SPECIAL COMPETITIVE STUDIES PROJECT

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ADAPTATION WAR

CONFRONTING THE NEW ADVERSARY LEARNING AND ADAPTATION BLOC

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The requirement that a force must adapt while it is in combat is built into the inherent nature of war.

Frank Hoffman, *Mars Adapting.*

Cooperation among China, Russia, Iran, and North Korea has been growing more rapidly in recent years, reinforcing threats from each of them individually while also posing new challenges to U.S. strength and power globally.

Annual Threat Assessment of the U.S. Intelligence Community, March 2025.

Adaptation War

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Executive Summary

Over the past three years, Ukraine and Russia have learned and adapted. Both sides have also *learned to learn* and to insert lessons into their military and industrial systems with increasing speed. The learning and adaptation ecosystem spawned by the war in Ukraine, also informed by the war in the Middle East, has now metastasised into an international learning and adaptation competition.

A new adversary learning and adaptation bloc has emerged. While not a formal alliance, China, Russia, Iran and North Korea have developed a mesh of different agreements and strategic partnerships that have allowed these authoritarian regimes to construct a connected knowledge market on 21st century strategic competition and conflict. Each of the contributors to this knowledge market can draw from it for their own purposes.

Building a better understanding of the relationships between nations in the adversary learning and adaptation bloc provides insights into the flows of knowledge between different nations. But the nature of these linkages, between Russia and Iran, as well as between Russia and China, also allows observation of the limitations of such relationships.[1] This in turn permits the construction of strategies to undermine such relationships. To aid in the development of such strategies, this report makes several key findings, which are accompanied by recommendations to remedy those findings.

Finding 1: Ukraine and Russia have *learned to learn* more quickly in the past three years, and to proliferate lessons into their military and industrial systems with increasing speed. This adaptation battle has technical dimensions as well as organisational and doctrinal aspects. The effectiveness of Ukraine and Russia's learning and adaptation is built on the existence of a learning and adaptation culture in military and other government institutions.

Recommendation: The Department of War must embrace adaptation as an integral aspect of its institutional culture. Senior leaders should nurture people and teams incentivised and resourced to continuously learn and that are capable of adapting quickly.[2] This culture begins with clear statements about leadership tolerance for risk and new ideas. Appropriate authorities are necessary for leaders to aggressively conduct decentralised, but linked, adaptation.

Recommendation: The Department of War should increase investment in learning how Ukrainian, Russian and other military organisations have learned how to learn. This extends into learnings of the defense industries and how these lessons intersect with military affairs.

Finding 2: Learning and adaptation in Ukraine, as well as in the Middle East, has metastasised into an international learning and adaptation competition. A new adversary learning and adaptation bloc has emerged. When one of the parties of this bloc learns, all of them can learn.

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1 András Rácz and Alina Hrytsenko, *Partnership Short of Alliance: Military Cooperation Between Russia and China,* CEPA, 16 June 2025, https://cepa.org/comprehensive-reports/partnership-short-of-alliance-military-cooperation-between-russia-and-china/

2 This senior advocacy is one of the essential elements of successful institutional learning and reform. For a useful case study involving the massive transformation of the US Army in the wake of the Vietnam War, see Don Starry, "To Change an Army", *Military Review*, March 1983, 20-27.

Recommendation: Vulnerable elements of the adversary learning and adaptation bloc should be targeted by America and its partners in a collaborative effort to match and better the adversary learning and adaptation bloc. The approach must balance learning from a military institution's own activities with those from foreign wars and exercises.

Recommendation: An Indo-Pacific version of the NATO Joint Analysis and Lessons Learned Centre should be formed and linked to the Commander of Indo-Pacific Command as well as the Department of War for rapid dissemination of lessons. The Department of War should develop translation mechanisms for Ukraine War lessons to ensure they are fit for military operations in the Pacific and other theatres.

Recommendation: The United States and its allies should develop a better understanding of the relationships between different authoritarian nations to better understand how the flows of knowledge between different nations are, and are not, impacting their military effectiveness. Better understanding the nature of these linkages, between Russia and Iran, as well as between Russia and China, would also provide insights into the limitations of such relationships.

Finding 3: With Western powers slower to recognise this emerging adaptation war, there remains a gap in time between when problems are recognised by an institution, solutions are identified, and the technological, conceptual and organisational elements of the solution are disseminated and implemented.

Recommendation: The learning and adaptation activities of the Department of War should focus on closing the gap between the emergence of new technologies and battlefield employment by having leaders take more risk with innovation. This will require an increased institutional tolerance for failure, which is a crucial element of learning and adaptation.

Recommendation: Leadership selection plays a central role in rapidly closing the gap between the emergence of new technology and its adoption by military institutions. The selection of all military leaders should include assessments of their risk tolerance, and how they nurture learning and innovation in subordinates. Service Chiefs and senior joint leaders must define the range of acceptable failures, and leaders at all levels must make clear statements about their willingness to absorb risk to permit subordinates learning and adaptation.[3]

Finding 4: New technologies to gather information from commercial and military sources and prioritise the analysis of the most compelling insights offers the potential to better understand adversary learning and adaptation, and to improve U.S. learning and adaptation.

Recommendation: True learning is as much about fusing insights from disparate sources as about the rate in which it spreads or how deep it permeates. The Department of War should implement tailored analytical AI for strategic and operational functions to support learning and adaptation. AI can help fuse disconnected learning processes, accelerate analysis, speed up and enhance the

[3] This senior advocacy is one of the essential elements of successful institutional learning and reform. For a useful case study involving the massive transformation of the US Army in the wake of the Vietnam War, see Don Starry, "To Change an Army", *Military Review*, March 1983, 20-27.

quality of military adaptation and strategic decision-making. The U.S. should share its learning and adaptation, and the supporting processes and technologies, to continue reaping the benefits of collective security activities, and coalition warfighting operations.

Finding 5: Peacetime, transition to war, and war adaptation will each have slightly different leadership imperatives and require different mindsets, readiness and force posture settings.

Recommendation: The imperatives of each type of adaptation should be incorporated into the 'lessons learned' functions of the Department of War. Each of the three types of adaptation demands different institutional settings and leadership philosophies at the service, national and international levels for learning and adaptation.

The 2018 National Defense Strategy described how "the current bureaucratic approach, centered on exacting thoroughness and minimizing risk above all else, is proving to be increasingly unresponsive."[4] The strategic threat of this institutional lack of agility is magnified by that posed by the adversary learning and adaptation bloc. The United States is now involved in an intensive, long-term Adaptation War with authoritarian powers. There is an urgent imperative for the Department of War and other western nations to enhance their existing mechanisms for sharing lessons across strategy, military, economic and information domains to counter the newly established adversary learning and adaptation bloc.

4 Department of Defense, *Summary of the 2019 National Defense Strategy of the United States of America*, 2018, 10.

Introduction

Since February 2022, Ukraine and Russia have *learned to learn* more quickly and to disseminate lessons into their military and industrial systems with increasing speed. This ongoing adaptation battle incorporates technical as well as organisational and doctrinal aspects.

Ukraine's adaptive stance is driven by an existential threat that is not always understood well in Western nations not currently at war. Ukraine's learning system, which is not always fully joined up from the tactical to strategic levels, offers lessons on how western militaries might improve and speed up their learning and adaptation processes and cultures. On the other hand, Russia has *learned to learn* better and faster as the war has progressed. Where they aren't innovative, they are fast followers.[5] This makes it a more dangerous adversary for Ukraine, as well as a much more capable and dangerous military to threaten Europe.

Perhaps the most important feature of this interactive adaptation struggle is that it can no longer be described purely as an Adaptation Battle; it is now an Adaptation War.[6] While there are important issues to research and analyse from the battlefield and at the strategic levels of war, there is now an important international dimension. Ukraine is sharing lessons with its partners and Russia has fostered the development of an active learning community with Iran, North Korea and China.

The learning and adaptation enterprise spawned by the war in Ukraine, as well as the different wars in the Middle East, has now metastasised into an international learning and adaptation competition. Ukraine, and the west, are part of an intensive, long-term Adaptation War against authoritarian powers. With the *Offset X Strategy* identifying adaptation as a core capability for generating military advantage, investigating, understanding and responding to this adaptation war is crucial for the long-term security of America and its allies.[7]

The aim of this report is to examine the components of this global Adaptation War. It commences with an examination of adaptation and when adaptation occurs. The report then explores the three levels of adaptation – battlefield, strategic, and international - with exemplar case studies for each, as well as the interaction between these levels. It then provides an overall characterisation of the adaptation war and concludes with the implications and options for western governments and military institutions to respond to, and master, this new global adaptation battle. The report includes an epilogue posing the following question: *is the new global learning and adaptation war a revolution in military affairs?*

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5 This insight was provided by the author's interviews of multiple senior Ukrainian military personnel during visits to Ukraine in 2025 and 2024.

6 Mick Ryan, "How Ukraine is winning in the adaptation battle against Russia", *Engelsberg Ideas*, 24 August 2022, https://engelsbergideas.com/essays/how-ukraine-is-winning-in-the-adaptation-battle-against-russia/

7 Special Competitive Strategies Project, *Offset-X: Closing the Deterrence Gap and Building the Future Joint Force,* Washington DC, 2023, 21-22. https://www.scsp.ai/wp-content/uploads/2023/05/Offset-X-Closing-the-Detterence-Gap-and-Building-the-Future-Joint-Force.pdf

Warfare in the 21st century is driven more than ever by the revolution in knowledge and insight delivered by the internet, big data, an explosion in the different kinds of networked sensors and the power of AI. As a result, adaptation in technology and tactics is now moving at a speed that is incomprehensible to many Western politicians and defence bureaucrats. This must change. Generating America's competitive advantage in the 21st century will hinge on how well it can compete, and lead, in the new adaptation war.

Part I: Understanding the Adaptation War

The early days of the full-scale war in Ukraine saw learning and adaptation start slowly, such as Ukraine's application of drones. But it has gained pace since then and has led to an expansive adaptation battle occurring at a rapid pace.

Adaptation

Adaptation theory is founded on early advances in research in the biological sciences. When Charles Darwin developed his theory of evolution and natural selection, he sought to explain how new species emerge and how others disappear.[8] In the 21st century, adaptation studies have shifted beyond the work of Darwin and is being employed in a range of scientific endeavours. The theory of adaptation is important for the exploration of learning and the development of organisations in societies, businesses and military institutions in the constant search for improvements in effectiveness.

Military organisations exist within a competitive learning environment, in peace and war. This drives the need to build and evolve learning and adaptation cultures, which include both individual and institutional concerns. In military literature, one of the best-known adaptive cycles is Colonel John Boyd's OODA (observe-orient-decide-act) loop.[9]

Military institutions rarely have the capacity to foresee every possible future contingency. Nor do they possess the ability to continuously and accurately predict the actions and reactions of their known (and potential) adversaries and allies. Uncertainty is an enduring component of war; little (has?) changed from when Carl von Clausewitz wrote on this topic in the early 19th century. Therefore, military organisations, as well as the larger national security enterprises they are part of, must learn how to learn better, apply what has been learned, and possess the ability to adapt to both expected and unexpected events.

Both Russia and Ukraine have learned and adapted throughout the war. This has resulted in an adaptation battle where both sides not only fight to attrit the forces and morale of their adversary, but they are also engaged in a struggle to learn, adapt and improve their military effectiveness faster than their enemy. In a more recent yet crucial development, this learning and adaptation in Ukraine has now grown into a global adaptation war.[10] This too is occurring at pace, especially in the

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8 Buss, D., et.al., 'Adaptations, Exaptions and Spandrels', *American Psychologist*, May 1998, 534; Charles Darwin, *The Origin of the Species: By Means of Natural Selection or The Preservation of Favored Races in the Struggle for Life*, Random House reprint, 1998, 636-7.

9 Grant Hammond, *The Mind of War: John Boyd and American Security*, (Washington: Smithsonian Institution Press, 2001), 35. Other useful studies of military institutions which have been successful at adaptation include Dr Aimee Fox's *Learning to Fight* as well as Murray and Millett's *Military Innovation in the Interwar Period*. Aimee Fox, *Learning to Fight: Military Innovation and Change in the British Army, 1914–1918*, (Cambridge: Cambridge University Press, 2017); and, Williamson Murray, *Military Innovation in the Interwar Period*, (Cambridge: Cambridge University Press, 1998).

10 Mick Ryan, "The New Adaptation War", *Futura Doctrina*, 16 April 2025, https://mickryan.substack.com/p/the-new-adaptation-war

collaboration and sharing of ideas and technologies among authoritarian states such as Iran, Russia, China and North Korea.

Both Ukraine and Russia can offer lessons in how contemporary military institutions might develop and sustain the learning culture that underpins adaptation – and success - at every level of military operations. [11] But that learning, and adaptation, begins well before the first shot is fired in a war.

When Does Adaptation Occur?

When exploring how contemporary adaptation is evolving, one requires an understanding of the kinds of adaptation that are taking place concurrently in the learning and adaptation processes of different nations. These are important to appreciate because different countries are currently undertaking different forms of adaptation. For example, Ukraine, Russia, Israel and Iran are adapting during war. Other countries, such as the UK, the United States and China, remain in peace time adaptation settings.

The examination of lessons from countries at war and countries at peace requires that both forms of adaptation are understood. Each has different organisational, operational, conceptual and leadership imperatives. If an institution appreciates these differences as well as which mode its friends and enemies are in, this can assist a nation to help its friends better, hinder its adversaries and develop improved strategies to respond to the overall pace of change in the strategic environment.

Three forms of adaptation are relevant to this examination of the adaptation war: adaptation before war; adaptation between peace and war; and adaptation during war.

Adaptation before war. Wartime adaptation is founded on peacetime innovation, and the learning culture that is established in military institutions. The organisational learning culture established in peacetime will have a very significant impact on how institutions prepare themselves for conflict. It also influences how military organisations learn and adapt in the transition to war, and how they perform, learn and adapt throughout the course of a war. As Williamson Murray has observed, "military culture may be the most important factor not only in military effectiveness, but also in the processes involved in military innovation, which is essential to preparing military organizations for the next war."[12]

The past two centuries hold many useful case studies of adaptation, or at least attempts at adaptation, before war. These bursts of institutional self-examination have often corresponded with the arrival of powerful new technologies as military organizations have sought to understand and incorporate them into their operations. Military adaptation literature has its roots in the writings of military theorists in the late 1800s who sought to address how military organisations might adapt, and

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11 Mick Ryan, "How Ukraine is winning in the adaptation battle against Russia" *Engelsberg Idea*s, 24 August 2022, https://engelsbergideas.com/essays/how-ukraine-is-winning-in-the-adaptation-battle-against-russia/

12 Williamson Murray, "Does Military Culture Matter?", *Orbis*, Volume 43, Issue 1, Winter 1999, 27.

how military effectiveness might be improved, in the wake of the new technologies that emerged from the Industrial Revolutions.

Rapid advancements in aviation, mechanized vehicles, and communications during the period between the First and Second World Wars reinvigorated investigation into the future direction of war and how military institutions might adapt and prepare themselves. As these new technologies emerged, military organizations were compelled to reassess traditional doctrines, develop innovative training methods, and restructure their organisations to meet the anticipated demands of modern warfare, fundamentally transforming their adaptation strategies.

The Post-World War Two period sought to address, again, new technologies that had appeared in the latter stages of the Second World War and in the immediate aftermath, such as atomic weapons, long range missiles and computers. In the modern era, starting with the 1973 Yom Kippur War and continuing through to the successful 2003 U.S. march on Baghdad, there was an intense 30-year period of learning and adaptation in military affairs.[13] This included the birth of modern precision munitions, anti-tank missiles, precision navigation and timing, portable computing and global strike operations. It also saw significant conceptual adaptation with the birth of Air-Land Battle,[14] Network Centric Warfare,[15] new era combined arms warfare, and the development of the theories that comprised the Revolutions in Military Affairs.[16]

An institution's proficiency with organisational learning can be a key determinant of its success or failure in future conflicts. This organisational stance enables and nurtures a culture of learning and adaptation in peacetime. Peacetime military organizations face the need to balance two continuously competing drives in an organization – exploitation and exploration. Exploitation is the application of existing competencies to well-understood problems, while exploration is the exploration of new competencies and solutions to emerging problems. As Frank Hoffman explains in *Mars Adapting*, "this balance or tension must be a constant for organisations that cannot live solely in the present lest they risk ceding market share to those with new ideas and competitors. They must exploit their

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13 Some contributions during this period include: Andrew Krepinevich, *The Military-Technical Revolution: A Preliminary Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, 2002); David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917–1945* (Ithaca: Cornell University Press, 2003); Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford: Stanford University Press, 2007); Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the U.S., and Israel*, (Stanford, CA: Stanford Security Studies, 2010); Stephen Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991); Sergey Rogov, *The Evolution of Military Reform in Russia*, (Alexandria: The CNA Corporation, 2001); Michael O'Hanlon, *Technological Change and the Future of Warfare*, (Washington, DC: Brookings Institution, 2000); Allen Millett and Williamson Murray, *Military Effectiveness*, (Cambridge: Cambridge University Press, 2010); and James Corum, *The Roots of Blitzkrieg* (Lawrence, KS: Kansas University Press, 1991).

14 Douglas Skinner, *Airland Battle Doctrine*, (Alexandria: Center for Naval Analyses, 1988).

15 One of the principal publications in the network centric warfare debate in the late 1990s and early 2000s was David Alberts, John Garstka and Frederick *Stein's Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington DC: C4iSR Cooperative Research Program, 1999). Other contributions include Arthur Cebrowski, "Network Centric Warfare: Its Origin and Future" *Proceedings*, No. 1139, Vol. 124, January 1998, https://www.usni.org/magazines/proceedings/1998/january/network-centric-warfare-its-origin-and-future; and, Christopher Smith, *Network Centric Warfare, Command, and the Nature of War* (Canberra: Land Warfare Studies Centre, February 2010), https://researchcentre.army.gov.au/sites/default/files/sp318ncwcommandandnatureofwarchristopher_smith.pdf

16 Andrew Krepinevich, *The Military-Technical Revolution: A Preliminary Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, 2002).

current competencies while being open to new ideas and opportunities as well."[17] To do so requires a military organization to hone many important attributes, foremost of which are good leadership, an organisational learning culture, robust learning mechanisms and effective dissemination methods.[18]

In peacetime, military institutions need to have the capacity to draw lessons from combat, analyse them, develop solutions to emerging problems, and then ensure that solutions are rapidly shared through the entire organisation. While such a system can emerge during a conflict, the existence of one beforehand, as part of an integral learning culture, is a superior and more efficient approach.

At the same time, the learning and adaptation processes developed in peacetime must be linked to evolving concepts of military effectiveness. Allan Millett and Williamson Murray have defined military effectiveness as "the process by which armed forces convert resources into fighting power."[19] Effective military organisations, while often focused on the day-to-day challenges of training in peacetime, also need to invest in updating their ideas for what makes a military institution most likely to succeed in war. Learning and adaptation provide a significant contribution to this.

The aggregate effect of many adaptations at various levels should be to assist senior military and political leaders to constantly redefine what an effective modern military looks like in peace and war. This is a crucial foundation for the adaptation of a military institution from peace to war. Possessing ideas about what makes a military organisation effective is a crucial element of adaptation: it provides a strategic aiming point for change and improvement. These aiming posts for military performance are almost certain to be adapted before and during wars.[20]

Adaptation from peace to war. The transition from peace to war is a different form of adaptation from that which occurs in peace time or during war. It is a shorter process, primarily cognitive, and involves a massive change in mindset overnight. As Mier Finkel writes in *Military Agility*, "a successful transition depends on many variables that are usually covered by the term readiness, [but] to conduct a successful transition from peace to war, other 'softer' aspects of readiness, such as cognitive and mental flexibility, must be addressed."[21]

This is a form of adaptation that is generally less studied than adaptation in peace and war. However, one modern study of this phenomenon is Trent Hone's *Learning War*. The book explores how the U.S. Navy between 1898 and 1945 developed what Hone calls "a sophisticated learning system."[22] This learning system was crucial to the U.S. Navy's response to the surprise at Pearl Harbour and its adaptation from peace to war. This learning system was "most valuable in the critical year of 1942,

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17 Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021, 35.

18 Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021, 44.

19 Allan Millett and Williamson Murray, *Military Effectiveness: Volume 1, The First World War*, Cambridge University Press, 2010, 2.

20 Mick Ryan, "Ukraine and Military Adaptation (II)", *Futura Doctrina*, 7 May 2024. https://mickryan.substack.com/p/ukraine-and-military-adaptation-1aa?utm_source=publication-search

21 Meir Finkel, *Military Agility: Ensuring Rapid and Effective Transition from Peace to War*, University Press of Kentucky, 2020, 1-8.

22 Trent Hone, *Learning War: The Evolution of Fighting Doctrine in the U.S. Navy, 1898-1945* (Naval Institute Press, 2018), 317.

when Admiral Nimitz and his subordinates faced an extremely complex problem." This pre-war learning system proved decisive as it allowed the Navy to quickly exploit what it learned in its early combat operations and transform these insights into new plans, tactics and force structures. As Hone notes, "it helped the Navy overcome initial Japanese advantages and maintain a faster rate of learning."[23] This overcoming initial enemy advantages and then outpacing their learning as time goes on is the essence of an effective 'peace to war adaptation' approach.

Four other aspects of peace to war adaptation should be highlighted.

First, this kind of adaptation requires not only a military response but a societal one. As such, just as military institutions require a peacetime learning and adaptation culture to better transition to wartime mindsets, governments must undertake a range of resilience and preparation activities to ensure societies are physically and morally capable of a rapid transition from peace to war.

Second, the capacity to adapt from peace to war will be influenced by whether a nation is the aggressor or if it is defending against another nation or alliance which commences hostilities. Obviously, those who chose to initiate hostilities will have more time to intellectually and physically prepare their military organisations (if not their societies) for war. Those who are on the other side of this equation, particularly those who are subject to some kind of surprise attack, will have much less time to adapt, and will do so from a position of disadvantage. The deliberate preparation for absorbing and adapting out of such surprise is an imperative for governments and military institutions.[24]

Third, the military and other institutions should have existing plans that guide the transition between peace and war. No plan can ever fully predict the actions of an adversary and its impacts, but they can provide a foundation for quick action in an emergency. A walking start for peace to war adaptation is better than a standing start.

A final aspect of this kind of adaptation is that some nations prefer to blur the distinction between peace and war and operate where possible in the liminal spaces (or grey spaces) between conflict and peace. David Kilcullen has described this as "liminal warfare". It is a form of conflict that exploits ambiguity, being neither totally overt nor clandestine while "rid(ing) the edge, surfing the threshold of detectability."[25] Consequently, a neat transition from war to peace is increasingly difficult to discern or to make long-term decisions about in government and military endeavours.

Notwithstanding this complication, military and national security institutions must undertake the appropriate preparation to adapt from peace to war. It will require the capacity of governments and military organisations to define the new situation as war, and the need to be able to rapidly shift routine methods of activity from those embedded in institutions optimized for peacetime processes

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23 Trent Hone, *Learning War: The Evolution of Fighting Doctrine in the U.S. Navy, 1898-1945* (Naval Institute Press, 2018), 335, 317.

24 This ability to respond to surprise and rapidly (and effectively) adapt from peace to war is the focus in Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford: Stanford University Press, 2007).

25 David Kilcullen, *The Dragons and the Snakes: How the Rest Learned to Fight the West*, Oxford University Press, 2020, 119.

to those essential in war.[26] As Frank Hoffman describes in *Mars Adapting,* in the transition from peace to war, "each institution had to adapt its predispositions and alter its repertoire of competences – in doctrine, organization, and equipment- in order to adapt to the shifting circumstance of a conflict that was not well anticipated."[27]

Adaptation in war. Wartime adaptation has an existential imperative and generally proceeds at a faster pace than peacetime learning and adaptation. However, the breadth of events that occur in a war can vastly outstrip those in peacetime, and this means leaders need to pay even more attention to learning and adaptation as part of their expanded wartime responsibilities.

