on NATO movements or even provide targeting data for long-range cruise and ballistic missile attacks against allied force generation nodes. In short, any attempt by either NATO or Russia to mass ground forces in preparation for a major strategic offensive would likely be detected and potentially disrupted.

Both NATO and Russia also possess robust ISR and strike capabilities that could frustrate offensive maneuver at the tactical level of warfare. As mentioned in Chapter 2, the current conflict in Ukraine has revealed the inherent difficulties of launching both large-scale offensives and small-unit assaults against entrenched defenses blanketed by sensors. Nevertheless, NATO's assumed ability to establish air control, discussed in more detail later, presents a fundamental difference between the current war and a hypothetical clash with Russia. Although they would require a nontrivial amount of time to attrit Russian air defenses in the opening phase of a conflict, NATO's air forces would most likely achieve eventual dominance over the VKS given their larger size and qualitatively superior

[80] Wood, 2024; Kelly Ng, "Ukraine: US Sanctions Chinese Firm Helping Russia's Wagner Group" BBC News, January 26, 2023.

[81] Andrew S. Bowen, *Russian Military Intelligence: Background and Issues for Congress*, Congressional Research Service, R46616, November 15, 2021; Bronk, Reynolds, and Watling, 2022, p. 26; Watling, Danylyuk, and Reynolds, 2023, p. 33.

aircraft and pilots.[82] Russia could, however, retain some ability to operate UASs in areas where it could no longer fly manned aircraft, thereby complicating NATO operations even after the Alliance established air control.

On balance, however, achieving air control would likely mean that NATO could subsequently employ powerful fixed-wing ISR assets to surveil Russian defensive lines and rear areas for potential vulnerabilities. Air control would also allow the Alliance to deliver fixed-wing and rotary-wing firepower against Russian positions to precipitate a breakthrough, although these aerial assets would still confront some Russian SAM and MANPADS threats. Russia's winter 2024 defeat of Ukrainian forces at Avdiivka appears to justify this point because the VKS facilitated ground successes by pulverizing Ukrainian fortifications and demoralizing Kyiv's exhausted troops with punishing UMPK strikes.[83] If air control and aerial-delivered fires are the keys to unlocking ground maneuver on today's transparent battlefield, NATO's potential for successful offensive operations in a war with Russia appears much greater than those of Russia or Ukraine in the present conflict.

Relevance of Observation 2: Both NATO and Russia Will Likely Encounter Difficulties Using Manned Aircraft for Suppression of Enemy Air Defenses, Although Russia Might Offset Its Deficiencies with the Innovative—and Currently Unanswered—Use of UASs

Given its historical preoccupation with NATO airpower, Moscow would likely prioritize the dispersion and protection of its air defense assets in the event of a large-scale conflict with the Alliance.[84] Indeed, the VKS's high-value strategic SAMs, such as the SA-20 (S-300P series) and SA-21 (S-400), are built on multi-wheeled chassis, while medium- and short-range systems subordinate to the Ground Forces (SV) employ either wheels or tracks to keep pace with maneuver units. This mobility enables them to quickly reposition and avoid enemy counterfire after they illuminate their radars and fire their missiles. Beyond such *shoot-and-scoot* maneuvers, mobile SAMs can also practice *pop-up* or *SAMbush* tactics to surprise unsuspecting enemy aircraft overflying contested territory. Ukrainian crews operating Soviet-era mobile SAMs have consistently demonstrated the lethality of this approach since the initial weeks of Russia's full-scale invasion.[85]

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[82] NATO eventually achieved air superiority in nearly every RAND Russia-centric wargame played in recent years. See Gian Gentile, John C. Jackson, Karl P. Mueller, D. Sean Barnett, Mark Hvizda, Bradley Martin, David A. Ochmanek, Clint Reach, and Barry Wilson, *Revisiting RAND's Russia Wargames after the Invasion of Ukraine: Summary and Implications*, RAND Corporation, RR-A2031-1, 2023, pp. 11–12.

[83] Grace Mappes, Riley Bailey, Karolina Hird, Angelica Evans, and Frederick W. Kagan, "Russian Offensive Campaign Assessment," Institute for the Study of War, February 17, 2024; Susie Blann, "Russia Says It Has Crushed the Last Pocket of Resistance in Avdiivka to Complete the City's Capture," Associated Press, February 19, 2024.

[84] Russia's fear of a massed aerospace attack at the outset of a war with NATO underwrites its Strategic Aerospace Operations (SAO) concept of operations. See Michael Kofman, Anya Fink, Dmitry Gorenburg, Mary Chesnut, Jeffrey Edmonds, and Julian Waller, *Russian Military Strategy: Core Tenets and Operational Concepts*, research memorandum, DRM-2021-U-029755-Final, Center for Naval Analyses, August 2021, pp. 55–64; and Clint Reach, Edward Geist, Abby Doll, and Joel Cheravitch, *Competing with Russia Militarily: Implications of Conventional and Nuclear Conflicts*, RAND Corporation, PE-330-A, June 2021, p. 12.

[85] Justin Bronk, "Getting Serious About SEAD: European Air Forces Must Learn from the Failure of the Russian Air Force over Ukraine," *RUSI Defence Systems*, Vol. 24, Royal United Services Institute, April 6, 2022.

In a future war with NATO, the Russian military would likely complicate allied suppression of enemy air defenses(SEAD)/destruction of enemy air defenses (DEAD) operations by deploying large numbers of mobile air defenses and decoys in multiple layers throughout the territory it controls. Doctrinally, each SV maneuver brigade and regiment contains multiple short-range anti-aircraft battalions while divisions control their own organic, medium-range air defense missile regiments. These formations operate independently of and beneath the umbrella of the VKS's broader IADS, which itself consists of strategic SAMs guarded by point defenses.[86] If the destruction of a single SAM unit were to require some aircraft to suppress the unit's radars, other aircraft to physically destroy the unit's launchers and radars, and still other offensive counter-air escorts to protect the SEAD package from fixed-wing threats, a comprehensive NATO SEAD/DEAD campaign at the outset of a war with Russia would require a large number of allied aircraft, sorties, and flight hours.[87]

Russian forces would face similar if not greater challenges. The VKS's inability to destroy Ukrainian mobile SAMs in February 2022 reflects the air service's historical deficiencies in SEAD/DEAD.[88] Since the conclusion of the Cold War, NATO's acquisition of modern GBADs has stagnated, which in turn has led the VKS to deprioritize the development of its SEAD/DEAD capabilities.[89] Nevertheless, Russian operations in Ukraine have revealed an alternative means of neutralizing GBADs that is much less reliant on highly specialized SEAD aircraft, weapons, and training. Unable to destroy them kinetically, Moscow now attempts to exhaust Ukrainian air defenses by overwhelming them with cheap OWA UASs.[90] The Kremlin has even begun the construction of a Shahed factory in Russia to enable domestic production of these Iranian-origin drones, implying that it intends to continue and expand its use of these weapons in the foreseeable future.[91]

OWA UASs present Russia with a potentially attractive means to suppress NATO air defenses in a potential conflict. Aside from exhausting interceptor magazines, UASs could be used to destroy air defense radars and enable successful follow-on strikes with cruise and ballistic missiles. Iran's 2019 combination UAS and missile attack on Saudi Arabia's Abqaiq oilfields—which were protected by the U.S.-built Patriot SAM system—provides a possible blueprint for this approach, and one that Russia has mimicked regularly in Ukraine.[92] Absent public demonstrations of NATO cost-effective C-UAS capabilities that could complement its legacy air defenses, Russia might conclude that it could

[86] Lester W. Grau and Charles K. Bartles, *The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces*, Foreign Military Studies Office, 2016, pp. 267–271; Army Threat Publication 7-100.1: Russian Tactics, U.S. Department of the Army, February 2024, pp. D-1–D-3; Justin Bronk, *Modern Russian and Chinese Integrated Air Defense Systems: The Nature of the Threat, Growth Trajectory, and Western Options*, Royal United Services Institute, January 15, 2020, pp. 15–20.

[87] Bronk, 2022; International Institute for Strategic Studies, *Defeating Threat Air Defences: The Return of the DEAD*, December 2020, p. 15.

[88] Zabrodskyi et al., 2022, p. 17.

[89] Collins, Kofman, and Spencer, 2023.

[90] Minic, 2023, p. 34.

[91] Dalton Bennett and Mary Ilyushina, "Inside the Russian Effort to Build 6,000 Attack Drones with Iran's Help," *Washington Post*, August 17, 2023.

[92] Stephen Kalin and Sylvia Westall, "Costly Saudi Defences Prove No Match for Drones, Cruise Missiles," Reuters, September 18, 2019.

feasibly leverage drones to compensate for its shortcomings in traditional fixed-wing SEAD/DEAD operations.

NATO could develop and employ its own UASs to reduce the SEAD burden on its fixed-wing aircraft or complement the efforts of fixed-winged aircraft to roll back enemy air defenses at the outset of a conflict with Russia. The Alliance has conducted recent testing of the ALTIUS-700M drone against a mock Russian SAM system.[93] Although NATO OWA UASs, such as Switchblade and Warmate, lack the strategic range of contemporary Ukrainian or Russian attack UASs, it is plausible that the Alliance will pursue such capabilities as it absorbs lessons from the current war. Even if NATO overcomes the technical hurdles involved in producing long-range attack UASs, however, it will still need to determine how to integrate them into existing force structures and concepts of operations before deploying them on future battlefields. Russia, on the other hand, enjoys some current advantages in this innovative type of UAS-based SEAD employment.

Relevance of Observation 3: Dumb (Unguided) and Smart (Precision) Artillery Systems Would Both Have Important Uses in a NATO-Russia War

Any potential fighting between NATO and Russia would hinge on a combination of both "dumb" (unguided) and "smart" (precision) firepower. Russia has devoted considerable resources to expanding its strategic precision-strike capabilities given their ability to inflict high levels of damage on the enemy without exceeding the nuclear threshold.[94] The Russian concept of Strategic Operations to Destroy Critically Important Targets (SODCIT) embodies this view: It calls for the use of precision weaponry to strike certain targets in the enemy's homeland to produce cascading, systemic effects and generate "deterrent damage."[95] Just as SODCIT has aggressively targeted Ukraine's electrical grid in the current war, Russian doctrine would call for it to employ precision cruise and ballistic missiles or drones in attempts to cause civilian psychological distress, fracture allied political will, and disrupt military force generation in the event of a conflict with NATO.

Similarly, the United States and NATO would likely employ their vast arsenal of precision-guided munitions (PGMs) in a future conflict, although these weapons would more likely be directed toward military targets rather than civilian infrastructure. The U.S. Army's Multi-Domain Operations (MDO) concept of operations—identified as a core tenet of the broader U.S. military's Joint Warfighting Concept (JWC)—specifically envisions long-range precision weaponry disabling hostile air defenses, coastal defense cruise missile batteries, and other systems designed to block or hinder U.S. intra-theater maneuver at the outset of war.[96] Once these defenses have been eroded, NATO could then target Russian C2 and logistical nodes supporting maneuver formations in much

[93] Thomas Newdick, "Our First Look at the ALTIUS-700M Loitering Munition Obliterating a Target," *The War Zone*, March 14, 2024.

[94] Clint Reach, Alexis A. Blanc, and Edward Geist, *Russian Military Strategy: Organizing Operations for the Initial Period of War*, RAND Corporation, RR-A1233-1, 2022, pp. 5–6.

[95] Reach, Blanc, and Geist, 2022, pp. 100–101; Kofman et al., 2021, pp. 68–71.

[96] See U.S. Army Training and Doctrine Command, *The U.S. Army in Multi-Domain Operations 2028*, TRADOC Pamphlet 525-3-1, U.S. Army, December 6, 2018; and Thomas A. Walsh and Alexandra L. Huber, "A Symphony of Capabilities: How the Joint Warfighting Concept Guides Service Force Design and Development," *Joint Force Quarterly*, No. 111, 4th Quarter 2023.

the same way that the UAF has in Ukraine. Kyiv's ability to consistently strike Russian points of vulnerability with land-based Guided Multiple Launch Rocket System (GMLRS) munitions and air-launched Storm Shadow cruise missiles demonstrates the overcentralization of the Kremlin's military system and its susceptibility to potentially paralyzing precision strikes. Importantly, NATO would also rely on PGMs in a war with Russia to limit civilian casualties in friendly territory occupied by Russian forces. This point bears additional weight given the Russian military's tendency to position legitimate military targets among schools, hospitals, and other civilian structures.[97]

Fighting in Ukraine has revealed that precision alone, however, may not enable victory. Although smart rockets, cruise missiles, and drones have captured international headlines, traditional dumb artillery has become a key determinant of tactical and operational success in an increasingly positional conflict. A war between NATO and Russia could similarly involve phases of attritional struggle—at least initially before NATO airpower could achieve air control—if, for example, Russian forces were to build defensive networks on captured territory before NATO ground forces could counterattack. In this case, sheer ground-based firepower could prove highly valuable for fixing Russian defenders, softening their fortifications, and degrading their artillery systems in the absence of sustained air support. A protracted fight could also strain U.S. and Russian inventories of precision weapons and drive a greater reliance on less-costly unguided munitions.

Beyond its cost benefits, dumb artillery would likely remain relevant in a NATO-Russia conflict because it cannot be jammed. Fighting in Ukraine has revealed the potential vulnerability of some ISR and precision strike assets to modern EW capabilities. Russian EW capabilities have the potential for further improvement as the conflict in Ukraine drags on and Moscow gains further opportunities to practice countermeasures against Western-donated equipment. Unguided artillery would therefore offer NATO a baseline means of attriting Russian forces if Russia develops the means to reduce the effectiveness of precision NATO firepower.

Relevance of Observation 4: Employing and Countering Uncrewed Systems Would Likely Remain a Central Concern for Both NATO and Russia in a Future Conflict

Uncrewed systems would likely play a pivotal role in any potential conflict between NATO and Russia considering both parties' ambitious plans to acquire them at scale: Russia's Uncrewed Aircraft Systems national project and the United States' Replicator initiative.[98] In the ground domain, both NATO and Russia could employ quadcopters and other sUASs to facilitate maneuver and enhance the striking power of their infantry formations. The inherent ISR and strike capabilities offered by sUASs may prove particularly critical for ground units if joint airpower is unavailable. In turn, the outsized tactical value of UASs could trigger a series of measures and countermeasures resembling the current cat-and-mouse game witnessed in Ukraine between uncrewed and EW systems. While Russia fields a robust array of EW systems and continues to refine them under combat conditions, NATO

[97] Jane Buchanan, Yulia Gorbunova, and Rachel Denber, *"Tanks on the Playground": Attacks on Schools and Military Use of Schools in Ukraine*, Human Rights Watch, November 9, 2023.

[98] "Russia Needs $6 Billion to Develop Putin's Drone Project" Reuters, April 24, 2023; Noah Robertson, "Replicator: An Inside Look at the Pentagon's Ambitious Drone Program," *Defense News*, December 19, 2023.

and its allies may need to reconsider their existing EW capabilities and investigate alternative approaches to effective and cost-efficient C-UAS operations.

