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A New Arsenal for A New Era:
Balancing Affordable Mass with Exquisite Capabilities

WEAPONS INDUSTRY STUDY GROUP PAPER

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- Marine Corps Warfighting Laboratory, Quantico, Virginia, March 6, 2025
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Executive Summary

The global weapons landscape is rapidly evolving amid technological innovation and intensifying great power competition. This paper analyzes drones, directed energy weapons (DEWs), and hypersonics and evaluates their strategic value, industrial base characteristics and considerations, and policy implications. Together, these systems form a continuum from affordable mass to exquisite capability, offering complementary tools integrated within a layered defense architecture for future conflict.

Figure 1. Vision of the 21st-Century Battlefield
Source: Picture generated with ChatGPT by Lieutenant Colonel K. Skidmore, April 14, 2025

A central insight framing the analysis is that defense customers diverge in their needs. Some prioritize affordable mass to saturate adversaries, complicate defenses, and sustain attrition; others require exquisite systems to penetrate contested environments and defeat advanced defenses. This tension shapes weapons development, the industrial base, customer relationships, and policy. Drones exemplify affordable precision mass; DEWs occupy a scalable middle ground; hypersonics represent the pinnacle of technical complexity.

The analysis identifies an enduring imbalance in U.S. defense acquisition: a persistent bias toward exquisite, low-quantity platforms that limits acquisition and operational scalability. Drones offer low-cost, high-volume solutions with rapid production potential. DEWs demand significant upfront investment but could provide scalable, low-cost defense once deployed. Hypersonics deliver unmatched speed and penetration at high cost and industrial complexity.

Adversaries have advanced their capabilities across these technologies. Russia has fielded and employed hypersonic and directed energy weapons and used weaponized drones widely in Ukraine. China leads in hypersonic research, drone mass production, and DEW development. Both have deployed drones extensively in recent years. Meanwhile, the U.S. industrial base faces critical vulnerabilities given reliance on foreign-sourced raw materials, narrow supplier networks, and slow acquisition cycles that hinder scaling and allied integration.

A Porter's Five Forces analysis reveals distinct market structures. The drone market is highly competitive with moderate entry barriers. Hypersonics and DEWs remain concentrated, high-barrier markets facing rising global competition. Government buyers exert dominant purchasing power across all systems although there is a robust commercial drone market, while supplier leverage fluctuates with material scarcity and technical specialization.

This paper proposes a strategy of "mass, maneuver, and momentum" to rebalance U.S. defense investments toward scalable, adaptable production. Recommendations include divesting legacy platforms to fund next-generation systems; reforming Foreign Military Sales (FMS) to enhance allied industrial integration; adopting a 1:10 research-to-production funding ratio; and embedding industrial capacity as a core pillar of strategic deterrence.

Future U.S. military advantage will depend not solely on technological superiority but on the ability to scale production rapidly to deliver layered, adaptable capabilities that balance mass and precision. Achieving this vision requires structural reform across acquisition, industrial policy, and international partnerships, shifting from a platform-centric to a capability-centric defense industrial strategy.

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1. Introduction

"Nothing remains static in war or military weapons, and it is consequently often dangerous to rely on courses suggested by apparent similarities in the past."[1] Admiral Earnest J. King's warning remains as true today as it was during World War II.

The so-called "battle lab" of the Ukrainian conflict validated what theorists anticipated. Autonomy and unmanned systems are reshaping modern conflict.[2] Ukraine's widespread use of cost-effective unmanned vehicles has provided critical capabilities to counter Russia's advances. Leveraging a multi-domain fight, Ukrainian forces have deployed countless drones, conducted long-range strikes, seized fortified defensive positions, and inflicted significant damage on Russia's Black Sea Fleet.[3]

Russia, in turn, has showcased hypersonic capabilities, launching Tsirkon and Oreshnik missiles combining extreme speed and maneuverability[4]. Elsewhere, Iran's mass drone attacks with Shahed one-way systems tested Israel's defenses[5], while Israel's Iron Dome system successfully intercepted them. By late 2025, Israel's Iron Beam high-energy laser will operationalize layered defense[6] and offering a conceptual model for the proposed Golden Dome

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[1] FADM(ret.) Earnest J. King, "Top 4 Earnest King Quotes (2025 Update) - QuoteFancy," accessed April 29, 2025, https://quotefancy.com/ernest-king-quotes.

[2] Michael C. Horowitz, "Battles of Precise Mass," *Foreign Affairs*, October 22, 2024, https://www.foreignaffairs.com/world/battles-precise-mass-technology-war-horowitz.

[3] Mick Ryan, "Why No One Is Winning in Ukraine," *Foreign Affairs*, February 21, 2025, https://www.foreignaffairs.com/russia/why-no-one-winning-ukraine-ryan.

[4] "Russia Has Used Its Hypersonic Oreshnik Missile for the First Time. What Are Its Capabilities?," AP News, December 9, 2024, https://apnews.com/article/russia-oreshnik-hypersonic-missile-putin-ukraine-war-345588a399158b9eb0b56990b8149bd9.

[5] Joshua A. Schwartz, "What Iran's Drone Attack Portends for the Future of Warfare - Modern War Institute," April 30, 2024, https://mwi.westpoint.edu/what-irans-drone-attack-portends-for-the-future-of-warfare/, https://mwi.westpoint.edu/what-irans-drone-attack-portends-for-the-future-of-warfare/.

[6] "Israel's Iron Beam Set For Historic Deployment," accessed April 29, 2025, https://www.nationaldefensemagazine.org/articles/2025/1/29/israels-iron-beam-set-for-historic-deployment.

for America (GD4A).[7] Global military powers are accelerating investments to stay at the forefront of these fourth industrial revolution breakthroughs.[8]

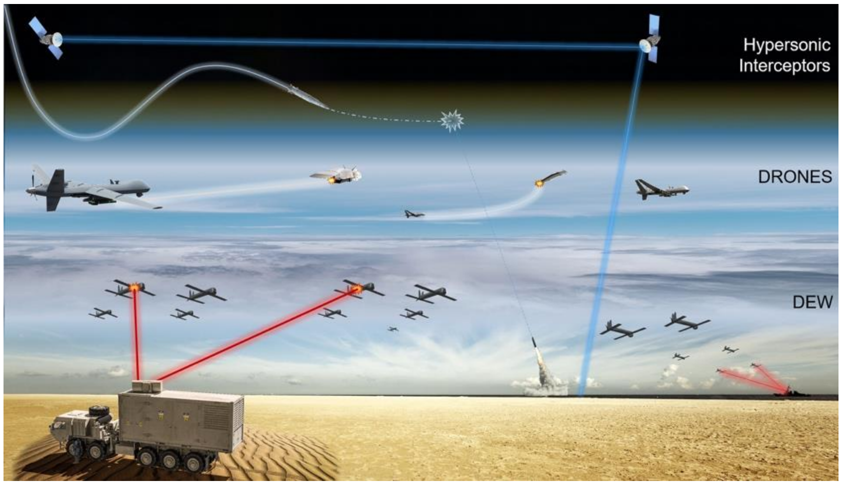

Figure 2. Multi-Layer Defense Concept
Source: collage of several pictures by CDR C. Norman, May 5, 2025

The United States is no exception. This paper focuses on three transformative weapons: hypersonics, DEWs, and drones. Their war-altering potential and today's geopolitical environment prompted the Eisenhower School (ES) to develop an Industry Study focused on these weapons technologies.

Hypersonic weapons, defined by speeds exceeding Mach 5, derive their strategic value from maneuverability at high velocities, differentiating them from ballistic missiles. This paper examines hypersonic glide vehicles (HGV) and hypersonic cruise missiles (HCM); referred to hereafter as hypersonics. These systems deliver significant effects but demand high investment and industrial complexity.

DEWs include Laser Weapons Systems (LaWS) and microwave or acoustic weapons systems. This analysis focuses on high-energy LaWS (above 2 to 5 kW output), given their

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7 Tim McMillan, "America's New 'Golden Dome': What to Know About the Next-Gen Missile Defense System," The Debrief, February 26, 2025, https://thedebrief.org/americas-new-golden-dome-what-to-know-about-the-next-gen-missile-defense-system/.
8 Klaus Schwab, "The Fourth Industrial Revolution," World Economic Forum, n.d., https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab/.

ability for battlefield lethality and operational viability. While DEWs require substantial upfront investment, they promise a low cost-per-shot in sustained operations.

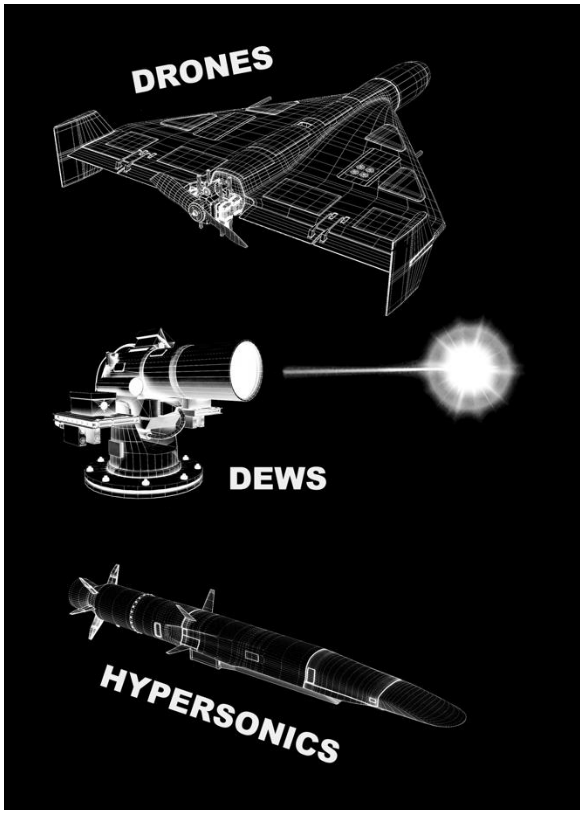

Figure 3. Advanced weapon systems included in this analysis
Source: modified pictures by CDR C. Norman from www.turbosquid.com, May 3, 2025

Drones are unmanned platforms and weapons operating remotely or autonomously across air, land, maritime, or subsurface domains. As a weapon system, they offer range from high-dollar value platforms for Intelligence, Surveillance, and Reconnaissance (ISR) missions to low-cost, expendable platforms for one-way kinetic strike capability. This paper focuses on drones employed as weapons: loitering munitions, one-way attack drones, and attritable or modified systems used to create kinetic or weapons effects against targets (not drones that serve as platforms, as those would be more appropriate for different ES industry studies such as aircraft). Maximum costs for military-unique attritable systems typically range from $2-10 million dollars,[9] while repurposed commercial systems can be less than $100, making drones especially attractive for delivering precision mass, as seen in Ukraine.

Crucially, the analysis frames these systems from a spectrum of affordable mass to exquisite capability. Drones represent scalable, low-cost, precision mass; DEWs occupy a middle ground; hypersonics exemplify exquisite, technically demanding systems. This underlying tension between affordability and complexity should inform U.S. investment strategy, industrial priorities, and policy choices throughout the paper.

This paper analyzes the current strategic environment affecting the U.S. weapons industry, global strategic competition, and industry stakeholder interests. It explores economic market forces and proposes a strategy and policy options to optimize investments in these weapons and enhance industrial performance.

2. Strategic Considerations for Industry and Weapons Manufacturing

2.1. Key issues affecting hypersonics, LaWS, and drone weapon industries

The Laser Weapon System (LaWS) industry spans firms producing optical devices, power storage and delivery systems, thermal management solutions, and detection and targeting technologies. The current state of LaWS technology faces persistent limitations: low energy yield (10 to 20%), vulnerability to atmospheric interference, complex thermal management needs, and fragile components under battlefield conditions.[10] Concerns over collateral effects, safety restrictions, and industrial reluctance to damage the prototypes also limit field testing and slow progress in overcoming operational shortcomings.

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[9] Daniel M Gettinger, "Defense Primer: Categories of Uncrewed Aircraft Systems," In Focus (Washington, D.C.: Congressional Research Service, October 25, 2024).
[10] Bernard Fontaine, "Les armes à énergie dirigée vont-elles entrer en service ?," *Défense & Sécurité Internationale*, no. 79 (March 2012): 84–91.

High development and integration costs further delay LaWS transition from prototypes to deployed systems. A 2024 NDIA report on DEW supply chains highlighted a lack of a unified DoD strategy.[11] Without centralized guidance, programs remain fragmented, deterring coordinated industrial investment. Overcoming these weapons limitations requires technological breakthroughs, sustained research funding, and policy reforms to incentivize production and integration.

The hypersonics industry faces equally dauting challenges. Hypersonic flight exposes materials and systems to extreme thermal, aerodynamic, and structural stresses, driving up development costs for materials science, propulsion, integration, and testing. These costs result in a very high cost-per-effect, forcing difficult funding decisions and capability trade-offs. Firms in this industry must invest heavily in infrastructure, research pipelines, and talent, while facing high risks if contracts are curtailed or canceled. The classification of hypersonic design, manufacturing, storage, and deployment further burdens the industry and limits new entrants.

Military drone usage and development have expanded rapidly, driven by technological advancements. With global revenues projected to increase 12% annually, low-cost airborne drone production offers flexibility and scalability.[12] Still, ethical and regulatory concerns persist. Drone communication and autonomy depend on cutting-edge cybersecurity, requiring continuous upgrades to prevent hacking and misuse. Regulatory frameworks, often intended to increase safety, reliability, other operational risks, impose constraints, but ensure accountability, particularly when drones operate over civilian populations.[13]

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[11] Rebecca Wostenberg, Wilson Miles, and Jordan Chase, "Directed Energy Weapon Supply Chains: Securing the Path to the Future" (Emerging Technology Institute, NDIA affiliate, January 2024), https://www.emergingtechnologiesinstitute.org/-/media/ndia-eti/reports/directed-energy-weapon-supply-chains/directedenergyweaponsreportdeeti.pdf.
[12] "Military Drone Market," Market.us, accessed April 30, 2025, https://market.us/report/military-drone-market/.
[13] "Military Drone Market."

The contrast between these systems reflects their position along the spectrum from affordable mass to exquisite capability. LaWS and hypersonics require high upfront investment and advanced industrial ecosystems, restricting their production to wealthy nations or partners with technology access. These complex systems increase demands for training, maintenance, and sustainment. Drones by contrast, offer affordable precision mass and lower barriers to entry, enabling smaller or less wealthy militaries to acquire and proliferate them.

2.2. Forecasts

Current LaWS capabilities, like the Navy's HELIOS[14] are limited to specific platforms and environments paired with large power sources. Future integration of Small Modular Reactors[15] offers opportunities for higher-density power, enabling LaWS deployment in more environments and platforms. This trend toward small, high-density power suggests long-term potential for LaWS operationalization, particularly in the Indo-Pacific maritime scenarios and layered defenses like the GD4A.

Ongoing LaWS development emphasizes AI-enhanced targeting,[16] modular open systems architectures (MOSA), and expanding roles in counter-drone and missile defense. Research and Development (R&D) focuses on improving energy storage, power density, thermal control, and atmospheric compensation. Advances in adaptive optics, wavelength modulation, and fast steering mirrors aim to extend LaWS' range and reliability.[17] DoD initiatives like the High

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[14] "HELIOS One Step Closer to Integrated LWS Capability" (Lockheed Martin Corporation, December 2021), https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/documents/directed-energy/HELIOS-WhitePaper-Dec-2021.pdf.

