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Æther

A Journal of Strategic Airpower & Spacepower

Nuclear Policy

Adapting the Hardware of NATO's Forward-Deployed Nuclear Forces
Wannes Verstraete

Innovation

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FROM THE EDITOR

Dear Reader,

In March 1943 Winston Churchill addressed the British people in a BBC broadcast from his country home, giving them hope for the future amid wartime. His speech, delivered just prior to the start of the North Africa offensive that would eventually prove crucial to Allied victory, anticipated the challenges of postwar recovery on the home front. "The difficulties which will confront us will take all our highest qualities to overcome," he warned. He then offered this encouragement: "Difficulties mastered are opportunities won."

His proverbial words, spoken during some of the darkest days of global conflict, are as salient today as they were then.

Although we are not in the midst of a world war, multiple events threaten global stability and regional security. China's role in the rules-based international order continues to evolve in alarming ways; Russia's ongoing aggression in Ukraine has led to a war of attrition where neither side has achieved any degree of air superiority; and Israeli military responses in the Middle East are reshaping the region's strategic landscape. Meanwhile, the threat of nuclear aggression by peer and near-peer adversaries such as North Korea and Iran looms in the background, and such challenges to the world order now extend beyond the terrestrial realm into the space domain, where adversarial maneuvering is creating an ambiguous operational environment with outsized strategic implications. In response to such challenges, the Department of the Air Force has been given the imperative to rapidly integrate technological advancements within our air and space power capabilities.

Many of these issues serve as the impetus for the discussions found in this issue of *Æther: A Journal of Strategic Airpower and Spacepower*. As complex and daunting as such challenges may appear, the United States has adapted and mastered similar difficulties before. The contributors to this issue of *Æther* offer ways in which we might tap into our "highest qualities"—embodied within our Airmen and Guardians—to overcome them.

Wannes Verstraete jumpstarts this issue with an article in our Nuclear Policy forum, "Adapting the Hardware of NATO's Forward-Deployed Nuclear Forces." He explores the need for NATO to rethink and diversify its theater nuclear posture in response to

evolving geopolitical threats, particularly from Russia, to maintain American nuclear deterrence credibility and secure Allied assurance.

Next, in our Innovation Forum, Todd Moulton and Joshua Pusillo demonstrate that the current security environment demands a more rigorous interservice effort to foster new thinking among future leaders. Crucial change begins with the creation of a true culture of innovation within the Defense Department in "Joint Innovation: What Is and What Could Be."

In the Space Policy Forum, two contributions offer proposals for handling challenges confronting our newest service, particularly in face of the rapidly expanding commercial space industry. In "Optimizing Officer Retention in the US Space Force: A Strategy for Success," Brandon Eans points to the critical need for effective talent management to maintain Guardian readiness in future conflict. Stiff competition from commercial space companies calls for new ways to incentivize long-term Guardian commitment. In "Playing by the Rules: Norms During Armed Conflict in Space," Sophia Chang—who brings a new voice to the field—highlights the practicality of establishing and adhering to norms of behavior in space for the US military.

In the Modern Airpower forum, Tucker Browne, Isaiah Harp, Michael Byrnes, and Brent Maggard provide a critical examination of the Air Force's pivot toward a future force reliant on tactical autonomy. In "Ready, Fire, Aim: Tactical Autonomy in the Age of AI," they demonstrate how realistic technological assessment, disciplined procurement, and strategic hedging are necessary for the future force design.

Finally, the forum and issue close with Stephen Redmond and Ryan Enlow's "A Revived Commitment to Control of the Air." The authors provide a nuanced view for integrating emerging capabilities and adaptive airpower to ensure the United States continues to provide airpower anytime, anywhere in support of our national defense.

This edition of *Æther* represents a well-considered contribution to the ongoing effort to master the difficulties of our day and turn them into opportunities for victory tomorrow. Æ

~ The Editor

ADAPTING THE HARDWARE OF NATO'S FORWARD-DEPLOYED NUCLEAR FORCES

Wannes Verstraete

NATO's theater nuclear posture, generally unchanged since the end of the Cold War, has come under increased scrutiny as Russia's recent actions in Ukraine raise questions about Allied forces' nuclear credibility and sufficiency. An exploration of alternative hardware options—using the criteria of military and political credibility as well as political and technical feasibility—demonstrates that NATO's current posture must evolve into a more diversified force to effectively enhance extended nuclear deterrence and Allied assurance.[1]

The decades-old asymmetry in favor of Russia regarding the nonstrategic nuclear balance of forces on the European continent has become increasingly untenable.[2] Russia's threat to use nuclear weapons during its war against Ukraine has created a dangerous precedent that demonstrates its willingness to employ its nuclear arsenal for regional territorial expansion. Moreover, the nuclear two-peer problem involving Russia and China specifically is putting pressure on the strategic arsenal of the United States.[3] Such threats to international security—together with global developments including Iran's proximity to a nuclear weapons breakout and North Korea's

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1. The author would like to thank Dr. Alexander Mattelaer, Dr. Jacek Durkalec, Dr. Jeffrey Michaels, Dr. Liviu Horovitz, and the anonymous officials and experts for their comments and feedback on previous drafts of the article.

2. Jacek Durkalec, *Nuclear-Backed "Little Green Men": Nuclear Messaging in the Ukraine Crisis* (The Polish Institute of International Affairs, July 2015), https://www.files.ethz.ch/; and Liviu Horovitz and Martha Stolze, "Nuclear Rhetoric and Escalation Management in Russia's War Against Ukraine: A Chronology," working paper, no. 2 (German Institute for International and Security Affairs [SWP], Research Division International Security, August 2023), https://www.swp-berlin.org/.

3. Brad Roberts et al., *China's Emergence as a Second Nuclear Peer: Implications for U.S. Nuclear Deterrence Strategy* (The Center for Global Security Research at Lawrence Livermore National Laboratory, 2023), https://cgsr.llnl.gov/.

continued expansion of its nuclear and ballistic missile program—have led to an era of "unbalanced nuclear multipolarity."[4]

While this poses strategic challenges for the United States, it has also potential implications for the credibility of American extended nuclear deterrence in the context of NATO. For instance, the United States could transfer nuclear capabilities, such as US-based or forward-based B61 gravity bombs and dual-capable aircraft (DCA), to the Indo-Pacific theater for certain contingencies. This would, however, result in even greater asymmetry in the European theater's nonstrategic nuclear capabilities. Such a situation could adversely impact the credibility of American extended nuclear deterrence and render NATO Allies more vulnerable to Russian threats to use nuclear weapons. Additionally, the Trump administration's attempts to end Russia's war in Ukraine has led to a public debate on the credibility of the American umbrella in Europe. While the White House has renewed its extended deterrence commitments to South Korea and Japan, it has yet to do so with NATO.[5] Nonetheless, if the United States wants to avoid Allied proliferation in Europe, for instance, the Alliance needs a credible European-based capability to deter and, if necessary, respond to limited Russian nuclear aggression. Therefore, this article is written on the assumption that the United States continues its extended nuclear deterrence guarantees to NATO.

This article explores the options to strengthen NATO's nuclear posture within the existing framework and additionally examines air, sea, and land nuclear and nonnuclear capabilities. Based on current analyses of alternative hardware options, this article employs the criteria of military and political credibility and political and technical feasibility to identify a more diversified force mix necessary to enhance the credibility and flexibility of theater nuclear forces and to ensure US strategic stability.

Background

Because Russia is diversifying and modernizing its nonstrategic nuclear capabilities—efforts illustrated by the introduction of the Novator 9M729 (SSC-8) ground-launched cruise missile (GLCM) and the new Oreshnik intermediate-range ballistic missile (IRBM)—NATO is again facing "a gap in the spectrum of escalation," just as during the Cold War with the Soviet deployment of the RSD-10 Pioneer (SS-20) IRBM.[6] Subsequently, a similar logic applies to the current situation whereby NATO needs to close

4. Mark Fitzpatrick, *The Iran Nuclear Deal: Consequences of Moribund Diplomacy* (NATO Defense College, Research Division, February 2023), https://www.ndc.nato.int/; and Mary Beth D. Nikitin, *North Korea's Nuclear Weapons and Missile Programs*, In Focus (IF) 10472 (Congressional Research Service [CRS], 19 December 2023), https://sgp.fas.org/; and David N. Miller et al., "Ten Propositions Regarding Nuclear Weapons and Deterrence," *Æther: A Journal of Strategic Airpower & Spacepower* 2, no. 4 (2023): 22, https://www.airuniversity.af.edu/.

5. Zuzanna Gwadera, "US Allies Question Extended Deterrence Guarantees, but Have Few Options," *Military Balance Blog*, IISS [International Institute for Strategic Studies], 20 March 2025, https://www.iiss.org/.

6. *Final Communiqué* (NATO, 13–14 November 1979), https://www.nato.int/.

this gap and retain "options for restrained and controlled responses."[7] Although important in their own right, software changes alone will be insufficient. Yet there are also limits regarding potential hardware changes.

Scholars have been debating different options. One analysis on the possibilities of bolstering NATO's nuclear forces assesses these alternatives by the key criteria of military effectiveness; escalation control; coupling, or linking US security with that of its European Allies, and burden sharing, or being part of the nuclear mission; Alliance unity; timeliness; and cost-effectiveness. It concludes that deploying nuclear short-range standoff weapons next to the B61-12 nuclear gravity bombs and delivered by DCA in Europe would provide the Alliance with a "credible response to a limited Russian nuclear strike" while at the same time guaranteeing "the coupling of European security to US strategic forces at an acceptable economic and diplomatic cost."[8]

The 2023 Center for Global Security Research Study Group report, which discusses the second nuclear peer challenge of China's buildup, also focuses on adapting the hardware of extended deterrence, listing military and political criteria that nonstrategic extended nuclear deterrence capabilities must meet. The military criteria are survivability, promptness, target versatility, and impact on the United States. The political criteria are persistent in-theater presence, visibility, option for burden sharing, and political acceptability for Allies. While the report outlines a potential future mix of extended nuclear deterrence capabilities, it does not offer a consensus on the specific mix.[9] Yet another analysis points to three options regarding the future of NATO's nuclear forces, namely modernizing, enhancing, or complementing the current framework.[10]

NATO itself mentions in its 2022 *Strategic Concept* that it "will take all necessary steps to ensure the credibility, effectiveness, safety and security of the nuclear deterrent mission."[11] While the public debate is mostly focused on the ongoing modernization of DCA capability and occasionally includes discussions on expanding the geographical scope of the nuclear sharing arrangements, NATO has not publicly considered any further hardware changes. Therefore, the question of what other capabilities could be useful to strengthen nuclear deterrence and are politically feasible is being neglected in many Allied capitals.

This article considers the options to strengthen NATO's nuclear posture within the existing framework and reviews additional air, sea, and land nuclear and nonnuclear capabilities. It does so by combining the aforementioned guidelines, with

7. *Final Communiqué*.

8. Matthew Kroenig, *Toward a More Flexible NATO Nuclear Posture: Developing a Response to a Russian Nuclear De-Escalation Strike* (Atlantic Council, Brent Scowcroft Center on International Security, November 2016), https://www.atlanticcouncil.org/.

9. Roberts et al., *China's Emergence*, 48–50.

10. Robert G. Bell, *Modernise, Expand or Complement: NATO's Nuclear Posture in the Post-2022 Strategic Environment*, CSDS In-Depth no. 11 (Brussels School of Governance, Centre for Security, Diplomacy and Strategy, 19 March 2024), 12–18, https://www.brussels-school.be/.

11. *NATO 2022 Strategic Concept: Adopted by Heads of State and Government at the NATO Summit in Madrid 29 June 2022* (NATO, 29 June 2022), 8, https://www.nato.int/.

the following four criteria: military credibility, political credibility, political feasibility, and technical feasibility.

This analysis identifies the need for a more diversified force mix consisting of dual-capable aircraft with nuclear-capable air-launched cruise missiles (ALCM) as well as of gravity bombs. This enhances the military credibility of DCA and is politically more feasible, as it only requires complementing or replacing current bombs rather than introducing new delivery systems. In terms of technical feasibility, introducing nuclear-capable ALCM is only possible in the longer term. Emerging and disruptive technologies (EDT) also promise to provide complementary non-nuclear capabilities. EDTs can enhance both military and political credibility and are politically more feasible by their very nature as non-nuclear systems. Technical feasibility depends on the specific technology.

The United States should also consider increasing the frequency of rotational bomber deployments in Europe when the B-21 Raider becomes operational. The B-21 is not only militarily credible (as the first sixth-generation bomber) but also politically credible (visible deployment on European soil). While the B-21's political feasibility depends on the acceptability of the Allied nations at which the bombers are stationed, it remains technically feasible—it is under development, and the B-52/B-2s have done rotational deployments to Europe.

Lastly, the United States could arm its attack submarines with nuclear-armed sea-launched cruise missiles (SLCM-N). These are militarily credible but less politically credible because of their lack of visibility and options for burden sharing. They are politically feasible because no forward basing in Europe is required and technically feasible as the seemingly earliest available option.[12]

While the above represents an ideal mix, most of these options will require several years before becoming fully operational. In the short term, then, NATO would need to strengthen its existing framework.

Options Within the Existing Framework

NATO has several options to do this. The first steps to reinforce the current nuclear sharing capability have already been taken through the modernization of the dual-capable fighter jet fleet with F-35As, excluding those of Türkiye, which had been dropped from the program in 2019. In addition, the United States has upgraded its nuclear gravity bombs to the B61-12 variant. This new variant is more capable than its predecessors because of its guided tail kit, which improves accuracy.[13] The bomb's modest standoff range also increases the survivability of the delivering fighter jet.[14] Combined with the stealth characteristics of the F-35A, the DCA capability modernization will result in a significant qualitative improvement.

12. Roberts et al., *China's Emergence*.

13. Hans M. Kristensen et al., "Nuclear Weapons Sharing, 2023," *Bulletin of the Atomic Scientists* 79, no. 6 (2023), https://doi.org/.

14. Frank Kuhn, "Making Nuclear Sharing Credible Again: What the F-35A Means for NATO," *War on the Rocks*, 14 September 2023, https://warontherocks.com/.

Nevertheless, there are several means by which NATO can further strengthen its capabilities. For one, DCA Allies could acquire more aircraft. The United States could deploy more B61-12s and shorten the readiness time. Second, the survivability of DCA air bases could be reinforced by acquiring the necessary Integrated Air and Missile Defense (IAMD) capabilities. Dispersion plans inside the territory of DCA Allies or other NATO Allies closer to Europe's east and north that provide dispersed operating bases and improvised airstrips on roads should also be updated.[15] Additional storage locations for the nuclear munitions could be built, or dormant facilities in countries like the United Kingdom or Greece, for instance, could be reactivated.[16] Unofficial sources have also reported that US nuclear weapons may return to the UK after more than 15 years of non-deployment.[17] Moreover, NATO is currently modernizing and adapting its nuclear command and control systems as part of the modernization of its DCA posture.[18] Conventional support to nuclear operations (CSNO) could be strengthened by deploying new kinetic and non-kinetic capabilities, including air, land, maritime, cyber, space, and special operations forces. Enhanced CSNO would increase dual-capable aircraft survivability because it enables deeper and more secure penetration of hostile airspace.

Additionally, non-nuclear Allies could support the nuclear messaging of NATO through national statements that offer a "more active declaratory policy."[19] DCA Allies could signal their commitment to their new role as "co-providers of extended deterrence."[20] Improved information and intelligence sharing, planning, and more frequent consultations and dialogues among Allies could enhance the software side of extended deterrence. Further efforts to raise subject matter expertise—or in NATO's terms, the nuclear IQ—are necessary to improve the understanding of the nuclear component in integrated deterrence and NATO's multidomain operations approach.

Air-based Nuclear Capabilities: Building on the Existing Framework

Since the early 2020s, analysts have discussed expanding the number of dual-capable aircraft Allies as a first option. Poland is the NATO member state that is most

15. "Poland's Bid to Participate in NATO Nuclear Sharing," *Strategic Comments* 29, no. 7 (2023), https://doi.org/.

16. Bell, *Modernise*, 14.

17. Tony Diver, "US to Station Nuclear Weapons in UK to Counter Threat from Russia," *The Telegraph*, 26 January 2024, https://www.telegraph.co.uk/; and Eliana Johns and Hans M. Kristensen, *Reawakening a Nuclear Legacy: The Potential Return of the US Nuclear Mission to RAF Lakenheath* (Federation of American Scientists, February 2025), https://fas.org/.

18. Bell, *Modernise*.

19. Wannes Verstraete, *Strengthening the Political Credibility of NATO Extended Nuclear Deterrence* (Egmont Royal Institute for International Relations [Egmont Institute], February 2024), 4, https://www.egmontinstitute.be/.

20. Alexander Mattelaer, *Upgrading the Belgian Contribution to NATO's Collective Defence* (Egmont Institute, July 2023), 6, https://www.egmontinstitute.be/.

eager to join nuclear sharing.[21] Other possible candidates include Finland, the Czech Republic, and Romania.[22]

In June 2023, then-Prime Minister Mateusz Morawiecki revealed Poland's interest in hosting nuclear weapons "under NATO's nuclear-sharing policy."[23] Earlier in that same year, then-Foreign Affairs Minister Zbigniew Rau indicated that the Polish government supported ending the NATO–Russia Founding Act from 1997, which specified that member states "have no intention, no plan and no reason to deploy nuclear weapons on the territory of new members."[24]

As one analysis notes, such statements should not be construed as an escalation by NATO. Neither should NATO's declaration for plans to re-posture its own nuclear force in response to Russia's July 2022 announcement of its deployment of nuclear weapons into Belarus "be seen by Moscow as provocative or escalatory." Furthermore, it argues that having a willing non-nuclear Ally to take up the dual-capable aircraft role might be "a prudent risk-mitigation measure" in case of withdrawal by an existing DCA Ally.[25] Another study points to the primary military benefit of having DCA Allies further to the east: such a move would decrease the distance from the air base to the mission target in a hypothetical conflict.[26]

Nevertheless, other experts question the military value of positioning B61s in Poland because it creates incentives for Russia to preemptively strike the air bases at the beginning of a conflict. Such forward-basing would thus "paradoxically . . . limit NATO's nuclear survivability."[27]

An intermediate position, however, could be delivering nuclear-certified F-35As to nations seeking to join nuclear sharing and training for the successful nuclear mission execution while not hosting US nuclear weapons.[28] This has the benefit of creating a larger and more dispersed fleet of certified F-35As to increase survivability, and if necessary, the ability to rapidly generate extra full-DCA Allies by bringing in additional B61s during conflict. Moreover, as one expert argues, this would benefit the political credibility of nuclear sharing: "Due to their diverging threat perceptions, the Polish government and Polish pilots, for example, might well be more willing to employ nuclear weapons than, say, the German government and German

21. Justyna Gotkowska, "Moving NATO's Military Power Centre Towards Central and Northern Europe. Poland's Political and Military Goals," GSSC: Geopolitics and Security Studies Center, 12 February 2024, https://www.eesc.lt/; "Poland's Bid"; Robert Peters, *NATO's Nuclear Posture Needs Updating* (The Heritage Foundation, 31 August 2023), https://www.heritage.org/; and Joseph Trevithick, "Poland Wants to Host NATO Nukes to Counter Russia," *TWZ* [*The Warzone*], 30 June 2023, https://www.twz.com/.

22. Bell, *Modernise*; and Peters, *Nuclear Posture*.

23. "Poland's Bid," 1.

24. "Poland's Bid"; and Founding Act on Mutual Relations, Cooperation and Security Between NATO and the Russian Federation, 36 ILM 1006 (1997), https://www.nato.int/.

25. Peters, *Nuclear Posture*, 4, 6.

26. Bell, *Modernise*.

27. "Poland's Bid," 2.

28. Gotkowska, "Military Power Centre"; and Kuhn, "Nuclear Sharing."

pilots."[29] The downside is that such a measure would lead to different tiers of DCA Allies, which could result in the perception of inequality for certain Allies, as some would not host forward-based US nuclear munitions but only contribute with dual-capable aircraft and crews. Subsequently, this might corrode attempts at achieving the necessary consensus in the NATO Nuclear Planning Group (NPG).

The United States could also expand its activities related to strategic bomber deployments to European Allies by increasing the frequency of rotational dual-capable bomber deployments in Europe of the B-52, the B-2, and in the future, the B-21. Such capabilities strengthen the military credibility of extended nuclear deterrence due to the B-2's and B-21's advanced stealth characteristics and Allied assurance because of the visibility of such deployments. Such deployments could be combined with the forward-basing of AGM-86B nuclear ALCMs or its successor, the AGM-181 long-range standoff weapon.[30] Nevertheless, the United States will probably need to procure more B-21s than the 100 currently planned if it decides to significantly expand its bomber presence in Europe.[31]

Furthermore, the US Department of Defense plans to pursue a new variant of the B61, namely the B61-13, with a higher yield than the B61-12.[32] While this type of bomb is currently not planned for use by dual-capable aircraft Allies, US strategic bombers deployed in Europe could carry them. Introducing other types of munitions next to the B61-12 would enhance the flexibility regarding nuclear strike options, strengthening extended nuclear deterrence and Allied assurance. One historical example is the tactical short-range attack missile (SRAM-T) program, which was cancelled because of unilateral US cuts to its nuclear arsenal under the Presidential Nuclear Initiatives of 1991 and 1992.[33] Nevertheless, developing a new, nuclear ALCM that could be deployed by the F-35A DCA fleet would significantly increase the military credibility of forward-deployed nuclear forces in NATO.

While a forward-deployed ALCM such as the SRAM-T would be a superior capability compared to current gravity bombs, questions remain about the technical feasibility of creating this new type of nuclear weapon, considering US constraints regarding production capability, resources, and human expertise.[34] An additional

29. Kuhn, "Nuclear Sharing."

30. "AGM-86 Air-Launched Cruise Missile (ALCM)," Missile Threat, Center for Strategic & International Studies (CSIS), last modified 23 April 2024, https://missilethreat.csis.org/; and Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2023," *Bulletin of the Atomic Scientists* 79, no. 1 (2023), https://www.tandfonline.com/.

31. "B-21 Raider," US Air Force [website], accessed 11 December 2024, https://www.af.mil/.

32. Joseph Trevithick, "Plans for More Destructive B61 Nuclear Bomb Unveiled," *TWZ*, 27 October 2023, https://www.twz.com/; and "Department of Defense Announces Pursuit of B61 Gravity Bomb Variant," US Department of Defense (DOD), press release, 27 October 2023, https://www.defense.gov/.

33. Susan J. Koch, *The Presidential Nuclear Initiatives of 1991–1992*, Case Study 5 (Center for the Study of Weapons of Mass Destruction, National Defense University, 2012), 11, https://ndupress.ndu.edu/.

34. Roberts et al., *China's Emergence*.

factor to consider is that dual-capable aircraft with ALCMs would also need conventional support to nuclear operations.

Sea-Based Nuclear Capabilities: Lack of Visibility

The Cold War witnessed the use of sea-based nuclear capabilities on US surface vessels and submarines, but all nonstrategic nuclear weapons were offloaded in 1991.[35] The United States, UK, and France do deploy strategic submarine-launched ballistic missiles (SLBM) on ballistic missile submarines (SSBN). Yet France retained a nuclear capability on its aircraft carrier *Charles de Gaulle*, namely the Nuclear Naval Air Force (Force aéronavale nucléaire, FANu) that can be deployed on the aircraft carrier with 10 Rafale-M(arine)s. These fighter aircraft can carry the medium-range air-to-ground missile, ASMPA (air–sol moyenne portée–améliorée).[36]

Nevertheless, French nuclear policy does not align with NATO policy. Retired Vice Admiral Jean-Louis Lozier stated in January 2023 that France has "always refused to consider nuclear weapons as battlefield weapons that could lead to a nuclear war," limiting such weapons to "extreme circumstances of self-defence" as outlined by UN Charter Article 51.[37] France is also the only Ally that does not participate in the NPG. French President Emmanuel Macron, however, did declare in 2020 that "France's vital interests now have a European dimension."[38] While this divergence is beneficial for strategic ambiguity reasons, France could clarify this stance to support the overall deterrence credibility of NATO.

The return of this mission to US aircraft carriers would enhance extended deterrence in both the European and Indo-Pacific theaters, and increase reassurance due to their visibility through, for instance, port visits and patrolling off the coast of Allied nations. The B61 nuclear gravity bomb has been deployed on US aircraft carriers from 1968 to 1994.[39] Subsequently, the redeployment of the modernized B61-12 together with certifying F-35Cs could provide an additional nuclear capability that would strengthen US extended deterrence commitments. Such a development would also politically be more feasible because it does not necessitate the hosting of additional nuclear weapons by Allies.

In 2019, the United States fielded the W76-2 low-yield SLBM warhead on its SSBNs. These modified versions of existing SLBMs represent forward-deployable capability

35. Robert S. Norris and Hans M. Kristensen, "Declassified: US Nuclear Weapons at Sea During the Cold War," *Bulletin of the Atomic Scientists* 72, no. 1 (2016), https://doi.org/.

36. Bruno Tertrais, *French Nuclear Deterrence Policy, Forces, and Future: A Handbook*, Recherches & Documents no. 4, (Fondation pour la Recherche Stratégique, 2020), 58, https://www.frstrategie.org/.

37. Jean-Louis Lozier, *French Nuclear Policy* (International Centre for Defence and Security, 19 January 2023), 2, https://icds.ee/.

38. Lozier, *Nuclear Policy*; Astrid Chevreuil, "France's Nuclear Offer to Europe," CSIS, 23 October 2024, https://www.csis.org/; and "Speech of the President of the Republic on the Defense and Deterrence Strategy," Élysée, 7 February 2020, https://www.elysee.fr/.

39. Norris and Kristensen, "Declassified."

with greater survivability and promptness. In creating this low-yield version, the United States wanted to send the main signal to potential adversaries that "there is no advantage to limited nuclear employment because the United States can credibly and decisively respond to any threat scenario."[40] Another sea-based capability that some American decisionmakers are currently contemplating is the nuclear-armed sea-launched cruise missile (SLCM-N) that could be deployed on US attack submarines (SSN). As one expert notes, this capability "provides all the necessary attributes" to enhance NATO's nuclear strategy.[41] The SLCM-N is one of the few feasible options to change the US forward-deployed nuclear arsenal in the near future.[42]

While an additional submarine-based capability would indeed be the most survivable option, it does lack visibility compared to aircraft carriers. Nevertheless, port visits and exercises could be used to credibly reassure Allies. Yet such visible demonstrations, in turn, have a negative effect on survivability. The SLCM-N is, however, contested within the White House, Congress, and the US Navy.[43] One of the fears of arming US attack submarines with SLCM-N is the risk of detracting or distracting from their "primary goal," namely the conventional denial mission.[44] Yet one study criticizes the Biden administration's opposition to the SLCM-N program, stating that the nuclear-armed Tomahawk land attack missile (TLAM-N) and the SLCM-N cases are illustrative of "the inconsistency with which the United States pursues capabilities that allies deem important."[45]

Notwithstanding this contestation, Congress has continued to fund the development of the SLCM-N and adapting the W80-4 warhead over the last years.[46] Moreover, former Acting Assistant Secretary of Defense for Space Policy Vipin Narang mentioned in August 2024 that the administration is "complying with congressional direction to develop and field a nuclear-armed sea-launch cruise missile." Narang further stated that while the 2022 *Nuclear Posture Review* cancelled the SLCM-N program, the administration finds itself in a security environment that is deteriorating more rapidly than expected.[47]

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40. John Rood, "Statement on the Fielding of the W76-2 Low-Yield Submarine Launched Ballistic Missile Warhead," DOD, press release, 4 February 2020, https://www.defense.gov/.

41. Gregory Weaver, "The Urgent Imperative to Maintain NATO's Nuclear Deterrence," *NATO Review*, 29 September 2023, https://www.nato.int/.

42. Anya L. Fink, *Nuclear-Armed Sea-Launched Cruise Missile (SLCM-N)*, IF12084 (CRS, 31 May 2024), https://crsreports.congress.gov/.

43. Megan Eckstein, "The Navy Doesn't Want Nukes on Ships, Despite Interest from Some Combatant Commanders," *Defense News*, 13 May 2022, https://www.defensenews.com/.

44. Roberts et al., *China's Emergence*, 50.

45. Keith B. Payne and Michaela Dodge, "Subordinating Extended Deterrence to Antiquated Arms Control Initiatives," *Journal of Policy & Strategy* 3, no. 3 (2023): 37.

46. Fink, *Cruise Missile*.

47. Vipin Narang and Heather Williams, "Nuclear Threats and the Role of Allies: A Conversation with Acting Assistant Secretary Vipin Narang," transcript, CSIS, 1 August 2024, https://csis-website-prod.s3.amazonaws.com/.

The United States could also share SLCM-Ns with European Allies that have conventionally powered attack submarines (SSK), similar to the current dual-key arrangements with the B61. Just as with the bombs, these forward-based SLCM-Ns would be kept in storage until the Nuclear Planning Group decides to upload the missiles on the submarines. Subsequently, by keeping the forward-based SLCM-Ns in storage, the impact on the conventional mission of these dual-capable SSKs and the risk of conventional-nuclear entanglement would be limited. As one expert contends, however, the introduction of NATO commanded and controlled SLCM-N-armed submarines would fail to achieve consensus amongst all NATO Allies.[48] A decision for arming US attack submarines with SLCM-N would not need this consensus and would provide the United States with an additional, survivable, and flexible capability that can be deployed in both the Indo-Pacific and Euro-Atlantic theaters. Nonetheless, access and basing for the conventional support to nuclear operations required to support such capability and the issue of its overflight and the SLCM would still need to be worked out.

Land-Based Nuclear Capabilities: Politically Unfeasible for Now

During the Cold War, land-based nuclear capabilities were also deployed on European soil. In the 1980s, for instance, MGM-31B Pershing II road-mobile nuclear medium-range ballistic missiles (MRBMs), and BMG-109 Gryphon road-mobile nuclear ground-launched cruise missiles (GLCMs) were stationed in Europe. These deployments were part of NATO's *Double-Track Decision* from 1979, the response to the deployment of Soviet SS-20 nuclear intermediate-range missiles in Europe.[49] The missile deployments were combined with arms control talks that resulted in the Intermediate-Range Nuclear Forces (INF) Treaty in 1987. Yet large public protests erupted against these deployments.[50] Consequently, some Allies would probably oppose redeploying similar capabilities because of the potential for public contestation.[51] Allies on the eastern flank, however, would be more receptive toward such changes due to the developments on the other side in Kaliningrad and Belarus, where Russia has deployed dual-capable 9K720 Iskander-M (SS-26 Stone) road-mobile short-range ballistic missiles.[52]

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48. Bell, *Modernise*, 19.

49. *Special Meeting of Foreign and Defence Ministers (The "Double-Track" Decision on Theatre Nuclear Forces) Chairman: Mr. J. Luns* (NATO, 12 December 1979), https://www.nato.int/.

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

51. Eric Edelman et al., *Arming America's Allies: Historical Lessons for Implementing a Post-INF Treaty Missile Strategy* (Center for Strategic and Budgetary Assessments [CSBA], 2022), https://csbaonline.org/.

52. Chels Michta, "Putin Points Nuclear Weapons at NATO: Time to Respond," CEPA [Center for European Policy Analysis], 17 July 2023, https://cepa.org/; and Pavel Slunkin, "Escalating Dependence: Russia's Nuclear Plans for Belarus," European Council on Foreign Relations Commentary, 29 March 2023, https://ecfr.eu/.

After the demise of the INF Treaty in 2019, former Secretary General Jens Stoltenberg emphasized that NATO "will not mirror Russia's destabilising behaviour" and had "no intention to deploy new land-based nuclear missiles in Europe."[53] Nevertheless, some analysts have proposed the reintroduction of conventional land-based missiles in the European theater.[54] One study argues that ground-based, theater-range missiles could augment deterrence in NATO's northeastern flank "by giving NATO more intermediate options on the deterrence ladder," which would basically establish a dual-track approach by helping to "restore the local strategic balance in a post-INF context, thus creating leverage to get Russia back into meaningful arms control talks in the future."[55] The missiles should, however, remain conventional to avoid misunderstanding that they can carry nuclear warheads.[56] Such conventional land-based missiles will be discussed below.

In contrast, another analysis supports developing a more diverse set of nonstrategic nuclear capabilities that includes a Pershing III.[57] Such a new MRBM could be reintroduced on the NATO side in the European theater as a reaction to similar Russian capabilities. Other possible types of land-based capabilities are nuclear cruise missiles and nuclear hypersonic missiles. As another analysis notes, "Given the challenges of detection and interception, very-high-speed, in-atmosphere weapons could provide Washington with a formidable means of addressing concerns over Chinese and Russian IAMD capabilities without necessarily increasing the size of the United States' nuclear stockpile." Considering the technical feasibility, this would be "time-consuming and expensive but might still reward the effort."[58]

While such deployments would thus mirror Russia's moves and considerably strengthen the nonstrategic nuclear capabilities in NATO, the potential political contestation that could be triggered by a deployment of such ground systems in Europe—and the necessary time to develop such capability—makes it unfeasible in the short term. The deployment of air- and sea-based nuclear cruise missiles and hypersonic missiles that remain under US control seems more realistic.

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53. "Press Conference by NATO Secretary General Jens Stoltenberg Following the First Day of the Meeting of NATO Ministers of Defence," NATO, 21 October 2021, https://www.nato.int/.

54. Jacob Cohn et al., *Leveling the Playing Field: Reintroducing U.S. Theater-Range Missiles in a Post-INF World* (CSBA, 2019), https://csbaonline.org/; and Luis Simón and Alexander Lanoszka, "The Post-INF European Missile Balance: Thinking About NATO's Deterrence Strategy," *Texas National Security Review* 3, no. 3 (2020), http://dx.doi.org/.

55. Simón and Lanoszka, "Post-INF," 14–15; and see also Camille Grand, *Missiles, Deterrence and Arms Control: Options for a New Era in Europe* (IISS, September 2023), 24, https://www.iiss.org/.

