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Recent advancements in artificial intelligence (AI) and the potential of this technology have led to the development and deployment of technologies that were once considered science fiction. From autonomous drones to military robots, the integration of AI into various sectors is reshaping warfare, national security, diplomacy, economy, governance, health, and beyond.

AI refers to the ability of machines to perform tasks that would otherwise require human intelligence, such as reasoning, perception, decision-making, recognizing patterns, learning from experience, drawing conclusions, and making predictions. The U.S. Department of Defense (DoD) describes AI as "the ability of machines to perform tasks that normally require human intelligence" and the Defense Advanced Research Projects Agency (DARPA) defines AI as "a programmed ability to process information."

Military AI capabilities include weapons as well as decision support systems that help leaders at all levels make better and timely decisions, from the battlefield to the boardroom, from combat to tactical to operation level.

Though rudimentary forms of AI have existed for decades, recent years have seen an enormous leap in the technology's capabilities. The roots of AI development trace back to the 1940s with the creation of artificial neurons by Warren McCulloch and Walter Pitts. Alan Turing, the father of modern computer science, introduced the Turing Test in 1950 to determine a machine's ability to exhibit human-like responses and intelligence. Japan developed the first 'intelligent' humanoid robot WABOT-1 in 1972.

In the 2000s, the key AI developments included the emergence of machine learning, the expansion of robotics and computer vision, and the rise of data mining and pattern recognition. The 2010s saw remarkable progress in AI across various domains, driven by deep learning breakthroughs, open-source collaboration, increasing computing power, and more research funding and investment. In 2015, OpenAI's establishment laid the groundwork for the current AI boom. In 2016, Google DeepMind's AlphaGo program defeated professional Go player, demonstrating deep reinforcement learning's potential for

(Image Credit: Rawpixel/via Freepik)

complex strategic games. In 2019, the world saw the launch of the first AI-enabled astronaut assistant.

The true turning point came with the launch of ChatGPT in late 2022, which brought AI into the public spotlight, generating widespread interest and investment. The post-2020 era is marked by groundbreaking developments in Generative AI, with large language models like OpenAI's ChatGPT-4, Google's Gemini (formerly Bard), Microsoft's Bing AI, and Mistral AI's Mixtral 8x7B, pushing the boundaries of human-machine interactions. Generative AI refers to programs that can create high-quality text, images, and other content based on the data they were trained on.

Artificial Intelligence Transforming Modern Warfare

With continuous advances in technology, the United States (U.S.), United Kingdom (UK), China, France, Russia, South Korea, and Israel are heavily investing in the development of weapons with increasing autonomy as other states are considering how to respond to the automation of warfare.

As more countries look to incorporate this technology into their militaries, these machines have prompted a debate about the development and deployment of weapons that can perform increasingly advanced functions with little or no human oversight. This led to the first-ever debate on AI at the United Nations Security Council meeting in July 2023, with a focus on the opportunities and risks posed by AI to international peace and security.

Beyond this initiative, several countries have started paying greater attention to the growing role of AI for military purposes. This culminated in the Responsible AI in the Military Domain (REAIM) summit, held in 2023 at The Hague.[1] The summit, which the Netherlands co-organized with South Korea, issued a declaration titled "call to action" on the responsible development, deployment, and use of AI in the military domain. This was endorsed by 57 states, including the U.S., UK, China, Japan, Germany and France, excluding Russia. The summit discussed general military and defense-related applications of AI as well as the lethal autonomous weapon systems (LAWS).

Countries have also made progress in governing military AI. In February 2020, the US Department of Defense (DoD) became the first military department in the world to adopt ethical principles for all its military AI applications.[2] This builds upon Directive 3000.09, established in 2012 and updated in January 2023, which governs the development and fielding of autonomous and semi-autonomous weapon systems. Other countries like the UK and France have developed national policies on military AI. Additionally, NATO unveiled its first AI strategy in 2021 for the responsible future use of AI.

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1. Responsible AI in the Military Domain Summit 2023, Ministry of Foreign Affairs, Government of the Netherlands, January 24, 2024. https://www.government.nl/ministries/ministry-of-foreign-affairs/activiteiten/reaim/

2. U.S. Department of Defense, DOD Adopts Ethical Principles for Artificial Intelligence, DOD Release, February 24, 2020. https://www.defense.gov/News/Releases/Release/Article/2091996/dod-adopts-ethical-principles-for-artificial-intelligence/

U.S. Ambitions to Become an AI-Empowered Military

The United States is leading the way in AI technology development, driven by its ambition to become an AI-empowered military. In September 2018, the Pentagon pledged to make the largest investment to date in artificial intelligence (AI) systems for US weaponry, committing to

(Image Credit: DARPA)

spend US$2 billion over the next five years through its Defense Advanced Research Projects Agency (DARPA), to "develop next wave of AI technologies".[3] DARPA has a long history of funding research on advanced technologies, including AI, at universities like the Massachusetts Institute of Technology (MIT) and Stanford University.

Recently, the U.S. military sought billions of dollars from lawmakers to enhance its AI and networking capabilities in the fiscal year 2024, aiming to become a more agile and interconnected force. The Pentagon aims to leverage AI for improved decision-making and to enhance unmanned platforms and other systems. A Chief Digital and AI Office (CDAO) has been established to facilitate technology integration.[4] The 2024 budget request includes $1.8 billion for artificial intelligence and machine learning (AI/ML) to deliver responsible AI-enabled capabilities and support workforce development and data management efforts. Additionally, the Defense Department in fiscal 2024 requested $1.4 billion for Joint All-Domain Command and Control (JADC2) initiatives to "transform warfighting capability."