[15] Defense Science Board, "Task Force on Energy Systems for Forward/Remote Operating Bases - Final Report" (DoD, August 1, 2016), https://dsb.cto.mil/wp-content/uploads/reports/2010s/Energy_Systems_for_Forward_Remote_Operating_Bases.pdf.

[16] Dan Linehan, "NPS Develops AI Solution to Automate Drone Defense with High Energy Lasers," Naval Postgraduate School, February 12, 2025, https://nps.edu/-/nps-develops-ai-solution-to-automate-drone-defense-with-high-energy-lasers.

[17] Henry "Trey" Obering, III, "Directed Energy Weapons Are Real... And Disruptive," *PRISM 8*, January 2020.

Energy Laser Scaling Initiative (HELSI) provide prototyping support, while the Army Rapid Capabilities and Critical Technologies Office (RCCTO) enables rapid testing and fielding.[18] The GD4A[19] and HELSI[20] investments signal LaWS are a strategic priority. Sustained operational evaluation remains critical to address technical and deployment challenges.

Major military powers continue to invest in hypersonics requiring advances in rockets, scramjet engines, high-temperature materials, and other critical technologies. There is rising interest in hypersonic interceptors and counter-hypersonic defenses, particularly for terminal or post-boost phases. Hypersonics development remains concentrated in nations with advanced space or ballistic missile programs. As underlying technologies mature and production methods become more accessible, hypersonics will likely proliferate globally, increasing the demand and cost of counter-hypersonics systems.

The drone market has shifted from large, platform-centric systems to smaller, expendable airframes optimized for kinetic effects. Early systems like the General Atomics (GA) MQ-9 Reaper and Northrop Grumman (NG) MQ-4 Triton prioritized removing humans from long-duration ISR missions.[21,22] Comparable international systems include Israel's Hermes 450 and Eitan, operated by multiple nations including the United States.[23] Naval developments like the

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[18] Kelley M. Sayler et al., "Department of Defense Directed Energy Weapons: Background and Issues for Congress" (Congressional Research Service, July 11, 2024), https://crsreports.congress.gov/product/pdf/R/R46925/8.
[19] Tim McMillan, "America's New 'Golden Dome': What to Know About the Next-Gen Missile Defense System," The Debrief, February 26, 2025, https://thedebrief.org/americas-new-golden-dome-what-to-know-about-the-next-gen-missile-defense-system/.
[20] Kelley M. Sayler et al., "Department of Defense Directed Energy Weapons: Background and Issues for Congress," July 11, 2024.
[21] "MQ-9A Reaper (Predator B)," General Atomics Aeronautical Systems Inc., accessed May 3, 2025, https://www.ga-asi.com/remotely-piloted-aircraft/mq-9a.
[22] "MQ-4C Triton," Northrop Grumman, accessed May 3, 2025, https://www.northropgrumman.com/what-we-do/air/https:www.northropgrumman.com/what-we-do/air/triton.
[23] "Hermes 450," accessed May 1, 2025, https://www.israeli-weapons.com/weapons/aircraft/uav/hermes_450/Hermes_450.html.

85-foot-long Orca extra-large unmanned underwater vehicle (XLUUV)[24] and unmanned surface vessel (USV) squadrons reflect similar trends.[25]

Russia's deployment of drones in Ukraine accelerated innovation toward low-cost, small-scale airframes like quadcopters and hand-launched drones. The conflict validated loitering munitions and one-way attack drones for kinetic effects. The Army aligned with this shift, awarding almost $1 billion Indefinite Delivery, Indefinite Quantity (IDIQ) contract to AeroVironment for loitering munitions.[26] Recent purchases include a $288 million order for upgraded Switchblade 300s, with plans to field the anti-armor Switchblade 600.[27] The Army's Maneuver Capabilities Development and Integration Directorate has further explored First Person View (FPV) and tethered drones for tactical operations.[28]

Recent conflicts, industry challenges, and technological advances continue to reshape the weapons industry. Competitor actions emphasize the need for agility, flexibility, and innovation in U.S. weapons acquisition.

2.3. Readiness and Supply Chain Factors Concerning Weapons Production

National security concerns drive governments to favor domestic production of sensitive components and systems. However, globalized supply chains often require sourcing critical inputs internationally.[29] Even domestically assembled systems may depend on materials crossing

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[24] Xavier Vavasseur, "First Look at the US Navy's Orca XLUUV with Massive Payload Module," *Naval News* (blog), June 12, 2024, https://www.navalnews.com/naval-news/2024/06/our-first-look-at-the-us-navys-orca-xluuv-fitted-with-payload-module/.
[25] Naval News Staff, "U.S. Navy Establishes Unmanned Surface Vessel Squadron Three," *Naval News* (blog), May 18, 2024, https://www.navalnews.com/naval-news/2024/05/u-s-navy-establishes-unmanned-surface-vessel-squadron-three/.
[26] Jon Harper, "Army, AeroVironment Ink Nearly $1B Contract for Switchblade Killer Drones," *DefenseScoop* (blog), August 28, 2024, https://defensescoop.com/2024/08/28/army-aerovironment-switchblade-contract-1b-killer-drones/.
[27] Harper.
[28] Editor Staff, "U.S. Army Eyes Formal Integration of FPV and Tethered Drones in 2025," SOFX, May 16, 2024, https://www.sofx.com/u-s-army-eyes-formal-integration-of-fpv-and-tethered-drones-in-2025/.
[29] David Levene, "The Paradox of Hypersonic Weapon Supply Chains" (Eisenhower School, April 20, 2025), 4.

multiple countries, introducing vulnerabilities to geopolitical disruption.[30] Hypersonic, DEW, and drone production face heightened supply chain risks, presenting both opportunities to deny adversaries critical materials and challenges in securing domestic supply.[31]

Military systems rely on purpose-built, dual-use, and commercial resources. Defense demand for many key materials represents a small fraction of global consumption, forcing weapons programs to compete with civilian industries.[32] Relatively small defense volumes may be deprioritized amid broader geopolitical or economic considerations.[33]

Manufacturing hypersonic, DEWs, and drone systems requires scarce materials, particularly mined minerals and REE, and advanced intermediate and finished goods such as software, engineering tools and devices, microelectronics, components, and production processes. While each system's production requirements vary, they share similar supply chain constraints affecting readiness and scalability.

For LaWS, domestic sourcing of critical minerals is constrained, and optical engineering talent is scarce. The United States relies heavily on foreign suppliers, particularly China, for key inputs. Allied cooperation, especially with Israel,[34] NATO, and Australia (under AUKUS), can help mitigate these vulnerabilities through technology sharing, joint R&D, and shared raw materials.

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[30] David Levene, 4.
[31] The U.S. Department of Defense (DoD) has explicitly recognized that the hypersonics industrial base extends beyond U.S. borders. Following Executive Order 14017, "America's Supply Chains," a report recommended that the DoD "identify partners and allies with the capabilities to aid in the development and expansion of [the U.S.] hypersonics supply chain, especially for materials and components where domestic sources may not exist." This DoD report recognized that the successful fielding of hypersonic weapons requires the DoD to source hypersonics technology and materials from abroad. However, this also opens the Department up to geopolitical-related trade vulnerabilities that would not exist in an entirely domestic industry. Source: Kelley M. Sayler, "Hypersonic Weapons: Background and Issues for Congress" (Congressional Research Service, February 11, 2025), 26, https://sgp.fas.org/crs/weapons/R45811.pdf.
[32] David Levene, "The Paradox of Hypersonic Weapon Supply Chains," 4.
[33] David Levene, 4–5.
[34] U. S. Mission Israel, "Remarks by Former President Biden at Arrival Ceremony," U.S. Embassy in Israel, July 13, 2022, https://il.usembassy.gov/remarks-by-president-biden-at-arrival-ceremony/.

The LaWS industrial base faces long lead times, small-batch production, limited prototype development capacity within each firm, and dependence on REEs like Yttrium and Praseodymium, mostly sourced from China.[35] Figure 1 illustrates key industries reliant on these elements. The raw material needs for weapons are in direct competition with other complex systems and manufacturing beyond the defense sector.

	21 Sc	39 Y	57 La	58 Ce	59 Pr	60 Nd	61 Pm*	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Lasers		✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Magnetics					✓	✓		✓			✓	✓	✓				
Metal alloys	✓		✓	✓		✓					✓					✓	
Catalysts			✓	✓		✓											✓
Nuclear†							✓	✓	✓			✓					
Computers						✓				✓		✓					
Televisions		✓							✓								

*Not classed as a critical mineral by the US Department of Energy †Reactors or batteries
Note: elements listed in order of Scandium, Yttrium, Lanthanum, Cerium, Praseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, Ytterbium and Lutetium
Source: Virginia Department of Energy

Figure 4. Examples of Rare-Earth Element Uses
Source: "A Visual Guide to Critical Materials and Rare Earths," The Economist, March 24, 2025

An NDIA report on DEW supply chains highlights industry reluctance to scale production without stable DoD demand.[36] The United States has a long history of developing and evaluating LaWS on *varied* platforms and domains. In the last five years, DoD invested an average of $1 billion in DEWs (Figure 2).

[35] "China Proposes Further Export Curbs on Battery, Critical Minerals Tech," Reuters, January 2, 2025, https://www.reuters.com/technology/china-proposes-further-export-curbs-battery-critical-minerals-tech-2025-01-02/.
[36] Rebecca Wostenberg, Wilson Miles, and Jordan Chase, "Directed Energy Weapon Supply Chains: Securing the Path to the Future," January 2024.

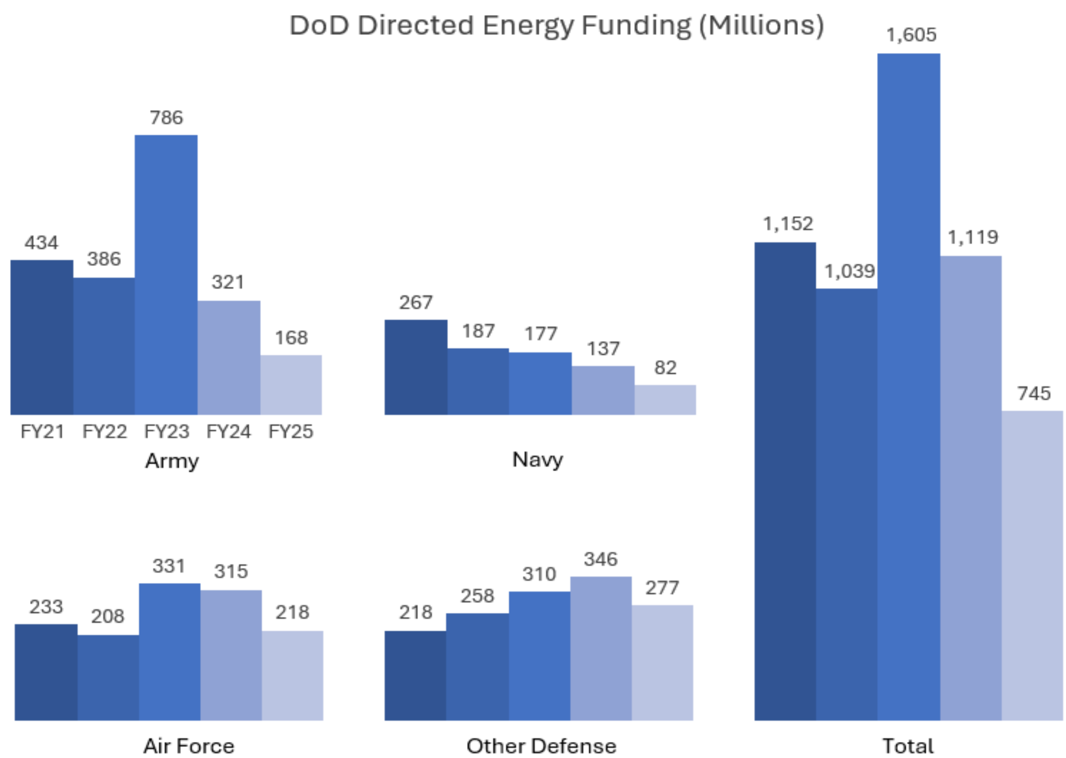

Figure 5. DoD budget allocated for DEWs over the last five years
Source: Shared by a Guest Speaker, Chatham House rules for non-attribution apply.

This funding allowed for the development of several prototypes. Current systems are primarily Technology Readiness Level (TRL) 6–7. While the United States has many DEW efforts, most U.S. DEW programs have only a small number of assets delivered or deployed.[37] The Army's Zeus system, officially in service, is notable, with several units delivered.[38] The current DoD LaWS portfolio represents capabilities across multiple domains (Figure 3).

[37] "EDITOR'S NOTES: Directed Energy Weapons: Here Now? Or 5 Years Off?," accessed May 3, 2025, https://www.nationaldefensemagazine.org/articles/2024/2/29/editors-notes-directed-energy-weapons-here-now-or-5-years-off.
[38] "ZEUS®," Parsons Corporation, n.d., https://www.parsons.com/products/zeus/.

Figure 6. U.S. High Energy Laser Prototype Systems, 2017-2025
Source: Shared by a Guest Speaker, Chatham House rules for non-attribution apply.

In comparison, hypersonics share similar and unique supply chain considerations. No country today manufactures an entire hypersonic system solely with domestic resources.[39] International trade is thus essential in hypersonics production, but also a vulnerability, subject to trade restrictions, supply chain disruptions, export controls, and international arms control agreements. Figure 4 shows an example of key raw materials, top producers, and assessed risks identified by NDIA:

[39] David Levene, "The Paradox of Hypersonic Weapon Supply Chains," 2.