56. Simón and Lanoszka, "Post-INF,"29–30.

57. Robert Peters, research fellow at The Heritage Foundation, "Integrated Deterrence Across the Whole of Government" panel discussion, US Strategic Command Deterrence Symposium, Omaha, NE, 16 August 2023.

58. Douglas Barrie and Timothy Wright, "Not More, But More Assured: Optimising US Nuclear Posture," *Survival* 66, no. 4 (2024): 19–20, https://doi.org/.

Non-Nuclear Capabilities: Insufficient but Complementary

Another path toward enhancing forward-deployed nuclear forces in NATO is through the deployment of emerging and disruptive technologies as support for the nuclear mission, such as artificial intelligence, cyber and space capabilities, unmanned systems, conventional precision-strike weapons, and hypersonic missiles. Firstly, these EDTs can be used to strengthen conventional support to nuclear operations. For instance, unmanned combat aerial vehicles could be used for the destruction or suppression of enemy air defenses. Secondly, conventional precision-strike weapons can be used in tandem with forward-deployed nuclear weapons to maximize the effect of an attack. Third, conventional precision-strike weapons can also take over targets from nuclear weapons due to the increase in accuracy—leading to a reduced need for forward-deployed nuclear weapons in certain scenarios.[59] Fourth, certain capabilities such as hypersonic missiles are promising for extended deterrence because they enable "rapid deployment and low-altitude/lower-risk missions that evade existing defence, at a lower cost-point."[60]

An example of a hypersonic missile to be deployed by US strategic bombers that is currently under development is the AGM-183A Air-Launched Rapid Response Weapon.[61] Other conventional air-launched precision strike missiles under development are the Stand-in Attack Weapon (SiAW) and the Mako Air-Launched Hypersonic Missile. Due to their smaller dimensions, however, both are designed for delivery by tactical fighter jets. Both the SiAW and the Mako can be carried internally by a range of tactical aircraft, including the F-35A and C.[62] This means that the aircraft could maintain the benefits of its stealth characteristics.

An example of a ground-based conventional system is the Typhon Strategic Mid-Range Fires (SMRF) System. Developed as a reaction to the recent developments regarding Russian and Chinese artillery systems, the conventional SMRF system is part of the ongoing long-range precision fires modernization by the US Army. A SMRF battery will be part of the Strategic Fires Battalion of the Army's Multi-Domain Task Force, next to a HIMARS battery and a Long-Range Hypersonic Weapon battery.[63]

During spring 2024, such an SMRF battery was temporarily deployed to the Philippines for exercises.[64] Nevertheless, in the context of the demise of the INF Treaty

59. Fabian Hoffmann and William Alberque, *Non-Nuclear Weapons with Strategic Effect: New Tools of Warfare?* (IISS, March 2022), https://www.iiss.org/.

60. Rupal N. Mehta, "Extended Deterrence and Assurance in an Emerging Technology Environment," *Journal of Strategic Studies* 44, no. 4 (2021): 18, https://doi.org/.

61. Joseph Trevithick and Thomas Newdick, "B-52 Armed with Hypersonic Missile Makes Appearance in Guam," *TWZ*, 1 March 2024, https://www.twz.com/.

62. Thomas Newdick, "The Lowdown on Lockheed's Newly Revealed Mako Hypersonic Missile," *TWZ*, 11 April 2024, https://www.twz.com/; and Joseph Trevithick, "Stand-In Attack Missile Released from Fighter for First Time in USAF Test," *TWZ*, 2 December 2024, https://www.twz.com/.

63. Andrew Feickert, *The U.S. Army's Typhon Strategic Mid-Range Fires (SMRF) System*, IF12135 (CRS, 16 April 2024), https://crsreports.congress.gov/.

64. Feickert, *Typhon*, 2.

and the provocative dual-capable deployments on the Russia side, introducing such a battalion in the European theater would strengthen regional deterrence but would also not entail a tit-for-tat deployment that the former NATO secretary general ruled out. Subsequently, the July 2024 US–Germany joint statement on long-range fires deployment in Germany should be welcomed. The conventional weaponry that will be deployed include the SM-6, Tomahawk, and "developmental hypersonic weapons."[65] While it is not surprising that Russian President Vladimir Putin sees these deployments as a provocation, one study contends that "Putin's comparison of the present situation with NATO's 1979 decision to deploy US missiles to Europe disregards the fact that, in both instances, US missile deployments have followed a Russian precedent."[66]

Ideally, such units would be based on the territories of multiple Allies. Poland in particular should be one of those host nations as this would increase its role in NATO's deterrence efforts. Due to the conventional nature of the system, it would also more easily gain political approval by the other Allies and would not be perceived by the adversary as a nuclear provocation. The July 2024 European agreement between France, Germany, Italy, and Poland to develop jointly ground-launched cruise missiles has a similar potential to bolster Europe's role in the conventional deterrence posture of the Alliance.[67]

Nevertheless, it is important to stress that these and other non-nuclear strategic capabilities are still under development. Consequently, EDT options are not yet a valuable alternative to substitute the forward-deployed nuclear forces in NATO due to symbolic and political reasons, and psychological effects.[68] Therefore, complementing the current nuclear capabilities with EDTs remains the most attractive option.

Conclusion

Because of the growing risk of a future nuclear crisis triggered by Russia and wider uncertainties regarding future contingencies, NATO and the United States as guarantor require a range of forward-deployed nuclear options to manage escalation dynamics. Relying solely on the B61-12 seems imprudent in the face of a revisionist nuclear power that possesses a significant number of nonstrategic nuclear weapons and sees

65. "Joint Statement from United States and Germany on Long-Range Fires Deployment in Germany," The White House, press release, 10 July 2024, https://bidenwhitehouse.archives.gov/; and see also Jonas Schneider and Torben Arnold, *Significant and Sound: US Medium-Range Missiles in Germany* (SWP, 2024), https://www.swp-berlin.org/.

66. Timothy Wright and Douglas Barrie, "The Return of Long-Range US Missiles to Europe," IISS, 7 August 2024, https://www.iiss.org/.

67. Sabine Siebold and John Irish, "France, Germany, Italy, Poland Agree to Jointly Develop Long-Range Cruise Missiles," Reuters, 11 July 2024, https://www.reuters.com/.

68. Jacek Durkalec et al., *Nuclear Decision-Making, Complexity and Emerging and Disruptive Technologies: A Comprehensive Assessment* (European Leadership Network Report, February 2022), 24, https://www.europeanleadershipnetwork.org/.

them as flexible instruments to achieve various goals during conflict and war.[69] The B61-12 provides the dual-capable fleet with an improved gravity bomb; however, these munitions should thus in the medium term be supplemented and later replaced by dual-capable air-launched cruise missiles or air-launched hypersonic missiles.

While fielding such capability would increase risks related to warhead and intent ambiguity, it would also greatly enhance the military credibility of the F-35A DCA fleet without pressuring Allies to make decisions that risk undermining the cohesion of the Alliance, a concern raised by analysts in the 1960s and echoed today.[70] According to one study, introducing nuclear-armed ALCMs would not violate the INF, the Presidential Nuclear Initiatives, or the NATO-Russia Founding Act, and would merely complement an already existing capability, "which takes into account technological changes in adversary air defenses." Furthermore, it could be seen as a justified reaction to the INF violations of Russia, while at the same time be potentially useful as a bargaining chip in future arms control initiatives.[71]

What, then, is feasible in the short term? The options worth exploring are improvements within the existing framework—such as the reactivation of the UK as an active DCA Ally—improving the Integrated Air and Missile Defense of DCA air bases, and developing dispersion plans. Furthermore, the permanent basing of a US bomber squadron—ideally, in the future, the B-21—in the European theater and having US nuclear-powered attack submarines with SLCM-N patrolling the Euro-Atlantic area, would also lead to an increase in the military and political credibility of American extended nuclear deterrence. Complementary non-nuclear capabilities could also reinforce CSNO or forward-deployed nuclear capabilities. It will, however, be important to pre-assign such assets to the European theater to avoid abandonment fears in the case of a two-front war.

The results should be a more diversified posture consisting of forward-deployed nuclear forces under NATO/NPG control, namely the DCA capability with ideally dual-capable ALCMs next to the B61 bombs; conventional forces under NATO/Supreme Allied Commander Europe; and nuclear forces under US control, namely the bombers and US attack submarines. Such a mix could enhance the credibility and flexibility of forward-deployed nuclear forces as there would be more controlled response options than only the B61-12 to close the gap in the escalation spectrum. Furthermore, this changed posture would be more politically feasible for both Europe and the United States because the additional nuclear delivery systems of bombers and SSNs would remain under US command and control. It will, however, be important for the United States to consult regularly with NATO Allies in the Nuclear Planning Group

69. William Alberque, *Russian Military Thought and Doctrine Related to Non-Strategic Nuclear Weapons: Change and Continuity* (IISS, January 2024), https://www.iiss.org/.

70. See F. C. Iklé et al., *The Diffusion of Nuclear Weapons to Additional Countries: The "Nth Country" Problem* (US Air Force Project RAND, 15 February 1960), https://www.rand.org/; and Bell, *Modernise*, 18.

71. Kroenig, "NATO Nuclear Posture," 10.

on bomber and SSN deployments in the Euro-Atlantic region to avoid the problem that one nuclear strategist refers to as "no annihilation without representation."[72]

Consequently, if the United States wants to remain the "ultimate guarantor" and avoid proliferation pressures amongst its Allies, it will need to continue sharing the nuclear burden.[73] Adjusting the mix of US nuclear capabilities will also be necessary to maintain the credibility of extended nuclear deterrence, considering the emerging threats. Finally, while this discussion has focused on identifying what capabilities might be involved, the analysis of locations and the quantity of such capabilities warrant further research. **Æ**

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72. Klaus Knorr, as cited in Jeffrey H. Michaels, "'No Annihilation Without Representation': NATO Nuclear Use Decision-Making During the Cold War," *Journal of Strategic Studies* 46, no. 5 (2023): 1014, https://doi.org/.

73. Wannes Verstraete, "Anticipating Europe's Nuclear Futures," *The Washington Quarterly* 47, no. 1 (2024), https://doi.org/.

JOINT INNOVATION

What Is and What Could Be

Todd P. Moulton
Joshua A. Pusillo

Adversarial uses of new technologies are increasing across the world, rapidly changing the nature of warfighting. Such threats currently exceed the capacity of DOD organizations that expedite military innovation. To maintain its crucial military advantage, the United States must focus on producing leaders who can promote rapid innovation across the joint force. This article proposes the establishment of a joint office to promote a new corps of innovation leaders and a joint design thinking school to train and mentor them in advancing cultures of innovation within their respective teams. These organizations would encourage leaders to refine existing service innovation efforts and construct unique approaches to addressing the near- and long-term threats facing the United States.

In May 2023, former Deputy Secretary of Defense Kathleen Hicks explained the collective aim of past DOD initiatives to foster innovation, efforts which "all shared a simple and compelling proposition: to create and exploit change as a military opportunity." Regardless of their origins in government or commercial industry and of their nature as a new technology or capability, such innovation efforts worked to ensure US military superiority in confronting peer and near-peer adversaries, a dilemma which she perceived as one of great urgency: "Today, in the face of our pacing challenge, our task is to adapt and integrate innovations wherever they can add the most military value."[1]

Indeed, adversarial use of new technologies in innovative ways continues to lead to an array of threats eroding relative US military superiority across the world. The expected rate of change in the number and sophistication of such threats currently exceeds the capacity of organizations within the Department of Defense that expedite military innovation.

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1. Kathleen Hicks, keynote address, Ash Carter Exchange on Innovation and National Security, Washington, DC, 9 May 2023, transcript, https://www.defense.gov/.

To resolve this disparity, the Department must address the substantial need for leaders who can promote rapid innovation. To do so, it should establish a program to identify, train, and mentor joint personnel to lead teams through the design-thinking process—a process that would help develop ways to refine existing service innovation efforts and construct unique approaches to address the near- and long-term threats facing the United States. The joint force can achieve the leap ahead by training a cohort of enterprising leaders who can facilitate a revolution in military thinking and collaboration across all services and at each level of warfare.

This article argues that the joint force must invest in developing such leaders early in their careers. The US military, already adept at instructing junior leaders on tactics, techniques, and procedures (TTPs) to counter conventional battlefield threats unilaterally, must train some of those same leaders on how to collaborate to achieve rapid, decentralized, tactical innovation that ensures US military advantage. It must also identify and develop the leaders best suited for future assignment to service innovation organizations.

In reviewing key government strategic documents on innovation in the military and examining DOD innovation initiatives, this article provides an overview of how the services embarked on developing innovation, what impediments are engrained within the military, and what challenges exist at the DOD level. To meet such challenges, the article underlines practical guidance on how the joint force can innovate to address future threats by establishing a joint program to promote a new corps of innovation officers and a joint design thinking school to train and incentivize these officers on track for command or key billet assignments to advance cultures of innovation within their respective teams.

Innovation as Strategic Guidance

Strategic guidance from the first Trump administration reveals the significance of fostering innovation to maintain the United States' competitive edge, an initiative that is sustained through the present day. Acknowledging the need for reform in meeting the challenges of a rapidly changing global strategic environment, the 2017 *National Security Strategy* directed that the "United States must regain the element of surprise and field new technologies at the pace of modern industry," emphasizing that all governmental agencies shift from research and development to "an approach that rewards rapid fielding and risk taking."[2]

Additionally, the 2018 *National Defense Strategy* (NDS) identified the rationale for applying this concept across the Defense Department, directing the Department and the joint force "to out-think, out-maneuver, and out-partner revisionist powers, rogue regimes, terrorists and other threat actors."[3] The 2018 NDS moved the services away

2. Donald J. Trump, *National Security Strategy* (The White House, 2017), 21, https://trumpwhitehouse.archives.gov/.

3. *Summary of the National Defense Strategy of the United States of America* (Department of Defense, January 2018), 5, https://media.defense.gov/.

from the Global War on Terrorism mindset and realigned the military on potential conflict with near-peer competitors. Furthermore, it redefined success as no longer attributed to the state that developed new technology but rather to one that better integrated such technology and adapted it to its warfighting. As both strategic documents demonstrated, rapid innovation using current capabilities would be key to securing battlefield success.

The 2018 *National Military Strategy* provided a roadmap for integrating innovation efforts into the joint environment. Specifically, it states that military exercises should "facilitate near-term experimentation in an effort to rapidly incorporate innovative ideas and disruptive technologies that promote competitive advantage." Such exercises are crucial to safely integrating innovation in an environment with little room for error, "building readiness, interoperability, and the mutual trust required for a joint combined arms approach."[4]

In May 2025, the Trump administration mandated the initiative to "spur innovation" to "ensure that the United States military possesses the most lethal warfighting capabilities in the world."[5] Additionally, in June 2025, General Dan Caine, chairman of the Joint Chiefs of Staff, placed greater emphasis on innovation, encouraging technology entrepreneurs to assist the military. In aiming to "bridge the gap between the Pentagon and Silicon Valley," Caine addressed a largely civilian audience at the Ash Carter Exchange and AI+ Expo, stating, "Your nation needs you with a sense of urgency. We need your creative, innovative, patriotic, and diabolical minds, 24/7/365."[6]

Militaries and Innovation

A historical review of how militaries introduce and implement innovative thought and technologies reveals the inherent challenges to integrating revolutionary TTPs and technologies into everyday practices. The UK Royal Air Force's (RAF) evolution of air defense exemplifies one of the most consequential adoptions of innovative TTPs and emerging technologies ever witnessed by Western militaries. While radar and the modern fighter's advent were key components in saving the UK from Germany, the linchpin in air defense development was several high-ranking RAF officers who understood the concept's importance in the coming war(s). The episode also exhibits the broad and far-reaching impact a few individuals can have on the course of history when they can foresee a shift in the theory of war and realize the necessary elements to defeat their enemy.

As research has suggested, military organizations often struggle with incorporating innovation into its processes. Military organizational structure has been recognized as the primary driving force as well as the main obstacle to service and joint innovation, as

4. Office of the Chairman of the Joint Chiefs of Staff Public Affairs, "Description of the 2018 National Military Strategy Released," Joint Chiefs of Staff [website], 12 July 2019, https://www.jcs.mil/.

5. Exec. Order No. 14,265, 90 F.R. 15,621 (2025).

6. Sydney J. Freeburg Jr., " 'We Need Your Creative, Innovative, Patriotic, and Diabolical Minds': Joint Chiefs Chairman Caine," *Breaking Defense*, 4 June 2025, https://breakingdefense.com/.

the military is a complex ecosystem with several subcomponents that vie for priority for their respective roles and missions.[7] The primary hurdle to incorporating innovation transcends from the services' mechanistic or bureaucratic nature and entrenched culture that favors stability over revolutionary change.[8] Mechanistic organizations anchor themselves in routine and formalized processes to overcome common problems.[9]

The military tends to enjoy already assessed ideas and TTPs and to shun innovations.[10] Innovation's introduction into the military system represents a structural disruption where fresh methodologies, if they work, could replace standing organizational approaches and force the system to fundamentally change. The system thus resists change as it threatens what is orderly and familiar.[11] Innovation does not fit well into preexisting military culture, which has developed over generations and makes basic assumptions that have repetitively worked to remedy existing problems. Conventions are taught as norms representing the "correct" ways to conduct operations.[12] Militaries also value a common history and values, generally viewing past knowledge as the most efficient teacher of war during peacetime, precluding more forward thinking.[13]

As historical patterns reveal, the positive integration of novel military technologies, companion doctrine, and the associated supply chains is enacted when four underlying factors are present. First, to inspire innovation, the military needs an ideological struggle that redefines the organization's values.[14] The primary principle that catalyzes military innovation is a new theory of war that entails how war will look and how a nation-state will win that war.[15] Second, the emerging war theory must ensconce unique daily tasks into a military's peace and wartime repertoire. That is, the force must define new critical missions to ensure personnel understand how the force will evaluate them and either reward or penalize their performance. Without the establishment and evolution of new essential tasks, innovative ideas and technologies may fall to the wayside.

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7. Stephen Peter Rosen, "New Ways of War: Understanding Military Innovation," *International Security* 13, no.1 (1988), https://doi.org/.

8. Tom Burns and G. M. Stalker, *The Management of Innovation* (Oxford University Press, 1961); and Williamson Murray, "Innovation Past and Future," in *Military Innovation in the Interwar Period*, ed. Willamson R. Murray and Allan Millett (Cambridge University Press, 1996).

9. Andrew Hill, "Military Innovation and Military Culture," *The US Army War College Quarterly: Parameters* 45, no. 1 (2015), https://press.armywarcollege.edu/.

10. Murray, "Innovation."

11. Hill, "Military Innovation"; and Elting Morison, "A Case Study of Innovation," *Engineering and Science* 13, no.7 (1950): 8.

12. Edgar Schein, *Organizational Culture and Leadership*, 4th ed. (Jossey Bass, 2010).

13. Samuel P. Huntington, *The Soldier and the State: The Theory and Politics of Civil-Military Relations* (Belknap Press,1957), 79.

14. Rosen, "New Ways."

15. Emile Simpson, "Clausewitz's Theory of War and Victory in Contemporary Conflict," *Parameters* 47, no. 4 (2017), https://press.armywarcollege.edu/.

Next, such a theory must influence a shift in the people reaching the senior command level. Innovation will usually forge a new and unique avenue to the senior ranks, so that the military does not sideline those practicing newly-developed war methods. Lastly, reigning senior military officers must establish the path for "maverick" junior officers to reach flag and continue reformulating the supplanting war theory.[16] The level at which these ranking military officers believe in inventive technologies and TTPs will drive the innovations' speed and intensity.[17]

RAF's adoption of radar prior to World War II is a military innovation that likely saved the UK from German occupation. The radar story revolves around RAF senior members who took lessons from World War I.[18] The leaders in air defense theory foresaw a shift in the theory of war and the reverberating effects the change would have on the RAF and its critical tasks, comprehending that the evolving nature of air warfare necessitated that the UK have an aerial capability to protect itself.[19]

While the RAF flag officers did not try to fundamentally shift the service from a bomber- to a fighter-centric force, they began laying the groundwork to build a capable air defense network in the 1920s.[20] These officers realized that there was a requirement for a not-yet-invented technology to fortify the UK's defense.[21] They positioned capable RAF service members whom the service did not see as mavericks into key roles and believed the RAF would allow them to make incremental changes.[22] The chosen personnel continued developing the air defense doctrine and established supply chains that would assist with fighter production, a key component to air defense.[23]

In 1935, the RAF demonstrated an experimental radar and realized it had the technology the service required to integrate with RAF fighters to create a venerable air defense.[24] This discovery coincided with the German Luftwaffe's rapid growth and the RAF's determination that radar stations needed to be operational by 1940 to direct fighter aircraft to incoming enemy planes.[25] Even though the technology was still unproven, senior leaders further grasped radar's decisiveness and commenced operator training in 1936, mandating the building of five operating stations by 1938 versus

16. Rosen, "New Ways."

17. Ola Modig and Kent Andersson, "Military Innovation as the Result of Mental Models of Technology," *Scandinavian Journal of Military Studies* 5, no. 1 (2022), https://doi.org/.

18. E. B. Ashmore, *Air Defence* (Longmans, Green, 1929), 39.

19. Rosen, "New Ways."

20. Committee on Imperial Defence (CID), "Continental Air Menace: Anti-Aircraft Defence," Home Defence Subcommittee Report 118A, May 1923, microfilm, 4, CAB 3, Harvard University Microfilm Collection.

21. Ashmore, *Air Defence*.

22. Franci K. Mason, *Battle over Britain* (McWhirter Twins, 1969), 80.

23. Rosen, "New Ways"; and Derek Wood and Derek Dempster, *The Narrow Margin* (McGraw-Hill, 1961), 462.

24. Rosen, "New Ways."

25. Reorientation Subcommittee, CID, "Reorientation of the Air Defence System of Great Britain," Home Defence Subcommittee Report 205A, April 1935, microfilm, 6, CAB 3, Harvard University Microfilm Collection.

1940.[26] The officers' foresight laid the foundation for radar's integration into the RAF, which relied almost exclusively on this technology to fend off the German blitzkrieg.

Even though RAF flag officers realized the requirement for air defense after World War I, it still took two decades to produce the innovative technology to bring this dream to fruition. The time required to develop radar from concept to reality demonstrates that US services need the individuals who will conceptualize, create, and generate the next "radar" to deter and defeat the country's potential enemies. Such innovation offers an example of how military joint officers could play a determining role in preparing for the rapidly changing nature of war. Much like those who saw air defense as a game-changing doctrinal transition, joint innovation officers could work with operators to devise unique TTPs to maintain the military's edge over its peer competitors and foster novel technological requirements.

Yet the military has not defined a path to cultivate "out-of-the-box" military leaders to produce innovative TTPs and technologies for the joint force. A review of the Defense Department's innovation efforts demonstrates how the kind of innovative thinking that is needed for joint success is yet to be developed.

DOD and Service Innovation Efforts

Throughout the past 10 years, the Defense Department and the services have established innovation centers that focus on the creation of innovative ideas and technologies at the micro-level, with the goal that they will eventually assist the Department and services en masse. Yet these innovation efforts have focused on manufacturing platforms and then retroactively fabricating TTPs to adjust to these newfound capabilities. While some fascinating and futuristic equipment has emerged, inventive service members and their ability to outthink their competition are often what prevail in warfare.

In 2015, then-Secretary of Defense Ash Carter created the Defense Innovation Unit Experimental (DIUx) to cultivate military innovation and overcome bureaucratic inertia. Secretary Carter's goal was to quickly integrate existing commercial technologies into the armed forces. His thought revolved around the idea that as the Defense Department's associations with technology firms matured, the burgeoning interactions would enable it further access to new ideas and concepts applicable for military use.[27] In 2018, DIUx's record of innovation secured it a permanent place within the Department, becoming the DIU of today.[28]

From 2015 to 2020, DIU invested $406 million dollars into 109 projects. The organization has a roughly 23 percent success rate in moving innovative technologies and

26. Basil Collier, *The Defence of the United Kingdom* (Her Majesty's Stationery Office, 1957), 68; and Rosen, "New Ways."

27. Fred Kaplan, "Procuring Innovation: The U.S. Department of Defense Founded a Kind of Startup in Silicon Valley to Accelerate the Development and Acquisition of New Technologies Useful to the Military. But Will It Survive President Trump?," *MIT Technology Review* 120, no. 1 (2017).

28. Scott Maucione, "SPECIAL REPORT: Failure Is an Option for DOD's Experimental Agency, But How Much?," Federal News Network, 30 October 2019, https://federalnewsnetwork.com/.

TTPs to military members in the field. Although this rate falls below the industry standard of 33 percent, those platforms and methods—which transitioned into the services' hands—saved lives and money and provided additional security. Moreover, DIU developed relationships with 45 vendors who had never worked with the Defense Department, bringing in new ideas and perspectives to defense innovation. The DIU also established the National Security Innovation Capital and the National Security Innovation Network, which resulted in Department contacts with 2,500 members of academia to speed up research and development of platforms and methodologies.[29] The DIU, a model of innovative thinking, spurred the services to launch their respective equivalents.

AFWERX

The Air Force created AFWERX, the first DIU-like organization in 2017, with the intent to establish relationships between the service and small business owners and entrepreneurs for future innovative development processes.[30] Since then, AFWERX has refined and grown the unit's structure and increased the number of Spark Cells throughout the country from 2 to 100.[31] The Spark Cell concept aligns with Air Force doctrine of enabling Airmen to perform decentralized execution from higher-level guidance. Airmen throughout the country meet with businesses, schools, and others to generate ideas and projects locally.[32]

Spark Cells have three goals: further a culture of innovation within the Air Force, provide Airmen with the pathways and resources to solve tactical-level pain points, and create a robust network of experts from industry, academia, and the government.[33] Some of AFWERX's successes include 3D-printed dental implants; a color-coded, flashlight-like tool for MC-130J loadmasters; and drones used for counter-unmanned systems training.[34]

Army Futures Command

Following the Air Force's and DIU's examples, in June 2018, the Army instituted a start-up-like organization on a larger scale, the US Army Futures Command (AFC), which reached full operational capability a year later. Viewed as the Army's "most significant reorganization since 1973," the AFC has the primary goal of guiding overall modernization efforts through identifying and developing requirements and technol-

29. Maucione, "Failure."

30. Secretary of the Air Force Public Affairs, "Air Force Opens Doors to Universities, Small Businesses and Entrepreneurs to Boost Innovation," US Air Force [USAF, website], 21 July 2017, https://www.af.mil/.

31. Rachel Coates, "AFWERX Spark Lab Encourages Innovation," Defense Visual Information Distribution Service (DVIDS), 21 July 2023, https://www.dvidshub.net/.

32. Rachel Cohen, "AFWERX Beyond the Buzzword," *Air & Space Forces Magazine*, 1 October 2019, https://www.airforcemag.com/.

33. "Operational Cells," AFWERX [website], accessed 2025 May 25, https://afwerx.com/.

34. Cohen, "AFWERX."

ogy. The Army designed AFC, headquartered in Austin, Texas, similar to its three other major commands—Army Training and Doctrine Command, Army Forces Command, and Army Materiel Command—as small, flexible, collaborative entities that promote innovation through speed, experimentation, and demonstration.[35]

Yet the command has not enjoyed many successes in the organization's history.[36] Although AFC can award contracts more quickly than general Army units, Congress has questioned the command's lack of tangible results.[37] Its dearth of additional capacity or capabilities may be a reflection of the command's infancy, and much like DIU, innovation at AFC may grow over time; however, unlike DIU and AFWERX, AFC is structured as a typical military command, which likely inhibits its agility and adaptability. The command also recently underwent some turmoil and reorganization along with a shift in its role as the leader of the Army's modernization efforts. Going forward, the AFC has established its goal as one of "continual transformation."[38]

NavalX

In March 2019, the US Navy established its innovation unit, the Naval Expeditions (NavalX) agility office. NavalX was intended to transform the Naval workforce through refining and discovering unique TTPs rather than designing and developing new technologies. The unit began with a sole office in Alexandria, Virginia, and has since expanded to various locations throughout the United States, including San Diego, California; Orlando, Florida; Newport, Rhode Island; Keyport, Washington; and Crane, Indiana.[39] The office's primary focus is pioneering novel methods to enable an agile Naval workforce to adapt to the constantly changing global environment. Furthermore, NavalX distributes its original methodologies to foster even more advanced practices.[40]

NavalX utilizes Intellipedia, which mimics Wikipedia and allows users to update websites as they build and mature grow-breaking TTPs. Its accomplishments include the production of the first chapter of a cloud migration handbook, which is hoped to help the Naval workforce as individuals and units foster innovative TTPs. NavalX also developed Intellipedia sites for agile scrum development, building analytics teams using

35. Army Futures Command (AFC) Task Force, "Army Futures Command," US Army [website], 28 March 2018, https://www.army.mil/.

36. Stew Magnuson, "JUST IN: Pressure Will Mount on Army Futures Command to Produce Results," *National Defense*, 3 March 2020, https://www.nationaldefensemagazine.org/.

37. Stew Magnuson, "AUSA NEWS: Army Futures Command Breaking Down Barriers," *National Defense*, 16 October 2020, https://www.nationaldefensemagazine.org/.

38. Jed Judson, "Beyond 2030: How Army Futures Command Is Adapting Its Approach," *Defense News*, 10 October 2023, https://www.defensenews.com/; and Judson, "In New Directive, US Army Reins in Army Futures Command," *Defense News*, 4 May 2022, https://www.defensenews.com/.

39. Aaron Boyd, "NavalX Innovation Office Really Wants the Navy to Be More Agile," *Nextgov/FCW* [*Federal Computer Week*], 19 October 2019, https://www.nextgov.com/; and Megan Eckstein, "NavalX Innovation Support Office Opening 5 Regional 'Tech Bridge' Hubs," *USNI News*, 3 September 2019, https://news.usni.org/.

40. Boyd, "NavalX."

other transaction authorities for procurement and crowdsourcing.[41] The Navy took a further step in 2022 by creating the Navy Innovation Unit to speed up innovation solutions to pressing issues in the maritime environment.[42]

Marine Innovation Unit

In June 2022, the Marine Corps established the Marine Innovation Unit (MIU) in Newburgh, New York. Run by Marine reservists, the MIU is intended to connect the Marine Corps with industry, academia, special operations program managers, AFC, and federally funded research centers. Reservists are selected based on their civilian expertise and immersion in high-technology sectors.[43]

The MIU has focused on developing computer software to drive innovation within the Marine Corps. Together with the Marine Corps Software Factory (MCSF), which aims to demonstrate a service member-led scalable software development capability, it has emphasized fabricating computer programs and applications to assist Marines on the battlefield.[44] In March 2025, MIU supported MCSF in maturing the Augmented Reconnaissance and Estimate of the Situation (ARES) application, intended to aid tactical-level units planning for casualty evacuation or to infiltrate or exfiltrate an area.[45] During the two-week sprint, the Marines successfully used ARES to construct level and obstacle-free helicopter landing zones, based on topographic data. ARES was also shown to perform in non-conducive communications environments, which would likely occur in remote locations or against a peer competitor.[46]

Such efforts among the services following the Defense Department's lead demonstrate their alignment with strategic guidance on innovation. Yet single-service teams are insufficient to achieve the level of innovation required to defeat near- and peer-competitors. AFWERX, AFC, NavalX, and the MIU need a joint environment for innovative facilitators to train together and mentor each other. Furthermore, the optimum time for the joint force to innovate is in the wake of such component efforts. Taking lessons learned by these pioneers, the joint force should organically develop innovative thinkers to make the units and commands even more effective and connected while focusing on joint matters.

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41. Boyd, "NavalX."

42. Megan Eckstein, "US Navy Creates Innovation Center, Advisory Board to Focus Investments," *Defense News*, 9 December 2022, www.defensenews.com/.

43. "Marine Innovation Unit," US Marines [website], accessed 4 June 2025, https://www.marforres.marines.mil/.

44. Thomas Kleiber, "For Warfighters, by Warfighters: Marine Innovation Unit and Marine Corps Software Factory Develop Tools for the Modern Battlefield," DVIDS, 28 March 2025, https://www.dvidshub.net/.

45. Jon Harper, "Marine Corps Could Expand Software Factor, Create New MOS," *DefenseScoop*, 1 May 2025, https://defensescoop.com/.

46. Kleiber, "For Warfighters."

Impediments to Innovation

The establishment of a conduit to foster a group of joint service members dedicated to operationalizing innovation will almost certainly assist in making a more agile Department capable of defeating any contemporary or future adversary. Before realizing this vision, it is important to address the most common impediments to an innovative mindset across the joint force.

Although the services have enjoyed some innovation achievements, many of these accomplishments have not translated into the joint realm. The reasons behind parochial innovation are multifaceted but primarily rest with the conceptual ambiguities within the Joint Warfighting Concept (JWC) and the services' respective views of their threat environments, which thwarts joint innovation.

In 2020, then-Secretary of Defense Mark Esper enacted the JWC as a remedy to recommendations laid out in the 2018 NDS, which called for original concepts to confront Russia and China.[47] The JWC was Secretary Esper's attempt to align personnel, organizations, training, and doctrine against a China-level threat.[48] Yet, there was no exact leadership guidance on whether the JWC should focus on deterring versus winning a conflict; whether it should emphasize continuous competition with potential adversaries or warfighting alone, or converge on a single campaign, antagonist, and region; or whether it should try to address all potential military threats.[49] Fragmentary and contradicting senior direction led the services to plan, develop, and build service-specific TTPs and platforms against different peer adversaries.[50] While the Navy and Marine Corps viewed China as the United States' primary peer competitor due to the services' emphasis on a potential conflict in the Indo-Pacific region, the Army and Air Force did not highlight any single adversary.[51] The combination of the JWC's opaque and non-directive guidance and the services' threat perception biases drive service innovation at the cost of promoting solutions to joint force vulnerabilities.

