Technological Surprise and Normalization Through Use: The Tactical and Discursive Effects of New Precision-Strike Weapons in the Russo-Ukrainian War

Cameron L. Tracy

Texas National Security Review 9, no. 2 (Spring 2026) | © 2026 by Cameron L. Tracy | DOI: 10.1353/tns.00035

Expectations of the performance of military technologies are marked by hopes that one's own systems perform well while those of adversaries perform poorly, and fears of the inverse. These expectations shape states' preparation for war and their conduct in war. But expectations frequently misalign with performance, such that the battlefield debut of novel or upgraded weapons technologies offers an opportunity for reassessment. In this article, I argue that the initial use of such weapons commonly drives a discursive process of normalization, wherein systems previously considered revolutionary or archaic are incorporated into existing modes of warfighting and accepted as normal components of those practices. I analyze the debut of several Russian long-range precision-strike weapons in the Russo-Ukrainian War, tracing the reassessment and normalization of hypersonic missiles, theater ballistic missiles, and glide bombs. This analysis shows that analysts would do well to moderate their expectations when forecasting the implications of weapons technologies.

Military strategists, policymakers, and scholars of security studies exhibit deep concern about the development of new weapons technologies and their security implications.[1] Following patterns of popular thinking about technology more broadly, analysts appear preoccupied with what Marita Sturken and Douglas Thomas term "visions of technology as life-transforming, in both transcendent and threatening ways."[2] Forecasts of the security implications of technologies like artificial intelligence (AI), quantum sensors, and hypersonic missiles frequently warn of imminent disruptions to the character of war. These narratives of technological revolution can be utopian, when one hopes that their polity can harness these technologies to decisive effect. For instance, Jamie McKeown identifies a pervasive belief among US intelligence communities in technological fixes to future geopolitical threats.[3] These narratives can also be dystopian, when one fears that adversaries will capitalize on technological opportunities first.[4] As Henry Kissinger wrote: "Every country lives with the nightmare that . . . its survival may be jeopardized by a technological breakthrough on the part of its

1 For examples of recent work seeking to anticipate the implications of new weapons technologies, see Steve Fetter and Jaganath Sankaran, "Emerging Technologies and Challenges to Nuclear Stability," *Journal of Strategic Studies* 48, no. 2 (2025): 252–96, https://doi.org/10.1080/01402390.2024.2433766; Avi Goldfarb and Jon R. Lindsay, "Prediction and Judgment: Why Artificial Intelligence Increases the Importance of Humans in War," *International Security* 46, no. 3 (2022): 7–50, https://doi.org/10.1162/isec_a_00425; Michael C. Horowitz, "Do Emerging Military Technologies Matter for International Politics?," *Annual Review of Political Science* 23 (2020): 385–400, https://doi.org/10.1146/annurev-polisci-050718-032725; Michael C. Horowitz, "Battles of Precise Mass: Technology Is Remaking War—And America Must Adapt," *Foreign Affairs* 103, no. 6 (2024): 34–40, https://www.foreignaffairs.com/world/battles-precise-mass-technology-war-horowitz; Mark A. Milley and Eric Schmidt, "America Isn't Ready for the Wars of the Future: And They're Already Here," *Foreign Affairs* 103, no. 5 (2024): 26–37, https://www.foreignaffairs.com/united-states/ai-america-ready-wars-future-ukraine-israel-mark-milley-eric-schmidt; Todd S. Sechser, Neil Narang, and Caitlin Talmadge, "Emerging Technologies and Strategic Stability in Peacetime, Crisis, and War," *Journal of Strategic Studies* 42, no. 6 (2019): 727–35, https://doi.org/10.1080/01402390.2019.1626725. For a discussion of defense officials' preoccupation with ostensively disruptive technologies, see Joshua Rovner, *Strategy and Grand Strategy* (Routledge, 2025), 133–60.

2 Marita Sturken and Douglas Thomas, "Technological Visions and the Rhetoric of the New," in *Technological Visions: The Hopes and Fears That Shape New Technologies*, ed. Marita Sturken, Douglas Thomas, and Sanda J. Ball-Rokeach (Temple University Press, 2004), 2.

3 Jamie McKeown, "A Corpus-Based Investigation of Techno-Optimism and Propositional Certainty in the National Intelligence Council's 'Future Global Trends Reports' (2010–2035)," *Discourse & Communication* 12, no. 1 (2018): 39–57, https://doi.org/10.1177/1750481317735625.

4 Vinsel distinguishes technology hype from "criti-hype," with the latter anticipating deleterious effects of a supposedly revolutionary technology. See Lee Vinsel, "You're Doing It Wrong: Notes on Criticism and Technology Hype," *Medium*, February 1, 2021, https://sts-news.medium.com/youre-doing-it-wrong-notes-on-criticism-and-technology-hype-18b08b4307e5.

opponent."[5] Scholars thus invoke the dire need for anticipatory analysis of new weapons technologies as a step toward adoption, adaptation, or mitigation.[6]

Alongside more familiar political and strategic factors, these technological hopes and fears influence states' conduct in war.[7] Perception and misperception of adversaries' battlefield capabilities are key determinants of conflict initiation and escalation.[8] States are more likely to escalate when they perceive an imbalance in these capabilities, as might result from expectations of an incipient technological disruption that some states harness, while others remain unprepared.[9] Caleb Pomeroy contends that even militarily powerful states suffer from a pervasive anxiety over adversary capabilities, and in conflict "might overreact . . . because their leaders see threats everywhere."[10] Misperception of one's own capabilities can be similarly influential. Marina Favaro and Heather Williams attribute the initiation of the Russo-Ukrainian War, in part, to the faulty expectations of technological supremacy that left Russia overconfident in the likelihood of a swift victory.[11] Technological expectations further shape how states prepare for war. In seeking advantage over rivals, states commonly pursue "offset strategies" wherein they rapidly develop and deploy bundles of technologies that leaders envision will drive military technological revolutions.[12]

Yet, while perceptions of technological capabilities and expectations of future capabilities have a real effect on state behavior, they may or may not align with the performance of weapons systems in the physical world. Humans' forecasting is notoriously error-prone, due in part to overreliance on the most extreme—and thus unrepresentative—past experiences when extrapolating into the future.[13] Thus, we may frequently anticipate technological revolutions or grave disappointments, even if such outcomes are rare in the historical record. The subsequent technological surprise that occurs when faulty expectations are tested can take two forms, with systems outperforming expectations or, as is frequently the case, failing to live up to them.[14] Indeed, the history of military strategy and the security studies literature are littered with predictions of technological revolutions that never came to pass, while effective technologies were frequently unanticipated.[15]

Technological surprise provides leaders and analysts an opportunity to revisit their prior expectations. Given that technological expectations shape leaders' thinking about external threats, and thus states' behavior in conflict, reactions to the testing of those expectations on the battlefield could similarly shape states' conduct. Curiously, while much is written about the predicted future effects of so-called "emerging technologies,"[16] these pre-

5 Henry A. Kissinger, "Arms Control, Inspection and Surprise Attack," *Foreign Affairs* 38, no. 4 (July 1960): 557–75, https://www.foreignaffairs.com/articles/1960-07-01/arms-control-inspection-and-surprise-attack.

6 See, for example, warnings in the prior decade about an incipient yet overlooked cyber-warfare revolution in Lucas Kello, "The Meaning of the Cyber Revolution: Perils to Theory and Statecraft," *International Security* 38, no. 2 (Fall 2013): 7–40, https://doi.org/10.1162/ISEC_a_00138.

7 In the parlance of science and technology studies, expectations are "constitutive," meaning they shape the future development of these technologies and the behavior of those engaged with these technologies. See Mads Borup, Nik Brown, Kornelia Konrad, and Harro van Lente, "The Sociology of Expectations in Science and Technology," *Technology Analysis & Strategic Management* 18, nos. 3–4 (2006): 285–98, https://doi.org/10.1080/09537320600777002.

8 Robert Jervis, *Perception and Misperception in International Politics* (Princeton University Press, 1976).

9 Stuart A. Bremer, "Dangerous Dyads: Conditions Affecting the Likelihood of Interstate War, 1816–1965," *Journal of Conflict Resolution* 36, no. 2 (1992): 309–41, https://doi.org/10.1177/0022002792036002005.

10 Caleb Pomeroy, "The Damocles Delusion: The Sense of Power Inflates Threat Perception in World Politics," *International Organization* 79, no. 1 (2025): 22, https://doi.org/10.1017/S0020818324000407.

11 Marina Favaro and Heather Williams, "False Sense of Supremacy: Emerging Technologies, the War in Ukraine, and the Risk of Nuclear Escalation," *Journal for Peace and Nuclear Disarmament* 6, no. 1 (2023): 28–46, https://doi.org/10.1080/25751654.2023.2219437.

12 Jeppe T. Jacobsen and Katrine Nørgaard, "Reading Security Imaginaries as Fantasies—Loss, Desire, and Enjoyment in the Military Quest for Explainable AI," *Millennium* 52, no. 2 (2024): 408–33, https://doi.org/10.1177/03058298231225753.

13 Daniel T. Gilbert and Timothy D. Wilson, "Prospection: Experiencing the Future," *Science* 317, no. 5843 (2007): 1351–54, https://doi.org/10.1126/science.1144161. On the prominence of fallacious extrapolation in expert forecasting of world politics, see Philip E. Tetlock, "Theory-Driven Reasoning About Plausible Pasts and Probable Futures in World Politics: Are We Prisoners of Our Preconceptions?," *American Journal of Political Science* 43, no. 2 (1999): 335–66, https://doi.org/10.2307/2991798.

14 Frank W. Geels and Wim A. Smit, "Failed Technology Futures: Pitfalls and Lessons from a Historical Survey," *Futures* 32, no. 9 (2000): 867–85, https://doi.org/10.1016/S0016-3287(00)00036-7.

15 For recent examples of unrealized expectations, see warnings of a bioweapons revolution in Susan B. Martin, "The Role of Biological Weapons in International Politics: The Real Military Revolution," *Journal of Strategic Studies* 25, no. 1 (2002): 63–98, https://doi.org/10.1080/714004040; a cyber-warfare revolution in Kello, "The Meaning of the Cyber Revolution"; and the 3-D printing of nuclear weapons in Matthew Kroenig and Tristan Volpe, "3-D Printing the Bomb? The Nuclear Nonproliferation Challenge," *The Washington Quarterly* 38, no. 3 (2015): 7–19, https://doi.org/10.1080/0163660X.2015.1099022. For a recent example of failure to anticipate an effective military technology, see the study of the proliferation of small drones in Dominika Kunertova, "Drones Have Boots: Learning from Russia's War in Ukraine," *Contemporary Security Policy* 44, no. 4 (2023): 576–91, https://doi.org/10.1080/13523260.2023.2262792.

