The Coming Military AI Revolution

Col. Joshua Glonek, U.S. Army

The simple fact is that we see everything the enemy is doing and they see everything we are doing. In order for us to break this deadlock we need something new, like the gunpowder which the Chinese invented and which we are still using to kill each other.

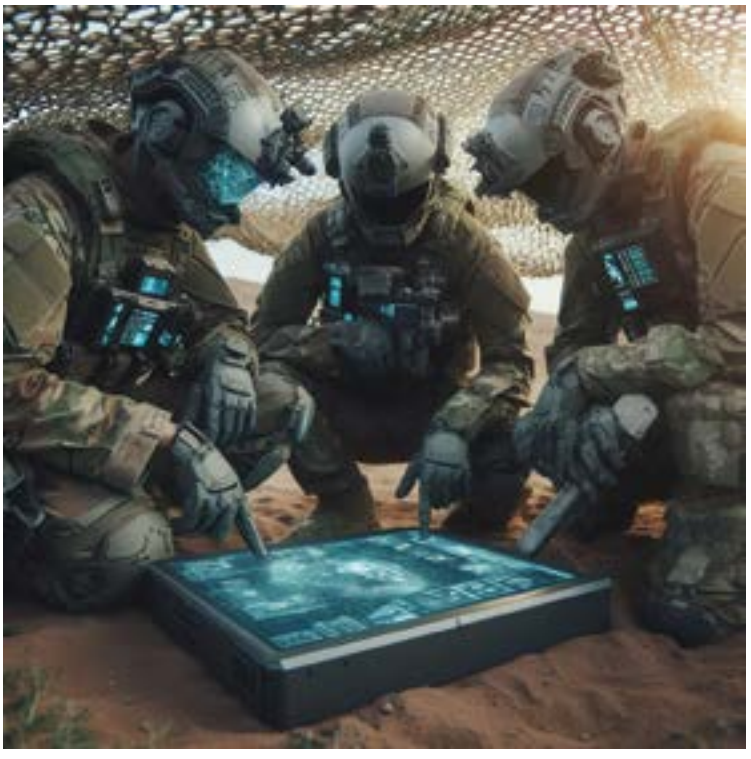
—Gen. Valery Zaluzhny, Former Ukrainian Armed Forces Commander in Chief

The U.S. military's long-held technological overmatch is quickly eroding.[1] Over the past twenty-five years, China has invested heavily in its military—the People's Liberation Army (PLA)—putting it on a path to "complete national defense and military modernization by 2035" and to transform the PLA into a "world-class military