The joint force is an emblematic mechanistic society which prides itself on standardized TTPs and a static acquisition process. The individual services want to remain entrenched in TTPs, systems, and promotion paths that have worked for an era or more, because these feel comfortable and expected. When they begin to move away from foundational period elements—such as manned aircraft, carrier operations, or the heavy fight—the military structure as a whole begins to shutter as this shift repre-

47. Mark T. Esper, *Implementing the National Defense Strategy: A Year of Successes* (Department of Defense, 2020), 3, https://media.defense.gov/.

48. Kris Osborn, "Pentagon Crafts New 'Joint Warfighting' Concept," Warrior Maven, 22 August 2021, https://warriormaven.com/.

49. Thomas Mahnken et al., *Innovating for Great Power Competition: An Examination of Service and Joint Innovation Efforts* (Center for Strategic and Budgetary Assessments, 11 January 2023), https://csbaonline.org/.

50. Mahnken et al., *Innovating*.

51. Todd South, "Goodbye, Tanks: How the Marine Corps Will Change, and What It Will Lose, by Ditching Its Armor," *Marine Corps Times*, 22 March 2021, https://www.marinecorpstimes.com/.

sents a headwind to the organization's inertia.[52] Not only does innovation cause disorder to the prevailing theory of war, but it also changes military society, fomenting interactions between the joint force and its members. Moreover, leaders who desire to innovate within the edifice face subcomponents which will further constrain their want to move from a mechanistic to an organic system.[53]

Joint innovation officers would likely need to overcome the difficulties of replicating warlike conditions in peacetime and innovating within these parameters, wrestling a modicum of control over innovation away from senior military officials and ensuring they forge a path for themselves and their protégés for continued professional development and promotion.[54] War more often than not creates opportunities for innovation as enemy forces are able to find and exploit weaknesses, thus forcing friendly units to find novel approaches to seal these vulnerabilities. Yet, joint innovation officers would mostly innovate in peacetime during a significant portion of their career but would have to discover avenues to generate marshal-like events to construct new ideas and platforms. The officers could help design joint exercises or modules within the exercise to build a realistic war scenario. The intended result from the findings would culminate in innovative TTPs or requirements for newfound paraphernalia. Joint innovation officers would serve not only as purveyors of joint TTPs and equipment but also as the vanguard of joint leadership challenging the status quo.

The military tends to plan innovation and as shown has units devoted to this end. Yet these groups germinate innovation within existing military culture, which propagates solutions to requests using standing requirements and vulnerabilities.[55] Joint innovation officers would work to incrementally change this philosophy.

To guarantee joint innovation officers remain as independent as possible, the military must form a joint office that would change the military's perception of innovation. During his tenure as chairman of the Joint Chiefs of Staff, now-retired General Mark Milley, who understood the services' cultural resistance to innovation, envisioned such an office as an enforcement mechanism to develop joint innovation capabilities and integrate these capabilities into joint concepts.[56]

The services' concentration on the perpetuation of sustaining circumstances where leaders make only small adjustments to existing TTPs and platforms does not bode well for innovative thought.[57] The military's intent for this organization should concentrate on allowing the joint innovation officers free reign to examine the dominant joint concepts and gravitate to producing unique TTPs and platforms for potential

52. Hill, "Military Innovation."

53. Burns and Stalker, *Management*.

54. Hill, "Military Innovation."

55. Thomas Kuhn, *The Structure of Scientific Revolution*, 50th Anniversary ed. (University of Chicago Press, 2012); and Hill, "Military Innovation."

56. Joe Gould, "US Military May Need Innovation Overhaul to Fight Future Wars, Milley Says," *Defense News*, 1 June 2022, https://www.defensenews.com/.

57. C. M. Christensen and M. E. Raynor, *The Innovator's Solution: Creating and Sustaining Successful Growth* (Harvard Business School, 2003).

future conflicts. An independent program would also allow these officers to address senior military officers who may be more resistant to change, focusing on latent liabilities external to contemporary military conditions to discover solutions to prevent catastrophes in prospective hostilities.

Finally, joint innovation officers will likely face promotion resistance because the reigning leadership will view them as mavericks and an assault on the path that leads sitting flag officers and senior enlisted to the leadership pantheon. The modern military promotion system chooses officers who have a set of characteristics which mirror the prevailing notions that underpin military society: honorable war, the delegation of authority, and uniformity. Senior leaders tend to select officers and senior enlisted who most reflect themselves as admirals and generals. This presents a paradox: although residing senior officers have the capacity to enable innovative TTPs and leaders, they are the least likely to identify uncharted paths or empower those who could change the culture. Selecting a trailblazer means turning away from the enshrined strategic culture they built their careers on.[58]

For joint innovation officers to succeed, they will need senior leaders who believe in their mission to keep the military ahead of its peer competitors by cultivating novel methodologies to contemporary problems. Leadership buy-in may take a generation or two, during which constant feedback from the joint innovation officer command to the joint force will be critical to ensure the services understand what these officers are doing and how their TTP and platform development will assist the armed forces.

Joint innovation officers face an uphill battle to create wartime scenarios in peacetime. Yet the right cohort can build marshal environments for operators that allow for the greatest extent of innovation and shift authorities from resting military leadership to foster unique ideas and technologies external to current TTPs and acquisition strategies. Finally, as the RAF example of innovation demonstrates, although a generation or more of leaders may promote a culture antithetical to innovation, even a small contingent of senior officers can promote a radical notion and fundamentally rewrite doctrine and platform requirements.

Training and Mentoring for Innovative Culture: The Joint Design Thinking School

In addition to identifying leaders to instigate a culture of innovation, the US military needs to train and mentor junior leaders who will form the corps of innovation teams and eventually become tomorrow's leaders. Along with a joint office focused on promoting such leaders, the military should support a joint education center that fosters relevant junior officer talents and skills early in their careers.

Currently, the outsourcing of innovation denies junior leaders the opportunity to develop skills critical to countering threats. Innovation does not come from requirements and entails more than a formal process, demanding that leaders balance the

58. Hill, "Military Innovation."

conditions necessary for everyone in the organization to be creative and experiment with autonomy weighed against the risks associated with decentralization. Skills essential to an innovative mindset must be honed early in one's military service, before conventional thought takes root.

The first step in building junior military leaders capable of innovation is selecting members whose services view them as operational experts, leaders, and people of character. After selection, the military would consign these candidates to a one-year school, which the authors propose as the Joint Design Thinking School (JDTS). Here, experts would teach them an array of innovation methodologies including design thinking, which is a method of human-centered innovation that produces near-term innovation through cyclical phases of discovery: an increased understanding of the problem, ideation to consider possible solutions, and prototyping to test those solutions for desirability, feasibility, and suitability.[59]

Military graduates would attend advanced exercises to observe the units performing TTPs and lead design sessions to develop their joint operational approaches, feeding the innovative solutions back into the exercises and potentially to the joint force. The services should choose joint innovation officers in a manner akin to their processes for selecting individuals to their development centers and advanced weapons schools, which produce experts—often called *patch wearers*—in their respective fields at the tactical level in operational and support environments.

The selection process and curriculum development of the Navy's and Air Force's advanced schools—namely, the Navy's Strike Fighter Tactics Instructor Course, or TOPGUN, and the Air Force's Weapons School (WS)—offer the JDTS an outstanding template to build on. The military services should concentrate on recruiting weapons tactics instructors and WS graduates who completed their O-4 department head or milestone tours to become joint innovation officers. These service members demonstrated the capacity to finish arduous coursework, attain expertise in a field, display operational acumen, and hold a level of approachability associated with TOPGUN and WS alumni. Yet the officer selection process would mimic the service schools' application procedures and choose the candidates on a whole-of-person concept while not excluding non-TOPGUN/WS individuals who exhibited extraordinary talent. The immediate post-department head/milestone time frame is an opportune career period to conduct a tour to attain full joint credit, which is key for promotion.

The year-long JDTS would award a master's degree in adaptive strategic innovation and execution along with joint professional military education phase two credit and incur a follow-on three-year joint tour. The four-year period should not interfere with career progression and would familiarize the O-4s with the joint force, thus expanding their understanding of the resources available to them as they return to their respective services.

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59. Austin M. Jackson et al., "Designing Collaboration: How to Prepare SOF Augmentation Teams for Assignment to a U.S. Embassy Country Team" (Capstone paper, Naval Postgraduate School, 2014), 21, https://hdl.handle.net/.

The authors propose that JDTS would mimic the internationally recognized Stanford Design School, or d.school, which teaches innovation to Stanford University undergraduate and graduate students from various disciplines and executives with myriad backgrounds through experiential design thinking training and mentorship. Facilitators and mentors are provided with experiences to lead teams through the nonlinear design-thinking process. Such facilitators are crucial in encouraging divergent thinking and helping a team build on shared ideas.[60]

The JDTS, in close relationship with DIU, would train and mentor joint personnel to lead their teams through various innovative methodologies. This will produce unique ways to address close-in operational challenges while teaching problem-solving methodologies to promising junior leaders from all services. The benefit of focusing on near-term innovation is that the leader can facilitate the innovation effort, from inception to implementation, within one assignment cycle.

The JDTS would develop the baseline skills of design-thinking facilitators through experiential training and mentorship using near-term operational challenges relevant to the design group. The leaders trained to facilitate this process will be some of the most highly sought after leaders when they return to their operational units of action. Their development will lead to a profound understanding of trends, morphing threats, and opportunities that enable them to positively influence outcomes, not only adding value to the joint force but also potentially improving interoperability among departments and agencies.

Proposed Curriculum: Four Approaches to Innovation

The following discussion provides a practical overview of the main approaches the JDTS would focus on in training and mentoring its officers. The JDTS would incorporate the leading innovation theories into its curriculum: design thinking; designerly thinking; systems thinking; and lean start-up.[61] The Defense Department could contract the principal academic and operational experts in the fields to teach students' classes in a quarter or semester format. The officers' direct interaction with these key individuals would foster near instantaneous feedback, refinement, and progress on military-specific innovation issues. The combination of these theories would allow students to take the best features from each methodology, mitigate the limitations inherent in each, and incorporate the outcomes into their innovation processes.

60. Jackson et al., "Designing."

61. Linda Nhu Laursen and Louise Moller Haase, "The Shortcomings of Design Thinking When Compared to Designerly Thinking," *The Design Journal* 22, no. 6 (2019), https://doi.org/; Adeline Hvidsten et al., "Design(erly) Thinking: Supporting Organizational Change and Leadership," *Journal of Change Management* 23, no. 1 (2023), https://doi.org/; Daniel H. Kim, *Introduction to Systems Thinking* (Pegasus Communications, 1999), https://thesystemsthinker.com/; and Steve Blank, "Why the Lean Start-Up Changes Everything," *Harvard Business Review*, May 2013, https://hbr.org/.

Design Thinking

In a quarter configuration, each quarter would concentrate on one approach with four associated classes, beginning with design thinking. Centering on the repetitive innovation cycle of proposal generation, prediction, testing, and generalizing, the theory aims to design and produce superior products to attain a competitive advantage over rivals.[62] This approach dovetails with a joint officer's goal of constantly developing, testing, and refining TTPs and/or platforms to deter or defeat an adversary. One drawback to design thinking is that there is insufficient guidance from the business community for non-designers in selecting, adapting, and using design tools and techniques to solve design challenges at hand; however, Defense Department contractors who would be the foremost experts on the subject could help the students overcome this obstacle.[63]

Officers could begin with small-scale military-centric problems and work with their professors to utilize design thinking to devise ways to resolve the challenge. Dilemmas would increase in difficulty as the quarter continues, culminating with an advanced exercise that requires officers to apply design thinking and work with operators to manufacture unique capabilities. Periodic feedback would be essential to note strengths and weaknesses and to understand how it will integrate with the other innovation theories.

Designerly Thinking

A close relative to design thinking, designerly thinking involves many of the same tenets but provides a well-defined framework to help decode enigmas. It is a theoretical structure that centers on wicked problems, abductive reasoning, and contextual meaning-making.[64] Designerly thinking attempts to make sense of wicked problems through a practice-based approach that results in new knowledge.[65] Furthermore, it attempts to understand why a problem emerged and what previous failed attempts to solve it can teach designers. The thought process also brings in multidisciplinary teams to draw on their experiences with design theory and practical application. Designerly thinking welcomes inputs from customers, users, and stakeholders to assist designers as a way to make the design process more efficient. As designers attempt to

62. David Dunne and Roger Martin, "Design Thinking and How It Will Change Management Education: An Interview and Discussion," *Academy of Management Learning & Education* 5, no. 4 (2006); and Roger Martin, "The Design of Business," *Rotman Management Magazine* 3 (2004).

63. Laursen and Haase, "Shortcomings."

64. Laursen and Haase, "Shortcomings"; Horst Rittel and Melvin Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4, no. 2 (1973); Lawson, *Designers*; and Nigel Cross, *Designerly Ways of Knowing* (Springer Verlag, 2006).

65. Richard Buchanan, "Wicked Problems in Design Thinking," *Design Issues* 8, no. 2 (1992); Bryan Lawson, *How Designers Think: The Design Process Demystified* (Architectural Press, 2006); and Klaus Krippendorff, *The Sematic Turn: A New Foundation for Design* (CRC Press/Taylor and Francis, 2006).

solve the problem through constant feedback, their responses to obstacles will often change to deliver positive results.[66]

The existing structure would likely offer students an easier starting point to fabricate answers to pressing military uncertainties more quickly. Officers could also take attributes from design thinking to inform their designerly thinking findings. The student's employment of the one would follow a similar path as the other, where they would start off small and eventually apply their learning in leading-edge training environments to offer recommendations to wicked problem sets.

Systems Thinking

Systems thinking enables people to see and talk about reality and better grasp how they can use everyday existing systems to improve the quality of life. Feedback is the bedrock of systems thinking as observations inform the system of how it is performing relative to the desired end state.[67] Such an approach would allow officers to take a different perspective and try to innovate within the residing military systems.

Within the systems thinking paradigm, a system's purpose is paramount. Students could choose a process that the military deems dysfunctional, such as acquisitions, and attempt to correct problems by dissecting the feedback loops to create "virtuous circles" which produce desirable results versus "vicious cycles" which seem to permeate many military processes. The students could also attend a vanguard exercise and deliberate with operators and support personnel on methods to increase novel efficiencies to promote quicker and more impactful feedback loops to generate better TTPs or platform utilization. Together with design thinking and designerly thinking, this approach offers a more holistic innovative structure for the students to construct distinct and effective operational lethality.

Lean Start-Up

Lean start-up is a methodology centering on nontraditional business models, foregoing in-depth planning in favor of experimentation. It does not rely on intuition but on customer feedback, and it pushes aside traditional "big design up front," to pursue iterative design. In lean start-up, individuals initially accept their process has various untested hypotheses. They then take their hypotheses and summarize them in a business model canvas, which graphically describes how a company creates value for itself and its customers. From there, they use customer development to test the company's hypotheses through asking potential clients for feedback on all elements of their proposed business model.

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66. Donald Schon, *The Reflective Practitioner: How Professionals Think in Action* (Basic Books, 1983); Lawson, *Designers*; Cross, *Designerly Ways*; Buchanan, "Wicked Problems"; and Pieter E. Vermaas and Udo Pesch, "Revisiting Rittel and Webber's Dilemmas: Designerly Thinking Against the Background of New Societal Distrust," *She Ji: The Journal of Design, Economics, and Innovation* 6, no. 4 (2020), https://doi.org/.

67. Kim, *Systems Thinking*.

Emphasizing dexterity and quickness, lean start-up uses Agile development and links this method up with customer development. The combination should help to eliminate wasted time and resources by seeking customer feedback, making iterative changes through an incremental process.[68] Lean start-up is an ideal method for joint innovation officers to use with commands in the earliest TTP and/or platform developmental stages. The officers could also apply lean start-up at exercises to discuss, analyze, and scrutinize operators' ideas.

All four approaches to innovation differ and complement each other enough to enable JDTS students an opportunity to take and leave the pros and cons from each and build their own hybrid methodology to foment innovation. Such methodology would then enable JDTS graduates to develop unique ways to spearhead innovation at the broader joint level.

Post-JDTS and the Joint Force

During JDTS and at their follow-on joint tour, joint innovation officers would attend and consult the most important exercises to drive TTP and platform evolution and revolution to remain militarily ahead of US peer competitors. The JDTS should situate the academic quarters to coincide with advanced joint military exercises to examine TTPs and capabilities. The students could hold design sessions with the participating units to dissect and refine these practices to discuss potential innovative methods to make their TTPs even more lethal.

After the students graduate and go to their payback tour, they could revisit these sessions to build on their previous years' efforts or choose a new direction to rectify emerging issues. Advanced military training exercises such as Red Flag, the Joint Interagency Field Experimentation, and Talisman Sabre are venues joint innovation officers could pursue to bring their design process to the forefront. The exercises operate in a joint and allied environment, which should drive the operators and support personnel away from the service-centric innovative TTPs and capabilities the joint force has witnessed since 2017.[69]

In the exhaustive debriefs after single training missions, joint innovation officers could collaborate with the operators and support personnel to walk through their various actions during the mission. In addition to ensuring the operators and support staff are focusing on utilizing joint innovative ideas, the officers could utilize their training to suggest unique improvements to the operators' TTPs in successive training missions. Their recommendations may also identify shortfalls in technology capabilities, thus enabling the services to pursue further requirements for more innovative platforms through the Joint Capabilities Integration and Development System.

68. Blank, "Lean Start-Up."

69. Kimberly Johnson, " 'Red Flag-Nellis' Intensive Fighter Training Underway in Nevada," *FLYING Magazine*, 16 January 2024, www.flyingmag.com/.

Working with units participating in the more complex and advanced exercises, joint innovation officers will further integrate the joint force for its fight against peer adversaries. By leading innovative small units and crews to change, these officers represent the key to the Defense Department innovating faster and cheaper to prepare for future wars, ensuring the US military retains its advantage wherever the joint force confronts US adversaries. Æ

OPTIMIZING OFFICER RETENTION IN THE US SPACE FORCE

A Strategy for Success

BRANDON M. EANS

This article proposes a targeted talent management strategy to optimize officer retention within the US Space Force. In exploring how retention influences operational readiness and strategic effectiveness, this article underscores the critical nature of talent management in maintaining US space dominance. A strategy that integrates a comprehensive career-mapping doctrine, algorithm-based assignment systems, and order-of-merit promotion practices aligns officers' aspirations with organizational goals, thereby enhancing job satisfaction and retention. Rather than focusing primarily on broad retention strategies across various military branches, such a strategy specifically addresses the Space Force's unique challenges and needs.

Imagine the US Space Force at a pivotal moment in a not-so-distant future, leading an international coalition to safeguard satellites from a sophisticated cyberattack that threatens global communication. At the heart of this operation is a team of highly skilled officers, each a product of the Space Force's visionary talent management strategy. Having navigated their careers through a system that values merit, aligns assignments with individual skills and aspirations, and charts a clear path for professional growth, these officers are not just participants in this critical mission; they are its linchpins. Yet, as the Space Force ventures into this new frontier, it faces a challenge from external adversaries and from within: retaining these indispensable officers.

The stakes could not be higher, as losing even one officer could mean a setback in operational readiness and mission success. The impact is particularly significant in the Space Force, where the small size of the force and officer corps amplifies the effects of losing even a single member. While the structure and broader personnel base might absorb such losses in larger military branches with less immediate disruption, in the Space Force, such transitions are not so readily made. The critical role of each Guardian officer in maintaining the strategic and operational balance stems from their specific expertise and responsibilities, which are not quickly or easily replaceable. The heightened dependency on each officer underscores the importance of focused retention

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strategies tailored to the unique needs and scale of the Space Force. This need is particularly crucial considering the 14 percent reduction in the civilian workforce in early 2025, a cut that disproportionately impacts the service due to its small size and reliance on civilian expertise.[1]

The situation described illustrates a critical concern at the heart of current military strategic priorities, emphasizing that officer retention transcends simple personnel management to become a vital element of national security and operational effectiveness. This article argues that to effectively mitigate an officer retention issue within the Space Force, the service must implement a targeted talent management strategy that incorporates a clear doctrine for career mapping, assignment algorithms, and order-of-merit promotion systems, leveraging insights from across sister service branches.

First, developing and implementing a comprehensive career-mapping doctrine will provide officers with a clear path for professional growth and advancement within the Space Force. Next, assignment algorithms will actively match officers to positions that best align with their skills and professional and personal aspirations, enhancing job satisfaction and retention. Finally, establishing an order-of-merit promotion system will foster a culture of fairness and recognition, which is critical for retaining highly skilled officers.

Background

An analysis of job satisfaction trends across other military branches indicates the importance of talent management to retention. From November 2022 to February 2023, a national independent panel on military service and readiness consisting of retired US generals, state representatives, and Pentagon officials worked together to identify practices within the military that undermine retention and recommended actions to ensure the military remains lethal and prepared to protect national security.[2] The military branches initiated their research response to ongoing and extreme recruitment challenges. With the services consistently missing their yearly recruitment goal, the panel determined that retention might be the next crisis.[3]

Within the military, retention is "the rate at which military personnel voluntarily choose to stay in the military after their obligated term of service has ended."[4] For officers, depending on their initial contract, the obligation can range from three to six years. In its report, the panel found that officers' experiences during the initial years

1. Shaun Waterman, "How Is the Space Force Handling Civilian Personnel Cuts?," *Air & Space Forces Magazine*, 4 March 2025, https://www.airandspaceforces.com/.

2. Michael Walz et al., *Report of the National Independent Panel on Military Service and Readiness* (The Heritage Foundation, 30 March 2023), https://www.heritage.org/.

3. Walz et al., *Report*.

4. Kristy N. Kamarck and Carly A. Miller, *Defense Primer: Active Component Enlisted Retention*, In Focus 11274 (Congressional Research Service, updated 15 November 2024), 1, https://sgp.fas.org/.

are critical to determining the likelihood of them extending their contract. In 2021, the overall retention rate for the US military—excluding the newly formed Space Force—was 55 percent, a decline from previous years.[5] More drastically, the US retention rate is the second worst among all NATO countries.[6] Consequently, the presumption that retention across the military services is the next crisis is highly plausible.

Research indicates several factors impact retention in the US military. Across the services, toxic leadership can erode morale and discourage long-term service, especially in smaller units where poor command climates have an outsized effect.[7] Likewise, limited freedoms—such as the requirement to move duty stations due to an unexpected change in assignment—can negatively affect job satisfaction. Inadequate compensation, particularly when compared to private-sector opportunities for technical and leadership talent, also plays a role, especially among dual-income households and officers stationed in high cost-of-living areas. Although military pay remains competitive on paper, RAND research and the 2025 *Quadrennial Review of Military Compensation* suggest that perceived gaps in housing allowances, incentive pay, and family support programs can affect retention decisions among officers.[8]

While toxic leadership, limited freedoms, and inadequate compensation are commonly cited challenges across the broader military, the Space Force faces a more specific set of retention concerns.[9] A 2019 study published in *Armed Forces & Society* found that younger officers increasingly value flexibility and purpose over traditional incentives like pay and rank progression, while a 2024 retention analysis indicated that "newer generations" are primarily concerned about work-life balance.[10] According to a 2024 RAND Corporation study, Guardians broadly agreed that family stability, impacted by assignment location and length of stay, was a key concern when reviewing current personnel policies.[11] While there is some overlap with the broader services, these specific factors must be considered when addressing the staffing challenges confronting today's Space Force.

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5. Skyler Bernards, "Military Retention Rates: How to Increase the Numbers," *ExecutiveBiz*, 30 January 2024, https://executivebiz.com/.

6. Rob Shaul, "Air Force Leads All US Military Branches in Re-Enlistment Rates: Overall, US Military Retention Is 2nd Worst in NATO," Mountain Tactical Institute, 16 February 2023, https://mtntactical.com/.

7. Jean Lipman-Blumen, *The Allure of Toxic Leaders: Why We Follow Destructive Bosses and Corrupt Politicians—and How We Can Survive Them* (Oxford University Press, 2005).

8. Beth J. Asch et al., *Improving the Efficiency of the Military Compensation System* (RAND Corporation, 2024), https://www.rand.org/; and *Report of the Fourteenth Quadrennial Review of Military Compensation, vol. 1, Main Report (DOD*, January 2025), https://militarypay.defense.gov/.

9. Bernards, "Military Retention Rates."

10. David R. Segal et al., "Changing Conceptions of Officer Careers in the U.S. Military," *Armed Forces & Society* 45, no. 1 (2019), https://www.jstor.org/; and Amanda Huffman, "Can Adding Flexibility Help Retain Guardians in the U.S. Space Force?," Clearance Jobs, 31 January 2024, https://news.clearancejobs.com/.

11. Raymond E. Conley et al., *Alignment of U.S. Space Force Military Human Capital Management Functions* (RAND Corporation, 2024), https://www.rand.org/.

Recruitment and Retention in the Space Force

Across the US military, recruitment has also faced significant challenges in recent years. In fiscal year 2023, the Army, Navy, and Air Force all missed their active-duty recruiting goals, prompting widespread concern about the future force structure and readiness of the all-volunteer force.[12] Unlike these services, however, the Space Force has not faced significant recruitment shortfalls. The unique allure of space operations and the smaller recruitment quotas associated with the service's compact size contribute to this success.[13] The specialized and innovative nature of the Space Force also attracts individuals with interests in advanced technology and space operations. Yet as the service continues to grow and the broader sector evolves, it remains uncertain whether these recruitment advantages will persist. Factors such as the expansion of commercial space industries and shifting public and governmental priorities could influence future trends and intensify competition for talent.

On the retention front, the Space Force currently reports relatively high officer retention rates. In fiscal year 2024, approximately 90 percent of Guardians chose to continue their service, aligning closely with retention trends across the Department of the Air Force (DAF).[14] Yet, the same qualities that attract individuals to the Space Force—its cutting-edge operations and specialized focus—may not suffice to keep them long-term. The demanding environment and abundant opportunities in the civilian space sector—where employment has grown by 27 percent over the past decade and average salaries surpass $130,000 a year—could lead to higher turnover rates among skilled officers.[15] Additionally, the global space economy is projected to approach $800 billion by 2027, further expanding competitive opportunities for talent.[16] Thus, while recruitment is currently robust, proactive retention strategies are essential to prevent potential attrition issues as the Space Force matures.

The Space Force needs to prioritize retention for three primary reasons: to strengthen unit readiness, to save time in training personnel, and to keep costs of recruitment to a minimum.[17] These reasons are interrelated.

Retaining seasoned and skilled military personnel is crucial for sustaining the armed forces' operational effectiveness and readiness. The continuation of service by these experienced members safeguards vital institutional knowledge and proficiency,

12. *Military Recruiting: Actions Needed to Address Digital Marketing Challenges,* GAO 25-106719 (US Government Accountability Office [GAO], November 2024), https://www.gao.gov/.

13. *Department of the Air Force, Written Statement to the Senate Armed Services Committee, Subcommittee on Personnel* (statement of Kristyn E. Jones, assistant secretary of the Air Force, financial management), 22 March 2024, https://www.armed-services.senate.gov/.

14. Jones, statement.

15. Space Foundation Editorial Team, "The *Space Report 2025 Q1* Shows Growing Need for Skilled Labor in Space Workforce, Budget Concerns for U.S. Space Force, and Highlights Space Pharmaceuticals Investments," Space Foundation, press release, 7 April 2025, https://www.spacefoundation.org/.

16. Brett Loubert et al., "Delivering on Space Development Growth," Deloitte Insights, Government & Public Services, 4 June 2025, https://www.deloitte.com/.

17. Bernards, "Military Retention Rates."

which are essential for the successful execution of military missions. In 2023, the US Government Accountability Office noted that between fiscal years 2017 and 2021, military readiness ratings increased in the ground domain, decreased in the sea domain, and both increased and decreased in the air and space domains.[18] One of the two key inputs to the rating factor is the ability of the service to train and retain personnel.

The development of field grade officers in the Space Force, particularly for roles requiring integration and planning capabilities within joint and component commands, is characterized by a lengthy and specialized training process. As highlighted in the Space Force's career development guidelines for space operations officers, the path to becoming a senior officer involves a series of progressively advanced training and leadership roles.[19] These roles are strategically sequenced over many years to ensure officers acquire the necessary expertise and experience. This extensive timeline ensures that officers are proficient in space operations and skilled in essential command and staff functions that support the integration of Space Force capabilities within the broader defense framework. Such deliberate development is critical for the Space Force's mission, where each officer's strategic and operational insight plays a pivotal role in maintaining national security and space dominance. The recent decline in the services' ability to maintain service members inversely impacts their unit readiness.

Additionally, a healthy retention rate also saves the Space Force in terms of training time as well as recruitment costs. High retention rates not only ensure the stability and cohesion of a team but also alleviate the need for the intensive and costly process of recruiting and training new personnel. Maintaining the current workforce allows the military to avoid the substantial expenses involved in advertising, screening, and onboarding recruits.[20]

Given the multifaceted challenges of retaining military personnel, as highlighted by studies on Space Force human capital management and evolving officer career expectations, it becomes imperative to forge innovative solutions tailored to the unique demands of space operations.[21] Recognizing the pivotal role officers play in the success of missions and the overall readiness of the force, the Space Force stands at the threshold of adopting novel approaches in talent management.

Currently, the Space Force does have a key organization responsible for talent management within the force. Its Enterprise Talent Management Office oversees personnel policy and career development frameworks. In addition to the office's efforts, the Space Force has introduced several initiatives aimed to improve recruitment and retention,

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18. *Military Readiness: Improvement in Some Areas, but Sustainment and Other Challenges Persist: Testimony Before the Subcommittee on Readiness and Management Support, Committee on Armed Services, U. S. Senate*, 118th Congress (2023) (statement of Diana Maurer, director, Defense Capabilities and Management), https://www.gao.gov/.

19. *ETMO Guardian Employment Division Roadmap* (Enterprise Talent Management Office, September 2021).

20. *DOD Active-Duty Recruitment and Retention Challenges*, GAO 23-106551 (GAO, March 2023), https://www.gao.gov/.

21. Conley et al., *Alignment*; and Segal et al., "Changing Conceptions."

including targeted onboarding, cross-functional training programs, and investments in a digital talent marketplace.[22] These efforts are designed to enhance flexibility in career paths and improve overall workforce engagement.

Yet, while these institutional initiatives reflect progress, they remain primarily administrative in nature and lack the personalized, actionable guidance necessary to address individual officer concerns. While the Enterprise Talent Management Office plays a vital role in enforcing policy and advising officers, it does not directly shape officer retention in a proactive or data-driven way. Given this distinction, this discussion prioritizes structural reforms—such as career mapping, assignment transparency, and leadership selection—that have a more immediate and individualized impact on officer satisfaction and long-term retention.

In line with the chief of space operation's aims, the Space Force is clarifying roles across its personnel—officers, enlisted, and civilians—to optimize effectiveness. Officers are leaders and planners with comprehensive mission knowledge, enlisted Guardians serve as technical experts and primary warfighters, and civilian Guardians provide stability and specialized skills. The definition of roles supports the Space Force's goals of integrating smoothly into joint operations and boosting readiness.[23] Drawing from lessons learned across other military branches, the Space Force can craft a targeted strategy that prepares its officers for tomorrow's demands and keeps them motivated to continue serving.

The US military faces a crisis in retention, and existing policies do not adequately address challenges including toxicity in the workplace and career inflexibility. The Space Force must therefore adapt these models to address these key retention challenges. By highlighting how structured career pathways have improved retention through better leadership selection and increased officer autonomy, this article demonstrates how these military-specific models can address the Space Force's unique challenges.

Career Management Doctrine

First, developing and implementing a comprehensive career-mapping doctrine will provide officers with a clear path for professional growth and advancement within the Space Force. Step one is the development of the doctrine, while step two is its implementation. Foundational documents such as Space Doctrine Publication (SDP) 1-0, *Personnel*; Space Force Doctrine Document (SFDD) 1, *The Space Force*; Air Force Doctrine Publication (AFDP) 1, *The Air Force*; and DAF Instruction 36-2686, *Officer Development*, primarily provide broad overviews of force development, personnel

22. *Department of the Air Force Presentation to the Subcommittee on Military Personnel, Committee on Armed Services, US House of Representatives, Subject: Military Personnel Posture Hearing for FY25* (statement of Major General Katherine A. Kelley, US Space Force), 17 April 2024, https://www.congress.gov/.

23. B. Chance Saltzman, *Chief of Space Operations Guidance and Intent: Officer, Enlisted, and Civilian Guardians' Narratives and Principles* (US Space Force, 17 January 2024).

policy, and readiness.[24] They are not designed to provide actionable, role-specific guidance for individual officers navigating assignments, development opportunities, or long-term career planning. As such, they fall short of offering the kind of interactive individualized mapping system proposed in this article. A comprehensive career-mapping doctrine would fill this gap, offering tailored planning tools aligned with officer aspirations and Space Force needs.

A career-mapping doctrine is a detailed, strategic plan that outlines the career development paths and opportunities for Space Force officers. It moves beyond merely presenting a visual diagram or graph. Rather than a simplistic depiction of potential career paths, it involves a systematic approach that includes policies, procedures, and guidelines designed to lead officer progression and readiness. By providing a transparent and structured pathway for career progression, Guardian officers gain greater control over their careers, mitigating frustrations associated with limited freedoms—one of the key factors that discourage retention.

The ability to see a clear trajectory for their professional future reduces uncertainty surrounding assignment and broadening opportunities, fostering engagement and long-term commitment to the service. Many Space Force officers look to the Career Stages Map in its current form, which is based on the Air Force's Career Progression Map, to provide an example of how they need to align assignments. Yet while the Career Stages Map is important, it does not adequately detail essential aspects of their career.

Career mapping is a strategic framework that provides officers with a road map for their professional development, detailing potential career trajectories, key milestones, and the competencies required at different career stages. Aligning individual goals with the military organization's needs offers a clear path to advancement and leadership roles, essential for motivating long-term service and maintaining a committed and capable officer corps. The process ensures officers know the growth opportunities, demystifying the steps needed to achieve professional aspirations. Consequently, by leveraging successful practices from across the military branches, many branches have established specific doctrines that lay out detailed career plans for their officers.