In her book, *Learning to Fight*, Aimee Fox describes how the British Army learned and adapted during the First World War. Her research challenges some of the existing narratives about intellectual rigidity in the allied high command. She found that "through a combination of its pre-war ethos and increased fluidity in wartime, the army displayed organisational and cultural flexibility, allowing for high levels of learning and adaptation. This was not limited to a single formation, branch or expeditionary force. It was an institutional undertaking."[28]

There are many notable developments in Ukrainian adaptation since 2022. The drone-counter adaptation battle is accelerating with the new drone wall[29], evolving electronic warfare,[30] new forms of AI for drone control,[31] and sophisticated drone interceptors[32] that are cheaper to produce than the Russian drones they destroy. Ukraine has developed a new, advanced defence manufacturing sector from minimal foundations in 2021, and it now produces a wide variety of advanced munitions, missiles, drones and digital systems.[33] Ground tactics are co-evolving between Russian and Ukrainian forces

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26 Meir Finkel, *Military Agility: Ensuring Rapid and Effective Transition from Peace to War*, University Press of Kentucky, 2020, 6.

27 Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021.

28 Aimee Fox, *Learning to Fight: Military Innovation and Change in the British Army, 1914–1918* (Cambridge: Cambridge University Press, 2017), 248.

29 Stefan Korshak, "Drone Wall in Action, Blasts and Bombs, Dead Deals, Estonia and Some Humor", *Kyiv Post*, 29 April 2025. https://www.kyivpost.com/opinion/51701; David Kirichenko, "Ukraine's drone wall is Europe's first line of defense against Russia", *Atlantic Council*, 2 July 2025. https://www.atlanticcouncil.org/blogs/ukrainealert/ukraines-drone-wall-is-europes-first-line-of-defense-against-russia/?utm_medium=email&_hsenc=p2ANqtz-8dHB6vrYnuH4P0WyfE-1SumpJ6PTKANiO1eL3L2FzYRWqGUt4oIyWuBwEtDaUhDTMMIU9ZPfYPIpHPkDpTCRu4GNYo9A&_hsmi=369766918&utm_content=369766918&utm_source=hs_email

30 Tereza Pultarova, "Ukraine's Bold Gamble on an Electronic Warfare "Wall", IEEE Spectrum, 19 May 2025, https://spectrum.ieee.org/electronic-warfare-ukraine

31 Olena Mukhina, "New Russian AI drones outsmart Ukraine's electronic warfare—experts say it's just beginning", Euromaidan, 7 May 2025, https://euromaidanpress.com/2025/05/07/new-russian-ai-drones-outsmart-ukraines-electronic-warfare-experts-say-its-just-beginning/

32 Oleksii Artemchuk, "Ukraine unveils new drone interceptor to counter constant Russian Shahed threats", *Ukrainska Pravda,* 9 April 2025. https://www.pravda.com.ua/eng/news/2025/04/9/7506727/

33 Kateryna Kuzmuk and Lorenzo Scarazzato, "The transformation of Ukraine's arms industry amid war with Russia", *Stockholm International Peace Research Institute*, 21 February 2025. https://www.sipri.org/commentary/topical-backgrounder/2025/transformation-ukraines-arms-industry-amid-war-russia

on a monthly basis, including the application of new technologies and new units such as the Russian motorcycle assault units.[34]

Finally, next generation robotic warfare has seen drones attack other drones, as well as carry drone sub-systems and offensive weapons. The methods, organisations and technologies for the learning and adaptation battle continue to improve and timescales for adaptation continue to contract. Ukrainian drone units can often adapt and update their software daily and evolve their tactics every 1-2 weeks.

Russian military capacity to learn and adapt has also drastically improved since 2022. It has 'learned to learn' better and has sped up its adaptation cycle across many aspects of military affairs. The Russians are close observers of Ukrainian operations, and they actively and quickly copy Ukrainian tactics that they believe work. Recent Russian adaptations include improvements to infiltration tactics[35] and tactical speed[36] to cross dangerous parts of the battlefield; and the widespread use of FPV drones and next-generation drone jammers.[37] In parallel, Russia has continuously evolved its recruiting and force generation methods.[38]

Williamson Murray has written that "over the past century, the effective incorporation of change is what war has increasingly been about."[39] Adaptation is not just part of war, it is inherent in its very nature. And given the increasingly integrated character of war, those who lead wartime innovation in military institutions must also understand the cultural, political and intellectual restraints on their combat and strategic learning and adaptation. And while there are many obstacles to wartime adaptation, such as time constraints, enemy action, and internal hierarchical and bureaucratic hurdles, the imperative to learn and adapt remains.

Insights from Adaptation Before and During War

Several themes from these earlier periods of adaptation stand out. The first is that military organisations are not always the stolid, conservative organisations that many have portrayed them as. They are partially like this, primarily because they possess knowledge that was won in blood on the battlefield, and they don't want to relearn those same lessons in the future. But, as a review of the

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34 Frontelligence *Insight, 21st-Century Dragoons: Dissecting Russia's Motorcycle Assault Tactics*, 24 June 2025. https://frontelligence.substack.com/p/21st-century-dragoons-dissecting; Mick Ryan, "Not All Adaptation is Good", *Futura Doctrina*, 3 July 2025. https://mickryan.substack.com/p/not-all-adaptation-is-good

35 Scott Pettigrew, "Russian and Chinese Infiltration Tactics Take Two Different Paths to Success", Red Diamond, 10 April 2025. https://oe.tradoc.army.mil/product/russian-and-chinese-infiltration-tactics-take-two-different-paths-to-success/

36 Daria Tarasova Markina and Tim Lister, Russian military turns to motorbikes to evade Ukrainian drones on frontline", *CNN World*, 27 April 2025. https://edition.cnn.com/2025/04/27/europe/russian-military-motorbikes-ukraine-drones-intl

37 Vikram Mittal, Russia Is Fielding New EW Counter-Drone Systems To Aid Struggling Offense", Forbes, 10 April 2025, https://www.forbes.com/sites/vikrammittal/2025/04/10/russia-is-fielding-new-ew-counter-drone-systems-to-aid-struggling-offense/

38 Kateryna Stepanenko, Tetiana Trach, Nate Trotter, Olivia Gibson, Daria Novikov, Anna Harvey, and Jessica Sobieski, "Russian Force Generation and Technological Adaptations Update June 18, 2025", *Institute for the Study of War,* 18 June 2025. https://www.understandingwar.org/backgrounder/russian-force-generation-and-technological-adaptations-updates-page

39 Williamson Murray, *Adaptation in War: With Fear of Change*, Cambridge University Press, 2011, 6.

historical literature on this topic exposes, some military institutions indeed do recognise the imperatives for change and adapt at different levels of the institution. Despite the popularity of narratives such as 'lions led by donkeys'[40] that emerged in the First World War, or the views of military incompetence developed in the wake of the Vietnam War and well-described by authors such as Norman Dixon,[41] multiple studies have described how military institutions can and do learn and adapt in peacetime.[42]

But a competing theme is that military institutions are not always enthusiastic adopters of new technology. Tradition and a reluctance to trust new technologies when older ones have proven themselves in battle has been apparent in the military since at least the start of the first industrial revolution. Examples of this included the restrictions placed on the use of submarines before the Second World War because surprise attacks on commercial ships were seen as dishonourable,[43] or the initial allocation of aircraft to the U.S. Army's Signal Corps because its functions were imagined to only include slightly faster transmission of messages on the battlefield. [44]

Other technologies failed to gain traction initially because of an obsession with historical methods by senior military leaders.[45] As Aimee Fox notes in *Learning to Fight*, even units under existential threat could engage in behaviour where "decisions were irrational, contributing to significant casualties…arrogance, intolerance and Blimp-ish pockets were inevitable."[46]

A final theme is that new technologies alone are insufficient to provide a decisive military advantage to military organisations. The contemporary obsession with drones as a kind of silver bullet in war by some in the media and analytical communities has many historical precedents. Just one example is the German obsession with wonder weapons in the Second World War.

The historical lessons available to inform adaptation before war demonstrate that the optimal path to integrating new technologies into military institutions is to accompany technological insertions with different ideas, evolved organisations and new leadership and training models[47] that are best able to

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40 Although the phrase appears to have been used in antiquity (Alexander the great is reputed to have said that "An army of sheep led by a lion is better than an army of lions led by a sheep."), it was popularised in the 20th century when British historian Alan Clark based the title of his book *The Donkeys* (1961) on it.

41 Norman Dixon, *On the Psychology of Military Incompetence* (London: Jonathan Cape publishers, 1976).

42 Among the studies that have described the learning and adaptation that has occurred in peacetime military institutions are the following: Trent Hone, *Learning War: The Evolution of Fighting Doctrine in the U.S. Navy, 1898-1945* (Naval Institute Press, 2018); Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021; Stephen Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991); Williamson Murray, *Military Innovation in the Interwar Period*, (Cambridge: Cambridge University Press, 1998).

43 E.E. Hazlett, "Submarines and the London Treaty", *Proceedings*, Vol. 62, No. 406, December 1936.

44 David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army 1917-1945*, (Cornell University Press, 1998), 40-42.

45 David Johnson describes one case study where the head of the U.S. Army's cavalry before the Second World War saw new motor vehicles only application as transporting horses to and from the battlefield and continuously thwarted the introduction of motor vehicles into the cavalry until he was removed from his position by the Chief of Staff of the U.S. Army. David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army 1917-1945*, (Cornell University Press, 1998), 136-140.

46 Aimee Fox, *Learning to Fight: Military Innovation and Change in the British Army, 1914–1918* (Cambridge University Press, 2017), 246.

47 For a contemporary example of new training and leadership models being applied to new technologies, see Kollen Post, How the next generation of Ukrainian drone pilots are being trained at UAV schools", Kyiv Independent, 25 March 2025. https://kyivindependent.com/inside-the-new-drone-schools-teaching-the-next-generation-of-ukrainian-uav-pilots/

exploit the new technologies. Andrew Marshall, who headed the Pentagon's Office of Net Assessment for several decades, undertook dozens of studies on this topic throughout his tenure. Writing about the lessons of military transformation, Marshall described how "the most important competition is not the technological competition…the most important goal is to be the first, to be the best in the intellectual task of finding the most appropriate innovations in the concepts of operation and making organisational changes to fully exploit the technologies already available."[48]

The Adaptation Imperative

The highly connected and rapid learning and adaptation ecosystem provides the intellectual and physical means for continuous organizational, doctrinal, and technological innovation in Ukraine and beyond. Much of the learning and adaptation from Ukraine is transparent to outside observers, making the proliferation of lessons – and the potential for wider learning – much greater. This enhanced visibility of Ukrainian, Russian and international adaptation affords insights that can inform more effective institutional and alliance postures towards learning and adaptation. To that end, the next section of the report examines the different components of the contemporary global adaptation war.

[48] Andrew Marshall, *Memorandum for the Record: Some thoughts on Military Revolutions – Second Version*, Office of Net Assessment, U.S. Department of Defense, 23 August 1993.

Part II. Components of the Adaptation War

> *The willingness to adopt tactical innovations, even those of the enemy, is a factor in long-term success and viability.*[49]

Adaptation is not a singular or holistic process that takes place at one level or in any single part of a military institution. In military organisations, there will be multiple instances of adaptation occurring at any single point in time, and these will be happening in different geographic areas as well as at different levels within the hierarchical construct of a military force.[50] The new Adaptation War has three important components: tactical, strategic and international adaptation systems. In this part of the report, each adaptation component is defined, and its manifestation during the war in Ukraine explored.

A final point must be made before exploring the components of the adaptation war. The tactical and strategic adaptations described in this section comprise adaptations taking place during war. However, the international adaptations are generally classified as 'adaptations before war'. This is an important caveat because the difference between whether nations are at war or preparing for war drives the pace, quality, resourcing and leadership imperatives of adaptation activities.

Component 1: Tactical Learning and Adaptation

At the most basic level of military operations, armies, navies, air forces, and their supporting networks must be able to fight and win battles and campaigns. Tactical adaptation is the sum of actions that underpin learning and improvement on the battlefield, the dissemination of those lessons to other battlefield elements, as well as the training that prepares reinforcements and new units. As Millett and Murray describe it, "tactical activity involves the movement of forces on the battlefield against the enemy, the provision of destructive fire upon enemy forces or targets, and the arrangement of logistical support directly applicable to engagements."[51]

Tactical adaptation includes the capacity to learn and then improve military effectiveness for the employment of major forces in the achievement of strategic aims in a theatre of war. Ukraine and Russia have both shown the capacity for tactical learning and adaptation during the war since 2022. Ukrainians accept that they have no choice but to learn and adapt, but that they also must continuously speed up their learning and adaptation given Russian improvements in the capacity to learn since February 2022.

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49 B.A. Friedman, *On Tactics: A History of Victory in Battle*, Naval Institute Press, 20217, 206.

50 Mick Ryan, "Ukraine and Military Adaptation", *Futura Doctrina*, 6 May 2024. https://mickryan.substack.com/p/ukraine-and-military-adaptation?utm_source=publication-search

51 Allan Millett and Williamson Murray, *Military Effectiveness: Volume 1, The First World War*, Cambridge University Press, 2010, 19.

Tactical adaptation during the war in Ukraine has been covered extensively since 2022. Notable books describing tactical innovation include *The War Came to Us* (2023) by Christopher Miller, *Overreach* (2022) by Owen Matthews, *To Ukraine with Love* (2023), edited by Benjamin Tallis; *War in Ukraine* (2024), edited by Hal Brands; *Beyond Ukraine: Debating the Future of War* (2024), edited by Tim Sweijs and Jeffrey Michaels. Military and strategic experts have contributed an array of journal articles and reports during the war. Journals such as the Royal United Services Institute, Survival, The Atlantic Council, Foreign Affairs, Parameters, Joint Forces Quarterly, Military Strategy Magazine, The Journal of Advanced Military Studies, The Lowy Institute, Military Review, Scandinavian Journal of Military Studies, the Carnegie Institution, the Center for Strategic and International Studies, the UK Defence Journal, PRISM, and the Australian Journal of Defence and Strategic Studies have all published multiple insights into the war, and on a variety of themes including the conduct and adaptation of combat operations, leadership, strike operations, logistics, planning, diplomacy, and economic sanctions.

Tactical adaptation is a crucial method to build advantage in many areas of warfighting concurrently, while at the same time negating enemy advantage by attempting to interfere with their learning and adaptation. It is an essential foundation for the continuous generation of advantage on the battlefield, and as such, effective tactical adaptation needs to be nurtured at every level of a military institution. Tactical adaptation is also key to learning about the enemy and improving the capacity of friendly forces to negate an adversary's advantages in technology, tactics, people and generation of smart ideas and massed capability over time. This occurs in war but as noted in Section I of this report, it must begin in peacetime.[52]

What are the most important tactical adaptations that have occurred since 2022? Broadly speaking, there are four areas which have been the principal focus of tactical adaptation during this period in both the Ukrainian and Russian military organisations: uncrewed systems; the democratization of digital command and control; tactics; and tactical organization.

The uncrewed systems war. Even though remotely operated systems have been employed by military organizations since the Second World War[53], and many new systems have been integrated into military forces since the 1970s, the past three and half years has been the most intense period of innovation and learning about uncrewed systems in the history of warfare.[54]

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52 Mick Ryan, "Dispatch from Ukraine: The adaptation battle intensifies", *The Interpreter*, The Lowy Institute, 17 March 2025. https://www.lowyinstitute.org/the-interpreter/dispatch-ukraine-adaptation-battle-intensifies

53 The U.S. Navy deployed drones during the Pacific War, primarily the Interstate TDR-1 assault drone. These drones, remotely controlled via television cameras in a modified TBM Avenger. The program was cancelled due to operational challenges and the success of cheaper conventional weapons. In the European theatre, the U.S. Army Air Force used old B-17 bombers filled with explosives and remotely controlled to attack Nazi submarine pens in France.

54 David Kirichenko, "Drone superpower: Ukrainian wartime innovation offers lessons for NATO", *Atlantic Council*, 13 May 2025. https://www.atlanticcouncil.org/blogs/ukrainealert/drone-superpower-ukrainian-wartime-innovation-offers-lessons-for-nato/; Stefan Korshak, "Drone Wall in Action, Blasts and Bombs, Dead Deals, Estonia and Some Humor", *Kyiv Post*, 29 April 2025. https://www.kyivpost.com/opinion/51701#articles-sub-title-1

The pace of learning and adaptation in uncrewed systems has also accelerated over the course of the war. Key developments however include the proliferation of drones across the air, maritime and land domains;[55] research, development and employment of fibre-optic controlled drones that can be very difficult to detect or jam; the advent of drone versus drone combat in aerial domain as well as across domains; the development of large drones that 'piggy-back' smaller reconnaissance and strike uncrewed systems, enhanced autonomy and 'last mile' targeting, the establishment of a new, independent Unmanned Systems Force in 2024,[56] and most recently, the development of a Ukrainian Drone Wall as a single, contiguous defensive zone along the entire eastern Ukraine frontline.[57]

The explosion in the employment of uncrewed systems by Ukraine and Russia has seen the emergence of massed precision on the battlefield and beyond. This has resulted in what Michael Horowitz has described as warfare that "…is collapsing the binary between mass and precision, scale and sophistication. Call it the age of "precise mass." Militaries find themselves in a new era in which more actors can muster uncrewed systems and missiles and gain access to inexpensive satellites and cutting-edge commercially available technology."[58]

The adaptation of uncrewed systems during the war in Ukraine since 2022 has played out together with advances in the conduct of electronic warfare (EW).[59] EW has been crucial to detecting, jamming or spoofing enemy drones, as well as degrading their navigation systems and discovering drone operations centres.[60] Learning and adaptation about uncrewed systems and EW now represents an example of co-evolution, a process where two or more species (or technologies) influence each other's evolution. While EW-resistant fibre-optic uncrewed systems increase in numbers, they remain a small proportion of overall drones used. As such the linkage between the adaptation of uncrewed systems and EW will remain as a feature of the war.[61]

A final component of the uncrewed systems battle during the war in Ukraine is the accelerating advances made in counter autonomy capabilities by both sides. Initiatives in Ukraine include drone

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55 In 2025, Ukraine's military expects to form uncrewed ground vehicle companies in each of its brigades.

56 President Zelenskyy signed the decree to establish the Unmanned Systems Force in February 2024. "Ukraine Unveils World's First Unmanned Systems Force: A New Era of Warfare and Vengeance", The Sign, 16 September 2024, https://www.thesign.media/blog/ukraine-unveils-worlds-first-unmanned-systems-force-a-new-era-of-warfare-and-vengeance

57 Dmytro Shumlianskyi "Vyriy Founder Compares Accuracy of Ukrainian and Russian Fiber Optic Drones", *Militarnyi*, 27 April 2025. https://militarnyi.com/en/news/vyriy-founder-compares-accuracy-of-ukrainian-and-russian-fiber-optic-drones/; David Kirichenko, Ukraine's Drone Forces Are Ready for Russia's Spring Offensive, The National Interest, 23 April 2025. https://nationalinterest.org/feature/ukraines-drone-forces-are-ready-for-russias-spring-offensive; News Desk, "For first time, Ukraine attacks Russian positions using solely ground, FPV drones", Kyiv Independent, 21 December 2024, https://kyivindependent.com/for-first-time-ukraine-attacks-russian-positions-using-solely-ground-fpv-drones/;

58 Michael Horowitz, Battles of Precision Mass", *Foreign Affairs*, 22 October 2024, https://www.foreignaffairs.com/world/battles-precise-mass-technology-war-horowitz?check_logged_in=1

59 Robert Wall, "Russia-Ukraine War Disrupts Western Electronic Warfare Strategies", Aviation Week, 14 May 2025, https://aviationweek.com/defense/sensors-electronic-warfare/russia-ukraine-war-disrupts-western-electronic-warfare

60 Jack Watling and Noah Sylvia, Competitive Electronic Warfare in Modern Land Operations, Royal United Services Institute, 2025, https://static.rusi.org/competitive-electronic-warfare-in-land-operations_1.pdf

61 "Ukraine's Unwave Serves Up "PATELNYA": The New Infantry EW System Turning Up the Heat on Enemy Drones", Tech Ukraine, 14 May 2025. https://techukraine.org/2025/05/14/ukraines-unwave-serves-up-patelnya-the-new-infantry-ew-system-turning-up-the-heat-on-enemy-drones/; Tereza Pultarova, "To Defend Itself, Ukraine Rethinks Electronic Warfare", IEEE Spectrum, 18 May 2025, https://spectrum.ieee.org/ukraine-air-defense

interceptors[62] and AI-controlled robotic machine guns[63] to shoot down battlefield uncrewed systems as well as the long-range Shahed drones. These Ukrainian efforts have been greatly assisted by British, American, and European projects to develop and deploy at scale cheaper methods to neutralise enemy uncrewed systems on the battlefield and beyond.[64] As we will return to later, this uncrewed systems battle has been a prominent element of the international dimensions of the global adaptation war.

Democratized digital command and control. The widespread employment of uncrewed systems would not have been as successful without the development and ongoing adaptation in Ukrainian digitised command and control (C2) systems since 2022. These digital C2 systems, blending civilian and military, new and existing technologies, have proliferated using C2 software on personal devices. It has enhanced the situational awareness of soldiers and commanders, drastically sped up targeting cycles and compressed kill chains, and has been crucial in the sharing of information collected by autonomous systems in a manner that enables its rapid exploitation.[65]

Exploiting the data provided by combining information from commercial and military sensors, battlefield leaders have been able to make more rapid decisions. This is beginning to transform how tactical leaders approach combat in Ukraine, at least in some brigades. For example, the Ukrainian *Delta* digital C2 system has significantly shortened decision cycles in many situations. *Delta* was developed in collaboration with NATO prior to 2022, and it combines real-time mapping with pictures and locations of enemy units, which can be input by anyone with access to a smart device with the *Delta* app and connection to a network.[66] It has evolved from a purely situational awareness tool to a fully integrated C2 system that is now employed by all services of the Ukrainian armed forces. Its functions now incorporate mapping, streaming of drone video (*Vezha*), integration of foreign weapon support software, AI-battlefield video analysis (Avenger), mission control and messaging.[67]

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62 The DroneFall initiative of Come Back Alive is one such initiative. This is now being widely deployed by frontline units. Olena Hrazhdan, "Come Back Alive Says 'Dronefall' Project Downed Russian Drones Worth $65M", *Kyiv Post*, 22 March 2025. https://www.kyivpost.com/post/49369

63 David Hambling, "Ukraine Turns To AI-Controlled Guns To Stop Russian Shahed Drones", *Forbes*, 27 May 2025. https://www.forbes.com/sites/davidhambling/2025/05/27/ukraine-turns-to-ai-controlled-guns-to-stop-russian-shahed-drones/

64 Joe Lacdan, "Joint Counter-Small UAS Office conducts successful counter drone-swarm demonstration", U.S. Army website, 26 July 2024. https://www.army.mil/article/278404/joint_counter_small_uas_office_conducts_successful_counter_drone_swarm_demonstration; U.S. Department of Defense, "DoD Announces Strategy for Countering Unmanned Systems", 5 December 2024. https://www.defense.gov/News/Releases/Release/Article/3986597/dod-announces-strategy-for-countering-unmanned-systems/; Companies such as Andruil (https://www.anduril.com/capability/counter-uas/) and AIM Defence (https://www.aimdefence.com), among many others, have also developed counter drone technologies, but are yet to be battle tested.

65 Isabelle Khurshudyan, Mary Ilyushina and Kostiantyn Khudov, "Russia and Ukraine are fighting the first full-scale drone war", *The Washington Post*, 2 December 2022. https://www.washingtonpost.com/world/2022/12/02/drones-russia-ukraine-air-war/

66 Lara Jakes, "For Western Weapons, the Ukraine War Is a Beta Test", *New York Times*, 15 November 2022; Kateryna Kistol, "Digital weapons of war: applications and software that help Ukraine to win", *War.Ukraine.Ua*, 13 December 2022. https://war.ukraine.ua/articles/digital-weapons-of-war-applications-and-software-that-help-ukraine-to-win/

67 Kateryna Bondar, *Does Ukraine Already Have Functional CJADC2 Technology?,* Center for Strategic and International Studies, December 2024, 4-9. https://csis-website-prod.s3.amazonaws.com/s3fs-public/2024-12/241211_Bondar_Ukraine%20CJADC2.pdf?VersionId=bxzcRKK.lmDJVz6xMtzeWwsmE2jkhcH5

In 2024, *Delta* passed NATO security audits, and has proven so successful that at least one NATO country is seeking a potential export deal to use the Ukrainian system for itself.[68]

Other systems such as *Kropyva* and *GIS Arta* are also used at brigade and unit level. However, it is the Delta system that provides the glue for Ukrainian digitised C2.[69] More importantly the *Delta* system underpins Ukraine's growing autonomous forces, and its overall vision for how it will eventually fight the Russians by replacing humans with autonomous systems.[70] The vision incorporates autonomous capabilities and advanced, digital C2 systems as well as advances in AI. As Kateryna Bondar notes, "Ukraine's defense industry is developing standalone AI-driven software that can be integrated across various platforms to expand battlefield autonomy." However, Bondar also notes that "Two major challenges lie ahead for AI-enabled autonomy: extending these capabilities to ground, sea, and undersea platforms and enabling swarming for aerial systems."[71] The degree to which human oversight can be retained as these developments accelerate remains uncertain. It is likely new command and control, and organisational concepts might be required.