Naval combat between NATO and Russia could also assume a different character in a future war because of recent technical and tactical innovations spearheaded by Ukraine. Kyiv currently employs sea drones as a substitute for conventional maritime power and has inflicted serious damage on the VMF. In a war with NATO, Russia may attempt to emulate Ukraine's asymmetric sea drone strategy given its own navy's inferiority compared with the Alliance. If the Baltic Fleet is restricted to Russian territorial waters, for example, the broader VMF would hold little military utility beyond its nuclear deterrence mission. However, sea drones covertly deployed from the Russian coast could allow Moscow to attack NATO warships, target energy infrastructure, or disrupt undersea cables in the Baltic. Sea drones could also enable Russia to threaten ports in NATO's strategic rear if this technology becomes sufficiently portable or long-range. NATO forces, alternatively, could employ uncrewed maritime systems to demine shipping pathways in the Baltic or North Atlantic if Russia were to employ mines to complicate naval access to these areas. They could also assume some of the operational burden encumbering scarce conventional ships, such as port surveillance and maritime infrastructure protection missions. Considering their many combat roles and the current lack of means available for countering them, uncrewed systems could feature prominently in a potential NATO-Russia conflict.

Relevance of Observation 5: NATO May Struggle to Produce Sufficient Volumes of Attritable Systems to Sustain the Fighting If a Future Conflict Were Protracted

Both Russia and NATO would likely employ large quantities of exquisite military capabilities at the outset of a potential conflict in Eastern Europe. However, once inventories of these weapons become more limited, both parties would become increasingly reliant on lower-cost, expendable, or highly reproducible platforms and munitions to satisfy their warfighting demands. For example, attritable UASs could fill some of the roles once performed by cutting-edge manned aircraft or larger and more-sophisticated UASs while proliferated satellite architectures might assume a portion of the communications burden previously shouldered by high-end military platforms. At the tactical level, Russian and NATO forces would likely resort to the use of traditional artillery after exhausting their stocks of PGMs. Although such technologies as Russia's UMPK and the United States' Joint Direct Attack Munition (JDAM) represent a middle-ground between smart and dumb qualities, even the use of these weapons would likely be constrained by finite inventories.

It is important to note that the flexibility and agility of both Russia's and NATO's defense industrial bases could prove decisive in a protracted conflict. After two years of high-intensity combat in Ukraine, Russia has demonstrated an ability to quickly produce dumb platforms and munitions—mostly of antiquated Soviet design—at scale despite dedicating the past decade to the production of new, smart military technologies. In the event of a war against Russia, it is likely that the United States and its European allies would take similar steps to redirect and increase defense production. However, whether the United States and its NATO allies would be able to shift their defense industrial bases to produce sharply higher outputs of unsophisticated systems in a period relevant to a potential conflict

remains uncertain. This inflexibility could prove to be a substantial challenge should a future war with Russia become protracted.

Relevance of Observation 6: NATO Is Unlikely to Rely on Civilian Smart Devices, But These Devices May Remain an Important Tool, and Vulnerability, for Russia

Because smartphones and mobile internet connections have become commonplace throughout Eastern Europe, any potential Russian military activities in the region would likely risk detection and documentation by local populations. Mirroring Ukrainians at the outset of Russia's 2022 invasion, civilians armed with smart devices would surely film Russian troop movements and share resistance information via social media and messaging apps. This form of civilian-driven surveillance could prove particularly effective against Russian forces if Moscow is unable to correct the OPSEC and C2 deficiencies its military initially exhibited in Ukraine. However, international law specifies that any civilians participating in activities intended to "adversely affect the military operations or military capacity of a party to an armed conflict" would legally expose themselves to military retaliation.[99] Such a risk carries additional weight given the Kremlin's penchant for brutality—even against those whom it has called the "brotherly" people of Ukraine.[100]

Similarly, if Russia enacts national mobilization and officially declares war against NATO, unauthorized cell phone use would likely skyrocket among its own forces as unwilling conscripts call home or film testimonials to protest their deployment. These appeals could dwarf those made by disgruntled reservists in fall 2022 given the scale and scope of such a wide-reaching mobilization. Persuading conscripts with little training and poor morale to recognize the dangers of smartphone use and mobile internet connections would likely be challenging.

One notable aspect of the Russia-Ukraine war has been the UAF's willingness to employ civilian-created apps to facilitate military operations. In a future conflict with Russia, however, NATO forces would most likely avoid such an impromptu communications architecture. First, NATO forces would not have the same need for the types of technological stopgap measures adopted by Ukrainian forces because of the Alliance's more-robust military communications architecture; necessity compelled Ukrainian civilians to militarize smartphone apps to compensate for the UAF's inherent C2 deficiencies at the outset of the war. As a military alliance, however, NATO has refined its tactical and operational coordination through two decades of war in Afghanistan and is also in the process of developing newer, more-secure communications networks.[101] Second, NATO's strict adherence to OPSEC standards would probably preclude its troops from using smart devices for military activities. The United States has become particularly sensitive to its servicemembers' use of smart devices in

[99] Nils Melzer, "Interpretative Guidance on the Notion of Direct Participation in Hostilities Under International Humanitarian Law," *International Review of the Red Cross*, Vol. 90, No. 872, December 2008, p. 1016.

[100] Telegraph Agency of the Soviet Union, "Putin Calls Ukraine 'Brotherly Country,'" December 19, 2023.

[101] North Atlantic Treaty Organization, "Using Quantum Technologies to Make Communications More Secure," September 27, 2022.

recent years and would most likely prohibit smartphone use on future battlefields.[102] Such rigid regulations may enhance OPSEC, but they may be difficult or time-consuming to implement in practice, particularly across more-diverse multinational forces. Furthermore, doing so could come at the cost of tactical flexibility. It is therefore uncertain whether NATO units—especially combined, multinational ones—using military-grade systems in a future conflict with Russia could act as rapidly as their Ukrainian partners act today using predominately civilian technologies.

Relevance of Observation 7: Nonkinetic Capabilities Are Crucial to Countering Uncrewed Systems Today, but Technological Advances May Drive the Need for Kinetic Solutions

To offset the persistent surveillance and long-range strike capabilities offered by uncrewed systems, both NATO and Russia would have strong incentives to saturate a future battlespace with a variety of EW assets and countermeasures to defeat them. Learning from the UAF's difficulties in countering cheap Russian quadcopters and drones, NATO will likely expedite the development of tactical EW-based C-UAS systems for use by small infantry units. For example, the Alliance has already donated multiple Skywiper Electronic Drone Mitigation 4 System (EDM4S) C-UAS devices to Ukraine, which allow individual troops to disrupt UASs by jamming their radiofrequency links to their controllers or blocking their connection to global navigation satellite system signals.[103] At higher echelons, the U.S. Army is also developing a suite of new EW platforms with offensive and defensive capabilities under its Terrestrial Layer System program. These assets could offer resilience and striking power to U.S. and NATO formations at the brigade, division, and corps echelons as they attempt to maneuver across a battlespace inundated by Russian electromagnetic effects.[104]

Applying lessons learned from the war in Ukraine, Russian forces would probably deploy GPS jammers (such as the Pole-21 and R-330 Zhitel) in a future war with NATO to protect critical C2 or logistical nodes from UAS observation or PGM attacks.[105] Moscow may also cover its maneuver units with new air defense systems specifically designed to shoot down drones or incoming PGMs while minimizing radar emissions. For example, the experimental 9M337 Sosna-R SAM system detects aerial targets using passive radar, meaning it does not emit an active radar signature that can be triangulated by hostile EW systems or SEAD/DEAD aircraft.[106] The 2S38 self-propelled anti-aircraft gun similarly targets drones and cruise missiles using optical sensors rather than detectable

[102] Horton, 2024; Liz Sly, "U.S. Soldiers Are Revealing Sensitive and Dangerous Information by Jogging," *Washington Post*, January 29, 2018.

[103] Olivia Savage, "Ukraine Conflict: Ukraine Deploying 1,000s of Lithuanian C-UAS Jammers," Janes, September 20, 2023.

[104] Andrew Eversden, "With New Contract, Army's Integrated EW and Intel System for Brigades Reaches Next Phase," *Breaking Defense*, July 15, 2022

[105] Watling and Reynolds, 2022, p. 10; Roman Olearchyk, "Military Briefing: Russia Has the Upper Hand in Electronic Warfare with Ukraine," *The Economist*, January 7, 2024.

[106] Paolo Valpolini, "Serial Production of Sosna Short-Range Air Defence System Unveiled," *European Defence Review*, August 24, 2018; OE Data Integration Network, "9M337 Sosna-R Russian Short-Range Air Defense Missile System," webpage, undated.

active radar emissions.[107] Many key assets such as strategic SAMs or long-range strike systems would also seek to passively counter NATO sensors using Nakidka radar-absorbing material or decoy emitters in alignment with the Russian military's long-standing *maskirovka* doctrine.[108]

Moreover, autonomy could arise as an effective countermeasure to jamming. Russian forces in Ukraine are currently experimenting with an autonomous tracking capability on the Lancet-3M loitering munition that protects the drone from electronic disruption in its terminal attack phase.[109] Ukrainian forces allegedly have equipped their own long-range attack drones with rudimentary autonomy, allowing them to avoid hostile jammers en route to striking oil refineries hundreds of kilometers within Russian territory.[110] The United States also intends to incorporate advanced decisionmaking algorithms into the thousands of new drones produced under the Replicator initiative, and the U.S. Army is developing Air-Launched Effects, small drones capable of autonomously detecting threats in EW-contested environments.[111] In short, the next iteration of the EW-uncrewed systems exchange has likely already begun.

Relevance of Observation 8: Commercial Space Systems Would Likely Provide Greater Benefits to NATO Than Russia

Any potential war with Russia would most likely spur NATO to continue or deepen its coordination with commercial firms in the space domain. Although the Alliance could use nonmilitary remote sensing assets to detect and publicly disclose Russian troop movements without revealing its own imagery capabilities, it could also leverage such systems as SpaceX's Starshield to supplement and expand its military SATCOM bandwidth.[112] Moreover, commercial systems could strengthen the resiliency of NATO's existing space architecture against Moscow's anti-satellite (ASAT) capabilities.[113] If Russian dazzling or jamming were to disable NATO military satellites, for example, the Alliance could feasibly maintain operational continuity by rerouting connectivity through constellations of vetted commercial platforms. These systems could even provide advantages over stand-alone satellites in the event of a Russian kinetic ASAT attack. With more of them in orbit than

[107] Janes, "BMP-3 Derivatsiya," *Land Warfare Platforms: Armored Fighting Vehicles*, updated September 23, 2021; "Bloggers Showed Photos of a Prototype Combat Vehicle 2S38 Complex 'Derivation-Air Defense,'" *Military Review*, January 27, 2018.

[108] Ilya Tsukanov, "Kalashnikov's Camouflage Cloak for Tanks: What Is It and How Does It Work?" Sputnik, June 29, 2023; Army Threat Publication 7-100.1, 2024, p. 5-31.

[109] David Hambling, "Russia's Automated Killer Drones May Not Be Working as Planned," *Forbes*, February 14, 2024.

[110] Vasco Cotovio, Clare Sebastian, and Allegra Goodwin, "Ukraine's AI-Enabled Drones Are Trying to Disrupt Russia's Energy Industry. So Far, It's Working," CNN, April 2, 2024.

[111] Frank Bajak, "Pentagon's AI Initiatives Accelerate Hard Decisions on Lethal Autonomous Weapons," Associated Press, November 25, 2023; Brad Dress, "Inside America's Plans for an Autonomous, AI-Powered Military," *The Hill*, September 27, 2023; Program Executive Office, Aviation, "Army Successfully Demonstrates Launched Effects System," U.S. Army, December 22, 2023.

[112] Sandra Erwin, "SpaceX Providing Starlink Services to DoD Under 'Unique Terms and Conditions,'" *Space News*, October 3, 2023.

[113] On Russian ASAT capabilities, see Kari A. Bingen, Kaitlyn Johnson, Makena Young, and John Raymond, *Space Threat Assessment 2023*, Center for Strategic and International Studies, April 14, 2023.

individual military platforms, they could offer a greater chance of surviving the massive debris fields that would follow a kinetic ASAT event in low-Earth orbit (LEO).[114]

Of course, any military application of commercial space assets would need to be weighed against the risk of penetration or even destruction by Russian forces. Whether private Western firms would be willing to risk the loss of their investments in an outright war with Russia—a situation with a notably higher chance of space conflict than the current war in Ukraine—remains an open question. The inherently commercial nature of these systems could also present unique political and technical challenges for NATO. For example, if Russia were to purchase access to the same commercial constellations used by the Alliance to compensate for deficiencies in its own aging space infrastructure, it might abstain from attacking them with ASAT weapons. However, the United States and its European allies would likely press firms controlling these systems to restrict or block Russia's access to them. Even if commercial firms agreed to curb Russia's exploitation of their systems, they may be unable to do so without simultaneously damaging NATO's own ability to use them. As mentioned in Chapter 2, Kyiv is currently struggling with this dilemma because efforts to block Russian Starlink access near the FLOT could degrade the UAF's own ability to use this critical but widely accessible service.

Conclusion

A future war between NATO and Russia would likely diverge from the ongoing conflict in Ukraine in several ways. First, and perhaps most importantly, NATO air dominance would probably upset the stagnation that defines current ground operations. Although attacking Russian ground forces could plausibly establish initial gains before NATO could mobilize a counterattack, the Alliance's airpower would eventually dominate the skies over Eastern Europe once Russia's air defenses could be sufficiently attrited. The neutralization of the Russian air defense umbrella would subsequently enable NATO surveillance aircraft to spot enemy weak points and troop movements while attack jets relentlessly bombard command posts, logistical nodes, and maneuver formations. Second, both NATO and Russia could incorporate lessons learned from the current conflict to correct some of their most glaring deficiencies before the next war begins. For example, NATO may dramatically improve its EW and C-UAS capabilities to counter the Russian OWA UAS threat, while the Kremlin could invest in newer and more-sustainable operational- and strategic-level ISR assets. Learning from the war may also upend certain offense-defense balances that appear obvious today. EW seems to hold great promise for C-UAS missions in 2024, but in the next decade, advances in autonomy may shift the balance in favor of uncrewed systems or galvanize the development of kinetic-kill C-UAS systems. This constant interaction between tactics and technology is a fundamental driver of war's dynamic character.

In this chapter, we have extrapolated multiple observations from Russia's ongoing invasion of Ukraine toward a hypothetical future conflict between NATO and Russia (Table 3.1). As both

[114] The phenomenon by which fields of space debris in LEO collide with each other to produce additional fields of debris is known as the Kessler Syndrome. See Norton A. Schwartz, Joel E. Williamsen, and James F. Heagy, *Orbital Debris and Kinetic Anti-Satellite Concerns: How a "Kessler Syndrome" Threatens U.S. Use of Space Assets*, NS D-21620, Institute for Defense Analyses, April 2021.