16 See, for example, Todd S. Sechser, Neil Narang, and Caitlin Talmadge, eds., *Emerging Technologies and International Stability* (Routledge, 2023).

dictions are rarely held to account. That is to say, the final stage of technological emergence—what happens when these technologies debut on the battlefield—is neglected by analysts and scholars. Does underperformance of an adversary's weapons technology prompt reassessment, assuaging anxiety among strategists and state leadership? Does overperformance heighten these anxieties, prompting recklessness? Or, are these expectations obdurate, such that the corresponding technological hopes and fears persist even in the face of contradictory evidence from the physical world?

Military history suggests that expectations can prove malleable, as when the success of US forces in the Gulf War, enabled in part by enhanced precision-strike technologies, quickly erased "pervasive" predictions of a military quagmire and "dire warnings" of heavy casualties akin to those of the Vietnam War.[17] Yet adaptation to unanticipated processes of technological change can also prove slow, as when British leadership failed to appreciate the effects of the machine gun on the efficacy of entrenched defenses early in the First World War.[18] It subsequently took the armies of the Western Front several years to develop the combined arms tactics that again enabled offensive operations in this new technological context.[19]

In this article, I systematically examine the reassessment process that follows the battlefield debut of weapons systems and the misalignment of their expected and actual performance, developing a theory of technology normalization through use. For weapons that underperform expectations, discourses of their revolutionary character are supplanted by depictions of them as "normal" weapons, comparable to older, more familiar varieties. For those that overperform expectations, depictions of them as unsophisticated technologies unworthy of significant attention are similarly supplanted by discourses of their modestly effective nature—in other words, their normality. In both cases, use serves to demonstrate that new weapons technologies can fit within existing structures of war, helping to temper anxieties about technological disruption to those structures and drawing attention to technological threats that were previously overlooked. To be clear, this is not to say that all weapons technologies follow this path; some, like nuclear weapons, clearly acquire an aura of exceptionalism following their use.[20] Rather, this is an argument about what is typical in processes of military technological change, and thus what should be most often expected in the forecasting of those processes.

I find misalignment between expectations and performance for all systems studied, following either overestimation or underestimation of performance.

I test this theory through analysis of the debut of several Russian long-range precision-strike systems in the ongoing Russo-Ukrainian War, and of subsequent reassessment of their capabilities and military implications by Russia's adversaries. Long-range precision-strike weapons, including missiles and guided bombs, offer an ideal subject for this analysis. Their purported security implications are widely discussed,[21] and several such systems, representing both novel and established weapons technologies, have been used for the first time over the course of the Russo-Ukrainian War. I find misalignment between expectations and performance for all systems studied, following either overestimation or underestimation of performance. I track the effects of these two modes of technological surprise on discourses—primarily among Russia's NATO adversaries—about the security implications of these weapons, observing a common trend of normalization. These findings indicate that those engaged in the assessment and anticipation of new weapons technologies would do well to consider, first and foremost, how these technologies might perform in operational roles corresponding to war as it is fought today, rather than speculating on how they might change the nature of warfare or assuming that they have little to offer on the modern battlefield.

I proceed by first reviewing the literature on technological revolutions in military affairs, noting the

17 Williamson Murray, *America and the Future of War: The Past as Prologue* (Hoover Institution Press, 2017), 25–27.

18 John Ellis, *The Social History of the Machine Gun* (Johns Hopkins University Press, 1986), 111–48.

19 Murray, *America and the Future of War*, 59.

20 Robert Jervis, *The Meaning of the Nuclear Revolution: Statecraft and the Prospect of Armageddon* (Cornell University Press, 1990).

21 See, for example, a recent special issue on the topic introduced in Joshua H. Pollack, "Introduction to the Special Section on Non-Nuclear-Armed States, Precision Strike, and Nuclear Risk," *The Nonproliferation Review* 27, nos. 1–3 (2020): 17–19, https://doi.org/10.1080/10736700.2020.2005293.

frequent inaccuracies of forecasts. Drawing from theory on the sociology of technological expectations, I then explain the process of normalization through use, wherein expectations of technological performance give way to normalizing discourses when confronted by experience with the use of a technology. Next, I analyze the recent debut, performance, and shifting discursive framing of four Russian weapons systems: the Kinzhal hypersonic boost-glide missile, the Tsirkon hypersonic cruise missile, the Oreshnik intermediate-range ballistic missile, and the UMPK glide bomb.[22] I end with a discussion of the implications of my findings for the analysis of new weapons technologies.

Expectations of Technological Revolution

Perhaps the most prevalent narrative of technological change in Western military discourses is that of technological revolution, wherein the development of a new technology or group of technologies fundamentally alters the character of war (as, for instance, in the example of the machine gun in the First World War). Strategists and policymakers appear particularly prone to high expectations about the performance and security implications of new weapons technologies.[23] These communities are thus incentivized to attempt to anticipate technological innovations, so as to avoid the deleterious effects of technological surprise.[24]

These expectations of technological disruptions manifest in the popularity of "offset strategies," which seek to compensate for adversary advantages through dominance in certain weapons technologies expected to prove decisive in future conflicts.[25] In the earliest manifestation of these strategies, the United States relied on nuclear weapons and their deterrent effects to offset inferiority to Cold War rivals in conventional forces (see Francis Gavin's contribution to this Roundtable). The "second offset strategy" emphasized the belief that innovations in intelligence, surveillance, reconnaissance, precision weapon guidance, stealth, and space-based communication technologies would revolutionize warfare—a belief seemingly confirmed by US success in the 1991 Gulf War. In the 2010s, the "third offset strategy" turned to autonomy, robotics, and big data to counter perceived threats from Russian and Chinese anti-access / area denial systems.[26] In recent years, some have called for a new, fourth offset, though it remains unclear precisely what bundle of technologies would comprise it.[27]

In parallel to these offset strategies, a focus on revolutions in military affairs (RMAs) emerged in Western security discourses in the 1990s. This discourse initially emphasized advancements in information technology and long-range precision-strike weapons. RMA theory points to purportedly disruptive, periodic shifts in "the character of warfare itself" due to the emergence of new, military-relevant technologies.[28] RMA proponents typically argue that military organizations must shift budgetary priorities and doctrines to adapt to these shifts, lest they be left in the wake of a changing technological basis for modern warfare.[29]

In addition to war planners and policymakers, scholars and analysts often warn of coming technological revolutions in warfare. For instance, some scholars predict an incipient cyber-warfare revolution,[30] while others predict "a cascade of nuclear weapons proliferation" as 3-D printing of nuclear warhead components becomes commonplace.[31] Perhaps the most common subject of revolution narratives in recent years is AI, based on the assertion that militaries must prepare for a near future in

22 The Kinzhal is sometimes described as an aeroballistic, rather than hypersonic, missile. The Oreshnik is sometimes described as a medium-range, rather than intermediate-range, ballistic missile. I discuss both distinctions in more detail later in the article.

23 Neil C. Renic, "Superweapons and the Myth of Technological Peace," *European Journal of International Relations* 29, no. 1 (2023): 129–52, https://doi.org/10.1177/13540661221136764; Ash Rossiter, "Hyping Emerging Military Technology: Probing the Causes and Consequences of Excessive Expectations," *International Relations* (2023), https://doi.org/10.1177/00471178231186256.

24 Michael I. Handel, "Technological Surprise in War," *Intelligence and National Security* 2, no. 1 (1987): 1–53, https://doi.org/10.1080/02684528708431875.

25 Jacobsen and Nørgaard, "Reading Security Imaginaries as Fantasies."

26 Gian Gentile, Michael Shurkin, Alexandra T. Evans, Michelle Grisé, Mark Hvizda, and Rebecca Jensen, *A History of the Third Offset, 2014–2018* (RAND Corporation, 2021), https://www.rand.org/pubs/research_reports/RRA454-1.html.

27 See, for example, Paul Calhoun, "Energy Web Dominance: A Proposal for a Fourth Offset Strategy," *Æther: A Journal of Strategic Airpower & Spacepower* 3, no. 2 (2024): 43–58, https://www.airuniversity.af.edu/Portals/10/AEtherJournal/Journals/Volume-3_Number-2/Calhoun.pdf; Louis A. Del Monte, *War at the Speed of Light: Directed-Energy Weapons and the Future of Twenty-First-Century Warfare* (University of Nebraska Press, 2021).

28 Eliot A. Cohen, "Change and Transformation in Military Affairs," *Journal of Strategic Studies* 27, no. 3 (2004): 395–407, https://doi.org/10.1080/1362369042000283958.

29 For an overview of RMA theory and the associated policy arguments, see Lawrence Freedman, *The Revolution in Strategic Affairs* (Oxford University Press, 1998).

30 Kello, "The Meaning of the Cyber Revolution." For older predictions of a coming cyberwar revolution, see John Arquilla and David Ronfeldt, "Cyberwar Is Coming!," *Comparative Strategy* 12, no. 2 (Spring 1993): 141–65, https://doi.org/10.1080/01495939308402915.

31 Kroenig and Volpe, "3-D Printing the Bomb?," 8.

which this technology "alters the nature of war."[32]

This attention to the potential military utility of future technologies aims to prevent one type of technological surprise, stemming from failure to anticipate and adapt to technological shifts. Technological surprise, however, can also result from inaccurate projections of the performance and implications of future technologies. In some cases, the technologies expected to emerge may fail to do so, as in the case of US plans to deploy various ballistic missile defenses, such as directed energy weapons, under the 1980s Strategic Defense Initiative. While skeptics pointed out that many of the planned technologies had "not yet been built in the laboratory, much less in a form suitable for incorporation in a complete defense system," enthusiasm for these systems persisted in defense communities.[33]

For those technologies that are developed and deployed, expectations are eventually confronted by the physical realities of use. As Herbert Lin points out in this Roundtable, disappointment on behalf of the user is a common outcome. Hype-cycle theories point to failure to live up to expectations as a general trend of technological innovation,[34] while research in the field of science and technology studies indicates that "evolution from broad sweeping promises to more down-to-earth assessments is inherent in technological developments."[35] While technological performance may sometimes exceed expectations, proponents of a given technology are incentivized to make grandiose claims so as to attract attention and funding, frequently prompting later disappointment.[36] These incentives influence not only actors like defense officials and contractors who are directly involved in weapons development, but also scholars and researchers who are frequently enrolled as supporters of such programs (and as recipients of associated funding).[37] Technological disappointment is seen in relation to many of the purported military revolutions discussed previously. For instance, early enthusiasm for the 1990s RMA waned as militaries brought digital technologies to the battlefield and encountered their limitations, particularly in irregular and unconventional conflicts like the Iraq War.[38] Predictions of cybercentric warfare have likewise failed to materialize, although cyber operations have played more modest roles in recent conflicts.[39]

Given the frequency with which strategists, policymakers, and analysts anticipate technological revolutions, and the frequency with which these predictions prove inaccurate, it behooves scholars to examine more closely what happens when technological expectations meet physical reality. This retrospection is particularly important for weapons technologies, which see unique patterns of use. Long periods of development—which create space for those forecasting performance to do so with minimal interference by the physical world—are punctuated by relatively brief periods of war in which those expectations are tested. Battlefield use offers an opportunity, though not a requirement, to reassess earlier predictions in light of new evidence. As Harro van Lente, Charlotte Spitters, and Alexander Peine argue, when it comes to technological emergence, "what happens after hype is probably more interesting than the occurrence of the hype itself."[40]

Technological Reassessment and Normalization Through Use

Research in science and technology studies, particularly work on the sociology of expectations, provides a basis for the study of weapons-technology assessment and reassessment following use.[41] Early

32 Kenneth Payne, *I, Warbot: The Dawn of Artificially Intelligent Conflict* (Oxford University Press, 2021), 83.

33 Ashton B. Carter, *Directed Energy Missile Defense in Space* (Office of Technology Assessment, 1984), 81. Four decades later, directed-energy weapons capable of defending against an intercontinental ballistic missile remain a speculative technology. For an overview of efforts to develop and deploy these technologies, see Lauren J. Borja, "High-Energy Laser Directed Energy Weapons," in *Routledge Handbook of the Future of Warfare*, ed. Artur Gruszczak and Sebastian Kaempf (Routledge, 2023), 353–63.