The evolving approach to digitized C2 in Ukraine has impacts well beyond the conduct of autonomous operations in the air, land and sea domains, and the coordination of artillery, drones and other battlefield effects. Ultimately, it allows for more deliberate interventions by commanders into tactical tempo, further closing kill chains but also providing greater situational awareness to more junior commanders. In due course, this will require different training and leadership development methods in military organisations to best exploit these technologies as a family of tactical systems.[72]

Adaptation in tactics. Ukrainian tactics have evolved throughout the war. In 2025, Ukrainian tactics focus on defence in depth employing fortified positions and autonomous systems to impose costs on Russian forces, coupled with longer-range strikes to impose costs on successive Russian echelons. The evolved Ukrainian tactics have been described by Watling and Reynolds as follows:

> *Ukrainian tactics are premised upon extending the depth of their fires and dispersing their force to avoid casualties. The pervasive threat from fires causes units to dig extensively, by hand in the forward positions, and to reduce force density. Some units favour greater concentration, relying on their ability to hide and employ decoys and reversionary positions*

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68 NATO Country Seeks Ukraine's Delta Combat System in Possible Export Deal, *Defense Mirror.com*, 30 April 2025. https://www.defensemirror.com/news/39391/NATO_Country_Seeks_Ukraine___s_Delta_Combat_System_in_Possible_Export_Deal

69 Audrey MacAlpine, Ukraine's Secret Weapon, 'Kropyva' Software, *United24,* 29 November 2024, https://united24media.com/war-in-ukraine/ukraines-secret-weapon-kropyva-software-4026; Mark Bruno, "Uber for Artillery – What is Ukraine's GIS Arta System?" T*he Moloch,* https://themoloch.com/conflict/uber-for-artillery-what-is-ukraines-gis-arta-system/

70 Kateryna Bondar, Ukraine's Future Vision and Current Capabilities for Waging AI-Enabled Autonomous Warfare, Center for Strategic and International Studies, March 2025, 1. https://csis-website-prod.s3.amazonaws.com/s3fs-public/2025-03/250306_Bondar_Autonomy_AI.pdf?VersionId=E2h8uqROea77udoc_og82HWsrfgfJRTZ

71 Kateryna Bondar, Ukraine's Future Vision and Current Capabilities for Waging AI-Enabled Autonomous Warfare, Center for Strategic and International Studies, March 2025, 1-4. https://csis-website-prod.s3.amazonaws.com/s3fs-public/2025-03/250306_Bondar_Autonomy_AI.pdf?VersionId=E2h8uqROea77udoc_og82HWsrfgfJRTZ

72 Clint Hinote and Mick Ryan, *Empowering the Edge: Uncrewed Systems and the Transformation of U.S. Warfighting Capacity*, Special Competitive Studies Project, Washington DC, 2023, 10-14.

to which they are able to relocate, while others revert to greater dispersion… The preference is to maximize attrition beyond line of sight. Armoured vehicles are used for both indirect and direct fire, though the latter is currently preferred. Because of the high latency of FPV sorties, armoured fighting vehicles tend to sally forwards from these hides to engage in direct-fire missions to break up enemy assault actions. The vehicles then return to their protected hides before they can be targeted.[73]

Key Ukrainian battlefield adaptations have included the continued development of its distributed digital C2 and fires enable rapid tactical kill chain, an expansion in use of deception, decoys and dummy equipment, a focus on force preservation over retention of territory at all costs since early 2024, improvements to casualty evacuation and tactical sustainment activities, continuous evolution of EW to now incorporate a dense network of EW systems, and some improvements in force rotation models.

The ability of Russian military organisations to learn and adapt has vastly improved over the course of the war. Russia has 'learned to learn better' and it has sped up its learning and adaptation cycle across most aspects of military affairs in the past year. Russia is now a much more capable and dangerous military institution than it was before the war, and it will use this to improve its operations in Ukraine as well as to threaten Europe.

The Russians are close observers of Ukrainian operations, and they actively copy Ukrainian tactics and methods that they believe work well. The Russians are 'fast followers' and they can scale up their changes – in tactics or technology – faster than Ukraine can. Throughout the course of the war, the Russians have evolved their tactics to attrit Ukrainian forces and seize Ukrainian territory. While 'meat tactics' have been employed by the Russians, and have received wide coverage in the press, the reality is that Russian tactical learning and adaptation has been more sophisticated and varied than the pure application of masses of poorly trained soldiers in massed attacks.

Current Russian tactical doctrine has evolved to incorporate what Jack Watling has described as the Russian Offensive Triangle. In concept, this is a very simple idea. First, Russian ground forces pin down Ukrainian frontline units with infantry and mechanized troops. Next, the Russians limit the maneuver of the Ukrainian ground troops and inflict attrition with uncrewed systems, particularly first-person view drones (FPVs), loitering munitions and indirect fires. The use of indirect fires (artillery) can also incorporate the employment of scatterable mines between and behind Ukrainian positions. Third, the Russians use UMPK glide bombs against the Ukrainian forces which are now fixed in their defensive positions by Russian ground troops and drones. While the use of these glide bombs is not new, there has been a significant acceleration in their use in 2024 and 2025.[74]

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[73] Jack Watling and Nick Reynolds, "Tactical Developments During the Third Year of the Russo–Ukrainian War", *The Royal United Services Institute for Defence and Security Studies*, 2025, 9-10. https://static.rusi.org/tactical-developments-third-year-russo-ukrainian-war-february-2205.pdf

[74] John Hoehn and William Courtney, *How Ukraine Can Defeat Russian Glide Bombs*, RAND Corporation, 28 June 2024, https://www.rand.org/pubs/commentary/2024/06/how-ukraine-can-defeat-russian-glide-bombs.html

As a 2025 report from the Royal United Services Institute for Defence and Security Studies notes, "this creates a competing dilemma: should the AFU hold and invest in static defensive positions to reduce attrition from FPVs and drone-enabled artillery, or retain mobility to avoid destruction from glide bomb strikes, which have the explosive yield to demolish or bury even well-prepared fortifications?"[75] Other examples of Russian adaptation in tactics in the past year include improvement in infiltration tactics, improved human-machine teaming for aerial and ground autonomous and remotely operated systems, streamlined tactical and operational strike kill chains, continuous improvement in the conduct of EW operations, and the development of motorcycle assault tactics.

Additionally, Russian forces have evolved their tactical use of drones within the offensive triangle. Their drones now routinely land beside roads to ambush Ukrainian vehicles. At the same time, they have expanded the range and increased the battlefield density of these tactical systems. As one Ukrainian commander described during the battle for Kostiantynivka in eastern Ukraine:

> *Before, they could hit targets within two or three kilometers. Now, they're striking every 10 to 20 minutes at a consistent range of 15 kilometers from the front line. Everything within that 15-kilometer zone is being destroyed*.[76]

But tactical adaptation is not restricted to combat operations of the land. In both the air and maritime domains, there have been notable adaptations in tactics. In the battle against Russian drones, the Ukrainians have adapted frequently to changes in Russian tactical employment of Shahed drones. This has included the development of AI-guided guns to engage drones, changing deployment models, and different forms of EW operations. At sea, Ukraine (as well as Russia) continues to evolve its family of small and sometimes semi-submersible maritime uncrewed platforms.[77] Not only does the Ukrainian Navy constantly adapt their technologies but they have simultaneously adapted their tactics[78] to now include the capacity to launch missiles at Russian helicopters and fighter aircraft,[79] and to launch drones to conduct reconnaissance and strike missions against land and maritime targets.

Adaptation in organisations. Finally, over the course of the war both Ukraine and Russia have continuously adapted their warfighting organisations. Russia quickly dispensed with its Battalion Tactical Groups not long after the failure of the Russian northern campaign in 2022. Since then, it has reformed brigade and division level formations. In 2023, due to battlefield needs, Russia formed new

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75 Jack Watling and Nick Reynolds, "Tactical Developments During the Third Year of the Russo–Ukrainian War", *The Royal United Services Institute for Defence and Security Studies*, 2025, 5-6. https://static.rusi.org/tactical-developments-third-year-russo-ukrainian-war-february-2205.pdf

76 Constant Méheut and Olha Konovalova, "Ukrainian Troops Struggle to Hold the Line on the Eastern Front", *New York Times*, 7 July 2025, https://www.nytimes.com/2025/07/07/world/europe/ukraine-war-russia-donetsk.html

77 H.I. Sutton, "Overview of Maritime Drones (USV) of the Russo-Ukrainian War", Covert Shores, 30 June 2025. http://www.hisutton.com/Russia-Ukraine-USVs-2024.html

78 Howard Altman," Two Russian Su-30 Flankers Downed By AIM-9s Fired From Drone Boats: Ukrainian Intel Boss", The Warzone, 3 May 2025, https://www.twz.com/news-features/two-russian-su-30-flankers-downed-by-aim-9s-fired-from-drone-boats-ukrainian-intel-boss

79 Anna Fratsyvir, "Ukrainian sea drone downs Russian fighter jet in 'world-first' strike, intelligence says", *Kyiv Independent,* 3 May 2025. https://kyivindependent.com/ukrainian-intelligence-says-sea-drone-downs-russian-fighter-jet-in-world-first-strike/

assault formations. Variously known as Assault Detachments, Storm-Z and Storm-V, these units were designed to be allocated to regular army formations to conduct assaults against Ukrainian fortifications. The establishment of assault detachments also extends into Russian airborne forces.[80]

Additionally, the Russians established a volunteer force in 2023. Designated the "First Expeditionary Volunteer Army Corps," it served as an umbrella formation uniting various so-called volunteer units which existed at that time or being formed. At least thirteen different units were known to be included in this volunteer corps. While there are differences in the size and equipping of these units, they were generally infantry-heavy with few infantry fighting vehicles (IFV).[81]

In the realm of uncrewed systems, the Russians have formed and expanded new drone units. While the Russians have employed drones throughout the war, it was not until 2025 that they formed a regimental sized unit. In January 2025, it was announced that Russia was forming the 7th Separate Unmanned Systems Reconnaissance Strike Regiment.[82] In May 2025, President Putin announced the formation of an independent drone force.[83] Additionally, a new Russian elite drone unit, called *Rubicon*, played a decisive role in 2025 battles in Kursk, as well as in the Battle of Kostiantynivka.[84]

Ukraine has also made multiple adaptations to its combat forces. Since the beginning of the full-scale invasion, multiple new drone units have been established. In the ground forces, the formation of drone units has proliferated beyond combat units, which now have company and battalion sized aerial drone units, to include medical and logistics units. From 2025, Ukrainian brigades have begun to form companies of uncrewed ground systems as well.[85] The Ukrainian National Guard, Navy and Unmanned Systems force have all formed units for uncrewed systems in the past three years.

And just as drones and EW have evolved on the battlefield, Ukrainian units have adapted to incorporate enhanced EW capabilities.[86] This uplift in capability has occurred across all the military

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80 Michael Kofman, Assessing Russian Military Adaptation in 2023, Carnegie Endowment for International Peace, October 2024, 17-20. https://carnegie-production-assets.s3.amazonaws.com/static/files/Kofman-Russia_final-12-5.pdf

81 Michael Kofman, Assessing Russian Military Adaptation in 2023, Carnegie Endowment for International Peace, October 2024, 25. https://carnegie-production-assets.s3.amazonaws.com/static/files/Kofman-Russia_final-12-5.pdf

82 Ivan Diakonov, "Russia creates separate regiments of unmanned systems to strengthen its army", *Ukrainska Pravda*, 29 January 2025. https://www.pravda.com.ua/eng/news/2025/01/29/7495735/

83 Rojoef Manuel, "Russian Military to Establish Independent Drone Force, Says Putin", *The Defense Post*, 18 June 2025, https://thedefensepost.com/2025/06/18/russia-independent-drone-force/

84 Constant Méheut and Olha Konovalova, "Ukrainian Troops Struggle to Hold the Line on the Eastern Front", *New York Times*, 7 July 2025, https://www.nytimes.com/2025/07/07/world/europe/ukraine-war-russia-donetsk.html

85 Kyiv Post, "Ukraine to Deploy 15,000 Robotic Systems to Front Lines in 2025", 1 April 2025. https://www.kyivpost.com/post/49960; Max Hunder, "Ukraine's military to roll out units of robotic vehicles", Reuters, 5 February 2025. https://www.reuters.com/business/aerospace-defense/ukraines-military-roll-out-units-robotic-vehicles-2025-02-05/

86 J. Agarkar, "Russia-Ukraine War: Lessons from and Electronic Warfare Perspective", *Centre for Land Warfare Studies,* 31 May 2025. https://claws.co.in/russia-ukraine-war-lessons-from-an-electronic-warfare-ew-perspective/

services of the Ukrainian Armed Forces, just as it has in the Russian military forces deployed in Ukraine.[87]

Another adaptation by the Ukrainian Armed Forces, three years into the war, is the formation of corps.[88] While several corps were formed for the 2023 counter offensive, the ground forces operated largely as brigades that were placed under temporary Operational Troop Grouping (OTU) structures, which themselves sat under more established Operational Strategic Groups (OSUV).

In February 2025, the President of Ukraine announced the formation of a significant number of army corps. These would aggregate existing brigades and provide battlefield enablers to shape and support the operations of multiple brigades within each corps.[89] As the Ukrainian Commander in Chief described in a June 2025 briefing, the army corps would replace OTU structures.[90] This is a major transformation of Ukrainian ground forces command and control structures. It is a transformation that aims to better coordinate combined arms operations and to do so at a higher level than has been done since 2022. This in turn should reduce inefficiencies in current approaches to planning operations, undertaking reinforcements and in the conduct of air-ground coordination (particularly for drones). Corps-level formations will also reduce the number of direct command formations currently under Operational Strategic Groups. As a whole, this reorganization aligns with several principles of war, including cooperation, economy of effort and concentration of force.[91]

Tactical Adaptation Ecosystem. The four areas of tactical adaptation examined above do not comprise the full spectrum of tactical adaptation since 2022. An array of other tactical adaptations have taken place, some recorded and some not. A full account of this ecosystem of tactical adaptation across the different battalions, brigades, and other units of the ground forces, national guard, Navy and Air Force would be impossibly large, and probably out of date as soon as it was published. Notwithstanding this, other areas of tactical innovation are worthy of mention. These include the following:

- Battlefield medical treatment and protected casualty evacuation.[92]

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87 Howard Altman, "Electronic Warfare Lessons from Ukraine Informing Air Force Special Operations Future" The War Zone, 5 May 2025. https://www.twz.com/news-features/electronic-warfare-lessons-from-war-in-ukraine-informing-air-force-special-operations-commands-future; Richard Scott, "Special Report: No time to lose as lessons from Ukraine force the pace in electronic warfare", *Janes*, 5 June 2024, https://customer.janes.com/display/BSP_75511-JDW;

88 In 2025, Ukraine has established multiple corps, including the 3rd, 15th, 17th18th, ,20th, 21st, and the Territorial Defence Corps. The Ukrainian Armed Forces, as at July 2025, had established 13 such organisations. "New Army Corps of the Ground Forces appeared", *MilitaryLand*, https://militaryland.net/news/new-army-corps-of-the-ground-forces-appeared/

89 Kateryna Hodunova and Chris York, "Ukraine's army is reforming its structure. Will it help the fight against Russia?", Kyiv Independent, 11 February 2025. https://kyivindependent.com/ukrainian-army-switching-to-corps-system-how-will-it-change-situation-on-battlefield/

90 "The army's transition to a new management structure", MilitaryLand, 23 June 2025, https://militaryland.net/news/the-armys-transition-to-a-new-management-structure/

91 Most military organisations maintain Principles of War to guide operations, training and doctrine. These three principles are common to British, American and Australian doctrine.

92 Aaron Epstein and 9 others, "Putting Medical Boots on the Ground: Lessons from the War in Ukraine and Applications for Future Conflict with Near-Peer Adversaries", *Journal of the American College of Surgeons*, Vol 237, No. 2, August 2023, https://pmc.ncbi.nlm.nih.gov/articles/PMC10344429/pdf/xcs-237-364.pdf; Timoth Hodgetts, D.N. Naumann and D.M. Bowley, "Transferable military

- The decentralization and automation of battlefield sustainment and logistics infrastructure.[93]
- Special operations activities.[94]
- Communications.[95]
- Military engineering support.[96]
- Tactical planning.[97]
- Deception operations.[98]

medical lessons from the Russo-Ukraine war", BMJ Military Health, No. 101, 2025, 101-104, https://militaryhealth.bmj.com/content/jramc/171/2/101.full.pdf; John Quinn and 13 others, "Prehospital Lessons From the War in Ukraine: Damage Control Resuscitation and Surgery Experiences From Point of Injury to Role 2", *Military Medicine*, Vol 189, Issue 1-2, January/February 2024, 17-29.

[93] Heinz Pfriemer, Ukraine Shows Need for More Flexible, Mobile Logistics Systems", National Defense, 25 October 2024. https://www.nationaldefensemagazine.org/articles/2024/10/25/industry-perspective-ukraine-shows-need-for-more-flexible-mobile-logistics-systems; Ronald Ragin and Christopher Ingram, "Theater Sustainment Transformation: Lessons from the Russia-Ukraine War", U.S. Army, 23 April 2024, https://www.army.mil/article/274914/theater_sustainment_transformation_lessons_from_the_russia_ukraine_war#:~:text=Pre%2Dpositioned%20and%20distributed%20storage,enough%20to%20meet%20operational%20requirements; Manuela Tudosia, "Lessons Learned from Ukraine: Logistics", European Security and Denfence, 23 June 2023, https://euro-sd.com/2023/06/articles/31845/lessons-learned-from-ukraine-logistics/#:~:text=There%20are%20many%20lessons%20to,it%20has%20become%20increasingly%20efficient.

[94] Doug Livermore, "The West must study the success of Ukraine's Special Operations Forces", Atlantic Council, 29 January 2025, https://www.atlanticcouncil.org/blogs/ukrainealert/the-west-must-study-the-success-of-ukraines-special-operations-forces/; Daniel Sullivan, Riley Murray, Rylan Neely, "Lessons from the Frontlines: Ukrainian SEAD Operations and Their Implications for Western Special Operations Forces" Irregular Warfare Initiative, 6 February 2025, https://irregularwarfare.org/articles/ukrainian-sead-operations-lessons-for-western-sof/

[95] Illia Kabachynskyi, "How Starlink Became Ukraine's Lifeline in War" 11 February 2025, https://united24media.com/war-in-ukraine/how-starlink-became-ukraines-lifeline-in-war-5774; "Battlefield Communication Networks: Strategic Lessons from Ukraine, MSS Defence, 21 August 2024, https://mssdefence.com/blog/battlefield-communication-networks-strategic-lessons-from-ukraine/; David Wiseman, "Communications Security: Lessons Learned From Ukraine" Blackberry, 8 November, 2022, https://blogs.blackberry.com/en/2022/11/communications-security-lessons-learned-from-ukraine;

[96] Matthew Holbrook, "Engineer Lessons Learned From the War in Ukraine", Engineer, Annual Issue, 2024. https://www.lineofdeparture.army.mil/Journals/Engineer/July-24-Engineer/Lessons-Ukraine/#:~:text=Engineer%20Lessons%20Learned%20From%20the%20War%20in,shortfall%20of%20bridging%20resources%20in%20the%20inventory; Jun Kiat Koh, "Bridging the Gap: Military Engineering Lessons From the Russo-Ukrainian War" Thesis for Master of Defence Studies, Canadian Forces College, 2024, https://www.cfc.forces.gc.ca/259/290/950/286/Koh.pdf; Eugeen Yoon, Engineer Reconnaissance Revisited: A Lesson from Ukraine, Modern War Institute, 29 August 2023, https://mwi.westpoint.edu/engineer-reconnaissance-revisited-a-lesson-from-ukraine/#:~:text=On%20June%2028%2C%202023%2C%20Scripps,of%20the%202023%20Ukrainian%20counteroffensive.

[97] Jack Watling, Oleksandr V Danylyuk and Nick Reynolds, *Preliminary Lessons from Ukraine's Offensive Operations, 2022–23,* Royal United Services Institution, 2024, 32-34. https://static.rusi.org/lessons-learned-ukraine-offensive-2022-23.pdf

[98] Mick Ryan and Peter Singer, *The Future of Deception in War: Lessons from Ukraine*, New America, 5 June 2025, https://www.newamerica.org/future-security/reports/the-future-of-deception-in-war/; Christopher Miller, "The decoy weapons leading Russian forces astray in Ukraine", *Financial Times*, 22 September 2023. https://www.ft.com/content/b0581f55-a449-439c-a92f-1dfb1ca5a181; Stephen Miller, Battlefield Decoys and Deception: Reaffirmed in Ukraine", *Armada International*, 20 September 2023, https://www.armadainternational.com/2023/09/battlefield-decoys-and-deception-reaffirmed-in-ukraine/; "Decoys and Deception – Ukraine's Use of Fake Weapon Systems", *Kyiv Post*, 12 September 2023, https://www.kyivpost.com/post/21544 ; Nicola Bonsegna, "The Strategic Role of Decoys in Warfare", *The Defence Horizon Journal*, 31 October 2024, https://tdhj.org/blog/post/decoys-conflict-ukraine/; John Hudson, Ukraine lures Russian missiles with decoys of U.S. rocket system", *Washington Post*, 30 August 2022, https://www.washingtonpost.com/world/2022/08/30/ukraine-russia-himars-decoy-artillery/; T.X. Hammes, "Game-changers:: Implications of the Russo-Ukraine War for the Future of Ground Warfare", *Atlantic Council*, April 2023, 11-13.

Component 2: Strategic Adaptation

In *Military Adaptation in War*, Williamson Murray describes how "adaptation at the strategic level may represent the easiest to recognise but the most difficult to accomplish."[99] Strategic activities incorporate plans that consider and direct the use of time, geography, missions and objectives, as well as the implementation and evolution of those plans.[100] Effective strategy also requires guiding direction provided by national objectives set by political leaders. Strategic adaptation therefore is the learning and adaptation that occurs at the national level and which impacts making and implementing national and military strategy, and that improves a military organization's capacity to support the achievement of political objectives. Strategic adaptation can both influence and drive the direction of a war.

Strategic adaptation aims to increase the strategic effectiveness of the institution undertaking such changes. As I described in *The War for Ukraine*, "Ukraine needs to be better than Russia at developing, implementing and evolving strategy. While it does not have to be better by much, it does need to consistently test its approach and assumptions about its strategy to ensure it stays ahead of Russian strategic thinking and action."[101] Both Russia and Ukraine have undertaken a range of strategic adaptations since the beginning of the large-scale Russian invasion in February 2022. The aim of this section is not to explore in-depth every example of strategic adaptation during the war, but to highlight three prominent strategic adaptations: long-range strike; air, drone and missile defence; and mobilization of industry.

Long-Range Strike Operations. Since the beginning of the full-scale invasion in 2022, Russia's armed forces have conducted long-range strike operations against targets in Ukraine and in the Black Sea region. Beginning with long-range strikes to disable Ukrainian air defence radars, communications facilities, munitions storage and other critical infrastructure, Russia has evolved both the priorities for its targeting and the kinds of strategic strike weapons it uses. In late 2022, Russia shifted the focus for its long-range strikes to Ukrainian power generation and distribution. In 2024, it appeared to shift the priority again to civilian infrastructure and cities.

Long-range strike has also been a key adaptation for the Ukrainians since the beginning of the Russian invasion. Initially founded on ground-based rocket launchers and old Soviet target drones, Ukraine has over the course of the war expanded its long-range strike arsenal to include armed drones, truck launched anti-ship missiles (the Neptune)[102], cruise missiles from Europe, and an increasingly sophisticated array of uncrewed naval strike vessels.

Like Russia, Ukraine's strike operations nest within a national military approach to war fighting. These strike operations employ forces in the physical domains, including missiles, drones, special forces and

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99 Williamson Murray, *Military Adaptation in War: With Fear of Change*, Cambridge University Press, 2011, 318.

