Emerging and Disruptive Technologies, Multi-domain Complexity, and Strategic Stability: A Review and Assessment of the Literature

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Over last couple of decades, Russia, China, and the United States have been engaged in the increasingly competitive pursuit of the military benefits of emerging technologies. Over the last decade, there has been an explosion of work on these "emerging and disruptive technologies" (EDT) by universities and think-tanks. This work is aimed principally at understanding the risks associated with these technologies (and with competition for and with them) and how to reduce and, where possible, eliminate those risks. The insights generated by this work are of rising interest to policymakers seeking to respond constructively to a new era of major power rivalry and to the perception of a rising risk of war in Europe or Asia.

Thus, it is useful now to take stock of what has been learned by the community of university and think-tanks experts. Toward that end, the Center for Global Security Research (CGSR) conducted a survey of the literature and prepared an annotated bibliography, which became available in February 2021 at the CGSR website.[1] It used English-language materials available at the end of 2020. This paper goes beyond the bibliography to characterize and assess the literature in policy-relevant terms. Both the bibliography and this paper were crafted as inputs to a joint project with the European Leadership Network with the aim of creating a baseline of common understanding about emerging disruptive technologies and their risks so that we can explore in a more informed way implications for crisis management and possible risk reduction measures.

The paper begins with initial observations about scope and contents of the literature, as these informed the development of our methodology in various ways. It then explores what has been learned about the impact of EDTs and multi-domain complexity (an addition explained below) on strategic stability. Toward that end, it develops a taxonomy of core propositions in the literature bearing on specific elements of strategic stability. It closes with a summary of observations about the literature and of possible next analytical steps.

Initial Observations

[1] I owe a special debt of gratitude to the authors of the bibliography: Lauren Borja, Zachary Davis, Krystyna Marcinek, Anna Peczeli, Brian Radzinsky, Brandon Williams, and especially the team lead, Jacek Durkalec. They provided essential research and analytical support throughout this project. I also owe a debt of gratitude to all those who commented on earlier drafts of this paper, including especially Ben Bahney, Mike Markey, and Jonathan Pearl.

The annotated bibliography was not CGSR's first look at EDTs or multi-domain complexity and our work shaped the approach adopted here. Over the past decade, CGSR has convened numerous workshops on specific technologies and their implications and on the challenges of integrating across domains for strategic deterrence effects. In support of these workshops, we prepared lightly annotated bibliographies aligned with the agenda. These are all available at the CGSR website. This work left a number of impressions that significantly shaped this paper.

First, a lot of excellent new thinking is now available. Much of the new literature offers timely insights into emerging challenges and meaningful policy-relevant findings. Some of that good work pre-dates the proliferation of studies of the last decade, such as a strong literature on military innovation[2] and on the combined impacts of missile defense and conventional prompt global strike capabilities on deterrence stability. But the focus here is on the technologies that have become more prominent in the last decade and that are characterized as emerging and disruptive: cyber, space, and artificial intelligence are chief among them.

Second, the sheer volume of work is impressive. One catalogue compiled by Dr. Andrew Futter of Leicester University, UK, includes nearly 300 reports, journal articles, and other publications. Accordingly, the focus here is selective, leaving out many interesting items and including only enough to illuminate patterns and key points of debate. Moreover, we have focused on English-language products by universities and think tanks in the United States and Europe, recognizing that there is a lot of good work elsewhere (and hoping to turn to it as a follow-on task).

Third, there are many gaps. Some of the most important new questions have very little associated analysis. In our effort to assemble bibliographies for our workshops, we have regularly had questions on our agendas for which we could not find relevant analysis. Accordingly, we have sometimes supplemented the literature review with selections from workshop summaries to address an argument not readily found in print.

Fourth, the existing literature is dominated by analyses of specific technologies (and their implications) and only rarely explores the complex interactions of multiple emerging technologies. This may be an analytic necessity or convenience, but the result is less than satisfying for the policymaker or military planner, who must deal with the complexities of multiple EDTs interacting with each other and with the other dynamics of a military crisis. Accordingly, we have tried to include here studies that specifically explore multi-domain complexity and its implications for strategic stability.

Fifth, the use of the label "disruptive" is rather free form. In many studies, the judgment that emerging technologies are inherently disruptive and therefore dangerous seems to be an input to, rather than an output of, analysis. Little attention is given to the facts that (1) all new technologies are disruptive, usually in both negative and positive ways and (2) certain disruptive benefits may be available to those who are skilled at the competition. EDTs are very often

[2] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Cornell University Press, 1994).

characterized as destabilizing without explaining how or why. Moreover, many authors seem to assume that there is broad agreement about those requirements; but there is not. Accordingly, we have tried to add some fidelity to the discussion of the requirements of strategic stability.

Finally, the literature is often crafted in highly specialized language, whether technical or academic. This reduces its accessibility to the policymaker or military leader. Accordingly, we have tried to avoid such language.

We also narrowed our approach to the core propositions in the literature—that is, conclusions or inferences about the particular impacts of EDTs and multi-domain complexity on strategic stability. Even with that narrower focus, we needed some organizing construct to help bring some coherence to the review. We chose to try to locate the core propositions across the so-called spectrum of conflict: peacetime, crisis, and war. The structure of this taxonomy is at table 1 below.