NATO and Russia continue to internalize various insights gleaned from the fighting, they will surely attempt to rectify their weaknesses and embolden their strengths. Yet, it is important to note that the war in Ukraine is simply one data point in the study of warfare. Additional conflicts—including the ongoing war in Gaza—may provide additional insights that either confirm or reject some of the original findings distilled from two years of combat in Ukraine.

Table 3.1. Key Tactical and Operational Attributes of a NATO-Russia War

Observation	Factors That Could Translate to a NATO-Russia War	Factors That Could Differ in a NATO-Russia War
1 The pairing of persistent surveillance capabilities with precision fires has created a new and unresolved dilemma for offensive operations	• Inability to achieve tactical, operational, or strategic surprise (during initial period of war before NATO air control can be established) • Inability to mass offensive forces before attacking (during initial period of war before NATO air control can be established) • Ability of both sides to operate UASs in areas where manned aircraft could not operate safely	• NATO's eventual air control could severely inhibit Russian ISR and strike capabilities, thereby facilitating NATO offensive ground maneuver
2 Air defenses have been resilient against manned aircraft but have been less effective against UASs	• Russia's employment of a dispersed, layered air defense network • Air defense systems' inability to counter the UAS threat effectively	• NATO would likely use specialized TTPs, stealthy aircraft, and high-speed missiles for SEAD against dispersed Russian air defense systems • Russia more likely than NATO to employ UASs for SEAD given current trends and progress
3 Dumb (unguided) and smart (precision) artillery systems have been complements, not substitutes	• Necessity of saturating fortified defenses with unguided firepower to enable maneuver (during initial period of war before NATO air control can be established) • Use of PGMs to attack key civilian and military nodes • Reliance on unguided artillery to overcome EW systems	• NATO's eventual air control could mitigate demand for unguided firepower
4 Employing and countering uncrewed systems has become a battlefield priority	• Mass acquisition of uncrewed systems and the devolution of ISR and strike capabilities to the lowest echelons • Use of USVs as an asymmetric naval weapon	• NATO's eventual air control could mitigate ground forces' demand for ISR and strike capabilities offered by UASs • Because of NATO's overmatch, Russia may prefer to employ USVs over conventional naval assets
5 Attritable systems have sustained protraction	• High-intensity large-scale combat operations could exhaust stocks of exquisite platforms and munitions	• NATO may not be capable of quickly restructuring its defense industrial base to facilitate the production of attritable systems

Observation	Factors That Could Translate to a NATO-Russia War	Factors That Could Differ in a NATO-Russia War
6 Smart devices have been powerful civilian tools and military targets	• Widespread availability of smartphones, apps, and internet connectivity in Eastern Europe • Civilian willingness to record military operations and post material to social media	• If a full Russian mobilization occurs, conscripts could be even more willing than volunteers and reservists to film their hardships or use phones liberally • NATO has less need for civilian technologies than UAF given existing infrastructure • NATO would likely be less willing to tolerate the use of civilian technologies and apps in support of military operations by either its own troops or civilians in occupied territories given retaliation risks
7 Constant adaptation has been required for effective EW	• Large-scale saturation of the battlespace with EW systems to counter uncrewed ISR and strike assets • Proliferation of EW-based C-UAS capabilities among small maneuver units	• NATO is deliberately building robust military-grade EW systems, while the UAF has innovated in a more ad hoc manner • Russia could field nonemitting air defense systems or passive countermeasures to defeat UASs without relying on EW capabilities • Wire guidance or autonomy could mitigate the effectiveness of EW assets in countering uncrewed systems
8 Commercial actors have enabled states with limited native assets to access sophisticated and resilient space capabilities	• Use of commercial imagery to expose military movements, allowing governments to conceal more-exquisite surveillance capabilities • Use of commercial SATCOM as an alternative to military systems	• NATO would be less reliant on commercial assets than Ukraine is currently given the Alliance's robust military space architecture • Nonkinetic and kinetic ASAT use could be more likely in a NATO-Russia war, creating greater risk to space assets and commercial interests

Chapter 4

Implications for a Potential Future U.S.-China War

To what extent does the fighting in Ukraine offer insights about how a war between the United States and China might unfold? A full-scale war between the two countries would likely have catastrophic consequences that would extend beyond the Indo-Pacific and dwarf the costs of the ongoing Russia-Ukraine war.[115] The direct involvement of two global powers, the breadth of terrain that could be involved, and the likely emphasis on air and naval power would present different operational challenges for both sides that would stress different types of forces and require different employment concepts.

Nevertheless, the war in Ukraine has illuminated structural changes in modern warfare that could shape future campaigns in the Indo-Pacific. Indeed, the United States, China, and other states in the region are studying the fighting to glean insights into the effectiveness of both new and emerging technologies and operating concepts tested on the European battlefield. The resulting challenge is how to distinguish adaptations that may be specific to Ukraine from those indicative of generalizable shifts in the conduct of warfare. Novel dynamics in Ukraine may also manifest in different ways when applied to different problems or translated through different military cultures, capabilities, or imperatives. A future war in the Indo-Pacific is unlikely to mimic the fighting in Ukraine, but it may exhibit some similar features.

Envisioning a Future U.S.-China War

In this chapter, we examine whether and how novel and notable aspects of the fighting in Ukraine at the tactical and operational levels could be relevant to a potential future U.S.-PRC conflict. As in Chapter 3, we assess whether the factors that contributed to observed characteristics of the current fighting are likely to reoccur in an Indo-Pacific campaign. To do so, we used prior, published analysis by RAND and other research organizations describing scenarios for a potential U.S.-PRC conflict.[116]

[115] David C. Gompert, Astrid Stuth Cevallos, and Cristina L. Garafola, *War with China: Thinking Through the Unthinkable*, RAND Corporation, RR-1140-A, 2016; Miranda Priebe, Bryan Frederick, Anika Binnendijk, Alexandra T. Evans, Karl P. Mueller, Cortez A. Cooper III, James Benkowski, Asha Clark, and Stephanie Anne Pillion, *Alternative Futures Following a Great Power War*: Vol. 1, *Scenarios, Findings, and Recommendations*, RAND Corporation, RR-A591-1, 2023.

[116] This research is also informed by Chinese-language sources, such as literature on Chinese doctrine and operational concepts, as well as sources such as China's national defense white papers. These sources represent the most-current publicly available information on the perspectives of Chinese researchers and, in the case of the national defense white papers, the Chinese government on these topics. However, because of their public nature, they likely do not represent a complete picture of PRC leadership thinking on a potential U.S.-PRC conflict.

Although analysts have identified a variety of potential disputes that could spark a war, we focused on scenarios involving a Chinese decision to invade Taiwan. Although the United States is not bound by treaty or other agreement to intervene directly in a PRC decision to invade the island, the possibility of a U.S.-China conflict involving Taiwan is commonly discussed and informs defense strategy in both countries.[117]

There are clear parallels between Russia's invasion of Ukraine and commonly discussed scenarios for a Chinese invasion of Taiwan. Like Russia relative to Ukraine, China possesses sizeable demographic, economic, geographic, and military advantages over Taiwan. In the event of an attempt to invade Taiwan, China would enjoy the benefits of deep interior lines of communication and a large and diverse industrial production base that grants a degree of resilience against international sanctions. Like Ukraine, Taiwan has benefited from international security assistance but does not have allies bound to come to its defense.

Despite these similarities, a conflict over Taiwan would also differ significantly from the Russia-Ukraine war. The most-obvious differences are geographic. Taiwan is a small island located close to China but thousands of miles away from the United States and separated by water from such U.S. allies as Japan. Although the war in Ukraine has been fought primarily on land, the terrain and distances involved dictate that a war over Taiwan would be fought, at least in its early stages, primarily at sea, in the air, and potentially in space. Without a land border to cross, resupplying forces in Taiwan would be far more difficult than in Ukraine, potentially for both sides. Moreover, the resulting war would embroil two of the world's largest economies and require the mobilization and movement of forces on two continents.

To scope our analysis and make it most useful for U.S. military planners, we again made a series of assumptions about the type of future conflict that would occur to ensure it would be highly stressing for both sides and would provide incentives for adaptation and the full commitment of national resources. We also included geographic assumptions about the location of the conflict to make it most stressing for U.S. forces, again to assist U.S. military planners in thinking through their more-difficult challenges. That said, we also assumed that the conflict remained below the nuclear threshold, as nuclear use on the battlefield would represent a new set of dynamics not previously observed, including in Ukraine. To summarize, here are our key assumptions about a potential U.S.-China conflict:

- China is unable to quickly seize Taiwan before U.S. intervention, resulting in a high-intensity conflict.[118]
- The fighting occurs primarily inside of the Second Island Chain.
- Neither the United States nor China employs nuclear weapons, at least in the initial phases of the conflict.

These assumptions are not intended to predict how an actual conflict over Taiwan would unfold, only to scope our analysis so that it is likely of greatest use to U.S. military planners.

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[117] See, for instance, David Brunnstrom and Trevor Hunnicutt, "Biden Says U.S. Forces Would Defend Taiwan in the Event of a Chinese Invasion," Reuters, September 19, 2022.

[118] We do not assume whether PLA forces have established a lodgment on the island. In the following sections, we note instances in which the presence of PLA forces in Taiwan would alter the applicability or nature of key observations.

Relevance of Observations from the Russia-Ukraine War

To assess the relevance of observations from the Russia-Ukraine war, we identified the major operational challenges likely to shape a future fight in the Indo-Pacific, compared these challenges with those shaping the fighting in Ukraine, and evaluated whether and how the technological or operational responses adapted by Russian or Ukrainian forces might apply. In characterizing how U.S., Taiwanese, or PLA forces might operate in a potential future conflict, we consulted publicly available literature on current and developing capabilities, investments, exercises, and operational concepts. The combat inexperience of PLA and Taiwanese forces does, however, introduce uncertainty about the extent to which both militaries will be able to leverage available technologies and operational concepts in conflict.[119] We have therefore noted instances in which inexperience, organizational cultures, or other factors could alter the applicability of these observations.

Relevance of Observation 1: The Significance of Persistent Surveillance Capabilities Will Hinge on Both Sides' Relative Ability to Share and Act on Real-Time Information

The war in Ukraine has demonstrated how a combination of improvements in remote sensing, automation, and data integration can enable military forces to better detect, locate, and track their adversaries and can also grant an advantage to whichever side can most quickly collect information and disseminate it to shooters on the battlefield. Although technological and doctrinal barriers remain, the trends exhibited in the Russia-Ukraine war likely have reinforced to Chinese, Taiwanese, and U.S. military leaders the importance of establishing domain awareness in a future conflict and the operational value of denying an opponent an equivalent ability.

To be sure, U.S. and Chinese strategists have long recognized the potential operational benefits of establishing persistent surveillance of an opponent. In response to technological improvements and adversary gains, DoD has endorsed operational concepts for integrating distributed sensors, shooters, and data from multiple domains to improve situational awareness, facilitate rapid decisionmaking, and enable more-effective direction and coordination of forces.[120] PLA strategists similarly view the collection, fusion, and dissemination of vast quantities of high-fidelity information about the battlefield as a core requirement to enable, among other military functions, rapid decisionmaking and the efficient use of precision strike capabilities.[121] This imperative has driven the PLA to prioritize improvements in space-based, ground, and airborne surveillance capabilities, as well as advanced

[119] Experts disagree about the importance of combat experience in determining a future conflict. For discussions of potential implications, see Mark Cozad, Keith Gierlack, Cortez A. Cooper III, Susan G. Straus, Sale Lilly, Stephanie Anne Pillion, and Kelly Elizabeth Eusebi, *Preparing for Great Power Conflict: How Experience Shapes U.S. and Chinese Military Training*, RAND Corporation, RR-A1554-1, 2023; and Timothy R. Heath, "China's Untested Military Could Be a Force—or a Flop," *Foreign Policy*, November 27, 2018.

[120] Air Force Doctrine Note 1-20, *USAF Role in Joint All-Domain Operations*, U.S. Department of the Air Force, March 5, 2020; Army Field Manual 3-0, *Operations*, Headquarters, U.S. Department of the Army, October 2022.

[121] Edmund J. Burke, Kristen Gunness, Cortez A. Cooper III, and Mark Cozad, *People's Liberation Army Operational Concepts*, RAND Corporation, RR-A394-1, 2020, p. 12; Mark Cozad, Jeffrey Engstrom, Scott W. Harold, Timothy R. Heath, Sale Lilly, Edmund J. Burke, Julia Brackup, and Derek Grossman, *Gaining Victory in Systems Warfare: China's Perspective on the U.S.-China Military Balance*, RAND Corporation, RR-A1535-1, 2023, pp. 53-58, 71.

sensors, big-data analytics, and deep-learning tools to integrate fragmentary information into a comprehensive operating picture.[122] Although the PLA's inexperience employing these capabilities in conflict raises questions about their effectiveness in a potential future war, the investments in ISR and associated capabilities reflect the importance the PLA places on establishing and being able to maintain persistent surveillance in a conflict.[123]

Yet the war in Ukraine has also underscored the challenge of operating under persistent surveillance and provided additional incentive for both sides to deprive the adversary of an equivalent ability to collect, distribute, and act on targeting data. This imperative is reflected in China's investments in space-based sensor and surveillance technologies, including ISR satellites, to augment the PLA's ability to find, fix, and target U.S. forces operating in the Western Pacific, deny or limit U.S. military access to the South and East China Seas, and compel U.S. forces to operate at greater range.[124] By supporting a broader anti-access/area denial strategy, PRC surveillance capabilities could impede U.S. freedom of surface and air movement and limit the United States' ability to support the forward fight between PLA and Taiwanese forces.[125] As one analyst forecast in 2016, "U.S. and adversary naval surface platforms will find themselves operating in an arena in which both sides can see the other well before they are within the range of each other's weapons."[126] To gain advantage early in a conflict, PLA concepts direct Chinese forces to "blind" U.S. and Taiwanese forces through attacks on reconnaissance, communications, and early warning systems.[127]

Despite major strides in developing dense sensing and surveillance architectures, the PLA may still struggle to replicate Ukraine's level of success in distributing and acting on real-time battlefield data. The PLA military culture of centralized command structures—as opposed to a more flexible, task-oriented command style—has hampered effective communications between the services during past exercises, which suggests that the organization may struggle to relay and distribute data efficiently in conflict, particularly as the PLA transitions to a joint force.[128] Although lower echelons would likely have access to situational awareness data, it is unclear whether lower-level leaders would or could independently direct their forces to act on these data in a conflict.[129]

Decentralized military operations require lower-level officers to take initiative, communicate effectively, and understand a commander's intent. PLA officers routinely struggle to deal with unexpected situations, make independent operational decisions, and understand higher authorities'

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[122] Michael S. Chase, Kristen Gunness, Lyle J. Morris, Samuel K. Berkowitz, and Benjamin Purser, *Emerging Trends in China's Development of Unmanned Systems*, RAND Corporation, RR-990-OSD, 2015; Burke et al., 2020, p. 22; Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, U.S. Department of Defense, 2023, pp. 89, 94, 97, 98.