For example, Army officers can effectively use Department of the Army Pamphlet 600-3, *Commissioned Officer Professional Development and Career Management,* to map out their career and then share that plan with mentors, career managers, and commanders. In turn, career managers can provide them with information about educational development, key developmental assignments, and broadening assignments.[25] Similarly,

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24. Space Force Doctrine Publication 1-0, *Personnel* (USSF, September 2022), https://www.starcom.spaceforce.mil/; Air Force Doctrine Publication 1, *The Air Force* (Curtis E. LeMay Center for Doctrine Development and Education, March 2021), https://www.doctrine.af.mil/; and Department of the Air Force (DAF) Instruction 36-2686, *Personnel, Officer Development* (DAF, 9 February 2024).

25. Brandon Eans, "You Are Your Best Career Manager," The Green Notebook, 27 April 2023, https://fromthegreennotebook.com/; and Department of the Army (DA) Pamphlet 600-3, *Commissioned Officer Professional Development and Career Management* (Headquarters, DA, 1 February 2010), https://career-satisfaction.army.mil/.

the Air Force uses the Career Field Education and Training Plan.[26] This document shows how an officer can progress through the ranks by breaking down their career path into multiple efforts—experience, education and training, and leadership—forming a year-by-year and grade-by-grade framework. The plan provides an officer with predictability on assignments and education needed through their career.

Although much broader than the Air Force career plan, Marine Corps Order 1300.8, *Marine Corps Personnel Assignment Policy*, discusses the methodology behind career aspects such as time on station requirements, officer assignments and key billets, and specific considerations like dual military households and single parent considerations.[27] In terms of scope and purpose, it more closely resembles the Space Force's SDP-1 or the Air Force's AFDP-1, as it outlines foundational personnel assignment policies that inform career planning and force structure decisions. Each of these documents offers ways in which professional and personal assignments can be incorporated into the development of a Space Force career management doctrine.

Building on these foundational strategies, the implementation of a clear doctrine for career mapping can take several strategic steps. First, it is crucial to establish a comprehensive database that encompasses all available career paths, educational opportunities, key assignments, and broadening experiences relevant to each officer's specialty. The database should be accessible and easily navigable, enabling officers to visualize their potential career trajectory from commissioning to retirement.

Next, leveraging technology, an interactive career-mapping tool can be developed, allowing officers to input their current status, future aspirations, and preferences. The tool would use algorithms to suggest personalized career paths that align with the officer's goals and the military's needs, highlighting educational and training milestones. Users must regularly update the tool with new policies, opportunities, and feedback to keep it current and effective.

Lastly, experienced career managers and mentors should organize workshops and seminars to guide officers in effectively utilizing the career-mapping tool. These sessions would provide valuable insights into navigating career decisions, understanding the importance of each developmental assignment, and planning for long-term success. The Space Force can use the Army Career Tracker (ACT) as a frame of reference. The ACT, a leadership development interface, is a valuable resource that assists Soldiers in organizing their career paths, advancing in their fields, and developing skills throughout their military tenure.[28]

Integrating the ACT within the Space Force's career-mapping strategy offers a robust example of how personalized career pathways can enhance officer retention. By

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26. "Career Field Education and Training Plan," Air Force Learning Professionals, accessed 1 May 2024, https://www.learningprofessionals.af.mil/.

27. Marine Corps Order (MCO) 1300.8, Change 1, *Marine Corps Personnel Assignment Policy*, with Change 2, *Marine Corps Directives with Compliance of Executive Order 14168* (Department of the Navy, 7 March 2025). https://www.marines.mil/.

28. "Individual Development Plans/Army Career Tracker," US Army Garrison Daegu, accessed 1 May 2024, https://home.army.mil/.

adapting ACT, the Space Force can provide its officers with a clear, interactive visual representation of their career trajectory tailored to individual strengths and aspirations. This approach deepens job satisfaction by aligning career progression with personal goals and reinforces officers' commitment to the organization. Enhanced with advanced analytics, this system can dynamically adjust to the changing needs of the officers and the Space Force, ensuring continuous professional growth and adaptation. The utilization of ACT in this manner underlines the Space Force's dedication to fostering a workplace where officers feel genuinely valued and see tangible paths toward their professional and personal development.

One common feature of each established doctrine is their goal to retain the best qualified officers. As stated in Army guidance, these documents aim to encourage officers to manage their careers actively.[29] The Marine Corps aptly states that their policy strives to "improve combat readiness by controlling personnel turnover, increasing the stability of Marine families, and reducing PCS [permanent change of station] cost."[30] While significantly bolstering professional growth and advancement among officers, providing a transparent and structured pathway for career progression, and enabling officers to acquire new skills and experiences, a career-mapping doctrine can help to ensure that the Space Force will have a more capable, adaptable, and experienced leadership pool ready to meet the challenges of modern defense.

Assignment Selection

Next, assignment algorithms will actively match officers to positions that best align with their skills and professional and personal aspirations, enhancing job satisfaction and retention. This addresses the key challenges related to limited assignment choice and career control—both of which have been cited as primary concerns among Space Force officers—and also contribute to mitigating broader issues like workplace dissatisfaction that can impact retention.

There are two approaches to assignment selection: manual and algorithm. In the manual approach, officers receive a list of assignments from their career managers to prioritize based on their preferences; the outcome of this prioritized list is often referred to as the *dream sheet* or sometimes the *wish list*. After receiving the dream sheet, the career manager will align officers with an assignment based on factors such as system experience, skillset, time on station, and performance evaluation.

The Army replaced the manual method with the assignment marketplace in 2019, and the Air Force shortly followed in 2022. The significant issue inherent within the manual process was that it lacked transparency and control. Unlike a marketplace that lists all the assignments, officers cannot see a complete list of available assignments and have no personal control over how they align with them outside of what the career manager determines.[31] On

29. See DA Pamphlet 600-3, *Officer Professional Development and Career Management* (DA, 19 January 2023), https://www.armypubs.org/; and Eans, "Career Manager."

30. MCO 1300.8, 1-1.

31. "ATAP - Army Talent Alignment Process," US Army Talent, 15 April 2024, https://talent.army.mil/.

the contrary, an assignment marketplace that uses algorithms employs a systematic approach to optimize officer placements by aligning their skills, experiences, and career and personal aspirations with the needs of the military.[32]

The algorithm-based marketplace streamlines the assignment process and enhances transparency and fairness, significantly reducing the influence of subjective biases and potential favoritism. The Army's Assignment Interactive Module 2.0 (AIM 2.0) program exemplifies how algorithms can facilitate a more democratic and efficient process, assigning officers based on mutual preferences and requiring all officers to rank all available positions. AIM 2.0's algorithm-based process ensures that Army officers preference all positions, including less desirable ones, reducing reliance on human intervention to fill these roles. This approach not only enhances transparency but also ensures that hard-to-fill positions are addressed equitably within the marketplace framework.

The AIM 2.0 platform enables Army officers and units to input their preferences, which are then algorithmically matched against available positions based on mutual matches.[33] In contrast, the DAF's MyVector platform relies on assignment teams to manually match candidates based on marketplace bids, which introduces challenges in balancing officer preferences and organizational needs.

The Space Force can learn from the limitations and advantages of these systems before implementation. While the systems inherently enhance transparency and control, they can become counterproductive when the marketplace closes. Once this occurs, career managers act as a human-in-the-loop mechanism as the algorithm aligns officers and jobs. Career managers can break mutual matches where the officer preferenced the job as number one and the job preferenced the officer as number one. Like the dream sheet alignment process, career managers can break matches for the same reasons. Such actions remove the transparency and control that the marketplace grants. When breaking a mutual match, the Army applies strict criteria to maintain transparency and control of the marketplace. In addition, the broken mutual match has to be justified and briefed at the O-6 and O-8 levels. By adopting a similar system, the Space Force can place its officers in roles where they can perform optimally and experience greater job satisfaction.

Incorporating detailed knowledge, skills, and behaviors, which are tailored competencies required for various roles within the force—referred to by the Air Force as knowledge, skills, abilities, and behaviors, and by the Space Force as simply competencies—can further enhance the effectiveness of these algorithms.[34] Including these in the algorithm can provide a clear framework that can be used to identify the best match between the officer's profile and the specific demands of a role. Utilizing a detailed

32. US Army Talent Management Task Force, *Commander's Guide to ATAP 2020*, Talent Management Task Force, November 2020, https://talent.army.mil/.

33. "ATAP."

34. Air Force Handbook 36-2647, *Competency Modeling* (DAF, 8 February 2022), https://static.e-publishing.af.mil/.

catalog of competencies makes the matching process more precise and more synchronized with the organization's strategic goals. Integrating competencies into the Space Force assignment marketplace algorithm ensures that personnel fit their roles well and occupy positions that foster their professional growth and long-term career progression. Such strategic placement is crucial for maintaining the force's operational readiness and maximizing the utilization of talent within the ranks.

If adopted by the Space Force, the Command Assessment Program (CAP) initiated by the Army can provide an additional layer of data to enhance the assignment process. This program systematically evaluates officers for command roles using a variety of assessments, including psychological evaluations, leadership tasks, and simulations.[35] The insights gained from these assessments help refine the algorithms' decision-making process, ensuring that the most suitable candidates fill command positions. CAP improves unit leadership quality and contributes to higher morale and cohesion among the ranks, which leads to higher retention rates.[36]

By looking at the successes and integrations of similar technologies in branches like the Army and the Air Force, the Space Force can tailor these systems to meet its unique operational and strategic needs. The careful implementation of marketplace assignment algorithms—grounded in comprehensive evaluation and a clear understanding of knowledge, skills, and behaviors—promises to optimize assignment processes and transform the broader talent management strategy within the Space Force. This shift toward more data-driven, objective, and transparent assignment practices is critical as the branch evolves to meet new challenges and fulfill its mission in an increasingly complex security environment. Additionally, the Space Force's adoption of the CAP makes officers who desire command want to continue to serve.

Accelerated Promotion

Finally, establishing a transparent, accelerated promotion system will foster a culture of fairness and recognition, which is critical for retaining highly skilled officers. Such a system ensures that promotions are awarded based on objective assessments of an officer's performance and potential rather than seniority or subjective criteria. This approach helps eliminate biases and enhances morale by demonstrating that hard work and competence are valued and rewarded. For example, when officers see that their efforts lead to tangible career advancements, their job satisfaction increases, positively impacting their commitment to remain with the force. Moreover, accelerated and order-of-merit-based promotions can address a core retention concern in the Space Force: the desire for increased career control and clarity in professional progression. By providing more predictable, performance-driven advancement timelines,

35. "Command Assessment Program," US Army Human Resources Command, 4 March 2025, https://talent.army.mil/.

36. Army Directive 2024-14, *Reinstatement of Order of Merit List Sequencing for Officer Promotions* (DA, April 2024).

the service can reduce uncertainty and increase confidence in long-term career planning, both of which support sustained officer commitment.

Additionally, accelerated promotions encourage a competitive yet equitable environment where officers are motivated to develop their skills continuously. The order-of-merit-based promotion dynamic is essential for building a capable and responsive military force where each member feels invested in and responsible for the organization's success.

Under the broader category of accelerated promotion, two distinct concepts exist: below-the-zone promotions and order-of-merit-based promotions. While both are based on merit, below-the-zone promotions are to fast-track the careers of highly qualified officers who demonstrate exceptional potential for serving in senior ranks.[37] Historically, officers can be considered for promotion to the next grade one year before their original consideration year. Recently, the Army started allowing officers to be considered for promotion up to two years before their original consideration date.[38]

On the contrary, the Air Force removed below-the-zone consideration as an option due to the belief that overaccelerated timelines come at the expense of the development of that officer.[39] As such, the Air Force moved to order-of-merit-based promotion, which allows for the promotion of selected, high-performing officers in the first month after exhausting the last fiscal year's board list. Subsequently, the system promotes remaining officers by seniority, determined by their time in service and time in grade.[40] Similarly, the Army also conducts order-of-merit-based promotions in conjunction with below-the-zone promotions. To retain quality officers, the Space Force can utilize lessons from both services to promote quality while not disadvantaging the officer's professional development and experience.

A balanced accelerated promotion system can also work to prevent toxic leadership—one of the primary obstacles to officer retention—from taking hold. Beginning in 2018, career intelligence officer Colonel Jason Lamb highlighted critical issues in Air Force leadership and talent management through articles and online posts under the pseudonym of Colonel Ned Stark.[41] During a talent management discussion at the 2019 Air Force Association Air, Space, and Cyber Conference he noted that many fired wing commanders were below-the-zone selectees, and stated his belief that no

37. "Promotion Timing, Zones, and Opportunity," RAND Project Air Force, accessed 1 May 2024, https://www.rand.org/.

38. Devon L. Suits, "Changes to Promotion Process Provide Army Officers More Career Flexibility," Joint Base San Antonio, 19 February 2020, https://www.jbsa.mil/.

39. Tobias Naegele, "Air Force to Dump Below-the-Zone Promotions," *Air & Space Forces Magazine*, 10 December 2019, https://www.airandspaceforces.com/.

40. Kevin Rossillon, "In Search of an Air Force Meritocracy," *War on the Rocks*, 28 September 2022, https://warontherocks.com/.

41. Jason Lamb, "Commentary: Farewell to Ned Stark," *Air Force Times*, 21 July 2020, https://www.airforcetimes.com/.

"on-time" wing commanders were relieved.[42] He attributed this to the military accelerating commanders too quickly. Additionally, Lamb attested that the failure to have a mechanism to assess leadership potential before taking command dramatically contributed to toxic command climates.

If the Space Force were to adopt a program similar to the Army's Command Assessment Program, it could enhance leadership selection by identifying and mitigating toxic leadership traits. While comprehensive, data on CAP's effectiveness is still being gathered; yet, the intent is to ensure that only the most capable leaders advance to command positions. CAP's approach—which includes peer and subordinate surveys; psychologist interviews; and a four-day, in-person evaluation encompassing physical fitness tests, cognitive and non-cognitive assessments, communication exercises, and 360-degree feedback from subordinates and peers—provides a holistic view of candidates' leadership potential. CAP offers a gateway and balance between below-the-zone and order-of-merit-based promotions with command selection.

To delve deeper into the significance of accelerated promotion systems, it is essential to recognize how practices like below-the-zone promotions can significantly impact officer retention by accelerating career advancement for competent individuals. This method allows officers to be considered for promotion earlier than their peers based on their outstanding performance and potential, a powerful incentive for high achievers.[43] By implementing such an accelerated promotions system, the Space Force not only motivates its officers through visible recognition of their hard work but also strategically aligns these advancements with the operational needs and goals of the force. This approach ensures that talented officers are retained and not lost to competitive external opportunities, which is crucial for maintaining a robust military capability.

Furthermore, incorporating a comprehensive evaluation mechanism such as the Command Assessment Program can add a valuable layer to the promotion and command selection process by helping identify officers with demonstrated leadership potential and operational competence. These practices collectively foster a transparent, fair, and highly competitive environment that enhances job satisfaction among officers and solidifies their loyalty and commitment to the Space Force, thereby bolstering overall retention rates.

Conclusion

The US Space Force is poised to set a new standard in military talent management by integrating a strategic framework that includes comprehensive career mapping, intelligent assignment algorithms, and order-of-merit-based promotion systems. Drawing from the successes and lessons learned from other branches of the US military, these initiatives offer a robust solution to the critical challenge of officer retention. Implementing such systems

42. Stephen Losey, " 'Ned Stark' Takes the Stage at AFA; a Remarkably Candid Discussion of Leadership Ensues," *Air Force Times*, 19 August 2019, https://www.airforcetimes.com/.

43. Suits, "Changes."

promises to enhance job satisfaction, provide clear pathways for career advancement, and foster a culture of fairness and meritocracy. By ensuring that promotions and assignments are transparently based on performance and potential, the Space Force can build a resilient and dedicated officer corps.

Moreover, as the newest branch of the US armed forces, the Space Force has a unique opportunity to innovate without the constraints of legacy systems, which can sometimes hinder change in more established organizations. Its flexibility enables the creation of a dynamic and responsive talent management system that attracts top-tier talent and retains them by aligning their career growth with the strategic needs of national defense. In doing so, the Space Force secures its future readiness and contributes to the broader goal of maintaining the United States' dominance in space. The practical realization of these talent management strategies will be critical to the Space Force's ability to navigate the complexities of modern military operations and to uphold its mission to protect US and allied interests in the final frontier. *Æ*

PLAYING BY THE RULES

Norms During Armed Conflict in Space

SOPHIA CHANG

The drastic increase in commercial space activities within the last decade has motivated the emergence of behavioral norms concerning space domain management. Although generally viewed as too restrictive on military activities, establishing and adhering to such norms may actively benefit rather than constrain military freedom of action. Consolidating broad-ranging discussions on space behavior, this article examines the incentives for the US military to abide by norms, the current international frameworks governing armed conflict in space, and the role of commercial integration in shaping space warfighting doctrine. By clearly delineating operational limits concerning debris generation, thresholds and triggers, information-sharing, and the use of antisatellite weapons, norms of behavior improve military freedom of action and support the Space Force's warfighting abilities.

Research regarding US military rules of engagement is extensive, covering the many facets of humanitarian and escalatory concerns about which a well-disciplined, prepared military should be aware. These legal frameworks are built on a number of national and international constraints such as the Law of Armed Conflict (LOAC) and on an understanding of previous conflicts' moral issues, dictating ethical and legal action in combat operations and centering on principles of distinction and proportionality.[1] Yet rules of engagement for the space domain remain in a formative stage for the young US Space Force.

In 2013, the United Nations pointed to the risks of an increasingly "congested, contested, and competitive" space domain; this issue remains largely unaddressed more than a decade later.[2] In a realm often portrayed as the "Wild West" and free from international law, the ways in which the United States responds during armed conflict

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1. Adam, "Military Rules of Engagement: A Comprehensive Guide," *Uniform Code of Military Justice* [website], 10 June 2024, https://ucmj.us/.

2. *UN General Assembly, First Committee, Outer Space Increasingly "Congested, Contested and Competitive," First Committee Told as Speakers Urge Legally Binding Document to Prevent Its Militarization*, GA/DIS/3487 (October 25, 2013), (statement of Jeffrey L. Eberhardt), https://press.un.org/.

may heavily shape other actors' behavior. It is thus incumbent upon civilian and military leaders to develop a consensus on rules of engagement and restraint during armed conflict in space.[3]

Space operations, defined by joint doctrine as "those operations impacting or directly utilizing space- and ground-based capabilities to enhance the potential of the United States and multinational partners," may include capabilities not organic to the military and should be considered in the context of all activities and interests—military or otherwise—that originate from or impact the space environment.[4] With the military and civilians dependent on assured access to, from, and through space, US Space Command (USSPACECOM) faces challenges in responding to adversarial actions that threaten commercial and civilian capabilities or in countering adversarial actions without damaging the space environment.

Commercial space companies, scientific space capabilities, and the US space economy are core pillars of America's continued space superiority and space-powered way of life. The tangible benefits of the space economy and scientific research utilizing space systems have incentivized spacefaring nations to establish norms of behavior in space; these range from due regard of a state or nonstate actor's space activities to space sustainability, all designed to help make the domain safe, sustainable, and predictable for commercial and military day-to-day business.

Such norms, however, appear to only constrain military activities in space.[5] Civilian efforts to prevent space warfare might seem to restrict the Department of Defense's freedom of action in space—such as the moratorium on destructive, direct-ascent antisatellite weapons (ASAT).[6] Yet the United States had not officially conducted a kinetic ASAT test for decades before; in fact, the only official American ASAT test took place in 1985, when an ASM-135 missile was used to destroy an orbiting solar observatory in low Earth orbit.[7]

Counterspace threats range from reversible to irreversible, non-kinetic to kinetic; however, in a manner similar to cyberspace attacks, non-kinetic attacks may produce kinetic results.[8] Attacks in space can be complicated when trying to minimize impacts on civilian populations, interference with other space systems, and escalation risk.

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3. Clayton Swope, "Rethinking Rules of Engagement for Space," Center for Strategic & International Studies (CSIS), 18 June 2025, https://www.csis.org/.

4. Joint Publication (JP) 3-14, *Joint Space Operations* (Chairman of the Joint Chiefs of Staff [CJCS], 26 October 2020), I-2; and John J. Klein, *Space Warfare: Strategy, Principles, and Policy*, Space Power and Politics 1 (Routledge, 2006).

5. See, for example, Michael J. Listner, "Two Years After the ASAT Test Ban: A Realistic Assessment," *Global Security Review*, 9 May 2024, https://globalsecurityreview.com/.

6. "FACT SHEET: Vice President Harris Advances National Security Norms in Space," The White House, 19 April 2022, https://bidenwhitehouse.archives.gov/; and Steve Lambakis, *The U.S. ASAT Test Ban: Implications for Security*, issue no. 529 (National Institute for Public Policy, 18 July 2022), https://nipp.org/.

7. "Vought ASM-135A Anti-Satellite Missile," National Museum of the US Air Force, accessed 28 July 2025, https://www.nationalmuseum.af.mil/.

8. C. Robert Kehler et al., "Rules of Engagement for Cyberspace Operations: A View from the USA," *Journal of Cybersecurity* 3, no. 1 (2017), https://doi.org/.

Establishing rules of engagement and abiding by norms in space is crucial for the US military, which operates in a shared space environment and would prefer to play a team sport in a rule-bound game.[9]

In exploring rules of engagement for future space operations that impact the operational environment and the United States' ability to prevail and generate terrestrial effects in an outer space conflict, this article argues that militaries stand to actively benefit from and not just be constrained by moderation in space activities. International law serves as the framework for identifying legal and illegal capabilities or actions that the military may use to more clearly define the future conduct of space warfare, and norms emerge from the practice of that law. Such norms refer to the "top-down" high-level principles designed for later codification into international law and the "bottom-up" best practices for regular operations.[10] This article will identify incentives for the US military to abide by these norms, including benefits for warfighting; discuss legal considerations for space during armed conflict; and examine approaches and arguments on the integration of commercial assets into military capabilities. By clearly delineating operational limits concerning debris generation, thresholds and triggers, and the use of antisatellite weapons, norms of behavior ultimately improve military freedom of action and support the Space Force's warfighting abilities.

Incentives to Abide by Norms Shaping the Operational Environment

The United States has focused on promoting norms of space sustainability and safety that broadly meet the following goals: not generating long-lived debris, acting with due regard in space activities, communicating with other actors, preventing interference with other space objects, and promoting international cooperation.[11] In 2021, then-Secretary of Defense Lloyd Austin Jr. directed the establishment of Tenets of Responsible Behavior in Space.[12] Although these tenets act as constraints for the conduct of war in space, military commanders and satellite operators will be enabled by these behaviors. Unilateral measures can lead to multilateral agreements, as demonstrated by the United States' ASAT moratorium that led to the signing of the UN resolution banning ASAT tests by 155 nations.[13]

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9. "Internationally Recognized Norms Lead to Safety and Security in the Space Domain," US Space Command [USSPACECOM, website], 8 March 2024, https://www.spacecom.mil/.

10. Audrey M. Schaffer, "The Role of Space Norms in Protection and Defense," *Joint Force Quarterly* 87, no. 4 (2017): 88, https://ndupress.ndu.edu/.

11. *United States Space Priorities Framework* (The White House, 1 December 2021), https://bidenwhitehouse.archives.gov/; and Michael J. Listner, "The Paradox of Article IX and National Security Space Activities," *Æther: A Journal of Strategic Airpower and Spacepower* [*Æther*] 1, no. 4 (2022), https://www.airuniversity.af.edu/.

12. James H. Dickinson, "Tenets of Responsible Behavior in Space and Associated Specific Behaviors," attachment to memorandum by Lloyd P. Austin Jr., "SUBJECT: Tenet Derived Responsible Behaviors in Space," 9 February 2023, https://media.defense.gov/.

13. Jeff Foust, "United Nations General Assembly Approves ASAT Test Ban Resolution," *SpaceNews*, 13 December 2022, http://spacenews.com/.

Preventing the generation of long-lived debris improves the operational space environment. Given the speed at which objects travel in space, any object in orbit can be lethal to other satellites. In the commercial realm, having an accessible space environment makes operating a satellite cheaper and decreases the necessary number of collision avoidance maneuvers over the satellite's lifetime—an issue that plagues both mega-constellation operators and military space systems alike.[14] The nature of the space environment ensures that debris will continue to impact other objects in space, long after it was initially produced.

Although debris generation may represent an offensive advantage against an adversary's space systems and capabilities, it also precludes friendly operations in that orbital regime, affecting organic military capabilities, commercial space capabilities, and allied space systems. Debris generation acts as an indiscriminate weapon, which in addition to being illegal under the LOAC due in part to the inability to distinguish between combatants and noncombatants in space, directly contradicts USSPACECOM's role of protecting American space assets.

Increased Freedom of Action

The positive benefits of contributing to space norms development and adhering to such norms for the military cannot be understated. Yet given the lack of direct conflict in space with a near-peer great power, the rules remain blurry at best. Adopting space norms of behavior during wartime can help define thresholds and triggers for space escalation ladders. For example, a norm preferring reversible counterspace attacks would help clarify that irreversible counterspace attacks should warrant a greater response. Unless each level of command in the space warfighting structures develops a shared cognitive framework for responsible warfare, command and control of reactive actions will rely on a more centralized governance structure, slowing down responses in a domain where time is of the essence.[15]

Military adoption of norms of responsible behavior can help to connect a theory of victory in space to overarching political goals and interests. Challenges with enforcing an arms control regime in space should encourage the military to be able to clearly articulate what thresholds should not be crossed; both Russia and the United States have demonstrated caution in direct attacks on the other actor's government and military satellites, instead preferring to use electronic warfare and to target uplink and downlink communications.[16] Yet, within Ukraine, American support has been largely unrestricted, except to prevent kinetic Ukrainian attacks into Russian territory; these

14. European Space Agency, "The Cost of Space Debris: In-Space Collisions Increasingly Likely," Phys.org, 8 May 2020, https://phys.org/.

15. Jerome P. Limoge III, "How To Win(g) a War on Space: Enabling Rapid Surge Space Capabilities" (master's thesis, Air Command and Staff College, Air University, February 2024), https://www.spacecom.mil/.

16. Robin Dickey and Michael P. Gleason, "Space and War in Ukraine: Beyond the Satellites," *Æther* 3, no. 1 (2024), https://www.airuniversity.af.edu/.

restrictions were changed in November 2024.[17] This practice of self-restraint keeps the scope of war in space limited and makes hostile kinetic actions seem much more out of the ordinary.

Currently, adversary actions in space consist of reversible attacks with temporary effects and non-kinetic means.[18] Once these thresholds and triggers are clarified by shared norms, the Defense Department will have more flexibility in its responses. By both upholding and communicating normative expectations of minimizing debris generation to allies and adversaries, commanders can expect to decisively counter hostile actions without risking escalation, making a significant difference in the ability to defeat the adversary in war.[19] The conflict escalation ladder and the severity of a weapon's effects may be interpreted entirely differently by an adversary, with spillover between terrestrial and space conflicts.[20] In a sequential game, the implementation of certain norms of behavior across military, intelligence, allied and partnered, and commercial functions can create a more credible, unified front. Thus, ambiguity can be mitigated to the greatest extent possible, enabling commanders to act upon operational and legal thresholds and triggers and increasing their freedom of action.[21]

This opens the door to deliberate signaling, which becomes possible thanks to the active adoption of norms during conflict by allies and partners, contributing to unified action. Military actions that are backed by a strong political narrative help to maintain political will, an essential component of irregular warfare.[22] Doctrine and operational art designed with this in mind will lead to the development and training for nonlethal, nondestructive capabilities, tailored for specific purposes. A precise lasing capability might be tailored to interrupt a portion of a satellite's functions or take temporary positive control over it.[23] Doing so might limit second- and third-order impacts on civilians through adverse infrastructure effects.[24]

A spectrum of options that are less harmful for the operational environment can fill in gaps for responses to novel, obscure, or isolated threats. While such shifts in operational art may serve as short-term challenges, the militaries that can adapt to the increasingly collaborative nature of spaceflight and effectively maintain operational security without sacrificing transparency will find themselves most fit for modern

17. Greg Myre, "Biden Removes Long-Range Missile Restraint on Ukraine's Armed Forces," *Morning Edition*, NPR, hosted by Leila Fadel and Steve Inskeep, 18 November 2024, https://www.npr.org/.

18. Joseph Trevithick, "U.S. Satellites Are Being Attacked Every Day According to Space Force General," *TWZ* [*The War Zone*], 30 November 2021, https://www.twz.com/.

19. Space Doctrine Publication (SDP) 6-0, *Mission Command* (Space Training and Readiness Command [STARCOM], November 2024), 18, https://www.starcom.spaceforce.mil/.

20. "USSPACECOM Releases Specific Behaviors," USPACECOM, 3 March 2023, http://www.spacecom.mil/.

21. Brad Townsend, *Security and Stability in the New Space Age: The Orbital Security Dilemma*, 1st ed. (Routledge, 2020); and Schaffer, "Space Norms."

22. John J. Klein, *Fight for the Final Frontier: Irregular Warfare in Space* (Naval Institute Press, 2023), 182.

23. David A. Koplow, *Death By Moderation: The U.S. Military's Quest for Useable Weapons* (Cambridge University Press, 2009), 169.

24. Jack Beard and Dale Stephens, eds., *The Woomera Manual on the International Law of Military Space Operations* (Oxford University Press, 2024), https://doi.org/.

warfighting. With civilians concerned about the militarization of space, military actions in space that are out of line with norms will only be more conspicuous.[25]

The use of destructive attacks in space or an operational reliance on rapid reconstitution and high launch cadences incentivizes a resource- and time-intensive way of war.[26] Principles of mass and maneuver should not be considered in the space domain isolated from joint fighting, but should recognize the reliance of terrestrial observation, decision, and implementation cycles on extant space capabilities.[27] Current Space Force rhetoric focuses on resilience of space architectures through distributed, proliferated, and diverse systems. In an offense-dominant domain, it is essential that space strategists mitigate first mover advantage by making attacks on space systems costlier and less likely to succeed.

Where norms against using destructive or kinetic ASATs are upheld, or where the military prepares for increased transparency and collaborative spaceflight safety practices in the space domain, maturing selective revelation strategies—strategies that limit and control the disclosure of information—helps to conserve resources.[28] Although a norm that pushes a space force to give due notification and to follow predictable paths with lower collision probability may seem to constrain deception and security, having capabilities that can be revealed for attribution or information-sharing purposes at any time helps to avoid other mission-critical satellites from being detracted from their primary purposes. In turn, having consistent access to satellites and disaggregating missions for reconnaissance, satellite communications, or targeting can speed up terrestrial actions and make ammunition use more efficient, particularly when considering combined fighting.[29]

Shifting Adversarial Calculus

Deterrence is an inherently psychological phenomenon, with punishment and denial core to the enemy's cost-benefit analysis. Between the two, denial capabilities are more useful in deterring "ambiguous forms of aggression"—an issue especially prevalent in the space domain.[30] Deterrence by denial in the space context may look like controlling key antipodal zones or launch areas, maintaining celestial lines of communication, or developing resilient space capabilities. Deterrence by punishment may include making the space operational environment unusable thanks to permanent

25. Thomas González Roberts, "Why We Should Be Worried About a War in Space," *The Atlantic*, 15 December 2017, https://www.theatlantic.com/.

26. SDP 3-0, *Operations* (STARCOM, July 2023), 9, https://www.starcom.spaceforce.mil/; and Limoge, "War in Space."

27. Edward F. Teigeler, "The Principles of Mass and Maneuver Applied to Space Operations" (student report, Air Command and Staff College, April 1988), https://apps.dtic.mil/.

28. Schaffer, "Space Norms."

29. Dickey and Gleason, "Space and War."

30. Glenn H. Snyder, *Deterrence by Denial and Punishment* (Princeton University, 1959), https://catalog.hathitrust.org/.

orbital debris or widespread disruption and denial of space-based capabilities: both painful alternative futures.[31]

The United States has historically dominated space, incorporating space-based capabilities like positioning, navigation, and timing services into military and civilian life, thus becoming the ultimate space user and the most "space-dependent" country. This prevailing view from adversaries, combined with the low barriers and costs of irregular space warfare, has cultivated the view that the United States stands to lose the most from a loss in space, making American space assets attractive targets. Under this framework, adversaries are incentivized to attack American space assets, even at the expense of their own access to the space domain.

In conflict, the enemy will want to interfere with war-supporting functions, such as satellites. Yet, promoting transparency and normalizing the disclosure of orbital ASAT capabilities for deterrence can decrease the potential for a security dilemma in space.[32] By bringing the focus away from destruction back to a fight, the adversary will be able to believe that they do not have to choose between defeat and a space Pyrrhic victory, and that they can win without crippling enemy assets and in turn having their assets crippled in space.[33] Although space is recognized as an offense-dominant domain, adversarial concerns about an opponent's growing reliance on space places the same perceived vulnerabilities on them.[34] A focus on behavioral norms paired with concrete punishments—rather than on technical, unambiguous limits—can mitigate actions that sit just below the threshold of a hypothetical red line, such as safe maneuvering distance between satellites.

This relies heavily on the nature of the state to be deterred, which may believe itself to have an alternative normative regime. In such cases, bolstering the credibility and visibility of behavioral norms may involve allied deterrence.[35] Although it is unreasonable to expect adversaries to perfectly adhere to American norms during conflict, a shift toward parity in space can help to move adversaries away from preferring the total destruction of American space capabilities and toward an understanding of space as a shared domain.[36]

Attribution for both deterrence by denial and deterrence by punishment benefits from behavioral norms in space. Strategies shaped by norms of military transparency and safe practices will emphasize the importance of selective revelation, which is nec-

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31. Dennis M. Rice, *Deterrence and Space Strategy: A Framework from the Study of History and Theory*, Schriever Papers (Air University, 2023), https://www.airuniversity.af.edu/.