CJADC2 – the future of joint warfare: The Combined Joint All-Domain Command and Control (CJADC2) is a warfighting concept of digitally connecting the joint force across air, land, sea, cyber, and space domains. This system is meant to connect data-centric information from all branches of service, partners, and allies, into an internet of military things, making information and cutting-edge decision support tools accessible anywhere, anytime for quick battlefield decisions. The Internet of Military Things (IoMT) is a network of sensors, wearable devices, robots, munitions, weapons, vehicles, and IoT devices that use cloud and edge computing to increase military capabilities and safety. The Defense Department has awarded contracts to four technology companies, Amazon Web Services, Google, Microsoft, and Oracle, to provide services in support of its joint warfighting cloud capability. The Pentagon's portfolio includes more than 800 AI-related unclassified projects, many in the testing phase.[5]

In October 2023, U.S. President Biden issued an executive order to promote the adoption of AI safety standards, harness AI's game-changing cyber capabilities, and reduce the potential

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3. DARPA, AI Next Campaign (Archived), Defense Advanced Research Projects Agent, March 25, 2024. https://www.darpa.mil/work-with-us/ai-next-campaign/

4. Chief Digital and Artificial Intelligence Office, U.S. Department of Defense, April 24, 2024. https://www.ai.mil/

5. Frank Bajak, Pentagon's AI initiatives accelerate hard decisions on lethal autonomous weapons, The Associated Press, November 25, 2023. https://apnews.com/article/us-military-ai-projects-0773b4937801e7a0573f44b57a9a5942/
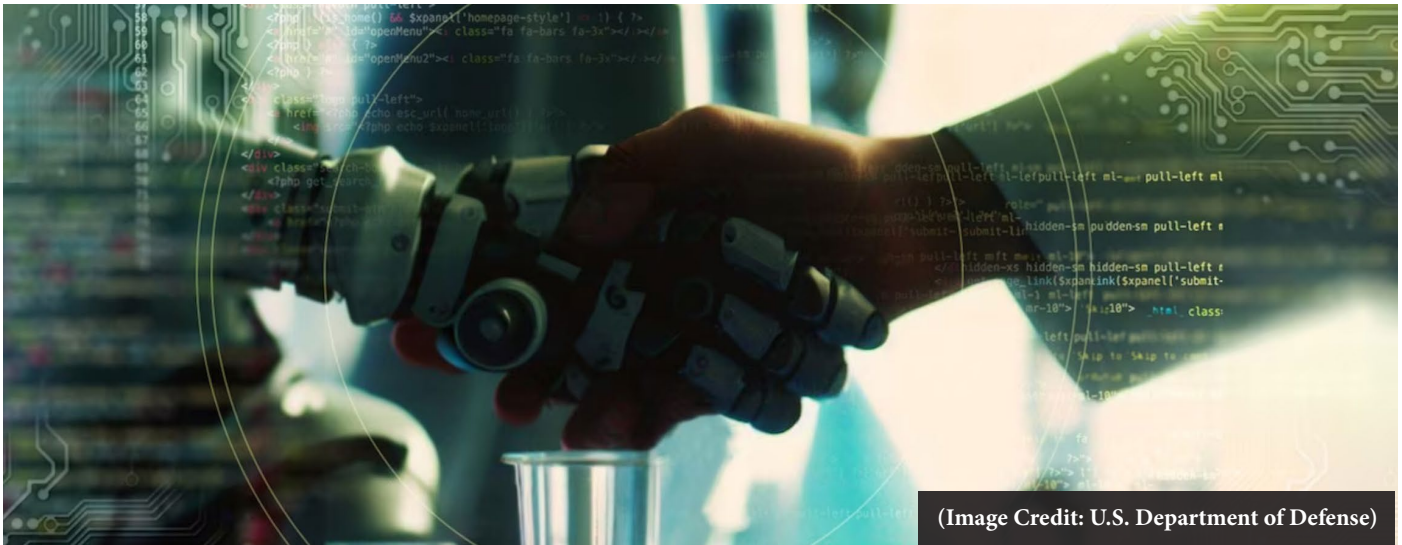
(Image Credit: U.S. Department of Defense)

risks that AI can pose. To keep up with the ever-evolving technology, DoD is adopting these innovations and integrating AI into operations to "develop a more modernized, data-driven, and AI-empowered military" to progress decision advantage by improving the speed, quality, and accuracy of decisions that can be decisive in a fight.

AI Strategy 2023: In late 2023, the Pentagon released a new data, analytics, and AI strategy to accelerate the department's adoption of AI capabilities to ensure U.S. warfighters maintain decision advantage on the battlefield. The document provides a foundation for DoD to leverage emerging technology in the years to come.[6] Developed by the CDAO, the strategy describes the approach to improving the organizational environment within which "DoD leaders and warfighters will be able to make rapid, well-informed decisions by expertly leveraging high-quality data, advanced analytics, and AI for enduring decision advantage".[7]

Former U.S. Chief Digital and AI Officer Craig Martell said the strategy prioritizes an agile approach by focusing on the fundamentals of speed, agility, responsibility, and learning. "Accelerating the adoption of advanced data, analytics, and artificial intelligence technologies presents an unprecedented opportunity to equip Department leaders, at all levels, with the data they need, to make better decisions faster, from the boardroom to the battlefield," he said.[8]

AUKUS: The U.S. is also collaborating with its international partners in the AI realm. The AUKUS alliance, comprising Australia, the United Kingdom, and the United States, conducted the first joint AI and autonomy trial held in the UK in April 2023. This test was followed by the Trusted Operation of Robotic Vehicles in a Contested Environment (TORVICE) trial conducted in the fall of 2023 at Cultana Training Area, South Australia. A team of AUKUS scientists participated in successful TORVICE trials for the integration of advanced autonomy

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6. Jospeh Clark, DOD Releases AI Adoption Strategy , U.S. Department of Defense News, November 2, 2023. https://www.defense.gov/News/News-Stories/Article/Article/3578219/dod-releases-ai-adoption-strategy/

7. U.S. Department of Defense, Data, Analytics, and Artificial Intelligence Adoption Strategy, DOD, June 27, 2023. https://media.defense.gov/2023/Nov/02/2003333300/-1/-1/1/DOD_DATA_ANALYTICS_AI_ADOPTION_STRATEGY.PDF

8. U.S. Department of Defense, Deputy Secretary of Defense Kathleen Hicks Announces Publication of Data, Analytics and AI Adoption Strategy, DOD Release, November 2, 2023. https://www.defense.gov/News/Releases/Release/Article/3577857/deputy-secretary-of-defense-kathleen-hicks-announces-publication-of-data-analyt/

and artificial intelligence (AI) in robotic vehicles for military operations.[9]

TORVICE was aimed at identifying and resolving vulnerabilities in autonomous systems in contested electronic warfare environments. Ground vehicles from the U.S. and UK simulated autonomous multi-domain launchers and conducted various missions, including long-range precision fires. This trial demonstrated the commitment of AUKUS nations to advanced capabilities in AI and autonomy, promoting security and stability in the Indo-Pacific region. Additionally, AUKUS partners are advancing resilient and autonomous AI technologies in land and maritime domains for force protection, precision targeting, intelligence, surveillance, and reconnaissance, with plans to integrate these technologies into national programs by 2024.