34 Harro van Lente, Charlotte Spitters, and Alexander Peine, "Comparing Technological Hype Cycles: Towards a Theory," *Technological Forecasting and Social Change* 80, no. 8 (2013): 1615–28, https://doi.org/10.1016/j.techfore.2012.12.004.

35 Geels and Smit, "Failed Technology Futures," 867.

36 Cameron L. Tracy, "Weapons Design, Engineering Ethics, and the Duty to Inform: A Case Study on US Hypersonic Missile Development," *IEEE Technology and Society Magazine* 43, no. 4 (2024): 83–95, https://doi.org/10.1109/MTS.2024.3434518.

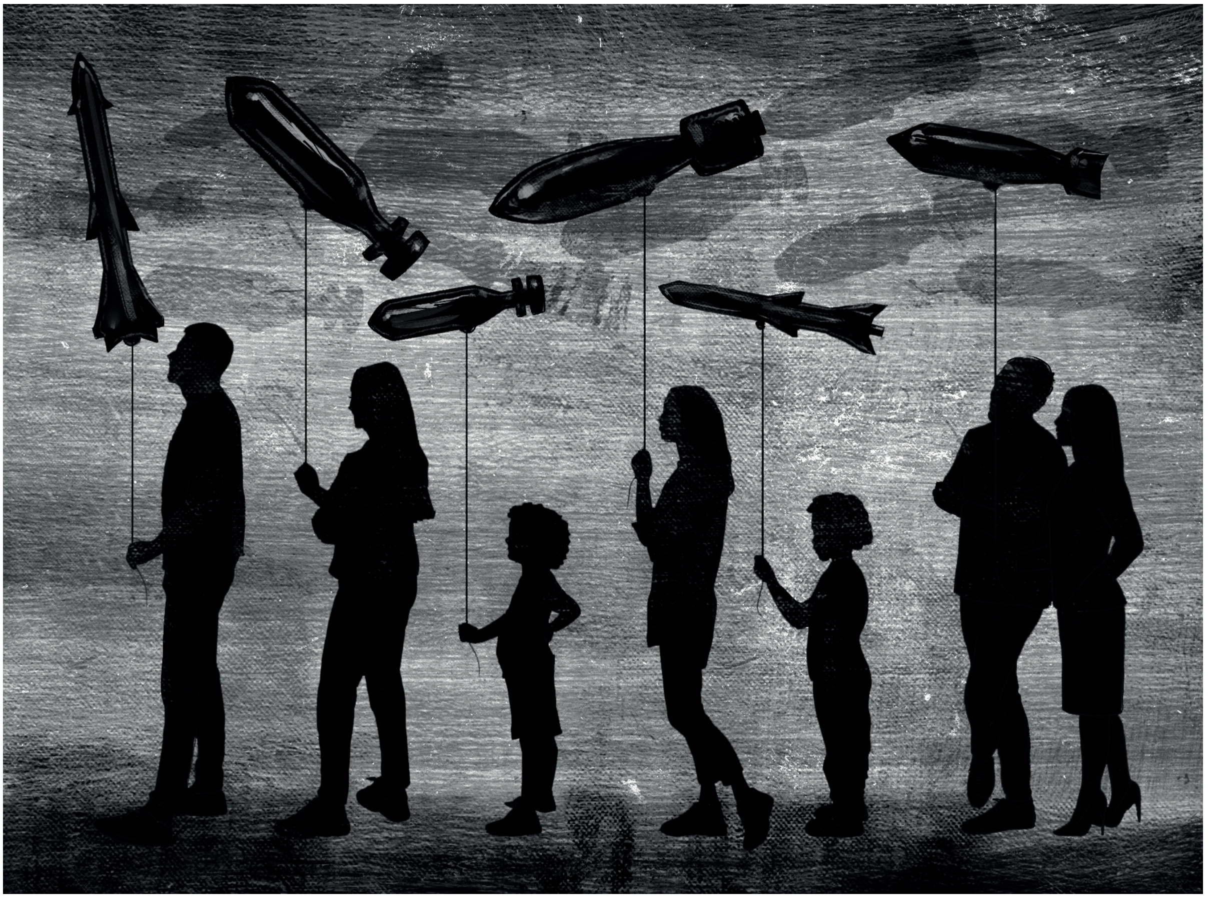
37 See, for example, the discussion of the enrollment of members of the scientific community as supporters of the Polaris missile program, such that "potential critics of the . . . development effort were drawn into the program and implicated in its activities," in Harvey M. Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government* (Harvard University Press, 1972), 48–50.

38 Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton University Press, 2004); Stephen Biddle, "The Past as Prologue: Assessing Theories of Future Warfare," *Security Studies* 8, no. 1 (1998): 1–74, https://doi.org/10.1080/09636419808429365; Keith L. Shimko, *The Iraq Wars and America's Military Revolution* (Cambridge University Press, 2010).

39 Erik Gartzke, "The Myth of Cyberwar: Bringing War in Cyberspace Back Down to Earth," *International Security* 38, no. 2 (Fall 2013): 41–73, https://doi.org/10.1162/ISEC_a_00136; Brandon Valeriano and Ryan C. Maness, *Cyber War Versus Cyber Realities: Cyber Conflict in the International System* (Oxford University Press, 2015).

40 Van Lente et al., "Comparing Technological Hype Cycles," 1625.

41 For an overview of research in this area, see Borup et al., "The Sociology of Expectations in Science and Technology."



work in the field developed the concept of technological "closure," describing processes wherein competing interpretations of the design, use, and implications of a technology stabilize within and between various social groups engaged with it.[42] A classic example involves the development of the air-filled bicycle tire in the late nineteenth century. Early in its development the technology proved divisive, with some promoting it as a more comfortable alternative to older tire designs, while others demonized it for aesthetic and safety reasons. Competitive cyclists were largely indifferent, if not hostile, such that "when, for the first time, the tire was used at the racing track, its entry was hailed with derisive laughter. This was, however, quickly silenced by the high speed achieved, and there was only astonishment left when it outpaced all rivals. . . . After a short period no racer of any pretensions troubled to compete on anything else."[43]

This example first demonstrates one variety of technological surprise, as the new tire technology outperformed the expectations of competitive cyclists. Yet it further demonstrates a subsequent process of normalization: Shortly after its debut, the technology was rapidly integrated into existing traditions of use, becoming a typical part of those practices rather than radically disrupting them.

A similar normalization process can be traced in the emergence of microelectronics in the 1980s, though starting in this instance from a place of outsized expectations. The promise of small-scale computing was initially "seen as transforming society and became the subject of a number of hopes and fears" revolving around, for instance, visions of mass disruption to labor markets as robotic devices supplanted human workers.[44] Yet Robin Williams argues that "today, when these technologies are widely adopted, their capabilities and implications are better understood and have come to be recognized as rather mundane," supplementing rather than supplanting laborers in most professions, and exhibiting many uses oriented toward entertainment and diversion rather than

42 Trevor J. Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *Social Studies of Science* 14, no. 3 (1984): 399–441, https://doi.org/10.1177/030631284014003004.

43 Pinch and Bijker, "The Social Construction of Facts and Artefacts," 427–28.

44 Robin Williams, "Compressed Foresight and Narrative Bias: Pitfalls in Assessing High Technology Futures," *Science as Culture* 15, no. 4 (2006): 333, https://doi.org/10.1080/09505430601022668.

productivity.[45] Michael Horowitz's contribution to this Roundtable outlines a related process by which computational technologies initially deemed "intelligent" are now seen as mundane relative to a newly constructed notion of "true" artificial intelligence.

We see here what John Gardner, Gabrielle Samuel, and Clare Williams describe as a process of "recalibration" after expectations of a technology's performance and implications meet with empirical observation of the use of that technology, thereby facilitating a shift from a "regime of hope" to a "regime of truth."[46] Those "truths," as mediated by the physical world, tend to be more mundane than those caught up in hopes and fears of technological revolutions would predict. Reassessment subsequently shapes how those engaged with a technology approach its use and governance, because technological closure "restructures the participants' world." In other words, "history is rewritten after such a closure," and older framings of a technology are supplanted by new framings.[47]

Beyond everyday technologies like bicycles and personal computers, should we expect the same for technologies of war? The history of the early battlefield use of chemical weapons, serving here as a revealing example, suggests that we should. Prior to their use, expectations of chemical armaments centered on conceptions of a perfidious weapon against which there could be no defense. Richard Price, in his analysis of reactions to the widespread use of these weapons in the First World War, contends that initial experience with their use prompted a dramatic shift in framing: "As soldiers became more familiar with the use of gas and defenses against it, many of the initial inhibitions ebbed and gas became increasingly—though grudgingly—accepted as another unavoidable technology of modern warfare that one may as well get used to."[48] By the end of that war, it was widely accepted among the combatants that "the chemical threat did not differ markedly from that posed by high explosive weapons" and "by no stretch of an informed imagination could it be seen as a super-weapon."[49] Records from the negotiation of the 1922 Washington Naval Conference on arms limitations show that American, British, and French representatives "who know gas, were emphatic that chemical warfare gases form a method of waging war similar to the older forms."[50] In short, high expectations of chemical-weapon performance were supplanted by disappointment in their actual effects, swiftly giving way to a discursive normalization that situated chemical munitions alongside less exotic systems like conventional explosives. This depiction contrasts starkly with pre-use discourses that, absent an empirical record of use against which to judge its implications, offered "fertile soil for vivid and terrifying imaginings of the future of gas warfare."[51]

Initial discourses that cast these technologies as either disruptive or archaic thus give way, in the wake of technological surprise, to discourses that place them in the same categories as more familiar, "normal" technologies.