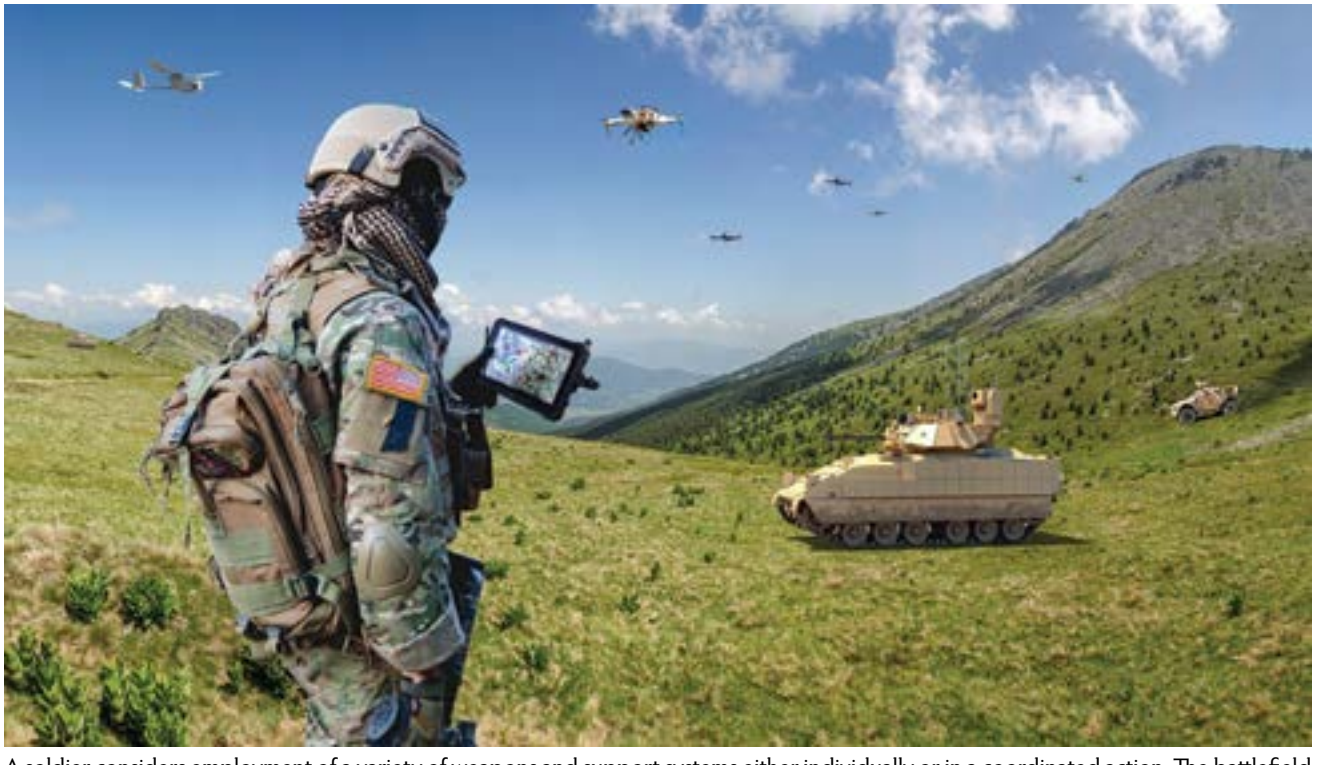
A video screen plays footage of Chinese People's Liberation Army soldiers on a robot from Chinese robot maker Jiangsu Eastern Gold Jade Intelligent Robot Company at the World Robot Conference in Beijing on 15 August 2018. (Photo by Mark Schiefelbein, Associated Press)

by the middle of the century."[2] China's increased military strength now presents a formidable challenge to the U.S.-led international order, and to the security of U.S. allies and partners.[3]

One technology in particular will determine the preeminence of military forces in the coming decades: artificial intelligence (AI). With the advent of self-driving cars and ChatGPT, AI has moved beyond the realm of science fiction and is now beginning to proliferate throughout society. This disruptive technology is also creating new opportunities for military forces. Dual-use applications of AI provide tools to quickly analyze large amounts of data, enhance links between sensors and shooters, and increase decision-making speed. The U.S. military must embrace this transformative technology and accelerate the development of innovative applications of AI to preserve its technological edge, deter adversary aggression, and, if necessary, prevail in armed conflict.



Soldiers employ AI to analyze collected data and prepare for a tactical-level operation. (AI image by Col. Joshua Glonek, U.S. Army)



A soldier considers employment of a variety of weapons and support systems either individually or in a coordinated action. The battlefield of the future will be characterized by a range of AI-driven weapons platforms and support systems, including unmanned aircraft and tactical vehicles. (Illustration by Jamie Lear, U.S. Army)

Alan Turing (1912–1954) at Princeton University in 1936. Turing was an English mathematician, computer scientist, cryptanalyst, and theoretical biologist. He is widely considered to be the father of theoretical computer science and one of the founding fathers of artificial intelligence. (Photo courtesy of Wikimedia Commons)

The coming military AI revolution is situated squarely within the wider geopolitical competition between the United States and China. The stakes of this competition are high and the outcome uncertain. China believes the United States is a superpower in decline. As the PLA grows in strength, its actions are becoming more aggressive. Over the last two years, the United States has documented over 180 instances of dangerous PLA air intercepts against U.S. allies and partners.[4] The South China Sea remains a contentious flashpoint, with China asserting illegitimate territorial claims and continuing to signal its willingness to use military force against Taiwan.[5] Tensions are high, and the risk of conflict is real.

Succeeding in this great power competition—and deterring war—will require the U.S. military to preserve its technological advantages. Achieving this, however, demands a groundbreaking innovation effort as China is quickly closing the gap. Determined to "intelligentize" warfare, the PLA is rapidly pursuing an entirely new generation of AI-enabled military systems.[6] In support, the Chinese Communist Party is marshalling a significant amount of state and private resources toward this effort. Progress is continuing to accelerate.