[123] "Xi Jinping Worries That China's Troops Are Not Ready to Fight," *The Economist*, November 6, 2023; Alastair Gale, "China's Military Is Catching Up to the U.S. Is It Ready for Battle?" *Wall Street Journal*, October 20, 2022.

[124] Office of the Secretary of Defense, 2023, p. 99.

[125] Sam J. Tagredi, "Anti-Access Strategies in the Pacific: The United States and China," *Parameters*, Vol. 49, No. 1, Spring/Summer 2019; Office of the Secretary of Defense, 2023, p. 89.

[126] Sean Cate and Jesse Sloman, "Operating Under Constant Surveillance," *Proceedings*, U.S. Naval Institute, Vol. 142/5/1,359, May 2016.

[127] Office of the Secretary of Defense, 2023, p. 98.

[128] Office of the Secretary of Defense, 2023, p. 86.

[129] Office of the Secretary of Defense, 2023, p. 86.

intentions—problems identified by Xi Jinping in 2015.[130] The PLA has taken some steps to fix these issues, including reforming the recruitment, training, and organizational structure of the military. However, it remains to be seen whether Russian challenges in Ukraine will encourage PRC leaders to expand these reforms, and whether the PLA could overcome its ingrained culture to conduct mission command or dispersed operations if directed or battlefield realities necessitate. Some PLA platoons and squads may therefore be less agile than their Russian and Ukrainian counterparts who have used real-time information collected by UASs to see over the horizon and maneuver, guide artillery, strike enemy positions, and conduct EW operations.[131] Yet, one should not preclude the possibility of PLA learning, particularly during a protracted conflict; Russian forces suffered from some of these same challenges at the outset of war but have adapted since.

If the PLA overcomes these barriers and can maintain persistent ISR and targeting data in the conflict, the United States' response would likely be twofold. First, the United States may seek to outpace Chinese kill chains by leveraging such new and emerging capabilities as next-generation sensors and automated decision support tools to accelerate data fusion and dissemination. If the United States can find and destroy PLA sensors and shooters first, it can disrupt Chinese kill chains and evade the threat. Second, the joint force may seek to evade or reduce the effectiveness of Chinese surveillance and targeting by dispersing its forces over large areas, as directed under the U.S. Navy's Distributed Maritime Operations (DMO) concept and the U.S. Air Force's Agile Combat Employment.[132] Successful employment of these concepts will require surmounting several barriers, including a limited number of operating bases, constraints on the inventory of long-range weapons and munitions, and technical challenges for communications and network technologies. As both sides gain access to a growing variety and number of sensors, they will find it increasingly difficult to avoid detection simply through dispersal and periodic displacement. Persistent information-sharing challenges may also impede efforts to disseminate and fuse allied and U.S. intelligence into a common coalition operating picture.[133]

Taiwan's capacity to leverage advanced sensors and information technologies is comparatively limited. Although Taiwan has increased its investments in space-based and UAS-based ISR systems, it would likely require substantial information and intelligence support from the United States and

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[130] The PLA termed these challenges the "Five Incapables" ("Start with the Source to Crack the 'Five Incapables' Problem [破解'五个不会'难题要从源头入手]," *PLA Daily* [*解放军报*], October 13, 2015). See also Joel Wuthnow, "Who Does What? Chinese Command and Control in a Taiwan Scenario," in Joel Wuthnow, Derek Grossman, Phillip C. Saunders, Andrew Scobell, and Andrew N. D. Yang, eds., *Crossing the Strait: China's Military Prepares for War with Taiwan*, National Defense University Press, 2022.

[131] Andrew E. Kramer, "From the Workshop to the War: Creative Use of Drones Lifts Ukraine," *New York Times*, August 10, 2022; Watling and Reynolds, 2023b; Zabrodskyi et al., 2022.

[132] Dispersion would also complicate Chinese targeting by creating more targets over a larger geographic area. For more information on ACE, see Air Force Doctrine Note 1-21, *Agile Combat Employment*, U.S. Department of the Air Force, August 23, 2022. For more on DMO, see Ronald O'Rourke, *Defense Primer: Navy Distributed Maritime Operations (DMO) Concept*, Congressional Research Service, IF12599, February 27, 2024.

[133] For a discussion of barriers to effective information sharing, see Jennifer D. P. Moroney, Stephanie Pezard, David E. Thaler, Gene Germanovich, Beth Grill, Bruce McClintock, Karen Schwindt, Mary Kate Adgie, Anika Binnendijk, Kevin J. Connolly, Katie Feistel, Jeffrey W. Hornung, Alison K. Hottes, Moon Kim, Isabelle Nazha, Gabrielle Tarini, Mark Toukan, and Jalen Zeman, *Overcoming Barriers to Working with Highly Capable Allies and Partners in the Air, Space, and Cyber Domains: An Exploratory Analysis*, RAND Corporation, RRA968-1, 2023.

other partners to establish or maintain pervasive battlefield awareness.[134] This could include the provision of real-time data streams and analyses of the PLA's positions if Taiwan and its partners can surmount expected PRC attempts to degrade Taiwan's communications infrastructure as well as U.S. and Taiwanese command, control, communications, and computer ISR networks.[135] Coordination challenges could also slow information-processing and reduce the operational value of any information collected. If Taiwan and its partners were able to develop efficient and secure systems for the sharing and distribution of information, they could augment their ability to maintain battlefield awareness and counter Chinese forces more effectively.

Relevance of Observation 2: Taiwan and PRC Air Defenses Are Vulnerable to UASs, but the United States and China Are Working to Fill This Gap

An important feature of the war in Ukraine has been both sides' inability to establish air superiority, partly because of the massed employment of UASs capable of overwhelming traditional air defenses. The air dynamics in Ukraine have illustrated the difficulty of maneuvering without air superiority; they have also underscored the importance of air defenses for protecting one's own forces and critical infrastructure and for denying the adversary critical advantages.

In a potential conflict with China, the United States and Taiwan would likely use U.S.-origin air defense systems similar to those donated to Ukraine. In Ukraine, Patriot and even older I-Hawk systems have been effective in defending against threats and dissuading adversaries from deploying their more-exquisite airborne platforms. Deficiencies in Taiwan's existing air defenses suggest that the island would be challenged in responding to PLA air threats on its own, so deterring PLA air operations would likely require the United States to provide additional air defense assets.[136] It is critical to note, however, that the PLA could plausibly conduct SEAD against Taiwan's air defenses using long-range ground-based rockets and missiles positioned on the Chinese mainland. Given the limited magazine depth and range of Taiwan's air defense systems, PLA Air Force (PLAAF) jets could also perform SEAD with overwhelming quantities of stand-off air-launched munitions. In either case, the PLAAF could ultimately achieve air superiority over the island despite Taipei's best defensive efforts. Taiwanese defense researchers have also expressed concern that China could attempt to use waves of massed UASs operating either individually or as swarms to deplete or suppress traditional air defense systems.[137] Given the size of its arsenal, the PLA could attempt to flood Taiwan's airspace to overwhelm the island's air defenses or destroy any residual systems that survive or are flushed out by an initial wave of SEAD strikes. Drones could also locate, acquire, and even strike other surface targets, creating more-favorable conditions for subsequent attacks using more-

[134] Tiffany M. Phan, "Limitations of Taiwan's Satellite Capabilities in a China-Taiwan Conflict," Air University, July 16, 2021.

[135] Timothy M. Bonds, *Keeping the World Close: How Taiwan Can Maintain Contact with Allies, Supporters, and Its Own People If Attacked*, RAND Corporation, PE-A2557-1, July 2023.

[136] Harry Halem and Eyck Freymann, "Ukraine Shows Why Taiwan Needs More Air Defense," *War on the Rocks*, April 7, 2022.

[137] Yimou Lee, James Pomfret, and David Lague, "Inspired by Ukraine War, Taiwan Launches Drone Blitz to Counter China," Reuters, July 21, 2023.

exquisite—but more-limited and costly—weapon systems.[138] This approach could become particularly attractive if the conflict becomes protracted and the United States degrades the PLAAF's conventional air and missile capabilities over time.[139]

Some U.S. air defense systems may still have difficulty countering large volumes of low-cost UASs, as has been demonstrated in Ukraine. For this reason, the U.S. Air Force has stated that it is making countering uncrewed systems a priority.[140] U.S. C-sUAS approaches may involve a combination of kinetic and nonkinetic tools, including operations in the electromagnetic spectrum and advanced integration of radar and C2.[141] However, although the United States has acknowledged that its air defense systems must be complemented by other C-UAS capabilities, the effectiveness of such approaches in conflict remains untested. The likely dispersal of U.S. forces over long distances may also complicate C-UAS efforts by straining the range and inventory of available systems, particularly if U.S. forces were not operating on Taiwan.

In addition to protecting friendly airspace, the United States and Taiwan may seek to leverage attritable UASs to flip the cost equation on the PLA's IADS. Massed low-cost UASs may be capable of achieving "a strategy of pure saturation"—that is replenishing at "a rate faster than the enemy can attrit it, until the enemy exhausts its on-hand inventory of interceptor missiles."[142] The massed employment of UASs could allow Taiwan and the United States to impose substantial costs on PLA air defense with relatively few fires. The ISR data provided by "targeting mesh[es]" (i.e., "large numbers of [UASs that] work together") could reduce the probability of targeting errors, thereby reducing the number of missiles required to degrade enemy IADS infrastructure.[143] If the conflict becomes protracted, the enhanced efficiency provided by UAS-based ISR streams could become critical. The United States could also employ UASs for communication jamming operations against PRC IADS, saturating them with false signals and undermining their aircraft identification systems.[144]

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[138] Notably, PLA investments and concepts for the use of uncrewed systems for the identification, suppression, or saturation of Taiwan's air defenses predate the war in Ukraine. For a discussion of available capabilities, see Elsa Kania, "The PLA's Unmanned Aerial Systems: New Capabilities for a 'New Era' of Chinese Military Power," China Aerospace Studies Institute, August 8, 2018b; Gabriel Honrada, "China Speeding into the Low-Cost Drone Swarm Lead," *Asia Times*, November 6, 2023; and Elsa B. Kania, "'Unmanned, Intangible, Silent Warfare'—New Threats and Options for Taiwan," *Global Taiwan Brief*, Vol. 3, No. 3, February 7, 2018a.

[139] Eric Heginbotham, Michael Nixon, Forrest E. Morgan, Jacob L. Heim, Jeff Hagen, Sheng Tao Li, Jeffrey Engstrom, Martin C. Libicki, Paul DeLuca, David A. Shlapak, David R. Frelinger, Burgess Laird, Kyle Brady, and Lyle J. Morris, *The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power, 1996–2017*, RAND Corporation, RR-392-AF, 2015.

[140] John A. Tirpak, "USAFE Boss Says Counter-IADS Is His Top Priority and Lesson from Ukraine," *Air and Space Forces Magazine*, August 22, 2023.

[141] David Vergun, "Countering Unmanned Aerial System Attacks a Priority," U.S. Department of Defense, November 14, 2023b, p. 14.

[142] Thomas Hamilton and David A. Ochmanek, *Operating Low-Cost, Reusable Unmanned Aerial Vehicles in Contested Environments: Preliminary Evaluation of Operational Concepts*, RAND Corporation, RR-4407-AF, 2020.

[143] Hamilton and Ochmanek, 2020, p. viii.

[144] Michael Bien, *Gaining Access with Modular Autonomous Drone Swarms (MADS)*, thesis, Marine Corps University Quantico, Defense Technical Innovation Center, May 8, 2019.

The United States is testing concepts for equipping UASs with EW payloads to degrade enemy IADS.[145]

Like the United States, China is preparing to counter loitering munitions and UASs by bolstering tactical air defense and EW capabilities.[146] This includes use of hybrid self-propelled air defense artillery systems, anti-aircraft artillery systems, and MANPADS.[147] The war in Ukraine has likely reinforced the importance of these systems but, as is the case with the United States, the effectiveness of PRC defenses against UASs in conflict is uncertain.

Relevance of Observation 3: Precision Munitions Would Be in High Demand, but the Importance of Unguided Weapons Would Grow over Time in Protraction

In a U.S.-China conflict, the United States and the PRC will need to determine whether to prioritize the acquisition of large numbers of unguided munitions or to concentrate on employing smaller numbers of more-expensive and more-precise guided weapons.

U.S., PRC, and Taiwanese investments in precision munitions reflect the importance all three states continue to place on high-cost, exquisite strike capabilities.[148] However, long-range precision fires require robust over-the-horizon targeting capabilities, which can create challenges even if one has the requisite munitions. Of the three, only the United States has employed precision technologies on the battlefield. By contrast, the PLA has had difficulty with its over-the-horizon targeting capabilities and is working to fill the gap.[149] Nonetheless, while the United States may demonstrate greater proficiency, historically, it has struggled to maintain sufficient inventories of PGMs, as demonstrated by shortages during conflicts in Kosovo, Afghanistan, and Libya, and during the Persian Gulf War and counter-Islamic State campaigns.[150] A war with China would likely generate far greater demand for PGMs, leading some analysts to conclude that the United States, despite efforts to grow its stockpiles in peacetime, might deplete its inventory of some categories of critical munitions within the first few weeks of a conflict.[151]

Although the United States and China would likely seek to increase wartime production, precision munitions are difficult to replace given that they often require complex manufacturing

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[145] Patrick Filbert, "Breaking Integrated Air Defence with Unmanned Aerial Vehicle Swarms: Developing and Testing the US Employment Concept," *Transforming Joint Air Power: The Journal of the Joint Air Power Competence Centre*, Volume 22, Spring/Summer 2016.

[146] Office of the Secretary of Defense, 2023, p. 50.

[147] Office of the Secretary of Defense, 2023, p. 49.

[148] Nathan J. Lucas, *Defense Primer: U.S. Precision-Guided Munitions*, Congressional Research Service, IF11353, updated November 15, 2022; Office of the Secretary of Defense, 2023, p. 69; David An, Matt Schrader, and Ned Collins-Chase, *Taiwan's Indigenous Defense Industry: Centralized Control of Abundant Suppliers*, Global Taiwan Institute, May 2018, pp. 6–7.

[149] Office of the Secretary of Defense, 2023, p 57.

[150] Tyler Hacker, "Money Isn't Enough: Getting Serious About Precision Munitions," *War on the Rocks*, April 24, 2023.

[151] Seth G. Jones, *Empty Bins in a Wartime Environment: The Challenge to the U.S. Defense Industrial Base*, CSIS International Security Program, Center for Strategic and International Studies, January 2023, p. 11. See also Stacie Pettyjohn and Hannah Dennis, *"Production Is Deterrence": Investing in Precision-Guided Weapons to Meet Peer Challengers*, Center for a New American Security, June 28, 2023, pp. 7–9.

processes and high-end materials and chips.[152] For example, the American Long-Range Anti-Ship Missile (LRASM) takes nearly two years to produce.[153] China has amassed large stockpiles of precision munitions and markedly grown and diversified its defense industrial base. Although the precise rates of production for precision munitions are unclear, China has, over a five-year span, increased its number of active ballistic missile launchers by approximately 15 percent, doubled its number of active intercontinental ballistic missile launchers, and grown its intermediate-range ballistic missile launcher inventory by almost fivefold.[154] China's production capacity could be a source of strength, but it, too, could face shortfalls over time if widespread economic disruptions, political upheaval, or damage to critical infrastructure hamper productivity levels or impede reconstitution.

