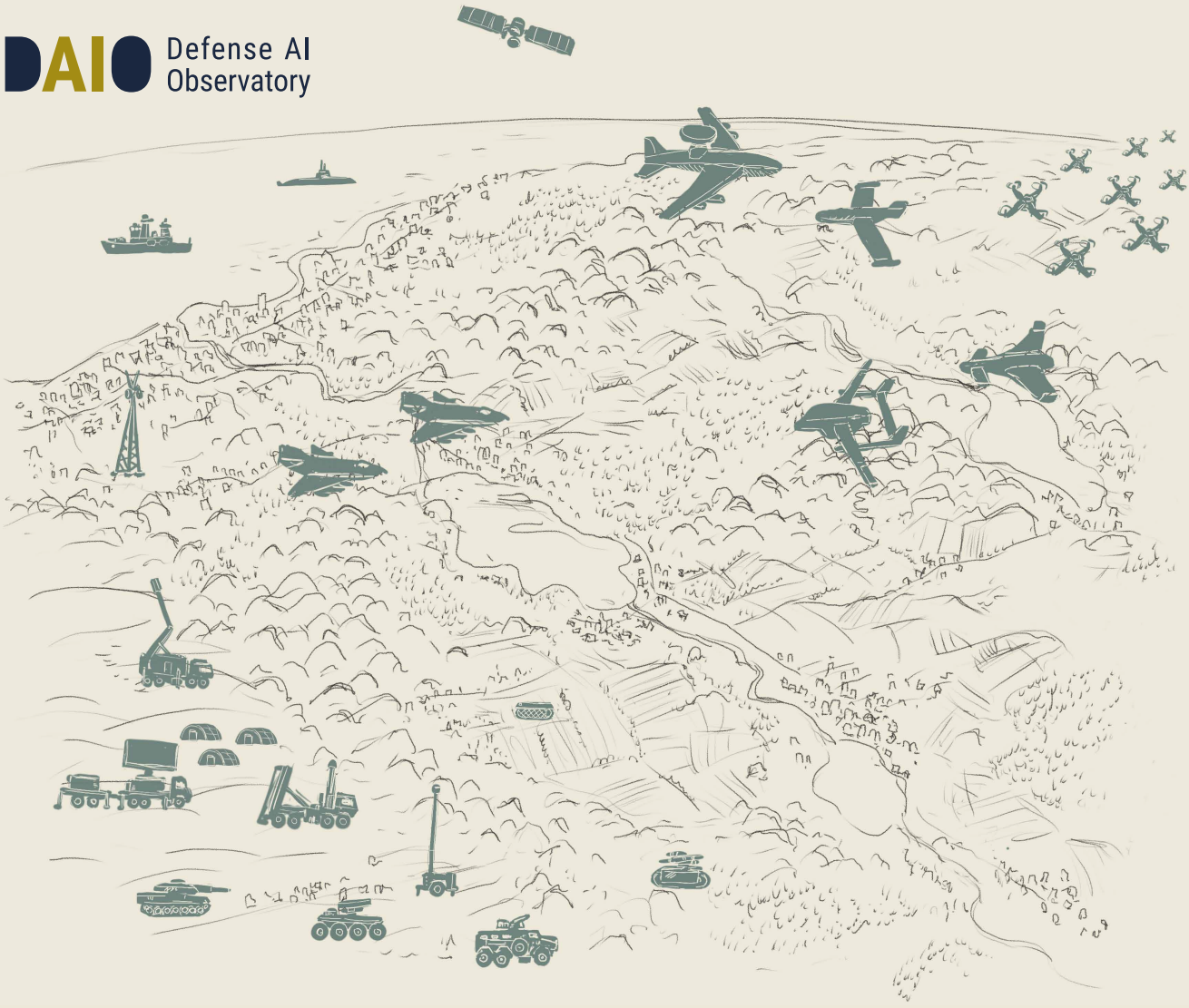
DAIO Defense AI Observatory



Risky Incrementalism

Defense AI in the United States

Lauren A. Kahn

DAIO Study 23|07

Ein Projekt im Rahmen von
dtec.bw
Zentrum für Digitalisierungs- und Technologieforschung der Bundeswehr

About the Defense AI Observatory

The Defense AI Observatory (DAIO) at the Helmut Schmidt University in Hamburg monitors and analyzes the use of artificial intelligence by armed forces. DAIO comprises three interrelated work streams:

- Culture, concept development, and organizational transformation in the context of military innovation
- Current and future conflict pictures, conflict dynamics, and operational experience, especially related to the use of emerging technologies
- Defense industrial dynamics with a particular focus on the impact of emerging technologies on the nature and character of techno-industrial ecosystems

DAIO is an integral element of GhostPlay, a capability and technology development project for concept-driven and AI-enhanced defense decision-making in support of fast-paced defense operations. GhostPlay is funded by the Center for Digital and Technology Research of the German Bundeswehr (dtec.bw).

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Her work has appeared in Foreign Affairs, Defense One, Lawfare, War on the Rocks, Bulletin of the Atomic Scientists, and Orbis, and has been featured in the Economist. She received her bachelor's degree in international relations from the University of Pennsylvania, and is currently pursuing a master's degree in computer and information technology at the University of Pennsylvania's School of Engineering and Applied Sciences. Her Twitter account is @Lauren_A_Kahn.

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Content

1 Summary

The United States remains the world's preeminent military and technological power. Over the last decade, the United States has increasingly viewed artificial intelligence (AI) proficiency as a vital U.S. interest and mechanism for assuring U.S. military and economic power, recognizing its potential as a force multiplier. In particular, over the last decade, artificial intelligence has become a critical capability for U.S. national defense, especially given the focus of the 2022 U.S. National Defense Strategy on the Indo-Pacific region and the pacing challenge of China.[1]

As a result, the U.S. Department of Defense (DoD) (and the U.S. government and defense establishment in general) has shown growing enthusiasm for AI and related emerging technologies. However, while the United States is currently making great advances in AI research and development in both academia and the private sector, the Department of Defense has yet to successfully, on a wide scale, translate commercial AI developments into real military capabilities.

The United States government is generally well-placed to leverage defense AI and AI-enabled systems. However, various bureaucratic, organizational, and procedural hurdles have slowed down progress on defense AI adoption and technology-based innovation within the Defense Department over the last few years. Critically, DoD suffers from a complex acquisitions process and a widespread shortfall of data, STEM,[2] and AI talent and training. Organizations working on AI and AI-related technologies and projects are often siloed, separated not only from each other but also necessary data and other resources, and there exists within the department a culture that favors tried-and-true methods and systems, sometimes trending towards Luddism. All of these factors have all contributed to a surprisingly slow pace of AI adoption. The National Security Commission's 2021 Final Report to Congress summarized that "despite exciting experimentation and a few small AI programs, the U.S. government is a long way from being AI-ready."[3]

1 2022 National Defense Strategy of The United States of America.
2 STEM: Science, Technology, Engineering, and Mathematics.
3 NSCAI 2021 Final Report, p. 2.

Thus, despite its potential to enhance U.S. national security and be an area of strength, and given the long U.S. tradition of military, innovation, and technological leadership, AI risks becoming a point of weakness, expanding "the window of vulnerability the United States has already entered."[4] AI will continue to be a point of insecurity if the United States does not pick up the pace of innovation to reach responsible speed and lay the institutional foundations necessary to support an AI-savvy military.

In the last year, the Defense Department made headway on some of these challenges, restructuring its approach to defense AI. In June 2022, the Department of Defense published a Responsible AI Strategy and Implementation Pathway that prioritized a more data-informed, responsible, and tractable AI effort and has since begun to execute it. Most significantly, the DoD has initiated a significant overhaul of its AI organizational structure, creating a new Chief Digital and Artificial Intelligence Office (CDAO) to consolidate its disparate AI projects and stakeholders, and better align them with the department's data streams. Notably, the United States DoD is currently undergoing significant changes and revitalization of its overall approach to defense AI. However, whether these new AI efforts will be sufficient to allow the U.S. to make up for time lost, remains to be seen.

4 Ibid, p. 7.

2 Thinking About Defense AI

The United States and other countries have recognized the potential power and efficiencies artificial intelligence (AI) can generate, especially in military contexts. China has famously declared its plan to become the world leader in AI by 2030, while Putin has argued that the state that becomes the first to conquer AI will become the "ruler of the world."[5]

The use of cutting-edge, emerging technologies—including AI—in the Russian-Ukraine conflict[6] has made the potential applications of these capabilities much more tangible for states and has spiked interest in everything from drones to Ukraine's so-called "Uber for Artillery."[7] Consequently, it has also made evident the condensed timeline militaries are facing to have these capabilities operational and deployed on the battlefields if they wish to remain competitive.

In line with this global trend, the United States views artificial intelligence as an enabling technology and force multiplier that will generate efficiencies and, if leveraged successfully, will reinforce (or arguably, renew) U.S. competitiveness and global technological and military dominance. Along with recent shifts in U.S. defense and security strategy to become more focused on addressing the pacing challenge with China, defense AI is acknowledged as essential for U.S. military capabilities around the world.