In response, the U.S. Department of Defense (DOD) has embarked on its own path of military modernization. Accelerating the adoption of AI is now a major priority for the DOD, as it seeks to harness the innovation power of the American private sector, home to the world's leading AI companies. By fielding AI-enabled systems at scale and employing them on the battlefield in new ways, the U.S. military intends to offset the PLA's progress and remain the world's unmatched superpower.

The consequences of the coming military AI revolution are enormous. If developed effectively, AI will permeate across all military systems and processes. Enormous efficiency gains will be realized as AI reduces the demands on humans to process data, preventing cognitive overload and enabling more thorough analysis. Situational awareness will grow, operations will become more precise, and decisions will be better informed. The speed of warfare will increase. Those with the best AI tools will be constantly exploiting the initiative, while those without will struggle to make sense of what is happening.

As the military AI revolution proceeds, it's incumbent on all members of the profession to prepare. From general to private, we will all have a role to play in the transformation of the force that will occur over the coming years. We must embrace what is new and adapt to the changing environment. As Italian airpower theorist Giulio Douhet once stated, "Victory smiles upon those who anticipate the change in the character of war, not upon those who wait to adapt themselves after the changes occur."[7] Douhet's words, written over a century ago, still resonate powerfully today.

A Brief History of AI

Although AI may seem like a relatively new phenomenon, British mathematician Alan Turing first devised the theory in 1950. Having played a key role in the development of computers, Turing believed AI would be achieved once machines became capable of generating answers to questions that were indistinguishable from human responses.[8] For the next two decades, AI researched flourished as the Defense Advanced Research Projects Agency funded the creation of AI labs at several major universities.[9] Despite this initial flurry of AI research, the lack of computational power and data storage found in

primitive computers led many to believe continued advancements were no longer feasible. As a result, funding was significantly reduced for most AI research.

AI development experienced a resurgence in the 1980s as advanced microprocessors enabled greater computing power. Consistent with a concept called "Moore's law," the capacity of computer chips continued to grow exponentially, doubling approximately every two years.[10] These more powerful semiconductors allowed computer scientists to access larger databases, enabling more sophisticated algorithms. A new series of programs known as "expert systems" were developed, which, for the first time, were able to replicate the decision-making of humans.[11] Expert systems contained an extensive collection of knowledge and facts about a specific topic. These programs could solve narrowly defined problems that would otherwise require human subject-matter experts. For example, the DOD employed expert systems to develop maintenance software that enabled users to input diagnostic data and receive a report on the underlying cause of the malfunction, as well as recommended solutions.[12] Although expert systems excelled at bespoke applications, they were incapable of engaging in problem-solving beyond their preprogrammed knowledge.[13]

IBM engineer Arthur Samuel with an early machine-learning computer he developed circa 1962 that improved at the game of checkers the more games it played. Samuel laid the groundwork for a series of breakthroughs in artificial intelligence at IBM during the 1990s. (Photo courtesy of IBM)

The next wave of AI progress came in the 1990s with the creation of machine learning. Unlike expert systems that had to be manually programmed, machine learning algorithms used training data to "learn" how to perform tasks and solve problems.[14] This allowed developers to fine-tune the models' parameters to achieve desired outcomes, resulting in highly flexible AI programs that could perform well in new environments. Further progress was made with the development of "deep learning" algorithms that used neural networks loosely modeled on those of the human brain. Combining deep learning with massive datasets has enabled "computer vision," which is the basis for a variety of applications from self-driving vehicles to facial recognition programs.[15]

The most recent breakthrough in AI was introduced to the world in November 2022 when OpenAI released its ChatGPT Large Language Model program. The Large Language Model capitalizes on the fact that natural language is arranged in a sequential order, creating logical connections between the words in a sentence. By reading a very large number