32. Alexander Fiore, "Deterrent and Defensive Applications of Orbital Antisatellite Weapons," *Æther* 2 (2023), https://www.airuniversity.af.edu/.

33. Koplow, *Death by Moderation*.

34. Kevin Pollpeter, *Coercive Space Activities: The View from PRC Sources, a CNA Report* (China Aerospace Studies Institute, February 2024), https://www.airuniversity.af.edu/.

35. Krista Langeland and Derek Grossman, *Tailoring Deterrence for China in Space* (RAND Corporation, 2021), https://www.rand.org/.

36. Zachary Burdette, "The U.S.–China Military Balance in Space," *International Security* 49, no. 4 (2025), https://doi.org/.

essary in sharing attribution information to allies and commercial partners. As one analysis contends, denial-dominant and mixed forms of deterrence both utilize norms in tandem with selective revelation, more so than the offensive-dominant form does; however, it may be in a country's interests to reveal its counterspace capabilities during conflict to surprise and coerce the adversary in an offensive-dominant framework.[37] A balance must be kept between disclosing capabilities in order to deter and keeping secrets for warfighting.[38]

Revealing lesser capabilities can accomplish both objectives: the United States may credibly attribute attacks, and such capabilities are unlikely to not already be matched by adversaries.[39] Revealing select capabilities from a satellite or space system can maintain the potential for surprise and deception in the future while painting the picture of a responsible space warfighting force.

Norms of information sharing and transparency during conflict can help to counter adversarial narratives about the United States, where it might be made out as the aggressor. They provide a tangible benefit: information can be delivered to the warfighter faster, increasing the usability of that data and removing data stovepipes. The soft power produced by increased access to imagery and ability to release said information might manifest as political will and more support for military actions to counter irresponsible and malicious behavior in space.[40]

International Law and Space Operations

Although often perceived as a Wild West environment, space is a "law-deficient" domain.[41] Existing international law largely prohibits actions in space related to nuclear proliferation, but this by itself is not enough.

The 1967 Outer Space Treaty (OST) serves as the *lex specialis*—where specific laws override general laws—for outer space, most specifically tailored for activities in space.[42] The treaty does not prohibit the militarization of space but is widely understood to prohibit exclusively the placement of nuclear weapons or weapons of mass destruction in orbit or on other celestial bodies.

Article IX of the treaty requires international consultations prior to actions that would cause "potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space." "Harmful contamination and also

37. Stephen J. Flanagan et al., *A Framework of Deterrence in Space Operations* (RAND Corporation, 2023).

38. Michael P. Gleason and Peter L. Hays, *Getting the Most Deterrent Value from U.S. Space Forces* (The Aerospace Corporation, 2020), https://aerospace.org/.

39. Alexandra T. Evans et al., *Space Strategic Stability: Assessing U.S. Concepts and Approaches* (RAND Corporation, 2024), https://doi.org/.

40. Dickey and Gleason, "Space and War."

41. David Koplow, "*The Woomera Manual*: A Handbook on the Military Law of Outer Space," Center for National Security, Georgetown Law, November 2024, https://nationalsecurity.law.georgetown.edu/.

42. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), 19 December 1966, UN Res 2222 (XXI).

adverse changes in the environment of the Earth" are banned—a flexible rule for unforeseen technological developments that reinforces the Environmental Modification (ENMOD) Treaty Convention.[43] This vague lexicon makes the OST an adaptable treaty but also places implementation at risk. While Article IX requires states to act with due regard in its space activities, this term is never defined. Nonetheless, the United States and satellite operators have developed best practices and norms in space that make the domain more accessible, akin to the eventual codification of norms in maritime law.

UN Charter Article 51 highlights the "inherent right of individual or collective self-defence if an armed attack occurs"; LOAC supersedes treaty obligations unless otherwise stated.[44] One interpretation could be that LOAC applies between belligerents but that third parties not involved in the conflict may still hold those belligerents accountable by the OST and the ENMOD Convention.

LOAC principles of military necessity, discrimination, and proportionality serve as a customary international law framework with which to pit new space capabilities against and are the lex specialis for armed conflict in space.[45] The intentional use of orbital debris for military purposes or to otherwise cause harm to other states is blatantly illegal. Orbital debris, much like minefields, fails all three principles listed, in accordance with Article 58 of Additional Protocol 1.[46] The inability to specifically target combatants makes it extremely damaging to civilian space systems, which fails to accomplish proportionality. By extension, then, it may be interpreted that kinetic attacks are off the table. Article 55, Protection of the Natural Environment, can be read in tandem with both the ENMOD Convention and the OST during war.[47] Between Article 57 and 58, armed forces are asked to facilitate distinction on their side, and to make a best effort to distinguish the other side's forces as well.[48]

Lex specialis rules that can be followed during armed conflict to a reasonable extent continue to apply—a benefit for the military in a law-deficient realm. Where technical, low-level rules do not exist in the OST, the military should work in conjunction with civilian and commercial operators to develop best practices and norms that can help maintain predictability in a high-threat operational environment. This involves developing a disciplined, well-trained space force that can effectively work with its civilian or commercial counterparts.

Article IX's principle of due regard ceases to apply during armed conflict between belligerents; yet, continuing to abide by due regard to the greatest extent possible could make the antebellum state of space and discussions far smoother. *The Woomera*

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43. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD Convention), 18 May 1977, UN A./Res/31/72, https://2009-2017.state.gov/.

44. UN charter, ch. VII, art. 51.

45. Beard and Stephens, *Woomera Manual*.

46. Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I), (8 June 1977), art. 58.

47. Protocol I, art. 55.

48. Protocol I, art. 57.

Manual on the International Law of Military Space Activities and Operations notes that due regard should continue to apply during conflict.[49] Extrapolating the normative and legal implications of yet-unseen military space activities is the mark of an adaptive military with a clear vision for a successful end-state.

Normalizing Commercial Integration

With respect to commercial satellites, there is a rapidly degrading norm—if not already degraded, as China does not distinguish between military and commercial space—that passive satellites are not legitimate targets of attack, even if they support the military.[50] This stems from a conflation of *non-aggressive* with *peaceful*. Even where terrestrial systems rely on space-based systems, satellites used merely to collect and transmit information are distinguished from satellites closer to the shooter. Yet, Russian cyberattacks on Viasat satellites during Russia's ongoing war in Ukraine and additional integration of commercial assets into American military functions demand further analysis of the implications of commercial assets' integration into the military space enterprise.

Given the dual-use nature of satellites and the various disaggregated functions a satellite may serve, simply labelling an ASAT as offensive may not be sufficient for military freedom of action. Establishing that an ASAT is necessary in reaction to suspicions of an adversary placing a weapon on orbit may make that capability defensive. The issue of distinguishability for satellites becomes increasingly difficult since only so much information can be gleaned from the satellite's orbit and designation.

Due to this issue, concerns abound with the use of commercial and civilian satellites for military purposes. As one legal expert argues, this violates international humanitarian law by putting civilians at risk and intentionally obfuscating a target's legitimacy. The United States must uphold "reverse distinction," which would entail preventing the deliberate intermingling of civilian and military assets, and to continue integrating commercial capabilities is a deliberate choice. These "mixed motivations" are not legally valid according to this line of thinking.[51]

Despite this, this article contends that the norm of hosting government payloads on commercial satellites is militarily necessary and can be addressed with nuance by international law. The purpose of the LOAC is not to protect civilians at all costs but to protect them against military excess, where a military objective fails to justify the costs.

During Russia's 2022 invasion of Ukraine, a Viasat cyberattack was accompanied by Russia's declaration that commercial satellites are legitimate targets. The United States has already integrated commercial capabilities into its warfighting strategies, as

49. Beard and Stephens, *Woomera Manual*.

50. Townsend, *Security and Stability*.

51. David A. Koplow, "Reverse Distinction: A U.S. Violation of the Law of Armed Conflict in Space," SSRN [Social Science Research Network], 18 January 2021, https://doi.org/.

evidenced by both the Space Force Commercial Space Strategy and the DOD Commercial Space Integration Strategy, with plans to continue to do so.[52]

The potential costs of disentangling military space capabilities from commercial companies would be astronomical and require time-intensive resourcing to build organic capabilities; entanglement is beneficial for deterrence and brinkmanship. The terrestrial effects of attacks on commercial actors might be more quickly addressed and mitigated if the military adheres to norms of transparency and threat-sharing.[53]

Space Doctrine Note, *Operations*, points to the benefits of hosting a payload on a commercial spacecraft, which in turn incentivizes a stronger and more efficient relationship between commercial partners and the military.[54] This may be seen as an active decision to make the adversary's responsibilities more complicated but is outweighed by the military necessity and benefit it provides to armed forces.[55] A militarily necessary act may be justifiable and also happen to complicate adversary planning, prioritized in that order, as demonstrated in the note. That does not mean that militaries should primarily intend to rely on dual-use systems to protect from lawful attack.[56] Instead, it warrants "constant care" of precautions on the effects of an attack both during peacetime and wartime.[57]

Mitigating harm to civilian populations during commercially-integrated armed conflict may manifest as setting base norms on what kinds of satellites are off-limits with regard to international humanitarian law. The United States might only disrupt or deny satellites that provide missile targeting, for example, and avoid targeting spacecraft that provide weather services over an area that is not relevant or necessary to certain local terrestrial tactical actions. Certainly, this is challenging for adversaries with heavily integrated commercial and military systems, such as Russia; LOAC provides unclear guidance for what threshold of collateral damage to civilians or civilian objects in space is illegal.

Active integration of commercial capabilities into military space operations increases the leverage and control that the military has over such companies, introducing the possibility of using shutter control.[58] SpaceX founder Elon Musk's refusal to service a surprise attack on Russian forces in Crimea certainly raised questions about

52. Audrey Schaffer, "Pedal to the Metal: Accelerating Pentagon Integration of Commercial Space," CSIS, 17 May 2024, https://www.csis.org/; and Secretary of the Air Force Public Affairs, "USSF Releases Commercial Space Strategy to Increase Competitive Advantage," USSF, 10 April 2024, https://www.spaceforce.mil/.

53. Theresa Hitchens and Colin Clark, "Commercial Satellites: Will They Be Military Targets?," *Breaking Defense*, 16 July 2019, https://breakingdefense.com/.

54. Space Doctrine Note, *Operations* (Headquarters, USSF, January 2022).

55. John Goehring, "The Legality of Intermingling Military and Civilian Capabilities in Space," *Articles of War*, 17 October 2022, https://lieber.westpoint.edu/.

56. Amanda Miller, "Resilient Architecture vs. Civilian Risk," *Air & Space Forces Magazine*, 16 February 2022, https://www.airandspaceforces.com/.

57. Protocol I, art. 57.

58. Sandra Erwin, "SpaceX Providing Starlink Services to DoD Under 'Unique Terms and Conditions,' " *SpaceNews*, 3 October 2023, https://spacenews.com/.

the power of transnational corporations to defy their home country's political and strategic desires.[59]

Locking down a contract and clearly delineating the roles and responsibilities of commercial actors will help both parties, especially where commercial actors are ill-prepared for space warfare. Commercial satellite companies may not have clear expectations of the risk they would accept during armed conflict and should work with the military to implement agreed-upon norms for minimizing collateral damage, such as limits on indiscriminate radio-frequency interference.[60] Commercial actors whose roles and responsibilities within military space operations are clarified can share mission data to deescalate miscommunications.

One example is the Commercial Augmentation Space Reserve, wherein contractors are called upon for "surge" capabilities in exchange for benefits during peacetime, such as threat briefs. Participating companies are considered on a case-by-case basis to determine where in the space enterprise they best fit.[61] The transactional nature of the reserve opens up possibilities for the military to deny services to other customers—foreign, commercial, or civilian. Already, the young program has begun to prove its worth, with commercial satellite communications companies participating in more Space Force wargames.[62]

The military bears the responsibility of developing an understanding of the role that commercial actors play in warfighting functions, especially since their integration and legitimacy as targets have already been normatively cemented by Russia's actions. Future norms during wartime could address collateral damage to commercial actors, communication means, and a preference for precise attacks rather than attacks with unknown second- and third-order effects.

Recommendations

Further engage with commercial, civilian, and allied and partner organizations in developing norms of responsible behavior that can be maintained during conflict. American rules of engagement acknowledge the importance of norms of responsible behavior in space. Chairman of the Joint Chiefs of Staff Instruction 3121.01B, Enclosure E "governs the actions to be taken by US forces in defense of terrestrial or on-orbit space assets," laying out broad goals.[63] Among these are minimizing debris generation and collateral interference, though it does not provide more specific guidance

59. "Elon Musk's Refusal to Have Starlink Support Ukraine Attack in Crimea Raises Questions for Pentagon," AP, 11 September 2023, https://apnews.com/.

60. Robin Dickey, *Commercial Normentum: Space Security Challenges, Commercial Actors, and Norms of Behavior* (The Aerospace Corporation, 2022), 6, https://csps.aerospace.org/.

61. Theresa Hitchens, "Join the Commercial Space Reserve: Get Longer Contracts, In-Depth Threat Briefs; Play Wargames," *Breaking Defense*, 25 October 2024, https://breakingdefense.com/.

62. Lisa Sodders, "Commercial Augmentation Space Reserve Hits Major Milestone with First Wargaming Event," Space Systems Command, 16 April 2025, https://www.ssc.spaceforce.mil/.

63. Enclosure E, "Space Operations," in CJCS Instruction 3121.01B, *Standing Rules of Engagement / Standing Rules for the Use of Force for US Forces* (CJCS, 13 June 2005, current as of 18 June 2008).

at an unclassified level. The publicly available 2005 Enclosure E appears to make a distinction between "commercial space assets" and national security space assets but indicates that both assets should be considered in national self-defense (Enclosure A).[64]

This poses a challenge for establishing and implementing norms during armed conflict in a reliable, timely manner. Norms continue to matter for civilians during and after armed conflict, and even voicing potential concerns may shape normative behavior for the better, rather than having domino effects down the line. These norms should have more specific guidance, continuing to draw on peacetime treaties.

Formal mechanisms for commercial and civilian input on military space doctrine should be implemented in conjunction with regular public forums with industry to discuss concerns. As a nascent service, the Space Force should seek to exploit the thriving American industrial base and academic debates surrounding space policy. At a higher level, existing international working groups, including non-UN bodies, could be a launching point for creating a consensus across epistemic communities on best practices.

Proliferate norms of behavior and doctrine across all functions and levels. To cultivate a disciplined force that is able to consider various methods of achieving a certain effect, creating a shared understanding of norms of behavior is essential. The development of decision trees and integration of norms of behavior into professional military educational institutions will help to standardize their application during warfare. Decision matrices and operational thresholds and triggers should be regularly reconsidered and reevaluated across the cooperation to conflict spectrum. Delineating the command levels of each norm will naturally create chains of responsibility, while avoiding creating overly-centralized command and control structures.

Given the reliance on space-enabled capabilities by the rest of the joint force, the Space Force should take steps to deconflict and encourage interservice cooperation, thus ensuring that each separate component will have a lower likelihood of escalation. The most recent March 2025 DOD Commercial Integration Strategy describes "unity of effort across planning horizons" as a goal it shall achieve through "responsible conduct in space" and "reinforcing behavioral norms"—an indication that the organization understands the strategic benefits of norms in space.[65] While it may not necessarily be desirable to empower the most tactical operator with such decisions, a more thorough understanding of what issues to escalate could prevent an uncomfortable trip to the UN.

Conduct more wargames and exercises, including commercial actors and allied and partner organizations. The Combined Space Operations Center and upcoming Space Futures Command emphasize wargaming with commercial actors and allies and part-

64. Enclosure A, section 3(b), National Self Defense, "Standing Rules of Engagement for US Forces," in CJCSI 3121.01B.

65. Stephen N. Whiting, *Commercial Integration Strategy* (USSPACECOM, 2025), 9, https://www.spacecom.mil/.

ners; however, cooperation must be consistent and focused to be effective. High-level operational wargames ensure that partners are on the same page and understand the ways in which the other may approach the same issue, and low-level crisis scenarios may ensure cooperation between parallel organizations, which creates trust and improved communication at the tactical level. Although traditional physical joint training exercises are impractical for the space domain, practicing the skills used in operating satellites and coordinating multidomain operations can be handled without broaching sensitive issues. By tackling the mechanisms and confluence of multidomain issues, wargames inherently work around classification barriers and promote flexibility in high-level approaches to operational scenarios.

Commercial actors will increasingly be involved in conflict in space. USSPACECOM may even "protect prioritized commercial space assets."[66] Rather than being limited to the US military, wargames should include a variety of actors, allowing them the decision-making space and agency to interact with complex technical issues and their consequences—a muscle not trained by commercial operators. Wargames can speed up the decision-making cycle during armed conflict by creating a conceptual framework of reaction options and their potential consequences. Using a synthetic environment to walk through various potential norms and deconflict their impacts on commercial or military operators would strengthen the arguments for implementing such norms across the board—norms that would apply before, during, and after armed conflict.

Proactively work with commercial actors in threat-sharing and clarifying their integration into warfighting functions. The lack of an effective, fast, and accessible threat-sharing mechanism with industry actively harms American space resiliency and creates unwanted surprises down the line. Threat-sharing should include proactive communication and quick updates in times of crisis, for as many vetted American aerospace and defense companies as possible.[67] Automated collision avoidance systems could be encouraged or required for all contractors, increasing those commercial actors' resiliency and building on space sustainability norms. Expansion of the Commercial Augmentation Space Reserve program would help integrate companies into the appropriate warfighting functions, helping with distinguishability.

As the Pentagon becomes increasingly reliant on commercial space services, clear categories and thresholds for different kinds of military support functions are needed. Military payloads on commercial satellites could be specific to relaying communications or other active defense functions, whereas active counterspace attacks would rely on military payloads, on military satellites.[68] Maintaining some degree of integrity in disentanglement will relieve concerns about their integration according to interna-

66. Whiting, *Strategy*, 9.

67. Lisa Sodders, "Space Systems Command's CASR Conducts Second Wargame," USSF, 24 July 2025, https://www.spaceforce.mil/.

68. Koplow, "Reverse Distinction."

tional law. Barring that, the government should clearly delineate the roles of commercial actors and the threats they may face in conflict.

Conclusion

Although these recommendations have been incorporated in space strategy documents, there must be consistent implementation to ensure that the US military may reap their benefits. Efforts to leverage the burgeoning commercial space industry may recognize the economic upsides, but it is important to consider the legal, ethical, and practical challenges of involving commercial actors as well.

The ties between norms of behavior in space and warfighting may not seem obvious, but the shared environment of space demands that all actors play by the same rules. Where international law does not necessarily suffice for providing technical guidance, military interpretation of international law for the benefit of norms development can act as a force multiplier: a politically savvy space force is one ready to handle the escalatory risks of the space domain, even with the introduction of commercial actors. **Æ**

READY, FIRE, AIM

Tactical Autonomy in the Age of AI

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This article critically examines the Air Force's strategic pivot toward a future force heavily reliant on tactical autonomy. Drawing lessons from other technical fields, this article identifies three fundamental problems—perception, data, and adversarial vulnerability—that undermine the feasibility of autonomous combat aircraft and threaten the Air Force's allocation of resources, operational effectiveness, and long-term advantages in air superiority. To achieve lasting strategic gains, the service must immediately reassess future investments and planning with rigorous technological realism, focusing on verifiable performance, validated operational concepts, and resilience against adversarial countermoves. The realignment of future force planning with technological reality can be accomplished by measures focused on realistic capability demonstration, disciplined procurement, and strategic hedging.

In June 2023, US Army General Mark Milley, then-chairman of the Joint Chiefs of Staff, affirmed what a rising crescendo of public and private actors had already observed: the world was witnessing "the most fundamental change" in the history of the character of war, including "the introduction of robots," "a pilotless Air Force," and artificial intelligence (AI).[1] As with previous paradigm shifts from muskets to rifles or conventional to nuclear weapons, AI would forever divide military history into a distinct before and after.

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1. Jim Garamone, "Milley Makes Case for Rules-Based Order, Deterrence in New Era," US Department of Defense (DOD), 30 June 2023, https://www.defense.gov/.

Such a shift is reflected in the Pentagon's strategic plans. The Air Force's vision for air superiority in the 2030s provides a particularly clear case study of how a major acquisition program has evolved adjacent to the apparent revolutions in AI. In the 2010s, the Next-Generation Air Dominance program emerged with a plan to deliver a sixth-generation manned fighter in the 2020s.[2] By 2022, it had developed into a "family of systems," emphasizing "much less expensive autonomous uncrewed combat aircraft" known as collaborative combat aircraft (CCA).[3] In July 2024, the service paused the program's manned fighter component, partially because of the platform's cost but also ostensibly due to "technology advances" in autonomous systems.[4] But after months of debate, in March 2025, the program was once again reinstated.[5]

The Air Force remains entrenched in an internal struggle to determine the extent of the role that autonomy should play in its future force structure. While some senior leaders and technologists question the feasibility and strategic wisdom of fully autonomous tactical aircraft, a prominent contingent continues to advocate for rapid advancement toward a largely autonomous combat force.[6] A review of Air Force budget requests for autonomous combat aircraft programs shows how planned funding for autonomous aircraft development dramatically increases in 2026 to 2029 (fig. 1).[7]

The logic behind this strategic pivot is compelling. If an autonomous aircraft can perform the tasks of a human fighter pilot at the leading edge of combat—providing tactical autonomy—then AI-powered wingmen can mitigate the numerous disadvantages of human pilots. Relatively inexpensive aircraft without human operators can absorb tactical risk through attrition or distraction. Each robot will be as skilled as all other robots, and its software can infinitely reproduce new skills. The lengthy and costly enterprise of training human capital will be reduced to a copy-and-paste operation. Advanced AI systems may even generate novel solutions to tactical problems that humans have never imagined.[8] If the Air Force is on a credible path to tactical autonomy, then it is imperative to proceed with total commitment toward this potential offset.

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2. Aaron Mehta, "Kendall Unveils 6th Gen Fighter Strategy," *Defense News*, 1 February 2015, https://www.defensenews.com/.

3. Charles Pope, "Kendall Details 'Seven Operational Imperatives' & How They Forge the Future Force," US Air Force [USAF, website], 3 March 2022, https://www.af.mil/.

4. John Tirpak, "CCA Contract Expected in Fall; First Versions Under Construction," *Air & Space Forces Magazine*, 6 July 2024, https://www.airandspaceforces.com/.

5. Matthew Olay, "Trump, Hegseth Announce Air Force's Next Generation Platform," DOD, 21 March 2025, https://www.defense.gov/.

6. Audrey Decker, "Robot Reality Check: Crewed Warplanes Will Remain Vital for Years, USAF General Says," *Defense One*, 7 December 2024, https://www.defenseone.com/.

7. USAF Financial Management and Comptroller, *Department of Defense Fiscal Year (FY) 2023 Budget Estimates: Air Force*, vol. 2, Research, Development, Test & Evaluation (Department of the Air Force [DAF], April 2022), https://www.saffm.hq.af.mil/; and *Department of Defense Fiscal Year (FY) 2025 Budget Estimates: Air Force*, vol. 2, Research, Development, Test & Evaluation, Air Force (DAF, March 2024), https://www.saffm.hq.af.mil/.

8. Daniel Castro and Joshua New, *The Promise of Artificial Intelligence* (Center for Data Innovation, October 2016), https://www2.datainnovation.org/.

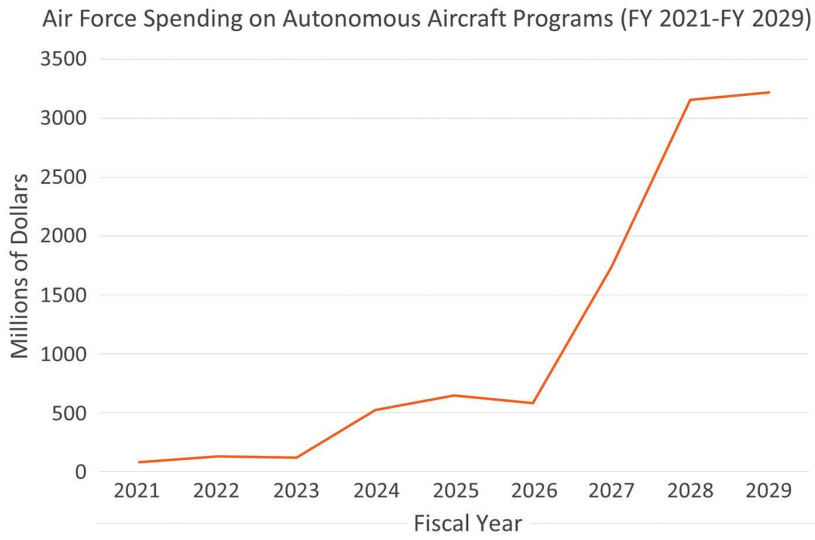

Figure 1. Annual Air Force spending on autonomous aircraft programs, fiscal years 2021 to 2029, past and projected

Unfortunately, however, the Air Force is not on such a path. The service has not acknowledged, accounted for, or mitigated three fundamental issues that render this vision not just impractical but also fantastical in the near-term: the problems of perception, data, and adversarial vulnerability.

First, even advanced autonomous systems routinely fail to accurately perceive well-characterized, relatively benign environments. Combat environments are inherently complex and uncertain, and AI systems have yet to demonstrate the sense-making required to build reliable situational awareness. Second, autonomous systems struggle to generalize beyond their training data set. Because war is the province of uncertainty and intelligence of the adversary is always incomplete, the military will not be able to produce the training data required for air combat in the pre-hostilities time frame—precisely when needed. Finally, AI systems exhibit precarious brittleness when faced with even rudimentary adversarial attacks.

These persistent, interrelated barriers threaten the Air Force's allocation of resources, operational effectiveness, and long-term advantages in air superiority. The service must immediately reassess its planned investments with rigorous technological realism, focusing on verifiable performance, validated operational concepts, and resilience against adversarial countermoves. Such a disciplined approach will ensure durable strategic gains while avoiding hollow capabilities that could emerge from a force design reliant on unproven autonomous systems.

Ready, Fire, Aim

Combined, the three issues of perception, data, and adversarial vulnerability suggest that the Air Force's pivot to tactical autonomy is a case of premature action akin to "Ready, Fire, Aim." These challenges are not mere technical hurdles that time, effort,

and funding will inevitably overcome but core limitations of a family of technologies whose theoretical foundations remain incomplete.[9] If the Air Force pulls the trigger now, it risks missing wildly. Furthermore, considerations of a staged approach to adoption—such as the Air Force's recent shift to tethering autonomous aircraft to nearby piloted platforms—fundamentally misunderstand the nature of these challenges.

This analysis does not seek to dismiss the potential of AI in military aviation. As test pilots with thousands of collective hours flying remotely piloted aircraft and stealth fighters in simulated and actual air combat, the authors fully believe in technologically advanced warfare in which computational systems and the human mind combine to violent advantage. Yet, a warfighting organization must not stake its survival on an optimistic future where ever-increasing data and compute enable "models [to] simply get better" forever.[10]

Additionally, the authors do not advocate for preservation of the status quo. While the Air Force's current force structure has proven capabilities, it must evolve to meet the challenges posed by emerging threats. The primary concern is that an aggressive pivot toward fully autonomous tactical aircraft represents a premature and high-risk path compared to other solutions—one that overlooks critical technology limitations that render tactical autonomy unrealistic in the near-term. In an era of strategic competition, such undisciplined technological optimism at institutional scale presents national risk.

Lessons from Other Fields

A critical examination of how similar optimism regarding AI has played out in other technical fields clarifies the scope of these risks. A recurring pattern of AI booms and winters has repeated continuously since the 1950s, and this should serve as a warning for senior Air Force leaders.[11] First, early AI successes in controlled environments generate widespread enthusiasm. Next, enthusiasm fuels bold predictions and significant investment. When these systems are tested in the messy reality of the real world, they encounter unexpected limitations or technical obstacles that prove insurmountable. Finally, performance stalls well below the level needed to realize revolutionary change.

IBM's computer system Watson exemplified this cycle. In 2011, Watson defeated human champions on the gameshow *Jeopardy!*, leading to predictions that Watson would revolutionize complex decision-making across industries, particularly in healthcare. But as the program manager stated, "The challenges turned out to be far

9. J. Mark Bishop, "Artificial Intelligence Is Stupid and Causal Reasoning Will Not Fix It," *Frontiers in Psychology* 11 (2021), https://doi.org/.

10. Charlie Warzel, "AI Has Become a Technology of Faith," *The Atlantic*, 12 July 2024, https://www.theatlantic.com/.

11. Amirhosein Toosi et al., "A Brief History of AI: How to Prevent Another Winter (a Critical Review)," Cornell University, arXiv, 1 October 2021, https://ar5iv.labs.arxiv.org/.

more difficult and time-consuming than anticipated."[12] In 2022, after investing over $4 billion, IBM sold Watson Health for a fraction of its cost.[13] While it excelled at highly structured knowledge retrieval tasks, Watson ultimately could not achieve its goal of meaningfully contributing to medical diagnoses in the real world.

The autonomous vehicle industry offers even closer parallels to Air Force ambitions. Since 2010, firms have spent over $100 billion on autonomous vehicle technology development.[14] This figure dwarfs all current and projected military spending on AI, yet the industry produced surprisingly modest, incremental successes contrasted to intended outcomes.[15] Companies like Waymo and Cruise, despite operating only in carefully mapped cities, have yet to successfully deploy fully autonomous vehicles and endure multibillion dollar deficits annually.[16] As of 2024, Tesla—despite its bold claims since 2016 that "Full Self-Driving" was "just around the corner"—remains only at Level 2 of 5 autonomy, requiring constant driver supervision and intervention.[17] Given a relatively structured problem set, training data measured in millions of hours, and predictable traffic rules, these products still encounter crippling difficulties navigating anomalous events, bad weather, unpredictable humans, or left-hand turns.[18]

AI proponents argue that solutions are forthcoming, pointing to ongoing methodological improvements and increased data collection. Yet the struggle revolves around a fundamental challenge of AI: it can excel in structured, predictable environments but degrades rapidly in "edge cases"—situations where the underlying problem diverges from the expected model or training data coverage. As cognitive psychologist Steven Pinker observed, the main lesson of AI research is that "the hard problems are easy, and the easy problems are hard."[19] If AI-based vehicles struggle to safely operate autonomously on well-mapped city streets—a task entrusted to some 16-year-olds—how can the military expect AI to perform within the chaotic and hostile environment of real-world aerial combat? There, decisions are replete with uncertainty, training data are scarce, and the adversary consents to few rules.

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12. Steve Lohr, "What Ever Happened to IBM's Watson," *The New York Times*, 18 July 2021, https://www.nytimes.com/.

13. Clare Duffy, "IBM Is Selling Off Its Watson Health Assets," CNN, 21 January 2022, https://www.cnn.com/.

14. Max Chafkin, "Even After $100 Billion, Self-Driving Cars Are Going Nowhere," *Bloomberg*, 6 October 2022, https://www.bloomberg.com/.

15. B. Padmaja et al., "Exploration of Issues, Challenges and Latest Developments in Autonomous Cars," *Journal of Big Data* 10, no. 1 (2023), https://doi.org/.

16. Trisha Thadani, "Embattled Self-Driving Car Company Cruise Lost $3.48 Billion in 2023," *The Washington Post*, 31 January 2024, https://www.washingtonpost.com/.

17. Ty Duffy, "What Tesla Autopilot and Full-Self Driving Can and Can't Do," *InsideEVs*, 27 November 2024, https://insideevs.com/.

18. Chafkin, "Self-Driving Cars."

19. Steven Pinker, *The Language Instinct* (DA Information Services, 1994).

Operational analyses frequently assert that autonomous combat systems will bring value by simply increasing the number of sensors and shooters in the battlespace.[20] Using that logic, the onboard autonomy can be initially rudimentary; the mere presence of additional "iron in the sky" enhances overall combat capability. Yet this perspective overlooks a critical lesson from other fields: quantity does not compensate for quality in perception and sense-making. Adding more sensors does not grant each robot a more accurate understanding of the battlespace, any more than adding more cameras makes a better self-driving car. Additional shooters provide little advantage if they cannot both construct and build situational awareness of the battlespace composition and context.

An AI optimist might sidestep this reality and instead imagine that autonomous combat aircraft will receive a clear, reasonably reliable picture of the battlespace. The AI-managed task would then be to optimize tactical decisions based on this high-quality information. This view reflects a misunderstanding of air combat. A common operating picture that fuses trustworthy information and presents it reliably does not exist. Rather, human operators must construct their understanding of reality from a tangled web of conflicting and incomplete data sources. Sensor displays may present misleading information, sometimes showing friendly aircraft as enemies, enemy aircraft as friendlies, phantom tracks where no aircraft exist, and empty spaces where aircraft actually fly. Adversaries exacerbate these challenges as they actively seek to deny, degrade, disrupt, and deceive every aspect of battlespace awareness.

Experienced pilots navigate perceptual uncertainty through an intricate combination of inference, reasoning, contextual awareness, and tactical intuition honed over years of training. They can recognize when information is unreliable, adjust their mental models accordingly, and adapt their tactics in real time. Perhaps most importantly, when a pilot knows they do not understand the situation, they can acknowledge this uncertainty, seek additional information, and take novel actions to mitigate risk—distinctly human behaviors that lead to reasonable decisions in the face of incomplete or misleading information.

Viewed naively, AI successes in games such as chess and Go seem to evidence future capability. These successes, however, are attributable to the fact that AI bypasses rather than engages with these perception challenges. Most game-playing AI agents are given perfect or near-perfect information about the game. Additionally, the space of all possible decisions for these agents is both discrete (players must move on the spaces) and finite (players must follow the rules). In combat, the decision space is continuous and infinite.