2.1 What Is the U.S. Understanding of Defense AI?

AI is widely considered one of the defining emerging technologies of the current era. AI has penetrated all sectors of life. It has captured public attention with developments such as the first-ever AI-generated magazine cover;[8] private investment in AI has doubled over the past year alone, reaching about $93.5 billion globally;[9] AI-related fields such as machine learning, natural language processing, and computer vision have seen massive growth over the past few years, with the number of English language AI publications nearing 335,000 in 2021 alone,[10] and over 30 countries have published national AI strategies to help guide state governments and militaries to become AI giants.[11]

However, despite agreement that AI will be transformational across sectors, there needs to be more consensus on what, exactly, artificial intelligence is, if successful

5 Vincent, "Putin says the nation that leads in AI 'will be the ruler of the world'."
6 Kahn, "How Ukraine Is Remaking War: Technological Advancements Are Helping Kyiv Succeed."
7 Vrijsen, „Oekraïners verbluffen Nederland en Duitsland met hun pantserhouwitsers."
8 Liu, "The World's Smartest Artificial Intelligence Just Made Its First Magazine Cover."
9 Zhang et al., The AI Index 2022 Annual Report, p. 3.
10 Zhang et al., The AI Index 2022 Annual Report, p. 17.
11 Angelo, "Visualizing 2022: Trends to Watch."

adoption is to be achieved. This difficulty can be attributed to the nature of the technology itself.

In computer science, artificial intelligence is generally defined in the broadest sense to be the study of rational agents. An agent (it can be a robot or a code chunk, or even a human) perceives its environment (through sensors) and then acts (through actuators) in that same environment.[12] As a result, artificial intelligence is considered an enabling, general-purpose technology much more comparable to electricity or the combustion engine rather than a specific system like a robotic arm or a Patriot missile. Moreover, it is a technology that, by necessity, evolves and learns. That inherent evolution has simultaneously enraptured the public and private sectors, states, militaries, and the general public and made organizing, regulating, and implementing the technology on a wide-scale notoriously challenging.[13]

When defining defense AI, militaries and states have faced similar challenges. It was in 2018, with the release of the first U.S. Department of Defense Artificial Intelligence Strategy, that there was a formalized definition of what AI means in U.S. defense contexts. The strategy concisely defined AI as "the ability of machines to perform tasks that normally require human intelligence."[14] Up until that point, much of the rhetoric of the U.S. defense community sometimes—inaccurately—made "artificial intelligence seem like a munition,"[15] rather than an enabler. Therefore, the 2018 formalization of the definition of AI was a significant step forward in getting the defense establishment closer to the mark when it came to AI. However, defining AI in this manner has been challenging for many in the national security enterprise to grasp. This definition encompasses decades-old technologies dating back to WWII, such as autopilot on aircraft, automated warning systems, and missile guidance, to more recent breakthroughs, such as facial recognition technology, autonomous vehicles, and machine and deep learning algorithms. These definitional lines are further blurred when distinguishing between artificial intelligence, automated/automatic systems (which respond mechanically to inputs), and autonomous systems (which operate on pre-programmed instructions), which may or may not be AI-enabled.

Thus, understanding and defining what defense AI means for the United States has been a persistent challenge intrinsic to the nature of the technology itself. It has also underpinned many of the other challenges the U.S. Department of Defense has been grappling with over the past five years regarding developing, integrating, adopting, deploying, and training for defense AI.

12 See Bansall, "Agents in Artificial Intelligence" for a detailed overview of rational agents.
13 O'Shaughnessy, "One of the Biggest Problems in Regulating AI Is Agreeing on a Definition."
14 "Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity."
15 Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power."

2.2 Why Does the United States Want AI?

United States military investments in AI blue-skies research and defensive applications have skyrocketed over the last decade. Out of the $773 billion requested by the Biden Administration for the Pentagon's FY2023 budget, $130.1 billion alone was designated for research and development for emerging technologies, including artificial intelligence.

From the Trump Administration to the Biden Administration, AI has become a key pillar in national strategies to achieve U.S. interests. In particular, when it comes to addressing national security challenges and the balance of power, progress in defense AI is often used as a heuristic metric for assessing U.S. military and technology leadership.

The Biden administration has identified China as the pacing challenge shaping current U.S. national defense and security strategy, as well as future military planning.[16] The White House, in its national security strategy explained this shift in strategy to meet a shifting global balance in power, as China has steadily become the "only competitor potentially capable of combining its economic, diplomatic, military, and technological power to mount a sustained challenge to a stable and open international system."[17] As a result, a unique emphasis has been placed on the Chinese threat to U.S. technological dominance.[18] Some former Pentagon officials went so far as to claim that the United States has no "fighting chance"[19] against China when it came to harnessing emerging technologies such as cyber, AI, quantum, and robotics.

As a result, much of the U.S. effort on defense AI and other emerging technologies has been contextualized concerning competition with China. Primarily, worry about Chinese AI advancements create a sense of urgency and a need to advocate for the United States to pick up the pace with responsible speed[20] when it comes to AI investment, research, development, acquisition, and deployment. The U.S. military believes AI investments could generate essential capabilities in several areas, with some closer to fielding and others still in the early stages of RDT&E.

16 Horowitz, "War By Timeframe: Responding to China's Pacing Challenge."
17 National Security Strategy, p. 8.
18 Kahn, "What the Defense Department's 2021 China Military Power Report Tells Us About Defense Innovation."
19 Manson, "US has already lost AI fight to China, says ex-Pentagon software chief."
20 Horowitz/Kahn/Resnick Samotin, "A Force for the Future"; Vergun, "China Remains 'Pacing Challenge' for U.S., Pentagon Press Secretary Says."

3 Developing Defense AI

The previous sections outline how the United States thinks about defense AI in terms of its national interests, goals, and security. Over the past five years, artificial intelligence has become an ascendant capability in defining U.S. technological leadership. This section will measure the progress the United States has made when it comes to successfully developing, adopting, and leveraging AI capabilities for defense. Subsequent sections will discuss the mechanisms for executing defense AI policy within the United States.

3.1 U.S. AI Strategy and its Evolution

In 2018 the Department of Defense published its first-ever AI strategy, Harnessing AI to Advance Our Security and Prosperity. It emerged from the recognition that technological advances have always been at the forefront to ensure that the United States had an enduring "competitive and military advantage,"[21] and that other states (and U.S. competitors China and Russia) were already making significant military investments in AI. The strategy accompanied the newly-created Joint Artificial Intelligence Center (JAIC), which was mandated to execute much of the DoD's vision and "synchronize DoD AI activities to expand Joint Force advantages."[22]

The strategy positioned AI as a human-centered tool that would help the DoD better support and protect U.S. servicemembers and civilians, enhance national security, and create a more efficient and streamlined organization. It outlined five key pillars:[23]

- Delivering AI-enabled capabilities that address key missions.
- Scaling AI's impact across DoD through a common foundation that enables decentralized development and experimentation.
- Cultivating a leading AI workforce.
- Engaging with commercial, academic, and international allies and partners.
- Leading in military ethics and AI safety.

The majority of DoD AI initiatives and strategies are department-wide, encompassing and applying to all of the service branches and sub-organizations within the institution. However, when the strategy was first published, the Deputy Secretary of Defense directed the armed services to each develop an annex outlining that specific department's tailored AI plans to execute the overarching strategy. The Air

21 "Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity" p. 5.
22 Ibid., p. 9.
23 Ibid., pp. 7–8.

Force, Marine Corps, Army, and Navy have all developed separate documentation regarding their approaches to AI. Only the Army and Air Force strategies are publicly available, with the Navy's being classified as Secret, and the Marine Corps being for official use only. All of the services have set up their own respective AI Task Forces, as well.[24]

Both the Army and Air Force's public AI Annexes have been criticized for lacking the baselines and metrics needed to "meaningfully assess progress toward its vision," and mostly serve as reinforcing documents for the overall AI strategy and establishing commitment to collaborating with AI focused cross-departmental initiatives.[25] It is also worth noting that many of these are in need of revision, given that many of these efforts were nested under the JAIC's efforts and initiatives, which under the recent reorganization in the Pentagon, is no longer the leader and owner of AI implementation across the Department.

The 2018 strategy was essential in driving early successes within the DoD, most notably elevating AI as a priority capability within the department and establishing key early regulations for the use of AI and autonomous technologies, such as the adoption of DoD's ethical principles for artificial intelligence in February 2020.[26] By 2022, the AI strategy was overdue for a refresh—due to rapid technological advancement and continuing geopolitical shifts. China has made significant progress in advanced technologies, including AI and quantum computing, and is becoming increasingly bold in the Indo-Pacific and concerning Taiwan. AI saw its first introduction to the battlefield, and mechanisms for testing, evaluating, and addressing bias in AI became a reality. The DoD saw a need for a modernized AI strategy, which is still pending.