100 Allan Millett & Williamson Murray, *Military Effectiveness, vol. 1: The First World War*, Cambridge University Press, 2010, 7.

101 Mick Ryan, *The War for Ukraine: Strategy and Adaptation Under Fire* (U.S. Naval Institute Press, 2024), 172.

102 The Neptune is a Ukrainian-developed anti-ship missile which is likely to have been responsible for the sinking of the Moskva in 2022. Jon Guttman, "The Neptune anti-ship missile: The weapon that may have sunk the Russian flagship Moskva", *Military Times*, 13 May 2022. https://www.militarytimes.com/off-duty/gearscout/2022/05/12/the-neptune-anti-ship-missile-the-weapon-that-may-have-sunk-the-russian-flagship-moskva/

other assets. But they may also include cyber operations or cognitive warfare by themselves, or in concert with actions in the physical world to generate shock, surprise, influence and systemic damage. Unlike Russia, Ukraine has had to construct its long-range strike capability for this war from almost nothing at the war's beginning in 2022. This makes its strategic adaptation in this area more notable.

Ukraine's evolving strike complex, which includes reconnaissance, planning, strike, deception and assessment components, aims to achieve multiple outcomes for Ukraine's strategy for the war.

The first objective is to support Ukraine's operational and tactical activities. One 2024 example of this was the 2024 shoot down of Russian air force A-50 Mainstay command and control aircraft providing sensor coverage of Crimea and southern Ukraine.[103] Its downing increased the effectiveness of the Ukrainian strike system in that area. Other examples of such strikes include the targeting of Russian headquarters, air defence sites, Russian ammunition storage sites and Russian logistics nodes in occupied Ukraine. Ukrainian forces have also targeted Russian airfields, most spectacularly during the June 2025 attacks, known as *Operation Spiderweb*, which used locally launched drones to destroy bombers at several Russian bases.[104]

Another objective of Ukrainian long-range strikes is to enhance Ukraine's strategic freedom of maneuver. A good example of this are the attacks on the Black Sea Fleet. This has allowed Ukraine to reopen a maritime trade corridor that is essential to grain export operations. A third function is to engage in economic warfare by degrading Russia's industrial capacity. Targets have included oil refineries as well as defence industrial plants that manufacture fibre optics, other optical systems, missiles, aircraft and other war materiel.[105] Finally, these long-range strikes seek to have an impact on Russia morale and to bring home to the Russians the cost of their President's war against Ukraine.

Air launched systems play an important role in the Ukrainian strike capability. The provision of the UK-built Storm Shadow missile was announced by Britain in May 2023. The missile, and its French SCALP-E equivalent, extended the ability of the Ukrainian armed forces to strike Russian targets.[106]

Additionally, Ukraine has been developing indigenous drones and missiles for longer range strikes, and these are playing an increasing role in allowing Ukraine to hit targets out to 2000km inside Russia. In August 2024, Ukraine announced the *Palianytsia* rocket drone, a long-range rocket drone, with a

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[103] Phelan Chatterjee, "Ukraine says it has downed second Russian A-50 spy plane in weeks", BBC, 24 February 2024, https://www.bbc.com/news/world-europe-68387232

[104] Alisa Orlova and Kateryna Zakharchenko, "'Spiderweb' Strikes Cripple 34% of Russian Bomber Fleet in $7 Billion Blow, SBU Confirms", Kyiv Post, 1 June 2025, https://www.kyivpost.com/post/53749; Joseph Dempsey, "Operation Spiderweb: an assessment of Russian Aerospace Forces losses", IISS Blog, 6 June 2025. https://www.iiss.org/online-analysis/military-balance/2025/062/operation-spiderweb-an-assessment-of-russian-aerospace-forces-losses/

[105] Anna Hirtenstein and Florence Tan, "Insight: Russia braces for oil output cuts as sanctions and drones hit", *Reuters*, 13 February 2025, https://www.reuters.com/world/europe/russia-braces-oil-output-cuts-sanctions-drones-hit-2025-02-12/

[106] James Gregory, "UK confirms supply of Storm Shadow long-range missiles in Ukraine", *BBC News online*, 11 May 2023. https://www.bbc.com/news/world-europe-65558070; Dan Carney, "Technical Overview of the Storm Shadow Cruise Missile for Ukraine", Design News, 12 May 2023. https://www.designnews.com/industry/technical-overview-storm-shadow-cruise-missile-ukraine

range of around 500-700 kilometres.[107] In that December, Ukraine unveiled the *Ruta* long-range cruise missile with reputed to have a range of between 500 and 800 kilometres.[108] That same month, Ukraine revealed the *Peklo (*Hell*)* compact cruise missile*,* with a range of up to 700 kilometres.[109] Then in January 2025, the Ukrainian Unmanned Systems Force announced that it had developed a long-range drone which could carry a 250 kilogram warhead for more than 2000 kilometres.[110] This is an extraordinarily rapid adaptation cycle for precision munitions, especially compared to the contemporary procurement cycles in Western military institutions.

An important trend in these recent hybrid drone missiles being produced by Ukraine is that they travel at higher velocities than previous generations of Ukrainian weapons to better penetrate Russian air defences, and transit through high threat areas at faster speeds. It also adds to the kinetic energy of the missile when hitting its target. Finally, the precision of the missiles has been improved to ensure that the smaller warheads that these missiles carry are more effective.[111]

The Ukrainians have developed an array of long-range maritime strike systems as well. These notably include the *Neptune* missile, which was used in the sinking of the Russian warship *Moskva* in April 2022.[112] In 2025, an upgraded version of this missile was tested to extend its range and ability to penetrate air defence systems.[113] A final element of this Ukrainian strategic adaptation has been their development and employment of a family of uncrewed surface vessels. These have been used to

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[107] Daria Svitlyk, "Everything we know about Ukraine's new Palianytsia missile-drone", *Kyiv Independent*, 1 September 2024. https://kyivindependent.com/everything-we-know-about-ukraines-new-palianytsia-missile-drone/; "Ukraine starts mass production of Palianytsia missile-drone for long-range strikes against Russia", *Army Recognition*, 5 December 2024, https://armyrecognition.com/focus-analysis-conflicts/army/conflicts-in-the-world/russia-ukraine-war-2022/ukraine-starts-mass-production-of-palianytsia-missile-drone-for-long-range-strikes-against-russia

[108] Capabilities and Specs of Ukraine's Ruta Drone: It May Seem New, But It's Been Around", *Defence Express*, 12 December 2024, https://en.defence-ua.com/weapon_and_tech/capabilities_and_specs_of_ukraines_ruta_drone_it_may_seem_new_but_its_been_around-12837.html#:~:text=In%20short%2C%20the%20main%20advantage,helicopters%20trying%20to%20intercept%20it.

[109] Bohdan Miroshnychenko, ""Hell" for the Russians. How Ukraine was creating a super-drone and ended up with a cruise missile", *Ukrainska Pravda,* 17 December 2024, https://www.pravda.com.ua/eng/articles/2024/12/17/7489459/

[110] Kateryna Denisova, "Ukraine deploys long-range drone capable of 2,000 km strike, military says", *Kyiv Independent,* 31 January 2025, https://kyivindependent.com/ukraine-deploys-long-range-drone-capable-of-2-000-km-strike-military-says/

[111] Mick Ryan, "Ukraine Strikes Back – Hard", *Futura Doctrina*, 28 March 2025, https://mickryan.substack.com/p/ukraine-strikes-back-hard

[112] H.I. Sutton, Overview of Maritime Drones (USVs) of the Russo-Ukrainian War, 2022-2024, Covert Shores, 20 June 2025, http://www.hisutton.com/Russia-Ukraine-USVs-2024.html

[113] Inder Singh Bisht, Ukraine Combat-Tests Longer-Range Indigenous Neptune Missile", *The Defense Post*, 18 March 2025, https://thedefensepost.com/2025/03/18/ukraine-tests-neptune-missile/

damage or destroy at least 15 Russian naval vessels,[114] as well as helicopters[115] and fighter aircraft[116] in the Black Sea.

Strategic Air, Drone and Missile Defence. In the first days of the Russian 2022 full scale invasion, Ukraine's air defence system was comprised of legacy Soviet systems including the S-300 (SA-12 *Gladiator* for NATO) long range systems, *Tor-M* short range systems and a variety of point defence weapons including SA-8 *Gecko*, SA-13 *Gopher* and SA-19 *Grison* systems.[117] These were supplemented with ZSU-23-4 *Shilka* self-propelled anti-aircraft guns as well as towed 23mm and 57mm anti-aircraft guns.

To link together and prioritize the interception of threats, Ukraine possessed several air defence radar systems which included those that were integral to its S-300, 2K12 *Kub*, *Tor* and *Buk-M1* air defence capabilities. Ukraine had also joined the NATO Air Situation Data Exchange program in July 2006. This program, designed to improve awareness and aviation safety through air situation data, provided vital early warning and location data for the Ukrainians in the early hours of the war.[118]

Russian jamming equipment and aerial decoys in 2022 were effective at degrading the Ukrainian air defence system. Russian strikes using ballistic and cruise missiles destroyed many of the Ukrainian air defence radars. Concurrently, surface to air missile systems such as the SA-11 and S-300 were attacked and destroyed. Consequently, ground-based air defence in the first days and weeks of the war was relatively ineffective. Overall defence of the air domain was carried out by Ukrainian air force fighters such as their old Mig-29 fighters.[119]

Since 2022, the Ukrainian armed forces have built an increasingly effective and highly integrated air, missile and drone defence system. With a stated presidential intention of "closing the skies"[120], the Ukrainian air defence system is now capable of detecting and intercepting drones as well as the most sophisticated of Russian cruise and ballistic missiles. This has provided vital air cover for military forces in the field, high value targets such as headquarters and logistics nodes, as well as for civilian infrastructure and cities.[121]

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[114] "Ukraine's Magura V5 Naval Kamikaze Drone Makes History as First to Sink a Warship in Combat", *Army recognition,* 28 December 2024, https://armyrecognition.com/focus-analysis-conflicts/army/conflicts-in-the-world/russia-ukraine-war-2022/ukraines-magura-v5-naval-kamikaze-drone-makes-history-as-first-to-sink-a-warship-in-combat.

[115] Boldizar Gyori, "Ukraine downed 2 Russian helicopters in sea drone attack, HUR says", Kyiv Independent, 2 January 2025, https://kyivindependent.com/ukraine-downs-2-russian-helicopters-in-sea-drone-attack/

[116] Howard Altman, "Two Russian Su-30 Flankers Downed By AIM-9s Fired From Drone Boats: Ukrainian Intel Boss", *The War Zone*, 3 May 2025, https://www.twz.com/news-features/two-russian-su-30-flankers-downed-by-aim-9s-fired-from-drone-boats-ukrainian-intel-boss

[117] International Institute for Strategic Studies, *The Military Balance 2021*, (London: International Institute for Strategic Studies, 2021), 209.

[118] *Relations with Ukraine*, North Atlantic Treaty Organization, 25 May 2023. https://www.nato.int/cps/en/natohq/topics_37750.htm

[119] Justin Bronk, Nick Reynolds and Jack Watling, *The Russian Air War and Ukrainian Requirements for Air Defence*, Special Report, (London: Royal United Services Institute, November 2022), 7.

[120] This was listed as the highest strategic priority by President Zelensky during my meeting with him in Kyiv in September 2022.

[121] Michael Marrow, "In Ukraine fight, integrated air defense has made many aircraft 'worthless': U.S. Air Force general", *Breaking Defense*, 7 March 2023. https://breakingdefense.com/2023/03/in-ukraine-fight-integrated-air-defense-has-made-many-aircraft-worthless-us-air-force-general/

But it has taken trial, error and much adaptation to get to this point. Russia has continuously changed the tactics of its long-range strike operations and drastically increased the scale of its attacks against Ukraine by drones and missiles.

While the challenge of countering Russian ballistic and cruise missiles has been present since the start of the war, a threat that only materialized once the war commenced was Russia's use of Iranian Shahed drones, and more recently, their Russian-built variants. Not only has this complicated the detection and interception challenge faced by Ukraine, but the Russians have also accelerated the scale of their strikes. In 2024, Russia fired on average 360 Shahed drones per month at Kyiv. In 2025, Russia launched an average of between three thousand and five thousand drones towards Ukraine each month.[122] It can now literally saturate Ukrainian airspace with drones on chosen nights, forcing the Ukrainians to make hard choices about which targets to defend and how many of their precious interceptor missiles and drones to employ.[123]

While the scale of Russian attacks has increased, Russia's constantly evolving tactics and deception activities means that their drones and missiles are harder to intercept. Routes for the Russian drones are constantly changed, different mixes of drones are used, and antennas are changed to prevent spoofing. In 2025, the Russians began to use larger, thermobaric warheads on these drones, making those that hit their targets more destructive.[124] This has forced adaptation in Ukraine's air defence structure and posture, so the existing system is not overwhelmed by the number of armed and decoy drones launched by the Russians.

The Ukrainians have moved through an adaptation 'spiral' in their development of counter actions for Russian long-range strike and drone operations. This has involved the development of better detection systems to plug the gaps caused by Russian strikes on the Ukrainian air defence radar network in February 2022. Additionally, Ukraine has developed mobile team units to intercept Shahed drones, integrated detection systems, shared data across all air defence systems, developed a more robust learning and analysis capability to evolve tactics and technology, and developed regional coordination centres which pull together detection, interception, analysis, training and adaptation measures.[125]

Increasing levels of automation have become a critical part of this integrated air, missile and drone defence network. Automated systems ensure the right data is delivered to the right node in a hierarchy of C2 centres. But this automated system also records all data and actions, which can then be used in post-strike assessments and to support the learning and adaptation of the overall system. A dedicated group of analysts, with technical and military backgrounds, now supports the commander of Ukrainian air defence. This team travels to various air defence command and control

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[122] Quinn Urich and Maryana Shnitser, The Russia-Ukraine War Report Card, July 2, 2025", Russia Matters, 1 July 2025, https://www.russiamatters.org/news/russia-ukraine-war-report-card/russia-ukraine-war-report-card-july-2-2025

[123] Benjamin Jensen and Yasir Atalan, Drone Saturation: Russia's Shahed Campaign, Center for Strategic and International Studies, 13 May 2025. https://www.csis.org/analysis/drone-saturation-russias-shahed-campaign

[124] Jake Epstein, "Inside a worsening threat: Russia's one-way attack drones packed with thermobaric bombs", *Business Insider*, 17 July 2025, https://www.businessinsider.com/russian-drones-with-thermobaric-bombs-are-worsening-threat-ukrainians-say-2025-7

[125] Author interview with senior Ukrainian air defence commander in March 2025.

sites around Ukraine to learn, analyse and develop best-practice for the air, missile and drone defence system. These lessons are included in each update of the software that underpins the high levels of automation inherent in the air defence network. They are also linked to external research and development entities as well for a two-way flow of information.

Russia too has learned and adapted its strategic air defence system since the beginning of the war. While the imperative to do so occurred much later for Russia than Ukraine, Ukraine's increasingly effective strategic strike activities have forced Russia to update and continuously adapt the readiness, locations and integration of its national air defence system.[126]

Mobilization of Industry. Long wars are wars of industrial production. As the world wars of the twentieth century demonstrated, sustaining operations over months or years requires not only the mobilization of people, but the mobilization of the productive capacity of a nation. The war in Ukraine, now into its fourth year, is yet another case study in the industrial mobilization necessitated by prolonged conflict. Both Russia and Ukraine have had to undertake significant strategic adaptation to expand and accelerate their production to support the war effort.

Russia's original plan for the war did not foresee the need for industrial mobilization. However initial reverses in the northern campaign, challenges in its following Donbas campaign and a realisation in the Kremlin that Ukraine would engage in a prolonged struggle to retain its sovereignty, meant that by late 2022, mobilization was essential.[127] The 2022 partial mobilization by Putin, which covered both people and industrial capacity, was a defining moment in the war and an important strategic adaptation that has restructured Russian society and industry as a war nation.[128] Despite the multitude of different economic sanctions applied to Russia, it has been able to find ways to expand its defence industrial production and to import the complex machine tools and other items required to produce drones, missiles and other military materiel.

In an April 2025 report that compared the industrial mobilization processes and outcomes of Ukraine, Russia and Europe over the period 2022 to 2024, Jack Watling and Oleksandr Danylyuk described how, in regard to industrial mobilisation, "one of the clear differences between Russia, Europe and Ukraine is that Moscow had a mobilisation plan and stockpiles from which to draw. The mobilisation plans included legislative changes. Russia has made massive investments in the defence industries, going well beyond the funds allocated to defence within the state budget. Such investments represent the partial mobilisation of the economy to a war footing, which has allowed Russia to significantly expand and modernise its defence-industrial enterprise."

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[126] Jacob Mezey, Russian and Chinese strategic missile defense: Doctrine, capabilities, and development", Atlantic Council, 10 September 2024. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/russian-and-chinese-strategic-missile-defense-doctrine-capabilities-and-development/

[127] Oleksandr V Danylyuk and Jack Watling, *Winning the Industrial War Comparing Russia, Europe and Ukraine, 2022–24*, Royal United Services Institution, 3 April 2025, 8.

[128] Vladimir Putin speech of 21 September 2022, reported by Washington Post Staff, "Putin's national address on a partial military mobilization", *Washington Post*, 21 September 2022. https://www.washingtonpost.com/world/2022/09/21/putin-speech-russia-ukraine-war-mobilization/

Additionally, the report found that the Russian industrial mobilization has generally been successful, although "the government retained an extremely high level of ownership over defence enterprises, which allowed them to be highly responsive to government direction". Significant latent capacity in these enterprises further enhanced their responsiveness to government needs.[129] Among other areas, it has allowed Russia to ramp up production of new tanks (rather than reconditioning of older vehicles in storage) to between 250 and 300 per year,[130] double its production of gunpowder and explosives production over a two year period from 2022,[131] and increase artillery production significantly.[132]

Like Ukraine, Russia has expanded its capacity to build drones. One type of drone, the smaller First Person View (FPV) drones, have seen an increase in production by orders of magnitude since the start of the war. In 2025, the Russian objective is to build 2 million FPV drones for use in Ukraine.[133] The other type of drone that Russia has stepped up manufacturing capacity for is the indigenous version of the Iranian-design Shahed drone, called the Geran-2. Russia has constantly upgraded these drones since first importing them in 2023, and now regularly uses western and Chinese technology and components to improve their penetration of Ukrainian defences and increase their precision through AI and high-definition cameras.[134] In 2025, Russia plans to build up to 5000 of these drones per month at production facilities established over the past two years.[135]

Ukraine's strategic adaptations have transformed its pre-2022 arms manufacturing industry. Over the first 24 months of the war, manufacturers of munitions and other military materiel suffered losses due to Russian targeted strikes and their proximity to some of the active fighting areas. Consequently, defence-related businesses had to relocate their facilities.[136] Demand from the expanded Ukrainian Armed Forces, and the massive consumption of materiel inherent in conventional warfare, has seen a significant surge in the productive capacity of the Ukrainian arms manufacturing sector. It has

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[129] Jack Watling and Oleksandr Danylyuk, *Winning the Industrial War Comparing Russia, Europe and Ukraine, 2022–24*, Royal United Services Institution, 3 April 2025, 52-54.

[130] Conflict Intelligence Team, "How Many T-90M Tanks does Russia Produce?" *Teletype*, 20 Juen 2025, https://notes.citeam.org/eng_t90

[131] Pavel Luzin, "Assessment of Gunpowder and Explosives Manufacturing in Russia", *Eurasia Daily Monitor*, The Jamestown Foundation, 1 June 2025, https://jamestown.org/program/assessment-of-gunpowder-and-explosives-manufacturing-in-russia/

[132] Dariia Mykhailenko, "The Economist Unveils Extensive Expansion of Russia's Defense Industry", United24, 2 July 2025, https://united24media.com/latest-news/the-economist-unveils-extensive-expansion-of-russias-defense-industry-8311

[133] Tim Zadorozhnyy, "Russia plans to produce 2 million FPV drones in 2025, Ukrainian intelligence says", *Kyiv Independent,* 7 July 2025, https://kyivindependent.com/russia-aims-to-produce-2-million-fpv-drones-in-2025-ukrainian-intelligence-says/

[134] Vlad Litnarovych, Russia Deploys Upgraded Shahed Drones With Nvidia AI and Western Tech, Ukrainian Intelligence Confirms", United24, 24 June 2025, https://united24media.com/latest-news/russia-deploys-upgraded-shahed-drones-with-nvidia-ai-and-western-tech-ukraina-intelligence-confirms-9363; RFE/RL's Ukrainian Service, "Russia Enhances Shahed Drones With Advanced Technology To Attack Ukraine", *Radio Free Europe/Radio Liberty*, 3 July 2025, https://www.rferl.org/a/ukraine-shahed-drones-iran-russia/33462133.html

[135] Dariia Mykhailenko, "From 2,000 to 5,000: Russia Plans to Escalate Shahed Drone Production Against Ukraine", *United24,* 5 June 2024, https://united24media.com/latest-news/from-2000-to-5000-russia-plans-to-escalate-shahed-drone-production-against-ukraine-8912; Matthew Bint and Fabian Hinz, "Russia doubles down on the Shahed", *Military Balance Blog*, Institute for International and Strategic Studies, 14 April 2025, https://www.iiss.org/online-analysis/military-balance/2025/04/russia-doubles-down-on-the-shahed/

[136] Kateryna Kuzmuk and Lorenzo Scarazzato, "The transformation of Ukraine's arms industry amid war with Russia", Stockholm International Peace Research Institute, 21 February 2025, https://www.sipri.org/commentary/topical-backgrounder/2025/transformation-ukraines-arms-industry-amid-war-russia

grown in both volume of material produced and in the array of different items, including all forms of drones, self-propelled artillery, and a range of munitions, since February 2022.

This expansion, driven by the existential threat of Russia, has been underpinned by four elements. The first part of this expansion has been facilitated by partnerships with foreign arms manufacturers. This includes partnerships with European companies that build and repair armoured vehicles and artillery, and at least two U.S. companies that build drones.[137] By the end of 2024, over 40 foreign companies were involved in physically producing weapons in Ukraine.[138]

A second element of this expansion has been investment in the domestic arms industry by the government of Ukraine, as well as preferential low-interest loan programs from the government to stimulate investment.[139] By 2024, over 500 arms manufacturers were in Ukraine, employing over 300,000 people[140], and Ukraine had tripled its output over the preceding year.[141]

The third element has been investment in Ukrainian industry by foreign aid providers. While these programs are yet to achieve their 10-billion-dollar objective, Ukraine has engaged foreign partners and raised over $1.5 billion for investment in its domestic arms industry from nine Western donor countries.[142] In addition to this, the U.S. in 2024 announced a two billion dollar program to establish a Ukraine Defense Enterprise Program and strengthen Ukraine's defence industrial base.[143]

In 2025, Ukraine aimed to produce 2.5 million drones per year. And while production tripled between 2023 and 2024, defence industrial capacity actually saw a seven-fold increase and contributed a third of Ukraine's GDP growth in the 2023-2024 period.[144]

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[137] Sinead Baker, "More US and European defense companies are setting up operations in Ukraine as the war rages on", *Business Insider*, 3 October 2024, https://www.businessinsider.com/western-defense-companies-set-up-operations-in-ukraine-war-continues-2024-10; Tim Zadorozhnyy, "Ukraine signs major drone co-production deal with US Swift Beat, Zelensky announces", *Kyiv Independent*, 7 July 2025, https://kyivindependent.com/ukraine-us-company-to-co-produce-hundreds-of-thousands-of-drones-in-2025-zelensky-announces-06-2025/

[138] "More than 40 foreign defense companies operate in Ukraine", *Militarnyi*, 19 November 2024, https://militarnyi.com/en/news/more-than-40-foreign-defense-companies-operate-in-ukraine/

[139] Taras Kuzio, "Ukraine Aspires to Become Arsenal to the West", The Eurasia Daily Monitor, Jamestown Foundation, 8 November 2024, https://jamestown.org/program/ukraine-aspires-to-become-arsenal-to-the-west/

[140] Kateryna Kuzmuk and Lorenzo Scarazzato, "The transformation of Ukraine's arms industry amid war with Russia", Stockholm International Peace Research Institute, 21 February 2025, https://www.sipri.org/commentary/topical-backgrounder/2025/transformation-ukraines-arms-industry-amid-war-russia

[141] "Ukraine's defence industry hits USD 9 billion milestone in 2024 with missile breakthroughs", Defence Industry Europe, 11 April 2025, https://defence-industry.eu/ukraines-defence-industry-hits-usd-9-billion-milestone-in-2024-with-missile-breakthroughs/

[142] Kateryna Kuzmuk and Lorenzo Scarazzato, "The transformation of Ukraine's arms industry amid war with Russia", *Stockholm International Peace Research Institute,* 21 February 2025, https://www.sipri.org/commentary/topical-backgrounder/2025/transformation-ukraines-arms-industry-amid-war-russia

[143] Bryant Harris, "US announces $2 billion to help Ukraine make its own weapons", *Defense News*, 17 May 2024, https://www.defensenews.com/global/europe/2024/05/16/us-announces-2-billion-to-help-ukraine-make-its-own-weapons/

[144] The Ukraine's Defense Industry Provided a Third of Own GDP Growth in 2024", *Freedom*, 15 April 2025, https://uatv.ua/en/the-ukraine-s-defense-industry-provided-a-third-of-own-gdp-growth-in-2024/

The rapid strategic adaptation by Russia and Ukraine to build or evolve modern arms manufacturing industries has been a significant part of the war since 2022. Like all large conventional wars, both sides are involved in a continuous and constantly evolving production battle. Given the attrition in equipment and materiel sustained by Ukraine and Russia, this strategic adaptation has been one of the most important of the war.