As Ukraine has done, the United States and China may supplement their precision arsenals with large volumes of dumb munitions to degrade their adversary's capabilities. A PLA invasion of Taiwan could begin with "tightly sequenced attacks [including] missile strikes and a bombing campaign."[155] To overwhelm Taiwan's forces in a short period of time, the PLA could complement its precision munitions with massed dumb bombs to cause extensive damage and degrade its adversaries' will to fight. Taiwan may similarly benefit from employing massed munitions to significantly degrade any PLA lodgments on Taiwan's beaches.

The utility of inexpensive massed dumb munitions may increase if the conflict enters a protracted phase. A protracted conflict would require combatants to attrit and outlive one another's capabilities, much like in Ukraine. Differences in relative production rates could lead to differences in the ratio and application of precision-to-unguided munitions employed by either side. But to sustain an attritional war, both parties would likely need to leverage weapons that are not only cheap but can be replenished on short production timelines. For these reasons, we expect that the United States, Taiwan, and China would balance mass with precision in a potential future conflict.[156]

Relevance of Observation 4: Low-Cost Uncrewed Systems Would Likely Play a Prominent Role, but the United States and China May Require Longer-Range and Higher-Payload Systems

A future U.S.-PRC conflict would likely feature the widespread use of uncrewed systems given the scale of current U.S., Taiwanese, and PRC investments in the technology and ongoing efforts to

[152] Trevor Phillips-Levine, Andrew Tenbusch, Walker D. Mills, Dylan Phillips-Levine, and Collin Fox, "Into the Pickle Barrel: How Thinking About Precision as a System Can Expand the Munition Stockpile," *War on the Rocks*, January 25, 2023.

[153] Jones, 2023, p. 11. For an overview of current U.S. production timelines, see Pettyjohn and Dennis, 2023, p. 17.

[154] Seth G. Jones and Alexander Palmer, *Rebuilding the Arsenal of Democracy: The U.S. and Chinese Defense Industrial Bases in an Era of Great Power Competition*, CSIS International Security Program, Center for Strategic and International Studies, March 2024, pp. 9–12, 18.

[155] Hal Brands, *Getting Ready for a Long War with China: Dynamics of Protracted Conflict in the Western Pacific*, American Enterprise Institute, July 25, 2022, p. 3.

[156] For a discussion on the strengths and weaknesses of the U.S. and Chinese defense industrial bases that may affect production capacities of precision and unguided munitions, see Tai Ming Cheung and Thomas G. Mahnken, *The Decisive Decade: United States–China Competition in Defense Innovation and Defense Industrial Policy in and Beyond the 2020s*, Center for Strategic and Budgetary Assessments, May 22, 2023.

develop associated operational concepts and military organizations.[157] Although U.S. and PRC investments predate the start of the war, Russian and Ukrainian operations have underscored the potential operational value of employing large numbers of low-cost and easy-to-use uncrewed platforms to contest airspace, divert and deplete an opponent's more-exquisite capabilities, and multiply the effects of conventional weapons. Senior U.S. and Taiwanese defense officials have cited Ukrainian military performance as justification for new programs to increase domestic production of attritable platforms.[158]

UAS could shape a future battlefield on or around Taiwan by bolstering the defending forces' ability to slow or deny an amphibious invasion. Taiwanese officials have expressed admiration of Ukraine's sUAS use and have directed increases in domestic production of uncrewed systems and renewed efforts to integrate these systems into the island's layered defenses.[159] As part of a strategy to leverage asymmetric capabilities against a numerically and qualitatively superior invading force, Taiwanese ground forces would likely leverage uncrewed systems to collect tactical intelligence, guide artillery strikes, conduct EW operations against PLA assets operating in the vicinity, and strike PLA maritime, ground, and amphibious forces operating on or near the island.[160] Citing Ukraine's success in using uncrewed systems for similar functions, U.S. analysts also have suggested large numbers of low-cost platforms—ones that operate in concert with loitering munitions, EW systems, and other conventional area-denial weapons—could deny PLA air or maritime access, extend communications, or perform ISR missions.[161] Noting their comparatively low cost and small footprint, some U.S. legislators and analysts have proposed stockpiling sUASs on the island in preparation for a potential protracted conflict that might include a Chinese blockade.[162]

However, the application (and utility) of uncrewed systems in a future conflict over Taiwan would likely diverge from the Russia-Ukraine war in some critical ways. Although Taiwan, as a weaker defender seeking to deny or delay a PRC landing, may benefit from the integration of a large number of the inexpensive, short-range uncrewed systems that have been a centerpiece of Ukrainian layered defenses, U.S. and PLA forces would likely rely on more-capable systems with greater range, payloads,

[157] Office of the Secretary of Defense, 2023, p. 64. See also Kania, 2018b; and Honrada, 2023.

[158] Lee, Pomfret, and Lague, 2023; Joseph Clark, "Defense Innovation Official Says Replicator Initiative Remains on Track," *DOD News*, U.S. Department of Defense, January 26, 2024.

[159] Lee, Pomfret, and Lague, 2023; Drew Thompson, "Winning the Fight Taiwan Cannot Afford to Lose," in Joel Wuthnow, Derek Grossman, Phillip C. Saunders, Andrew Scobell, and Andrew N. D. Yang, eds., *Crossing the Strait: China's Military Prepares for War with Taiwan*, National Defense University Press, 2022; Kelvin Chen, "President Tsai Ing-Wen Lauds Taiwan's Drone Development Efforts," *Taiwan News*, December 5, 2023.

[160] Lee, Pomfret, and Lague, 2023. For examples of similar proposals predating the Russia-Ukraine war, see James Timbie and James O. Ellis, Jr., "A Large Number of Small Things: A Porcupine Strategy for Taiwan," *Texas National Security Review*, Vol. 5, No. 1, Winter 2021/2022; Hamilton and Ochmanek, 2020; and David Ochmanek, *Sustaining U.S. Leadership in the Asia-Pacific Region: Why a Strategy of Direct Defense Against Antiaccess and Area Denial Threats Is Desirable and Feasible*, RAND Corporation, PE-142-OSD, 2015, p. 15.

[161] See, for instance, Maximillian K. Bremer and Kelly A. Grieco, "Air Denial: The Dangerous Illusion of Decisive Air Superiority," Atlantic Council, August 30, 2022; and Andrew Hoehn and Thom Shanker, "Are Cheap Drones the Answer to Tension in the Taiwan Strait?" *Defense News*, June 29, 2023. For related prewar analysis, see Hamilton and Ochmanek, 2020.

[162] Bryant Harris, "China Committee Wants Congress to Establish a Taiwan Weapons Stockpile," *Defense News*, May 24, 2023a.

and survivability.[163] For example, uncrewed systems that can transit long distances, survive contested airspaces, and loiter for extended periods generally are larger and more expensive than the systems that Ukrainian forces have operated.

The geography of war over Taiwan might also encourage greater use of USVs and uncrewed underwater vehicles (UUVs) than has been observed in Ukraine. Taiwan has cited Ukrainian success against the VMF in explaining its decision to increase development of USVs for potential reconnaissance and strike functions.[164] If Taiwan can amass a large enough fleet of USVs, it could employ them to impose costs on PLA naval forces crossing the Taiwan Strait, slowing a Chinese invasion and hindering efforts to resupply any forces that landed on the island.[165] Given its recent investments in USV development and training on USV employment in the Indo-Pacific, the U.S. Navy could also potentially support Taiwan in USV operations.[166]

Whether and how China might employ uncrewed naval platforms is more uncertain. China has increased research and development of USVs and UUVs over the past decade, appears to be exploring their military application, and is well positioned to draw lessons from Ukrainian employment of similar systems in the Black Sea.[167] In theory, the PLA Navy could dispatch UUVs or USVs across the Taiwan Strait ahead of manned vessels to detect incoming threats or to attack Taiwan's port facilities and surface vessels. Explosive USVs could also be used for OWAs against vessels operating beyond the island, although, given range considerations, it is unclear whether this would provide advantages over other fires options.[168] It is more likely, however, that the PLA would use uncrewed systems for defensive purposes, such as to clear mines placed by Taiwanese forces or to monitor its own naval mine fields and attack U.S. or Taiwanese mine-clearing operations.[169]

The United States' ability to fully leverage the benefits of massed, low-cost UASs will depend on its ability to stockpile systems in advance of a conflict while building the capacity for rapid production in conflict. Although such initiatives as Replicator may help jumpstart U.S. production rates, China still dominates the global consumer drone market and likely could repurpose many of these production lines for military use.[170] By contrast, operator proficiency, rather than production rates, may limit China's ability to exploit its production advantages. For example, the relatively small size

[163] Caitlin Lee, "Winning the Air Battle for Taiwan: Lessons from Ukraine's Drone Operations," *War on the Rocks*, February 28, 2023.

[164] Lo Tien-ping, "Sea Drone Production Could Start Soon," *Taipei Times*, November 6, 2023.

[165] Scott Savitz, "Could Taiwan Defend with Uncrewed Surface Vessels?" *RealClearDefense*, January 7, 2023.

[166] Sam Lagrone, "U.S. Navy's Unmanned Future Remains Murky as China Threat Looms," *USNI News*, U.S. Naval Institute, November 30, 2023.

[167] Chase et al., 2015, p. 3.

[168] Scott Savitz, "The Age of Uncrewed Surface Vessels," *RAND Blog*, RAND Corporation, November 15, 2022.

[169] Yasuhiro Kawakami, "Mine Warfare in a Taiwan Contingency—Scenarios for Naval Mine Use and Its Impact on Japan," *International Information Network Analysis*, Sasakawa Peace Foundation, February 25, 2022; Lyle Goldstein and Nathan Waechter, "Landmines in Ukraine: Lessons for China and Taiwan," *The Diplomat*, September 26, 2023.

[170] Eva Dou and Gerrit De Vynck, "Pentagon Plans a Drone Army to Counter China's Market Dominance," *Washington Post*, December 1, 2023.

and signature of UASs may present challenges for PLA forces that already struggle to exercise airspace control in joint engagement zones, increasing the risk of fratricide.[171]

Relevance of Observation 5: The Value of Attritable Systems May Increase If the War Becomes Protracted

The conflict in Ukraine has evolved into a war of attrition in which both sides are fighting to outlast their adversary. The attritional nature of the war has created a need for fires, ISR, and other systems that are relatively cheap to produce and ultimately expendable. Although attritable systems have become critical to the battlefield in Ukraine, it is not guaranteed that the same dynamics will apply to a potential future conflict over Taiwan.

Both the United States and China wish to avoid a protracted war with each other and have been preparing to act swiftly in any future conflict. Chinese military doctrine suggests that the PLA favors prompt, overwhelming strikes and would attempt to quickly defeat Taiwan before a substantial U.S. intervention could take place.[172] The United States has also tended to focus on preparing for the early stages of potential counter-PRC operations in Taiwan.[173] During the opening stages of a war, U.S. and Taiwanese forces could attempt to thwart a PLA landing by using masses of attritable systems to disrupt the PLA's ability to mobilize, deliver long-range fires, and cross the Strait. Emerging concepts such as the U.S. Navy's *hellscape* concept—which "calls for thousands of lethal drones on, above and under the sea, creating chaos for the invaders"[174]—suggest this would require a sharp burst of activity in a condensed window.

Even though all sides might be planning for a short, intense conflict, this outcome is not predetermined, especially if neither side is able to achieve its objectives in that time frame. Should the conflict drag on, both sides may turn to attritable systems to supply a wider set of missions as inventories of other capabilities are depleted, as has occurred in Ukraine.

Whether both sides will be prepared for a shift to a protracted conflict is a more difficult question. A recent analysis of PLA spending has noted that "the protracted nature of the fighting in Ukraine is likely to have driven the PLA Army leadership to re-examine operational plans for long-term industrial and logistic sustainment."[175] Since before the war in Ukraine, the PLA has been investing in attritable UASs that could help sustain a potential war over Taiwan.[176] The PLA has also invested in other resilient systems, such as space-based ISR and communications platforms that would allow the continuation of operations after an initial series of attacks and counterattacks on the ground. The U.S.

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[171] Jasmin Alsaied, "The People's Liberation Army's Command and Control Affects the Future of Out-of-Area Operations," *Journal of Indo-Pacific Affairs*, Vol. 6, No. 3, March-April 2023.

[172] Brands, 2022.

[173] Brands, 2022.

[174] For the U.S. Navy's emerging "hellscape" concept, see Lagrone, 2023. For a discussion of how the Replicator initiative could support this concept, see Joseph Clark, "Defense Officials Report Progress on Replicator Initiative," U.S. Department of Defense, December 1, 2023; and Patrick Tucker, "Navy Envisions 'Hundreds of Thousands' of Drones in the Pacific to Deter China," *Defense One*, February 16, 2024.

[175] International Institute for Strategic Studies, "Chapter Five: Asia," in *The Military Balance*, Vol. 124, No. 1, 2024, p. 235.

[176] Office of the Secretary of Defense, 2023, p. 64. See also Kania, 2018b.

experience attempting to supply Ukraine with sufficient munitions for its defense has revitalized discussions about the strength of the U.S. defense industrial base and the output limitations of expensive platforms and munitions.[177] Attritable systems would likely have important roles to play in the early stages of a U.S.-China conflict, and their role would only grow in the event that the conflict became protracted and other systems became scarce or unavailable.

Relevance of Observation 6: Smart Devices Are Unlikely to Play a Large Role in a U.S.-China War Given Anticipated Communications Blackouts on Taiwan and Military Information Cultures

A potential future conflict over Taiwan is unlikely to lend itself to the use of civilian communications devices in the same ways they have been employed in Ukraine. The PLA maintains robust communications equipment and networks and has continued to modernize these systems against evolving threats, including advances in U.S. and Taiwanese EW.[178] Given the PLA's preference for exercising tight oversight of its operations and lower-level officers, it is unlikely to permit the transmission of official information over private devices and networks. Even if it were to relax these restrictions, however, PLA forces may decide to degrade the island's communications infrastructure prior to invasion to reduce the effectiveness of Taiwanese resistance.

Similarly, the United States and Taiwan are not likely to rely heavily on civilian devices during counter-PRC operations. We do not expect U.S. military personnel to use personal devices when conducting operations in support of Taiwan given the military's strict culture around OPSEC. Although Taiwan's forces have a record of using personal smartphones in secure settings, Taiwan has recently adopted measures to restrict the use of personal devices in sensitive settings, in part because of widespread evidence of Chinese infiltration of telecommunications infrastructure on the island.[179] Citing lessons learned from the Ukrainian government's performance, Taiwanese officials have stated that the island is seeking to improve the resilience of military communications channels, including through investments in space-based alternatives to the fragile underseas cables on which it currently relies.[180] The United States has also assisted efforts to expand and fortify Taiwan's military communications systems against anticipated PLA threats.[181] These investments suggest that Taiwan understands the vulnerabilities associated with civilian devices and will seek to limit their use during a

[177] Courtney Weinbaum, Caolionn O'Connell, Steven W. Popper, M. Scott Bond, Hannah Jane Byrne, Christian Curriden, Gregory Weider Fauerbach, Sale Lilly, Jared Mondschein, and Jon Schmid, *Assessing Systemic Strengths and Vulnerabilities of China's Defense Industrial Base: With a Repeatable Methodology for Other Countries*, RAND Corporation, RR-A930-1, 2022; Cheung and Mahnken, 2023.