In the meantime, DoD is moving forward with related AI efforts that will nest under the new AI strategy. For example, in June 2022, the office of the new Chief Digital and AI Officer published the Responsible Artificial Intelligence (RAI) Strategy and Implementation Pathway (RAI S&IPathway).[27] The RAI strategy emphasizes the need for responsible AI for defense: AI that is both efficacious as well as "consistent with our national values, shared democratic ideals, and...[the] military's steadfast commitment to lawful and ethical behavior."[28] The RAI strategy acknowledges that AI requires a more holistic and integrated approach. It describes six foundational tenets:[29]

24 GAO, Artificial Intelligence: DOD Should Improve Strategies, Inventory Process, and Collaboration Guidance, p. 19.
25 Tarraf, "The Department of Defense Posture for Artificial Intelligence: Assessment and Recommendations," pp. 48–50.
26 "DOD Adopts Ethical Principles for Artificial Intelligence"
27 DoD Responsible AI Working Council, U.S. Department of Defense Responsible Artificial Intelligence Strategy and Implementation Pathway.
28 Ibid., p. 2.
29 Ibid., p. 18.

- RAI Governance (this would see the modernization of overseeing governance structures and processes)
- Warfighter Trust (this would standardize technological familiarity and proficiency for AI-enabled system operators)
- AI Product and Acquisition Lifecycle (this would ensure an appropriate balance between safety and the increased speed needed to develop AI capabilities)
- Requirements Validation (this would further ensure AI capabilities met operational needs)
- Responsible AI Ecosystem (this would promote shared understandings both internally, as well as with domestic and international partners working to develop AI)
- AI Workforce (this would promote AI education and literacy)

These tenets also connect with other DoD policies on AI and autonomous systems, such as Directive 3000.09—which established guardrails for autonomy in weapons systems.[30] The updated RAI strategy also formally enshrines DoD's recently launched AI ethical principles by having them form the basis for an updated policy for AI.

Adopted in February 2020, the DoD's ethical AI principles have become essential guardrails the department has used to inform its more recent AI efforts, spanning everything from experimentation to use. The five principles are laid out as follows:[31]

- Responsible. DoD personnel will exercise appropriate levels of judgment and care, while remaining responsible for the development, deployment, and use of AI capabilities.
- Equitable. The Department will take deliberate steps to minimize unintended bias in AI capabilities.
- Traceable. The Department's AI capabilities will be developed and deployed such that relevant personnel possess an appropriate understanding of the technology, development processes, and operational methods applicable to AI capabilities, including with transparent and auditable methodologies, data sources, and design procedure and documentation.
- Reliable. The Department's AI capabilities will have explicit, well-defined uses, and the safety, security, and effectiveness of such capabilities will be subject to testing and assurance within those defined uses across their entire life-cycles.
- Governable. The Department will design and engineer AI capabilities to fulfill their intended functions while possessing the ability to detect and avoid unintended consequences, and the ability to disengage or deactivate deployed systems that demonstrate unintended behavior.

30 "Department of Defense Directive 3000.09: Autonomy in Weapon Systems"; Kahn, "A Refreshed Autonomous Weapons Policy Will Be Critical for U.S. Global Leadership Moving Forward."
31 "DOD Adopts Ethical Principles for Artificial Intelligence."

Crucially, in the execution of this updated strategy, the department has made some dramatic internal organizational shifts to align data with AI better, fix siloed data streams, and increase data transparency. The hope was that this would help catalyze the DoD's broader AI efforts and make it a more data- and software-oriented organization.[32]

3.2 The United States: Falling Behind?

For decades, the United States has been the world's leading military power and the foremost technological innovator—two distinct yet mutually reinforcing designations. Compared to other states, the United States military is uniquely positioned to capitalize on advances in artificial intelligence and other emerging technologies. The academic and private sectors within the United States have become the preeminent contributors to furthering the field of AI. Whether in the form of AI conference citations or repository contributions, the weighted citation impact of corporate-academic publications, or attracting much of the world's AI and machine learning talent, the United States surpasses its peers.[33] Despite having a rich AI ecosystem at its fingertips, the United States Department of Defense has failed to become a driving force of AI progress—less than 3% of all AI publications in the United States were government sponsored.[34] In contrast, in China and the European Union—after academia—the government consistently contributes the highest percentage of peer-reviewed AI publications, whereas, for the United States, corporate publications followed.[35]

As Kahn, Horowitz, and Resnick Samotin put it, "leading militaries often grow overconfident in their ability to win future wars, and there are signs that the U.S. Department of Defense could be falling victim to complacency. Although senior U.S. defense leaders have spent decades talking up the importance of emerging technologies, including AI and autonomous systems, action on the ground has been painfully slow."[36] It is clear that when it comes to successful defense AI adoption, let alone leadership, just having the technology is insufficient and must be accompanied by organizational and bureaucratic change and integration.

32 Vergun, "DOD Aims to Transform Itself Into a Data-Centric Organization."
33 Zhang et al., The AI Index 2022 Annual Report, pp. 16–35; Zhang et al, The AI Index 2021 Annual Report, p. 24; Zwetsloot et al., The Immigration Preferences of Top AI Researchers; Zwetsloot et al., "Skilled and Mobile: Survey Evidence of AI Researchers' Immigration Preferences."
34 Zhang et al., The AI Index 2022 Annual Report, p. 20.
35 Zhang et al., The AI Index 2021 Annual Report, pp. 21–22.
36 Horowitz/Kahn/Resnick Samotin, "A Force for the Future: A High-Reward, Low-Risk Approach to AI Military Innovation," p. 158.

3.3 AI Backsliding, Luddism, and the "Valley of Death"

Artificial intelligence and other general-purpose emerging technologies that will have defense and national security applications but are being advanced and developed largely by the private sector will proliferate relatively quickly.[37] Already, the increased reliance on AI-enabled, autonomous, and commercial technologies in the Russia-Ukraine conflict demonstrates that technology is useful but is not a silver bullet. The competitive advantage of a given technology largely lies in a military's ability to innovate how it integrates and uses it.[38] Thus, acquiring a technical edge in artificially intelligent systems does not guarantee a successful embrace of defense AI. In general, it is important to note that military innovations are often perceived as one and the same or anchored in the emergence of new technologies. However, this is an oversimplification. As Michael C. Horowitz explains, "military innovations are significant changes in organizational behavior and ways that a military fights that are designed to increase its ability to translate capabilities into power effectively. The use of aircraft carriers as mobile airfields by the United States and Japan is a prototypical example."[39] While the ubiquitous inclusion of AI in more recent U.S. policy and national strategy, it is important to note that within the United States, while AI has the potential to enable several military innovations, it has not yet reached that threshold.

The 2018 National Defense Strategy noted that regarding emerging technologies like AI, "success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting."[40] Being slightly more realistic, and in acknowledging much of AI development is not being pioneered in government, the 2022 National Defense Strategy has promised that the DoD will become a "fast-follower" of market- and commercially-driven technological capabilities with military relevance.[41] However, as of writing, the United States has yet to match its execution with its stated intentions and outlined AI strategies fully.

Implementation of this vision for AI leadership has been challenging for the U.S. defense establishment for several reasons:

- Difficulty in transitioning AI research into scalable programs of record supported by the services;

37 Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power."
38 Kahn, "How Ukraine Is Remaking War: Technological Advancements Are Helping Kyiv Succeed."
39 Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power."
40 "Summary of the 2018 National Defense Strategy of The United States of America: Sharpening the American Military's Competitive Edge," p. 10.
41 2022 National Defense Strategy of The United States of America, p. 19.

- Siloed research, AI programs, and data streams;
- Lack of STEM and AI talent and general technological literacy and training opportunities.

Like many other large, bureaucratic systems, the Department of Defense is often biased in favor of tried-and-true, existing capabilities over new tools and technologies.[42] Despite its recognized potential as a force multiplier and military innovation enabler, AI, in particular, has faced resistance within the DoD. This hesitancy might be due to perceptions that AI distances humans from decision-making on the battlefield by enabling systems to operate more autonomously. Some within the armed forces have noticed this trend of luddism within the department, calling this "deliberate incrementalism," whereby AI projects that often meet set requirements and pass testing and verification procedures with flying colors are purposefully delayed when it comes to deployment with "cautious and lengthy feasibility studies," and sometimes cancellation.[43]

For example, in the early 2000s, the U.S. Air Force and Navy partnered to create a series of autonomous aircraft capable of conducting surveillance and military strikes, which have evolved into the X-45, the X-47A, and X-47B prototypes. Within two decades, the aircraft were already proving their mettle. Not only could they accomplish complex missions with little human oversight, such as landing on aircraft carriers, and completing aerial refueling operations, but they often did so better than the crewed systems.[44] Despite the promise the prototypes demonstrated, in what some have called a "case of technological infanticide," the Air Force viewed the systems not as an improvement but as a threat to the F-35 fighter jet, and dropped out of the joint program. The Navy continued with the program for a few more years until it canceled it due to internal debate.[45] Other AI and autonomous experiments such as Alpha Dogfight[46]—DARPA's program to train AI algorithms to beat a human pilot in a simulated aerial dogfight—which has been touted as successes,[47] have failed to lead to any actual implementations.