Broader Areas of Strategic Adaptation. Like the tactical adaptations explored earlier, there are a myriad of other strategic adaptations during the war in Ukraine that are worthy of study. These include:

- The transition to a NATO style military. This began in 1997, accelerated after 2014, and was supercharged from February 2022. It is, however, an incomplete endeavor.[145]
- Societal mobilization – this includes crowd funding and institutions such as Brave1 and Come Back Alive but also includes an array of other measures that has transitioned society into a wartime mindset.[146]
- Increased use of AI in strategic agencies.[147]
- Increased use of economic warfare since late 2023, particularly in attacks on Russian oil infrastructure.
- Strategic deception.[148]

Key Russian strategic adaptations have included the following:

- Mobilizing people more effectively than Ukraine since 2022.[149]
- The ongoing adaptation of Russia's national integrated air, missile and drone defence.

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[145] This is examined in detail in Mick Ryan, *The War for Ukraine: Strategy and Adaptation Under Fire* (Naval Institute Press, 2024).

[146] Large fundraising organisations have also become research organizations. For example, *Come Back Alive* undertakes fundraising as well as research for evolved military capabilities such as countering Russian reconnaissance drones. The *Brave1* cluster is a collaboration between different Ukrainian government departments to fund research into a range of capabilities related to military and national security requirements. Come Back Alive initiated the *DroneFall* project, which has delivered dozens of drone interceptor systems. These are delivered as a system and include the interceptors, vehicles, logistics, training and ongoing support for the detection and downing of Russian drones, particularly the higher-flying surveillance drones.

[147] Mobilization legislation in 2024 is delivering soldiers into the Army but remains problematic. However, as brigade commanders noted to me, mobilization has brought into the military many people and skills that they might overwise not have access to. This has been important for IT skills but also links back into industry to speed up adaptation. It was also described to me that mobilized soldiers often had a different and more flexible mindset for problem solving.

[148] The Ukrainians have improved at strategic level deception: their Kursk operation in 2024 was an example. Ukraine clearly had an intricate and cleverly devised deception plan which was developed and implemented in the months leading up to the moment when Ukrainian soldiers crossed the border and began their break into the Russian defensive lines in Kursk. They deceived the Russians and their supporters about the very potential for any large-scale offensive operations in 2024. Perhaps more importantly, the Ukrainians were able to deceive their Western supporters about the potential for an offensive in 2024, which prevented leaks of the kind that had an impact on the 2023 counteroffensive. Ultimately, the Ukrainians proved (again) that deception is an integral part of planning, not just at the tactical level, but at the strategic level as well.

[149] Dara Massicot, Russian Military Reconstitution: 2030 Pathways and Prospects, Carnegie Endowment, September 2024, https://carnegie-production-assets.s3.amazonaws.com/static/files/Massicot-Reconstitution-final_10-1.pdf; Vira Kravchuk and Yana Olynets, "Ukraine intelligence: Russia can theoretically mobilize 25 million people. Only 3 million would be combat ready", *Euromaidan*, 26 May 2025, https://euromaidanpress.com/2025/05/26/ukraine-intelligence-russia-can-theoretically-mobilize-25-million-people-only-3-million-would-be-combat-ready/

- Evolution in its command-and-control structures for operations in Ukraine, as well as potential subsequent operations in eastern Europe.
- Development of a war economy, sanctions busting measures, and economic warfare.
- Force generation.[150]

Interlude: Has Tactical and Strategic Adaptation Improved the Military Effectiveness of Ukraine and Russia?

Allan Millett and Williamson Murray defined military effectiveness as "the process by which armed forces convert resources into fighting power."[151] Brooks and Stanley define military effectiveness as "the capacity to create military power from a state's basic resources in wealth, technology, population, and human capital."[152]

Military effectiveness is a concept that is central to the design, functioning and adaptation of military institutions. How military organisations perceive their effectiveness (and that of their adversaries, influences the kind and quantity of forces they deploy in wartime as well as the functioning of the many different military support organisations such as schools, intelligence, logistics and headquarters. Professional military institutions invest in researching, analysing and investing in the constant adaptation and improvement of their military effectiveness.

The military effectiveness of 21st century organisations is determined by how successfully they are able to convert resources, like people, material and ideas, into the ability to fight and win within an integrated joint and national construct. In *The War for Ukraine*, I described how adaptation and innovation is not the same as enhancing the military effectiveness of an institution.[153] Not all new ideas are good ideas, and even good ideas can be difficult to disseminate, implement and translate into more successful battlefield performance. Adaptation should contribute to the maintenance and improvement of military effectiveness. Has this been the case for the war in Ukraine?

The war in Ukraine is ongoing, and therefore a definitive assessment of the impact of tactical adaptation on military effectiveness. However, an interim assessment might be constructed based on the performance of Russian and Ukrainian forces since February 2022.

Russia has converted its significant advantages in population (nearly four times that of Ukraine) and industrial capacity into a much larger military institution (as of 2025) than that which existed in 2022. Thus, it has demonstrated military effectiveness at the strategic level in achieving this. This

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[150] Regular updates on Russian force generation are provided by the Institute for the Study of War in Washington DC. An example of these updates can be found at: Kateryna Stepanenko, Nate Trotter, Christina Harward, Tetiana Trach, Jennie Olmsted, Olivia Gibson, and George Barros, Russian Force Generation and Technological Adaptations Update, 27 June 2025, https://www.understandingwar.org/backgrounder/russian-force-generation-and-technological-adaptations-update-june-27-2025. See also Dara Massicot, Russian Military Reconstitution: 2030 Pathways and Prospects, Carnegie Endowment, September 2024, https://carnegie-production-assets.s3.amazonaws.com/static/files/Massicot-Reconstitution-final_10-1.pdf

[151] Allan Millett & Williamson Murray, *Military Effectiveness, vol. 1: The First World War* (Cambridge: Cambridge University Press, 2010), 2.

[152] Risa Brooks and Elizabeth Stanley, *Creating Military Power*, (Stanford: Stanford University Press, 2007), 9.

[153] Mick Ryan, *The War for Ukraine: Strategy and Adaptation Under Fire* (Naval Institute Press, 2024), 201-203..

conversion of resources into fighting forces has required multiple tactical adaptations as well as strategic adaptations by the Russians, which have been explored in the previous pages. The application of these forces has seen the Russians suffer casualties at a rate that is 2-4 times that of the Ukrainians (depending on which casualty data sets are used)[154], and the loss of tens of thousands of tanks, armoured vehicles, wheeled vehicles, artillery, aircraft, helicopters, radars, and various classes of military drones.

Russia has not been able to turn strategic effectiveness in mobilizing manpower and industry into tactical effectiveness. It has not translated its overwhelming advantages in manpower and equipment, and the accelerating adaptation of how they are used, into significant gains in territory. In February 2022, when Russia commenced its full-scale invasion of Ukraine, it occupied about 7% of Ukrainian territory in the Donbas and Crimea. In the time since, Russia has only managed to seize and occupy another 12% of Ukrainian territory.[155] The only assessment that might be made against such achievements is that Russian adaptation has had some impact on the military effectiveness, but is yet to provide the wherewithal for any kind of significant breakthrough on the ground or collapse of Ukrainian ground or air defence forces.

However, despite the slow progress of the Russian ground forces, the Russian president has been able to exploit the gains they have made for propaganda purposes for his domestic audience. This has also influenced his partners abroad as well as western politicians and citizens.

In the case of Ukraine, its small size and smaller pool of manpower and industrial resources has meant that it has had to 'outthink' the Russians from day one, rather than out-spend them in a war of attrition. Its early innovations in drone warfare resulted in significant tactical and doctrinal adaptation (which remains ongoing) and this adaptation alone has significantly increased the military effectiveness of the Ukrainian Armed Forces. This is perhaps even more significant in the maritime domain where Ukrainian adaptation with its uncrewed naval vessels has seen the Ukrainians seizing control of the western regions of the Black Sea.[156] As Peter Dickinson has written:

> *Ukraine's stunning success in the Battle of the Black Sea has yet to receive the international attention it deserves. By breaking the Russian naval blockade of Ukraine's seaports, it has allowed Kyiv to resume maritime exports and secure a vital economic lifeline.*[157]

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[154] Quinn Urich and Maryana Shnitser, The Russia-Ukraine War Report Card, July 2, 2025", Russia Matters, 1 July 2025, https://www.russiamatters.org/news/russia-ukraine-war-report-card/russia-ukraine-war-report-card-july-2-2025

[155] Quinn Urich and Maryana Shnitser, The Russia-Ukraine War Report Card, July 2, 2025", Russia Matters, 1 July 2025, https://www.russiamatters.org/news/russia-ukraine-war-report-card/russia-ukraine-war-report-card-july-2-2025

[156] Heather Mongilio, "A Brief Summary of the Battle of the Black Sea", USNI News, 15 November 2023, https://news.usni.org/2023/11/15/a-brief-summary-of-the-battle-of-the-black-sea; Patrick Kornegay and Hayden Toftner, Lessons from Ukraine in the Black Sea, *Wilson Center*, 2 October 2024, https://www.wilsoncenter.org/article/lessons-ukraine-black-sea

[157] Peter Dickinson, "Ukraine is shaping the future of drone warfare at sea as well as on land", *Atlantic Council*, 12 June 2025, https://www.atlanticcouncil.org/blogs/ukrainealert/ukraine-is-shaping-the-future-of-drone-warfare-at-sea-as-well-as-on-land/

Ukrainian adaptation at the tactical and strategic levels has enhanced the military effectiveness of their armed forces to a greater degree than it has the Russian armed forces. In war, which is a competitive endeavour where relative advantage matters, this can make all the difference between winning and losing.

Component 3: International Learning and Adaptation

Ukraine and Russia, while engaged in a bitter adaptation battle with each other, have at the same time improved their capacity to share their lessons with their partners. For Ukraine, both formal and informal mechanisms for sharing insights from the war have emerged. Ukraine has shared a range of lessons with its supporters and partners. Some of this has been deliberate and systemic. Other times, the sharing of lessons has been vicarious.

These lessons have begun to penetrate NATO forces and been shared widely. However, the pace of demonstrated learning and change among most Western nations has not been as rapid as needed to address the challenge of the current authoritarian confrontation.

The result of this close study of the war by outside observers has been the development of an international learning community for the West and for authoritarians. While nations in Europe, North America and Asia have all engaged or visited Ukraine as part of this process, authoritarian nations have also observed and learned from the performance of Ukraine's armed forces since 2022. As I wrote in *The War for Ukraine*:

> *Nations beyond Europe and North America are also watching the war and drawing their own conclusions. The People's Liberation Army in China is watching and probably learning strategic and tactical lessons from the war in Ukraine …One important subject for review by the leadership of the People's Liberation Army will be their current warfighting doctrines to ensure these are updated and appropriate to the circumstances they are likely to face against the United States and its allies in any Indo-Pacific conflict.*[158]

A learning and adaptation bloc has now emerged among the authoritarian powers of Russia, Iran, China and North Korea. This learning and adaptation bloc is the core of a wider and systemic learning and collaboration culture among authoritarians and by extension, their proxies. This learning community assembles various sets of knowledge to build a much-improved knowledge base. It is currently taking tactical lessons from the war in Ukraine, and the Middle East, as well as strategic and political insights to assist in each member achieving their respective regional political and military objectives. As the 2025 U.S. Intelligence Community Threat Assessment notes:

[158] Mick Ryan, *The War for Ukraine: Strategy and Adaptation Under Fire* (Naval Institute Press, 2024), 117-118.

Cooperation among China, Russia, Iran, and North Korea has been growing more rapidly in recent years, reinforcing threats from each of them individually while also posing new challenges to U.S. strength and power globally.[159]

Key areas of learning in this learning and adaptation bloc, to be explored in the following pages are as follows:

- Tactical learning – Russia and North Korea.
- Tactical and strategic learning – Russia and Iran.
- Strategic Learning – Russia and North Korea.
- Strategic Learning – Russia and China.

Tactical learning – Russia to North Korea. While the recent Iran-Israel war has provided a demonstration of the limitations in cooperation between authoritarian states,[160] the North Korean deployment of combat forces to Russia challenged previous assumptions about such limitations.[161] The North Korean contingent, destined to serve alongside Russian soldiers in their continuing war against Ukraine, arrived in Russia in October of 2024 to begin the process of familiarising themselves with Russian equipment and tactics. Trained at Russian bases in Ussuriysk, Ulan-Ude and elsewhere, the North Koreans found themselves in combat against the Ukrainian force lodged in Russia's Kursk region by the end of the year.[162]

An April 2025 statement by the North Korean state news outlet, KNCA, described the deployment of North Korean troops as fulfilling a pledge of mutual defence and assistance agreed during a June 2024 summit in Pyongyang between the Russian and North Korean leaders.[163] The treaty was signed into Russian law by President Putin in November 2024.[164]

Initial North Korean combat operations in Kursk showed their inexperience with modern combat conductions. Key areas of weakness included their inability to deal with the threat of drones and their limited capacity for the conduct of combined arms operations. Their early assaults against Ukrainian positions were more reminiscent of 2022 Russian operations, or even 1952 Korean War attacks, rather than the situation that prevailed by the end of 2024. The North Koreans assembled and

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[159] Director of National Intelligence, *Annual Threat Assessment of the U.S. Intelligence Community,* March 2025, Washington DC, 29.

[160] Paul Sonne, "Despite Close Ties With Iran, Russia Stands Aside as Israel Attacks", *New York Times*, 17 June 2025, https://www.nytimes.com/2025/06/17/world/middleeast/iran-russia-relationship-analysis.html

[161] Jake Rinaldi, "North Korea in Ukraine: Analyzing Authoritarian Cooperation", Strategic Studies Institute, US Army War College, 18 March 2025, https://ssi.armywarcollege.edu/SSI-Media/Recent-Publications/Article/4122913/north-korea-in-ukraine-analyzing-authoritarian-cooperation/

[162] North Korea did not confirm this deployment of combat troops until April 2025. Joel Guinto and Jean Mackenzie, "N Korea confirms it sent troops to fight for Russia in Ukraine war", BBC News, 28 April 2025, https://www.bbc.com/news/articles/ckg25wxvpy2o; Republic of Korea National Intelligence Service, "North Korean Special Forces Participation in the Russia-Ukraine War Confirmed", press release, October 18, 2024.

[163] Anthony Kuhn, "Concerns mount as Russia and North Korea commit to a mutual defense pact", *NPR*, 20 June 2024, https://www.npr.org/2024/06/20/nx-s1-5011604/leaders-of-russia-and-north-korea-sign-pact-indicating-a-deeper-cooperation;

[164] Reuters, *Putin signs into law mutual defence treaty with North Korea*, 10 November 2024, https://www.reuters.com/world/europe/putin-signs-mutual-defence-treaty-with-north-korea-2024-11-09/

attacked in large formations, and generally did not coordinate their assaults with artillery, drones or armoured vehicles. They were highly vulnerable to the tactics and technologies developed since 2022, and the Ukrainians made short work of these early North Korean attacks.[165]

But the North Koreans learned, and they adapted. By February 2025, the North Koreans had changed their formations, tactics and coordination of fire support from drones and artillery. They learned rapidly to identify, avoid and destroy Ukrainian drones. Additionally, the North Koreans coordinated their operations more closely with Russian forces. Used as shock troops by Russia, the North Koreans would assault a Ukrainian position, and if successful, they would then clear the position before it was then occupied by second echelon Russian troops. The North Koreans would then move on to their next assault objective. [166]

The combat experience gained by North Korean troops in Russia and Ukraine is likely to result in an uplift in the military effectiveness of North Korean troops on the Korean peninsula.[167] As a recent assessment by the U.S. Army's Strategic Studies Institute describes:

> *Operationally, North Korean forces also stand to gain valuable combat experience from their deployment in Ukraine. Participating in a modern, high-intensity conflict allows North Korean troops to observe and adapt to emerging technologies, particularly the use of drones and precision fires by both Ukrainian and Russian forces. Notably, the deployment of special operations forces, designed to be more resilient and adaptable in extreme conditions, may be an intentional effort to ensure sufficient personnel endure the conflict to relay critical insights.*[168]

Notwithstanding the losses they have suffered so far, estimated at around 4000 dead and wounded, North Korea clearly believes it is gaining significant political, strategic and military value from the deployment of its troops to Russia and Ukraine. In July 2025, it emerged that North Korea may deploy an additional 25,000 to 30,000 troops for service in Russia and Ukraine. This is a far more substantial number than the original deployment and may provide a decisive force in the northeast and east of Ukraine, depending on where it is employed.[169] This will build on the tactical learning and adaptation already demonstrated by the North Koreans in their historic first deployment to eastern Europe, and comprises an important component of the adversary learning and adaptation bloc.

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[165] Jane Lytvynenko, Dasl Yoon and Alistair MacDonald, "The Battlefield Lessons North Korea Has Learned Fighting Ukraine", *The Wall Street Journal*, 8 April 2025, https://archive.is/Ei5K2#selection-2029.0-2029.64; "Russian Paratroopers and Special Forces Train DPRK Military at Five Training Grounds in Russia," *SPRAVDI*, 31 October 2024, https://spravdi.gov.ua/en/russian-paratroopers-and-special-forces-train-dprk-military-at-five-training-grounds-in-russia/

[166] Jane Lytvynenko, Dasl Yoon and Alistair MacDonald, "The Battlefield Lessons North Korea Has Learned Fighting Ukraine", The *Wall Street Journal*, 8 April 2025, https://archive.is/Ei5K2#selection-2029.0-2029.64

[167] Director of National Intelligence, *Annual Threat Assessment of the U.S. Intelligence Community,* March 2025, Washington DC, 28.

[168] Jake Rinaldi, "North Korea in Ukraine: Analyzing Authoritarian Cooperation", Strategic Studies Institute, US Army War College, 18 March 2025, https://ssi.armywarcollege.edu/SSI-Media/Recent-Publications/Article/4122913/north-korea-in-ukraine-analyzing-authoritarian-cooperation/

[169] Nick Paton Walsh, and six others, "North Korea to send as many as 30,000 troops to bolster Russia's forces, Ukrainian officials say", *CNN*, 2 July 2025, https://edition.cnn.com/2025/07/02/europe/north-korea-troops-russia-ukraine-intl-cmd

Russia and Iran: Comprehensive Collaboration, Learning and Adaptation. In January 2025, the Russian and Iranian presidents signed the *Iranian Russian Treaty on Comprehensive Strategic Partnership*. The comprehensive agreement, containing 47 articles, covered areas as diverse as transport, international payments, oil and gas development, nuclear energy, agriculture, customs, education, mass media, natural disaster response, and ironically, arms control. However, the subject of arms control and military technological collaboration was not included. This had already been an area of long-standing cooperation.

A key area of this learning and adaptation relationship has been long-range strike capability. Both Russia and Iran have entered what might be colloquially described as 'the precision club' with regards to military operations. The possession of a variety of different long-range, precision strike missiles and drones has evolved their views, and doctrine, on war and military operations. And perhaps no other subject has been as discernible in the tactical learning interaction of Russia and Iran as the conduct of long-range strike.

While many of the missiles and drones exchanged in this relationship have been from Iran to Russia since 2022, a large proportion of the key enablers for long range strike have been areas of cooperation. Russia has provided electronic warfare capabilities and doctrine to Iran, including the capacity to jam and spoof different space-based Precision Navigation and Timing systems. Russia has also supported Iran's space and satellite programs. These are crucial to the long-range surveillance and mission planning required for long range strike operations.[170]

The Iranian strikes against Israel in 2024 demonstrated all the hallmarks of the kinds of complex, multi-system aerial attacks that Russia had been conducting against Ukraine in the preceding year. The April 2024 attack by Iran against Israel saw the employment of 170 drones, 120 ballistic missiles and 30 cruise missiles. Drones were launched first, to draw responses from Israeli air defences, and these were followed by ballistic missiles and cruise missiles.[171]

But, as highlighted in a previous section of this paper, not all learning and adaptation results in improved military effectiveness. The Israeli air defence network, intelligence community, air force strikes and support from allies combined to largely negate this Iranian long-range strike adaptation during the 2024 Iranian strikes against Israel, as well as during the 2025 Iran-Israel conflict, even if some Iranian drones and missiles did penetrate Israel's defences.[172]

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[170] Karolina Hird and Kitaneh Fitzpatrick, *The Russia-Iran Coalition Deepens*, Institute for the Study of War, January 2025, 20-24. https://www.understandingwar.org/sites/default/files/The%20Russia-Iran%20Coalition%20Deepens%20013025.pdf

[171] Laura Kelly, "Iran's attack on Israel built on lessons from Russia's war in Ukraine" The Hill, 15 April 2024, https://thehill.com/policy/international/4595937-irans-attack-on-israel-built-on-lessons-from-russias-war-in-ukraine/; Maya Carlin, "What Iran Is Learning From Russia's 2,000 Missile Strikes In Ukraine", 1945, 21 May 2022, https://www.19fortyfive.com/2022/05/what-iran-is-learning-from-russias-2000-missile-strikes-in-ukraine/

[172] Zvi Smith and Benoit Faucon, "Through Trial and Error, Iran Found Gaps in Israel's Storied Air Defenses", *Wall Street Journal,* 15 July 2025, https://www.wsj.com/world/middle-east/iran-israel-air-defense-362826e3

The provision of Iranian drones to Russia has been a significant component of Russia's air campaign against Ukraine in the past 18 months. It provides a counterpoint to Iran's lack of success in duplicating Russia's aerial attack tactics against Israel. Russia's application of Iranian drones has been very successful. Three classes of Iranian drones were originally supplied to Russia: the 900km range Shahed-131; the 2500km range Shahed-136 and the 200km range Mohajer-6 drone which carries bombs as well as guiding Shahed drones to their targets.[173] Thousands of these have been provided by Iran, and they provide the design foundation for the Russian version, the Geran-2.[174] Russia is now able to launch hundreds of such drones in a single night in its aerial campaign to overwhelm Ukraine's air defences, destroy infrastructure and terrorise the Ukrainian population into forcing a political accommodation upon the Ukrainian government. North Korea has also provided an enormous quantity of munitions for the Russian war effort.

Beyond drones and munitions, the Russia-Iran learning and adaptation ecosystem has extended into defence industrial development, strategies for coercion, joint military exercises, economic cooperation (including sanctions evasion), energy, diplomatic and military cooperation. As a recent report from the Institute for the Study of War notes,

> *Iran and Russia are learning from each other's respective conflicts—Russia's war in Ukraine and Iran's escalation cycle with Israel and its peripheral involvement in the Israel-Hamas war. The battlefield in Ukraine has become a testing ground for Russia's partners [like] Iran.*[175]

The Russia-Iran relationship provides a useful model for how components of the adversary learning and adaptation blocs collaborate. It highlights not only the benefits of such partnerships but also their limitations, thus potentially unveiling vulnerabilities that might be targeted by America and its partners. The lessons that are emerging from the Iran-Russia learning community are shaping military innovation and operational art for both nations. A similar pattern is evident in the relationship between Russia and North Korea, where joint learning and adaptation are increasingly significant.