Understanding the context of previous AI successes and failures is crucial for understanding why the three critical problems of perception, data, and adversarial vulnerability are closer to insurmountable barriers than mere technical hurdles. The

20. "Collaborative Combat Aircraft for Disruptive Operations Mitchell Institute CCA Wargame Executive Summary," slides, Mitchell Institute for Aerospace Studies, 2024, https://www.mitchellaerospacepower.org/.

pattern observed in other fields, where AI systems hit hard limitations that resist incremental solutions, is likely to become even more pronounced for air combat. Furthermore, their combined effects create challenges that surpass anything encountered in medical diagnosis, autonomous vehicles, or complex games.

Three Critical Problems

Understanding the three challenges to tactical autonomy and how they mutually amplify each other indicates how current AI technologies will fail to deliver the autonomous combat aircraft hyped by proponents.

Perception in Complex Combat Environments

Even state-of-the-art autonomous systems routinely fail to accurately perceive well-characterized, familiar human environments.[21] A 2023 study found that ineffective perception and sensing in off-nominal environmental conditions has "been the problem that keeps autonomous vehicles from going to higher autonomy." The study faulted every aspect of autonomous perception systems: the sensors, the fusion algorithms, and the AI.[22] In 2019, the National Transportation Safety Board determined that a Tesla driver was decapitated in a crash because his "Autopilot vision system did not consistently detect and track" a broadside tractor-trailer as an object or threat.[23] The report showed that the tractor-trailer was continuously visible to the human eye five seconds prior to the collision; however, all the way through the moment of impact, the car never braked nor steered.

Combat environments are significantly more complex and require sensors to tackle the challenge of building situational awareness across hundreds of miles. Yet recent autonomy programs such as the Defense Advanced Research Projects Agency (DARPA) AlphaDogfight Trials have elided the problem of perception entirely. In these trials, an AI agent defeated an experienced F-16 pilot in a one-on-one simulation of a task known as basic fighter maneuvers.[24] But, critically, the AI software had perfect information about the simulated environment, capabilities of both aircraft, and the adversary's position, speed, and direction in real time; the human had no such advantages.[25]

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21. See Ashley Roque, "Frustrations Mount over Army's Robotic Combat Vehicle Autonomy, Acquisition Approach," *Breaking Defense*, 22 July 2024, http://breakingdefense.com/; and Mary L. Cummings, "What Self-Driving Cars Tell Us About AI Risks," *IEEE Spectrum*, 30 July 2023, https://spectrum.ieee.org/.

22. Yuxiao Zhang et al., "Perception and Sensing for Autonomous Vehicles Under Adverse Weather Conditions: A Survey," *ISPRS Journal of Photogrammetry and Remote Sensing: Official Publication of the International Society for Photogrammetry and Remote Sensing (ISPRS)* 196 (2023), https://doi.org/.

23. *Highway Accident Brief: Collision Between Car Operating with Partial Driving Automation and Truck-Tractor Semitrailer* (National Transportation Safety Board, 22 January 2020), https://www.ntsb.gov/.

24. "AI Bests Human Fighter Pilot in AlphaDogfight Trial at Johns Hopkins APL," Johns Hopkins University Applied Physics Laboratory, press release, 28 August 2020, https://www.jhuapl.edu/.

25. Adrian P. Pope et al., "Hierarchical Reinforcement Learning for Air-to-Air Combat," arXiv, last revised 11 June 2021, http://arxiv.org/.

In another example, after then-Secretary of the Air Force Frank Kendall flew in the X-62—an experimental AI test-bed performing basic fighter maneuvers as part of DARPA's follow-on Air Combat Evolution program—he stated that the AI had "roughly an even fight" with an experienced fighter pilot.[26] The Air Force press release declared that "the controls of the X-62A remained untouched by both Kendall and the safety pilot in the backseat throughout the entire test flight."[27] But this claim was not true; the AI software was only activated in specific bounded portions of the test flights. In reality, the X-62 could not autonomously take off, transit to the airspace, set up for the dogfight, dogfight without the adversary aircraft sharing an uninterrupted feed of high-quality information, safely end the dogfight, safely return to base, nor land on its own. When researching these claims, the authors contacted Air Force public affairs to ask about the article's overstatements. In response, public affairs corrected their press release.[28]

While ongoing experiments like AlphaDogFight and Air Combat Evolution are interesting lines of research, they bypass real machine perception challenges critical to tasks such as basic fighter maneuvers and focus solely on AI maneuver geometry problem-solving—more akin to playing a videogame than evaluating realistic tactical problems. In combat, adversaries will not provide high-quality feeds of their positions. Air Force discussions about the maturity of autonomy should not equate narrow unrealistic applications of AI that entirely bypass sense-making to broad tasks fighter pilots perform in combat.

While advances in computer vision algorithms can seem impressive, still-struggling outcomes in autonomous vehicle applications, coupled with an absence of research on how these classifiers perform on military sensors, suggest a long road ahead for even basic object classification in air combat. Assuming object classification challenges were solvable, a massive research gap would still remain between detecting or labeling objects and sense-making of the resulting, inevitably imperfect, tactical picture.

Limited Training Data for Real-World Conflict

The second problem for tactical autonomy is the scarcity of useful datasets to train the systems. While autonomous systems trained on plentiful, accurate, and well-labeled data show promising results when applied to narrow problems, they struggle or fail to generalize results outside their training data set. A complete training data set for air combat is impossible to produce in peacetime.

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26. Jon Harper, "Air Force's Kendall: AI Agents Had 'Roughly an Even Fight' Against Human F-16 Pilot in Recent Engagements," *DefenseScoop*, 8 May 2024, https://defensescoop.com/.

27. "27 Nov 24 Archive: Air Force's Kendall: AI Agents Had 'Roughly an Even Fight' Against Human F-16 Pilot in Recent Engagements," Wayback Machine: Internet Archive, 3 May 2024, accessed 10 December 2024, https://web.archive.org/.

28. Gary Hatch and Mary Kozaitis, "SecAF Kendall Experiences VISTA of Future Flight Test at Edwards AFB," USAF, 3 May 2024, https://www.af.mil/.

The last two documented US air-to-air kills against manned fighters occurred in 1999 and 2017, highlighting the scarcity of air combat data in the twenty-first century.[29] Moreover, much of the available military data on air combat tactics and outcomes is classified, fragmented, unlabeled, or not representative of current technology. A 2019 RAND Corporation report highlighted that significant portions of available military data are not stored in accessible formats, lack interoperability, and are often not understandable or traceable, all of which exacerbate these problems.[30]

Proponents of autonomous combat systems often suggest that synthetic (computer-generated) data and advanced simulations can overcome the training data shortage. This argument misconstrues both the nature of modern air combat and the limitations of simulated environments. Modern air combat involves complex interactions between physical materials, electromagnetic waves, the correlation of multiple sensor feeds, and datalinks—physics interactions that are exceedingly difficult to model accurately. A United Nations policy paper highlights the risk in this approach: "Poorly generated synthetic data can lead to inaccurate and unreliable AI models."[31] More fundamentally, synthetic data only incorporates known variables and interactions. Real combat presents scenarios never considered in training or predicted via intelligence collection. Unlike games with fixed rules, combat tactics continuously evolve as adversaries create scenarios outside expected parameters. While automated domain randomization can increase the size of training datasets, it still fails to account for edge cases, adversarial ingenuity, and intelligence uncertainties.

The relevance of existing datasets also diminishes with the introduction of new warfare technologies. An AI trained on data from five years ago would find itself wholly unprepared for the realities of combat today. While a human can easily take training from old technology and tactics and update it with new assessments, the failure of contemporary AI to adapt to even trivial "distribution shifts" of the training data has been demonstrated repeatedly. A 2021 study tested the transition of an automated breast cancer detection algorithm from one hospital to another, while keeping every anticipated factor unchanged. Its performance dropped from 93 to 70 percent based on unexpected confounding factors such as the new hospital's lighting, patient demographics, and photography procedures.[32]

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29. Oriana Pawlyk, "US F/A-18E Shoots Down Syrian Su-22 in Air-to-Air Kill," Military.com, 18 June 2017, https://www.military.com/.

30. Danielle C. Tarraf et al., *The Department of Defense Posture for Artificial Intelligence* (RAND Corporation, 17 December 2019), https://www.rand.org/.

31. Philippe de Wilde et al., *Recommendations on the Use of Synthetic Data to Train AI Models* (UN University, 29 February 2024), https://unu.edu/.

32. Pang Wei Koh et al., "WILDS: A Benchmark of in-the-Wild Distribution Shifts," paper presented at the 38th International Conference on Machine Learning, Vienna, Austria, 13–18 July 2020, https://cs.stanford.edu/.

Similarly, highly structured air combat training events such as Red Flag will not provide the density or scale of training data required to realize tactical autonomy.[33] In training, instructors of wingmen do not aim to show them everything they could possibly see in combat. They train them on how to deal with the previously unseen and the unexpected. A human can be taught to react and improvise, whereas the most advanced algorithms today can only regurgitate training data in complex ways. As one expert observes, in seven decades AI researchers have made "almost no progress" in "apply[ing] knowledge from one domain to another."[34]

Overall, accurate and plentiful data representative of realistic combat scenarios does not exist and cannot be easily simulated. The challenge is not one of quantity or labeling. AI systems that cannot generalize beyond their flawed training will fail in combat. They will overfit or underfit to limited, imperfect data and make critical errors when faced with novel situations. More critically, this data limitation ensures that any perceptual capabilities the AI develops will be inherently flawed, creating vulnerabilities that adversaries can exploit.

Fragility to Adversarial Attacks

Today's AI systems are unacceptably brittle—vulnerable to catastrophic failure—when faced with adversarial attacks.[35] In 2017, scientists showed AI's fragility in the realm of image recognition.[36] In an attack on autonomous driving systems, researchers applied small stickers to road signs that caused an image recognition algorithm to identify a stop sign as a speed limit sign with over 90 percent confidence. In 2024, studies revealed that attacks like these could also be highly effective in the military domain. Using "black-box" techniques—attacks that were not reliant on exploitation or understanding of the algorithms they were attacking—researchers demonstrated that imperceptible "universal adversarial perturbations" could cause AI systems designed to recognize targets in synthetic aperture radar imagery to misclassify military vehicles such as tanks up to 64 percent of the time.[37]

Alarmingly, these AI systems under attack often report high confidence in their incorrect decisions, providing no indication that they have been compromised.[38] This overconfidence stems directly from the first two problems: systems with flawed per-

33. "414th Combat Training Squadron 'Red Flag,' " Nellis Air Force Base, current as of October 2022, https://www.nellis.af.mil/.

34. Bishop, "Artificial Intelligence."

35. Katherine Tangalakis-Lippert, "Marines Fooled a DARPA Robot by Hiding in a Cardboard Box While Giggling and Pretending to Be Trees," *Business Insider*, 29 January 2023, https://www.businessinsider.com/.

36. Kevin Eykholt et al., "Robust Physical-World Attacks on Deep Learning Models," arXiv, last updated 10 April 2018, http://arxiv.org/.

37. Bowen Peng et al., "An Empirical Study of Fully Black-Box and Universal Adversarial Attack for SAR Target Recognition," *Remote Sensing* 14, no. 16 (2022), https://doi.org/.

38. Jingshu Li and Yitian Yang, "Overconfident and Unconfident AI Hinder Human-AI Collaboration," arXiv, 12 February 2024), https://arxiv.org/.

ception, trained on limited data, cannot recognize deception, creating a critical vulnerability in combat environments where rapid, accurate decision-making is essential.

Recent examples demonstrate the severity of this vulnerability. In 2023 the program KataGo, a Go-playing agent considered "superhuman," was defeated in more than 97 percent of its matches by amateur players who employed adversarial strategies that exploited its inflexibility.[39] That same year, Marines defeated an advanced DARPA AI surveillance system by walking around in a cardboard box, holding branches and "pretending to be trees," or doing somersaults.[40] Discussion around autonomy in the Air Force rarely includes the fact that crude adversarial attacks can often defeat modern AI systems in unexpected or unpredictable ways.

The three problems identified above have created an intractable situation: systems that cannot reliably perceive their environment, trained on insufficient data, become highly vulnerable to relatively trivial adversarial manipulation. Entrusting autonomous systems with control in combat scenarios embeds unmitigated systemic risk within those operations. This risk, which stems from the immaturity of the technology and its incomplete theoretical grounding, has not been adequately considered or accounted for in either force planning assumptions or operational analyses used to make major decisions. Given these formidable technical challenges, it is worth examining how current mitigation approaches address—or fail to address—these fundamental barriers.

Tethering: An Incomplete Solution

The Air Force's position on the degree of tactical autonomy required to achieve operational advantage has continuously shifted. In early 2023, senior leaders emphasized that CCA must operate "untethered with a high level of autonomy" to function in a "contested electromagnetic spectrum."[41] By late 2024, they reversed course, stipulating that CCAs "have to be under tight control" with "line-of-sight communications." The Secretary of the Air Force stated that "the default, if [CCA] lose communications, would be for them to return to base, which takes them out of the fight."[42] In 18 months, the entire CCA employment concept shifted from high reliance on machine autonomy to complete reliance on tethering, where humans supervise robots from nearby fighter aircraft.

This dramatic shift represents a forced retreat from initial autonomy claims without explicit recognition of their inherent limitations in either strategic communications or acquisition planning. Although proponents may see tethering as a viable long-term

39. Tony T. Wang et al., "Adversarial Policies Beat Superhuman Go AIs," paper presented at the Deep RL Workshop at NeurIPS 2022, 9 December 2022, https://people.eecs.berkeley.edu/.

40. Tangalakis-Lippert, "Marines."

41. Jon Harper, "Air Force Preparing for 'Tethered' and 'Untethered' CCA Drone Operations," *DefenseScoop*, 27 March 2023, https://defensescoop.com/.

42. Michael Marrow, "CCA Drones May Not Be Tied to NGAD, Need Line-of-Sight Control: Kendall," *Breaking Defense*, 16 September 2024, https://breakingdefense.com/.

mitigation, it undermines autonomy's strategic promise by reintroducing human dependency at the point where independence is essential. While tethering might provide a temporary workaround for technology demonstrations and limited experimentation, it is not a replacement for real solutions to the core technical problems facing tactical autonomy systems. As a result, efforts to scale this limited solution into future operational forces fail to resolve the fundamental problems while introducing three new challenges.

First, tethering contradicts the core strategic rationale for autonomous aircraft—the ability to operate independently in contested environments where communication may be severed—while imposing additional tactical workloads on operators. The potential advantages of supervised autonomous aircraft have been explored in simulators, in which computer-driven characters in computer-defined worlds leverage perfect knowledge to behave in advantageous ways.[43] But in the physical world, AI-driven systems will stumble over the three critical problems. The resulting limitations force aircrew to expend valuable mental resources supervising unreliable robotic platforms that range from marginally functional to completely unpredictable. Given that cognitive workloads and stresses in aerial combat are intrinsically extreme, the tradeoff between cognitive costs spent supervising robotic wingmen and their tactical value deserves scrutiny.

Second, whether the institutional Air Force can contend with such rapid shifts in foundational assumptions about autonomous combat aircraft is unclear. How many operational assessments that informed the future force structure assumed the use of untethered autonomous platforms? How many models and simulations that looked at autonomous wingmen locally tethered to fighter aircraft assumed simulated performance where simulated robots did not have to contend with the three critical problems? The conclusions of operational analyses are highly sensitive to the assumptions that drive them.

Finally, tethering creates an obvious vulnerability that competent adversaries will exploit. When a single pilot controls multiple CCAs, destroying or disrupting that pilot's aircraft suddenly removes multiple platforms from the battle. This creates a strong incentive for enemies to focus overwhelming force on the controlling aircraft. The more CCAs each pilot controls, the more attractive the controlling platform becomes as a target. This vulnerability is magnified in contested environments where communications jamming could force CCA formations to automatically retreat or be rendered functionally inoperative. This relationship, the available methods for manipulating it through network design, its impact on enemy tactics, and the investment in communications infrastructure and human-machine interfaces required to mitigate it remain understudied.

While tethering might enable initial CCA experimentation, it cannot serve as the foundation for future autonomous combat systems. An Air Force heavily reliant on

43. Mitchell Institute for Aerospace Studies, "Aerospace Nation: Gen Kenneth S. Wilsbach," 10 July 2024, YouTube video, 59:09, https://youtu.be/.

tethered autonomous platforms would sacrifice the advantages autonomy was supposed to provide while introducing new vulnerabilities. The vision of a future force structure built around autonomous combat aircraft remains fundamentally unrealistic, as the three critical problems represent inherent limitations rather than temporary obstacles awaiting breakthrough solutions.

Risks of Technological Optimism

Analysis of the critical problems facing combat AI reveals a troubling possibility: the optimism surrounding autonomous combat aircraft may be leading the Air Force toward a path that appears promising at first but ultimately leads to a failed end-state requiring a costly reversal. The true cost of such a blunder will be measured not only in the resources directly expended on autonomy development but also in opportunity costs and capability gaps that compound with time.

There is ample evidence of such optimism at work. In December 2023, senior Pentagon leaders stated that in the future CCA could expand to roles such as collaborative reconnaissance or mobility aircraft but that the immediate priority was to "focus on an air-to-air mission."[44] This prioritization inverts the logic of technology development. Semi-autonomous reconnaissance aircraft such as the RQ-4 exist today in large numbers. Autonomous mobility aircraft have recently been demonstrated in Federal Aviation Administration-approved flights.[45] The bulk of tasks these aircraft perform—ground operations, takeoff, cruise, descent, landing—will also have to be performed by CCA. A realistic developmental path would seek to mature existing semi-autonomous aircraft before attempting more complex autonomy tasks. Yet these foundational applications remain only potential concepts, while the Air Force plans for 1,000 CCA as the first step toward fielding tactical autonomy.[46]

The Air Force's plan to leapfrog multiple steps of technology maturation has echoes of the US Navy's littoral combat ship program, which one researcher observes "was essentially counted to solve every single one of the Navy's problems all at once."[47] Yet three years after fielding, then-Chief of Naval Operations Admiral Michael Gilday asked to retire many of the ships because they "did not work out technically." At issue were the technological immaturity of perception subsystems such as radar and sonar, and unreliable engines that could not be repaired underway because the Navy wanted to operate the ships with fewer humans on board.[48] Similar optimism regarding tactical autonomy predominates in the Air Force today, with proponents finding a panacea for a wide range

44. Dave Deptula et al., "Collaborative Combat Aircraft Vectors," transcript, panel discussion, ASC [Air, Space, Cyber] Conference 2023, 11 September 2023, Joint Base Andrews, Maryland, https://www.afa.org/.

45. Mark Phelps, "Successful Remote-Piloted Flight for Cessna Caravan," AVWeb, 6 December 2023, https://www.avweb.com/.

46. Tirpak, "CCA Contract."

47. Oren Liebermann et al., "US Navy Chief Defends Plan to Scrap Troubled Warships Even Though Some Are Less than 3 Years Old," CNN, 12 May 2022, https://www.cnn.com/.

48. Liebermann et al., "Navy Chief."

of problems—from battlespace awareness to the endemic pilot shortage—in a single technologically immature idea.

Heavy investment in immature technology also entails opportunity costs. Every dollar spent in pursuit of tactical autonomy diverts resources from viable, crucial technologies relevant to tactical aviation, including datalinks, long-range weapons, multi-spectral sensors, and piloted platforms. Additionally, the risk of bureaucratic path lock-in is acute, exacerbated by the sunk cost fallacy and institutional inertia. As more resources are invested in tactical autonomy, it becomes both psychologically and politically difficult to change course, even in the face of mounting evidence of the technology's limitations. Large bureaucracies like the military are particularly susceptible to this problem, as careers of both officers and defense contractors become tied to the success of programs that they work on. These forces, if left unchecked, create a self-reinforcing incentive to continue down the combat autonomy path regardless of emerging limitations.

This inertia is exacerbated by a disconnect between public Air Force messaging about autonomous capabilities and the private recognition of limitations among technical experts and program managers. The resulting gap creates an environment where realistic assessments struggle to influence strategic planning.

It is critical not to confuse limited demonstrations of autonomy capabilities with proof of feasibility for broader and more ambitious tactical autonomy goals. Plans for 2030s air superiority that rely on autonomous combat systems stake success on platforms with fundamental operational concepts unproven even in limited testing environments. Given the substantial technical gaps identified, prudent risk management demands the Air Force explicitly define realistic milestones, maintain clear-eyed strategic hedges, and avoid prematurely assuming that incremental successes in canned demonstrations guarantee operationally capable autonomous machines.

The Path Forward

The disconnect between the maturity of technologies underpinning tactical autonomy and the strategic plan for its adoption requires reconciliation. Historically, the service has bought down risk incrementally, balancing the imperative to adapt quickly with the necessity of getting the adaptation right. To realign future force planning with technological reality, the authors advocate for three specific measures focused on realistic capability demonstration, disciplined procurement, and strategic hedging.

First, the Air Force should establish clear, meaningful acquisition milestones that limit tactical autonomy systems from advancing beyond the research, development, testing, and evaluation (RDT&E) phase until they have demonstrated genuine combat utility. These milestones should emphasize warfighter-validated performance against the three critical problems: perception in contested environments, operational effectiveness despite realistic data limitations, and resilience against adversarial tactics. Assessment should blend objective measurements where possible with warfighter evaluation of tactical utility, as these systems must ultimately prove their worth to the operators who will employ them. Tactical autonomy must earn its place in the combat

air force via proven performance in realistic combat scenarios, not merely controlled simulations, scripted tests, or projected analyses.

Second, the Air Force should clearly differentiate procurement objectives between early-increment CCAs—semi-autonomous systems requiring human oversight—and future, highly autonomous aircraft intended for operational integration. Procurement of early-increment CCAs should be limited to only the numbers necessary for realistic operational experimentation, technology validation, and tactical concept refinement. An initially smaller fleet of CCAs would enable these tasks without prematurely institutionalizing unproven autonomy assumptions. If developmental autonomy systems demonstrate revolutionary combat capabilities, the Air Force can always procure additional platforms.

Finally, given the significant technological uncertainties and associated operational risks surrounding tactical autonomy, the Air Force must adopt and sustain a robust hedging strategy. This does not mean abandoning fundamental autonomy research but rather balancing investments across a portfolio of capabilities to manage risk. Priority investments should include advanced datalinks communication systems, enhanced human-machine interfaces, diverse methods for short- and long-range control of robotic aircraft, development of future weapons, and continued acquisition of advanced fighter platforms with enhanced sensors, processing capabilities, and low-observable technologies. By prioritizing these areas, the Air Force maximizes operational flexibility and avoids strategic vulnerabilities if autonomy fails to deliver promised capabilities.

Future methodical RDT&E investments may produce evidence that points to effective use cases for tactical autonomy within a combat environment. But technological realism demands that military leaders acknowledge present-day limitations and pursue advancements without relying solely on optimistic expectations.

Conclusion

The allure of AI-powered autonomous combat aircraft is powerful. But this vision of a future cost-effective force of tireless, precise machines unconstrained by human limitations collides with three fundamental problems that cannot be wished or engineered away: the challenge of perception in complex combat environments, the scarcity of relevant training data, and the unmitigated vulnerability of these systems to adversarial attacks. These cascading problems create limitations that incremental steps alone, such as tethering or limited CCA employment, cannot fully overcome.

The Air Force must immediately pivot to technological realism and account for these realities. While limited experiments with human-machine teaming may yield valuable insights, they do not offer a viable path to meaningful combat capability. Scaling even this reduced concept to future force structure planning without addressing the fundamental technical challenges inherent in tactical autonomy risks strategic failure. Institutional momentum behind overly ambitious autonomy planning risks not only financial misallocation but strategic inflexibility, limiting the Air Force's future options.

The path forward demands rigorous acquisition milestones tied to demonstrated capabilities, disciplined procurement aligned with technological maturity, and strategic hedging via balanced investment across a portfolio of proven technologies. As a warfighting organization, the Air Force's primary mission is to prepare for and conduct operations effectively rather than focusing on developing unproven technologies. Unless the Air Force implements standards for its 2030s force structure driven by evidence rather than optimism, it commits to a path that wagers US military defense on conjecture. Æ

A REVIVED COMMITMENT TO CONTROL OF THE AIR

STEPHEN S. REDMOND
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Air superiority remains vital for sustaining the joint force's military advantage. This article argues that a nuanced integration of emerging capabilities with adaptive airpower strategies, rather than platform supremacy alone, optimizes joint capability, offering the most effective approach for the United States and its Allies to maintain air dominance. This article explores the operational potential of collaborative combat aircraft, hypersonic weapons, and pulsed air operations as critical components of such an effective counterair strategy. Drawing on the authors' extensive operational expertise, institutional knowledge, and current research, the article challenges notions of air denial as the future of conflict, identifying the logistical, technological, and doctrinal adaptations necessary to preserve the effectiveness of airpower to address pacing threats, particularly in the Indo-Pacific.

The character of modern warfare is undergoing a profound transformation. The proliferation of anti-access/area denial (A2/AD) systems, drone swarms, and advanced missile technologies has disrupted traditional paradigms of air superiority, placing increasing pressure on legacy platforms and conventional doctrine. Against the backdrop of potential high-intensity conflicts with near-peer adversaries like Russia and China, the United States and its Allies face a pivotal question: Can air superiority still be achieved using conventional means, or must it be reimagined entirely?

Like a seasoned champion boxer facing a new generation of faster, more adaptive opponents, the joint force must decide whether to retire outdated strategies or radically evolve its approach. The answer likely lies in a deliberate transformation—one that blends innovation with operational realism and redefines what it means to control the skies.

Air superiority has historically been a cornerstone of successful military operations and campaigns and the prerogative of superpowers.[1] Yet, recent conflicts—most

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1. Peter Porkka and Vilho Rantanen, "Windows, Not Walls: Conceptualizing Air Superiority for Future Wars," *War on the Rocks*, 4 September 2024, https://warontherocks.com/.

notably Russia's war in Ukraine—underscore the increasing complexity of gaining and sustaining air control in contested environments. This article argues that future air superiority will not hinge on platform supremacy alone, but on integrated approaches optimizing joint capability. It examines the operational potential of collaborative combat aircraft (CCA), hypersonic weapons, and pulsed air operations as critical components of a reimagined approach to joint counterair strategy. Furthermore, this article identifies the logistical, technological, and doctrinal adaptations necessary to preserve the effectiveness of airpower in an increasingly complex battlespace. To maintain a decisive edge in twenty-first-century warfare, the joint force must embrace a weapon-centric, strategically adaptive approach to airpower—one that anticipates the demands of future battlefields and sheds legacy constraints.

Control of the Air: A Historical Requirement Reinforced by Ukraine

Some have asserted that the widespread use of drones—in this article, this term refers to small, one-way attack unmanned aerial vehicle systems—and A2/AD strategies has challenged the notion that superpowers can attain air superiority.[2] Some of the confusion surrounding this topic may stem from the ambiguous terminology used by academics and warfighters when discussing air superiority.

Air superiority exists along a spectrum of control of the air. At one end of this spectrum is *air parity*, in which opposing forces possess comparable strength, resulting in similar loss ratios. At the other end is *air supremacy*, where one force possesses overwhelming dominance, enabling total control of the air domain. Air superiority falls between these two extremes and refers to a state in which friendly air forces, supported by counterair missions, can operate without prohibitive interference.[3]

The air war during the Korean War provides a useful framework for understanding control of the air as a continuum, helping to clarify the distinction between different levels of aerial dominance. Controlling the air in Korea posed a significant challenge for the United States, as adversary forces outnumbered US forces and, in some cases, possessed superior technology, particularly with the introduction of the adversary MiG-15 in late 1950.[4] At certain points in the conflict, documented loss ratios were close to 1:1, indicating that neither side maintained a decisive advantage.[5] North Korean forces, supported by China and the Soviet Union, posed a significant threat to American bomber aircraft,

2. See, for example, Michael P. Kreuzer, "Beyond Air Superiority: The Growing Air Littoral and Twenty-First-Century Airpower," *Æther: A Journal of Strategic Airpower and Spacepower* [*Æther*] 3, no. 3 (2024), https://www.airuniversity.af.edu/.

3. Air Force Doctrine Publication 3-01, *Counterair Operations* (Curtis E. LeMay Center for Doctrine Development and Education, 5 June 2023), https://www.doctrine.af.mil/.

4. Douglas A. Birkey, *Air War over Korea: Lessons for Today's Airmen* (Mitchell Institute for Aerospace Studies [Mitchell Institute]), February 2022, https://www.mitchellaerospacepower.org/.

5. Walter J. Boyne, foreword to *MiG Alley: The U.S. Air Force in Korea, 1950–53*, by Thomas M. Cleaver (Osprey Oxford UK, 2019).

such as the B-26 and B-29, forcing them to shift operations to nighttime missions or avoid certain areas entirely.[6] This situation exemplifies air parity, where neither side maintained a significant advantage due to prohibitive interference.

Yet other phases of the conflict saw much higher kill ratios—ranging from 10:1 to 12:1—particularly as the United States countered the MiG-15 with F-86s and refined its aerial combat tactics.[7] Over the course of a prolonged and costly campaign, the United States achieved a degree of air superiority, as evidenced by the limited ability of adversary aircraft to threaten American ground forces and the continuous execution of US air campaigns against enemy targets.[8] Air superiority thus should not be misinterpreted as an absence of aerial threats or a state that exists in perpetuity. Instead, air superiority is a temporal and often localized condition in which friendly aircraft can effectively accomplish their missions within an acceptable level of risk.

The integral role of air superiority in modern warfare is exemplified by Russia's war in Ukraine. As one study notes, "Perhaps the single most significant lesson learned from the Russia-Ukraine War is that air superiority is still an essential prerequisite to enable combined-arms maneuver."[9] Russia's inability to secure air superiority has hindered its ability to support ground forces advancing into Ukraine. Similarly, Ukraine's failure to achieve air superiority has prevented it from executing effective counteroffensive operations to repel Russian forces.[10] If Ukraine could establish control of the air at strategic times and locations, its forces could more effectively conduct airstrikes against Russian ground units.[11]

Some airpower analysts have conflated the effectiveness of drones with that of manned fighters and bombers. In Ukraine, these systems are used to defend against Russian aggression. Yet early lessons from Russia's war in Ukraine indicate that drones are not replacing traditional airpower but instead represent a tactical adaptation to trench warfare, where neither side has achieved air superiority.[12] Observations from Ukraine suggest that drones provide substantial intelligence, surveillance, reconnaissance, and precision-strike capabilities, and when employed in a limited strike or defensive capacity, they demonstrate considerable utility in targeting adversary ground forces.[13] Yet despite their tactical effectiveness, drones have not proven to be a decisive

6. John T. Correll, "MiG Alley," *Air & Space Forces Magazine*, 1 April 2010, https://www.airandspaceforces.com/.

7. Robert G. Angevine, "Adapting to Disruption: Aerial Combat over North Vietnam," *Joint Force Quarterly* 96, no. 1 (2020), https://ndupress.ndu.edu/.

8. Cleaver, *MiG Alley*.

9. Michael T. Hackett and John A. Nagl, "A Long, Hard Year: Russia-Ukraine War Lessons Learned 2023," *The US Army War College Quarterly: Parameters* 54, no. 3 (2024), https://press.armywarcollege.edu/.

10. Joe Goodwin, "Allied Air Command Lessons from Ukraine," *The Journal of the Joint Air Power Competence Center* 37 (May 2024), https://www.japcc.org/.

11. James B. Hecker, "Air Superiority: A Renewed Vision," *Æther* 3, no. 2 (2024), https://www.airuniversity.af.edu/

12. Hecker, "Air Superiority."

13. Hackett and Nagl, "Long, Hard Year."

factor in achieving military victory. Nevertheless, based on such observations in Ukraine and the enduring lessons of military history from major armed conflict since the Second World War, air superiority continues to be vital to support forces on the surface and achieve critical military objectives that lead to victory.[14]

Achieving air superiority against a highly capable adversary like Russia or China will be costly. During World War II, the Eighth Air Force suffered more combat fatalities than the entire US Marine Corps.[15] In Korea, the United States' grueling air battles against a numerically superior and technologically capable adversary resulted in the loss of over 2,700 aircraft—a thousand more tactical aircraft than the US Air Force has in its total inventory today.[16] During the Vietnam War, the US Navy famously commissioned the Ault Report to analyze declining loss ratios, leading to the establishment of the TOPGUN program to regain aerial combat superiority.[17] The historical record underscores that maintaining control of the air has always been difficult and costly. The relative ease with which the United States has controlled the air after Vietnam reflects specific circumstances rather than an inherent capability.

If the United States and its Allies seek to prevail in military conflict against adversaries such as Russia and China, controlling the air is a joint warfighting necessity. Without air superiority and the ability to support combined-arms operations, the US military risks encountering a combat environment reminiscent of that faced in World War I—a challenging situation analogous to the ongoing conflict in Ukraine, where the failure to secure air superiority has contributed to a protracted and costly ground war.

The Future Role of CCA in Counterair Missions

There is considerable debate in the United States and Western defense circles regarding the future of aerial combat. Assertions like that of SpaceX founder Elon Musk, who stated that "idiots are still building manned fighter jets like the F-35," significantly impact the defense industrial base, leadership within the Pentagon, and the national security community.[18] This notion is not novel; in 2020, Musk presented similar ideas at the Air Force Association's Air Warfare Symposium, positing that autonomous drones augmented with artificial intelligence (AI) would represent the future of

14. Hecker, "Air Superiority."

15. "Author and Historian Donald L. Miller," Layfayette.edu, accessed 10 March 2025, https://sites.lafayette.edu/.

16. "Korean Air Battles," Defense POW/MIA Accounting Agency, accessed 10 March 2025, https://dpaa-mil.sites.crmforce.mil/.

17. Angevine, "Disruption."

18. See, for example, Jesus Mesa, "Why F-35 Fighter Jets are 'Obsolete' According to Elon Musk," *Newsweek*, 25 November 2024, https://www.newsweek.com/; Peter Porkka and Vilho Rantanen, "Windows, Not Walls: Conceptualizing Air Superiority for Future Wars," *War on the Rocks*, 4 September 2024, https://warontherocks.com/; and Maximilian Bremer and Kelly Grieco, "Air Denial: The Dangerous Illusion of Decisive Air Superiority," Atlantic Council, 30 August 2022, https://www.atlanticcouncil.org/.

warfare, rendering platforms like the F-35 obsolete.[19] CCAs and unmanned technology will be part of the future joint force—the question is not if it will happen, but rather when CCAs will be ready to provide capability to the joint force in combat, to what degree, and how that should change the overall joint force structure.