Drawing on this insight, I argue that normalization through use should be expected as a general outcome of the battlefield debut of new weapons systems. This perspective constitutes an alternative view of military technological change: not one of periodic revolutions in military affairs, where new technologies disrupt and radically reconfigure ways of war, but rather one in which dominant modes of warfare are obdurate, disruptions to them are rare, and new technologies tend to be subsumed into existing ways of war. I further argue that this normalization process manifests in dominant discourses about these weapons, serving to reconcile

45 Williams, "Compressed Foresight and Narrative Bias."

46 John Gardner, Gabrielle Samuel, and Clare Williams, "Sociology of Low Expectations: Recalibration as Innovation Work in Biomedicine," *Science, Technology, & Human Values* 40, no. 6 (2015): 998–1021, https://doi.org/10.1177/0162243915585579.

47 Wiebe E. Bijker, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change* (MIT Press, 1997), 85.

48 Richard M. Price, *The Chemical Weapons Taboo* (Cornell University Press, 1997), 65–66. Effective defenses included simple measures like the use of gas masks or even urine-soaked rags wrapped around the face.

49 Julian Perry Robinson and Milton Leitenberg, *The Problem of Chemical and Biological Warfare, Volume I: The Rise of CB Weapons* (*SIPRI*, 1971), 248.

50 *Conference on the Limitation of Armament, Washington, November 12, 1921–February 6, 1922* (US Government Printing Office, 1922), 730.

51 Price, *The Chemical Weapons Taboo*, 67. In addition to this relationship between use and normalization, the inverse is apparent. Price attributes the negotiation of the Chemical Weapons Convention, in part, to a protracted period of non-use of these weapons in conflicts between Western powers (including in the European theater of the Second World War), alongside their association with colonial conflicts, the North Yemeni Civil War, and the Iran-Iraq War, which together prompted a renewed exoticization of chemical warfare. See Price, *The Chemical Weapons Taboo*, 70–163.

unrealized expectations about weapons-technology performance with experience and observation that proves hostile to those earlier imaginings. Initial discourses that cast these technologies as either disruptive or archaic thus give way, in the wake of technological surprise, to discourses that place them in the same categories as more familiar, "normal" technologies. Crucially, and in contrast to hype-cycle models, this theory of normalization through use is symmetric, applying equally to technologies whose performance is initially both overestimated and underestimated. In the remainder of this article, I demonstrate how normalization through use proceeded for four long-range precision-strike systems that made their debut in the ongoing Russo-Ukrainian War.

Expectations, Use, and Reassessment of Russian Long-Range Precision-Strike Weapons

Testing this theory of normalization through use requires the tracing of expectations of—and reactions to—processes of military technological change. Note that technological change is not the same as invention or innovation. It includes both, but also includes distinct processes like the readoption of technologies after a period of non-use or the incremental redesign of established technologies. Looking at the global history of technology over the last century, David Edgerton argues that the latter processes are both widespread and frequently underappreciated by scholars.[52]

Following this logic, I analyze the debut of weapons systems that are based on both "old" and "new" technologies. This dual focus facilitates the analysis of both forms of technological surprise discussed previously: overestimation of the performance of ostensibly revolutionary technologies and underestimation of the performance of ostensibly archaic technologies. Thus, rather than selecting cases for analysis based on the valence of expectations, I select a category of weapons system—long-range precision-strike weapons—and analyze the systems that Russia first used in the Russo-Ukrainian War. This conflict presents a rare instance of a militarily powerful state engaging in the full-scale invasion of an adversary armed with sophisticated military technologies—many provided by the United States and the European Union—making this war an ideal setting for study of the debut of weapons systems. Indeed, Russia has debuted a wide range of military technologies over the course of the war.[53]

I focus on systems that allow for the projection of force via accurate delivery of large explosive devices from standoff distances ranging from around one hundred to a few thousand kilometers. Having failed repeatedly to establish air superiority in Ukraine, Russia has made extensive use of these long-range precision-strike systems, including a variety of missile and glide-bomb technologies, to attack Ukrainian positions while keeping launch platforms outside the range of Ukrainian strike capabilities and air defenses.[54] Note that my analysis excludes the small drones that have been widely used in the Russo-Ukrainian War, since those carry explosives of relatively low yield and thus execute missions distinct from those of missiles and glide bombs.[55]

Below, I assess four long-range precision-strike weapons that Russia first used in this conflict: the Kinzhal hypersonic boost-glide missile, the Tsirkon hypersonic cruise missile, the Oreshnik intermediate-range ballistic missile, and the UMPK glide bomb. Hypersonic weapons are a relatively novel class of missile technology not previously used on the battlefield. Intermediate-range ballistic missiles were first deployed in the late 1950s, but were not deployed by the United States or Russia for many decades under the terms of the recently abandoned 1987 Intermediate-Range Nuclear Forces Treaty, and lack a history of use. In contrast to both, glide bombs have seen extensive use since the Second World War. Thus, while all four of the Russian systems studied are new, the technologies on which they are based represent a broad spectrum in terms of novelty and in terms of initial expectations of their performance and military implications.

For each system, I analyze pre-use expectations regarding its capabilities, assess its actual battlefield performance relative to those expectations, and trace post-use evolution in discourses about its military implications. I focus on the expectations of policymakers, analysts, and scholars engaged in fields relevant to international security, as expressed in governmental reports and scholarly literature, as well as quotations in mass media. While expectations differed widely among these systems—from intense hype of hypersonic weapons to broad disinterest in glide bombs—in all cases, assessments evolved rapidly following use, converging toward a normalized discourse of significant yet modest efficacy.

52 David Edgerton, *The Shock of the Old: Technology and Global History Since 1900* (Oxford University Press, 2007).

53 Emmanuel Grynszpan, "Russia Steps Up Use of New Military Technologies Against Ukraine, Including AI," *Le Monde*, June 7, 2025, https://www.lemonde.fr/en/international/article/2025/06/07/russia-steps-up-use-of-new-military-technologies-against-ukraine-including-ai_6742108_4.html.

54 Jaganath Sankaran, "The Failures of Russian Aerospace Forces in the Russia–Ukraine War and the Future of Air Power," *Journal of Strategic Studies* 47, nos. 6–7 (2024): 860–87, https://doi.org/10.1080/01402390.2024.2345899.

55 Kunertova, "Drones Have Boots."

Kh-47M2 Kinzhal

The Kinzhal (Russian for "dagger") is an updated version of the ground-launched Iskander-M missile, modified for launch from MiG-31 and Su-34 aircraft.[56] It likely has an operational range, once launched from the aircraft carrying it, of around 500 kilometers, and achieves a maximum velocity in the range of Mach 5–10. The Kinzhal is often described as a hypersonic missile, although this term is poorly defined.

The "hypersonic" designation refers, in a technical sense, to a velocity regime of greater than Mach 5, or five times the speed of sound.[57] This definition does not, however, reflect the term's use in the world of weapons technology. All ballistic missiles with ranges greater than a few hundred kilometers achieve these speeds, but ballistic missiles are conventionally excluded from the hypersonic weapons category. What ultimately distinguishes hypersonic missiles from their ballistic counterparts is their reliance on aerodynamic lift to stay aloft for much of their flight trajectories.[58] Hypersonic boost-glide missiles, after a brief period of acceleration during an initial boost phase, spend much of their flight gliding, unpowered, through the atmosphere at hypersonic speeds. They are designed to generate lift sufficient to sustain that flight to their targets. Ballistic missiles might also fly through the atmosphere at hypersonic speeds, particularly when launched on depressed trajectories, but they rely on a high initial velocity to reach their targets, rather than aerodynamic glide. The generation of lift by hypersonic missiles, in addition to extending their range, grants them the ability to maneuver during the glide portion of their flight, although this incurs significant costs in terms of range and velocity.[59] The Kinzhal is sometimes described as aeroballistic rather than hypersonic because, while it flies at hypersonic velocities through the atmosphere, its ability to generate lift and to maneuver may be more limited than that of other hypersonic missile systems.[60] The distinction between these two classes of missile, however, is ambiguous.

On first publicizing the development of the Kinzhal in 2018, Russian President Vladimir Putin described it as a hypersonic weapon, and this framing was subsequently adopted by many commentators.[61] This classification aligned the weapon with a widespread pattern of both hype and anxiety, among Western analysts, over Russia's deployment of hypersonic systems. Journalists, scholars, and government officials widely depicted hypersonic weapons, the Kinzhal among them, as a "game-changing technology"[62] poised to "revolutionize warfare."[63] Their speed and the supposed difficulty of detecting them with existing sensors[64] would purportedly leave those targeted with "insufficient time . . . to confidently identify and confirm the nature of an incoming attack, let alone to decide how to respond."[65] This combination of speed and stealth was also claimed to render interception of hypersonic missiles impossible. In the words of former US Chairman of the Joint Chiefs of Staff Mark Milley: "There is no defense against hypersonic. . . . Those things are going so fast, you're not going to get it."[66]

56 Jill Hruby, *Russia's New Nuclear Weapon Delivery Systems: An Open-Source Technical Review* (Nuclear Threat Initiative, 2019), https://media.nti.org/documents/NTI-Hruby_FINAL.pdf.

57 John D. Anderson Jr., *Hypersonic and High-Temperature Gas Dynamics*, 3rd ed. (American Institute of Aeronautics and Astronautics, 2000).

58 David Wright and Cameron L. Tracy, "Hypersonic Weapons: Vulnerability to Missile Defenses and Comparison to MaRVs," *Science & Global Security* 31, no. 3 (2023): 68–114, https://doi.org/10.1080/08929882.2023.2270292.

59 Cameron L. Tracy and David Wright, "Modeling the Performance of Hypersonic Boost-Glide Missiles," *Science & Global Security* 28, no. 3 (2020): 135–70, https://doi.org/10.1080/08929882.2020.1864945; Wright and Tracy, "Hypersonic Weapons."

60 Hruby, *Russia's New Nuclear Weapon Delivery Systems*.

61 See, for example, Matthew Bodner, "Russia's Hypersonic Missile Debuts Alongside New Military Tech at Parade," *Defense News*, May 9, 2018, https://www.defensenews.com/industry/techwatch/2018/05/09/russias-hypersonic-missile-debuts-alongside-new-military-tech-at-parade/; Shannon Bugos and Kingston Reif, *Understanding Hypersonic Weapons: Managing the Allure and the Risks* (Arms Control Association, 2021), https://www.armscontrol.org/sites/default/files/files/Reports/ACA_Report_HypersonicWeapons_2021.pdf; Sidarth Kaushal, "Putting the Russian Hypersonic Threat in Perspective," Royal United Services Institute, September 28, 2021, https://www.rusi.org/explore-our-research/publications/commentary/putting-russian-hypersonic-threat-perspective; Robert J. Smith, "Hypersonic Missiles Are Unstoppable. And They're Starting a New Global Arms Race," *The New York Times*, June 19, 2019, https://www.nytimes.com/2019/06/19/magazine/hypersonic-missiles.html.