Believing that technology with global impact demands collective action, the U.S. is also engaging with other countries on responsible military use of AI applications. U.S. defense officials plan to meet with representatives from over 50 nations by mid-2024 to discuss a newly established framework for the responsible development and deployment of AI and autonomous military technologies. The 'Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy', initiated in early 2023, has garnered endorsements from more than 51 countries. This declaration aims to create international consensus and provide guidance for states in the military AI domain, fostering exchanges of best practices and facilitating capacity building among endorsing states.[10]

China's Application of AI in Military

China is also at the forefront alongside the United States in advancing AI technology for military applications. The country is aggressively pursuing AI capabilities with ambitions to lead the world in AI by 2030.[11] China has spearheaded a global surge in investment in generative artificial intelligence (AI) in the first half of the year, with the country leading in the number of startups in the sector to secure funding, according to a 2023 research report.[12] In the first half of the year 2023, China had 22 generative AI startups that received funding, followed by the US with 21 and the UK with four, according to a report by Zhidongxi, a Chinese AI-focused research firm.[13]

Despite having the highest number of generative AI start-ups securing funding, U.S. firms received more total funding, the report indicated. China's leading tech firms and startups are striving to close the gap with their US counterparts following the launch of ChatGPT by

9. IRIA, AUKUS conducts trials for advanced AI-controlled robotic vehicles, IRIA News, February 7, 2024. https://www.ir-ia.com/news/aukus-conducts-trials-for-advanced-ai-controlled-robotic-vehicles/

10. U.S. Department of State, Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy, DOS Bureau of Arms Control, Deterrence, and Stability, November 9, 2023. https://www.state.gov/political-declaration-on-responsible-military-use-of-artificial-intelligence-and-autonomy-2/

11. Rabi Sankar Bosu, China's presence glorifies the AI Safety Summit 2023, CGTN News, November 2, 2023. https://news.cgtn.com/news/2023-11-02/China-s-presence-glorifies-the-AI-Safety-Summit-2023-1ooX4T0Iev6/index.html/

12. Xinmei Shen, China leads world in number of generative AI start-ups to receive funding in first half of 2023, report finds, South China Morning Post, July 10, 2023. https://www.scmp.com/tech/tech-trends/article/3227197/china-leads-world-number-genera-tive-ai-start-ups-receive-funding-first-half-2023-report-finds/

13. Global Times, Companies rush to launch LLMs amid global AI frenzy, GT, November 7, 2023. https://www.globaltimes.cn/page/202311/1301370.shtml/

Microsoft-backed OpenAI last year. Chinese tech giants including Tencent Holdings, Baidu, and Alibaba Group are investing heavily in the field with a focus on developing their own large language models (LLMs).

China is also extending its lead over the U.S. in AI patent filings, with Chinese institutions submitting 29,853 AI-related patents in 2022, compared to a decrease in U.S. filings. China now accounts for over 40% of global AI patent applications, according to data from the UN-affiliated World Intellectual Property Organization.[14]

China is actively pursuing AI supremacy, aiming to become a global leader in both economic and military applications. China was probably the first to enter into the ranks of AI-empowered countries with the launch of its 'New Generation Artificial Intelligence Development Plan' in 2017, laying out a comprehensive blueprint for AI development in private and public sectors.

Robots are displayed at the opening of the three-day 2023 World Artificial Intelligence Conference in Shanghai on July 6, 2023. (Image Credit: VCG/GT)

Over the years, China has been actively capitalizing on the application of AI in the People's Liberation Army (PLA), with significant implications for international and regional security dynamics. The Chinese leadership's vision encompasses utilizing AI to bolster both economic competitiveness and military capabilities. The Chinese government has implemented a multifaceted approach encompassing various strategies such as 1) resource mobilization for AI development, including financial investments, and research initiatives, 2) cultivating a skilled workforce in AI-related fields through educational and academic programs, 3) engaging with international partners and institutions to acquire knowledge and expertise in AI through collaborations, joint research initiatives, and technology transfer agreements.[15]

In the realm of military affairs, the PLA views AI as a transformative force that is reshaping the nature of warfare. PLA strategists and academics describe current trends as heralding a new military revolution driven by AI and related technologies. The application of AI in military operations encompasses a wide range of capabilities, including:

Unmanned Intelligent Combat Systems: China is heavily investing in the development of unmanned intelligent vehicles, platforms, and weapons systems, leveraging AI to enhance

14. Bloomberg News, China Widens Lead Over US in AI Patents After Beijing Tech Drive, Bloomberg, October 24, 2023. https://www.bloomberg.com/news/articles/2023-10-24/china-widens-lead-over-us-in-ai-patents-after-beijing-tech-drive

15. Jiayu Zhang, China's Military Employment of Artificial Intelligence and Its Security Implications, The International Affairs Review, August 16, 2020. https://www.iar-gwu.org/print-archive/blog-post-title-four-xgtap/

battlefield reconnaissance, surveillance, communication, and combat assessment. These AI-enabled systems are expected to disrupt traditional warfare paradigms by enhancing speed, accuracy, and operational effectiveness.

Multi-Domain Offense and Defense: AI is being integrated into offensive and defensive capabilities across multiple domains, including nuclear, cyber, and space. The PLA seeks to leverage AI-driven big data analytics, machine learning, and automation to enhance situational awareness, defense of critical networks, and the scalability of offensive cyber operations.