Table 1

Phases of Conflict	Potential Impacts of EDTs and Multi-Domain Complexity On:
Peacetime	• the ability to gain new advantages of political or military consequence • the willingness to commit to mutual restraint • the ability to verify treaty compliance • alliances and coalitions
Crisis	• the ability to assess the adversary's course of action • the ability to consult and deliberate • signaling to adversaries and allies • the integration of operations for strategic effect
War	• the initiation of war • the perceived value and necessity of preemption • the control of war • the incentives for nuclear employment • the restoration of deterrence • de-escalation and war termination

For each of the potential impacts, one or more core propositions have emerged in the literature. After identifying those propositions, this essay then provides some specific illustrations.

The discussion presented here proceeds in reverse order though the above spectrum, beginning with war, then turning to crisis and lastly peacetime. This follows the balance of focus evident in the literature (which falls heavily on the potential impacts of EDTs and mult-domain complexity on escalation, de-escalation, and war termination; less heavily on the potential impacts on crisis management; and least of all on the potential impacts on peacetime rivalry).

Part 1: Multi-domain Warfare and Escalation, De-Escalation, and War Termination

The literature identifies six potential impacts on warfare of EDTs and multi-domain complexity bearing on strategic stability. These include impacts on:

1. the initiation of war
2. the perceived value and necessity of preemption
3. the control of war
4. the incentives for nuclear employment
5. the restoration of deterrence
6. de-escalation and war termination.

For each, one or more core propositions can be found in the literature (or in subsequent workshop exchanges among experts).

Core Propositions re: EDT impacts on the initiation of war. Multi-domain warfare will:

- *Increase incentives for early, decisive action*
- *Compress decision time while adding to the fog of war*
- *Have effects more evolutionary than revolutionary*

The following citations are illustrative:

> "Advances in sensors and weapons make disarming counterforce strikes more tempting than ever."[3]
>
> "The speed associated with LAWS [lethal autonomous weapon systems] could potentially threaten first strike stability in a crisis. The ability to fight at machine speed means a state could win faster – but it also means that state could lose faster… Now, there is nothing necessarily unique about the weapons being autonomous in this scenario – fast weapon systems that can threaten command and control systems can place pressure on strategic stability in general…"[4]
>
> "These new technologies are shrinking America's senior-leader decision time to such a narrow window that it may soon be impossible to effectively detect, decide, and direct nuclear force in time."[5]
>
> "Contrary to some public concern and media hype, unless AI capabilities reach truly science fiction levels, their impact on national and subnational military behavior, especially interstate war, is likely to be relatively modest. Fundamentally, countries go to war for political reasons, and accidental wars have traditionally been more myth than reality."[6]

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[3] Joshua Rovner, "Give Instability a Chance?" *War on the Rocks*. July 28, 2020. https://warontherocks.com/2020/07/give-instability-a-chance/.

[4] Michael C. Horowitz, "When speed kills: Lethal autonomous weapon systems, deterrence and stability." *Journal of Strategic Studies* 42, no. 6 (2019): 782. DOI: 10.1080/01402390.2019.1621174.

[5] Adam Lowther and Curtis McGriffin, "America Needs a 'Dead Hand'." *War on the Rocks*. August 16, 2019. https://warontherocks.com/2019/08/america-needs-a-dead-hand/.

[6] Horowitz, "When speed kills," 783-784. DOI: 10.1080/01402390.2019.1621174.

Core propositions re: EDT impacts on the perceived value and necessity of preemption. Multi-domain warfare will:

- *Increase the perceived value of preemption by increasing the first-mover advantage and improving the prospects for success with improved targeting*
- *Reduce the perceived value of preemption by decreasing the prospects for success with improved survivability*
- *Reduce the perceived value of preemption because no actor can escape mutual vulnerability*

The following citations are illustrative:

> "Multi-domain strategic competition will have a corrosive impact on crisis stability. There are several factors that can make crises less stable. In particular, with new technologies, there are more significant risks of a perceived first strike advantage, fears of a preemptive attack, or beliefs that the conflict cannot be managed and, therefore, escalation is inevitable."[7]

> "With regards to new domains, any actor that understands military operations in cyber space and outer space will likely understand that there is no possibility of escaping some significant form of retaliation, if a first strike is conducted in these domains. Also, offensive actions in space and cyber do not necessarily limit damage to one's own space and cyber capabilities. Therefore, mutual vulnerability may induce caution and reinforce crisis stability."[8]

Core propositions re: EDT impacts on the control of war. Multi-domain warfare will:

- *Reduce control of war by reducing the time to deliberate and complicating the task of reading an adversary's intent*
- *Improve the control war by those with the superior ability to integrate operations and effects*
- *Increase the risks of unwanted escalation by contributing to a false sense of confidence in the ability to control escalation with more information and more options*

The following citations are illustrative:

> "Any government faced with the possibility that hypersonic missiles would be employed against it—particularly in a decapitating attack— would plan countermeasures, many of which could be destabilizing. For example, countermeasures could include devolution of strategic forces' command and control so that lower levels of authority could execute a strategic strike, which would obviously increase the risk of accidental strategic war; or strategic forces could be more widely dispersed— a tactic risking greater exposure to subnational capture. An obvious measure would be a launch-on-warning posture—a hair-

[7] Center for Global Security Research, Lawrence Livermore National Laboratory. *5th Annual LLNL Deterrence Workshop Multi-Domain Strategic Competition: Rewards and Risks.* Workshop Summary. Livermore, California: CGSR, November 2018, p. 11. https://cgsr.llnl.gov/content/assets/docs/Deterrence_Workshop_Summary_Final2018.pdf.
[8] Ibid., p. 12.