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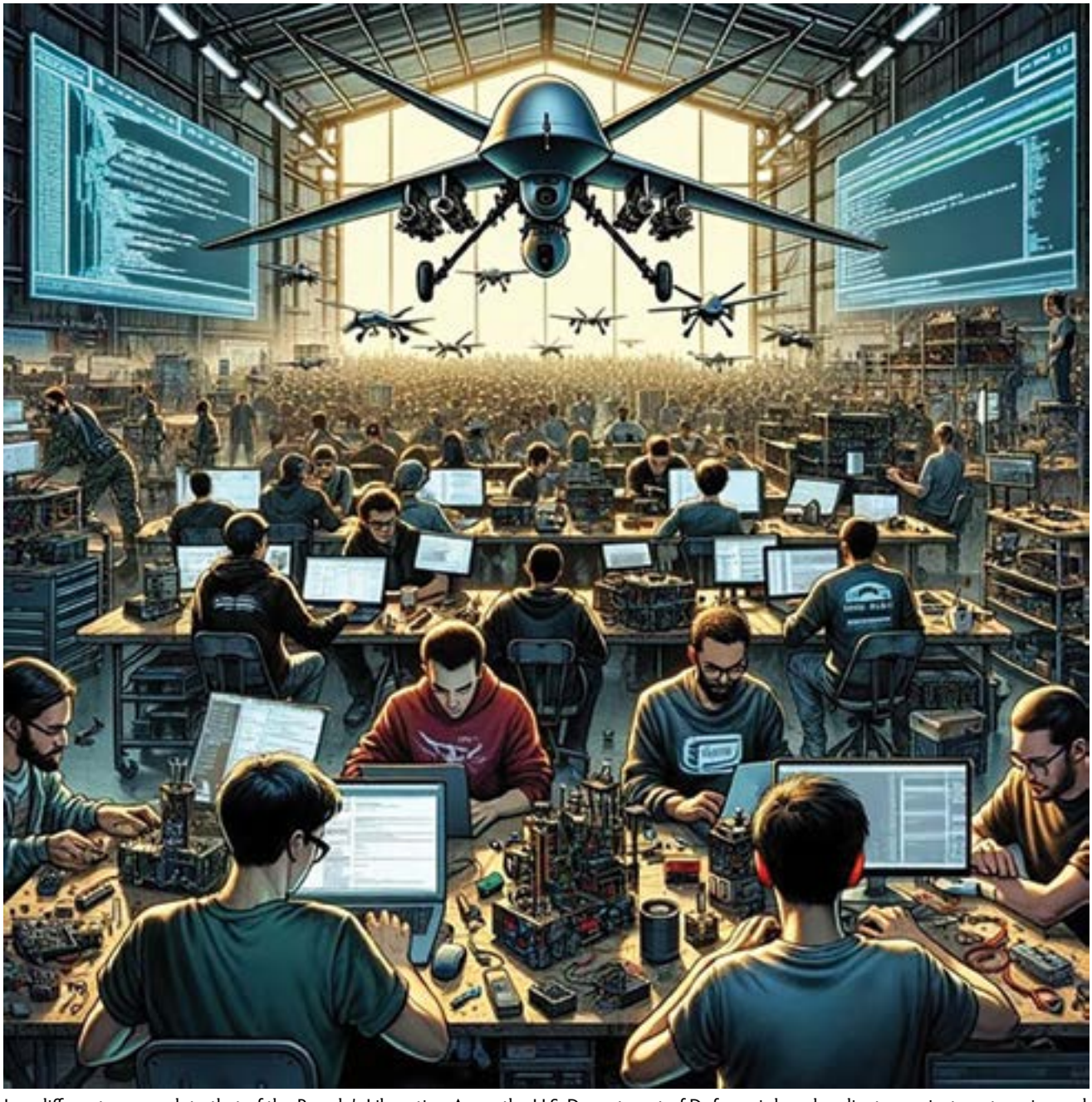
China's approach to developing military technology is a strategy of military-civil fusion characterized by direct military involvement in research and development with private Chinese businesses synchronized by centralized government control. (AI image by Gerardo A. Mena Jr., Army University Press)

of sentences during training, these models become effective in predicting the arrangement of words in a coherent manner.[16] Ask ChatGPT to write a book report, create a business plan, or compose poetry and it will do so near instantaneously with a high degree of effectiveness. And because words are simply a form of data, these new techniques are not limited only to language. New applications of generative AI are emerging with the capability to create images and videos, compose music, and write computer code.