Materials	Top Producers	Vulnerability	Explanation
Tantalum	Congo, Brazil, Rwanda		Ores and concentrates sourced from ally, but metal and powder sourced from China.
Rare Earths	China, U.S., Australia		China dominates mining and processing
Cobalt	Congo, Indonesia, Russia		U.S. imports from partners/allies, despite China dominating processing
Aluminum	China, India, Russia		Half of U.S. imports are from an ally
Titanium	China, Mozambique, South Africa		Over half of U.S. imports are from partners or allies
Nickel	Indonesia, Philippines, Russia		U.S. imports from allies despite China dominating processing
Carbon Fiber	Japan, U.S.		Demand may outpace supply in the near-term
Ammonium Perchlorate	China		Only two DoD-approved suppliers
Carbon-Carbon	Japan, China, U.S.		Only three available suppliers, and manufacturing & distribution is expensive
Neon and C4F6	Ukraine (Neon); Japan, South Korea (C4F6)		War in Ukraine disrupted supply but major companies have multiple suppliers
Plastics (ABS–M30, ABSi, Nylon, Polycarbonate)	South Korea, U.S., Germany, China, Japan		Short-term disruptions, but market will likely rebound long-term

Figure 7. Key hypersonic-related raw materials and associated risks
Source: Rebecca Wostenberg et al., "Hypersonics Supply Chains: Securing the Path to the Future" (Emerging Technologies Institute (NDIA), May 2023)

As shown, U.S. hypersonic programs depend on multiple foreign-sourced materials,[40] but the implications of these dependencies extend to other types of production. Since many raw materials can be used for a wide range of defense systems and other applications, similar considerations exist for different types of weapons. Often, developing countries produce large quantities of basic materials, particularly those that are mined or extracted as raw minerals.[41] China's status as the pacing threat makes its dominance in markets like cobalt and REEs a strategic vulnerability for the United States.[42]

The COVID-19 pandemic and rising geopolitical tensions have increased global focus on reducing foreign dependency for critical materials. In the United States, recent policy efforts aim

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[40] Overall, the materials shown in Figure 2 are sourced from many countries and used for various hypersonic applications. These include high-temperature materials, composites, ceramics, coatings, microelectronics, additive manufacturing, engines, airframes, fuels and fuel tanks, and thermal protection, making raw materials trade access one of the most critical parts of hypersonics production. Sources: Levene, 5, and Wostenberg et al., 11–14.
[41] David Levene, "The Paradox of Hypersonic Weapon Supply Chains," 5.
[42] David Levene, 6.

to start or expand domestic mining, refining, and processing. While environmental and profitability concerns have previously hampered domestic rare earth and mineral production, the United States now recognizes that "processed critical minerals and their derivative products are essential for economic security and resilience because they underpin key industries," leading to high-level efforts to reduce reliance on foreign sources, including a recent Executive Order.[43] Efforts also include allied and friendly nation partnerships to reduce dependence on adversary-controlled critical materials to remove a core U.S. vulnerability.[44]

However, the ramp-up timelines and capital required to establish new primary mineral sources are high, and costs in the West likely exceed comparable costs from Africa or Asia. Even with government subsidies or regulatory incentives, new mines and processing facilities are unlikely to be fully functional and capable of replacing existing trade needs soon.[45] Purchases directly from adversaries are not always necessary, as "there are international markets for most raw materials," but many "necessary materials flow through adversary supply chains at some point, forming nodes of vulnerability."[46]

In addition to raw materials, "some intermediate and finished goods that serve as critical parts of weapons production are also traded internationally."[47] Semiconductors, software, chemicals, and engineering and test equipment are also traded internationally.[48] Since "many countries consider the details of their military supply chains sensitive, it can be difficult to fully

[43] Donald Trump, "Ensuring National Security and Economic Resilience Through Section 232 Actions on Processed Critical Minerals and Derivative Products," The White House, April 15, 2025, https://www.whitehouse.gov/presidential-actions/2025/04/ensuring-national-security-and-economic-resilience-through-section-232-actions-on-processed-critical-minerals-and-derivative-products/.
[44] David Levene, "The Paradox of Hypersonic Weapon Supply Chains," 7.
[45] Ibid., 7.
[46] Ibid., 7.
[47] Ibid., 8.
[48] Ibid., 8.

understand the trade relationships" and supply chain concerns that affect more advanced goods and capabilities.[49] Supply chains remain an embedded dimension of global competition.

3. Worldwide Strategic Competition

The United States is not alone in recognizing the effectiveness and strategic capability of drones, DEWs, and hypersonics. Many countries have initiated or increased programs to develop these systems, positioning them as central features of great power competition. China and Russia lead these domains, while Iran pursues more limited capabilities to enhance its regional influence, contingent on the alliances formed.

3.1. Hypersonics

China and Russia have surged in hypersonics development. China leads the world in hypersonics development and fielding, and its progress comes after two decades of heavy, sustained investment in hypersonic R&D infrastructure.[50] Its programs include HGV (e.g., the DF-ZF) and HCM tested in various ranges.[51]

Russia, meanwhile, has already deployed multiple hypersonics, including the Kinzhal air-launched ballistic missile, the Avangard nuclear-capable glide vehicle, and the Zircon anti-ship missile.[52] Russia became the first nation to deploy hypersonics in combat, reflecting its prioritization of rapid development and deployment. A SIPRI report observed that "Russia was the first state to field missiles that it describes as hypersonic weapons with both 'theatre-range'

[49] Ibid., 8.
[50] Seth G. Jones, *Rebuilding the Arsenal of Democracy: The U. S. and Chinese Defense Industrial Bases in an Era of Great Power Competition*, 1st ed (Blue Ridge Summit: Center for Strategic & International Studies, 2024).
[51] Paul Bernstein, "China's Hypersonic Weapons | GJIA," *Georgetown Journal of International Affairs* (blog), January 27, 2021, https://gjia.georgetown.edu/2021/01/27/chinas-hypersonic-weapons/.
[52] Josh Luckenbaugh, "Testing Top of Mind as U.S. Lags China In Hypersonics Race," National Defense, July 24, 2024, https://www.nationaldefensemagazine.org/articles/2024/7/24/testing-top-of-mind-as-us-lags-china-in-hypersonics-race.

(the medium-range air-launched aeroballistic missile Kinzhal) and ‘strategic range’ (the intercontinental-range silo-based boost-glide system Avangard).”[53] Russia will also “likely be the first to operate a ‘hypersonic triad.’”[54]

Iran recently signaled entry into hypersonics, unveiling the “Fattah” ballistic missile in 2023, though its progress lags behind a true hypersonic.[55]

China and Russia have pursued HGV and HCM variants, and “are credited with currently enjoying a lead over other states developing hypersonic missiles, likely driven by their concerns over U.S. missile defenses.”[56] This lead provides operational advantages. SIPRI further noted that while China and Russia’s “lead does not reflect military or technological superiority, it provides advantages through their ability to gain operational experience in day-to-day planning and maintenance operations, exercises and deployment to distant staging areas.”[57,58]

3.2. Drones

China and Russia both view drones as central to future warfare. China’s People’s Liberation Army (PLA) “has invested heavily in an array of unmanned aircraft.”[59] The PLA fields diverse systems: the Chengdu Aircraft Industry Group Wing Loong family, CH-4 strike

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[53] Kolja Brockmann and Dmitry Stefanovich, “Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime” (Stockholm International Peace Research Institute (SIPRI), April 2022), https://www.sipri.org/publications/2022/policy-reports/hypersonic-boost-glide-systems-and-hypersonic-cruise-missiles-challenges-missile-technology-control.
[54] Ibid..
[55] Parisa Hafezi, “Iran Presents Its First Hypersonic Ballistic Missile, State Media Reports,” *Reuters*, June 6, 2023, sec. Middle East, https://www.reuters.com/world/middle-east/iran-unveils-its-first-hypersonic-ballistic-missile-state-media-reports-2023-06-06/.
[56] Kolja Brockmann and Dmitry Stefanovich, “Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles.”
[57] Ibid.
[58] RAND Corporation report confirms the global trend: *“Hypersonic missiles are currently being developed mainly by the United States, Russia, and China. Other countries besides these three are also developing hypersonic technology to some degree. France and India are the most committed, and both draw to some extent on cooperation with Russia. In terms of level of effort, the next programs are those of Australia, Japan, and European entities.”* Richard H. Speier et al., “Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons” (RAND Corporation, September 27, 2017), https://www.rand.org/pubs/research_reports/RR2137.html.
[59] Christopher Woody, “Taiwan Has a Problem: China Has Gone ‘Mad for Drones,’” *19FortyFive* (blog), September 3, 2022, https://www.19fortyfive.com/2022/09/taiwan-has-a-problem-china-has-gone-mad-for-drones/.

UAVs, supersonic reconnaissance UAVs (like the WZ-8), and experimental "swarm" drone technology.[60] China has begun exporting drones capable of carrying arms to partners worldwide.[61] These systems give Beijing enhanced surveillance and strike options in the Indo-Pacific; for instance, the new hypersonic MD-19 reconnaissance drone[62] and supersonic models like WZ-8 could "challenge air defenses over Taiwan, South Korea, and Japan."[63]

The PRC has also been pacing with the United States and allied capabilities, like the Wing Loong series and Hongdu GJ-11 with similar ISR and anti-tank missile capabilities, with little emphasis on drones until recently.[64] Asia Times reported in February 2024 that China is developing a 2035 operational scenario centered on heavy drone use, with systems maneuvering and ambushing across multiple battlespaces.[65] Unlike Russia, China has not tested these systems in direct combat.

Russia's drone capabilities have also expanded, complementing rather than replacing its manned aviation. Russia has also been developing medium-sized tactical unmanned aerial systems since 2009 and unveiled its first loitering drone, ZALA Lancet 1, in 2019. The ZALA Lancet 3 closely followed and can carry a larger three-kilogram warhead for heavy armored vehicles.[66] Russia adopted Iran's Shahed-136 loitering munition, relabeled as Geran-2, and

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[60] Gabriel Honrada, "China Leaks a Blueprint for Drone War Dominance," Asia Times, February 7, 2024, https://asiatimes.com/2024/02/china-leaks-a-blueprint-for-drone-war-dominance/#.
[61] Michael C. Horowitz, Joshua A. Schwartz, and Matthew Fuhrmann, "China Has Made Drone Warfare Global," *Foreign Affairs*, November 20, 2020, https://www.foreignaffairs.com/articles/china/2020-11-20/china-has-made-drone-warfare-global.
[62] Brandon J. Weichert, "China's New MD-19 Hypersonic Drone Is a Nightmare for U.S. Air Defense - The National Interest," The National Interest, April 25, 2025, https://nationalinterest.org/blog/buzz/chinas-new-md-19-hypersonic-drone-is-a-nightmare-for-u-s-air-defense.
[63] Caleb Larson, "Stunning Drone Breakthrough: China Is Exposed Wanting Hypersonic UAVs," *19FortyFive* (blog), April 28, 2025, https://www.19fortyfive.com/2025/04/stunning-drone-breakthrough-china-is-exposed-wanting-hypersonic-uavs/.
[64] "CAIG Wing Loong II," ArmedForces.eu, accessed May 1, 2025, https://armedforces.eu/air_forces/drone/CAIG_Wing_Loong_II.
[65] Gabriel Honrada, "China Leaks a Blueprint for Drone War Dominance."
[66] Bohdan Tuzov, "Analysis: Russian Lancet Kamikaze Drone in Ukraine: An Overview," Kyiv Post, November 12, 2023, https://www.kyivpost.com/analysis/23923.

deployed it with the Lancet in the Ukraine War. This adoption of "massive numbers of uncrewed projectiles" has been used in Ukraine to overwhelm Ukrainian air defenses.[67]

Iran has emerged as a leading proliferator of drone technology. Tehran has supplied drones to its proxies and allied militaries.[68] Since 2022, Iran has dramatically increased production: over a thousand Iranian attack drones have reportedly been delivered to Russia for use in Ukraine.[69] Strategically, Iran's UAS focus is a low-cost attacker/exporter, rather than a peer competitor in cutting-edge drone technology.

3.3. Directed Energy Weapons

China actively pursues DEW development, focusing on ground-based lasers for counter-space applications targeting satellite sensors and potentially satellite structures by the mid-to-late 2020s.[70]

China's LW-30 laser defense system, reportedly with multi-kilometer range, reflects progress in counter-drone applications.[71] In 2024, China fielded the Type 071 amphibious transport ship fitted with a new laser turret.[72] Most Chinese DEWS testing remains land-based, but Beijing has exported a laser counter-drone system to Iran.[73]

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[67] Peter Suciu, "Putin's Wants to Turn Ukraine Into Drone Hell (It Won't Work)," *19FortyFive* (blog), January 4, 2023, https://www.19fortyfive.com/2023/01/putins-wants-to-turn-ukraine-into-drone-hell-it-wont-work/.
[68] Daniel E. Mouton, "Iranian Drones Have Proliferated under US Watch," *Atlantic Council* (blog), April 2, 2024, https://www.atlanticcouncil.org/blogs/iransource/iran-drones-uavs-proliferation-us-policy/.
[69] Ibid.
[70] Audrey Decker, "How China Is Expanding Its Anti-Satellite Arsenal," Defense One, April 3, 2025, https://www.defenseone.com/threats/2025/04/how-china-expanding-its-anti-satellite-arsenal/404283/.
[71] Cao Siqi, Liu Xuanzun, and Fan Wei, "China Unveils 'drone Killer' Laser Weapon at Airshow China, Can Shoot down Target at Low Cost - Global Times," Global Times, November 11, 2022, https://www.globaltimes.cn/page/202211/1279311.shtml.
[72] Alex Luck, "Chinese Navy Testing Laser Turret On Type 071 LPD," *Naval News* (blog), August 23, 2024, https://www.navalnews.com/naval-news/2024/08/chinese-navy-testing-laser-turret-on-type-071-lpd/.
[73] Joseph Trevithick, "Chinese Laser Anti-Drone System Spotted In Iran," The War Zone, October 7, 2024, https://www.twz.com/air/chinese-laser-anti-drone-system-spotted-in-iran.

Russia's DEW research since the 1960s, emphasizes HELs and ground-based, airborne, and space-borne laser weapons, using both nuclear and solid-propellant generators for several megawatt power levels.[74] Russia's DEWS efforts include the Peresvet laser "dazzler," fielded alongside mobile ICBMs, purportedly to blind satellites or missiles.[75] In 2022, the Russian government announced a follow-on "Zadira" laser, claimed to be capable of destroying drones thermally.[76] The Kremlin is prioritizing next-generation DEWs as part of its military modernization. Peresvet and Zadira assets are the most publicized systems, though sensitive details and status are not publicly known.[77] Russian and Chinese efforts pose technological and strategic challenges for the West, especially as they scale production for asymmetric and A2/AD operations. Iran's DEW efforts remain limited to prototype or demonstration stage, with performance far behind the great powers.[78]

3.4. The Strategic Imperative for the United States

"China now has the world's leading hypersonic arsenal," while "Russia currently has three deployed hypersonic weapon systems, including two that have been used in conflict against Ukraine."[79] These realities highlight the struggle to catch-up with fielding hypersonics.[80] China generally emphasizes mass, while Russia focuses on modernized and exquisite systems.

This divergence complicates the response: countering both quantity and exquisite capability demands tailored solutions. Iran remains a secondary player in this area.

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[74] Janes, "Directed Energy Weapons (DEW)," July 24, 2015, https://customer.janes.com/display/JSWS0532-JSWS.
[75] "Peresvet (Laser Weapon)," in *Wikipedia*, December 29, 2024, https://en.wikipedia.org/w/index.php?title=Peresvet_(laser_weapon)&oldid=1265946959.
[76] Theresa Hitchens, "Don't Be Dazzled by Russia's Laser Weapons Claims: Experts," Breaking Defense, May 19, 2022, http://breakingdefense.com/2022/05/dont-be-dazzled-by-russias-laser-weapons-claims-experts/.
[77] On December 1st, 2019, Minister of Defense of Russia Sergei Shoigu announced that Peresvet was deployed with five divisions of the Strategic Missile Forces with road-mobile ICBMs to cover their maneuvers.
[78] Joseph Trevithick, "Chinese Laser Anti-Drone System Spotted In Iran."
[79]Josh Luckenbaugh, Testing Top of Mind as U.S. Lags China In Hypersonics.
[80] Amy McCullough, "The U.S. Is Playing Catch-Up on Hypersonics. Here's How.," Air & Space Forces Magazine, March 25, 2021, https://www.airandspaceforces.com/the-u-s-is-playing-catch-up-on-hypersonics-heres-how/.

The future operational environment will likely be saturated with DEW, hypersonic, and drone-enabled weapons. These technologies will define the next generation of military capability. U.S. and allied governments must sustain and expand investment in these weapons to secure technological relevance and ensure credible countermeasures.

4. Stakeholder Interests

Primary stakeholders in developing these weapons include U.S. government agencies such as the Office of the Under Secretaries of Defense for Research and Engineering (USD(R&E)), Acquisition and Sustainment (USD(A&S)), the Defense Advanced Research Projects Agency (DARPA), the Missile Defense Agency (MDA), and Service-level development organizations such as the Air Force Materiel Command (AFMC), Naval Surface Warfare Center (NSWC), and Army RCCTO. Warfighting requirement stakeholders include the Combatant Commands, Services, and the Joint Chiefs of Staff.