[178] Office of the Secretary of Defense, 2023, p. 94.

[179] "Bases Ban Chinese Phones," *Taipei Times*, May 8, 2018; Sarah Wu and Yimou Lee, "Fear of the Dark: Taiwan Sees Wartime Frailty in Communication Links with World," Reuters, March 15, 2024; "Hackers Stole 'Sensitive' Data from Taiwan Telecom Giant," France 24, March 1, 2024.

[180] Wu and Lee, 2024.

[181] "US Approves $300 mln Support for Taiwan's Tactical Information Systems," Reuters, December 16, 2023.

potential conflict with the PRC. How strictly Taiwan will be able to implement these limitations and discipline a majority-conscript military during a conflict remains an open question, however.[182]

Relevance of Observation 7: In a Protracted Conflict, the United States and China May Employ and Adapt to EW in a Cat-and-Mouse Game

As with the Russia-Ukraine war, a potential future U.S.-PRC conflict over Taiwan is likely to feature the employment of EW capabilities by both sides. PLA operational concepts emphasize the importance of establishing supremacy in the electromagnetic domain by both limiting an adversary's use of the spectrum and preserving the PLA's ability to operate in contested environments.[183] Based on information gleaned from PLA literature and exercises, it seems likely that the PLA would use EW to target data links and vital information flows as a means of countering U.S. and Taiwanese radar, communications, and navigation.[184] Yet the PLA would also have to grapple with potential Taiwanese and U.S. threats to its own access to the electromagnetic spectrum. Taiwan's Overall Defense Concept envisions using EW to counter UASs and to reduce the effectiveness of PLA precision fires, thereby lowering the burden on the island's other limited air defenses.[185] Because Taiwan's own EW capabilities are limited, it would likely rely on its partners—especially the United States—to conduct some of these operations. After a post–Cold War lull in investment, the United States is striving to reinvigorate its EW enterprise through the development of new concepts for operating in contested and degraded electromagnetic environments and the procurement of new airborne, ground, and satellite-based capabilities.[186] Having observed the critical role that EW operations have played in Ukraine, the U.S. Air Force is working to quickly upgrade EW systems aboard aircraft.[187]

If the PLA's invasion of Taiwan is swift and decisive, forces may not have adequate time for learning and adaptation with respect to EW operations and countermeasures. However, in a protracted scenario, we expect that U.S., Taiwanese, and PRC forces would seek to adapt to their adversaries' EW operations and EW countermeasures. The U.S. military has already developed several anti-jamming technologies, including jam-resistant navigation systems for ground vehicles and jam-resistant payloads for communications satellites.[188]

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[182] For a discussion of Taiwan's personnel challenges and shortfalls, see Michael A. Hunzeker, written testimony for the hearing on Deterring PRC Aggression Toward Taiwan, U.S.-China Economic and Security Review Commission, February 18, 2021.

[183] Burke et al., 2020, pp. 13–14; Jeffrey Engstrom, *Systems Confrontation and System Destruction Warfare: How the Chinese People's Liberation Army Seeks to Wage Modern Warfare*, RAND Corporation, RR-1708-OSD, 2018; Office of the Secretary of Defense, 2023, p. 95.

[184] In addition to training on these capabilities, the PLA has bolstered its EW capabilities in the South China Sea, in areas around territorial disputes. Office of the Secretary of Defense, 2023, p. 95. Matthew P. Funaiole, Joseph S. Bermudez, Jr., and Brian Hart, "China Is Ramping Up Its Electronic Warfare and Communications Capabilities Near the South China Sea," Center for Strategic and International Studies, December 17, 2021.

[185] Thompson, 2021, p. 325; Kania, 2018b, p. 9.

[186] John R. Hoehn, *Defense Primer: Electronic Warfare*, Congressional Research Service, IF11118, November 14, 2022.

[187] Colin Demarest, "Electronic Warfare in Ukraine Informing US Playbook," *C4ISRNET*, September 13, 2023b.

[188] Northrup Grumman, "Anti-Jam MilSatCom," webpage, undated; Colin Demarest, "US Army Jam-Resistant Navigation Kit for Vehicles Passes Pentagon Test," *C4ISRNET*, February 22, 2023a.

The PLA would also seek to adapt to its adversaries' jamming operations. PLA forces regularly participate in jamming and anti-jamming exercises.[189] The PLA has also significantly upgraded its EW aircraft, including the new Y-9 DZ aircraft, which can also conduct electronic intelligence, electronic support measures, enemy surveillance, electronic jamming, and psychological warfare.[190]

Relevance of Observation 8: Commercial Space Capabilities Are Likely to Augment Both U.S. and PRC Military Capabilities in a Potential Conflict

Both the United States and China are likely to use commercial space capabilities in a potential conflict, although the sophistication of their native military space programs may reduce their reliance on nongovernmental service providers. Even before the war in Ukraine began, U.S. space policy has directed DoD to enhance cooperation with commercial space firms to strengthen resilience, reduce acquisition timelines, and bolster innovation.[191] Although China's commercial space sector still lags behind the United States, it "is on pace to become a major global competitor by 2030," according to a U.S. intelligence community assessment.[192] Given China's ongoing investments and capacity to mobilize private-sector resources, we expect China to leverage private-sector space technology in a potential future war with Taiwan and the United States.

For Taiwan, Ukraine's use of commercial space architectures offers both an opportunity and a warning. The war has amplified leaders' concerns about the island's communications infrastructure, raised questions about Taiwan's ability to access such major commercial services as Starlink in a conflict with China, and spurred new interest in developing a proliferated space architecture that could support civilian and military communications.[193] Many have also urged Taiwan to build its own indigenous architecture rather than risk becoming dependent on a sole commercial provider as Ukraine has.[194] President Tsai Ing-wen has pledged $1.3 billion for Taiwan's space program, and the

[189] Office of the Secretary of Defense, 2023, p. 95.

[190] Office of the Secretary of Defense, 2023, p. 63.

[191] U.S. Space Command, *Commercial Integration Strategy Overview*, April 8, 2022; Emmi Yonekura, Brian Dolan, Moon Kim, Krista Romita Grocholski, Raza Khan, and Yool Kim, *Commercial Space Capabilities and Market Overview: The Relationship Between Commercial Space Developments and the U.S. Department of Defense*, RAND Corporation, RR-A578-2, 2022; Theresa Hitchens, "SPACECOM Plans New, Unified 'Commercial Integration Office' to Work with Private Firms," *Breaking Defense*, March 3, 2023.

[192] Office of the Director of National Intelligence, *Annual Threat Assessment of the U.S. Intelligence Community*, February 6, 2023, p. 8. China first opened parts of its space sector to private capital in 2014 and has increased direct investments in commercial space capabilities since (Irina Liu, Evan Linck, Bhavya Lal, Keith W. Crane, Xueying Han, and Thomas J. Colvin, *Evaluation of China's Commercial Space Sector*, Institute for Defense Analysis, IDA Document D-10873, September 2019). In fact, at the Central Economic Work Conference in 2023, President Xi identified the commercial space industry as a strategic emerging industry that the government would focus on supporting and growing (State Council, "Xi Delivers Important Speech at Central Economic Work Conference," press release, People's Republic of China, December 14, 2023).

[193] Meaghan Tobin and John Liu, "Why Taiwan Is Building a Satellite Network Without Elon Musk," *New York Times*, March 14, 2024.

[194] Tobin and Liu, 2024.

government has set an ambitious launch schedule, but it remains to be seen whether Taiwan will be able to surmount the limitations of its nascent space sector.[195]

In the event of a U.S.-China war over Taiwan, however, commercial space service providers may face greater pressures than those observed in the war in Ukraine. Dual-use commercial assets that provide military services have been identified as legitimate targets, and U.S. Space Command has warned that U.S. adversaries may target privately owned space assets that are providing—or could provide in the future—services to the U.S. military.[196] China maintains a variety of counterspace capabilities and probably intends to pursue additional capabilities designed to counter proliferated architectures, such as Starlink.[197] Short of these direct attacks, China could also attempt to coerce commercial providers to withhold services from Taiwan by denying or threatening to deny access to the Chinese market, particularly if it is unable to develop effective options for targeting proliferated architectures. The effectiveness of such a strategy may vary, however, depending on targeted firms' reliance on Chinese suppliers or markets, their contractual obligations with Taiwan or the U.S. government, and the extent of U.S. involvement in ensuring Taiwan's access to space-based services.[198]

Conclusion

Policymakers from the United States, Taiwan, and China will likely continue to make adaptations to strategy and plans based on their observations of Ukraine in the coming years. However, it is important to remember fundamental differences from the Ukrainian case that could drive different dynamics and outcomes in a potential future conflict over Taiwan. An important factor underlying many potential points of divergence is Taiwan's isolated geography, which will complicate assistance efforts. Taiwan's geography may also influence the nature of weapon systems most dominant in a potential future conflict. Although armor and artillery have played a pivotal role in Ukraine, a conflict in Taiwan is likely to feature a heavier emphasis on air and maritime systems, which have not played as prominent a role in the Russia-Ukraine war and about which we may have fewer relevant observations.

In addition to geography, it is also important to consider more-intangible factors in a Taiwanese contingency that could diverge from Ukraine. Analysts would be remiss to not consider the impact of Ukraine's will to fight on its ability to resist Russia's invasion. Much of Taiwan's society expresses strong opposition the prospect of a PRC invasion; however, it is hard to know with certainty how Taiwan would respond when pummeled by China's kinetic threats and influence operations or if it were cut off from supplies via a Chinese blockade.

Although we should be wary of drawing false parallels between the Russia-Ukraine war and a potential future conflict between the United States and China, some of the key dynamics regarding

[195] Tobin and Liu, 2024; Chen Chuanren, "Taiwan Dips Its Toes into Commercial Cubesat Market," Aviation Week Network, August 16, 2023.

[196] Lee Ferran, "Space Force Commander Cannot 'Forgive' Russia for 'Reckless' ASAT Test," *Breaking Defense*, October 14, 2022; Wen Zhou, "Topic 3: Protection of Civilians, Civilian Objects, and the Natural Environment in Relation to Threats Arising from State Behaviours with Respect to Outer Space," presentation given at the Open Ended Working Group on Space Threats, United Nations Office of Disarmament Affairs, May 11, 2022.

[197] Office of the Secretary of Defense, 2023, pp. 93, 97–100.

[198] Tobin and Liu, 2024.

persistent surveillance, precision strike, and the use of uncrewed systems and space capabilities are likely to have clear relevance. This analysis is summarized in Table 4.1.

Table 4.1. Key Tactical and Operational Attributes of a U.S.-China War

Observation	Factors That Could Translate to a U.S.-China War	Factors That Could Differ in a U.S.-China War
1 The pairing of persistent surveillance capabilities and with precision fires has created a new and unresolved dilemma for offensive operations	• The PRC and the United States are investing in advanced surveillance capabilities	• The PRC's centralized command culture may inhibit rapid distribution of and responses to ISR data • The United States may seek to overcome surveillance by outpacing PRC kill chains and dispersing forces • Coordination challenges may hamper Taiwan's ability to receive and act on partner ISR data
2 Air defenses have been resilient against manned aircraft but have been less effective against UASs	• The United States and Taiwan are investing in UAS options to challenge PRC air defenses • Taiwan fears the PLA could also employ UAS swarms to overwhelm its air defenses	• Taiwan's air defense systems are substantially lacking compared with manned PLA air threats • The United States and the PRC are bolstering kinetic and nonkinetic c-UAS options
3 Dumb (unguided) and smart (precision) artillery systems have been complements, not substitutes	• The United States and the PRC are investing in precision munitions • Both sides may benefit from the integration of massed, unguided weapons and precision strikes during the initial and protracted phases of conflict • Taiwan may benefit from mobile artillery	• Taiwan's investments in precision munitions have been limited • The United States' use of unguided munitions is dependent on its penetration of PRC IADS
4 Employing and countering uncrewed systems has become a battlefield priority	• Both sides are investing in uncrewed systems • Taiwan would benefit from a large volume of cheap short-range uncrewed systems; otherwise, it has limited capabilities compared with China	• The United States and the PRC may require longer-range and higher-payload systems than those used by Ukraine • The conflict's geography may compel greater use of uncrewed systems in the maritime domain
5 Attritable systems have sustained protraction	• Both the United States and the PRC are investing in attritable capabilities • Long-term sustainability challenges for the United States' and the PRC's defense industrial bases may slow production of attritable capabilities	• Not applicable

Observation	Factors That Could Translate to a U.S.-China War	Factors That Could Differ in a U.S.-China War
6 Smart devices have been powerful civilian tools and military targets	• Not applicable	• Anticipated communications blackouts would preclude the use of civilian smart devices by Taiwanese forces • U.S. OPSEC culture would preclude the use of civilian smart devices • The PRC's oversight of operations would preclude the use of civilian smart devices
7 Constant adaptation has been required for effective EW	• Both sides are investing in EW capabilities • The United States and the PRC are investing in EW countermeasures	• If a U.S.-PRC war is short, it may not allow time for adaptation and learning • The United States may face difficulties assisting Taiwan with EW countermeasures given anticipated communications blackouts
8 Commercial actors have enabled states with limited native assets to access sophisticated and resilient space capabilities	• The PRC's commercial space sector is growing • The U.S. government has prioritized commercial space sector integration • Taiwan recognizes the importance of resilient, space-based communications and is investing in them	• Not applicable

Chapter 5

Conclusion

The United States has been reorienting its military to prepare for a potential conflict with a near-peer adversary for several years. However, its experience with interstate warfare in recent decades has been limited to short conflicts against technologically inferior adversaries. Preparing for a potential future conflict against China—with its sophisticated, well-resourced, and yet inexperienced military—presents a substantial analytic challenge. How should the United States prepare to fight such an adversary? How can it more accurately assess the competence of a highly modernized force that has not conducted major combat operations in more than 40 years? Many of the capabilities and concepts of operations likely to be essential in this hypothetical clash have not previously been employed at scale in interstate warfare; it may, therefore, be challenging to shift U.S. planning and resources sufficiently toward new approaches absent clear evidence of the inadequacy of existing efforts.

Despite the immense human tragedy it has caused, the Russia-Ukraine war provides an important opportunity and motivation for the United States to learn about the use and interaction of different capabilities in a high-intensity conflict in a way that was not previously possible. Still, the novelty of many aspects of the conflict notwithstanding, battlefield dynamics observed in Ukraine may not be easily transferrable. Ukraine itself differs greatly from the United States and its allies in its capabilities, resources, and strategic culture. Russia and China differ substantially in these areas as well, and even in a conflict with NATO, Russia may choose to fight differently than it has in Ukraine. Although the opportunity to learn from this war is important, it is equally important not to mislearn lessons or uncritically apply observations that are contingent on specific characteristics of the Ukrainian battlefield to other contexts.