In recent years, advancements in AI have led to significant achievements. In 2016, Google DeepMind's AlphaGo computer program defeated world champion Go player Lee Sedol in a five-game match. During the second game, AlphaGo made an unorthodox move that onlooking experts initially thought was a mistake. As the game progressed, it became apparent that the "mistake" proved pivotal to the machine's victory.[17] Yet another milestone was achieved in 2020 when an AI-agent decisively defeated an elite human fighter pilot in a Defense Advanced Research Projects Agency-sponsored virtual dogfight competition. When asked about his repeated losses, the human pilot responded, "The standard things that we do as fighter pilots aren't working."[18] These feats are not only stunning demonstrations of AI prowess in complex scenarios, but they also show how AI is capable of learning new techniques and strategies that outwit even the best humans.

The Race to Develop Military AI

Across a variety of narrow applications, AI is already winning. Both the United States and China understand this and are racing to incorporate AI into their military strategies. In 2018, the DOD released its first *Artificial Intelligence Strategy*, intended to accelerate the adoption of AI by the U.S. military. The report highlighted the



In a different approach to that of the People's Liberation Army, the U.S. Department of Defense is largely reliant on private enterprise and economic competition between competing private businesses in its programs of defense technology development. This approach assumes free enterprise promotes greater freedom in creativity and innovation. (Illustration courtesy of DroneXL, https://www.dronexl.co)

fact that China was "making significant investments in AI for military purposes," which "threaten to erode our technological and operational advantages."[19] In 2019, China published a defense white paper, which argued a "Revolution in Military Affairs with Chinese characteristics" was underway.[20] Aided by new advancements in emerging technologies, the report emphasized the importance of AI in future warfare as big data, cloud computing, and the internet of things were "gathering pace in the military field."[21] The idea that AI would transform the character of warfare was now at the forefront of both nations' military strategy.

Unlike some important military innovations of the past such as the longbow, gunpowder, or the tank, which had relatively specific uses, AI is a general-purpose technology with a diverse array of applications.

A soldier uses a handheld device to employ artificial intelligence for data analysis to guide rapid planning and execution of tactical-level operations. (AI image by Gerardo A. Mena Jr., Army University Press)

More akin to the advent of electricity, which generated advances in lighting, heating, transportation, and communications, AI will diffuse across many other technologies, greatly increasing their capability and effectiveness. Today, in both the U.S. and Chinese defense sectors, there is a proliferation of AI research and development pursuing a variety of military uses, including autonomous vehicles, intelligence collection, predictive logistics, cybersecurity, and command and control. The outcome of the AI race will not be decided based upon one specific application but rather will be determined by the side that can best integrate AI across a variety of systems and processes in all domains of warfighting.

The United States has long been the world leader in the development of military hardware, enabled by a strong culture of innovation and well-established defense industrial base. In recent years, China has made significant progress with a deliberate state focus on military modernization. Both nations, however, are facing a new challenge in the race for AI-enabled military systems. Unlike many technological innovations of the past that were developed through government-sponsored research programs, the most cutting-edge AI technology today currently resides in the private sector. Gaining access to this technology requires the DOD and PLA to forge new partnerships with commercial firms to develop dual-use applications. Traditional defense contractors and state-owned enterprises in both the United States and China simply can't keep up with the pace of AI innovation in the private sector.

China's approach to solving this problem is to exploit the power of the state to deepen public-private integration through a strategy of military-civil fusion.[22] Over recent years, several facets of the strategy have successfully contributed to closer integration between the PLA and private Chinese businesses. These include

the establishment of joint laboratories to facilitate dual-use research among military, academic, and commercial enterprises; creation of the Agile Innovation Defense Unit, which focuses on providing the PLA access to commercial technologies; and PLA sponsorships of challenges and competitions intended to promote creative solutions to military problems.[23] Furthermore, military-civil fusion is proving successful in expanding the PLA's reach into the commercial sector. One recent study from the Center for Security and Emerging Technology found that the PLA acquired the majority of its AI-related equipment from private Chinese technology companies, not legacy state-owned enterprises.[24] While corruption and bureaucratic inefficiencies remain limitations of China's authoritarian system, impressive progress has been made thus far.