62 Smith, "Hypersonic Missiles Are Unstoppable."

63 Robert Ashley, "Statement for the Record, Worldwide Threat Assessment, Armed Services Committee, US Senate," March 6, 2018, https://www.armed-services.senate.gov/imo/media/doc/Ashley_03-06-18.pdf.

64 Masao Dahlgren, "Getting on Track: Space and Airborne Sensors for Hypersonic Missile Defense," CSIS, 2023, https://csis-website-prod.s3.amazonaws.com/s3fs-public/2023-12/231218_Dahlgren_Getting_Track_0.pdf.

65 Seyom Brown, "The New Nuclear MADness," *Survival* 62, no. 1 (2020): 81, https://doi.org/10.1080/00396338.2020.1715067.

66 Statement by Gen. Mark Milley, quoted in Senate Armed Services Committee, *Hearing to Receive Testimony on the Department of Defense Budget Posture in Review of the Defense Authorization Request for Fiscal Year 2021 and the Future Years Defense Program* (Alderson Court Reporting, 2020), 99–100, https://www.armed-services.senate.gov/imo/media/doc/20-13_03-04-2020.pdf. The former commander of STRATCOM, Gen. John Hyten, concurred: "We do not have any defense that could deny the employment of such a weapon against us." See Senate Armed Services Committee, *Hearing to Receive Testimony on the United States Strategic Command in Review of the Defense Authorization Request for Fiscal Year 2019 and the Future Years Defense Program* (Alderson Court Reporting, 2018), 14, https://www.armed-services.senate.gov/imo/media/doc/18-28_03-20-18.pdf.

These expectations of revolutionary performance first met with battlefield experience in March 2022, when Russia launched Kinzhals at two Ukrainian supply depots.[67] Russia followed up in subsequent months with launches targeting the cities of Odesa and Kyiv.[68] Notably, these storage sites and urban centers were targets that Russia could have attacked with non-hypersonic ballistic or cruise missiles, to similar effect.[69] Indeed, while the first use of this much-vaunted weapon was notable enough to prompt a reply from US President Joe Biden, his take was relatively measured: "It's a consequential weapon . . . but with the same warhead on it as any other launched missile. It doesn't make that much difference, except it's almost impossible to stop it."[70] This downplaying of the Kinzhal's security implications was mirrored by then–Secretary of Defense Lloyd Austin, who stated that he "would not see it as a game changer,"[71] and by Milley, who noted that "we are not seeing really significant or game-changing effects to date with the . . . hypersonics that the Russians have used."[72] Foreign counterparts concurred, with the United Kingdom's Ministry of Defense concluding that "deployment of Kinzhal is highly unlikely to materially affect the outcome" of the war.[73] One analyst summed up the general sentiment thusly: "A missile is a missile, and the Russians shot nearly one thousand of them at Ukraine. It is not significant that the missile . . . flies over Mach 5 or not."[74]

These reactions from analysts, scholars, and government officials, including those who previously espoused a belief in the game-changing nature of hypersonic weapons, illustrate the initial stages of a normalizing discourse, minimizing the security implications of this weapons system's deployment and grouping it alongside other, less exoticized missile technologies. Still, narratives of the impossibility of defense against hypersonic weapons persisted, as seen in President Biden's statement. By this point, the Kinzhal had not yet been tested against the missile defenses that Ukraine employed. That changed in the subsequent year.

Ukraine has since continued to intercept Kinzhals, reportedly succeeding in about one-quarter of intercept attempts.

On May 4th, 2023, Ukrainian forces responded to a Kinzhal attack on Kyiv using a MIM-104 Patriot missile-defense system, produced by the United States and supplied by Germany.[75] The Patriot system successfully intercepted the incoming missile. On May 16th, Ukraine again neutralized a Kinzhal attack, this time intercepting a volley of six.[76] Ukraine has since continued to intercept Kinzhals, reportedly succeeding in about one-quarter of intercept attempts.[77] This rate of success is similar to

67 Tom Ball, "Russia's First Hypersonic Missile Strikes Hit Fuel and Storage Depots in Ukraine," *The Times*, March 21, 2022, https://www.thetimes.com/world/russia-ukraine-war/article/russia-launches-first-hypothermic-missile-strikes-on-fuel-and-storage-depots-in-ukraine-r83qxhv6t.

68 Tom Balmforth and Dan Peleschuk, "Russian Strikes Kill 11 in Ukraine, Zelenskiy Says Intimidation Effort Failed," *Reuters*, January 26, 2023; Laura King, Jaweed Kaleem, and Sarah Parvini, "Odesa Pounded by Multiple Missiles as Russia Hits Ukraine's Ports," *The Los Angeles Times*, May 10, 2022, https://www.latimes.com/world-nation/story/2022-05-10/ukraine-russia-odesa-missiles-attack-ports.

69 Spenser A. Warren, "Russian Novel Nuclear Weapons and War-Fighting Capabilities," *Parameters* 55, no. 1 (2025): 39–52, https://doi.org/10.55540/0031-1723.3330.

70 The White House, "Remarks by President Biden Before Business Roundtable's CEO Quarterly Meeting," https://bidenwhitehouse.archives.gov/briefing-room/speeches-remarks/2022/03/21/remarks-by-president-biden-before-business-roundtables-ceo-quarterly-meeting/.

71 "Transcript: Defense Secretary Lloyd Austin on 'Face the Nation,' March 20, 2022," *CBS News*, March 20, 2022, https://www.cbsnews.com/news/lloyd-austin-defense-secretary-transcript-face-the-nation-03-20-2022/.

72 House of Representatives Committee on Appropriations, *Hearings Before a Subcommittee of the Committee on Appropriations: House of Representatives, One Hundred Seventeenth Congress, Second Session, Subcommittee on Defense* (US Government Publishing Office, 2022), 47, https://www.congress.gov/117/chrg/CHRG-117hhrg48815/CHRG-117hhrg48815.pdf.

73 UK Ministry of Defence (@DefenceHQ), "Latest Defence Intelligence Update on the Situation in Ukraine—21 March 2022," Twitter, March 21, 2022, https://x.com/DefenceHQ/status/1506031949386813446?t=ZMvpMrU8v2etZUMuPlha_A.

74 Thomas Novelly, "Russia's Alleged Use of First Hypersonic Missile in Combat Downplayed by US Military and Allies," *Military.com*, March 22, 2022, https://www.military.com/daily-news/2022/03/22/russias-alleged-use-of-first-hypersonic-missile-combat-downplayed-us-military-and-allies.html. For examples of similar treatment in the scholarly literature, see Favaro and Williams, "False Sense of Supremacy," 34, where the authors write that "use of hypersonics does not seem to have conferred any strategic advantage in the war in Ukraine for Moscow," and Warren, "Russian Novel Nuclear Weapons and War-Fighting Capabilities," 42, where the author writes that the effects of the Kinzhal were "not significantly different from the impact of other ballistic missiles Russia has used throughout the war."

75 David Rising, "Ukraine Downs Russian Hypersonic Missile with US Patriot," *AP News*, May 6, 2023, https://apnews.com/article/russia-ukraine-war-patriot-kinzhal-6b59af8e60853b4d6d16dd8d607768be.

76 Victoria Kim and Eric Schmitt, "Ukraine Says It Shot Down Hypersonic Russian Missiles over Kyiv," *The New York Times*, May 16, 2023, https://www.nytimes.com/2023/05/16/world/europe/ukraine-russia-hypersonic-kinzhal-patriot.html.

77 Jake Epstein, "Russia's Unstoppable Hypersonic Missiles Had Another Bad Night," *Business Insider*, November 19, 2024, https://www.businessinsider.com/russia-unstoppable-hypersonic-missiles-had-another-bad-night-ukraine-says-2024-11.

or better than the performance of Patriot systems against Iraq's "remarkably primitive" Scud ballistic missiles during the Gulf War, according to analysis by Theodore Postol.[78] Notably, in its early interceptions of the Kinzhal, Ukraine did not use the most modern version of the Patriot interceptor, but rather the PAC-3 Cost Reduction Initiative (CRI), an interceptor first deployed in the late 1990s.[79]

These engagements demonstrated not only that interception of the Kinzhal was possible, but also that it could be accomplished using relatively old interceptor technologies, suggesting that defense against this missile posed a challenge comparable to the interception of more familiar ballistic missile designs. This battlefield experience with the practicability of hypersonic missile defense swiftly reshaped narratives about the military implications of hypersonic weaponry. Heath Collins, the director of the US Missile Defense Agency, subsequently explained to Congress: "Hypersonic defense is feasible. We have, today . . . already fielded capability to intercept hypersonics in the terminal phase. . . . Hypersonic glide phase intercept capabilities is feasible."[80] Discourses elsewhere followed similar patterns. One Chinese analyst, for instance, criticized the Kinzhal as "outdated 1980s Cold War technology."[81]

These discursive shifts demonstrate a quick and comprehensive reassessment, among defense practitioners and expert communities, of the threat posed by the Kinzhal and of its role in modern warfare. Earlier imaginings of a revolutionary weapon that would upset the balance between missile and missile-defense technologies gave way to an emphasis on this system's unremarkable effects and its origin as an incremental update to older missile technologies. The normalization process evident in these reassessments is perhaps best summed up in the words of one of the Ukrainian Patriot operators who first intercepted a Kinzhal: Recognizing that the threat these missiles posed was not fundamentally different from that posed by other missile technologies, he concluded that defending against them was "just a matter of getting on with the job."[82]

3M22 Tsirkon

The Tsirkon (named after the zirconium-bearing silicate mineral zircon) is a ship- and ground-launched hypersonic cruise missile.[83] Russia claims that it has an operational range of over 1,000 kilometers and reaches a velocity of Mach 9, although this has not been independently verified.[84]

Unlike hypersonic boost-glide missiles, which are accelerated by a rocket booster in the initial phase of their flight but are otherwise unpowered, hypersonic cruise missiles carry an air-breathing engine that generates continuous thrust after booster burnout.[85] Thus, what distinguishes them from subsonic and supersonic cruise missiles is their flight speed: Hypersonic cruise missiles fly in the hypersonic velocity regime (above Mach 5), while the others fly more slowly. Due to limitations in the thrust generated by currently available fuels, hypersonic cruise missiles are limited to velocities below about Mach 10.[86]

As a hypersonic weapon, pre-use expectations of the Tsirkon's performance mirrored those of the Kinzhal: unmatched speed, minimal observable signatures, and immunity to interception by missile defenses. The Tsirkon, however, is widely seen as the more capable of the two systems.[87] As discussed previously, the Kinzhal's inclusion in the exalted hypersonic missile category is contested, while the Tsirkon's inclusion is uncontroversial. Thus, for many commentators, observation of the Kinzhal's surprisingly lackluster battlefield performance did little to dampen expectations of the Tsirkon's performance, as it was expected that the latter "should present a much greater

78 Theodore A. Postol, "Lessons of the Gulf War Experience with Patriot," *International Security* 16, no. 3 (1991): 119–71, https://doi.org/10.2307/2539090. See also George N. Lewis and Theodore A. Postol, "Video Evidence on the Effectiveness of Patriot During the 1991 Gulf War," *Science & Global Security* 4, no. 1 (1993): 1–63, https://doi.org/10.1080/08929889308426392.