trigger tactic that would increase crisis instability. Or the target nation could adopt a policy of preemption during a crisis—guaranteeing highly destructive military action."[9]

"Integration offers many potential benefits to the United States and its allies. It adds to the non-nuclear means of deterrence, defense and, if necessary, escalation. It helps to restore the promise of decisive effects no longer available at the conventional level of war, while also reducing reliance on nuclear threats where they may not be credible… Integrated strategic deterrence requires much more than the integration of cyber and space into existing deterrence strategy. It requires a comprehensive view of all of the capabilities relevant to shaping an adversary's escalation calculus and of the elements of coherent strategy."[10]

"A central risk posed by AI may not be the generation of bias, or decisions based on AI fuzzy logic, but rather the temptation to act with confidence and certainty in response in situations that would be better managed with caution and prudence…the distinction between the impact of AI at a tactical and strategic level is *not a binary one*: technology designed to augment autonomous tactical weapons ostensibly will be making decisions in the use of lethal force that informs and shape overarching strategic war-faring calculations."[11]

Core propositions re: EDT impacts on the prospects for nuclear employment. Multi-domain warfare will:

- *Increase the risk of nuclear use by entangling conventional and nuclear operations*
- *Reduce the risk of nuclear use by increasing the number and availability of non-nuclear response options*

The following citations are illustrative:

"Entanglement could lead to escalation because both sides in a U.S.-Chinese or U.S.-Russian conflict could have strong incentives to attack the adversary's dual-use C3I capabilities to undermine its nonnuclear operations. As a result, over the course of a conventional war, the nuclear C3I systems of one or both of the belligerents could become severely degraded. It is, therefore, not just U.S. nonnuclear strikes against China or Russia that could prove escalatory; Chinese or Russian strikes against American C3I assets could also—a possibility that scholars have scarcely even considered since the end of the Cold War."[12]

"These contrasting beliefs about the feasibility of controlling conventional and nuclear escalation suggest that a conventional conflict is more likely to escalate to high levels of

[9] Speier et al, "Hypersonic Missile Nonproliferation," p. 17.
[10] Brad Roberts, *Toward New Thinking About Our Changed and Changing World: A Five-Year CGSR Progress Report.* Livermore, California: CGSR, October 2020, p. 63. https://cgsr.llnl.gov/content/assets/docs/CGSRfiveDIGITAL.pdf.
[11] James Johnson, "Delegating strategic decision-making to machines: Dr. Strangelove Redux?" *Journal of Strategic Studies* (2020): 3-4, 10. DOI: 10.1080/01402390.2020.1759038
[12] James M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War." *International Security* 43, no. 1 (August 2018): 58. https://www.mitpressjournals.org/doi/pdf/10.1162/isec_a_00320.

intensity, increasing the chances of nuclear escalation. China, for example, could take actions it believes will deter the United States at the conventional level, only to be confronted with a U.S. desire to overmatch China in response and establish the same extent of conventional dominance that the United States has enjoyed for several decades against other adversaries…If the two countries have different views about when the natural firebreaks in a conflict will occur, they may focus on negotiating an end to the conflict at different times in this escalatory spiral and therefore miss opportunities to negotiate an end to the conflict altogether."[13]

Core propositions re: EDT impacts on restoring deterrence. Multi-domain warfare will:

- *Erode confidence in assured retaliation by increasing the risk of a successful enemy counterforce strike*
- *Encourage greater risk taking to restore confidence in assured retaliation*
- *Increase that willingness to keep escalating by a variety of means that may seem less risky than others*
- *Do little to change the calculus of deterrence among large nuclear-armed states with robust capabilities*

The following citations are illustrative:

"Changes in technology… are eroding the foundation of nuclear deterrence. Rooted in the computer revolution, these advances are making nuclear forces around the world far more vulnerable than before. In fact, one of the principal strategies that countries employ to protect their arsenals from destruction, hardening, has already been largely negated by leaps in the accuracy of nuclear delivery systems. A second pillar of survivability, concealment, is being eroded by the revolution in remote sensing. The consequences of pin-point accuracy and new sensing technologies are numerous, synergistic, and in some cases nonintuitive. Taken together, these developments are making the task of securing nuclear arsenals against attack much more challenging."[14]

"Automation is often brittle and lacks the flexibility humans have to react to events in their broader context. The states most likely to be willing to tolerate these risks for the perceived capability gains would be those that have significant concerns about the viability of their second strike deterrents. Thus, the more a country fears that, in a world without using

[13] Fiona S. Cunningham and Taylor M. Fravel. "Dangerous Confidence? Chinese Views on Nuclear Escalation." *International Security* 44, no. 2 (Fall 2019): 61-109. https://www.mitpressjournals.org/doi/full/10.1162/isec_a_00359.