Congress plays a pivotal role as both funder and policymaker, shaping program authorizations, appropriations, and oversight that influence priorities, timelines, and industrial base decisions. Congressional committees, particularly the Armed Services and Appropriations Committees, serve as gatekeepers and oversight for large-scale investments, program continuations, and regulatory reforms affecting defense innovation and production capacity. Their legislative mandates and political considerations make them a critical external stakeholder with direct influence over program scope and funding stability.

U.S. and international defense contractors range from startups to major firms and are both publicly traded and privately held. In recent decades, a small number of major defense firms dominated the weapons industry, but in recent years, smaller, more agile companies entered the market and expanded the competitive landscape.

During the Industry Study, in-depth analysis was conducted on the business models of BAE, RTX, Boeing, Northrop Grumman, Leidos, and Thales. The course also explored several small companies, as shown on pages 3 and 4.

4.1. Foreign Military Sales

FMS have become a key instrument of U.S. power projection, linking the defense industry, diplomacy, and alliances. In FY2024, U.S. FMS approvals exceeded $117.9 billion, reflecting robust global demand for American systems amid rising geopolitical threats.[81]

Drones dominate recent U.S. exports. Systems like the MQ-9 Reaper have been delivered to allies, including the U.K., Italy, France,[82] and Taiwan.[83] However, a CNAS report[84] highlights that since 2018, Türkiye, China, and the United States collectively made 69 armed drone sales to 40 countries. Türkiye accounted for 65%, China 26%, and the United States just 8%. Türkiye and China capitalized on fewer restrictions and faster delivery timelines, prompting some partners to bypass U.S. providers for quicker access, mostly related to US policy regarding drone's export.[85]

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[81] Bureau of Political-Military Affairs, "Fiscal Year 2024 U.S. Arms Transfers and Defense Trade," *United States Department of State* (blog), January 24, 2025, https://www.state.gov/fiscal-year-2024-u-s-arms-transfers-and-defense-trade/.
[82] Wiley Stickney, "Unmanned Dominance: The General Atomics MQ-9 Reaper and Its Strategic Evolution - Bolt Flight," Bolt Flight, April 24, 2025, https://boltflight.com/unmanned-dominance-the-general-atomics-mq-9-reaper-and-its-strategic-evolution/.
[83] Kris Osborn, "Why China Is Afraid—America's MQ-9 Reaper Drone Is Coming to Taiwan," The National Interest, May 27, 2021, https://nationalinterest.org/blog/reboot/why-china-afraid-americas-mq-9-reaper-drone-coming-taiwan-186185.
[84] Molly Campbell, "Drone Proliferation Dataset" (Center for a New American Security, September 10, 2024), https://www.cnas.org/publications/reports/drone-proliferation-dataset.
[85] Bureau of Political-Military Affairs, "U.S. Policy on the Export of Unmanned Aerial Systems," *United States Department of State* (blog), accessed May 5, 2025, https://2017-2021.state.gov/u-s-policy-on-the-export-of-unmanned-aerial-systems-2/.

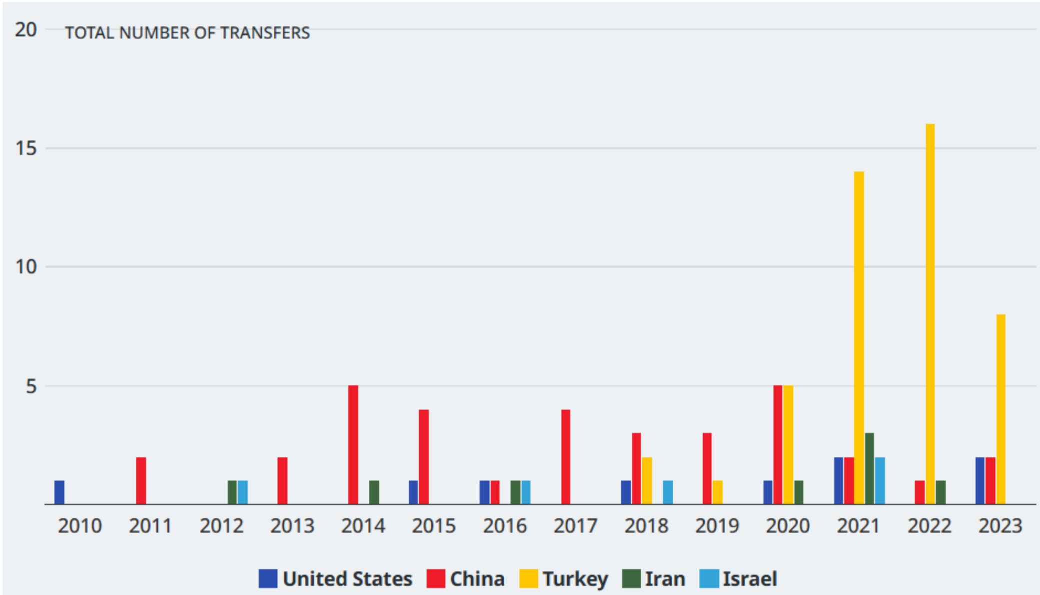

Figure 8. Armed Drone Transfers, 2010-2023
Source: Molly Campbell, "Drone Proliferation Dataset" (Center for a New American Security, September 10, 2024)

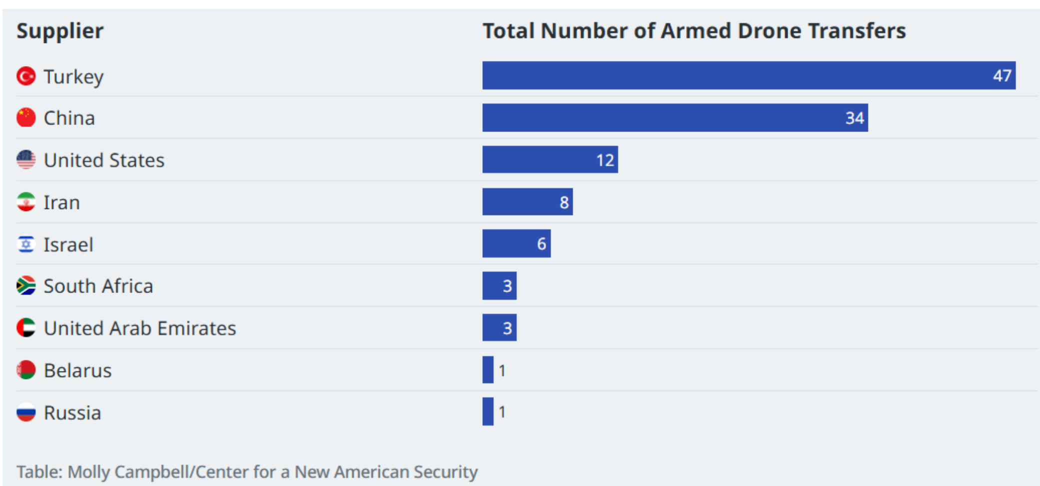

Figure 9. All Armed Drone Suppliers, 1995-2023
Source: Molly Campbell, "Drone Proliferation Dataset" (Center for a New American Security, September 10, 2024)

Exports of hypersonics and DEWs remain limited. Arms control agreements like the Missile Technology Control Regime (MTCR) restrict U.S. sales of these technologies.[86] No

[86] The White House, "FACT SHEET: Biden-Harris Administration Introduces New Guidance for Missile Technology Exports to Advance Nonproliferation Goals and Bolster Allied Defense Capabilities," The White House, January 7, 2025, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2025/01/07/fact-

hypersonics have yet been sold; DEWs remain at prototype stages. Still, allies are increasingly push for co-development roles, especially under partnerships like AUKUS Pillar II.[87]

The FMS process itself faces scrutiny. Delays of 12 to 36 months frustrate allies and open opportunities for strategic competitors. Defense firms like Lockheed Martin and General Atomics are lobbying for streamlined, flexible procedures to maintain U.S. competitiveness.[88]

Meanwhile, business-government dynamics are shifting. Industry seeks a more risk-tolerant export policy, the government must weigh alliance needs against technology security. Reform efforts are underway but progressing slowly.

In today's strategic environment, FMS is no longer merely an arms transfer tool but a test of influence, trust, and timeliness. If the United States cannot swiftly equip allies with next-generation systems, it risks falling behind in capability and credibility as they turn elsewhere.

4.2. R&D

The United States invests heavily in next-generation defense technologies, but R&D success increasingly hinges on speed and scalability.[89] In FY2024, the Pentagon requested over $11 billion for hypersonics, reflecting urgency as China and Russia field operational systems like the DF-17 and Avangard while U.S. programs remain in testing.[90]

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sheet-biden-harris-administration-introduces-new-guidance-for-missile-technology-exports-to-advance-nonproliferation-goals-and-bolster-allied-defense-capabilities/.

[87] "Breaking the Barriers: Reforming US Export Controls to Realise the Potential of AUKUS," United States Studies Center, May 17, 2023, https://www.ussc.edu.au/breaking-the-barriers-reforming-us-export-controls-to-realise-the-potential-of-aukus.

[88] Michael T. Klare, "Competition for Defense Contracts May Drive Divides Within Trump's Inner Circle," Truthout, February 10, 2025, https://truthout.org/articles/competition-for-defense-contracts-may-drive-divides-within-trumps-inner-circle/.

[89] Dale Swartz, Ryan Brukardt, and Karl Hujsak, "Creating a Modernized Defense Technology Frontier," McKinsey & Company, February 12, 2025, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/creating-a-modernized-defense-technology-frontier.

[90] Kelley M. Sayler, "Hypersonic Weapons: Background and Issues for Congress" (Congressional Research Service, February 11, 2025), https://sgp.fas.org/crs/weapons/R45811.pdf.

The Army's Long-Range Hypersonic Weapon[91] and the Navy's Conventional Prompt Strike (CPS) lead the charge, but despite rising funding, program fragility has delayed progress.[92]

In DEWs, systems like the Navy's HELIOS and the Army's IFPC-HEL promise counter-drone and missile defense yet struggle to move from prototypes to operational use.[93] DEWs face persistent hurdles in power generation, material science, and ruggedization.

Drone R&D, however, thrives. Firms like Anduril, Skydio, and Shield AI rapidly translate commercial innovation into defense, aided by streamlined acquisition channels like DIU and AFWERX.[94] Anduril's $1.5 billion DoD contract signals growing confidence in agile, non-traditional defense developers.[95] Similarly, its recent $642 million, 10-year contract with the Marine Corps to deliver counter-UAS systems further cements its role as a major player in defense innovation.[96]

Nevertheless, across all three domains, mobilization readiness remains a weak link. Critical materials, skilled labor, and secure manufacturing capacity remain insufficient. The Pentagon's response, with academic partnerships, industrial revitalization, and regional tech hubs, is underway but incomplete.

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[91] "Army Announces Official Name for Its Long-Range Hypersonic Weapon," U.S. Department of Defense, April 24, 2025, https://www.defense.gov/News/Releases/Release/Article/4164997/army-announces-official-name-for-its-long-range-hypersonic-weapon/.

[92] "Dark Eagle LRHW Hypersonic Missile," Global Defense News - Army Recognition Group, April 20, 2025, https://www.armyrecognition.com/military-products/army/missiles/hypersonic-missiles/dark-eagle-lrhw-hypersonic-missile.

[93] Joe Saballa, "US Navy's Burke-Class Destroyer Unleashes HELIOS Laser in Breathtaking New Photo," *The Defense Post* (blog), February 4, 2025, https://thedefensepost.com/2025/02/04/us-navy-helios-laser/.

[94] Hugo Mollet, "Anduril, Skydio and Applied Intuition: The Rise of Defense Startups in the United States," Actu.ai, February 19, 2025, https://actu.ai/en/anduril-skydio-and-applied-intuition-the-rise-of-defense-startups-in-the-united-states-20193.html.

[95] Satyabrata Kar, "Airforce Technology Excellence Awards 2024: Anduril Industries," *Airforce Technology* (blog), November 25, 2024, https://www.airforce-technology.com/excellence-awards/featured-company/2024-anduril-industries/.

[96] Anduril Industries, "Anduril Awarded 10-Year $642M Program of Record to Deliver CUAS Systems for U.S. Marine Corps," March 13, 2025, https://www.anduril.com/anduril-awarded-10-year-642m-program-of-record-to-deliver-cuas-systems-for-u-s-marine-corps/.

In this landscape, stakeholder interests are converging. Industry demands production incentives and fewer barriers; the government needs a rapid transition from R&D to fielded capability. Success depends on U.S. innovation and delivery speed. Public-private incentives, such as multiyear procurement contracts, tax credits, advance market commitments, and cooperative agreements, provide mechanisms to align these interests by lowering production risk for firms while accelerating fielding timelines for the government.[97] These incentives create shared confidence in scaling production capacity and reducing industrial fragility.

4.3. Jointness

For over thirty years, the DoD has prioritized jointness to enhance U.S. military effectiveness.[98] In weapons development, this effort emphasizes interoperability across services and reducing duplicative efforts in acquiring exquisite systems, especially amid defense industrial base (DIB) constraints.[99]

With the shift to the Indo-Pacific theater and China as the number one pacing challenge, U.S. focus shifted toward systems tailored for this environment, such as underwater drones and hypersonics. To achieve this, the DoD must issue a clear demand signal to industry, nested within an effective strategy aligned with political aims.

Collaborative investment in hypersonics is essential since these weapons enable joint long-range strike capabilities but are very expensive.[100] In 2023, the Congressional Budget Office estimated producing 300 AGM-183A Air-Launched Rapid Response Weapon (ARRW)

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97 "National Defense Industrial Strategy (NDIS)" (OUSD A&S, November 16, 2023).
98 Mark Cozad et al., "Rethinking Jointness? The Strategic Value of Jointness in Major Power Competition and Conflict" (RAND Corporation, September 5, 2023), https://www.rand.org/content/dam/rand/pubs/research_reports/RRA1500/RRA1560-1/RAND_RRA1560-1.pdf.
99 Mark Cozad et al.
100 Eric Tegler, "Is DoD's Approach To Buying Hypersonic Weapons Too Expensive?," Forbes, January 4, 2024, https://www.forbes.com/sites/erictegler/2024/01/04/is-dods-approach-to-buying-hypersonic-weapons-too-expensive/.

hypersonic boost-glide weapons by Lockheed Martin would cost $5.3 billion.[101] For DEWs, the supply chains remain limited, producing small quantities with long lead times.[102]

Thus, the services must clearly communicate future requirements and collaborate across the joint force to ensure the DoD fields the correct weapon systems to deter and potentially fight adversaries.

4.4. Allies & Partners

Strong, mutually-beneficial alliances and partnerships are central to U.S. national security, and this has remained true across different administrations and changing eras of geopolitics. The 2022 National Defense Strategy declared, "Close collaboration with Allies and partners is foundational for U.S. national security interests and for our collective ability to address the challenges that [China] and Russia present, while responsibly managing the array of other threats we face."[103] Similarly, the 2018 National Defense Strategy asserted that "a more lethal, resilient, and rapidly innovating Joint Force, [104], will sustain American influence and ensure favorable balances of power that safeguard the free and open international order." To enable peace through strength, the United States must collaborate with its allies and partners to ensure each is equipped with effective, modern weapon systems. This collaboration must go beyond sales to include joint development, production, and operations to create the synergistic effects of a multinational industrial base and interoperable military forces.