Training, Simulation, and Wargaming: AI technologies are being utilized to enhance the sophistication of military simulations, war-gaming, and training exercises. With limited opportunities for actual combat experience, the PLA places great emphasis on simulation-based training methods to prepare commanders and soldiers for diverse operational scenarios.

Ukraine War – A Testing Ground for Military AI

Russia's ongoing invasion of Ukraine has been a testing ground for new applications. Some Pentagon officials see it as a valuable learning opportunity for the U.S. military regarding the strategic use of drones and artificial intelligence, particularly evident in the significant role played by drones with semi-autonomous capabilities.

While low-cost unmanned systems have appeared in recent conflicts, including the 2021 war between Armenia and Azerbaijan, the war in Ukraine offers a unique learning opportunity about AI-enabled platforms. As Ukraine increasingly integrates AI into its military systems, there is a growing emphasis on understanding the evolving nature of warfare and harnessing technology for strategic advantage. The Pentagon is closely observing Ukraine's advancements in AI as it develops its own algorithms and AI-enabled platforms, recognizing the transformative impact of technology on modern warfare.

In addition to autonomous weapons, there have been other noteworthy AI tech adaptions. For instance, Ukrainian AI company Primer modified its commercial AI-enabled voice transcription and translation service so that it could process intercepted Russian communications and automatically highlight information concerning the Ukrainian forces. Ukraine has also used U.S.-based startup Clearview AI's facial recognition technology software to identify deceased Russian personnel through their social media profiles to notify their relatives and transfer their bodies. The Clearview AI database helped Ukraine identify the dead easily without the need to match fingerprints and works even if there is facial damage.

Data analytics company Palantir's role in facilitating targeting efforts in Ukraine underscores the pivotal role of advanced targeting capabilities and algorithms in modern warfare. The U.S.-based company's software helps Ukraine target, for instance, tanks and artillery. Palantir CEO Alex Karp has said Ukraine's use of emerging technologies has given it the edge over one of the world's foremost military powers. Speaking at the Dutch government's Responsible AI in the Military Domain (REAIM) event. Karp said that in modern warfare, militaries lacking advanced targeting capabilities and algorithms are significantly disadvantaged. "The old way of targeting where algorithms aren't used is clearly a failure. If you go into battle with old-school technology even if you're spending $65 billion a year and you're highly accomplished

Serviceman of the 80th Airborne Assault Brigade of the Armed Forces of Ukraine prepares to operate an FPV-drone in Donetsk region on November 7, 2023. (Image Credit: Reuters/Alina Smutko)

warfighters like Russia, and you have an adversary that knows how to install and implement digitalized targeting and AI, you're at a massive disadvantage," Karp said.[16]

With AI-driven targeting becoming commonplace in warfare, the strategic significance of AI technologies has risen to the top of global military and political agendas. "We are really convinced that ongoing and future conflicts may be won, lost or heavily impacted by AI speed, AI efficacy and who is actually using AI in the battlefield," Dr Nikos Loutas, NATO's head of data and artificial intelligence (AI) policy said at the AI Summit London.

Applications of Artificial Intelligence in Military and Defense

Artificial intelligence is revolutionizing military and defense operations across the land, air, space, sea, and cyber domains, enhancing situational awareness, decision-making, and operational efficiency. Its applications span from autonomous weapons systems and drones to predictive analytics, from intelligence analysis to reconnaissance, cybersecurity, and logistics, marking a new era of warfare characterized by advanced technology. Some of the key applications are as follows:

- Training and Simulations
- Logistics and Transport
- Medical Support and Healthcare
- Cybersecurity
- Decision Support Systems
- Autonomous Weapon Systems
- Target recognition and tracking

AI-powered Training and Simulations

The integration of simulators in military training has revolutionized soldier preparedness for combat. These simulators offer a cost-effective, safe, and immersive alternative to traditional methods, providing realistic scenarios without endangering lives. Advanced AI technologies and immersive virtual reality (VR) and augmented reality (AR) simulators are critical to keep soldiers ready and improve their skills for an ever-changing battlespace.[17]

16. Ben Wodecki, Ukraine War One Year On: How AI Has Shaped the Battlefield, AI Business, February 24, 2023. https://aibusiness.com/verticals/ukraine-war-one-year-on-how-ai-has-shaped-the-battlefield/
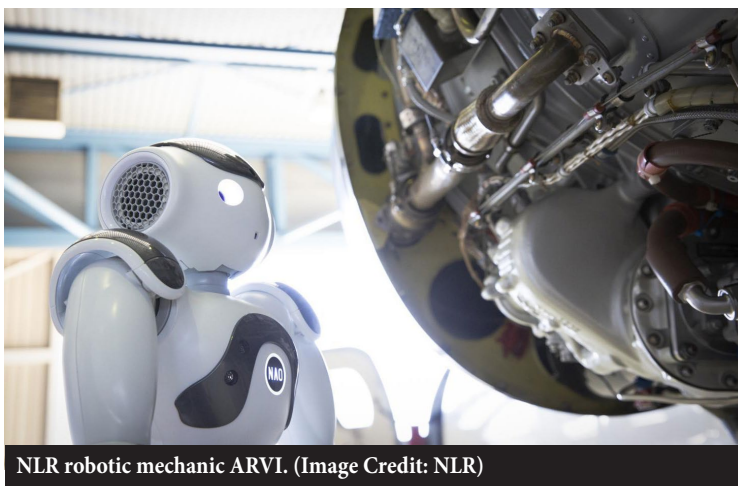
17. Aerospace and Defense Review, Military Simulations: The Power of AI, AR/VR, and Machine Learning, October 9, 2023. https://www.aerospacedefensereview.com/news/military-simulations-the-power-of-ai-arvr-and-machine-learning-nwid-1389.html/