[14] Keir A. Lieber and Daryl G. Press. "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence." *International security* 41, no. 4 (2017): 9-10. https://www.belfercenter.org/sites/default/files/files/publication/isec_a_00273_LieberPress.pdf.

autonomous systems, its ability to retaliate to a nuclear strike would be at risk, the more attractive autonomous systems may appear."[15]

"Across multiple groups, respondents were more willing to deploy drones into dangerous areas and more willing to shoot down another country's drone in a contested area, compared to inhabited aircraft. Respondents were less willing, however, to escalate in response to their own country's drone being shot down than if it was an inhabited aircraft. This suggests that while drone proliferation may lead to more aircraft incursions and drone shoot downs, these incidents may not escalate into hostilities against inhabited aircraft."[16]

"While some worry that AI could achieve near-perfect performance and thereby enable an effective counter-force capability, inherent technological limitations will prevent it from doing so for the foreseeable future. AI may bring modest improvements in certain areas, but it cannot fundamentally alter the calculus that underpins deterrence by punishment."[17]

"While the technological importance of quantum technology applications, in general, is very high, its potential for disrupting submarine near- invulnerability in the near future remains relatively low. Despite improvements in sensitivity, quantum sensors will not make oceans fully transparent and endanger the status-quo of SSBN near- invulnerability, at least not in short to the middle timeframe."[18]

Core propositions re: EDT impacts on de-escalation and war termination. Multi-domain warfare will:

- *Have an unpredictable effect on de-escalation and war termination*
- *Make a negotiated outcome impossible because one party to the conflict has been decapitated through attacks on "continuity of government" capabilities.*

The following citation is illustrative (the proposition on decapitation was set forth in a not-for-attribution workshop discussion):

"Although existing theories of escalation dynamics and conflict termination may serve as useful points of departure, what is understood very poorly today is how these theories may

[15] Michael C. Horowitz, Michael C., Paul Scharre, and Alexander Velez-Green. "A Stable Nuclear Future? The Impact of Autonomous Systems and Artificial Intelligence." Unpublished manuscript, December 2019, p. 4. https://arxiv.org/abs/1912.05291.

[16] Michael C. Horowitz, Paul Scharre, and Ben FitzGerald. "Drone Proliferation and the Use of Force: An Experimental Approach." Washington, DC: Center for a New American Security, 2017, p. 8. http://drones.cnas.org/wp-content/uploads/2017/03/Drone-Proliferation-and-the-Use-of-Force-Proliferated-Drones.pdf.

[17] Rafael Loss and Joseph Johnson, "Will Artificial Intelligence Imperil Nuclear Deterrence?" *War on the Rocks*, 19 September 2019. https://warontherocks.com/2019/09/will-artificial-intelligence-imperil-nuclear-deterrence/.

[18] Katarzyna Kubiak, "Quantum technology and submarine near-invulnerability." ELN Global Security Policy Brief, December 2020, p. 9. https://www.europeanleadershipnetwork.org/wp-content/uploads/2020/12/Quantum-report.pdf.

apply in cyberspace. In the future, finding ways to manage cyber conflict will be even more intellectually challenging than it was for traditional conflict."[19]

Part 2: EDTs, Multi-domain Complexity, and Crisis Management

The literature identifies four potential impacts of EDTs and multi-domain complexity on crisis management. These are potential impacts on:

- the ability to assess the adversary's course of action
- the ability to consult and deliberate
- signaling to adversaries and allies
- the integration of operations for strategic effect

For each, one or more core propositions can be found in the literature or in subsequent workshop exchanges among experts.

Core propositions on EDT impacts of new technologies on the ability to assess the adversary's course of action. Multi-domain complexity will:

- *Undermine such assessments because of improved abilities to act covertly, thereby adding to the risks of crisis instability*
- *Improve confidence in such assessments by making an enemy's capabilities and actions more transparent, thereby reinforcing crisis stability*

The following citations are illustrative:

"Potential convergences might produce strategic surprises that confuse and confound friends and foes alike, making the fog of war even more impenetrable and increasing the risk of escalation." [20]

"Machine learning will be an important tool for all-source analysts, who are increasingly required to consider information from a combination of sources, locations, and disciplines to understand the global security environment. To the extent that better information leads to informed decisions, applying AI to these collection and analysis problems will benefit strategic stability."[21]

Core propositions re: EDT impacts on the ability to consult and deliberate. Multi-domain complexity will:

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[19] Herbert Lin, "Escalation Dynamics and Conflict Termination in Cyberspace." *Strategic Studies Quarterly* 6, no. 3 (2012): 68. https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-06_Issue-3/Lin.pdf.

[20] Zachary S. Davis, "Artificial Intelligence on the Battlefield. An Initial Survey of Potential Implications for Deterrence, Stability, and Strategic Surprise." Livermore, CA: Center for Global Security Research, March 2019, p. 11. https://cgsr.llnl.gov/content/assets/docs/CGSR-AI_BattlefieldWEB.pdf.

[21] Ibid., p. 6.

- *Rob the consultative process of time and clarity*
- *Drive increased reliance on autonomous systems, reducing human control.*

The following citations are illustrative:

> "In the emerging strategic SA [situational awareness] ecosystem—where the volume, velocity, and variety of information have increased considerably, and the veracity of information may at times be unclear—information overload is likely to become a more pronounced concern for decisionmakers."[22]

> "States rely on the integrity of operational information provided through information technology (IT); if the information is unreliable, the decision- maker's ability to respond accurately and effectively will also be compromised."[23]

> "Over-reliance on an autonomous system may result in automation bias, where the data is believed without being questioned by both human operators and decision-making machines."[24]

Core propositions re: EDT impacts on signaling to adversaries and allies. Multi-domain complexity will:

- *Add to the fog of war, complicating messaging*
- *Improve signaling by providing for more direct channels*
- *Reinforce the strength of messages from dominant to weaker states*

The following citations are illustrative:

> "Modern military operations increasingly turn upon elements of military power that depend almost entirely on secrecy for their battlefield effectiveness. But the very secrecy that drives their battlefield impact can interfere with the political objectives military power is meant to serve, like deterrence."[25]

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[22] Rebecca Hersman et al. "Under the Nuclear Shadow: Situational Awareness Technology and Crisis Decisionmaking." Washington, DC: Center for Strategic and International Studies, March 18, 2020, p. 39. https://ontheradar.csis.org/analysis/final-report/.