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[101] Eric Tegler.
[102] Rebecca Wostenberg, Wilson Miles, and Jordan Chase, "Directed Energy Weapon Supply Chains: Securing the Path to the Future" (Emerging Technology Institute, NDIA, January 2024), https://www.emergingtechnologiesinstitute.org/-/media/ndia-eti/reports/directed-energy-weapon-supply-chains/directedenergyweaponsreportdeeti.pdf.
[103] Lloyd Austin, "2022 National Defense Strategy of The United States of America," October 27, 2022, 14, https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf.
[104] Christine Wormuth, "The Role of Allies and Partners in U.S. Military Strategy and Operations" (RAND Corporation, September 23, 2020), https://www.rand.org/content/dam/rand/pubs/testimonies/CTA800/CTA867-1/RAND_CTA867-1.pdf.

This was evident in U.S. support for Ukraine's defense against Russia. The United States spent $13 billion in 2022 supplying Ukraine with weapons, including drones that proved vital to Ukraine's fight.[105] One American firm, Neros, won a contract in early 2025 to supply 6,000 FPV attack drones to Ukraine over six months, the highest number ever for a U.S. company.[106]

Beyond drones, collaboration with allies and partners on DEWS production is crucial. Nearshoring opportunities with countries like Australia provide access to critical raw materials otherwise dominated by China, while offering real-world testing environments.[107] However, foreign sales processes must be streamlined for such efforts to succeed. Concurrently, export controls and the classification protocols must also be reevaluated to increase transparency among international partners on system capabilities.[108]

5. Industry Analysis through Porter's Five Forces Framework

Emerging technologies are reshaping modern warfare. Using Michael Porter's Five Forces framework, this paper analyzes the strategic environment of drones, DEWS, and hypersonic weapons, focusing on competitive dynamics, entry barriers, supplier and buyer power, and substitution potential. While these technologies differ in maturity and application, each plays a critical role in future defense postures.

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[105] Jordan Williams, "Here's Every Weapon US Has Supplied to Ukraine with $13 Billion," The Hill, August 26, 2022, https://thehill.com/policy/defense/3597492-heres-every-weapon-us-has-supplied-to-ukraine-with-13-billion/.
[106] David Hambling, "Neros Wins Contract To Send 6,000 American-Made Drones To Ukraine," Forbes, February 21, 2025, https://www.forbes.com/sites/davidhambling/2025/02/21/neros-wins-contract-to-send-6000-american-made-drones-to-ukraine/.
[107] Rebecca Wostenberg, Wilson Miles, and Jordan Chase, "Directed Energy Weapon Supply Chains: Securing the Path to the Future," January 2024.
[108] Rebecca Wostenberg, Wilson Miles, and Jordan Chase.

5.1. Industry Rivalry

Military Drones. The military drone market is intensely competitive. Over 300 small firms compete alongside traditional U.S. defense suppliers like General Atomics and Huntington Ingalls Industries. Agile startups like Red Cat and Anduril have disrupted the market by emphasizing modularity, cost-efficiency, and rapid operational feedback. The global market is projected to grow from $14 billion to $47 billion by 2030, fueling further competitive pressures.[109] Sustained growth will compel firms to innovate quickly and differentiate to remain viable.

Hypersonic and DEWs. Rivalry in these sectors is equally fierce, driven by geopolitical competition among major powers. Hypersonics have become crucial for strategic deterrence, with the United States, China, and Russia racing to deploy operational systems. DEW competition is growing as firms seek to prove battlefield performance. U.S. primes such as Lockheed Martin, RTX, and Northrop Grumman dominate both sectors, intensifying internal competition as they race to deliver cutting-edge capabilities.[110] Rivalries between companies can offer buyers more options and reduce prices, but the effective oligopoly for these exquisite defense technologies keeps prices relatively high.

5.2. Threat of New Entrants

Military Drones. Defense markets traditionally pose high entry barriers due to capital, security, and technical requirements, but the military drone market has become more accessible.

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[109] "Military Drone Market Size, Share, Industry Growth Report [2032]," Fortune Business Insights, April 14, 2025, https://www.fortunebusinessinsights.com/military-drone-market-102181.
[110] Rebecca Wostenberg et al., "Hypersonics Supply Chains: Securing the Path to the Future" (Emerging Technologies Institute (NDIA), May 2023), https://www.ndia.org/-/media/ndia-eti/reports/hypersonics/hypersonics-supply-chain-reportfinal2.pdf.

Regulatory hurdles and capital requirements remain, but programs like the Defense Innovation Unit's Enterprise Test Vehicle initiative have cut procurement timelines from 12 to 15 years to under two.[111] This shift, along with the growing availability and acceptability of dual-use commercial technologies, lowers barriers to entry and enables smaller firms to compete effectively—making the threat of new entrants high.

Hypersonic and DEWs. Entry barriers remain steep due to extreme technological and regulatory barriers. Hypersonics require expertise in materials science, propulsion, and thermal management. DEWs need mastery in energy storage, beam control, and targeting. Only firms with the resources, security clearances, and government trust can compete at scale. Modular technologies may eventually lower barriers for niche DEW components, but core platforms remain inaccessible to most newcomers.[112] The capital-intensive nature of both sectors favors established defense contractors.

5.3. Bargaining Power of Suppliers

Military Drones. Supplier power varies. The sector relies on global supply chains, notably for components like semiconductors. While China dominates 80% of the global commercial drone market, Ukraine has emerged as a significant military drone producer, delivering over 1.3 million in 2024. This diversification and competition among roughly 300

[111] Mikayla Measley, "DIU, Air Force Move Forward with 2 Vendors to next Phase of Enterprise Test Vehicle Program," *DefenseScoop* (blog), March 5, 2025, https://defensescoop.com/2025/03/05/anduril-zone-5-enterprise-test-vehicle-franklin/.
[112] "NDIS 2023."

military drone firms reduces supplier power to moderate or low.[113] The presence of numerous military drone firms fosters competition while diminishing individual supplier influence.

Hypersonic and DEWs. Supplier bargaining power is high. Scarcity of thermal-resistant materials, high-powered energy systems, and scarce raw materials grants suppliers leverage. Delays in component supplies can stall programs. Few alternative suppliers meet military standards, deepening dependency. Aerojet Rocketdyne, for example, plays a pivotal role in hypersonic propulsion, bolstered by a $22 million DoD contract to streamline scramjet manufacturing. A limited supplier pool constrains costs and timeliness.[114]

5.4. Bargaining Power of Buyers

In all three sectors, buyers, governments wield high bargaining power. Defense agencies like the DoD control funding and dictate specifications, delivery timelines, export regulations, foreign supply sourcing policies, and performance standards.

Military Drones. Procurement remains highly centralized, with buyers demanding rapid innovation that balances cost with effectiveness. Ukraine's battlefield experience underscores the value of flexible, low-cost acquisition models to accelerate deployment and innovation under combat conditions[115] Buyer power increases when commercial markets exist and governments are willing to adopt commercial off-the-shelf (COTS) drones and components. Commercial

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[113] Thibault Spirlet, "Ukraine Says It's Taken the Top Spot in the Race to Make Combat Drones," Business Insider, February 25, 2025, https://www.businessinsider.com/ukraine-says-world-largest-producer-tactical-strategic-drones-war-russia-2025-2.
[114] Evan Beebe, "The Latest on Additive Manufacturing in Hypersonics," Institute for Defense & Government Advancement, May 28, 2024, https://www.idga.org/command-and-control/articles/latest-on-additive-manufacturing-in-hypersonics.
[115] Thibault Spirlet, "Ukraine Says It's Taken the Top Spot in the Race to Make Combat Drones."

markets introduce new competition that shifts the market dynamics in the buyer's favor. However, government restrictions on the application of COTS products to certain military uses diminishes competition, increases costs, and narrows supply chains. These types of restrictions can create additional risks for buyers.

Hypersonic and DEWs. The DoD's monopsony is even more pronounced here. Hypersonic projects like the Conventional Prompt Strike (CPS) and DEWs initiatives like DE M-SHORAD illustrate how government buyers shape entire markets.[116] However, once committed, switching vendors carries high switching costs. Buyers cannot easily switch vendors without risking very high costs and strategic setbacks. While open architectures and modularity can reduce some risks, this dynamic simultaneously empowers and limits buyer leverage.

5.5. Threat of Substitutes

Military Drones. The threat of substitutes for military drones is low. While manned operations can perform missions like ISR and strike, their cost, risk to personnel, and logistical burden make them less viable. Ukraine's current battlefield showcases how drones are replacing traditional combatants entirely. One Russian soldier who surrendered to the Ukrainians said, "I did not see a single Ukrainian soldier… Only drones, and there are lots of them."[117] Future applications, such

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[116] U. S. Government Accountability Office, "Hypersonic Weapons: DOD Could Reduce Cost and Schedule Risks by Following Leading Practices | U.S. GAO" (GAO, July 29, 2024), https://www.gao.gov/assets/gao-24-106792.pdf.

[117] Kateryna Bondar, "Ukraine's Future Vision and Current Capabilities for Waging AI-Enabled Autonomous Warfare" (CSIS, March 6, 2025), https://csis-website-prod.s3.amazonaws.com/s3fs-public/2025-03/250306_Bondar_Autonomy_AI.pdf.

as Collaborative Combat Aircraft (CCA)[118], the Lionfish Small UUV (SUUV)[119], and the Global Autonomous Reconnaissance Craft (GARC) USV[120] further solidify the drones as indispensable.

Hypersonics and DEWs. The threat of substitutes varies. Hypersonics outperform ballistic and cruise missiles in speed and maneuverability, increasing their utility against modern Integrated Air Defense Systems (IADS). However, the cost per unit and certain operational considerations may limit inventory size, leading military leaders to favor cheaper alternatives for flexibility. In this sense, purchasing higher numbers of less expensive munitions could be less costly and more battlefield flexible. Thus, various non-hypersonic weapons may serve as possible substitutes for hypersonics.

On the other hand, DEWs are likely to complement rather than replace existing systems in the short term.[121] Decades of DEW investment reflects a lack of adequate substitutes for some of the offensive and defensive missions for which DEWs are optimized, such as counter-UAS and counter-space. The extreme costs of missile defense make DEWs attractive for point defense. Other acoustic, laser, and microwave capabilities, particularly counter-personnel systems, are under development precisely because they provide non-kinetic or reversible effects where no substitute technology exists. DEWs offer lower cost per shot and faster response, but operational challenges like power generation and weather sensitivity remain.

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118 "Collaborative Combat Aircraft (CCA), USA - Airforce Technology," accessed May 3, 2025, https://www.airforce-technology.com/projects/collaborative-combat-aircraft-cca-usa/.
119 Naval News Staff, "HII Delivers Initial Lionfish UUV to U.S. Navy Under Multi-Year Program," *Naval News* (blog), April 19, 2025, https://www.navalnews.com/naval-news/2025/04/hii-delivers-initial-lionfish-uuv-to-u-s-navy-under-multi-year-program/.
120 "Navy Ramping up Production of Autonomous GARC Vessels | DefenseScoop," accessed May 3, 2025, https://defensescoop.com/2025/01/17/navy-garc-global-autonomous-reconnaissance-craft-ramp-up-production/.
121 Kelley M. Sayler et al., "Department of Defense Directed Energy Weapons: Background and Issues for Congress" (Congressional Research Service, July 11, 2024), https://crsreports.congress.gov/product/pdf/R/R46925/8.

5.6. Five Forces Summary

As this analysis shows, as weapons become more exquisite, buyer power increases while supplier options shrink, creating a balance that defines advanced weapons markets. Industry rivalry remains high across drones, DEWs, and hypersonics due to rapid technological advancement, geopolitical competition, and increasing demand for next-generation military capabilities. This competitive pressure fuels innovation and intensifies competition for limited government contracts. However, it does not appear that high buyer power fully drives prices, as the limited number of specialist suppliers for exquisite systems often has a greater effect than the small number of buyers.

Together, these forces reflect a defense technology landscape full of opportunity and fraught with volatility. Long-term success will depend on technological innovation and strategic navigation of market forces, supply chains, regulatory environments, and complex government-defense contractor relations.

6. Mass, Maneuver, and Momentum: A Strategy for Next-Generation Weapons

The United States must recalibrate defense investments to maintain an operational advantage against adversaries while leading allies and partners. **The United States must prioritize affordable mass, including high-volume drone platforms, scalable DEWs, and operationally relevant hypersonic capabilities. This approach can maximize operational effectiveness and utility while minimizing strategic waste through public-private incentives, allied co-development, and streamlined FMS pathways.**[122]

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[122] Seth G. Jones, "Empty Bins in a Wartime Environment: The Challenge to the U.S. Defense Industrial Base" (CSIS, January 2023), https://csis-website-prod.s3.amazonaws.com/s3fs-public/2023-01/230119_Jones_Empty_Bins.pdf.

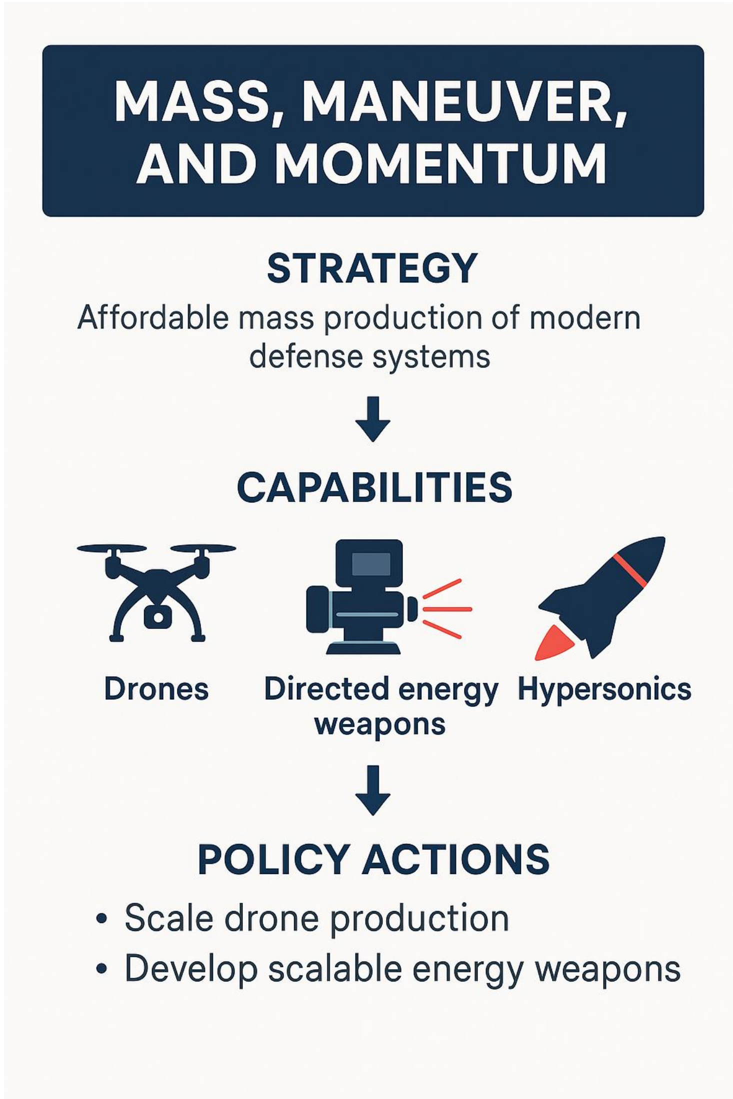

Figure 10. Visual of the Strategy
Source: Picture generated with ChatGPT by Lieutenant Colonel K. Skidmore, April 14, 2025