79 Steve Trimble, "PAC-3 MSE Was in Testing at Time of Kinzhal Shoot Down," *Aviation Week Network*, May 11, 2023, https://aviationweek.com/defense/missile-defense-weapons/pac-3-mse-was-testing-time-kinzhal-shoot-down.

80 Statement by Gen. Heath Collins, as quoted in House of Representatives Committee on Armed Services, *Subcommittee on Strategic Forces Hearing on Fiscal Year 2025 Budget Request for Missile Defense and Missile Defeat Programs* (US Government Publishing Office, 2025), 16, https://www.congress.gov/118/chrg/CHRG-118hhrg57193/CHRG-118hhrg57193.pdf.

81 Lyle Goldstein and Nathan Waechter, "China Evaluates Russia's Use of Hypersonic 'Daggers' in the Ukraine War," *The Diplomat*, January 11, 2024, https://thediplomat.com/2024/01/china-evaluates-russias-use-of-hypersonic-daggers-in-the-ukraine-war/.

82 "How Kyiv Fended Off a Russian Missile Blitz in May," *The Economist*, June 13, 2023, https://www.economist.com/europe/2023/06/13/how-kyiv-fended-off-a-russian-missile-blitz-in-may.

83 Hruby, *Russia's New Nuclear Weapon Delivery Systems.*

84 The Kremlin, "Presidential Address to Federal Assembly," February 20, 2019, http://www.en.kremlin.ru/events/president/transcripts/59863/print.

85 David Wright and Cameron L. Tracy, "Hypersonic Cruise Missiles," *Science & Global Security* 32, no. 1 (2024): 219–68, https://doi.org/10.1080/08929882.2024.2447176.

86 Wright and Tracy, "Hypersonic Cruise Missiles."

87 Warren, "Russian Novel Nuclear Weapons and War-Fighting Capabilities."

challenge to Ukraine's air defenses."[88] One analyst, writing after the first interception of the Kinzhal, described the Tsirkon as "a potential Russian answer to US sea-based ballistic missile defence systems."[89] The commander of USNORTHCOM, Gen. Gregory Guillot, warned that the arming of Russian submarines with this weapon would "pose a persistent conventional threat to critical infrastructure throughout most of North America."[90]

The operational history of the Tsirkon is less clearly documented than that of the Kinzhal, but most reports agree that Russia first used this system in an attack on Kyiv's residential and energy infrastructure in February 2024,[91] reportedly followed by another attack on Kyiv in March.[92] Like the earlier use of Kinzhals, this strike on a large urban area was undemanding in terms of missile accuracy or yield. Also like the Kinzhal, Ukrainian media reported that both Tsirkons launched in the latter attack were intercepted by Ukrainian missile defenses, although this claim has not been more widely verified.[93] A spokesperson for the Ukrainian Air Force noted that, because these missiles slow as they dive through dense, low-altitude air to their targets, they are vulnerable to both US-made Patriot systems and Sol-Air Moyenne-Portée / Terrestre (SAMP/T) missile-defense systems jointly developed by France and Italy.[94] By the end of 2024, Ukraine had reportedly intercepted slightly more than one-third of the Tsirkons used by Russia.[95]

Just as the use and performance of the Tsirkon mirrored that of the Kinzhal, so too did reactions to its performance. Subscribing to the narrative that Russia's hypersonic weapons are more vulnerable to currently deployed missile defenses than was previously assumed, many commentators were "not impressed" with these systems.[96] Experience with their battlefield use prompted a widespread sentiment that "Zircon is not all that it's cracked up to be" and "not the game-changing super weapon that Vladimir Putin says it is."[97] Spenser Warren, in a detailed retrospective on Russian employment of new warhead-delivery systems in the Russo-Ukrainian War, concluded: "Russian claims about their invulnerability are either intentional disinformation or misperceptions of their own capabilities. . . . Their current impacts may be strategically unimportant."[98]

Still, the resilience of predictions of the Tsirkon's purported capabilities faltered once this weapon debuted on the battlefield.

Again, this discursive evolution illustrates a process of reassessment following technological underperformance. The technological surprise of Kinzhal interception did little to dampen expectations of the Tsirkon's performance. Rather than reassessing hypersonic weapons as a category, many commentators simply reframed the former as something other than a true hypersonic system. Still, the resilience of predictions of the Tsirkon's purported capabilities faltered once this weapon debuted on the battlefield. As discourses of technological disruption and revolution retreated, they were supplanted by dis-

88 See, for instance, Thomas Newdick, "Is Russia Really Using Zircon Hypersonic Cruise Missiles in Ukraine?," *The War Zone*, February 13, 2024, https://www.twz.com/air/is-russia-really-using-zircon-hypersonic-cruise-missiles-in-ukraine.

89 John McFarland, "The Development of Hypersonic Weapons in the US, China and Russia," *The RUSI Journal* 168, nos. 1–2 (2023): 14, https://doi.org/10.1080/03071847.2023.2199785.

90 Statement by Gen. Gregory Guillot, as quoted in Senate Committee on Armed Services, *Department of Defense Authorization Request for Appropriations for Fiscal Year 2025 and the Future Years Defense Program* (US Government Publishing Office, 2024), 12, https://www.congress.gov/118/chrg/CHRG-118shrg62124/CHRG-118shrg62124.pdf.

91 Yuliia Dysa, "Russia Uses Zircon Hypersonic Missile in Ukraine for First Time, Researchers Say," *Reuters*, February 12, 2024, https://www.reuters.com/world/europe/russia-uses-zircon-hypersonic-missile-ukraine-first-time-researchers-say-2024-02-12/; Warren, "Russian Novel Nuclear Weapons and War-Fighting Capabilities."

92 Chris York, "What We Know About Hypersonic Zircon Missiles—Russia's Latest Threat," *The Kyiv Independent*, March 30, 2024, https://kyivindependent.com/hypersonic-zircon-missiles-russias-latest-threat/.

93 Bohdan Tuzov and Steve Brown, "Russia's Tsirkon Hypersonic Missiles—Reality Versus Propaganda," *The Kyiv Post*, March 28, 2024, https://www.kyivpost.com/post/30224.

94 "Макрон вступить у війну, НАТО збиватиме ракети РФ над Україною? Фронт, Харків І Свобода.Ранок [Will Macron Enter the War, Will NATO Shoot Down Russian Missiles over Ukraine? Front, Kharkiv I Svoboda.Ranok]," *Radio Free Europe / Radio Liberty*, March 27, 2024, https://www.youtube.com/watch?v=OQPWy5HHxEE.

95 Epstein, "Russia's Unstoppable Hypersonic Missiles Had Another Bad Night."

96 Tom Sharpe, "Putin's Hypersonic 'Zircon' Super-Weapon Has Now Seen Combat. As a Specialist, I'm Not Impressed," *The Telegraph*, April 3, 2024, https://www.telegraph.co.uk/news/2024/04/02/russia-war-hypersonic-ukraine-zircon-strikes-naval-missile/.

97 Lewis Page, "Russia's 'Zircon' Hypersonic Super Weapon Has Failed in Ukraine. Putin Is Egg-Faced Again," *The Telegraph*, February 13, 2024, https://www.telegraph.co.uk/news/2024/02/13/russia-zircon-hypersonic-super-missile-ukraine-failure-kyiv/.

98 Warren, "Russian Novel Nuclear Weapons and War-Fighting Capabilities," 40.

courses of normality. The Tsirkon was not cast as a useless weapon—while some were intercepted, most managed to bypass Ukrainian missile defenses—but rather as an ordinary one, unworthy of previous hype.

Oreshnik

The Oreshnik (Russian for "hazel tree"), a medium- or intermediate-range ballistic missile (MRBM/IRBM), debuted amidst an anticipatory context dramatically different from those of the previously discussed systems.[99] "Medium-range" and "intermediate-range" refer to missiles with maximum-achievable ranges of 1,000–3,500 kilometers and 3,500–5,500 kilometers, respectively. Missiles of this sort are useful for strikes within a theater of war, but not for intercontinental strikes between, for instance, the US and Russian homelands. The United States and the Soviet Union deployed large numbers of nuclear-armed MRBMs and IRBMs in Europe during the Cold War, precipitating a crisis among the European states caught between these world powers.[100] The solution was found in negotiation of the Intermediate-Range Nuclear Forces (INF) Treaty, which entered into force in 1988, banning deployment of all ballistic and cruise missiles with ranges between 500 and 5,500 kilometers—both nuclear and conventionally armed—by the United States and the Soviet Union.[101] Thus, for several decades, this class of weapon remained largely absent from the global stage.

In 2019, following years of accusations by both the United States and Russia that the other was in violation of their INF obligations, both states suspended their commitment to the treaty.[102] This development gave rise to a global missile-technology environment that, while not new, was unfamiliar: a world in which the two states leading in missile-technology development were again free to deploy and use MRBM and IRBM systems. While these systems could be considered "normal" weapons, in that they were widely deployed prior to the INF and were still deployed in the interim by non-signatory states, they lacked a significant history of use.[103] Just as the battlefield use of weapons, I argue, tends to foster a discursive normalization of those weapons, traditions of non-use may contribute to an inverse process of exoticization. Consider, for instance, Price's study of patterns of alternating chemical weapons use and non-use in global conflicts. He concludes that periods of non-use of a weapons technology can yield a "sense of its strangeness" and a discursive differentiation of that technology from more familiar weapons systems and modes of war.[104] Consequently, the use of MRBMs or IRBMs in the Russo-Ukrainian War was largely unanticipated. This context rendered Oreshnik's battlefield debut a technological surprise, despite the established nature of the missile technologies underpinning this weapon.

Russia launched an Oreshnik at a Ukrainian manufacturing facility in the city of Dnipro in November 2024, the only use of this weapon to date.[105] This strike immediately prompted alarmist discourses about the weapon, which attributed to it characteristics of other, more remarkable missile technologies. Ukrainian officials initially alleged that the Oreshnik was an intercontinental-range ballistic missile (ICBM), a strategic weapon deployed exclusively for the delivery of nuclear warheads.[106] Indeed, many reactions stressed the fact that this missile was capable of carrying a nuclear warhead, overlooking the fact that this is true of many of the missiles that Russia has routinely used throughout the war.[107] Following Putin's use of the term, early reporting widely designated the Oreshnik as "hypersonic," despite the fact that it lacks the glide or maneuvering capabilities that define these weapons.[108] Both

99 The precise range of the Oreshnik is unclear. See Marc Santora, Lara Jakes, Valerie Hopkins, Andrew E. Kramer, and Eric Schmitt, "With Use of New Missile, Russia Sends a Threatening Message to the West," *The New York Times*, November 21, 2024, https://www.nytimes.com/2024/11/21/world/europe/russia-ballistic-missile-ukraine-war.html.