That is why in this report we have carefully assessed how tactical and operational observations from the fighting in Ukraine may or may not translate to the two major potential conflicts for which the United States has been preparing: a NATO-Russia war and a U.S.-China war that also involves U.S. allies and partners in the Pacific. These analyses are summarized in Table 5.1. In the next section, we summarize the five main implications for these potential fights that are likely to be relevant across theaters, building on the detailed analyses in earlier chapters to inform these higher-level findings. The chapter ends with a list of recommendations for the DAF, DoD, and the U.S. government.

Implications for Future U.S. High-Intensity Conflicts

The delivery of mass is changing. The fighting in Ukraine highlights the ongoing importance of mass in winning high-intensity conflicts. In Ukraine, this mass has been primarily delivered as artillery, albeit with its effectiveness enhanced because of improvements in surveillance and targeting. However, in future U.S.-involved conflicts, the delivery may be quite different. UASs have been used

as massed attack weapons in Ukraine designed to evade and overwhelm traditional air defenses, but in future conflicts involving even more-capable and better-resourced combatants, their importance as a tool for delivering mass to targets may increase further. Large volumes of UASs have the potential to provide an additional solution to operational problems that were previously the domain of long-range precision fires, and to do so more sustainably in a protracted conflict. However, UASs are unlikely to fully supplant artillery, which provides shock and suppression in a way that drones cannot.

The distinction between cruise missiles and OWA UASs is blurring. Relatedly, the Ukrainian and Russian use of OWA UASs to flexibly deliver payloads at long ranges suggest that the distinction between drones and cruise missiles is likely to blur in the future. At present, cruise missiles likely retain advantages in speed, payload, and resistance to jamming over most UASs, while UASs allow for the possibility of loitering to enhance targeting options and are dramatically cheaper. But technological advances likely will enable states to develop UASs with faster propulsion systems, and both UASs and cruise missiles are likely to be enhanced with greater autonomy, reducing their vulnerability to jamming and improving their agility. Future warfighters may consider different types of OWA UASs and cruise missiles as falling along the same continuum and select specific platforms with specific capabilities as needed for particular missions.

Offensive operations are confronting enhanced challenges. Offense-defense balances can change quickly, and we should not expect future wars to be attritional stalemates just because that is what has been observed in Ukraine. As we discuss in the final implication, the lack of air superiority for either side has been a critical condition for sustaining the stalemate. However, the Russia-Ukraine war does demonstrate a series of enhanced challenges that offensive operations must now contend with because of technological changes that are likely to stress attackers on both sides in future U.S.-involved high-intensity conflicts.

First, persistent surveillance and greater battlefield transparency at this moment appear to advantage defenders because mobile forces are generally visible to the adversary while defending forces are better able to take advantage of shelters and CCD approaches to reduce their vulnerability, at least temporarily. It is possible that surveillance will improve to the point where stationary forces are just as visible as forces in motion, at which point remaining still may become quite deadly. But for the time being, persistent surveillance capabilities appear to give a structural advantage to in-place defenders because of their lower vulnerability to fires.

Second, despite efforts to promote multi-domain concepts, neither side in Ukraine has been able to establish an advantage in all domains simultaneously and, as a result, both sides have struggled to translate localized battlefield gains into strategic advantages. A similar phenomenon is likely in a potential NATO-Russia or U.S.-China conflict given all sides' investments in capabilities to disrupt their opponent's C2, degrade information flows, and thereby reduce their ability to combine arms.

Third, the fighting in Ukraine has demonstrated how persistent surveillance and long-range fires can enhance the effectiveness of traditional defensive measures, such as minefields, by threatening personnel engaged in clearing operations. In the Russia-Ukraine war, this has played out on land, but the same dynamics may apply to other domains and geographies should defenders have the time and resources to invest in them and put them in place.

Protraction requires adaptation. Neither side in the Russia-Ukraine war started the fighting prepared for a protracted high-intensity conflict, but the relative stalemate on the battlefield quickly

drove both sides to prepare for and adapt to the reality that the fighting would persist at this intensity for a long period of time. Fighting such a protracted conflict demands a different set of replaceable, cost-effective capabilities that can be employed quickly as opposed to those that require years of preparation. In Ukraine, both sides have had to spontaneously adapt to protraction, remaking their defense industrial bases, foreign supply sources, and operational concepts to match the reality of what types of munitions and systems remain available to them. In a future U.S.-involved conflict, if neither side can achieve its objectives quickly, generating mass at a low cost will also become vital. Outcomes on the battlefield may then be dictated by production decisions at home, including both those taken in advance and those that both sides scramble to implement during the fighting.

The need to seek external support to sustain protracted conflict is not a question of "if" but "how much?" External support is an essential element for waging high-intensity wars over a protracted period. Despite its large industrial base, extensive military stockpiles, and emphasis on self-sufficiency, Russia has been compelled to seek out alternative sources for munitions and military equipment as its invasion of Ukraine has dragged on. Western sanctions that impeded domestic production in some areas are a contributing factor, but Russia's search for foreign assistance has also been driven by the sheer volume of material required and a recognition of the benefits conferred by foreign-made equipment to address challenges that may not have been apparent before the conflict (as seen in Russia's increasing reliance on Iranian Shahed drones). Of course, any combatant with lesser domestic production capacity would face that need earlier and more acutely, as Ukraine has and as Taiwan certainly would, and any combatant with greater domestic production potential, such as China or the United States, may be able to rely on indigenous capabilities for longer. But the incentives to seek out external support to sustain or better adapt to protracted high-intensity conflict using capabilities that could be provided by allies or partners will remain to greater or lesser degrees for all states, and the value of preventing or interrupting such transfers would be proportionately important for their opponents.

Competency matters as much as, if not more than, technology. Purely technical prewar comparisons of Russian and Ukrainian military capabilities could not have forecasted the current stalemate in Ukraine. Indeed, the conflict has underscored the importance of soft aspects of military power, such as tactical proficiency, sound operational planning, and coherent strategy. Because these traits directly influence attrition and territorial control during the initial period of war—and in turn set the conditions for subsequent phases of fighting—these intangible qualities bear equal or greater importance than most material capabilities. Military analysts must therefore devise new ways to measure these immaterial aspects of military power for forces untested by battle.[199]

Air superiority is critical. Many of the dilemmas highlighted in Ukraine arise from the inability of either side to achieve air superiority. This is unusual historically; although, since Korea, few high-intensity interstate wars have had technologically similar opponents. This inability to establish air

[199] It should also be noted that, given the protraction of the current war in Ukraine, the importance of competency may diminish over time. The qualitative gap between Russian and Ukrainian forces has decreased since February 2022 because Moscow's forces have learned from many of their early mistakes, and Kyiv's most-capable troops have been removed from the battlefield. Russia has also embraced a strategy of exhaustion for prosecuting the war, relying on its larger population and industrial potential to outlast both Ukraine and its Western backers. At some point, the Russian military's sheer mass and high tolerance for attrition could offset the same intangible factors that provided Ukraine a military advantage at the outset of the full-scale invasion.

superiority might be more likely to reoccur in the Indo-Pacific but is less certain in a potential future NATO-Russia fight given the deficiencies in Russian air power demonstrated to date in Ukraine.

Even though NATO can expect to achieve superiority in the air in the traditional sense of keeping the enemy's aircraft out of its airspace and being able to operate its own aircraft over enemy-held territory, air superiority will no longer be a guarantee of protection against observation and attack from the air. Russia will likely remain capable of mounting some operations deep inside NATO territory with large salvos of ballistic and cruise missiles, OWA drones, and sUASs for reconnaissance. This will compel NATO forces either to make substantial investments in missile defenses and a variety of counter-UAS capabilities or to adapt to operating behind the front lines under greater threat of attack.

Table 5.1 summarizes our key findings pertaining to potential future conflicts against Russia and China.

Table 5.1. Relevance of Observations from Russia-Ukraine War for Potential Future U.S. Conflicts

	Observation	Relevance for Potential NATO-Russia War		Relevance for Potential U.S.-China War	
		Degree	Notes	Degree	Notes
1	The pairing of persistent surveillance capabilities with precision fires has created a new and unresolved dilemma for offensive operations	✓	Persistent surveillance capabilities and precision fires would initially challenge offensive operations for either force until NATO gains air control	?	The significance of persistent surveillance capabilities will hinge on both sides' relative ability to share and act on real-time information
2	Air defenses have been resilient against manned aircraft but have been less effective against UASs	✓	Both NATO and Russia will likely encounter difficulties using manned aircraft for SEAD, although Russia might offset its deficiencies with innovative—and currently unanswered—use of UASs	✓	Taiwanese and PRC air defenses are vulnerable to UASs, but the United States and China are working to fill this gap
3	Dumb (unguided) and smart (precision) artillery systems have been complements, not substitutes	✓	Unguided and precision artillery systems would both have important uses in a NATO-Russia conflict	✓	Precision munitions would be in high demand, but the importance of unguided weapons would grow over time in protraction
4	Employing and countering uncrewed systems has become a battlefield priority	✓	Employing and countering uncrewed systems would likely remain a central concern for both NATO and Russia in a future conflict	✓	Low-cost uncrewed systems would likely play a prominent role, but the United States and the PRC might require longer-range and higher-payload systems
5	Attritable systems have sustained protraction	?	NATO might struggle to produce sufficient volumes of attritable systems to sustain the fighting if a future conflict were protracted	?	Attritable and other lower-cost systems will play prominent roles in protracted conflicts
6	Smart devices have been powerful civilian tools and military targets	—	NATO is unlikely to rely on civilian smart devices, but these devices might remain an important tool and vulnerability for Russia	—	Smart devices are unlikely to play a large role given military information cultures and anticipated communications blackouts on Taiwan

Observation	Relevance for Potential NATO-Russia War		Relevance for Potential U.S.-China War	
	Degree	Notes	Degree	Notes
7 Constant adaptation has been required for effective EW	✓	Nonkinetic capabilities are crucial to countering uncrewed systems today, but technological advances might drive the need for kinetic solutions	✓	In a protracted conflict, the United States and the PRC might employ and adapt to EW in a cat-and-mouse game
8 Commercial actors have enabled states with limited native assets to access sophisticated and resilient space capabilities	?	Commercial space systems would likely provide greater benefits to NATO than Russia	?	Commercial space capabilities are likely to augment both U.S. and PRC military capabilities

NOTE: A checkmark indicates a high degree of relevance for a potential conflict, a question mark a mixed degree, and a dash a low degree.

Factors That Could Alter This Analysis

The implications highlighted previously reflect the changes in the character of warfare that we have observed from Russia's assault on Ukraine to date. However, the war is not yet over, and other factors could still alter the implications we draw from it. Although some uncertainty regarding future developments is inevitable, in this section, we highlight three plausible factors that could alter the Russia-Ukraine war's influence on future conflicts and would require reassessment of the implications we highlighted previously. Our approach to managing uncertainty stemming from the future trajectory of the war is discussed in greater detail in Chapter 1 of the summary volume of this report series.[200]

Russia's Use of Nonstrategic Nuclear Weapons Against Ukraine

Although, as of this writing, nuclear weapons have not been used, Russia has frequently threatened their use in its invasion of Ukraine. Moscow could still decide to detonate a nonstrategic nuclear weapon (NSNW) on Ukrainian soil should it assess that doing so is necessary to reverse its fortunes. Indeed, U.S. officials seriously considered the prospect of Russian tactical nuclear weapon use to halt the collapse of Russian lines outside Kherson in fall 2022.[201] The trajectory of the conflict is uncertain, but it remains plausible that future reversals of fortune for Russia could create similar threats to the Russian position.

Whether an NSNW is employed offensively against a Ukrainian military formation or simply detonated on Ukrainian soil as a demonstration, such an action would have far-reaching implications. The main change such an act could engender is the normalization of nuclear weapons use in warfare and the weakening or breaking of the nuclear taboo. Such a change is not inevitable following a single use by Russia that would doubtless be widely condemned, but the weakening of the taboo because of Russia's actions would certainly be plausible if states perceived that Russia gained advantages from NSNW use and did not suffer sufficient costs from doing so.

If nuclear weapons were to become viewed as beneficial warfighting weapons in future conflicts, there would be numerous follow-on effects regarding the character of warfare. The challenge of massing forces to conduct breakthroughs would become even more pronounced, as large formations concentrating to conduct major offensives could find themselves the target of a devastating attack designed to eradicate entire brigades and divisions in one strike. Defenders willing to use nuclear weapons could also direct their fire toward the enemy's second-echelon or reserve forces, all but ensuring the attacker's inability to exploit tactical penetrations—and thereby increasing the chance of a long-term stalemate. Conversely, protraction might become less likely in a world more prone to nuclear employment. Targeted strikes on defense-industrial capacity would likely devastate any state's warmaking capabilities, thereby decreasing its probability of enduring a prolonged conflict.

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[200] Frederick et al., 2025.

[201] Jim Sciutto, "US Prepared 'Rigorously' for Potential Russian Nuclear Strike in Ukraine in Late 2022, Officials Say," CNN, March 9, 2024.

Unrestrained attitudes toward low-yield nuclear weapon employment could also preclude third parties from providing aid to active combatants, which would further inhibit protraction. External actors could be deterred from lending aid for fear that their contributions would be destroyed at air or seaports on delivery. Worse yet, their own homelands could be targeted with nuclear retaliation.

None of these changes are inevitable in response to Russian nuclear use. U.S. policy would likely focus on imposing costs on Russia for its nuclear use in part to reduce the risks that such changes would occur. However, we highlight them here as examples of how the implications presented earlier in this chapter, and the character of warfare more generally, could plausibly be affected by Russian nuclear use in Ukraine.

Russia's Use of a Kinetic Anti-Satellite Weapon in Low-Earth Orbit

Inheriting a variety of capabilities from the Soviet Union and improving on them in recent years, Russia maintains a formidable arsenal of both nonkinetic and kinetic ASAT weapons.[202] While nonkinetic weapons (such as jammers and laser-dazzlers) can temporarily degrade or disable a satellite's functionality, kinetic-kill weapons (such as Russia's PL-19 Nudol complex) cause permanent damage and produce massive clouds of debris that can pollute LEO. When Moscow last tested the Nudol in 2021 by targeting the inoperable Comos-1408 satellite, the resulting impact produced 1,500 pieces of trackable wreckage that threatened other LEO-based satellites and the International Space Station.[203] More recently, U.S. Assistant Secretary of Defense for Space Policy John Plumb confirmed in May 2024 that Russia is developing an "anti-satellite capability related to a new satellite carrying a nuclear device" and capable of destroying several satellites in a single attack.[204] This weapon appears to be ideally suited for disabling large constellations of commercial satellites, including SpaceX's 6,000-unit Starlink constellation. Because Ukrainian forces have extensively used Starlink to combat Russian troops, the system could be a plausible target for Russian kinetic ASAT should all other efforts to counter it fall short.