In contrast to the Chinese top-down approach, the U.S. strategy is to leverage its vibrant and innovative market-based economy to generate new AI-enabled military technologies. In doing so, the DOD seeks to rebalance the force away from legacy combat platforms that are exquisite, manned, and high cost toward a new generation of systems that are expendable, autonomous, and relatively inexpensive. Through an initiative dubbed "Replicator," the DOD has established a goal of fielding these systems at a scale of "multiple thousands, in multiple domains, within the next 18–24 months."[25] Intended to offset the PLA's conventional advantage in mass, Replicator seeks to complement U.S. conventional capabilities with large concentrations of AI-enabled systems that can effectively operate in highly contested environments.

Serving as the lead for the development of these technologies is the Defense Innovation Unit (DIU), which was created to foster closer partnership between the DOD and the private sector. In 2023, the DIU was elevated to a direct reporting unit to the secretary of defense in order to "catalyze engagement with and investment into private sector communities where commercial technology can be adapted and applied to meet our warfighters' requirements."[26] In places like Silicon Valley, the best commercial AI companies in the world possess the expertise to develop dual-use applications of their technologies but are often hindered by the DOD's cumbersome acquisition procedures. DIU helps to overcome this challenge by streamlining the process, drawing more nontraditional companies into the defense sector. This enables greater innovation, a wider variety of AI applications, and faster adoption of these systems into the military. As the Replicator initiative proceeds, DIU will play a leading role in coordinating the development of AI technologies that are tailored to the needs of the military services and combatant commanders.

Seeing through the Fog of War

Military operations are characterized by a prevailing "fog," which exists due to the inherent uncertainty of war.[27] The inability to predict how battle will unfold is part of war's essential nature and cannot be completely eliminated. Some of the fog, however, is the result of an enormous amount of data and information that cannot be processed fast enough to clearly understand its meaning. After action reviews from combat training centers routinely highlight the shortcomings of units that become overwhelmed by cascades of information. Rarely are staffs able to effectively synthesize the abundance of data in ways that bring clarity to the overall situation. The question "who else needs to know?" is commonly asked, as a technique to offset the tendency of information to remain isolated in functional "stovepipes." Despite the development of knowledge management procedures designed to better identify, organize, store, and disseminate information, the fundamental problem of data overload still exists.

On today's modern battlefield, sensors are nearly ubiquitous, constantly streaming information to military command posts. Staffs struggle to keep pace with the sheer volume of data that is available: information, surveillance, and reconnaissance assets provide data on enemy forces through a combination of imagery, video feeds, signal intercepts, and electromagnetic detections; friendly forces provide status updates and requests for support over a variety of command-and-control systems; and other factors, such as changes to the weather, the presence of civilians on the battlefield, or the introduction of disinformation, add further complexity to the operational environment. The flood of available data can create a state of "analysis paralysis" that stymies effective decision-making. By the time decisions are finally made, they are no longer relevant to the current conditions.

This is where AI can help. Today's AI systems and the high-power computers that run them can process vast quantities of data at unprecedented speeds. Tasks

that would normally take humans days or weeks can be done by AI in a matter of seconds. Take the banking industry, for example. Financial institutions use AI to track credit card usage in real time. When irregular buyer behavior is identified, transactions are denied before fraud can occur.[28] Compared to traditional methods that rely on manual human verification, the resulting efficiency gains are enormous. Furthermore, AI systems are proving more accurate than human experts in a variety of areas. For example, in the medical field, machine learning systems are demonstrating greater accuracy in predicting cancer than highly trained clinicians.[29] Applying these same technologies to common military tasks can produce similar gains in efficiency and effectiveness. In essence, AI can help clear some of the fog of war.