Strategic Learning – Russia and North Korea. Russia and North Korea have developed a strategic learning and adaptation system in the last few years, supercharged by the war in Ukraine. It was reinforced by the signing of the Comprehensive Strategic Partnership Treaty agreed by the two nations in June 2024.[176] While this strategic relationship has largely been founded on the provision of North Korean munitions to Russia and the experiences of North Korean troops in Kursk combat

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[173] Karolina Hird and Kitaneh Fitzpatrick, *The Russia-Iran Coalition Deepens*, Institute for the Study of War, January 2025, 17.

[174] Matthew Bint and Fabian Hinz, "Russia doubles down on the Shahed", *Military Balance Blog*, Institute for International and Strategic Studies, 14 April 2025, https://www.iiss.org/online-analysis/military-balance/2025/04/russia-doubles-down-on-the-shahed/

[175] Karolina Hird and Kitaneh Fitzpatrick, *The Russia-Iran Coalition Deepens*, Institute for the Study of War, January 2025, 11.

[176] Christopher Watterson, *The DPRK-Russia 'Comprehensive Strategic Partnership' and the future of sanctions against North Korea,* commentary, United States Studies Centre, 27 June 2024, https://www.ussc.edu.au/the-dprk-russia-comprehensive-strategic-partnership-and-the-future-of-sanctions-against-north-korea;

operations, there are additional dimensions. As one analyst has argued, this expansion of the Russia-North Korea relationship has four interlinked elements:

> *A desire for the North Korean regime to gain food, financial and, crucially, military assistance from Russia; Russia's isolation and need for munitions to win the Ukraine war; a longer-term objective for North Korea to gain a great power partner to undermine international security institutions; and North Korea's ongoing desire to strengthen its domestic nuclear weapons and missile development, to serve Kim Jong Un's ultimate goal of regime survival.*[177]

Multiple sources, including Reuters as well as the recent report from the Multilateral Sanctions Monitoring Team, have documented the large-scale transfer of munitions from North Korea to Russia. The Multilateral Sanctions Monitoring Team found that "transfers of arms and related materiel via sea, air, and rail including shipments of artillery, ballistic missiles, and combat vehicles from the DPRK to Russia for use in Russia's war against Ukraine" have taken place.[178] As the report notes:

> *According to an MSMT participating state, Russian-flagged cargo vessels delivered as many as 9 million rounds of mixed artillery and multiple rocket launcher ammunition from the DPRK to Russia in 2024. Using open-source information, the Open-Source Centre (OSC) has estimated that Russian vessels delivered 4.2 to 5.8 million rounds of 122mm and 152mm munitions between August 2023 and March 2025.*[179]

These transfers from North Korea to Russia can be viewed as the down payment by North Korea to receive insights from the war in Ukraine, as well as Russian technological transfers. North Korean weapons are therefore a large part of the foundation for the Russia-North Korea learning and adaptation relationship. Russia has transferred air defence systems to North Korea as partial compensation for the quantity of munitions provided to the Russian military by North Korea.[180]

North Korea has leveraged their Russia relationship to improve its defence industrial capacity. Under the supervision of its leader, Pyongyang has improved both the quality of military manufacturing and

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[177] Edward Howell, *North Korea and Russia's dangerous partnership*, Research Paper, Chatham House, December 2024, 1, https://www.chathamhouse.org/sites/default/files/2024-12/2024-12-04-north-korea-russia-dangerous-partnership-howell.pdf

[178] Multilateral Sanctions Monitoring Team, *Unlawful Military Cooperation including Arms Transfers between North Korea and Russia,* Report 1 of 2025, 29 May 2025, 2, https://msmt.info/Publications/detail/MSMT%20Report/4195

[179] Multilateral Sanctions Monitoring Team, *Unlawful Military Cooperation including Arms Transfers between North Korea and Russia,* Report 1 of 2025, 29 May 2025, 5, https://msmt.info/Publications/detail/MSMT%20Report/4195

[180] Tom Balmforth and Mariano Zafra, "Thousands of troops, millions of shells", Reuters, 15 April 2025, https://www.reuters.com/graphics/UKRAINE-CRISIS/NORTHKOREA-RUSSIA/lgvdxqjwbvo/

expanded its industrial output. To support this learning process, Russian military production facilities have hosted North Korean personnel, enabling direct knowledge transfer and practical exposure.[181]

Technical assistance from Russia has probably been crucial to North Korea's (attempted) launch of a reconnaissance satellite in 2024 as well as upgrades to North Korea's aircraft plants.[182] In addition, Russia has transferred the intellectual property necessary to build its version of the Shahed drone. Thousands of North Korean workers have been sent to Russian drone factories, where they are being trained to transfer this expertise back to newly established drone production lines in North Korea.[183]

There are multiple implications of the strategic learning and adaptation relationship between Russia, and the two-way flow of knowledge and materiel.

First, North Korean assistance is providing a measurable impact on the battlefield in Ukraine. North Korean munitions now account for a significant proportion of artillery ammunition used by Russian forces in eastern and northeastern Ukraine. According to a July 2025 report from Ukrainian military intelligence, North Korea may now be supplying up to 40% of the munitions used by Russia.[184] This provides a vital part of Russia's current way of war for overwhelming Ukrainian ground forces, while also potentially allowing the Russian defence industry to refocus resources on the manufacture of the drones and long-range missiles that are crucial to its ongoing aerial assault against Ukraine's cities and civil infrastructure.

Second, this reinvigorated Russia-North Korea relationship offers North Korea additional mechanisms to skirt UN sanctions. The Comprehensive Strategic Partnership commits both nations to cooperation in several areas that are currently regulated under UN sanctions, such as foreign investments, financial services, and cooperation in science and technology.[185]

Third, the strategic learning and adaptation by North Korea as a result of Russian technical assistance might have significant consequences for the correlation of military forces on the Korean Peninsula. The North Koreans for the first time in decades may be able to field a more effective air defence capability and improve many of their ground force weapons including artillery, anti-tank weapons,

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[181] Choong-Koo Lee, "Putting the Screws on the Partnership Between North Korea and Russia", *War on the Rocks*, 1 April 2025, https://warontherocks.com/2025/04/putting-the-screws-on-the-partnership-between-north-korea-and-russia/

[182] Josh Smith, Cynthia Kim and Satoshi Sugiyama, "North Korea says its latest satellite launch exploded in flight", Reuters, 28 May 2024, https://www.reuters.com/world/asia-pacific/north-korea-fires-suspected-rocket-after-warning-satellite-launch-2024-05-27/

[183] Howard Altman, "North Korea Sending Russia Thousands Of Workers To Build Shahed Drones: Report", *The War Zone*, 19 June 2025, https://www.twz.com/news-features/north-korea-sending-russia-thousand-of-workers-to-build-shahed-drones-report: Howard Altman, "Russia Giving North Korea Shahed-136 Attack Drone Production Capability: Budanov" The War Zone, 9 June 2025, https://www.twz.com/news-features/russia-giving-shahed-136-attack-drone-production-capabilities-to-north-korea-budanov

[184] Yevheniia Hubina, "North Korea supplies 40% of Russia's weapons – Ukraine's Defence Intelligence chief", Ukrainska Pravda, 11 July 2025, https://www.pravda.com.ua/eng/news/2025/07/11/7521312/

[185] See UN Security Council Committee resolution 1817 (2006), https://main.un.org/securitycouncil/en/sanctions/1718; Christopher Watterson, *The DPRK-Russia 'Comprehensive Strategic Partnership' and the future of sanctions against North Korea,* commentary, United States Studies Centre, 27 June 2024, https://www.ussc.edu.au/the-dprk-russia-comprehensive-strategic-partnership-and-the-future-of-sanctions-against-north-korea;

electronic warfare, surveillance and the integration of these into combined arms warfare.[186] The lessons from North Korean forces in Ukraine are likely to have already flowed back into the training of North Korean forces at home, presenting increased dangers to Korean and American forces in a conventional conflict.

Fourth, the Russia-North Korea interactions have increased the overall production of the arsenal of authoritarians. As a recent assessment by the Royal United Services Institute describes, "the available evidence suggests that both Russian and North Korean factories are working to churn out more rounds than ever, with new production lines established and their legacy factories operating at maximum capacity."[187] Not only will this have an impact on the war in Ukraine but also provide additional capacity for North Korea should it wish to engage in further military aggression on the Korean peninsula. North Korea may be able to saturate the skies on the Korean peninsula with drones, posing a threat a 'massed precision'[188] threat even greater than their large force of over 21,000 items of gun and rocket artillery.[189]

Finally, Russian assistance may contribute to the improvement of North Korea's nuclear weapons development, manufacture and deployment as well as the systems to deliver nuclear warheads.[190] This would further destabilise the security situation on the Korean Peninsula and in the western Pacific more broadly.

North Korean production has provided a significant contribution to Russia's ground war against Ukraine. Its troops have made a more marginal contribution but that could change given the potential for an additional deployment of up to 30,000 North Korean troops in 2025. But the most significant impacts of the Russia-North Korea strategic learning and adaptation relationship has been the modernisation of North Korea's military forces and its defence industrial base. This could have major impacts on the security situation in the western Pacific in the coming years.

Strategic Learning – Russia and China. The strongest link of the adversary learning and adaptation bloc is the China-Russia relationship. The Chinese and Russian leaders have met more frequently than any other leadership relationship within the bloc, and the breadth of their collaboration exceeds that of other relationships.[191] And while it is a relationship that has been described by one academic as

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[186] Ankit Panda, "The Russia-North Korea nexus is a rising global threat: Ankit Panda for Inside Policy", *Macdonald-Laurier Institute*, 25 June 2025, https://macdonaldlaurier.ca/the-russia-north-korea-nexus-is-a-rising-global-threat-ankit-panda-for-inside-policy/

[187] Sam Cranny Evans, *Brothers in Arms: Assessing North Korea's Contribution to Russia's War in Ukraine*, Royal United Service Institute, 6 May 2025, https://www.rusi.org/explore-our-research/publications/commentary/brothers-arms-assessing-north-koreas-contribution-russias-war-ukraine; Yoonjung Seo and Helen Regan," North Korean factories making arms for Russia are 'operating at full capacity,' South Korea says" CNN, 28 February 2024, https://edition.cnn.com/2024/02/28/asia/north-korea-munitions-factories-shipments-russia-ukraine-intl-hnk

[188] Michael Horowitz, Battles of Precision Mass", *Foreign Affairs*, 22 October 2024, https://www.foreignaffairs.com/world/battles-precise-mass-technology-war-horowitz?check_logged_in=1

[189] The International Institute for Strategic Studies, *The Military Balance*, 2025, 268

[190] Wojciech Pawlus, *Russia is Now Actively Funding North Korea's Nuclear Programme*, Royal United Services Institute, 24 June 2025, https://www.rusi.org/explore-our-research/publications/commentary/russia-now-actively-funding-north-koreas-nuclear-programme

[191] Karolina Hird, Daniel Shats, and Kiley Pittman, *The Strengthening China-Russia Nexus*, Institute for the Study of War, Washington DC, 2025, 24-25.

"indispensable but uneasy", it is one that is yielding many insights for China on modern conflict, and is fundamental to Russia's war effort.

China, and the People's Liberation Army (PLA), have long demonstrated both the willingness and ability for learning and adaptation based on their study of foreign wars. The 1991 Gulf War shocked the PLA into a multi-decade modernisation and transformation of its military.[192] This has resulted in reforms to strategic and operational command and control, including better joint integration. Chinese lessons from the 1991 Gulf War – as well as the wars spawned by 9/11 – have included a reformation in their operational doctrine and has resulted in concepts such as 'intelligentization' and 'systems destruction warfare.'[193] In 2023, Toshi Yoshihara examined China's study of the lessons of the Pacific War, writing that "Chinese interpretations of past great power wars can reveal much about the PLA's expectations about the character of warfare in the coming years."[194]

A recent report by the CEPA noted that "the Sino-Russian relationship is neither the "limitless friendship" touted by Vladimir Putin and Xi Jinping nor a fatally flawed marriage of convenience."[195] China appears to have been studying the lessons from the war in Ukraine. As a report from the RAND Corporation notes:

> *The Chinese Communist Party (CCP) and its military, the People's Liberation Army (PLA), have committed significant efforts to studying the Russia-Ukraine war and drawing lessons for Chinese policy. CCP leaders considering what the outbreak of war indicates about China's broader security environment have accordingly calibrated China's diplomatic strategy.*[196]

Two scholars from the China Studies Program at the Center for Naval Analyses go even further. They propose that:

> *The war is a true "research hot spot"; just about every university, think tank, and military research institution in the PRC has an effort underway to analyze some component of this conflict.*[197]

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[192] Michael Dahm, China's Desert Storm Education, Proceedings, Vol. 147, March 2021, https://www.usni.org/magazines/proceedings/2021/march/chinas-desert-storm-education

[193] Jeffrey Engstrom, *Systems Confrontation and System Destruction Warfare,* RAND Corporation, 1 February 2018, https://www.rand.org/pubs/research_reports/RR1708.html

[194] Toshi Yoshihara, *Chinese Lessons from the Pacific War: Implications for PLA Warfighting*, Center for Strategic and Budgetary Analysis, Washington DC, 2023, i.

[195] "Moscow-Beijing Nexus: Cooperation and Competition", *Center for European Policy Analysis,* https://cepa.org/programs/democratic-resilience/russia-china-cooperation-and-competition/

[196] 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, 2025, 1. https://www.rand.org/content/dam/rand/pubs/research_reports/RRA3100/RRA3141-4/RAND_RRA3141-4.pdf

[197] Maryanne Kivlehan-Wise and Tsun-Kai Tsai, "PRC Lessons Learned from Russia's Invasion of Ukraine: Implications for a Taiwan Conflict", in *The PLA in a Complex Security Environment*, The National Bureau of Asian Research, Washington DC, 2025, 111.

According to Kivlehan-Wise and Tsun-Kai, the key lessons the Chinese leadership and the People's Liberation Army (PLA) has learned from Russia and the broader war in Ukraine include the following:

- *The Centrality of Escalation Control*. In the current strategic environment, Chinese observing the war have taken a lesson that controlling escalation in a conflict between major powers is a very complex undertaking, and that failing to control escalation might have devastating consequences. Understanding this dynamic is more important now than it has been for decades because, as PLA authors have argued, "most major-power wars since the end of the Cold War can be categorized as asymmetric…These authors counter that the Ukraine conflict demonstrates that symmetric conflict between great powers is still possible."
- *The importance of external aid*. Assistance to Ukraine from European nations, America and other countries, in the form of military, diplomatic, economic and other forms of aid, has had a major impact on the trajectory of the war. It has been a component of most Ukrainian military successes since 2022.
- *Modern War* is *Multidomain War.* While PLA authors emphasise the importance of hybrid operations and the cognitive domain, they have also acknowledged that competence in all the warfighting domains in conventional warfare is crucial. This includes the need to shift to a much greater proportion of uncrewed systems across the land, air and maritime domains.[198] Over the past decade, the PLA has been undergoing a process of transformation that has reduced the traditional influence of the Army.

Three points about these lessons bear noting. First, PLA analysts reportedly believe that Russian strategists may have overestimated their capacity to deter military escalation using nonmilitary tools of hybrid warfare and that this has resulted in suboptimal outcomes on the battlefield. As a recent RAND study on China's lessons from the war in Ukraine notes, "given this failure, the PLA may be becoming doubtful that it can prevent U.S.-China competition from rupturing into conflict."[199] Second, while China may have learned this lesson from the war, Russia has drawn its own conclusions. In particular, Russia has learned that external aid – weapons from Iran and North Korea, and a step up of economic interaction with China – has proven vital to sustaining their war effort. And finally, the lessons from the war in Ukraine have reinforced the imperative for learning and adaptation but have also informed how this is conducted. The aim, in President Xi's words, is to "create a joint force that can fight and win". This has been rehearsed in Joint Swords and Strait Thunder exercises in 2024 and 2025.[200]

These lessons sit primarily in the political domain, although they do dip into the military strategic realm as well. But they are far from the only learning that China has been doing based on its observations of the war and its broad range of interactions with Russian state ministries and the

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[198] Maryanne Kivlehan-Wise and Tsun-Kai Tsai, "PRC Lessons Learned from Russia's Invasion of Ukraine: Implications for a Taiwan Conflict", in *The PLA in a Complex Security Environment*, The National Bureau of Asian Research, Washington DC, 2025, 114-122.

[199] 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, 2025, v.

[200] John Dotson, *The PLA's Joint Sword 2024B Exercise: Continuing Political Warfare and Creeping Territorial Encroachment*, Global Taiwan Institute, 30 October 2024, https://globaltaiwan.org/2024/10/the-joint-sword-2024b-exercise/

Russian military institution. Other important insights from the war that are driving adaptation in the Chinese system include those examined in the following paragraphs.

Protraction in Modern War. Chinese researchers believe that American technological advantages can be mitigated through protraction of conflict. This is an important point because it exploits the current assessment about the shortfalls in the U.S. defense industrial base.[201] As Wong and Zakheim had written of Chinese discussions on this topic, "the United States, the West, and their proxies have obvious technological advantages over the Russian military, but they gradually lost this advantage as the war developed… protraction through accepting high human costs could shift the key factors of victory from modernization level to defense industrial base capacity and national defense mobilization."[202]

US Power and Alliances. Chinese scholars have taken the view that the U.S. alliance architecture is sustained by necessity rather than through a sense of common values. They generally diminish the interests and decision-making capacity of all nations within these relationships and believe that this heavy reliance on alliances is a critical American vulnerability.[203]

How Western Leaders Make Decisions. Drew Holliday has written that "the Chinese Communist Party considers the political aspects of a crisis to be of central importance. Institutional structures and processes for responding to crises are designed to manage and shape their political ramifications."[204] Thus, China will be drawing on Russian sources, as well as its own observations about how western political leaders make decisions during wartime, hoping this will inform the calculus of western nations during any Taiwan crisis. The Chinese leader will have been closely observing how American Presidents as well as the NATO alliance makes policy decisions about the war in Ukraine, as well as the intricacies of how Russian policies and actions have influenced Western decision-making about Ukraine. At the same time, the Chinese leadership will be seeking insights from Russia about which capabilities (including nuclear signalling) have deterred the West from broadening, or speeding up, its support to Ukraine. And they will be assessing the war and taking insights on the importance of decapitating the government of Taiwan in a future conflict.[205] Finally, Chinese are not only watching how politicians make decisions, but how western media influences or responds to such decision making, as well as how citizens influence government decisions.[206]

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[201] Seth Jones and Alexander Palmer, *Rebuilding the Arsenal of Democracy*: *The U.S. and Chinese Defense Industrial Bases in an Era of Great Power Competition*, Center for Strategic and International Studies, Washington DC, 2025. https://www.csis.org/analysis/china-outpacing-us-defense-industrial-base

[202] 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, 2025, 34.

[203] 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, 2025, 20.

[204] Drew Holliday, PRC Crisis Response Behaviours at the End of Xi Jinping's Second Term, National Bureau of Asian Research, 26 September 2023, https://www.nbr.org/publication/prc-crisis-response-behaviors-at-the-end-of-xi-jinpings-second-term/

[205] Joel Wuthnow, *Rightsizing Chinese Military Lessons from Ukraine*, Strategic Forum no. 311, National Defense University, Washington DC, September 2022, 6.

[206] Mick Ryan, "China is Learning About Western Decision Making from the Ukraine War", *Futura Doctrina*, 17 September 2024, https://mickryan.substack.com/p/china-is-learning-about-western-decision

Strategic Influence Operations. Both China and Russia see the information domain, and the conduct of misinformation and strategic influence activities, as crucial elements of their competition with the United States. While Russia and China employ these operations to break down western alliances and relationships by presenting America as a nation that imposes its values on others, they have often used different technologies and methods to do so. But since the beginning of the full-scale Russian invasion of Ukraine in 2022, there is evidence that China and Russia are engaged in a closer collaboration and learning from each other. China's influence operation, *Spamouflage*,[207] has been adapted based on insights from Russia and applied against America as *MAGAflouge*. According to an investigation by the *Japan Times*, "Beijing and Moscow penned a ministerial level agreement on media collaboration [which describes how] Both sides are determined and obliged to work in the sphere of information sharing, promoting objective, comprehensive and accurate coverage of the world's most important events by the mass media of Russia and China."[208] China has also amplified Russian messaging about the war since 2022.[209]

Efforts to detect and counter the collaboration between China and Russia in their strategic misinformation activities has even spawned a new term: Narrative Intelligence (NARINT).[210] However even with the importance that China attributes to the conduct of information operations, or cognitive warfare, it has accepted that the war in Ukraine indicates there are limits to what these activities can achieve. As Kivlehan-Wise and Tsun-Kai note:

> *Early in the war, there was much discussion—both in PRC and global media—about the role information, and especially social media, would play in garnering international support, sowing confusion among adversaries, gaining tactical advantage, and collecting battlefield intelligence. Some portrayed information as a game-changer that would determine the course of the war. However, this discourse now reflects a recognition that, while information and intelligence remain critical wartime assets, in order to defeat an adversary, operations in the physical and nonphysical domains must be coordinated and combined.*[211]

Joint Operations. Russia and China have stepped up their combined operational activities since 2022. They have undertaken multiple joint bomber patrols in the Pacific and combined maritime exercises in the Pacific as well. These do not appear to be rehearsals for any contingency but are more focussed on messaging the United States and other nations about solidarity between China and Russia. Interestingly, China and Russia have never fought side-by-side in any war, and therefore the mutual

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[207] Shannon Bond, "China is pushing divisive political messages online using fake U.S. voters", NPR, 3 September 2024, https://www.npr.org/2024/09/03/nx-s1-5096151/china-tiktok-x-fake-voters-influence-campaign

[208] Maya Sobchuk, "China is taking a page from Russia's disinformation playbook", *Japan Times*, 25 December 2024, https://www.japantimes.co.jp/commentary/2024/12/25/world/russia-china-disinformation-online/

[209] Joseph Bodnar, Bret Schafer and Etienne Soula, A Year of Disinformation: Russia and China's Influence Campaigns During the War in Ukraine", German Marshall Fund, 24 February 2023, https://securingdemocracy.gmfus.org/a-year-of-disinformation-russia-and-chinas-influence-campaigns-during-the-war-in-ukraine/#Limits_to_the_"No_Limits"_Partnership

[210] Joe Stradinger, *Narrative Intelligence: Detecting Chinese and Russian Information Operations to Disrupt NATO Unity,* Foreign Policy Research Institute, 5 November 2024, https://www.fpri.org/article/2024/11/intelligence-china-russia-information-operations-against-nato/

[211] Maryanne Kivlehan-Wise and Tsun-Kai Tsai, "PRC Lessons Learned from Russia's Invasion of Ukraine: Implications for a Taiwan Conflict", in *The PLA in a Complex Security Environment*, The National Bureau of Asian Research, Washington DC, 2025, 117.

opportunities for learning from these combined military exercises may well be considerable. Beyond these activities, China has refused to provide military forces or materiel to Russia for its war against Ukraine despite the 'no limitations' relationship. At present, the lack of will from the Chinese leadership to participate in the war in Ukraine as a belligerent (rather than strategic enabler) remains unlikely to change. As a RAND report on China-Russia military cooperation found, "Strategic cooperation and coordination in the overall military-to-military relationship suggests that expanded cooperation might eventually include some form of combined military operation, but this possibility remains uncertain at best."[212]

Advanced Technology Learning and Adaptation. The China-Russia collaboration in the technologies essential for modern war has accelerated since 2022. PLA academics have produced a large body of publications since 2022 that have proposed the future of warfare as "unmanned, invisible and silent."[213] An important area of collaboration and learning is in drone design and manufacturing. China appears to have assisted Russia in the design of more sophisticated drones, incorporating technologies such as electronics, navigation, optical and telemetry systems, microcircuits, processor modules, antenna field systems, control boards, and navigation. Beyond technical design, China appears to have contributed to the learning and adaptation relationship by helping with the building of more effective, large-scale manufacturing plants for drones.[214] The Ukrainian government has also accused China of sending its citizens to Russia to work in drone factories so this knowledge can be returned to China.[215]

Counter UAV technologies and systems are another area of learning and adaptation between Russia and China. As one report notes, the advances in Chinese counter UAV efforts in the past three years is a demonstration of "the PLA's dedication to learning from conflict and tech trends and its determination to dominate the electromagnetic battlespace." As a result of its insights from Ukraine, and lessons from Russia, China now has over 3000 manufacturers producing counter-UAS capabilities and components.[216]

In 2021, China and Russia announced their collaboration on a future moon station.[217] But, Russia-China interaction on satellites and space-based capability appears to have accelerated since 2022. Both Russia and China have advanced capabilities for developing and launching satellites, as well as the

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[212] Mark Cozad and 7 others, *Future Scenarios for Sino-Russian Military Cooperation: Possibilities, Limitations, and Consequences*, RAND Corporation, 18 June 2024, https://www.rand.org/pubs/research_reports/RRA2061-5.html

[213] Mina Marcus, *China's Conceptual Approaches to Counter-UAS and Lessons Drawn from Recent Conflicts*, China Aerospace Studies Institute, US Air Force, April 2025, 1, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Other-Topics/2025-04-28%20China's%20Conceptual%20Approach%20to%20Counter%20UAS.pdf?ver=9abEad2CImPfK8DP6yO_kg%3d%3d

[214] Veronika Melkozerova, "China helps Russia pull ahead in lethal drone war race with Ukraine", *Politico*, 5 June 2025, https://www.politico.eu/article/china-russia-lethal-drone-war-race-ukraine-war-invasion-manufacture-putin-tech/

[215] Katherine Spencer, "Kyiv accuses China of deepening involvement in Russia's Ukraine war" *Atlantic Council,* 29 April 2025, https://www.atlanticcouncil.org/blogs/ukrainealert/kyiv-accuses-china-of-deepening-involvement-in-russias-ukraine-war/

[216] Tye Graham and Peter Singer, "China's counter-UAV efforts reveal more than technological advancement" *DefenseOne*, 2 May 2025, https://www.defenseone.com/technology/2025/05/chinas-counter-uav-efforts-reveal-more-technological-advancement/405031/

[217] Government of China, "China, Russia welcome int'l partners in moon station cooperation", 25 April 2021, https://www.cnsa.gov.cn/english/n6465668/n6465670/c6811943/content.html#:~:text=China%20and%20Russia%20signed%20a,interested%20countries%20or%20international%20organizations.

application of multiple different capabilities deployed by these satellites. Both nations also have counter-space programs.[218] While Russia may have once played a dominant role, China has grown its expertise and with considerable resources, risen as a major space power. A May 2023 joint report from the Center for Naval Analyses and China Aerospace Studies Institute proposes that the China-Russia space collaboration has military, strategic, diplomatic and economic dimensions, and that:

> *China-Russia space relations indicate deepening trust between the two countries… indicate an effort to balance against U.S. dominance [and]… indicate an effort to deter and counter the U.S. militarily*.[219]

China's National Space Administration, and Russia's Roscosmos, in 2022 also signed a bilateral space cooperation agreement. The agreement includes three phases for the joint development of their Lunar Station and exploration of the moon.[220] This is a significant technological collaboration which will be a key area of strategic learning and adaptation for Russia and China into the 2030s.