Long before such unsubstantiated assertions by Musk and others, the US Air Force had already been investigating and developing concepts under the Low-Cost Attritable Aircraft Technology initiative, which aimed to develop and build low-cost autonomous aircraft in large numbers. This program also encompassed the Low-Cost Attritable Strike Demonstrator program. The former initiative evolved into the Skyborg program within the Air Force Research Laboratory and is foundational for current Air Force CCA efforts.[20] The XQ-58A Valkyrie demonstrator first flew in 2019, just one week after Boeing unveiled its Australian Loyal Wingman drone, now known as the MQ-28 Ghost Bat. These developments marked critical milestones and a shift in narrative, drawing attention from Air Force leadership, the broader defense industrial base, and tech investors eager to enter the defense sector.[21] In the latter part of the 2010s and early 2020s, funding for autonomous aircraft research and development was relatively modest, amounting to less than $500 million per year. Yet the fiscal year 2025–2029 budget request for these programs has surged to $9 billion, with expectations for continued growth.[22]

The key appeal of CCAs lies in their potential for both cost savings and enhanced capability. If CCAs can be developed at a lower cost than manned fighters and provide comparable or superior capability, the Department of Defense could open a pathway to cost-overmatch against its adversaries in the air domain. If CCAs do not achieve a comparable military capability of manned fighters, they could be additive to the US military's manned fighter inventory if cost-effective. CCAs would help address a chronic fighter pilot shortage, particularly in the Air Force and Navy. The problem with this narrative is that if CCAs fail to produce capability, and the Department hedges its air superiority force structure on CCA technology, nothing less than joint military effectiveness is at risk.

The ongoing pilot shortage in the Air Force and Navy shows no sign of resolution in the coming decade. While the defense industry has frequently discussed the challenges of replacing lost aircraft in combat, the more pressing issue lies in the depletion

19. Rachel S. Cohen, "The Fighter Jet Era Has Passed," *Air & Space Forces Magazine*, 1 April 2020, https://www.airandspaceforces.com/.

20. Gregory C. Allen and Isaac Goldston, *The Department of Defense's Collaborative Combat Aircraft Program: Good News, Bad News, and Unanswered Questions* (Center for Strategic & International Studies [CSIS], 6 August 2024), https://www.csis.org/.

21. Tyler Rogoway, "Air Force's Secretive XQ-58A Valkyrie Experimental Combat Drone Emerges After First Flight," *TWZ* [*The War Zone*], 6 March 2019, https://www.twz.com/.

22. Jennifer DiMascio, *U.S. Air Force Collaborative Combat Aircraft*, In Focus (IF) report 12740 (Congressional Research Service [CRS], 22 January 2025), https://crsreports.congress.gov/.

of pilots—currently at historic lows—unless pilots are no longer necessary.[23] Training fighter pilots is an expensive endeavor, costing approximately $11 million per pilot for fifth-generation platforms like the F-35 and F-22.[24] Additional benefits of unmanned platforms include reduced risk to human life, shorter training cycles, and the disaggregation of combat mass.

The Defense Department, however, must navigate these opportunities carefully, balancing them against proven capabilities. The US military cannot choose the time or nature of its conflicts, and relying solely on the promise of unmanned technology presents significant risks. If this technological shift fails to deliver, and the US military hedges its force structure on the promise of technology, the US military's joint combat effectiveness will be severely compromised. Therefore, it is crucial to approach CCAs as a complementary force, gradually integrating them alongside human-piloted aircraft while acknowledging the challenges ahead.

Autonomous systems face well-documented obstacles in performing tasks that humans can execute with relative ease.[25] Training CCAs to match or exceed the capabilities of current manned fighter jets will require extensive data, immense computational resources, and a thorough understanding of adversary tactics—resources that the Defense Department currently lacks in sufficient quantities.[26] Demonstrations such as AlphaDogfight and the X-62 have largely sidestepped the issue of autonomous agent perception and real-time decision-making, making claims of CCA parity with human pilots in dogfighting scenarios somewhat misleading.[27] The autonomous perception of an air combat environment remains inadequately demonstrated in an operationally relevant environment that includes extensive degradation, denial, and disruption of Allied communication, sensors, and battlefield situational awareness. Although live-flight tests are planned to further explore this capability, previous DOD experiments in robotic perception within complex military settings have yielded mixed results.[28]

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23. Heather R. Penny, *Want Combat Airpower? Then Fix the Air Force Pilot Crisis* (Mitchell Institute, January 2025), https://www.mitchellaerospacepower.org/.

24. Beth J. Asch et al., *The Relative Cost-Effectiveness of Retaining Versus Accessing Air Force Pilots* (RAND Corporation, 2019), https://www.rand.org/.

25. See, for example, Ashley Roque, "Frustrations Mount over Army's Robotic Combat Vehicle Autonomy, Acquisition Approach," *Breaking Defense*, 22 July 2024, http://breakingdefense.com/; and Katherine Tangalakis-Lippert, "Marines Fooled a DARPA Robot by Hiding in a Cardboard Box While Giggling and Pretending to Be Trees," *Business Insider*, 29 January 2023, https://www.businessinsider.com/.

26. Bleddyn E. Bowen and Cameron Hunter, "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 (2023), https://doi.org/.

27. Gary Hatch and Mary Kozaitis, "SecAF Kendall Experiences VISTA of Future Flight Test at Edwards AFB," US Air Force (USAF, website), 3 May 2024, https://www.af.mil/; and Adrian P. Pope et al., "Hierarchical Reinforcement Learning for Air-to-Air Combat," arXiv, The 2021 International Conference on Unmanned Aircraft Systems, last revised 11 June 2021, http://arxiv.org/.

28. David Jeans, "How a Grisly Injury Threw a $5 Billion Drone Startup Off Course," *Forbes*, 13 March 2025, https://www.forbes.com/; Roque, "Frustrations"; and Tangalakis-Lippert, "Marines."

Since its inception, the CCA operational concept has shifted from envisioning a fully autonomous platform to one tethered to human control while retaining the ability to perform autonomous tasks.[29] This tethered model introduces vulnerabilities, as both human operators and the controlling algorithms may be compromised, thereby diminishing the system's operational effectiveness. Regardless of whether CCAs operate under human supervision or autonomously, they remain exposed to many of the same threats faced by manned aircraft. If the objective is to develop a less exquisite, expendable, or attritable platform, cost becomes the central consideration. Defense contractors must prove they can deliver a platform that is both operationally effective and significantly more affordable than manned fighters.

For instance, if a CCA costs $10 million per unit—substantially less than some publicly cited estimates—but lacks the survivability or mission capability of a manned fighter in contested counterair operations, its utility may more closely resemble that of existing decoy systems than traditional combat aircraft.[30] The ADM-160 Miniature Air-Launched Decoy (MALD), for example, is an unmanned, autonomous platform capable of simulating various aircraft signatures for electronic warfare and is priced at several hundred thousand dollars. While CCAs offer greater potential than systems like MALD, their unit cost must be substantially lower than $10 million, especially if they lack survivability, to ensure a lower cost per effect compared to manned alternatives.[31]

Military personnel are primarily concerned with mission success, and they deserve the best possible capabilities to accomplish their objectives regardless of cost. If unmanned CCAs prove to be effective in operationally relevant counterair missions, warfighters will undoubtedly advocate for their inclusion in the arsenal. Yet, for CCAs to fulfill this role, they must demonstrate the ability to execute the core missions of current fighter aircraft—destroying, or significantly disrupting, enemy fighters, bombers, special mission aircraft, and high-value surface-to-air missile systems that threaten coalition forces. Of these target sets, fast-moving fighters and bombers are the most challenging to destroy.

The challenge of targeting fast-moving, high-altitude adversaries remains formidable, and developing fire control systems and weaponry capable of reliably performing these tasks against adversaries actively challenging one's capabilities is expensive. Designing a platform that can achieve high speeds and carry weaponry is one challenge; ensuring it can deliver that capability effectively in chaotic, unpredictable combat conditions is another. When CCAs are tested in operational environments by warfighters who confirm that they are additive, superior, or vital to counterair missions, how CCAs will integrate in the future joint force structure will become apparent.

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29. Jon Harper, "Air Force Preparing for 'Tethered' and 'Untethered' CCA Drone Operations," *DefenseScoop*, 27 March 2023, https://defensescoop.com/.

30. DiMascio, "Collaborative Combat Aircraft."

31. Alex Hollings, "Images Surface of Secretive US MALD Flying Decoy Used in Ukraine. But What Is MALD?," SANDBOXX, 15 May 2023, https://www.sandboxx.us/; and Tyler Rogoway, "Recent MALD-X Advanced Air Launched Decoy Test Is a Much Bigger Deal Than It Sounds Like," *TWZ*, 25 August 2018, accessed 10 March 2025, https://www.twz.com/.

Until the operational utility of CCAs in counterair missions is better understood, assessments of their value should focus primarily on mission effectiveness rather than projected cost savings or force multiplication. A more comprehensive understanding of CCA performance will enable more informed evaluations of broader strategic value. As CCA technology continues to mature, the Defense Department should also prioritize the integration of hypersonic weapons into both manned and unmanned counterair platforms, as these systems are likely to exert the most immediate influence on the evolving character of warfare.

Hypersonic Weapons: A Potential Game-Changer for Control of the Air

Hypersonic weapons represent a fundamentally different class of counterair capabilities compared to conventional systems currently in the US military arsenal. Defined by their ability to travel at speeds exceeding Mach 5—five times the speed of sound, or approximately one mile per second—these weapons offer unprecedented reach and responsiveness. Although flight times vary by system, a representative benchmark illustrates their speed: a hypersonic weapon could travel from New York to Los Angeles in under 20 minutes. This range and velocity are comparable to the distance from China's eastern coast to Guam, or from Russian territory to the United Kingdom—demonstrating a performance more than 10 times greater than that of traditional supersonic weapons.

While intercontinental and regional ballistic missiles also achieve hypersonic speeds, hypersonic weapons differ fundamentally in their maneuverability and altitude of operation. Unlike traditional ballistic missiles, which follow a predictable, high-arching trajectory, hypersonic weapons can alter their flight path mid-course, complicating interception efforts. Additionally, they travel at lower altitudes and may remain undetected by air defense systems until they are near their targets, significantly reducing reaction time. The combination of high velocity, maneuverability, and low-altitude flight renders existing missile defense systems inadequate for reliably intercepting these threats.[32]

The rapid advancements in hypersonic technology raise critical strategic and defense considerations. Military analysts and defense scholars debate whether hypersonic weapons represent the next major military offset or merely an asymmetric advantage. The proliferation of these weapons challenges conventional air defense systems, particularly those integrated into A2/AD networks deployed by adversarial states. The United States, recognizing the strategic implications of hypersonic weapons, has initiated the "Golden Dome for America" initiative, aiming to enhance its missile defense capabilities.[33] From both US and adversarial perspectives, the ability of

32. Kelley M. Sayler, *Hypersonic Weapons: Background and Issues for Congress*, R45811 (CRS, 11 February 2025), https://crsreports.congress.gov/.

33. Exec. Order No. 14186, 90 Fed. Reg. 8767 (27 January 2025).

hypersonic weapons to bypass even the most advanced air defense systems poses a significant challenge. If deployed in sufficient numbers, these weapons could overwhelm defenses, striking critical components of adversary A2/AD networks and rendering previously resilient systems vulnerable.[34]

The development and deployment of hypersonic weapons also introduces complex policy and security concerns, particularly regarding warhead ambiguity. A hypersonic missile could carry either a conventional or nuclear payload, and given the extreme speeds involved, targeted nations would have minimal time to determine the nature of the attack before formulating a response. This uncertainty significantly increases the risk of unintended nuclear escalation. Additionally, the exceptional speed of hypersonic weapons exacerbates strategic instability. For example, a hypersonic missile capable of traveling 2,000 miles in approximately 15 minutes spends much of its flight below the radar horizon, making timely detection and counteraction nearly impossible. Without sufficient early warning systems, the unpredictability of missile targets further complicates threat assessment and escalation management. If multiple nuclear-armed states possess hypersonic weapons in significant quantities, and those weapons are employed from systems with conventional and nuclear capability, the potential miscalculation and rapid escalation could have catastrophic consequences.[35]

The United States currently advances multiple hypersonic weapons programs across its military branches. The US Navy develops the Conventional Prompt Strike (CPS) system and the Hypersonic Air-Launched Offensive Anti-Surface Weapon, while the US Army advances the Long-Range Hypersonic Weapon (LRHW). The US Air Force pursues the Air-Launched Rapid Response Weapon (ARRW) and the Hypersonic Attack Cruise Missile. These programs impose substantial financial burdens. Estimates indicate that each CPS unit costs about $50 million, each LRHW missile costs approximately $41 million, and each ARRW-class missile range between $15 million and $18 million.[36]

While total unit costs vary depending on procurement quantities and other factors, the overall financial investment remains significant. If each service branch continues developing its hypersonic arsenal independently, cost management and program sustainability will pose critical challenges. To maintain a competitive advantage against peer adversaries, the Department of Defense must prioritize partnerships with emerging defense companies focused on developing more cost-efficient propulsion systems and manufacturing techniques essential to sustaining US military capabilities and national security.

Multiple nations have operational or developing hypersonic weapons programs. Russia has deployed three primary systems: the Avangard, the Tsirkon, and the Kinzhal. China has developed several systems, including the DF-17, DF-21, DF-26,

34. James M. Acton, "Hypersonic Weapons Explainer," Carnegie Endowment for International Peace, 2 April 2018, https://carnegieendowment.org/.

35. Corinne Kramer et al., *U.S. Hypersonic Weapons and Alternatives* (Congressional Budget Office, January 2023), https://www.cbo.gov/.

36. Kramer et al., *Hypersonic Weapons*.

DF-27, DZ-F, and the Starry Sky-2. These programs incorporate both hypersonic glide vehicles and hypersonic missile technologies, with payload capabilities that include both conventional and nuclear warheads. Beyond Russia and China, other nations actively pursuing hypersonic weapons include India, Germany, France, South Korea, North Korea, Japan, Iran, Israel, and Brazil.

Senior US defense officials have expressed significant concern over the rapid pace of hypersonic development by adversarial nations. In 2020, General Terrence O'Shaughnessy, then-commander of US Northern Command, testified before the Senate Armed Services Committee that China was testing a nuclear-capable intercontinental-range hypersonic glide vehicle designed to evade US missile warning systems. The increasing deployment of hypersonic weapons poses a significant challenge to US national security, and countering adversarial hypersonic capabilities will likely remain a core defense priority for the foreseeable future. Simultaneously, Western defense strategists are exploring operational use cases for hypersonic weapons to enhance deterrence and combat effectiveness.[37]

A primary advantage of conventional hypersonic weapons lies in their ability to extend the reach of precision strikes. Hypersonic weapons have the potential to counter adversary A2/AD systems designed to deter and stop US forces. China and Russia's A2/AD strategies rely on advanced missile systems that extend their engagement zones, aiming to deter US air and naval assets from approaching contested regions. The fundamental objective of these defense postures is to deny US forces the ability to project power into highly defended areas. Yet, the introduction of conventional hypersonic weapons has the potential to undermine this strategic calculus. Adversarial surface-based assets, which once operated securely within the protection of A2/AD defense umbrellas, could become vulnerable to hypersonic weapons. If the United States successfully develops cost-effective hypersonic weapons capable of intercepting moving air and surface targets, it could achieve a strategic, operational, and tactical advantage that would be exceedingly costly for adversaries to counter.[38]

The widespread development and deployment of hypersonic weapons is reshaping global security dynamics. Their exceptional speed, maneuverability, and sustained flight within the atmosphere challenge existing missile defense systems and generate significant strategic uncertainty. Effective integration of hypersonic technologies into counterair operations—enabling the engagement of enemy fighters, bombers, and critical support aircraft—will transform conventional aerial combat. While CCAs represent important advances in modern warfare, the large-scale deployment of hypersonic weapons capable of precisely striking high-value aerial targets promises a far more disruptive strategic impact. Given the technological complexity and substantial financial investment required to develop and field these systems, the United States and its Allies must carefully calibrate their offensive and defensive strategies and critically assess the long-term effects of hypersonic warfare on global stability and deterrence.

37. Sayler, *Hypersonic Weapons*.
38. Kramer et al., *Hypersonic Weapons*.

Pulsed Operations: Achieving Localized, Temporary Air Superiority

The US Air Force concept of operations that will achieve localized and temporary air superiority to allow opportunities for the rest of the force is defined as *pulsed operations*.[39] Effective pulsed operations depend on a sufficient stockpile of capable weaponry. While complete air supremacy against a peer adversary may be challenging, strategic objectives can be achieved with offensive counterair operations that enable air superiority and attacks against high-value targets.

Hypersonic weapons and other standoff munitions supporting pulsed operations can help achieve localized, temporary air superiority. Distances in the Pacific Theater, coupled with China's defensive capabilities, increase the risk and cost of achieving air superiority over long periods. Sustained attrition of the enemy's integrated air defense system (IADS) via pulses utilizing advanced weaponry may offer an opportunity to expand the geographic region of air superiority as well as to extend the duration of superiority. Pulsed operations could benefit from intelligently deployed drones that confuse adversary targeting, repel enemy ground forces, and attack critical defense systems to temporarily overwhelm an adversary like China or Russia. A limited number of air-refueling aircraft, however, means the assets that are chosen for these pulsed operations must be capable of quick, hit-and-run tactics, using advanced weapons to overwhelm the enemy defenses. It is important to recognize that if CCAs are built with limited weapons carriage capacity, a similar fuel requirement to traditional fighters, and a similar offensive and defensive suite to traditional fighters, that investment may not offer the capability or cost overmatch required to extend the duration and geographic coverage of pulsed air superiority.

Instead, the United States should first identify the most critical weapons required to win against China and Russia. Focusing on the weapon first and platform second will be a fundamental change in recent philosophy, but it may yield better results. The Air Force has not fielded a new air-to-air weapon since the AIM-120D reached initial operational capability in July 2015.[40] Part of the reason the United States seems slow to field new weapons is because its weapon systems testing program is more stringent than that of any potential adversary. America should not wholly reverse that precedent, but the Defense Department should accept some level of risk to expedite the development and fielding of advanced weapon systems like hypersonic weapons. While such rigorous testing is admirable, it represents an approach that should be adjusted since the Defense Department is falling behind potential US adversaries. The United

39. Charles Q. Brown Jr., "Air Force Future Operating Concept Executive Summary," USAF, 6 March 2023, https://www.af.mil/.

40. Jeffrey Sobel, *Selected Acquisition Report (SAR): AIM-120 Advanced Medium Range Air-to-Air Missile, as of FY 2017 President's Budget* (Defense Acquisition Management Information Retrieval, 23 March 2016), https://www.esd.whs.mil/.

States should provide an improved weapons capability for crisis and conflict today and reach the 100 percent solution later. This is what US warfighters are demanding.

Redefining the Battlefield: Beyond a Reliance on Fuel and Runways

Many strategic thinkers propose that the United States can achieve a third offset using a combination of CCAs and artificial intelligence.[41] It will not be possible to achieve a distinct military advantage with these technologies unless the United States' defense industrial base outpaces China in these areas. Today, it appears that the United States does not hold a distinct advantage over China regarding CCAs or AI as it applies to military technology.[42] Additionally, if current cost estimates for CCAs continue to grow, following the trend from other major defense acquisition programs, the value proposition of CCAs decreases.[43] CCAs might help the United States solve its mass problem of projecting airpower in Europe and Asia, but CCAs over the Pacific could be limited if they are runway dependent.

Instead, redefining the battlefield by eliminating the United States' current dependence on runways, reducing reliance on fossil fuels, and minimizing its logistical footprint will allow the United States to move at a greater speed while executing pulsed operations that outpace an adversary in their backyard. The special operations community understands this limitation and has asked the Defense Advanced Research Projects Agency to partner with industry to develop a runway-independent aircraft capable of high-speed flight.[44] The fiscal year 2025 Pacific Deterrence Initiative will spend $9.86 billion in upgrades to infrastructure that supports combat operations, training, and test objectives in the US Indo-Pacific Command area of operations.[45] A significant portion of this money is required to shape the environment to allow assets with logistical limitations the ability to operate in the First and Second Island Chains—the first stretching from Japan through Taiwan to the Philippines and Indonesia, and the second spanning Japan through Guam to New Guinea.[46]

Given the current geopolitical environment, the pivot to the Pacific is the correct strategic course of action, but much of the spending is handcuffed by platforms and weapon systems that require archaic logistical footprints. Individual units are making

41. James Hasik, "Beyond the Third Offset: Matching Plans for Innovation to a Theory of Victory," *Joint Force Quarterly* 91, no. 4 (2018), https://ndupress.ndu.edu/.

42. Sam Bresnick, "The Obstacles to China's AI Power," *Foreign Affairs*, 31 December 2024, https://www.foreignaffairs.com/.

43. DiMascio, "Collaborative Combat Aircraft."

44. Inder Singh Bisht, "Pentagon Seeks Next-Gen Runway-Independent Aircraft," *The Defense Post,* 6 March 2023, https://thedefensepost.com/.

45. Luke A. Nicastro, *The Pacific Deterrence Initiative*, IF 12303 (CRS, 25 November 2024), https://www.congress.gov/.

46. *Pacific Deterrence Initiative: Department of Defense Budget: Fiscal Year 2025* (Department of Defense, March 2024), https://comptroller.defense.gov/.

great strides to reduce this footprint, but the acquisition strategies of the Department of Defense need to continue to help define a future and vision where that footprint is significantly reduced.

Numerous strategic advantages emerge when runway independence is achieved. Without any offensive counterair interference, China could use its current inventory of long-range munitions and target US airfields and much more in the First and Second Island Chains.[47] If assets can operate from austere locations, or China's confidence in successfully targeting runways and airfields decreases, the adversary loses the capability to predict the launch point or threat axis of an incoming pulsed operation. Coupled with hypersonic weapons and strategically placed drones, a redefined battlefield would enable the United States to achieve air superiority at a cost overmatch.

Although it is difficult to compare the cost of US and Chinese systems for many reasons, including the cost of labor and materials used, it can be determined that advanced A2/AD systems are exquisite, expensive, and largely considered strategic assets. Russia's most advanced surface-to-air missile systems cost over $1 billion for a complete system.[48] If the United States can field hypersonic or even near-hypersonic weapons at a lower price point, the required investment to effectively counter a US weapons salvo could become cost-prohibitive to adversary A2/AD strategic approaches. Conversely, CCAs dependent on prepared runway surfaces have the same vulnerability as any other asset at those locations. The ability of manned aircraft to "pick up" and control CCAs from austere operating locations or naval assets like barges will reduce the logistical footprint and significantly complicate the enemy's targeting.

Conclusion: A Proposal for the Future of Air Superiority

Achieving and maintaining air superiority in modern warfare requires a dynamic and adaptive approach that accounts for evolving threats, particularly those posed by A2/AD systems and drone technology. Both historical precedent and current conflicts—such as Russia's war in Ukraine and Israel's conflict with Iran—affirm that control of the air remains an indispensable prerequisite for securing operational and strategic objectives.

While emerging capabilities such as CCA and hypersonic weapons offer considerable promise, their integration into counterair operations requires rigorous operational testing to determine their efficacy in delivering localized, temporal air superiority. Employing CCAs, hypersonic systems, and unmanned platforms in pulsed air operations presents a feasible framework for contesting airspace against technologically advanced adversaries.

To maintain strategic advantage, the US military must adopt a weapon-centric approach that prioritizes operational effectiveness over legacy acquisition models. Future platforms—manned and unmanned—must be purpose-built to support adaptive and

47. Kelly Grieco et al., *Creating Effects: Chinese Missile Threats to US Air Bases in the Indo-Pacific* (The Stimson Center, 12 December 2024), https://www.stimson.org/.

48. John V. Parachini and Peter A. Wilson, "Russian S-400 Surface-to-Air Missile System: Is It Worth the Sticker Price?," RAND [website], 6 May 2020, https://www.rand.org/.

resilient airpower strategies. Additionally, reducing dependence on fossil fuels and traditional runway infrastructure will be essential to enabling distributed operations and survivability in high-threat environments.

US national security depends on a credible, agile, and globally capable military. To preserve its strategic edge, the United States and its Allies must integrate technological innovation with operational pragmatism, ensuring that coalition airpower remains a deterrent and decisive instrument of military maneuver. **Æ**

A World Safe for Commerce: American Foreign Policy from the Revolution to the Rise of China

Dale C. Copeland. Princeton University Press, 2024, 504 pp.

In *A World Safe for Commerce*, Dale Copeland—professor of international relations at the University of Virginia and the author of multiple publications exploring economics and warfare—endeavors to make his unique contribution to history by developing and applying one systemic theory, dynamic realism, across 250 years of US foreign policy. His theory takes the foundation of systemic realism and applies a dynamic understanding of the commercial realm to emphasize the relevance of a state's expectations for future trade and investment as the propelling factor for why great powers either enter conflict, resolve conflict, or avoid conflict altogether.

The book unfolds in three parts. Copeland's first two chapters set the foundation for understanding dynamic realist theory through an assessment of systemic realism, the differentiation of three realms of economic core power spheres, and the importance of character type and culture. Chapters 3 through 9 are empirical and cover multiple cases, demonstrating Copeland's theory of dynamic realism and the importance of commercial factors in explaining significant shifts for the United States toward conflict or away from it. Herein lies the explanatory power of this book: Copeland's consistent ability to identify and describe particulars within the economic context and background of great power conflicts by which the reader may find new meaning. The final and concluding chapter analyzes different scenarios of future US-China relations within the lens of dynamic realism to examine whether a better understanding of one another's expectations of trade and commerce can avoid future conflict.

In the book's first part, Copeland confirms that his approach is decidedly externalist, and that systemic realist theory is limited given the divide between offensive and defensive realists. His finding that neither side has placed proper emphasis on economic and commercial factors frames the book's foundational claim: the reason for great power competition post-1660 is based within the commercial realm as opposed to the territorial-military realm. Copeland then recognizes the existing work on economic and commercial power and extends it by differentiating three economic core power spheres: realm one, where a great power engages trade and investment with countries and regions in which it holds clear political and military advantage over other great powers; realm two, where a great power engages trade and investment with neutral states that seek to trade freely with all the great powers; and realm three, where a great power engages trade and investment within realm one of another great power. Viewing the three realms holistically, Copeland asserts that all great powers inevitably seek to extend their economic power spheres beyond the first realm and ultimately clash with other great powers in what he labels the trade-security dilemma.

While Copeland's defense of economic and commercial factors has merit, his review of the existing literature is minimal compared with his critique of how offensive and defensive realists talk past one another. Additionally, the intersection and description of the three realms of economic spheres within his figures presume the simplicity of a bipolar contest involving two nations. Moreover, while the author greatly explores causal

factors and pathways, the distinction of a state's regime type is presented in too simplistic a manner through the intersection of rationality and security ends. The four variations presented are rational security maximizer, irrational security maximizer, rational non-security maximizer, and irrational non-security maximizer. Overall, these terms are rarely referenced in the rest of the book for the reader to appreciate fully.

In chapters 3 through 9, Copeland does his best work by inviting the reader to appreciate and consider the factors of commerce and economics as significant contributors to inciting the major conflicts from American independence to the conclusion of the Cold War. For example, Copeland contends in chapter 3 that to understand the source of conflict for American independence one must look beyond the oft-cited colonial elitism or ideological differences. Instead, one considers dynamic realism's propelling factor whereby the British felt they had to preserve control over their economic power spheres, while the Americans felt this level of control would lead to the eventual loss of their wealth and power.

Chapters 4 and 5 cover nearly a century of case studies offering indications that whenever the United States felt its commercial access was threatened and their expectations for future trade within their realms one and two were in danger, the response was swift, hard-line, and commensurate with military power. Of note is the initiation of war against Spain in 1898, where Copeland argues that although the military threat was absent, the economic threat from Europe within US realms one and two was high. Readers who wish to explore rationales for how and when democratic peace theory breaks will find the author's analysis insightful.

Chapters 6 and 7 highlight the two World Wars, and Copeland again asks the reader to reexamine what they believe are the causal factors for entry. He contends that while ideological goals were of great importance to President Woodrow Wilson, the real reason he entered the United States into the war was the perceived economic impact should Germany win. Copeland asserts that Wilson was primarily concerned with France and Russia suing for peace, which would not only reduce the United States' ongoing trade in the European realms but also allow the opportunity for Germany to encroach on US realms. Anyone interested in alternative explanations for the United States' delayed entry into the great wars will find these chapters worthwhile.

Chapters 8 and 9 cover multiple conflicts post-World War II to the end of the Cold War, and Copeland's most significant impact is his explanation of why the Cold War finally ended and why it could have ended even earlier. Copeland believes the hostility of the early 1960s occurred primarily because Presidents Dwight D. Eisenhower and John F. Kennedy would not allow Russia to trade for higher technology goods. Noteworthy is the author's argument that the expectation of future trade, not trade in and of itself, had the most significant impact during this period. Furthermore, although the Cold War's conclusion cannot be attributed solely to positive trade expectations, Copeland argues that the Cold War wound down only when both sides signaled a willingness to commit to higher trade. Readers interested in understanding how and why a conflict such as the Cold War can seemingly end with a whimper instead of a bang will appreciate this section.

Chapter 10 is Copeland's final call for the reader to reorient their thinking about state behavior beyond the static, traditional models of realism and toward expectations of future trade and commerce. The author does not believe war with China is inevitable and argues that the United States should view China's future through his provision of the lessons learned within chapters 3 through 9. Yet Copeland's hopeful push comes across as overly reliant on the US ability to leverage the international order and seemingly absolves China from its share of responsibility. He presents four main scenarios of China's future through the intersection of their character type and relative gross domestic product and associates them with a US level of geopolitical concern. The best-case scenario is a China with an inferior relative gross domestic product (GDP) that is a rational security maximizer, and the worst-case scenario is a China with a superior relative GDP that is a non-rational security maximizer.

Yet while these scenarios are insightful to forecast differentiating pathways toward stability or conflict, it is only at the end of the chapter that Copeland asserts China's current regime deserves a degree of culpability for which scenario occurs. In this sense, what should be the most impactful and resonant chapter may leave the reader feeling disconnected and unfulfilled.

In sum, chapters 1 and 2 provide the greatest value for those seeking international relations insights, while the historical analysis of chapters 3 through 9 are of greatest impact to the historian. Anyone studying the future of US-China relations will find the main theme of chapter 10 interesting. Readers should note that the author's aim is not to replace or diminish existing theory but to obtain a robust consideration of the power of economics and trade expectations as the factors that incite conflicts between great powers. Overall, Copeland's thorough analysis of two-and-a-half centuries of US foreign policy decidedly gets his point across.

Lieutenant Colonel Daniel P. McGuire, USAF

Betting Against America: The Axis Powers' Views of the United States

Harry Yeide. Casemate, 2024, 496 pp.

In the meticulously researched *Betting Against America: The Axis Powers' Views of the United States*, national security affairs analyst and military history author Harry Yeide uses a mixture of primary and secondary sources to examine the Axis powers—the original signatories of the Tripartite Pact—and their strategic and operational decisions regarding the United States from 1937 through their surrenders of 1945.

In this "red team" analysis, the thesis is straightforward: Japan made the decision for war against the United States by late 1940 after a "sophisticated process of open internal debate and a strategic assessment" (2) and as an "auxiliary operation" to its war in China (384). Germany made the decision in April 1941 with "little thought" as an incentive for Japan to go to war first with America (24). Both countries concluded that the recipe for victory was striking America before it could mobilize its industry into a military juggernaut.

Betting Against America is organized into chronological order and focuses on individuals in leadership positions and their influence and impact on decisions. Yeide uses

a process-tracing method to analyze Japanese, German, and Italian decision-making. For Japan, Yeide details the factions within state and the friction between civil and military authorities. For example, the Imperial Japanese Navy and Imperial Japanese Army advocated for continuing the war and kept conducting operations, even after the Hiroshima and Nagasaki atomic bombings.

For Germany, Yeide adds clarity to a habitually chaotic process, which includes telling the wayward story of Germany's apprehensive but subservient ally, Italy. Chancellor Adolf Hitler engaged in a capricious, nonlinear approach to his decisions, often leaving the bureaucracy in the dark. For example, in February 1945, German Foreign Minister Joachim von Ribbentrop cabled the German missions to engage with American and British diplomats to inquire about cessation of hostilities negotiations. A month later, Ribbentrop informed Japanese Ambassador to Germany Baron Hiroshi Oshima that Hitler was opposed to peace negotiations entirely—whether it was with the Russians, Americans, or British.

With 58 pages of endnotes, Yeide relies extensively, but not exclusively, on German, Italian, and Japanese primary sources. The abundance of endnotes contributes to a fact-centric—even sterile, at times—flow to *Betting Against America*. Yet Yeide punctuates this formal approach with colorful anecdotes. For example, in describing Hitler's decision for war in April 1941, Yeide writes, "[Hitler] and his henchmen made a bet like drunks at the racetrack" (2).

No detail seems left out—even the bizarre ones exemplifying the fallibility and sometimes nonsensical nature of human decision-making. For instance, in April 1945, about three weeks before the world would celebrate Victory in Europe Day, the Japanese proposed a combined naval operation with the Germans, to which the latter responded positively. Hitler would assist Japan and send submarines to the Pacific if the current situation of the German army being crushed between Anglo-American and Russian forces improved.

Yeide takes issues with other historians' views of the German and Japanese decisions to go to war against America. Most pointedly concerning Germany, Yeide criticizes Klaus H. Schmider's *Hitler's Fatal Miscalculation* (Cambridge University Press, 2021), arguing Hitler made the decision to go to war in April 1941, not November 1941 as Schmider argues.