The U.S. Army's new training simulators, set for delivery in 2024, would become a crucial component of modern warfare preparations. These tools allow soldiers to coordinate helicopters, tanks, and infantry effectively. Recent tests showcased the equipment's capabilities, with drones coordinating artillery strikes against attacking forces, demonstrating their effectiveness in combat simulations. The simulators cover a range of vehicles and aircraft, including the M1 Abrams tank, Black Hawk helicopter, CH-47 Chinook transport helicopter, RQ-7 Shadow drones, and MQ-1C Gray Eagle drone, enhancing training realism and readiness for future missions.[18]

In 2023, Rowan University secured a $3 million grant from the U.S. Department of Defense (DoD) to develop virtual and mixed-reality combat simulations enhanced by AI. This initiative builds upon a $5.5 million partnership between Rowan University and the U.S. Army Combat Capabilities Development Command Armaments Center. Led by Dr. Nidhal Bouaynaya, the project aims to refine next-generation gunner turret systems by developing immersive and autonomous

Dr. George Lecakes, director of Rowan University's Virtual Reality Center and Rowan senior Garrett Williams demonstrate a training scenario designed for the U.S. Army. (Image Credit: Rowan Today)

mixed-reality environments. These environments simulate combat scenarios, utilizing virtual, augmented, and mixed-reality technologies, along with secure communication systems and sensor suites. By integrating AI algorithms, the project seeks to enhance situational awareness and threat detection capabilities for military personnel. The team has made significant progress, developing a virtual environment with realistic visuals and demonstrating the AI system's ability to detect real-time aerial drone threats.[19]

NLR robotic mechanic ARVI. (Image Credit: NLR)

In Europe, the Netherlands Aerospace Center (NLR) has developed ARVI (autonomous robot for visual inspections) which features a sophisticated sensor system, and autonomous vehicle, allowing it to navigate through hangars and conduct aircraft inspections, serving as an apprentice to the human mechanic, enhancing the productivity of maintenance workforce.[20] NLR is engaged in initiatives to automatically or autonomously detect damage to components such as helicopter

18. Sam Skove, Army's new training simulators on track for 2024 delivery, Defense One, July 24, 2023. https://www.defenseone.com/technology/2023/07/armys-new-training-simulators-track-2024-delivery/388797/

19. Rowan Today, Using AI and simulations, Rowan engineers are helping the Army reshape the future of combat, Rowan University, January 6, 2023. https://today.rowan.edu/news/2023/01/ai-engineering-reshaping-future-combat.html/

20. Netherlands Aerospace Center, Maintenance Technology, NLR Aerospace Systems Division. https://www.nlr.org/capabilities/maintenance-technology/

rotor blades using cameras, robotics, and software, reducing human involvement in tedious and difficult aircraft inspections. Arjan de Jong, NLR's principal for maintenance and engineering, says their focus is on automating inspections, requiring sensors, robots, and automation technology for assessing aircraft and components for damages.

Lockheed Martin, one of the largest contractors for aerospace, security, and military support systems, invests heavily in AI to bolster US military capabilities. The creation of Lockheed Artificial Intelligence Center (LAIC) demonstrates its commitment to AI development, with initiatives like the AI Factory aimed at scaling AI implementation. This Factory standardizes tools and processes across divisions, streamlining access to ML/AI and alleviating complexities in infrastructure and machine learning operations. Through initiatives like the AI Factory, the American aerospace and defense firm Lockheed aims to democratize AI development and ensure compliance with ethical and privacy standards while fostering partnerships with innovative companies like RedHat, Microsoft, and NVIDIA.[21]

BAE Systems, the British defense company and leading provider of cutting-edge defense and aerospace solutions, is working with different companies to harness the power of AI and VR in the next generation of military training. In November 2023, BAE Systems announced a collaboration with Red 6, an augmented reality (AR) technology firm specializing in military air combat training, and PLEXSYS, a simulation software company.[22] Together, they aim to transform military training by integrating Red 6's AR headset technology and PLEXSYS's immersive simulation into BAE Systems' synthetic training environment under 'Project OdySSEy.'[23] This partnership seeks to enhance mission readiness in future contested battlespaces, leveraging the collective expertise of the three companies.

BAE Systems Project OdySSEy single synthetic military training environment. (Image Credit: BAE)

21. Lockheed Martin News, Accelerating Artificial Intelligence (AI) at Scale, Lockheed Martin, May 05, 2022. https://www.lockheedmartin.com/en-us/news/features/2022/accelerating-artificial-intelligence-ai-at-scale.html/

22. BAE News, Project OdySSEy to form backbone of new military training collaboration, BAE Systems, November 28, 2023. https://www.baesystems.com/en/project-odyssey-to-form-backbone-of-new-military-training-collaboration/

23. BAE, Project OdySSEy, BAE Systems. https://www.baesystems.com/en/feature/project-odyssey/

Logistics and Transport

"One way to avoid war is being so prepared to prevail on the logistics front that the enemy understands the folly of aggression" - U.S. Army Brig. Gen. Stephanie Q. Howard.

Advances in emerging technologies such as autonomous drones, 3D printing, and mixed reality have revolutionized whole industries. It can revolutionize the defense logistics too. Innovation in logistics is considered crucial to deter aggression and new threats. Logistics and sustainment are vital for military effectiveness, readiness, and endurance, serving as the backbone of military power. Recognizing this, the Department of Defense is exploring the use of AI/ML technologies to enhance military logistics and sustainment, aiming to maintain equipment, lower operational costs, and boost readiness. AI in military logistics has the potential to enhance efficiency and decision-making capabilities.