Modern conflict rewards speed, mass, and survivability. U.S. industrial output cannot sustain a high-intensity conflict without rapid replenishment,[123] and in some scenarios, precision munitions could be depleted within weeks. Meanwhile, adversaries exploit quantity: Russia's drone and missile saturation in Ukraine, Iran's proxy strikes in the Middle East, and China's

[123] Seth G. Jones.

expansion of drone swarms and missile salvos.[124] A War on the Rocks analysis underlines that future victory depends on superior platforms and deploying massed effects at scale.[125]

Drones offer the most straightforward path to rapid, affordable mass production that could enable a shift from exquisite, limited-platform fleets to large numbers of attritable, resilient, low-cost unmanned systems. Attack drones and loitering munitions can saturate adversary defenses, complicate targeting, and extend operational reach without posing risks to manned assets.[126] Massed drones provide persistent surveillance, strike flexibility, and decision-cycle dominance, particularly in contested environments. Recent conflicts show requirements of 3,000 to 5,000 unmanned systems monthly to sustain offensive momentum.[127] Drone investments also address rising personnel costs through force augmentation.[128]

DEWs such as LaWS offer low-cost-per-shot solutions against drone swarms, cruise missiles, and artillery. Unlike kinetic interceptors, DEWs provide persistent defense without depleting missile inventories.[129] Their scalability enables layered defense architectures that can provide both point and localized area defense. DEWs could absorb attacks from multi-target threats, such as swarms, while reducing prohibitive sustainment costs by eliminating reliance on expensive munitions.[130] However, operational testing demonstrates that overcoming power

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[124] Harry Lyons, "The Drone Age: Warfare's Next Chapter," Boundless Discovery, December 3, 2024, https://newsletter.boundlessdiscovery.com/p/the-drone-age-warfare-s-next-chapter.
[125] Michael Horowitz and Joshua Schwartz, "Stealth and Scale: Quality, Quantity, and Modern Military Power," War on the Rocks, December 18, 2024, https://warontherocks.com/2024/12/stealth-and-scale-quality-quantity-and-modern-military-power/.
[126] "Understanding Israel's Aerial Threats and Defensive Capabilities," *Israel Policy Forum* (blog), accessed May 5, 2025, https://israelpolicyforum.org/the-asymmetrical-missile-rocket-drone-paradigm-understanding-israels-aerial-threats-and-defensive-capabilities/.
[127] Michael R. Gordon, "Exclusive | U.S. Army Plans Massive Increase in Its Use of Drones," Wall Street Journal, May 1, 2025, https://www.wsj.com/politics/national-security/us-army-drones-shift-20cc5753.
[128] Edward G. Keating, John Kerman, and David Arthur, "Usage Patterns and Costs of Unmanned Aerial Systems" (Congressional Budget Office, June 2021), https://www.cbo.gov/publication/57260.
[129] Jon Ludwigson, "Directed Energy Weapons, DOD Should Focus on Transition Planning" (United States Government Accountability Office, April 17, 2023), https://www.gao.gov/assets/820/819139.pdf.
[130] Todd South, "This Marine Unit Now Has Its Own Tool to Blast Drones out of the Sky," Marine Corps Times, December 17, 2024, https://www.marinecorpstimes.com/news/your-marine-corps/2024/12/17/this-marine-unit-now-has-its-own-tool-to-blast-drones-out-of-the-sky/.

generation, beam control, and environmental interference remains essential[131] Reducing DEW testing and development overregulation under a Directed Energy Acceleration Authority will help accelerate scaling.

Hypersonics must be rebalanced toward operational value and survivability. The United States should invest to increase the number of hypersonics across all types available to Combatant Commands. HCMs offer tactical advantages in priority theaters. In general, hypersonics offer radar-evading profiles and flexible launch options. Once the costly design and technology maturation is completed, HCMs will be more cost-effective.[132] These systems improve detection avoidance, due to their flight profile, enabling deeper penetration into contested environments and integration into layered strike architectures. Prompt fielding of mature HCM variants would strengthen deterrence through credible first-strike survivability.[133] Investments in defenses against hypersonics could also enhance broader capabilities against a wide range of fast-moving threats.[134] The Atlantic Council notes that hypersonics impose dilemmas on adversaries even before launch.[135] Achieving these effects requires disciplined investment.

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[131] Todd South.
[132] Mikayla Easley, "Physics and Cost Are Shaping Pentagon's Hypersonics Paths," *DefenseScoop* (blog), April 11, 2023, https://defensescoop.com/2023/04/11/physics-and-cost-are-shaping-pentagons-hypersonics-paths/.
[133] Andrew F. Krepinevich Jr., *The Origins of Victory: How Disruptive Military Innovation Determines the Fates of Great Powers* (Yale University Press, 2023), 9-10.
[134] Speier et al., "Hypersonic Missile Nonproliferation."
[135] Michael E. White, "The Hypersonic Imperative," *Atlantic Council* (blog), March 12, 2025, https://www.atlanticcouncil.org/wp-content/uploads/2025/03/The-hypersonic-imperative.pdf.

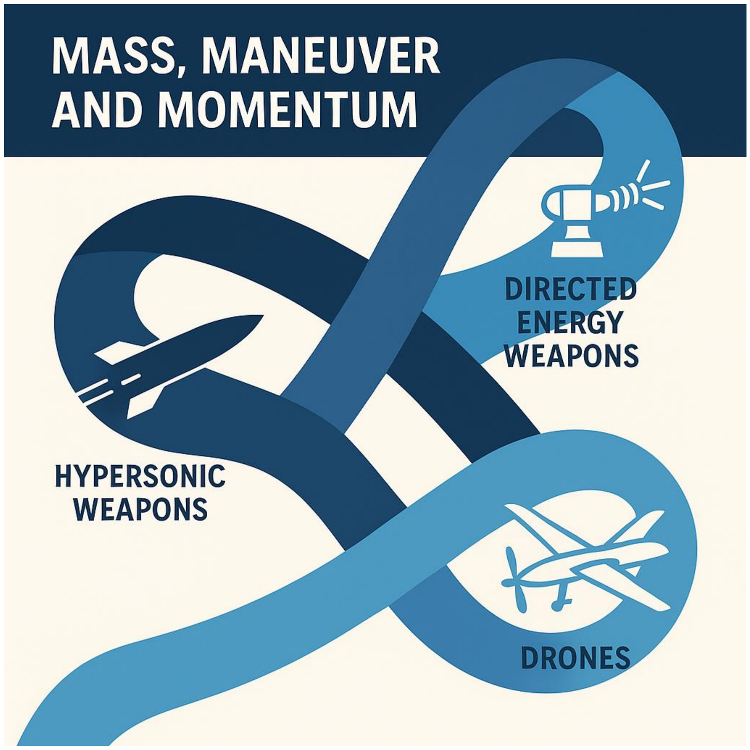

Figure 11. New Arsenal for a New Era
Source: Picture generated with ChatGPT by Lieutenant Colonel K. Skidmore, April 14, 2025

Strategic success requires industrial resilience paired with layered, integrated offense and defense. When mature, DEWs can dominate short-range engagements against drone swarms, low-flying aircraft, incoming artillery, and potentially even missile threats at marginal cost-per-shot, preserving valuable interceptors for more complex threats. Mid-range drones and loitering munitions can saturate enemy defenses while providing ISR coverage and precision strike capabilities.[136] These unmanned systems will complement conventional tube and rocket artillery, creating combined-arms networks that strain adversary responses. Long-range, hypersonic missiles paired with cruise and ballistic missile systems will execute critical strikes against command nodes, forward staging areas, and strategic infrastructure. Traditional munitions

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[136] Michael Horowitz and Joshua Schwartz, "Stealth and Scale."

provide mass, scale, reliability, and proportionate response options.[137] This layered approach would create multiple dilemmas that no single adversary defense can easily counter.

This structure provides strategic depth and operational flexibility. Public-private partnerships must shift from exquisite prototypes to mass manufacturing.[138] A restructured FMS or partnership program is essential for scaling production and funding DIB modernization. Shifting to a proactive "push" system with pre-approved weapons by country tiers would streamline the process.[139] Increasing the FMS surcharge from 3.2% to 5-7% could generate an additional $2.1 to 4.5 billion annually for manufacturing capacity, creating a virtuous cycle where foreign sales strengthen domestic capabilities. An increased surcharge would likely not deter customers,[140] given the surcharge.[141]

This strategy carries risks requiring mitigation. Scaling production too rapidly without sufficient quality control could compromise the reliability and resilience of manufactured products. DEWs face technical maturity barriers,[142] addressable through iterative fielding and modular upgrades. Hypersonics risk becoming fiscal drains without tight alignment between program objectives,[143] requirements, and deliverables. Industrial fragility, particularly in specialized materials and supplier networks, necessitates early investment in critical supply chains and workforce development.[144] The ethical dimension of massed autonomy demands human-in-the-loop oversight to maintain lawful, discriminate force application, while sustaining

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[137] Kelley M. Sayler, “Hypersonic Weapons: Background and Issues for Congress.”
[138] “NDIS 2023.”
[139] Andrew Zang, “FMS as Strategic Industrial Policy” (Eisenhower School, April 20, 2025).
[140] Harrison Stetler, “France’s Weapons Industry Is Growing Rich off Dictatorships,” *Jacobin*, June 11, 2022, https://jacobin.com/2022/11/france-arms-exports-authoritarian-europe-military-industrial-complex.
[141] Thomas Verchere, Personal Interview with French Liason Officer with OUSD(R&E), Signal, April 16, 2025.
[142] Jon Ludwigson, “Directed Energy Weapons, DOD Should Focus on Transition Planning.”
[143] Kelley M. Sayler, “Hypersonic Weapons: Background and Issues for Congress.”
[144] “NDIS 2023.”

human operational resilience against AI degradation.[145] while maintaining human operational resilience against AI degradation.[146]

This strategy balances layered defense, massed offense, and credible long-range strike capabilities to achieve operational depth and flexibility. While other critical weapon systems remain essential across the force, this analysis focuses on drones, directed energy weapons, and hypersonic systems as key drivers of mass and agility within the scope of the Weapons Industry Study. It builds a formidable and integrated precision-mass weapons ecosystem by combining layers of affordable and exquisite systems. Allied and partner collaboration supports reshoring critical production, expanding industrial capacity, and co-developing next-generation technologies. At the same time, ethical constraints and adherence to international humanitarian law remain important considerations in allied integration.[147] Adaptive acquisition processes accelerate innovation, industrial scaling, and integration across allied and partner networks. Together, these efforts ensure that the United States and its allies maintain a decisive operational and technological edge in future conflict.

7. Rewiring the Arsenal: Policy Actions for Industrial Agility and Strategic Scale

To realize this strategic vision, the United States must implement policy reforms transitioning from legacy acquisition to an agile, scalable ecosystem. These reforms must align industrial capabilities with operational demand and ensure U.S. military advantage through sustainable mass and layered deterrence.

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145 Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: W. W. Norton, 2018).
146 Maya Posch, "Why AI Usage May Degrade Human Cognition And Blunt Critical Thinking Skills," Hackaday, February 13, 2025, https://hackaday.com/2025/02/13/why-ai-usage-may-degrade-human-cognition-and-blunt-critical-thinking-skills/.
147 Brian Bothwell, "Science & Tech Spotlight: Directed Energy Weapons" (GAO, May 25, 2023), https://www.gao.gov/assets/830/825926.pdf.

7.1. U.S. Government Actions: Realignment of Statutes, Resources, and Regulation

7.1.1. Divest Legacy Platforms to Fund Strategic Mass

The persistence of platform-centric statutory mandates undermines the transition to scalable capabilities. Reducing funding for legacy platforms could free up resources for investments that support updated doctrine. For example, despite mounting evidence that large surface vessels are increasingly vulnerable, Congress continues to mandate 11 aircraft carriers.[148,149] Four Nimitz-class carriers should be decommissioned, and future Ford-class construction should be paused unless already under contract. This could free approximately $17 billion in funding.[150] The cost of a single Ford-class carrier could fund over 150,000 tactical drones, underscoring the opportunity cost of legacy investments.[151,152]

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148 "10 U.S.C., United States Code, 2019 Edition, Title 10 - ARMED FORCES, Subtitle C - Navy and Marine Corps, PART I – ORGANIZATION, CHAPTER 807 - COMPOSITION OF THE DEPARTMENT OF THE NAVY, Sec. 8062 - United States Navy: Composition; Functions" (the U.S. Government Publishing Office), accessed May 5, 2025, https://www.govinfo.gov/content/pkg/USCODE-2019-title10/html/USCODE-2019-title10-subtitleC-partI-chap807-sec8062.htm.

149 Dmitry Filipoff, "Fighting DMO, Pt. 8: China's Anti-Ship Firepower and Mass Firing Schemes | Center for International Maritime Security," May 1, 2023, https://cimsec.org/fighting-dmo-pt-8-chinas-anti-ship-firepower-and-mass-firing-schemes/.

150 Brent M. Eastwood, "Nimitz-Class Aircraft Carriers, Explained: Capabilities, Challenges, and Strategic Importance," *National Security Journal* (blog), July 9, 2024, https://nationalsecurityjournal.org/nimitz-class-aircraft-carriers-explained-capabilities-challenges-and-strategic-importance/.

151 Stavros Atlamazoglou, "The Ford-Class Might Be The Last U.S. Navy Aircraft Carriers - The National Interest," The National Interest, November 10, 2024, https://nationalinterest.org/blog/buzz/ford-class-might-be-last-us-navy-aircraft-carriers-211228.

152 Brandi Vincent, "US Considers Israeli Request for Hundreds of Switchblade 600 Attack Drones," *DefenseScoop* (blog), November 8, 2023, https://defensescoop.com/2023/11/07/us-considers-israeli-request-for-hundreds-of-switchblade-600-attack-drones/.

Figure 12. Affordable Mass Trade-off
Source: Collage made by CDR C. Norman, May 5, 2025

These resources should be reallocated to scale attritable, autonomous drones across all domains. Using a formal 1:10 R&D-to-production funding ratio will allow DoD to prototype and mass produce drones at a pace aligned with operational demands; this manufacturing support addresses a chronic gap in defense innovation.[153] Rewriting statutory mandates will require bipartisan legislative engagement and coordination with the Navy and other service force planners.

The principal risks of reduced global response flexibility can be mitigated through enhanced deployment of distributed unmanned systems, dynamic force employment, persistent ISR assets, and investments in undersea unmanned vehicles that deliver superior operational effects at lower

[153] "NDIS 2023."

cost. In addition, expanding prepositioned assets and leveraging allied naval capabilities in non-priority theaters will be key mitigation efforts. Another risk is the significant political resistance from carrier-dependent constituencies. To combat this risk, investments in unmanned maritime systems to preserve naval industrial jobs and modernize the fleet will be important initiatives.