Economic resilience. A 2025 report from CEPA has described how the China-Russia economic relationship has developed to a point where it is a deeper relationship that policy makers in Washington DC appreciate.[221] Russia has used its deepening economic relationship with China since 2022 to skirt the economic isolation imposed upon it by western sanctions. And while there has been an expansion in the relationship,[222] particularly with energy supplies, it is an unbalanced one. Moscow is more reliant on China than China is reliant on Russia. The Mercator Institute for China Studies has described the economic dimensions of the China-Russia relationship as "asymmetrical, yet indispensable".[223] And as one investigation of this issue has described, "an interagency group, set up by China in the months following the full-scale invasion, has The situation since 2022 has created a significant learning opportunity for Russia and China as they find ways to minimise the impact of western sanctions and gain better insights into western decision-making about international trade and economic issues studied the impact of sanctions and produced reports regularly for the country's

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[218] Clayton Swope and 3 others, *Space Threat Assessment 2025*, Center for Strategic and International Studies, April 2025. https://aerospace.csis.org/wp-content/uploads/2025/05/250425_Swope_Space_Threat.pdf

[219] Kevin Pollpeter and 4 others, *China-Russia Space Cooperation: The Strategic, Military, Diplomatic, and Economic Implications of a Growing Relationship*, Center for Naval Analyses and China Aerospace Studies Institute, May 2023, https://www.cna.org/reports/2023/06/China-Russia-Space-Cooperation-May-2023.pdf

[220] https://tass.ru/kosmos/16711435; Eduardo Baptista, "China, Russia may build nuclear plant on moon to power lunar station, official says", *Reuters*, 24 April 2025, https://www.reuters.com/business/energy/china-led-lunar-base-include-nuclear-power-plant-moons-surface-space-official-2025-04-23/

[221] Natalia Chabarovskaya, "Going Steady: China and Russia's Economic Ties are Deeper than Washington Thinks", *CEPA*, 16 June 2025, https://cepa.org/comprehensive-reports/going-steady-china-and-russias-economic-ties-are-deeper-than-washington-thinks/

[222] Clara Fond and Lindsay Maizland, "China and Russia: Exploring Ties Between Two Authoritarian Powers", *Council on Foreign Relations,* 20 March 2024, https://www.cfr.org/backgrounder/china-russia-relationship-xi-putin-taiwan-ukraine; Figures on this expanding relationship can be found here: "China-Russia Dashboard: a special relationship in facts and figures", Mercator Institute for China Studies, https://merics.org/en/china-russia-dashboard-facts-and-figures-special-relationship

[223] Filip Rudnik, "China-Russia trade: asymmetrical, yet indispensable", Mercator Institute for China Studies, 7 May 2025, https://merics.org/en/comment/china-russia-trade-asymmetrical-yet-indispensable

leadership."[224] An article in *Foreign Affairs* by Evan Feigenbaum and Adam Szubin put the nature of China's economic learning and adaptation succinctly:

> *The current Ukraine conflict has at long last given Beijing an opportunity to study the strategy, tactics, and capabilities of a Western sanctions coalition as it works to cripple one of the world's largest economies.*[225]

Human Capacity. Both Russia and China have sustained the employment of conscript systems in their military organisations. The myriad of issues with Russian conscripts and their performance in Ukraine has been chronicled in detail over the past three years. The Russians have evolved their recruiting and training frameworks, including the emptying of jails, and have generally been able to recruit enough people to replace their losses while slowly building the overall size of the Russian military. This has not however improved the quality of the Russian ground forces. This is an issue of concern for the Chinese, which has also modelled its military on the intake of over 500,000 conscripts each year. As Singer, Xiu and Corbett have written on this topic, "the PLA is surely watching with concern as a conscript force with at least some similarities to its own fares so poorly, and will likely redouble their campaign to attract more, and preferably higher-quality, voluntary recruits."[226] The lesson from Ukraine for the Chinese leader is that he may need to accelerate PLA reforms to increase the quality of training and education in the PLA.

China has also been described by NATO as the "decisive enabler of Russia's war against Ukraine through its so-called "no limits" partnership and its large-scale support for Russia's defence industrial base."[227] But there are limits. These include China's unwillingness to deploy military forces to Ukraine, China's refusal to acknowledge Russian territorial gains in Ukraine since 2014[228] as well as allegations about Chinese hacking into Russian military databases to support its learning and adaptation from the war in Ukraine.[229]

There is an important caveat to be made about Chinese learning and adaptation that has occurred because of the war in Ukraine, and the interaction of Chinese and Russian political and military leaders. As Joel Wuthnow has written, "lessons from Ukraine could influence PLA doctrine or force posture, but it is still not necessarily the case that those changes will be sufficient to affect Chinese use of force decisions. At best, the effect would be to update Chinese leaders' perceptions of the PLA's

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[224] George Kantchev and Lingling Wei, "China Is Studying Russia's Sanctions Evasion to Prepare for Taiwan Conflict", *Wall Street Journal,* 1 December 2024, https://www.wsj.com/world/china/china-is-studying-russias-sanctions-evasion-to-prepare-for-taiwan-conflict-5665f508

[225] Evan Feigenbaum and Adam Szubin, "What China Has Learned From the Ukraine War", *Foreign Affairs*, 14 February 2023, https://www.foreignaffairs.com/china/what-china-has-learned-ukraine-war

[226] Thomas Corbett, Ma Xiiu and Peter Singer, "What Is China Learning from the Ukraine War?", *DefenseOne*, 3 April 2022, https://www.defenseone.com/ideas/2022/04/what-lessons-china-taking-ukraine-war/363915/

[227] Washington Summit Communique, NATO, 10 July 2024, https://www.nato.int/cps/en/natohq/official_texts_227678.htm

[228] András Rácz and Alina Hrytsenko, *Partnership Short of Alliance: Military Cooperation Between Russia and China,* CEPA, 16 June 2025, https://cepa.org/comprehensive-reports/partnership-short-of-alliance-military-cooperation-between-russia-and-china/

[229] Megha Rajagopalan, "China Unleashes Hackers Against Its Friend Russia, Seeking War Secrets", *New York Times,* 19 June 2025, https://www.nytimes.com/2025/06/19/world/europe/china-hackers-russia-war-ukraine.html

likely effectiveness in a conflict."[230] While China and Russia may have built an enhanced strategic relationship and undertaken a process of learning and adaptation from each other, this is not predictive of how the Chinese will make decisions and fight in a future conflict.

[230] Joel Wuthnow, *Rightsizing Chinese Military Lessons from Ukraine*, Strategic Forum no. 311, National Defense University, Washington DC, September 2022, 3.

Part III. Challenges with Military Learning

> *The idea that setbacks are frequently the consequence of mere bad luck is a seductive one. It is psychologically comforting to those who have not themselves experienced disaster.*[231]

One of the risks of exploring the learning and adaptation mechanisms and outcomes of potential adversaries is that the challenges of learning, analysing, sharing and implementing lessons can be understated. As Frank Hoffman and George Garrett remind us in their 2024 article, *A Break in the Clouds,* learning lessons from past and current wars is a complicated endeavor.[232] And as Joseph Collins wrote in the wake of the 1991 Gulf War, "accurate and timely lessons count, but even concerted effort is no guarantee of success in learning them."[233]

Military Learning: Limitations

A large body of literature exists on how organisations learn. The business world has been the focus of much investigation and publication with regards to faster or higher quality learning, innovation and dissemination of ideas. Seminal works such Senge's *The Fifth Discipline: The Art and Practice of the Learning Organization*[234] and Clayton Christensen's *The Innovator's Dilemma*[235] explore the obstacles to innovation and learning and propose ways that organisations can overcome them.

In military literature, there exists a rich body of work that can be mined for insights into how military organisations learn, what are consistent obstructions to learning, and what best practices might be extracted for contemporary institutional leaders. In the past three decades, scholars such as David Johnson (*Fast Tanks and Heavy Bombers*, 2003)[236], and Meir Finkel (*Military Agility*, 2020[237]; and, *On Flexibility*, 2007[238]) have offered examinations of how institutional culture can both obstruct and support adaptation. Dima Adamsky has also been an influential contributor to the literature on military adaptation, including his publications *The Culture of Military Innovation* (2010)[239] and *Contemporary Military Innovation: Between Anticipation and Adaption* (2012).[240]

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231 Eliot Cohen and John Gooch, *Military Misfortunes: The Anatomy of Failure in War*, (Vintage Books, 1991), 243

232 Frank Hoffman and George Garrett, "A Break in the Clouds: Learning Lessons from the Sea", *Texas National Security Review,* Vol. 7, Issue 3, (Summer 2024), 100

233 Jospeh Collins, "Desert Storm and the Lessons of Learning", *Parameters* 22, No. 1, (1992), 83.

234 Peter Senge*, The Fifth Discipline: The art and practice of the learning organization: Second edition* (Century Trade books, 2006).

235 Clayton Christensen, *The Innovator's Dilemma* (Harvard Business School Press, 1997).

236 David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917–1945* (Ithaca: Cornell University Press, 2003).

237 Meir Finkel, *Military Agility: Ensuring Rapid and Effective Transition from Peace to War*. (Lexington: University of Kentucky Press, 2020).

238 Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford: Stanford University Press, 2007).

239 Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the U.S., and Israel*, (Stanford, CA: Stanford Security Studies, 2010).

240 Dima Adamsky and Kjell Inge Bjergan(eds.), Contemporary Military Innovation: Between Anticipation and Adaption (New York: Routledge, 2012)

Other insights can be drawn from Michael Horowitz's *The Diffusion of Military Power* (2010)[241], which advanced his theory of institutional absorption capacity; Frank Hoffman's *Mars Adapting* (2021)[242] which explored organisational learning cultures in adaptation; and Michael O'Hanlon's *Technological Change and the Future of Warfare* (2000).[243] Other contributions include Stephen Rosen's *Winning the Next War* (1991)[244]; Sergey Rogov's *The Evolution of Military Reform in Russia* (2001)[245]; Laird and Mey's *The Revolution in Military Affairs: Allied Perspectives* (1999)[246]; Serena Chad's *A Revolution in Military Adaptation: The US Army in the Iraq War* (2011)[247]; as well as Nora Bensahel and David Barno's examination of wartime innovation and adaptation, *Adaptation Under Fire: How Militaries Change in Wartime* (2020).[248]

Military institutions are not always enthusiastic adopters of new technology or new ideas. Tradition and a reluctance to trust new technologies and doctrines when older ones have proven themselves in battle has been a theme in the relationship between military organisations and new technologies since at least the start of the First Industrial Revolution. Examples of this included the restrictions placed on the use of submarines before the Second World War because surprise attacks on ships were seen as dishonourable, through to initial allocation of aircraft to subordinate roles in the U.S. Army's Signal Corps because its functions were imagined to only include slightly faster transmission of messages between different parts of the battlefield.

Some technologies have historically failed to gain traction, at least initially, because of the obsession with established historical methods by senior military leaders. David Johnson describes one incident where the head of the U.S. Army's cavalry during the lead up to the Second World War, Major General John Herr, saw new motor vehicles only as a means to transport his horses to and from the battlefield and continuously thwarted the introduction of motor vehicles into the cavalry until he was removed by the Chief of the U.S. Army.[249]

Parsing the right lessons from contemporary wars offers additional challenges. As Joseph Steib notes, "lesson-learning faces a major paradox. Highly specific lessons provide little value for applying to new cases. Nevertheless, general lessons that might be applicable across cases are usually so banal

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241 Michael Horowitz, *The Diffusion of Military Power* (Princeton: Princeton University Press, 2010).

242 Frank Hoffman, *Mars Adapting: Military Change During War* (Annapolis: Naval Institute Press, 2021).

243 Michael O'Hanlon, *Technological Change and the Future of Warfare*, (Washington, DC: Brookings Institution, 2000).

244 Stephen Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991).

245 Sergey Rogov, *The Evolution of Military Reform in Russia*, (Alexandria: The CNA Corporation, 2001).

246 Robbin Laird and Holger Mey, *The revolution in military affairs: allied perspectives*, (Washington DC: National Defense University, 1999).

247 Serena Chad, *A Revolution in Military Adaptation: The US Army in the Iraq War (*Georgetown University Press, 2011).

248 Nora Bensahel and David Barno, *Adaptation Under Fire: How Militaries Change in Wartime* (New York: Oxford University Press, 2020).

249 David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army 1917-1945*, (Cornell: Cornell university Press, 1998), 136-140.

that they offer no insight."[250] And, as Collins notes, "technology-inspired lessons from a single war are likely to have a very short life."[251]

The 2012 Department of Defense publication, *Decade of War, Volume I: Enduring Lessons from the Past Decade of Operations*, describes how the foundations for adapting U.S. military forces during operations were not as sturdy as they should have been. Rigid conventional doctrine, slow fielding of new equipment and laborious processes for changing processes and doctrine all hindered military operations. And where learning did take place, it was uneven. As the report describes:

> *While units learned and adapted to their operating environments, their experiences, best practices, and lessons were not always shared, either within theater or with the larger DOD institutions. Although there were many Service lessons learned organizations with active data collection efforts operating in theater, their efforts tended to stay in their respective stovepipes and were rarely integrated across the joint force.*[252]

At the same time, the U.S. military forces have shown weaknesses in observing and learning lessons from foreign wars. In his extensive study of this topic, Brent Sterling finds that "looking for practical benefits from investigations of other people's wars, the US military, especially the army tended towards rapidly drawing preliminary findings and seeking hard data to support such findings…this orientation problematically discourages attention to operational and strategic elements and dangerously promotes static, not dynamic learning."[253]

Learning from one's own military operations, and those of allies as well as adversaries, is a necessary undertaking by military institutions.

Understanding Learning and Adaptation Systems

Building and sustaining an effective learning culture, including the collection, assessment and dissemination of lessons is difficult. The lessons from military history and more recent research into business innovation demonstrate this. However, the case is not hopeless. It is possible to construct the right conditions to foster learning and adaptation in peace and war. In drawing together the array of literature on innovation, learning organisations and military adaptation, several key insights stand out which might assist in understanding our adversaries learning and adaptation approaches while also assisting in building the appropriate response in our own and friendly institutions.

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[250] Jospeh Steib, "History Has No Lessons for You: A Warning for Policymakers", War on the Rocks, 6 February 2024, https://warontherocks.com/2024/02/history-has-no-lessons-for-you-a-warning-for-policymakers/

[251] Jospeh Collins, "Desert Storm and the Lessons of Learning", *Parameters* 22, No. 1, (1992), 87.

[252] U.S. Joint Staff J7, *Decade of War, Volume 1. Enduring Lessons from the Past Decade of Operations*, (Washington DC, 2012), 20.

[253] Brent Sterling, *Other People's Wars*, (Georgetown University Press, 2021), 8.

Contextual Appreciation. No lessons, learned or otherwise, are free of the context within which observations are made, analysed and disseminated. One of the most significant insights provided in the compilation of U.S. lessons from its wars in Iraq and Afghanistan is that understanding the environment, inclusive of political context, geography, the operational environment, resource and people issues, is crucial. As the report noted, "a failure to recognize, acknowledge, and accurately define the operational environment led to a mismatch between forces, capabilities, missions, and goals."[254] The context of observations which lead to lessons is crucial. For example, the war in Ukraine is producing many insights, but not all of them will be critical in theatres beyond eastern Europe. For example, the application of maritime forces will be different in the Pacific than they are in the Black Sea, and the impact of drones in the heavily vegetated, high precipitation of the Pacific might be different to their contribution to operations in Ukraine.

Organizational Culture. Culture has a very significant impact on the success or otherwise of military institutions in peace and war. Made up of beliefs, ideas, norms and assumptions within a body of an organization, organisational culture can however often "lie hidden under more visible organizational doctrine and symbols".[255] But culture exerts a powerful influence on an organization's learning and adaptation capacity. This is because culture can influence the degree to which leaders, from battlefield to institutional levels, accept that change is occurring and how much risk they will accept to remain an effective military organization in the midst of change.

Formal processes for Lessons Learned. The concepts of formal lessons learned extends back to the First World War where many nations, including Germany and Britain, implemented formal structures and processes for the collection, analysis and dissemination of battlefield lessons.[256] Operational analysis was employed by the British and the Americans in the European and Pacific theatres during the Second World War to enhance the operational effectiveness of military forces.[257]

Learning in contemporary western military organisations and alliances is partially structured around lessons learned processes and organisations. These learning and adaptation systems are not always well synchronised. And, because western democracies are still in a pre-war learning and adaptation phase, rather than a wartime learning and adaptation phase like Russia and Iran, the level of bureaucracy and risk aversion can often be too high. Different nations can interpret the lessons of the war in Ukraine (and Iran) differently because of different political systems, different geography, and different strategic circumstances pertaining to individual nations and different regional security groupings.

Finally, the lessons processes for military organisations must balance learning from their own activities with learning from foreign wars and military activities.

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[254] U.S. Joint Staff J7, *Decade of War, Volume 1. Enduring Lessons from the Past Decade of Operations*, (Washington DC, 2012), 3.

[255] Peter Mansoor and Williamson Murray, "Introduction" in Peter Mansoor and Williamson Murray (eds), *The Culture of Military Organizations*, Cambridge University Press, 2019), 1.

[256] Aimee Fox, *Learning to Fight: Military Innovation and Change in the British Army, 1914–1918* (Cambridge: Cambridge University Press, 2017).

[257] Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021, 49-52.

Dissemination and Absorption Mechanisms. To ensure that lessons are truly learned, and that an institution's learning culture enhances its military effectiveness, dissemination mechanisms are required. As Hoffman notes in *Mars Adapting*, "within the military innovation literature, the focus is on the production of doctrine and lessons learned."[258] But the dissemination of learning must extend beyond the production of new doctrine, as important as that might be. As such dissemination mechanism, which will have both formal and informal[259] methods must also penetrate the development of evolved command and control structures, organisations, the development of new equipment and munitions, defence production, infrastructure, and training.

Leadership. The core attribute for effective institutional learning and adaptation is leadership. As Peter Senge notes, leaders must be able to "help people understand the systemic forces that shape change."[260] The need for adaptive leaders was another insight provided in the 2012 publication on the U.S. military lessons from Iraq and Afghanistan, noting that the military should "develop and promote leaders who remain flexible, question existing paradigms, assume risk, and foster interorganizational collaboration."[261] An array of historical studies on this topic have found that new promotion pathways are a crucial element in unearthing adaptive leaders and allowing them to lead in less conventional ways that nurtures and champions innovation. At the same time, the institutional reporting methods in military services that focus exclusively on commentary by superior officers do not adequately capture some of the elements of adaptive leaders, such as risk tolerance and openness to new ideas.

Finally, as Ukraine has demonstrated, more decentralised command and leadership models assist in the learning and adaptation process for military organizations.[262] More centralised models of command, as used by the Russians early in the war, tend to hinder innovation. In his book, *The Great Gamble*, Gregory Feifer wrote that "an over centralized military command that reserved most decision making for the top was ineffective for taking quick actions and facilitating the rapid mobility needed."[263] As explored in my book, *The War for Ukraine: Strategy and Adaptation Under Fire,* the Russian preference for more centralised forms of command and control hindered the exercise of adaptation in the early phases of the war in Ukraine. [264]

This learning and adaptation structure – context, culture, lessons, dissemination and leadership – provides a framework which might be applied to better understanding the full dimensions of how our

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[258] Frank Hoffman, *Mars Adapting: Military Change During War*, Naval Institute Press, 2021, 52.

[259] For an examination of informal methods, see Rob Johnson, Martijn Kitzen, and Tim Sweijs, *The Conduct of War in the 21st Century: Kinetic, Connected and Synthetic* (Routledge Advances in Defence Studies, 2021), 192.

[260] Peter Senge*, The Fifth Discipline: The art and practice of the learning organization* (Random House, 1992), 356.

[261] U.S. Joint Staff J7, *Decade of War, Volume 1. Enduring Lessons from the Past Decade of Operations*, (Washington DC, 2012), 21.

[262] Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Stanford: Stanford University Press, 2007), 108-110; Frank Hoffman, *Mars Adapting: Military Change During War* (Naval Institute Press, 2021), 46;

[263] Gregory Feifer, *The Great Gamble: The Soviet War in Afghanistan* (HarperCollins, 2009), 119.

[264] Mick Ryan, *The War for Ukraine: Strategy and Adaptation Under Fire* (Naval Institute Press, 2024), 128.

potential adversaries are collaborating, learning and adapting. Alone and in combination, these factors allow for the structured and deliberate study of the activities and effectiveness of the international learning and adaptation that is taking place among nations such as Russia, China, North Korea and Iran.

At the same time, this framework offers insights into how the United States might structure and confront the learning and adaptation activities of its adversaries. Notwithstanding these challenges, there are a range of organisations and resources that might be brought to bear, and evolved, in the short term to counter the adversary learning and adaptation bloc, and ensure that America and its partners are competing, and can eventually prevail, in the new Adaptation War. These resources and institutions include the following:

- The lessons learned institutions in the military services of the United States military and joint organisations established in the U.S. and in combatant commands.
- The lessons learned organisations of foreign military institutions, both service and joint, that can collect, analyse and disseminate lessons.
- Alliance lessons learned and analytical capability, such as that already resident within NATO.
- Service and joint schools in America and its allies, as well as think tanks and academic institutions, that can be used to supplement the analytical capacity of dedicated lesson learned organisations.

Part IV. Characterising the Modern Adaptation War

> *War is… chameleon-like in character, because it changes its colour in some degree in each particular case.*[265]

In drawing together the information and insights examined in the preceding pages, it is now possible to develop a sense of the character of the modern adaptation war. It is important to appreciate the broad character of the adaptation war because by doing so, it provides insight into the strategic strengths and vulnerabilities of potential adversaries, and to prioritise the kinds of learning and adaptation required by America and its allies.