The lofty promises of defense AI juxtaposed with the reality of the conservatism of the military services in AI adoption have contributed to a widening of the "valley of death"—the chasm a technology developed in the private sector has to cross before its acquisition by the militaries. Whereas in the early 1960s, it might take a new technology five years on average to bridge the gap, today, it can take a

42 Horowitz/Kahn/Resnick Samotin, "A Force for the Future: A High-Reward, Low-Risk Approach to AI Military Innovation," p. 160.
43 Spataro/Phillips-Levine/Tenbusch, "Winged Luddites: Aviators are the Biggest Threat to Carrier Aviation."
44 Ibid.
45 Osborn, "X-47B UCLASS Stealth Drone: The U.S. Navy's Big Mistake?"
46 Halpern, "The Rise of A.I. Fighter Pilots."
47 Gould, "AI's dogfight triumph a step toward human-machine teaming."

decade or more for a capability to move from the lab to the battlefield.[48] While some features of AI may have exacerbated the gap, it exists as the U.S. armed forces often require "a higher level of technology maturity than the science and technology community is willing to fund and develop."[49]

While the U.S. DoD may have been able to avoid the valley of death previously, this has become an incredibly sharp sticking point recently. AI and other newer technologies are increasingly software-based and originate almost entirely in the private and academic sectors. Historically, the Department of Defense has struggled with "developing, procuring, and developing software-centric capabilities," with the acquisition process moving much slower for software-based systems than hardware and weapons systems.[50] Thus, some institutions within the DoD, such as the Defense Innovation Unit[51] have taken on roles as an "accelerator" or "translator" of commercial technology for national security and circumvent some of the hurdles through providing funding and faster contract times. Nevertheless, such institutions still face challenges in gaining access to acquisition resources. Moreover, such efforts are merely stopgaps to a broader acquisitions system problem.

Subsequent sections will detail the organizational, funding, and training challenges the U.S. Defense Department faces regarding AI development, adoption, integration, and deployment, as well as initiatives and efforts to address them in recent years. In the past six months, there have been some early hints of progress in overcoming the difficulties described above. Some signposts include the U.S. Air Force fast-tracking development of the Phoenix Ghost loitering munition for almost immediate use in Ukraine,[52] and indications that the Air Force is also considering a new program of record for a next-generation autonomous aircraft.[53]

48 Grenwalt/Patt, "Competing in Time: Ensuring Capability Advantage and Mission Success Through Adaptable Resource Allocation."
49 GAO, Defense Advanced Research Projects Agency: Key Factors Drive Transition of Technologies, but Better Training and Data Dissemination Can Increase Success, p. 4.
50 GAO, Artificial Intelligence: DOD Should Improve Strategies, Inventory Process, and Collaboration Guidance, p. 21.
51 "Who We Are/Our Mission: Defense Innovation Unit (DIU)."
52 Insinna, "Meet 'Phoenix Ghost,' the US Air Force's new drone perfect for Ukraine's war with Russia."
53 Insinna, "Air Force pilots to try out XQ-58A Valkyrie drones ahead of potential UAV wingman program."

4 Organizing Defense AI

The United States defense establishment has had a rollercoaster relationship with AI. AI has had a history of sudden periods of progress and overhype—generating sudden boons in funding—followed by troughs of divestment when reality fails to match heightened expectations. The up-and-down has sometimes led to "back-sliding" in defense AI progress.[54]

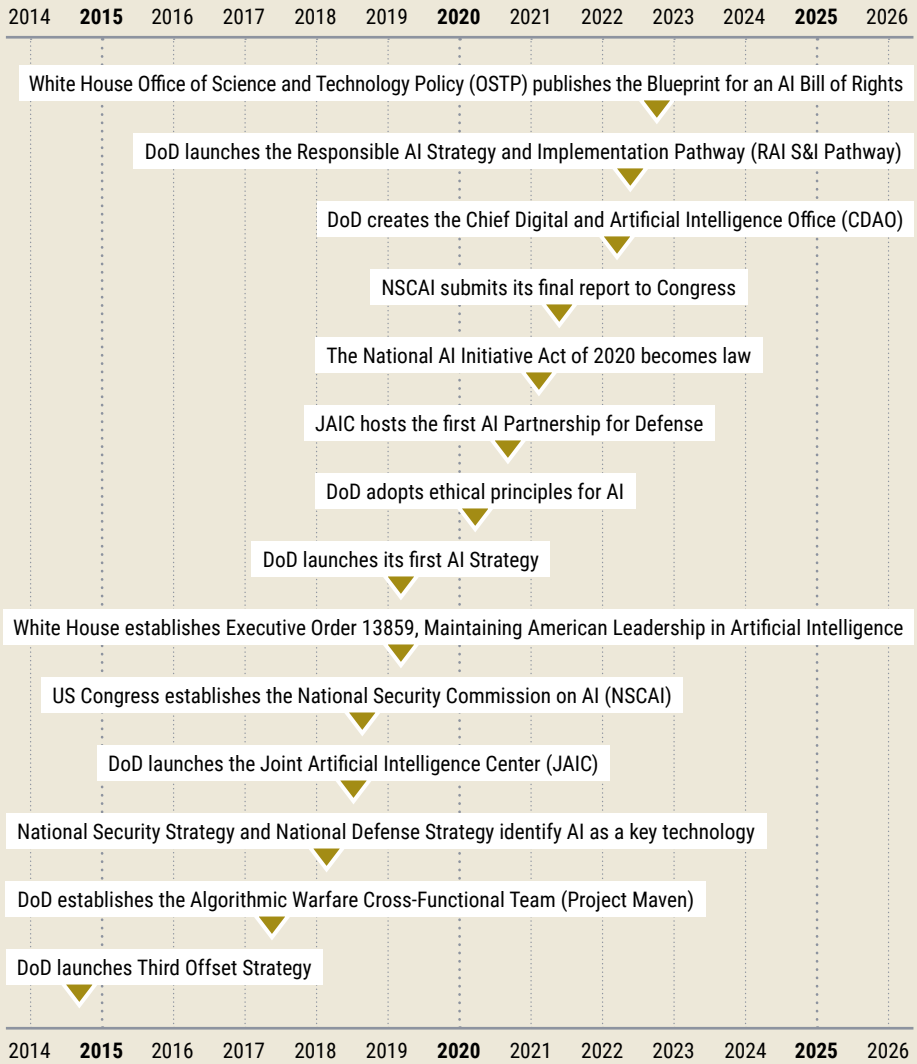
In the very early days of the field, even before the term "artificial intelligence" was coined in 1956, AI research was heavily funded by organizations like the Office of Naval Research (ONR) and the Advanced Research Projects Agency (ARPA) (now known as the Defense Advanced Research Projects Agency, or DARPA).[55] The hope was to use machine translation to aid the U.S. Navy during the Cold War by automatically translating Russian to English. However, stalls in progress in machine translation and slow-moving development in other related AI fields led DARPA and other organizations to fund less and less blue-skies and fundamental research in favor of more applied projects. As a result, many refer to this period during the 70s as the first "AI Winter."

In the 1980s, AI again captured the U.S. military's interest. DARPA invested $1 billion in a strategic computing initiative[56] that hoped to reach a level of machine intelligence that would propel the United States ahead of competitors like Japan which was experiencing an economic, industrial, and technological boom, at the time. The project ultimately over-promised, ushering in a second—much longer—AI Winter[57] during which the U.S. military once again shied away from the field.

It is only in the last decade—due to significant advances in machine learning, natural language processing, and computer vision—that AI has once again become a priority for the U.S. national security enterprise. In 2014, the Department of Defense announced its Third Offset Strategy, the aim of which was "to draw on U.S. advanced technologies to offset China's and Russia's technological advances."[58] One of the central tenets was to "find new ways to cultivate technological innovations and interact with the commercial world" to counter DoD's diminished role in driving innovation. While the Third Offset only lasted in an official capacity until 2018,[59] it significantly influenced the 2018 National Defense Strategy which argued that a new cohort of technologies, including AI, autonomy, advanced computing, big data analytics, robotics, directed energy, hypersonics, and biotechnology would be the technologies to "ensure we will be able to fight and win the wars of the future."[60]

54 Ciocca/Horowitz/Kahn, "The Perils of Overhyping Artificial Intelligence: For AI to Succeed, It First Must Be Able to Fail."
55 Schuchmann, "History of the First AI Winter."
56 Roland/Shiman, Strategic Computing: DARPA and the Quest for Machine Intelligence, 1983–1993.
57 Schuchmann, "History of the Second AI Winter."
58 Gentile et al., A History of the Third Offset, 2014–2018.
59 Ibid., p. 72.
60 "Summary of the 2018 National Defense Strategy of The United States of America: Sharpening the American Military's Competitive Edge," p. 3.

Figure 1: Recent Policy Developments Related to Defense AI



Since 2018, AI has become a key pillar in U.S. defense and national security strategy. As technology has developed and progressed, and DoD's prioritization has shifted dramatically over the last five years, so has DoD's approach to organizing for AI. The progression of AI within the U.S. military can be divided into three distinct periods or eras, primarily differentiated by how defense AI has been organized within the DoD itself. These include the Project Maven Era: 2017–2018, JAIC Era: 2018–2022, and the CDAO Era: 2022-present.