These productivity gains will ultimately enable more rapid and effective decision-making, a critical advantage in warfare. John Boyd characterized military competition through a process known as the observe, orient, decide, act (OODA) loop.[30] Boyd's idea was that whichever side executed the process faster could get inside an opponent's decision cycle and achieve a relative military advantage. AI systems will greatly accelerate the OODA loop process by increasing situational awareness, rapidly processing large amounts of information, calculating decision options, and automating operations. Intelligence analysts will use computer vision to filter through scores of images and videos to locate enemy forces. Operators will employ autonomous swarms of drones to overwhelm enemy defenses. Logisticians will use data analytics to optimize resupply missions or equipment maintenance. Military planners will use large language models to draft operations orders and generate decision briefs. Cyber warriors will leverage machine learning to identify anomalies and deny adversary network intrusions. These are just a few of the many coming military applications of AI.

Determining just how fast the OODA loop accelerates will depend, in part, on the level of trust humans place in AI. As with any new technology, AI is subject to error and will require refinement over time as it continues to evolve and mature. For the foreseeable future, there is good reason to maintain human control and oversight, also known as "human in the loop." For one, AI demonstrates the ability to "hallucinate," producing outputs or answers that are plausible but nevertheless do not correspond to reality.[31] This occurs when an AI model makes a statistical inference based on its training data that leads to inaccurate results when applied to a real-world environment. For an AI program aiding in military activities, the consequences of a spurious output could be severe. Another challenge with many AI models is that they lack "explainability," meaning the system is unable to describe the logic and data underlying its conclusions.[32] As a result, decisions appear to be made inside a "black box," preventing users from tracing the system's thought process. This lack of transparency will require trust in military AI to be built over time through experience. AI is also vulnerable to spoofing where an adversary could adjust data inputs, leading the model to draw false conclusions.[33] Imagine using computer vision software for targeting that is manipulated into concluding that friendly forces or civilians are enemy high-payoff targets. For all these reasons, most near-term applications of military AI will likely augment, rather than replace the role of humans.

Although the United States and China have enacted AI governance, cultural differences may influence the speed of adoption. A recent survey found that 78 percent of Chinese citizens believed AI had more benefits than drawbacks, as opposed to only 35 percent of Americans.[34] In 2020, the DOD adopted a series of ethical principles for the use of AI intended to guide the development of new technologies in a safe and responsible manner.[35] The PLA has not released a similar set of principles and appears to be less constrained by the risks posed by AI. In contrast to the robust debate in the United States on the ethics of employing autonomous military systems, discussion of this topic is largely absent from Chinese open sources.[36] These contrasting perspectives in AI ethics and regulation may influence the rate at which the United States and China adopt and integrate AI into their respective militaries. While the United States appears more cautious and deliberate in its approach, China seems to be less constrained by the potential risks of AI.

Conclusion

While technology alone does not guarantee the outcome of war, throughout history, militaries that best innovate have a decisive advantage on the battlefield.[37] The American military has long enjoyed

In the global operational environment of the future, AI will play a significant role in military analysis and decision-making at the strategic, operational, and tactical levels of command and control. (Illustration by NIWC Pacific, 7 April 2018)

technological superiority over its adversaries, however, this advantage is now diminishing. China's national-level focus on AI innovation has manifested in significant technological advancements, enabling the PLA toward achieving its goal of becoming a world-class military. Within this ongoing geopolitical rivalry, the competition to harness the power of AI will shape the global balance of power for years to come.

Preserving U.S. miliary overmatch requires an acceleration of AI development across the DOD. Strengthened partnership with the private sector is essential to making the progress needed to outpace the PLA. Although China's military-civil fusion strategy has yielded impressive results, the most capable AI companies reside in the United States. These firms, with their highly skilled workforce and cutting-edge research, have the potential to produce the most advanced military applications of AI. The United States' market-based system holds a distinct advantage in fostering innovation, but the DOD must continue to adapt to fully harness its potential. The ongoing Replicator initiative represents the DOD's biggest bet in AI development. Its success is crucial for the future of the U.S. military.

While new technologies are always under development, rarely do they pose as much potential as AI. Military advantage is normally gained by the side that better understands the environment, the enemy, and themselves. Battles are typically won by

commanders who make timely, well-informed decisions. AI is a technology that will enable all of this.

The military AI revolution has only begun. How it proceeds—and whether the United States ultimately prevails—will depend upon the urgency with which we approach this opportunity, the adaptability of our organizations, and the perseverance of our people. The potential of AI is limitless but only if we have the foresight to understand it and the fortitude to embrace the challenge. ■

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