7.1.2. Monetize Legacy Systems via Enhanced Foreign Military Sales (FMS)

Beyond decommissioning irrelevant assets, monetizing unneeded systems through FMS can generate resources for modernization while strengthening ally and partner capabilities. There are recent cases of defense companies that have taken risks by using their own funds prior to contract approvals to procure resources needed to support FMS cases because the process moved too slowly. It is unrealistic for the government to rely on companies to use their own money in this manner. By forcing companies to front costs without certainty of reimbursement, the government effectively shifts financial risk to private firms, tying up their capital in uncertain outcomes. Beyond program risk, this represents an inefficient use of capital that drains resources from other business priorities – potentially undermining DIB stability at scale. Sluggish U.S. processes and slow delivery can also drive partners to turn elsewhere. Legislation establishing a dedicated "Legacy-to-Future Fund" would ensure FMS proceeds directly support next-generation systems rather than being absorbed into general accounts.[154]

A key risk is that partners acquiring divested legacy systems will expect U.S. sustainment support, inadvertently diverting resources from modernization priorities. Policy must pair sales with clear timelines for maintenance and spares phase-out to avoid indefinite legacy dependencies.

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[154] This fund should prioritize investments in drone production capacity, DEWs scaling, and hypersonic cruise missile development to create a virtuous cycle of divestiture and reinvestment. The implementation challenges of export approval timelines, end-user restrictions, and bureaucratic friction require streamlined interagency processes for systems already declared surplus to U.S. needs.

7.1.3. Reform Regulatory Barriers to Directed Energy Testing and Fielding

While DEWs technological readiness has improved, excessive regulations limit real-world testing compared to kinetic systems. Congress should establish a Fielding Acceleration Authority to allow limited operational deployment with NEPA exemptions and pre-approved facilities or geographical areas where DEW testing is fast-tracked. Operational experimentation is integral to iterative improvement and not only final validation. This would accelerate the deployment of short-range DEWs critical for counter-drone, counter-artillery, and air defense capabilities. To mitigate opposition, DoD must demonstrate safety through testing and transparency around sites and results; proactive stakeholder engagement and compensation mechanisms will be critical to sustain public and political support.

7.1.4. Transform Foreign Military Sales from Process to Strategic Asset

Restructure FMS with a tiered country framework that pre-categorizes nations and weapon systems, replacing individual Congressional notifications with an annual FMS authorization. Increase the administrative surcharge from 3.2% to 5%, directing the differential to manufacturing investments through a dedicated "Legacy-to-Future Fund." Implement standardized co-production templates with allies to distribute manufacturing while protecting U.S. intellectual property. At the same time, streamlining FMS notifications risks perceptions of weakened legislative oversight; mitigation requires annual Congressional briefings and opt-out provisions to preserve transparency and accountability.

7.2. Department of Defense Actions: Reform Acquisition and Cultural Barriers

7.2.1. Rebalance Hypersonic Investment Toward Cruise Systems and Defense

DoD should continue or increase funding for the development, testing and fielding of all types of hypersonics. Funding should prioritize HCM due to their superior survivability, superior expected cost-per-effect, and broader spectrum of delivery platforms. This rebalancing should target a 60/40 split between HCM and HGV by FY27. Hypersonic defense must be elevated to co-equal priority, with investments in sensing networks, counter-hypersonic interceptors, and AI-enhanced tracking for a future GD4A capable of neutralizing ballistic missile threats.[155]

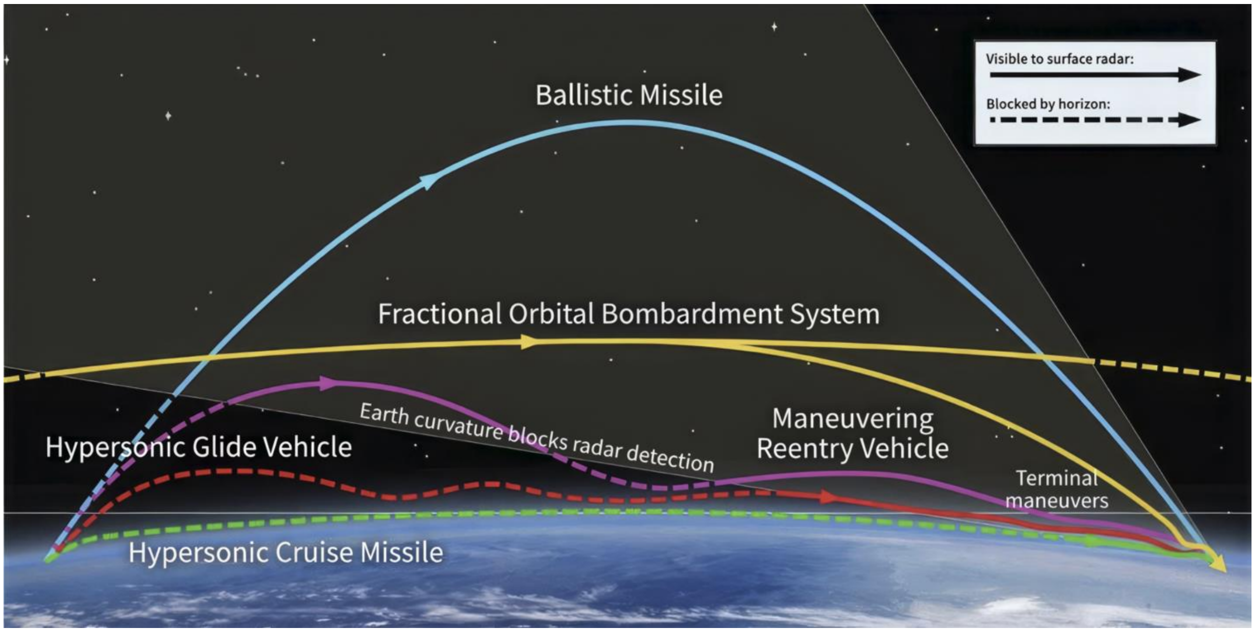

Figure 13. Counter-detection advantage of HCMs
Source: David Roza, "Why Hypersonic Missiles' Greatest Strength Also Makes Them Vulnerable: New Report," Air & Space Forces Magazine, December 20, 2023

7.2.2. Institutionalize Unmanned Systems to Offset Personnel Costs

[155] This could serve as a deterrent substitute if nuclear missile viability is eroded. The GD4A should not be seen as a defensive hedge alone, but as a pace-setting framework that reshapes adversary calculations.

With 41% of DoD's budget in pay and benefits, unmanned systems offer a structural response to rising personnel costs and recruitment challenges.[156] Current models fail to treat autonomy as a workforce offset. DoD should codify autonomous systems as a force structure offset in the FYDP with specific unmanned-to-manned replacement ratios by mission type and operational environment. This requires CONOPS revisions for attritable mass, expanded remote operator training and tools, and a clear manned-unmanned teaming doctrine. Risks of immature autonomy technology and ethical concerns can be mitigated through human-in-the-loop requirements for lethal systems and context-specific autonomy protocols. Institutionalizing unmanned offsets also risks atrophy of human expertise in high-end missions; policies must sustain training pipelines for manned operations alongside autonomy integration. While technology may not be mature enough today to fully implement workforce offsets, incorporating the concept now sets the Department up to react quickly to future capabilities.

7.2.3. Disrupt Cultural Bias Toward Legacy Vendors and Acquisition Patterns

Many acquisition leaders remain biased toward traditional primes, broadly accepting lengthy timelines and risk aversion as truisms in defense procurement. Policy should mandate that each major acquisition program includes at least one non-traditional vendor with milestone-linked compliance. The fail-fast culture of firms like Anduril—iterating designs rapidly and accepting failure as progress—contrasts sharply with DoD's historical risk aversion.[157] This mindset must change.

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[156] Mackenzie Eaglen, "The Paradox of Scarcity in a Defense Budget of Largesse," *American Enterprise Institute - AEI* (blog), July 18, 2022, https://www.aei.org/research-products/report/the-paradox-of-scarcity-in-a-defense-budget-of-largesse/.

[157] Anne Wainscott-Sargent, "Aerospace's Innovation Disruptors – Anduril, Astroscale, and Electra Define Innovation and What It Means for Their Companies," Aerospace America, April 7, 2025, https://aerospaceamerica.aiaa.org/institute/aerospaces-innovation-disruptors-anduril-astroscale-and-electra-define-innovation-and-what-it-means-for-their-companies/.

DoD should integrate innovation unit staff[158] into program offices to inject agile practices. Disruption to program continuity and vendor friction are acceptable tradeoffs for increased competition, innovation, and risk diversification if they achieve improved outcomes and faster fielding. Non-traditional firms may also lack infrastructure to sustain large-scale fielding or meet mission assurance standards; policy must pair innovation incentives with phased maturity pathways to transition to high-reliability production. Non-traditional firms may also lack infrastructure to sustain large-scale fielding or meet mission assurance standards; policy must pair innovation incentives with phased maturity pathways to transition to high-reliability production.

7.2.4. Mandate Exportability as a Key Performance Parameter

Require an FMS Key Performance Parameter for most new major weapons systems with exportable variants designed from inception. This distributes development costs across a larger production base while incentivizing modular systems with appropriate security partitioning to avoid export-constraining overclassification. Embedding exportability as a core parameter risks tradeoffs in system sophistication, intellectual property, and security; mitigation requires modular export controls and dual-track development of exportable and domestic-only configurations.

[158] Staff from DIU and AFWERX as examples.

7.3. Defense Industrial Base (DIB) Initiatives: Capacity, Modularity, and Incentives

7.3.1. Set a 1:10 R&D to Production Funding Ratio

Prototype systems often lack a funding pathway to production. Congress and DoD should establish a formal 1:10 R&D-to-production benchmark for fieldable systems, prioritizing drone and DEWS portfolios. Codify this in the National Defense Industrial Strategy with specific scaling targets to align planning with demand and reduce waste from failed transitions. Address budgetary timing challenges through multi-year contracting authorities and advanced procurement agreements guaranteeing minimum orders. These provide supplier stability for manufacturing investment while maintaining flexibility for design iteration based on operational feedback.

7.3.2. Expand the Supplier Base through Dual-Use and Modular Incentives

The supplier base for next-generation systems remains concentrated. Innovative small and mid-sized firms struggle to navigate defense acquisition. SBIR/STTR programs should target modularity related to autonomy, sensor fusion, and low-cost DEWS components. Currently, many promising firms fall into a "missing middle" without clear pathways to production contracts – a critical choke point. Expand modularity mandates across drone and DEWS platforms to enable tier-two and tier-three supplier participation. While hypersonic production is highly complex, expanding modularity to subsystems and components could greatly increase the supplier base and reduce costs while improving resilience. Despite verification and integration challenges, if successfully managed, benefits include faster fielding, price competition, and surge resilience. Increased participation of lower-tier suppliers raises integration risks; mitigation entails standardized interface protocols, automated verification systems, and strengthened program integrators.

7.3.3. Accelerate Allied Co-Production and Licensing Agreements

U.S. production capacity alone is insufficient; allied integration provides strategic advantages. Establish standardized co-production templates tied to the NTIB for expanded manufacturing and interoperability. Design public-private industrial clusters to serve surge needs with shared logistics hubs and reserve capacity, like munitions sharing efforts that benefit Ukraine. Protect core intellectual property while encouraging burden sharing by mitigating unauthorized technology transfer through export controls, ITAR harmonization, anti-tamper features, and strengthened coalition compliance and sharing mechanisms, including pre-approval of exportable software, components, and systems. Co-production may encounter allied regulatory hurdles, labor disputes, or political shifts impacting timelines; mitigation requires pre-negotiated industrial readiness standards and contingency surge clauses. Moreover, expanding allied co-production risks shifting high-value work abroad; offsetting measures include reserving critical subcomponent manufacturing for domestic suppliers and incentivizing allied investments in U.S.-based facilities.

7.4. Demand Signaling: Transparency, Tempo, and Strategic Communication

7.4.1. Publicly Commit to Quantifiable Production Targets

Industry requires predictable demand signals to justify investments. DoD should announce specific production targets; for example, 5,000 attritable drones monthly by FY27, 200 DEW systems annually by FY28, and 50 hypersonic cruise missiles quarterly by FY29.

Formalize these in the DIB strategy and posture statements. Such signals reduce supplier risk, drive modernization investments, and attract private capital. Manage the risk of missing targets by aligning with budgeted programs and adjusting timelines based on testing, operational events, or milestones. This could include bonuses for contractors that deliver capabilities ahead of schedule. Public production commitments risk reputational harm and deterrence erosion if unmet; mitigation entails conservative initial targets with tiered escalation and transparent adjustment mechanisms tied to operational milestones.

7.4.2. Integrate Industrial Readiness into Deterrence Doctrine

DoD should formally integrate production and reconstitution capacity into strategic deterrence frameworks. This includes wargaming supply chain resilience, modeling surge timelines, and demonstrating rapid regeneration capabilities publicly. This policy reinforces the strategic logic of attritable systems and mass production by treating industrial tempo as a core element of deterrence. It also justifies investments in manufacturing technology, workforce development, and supply chain resilience as vital components of national security strategy and increases the public’s sense of investment and involvement in national security.

7.4.3. Institutionalize Industrial Signaling as Deterrence

Recognize that visible industrial capacity and production tempo are powerful deterrent signals. Publish quarterly production metrics for key systems, conduct public demonstrations of surge manufacturing capabilities, and highlight allied co-production achievements. This transparency signals to adversaries that the United States can absorb combat losses and regenerate weapons and forces faster than they can sustain offensive operations. Yet, it also carries escalation risks if misinterpreted as mobilization. Mitigation includes pairing transparency with diplomatic engagement, strategic communications, and narrative framing to emphasize defensive intent.

7.5. Policy Conclusion: From Platforms to Capabilities, From Scarcity to Scale

This policy framework enables transition to affordable mass by aligning reforms across Congress, DoD, industry, and international partners. Modern deterrence hinges on capabilities and visible industrial capacity to generate combat power at scale. Implementation requires leadership commitment, bipartisan support, industrial cooperation, and a culture change in procurement, FMS, and risk acceptance. The strategic benefit—imposing multiple dilemmas on adversaries while preserving operational flexibility—is essential for maintaining U.S. military advantage amid technological change and strategic competition. This strategy shifts from platform-centric to capability-centric deterrence through integrated reforms to U.S. investment priorities, acquisition processes, and industrial policy. The strategic inflection point demands rewiring both the industrial approach and deterrence thinking to maintain advantage where speed, scale, and sustainability determine effectiveness. While each policy carries inherent political, industrial, and operational risks, careful sequencing, transparency, and adaptive governance are essential to transform these risks into manageable tradeoffs aligned with strategic advantage.