4.1 Project Maven Era (2017–2018)

Since its establishment in April 2017 as the Algorithmic Warfare Cross-Functional Team,[61] Project Maven has become the most visible proof-of-concept for the application of AI for defense purposes in the United States. The idea behind the initiative was to relieve the burden on human operators tasked with analyzing video footage obtained from uncrewed aerial systems (UAS). The Maven algorithms augmented or fully automated the object detection, classification, and alert tasks using computer vision in support of the Defeat-ISIS campaign.

Unlike previous DoD-funded AI projects, Maven was a resounding success and surpassed expectations. Even in the face of a public controversy[62] early in its creation that saw Google letting its contract with DoD expire,[63] by the end of its first year, Maven had its first models working directly in combat operations. By 2020, Maven was being applied across multiple conflicts, marking "a monumental early AI-driving win for DoD."[64]

Undoubtedly, Project Maven's swift and sweeping success was "enabled by its organizational structure: a small, operationally focused, cross-functional team that was empowered to develop external partnerships, leverage existing infrastructure and platforms, and engage with user communities iteratively during development."[65] Maven was the first of its kind in that it was set up to leverage AI for a clear, well-defined purpose effectively. In addition, there was an explicit data-labeling and cleaning effort to ensure models were trained and applied to the best data, as well as a concerted emphasis on timeliness, with a requirement that algorithm-based technology would be integrated with Programs of Record in 90-day "sprints."[66] The launch of Project Maven was accompanied by the release of DoD's first-ever AI strategy, discussed above.

4.2 JAIC Era (2018–2022)

Emboldened by project Maven's success, in 2018, the DoD established the Joint Artificial Intelligence Center (JAIC) as the centralized hub for AI within the Department to "seize upon the transformative potential of Artificial Intelligence

61 "Memorandum For: Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)."
62 Simonite, "3 Years After the Project Maven Uproar, Google Cozies to the Pentagon."
63 Statt, "Google reportedly leaving Project Maven military AI program after 2019."
64 Vincent, "Amid a high-stakes transition, questions linger about Project Maven's future management."
65 Allen, "Project Maven brings AI to the fight against ISIS."
66 "Memorandum For: Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)."

technology for the benefit of America's national security."[67] The creation of the JAIC marked a key inflection point in the U.S. approach to defense AI. It had both significant funding and a high degree of internal and external visibility, which signaled a clear message: AI was going to be critical for the future of U.S. national security.

In the months following its establishment, in quick succession, Congress established the National Security Commission on Artificial Intelligence (NSCAI),[68] the JAIC received its first director, the White House enacted Executive Order 13859 on Maintaining American Leadership in AI, and the DoD published its first-ever AI Strategy.

The JAIC's introduction marked the beginning of the AI spring within the U.S. defense enterprise, succeeding in elevating AI and laying the foundation for the widespread recognition of AI as critical for the future of U.S. national security and defense that is bearing fruit today. In particular, the JAIC "made headway on AI adoption and data literacy, with initiatives like "AI 101," and on the data integration issue, as part of the Artificial Intelligence and Data Initiative (AIDA)."[69] AI R&D within the Defense Department has steadily grown, with the military services investing more in AI and related technologies, projects, and programs.

Ironically, as the JAIC succeeded in its original intent—as AI evolved and U.S. investment in the technology skyrocketed—it had become "torn between being a developer of algorithms itself and being an enabler that helps the military services figure out how to develop and implement algorithms within relevant military programs."[70] While the organization of the JAIC "followed best practices from military innovation and business innovation literature" at the time, "which advocated for surrounding the need to create spinoff or separate sub-organizations to value the potential of emerging technologies,"[71] the institution had since outgrown itself, becoming less clear in its aim as it became the owner of an increasingly varied portfolio of projects, technologies, and responsibilities. Furthermore, while well-funded, it had lacked real authority "to compel the military services and other institutions to collaborate "[72] on AI and AI-related projects.

During this time, the DoD also began to think about the broader implications and potential risks of using AI and released its first set of guiding ethical principles for defense AI.

67 "About the JAIC: The JAIC Story."
68 "NSCAI: About Us."
69 Horowitz/Kahn, "Why DoD's New Approach to Data and Artificial Intelligence Should Enhance National Defense."
70 Horowitz/Kahn, "Two Cheers for the Department of Defense's New Data and Artificial Intelligence Leadership Initiative."
71 Ibid.
72 Ibid.

4.3 CDAO Era (2022-Present)

In its eagerness over the past five years to bring the Department of Defense up to working speed on AI, the defense AI enterprise within the United States needs to be more efficient. While the DoD created more and more separate projects and institutions like Maven and the JAIC (with varying degrees of success, funding, and support), the organizational and bureaucratic infrastructure were not well-suited to a technology that, by definition, was broad in its forms, applications, and use-cases. The defense AI enterprise within DoD remained siloed. As many as "fifteen separate departments and organizations funded and worked on AI and AI-adjacent technologies, often without formal coordination or throughlines," resulting in "redundancies, gaps, inconsistencies in application and access to data and resources."[73]

In recognition of this, the Department of Defense moved to reorganize its major institutional AI players in early 2022, restructuring the AI efforts it had built piecemeal from the ground up. Hoping to achieve a more integrated approach to defense AI, the Pentagon created a new office—the Chief Digital and Artificial Intelligence Office (CDAO),[74] which would subsume the JAIC, the Defense Digital Service (DDS), and the office of the Chief Data Officer (CDO). Other significant reconfigurations of DoD's defense AI infrastructure have followed, with project Maven slated to move[75] from its longstanding home within the Office of the Under Secretary of Defense for Intelligence and Security to the National Geospatial Intelligence Agency. The idea behind the move was to support the "concerted push by the Defense Department to study, test and more effectively apply AI on the battlefield and behind the scenes."[76]

Deputy Defense Secretary Kathleen Hicks has argued that the sweeping reorganization has been essential to allowing DoD to "make a drastic move from a hardware-centric to a software-centric enterprise," with the CDAO playing the key role of "technical architect."[77] While Maven and the JAIC symbolized DoD's efforts to get smart on AI five years ago, these recent changes to the United States' defense AI organizational architecture "represents a maturation of the U.S. AI approach—one that elevates the importance of AI in national defense."[78] With the renewed approach emphasizing the interweaving of AI, emerging technologies, and data efforts.

73 Horowitz/Kahn, "Why DoD's New Approach to Data and Artificial Intelligence Should Enhance National Defense."
74 "Initial Operating Capability of the Chief Digital and Artificial Intelligence Officer."
75 Demarest, "Pentagon's Project Maven transition stymied by Congress, official says."
76 Ibid.
77 Vincent, "Amid a high-stakes transition, questions linger about Project Maven's future management."
78 Horowitz/Kahn, "Why DoD's New Approach to Data and Artificial Intelligence Should Enhance National Defense."

The CDAO is now producing a new data and AI strategy. As of writing, the reorganization remains in progress, and the CDAO is less than a year old. For U.S. defense AI adoption, aligning these organizations could be potentially game-changing and accelerate AI adoption throughout the U.S. military. It better bridges the gaps between institutional players, and "it links DoD's AI efforts with data, the fuel AI requires."[79]

4.4 The Defense AI Ecosystem More Broadly

The defense AI ecosystem within DoD is encompassed, in part, by the broader Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&D)) organizations. This includes defense agencies and field activities such as the Defense Innovation Board, the Small Business Innovation Research and Small Business Technology Transfer Programs (SBIR/STTR), the Innovation Steering Group, Science and Technology Futures, the Offices of the Deputy Chief Technology Officer (CTO) for Science & Technology, and for Critical Technologies, DARPA, and more.[80]

Since its early involvement in the '50s, DARPA has continued to "lead innovation in AI research as it funds a broad portfolio of R&D programs, ranging from basic research to advance technology development."[81] In September of 2018, it launched its over $2 billion "AI Next" campaign, focusing on generating robust, adversarial, and high-performance next-generation AI capabilities.[82] As of writing, DARPA has over 50 currently ongoing AI-related projects, on applications of AI ranging from making machine learning more explainable (its Explainable AI, or XAI program) to using AI to better assess secures of critical mineral supplies (the competition winners were just announced in December 2022).[83] Most famously, its Air Combat Evolution (ACE) program generated extensive media coverage with its series of Alpha Dogfight trials.

Critically, as DARPA has its own streamlined contracting procedures and funding mechanisms, and because it is focused on R&D, it has had the flexibility to conduct more early-stage blue-skies research, via its AI Exploration (AIE) program, which has focused on funding "high-risk, high payoff projects where researchers

79 Ibid.
80 A complete organizational chart can be found on the Office of the Under Secretary of Defense for Research and Engineering website, https://www.cto.mil/ (last accessed December 23, 2022).
81 "AI Next Campaign."
82 Ibid.
83 Clark, "DARPA announces AI for Critical Mineral Assessment Competition winners."

work to establish the feasibility of new AI concepts within 18 months of award."[84] While not all projects have translated into concrete capabilities or programs of record, DARPA is a consistent, key contributor to the overall defense AI ecosystem, as well as the defense research and engineering ecosystem more broadly.