[23] Beyza Unal and Patricia Lewis, "Cybersecurity of Nuclear Weapons Systems Threats, Vulnerabilities and Consequences." London, UK: Chatham House, January 2018, p. 9. https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-11-cybersecurity-nuclear-weapons-unal-lewis-final.pdf.

[24] *Ibid.,* p. 7.

[25] Brendan R. Green and Austin Long, "Invisible Doomsday Machines: The Challenge of Clandestine Capabilities and Deterrence." *War on the Rocks*, December 15, 2017. https://warontherocks.com/2017/12/invisible-doomsday-machines-challenge-clandestine-capabilities-deterrence/.

> "Cyber operations rely on hiding information, but nuclear deterrence relies on clear communication. Deception and deterrence are at odds with one another. In a brinkmanship crisis, the former undermines the latter."[26]
>
> "All of this suggests why drones could coerce without sending costly signals. Armed drones may not risk the lives of warfighters, drain the treasury, or put the domestic and international reputation of political leaders on the line. But they do offer substantial improvements in a state's ability to sustain conflict, decapitate an adversary's leadership, increase the certainty of punishment, reduce the lag time between decision and strike to zero, and impose disproportionate costs on a target."[27]

Core propositions re: EDT impacts on integration for strategic effect. Multi-domain complexity will:

- *Strengthen the capability for integration by advanced states*
- *Favor those with advanced command-and-control systems enabling all-domain operations*
- *Erode the ability to dominate the battlespace*

The following citations are illustrative:

> "National power today depends on fully integrating space and cyber with the traditional mix of nuclear and conventional capabilities for military, diplomatic, and economic effect. The U.S. is only at the beginning stages of understanding how to integrate these complex and unlike means to advance our interests and those of our allies. Meanwhile, major power adversaries are developing their own space and cyber capabilities and are also attempting to integrate them for undermining U.S. and allied interests."[28]
>
> "The PRC and Russia both see their military options as requiring the ability to deny the United States the advantages of its space-based capabilities— capabilities that underpin the deterrent and warfighting power of the United States by enabling the U.S. to impose costs on an aggressor, respond to crises rapidly, strike precisely, project power globally, and command and control forces in multiple distant combat theaters simultaneously."[29]

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[26] Erik Gartzke and Jon R. Lindsay, "The Cyber Commitment Problem and the Destabilization of Nuclear Deterrence." In *Bytes, Bombs, and Spies: The Strategic Dimensions of Offensive Cyber Operations*, edited by Lin, Herbert and Amy Zegart. Washington, D.C.: Brookings Institution Press (2018).

[27] Amy Zegart, "Cheap fights, credible threats: The future of armed drones and coercion." *Journal of Strategic Studies* (2018): 27. https://doi.org/10.1080/01402390.2018.1439747.

[28] *Space Strategy at a Crossroads: Opportunities and Challenges for 21st Century Competition*. Edited by Benjamin Bahney. Livermore, CA: Center for Global Security Research, May 2020, p. 59. https://cgsr.llnl.gov/content/assets/docs/space-strategy-at-a-crossroads.pdf

[29] *Ibid.,* p. 9.

Part 3: Multi-domain Competition and Peacetime Rivalry

The literature identifies four potential impacts of EDTs on competition and peacetime rivalry, including impacts on:

1. the ability to gain new advantages of political or military consequence
2. the willingness to commit to mutual restraint
3. the ability to verify treaty compliance
4. alliances and coalitions

For each, one or more core propositions can be found in the literature or in subsequent workshop exchanges among experts.

Core propositions re: EDT impacts on the ability to gain new advantages of political or military consequence. Multi-domain competition will:

- *Favor those first to master the needed doctrinal and operational innovations*
- *Favor those capable of managing complexity*
- *Create advantages that are likely to prove short-lived*
- *Encourage competition in complex and poorly understood technologies, thereby eroding arms race stability*

The following citations are illustrative:

> "Due to the tremendous power of quantum computing, the first-mover advantage afforded to the successor in this race will be immense. In the foreseeable future, a major, very real threat for the U.S. and its allies is the possibility that a strategic competitor could develop quantum computing in secret and use it against sensitive communications in order to outmaneuver or strategically outflank the U.S. In a wartime scenario, this potential infiltration of isolated networks could enable efforts to preempt operational movements or sabotage U.S. systems, without the U.S. knowing the source of this vulnerability."[30]

> "Throughout history, militaries have tried to defeat weapons by creating the next most advanced version of those weapons. […] It is important to acknowledge each technological leap not as a permanent solution but as part of an ongoing cycle. […] No one method or technology can exist for long without a countermeasure."[31]

> "Space and cyberspace can, in different circumstances, amplify or interfere with advantages of other domains for war fighting or coercion. Space-based ISR makes surprise attack less likely to succeed, which is stabilizing. Cyber exploitation of enemy nuclear command and control, by contrast, could be profoundly destabilizing. […] Efforts to win the counterforce

[30] Elsa B. Kania and John K. Costello, "Quantum technologies, U.S.-China strategic competition, and future dynamics of cyber stability," 2017 International Conference on Cyber Conflict (CyCon U.S.), Washington, DC, 2017, p. 95, doi: 10.1109/CYCONUS.2017.8167502.