Like the character of war, the character of the modern adaptation war will evolve over time. As such, ongoing assessments of the character and components of the adaptation will be necessary. However, in 2025, the character of the adaptation war might be described as follows:

Concurrency. As this report has examined, learning and adaptation is occurring at many different levels, in many different organisations across multiple geographic regions concurrently. It is a multi-domain learning and adaptation environment, with efforts underway in the ground, air, space, maritime, cyber and information domains. This parallel learning and adaptation can complicate understanding the entirety of all dimensions of the adaptation war. But the enormous complexity of concurrent learning at multiple levels of organisations and nations, because of the human nature of learning and adaptation, will also unveil many gaps and vulnerabilities in adversaries and in our allies.

One Learns, All Can Learn. For the first time in human history, the adaptation war has spawned the potential for a real-time, global knowledge market among authoritarians and potentially, among America's allies and security partners. Unlike previous eras where learning took time to be absorbed into organisations, and even longer to share between organisations and nations, now there is the potential for all members of an adaptation community, regardless of their location, to access lessons almost as soon as one member can collect and analyse insights. This means that among America's competitors, when one learns a lesson about America's weaknesses or vulnerabilities, all of them can benefit from the lesson (if they can overcome obstacles to learning described in Part III).

Uneven Learning. Notwithstanding the potential for the global knowledge market in the adaptation war, learning and adaptation is ultimately a human endeavour. Organisations might seek to automate collection, analysis and dissemination through AI, but this system still requires humans at the point of learning and collection and for humans to accept and implement lessons at different organisational levels and in different cultures and nations. This human dimension of the adaptation war can be a strength but also provides many vulnerabilities.

Military institutions, and the different agencies in a nation's security apparatus, rarely compromise a monoculture. For example, the services within each military organization possess their own cultures and even sub-cultures. For example, the culture of submariners in a navy can be very different to

[265] Carl von Clausewitz, *On War*, Book I, https://www.gutenberg.org/files/1946/1946-h/1946-h.htm#chap01

those of naval aviators. As Mansoor and Murray have written, "organizations often have subcultures" and that the amalgamation of these subcultures can "run into difficulties when a military faces off against a near-peer competitor."[266] Different cultures arise within individual organisations, which can provide targetable seams. Therefore, a key vulnerability is that the capacity of learning cultures differs between institutions and nations, and therefore, learning and adaptation is uneven. Uneven learning is the start point for vulnerability assessments.

Imperfect Insight. It is unlikely that full visibility about what the adversary learning and adaptation bloc is doing, as individual nations or collectively, will be possible. Just as war is full of uncertainty, friendly knowledge of adversary learning and adaptation endeavours will also be rife with uncertainty. The efforts of military attaches, intelligence agencies, open-source collection, business intelligence and luck will all provide insight into how adversaries learn and adapt. But there will always be gaps and sources of uncertainty.

Not a Technological but an Intellectual Competition. As highlighted above, learning and adaptation is a human trait and a human undertaking. While insights about technology will play a prominent role in learning and adaptation, as shown by the many examples included in this report, human decision-making, energy, drive and creativity is the critical component of learning and adaptation. Even if AI becomes more critical in supporting learning and adaptation at different levels, the adaptation war will remain a largely human endeavour. Providing the right purpose and incentives for learning and adaptation, and undertaking the right training, educational and organization reform to improve friendly learning and adaptation is vital.

However, as explored in Part III, military institutions of all types and nationality experience bureaucratic inertia and other human factors that impede change. This has been observed and documented in all western military institutions as well as in Russia and China. For example, obstacles to reform in the Russian military have been assessed by some as the result of imbalances in civil-military relations and dysfunctional civilian control.[267] Others have pointed to a highly centralised bureaucracy, widespread corruption and an over-emphasis on theory over implementation.[268]

China too has experienced challenges in military reform. As Joel Wuthnow and Phillip Saunders have written, the historical dominance of the ground forces and inter-service rivalry has impeded change.[269] Other issues for the reform of the People's Liberation Army have been identified as corruption and distrust between the Chinese president and his military forces.[270] The imperative for

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[266] Peter Mansoor and Williamson Murray, "Conclusion" in Peter Mansoor and Williamson Murray (eds), *The Culture of Military Organizations*, Cambridge University Press, 2019, 457.

[267] Kirill Shamiev, "Brass Tacks: Why Russia's Military Fails to Reform", *European Council on Foreign Relations*, 15 May 2024. https://ecfr.eu/publication/brass-tacks-why-russias-military-fails-to-reform/

[268] Katherine Kjellstrom Elgin, More of the Same" The Future of the Russian Military and its Ability to Change, Center for Strategic and Budgetary Analysis, 2024, 9-11.

[269] Joel Wuthnow and Phillip Saunders, *Chinese Military Reform in the Age of Xi Jinping*, China Strategic Perspectives 10, Institute for National Strategic Studies, National Defense University Press, 2017, 2.

[270] K. Tristan Tang, Xi Struggles to Keep Military Construction Reform on Course at Two Sessions, The Jamestown Foundation, 15 March 2025. https://jamestown.org/program/xi-struggles-to-keep-military-construction-reform-on-course-at-two-sessions/; Masaaki Yatsuzuka, "New Chinese

political indoctrination and conformity in the People's Liberation Army may also conflict with the ability of commanders to lead the development of a learning culture and military innovation.[271]

Therefore, while human agency plays a central role in learning and adaptation, it can also lead to obstacles in the innovation process. This in turn results in targetable vulnerabilities

Speed. What makes this new global adaptation war more challenging, and difficult to respond to, is the speed at which authoritarian actors are learning, adapting and sharing lessons among themselves. Many surveys of the contemporary security environment note that the pace of technological change is increasing. As the British *Future Operating Environment 2035* report notes, "the rate of technological change will accelerate out to 2035, serving to highlight inadequacies in less adaptable procurement processes within Defence. Civil companies will be able to raise revenue far more quickly, driving technology development in new directions and at faster rates."[272]

Since 2022, both Russia and Ukraine have demonstrated the ability to learn how to learn better, and to do this learning and adaptation at a faster pace over time. Throughout military history, revolutionary change has generally occurred when one nation has changed the pace at which it can adapt, or when combatants are able to change the frequency at which it operates and thus interfere with its adversary's frequency (and ability to respond). Examples of exploiting a different frequency include the German Army's invasion of France in 1940, the 1991 US Army's offensive operations in Kuwait to eject the Iraqi Army, and Ukraine's offensives into Kharkiv and Kursk since 2022. The adaptation described in this report is now taking place at a frequency that is much faster than even a few short years ago. Examples of this since 2022 include:

- The drone-counter and drone adaptation battles are ongoing and accelerating. Achieving hard kill using drone interceptors,[273] and mobile team gun systems, continues to gain prominence in the fight against Russian drones. Drone software updates often occur daily, and drone technology and tactics changes every week or two. At the same time, Russia's development of faster, higher flying Shahed drones is forcing Ukraine to use more expensive interceptor missiles.[274]
- Faster organisational reform is having an impact on the drone operations of both Ukraine and Russia. For Ukraine, the development of the Unmanned Systems Force is slowly unifying drone and EW operations, learning and adaptation processes, and is also designed to provide better battlefield feedback to defence industry. Russian efforts, including its 2024 development of the Rubicon Centre of Advanced Unmanned Systems, is seeing an increase in the effectiveness

reform addresses overlaps, reflects challenge of military control", The Strategist, Australian Strategic Policy Institute, 22 April 2024, https://www.aspistrategist.org.au/new-chinese-reform-addresses-overlaps-reflects-challenge-of-military-control/

271 Joel Wuthnow and Phillip C. Saunders, *China's Quest for Military Supremacy*, (Polity books, 2025), 22-23, 29-30.

272 UK Ministry of Defence, *Future Operating Environment 2035* (Shrivenham: Development, Concepts and Doctrine Centre, 2015), 14-15.

273 David Hambling, "Ukraine Deploying 'Tens Of Thousands' Of Interceptors To Stop Shaheds", *Forbes*, 15 July 2025, https://www.forbes.com/sites/davidhambling/2025/07/15/ukraine-deploying-tens-of-thousands-of-interceptors-to-stop-shaheds/

274 Insights into timeframes for change gained from author interviews with key Ukrainian military personnel in 2024 and 2025.

of Russian drone units, a speed up in adaptation cycles through less red tape and greater independence within the Russian military.[275]

- Underpinning this adaptation battle is increasing levels of autonomy in drone operations, which may see even larger numbers of drones being orchestrated in individual tactical missions or strategic strike operations.
- Battlefield tactics are changing frequently. Russia is changing its tactics every 2-3 months. At the same time, deception measures constantly evolve and as one commander noted, "what worked last year no longer works". [276]
- Ukrainian strategic strike tactics, and in the development of new, indigenously designed hybrid cruise missile drones is happening more quickly. Ukraine has been developing capabilities for longer range strikes, allowing Ukraine to hit targets out to 2000km inside Russia. New systems were announced in August and December 2024 as well as in January 2025.

Given the increasing application of AI in military organisations, and its potential to significantly accelerate learning and adaptation, the pace of the adaptation war is likely to increase.[277]

[275] Dara Massicot, Twitter post, 5 August 2025, https://x.com/MassDara/status/1952400614928896144; David Axe, "Lying In Wait On The Ground, Russia's Best Attack Drones Devastate Ukrainian Convoys", Forbes, 16 March 2025, https://www.forbes.com/sites/davidaxe/2025/03/16/lying-in-wait-on-the-ground-russias-best-attack-drones-devastate-ukrainian-convoys/

[276] Insights into timeframes for change gained from author interviews with key Ukrainian military personnel in 2024 and 2025.

[277] See my exploration of how AI can improve learning and adaptation here: Mick Ryan, *Supercharging Adaptation: AI and War in the 21st Century,* Australian National University, 19 February 2025, https://bellschool.anu.edu.au/event/supercharging-adaptation-ai-and-war-21st-century

Part V. Findings and Recommendations

Military institutions and other national security agencies that seek to learn, adapt, and to build their effectiveness for 21st century conflict, must invest in the incentives and processes that nurture collection, analysis, dissemination and implementation of the right lessons at the right level of military and national security endeavours. Partially, this is about resourcing, but it is also about organisations setting the priorities for adaptation higher than they may have done previously. Crucially, a new approach to institutional learning and adaptation to counter that being undertaken by current and potential adversaries must involve the evolution of existing military services and agencies to achieve a better balance of what Andrew Gordon described in *The Rules of the Game* as innovative 'ratcatchers', and managerial 'regulators'.[278]

What might the Department of War do to improve its collective capacity for learning and adaptation at different levels? This section proposes key findings and recommendations to provide the adaptive stance necessary to succeed in 21st century military affairs.

Finding 1: Ukraine and Russia have *learned to learn* more quickly in the past three years, and to proliferate the lessons of that learning into their military and industrial systems with increasing speed. This adaptation battle has technical dimensions as well as organisational and doctrinal aspects. The effectiveness of Ukraine and Russia's learning and adaptation is built on the existence of a learning and adaptation culture in military and other government institutions.

Recommendation: The Department of War must embrace adaptation as an integral aspect of its institutional culture. Senior leaders should nurture people and teams incentivised and resourced to continuously learn and that are capable of adapting quickly.[279] This culture begins with clear statements about leadership tolerance for risk and new ideas. Appropriate authorities are necessary for leaders to conduct decentralised but linked multilevel adaptation.

Recommendation: The Department of War should increase investment in learning how Ukrainian, Russian and other military organisations have learned how to learn. This extends into learnings of the defense industries and how these lessons intersect with military affairs.

Finding 2: The learning and adaptation enterprise spawned by the war in Ukraine, as well as the war in the Middle East, has now metastasised into an international learning and adaptation competition. A new adversary learning and adaptation bloc has emerged. When one of the parties of this bloc learns, all of them learn and can adapt as well.

Recommendation: Vulnerable elements of the adversary learning and adaption bloc should be targeted by America and its partners. The approach must balance learning from a military institution's own activities with those from foreign wars and exercises.

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[278] Andrew Gordon, *Rules of the Game: Jutland and British Naval Command* (U.S. Naval Institute Press, 2013).

[279] This senior advocacy is one of the essential elements of successful institutional learning and reform. For a useful case study involving the massive transformation of the US Army in the wake of the Vietnam War, see Don Starry, "To Change an Army", *Military Review*, March 1983, 20-27.

Recommendation: An Indo-Pacific version of the NATO Joint Analysis and Lessons Learned Centre should be formed and linked to both the Commander of Indo-Pacific Command as well as the Department of War for rapid dissemination of lessons. The Department of War should develop translation mechanisms for Ukraine War insights to ensure that lessons are fit for the military institutions as well as the political and operational environments where the insights are applied.

Recommendation: *The United States and its allies should develop a better understanding of the relationships and information flows between different authoritarian nations in order to better understand how the flows of knowledge between different nations are and are not impacting their military effectiveness. Better understanding the nature of these linkages, between Russia and Iran, as well as between Russia and China, would also provide insights into the limitations of such relationships. For example, the limited support from China and Russia for Iran in 2025, China's unwillingness to deploy military forces to Ukraine, and China's refusal to acknowledge Russian territorial gains in Ukraine since 2014 provide examples of these limits to authoritarian collaboration.*[280]

Finding 3: With Western powers slower to recognise this emerging adaptation war, there remains a gap in time between when problems are recognised by an institution, solutions are identified, and the technological, conceptual and organisational elements of the solution are disseminated and implemented.

Recommendation: The learning and adaptation activities of the Department of War should focus on closing the gap between the emergence of new technologies and battlefield employment by having leaders take more risk with innovation. This will require an increased institutional tolerance for failure, which is a crucial element of learning and adaptation.

Recommendation: Leadership selection plays a central role in rapidly closing the gap between the emergence of new technology and its adoption by military institutions. The selection of all military leaders should include assessments of their risk tolerance, and how they nurture learning and innovation in subordinates. Service Chiefs and senior joint leaders must define the range of acceptable failures, and leaders at all levels must make clear statements about their willingness to absorb risk to permit subordinates learning and adaptation.[281]

Finding 4: New technologies to gather information from both commercial and military sources and then prioritise the analysis of the most compelling insights offers the potential to better understand adversary learning and adaptation, and to improve the speed and quality of U.S. and allied learning and adaptation.

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[280] András Rácz and Alina Hrytsenko, *Partnership Short of Alliance: Military Cooperation Between Russia and China,* CEPA, 16 June 2025, https://cepa.org/comprehensive-reports/partnership-short-of-alliance-military-cooperation-between-russia-and-china/

[281] This senior advocacy is one of the essential elements of successful institutional learning and reform. For a useful case study involving the massive transformation of the US Army in the wake of the Vietnam War, see Don Starry, "To Change an Army", *Military Review*, March 1983, 20-27.

Recommendation. Rapidly implement tailored analytical AI for strategic and operational functions across the DOD and the military services to support the learning and adaptation process. AI might be applied to fuse disconnected learning processes, accelerate analysis, and speed up and enhance the quality of military adaptation and strategic decision-making in peace and war. As some of the early adopters of AI in military institutions have shown, there is unlikely to be a one size fits all algorithm or process that can enhance learning and adaptation at every level of military endeavours.[282] *A variety of learning and adaptation support algorithms will be needed to improve the quality and speed of friendly learning and adaptation. The U.S. Department of War should consider the sharing of its learning and adaptation, and the supporting processes and technologies, if it is to remain capable of collective security activities, and coalition warfighting operations.*

Finding 5: Military services must better appreciate the differences in the three forms of military adaptation. Peacetime adaptation, transition to war adaptation, and war adaptation. Peacetime adaptation is more resource constrained than other forms of adaptation, affords more time for experimentation and analysis, and often faces greater bureaucratic obstacles. Wartime adaptation has an existential imperative and generally proceeds at a faster pace. Finally, the transition from peace to war is a different form of adaptation again. It is a shorter process, primarily cognitive, and involves a massive change in mindset overnight.

Recommendation. Each type of the three types of adaptation requires different institutional settings and leadership philosophies at the service, national and international levels for learning and adaptation. An appreciation of the imperatives of each type of adaptation must be implicit in the 'lessons learned' process of the Department of War.

[282] Lauren Williams, "INDOPACOM brings AI to wargaming exercise", *Defense One*, 30 May 2025, https://www.defenseone.com/technology/2025/05/indopacom-brings-ai-wargaming-exercise/405708/; Defense Innovation Unit, *DIU's Thunderforge Project to Integrate Commercial AI-Powered Decision-Making for Operational and Theater-Level Planning*, 5 March 2025, https://www.diu.mil/latest/dius-thunderforge-project-to-integrate-commercial-ai-powered-decision-making.

Conclusion

> *Military organisations have proven resistant to change throughout the twentieth century even during times of conflict, and more often than not, they have paid for adaptation with the blood of their maimed and dead rather than through the exercise of their minds and mental agility.*[283]

Ukraine, and now Western democracies, are involved in an intensive, long-term Adaptation War with authoritarian powers. Investigating, understanding and responding to this adaptation war is crucial for the long-term security of America and its allies. There is an urgent imperative for western nations to enhance their existing mechanisms for sharing lessons (alliances, coalitions of the willing, 5 eyes, etc) across strategy, military, economic and information domains to counter the newly established adversary learning and adaptation bloc. Incorporation of mechanisms to challenge and out-compete this bloc should be integral to the 2026 U.S. National Defense Strategy.

Learning, adaptation and learning to learn, while unevenly distributed at times, has gained momentum and is central to both sides strategies for fighting this war. Both have also been active in sharing their lessons with their partners. The global nature of this adaptation war, and the potential strategic advantages being derived by authoritarian nations from their rapidly moving learning and adaptation community, are worthy of additional study.

To engage in this adaptation war effectively *s*enior political and military leaders must appreciate the breadth of learning available from the war in Ukraine – from political to tactical. These lessons, which include political, military, economic and cognitive warfare lessons, provide a start point for learning about modern war.

The Ukraine War insights, and trends in war made apparent by the last three and half years of war in eastern Europe should not be viewed as THE future of war. Rather, these are lessons that will SHAPE many elements of future conflict. Every war has a different context and therefore not every lesson from Ukraine will be directly applicable, or applicable at all, in the Pacific theatre. That said, the vast majority of lessons reviewed by the author in the past three and a half years retain some level of relevancy for military institutions and governments in the Pacific theatre.

While military adaptation is often the result of military failure, or strategic surprise, it can also assist to anticipate failure and the efforts to prevent it. The war in Ukraine has proved (again) that an adaptive stance is part of successful military strategy. Over the course of this war, both Ukraine and Russia have demonstrated the ability to learn and adapt.

Political and military leaders must nurture innovation as well ensure a link between battlefield learning and institutional adoption of new ideas, tech and organisations. While there are individual imperatives in some circumstances for rapid learning and adaptation, even the most immediate of learnings need to be shared to enhance the overall survivability of teams and larger formations.

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[283] Williamson Murray, *Adaptation in War: With Fear of Change*, Cambridge University Press, 2011, 4

Military leaders must improve their capacity to nurture innovation as well as ensure the functional linkages between battlefield learning and the institutional adoption of new ideas, technology and military structures.

The alignment of the authoritarian nations of China, Russia, North Korea and Iran has underpinned the establishment of an adversary learning and adaptation bloc. This bloc poses a significant challenge to the political systems and military institutions of the United States and other democracies. The pace and breadth of learning, as well as the productive challenge of these four states combined means that they pose a considerable challenge to global stability as well as the security of individual democratic states, most profoundly Ukraine and Taiwan. But as the recent Israel-Iran conflict has demonstrated, this adversary learning and adaptation bloc is not without its limitations.

The four major authoritarian nations, while aligned in their opposition to the American-led international system that has existed since 1945, are a considerable but not insurmountable challenge. But to overcome the challenge of this new Adaptation War will take deeper learning collaboration within the DoD, and between the military, intelligence and other national security agencies of other democratic nations. Most importantly, sustained and visible leadership from political and military leaders to build and sustain adaptation cultures will be crucial.

Epilogue

Is the Adaptation War a Revolution in Military Affairs?

Since the 1990s, Revolutions in Military Affairs have been studied at various intervals. The most intense period of study was the 1990s and early 2000s as the United States and other nations undertook studies of past revolutions in military affairs to inform their development of modern military force structures. The subject of military technical revolutions had been examined earlier by the Soviets in the 1970s, but its study in the West was given impetus of the Director of Net Assessments, Andrew Marshall, who wrote that:

> *In late 1990 or perhaps early 1991, shortly after Andrew Krepinevich had joined the office, I asked him to undertake an assessment to decide still more clearly if we really believed that the Soviet theorists were correct in their belief that technological developments would lead to major changes in warfare.*[284]

An early publication on this subject was an article by Williamson Murray, called "Thinking About Revolutions in Military Affairs" in *Joint Forces Quarterly* in the summer of 1997.[285] Murray offered a definition for RMAs, as well as proposing a framework that differentiated between Military Revolutions and Revolutions in Military Affairs. In *The Dynamics of Military Revolution, 1300-2050*, Murray and Knox refined their ideas, defining Military Revolutions as historical events that fundamentally changed the nature of warfare:

> *Such "military revolutions" recast the nature of society and the state as well as of military organizations. By so doing they altered the capacity of states to project military power and allowed the military to kill people and break more effectively.*[286]

On the other hand, Revolutions in Military Affairs were viewed by Murray and Millett as a more limited phenomenon that required the aggregation of different tactical, organizational, doctrinal, and technological innovations to construct a new conceptual paradigm in military operations. As Murray notes, "the record further suggests that the crucial element in most revolutions in military affairs is conceptual in nature."[287] He also wrote that, if a military revolution is an earthquake, then revolution in military affairs are the pre-shocks and aftershocks that accompany the earthquake.

With this as context, what assessment can be made of the question about whether the global adaptation war is a new revolution in military affairs? Given that the crucial element in most

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[284] Andrew Krepinevich, The Military Technical Revolution: A Preliminary Assessment, Center for Strategic and Budgetary Assessments, Washington DC, 2002, i.

[285] Williamson Murray, "Thinking About Revolutions in Military Affairs", *Joint Forces Quarterly*, Summer 1997, 69-76.

[286] Williamson Murray and MacGregor Knox, "Thinking about Revolutions in Warfare", in *The Dynamics of Military Revolution, 1300–2050*, Cambridge University Press, 2001, 7.

[287] Williamson Murray, "Thinking About Revolutions in Military Affairs", *Joint Forces Quarterly*, Summer 1997, 70.

revolutions in military affairs is that they are conceptual in nature, I must provide the following answer: *quite possibly.*

The reason for this conclusion is that learning and adaptation, which has many manifestations in the physical world, is a primarily macro-concept for how human beings can improve and evolve their effectiveness in all the endeavours that involve different societies. This includes war.
The rapid and accelerating adaptation war examined in this report is driving an array of new military concepts which include human-drone operating concepts, evolved command and control to take account of enhanced battlespace visibility and the access of military personnel to more information, 21st century manufacturing to support greater attrition in war, and evolved concepts for escalation and integration of different force elements on the battlefield (such as conventional and special operations units).

The conduct of enhanced and accelerated learning and adaptation, and the demonstrated ability of modern military organisations to learn how to learn better, are providing the intellectual and physical foundations for tactical, organizational, doctrinal, and technological innovation. As such, they comprise the 'cluster of changes' which lead to 'new ways of destroying opponents described by Murray and Millett.[288]

This is not definitive proof that the new adaptation war comprises a modern revolution in military affairs. But it does indicate that there is sufficient evidence for further investigation of this topic so that Western nations can both understand and exploit this phenomenon.

[288] Williamson Murray and MacGregor Knox, "Thinking about Revolutions in Warfare", in *The Dynamics of Military Revolution, 1300–2050*, Cambridge University Press, 2001, 12.

Author Biography

Mick spent 35 years in the Australian Army and commanded at troop, squadron, regiment, task force and brigade levels. He served in East Timor, Iraq and Afghanistan. Mick has published three books since 2022: *War Transformed (*2022*), White Sun War: The Campaign for Taiwan (2023)*, and *The War for Ukraine: Strategy and Adaptation Under Fire (2024)*. Mick is a strategic advisor to several companies and organisations including U.S. drone company *Skydio*, the Washington DC-based *Special Competitive Studies Project*, Australia's *Beaten Zone* defence venture capital company, the *Useful Fiction* company, and the UK-based *Janes*. Mick is the inaugural Senior Fellow for Military Studies at the Lowy Institute in Sydney, and an adjunct fellow at the Center for Strategic and International Studies in Washington DC.