A few other, cross-departmental, specialty organizations designed to target AI and other emerging technologies have been established under this umbrella, which has helped to direct funding and investment in capabilities. Namely, the Defense Innovation Board (DIB), established in 2016, was constructed to provide independent recommendations to the Secretary of Defense and other senior leaders within the DoD on emerging technologies that the military should adopt.[85] Most recently, in September 2020, the DIB published recommendations for testing, evaluation, validation, and verification (TEV/V) principles for AI.[86] The Defense Innovation Unit (DIU) was stood up specifically to field and scale commercial emerging technologies across the U.S. military, and from June 2016 to September 2021, has leveraged $20.1 billion in private investment, and award $892.7 million in contracts.[87] DoD is also adapting its policy components to more strongly support emerging technologies such as AI, creating an Emerging Capabilities Policy Office within the Office of the Under Secretary of Defense for Policy.

Outside of the DoD itself, some private sector initiatives have also emerged, attempting to further facilitate the transition of commercial-sector emerging technologies into government and the Department of Defense and serve as essential connective tissue between Silicon Valley and the Pentagon. The Special Competitive Studies Project (SCSP) grew as an informal continuation of the NSCAI, as many of the leadership and staff worked on the commission. The idea behind the project was to ensure "America's long-term competitiveness for a future where artificial intelligence (AI) and other emerging technologies reshape our national security, economy, and society."[88] Similarly, In-Q-Tel, the venture capital firm founded in 1999 to equip the U.S. intelligence community with "cutting-edge, innovative, and impactful technologies coming out of Silicon Valley and beyond," has been increasingly focusing on AI and machine learning, autonomy, and data.[89]

Key private sector companies contributing technology itself are covered in later sections on funding defense AI.

84 "AI Next Campaign."
85 "Defense Innovation Board: About."
86 "Artificial Intelligence Test, Evaluation, Validation & Verification (AI TEV/V) for DoD: Introduction Sheet."
87 "DIU Annual Report FY 2021 In Review," p. 7.
88 Mid-Decade Challenges to National Competitiveness.
89 "About IQT"

4.5 Working with Allies and Partners

Artificial intelligence has also become a new binding mechanism between the United States and its allies and partners. As a significant component of the messaging and strategy surrounding the US approach to defense AI has been to counter China's growing technological primacy, many of the DoD's efforts on AI have been folded into broader efforts to collaborate with partners in the region.

For example, as a part of the Indo-Pacific Strategy released by the White House in February 2022, the Biden Administration announced the creation of a new Quad Fellowship[90] which would recruit and financially support students from the United States, Japan, Australia, and India to pursue graduate degrees in STEM fields at U.S. institutions starting in 2023.

The trilateral security pact between Australia, the UK, and the US known as AUKUS which was created to further deter China, has revolved significantly around technology transfer and cooperation on the development of emerging technologies including AI and autonomy. As some have put it, "AUKUS seeks to win the technology competition with China by pooling resources and integrating supply chains for defense-related science, industry, and supply chains. This will be the decades-long and multifaceted purpose of AUKUS—a transnational project racing to seize advantages in artificial intelligence, quantum computing, and cyber technology."[91]

There has been more regular, albeit less formalized coordination on topics like AI governance and ethics with other states developing AI, including "academic conferences, Track II academic-to-academic exchanges, bilateral and multilateral dialogues, and discussions in various international forums."[92] In line with this, as early as 2020, the DoD began hosting the "AI Partnership for Defense"—a "recurring forum for like-minded defense partners to discuss their respective policies, approaches, and challenges in adopting AI-enabled capabilities." The forum initially included delegations from Australia, Canada, Denmark, Estonia, Finland, France, Israel, Japan, Norway, the Republic of Korea, Sweden, and the UK, and has since expanded to include Germany, the Netherlands, and Singapore. As of December 2022, the DoD has facilitated five such convenings on topics such as developing effective defense AI partnerships, ethics, and governance practices.[93]

90 Indo-Pacific Strategy of the United States, p. 10.
91 Tarapore, "AUKUS Is Deeper Than Just Submarines."
92 Scharre/Lamberth, "Artificial Intelligence and Arms Control."
93 JAIC Public Affairs, "DoD Joint AI Center holds fifth International Dialogue for AI in Defense"

5 Funding Defense AI

While complete details of the official Department of Defense budget and project spending are not publicly available, analysis of unclassified requests by the DoD paints a clear picture of a steady increase in the amount of funding designated for AI and other related and emerging technology research, development, testing, and evaluation (RDT&E) over the last few years. In Fiscal Year (FY) 2021, Stanford University's institute for Human-Centered Artificial Intelligence estimated that there were about 305 unclassified DoD RDT&E programs that specified the use of AI or machine learning technologies, comprising about $5 billion.[94] DARPA's 2021 investment alone invested around $568.4 million in AI (a significant jump from its estimated $82 million in FY2020).[95] In FY 2022, the Navy was projected to be the top-spending DoD department on AI-related projects and research, with an estimated $1.86 billion in investments. The Army ($1.7 billion), Office of the Secretary of Defense ($1.1 billion), and Air Force ($883 million) were not far behind.[96] Govini has estimated that from FY17-FY21, the U.S. government spent about $50 billion on AI, machine learning, and autonomy technology.[97] Approximately 84% of which was funded via direct contracts, 15% by grants, and the rest from other transaction authorities (OTAs).[98]

While the majority of these contracts and grants were awarded to the regular spread of large U.S. defense companies—Lockheed Martin, Northrop Grumman, General Dynamics, BAE, Raytheon, and Booz Allen Hamilton were all in the top 10 vendors[99] —there have been "emergent" companies that have benefited from the work of the DIU and the other organizations that have made it their mission to facilitate collaboration between Silicon Valley and the Pentagon, such as Anduril, Applied Intuition, Databricks, ModalAI, Rebellion Defense, and ShieldAI.[100] There are also stakeholders like C3 AI[101] and Palantir, which just recently received large media attention for the algorithmic power it has provided to Ukraine,[102] that don't quite fit into either bucket but are increasingly becoming key players when it comes to developing AI for defense.

The number of tech companies working with the U.S. government on AI and the overall amount of funding for AI is expected to continue to grow as technology becomes a key indicator for the health of U.S. global competitiveness, and AI becomes inextricably linked to direct defense and security strategy and China

94 Zhang et al, The AI Index 2021 Annual Report, p. 168.
95 Ibid., p. 189.
96 Zhang et al., The AI Index 2022 Annual Report, p. 191.
97 The National Security Scorecard: Critical Technologies Edition, p. 2.
98 Ibid., p. 24.
99 Ibid., p. 25.
100 For more on these companies, see: https://www.anduril.com/, https://www.appliedintuition.com/, https://www.databricks.com/, https://www.modalai.com/, https://rebelliondefense.com/, https://shield.ai/ (last accessed December 23, 2022).
101 See also: https://c3.ai/industries/enterprise-ai-for-defense/ (last accessed December 23, 2022).
102 Ignatius, "How the algorithm tipped the balance in Ukraine"; Ignatius, "A 'good' war gave the algorithm its opening, but dangers lurk."

policy. In March 2022, the Biden Administration set a "record peacetime national defense budget of $813 billion which earmarked $773 billion for the Pentagon."[103] A staggering 17% of the funds directed towards the Pentagon are being allocated to research and development. In announcing the FY2023 budget request,[104] the administration argued that the "all-time high" $130.1 billion for research and development reflected the understanding of the United States' "need to sharpen our readiness in advanced technology, cyber, space and artificial intelligence," in particular. The budget builds on "DoD's progress to modernize and innovate," not only "including the largest investment ever in RDT&E—more than 9.5% over the FY 2022 enacted level,"[105] but also dedicated $16.5 billion to Science and Technology, $3.3 billion to microelectronics, and $250 million to 5G, and an undisclosed amount to artificial intelligence as a part of its efforts on "Advanced Capability Enablers."