[31] Clarence Abercrombie and Heather Venable, "Muting the Hype over Hypersonics: The Offense-Defense Balance in Historical Perspective." *War on the Rocks*. May 28, 2019. https://warontherocks.com/2019/05/muting-the-hype-over-hypersonics-the-offense-defensebalance-in-historical-perspective/.

contest in the cyber domain thus make it more likely that deterrence will fail in the nuclear domain. The pursuit of synergies and avoidance of interferences is by necessity an ongoing and dynamic process."[32]

"The key question is therefore not if, but when, how and by whom these recent advances of AI will be adopted in nuclear force architectures. However, these technological developments are still only a few years old and little detailed information is available in official sources about how nuclear-armed states see the role of AI in their nuclear force development or modernization plans."[33]

Core propositions re: EDT impacts on the willingness to commit to mutual restraint. Multi-domain competition will:

- *Decrease such willingness because of the fear that adversaries will compete covertly to gain new advantages*
- *Increase such willingness over the longer-term because mutual vulnerability is inescapable*
- *Impose new burdens on arms control to adapt to remain relevant to strategic stability and risk reduction.*

The following citations are illustrative:

"The United States does not possess a clear advantage; China and Russia are 'near-peers' (if not actual peers in key technologies). Both countries realize the United States has fallen behind in some areas, and that will make them reluctant to make concessions or even enter into negotiations."[34]

"Strategic vulnerability cannot be eliminated, only mitigated….But because the United States cannot escape its growing vulnerability to China unilaterally, Chinese agreement is needed; therefore, mutual restraint must address Chinese interests as well. Our core idea is that mutual vulnerability calls for mutual restraint in the nuclear, space, and cyber domains."[35]

"Emerging technologies can exacerbate these perceptions of vulnerability in the capability/vulnerability paradox, whereby the revolution in military technology creates 'novel vulnerabilities' that could increase incentives for first strike. This aspect of emerging technology adds an additional level of complexity for efforts to apply arms

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[32] Jon R. Lindsay and Erik Gartzke, "Politics by many other means: The comparative strategic advantages of operational domains." *Journal of Strategic Studies*, 2020, pp. 26-27. https://doi.org/10.1080/01402390.2020.1768372

[33] Vincent Boulanin et al. *Artificial Intelligence, Strategic Stability and Nuclear Risk*. Solna, Sweden: Stockholm International Peace Research Institute, June 2020, p. ix). https://www.sipri.org/sites/default/files/2020-06/artificial_intelligence_strategic_stability_and_nuclear_risk.pdf

[34] James A. Lewis, "Emerging Technologies and Next Generation Arms Control." Washington, DC: Center for Strategic and International Studies, October 21, 2019. https://www.csis.org/analysis/emerging-technologies-and-next-generation-arms-control.

[35] David C. Gompert and Phillip C. Saunders. "Sino-American Strategic Restraint in an Age of Vulnerability." *Strategic Forum* (January 2012), pp. 1-2. http://ndupress.ndu.edu/Portals/68/Documents/stratforum/SF-273.pdf.

control…Expanding the objectives of strategic stability and arms control opens creative approaches for addressing asymmetries in capabilities and domains. This challenges the conventional wisdom that strategic stability and arms control are out-dated Cold War practices. Indeed, history demonstrates that opportunities for arms control often arise unexpectedly and creative visions that cross-domains and combine informal approaches with multi-stage agreements can lay the groundwork for when political conditions become more favorable for cooperation."[36]

Core propositions re: EDT impacts on the ability to verify treaty compliance. Multi-domain competition will:

- *Enhance the ability to verify by adding transparency*
- *Erode the ability to verify by expanding the space for covert operations*

The following citations are illustrative:

"AI technology could be used to develop new verification and validation systems that can automatically test software for known cyber vulnerabilities before the new software is operationally deployed. DARPA has several promising research projects seeking to utilize AI for this function."[37]

"Some states have questioned what verification and monitoring measures would be associated with any new international ban. Given the inherent lack of transparency of many AI systems, states have expressed concern that signatories to any ban might not live up to their international commitments."[38]

Core propositions re: EDT impacts on alliances and coalitions. Multi-domain competition will:

- *Amplify pre-existing problems related to the stratification of alliances between/among the more and less capable of multidomain situational awareness*
- *Galvanize innovation in alliances long reluctant to embrace major changes to their deterrence postures*
- *Strengthen extended deterrence by enhancing the military potential of advanced countries*
- *Weaken assurance of allies who fear being left behind or pawns in an escalating but non-nuclear conflict*

[36] Heather Williams, "Asymmetric arms control and strategic stability: Scenarios for limiting hypersonic glide vehicles." *Journal of Strategic Studies* 42, no. 6 (2019): 810. https://doi.org/10.1080/01402390.2019.1627521.
[37] Michael C. Horowitz, Gregory C. Allen, Edoardo Saravalle, Anthony Cho, Kara Frederick, and Paul Scharre. "Artificial Intelligence and International Security." Washington, DC: Center for a New American Security, July 2018. https://www.cnas.org/publications/reports/artificial-intelligence-and-international-security.
[38] Forrest E. Morgan, "Military Applications of Artificial Intelligence. Ethical Concerns in an Uncertain World." Santa Monica, CA: RAND Corporation, 2020, p. 123. https://www.rand.org/content/dam/rand/pubs/research_reports/RR3100/RR3139-1/RAND_RR3139-1.pdf.