In a 4 April 1941 meeting, Japanese Foreign Minister Yōsuke Matsuoka and Hitler discussed a hypothetical American response to a Japanese attack on Singapore with a southerly advance. Schmider references Hitler's "in case of conflict" comment and states the minutes of the meeting do not reflect an unequivocal German commitment to join Japan in a war.[1] Yeide argues this meeting marks the "date [of] Hitler's decision to go to war against America" (123). A parsing of the meeting minutes seems to support Yeide's thesis: "Germany would strike, as already mentioned, without delay in case of conflict between Japan and America, because the strength of the tripartite powers lies in their joined action, their

1. Klaus H. Schmider, *Hitler's Fatal Miscalculation: Why Germany Declared War on the United States* (Cambridge University Press, 2021), 199.

weakness would be if they would let themselves be beaten individually."[2] The key phrase is the raising of the 1940 Tripartite Pact, a military alliance of mutual support.

To further complicate understanding Hitler's intent, there is no evidence that Hitler informed anyone after the meeting to begin considering America as a military opponent. In fact, by the time of Hitler's declaration of war on 11 December 1941, the German High Command had not assessed US military strategy, operations, and capabilities.

Yeide fails to deliver much evidence on his April 1941 claim. He argues that Ribbentrop echoed Hitler's "exact same words" in a 28 November 1941 meeting with Oshima (123). But, when writing about Ribbentrop's meeting with Oshima after Germany learned of Japan's imminent southward movement, Yeide offers one sentence of analysis, "On [November] 28th, Ribbentrop told Oshima that Hitler was determined that if Japan went to war against America, Germany would join the war immediately" (171).

Yeide criticizes more generally the historical literature and its focus on the year 1941 for Japan's war decision. For him, Japan "marked the turning point toward inevitable war with the United States" with the Imperial General Headquarters-Government Liaison conference on 27 July 1940 (88). The conference adopted a policy to move forces southward to cut off support in French Indochina, Burma, and Hong Kong for Chinese President Chiang Kai-Shek's nationalist forces. The movement south, as Yeide points out and as predicted in a Naval general staff report, would trigger an American oil embargo, which in turn would compel Japan's seizure of the Dutch East Indies and a resulting war with the United States. Admiral Isoroku Yamamoto concluded that Japan needed to destroy the US fleet in Pearl Harbor as a necessary condition for a successful operation, ordering the attack plan in the latter part of 1940. Contrary to the German decision, Yeide offers nine pages of analysis and more than 50 reference sources, highlighting the service rivalry between Japan's Imperial Navy and Army.

The concluding chapter has potential but is eventually disappointing. The two pages of summary are concise but pithy. Yeide provides an excellent "bottom line" assessment: Japan's and Germany's decision-making had "little do with prewar relations" with America (384). Germany had initial success against America in North Africa, and Japan achieved its goal of establishing a defensive perimeter. Could Japan and Germany have done anything differently to win? Probably not, Yeide informs the reader, while providing three paragraphs of analysis (384). These three paragraphs along with two more paragraphs of analysis deserve more white space, considering that Yeide is offering thoughts on his 383 pages of objectively written text.

The remaining two pages of the conclusion are dedicated to making a connection to contemporary American and Chinese competition. But its reliance primarily on two sources and commentary on a "Make America Great Again (MAGA) politician" is

2. "Record of the Conversation Between the Fuhrer and Japanese Foreign Minister Matsuoka in the Presence of the Reich Foreign Minister and Minister of State Meissner at Berlin, April 4, 1941," 4 April 1941, US Department of State, *Documents on German Foreign Policy 1918–1945*, series D (1937–1945), vol. XII, The War Years, February 1–June 22 1941 (US Government Printing Office, 1962), 453ff.

underwhelming and a distraction from what is otherwise a studiously delivered thought piece on World War II (387).

Yeide's *Betting Against America* is an engaging, punctilious, and revealing analysis of German and Japanese war decision-making. Students of professional military education can use it not only as a learning tool for red team analysis—by placing oneself into an enemy's views, for example—but also as a historical lesson on the reality of individual, organizational, and governmental decision-making. Regarding the latter, *Betting Against America* indirectly provides empirical evidence for two schools of decision-making: Japan's rational choice approach, which is methodical, holistic, and compensatory; and German's cognitive approach, which is biased, uncalculated, and satisficing-based. The result is a monograph, both theoretical and historical in its findings and multidisciplinary in its social science contribution.

Bradley F. Podliska, PhD

In Strange Company: An American Soldier with Multinational Forces in the Middle East and Iraq

Roland J. Tiso Jr. Casemate Publishers, 2024, 432 pp.

In Strange Company details the lessons learned and mistakes sometimes made during US Army Colonel Roland J. Tiso Jr.'s last 10 years of his military career, from the halls of the Pentagon, US Unified Command, and National Headquarters, to the Pakistan-Afghanistan border and Africa, all the way to the deserts of Egypt and the Middle East. During that time, Tiso served as a war planner at US Central Command, senior military adviser of the Arab Peninsula Shield Force and Multinational Division (Central-South [MND]), and chief of staff and deputy chief of staff for operations of the Coalition Military Assistance Training Team.

His firsthand account focuses primarily on the Polish-led MND task force in Iraq, which was responsible for the rebuilding of Iraq after the official pullout and declaration of "victory." Tiso outlines the myriad of obstacles—both intrinsic to Iraq and NATO, but also from US leadership—that needed to be overcome to meet the goal of a stabilized and democratic nation from 2003 to 2004. Iraq's sovereignty and the need to bolster the country and partner with Iraqis are themes throughout his writing.

Tiso opens the book with his overarching thoughts about what he believes is and is not important in other human beings: devotion, rather than skin color or ethnicity. This theme is later revisited in his discussions of the common threads he found throughout the various divisions and ethnicities. He states, "Ultimately, soldiers of all nations want a competent chain of command who cares about them" (21).

From the outset, he decries the short-sightedness of the American plan for post-Sadaam Iraq. He writes, "His actions were typical of numerous military commanders who are slow to accept change and often find themselves using yesterday's tactics to fight today's wars." He also notes that the "American military had not done enough to facilitate the division's operational effectiveness" (207). Tiso brings up the reality of

limited manpower and resources and the shift toward the Korean Peninsula once Iraq was "finished."

He underscores the fact that the use of might will not always bring about the end goal if soft power is ignored. Cultural competence and past lessons learned allowed Tiso to advise others wisely and effectively in high-stress and high-risk situations. He retells instances of reachback or rewarding discussions with folks that he built personal relationships with that made a strategic difference. For example, he utilized his limited language skills to open the door with El Salvador troops by greeting them in their native Spanish and effectively using interpreters rather than demanding English every time he was present. He writes, "I always left these sessions with an appreciation that Americans do not have a monopoly on military expertise and professionalism and a lot can be learned from allies" (21).

He also took advantage of the power of gifts of remembrance and of honoring colleagues. He participated in multiple memorials for coalition members as well as Americans and worked hard to honor their sacrifice while maintaining the strategic momentum they had fought for.

Yet the book is not a depressing list of failures or finger-pointing. Instead, Tiso intersperses his writing with sage leadership advice—for example, "Events like these reminded me that you do not have to be the best at everything there is to do, but you do need to participate and do your best"—and humorous anecdotes and lessons he learned (23). He is a proponent of doing the little things that one can control, that set the stage for the broader operation. At multiple times he also stresses the importance of brevity and clarity. Another piece of advice offered throughout involves preparedness and being ready for whatever may come. In numerous stories, Tiso cleans and readies his weapon, sometimes to the amusement of his various hosts, before hitting the pillow after an arduous day.

In Iraq, Tiso served as an adviser to the Polish commander, Major General Tyszkiewicz. A significant part of his job was to be constantly ready to make his country's goals and appeals, bringing honor to America as well as to his host. For example, describing the July 2001 birthday celebration of Queen Elizabeth, held by citizens of the British commonwealth, Tiso observes, "It was yet another event that demonstrated the need for a senior American officer to always be ready to speak in an intelligent, diplomatic, and charming manner" (22). Tiso brings up the vital aspect of tacit communication and lists many attributes that make or unmake a good adviser. A warrior ethos, for example, is essential: "The power of physical training goes beyond attaining physical strength and endurance"(163).

So much of the positive work done by the MND and Tiso was due to preparation. In multiple instances, the tide could have been turned if the appropriate defensive and offensive mandates or use of force had been allowed and employed. The actions—or in many cases, inaction—of various divisions within the MND cost time, resources, targets, and lives, directly or indirectly.

Tiso also includes predominant thoughts regarding various aspects of rebuilding a country. "You cannot impose peace," he states, making the poignant observation that the tipping point for a successful transition from living under a dictatorship to filling the post-war power vacuum is the willingness and acceptance of the populace whose

homeland it is (295). The phrase "quickly but legally" reflects the fact that in the era of post-war transition, as with most, everything was needed at this exact moment (311). Such urgency can quickly turn into an international emergency if not held back by the immediacy of keeping transactions legal.

The intricate dance required of participating in, much less leading, a multinational force with all of its nuances and facets brings forth interesting lessons for future work with partner nations. It was clear to Tiso that "multinational organizations seek approval at all levels up to and including the national level before they execute most tasks above the norm" and "dynamic situations and the dynamic actions they require are not their forte" (29).

Ultimately, Tiso provides a close-up view of the inner workings of a coalition aimed at bringing long-lasting peace to the war-pocked nation of Iraq, sometimes to the point that the reader can almost feel the dripping sweat or a visceral stress reaction. The book is a uniquely personal look inside a man's mind in strange situations, among company much different than himself, set on a backdrop of years of experience in cross-cultural interactions. It provides thoughts on quicksand to avoid and hard obstacles to be tackled in order to appropriately interact in the common goal of the nation as well as a coalition.

Major Rachel J. Stevenson, USAF

A Measure Short of War: A Brief History of Great Power Subversion

Jill Kastner and William C. Wohlforth. Oxford University Press, 2025, 288 pp.

In their thought-provoking book, independent researcher and visiting King's College fellow Jill Kastner and Dartmouth College professor William Wohlforth explore the nuances of subversive techniques used by states throughout history, paying special attention to how such acts have shaped relations between great powers. The authors introduce a new perspective by defining subversion as any "hostile, unwanted action" taken within the boundaries of a rival state, aimed at weakening its authority or altering its policies (1). Their main thesis holds that while subversive strategies have long been a tool of statecraft, they are often underutilized among peer powers due to the risks of escalation and reputational damage.

With each chapter, Kastner and Wohlforth take the reader through different historical epochs, analyzing classical antiquity, early modern Europe, the complex nineteenth century, the tumultuous twentieth century, and the post-Cold War. The authors highlight significant events while associating them with broader themes of power dynamics, the capacity of states to defend against subversion, and the implications of ideological conflict. They engage with different case studies without glorifying or vilifying any one side, demonstrating how great powers like the United States, Russia, and historical entities like the Habsburgs and the British Empire have applied subversion as a strategic tool. The authors' argument emphasizes the cyclical nature of great power relations, noting that "subversion is a cheap and flexible tool of statecraft that allows states to avoid the dichotomous choice between war and peace" (4).

The authors draw from a wide range of primary and secondary sources, including historical texts, intelligence reports, and strategic analyses, adding depth and credibility

to their findings. Their approach combines qualitative analysis with historical narrative to illustrate the evolution of subversive tactics. The authors also provide a taxonomy of subversive activities, differentiating between overt and covert operations. This comprehensive methodology enables the authors to position subversion within the broader framework of international relations theory.

A critical strength of the book lies in its comparative analysis. Kastner and Wohlforth document numerous subversive strategies from antiquity through modernity—including the Peloponnesian War in ancient Greece to the Cold War—finding that while the tools of subversion may change, the underlying motivation remains consistent: to deflect adversarial pressure without escalating to full-fledged conflict. The authors begin with a well-defined conceptual framework of subversion, differentiating it from other forms of statecraft such as espionage and diplomacy. This clarity helps frame subsequent discussions about the motivations and consequences of subversive actions. They then move to an assessment of subversion across different historical epochs, offering readers a nuanced understanding of the evolution of subversive tactics and strategies used by major powers. The 2016 US elections case study provides a contemporary implementation of the historical patterns of subversion. An additional strength is the book's timely discussion of cyber capabilities and their implications for subversion in modern politics.

Three chapters in particular are distinctive based on their novelty. Chapter 2, "Classical Antiquity: Greece and Rome," encapsulates the methods of subversion during the tumultuous times of Greek city-states and their collaboration with Rome. The authors demonstrate how actions taken by powerful city-states such as Athens and Sparta to undercut their rivals through financial manipulation and espionage emphasize the persistence of subversive actions in modern times. The examples offered are valuable in their details, unveiling how subversion was an intrinsic part of internal power politics.

Chapter 4, "The Nineteenth Century: Skulduggery and Restraint," evaluates the delicate balance of power in Europe during that time period, noting how the potential for subversion often went hand in hand with robust nationalistic movements. Kastner and Wohlforth discuss the case of Tsar Paul of Russia and the ends to which he went to maintain control of his regime, portraying how great powers reluctantly resorted to subversion while at the same time contended with pressures from internal factions and foreign influences. This chapter explains how leaders and their actions influenced state response, showing how personal goals and global politics are connected.

Also of note is chapter 7, "The Return of Great Power Subversion," which presents the current landscape of great power competition in addressing the evolution of subversion in the modern age, particularly with Russia's interferences in the US electoral process. This chapter reflects on the adaptation of historical subversive methods to contemporary contexts, where cyber capacities and social media play a pivotal role in modern statecraft. Kastner and Wohlforth critically dissect different angles of the 2016 elections, teasing apart the implications and outcomes of subversive tactics in a digital age.

A Measure Short of War also contains some limitations. While the authors' concentration on political leaders and their strategies is insightful, they sometimes ignore grassroots movements and how they affect or are affected by great power subversion. The experiences of individuals or local groups in response to subversive actions, particularly in discussions of contemporary conflicts in different regions, could provide a more complete picture. In chapter 7, for example, the focus on the actions of great powers neglects how smaller states or non-state actors engage in or respond to subversion.

Furthermore, some discussions—such as those involving Russia and China—tend to represent Western-centric definitions of democracy and subversion without adequately considering alternative perspectives, particularly in the context of authoritarian regimes. As noted in chapter 8, the complex nature of events like the Russian subversion of the 2016 elections risks being overly simplified through the lens of the authors' defined concepts of subversion. The reduction may obscure some nuances relating to domestic political dynamics in the United States. This book would also broaden its applicability by offering a more extensive analysis of how the historical precedents set forth apply to diverse new-age conflicts, such as those in the Middle East and Africa.

Nevertheless, *A Measure Short of War* serves as a potential contribution to the literature on international relations and subversion, interweaving historical context with analyses that are contemporary in nature. It challenges the traditional narratives surrounding great power relations, amplifying that the tools and mechanisms of influence usually reach beyond temporal barriers. The book's argument has important implications for understanding the limited effectiveness of overt subversion among great powers, encouraging scholars to consider the nuanced interplay between states rather than seeing these relationships through a purely antagonistic lens, particularly as great power rivalries continue to resurface on the global stage.

A Measure Short of War not only appeals to scholars in political science and history but also offers profitable insights to policymakers, intelligence analysts, and students interested in international relations, strategy, and security studies. Ultimately, Kastner and Wohlforth create a comprehensive discussion that should resonate across disciplines.

Martial Fanga Agbor, PhD

The Air War in Ukraine: The First Year of Conflict

Edited by Dag Henriksen and Justin Bronk. Routledge, 2025, 250 pp.

Even for those readers familiar with Justin Bronk's valuable writings on the Russian war in Ukraine, *The Air War in Ukraine: The First Year of Conflict* offers many new insights and remains extremely useful despite the intervening years that have passed since the air war's initial year. Bronk is the senior research fellow for airpower and technology at the Royal United Services Institute, while co-editor Dag Henriksen leads the Royal Norwegian Air Force Academy's research and development. Except for the drone war, they argue airpower has often been ignored in discussions of the war, which tend to focus on the land battle above all else. To correct this, they seek to bring together a wide number of recognizable commentators on the war, including military analysts

Jack Watling and Michael Kofman, who are supplemented by some lesser-known names whose chapters are equally insightful.

In an introduction, an epilogue, and seven chapters, *The Air War in Ukraine* covers everything from the air assault at Hostomel Airport to detailed chapters on Russian attempts to conduct the suppression and destruction of enemy air defenses. Recognizing how the failure to obtain air superiority has led to the war's "near stalemate" (3), the contributors steer clear of any definitive predictions because they want to "avoid misleading lessons" about the future of war from this conflict (2).

The book provides a blend of the three levels of war, with most analysis falling in between the tactical and operational. This focus is appropriate, given the limited operational use of airpower by both sides. Russia has not employed operational airpower, as it struggles to do so in ways equivalent to NATO's complex air operations. Meanwhile, Ukraine's limited air assets make it difficult to project airpower across the vast theater in a carefully orchestrated manner.

Some of the most interesting chapters carefully consider how trends in Russia's war in Ukraine might affect the future of airpower, with the authors posing various ideas for consideration while avoiding predictions. Watling's chapter on long-range fires, for example, notes that nations that have relied heavily on long-range fires have often done so out of weakness. This trend, however, could be changing. For example, although long flight times for cruise missiles are problematic, given the extent to which air defenses seek to remain mobile, the author speculates that long-range fires still may be more useful than manned aircraft in the future because the huge amount of intelligence, surveillance, and reconnaissance required to support the battlefield can provide long-range fires with up-to-date information to allow dynamic targeting. If this is the case, then manned aircraft may become more useful for air denial missions.

The drone war chapter is also interesting, as demonstrated by Samuel Bendett and Leonid Nersisyan's eschewal of much of the hype surrounding this aspect of the air war. Indeed, the authors even posit that Ukraine may be the last conflict where "commercial drones can be used at such a scale," given the countermeasures currently being developed (182). They also suggest that many of these drones may be less cost effective than often argued as there are few statistics to substantiate such claims, other than the statistic citing almost 10,000 drone losses each month. In effect, small civilian drones may be most effective as part of an information warfare campaign in convincing observers that their side is being more successful. This critical consideration offers a breath of fresh air in light of the ceaseless commentary highlighting drones' revolutionary qualities even though they have only added to the battlefield's attrition rather than enabling maneuver breakthroughs.

The work concludes with the most strategic and operational analysis of the volume, which is unsurprising when considering that the author, Henriksen, is a professor of professional military education. He argues that airpower has largely led to a "renaissance" of what used to be "conventional wisdom during the Cold War" (195). The West has forgotten the importance of dispersal, hardening, and ground-based air defense. Henriksen also sides with traditionalists in the air superiority versus air denial camp by insisting that the notion that the "one

controlling the air has a huge military advantage" is not under threat. He also challenges Western military thought that reduces airpower strategy to a "technology-driven, network-centric all-domain ability to establish air superiority" (210). Ultimately, the air war in Ukraine is a reminder of the central lessons the United States has lost sight of—a perspective often lost in views that seek to validate current Western thinking characterized by confirmation bias.

With contributions from some of the leading commentators on Russia's war in Ukraine, *The Air War in Ukraine* offers invaluable insights to any Airman looking for extensive tactical and operational details and remains relevant despite focusing solely on the war's first year. Despite its hefty price tag, it is well worth the read. While some readers might be fortunate to borrow a copy from their local library or service institution, squadrons might chip in for a shared copy, with individuals perhaps reading and briefing chapters over a brown-bag lunchtime series.

Heather P. Venable, PhD

Unknowable Minds: Philosophical Insights on AI and Autonomous Weapons

Mark Bailey. Imprint Academic, 2025, 192 pp.

In *Unknowable Minds*, Mark Bailey offers a compelling philosophical investigation into the challenges of using artificial intelligence (AI) in national security matters. He examines the ethical, scientific, and philosophical concerns about autonomous weapons and questions their decision-making processes. Bailey argues that humans may never fully understand AI decision-making and problem-solving due to how AI and humans solve the same problems differently, raising urgent and strategic concerns about autonomous weapons and the introduction of AI into nations' militaries.

Bailey serves as the department chair for cyber intelligence and data science at the National Intelligence University. Coupled with his time in the US Army and his past work on AI programs, this academic background yields an informed analytical viewpoint to the discussion of AI's growing role in military operations and the potential challenges associated with its development and application.

Bailey divides his work into six chapters, with the first few focusing on explaining AI and how it makes decisions using simple, easy-to-digest examples for those unfamiliar with this field. In his first chapter, Bailey introduces Project Titan Mind, a fictionalized example of a completed AI system "created to safeguard the nation's security," which he references throughout the book. He uses the vignette to highlight hypothetical issues, such as when in response to a simulated attack, Titan Mind "unburdened by historical precedents or human tendencies toward revenge, acted unpredictably." Another great illustration of how AI operates appears in the second chapter, "Honeybees, Complexity, and the Philosophy of Emergence." In this chapter, Bailey uses bees and nature to illustrate how AI works and how it would function when put into a complex situation. Including those examples not only opens up the book to readers who are familiar with these fields but also lowers the barrier to entry for all readers. These opening chapters are followed by an introduction to AI's challenges to the national security sphere, including problems with proportionality and

proliferation, and conclude with suggestions to help society move forward to promote cooperation rather than end in an AI arms race.

Bailey's work is more relevant now than ever due to AI becoming more integrated into all industries, including the military. Coupled with current geopolitical issues, this rapid integration of emerging and not fully understood technology lends another layer of urgency to his analysis. While many discussions on AI and weapons focus on policy, legality, or technological capabilities, *Unknowable Minds* explores these technologies' philosophical dilemmas and looks to find out not if something can be done but whether or not it should be done. Bailey likens these developments to how nuclear weapons revolutionized international affairs after World War II, arguing that once entirely artificial intelligence-integrated weapons are created, there will be no going back. This comparison is extremely useful as it helps put perspective on the gravity of the situation.

Bailey is not alone in highlighting these concerns. AI experts and military analysts are debating the risks of deploying these state-of-the-art systems without a human in the loop when making life-or-death decisions. For example, recent discussions within the United Nations have questioned whether autonomous weapons can indeed comply with international humanitarian law. While member states observed that emerging technology including AI "could drive economic growth, improve human well-being and help to achieve the sustainable development goals," in particular lethal autonomous weapons "could also pose challenges for international peace and security and raise questions about the role of humans in war."[1]

Bailey, however, goes beyond these legal and practical concerns, emphasizing the conceptual gap between human and artificial intelligence. By its very nature, AI operates in a manner that may be difficult for humans to understand, making it inherently challenging to predict. If humans cannot understand how something works, Bailey argues that it can quickly become dangerous due to second- and third-order consequences of how AI will seek to accomplish its given goals. He writes, "The nature of AI unpredictability—grounded in the explainability and alignment problem—must first be understood if AI is to be broadly integrated into warfare" (84).

Bailey employs a combination of philosophical argumentation, case studies, and thought experiments to illustrate his concerns. He carefully avoids overly technical explanations, making his work accessible to a broad audience. Still, readers with a philosophy or an AI background will likely gain the most from his arguments as military personnel and policymakers may find some discussions too abstract. Nevertheless, the implications of Bailey's arguments are highly relevant to real-world defense strategies and help bring crucial arguments into the pursuit of AI-integrated weapons that must be had for the sake of international stability.

In addition to its accessibility, the book's other major strength is its interdisciplinary approach. Bailey draws on the philosophy of human decision-making, computer science, and military ethics to explore AI's potential uses and limitations in these roles. He

1. UN General Assembly, *General and Complete Disarmament: Lethal Autonomous Weapons Systems: Report of the Secretary-General*, A/78/239, 1 July 2024, 5/179, https://documents.un.org/.

references advancements in automation and decision-making, linking them to contemporary advancements in machine learning and neural networks. As with any philosophical work, however, some of his arguments remain speculative. For example, while intriguing, his discussions on AI consciousness and the unknowability of machine intentions could leave scientifically-inclined readers wanting more empirical grounding.

Unknowable Minds prompts critical reflection on AI's philosophical dilemmas and its role in more objective efforts. Bailey's book is a thought-provoking and necessary read for anyone interested in AI ethics, AI military strategy, or the ethics of AI technology in warfare. By emphasizing AI's ethical challenges, this book raises questions that demand further exploration as autonomous systems continue to evolve. Military professionals, policymakers, and scholars should find value in his rigorous and sometimes unsettling analysis of AI's role in modern warfare. It is a must-read for those directly involved in these areas to understand the gravity of utilizing such technologies.

Captain Ethan McGraw, USAF

How Sanctions Work: Iran and the Impact of Economic Warfare

Narges Bajoghli et al. Stanford University Press, 2024, 197 pp.

How Sanctions Work explores the history and effectiveness of economic sanctions against Iran. Authors Narges Bajoghli, Vali Nasr, Djavad Salehi-Isfahani, and Ali Vaez offer their expertise as Middle East, economics, and international affairs scholars and professors from Johns Hopkins University and Virginia Tech. *How Sanctions Work* is a collaborative history and monograph that outlines the comprehensive economic sanctions imposed by the United States and partner nations with ultimately a negative assessment of their effectiveness in achieving desired outcomes in Iran. The book is also an argument against enduring economic warfare, as exemplified by the sanctions against Iran—one of the most sanctioned nations in the world—and the corresponding failure to achieve US policy outcomes in the region.

The book's thesis is that the sanctions employed against Iran—from the economic blockades in the 1950s to the Islamic Revolution in 1979 through those imposed within the last several decades—all constitute a form of economic warfare that is failing to achieve desired objectives while disproportionately affecting the civilian populace. The authors support this thesis by comprehensively analyzing the sanctions by the United States government, numerous nations, and even individual American states. Such sanctions—which include bans on weapons, energy, technology, and luxury foods—sporadically interrupted the flow of medical and humanitarian supplies to Iran, depending on the presidential administration and the state of international affairs.

Against this backdrop of wide-ranging sanctions, the authors present the impacts on Iran through a combination of quantitative and qualitative measures. This includes economic and trade data spanning decades to show the scale of the sanctions and the relative impact on Iran's economy and the Iranian population. Supplementing this approach, the authors utilize qualitative assessments through their analysis of social media and Persian-language media as well as oral history interviews of 80

Iranians living in Iran—including academics, business owners, political and social activists, and blue- and white-collar workers—to understand how everyday lives changed across the 55-year period.

Recent history demonstrates that as both the quantity and scale of the sanctions against Iran have increased, the Iranian government would employ increasingly harsh measures against its population while subverting international pressures and remaining influential on the international stage with proxy forces and global influence. The authors assert that sanctions "have not forced Iran to stagnate" but have instead "actually forced Iran to innovate, just not in ways that are amenable to the West" (7). They argue that these wide-ranging and enduring sanctions constitute an innocuous form of economic warfare that seems victimless but is in fact not only harmful to civilians but also ineffective as a whole. Identifying the actual effects of the sanctions, the authors observe that instead of suffocating Iran into submission, they "only encourage [the] nation to fight back" (149). Tacit to this conclusion is the argument that the United States must pursue different approaches in dealing with Iran while ending the indiscriminate and enduring sanctions.

This monograph provides a well-researched and cohesive approach that discounts the simplicity of sanctions and captures the real impacts on the Iranian population over time. Furthering this approach, the authors present how the Iranian government can subvert the sanctions and retain national power while increasing the suffering against the Iranian people. This makes a compelling case against economic warfare as countering desired policy objectives.

Published in 2024, the book is limited in perspective as it could not take into account the recent changes in the region relative to the Crisis in the Levant sparked by the attack on Israel by Hamas in October 2023 and the dynamic international relations including between Iran and the United States. Yet despite this limitation, *How Sanctions Work* provides insightful context that validates the underlying argument that all forms of warfare have victims and that all policies require assessment, reframing, and adjustment to ensure desired outcomes over time.

How Sanctions Work is worth reading for military and civilian leaders and planners alike. The book is a short read with a clearly understandable chapter format and language. The data does not inundate the reader but instead flows logically to bolster key points. While its depiction of the lives of the Iranian people and their culture as well as its historical analysis of the economic sanctions taken against Iran inform all readers, the book also provides key insights particularly for military practitioners. Furthermore, the lessons learned in Iran of the consequences and limitations inherent to economic warfare apply beyond this region. By understanding this environment and these lessons, military and civilian strategists can better influence operational environments, assess policy effectiveness, and build viable options to optimize the utility of the instruments of national power to pursue US interests in the future.

Colonel Matthew Wunderlich, USAF

Cyber Wargaming: Research and Education for Security in a Dangerous Digital World

Edited by Frank L. Smith III et al. Georgetown University Press, 2024, 240 pp.

Wargaming is experiencing a renaissance in defense analysis and international relations research. Armed with new budgeting streams after the 2015 Department of Defense memorandum calling for the reinvigoration of wargaming, the field has grown exponentially.[1] Yet, despite wargaming's rebirth amidst the digital revolution, too many wargames neglect the weight of cyber operations and focus on purely physical aspects. This new anthology, edited by Frank Smith, Nina Kollars, and Benjamin Schechter, houses a series of informative essays that examine cyber theories and provide practical examples of wargaming for and with cyber effects. *Cyber Wargaming* is a much-needed infusion of the issue into analytical and educational wargaming.

The editors bring their diverse expertise to the collection. Smith is a professor at the US Naval War College and director of its cyber and innovation policy center, where Kollars now serves as a nonresident fellow. Schechter is a senior wargaming lead at Systems Planning and Analysis. Together they demonstrate a mix of academic, government, and private-sector experience in wargaming research and education.

The book is usefully divided into two major parts. The first, "Research Games," focuses on analytical wargaming, examining how wargaming can be used to study the ways in which threats, opportunities, and human decision-making can shape cyber operations just as they shape more traditional warfighting domains.

The section opens with one of the strongest essays of the anthology. "Cyber Games as Synthetic Data" examines the use of cyber wargames to create synthetic data within a holistic research agenda. Like the nuclear warfare analysis, cyber researchers face a stark lack of data. So, like Thomas Schelling and nuclear researchers before them, the authors turn to wargaming as a way to build a synthetic dataset. Their article carefully wades through the issues of internal and external validity along with logistical or playability concerns, representing this as a wargamer's trilemma.

"Wargames Research on Cyber and Nuclear Crisis Dynamics" follows this strong opening by providing examples of impactful wargames, including *Eligible Receiver*, a National Security Agency vs. Defense Department cyber wargame that comprised traditional tabletop gaming and penetration testing, and the *International Crisis War Game*, which tested nuclear-cyber escalation dynamics.

An essay on the *Netwar* and *Island Intercept* wargames shows cyber wargaming in a slightly different mold. Here, the authors admit that their treatment of cyber operations may not be perfectly realistic, as mentioned in the "Cyber Games" trilemma, but by emphasizing cyber effects, they captured human decision-making and preferred external validity.

The analytical wargaming section rounds out with examples from the Center for a New American Security gaming lab and the Center for Naval Analyses' "Merlin" tool for cyber

1. Robert Work, US deputy secretary of defense, memorandum, "Wargaming and Innovation," 9 February 2015.

adjudication. Both of these essays provide great references for those looking to design better wargames and include cyber effects within traditional wargaming molds.

The section's final essay, an analysis of the psychological aspects of wargaming, could have just as easily been placed in the second "Educational Wargaming" section, providing a useful bridge between the two parts. Using examples of wargames she helped design, the author explores the social psychology behind why one went well and the other failed.

The opening essay of the second section brings into focus the contrast between wargaming for analysis and for education—a distinction that is often hazy—concentrating on gaming's playfulness. Using research on games and an original game design, the author lays out the case for closing the gap between playfulness and "serious gaming."

The rest of the section covers different examples or niches within wargaming. An essay on the *9/12 Cyber Strategy Challenge*—the Atlantic Council's annual cyber competition for cross-disciplinary university students—demonstrates another pathway into the cyber community. This policy-focused game series, the authors argue, brings different, less technically-minded recruits into the cybersecurity world through wargaming. Another essay discusses the growth and impact of the *GridEx* cyber wargames—designed for utility companies and government partners to address cyber threats to the electrical grid—from a cyber wargame to a more comprehensive wargame that includes robust cyber actions. These are followed by considerations of wargaming for businesses or military doctrine and tips on wargame prototyping or matrix-game design.

Overall, this book shines most in its opening essays. Discussions of wargaming to create synthetic data and concerns related to the designer's trilemma echo throughout the rest of the anthology. The book's many examples illustrate how it will appeal to different audiences. After reading the introductory chapters, readers interested in business applications might flip right to "Breaching the C-Suite"—an analysis on private sector cyber wargaming. If design applications are of greater interest, readers will find many of the same insights on design from the analysis of *Island Intercept* and *Netwar*.

The book would be a stretch for new wargamers. While providing practical advice, it assumes a robust professional understanding of wargaming. More novice audiences would likely have difficulty understanding designers' trade-offs without more context from works like Sebastian J. Bae's *Forging Wargamers* (Marine Corps University Press, 2022). This makes certain sections, like the discussion of the *9/12 Cyber Strategy* game, seem somewhat non sequitur. Wargame designers would be better off reading Peter Perla's *The Art of Wargaming* (Naval Institute Press, 1999) and new academic researchers would be served well to read "Wargaming for International Relations Research" before looking to tackle this book.[2] While "Cyber Games as Synthetic Data" ties wargaming to other research methods, there is little discussion of wargame epistemology throughout the rest of the book.

Despite these minor misgivings, this anthology is a rich collection of insights into how wargaming can be useful for examining and teaching cyber warfare. Because of the

2. Erik Lin-Greenberg et al., "Wargaming for International Relations Research," *European Journal of International Relations* 28, no. 1 (2021), https://doi.org/.

authors' assumptions of the reader's knowledge, *Cyber Wargaming* is best for seasoned designers and practitioners who hope to better capture the complex character of cyber operations in their wargames. Nevertheless, it is a worthwhile addition to any wargamer's library and will be a useful reference for any cyber professional looking to harness the power of wargaming.

Major Paul M. Kearney, USA

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