The need for more defense AI funding has noticeably gained the attention of U.S. Congress, as well, with the number of mentions of AI in U.S. Congressional records growing significantly since 2017. There were 149 mentions in the 115th Congress, 506 in the 116th, and the 117th Congress is "on track to record the greatest number of AI-related mentions."[106] Out of the 295 recorded mentions, 139 were in the legislation itself, 129 from Congressional Research Service Reports, and 27 from Committee Reports.[107] The increase in focus on AI can, in part, be attributed to the National Security Commission on Artificial Intelligence (NSCAI), established by the FY2019 NDAA and delivered its Final Report to Congress in March 2021.[108] As a result, Congress has largely been responsible for funding the implementation of the report's recommendations. However, while excitement has been high, actual momentum has been slow—in 2021, out of the 130 proposed federal bills relating to AI, only three have since been passed.[109]

For example, recent Senate amendments proposed[110] to the 2023 National Defense Authorization Act (NDAA)[111] have focused on augmenting funding for defense AI and other emerging capabilities efforts. For example, the Advancing American AI Act was submitted for NDAA inclusion with the hope that it would "encourage agency artificial intelligence-related programs and initiatives that enhance the competitiveness of the United States and foster an approach to artificial

103 Stone, "U.S. Congress moves to boost Biden's record defense budget."
104 "The Department of Defense Releases the President's Fiscal Year 2023 Defense Budget."
105 Ibid.
106 Zhang et al., The AI Index 2022 Annual Report, p. 183.
107 Ibid., p. 183.
108 "NSCAI: About Us"
109 Zhang et al., The AI Index 2022 Annual Report, p. 178.
110 Kelley, "A Look Into Proposed Tech Amendments for the 2023 NDAA."
111 "H. Rept. 117–397 - NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2023: Report of the Committee on Armed Services House of Representatives on H.R. 7900."

intelligence that builds on the strengths of the United States in innovation."[112] Similarly, the proposed United States-Israel Artificial Intelligence Center Act would foster more bilateral collaboration on capabilities like natural language processing and computer vision.[113]

112 "Text of Senate Amendment 6391; Congressional Record Vol. 168, No. 158."
113 "S.2120 United States–Israel Artificial Intelligence Center Act."

6 Fielding and Operating Defense AI

Despite some of the difficulties discussed above, the United States has been actively prototyping, fielding, and operating defensive applications of AI across the Department of Defense and the armed services. It is important to note, however, that most applications of AI are software-based rather than hardware-based, which has proved more challenging for the DoD. DoD is pursuing these capabilities, but with the caveat that "the majority of its advanced AI capabilities for warfighting are still in development as DoD grapples with their differences from traditional software."[114]

While the uses for AI in defense contexts are seemingly endless, from using AI to enhance the precision and accuracy of existing systems to generating simulation-based training initiatives and wargames, some of the more visible, established applications of AI the DoD has been pursuing are in the following areas:

- Intelligence, Surveillance, and Reconnaissance (ISR)
- Cyber
- Autonomous Systems and Vehicles
- Command and Control
- Disaster Relief
- Logistics

While these focus areas have been categorized here, most defense AI projects currently in development can be integrated or adapted into multiple contexts and missions, such as different platforms or used by different military services. Illustrating this point, a Government Accountability Office (GAO) report identified almost 700 DoD AI projects in FY2021, most of which were "not yet aligned to specific systems but have potentially broad applicability to multiple systems."[115] Additionally, only 17 out of 88 reported major weapons systems "had associated AI projects clearly identified."[116] The below sections detail some examples of the more visible, mission-specific applications of AI the U.S. military has pursued.

6.1 Intelligence, Surveillance, and Reconnaissance (ISR)

AI is already demonstrating the dramatic impact it can have on ISR capabilities due to its ability to recognize patterns quickly and analyze large swaths of dispa-

114 GAO, Artificial Intelligence: DOD Should Improve Strategies, Inventory Process, and Collaboration Guidance, pp. 15–16.
115 Ibid., p. 17.
116 Ibid., p. 17.

rate data from various sources. The use of AI for ISR was arguably one of the first recognized applications for AI for U.S. defense purposes. Project Maven, which used computer vision and algorithms to aid in video and image analysis, was the first AI project within DoD to be considered a resounding success. In part, Maven reignited U.S. interest and investment in defense AI. Other, more recent AI initiatives have emerged from Project Maven's success. For example, the Army's Scarlet Dragon[117] uses data from Maven to provide AI-augmented targeting assistance for large-scale combat operations, while the Marine Corps is working to "incorporate algorithms developed as part of Project Maven into their capabilities and to modernize legacy weapon systems."[118] AI is also being used in a layered manner—using multiple applications and techniques in conjunction. For example, the Navy's Task Force 59 is working to create cost-effective, fully autonomous vehicles that also have AI-enabled surveillance capabilities to monitor threats ranging from "hostile Iranian drones to an aggressive Chinese posture to rogue pirates."[119]

More generally, other AI-enabled technologies are also used within the Department of Defense. Facial recognition technology is already employed across the DoD and Intelligence Community to "identify individuals known or suspected to be terrorists, research derogatory information about a suspected threat actor, and monitor or surveil locations to search for a person of interest."[120]

6.2 Cyber

Concerning how AI might impact cybersecurity and cyberoperations, much of the discourse within the United States has been about its disruptive potential. For example, AI is expected to "make the work of cyber defenders more difficult over time, with faster and faster computers enabling increasingly complex attacks and more rapid network intrusion."[121] Similarly, technologies such as natural language processing and deepfakes, especially when used in conjunction with cyber attacks, are already improving the fidelity of influence operations or spear-phishing attempts.

The Navy and the Army both employ commercial machine learning algorithms, trained on commercial and government data, to better detect cyber threats.[122] Overall, the DoD has worked closely with U.S. Cyber Command to employ AI

117 Wasserbly, "AUSA 2021: US Army's 'Scarlet Dragon' project aims to use AI, satellites for targeting."
118 GAO, Artificial Intelligence: DOD Should Improve Strategies, Inventory Process, and Collaboration Guidance, p. 20.
119 Barnett, "Task Force 59: The future of the Navy's unmanned systems or a one-off win?"
120 GAO, Facial Recognition Technology: Current and Planned Uses by Federal Agencies, p. 21.
121 Segal/Goldstein, "Confronting Reality in Cyberspace: Foreign Policy for a Fragmented Internet," p. 31.
122 Kenyon, "US DoD selects Torch.AI for cyber security capabilities."

to enhance network protection tools. Moreso, Marine Corps Lt. Gen. Michael S. Groen has argued that artificial intelligence and data are driving a departmental-wide "mind-shift" in protecting and making networks more resilient.[123]

6.3 Autonomous Systems and Vehicles

While most AI applications do not constitute weapons systems, and while AI is not the same thing as autonomy, increasingly, autonomous systems are advertised as physical manifestations of AI. Advances in AI—and in particular, the integration of AI into piloting, guidance, navigation, and ISR and target acquisition systems on platforms—have enabled greater degrees of autonomy in everything from vehicles to munitions. Real advances have also been made in ideas such as system coordination to result in capabilities such as collaborative combat or swarming. Such R&D projects currently in development include the U.S. Navy's Ghost Fleet—the goal of which is to have nearly one in three warships be entirely autonomous, without any human crew aboard, by 2045[124]— and the U.S. Air Force's Golden Horde experiments, which hope to develop swarming air-fired and air-dropped smart weapons that can autonomously share information, change course, and seek high-priority targets.[125]

6.4 Command and Control

AI is also increasingly used to collect, identify, and synthesize multiple data streams to improve battlefield and situational awareness in real-time and better connect sensors with operators and decision-makers. Using AI to create a single source of information in this manner is sometimes referred to as a "common operating picture" (or a glass battlefield in other countries).[126] A Congressional Research Service report points out that "currently, information available to decision-makers comes in diverse formats from multiple platforms, often with redundancies or unresolved discrepancies."[127] In this regard, AI is seen as the key component to implementing the U.S. DoD vision of Joint All-Domain Command and Control (JADC2)—"which aims to centralize planning and execution of air-, space-, cyberspace-, sea-, and land-based operations" to create a wholly-con-

123 Vergun, "General Says Artificial Intelligence Will Play Important Role in Network Defense."
124 Mizokami, "By 2045, One-Third of U.S. Navy Warships Will Be Robotic 'Ghost Ships'."
125 Osborn, "Golden Horde: This Air Force Weapon Can Communicate and Maneuver in Flight"; Insinna, "US Air Force completes tests of swarming munitions, but will they ever see battle?"
126 Barnett, "DARPA wants a common operating picture to 'complement' JADC2"; Frantzman, "Germany hires Rafael and Atos to create a 'glass battlefield'."
127 Sayler, Artificial Intelligence and National Security, p. 13.

nected and in-sync military. The DoD released their JADC2 Implementation Plan in March 2022, which elaborated that "JADC2 enables the Joint Force to 'sense,' 'make sense,' and 'act' on information across the battle-space quickly using automation, artificial intelligence (AI), predictive analytics, and machine learning to deliver informed solutions via a resilient and robust network environment."[128] Data and AI have become so central, that moving forward, the CDAO will be heading up the strategy element of JADC2.[129]

All of the service's JADC2 projects--the Army's Project Convergence,[130] the Navy's Project Overmatch, and the Air Force's Advanced Battle Management System[131] have indicated the use of AI in some shape or form. For example, the Army used its AI-powered network, Firestorm,[132] to transmit intelligence directly from U.S. Army sensors to Australian and British forces in a recent Project Convergence experiment with allies.[133] The Air Force has also launched a series of Global Information Dominance Experiments (GIDE)[134] to give more time to commanders to make decisions "by integrating more information from a global network of sensors and sources, using the power of AI and machine-learning techniques to identify the important trends within the data, and making both current and predictive information available."[135]