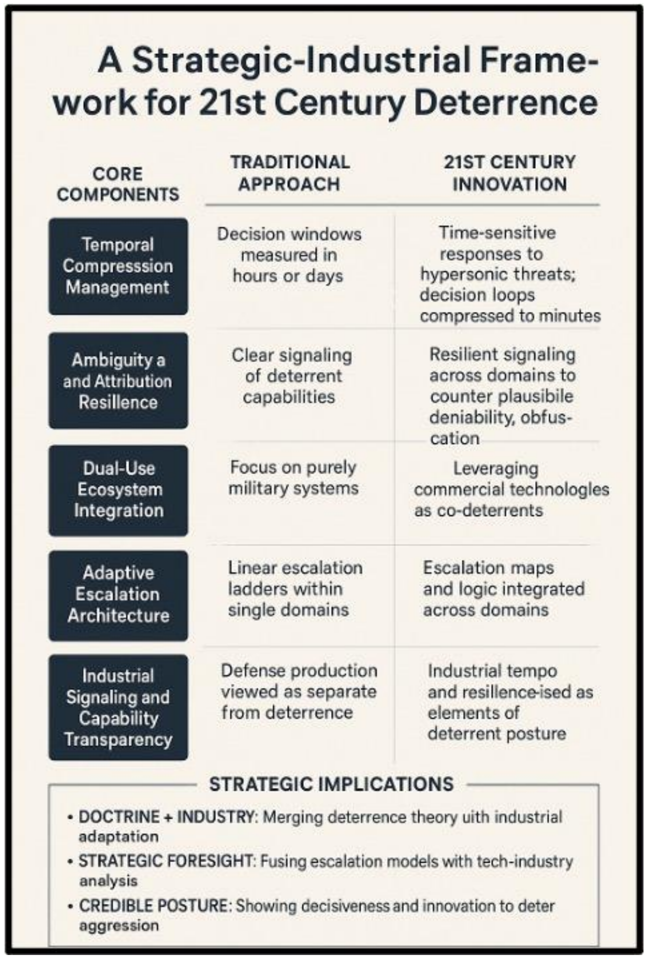

Figure 14. The Defense-Industrial Deterrence Model
Source: Deterrence Reimagined: How Hypersonics, Directed Energy, and Drones are Reshaping Strategy & Industry, Lieutenant Colonel K. Skidmore, April 20, 2025

8. Conclusion

The ES Weapons Industry Study examined drones, DEWs, and hypersonics through first-person interviews, site visits, war games, and research. These weapons are critical to building layered defensive and offensive capabilities. The “battle lab” in Ukraine has validated the operational impact of drones, signaling a future shaped by both low-cost precision mass and high-cost, high-effect platforms like DEWs and hypersonics.

Beyond their military relevance, these technologies offer an opportunity to revitalize the U.S. DIB. Growing demand for small, attritable drones creates market space for new and smaller firms, diversifying the industrial base, and expanding production capacity. Reforming FMS to better integrate allied industrial efforts will further strengthen this expansion. Focused research and development on the most effective applications of hypersonics and DEWs will sustain technical advantages while improving cost-efficiency.

Balancing high-cost, high-effect systems with low-cost, scalable mass will be critical to building an adaptable future force. Emphasizing capabilities over platforms will foster industrial flexibility and operational agility. This balance underpins a strategy of "mass, maneuver, and momentum"—a deliberate shift to scalable, adaptable production aligned with the demands of modern conflict.

The weapons industry stands at the center of sustaining deterrence and preserving U.S. advantage in great power competition. Bold policy and regulatory reforms are essential to unlock the potential of this sector, strengthen industrial resilience, and deliver an agile, modern fighting force ready to prevail across a contested global landscape.

Annex A – Artificial Intelligence (AI)

AI is rapidly transforming the defense sector by accelerating innovation, enhancing operational effectiveness, and redefining manufacturing, countermeasures, autonomous systems, and cybersecurity paradigms. This annex highlights key AI applications influencing critical technologies such as hypersonics, drones, DEWs, and cyber defenses.

1. AI Applications in Defense Manufacturing

Identifying New Materials and Reducing Reliance on Rare Earth Minerals AI expedites the discovery of novel materials or complex compounds, offering alternative solutions to reduce reliance on crucial rare earth minerals for the defense industry. AI-driven platforms have demonstrated potential in predicting material properties and enabling rapid experimentation and validation.

Design Optimization for Hypersonic Engines AI design methods optimize hypersonic engine configurations by integrating advanced simulation data, maximizing aerodynamic efficiency while minimizing structural stress and thermal load. These approaches enable faster iteration cycles and improved performance reliability under extreme conditions.

2. AI in Defensive Countermeasure Systems

Trajectory Prediction and Precision Guidance Advanced AI systems significantly enhance real-time tracking of incoming threats, improving the precision and timing of defensive countermeasures such as DEWs and missile interceptors.

Detection and Threat Assessment AI-driven sensors and data fusion techniques substantially elevate threat detection capabilities through rapid classification, allowing faster decision-making and deployment of countermeasures in complex, dynamic environments.

3. AI in Autonomous Systems

Autonomous Drone Operations and Swarm Coordination AI technology enhances drone autonomy, enabling self-directed reconnaissance, offensive operations, and sophisticated swarm coordination. These capabilities increase operational resilience and reduce human risk exposure.

AI Piloting of Hypersonic Gliders With their extreme speeds and complex flight dynamics, hypersonic gliders require AI-enabled adaptive flight control for real-time optimization of flight paths, threat evasion, and survivability.

4. Cybersecurity and AI Integration

AI-powered cybersecurity measures are critical for securing sensitive weapons systems and manufacturing processes against increasingly sophisticated threats. AI enhances real-time threat detection, prediction, and mitigation across complex digital networks.

5. Impacts and Trends of AI on the Weapons Industry

AI is reshaping the weapons industry by driving increased autonomy, operational efficiency, and accelerated innovation cycles. Key trends include:

- **Expansion of Autonomous Systems:** Rapid proliferation of AI-driven drones, autonomous vehicles, and hypersonic platforms.
- **Integration into Decision-Making:** Greater reliance on AI for tactical decision support, operational planning, and logistics optimization.
- **Advancements in Cybersecurity:** Deeper integration of AI into cyber defense to counter increasingly sophisticated threats.
- **International Competition:** Escalating global competition over AI capabilities will shape defense policies, industrial standards, and alliance strategies.

AI is fundamentally reshaping the weapons industry—streamlining design, accelerating production cycles, enabling autonomous platforms, and transforming defensive systems. AI-driven innovation now underpins hypersonic development, precision countermeasures, cyber resilience, and adaptive manufacturing.

As global competitors embed AI across their defense sectors, the U.S. weapons industry must do the same to sustain its edge. Future military dominance will hinge not on legacy platforms, but on the speed, precision, and adaptability AI brings to the DIB.

Annex B – War Gaming

An Academic Tool to Understand Decision-making, Resource Scarcity, and Partnerships

Background

The ES' *Weapons Free—Or Are They?* war game complements the AY25 Weapons Industry Study by immersing mid-career, graduate students in the strategic dynamics of weapons development, production, and international coordination amid competition, diplomacy, and uncertainty. Rather than emphasizing victory, the game challenges students to make deliberate decisions within national capabilities and strategic intent constraints. It reflects Richard Rumelt's concept of good strategy: a "coherent response to an important challenge" grounded in diagnosis, guiding policy, and coordinated action.[159]

Teams represent a fictional nation with distinct industrial, diplomatic, and geopolitical traits. Each team must determine how best to invest limited resources across weapons systems of hypersonics, DEWs, high- and low-cost drones, and conventional munitions while leveraging trade, diplomacy, and joint ventures as instruments of national policy.

The simulation captures the mobilization and deterrence dilemmas outlined in the 2022 National Defense Strategy, forcing students to weigh immediate capacity-building against longer-term technological bets and consider associated tradeoffs.[160]

Setting

[159] Richard P. Rumelt, *Good Strategy, Bad Strategy : The Difference and Why It Matters*, 1st ed. (Crown Business, 2011), https://research.ebsco.com/linkprocessor/plink?id=d41da9a0-5e77-3d91-a0d0-6420803aa70b.
[160] Department of Defense, "National Defense Strategy" (Office of the Secretary of Defense, October 27, 2022).

The game operationalizes strategic dilemmas through token investments, card-based scenarios, and simulated market and diplomatic shocks.

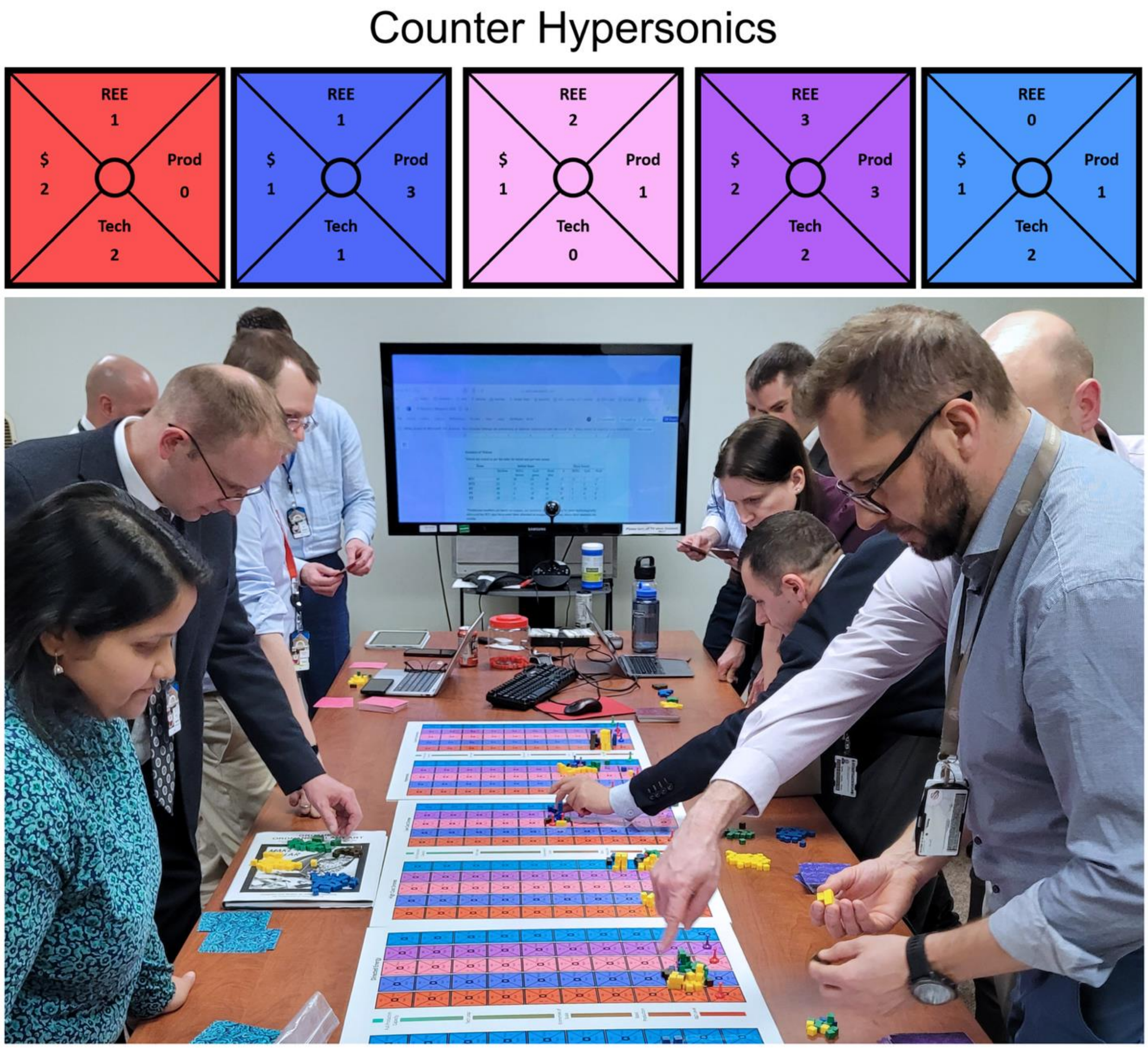

Figure 15. Seminar 20 students playing the war game
Source: Seminar 20, Lesson 12 - Weapons Free—Or Are They?, March 13, 2025

Teams receive tokens representing money, production capacity, rare earth elements (REEs), and technology goods from the bank each round. Teams may trade tokens, form partnerships, and act independently to reflect real-world dynamics of defense industrial management and international coordination.

Takeaways

This wargame reinforced that success in weapons development strategy depends on acquiring capabilities and shaping the broader industrial and operational environment. Teams confronted real-world constraints that tested their ability to prioritize, collaborate, adapt, and manage risk. Key lessons emphasized the interconnectedness of strategy, diplomacy, resource management, scarcity, and industrial resilience in a contested security environment.

1. **Strategic Planning Requires Discipline and Adaptability**

   Teams that balanced short-term readiness with long-term technological edge, primarily through diversified investments, demonstrated greater resilience. Strategic agility proved essential under constant resource pressure.

2. **Alliances and Diplomacy Are Force Multipliers**

   Partnerships that enabled resource-sharing and joint R&D accelerated development and reduced risk. Teams that remained isolated suffered inefficiencies and stagnation.

3. **Industrial Base Capacity Drives Strategic Options**

   Teams that invested in resilient, scalable industrial infrastructures maintained momentum despite external shocks. Industrial readiness directly shaped strategic freedom of action.

4. **First-Mover Advantage Demands Sustained Investment**

   Early adopters of advanced weapons systems, such as hypersonics or DEWs, secured strategic leverage only if they sustained investment, protected intellectual property, and maintained collaborative production efforts.

5. **Technology Development Is Long, Costly, and Unpredictable**

   Teams misjudging technological timelines suffered delays or irrelevance. Realistic R&D planning, paired with resilience to setbacks, proved essential.

6. **Strategic Trade Accelerates Gains—at a Cost**

   While trading rare earths or technology or negotiating trade agreements expanded resource access and accelerated development, reliance on or overdependence on unstable partners introduced risk. Trust, vetting, and diversification proved critical.

7. **Arms Races Distort Strategic Coherence**

   Competitive escalation prompted by peer actions often led teams to overextend into high-end systems while neglecting core capabilities, weakening overall strategic posture.

8. **Realistic Assessment of National Strengths and Constraints is Essential**

   Teams that aligned strategies with their nation's industrial scale, technological maturity, and political stability outperformed those pursuing unrealistic or aspirational approaches.

9. **Strategic Flexibility Outperforms Rigid Planning**

   Success favored teams that adapted to evolving conditions and embraced uncertainty. Fixed plans quickly broke under the dynamic pressures of game competition.

10. **Resource Stewardship Drives Competitive Endurance**

    Teams that effectively managed fiscal, industrial, and human capital resources (e.g., banking assets when prudent and surging at decisive moments) achieved greater long-term viability.

In summary, *Weapons Free—Or Are They?* serves as more than a simulation—it is a crucible for developing strategic insight under conditions of uncertainty, scarcity, and interdependence. The wargame compels participants to confront the complexity of modern defense planning, where technological ambition must be tempered by industrial reality, and where strategic advantage is as much about alliances and adaptability as it is about capability acquisition. As a capstone experience, it deepens student understanding of how strategic logic, national power, and resource management intersect in the real world—reinforcing that success in today's security environment demands not just decisive action, but disciplined, resilient, and informed strategy.

Annex C – Seminar 20 individual papers

Lindsay Buckalew	High Cost or High Volume: A Comparison of Counter Unmanned Aerial System Strategies and Capabilities
Emily Lazear	How Drones Are Changing the Psychological Nature of Warfare
David Levene	The Paradox of Hypersonic Weapon Supply Chains
Christopher Norman	Hypersonics: forcible action retread with invisible impact
Jacek Najs	Building Ammunition Resilience
Jonathan Pederson	Game of Drones: Is the U.S. prepared to play in the undersea realm?
Ion Roratu	Small State, Smart Strategy: How the Republic of Moldova Can Craft an Optimal Defense Procurement Strategy
Tejal Shah	Strategic Superiority Without Strategic Waste: A Disciplined Framework for Defense Investment in Critical Weapons Technologies
Kristofer Skidmore	Deterrence Reimagined: How Hypersonics, Directed Energy, and Drones are Reshaping Strategy & Industry
Emanuel Velez	The Ethical Dilemma of Hypersonic Weapons in Strategic Deterrence
Thomas Verchère	Directed Energy Weapons/Laser: Will it Ever Cross the Canyon of Death?
Andrew Zang	An Opportunity for DIB Invigoration: Restructuring the Foreign Military Sales Program