Russia's hypothetical use of a kinetic ASAT weapon against commercial satellites in LEO would significantly affect the way modern wars are fought. The destruction of proliferated commercial communications satellites throughout LEO could complicate command, control, and communications for militaries like the UAF that lack their own national space infrastructure. Any drones or uncrewed systems that rely on space-based internet connectivity from such commercial services for control would also fail to function. In turn, states that maintain their own hardened communications satellites or position their assets outside LEO would likely retain such capabilities. Similarly, the degradation of commercial remote sensing platforms in LEO, such as those operated by Planet Labs and Maxar,

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[202] See Brian Weeden and Victoria Samson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, Secure World Foundation, April 2024, "Russia," Section 1.02, pp. 2-01 to 2-39.

[203] U.S. Space Command Public Affairs Office, "Russian Direct-Ascent Anti-Satellite Missile Test Creates Significant, Long-Lasting Space Debris," November 15, 2021; Secure World Foundation, "SWF Statement on Russian ASAT Test," November 16, 2021.

[204] John F. Plumb, "Fiscal Year 2025 Strategic Forces Posture," testimony before the Subcommittee on Strategic Forces, House Armed Services Committee, March 21, 2024, p. 4. For White House comments on the capabilities' potential implications, see Dustin Volz and Gordon Lubold, "White House Confirms Russia Is Developing Antisatellite Weapon," *Wall Street Journal*, February 15, 2024.

could inhibit the ability of non-spacefaring states to collect ISR and track the movements of hostile militaries. From a warfighting perspective, the use of a kinetic ASAT in LEO could reverse the democratization of dual-use, space-based capabilities that commercial firms have dramatically accelerated in recent years.

Russia Achieves a Cost-Effective Breakthrough That Resolves Existing Operational Challenges

Throughout Russia's assault on Ukraine, both militaries have experimented with new technologies and operational concepts to solve the operational challenges they have confronted.[205] We expect that each force will continue to explore adaptations and innovations as the war progresses. It is therefore plausible that either military could achieve a cost-effective breakthrough that would solve one of the major operational challenges discussed earlier in this report, such as the challenge of operating under persistent surveillance or the challenge of countering UASs in a cost-effective manner.[206] Useful innovations to resolve these problems could include battlefield technologies with kinetic or nonkinetic effects and new operational concepts.

If either Russia or Ukraine achieves a cost-effective breakthrough, we expect that some of the operational challenges described in this report would be less salient in potential future conflicts. For example, if Russia or Ukraine develop an effective and efficient C-sUAS technology, we expect other countries would seek to replicate and scale the technology for their own forces. As a result, we expect that UASs would be employed on a smaller scale or have less of an impact on operations than we predicted in potential future conflicts between Russia and NATO or between the United States and the PRC. UASs could become less reliable for the decentralized collection of ISR data and for informing decentralized targeting decisions given that they would be more vulnerable to attack or compromise.

If either side achieved such a breakthrough, we expect that it would be closely studied and likely quickly replicated by other militaries with potentially wide-ranging effects on the operational dilemmas highlighted previously, depending on the nature of the breakthrough.

Recommendations

Our analysis highlights several recommendations. We have grouped these recommendations by target audience.

[205] For examples of wartime innovation to date, see Marcel Plichta, "Russia's Growing Kamikaze Drone Fleet Tests Ukraine's Limited Air Defenses," Atlantic Council, May 14, 2024; and Seth G. Jones, Riley McCabe, and Alexander Palmer, "Ukrainian Innovation in a War of Attrition," brief, Center for Strategic and International Studies, February 27, 2023.

[206] We focus on these two operational challenges in this section only as examples to illustrate the main points of our analysis. There are other operational challenges, such as C2 in a degraded communications environment, that could be resolved by future innovations and thus have implications for future conflicts.

For the U.S. Air Forces in Europe–Air Forces Africa, the U.S. Air Force, and the U.S. Space Force

- **Invest in the development of affordable extended-range munitions.** The resilience of Ukrainian air defenses has pushed Russia to develop longer-range, affordable munitions that can be fired from relative sanctuary. The United States might face similar challenges with resilient adversary air defenses and has invested heavily in exquisite, expensive long-range fires. But it lacks options that are comparatively affordable and can be produced in large volumes, even if it might accept trade-offs in other characteristics. For example, the U.S. Air Force's planned Extended Range Attack Munition could provide one solution, but it remains unclear whether it will be designed to enable large-scale, more-affordable production.[207]
- **Continue development of proliferated satellite constellations and hybrid space architectures.** The resilience of commercial satellite constellations supporting Ukrainian operations has highlighted the value of distributed approaches to space capabilities and the operational capability of commercial space providers. Although adversaries might be willing to take additional steps to disrupt U.S. space capabilities in the event of a future conflict, the redundancy provided by proliferated and hybrid satellite constellations is likely to remain essential. The U.S. Space Force's *Commercial Space Strategy* marks a positive step toward promoting the development of more-diverse, proliferated, and distributed space architectures, but continued effort will be needed to develop the requisite systems and to integrate commercial solutions into U.S. Space Force doctrine, strategy, and concepts.[208]

For the U.S. Department of Defense

- **Prioritize the development and integration of high-volume kinetic counter-UAS capabilities.** U.S. adversaries are highly likely to develop large volumes of UASs for attack missions, a capability Russia is already using in Ukraine. Although EW might provide a partial counter to some types of UASs in some circumstances, kinetic responses might be required in others, particularly if adversaries develop UASs with higher levels of autonomy. Although the United States has kinetic options to destroy individual UASs, doing so at scale in a cost-effective manner that can be sustained will likely require the development of new capabilities. The Joint Counter-Small Uncrewed Aircraft Systems Office is exploring numerous potential c-UAS solutions, some of them kinetic, and the U.S. Army has taken a lead role through its Low, Slow, Small, Uncrewed Aircraft Integrated Defeat System.[209] However, how quickly and effectively such solutions are able to be developed and fielded at

[207] Joseph Trevithick, "Mini Anti-Ship Cruise Missile that Fits Inside An F-35 Is on the Navy's Wish List," *War Zone*, February 7, 2024.

[208] U.S. Space Force, *U.S. Space Force Commercial Space Strategy: Accelerating the Purposeful Pursuit of Hybrid Space Architectures*, April 8, 2024.

[209] Michael Marrow, "Amid Ukraine and Israel Conflicts, Pentagon Acquisition Chief Sees Counter-Drone 'Crisis,'" *Breaking Defense*, December 4, 2023; Jon Harper, "Army Seeks More Than $400M in Fiscal 2025 for Systems to Counter Small Drones," *DefenseScoop*, March 11, 2024.

scale and then integrated into units trained to take advantage of them remains unclear, and in the interim, adversary UASs are likely a more mature capability.

- **Accelerate large-scale investments in and integration of OWA UASs and USVs.** Degrading or defeating adversary air defense systems is likely to be a major challenge for future U.S. operations given the degree of adversary investment in these systems. OWA UASs have the potential to destroy, saturate, or degrade the effectiveness of air defense systems if employed in sufficient numbers. Employing masses of USVs against adversary naval targets in a similar manner could likewise be effective in overcoming traditional countermeasures. DoD has begun efforts to acquire and field such capabilities, but many steps remain before they could be employed at scale in combat, and sustained attention will be required to overcome barriers quickly.[210]
- **Evaluate the utility and robustness of concepts for sensing and targeting enemy surface forces in highly contested environments**. Ukrainian forces have shown that sUASs in large numbers can allow a force to locate, identify, track, and target enemy forces even in the absence of air superiority. This likely will be a central task for U.S. and partner forces in the opening phase of a conflict with Russia or China. DoD has taken steps to expand the number of units equipped with sUASs, but additional effort is required to develop associated TTPs and ensure operators' proficiency in integrating the data provided into timely operations. DoD's Replicator initiative could provide large numbers of attritable UASs that could support a resilient sensing capability, but development and execution will require further, sustained effort.[211]
- **Emphasize decentralized decisionmaking in exercises and training.** Continued improvements in persistent surveillance and precision strike capabilities are likely to increase the demand for dispersed operations. Although the United States has long recognized the benefits of enabling forces to make some tactical and operational decisions without centralized direction, this agility could become more important in conflicts against authoritarian opponents that would be challenged to replicate the U.S. culture of flexibility and risk-taking. Although U.S. C2 capabilities would likely be more robust than Ukraine's, continued efforts to improve training and exercises to operate independently can prepare U.S. forces to press this advantage.
- **Evaluate the potential for uncrewed systems to enhance the effectiveness of naval minefields.** Minefields have been unexpectedly effective in Ukraine, in part because of the development of persistent surveillance capabilities and loitering munitions that have sharply increased the difficulty of clearing operations. Naval mines have been discussed as a potential capability that could challenge a PRC amphibious landing of Taiwan. Whether UASs, USVs, or UUVs could be used in conjunction with naval mines to enhance their effectiveness is worthy of closer consideration.

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[210] Patrick Tucker, "'Hellscape': DOD Launches Massive Drone Swarm Program to Counter China," *Defense One*, August 28, 2023b; Sam Lagrone and Aaron-Matthew Lariosa, "Pentagon Puts Out Call for Swarming Attack Drones That Could Blunt a Taiwan Invasion," *USNI News*, U.S. Naval Institute, January 30, 2024.

[211] Kelley M. Sayler, *DOD Replicator Initiative: Background and Issues for Congress*, Congressional Research Service Report, IF12611, March 22, 2024.

- **Identify priority munition systems for scaled-up, rapid production in the event of a protracted conflict.** The effort to supply Ukraine with munitions for its protracted defense against the Russian invasion has stressed U.S. and allied defense industrial bases. In a future conflict of its own, the United States would likely face similar challenges and trade-offs. Identifying, in advance, which munitions the United States will rely on to sustain a protracted conflict could be critical.

For the U.S. Government

- **Sustain and focus defense industrial base investments to build capacity for priority munition systems needed for a protracted conflict.** The United States has taken steps to strengthen its industrial base, including by increasing production of select systems and releasing the first-ever National Defense Industrial Strategy to direct improvements in workforce readiness, acquisition processes, and supply chain resilience, among other issues.[212] Yet congressional opposition has stymied efforts to use multiyear procurement authorities to create the demand signals required to promote long-term expansions in production capacity.[213]
- **Plan to deny U.S. and allied commercial space assets to adversaries.** Russia has been able to take advantage of commercial space systems operated by U.S. and allied commercial entities to support its operations in Ukraine, despite intense and far-reaching sanctions. Planning for how to prevent such exploitation by U.S. adversaries in a potential future conflict is likely to involve a coordinated diplomatic, commercial, and intelligence effort.

[212] U.S. Department of Defense, *National Defense Industrial Strategy*, November 16, 2023; David Vergun, "Emphasis in DOD 2024 Budget Includes Munitions," U.S. Department of Defense, March 15, 2023a.

[213] Bryant Harris, "GOP, Dems Clash on Multiyear Munitions Buys as Shutdown Looms," *Defense News*, September 25, 2023b.

Abbreviations

AFAFRICA	Air Forces Africa
ASAT	anti-satellite
C2	command and control
CCD	camouflage, concealment, and deception
C-UAS	counter-uncrewed aircraft system
DAF	U.S. Department of the Air Force
DEAD	destruction of enemy air defenses
DoD	U.S. Department of Defense
EW	electronic warfare
FLOT	forward line of troops
FPV	first-person view
GBAD	ground-based air defense
GPS	Global Positioning System
IADS	integrated air defense system
ISR	intelligence, surveillance, and reconnaissance
LEO	low-Earth orbit
MANPADS	man-portable air defense systems
NATO	North Atlantic Treaty Organization
OPSEC	operational security
OWA	one-way attack
PGM	precision-guided munition
PLA	People's Liberation Army
PLAAF	PLA Air Force
PMC	Private Military Company
PRC	People's Republic of China
SAM	surface-to-air missile
SATCOM	satellite communications
SEAD	suppression of enemy air defenses
sUAS	small uncrewed aircraft system
SV	Ground Forces
TTP	tactic, technique, and procedure
UAF	Ukrainian Armed Forces
UAS	uncrewed aircraft system
UMPK	Unified Gliding and Correction Module

USAFE	U.S. Air Forces in Europe
USV	uncrewed surface vehicle
UUV	uncrewed underwater vehicle
VKS	Russian Aerospace Forces
VMF	Russian Navy

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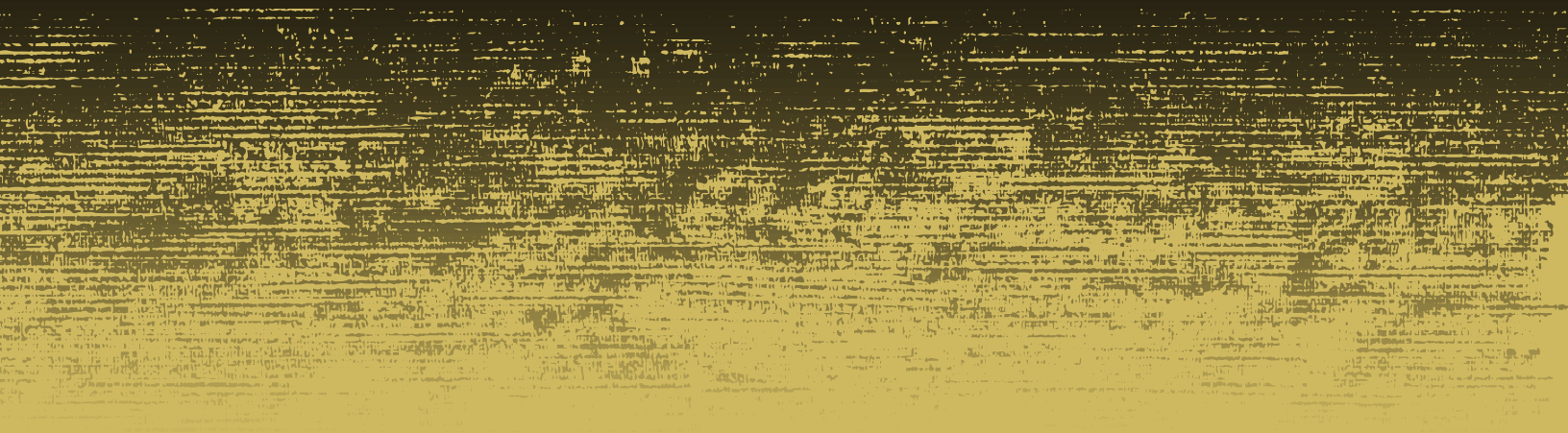
The authors also use these observations to forecast the character of future wars by evaluating whether and how their observations might translate to two potential U.S.-involved conflict scenarios: a war in Eastern Europe between North Atlantic Treaty Organization members and Russia and a war in the Indo-Pacific between the United States and the People's Republic of China. The authors conclude by highlighting the implications of their observations and providing recommendations for the Department of the Air Force, the Department of Defense, and U.S. government policymakers.



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