100 Susan Colbourn, *Euromissiles: The Nuclear Weapons That Nearly Destroyed NATO* (Cornell University Press, 2022).

101 Arms Control Association, "The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance," https://www.armscontrol.org/factsheets/intermediate-range-nuclear-forces-inf-treaty-glance.

102 Amy F. Woolf, "US Withdrawal from the INF Treaty: What's Next?" Congressional Research Service, https://www.congress.gov/crs_external_products/IF/PDF/IF11051/IF11051.7.pdf.

103 One recent potential exception is the 2017 use of the Burkan-2H missile by the Houthis against a target in Saudi Arabia. This missile appears to have a maximum range of roughly 1,000 kilometers, which would make it an MRBM. See Ralph Savelsberg, "Houthi Missiles: The Iran Connection; Scuds Are Not Dead Yet," *Breaking Defense*, May 17, 2018, https://breakingdefense.com/2018/05/houthi-missiles-the-iran-connection-scuds-are-not-dead-yet/.

104 Price, *The Chemical Weapons Taboo*, 78.

105 Santora et al., "With Use of New Missile, Russia Sends a Threatening Message to the West."

106 Santora et al., "With Use of New Missile, Russia Sends a Threatening Message to the West."

107 See, for example, Robyn Dixon, "What Putin's Nuclear-Capable Oreshnik Missile Means for NATO Security," *The Washington Post*, November 30, 2024, https://www.washingtonpost.com/world/2024/11/30/russia-oreshnik-missile-nuclear-nato-putin/.

108 See, for example, Lucy Papachristou, "Russian and Belarusian Military Exercises Next Month to Involve Oreshnik Hypersonic Missile," *Reuters*, August 13, 2025, https://www.reuters.com/business/aerospace-defense/russian-belarusian-military-exercises-next-month-involve-oreshnik-hypersonic-2025-08-13/; "Russia Has Used Its Hypersonic Oreshnik Missile for the First Time. What Are Its Capabilities?," *AP News*, December 9, 2024, https://apnews.com/article/russia-oreshnik-hypersonic-missile-putin-ukraine-war-345588a399158b9eb0b56990b8149bd9.

nuclear and hypersonic associations were commonly deployed in rhetoric amplifying the threat posed by the Oreshnik to Russia's adversaries.

The technological surprise that accompanied use of the Oreshnik differed substantially from that associated with the Kinzhal and Tsirkon, as it was marked by unexpectedness rather than inflated expectations. Nevertheless, as was the case for the two hypersonic systems, analysis of the Oreshnik's battlefield effects prompted a swift reassessment of its initially alarmist discursive framing. The damage caused by the strike on Dnipro was reportedly limited in scope,[109] leading one analyst to describe the attack as "an incredibly expensive way to deliver what is probably not that much destruction."[110] Others contested the novelty of the system, arguing that it was merely "an application of old technology" in a new configuration,[111] and that, while its name was new, "the weapon itself was likely not much different from known versions of Russian intermediate-range ballistic missiles."[112] Western governments concurred. A US official stated that "it will not be a game changer in this conflict," while a NATO spokesperson offered assurances that "this capability will neither change the course of the conflict nor deter NATO allies from supporting Ukraine."[113]

This case illustrates a different form of technological surprise than was evident in the previous cases. Rather than a deviation of battlefield performance from expectations, the first use of the Oreshnik took place absent a coherent anticipatory narrative. The ensuing evolution of discourses about this new weapons system, however, followed a remarkably similar trajectory. Its use initially prompted hype and anxiety narratives similar to those constructed around Russia's hypersonic weapons, alongside attempts to frame the Oreshnik itself as a member of that class. As with the previous two cases, these narratives were followed by a rapid reassessment of the technology. Normalization then proceeded via association of the weapon with more familiar technologies, along with minimization of its security implications. While the Oreshnik briefly became—in a discursive sense—an ICBM, a hypersonic weapon, and a nuclear threat, as with the Kinzhal and Tsirkon it quickly reverted to a normal weapon, worthy of the same degree of attention afforded to other Russian missile technologies. This case demonstrates the ubiquity of the process of normalization through use: It proceeds not only in response to the battlefield testing of hype narratives, as explained by hype-cycle theories, but also in response to technological surprise that arises absent an anticipatory narrative.

UMPK

The UMPK (an acronym translated as "Unified Gliding and Correction Module") is a recently deployed Russian glide bomb. Unlike typical bombs, glide bombs are fitted with guidance systems and small control surfaces, like wings or fins, allowing them to glide to distant targets after they are released from aircraft. Like the MRBM and IRBM, the glide bomb is an established weapons technology, first used by Germany in the Second World War in the form of the radio-guided Fritz-X and the Henschel Hs 293.[114] The latter was equipped with a small rocket engine to extend its range, making it an early forerunner of air-launched missile technologies. These systems were used primarily to attack small targets, like naval vessels, while staying outside the range of anti-aircraft fire.

Glide bombs have been widely designed, deployed, and used in subsequent decades, earning them the status of a "classic"[115] though "primitive"[116] weapon that is, to quote Ukraine's minister of foreign affairs, "very simple in essence."[117] Prior to Russia's deployment of the UMPK, this technology was given little consideration in contemporary imaginings of the future of warfare, and it was by no means considered an "emerging" technology. Study of the UMPK's debut in the Russo-Ukrainian War thus offers an opportunity to analyze a form of technological surprise

109 Tom Balmforth and Gerry Doyle, "New Russian Missile Fired at Ukraine Carried Warheads Without Explosives, Sources Say," *Reuters*, November 26, 2024, https://www.reuters.com/world/europe/new-russian-missile-fired-ukraine-carried-warheads-without-explosives-sources-2024-11-26/.

110 Balmforth and Doyle, "New Russian Missile Fired at Ukraine Carried Warheads Without Explosives, Sources Say."

111 Gerry Doyle, Tom Balmforth, and Mariano Zafra, "Enter 'Oreshnik,'" *Reuters*, November 27, 2024, https://www.reuters.com/graphics/UKRAINE-CRISIS/RUSSIA-MISSILE/gdpzknajgvw/.

112 Santora et al., "With Use of New Missile, Russia Sends a Threatening Message to the West."

113 Chris York and Martin Fornusek, "'Don't Overreact'—Oreshnik Missile Isn't as New as Russia Claims, Experts Say," *The Kyiv Independent*, November 22, 2024, https://kyivindependent.com/what-is-russias-oreshnik-missile-and-what-happens-next/. See also the conclusion that this weapon "isn't a game-changer on the battlefield" in "Russia Has Used Its Hypersonic Oreshnik Missile for the First Time."

114 Martin J. Bollinger, *Warriors and Wizards: The Development and Defeat of Radio-Controlled Glide Bombs of the Third Reich* (Naval Institute Press, 2010).

115 Adrian Mirea, "Countering the Glide Bombs Threat in the Ukrainian Conflict," *Bulletin of "Carol I" National Defence University* 14, no. 2 (2025): 257, https://doi.org/10.53477/2284-9378-25-28.

116 Kateryna Hodunova, "Russia's Primitive Glide Bombs Are Still Outmatching Ukraine's Air Defenses, Killing More Civilians," *The Kyiv Independent*, January 20, 2025, https://kyivindependent.com/russias-primitive-glide-bombs-are-still-outmatching-ukraines-air-defenses-killing-more-civilians-2/.

117 Dan Peleschuk, "Key Facts About Russia's Highly Destructive 'Glide Bombs,'" *Reuters*, September 25, 2024, https://www.reuters.com/world/europe/russian-guided-bombs-wreaking-havoc-ukraine-2024-09-25/.

distinct from that seen in the previous cases, resulting from performance of a familiar weapons system that substantially exceeds expectations.

The UMPK was designed as a cheaply produced kit that could be affixed to stockpiled FAB-500 and FAB-1500 bombs, neither of which possesses guidance capabilities absent this conversion.[118] UMPKs feature deployable wings and satellite guidance, providing a glide range of roughly 70 kilometers after release from Su-34 and Su-35 aircraft.[119] Russia first used the UMPK in early 2023 to attack Ukrainian forces outside the range of man-portable air-defense systems (MANPADS) and other air defenses. In line with the archaic image of these weapons, they "were initially considered individually dangerous but not game-changing" and their use "a sign of Russian desperation" as its military ran low on stocks of other strike systems.[120]

The UMPK has been cited as a key driver of recent advances of Russian lines.

Yet UMPKs have since proven highly effective on the battlefield. They exhibit short flight times and, due to their small size, low speed, and lack of propulsion, produce minimal thermal or radar signatures. These characteristics make it difficult for defensive systems to detect or track them, particularly when used in large numbers.[121] Despite concerted effort, Ukrainian forces have had little success countering these weapons using either kinetic or electronic means.[122] The challenge is so great that NATO dedicated its most recent biannual Innovation Challenge event to the design of countermeasures against this "particularly urgent threat."[123] In contrast to the hypersonic weapon cases, wherein analysts pessimistic about the possibility of defense were surprised by interception rates, defense against Russian glide bombs proved a far greater challenge than was anticipated.

Russian use of this weapon expanded dramatically in 2024 and 2025, with Ukraine's minister of foreign affairs warning that Ukrainian forces "are being massively and I would say even routinely attacked by guided aerial bombs that wipe out our positions."[124] The UMPK has been cited as a key driver of recent advances of Russian lines.[125] Beyond their physical capabilities, analysts point to evidence of a powerful psychological effect of their large-scale deployment. Because these weapons tend to destroy the bodies of those caught in the blast, identification of the Ukrainian soldiers they kill and provision of monetary compensation to those soldiers' families is hindered, damaging morale.[126] Russia ordered over 70,000 UMPKs for 2025,[127] and starting in 2024 began use of a second glide-bomb design, the UMPB D-30SN.[128]

Initially overlooked by analysts, Russia's glide bombs were widely reassessed after they drastically outperformed early expectations. Common rhetoric about these weapons currently exhibits a distinct ambivalence. While they are depicted as "Russia's most effective aerial weapon for targeting Ukrainian troops"[129] and as a system that is routinely "outmatching Ukraine's air defenses,"[130] they have not escaped their reputation as "Soviet-era weapons that have been retrofitted for 21st-century warfare."[131] Eschewing the attribution of revolutionary characteristics to these weapons, one Ukrainian Air Force officer has described them as an "evolution of the air war," part of a process of incremental

118 Jack Watling and Nick Reynolds, *Tactical Developments During the Third Year of the Russo–Ukrainian War* (Royal United Services Institute, 2025), https://static.rusi.org/tactical-developments-third-year-russo-ukrainian-war-february-2205.pdf.