The following citations are illustrative:

> "AI could pose challenges to operational coordination by complicating burden-sharing and the interoperability of multinational forces. Not all alliance or coalition members will possess AI capabilities, raising barriers to military cooperation as AI-enabled warfare becomes increasingly common. States with AI technologies will also need to overcome political barriers to sharing the sensitive data required to develop and operate AI-enabled systems. At the same time, rivals can stymie multinational coordination by using AI to launch deception campaigns aimed at interfering with an alliance's military command-and-control processes."[39]

> "AI could hamper alliance and coalition decision-making by straining the processes and relationships that undergird decisions on the use of force. By increasing the speed of warfare, AI could decrease the time leaders, from the tactical to strategic levels, have to debate policies and make decisions. These compressed timelines may not allow for the complex negotiations and compromises that are defining characteristics of alliance politics. Decision-making may be further hampered if the "black box" and unexplainable nature of AI causes leaders to lack confidence in AI-enabled systems. And, just as adversaries could use AI to interfere with command and control, they could also use AI to launch misinformation campaigns that sow discord among allies and heighten fears that allies will renege on their commitments."[40]

> "The introduction of newer capabilities may indeed be one such example of the US working to expand its scope and capacity to provide defensive commitments to reduce the costs of the supply of defensive capabilities. This is likely to be especially salient with the emergence of potentially cheaper additions to force structure, in the domains of cyber and unmanned drone capabilities, that while requiring initial investments in infrastructure, technology, and manpower, do not necessitate the loss of human life when used in combat. With the expansion of the US arsenal to protect its allies using these technologies in tandem with reductions of other forms of capabilities, it is possible that the overall cost of extended deterrence agreements may actually decrease over time. If, for example, the ability to credibly deter and assure can be primarily accomplished with a combination of cross-domain capabilities, particularly with a reliance on some of the less costly power-projecting forces, it may also succeed in reducing domestic costs on US forces."[41]

> "Worried about being caught as collateral damage in a fight between major powers such as Russia and China against the United States, allies may fear that even conventional-only hypersonic vehicles may increase the risk of conflict to unacceptable levels – producing uncertainty about whether they would actually be used in combat. This concern about the

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[39] Erik Lin-Greenberg, "Allies and Artificial Intelligence: Obstacles to Operations and Decision-Making." *Texas National Security Review* 3, no. 2, (2020): 56-76. https://tnsr.org/2020/03/allies-and-artificial-intelligence-obstacles-to-operations-and-decision-making/.

[40] *Ibid*.

[41] Rupal N. Mehta, "Extended deterrence and assurance in an emerging technology environment." *Journal of Strategic Studies* (2019): 7. DOI: 10.1080/01402390.2019.1621173.

actual likelihood of use mirrors that in the conversations over nuclear use. Most allies are uncertain as to whether the United States would actually invoke nuclear weapons in their defence for fear of escalation. If hypersonic glide vehicles produce the same cycles of miscalculation, strategic instability and uncertainty, they are unlikely to serve as useful complements to extended deterrence."[42]

CORE PROPOSITIONS ABOUT THE IMPACTS OF EDTS AND MULTI-DOMAIN WARFARE ON ESCALATION, DE-ESCALATION, AND WAR TERMINATION
Impacts on the initiation of war:
• Increases incentives for early, decisive action • Compresses decision time while adding to the fog of war • Generates effects more evolutionary than revolutionary on the initiation of war
Impacts on the perceived value and necessity of preemption:
• Increases the perceived value of preemption by improving the prospects for success • Reduces confidence in successful preemption • Reduces the perceived value of preemption because no actor can escape mutual vulnerability
Impacts on the control of war:
• Reduces the time to deliberate and complicates reading an adversary's intent • Improves the ability to control war for those with the superior ability to integrate operations and effects • Adds misplaced confidence to the list of factors leading to unwanted escalation
Impacts on the incentives for nuclear employment:
• Increases the risk of nuclear use by entangling conventional and nuclear operations • Reduces the risk of nuclear use by increasing the number and availability of non-nuclear response options
Impacts on the restoration of deterrence:
• Erodes confidence in assured retaliation by increasing the risk of a successful enemy counterforce strike • Encourages greater risk taking to restore confidence in assured retaliation • Increases the willingness to keep escalating by a variety of means that may seem less risky than others • Does little to change the calculus of deterrence among large nuclear-armed states with robust capabilities
Impacts on de-escalation and conflict termination:
• Has an unpredictable effect on de-escalation and war termination • Makes a negotiated outcome impossible because one party to the conflict has been decapitated through attacks on "continuity of government" capabilities

[42] *Ibid.,* pp. 18-19.

CORE PROPOSITIONS ABOUT THE IMPACTS OF EDTS AND MULTI-DOMAIN COMPLEXITY ON CRISIS MANAGEMENT
Impacts on the ability to assess the adversary's course of action:
• Erodes crisis stability by improving the ability to act covertly and thus take escalation risk • Improves crisis stability because it reinforces mutual vulnerability
Impacts on the ability to consult and deliberate:
• **Robs the consultative process of time and clarity** • **Drives increased reliance on autonomous systems, reducing human control**
Impacts on signaling to adversaries and allies:
• Adds to the fog of war, complicating messaging • Improves signaling by allowing more direct channels • Creates strong one-way messaging opportunities for the stronger actor
Impacts on integration for strategic effects:
• Strengthens the capability for integration by advanced states • Erodes the ability to dominate