The U.S. Air Force's Air Mobility Command (AMC) is currently testing a new cloud-based AI tool, called Artiv, designed to streamline logistics planning amid challenging conditions and disruptions such as an enemy attack or natural disaster. Developed by DEFCON AI, the tool has the potential to complete "highly complicated operational wargaming analysis" in a matter of minutes instead of days, according to Col. Bradley Rueter, who leads the AMC Commander's Initiative Group.[24]

In the context of modern warfare and contested logistics, defense organizations can leverage AI to enhance resilience and efficiency. Here are some of the key applications of AI in defense logistics:
1. Utilizing AI-driven preventive maintenance to enhance efficiency and effectiveness
2. Leveraging cloud services for centralized logistics data storage and processing to facilitate informed decision-making
3. Exploring self-driving vehicles for autonomous resupply missions.
4. Using AI-powered analytics to forecast demand for critical supplies and make informed decisions regarding the defense supply chain.
5. Utilizing self-driving vehicles and AI-powered autonomous systems for logistics and route planning, and fleet management and to resupply outposts and bases, reducing risks associated with traditional supply convoys.
6. Facilitating joint forces collaboration through AI and automation, enabling faster, coordinated decision-making.
7. Proactively detecting and mitigating risks in logistics operations using AI. This will help safeguard defense supply chains against unforeseen challenges.

The integration of AI in military logistics holds the potential to revolutionize operations through process optimization, task automation, and enhanced effectiveness. While cybersecurity and ethical concerns remain, valuable insights from the commercial sector's extensive AI utilization in logistics can inform the military's implementation of AI-enabled solutions.

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24. Audrey Decker, Can AI reduce Air Force logistics planning from days to minutes?, Defense One, February 1, 2024. https://www.defenseone.com/threats/2024/02/can-ai-reduce-air-force-logistics-planning-days-minutes/393850/

Medical Support and Healthcare

While AI is already being used in weapons technology, it has a restorative role in military medicine. AI can be deployed by military doctors to speed up the decision-making process in triaging the injured based on who needs medical attention first.

AI has become an increasingly powerful tool for emergency room triage, providing critical care to the right person at the right time. A recent study published by the American College of Surgeons highlights AI's crucial role in supporting clinicians in triaging post-operative patients for intensive care. At Brussels University Hospital, AI has seamlessly integrated into the radiology department's daily workflow, providing essential support in managing large volumes of images. With its potential to alleviate the burden on emergency rooms (ERs) and intensive care units (ICUs), AI is poised to become more reliable in supporting physicians in the coming years.
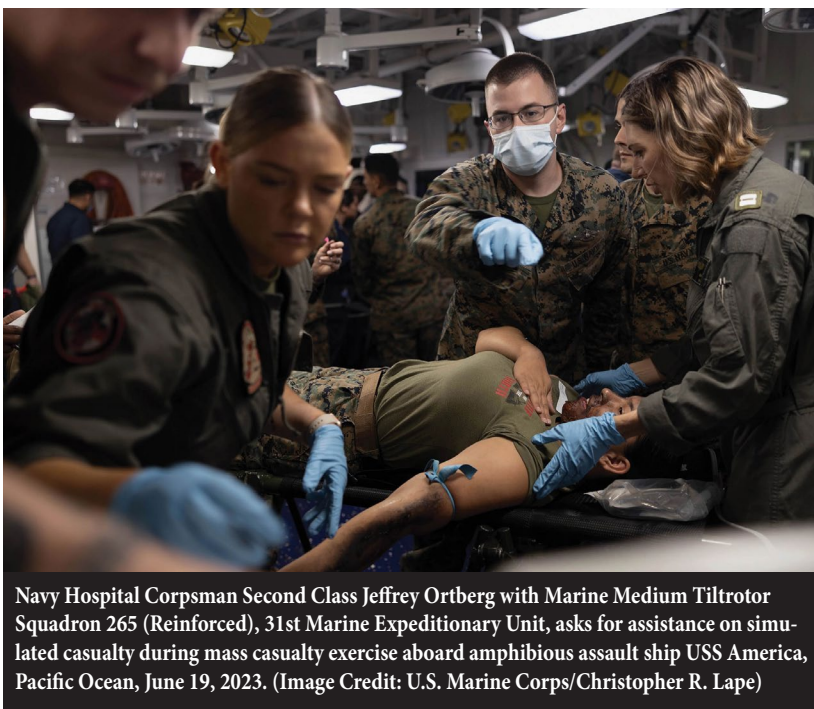
Navy Hospital Corpsman Second Class Jeffrey Ortberg with Marine Medium Tiltrotor Squadron 265 (Reinforced), 31st Marine Expeditionary Unit, asks for assistance on simulated casualty during mass casualty exercise aboard amphibious assault ship USS America, Pacific Ocean, June 19, 2023. (Image Credit: U.S. Marine Corps/Christopher R. Lape)

Artificial intelligence holds immense potential for enhancing the capability to care for combat casualties during large-scale operations. To fully leverage this technology, U.S. Colonel Benjamin Donham suggested that the military health system must establish a cross-functional team comprising data scientists, computer experts, communications specialists, and battlefield medicine providers. This team should create a standardized data dictionary to consolidate various datasets and transition from analog to digital data organization. With the foundational data infrastructure in place, it will facilitate the development of diverse medical AI capabilities. While numerous applications exist for medical AI in battlefield medicine, priority should be given to developing a high-quality mass casualty triage algorithm, to optimize medical care impact, and a dedicated medical AI capability strategy to improve combat casualty care and reduce strategic risk to the joint force.[25]

The U.S. Defense Health Agency, which ensures medical readiness for Army, Navy, and Air Force units, is spearheading the shift towards digital-first healthcare delivery, integrating cutting-edge technologies like AI and ML. At the forefront of this effort is Dr. Lester Martinez-Lopez, who sees immense potential in AI, machine learning, and predictive algorithms to improve healthcare.

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25. Benjamin P. Donham, It's Not Just About the Algorithm: Development of a Joint Medical Artificial Intelligence Capability, Joint Force Quarterly 111, National Defense University Press, October 2023. https://ndupress.ndu.edu/JFQ/Joint-Force-Quarterly-111/Article/Article/3569597/its-not-just-about-the-algorithm-development-of-a-joint-medical-artificial-inte/

Experts at the Defense Health Information Technology Symposium 2023 in New Orleans, underscored the pivotal role of AI and machine learning in driving down costs, boosting readiness, and optimizing performance. "From predicting emergency room wait times to advanced medical diagnostics, the underlying techniques of machine learning have huge potential to improve how we provide health care in an impactful and meaningful way," Martinez said. U.S. Navy Cmdr. (Dr.) John de Geus believes that AI will enable doctors to quickly and efficiently access all the various military and occupational standards relevant to service members and the clinical care being provided to them. However, he emphasized that despite the emergence of AI tools altering healthcare delivery, they will never replace the human element in healthcare. AI will continue to serve as a tool to enhance the effectiveness of medical staff in their roles. The success of the tech initiatives hinges on robust data accessibility and interoperability, ensuring timely and accurate support for healthcare providers.