119 Mirea, "Countering the Glide Bombs Threat in the Ukrainian Conflict."

120 Watling and Reynolds, *Tactical Developments During the Third Year of the Russo–Ukrainian War*, 7.

121 The low cost of UMPK kits, coupled with the large number of stockpiled FAB bombs, facilitates their use in numbers.

122 Mirea, "Countering the Glide Bombs Threat in the Ukrainian Conflict." Note that these capabilities are similar to those frequently attributed, often inaccurately, to hypersonic missiles.

123 Allied Command Transformation, NATO's Strategic Warfare Development Command, "Harnessing Innovation to Counter Glide Bombs," *NATO*, March 28, 2025, https://www.act.nato.int/article/harnessing-innovation-counter-glide-bombs/.

124 Christopher Miller, "Military Briefing: Russian 'Glide Bombs' Pound Ukrainian Troops and Towns," *Financial Times*, April 6, 2024, https://www.ft.com/content/0d6612f2-5d59-4ce2-bb2f-592309991430.

125 Miller, "Military Briefing"; Peleschuk, "Key Facts About Russia's Highly Destructive 'Glide Bombs.'"

126 Watling and Reynolds, *Tactical Developments During the Third Year of the Russo–Ukrainian War*.

127 Watling and Reynolds, *Tactical Developments During the Third Year of the Russo–Ukrainian War*.

128 Thomas Newdick, "Russia's Small Diameter Bomb-Like Weapon Seen in Action for the First Time," *The War Zone*, May 23, 2024, https://www.twz.com/air/russias-small-diameter-bomb-like-weapon-seen-in-action-for-the-first-time.

129 Max Boot, "Weapons of War: The Race Between Russia and Ukraine," *Council on Foreign Relations*, April 24, 2024, https://www.cfr.org/expert-brief/weapons-war-race-between-russia-and-ukraine.

130 Hodunova, "Russia's Primitive Glide Bombs Are Still Outmatching Ukraine's Air Defenses, Killing More Civilians."

131 Miller, "Military Briefing."

change where "they are constantly looking for a solution to strike us, and we are looking for one to intercept them."[132] Thus, while initial expectations for Russia's glide bombs differed greatly from those assigned to Russia's hypersonic missile arsenal, experience with the battlefield use of both classes of weapons in the Russo-Ukrainian War led to broadly similar, normalized discourses of their efficacy and implications. The underperformance of unfamiliar hypersonic weapons did not generally prompt denigration of their utility, nor did overperformance of glide bombs prompt runaway hype narratives. Rather, framings of both technologies converged in narratives of modest military relevance.

This case illustrates again a process of normalization, but one proceeding in the opposite direction—in terms of the valence of discourses—of those seen previously. A weapons technology previously seen as archaic became worthy of the same degree of attention devoted to novel technologies like hypersonic missiles. As with the long-range precision-strike systems discussed previously, reassessment of Russia's glide-bomb technologies is most evident in rhetoric framing them in relation to other weapons technologies. Commentators assessing the difficulty that Ukrainian forces have faced intercepting the UMPK, for instance, have concluded that "these bombs are even harder to hit than the hypersonic Kinzhal missiles."[133]

What this case demonstrates, considered alongside those discussed previously, is the generality of the process of normalization through use. This process appears not only as a corrective to pre-use hype narratives, but also to systems debuted absent a coherent anticipatory narrative and those deemed largely inconsequential. These convergent discursive processes render technological surprise, whether starting from a point of underprediction, overprediction, or lack of prediction, remarkably short-lived.

The Effects of Normalization

This analysis illustrates the transience of technological expectations and technological surprise. In each of the four cases, swift reassessment of the performance and security implications of long-range precision-strike weapons followed their initial battlefield use. This reassessment tended toward normalization, tracing discursive pathways from framings of these technologies as either revolutionary or obsolete toward framings of them as relatively normal tools of war with effects and implications comparable to those of other, more familiar systems. These paths typically culminated in narratives grouping these weapons alongside their predecessors, rather than holding them apart in narratives of technological disjuncture or military "revolution." Through this discursive mechanism, hypersonic weapons became just another variety of standoff weapon, as did IRBMs, MRBMs, and glide bombs.

Rhetoric regarding the possibility of defense against these weapons appeared as a recurring motif in these discursive evolutions. Narratives of the revolutionary nature of hypersonic weapons hinged on expectations of their ability to bypass all missile defenses, yet this discourse was disrupted by Ukraine's repeated interception of Kinzhals and Tsirkons. Conversely, growing appreciation for the efficacy of Russian glide bombs arose from the difficulty Ukrainian forces faced in attempts to counter them.

Returning to Price's work on the discursive framing of chemical weapons, we see abundant parallels. Initially, "gas was . . . feared as a weapon against which physical barriers such as hills, trenches, and buildings were not effective," yet after experience with its effects on the battlefield, recognition of "the possibility of defenses against gas provided a powerful counter-discourse that threatened to normalize perceptions of gas weapons."[134] In the long-range precision-strike case, perceptions of the feasibility or infeasibility of defense are similarly implicated as powerful determinants of technological anxiety and normalization.

Recent work critiquing revolution narratives applied to other military technologies suggests that these findings are generalizable. Consider, for instance, recent discourses framing militarized uncrewed aerial vehicles (UAVs), also known as drones, as revolutionary weapons technologies.[135] While these weapons have proven effective in many recent conflicts, including the Russo-Ukrainian War, systematic analysis of their deployment by Antonio Calcara et al. found little evidence to support a theorized "drone revolution in military affairs."[136] Rather, the authors conclude that these weapons represent merely the latest evolution of a continuous competition between air defenses

132 Jeffrey Gettleman and Eric Schmitt, "Russia's Old Bombs Elude Ukraine's Modern Defenses," *The New York Times*, May 25, 2023, https://www.nytimes.com/2023/05/25/world/europe/russia-ukraine-soviet-bombs.html.

133 Gettleman and Schmitt, "Russia's Old Bombs Elude Ukraine's Modern Defenses."

134 Price, *The Chemical Weapons Taboo*, 64.

135 See, for instance, Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," *Orbis* 51, no. 2 (2007): 251–65, https://doi.org/10.1016/j.orbis.2007.01.005; Michael J. Boyle, *The Drone Age: How Drone Technology Will Change War and Peace* (Oxford University Press, 2020).

136 Antonio Calcara, Andrea Gilli, Mauro Gilli, Raffaele Marchetti, and Ivan Zaccagnini, "Why Drones Have Not Revolutionized War: The Enduring Hider-Finder Competition in Air Warfare," *International Security* 46, no. 4 (2022): 133, https://doi.org/10.1162/isec_a_00431.

and penetration tools. Likewise, Cameron Hunter and Bleddyn Bowen have assessed visions of rapid, AI-driven military planning and command, arguing that these visions misalign with the realities of warfighting. Those authors conclude that "AI technologies may at best amount to . . . a narrow intelligence that has encyclopaedic empirical knowledge yet is woefully ill-equipped in the relevant skills of command in war."[137] Again, when analyzed in the context of use, rather than envisioned futures, these technologies appear as potentially useful but decidedly normal.

What do these findings mean for the evolution of risk during conflict? The prior literature, discussed above, suggests a substantial influence of technological expectations—hopes, fears, and anxiety—on state behavior during international conflict, particularly with respect to threat perception and the risks of escalation. The findings reported here indicate that the battlefield debut of weapons systems and the ensuing processes of technological normalization can act as a corrective to these risks. In cases where inflated expectations of weapons performance are recalibrated following use, we should expect a corresponding reduction in overconfidence on the part of the possessor and in technological anxiety on the part of their adversaries, both of which might reduce risks of conflict escalation. For instance, the debut of hypersonic and modern medium- or intermediate-range ballistic missiles in the Russo-Ukrainian War served as a demonstration that these weapons need not precipitate catastrophic processes of technological surprise.[138] Similarly, in cases where underestimation of a system's performance is corrected following use, we should expect a subsequent process of adaptation—as, for example, with NATO's rush to develop defenses against UMPK glide bombs—that could ameliorate the disruptive potential of that weapon.

These findings align with conceptions of war as a problem of information asymmetry. As James Fearon has shown, states frequently misperceive the capabilities of adversaries, and by acting on these faulty expectations enter into wars that might have otherwise been avoided.[139] Misestimation of the performance of untested or unfamiliar weapons technologies is one source of such misperception. What I show here, however, is the potential for rapid revision to these perceptions during war, in a variety of anticipatory contexts (overestimation, underestimation, and lack of anticipation).

Lastly, what do these findings mean for the analysis of military technological change and its implications for international security? They suggest that we should typically expect the incorporation of new military technologies into existing systems of warfare, rather than technological disruption of those systems. Those studying technologies of war would do well to theorize practices of warfare as durable constructions that resist disruption. We should therefore take care not to overlook the material instantiations of those practices—the weapons technologies currently in use—that may stubbornly refuse to be supplanted by newer technologies. As Frank Geels and Wim Smit argue: "In speculations about the future, the role of a new technology is often phrased in terms of replacing or substituting the old technology. . . . In reality, however, old and new technologies often co-exist."[140]

Cameron Tracy *is a senior research scholar at the Berkeley Risk and Security Lab (BRSL) in the University of California, Berkeley's Goldman School of Public Policy.*

University of California, Berkeley, Berkeley, CA, USA, email: cltracy@berkeley.edu.

Acknowledgments: *The author thanks Lindsay Rand, Elaine Korzak, Andrew Reddie, Leah Walker, and participants in a workshop hosted by the Institute for Peace Research and Security Policy (IFSH) at the University of Hamburg for helpful comments on earlier versions of this research.*

137 Cameron Hunter and Bleddyn Bowen, "We'll Never Have a Model of an AI Major-General: Artificial Intelligence, Command Decisions, and Kitsch Visions of War," *Journal of Strategic Studies* 47, no. 1 (2024): 116–46, https://doi.org/10.1080/01402390.2023.2241648.

138 This is not to claim, however, that use is inherently desirable. Regular use of nuclear weapons, for instance, might be expected to normalize perceptions of these systems, but normalization of an immensely destructive and indiscriminate weapon is clearly undesirable.

139 James D. Fearon, "Realist Explanations for War," *International Organization* 49, no. 3 (1995): 379–414, https://doi.org/10.1017/S0020818300033324. As Fearon points out, these misperceptions sometimes result from deliberate obfuscation on the part of an adversary.

140 Geels and Smit, "Failed Technology Futures," 877.

141 For image, see https://commons.wikimedia.org/wiki/File:2018_Moscow_Victory_Day_Parade_66.jpg.