CORE PROPOSITIONS ABOUT THE IMPACTS OF EDTS AND MULTI-DOMAIN COMPETITION ON PEACETIME RIVALRY
Impacts on the ability to gain new advantages of political or military consequence:
• Creates a potential for significant new strategic military advantages for those first to master the needed doctrinal and operational innovations • Creates advantages that are likely to prove short-lived • Favors those capable of managing complexity
Impacts on the willingness to commit to mutual restraint:
• Decreases the willingness because of the competitive advantages still to be gained • Increases the willingness to restrain because mutual vulnerability is inescapable • Burdens arms control with the need to adapt to remain relevant to strategic stability and risk reduction.
Impacts on the ability to verify treaty compliance:
• Enhances the ability to verify by adding transparency • Erodes the ability to verify by expanding the space for covert operations
Impacts on alliances and coalitions:
• Constrains allied decision-making by increasing the speed at which decisions must be made • Amplifies pre-existing problems related to the stratification of alliances between/among the more and less capable of multidomain situational awareness • Strengthens extended deterrence by enhancing the military potential of advanced countries

Supplemental Observations About the Literature

Drawing on this taxonomy, some additional observations about the literature can now be made.

First, the literature does not map evenly across the three-part analytical construct. The literature on the impacts of EDTs and multi-domain complexity on war is more robust than the literature on the impacts on crisis management; peacetime competition gets the least attention. As with the nuclear literature, there is much more focus on escalation than on de-escalation and war termination. There is also much more interest in the impacts of EDTs and multi-domain conflict on nuclear risk rather than on other forms of escalation risk.

Second, essentially every hypothesis about the disruptive effects of EDTs and multi-domain complexity has generated a counter-hypothesis. Given the speculative nature of these inquiries and the absence of a lot of real data, it may prove difficult to settle these debates.

Third, the literature generally lacks specificity about how long it may take for technologies to mature to the point where they have the predicted impacts. The conflation of timelines across technology sectors creates a misleading picture of nearly unmanageable complexity.

Fourth, the literature mostly emanates from outside government. Thus, it generally lacks the perspective of the senior official charged with formulating policies or making decisions in time of crisis and war.

Preliminary Conclusions

What preliminary conclusions can be drawn from this initial survey of recent literature? What are their implications?

Two very different stories can be told, drawing on the literature surveyed here. One knits together all of the most dire core propositions to draw the conclusion that the complexity will overwhelm us, resulting in a catastrophe of historic dimensions. The flaw in this way of thinking is that its assumes a near simultaneous convergence of challenges—when we know that these problems are maturing at different rates. The other knits together the more optimistic propositions to draw the conclusion that the temptation to compete and win by multi-domain means will give way to caution and new forms of reciprocal restraint as the risks become clearer. The flaw in this way of thinking is that none of the major powers can afford to stand aside from competition if doing so creates a major vulnerability.

The literature points to more nuanced conclusions. In war, EDTs and multi-domain complexity will likely favor those most prepared conceptually, organizationally, and operationally for all domain operations. The primary disruptive aspects of EDTs and multi-domain complexity are likely to flow from the asymmetry of capability, the asynchronous deployment of advanced military applications, and the increased risk of unwanted escalation. It may be possible to mitigate these risks through improved strategic dialogue about them and a greater shared appreciation of shared risks.

In crisis, EDTs and multi-domain complexity will likely magnify existing sources of instability and create some new ones. But its impact on the nuclear threshold is likely to be marginal as there is so far nothing in the technology portfolio that promises complete success in eliminating an enemy's capacity for nuclear retaliation or other actions to jeopardize the vital interests of the attacker. The "nuclear revolution" (affecting the calculus of major power war) may be eroding but reversing it appears beyond the reach of even the most capable actor. These risks may be mitigated through new rules of the road, other informal measures, and perhaps also formal agreements. But this seems likely to require a catalyst of some kind—that is, a near-brush—along with diplomatic champions.

In peacetime, EDTs and multi-domain complexity fuel the hope of gaining first-mover advantages and of strengthening deterrence. But there appears to be no escape from mutual vulnerability, however well one competes and how long the competition goes on. This opens the door to future restraint, once the hope for sustained advantage is lost. This requires that the policy community be ready with new concepts of formal and informal arms control tailored to competition in these new domains.

Possible Next Steps

Presented with this array of potential benefits, costs, and risks, national and allied policymakers should pursue a comprehensive approach that encompasses efforts to better understand emerging opportunities and challenges, prepare for the conflicts that may engage us, to seize disruptive benefits where possible without unwanted second and third-order effects, and reduce and eliminate risks where they can. What steps might be taken now to advance understanding of these opportunities and challenges? Possibilities include the following.

1. Fill significant gaps in the literature.
2. Juxtapose and test competing hypotheses in focused debate or with war-gaming techniques.
3. Select out and elaborate the more positive hypotheses (in terms of crisis avoidance, war-time de-escalation, and peacetime risk reduction) and develop a coherent, multi-phase risk reduction strategy.
4. Conduct a US-centric study to identify where it can reasonably expect to seize and hold disruptive advantages and to mitigate undesired costs and risks (foundational analysis for a comprehensive strategy).
5. Conduct a comparable NATO-centric study.
6. Map out the comparable literatures of the expert communities in Russia and China and then compare with this review for areas of convergence and divergence.
7. Conduct a net assessment of the differential impacts on EDT competition on the major powers (who is running more risk, who less, and why?). Include assessments of different capabilities and capacities to develop and militarily exploit technologies, to tolerate developmental failures, and to accept risk.

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