The future of healthcare technology in the military health system was also explored at the Digital Health Transformation Summit in Maryland, held in December 2023. Discussions highlighted the need for the military health system to adapt to the fourth industrial revolution, the era of connectivity, advanced analytics, and automation, emphasizing the role of technology in enhancing healthcare delivery. The use of AI, machine learning, and other digital tools to address future challenges in military medicine, such as evolving conflicts and advances in medical treatment, were among the key topics discussed. "The breakthroughs happening in medical technology and in artificial intelligence are not just central to our responsibilities as medical professionals — they're central to our responsibility as national security professionals," said Martinez.

Cybersecurity

In an ever-changing cyber threat landscape, AI emerges as a robust tool for strengthening the country's cyber defenses and military cybersecurity efforts. By consistently monitoring and analyzing network traffic, AI-powered cybersecurity systems can swiftly identify anomalies, detect potential cyber threats, and promptly respond to them.

Cyber defense experts at NATO's flagship exercise Cyber Coalition 2023. (Image Credit: NATO/Paolo Giordano)

Industry experts have repeatedly highlighted the rising opportunities and challenges in using AI for cybersecurity. In May 2023, Eric Horvitz, Microsoft's Chief Scientific Officer, testified before the U.S. Senate Armed Services Committee Subcommittee on Cybersecurity, emphasizing the growing importance of AI in cyber defense. He stressed the need for significant investments in cybersecurity workforce training, monitoring, engineering, and research to counter the evolving AI-powered cyberattacks.[26]

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26. Microsoft Corporate Blogs, Applications for artificial intelligence in Department of Defense cyber missions, Microsoft, May 3, 2022. https://blogs.microsoft.com/on-the-issues/2022/05/03/artificial-intelligence-department-of-defense-cyber-missions/

AI methods are being applied across all stages of security, including prevention, detection, investigation and remediation, discovery and classification, threat intelligence, and security training and simulations, he said. AI technologies can alleviate the workload of cybersecurity experts by enabling automated and large-scale detection, prioritization, and response. However, advances in AI also raise concerns, particularly regarding the fabrication of deepfakes, which pose threats to national security. In March 2022, a deepfake video of Ukrainian President Zelenskyy surfaced, asking Ukrainians to lay down their weapons and surrender to Russia emerged on social media. To address these vulnerabilities in AI systems, Horvitz recommended securing engineering supply chains, raising awareness among development and cybersecurity teams, and investing in research on trustworthy and secure AI systems.

To develop systems to identify and fix software vulnerabilities, the U.S. administration is working with four leading artificial intelligence firms – OpenAI, Anthropic, Microsoft, and Google – to launch a cybersecurity contest. Led by DARPA, the "AI Cyber Challenge" is aimed at protecting the US's critical infrastructure and making software more secure.[27]

To address the challenge of weapon system cybersecurity, the U.S. Army recently partnered with Shift5, a cyber defense and predictive maintenance company, to enhance the security of its M142 High Mobility Artillery Rocket Systems (HIMARS) against virtual threats. Through this engagement, HIMARS will be equipped with digital anomaly detection capabilities to bolster cyber resilience and enable predictive maintenance assessments.[28] Josh Lospinoso, co-founder and CEO of Shift5, has emphasized the need for implementing best practices to accelerate weapon system cybersecurity. Arguing that "We cannot solve weapon system cybersecurity without AI," he has warned that "Without AI, the DoD will never be able to keep these weapon systems cyber secure." Effective AI systems depend on high-quality data, he says, and to ensure that military weapon systems can capitalize on the advancements in AI-powered technology, every major weapon system should collect, translate, enrich, and disseminate its data.

Decision Support Systems

An AI system can replicate the human decision-making processes. This means it can offer support, augment, and potentially substitute human decision-making in certain cases. Some of its applications in the defense domain include aiding decision-making in conflict scenarios, object recognition from images or videos, data analysis, equipment failure prediction, and automated defensive responses.

Military decision-making occurs in complex realms and often requires coordination across domains — land, air, sea, space, and cyberspace. Artificial Intelligence (AI) plays a crucial role in enhancing decision-making by processing vast amounts of data effectively. AI systems in the

27. The White House, Biden-Harris Administration Launches Artificial Intelligence Cyber Challenge to Protect America's Critical Software, U.S. White House Briefing Room, August 9, 2023. https://www.whitehouse.gov/briefing-room/statements-releases/2023/08/09/biden-harris-administration-launches-artificial-intelligence-cyber-challenge-to-protect-americas-critical-software/

28. Shift 5, Shift5 Partners with U.S. Army to Secure High Mobility Artillery Rocket System (HIMARS) Against Cyber Threats, December 5, 2023. https://shift5.io/press-release/shift5-army-himars-contract/

military can process data more efficiently than traditional systems, facilitating command and control. It can act as a powerful aid for human decision-making, significantly improving the decision support systems (DSS) to improve decision-making in the military. Decision support systems are also defined as "interactive computer-based systems that aid users in judgment and choice activities". However, the decision-making should be a collaborative effort collaboration between humans and intelligent machines, where both parties recognize each other's strengths, limitations, and objectives.