In November 2021, Project Overmatch launched an "AI Challenge" designed to leverage "AI-enabled technologies to address current and future warfighting gaps."[136] Even the relatively young Space Force has begun to work on similar capabilities, partnering with the Air Force to develop an AI-based domain awareness capability tailored to outer space.[137]

Similarly, DARPA has also launched programs to leverage AI to "network systems and sensors, prioritize incoming sensor data, and autonomously determine the optimal composition of forces" in the form of the Air Space Total Awareness for Rapid Tactical Execution (ASTARTE) project.[138]

128 See "DoD Announces Release of JADC2 Implementation Plan" for the full announcement; Sayler, Artificial Intelligence and National Security.
129 Pomerleau, "DOD creates new JADC2 integration office, puts CDAO in charge of data integration."
130 Feickert, The Army's Project Convergence.
131 Hoehn, Advanced Battle Management System (ABMS).
132 Strout, "Inside the Army's futuristic test of its battlefield artificial intelligence in the desert."
133 Lacdan, "Project Convergence 2022: Army to work closely with allies in the future fight."
134 Barnett, "DOD tests new machine learning capabilities for JADC2"
135 North American Aerospace Defense Command and U.S. Northern Command Public Affairs, "NORAD, USNORTHCOM lead 3rd Global Information Dominance Experiment."
136 Gamboa, "NAVWAR Announces Project Overmatch Prize Challenge Winners."
137 Hitchens, "Space Force sees AI as 'absolutely essential' for JADC2."
138 Sayler, Artificial Intelligence and National Security, p. 13; Barnett, "DARPA wants a common operating picture to 'complement' JADC2."

6.5 Disaster Relief

The DoD is also pursuing AI for use cases with humanitarian goals. When the JAIC was first established in 2018, it had two initial capability delivery projects called National Mission Initiatives (NMIs)[139] it was tasked with, one of which was Humanitarian Assistance and Disaster Relief (HA/DR). The idea behind the NMI is to use AI and machine learning to power "problem-solving prototypical applications to quickly identify and locate people and infrastructure impacted by natural and manmade disasters."[140] Predictive geospatial intelligence and computer vision, for example, are both in development for use in these situations. For example, in 2018, the DIU hosted the xView2 Challenge,[141] which tested computer vision algorithms to score and rank structural damage to buildings via satellite imagery after a natural disaster so as to more efficiently allocate emergency response teams and resources

6.6 Logistics

The second NMI that the JAIC was initially tasked with was Predictive Maintenance (PMx). A large component of logistics is ensuring that materiel is up to standards and is well-maintained. The idea behind the NMI was to use AI to generate efficiencies and reduce costs associated with maintenance by predicting in advance when a component might fail—a technique known as predictive maintenance.[142] In this way, instead of waiting for a system or part to fail before fixing it or relying on set, force-wide maintenance schedules, AI could provide a unit-based, specially tailored recommendation.

For example, the JAIC partnered with the U.S. Special Operations Command's 160th Special Operations Aviation Regiment to create a natural language processing tool called the Work Unit Code Corrector to improve "the overall quality of H-60 helicopter maintenance records for improved fleet health reporting."[143] Similarly, the U.S. Army's Logistic Support Activity (LOGSA) contracted IBM's Watson back in 2017 to develop tailored maintenance schedules for some of its armored vehicles based on sensor data, and, once that project proved a success, extended the contract to have Watson optimize spare part transportation.[144]

139 Moon, "DOD's Artificial Intelligence Initiatives Outlined Before Senate."
140 "Esri Chosen To Support Department Of Defense JAIC Emergency Response Program."
141 "Artificial Intelligence Portfolio: xView Challenge Series."
142 Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment (DODIG-2022–103), p. 2.
143 "JAIC partners with USSOCOM to deliver AI-enabled predictive maintenance capabilities."
144 Stone, "Army logistics integrating new AI, cloud capabilities."

7 Training for Defense AI

One of the most widespread, recurring points of concern about U.S. defense AI adoption is the broad lack of STEM[145] expertise and talent in government.[146] In fact, according to the NSCAI's final report, it is the "alarming" deficient of diverse and tech-savvy talent within both the DoD and U.S. Intelligence Community (IC) that stands as the "greatest impediment to the United States being AI-ready by 2023".[147] The report continues, warning that if the government fails to invest in building a digital workforce, the United States "will remain unprepared to buy, build, and use AI and its associated technologies."[148]

While the United States is attractive to members of the global AI talent pool,[149] the U.S. public sector has failed to compete with academia and industry. A survey of 254 U.S. AI Ph.D. graduates, for example, indicated that only 31% would even consider a government role, citing a lack of access to both computing and data resources as well as growth opportunities, and an inability to pursue research.[150] Furthermore, fewer than one in five had been approached by a government recruiter, compared to four in five that a large company had approached, and over half by an academic institution.[151]

The NSCAI report says that some policymakers in Washington have argued that the "government should focus on project management and data collection and management, and outsource all development" and that it would not be "feasible for the government to hire or train its own AI experts."[152] However, the Commission argued that such an approach was short-sighted and outlined a detailed set of recommendations to overcome the training and talent issue. Despite the blueprint provided by the NSCAI report and a congressional mandate to develop an AI workforce and education strategy in the 2020 NDAA,[153] there has not been any comprehensive effort to enact many of the recommendations outlined, nor to reform hiring, recruiting, and training processes in either the DoD or IC.

However, a few small, piecemeal, and one-off initiatives have been launched. For example, in April 2020, the Joint Artificial Intelligence Center released a master guide to artificial intelligence designed to help the many officials throughout the department who were being "asked to make decisions about AI"[154] before they had developed an appropriate understanding of the technology's basics, to

145 STEM: Science, Technology, Engineering, and Mathematics.
146 Horowitz/Kahn, "The AI Literacy Gap Hobbling American Officialdom"; Kahn, "How DoD Can Remedy the Talent Deficit Harming U.S. Technological Competitiveness."
147 NSCAI 2021 Final Report, p. 121.
148 Ibid.
149 Zwetsloot et al., The Immigration Preferences of Top AI Researchers.
150 Aiken/Dunham/Zwetsloot, Career Preferences of AI Talent, pp. 2, 13.
151 Ibid.
152 NSCAI 2021 Final Report, p. 123.
153 "National Defense Authorization Act for Fiscal Year 2020."
154 Allen, "Understanding AI Technology."

study up fast. In September 2022, it was announced that the CDAO would contract FedLearn, an online educational tool provider, to prototype an AI training experience.[155]

Finally, since the announced creation of the CDAO and absorption of the JAIC, the CDAO has begun to emphasize its capacity for internal AI advocacy and education. As a result, the CDAO has begun to design and propagate a consistent AI education strategy[156] to improve general understanding of AI across the department and the armed services, which started in February 2022 through the launch of a series of "AI 101" educational pilot programs.[157] Forty-seven different organizations, including multiple offices of each of the armed services, members of the intelligence community, and the Joint Chiefs of Staff, were all engaged in its development.

155 Federal Times Staff, "Pentagon to test FedLearn's artificial intelligence platform."
156 2020 Department of Defense Artificial Intelligence Education Strategy.
157 Barnett, "JAIC piloting artificial intelligence education for DOD."

8 Conclusion

The United States has both the desire and means to achieve world leadership in defense applications of artificial intelligence—there is support from top leaders and policymakers across the government, and a rich AI research ecosystem exists across the private and academic spheres. Moreover, AI is increasingly viewed as critical in addressing national security concerns, particularly in capability-matching U.S. adversaries and addressing the pacing challenge with China that animates the 2022 National Defense Strategy.

Surprisingly, despite these stimuli, the U.S. government, particularly the Department of Defense, has yet to seriously, and on a broad scale, employ AI beyond one-off projects or initiatives. The lag is partly due to a predisposition to favoring and being more accustomed to hardware-based capabilities rather than software and momentum that biases the status quo. However, the most considerable obstacles slowing down U.S. defense innovation, and AI adoption especially, have been 1) an organizational structure and acquisitions process that is not best suited to translating general-purpose technologies of commercial and civilian origins into fundamental capabilities to be used in national security and defense contexts, and 2) a significant AI/STEM talent deficit.

Over the last year, significant geopolitical changes and events, including the Russia-Ukraine conflict and continuing evidence of China's technological rise, have crystallized the near-term military impact of emerging technologies, including AI. The United States Department of Defense has reacted by increasing the urgency with which it has pursued its AI goals. Namely, by creating new organizations designed to improve DoD's AI adoption capacity, releasing a Responsible AI Strategy and Implementation Pathway, formalizing a set of guiding ethical principles, increasing funding and support for projects and acquisitions mechanisms tailor-made for AI, and reorganizing its internal AI and data ecosystem.

There has been some early indication of progress due to these recent course-correction measures. That after years of unmet potential, DoD is now more effectively moving forward towards the creation of a more AI-enabled US military is promising. However, only time will tell what the long-term implications will be, and whether recent efforts will be sufficient to launch a fully AI-enabled U.S. military.

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