In his paper, U.S. Marines Corps Major James D. Pineiro explored the AI adoption by the Marines as a DSS to enhance planning-decision-execution cycles and gain an advantage over near-peer adversaries. He concluded that AI, through data analytics and machine learning, provides faster information processing and decision-making capabilities compared to human processes. The Marine Corps can no longer rely on outdated decision support systems for tactical decision-making as a commander "equipped with an AI-DSS will make more informed decisions at a faster rate than his adversary." However, implementing AI DSS for Expeditionary Advanced Base Operations (EABO) requires addressing hurdles, such as developing an AI concept of support, prioritizing and resourcing AI efforts, enhancing data management, and leveraging Army AI experimentation for multi-domain operations.[29]

But it all comes down to the humans developing and utilizing these systems. As highlighted in the U.S. Marines publication: "Whatever the age or technology, effective command, and control will come down to people using the information to decide and act wisely. And whatever the age or technology, the ultimate measure of command and control effectiveness will always be the same: Can it help us act faster and more effectively than the enemy?"

The latest advancements in data, analytics, and AI technologies empower leaders to make faster and better decisions, improving defense operations and warfighting capabilities. Accelerating the adoption of these technologies presents a unique opportunity to equip leaders at all levels with the necessary data and unlock the full potential of human decision-making capabilities.

For the United States and its military, the emphasis has always been on improving decision-making. "As we focused on integrating AI into our operations responsibly and at speed, our main reason for doing so has been straightforward: because it improves our decision advantage," U.S. Deputy Defense Secretary Kathleen Hicks said while unveiling the data, analytics, and AI adoption strategy 2023. The strategy emphasizes an agile approach to AI development and application, prioritizing speed of delivery and scalability to achieve five specific decision advantage

U.S. Deputy Secretary of Defense Dr. Kathleen Hicks with Vice Chairman of the Joint Chiefs of Staff Admiral Chris Grady. (Image Credit: Department of Defense)

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29. Major James D. Pineiro, Gaining a Cognitive Advantage: Artificial Intelligence (AI) as a Decision Support System (DSS), Master of Military Studies (MMS) thesis, USMC Command and Staff College Marine Corps University, March 31, 2020. https://apps.dtic.mil/sti/trecms/pdf/AD1177825.pdf

outcomes: superior battlespace awareness, adaptive force planning, fast, precise, and resilient kill chains, sustainment support, and efficient enterprise operations. Additionally, the strategy outlines key goals related to data, analytics, and AI, including investment in interoperable infrastructure, ecosystem advancement, talent management, foundational data improvement, capability delivery, and governance enhancement.

Command and Control Systems: In the dynamic realm of defense operations, efficient command and control (C2) systems are paramount. Integrating AI into C2 systems can provide real-time data analysis, situational awareness, and decision support for commanders, enabling swift responses to emerging threats and more effective coordination of forces. By streamlining communication and improving response times, AI holds transformative potential in enhancing the overall effectiveness of military operations. A research report suggested that "the side that successfully implements AI in its command and control system can become the best and fastest at analyzing information and as a result can make quicker decisions and gain an operational advantage over its opponent."[30]

Autonomous weapons system

There is no internationally agreed definition of autonomous or lethal autonomous weapons but the U.S. Defense Department offers one. It describes an autonomous weapon system as "a weapon system that, once activated, can select and engage targets without further intervention by an operator. This includes, but is not limited to, operator-supervised autonomous weapon systems that are designed to allow operators to override operation of the weapon system, but can select and engage targets without further operator input after activation."

The Department of Defense announced an update to DoD Directive 3000.09 on Autonomy In Weapon Systems, reaffirming its commitment to responsible policies regarding military use of autonomous systems and AI. U.S. Deputy Secretary of Defense Dr. Kathleen Hicks emphasized the importance of safety and lawful use in developing and employing weapon systems with autonomous features. "Given the dramatic advances in technology happening all around us, the update to our Autonomy in Weapon Systems directive will help ensure we remain the global leader of not only developing and deploying new systems but also safety," Hicks said. The Directive aims to minimize the risk of unintended engagements by ensuring human judgment is exercised over the use of force. Key requirements include designing autonomous and semi-autonomous weapon systems for human oversight, adhering to legal and ethical guidelines, and demonstrating reliability and effectiveness under realistic conditions.

Replicator initiative: Meanwhile, the United States is heavily investing in modernizing its autonomous capabilities. The Pentagon intends to deploy thousands of small autonomous systems within the next two years to counter China's extensive military buildup and dominance in robotic platforms. "Replicator is meant to help us overcome the PRC's biggest advantage,

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30. Johan Schubert, Joel Brynielsson, Mattias Nilsson, Peter Svenmarck, Artificial Intelligence for Decision Support in Command and Control Systems, Department of Decision Support Systems Division of Defence and Security, Systems and Technology, Swedish Defence Research Agency, 23rd International Command and Control Research & Technology Symposium "Multi-Domain C2", 2018. https://www.foi.se/download/18.41db20b3168815026e010/1548412090368/Artificial-intelligence-decision_FOI-S--5904--SE.pdf

which is mass. More ships. More missiles. More people. Before Russia invaded Ukraine again in February, they seemed to have that advantage too," according to Kathleen Hicks. The goal for Replicator is highly ambitious: to field "multiple thousands" of drones in "multiple domains" within the next 18-24 months.[31]

V-BAT drones: Shield AI is one of the defense tech startups working with the Pentagon to transform military tools using cutting-edge technology. The company is helping advance the goal of deploying powerful unmanned aerial vehicles, and autonomous drones. In December 2023, Shield AI announced the expansion of its funding to $500 million which will accelerate the development of artificial intelligence (AI) pilots without the need for remote operators or GPS. Shield AI is now the fourth startup valued in the multi-billion-dollar range in the past 20 years, joining SpaceX, Palantir, and Anduril. The startup's AI pilot, Hivemind, has flown a fighter jet (F-16), a vertical takeoff and landing drone (V-BAT), and a quadcopter (Nova). The V-BAT Teams, enable one human operator to command a minimum of four V-BATS, generate real-time AI-driven flight paths, and exhibit dynamic read-and-react behaviors autonomously. In December 2022, Shield AI made aviation history

V-BAT Unmanned Aircraft System. (Image Credit: MartinUAV)

by autonomously maneuvering a modified F-16 in real-world air-combat scenarios, laying the groundwork for the jets to be piloted by computers.

LAWS: As advancements in autonomous weapons accelerate, an increasing number of states and non-governmental organizations are urging the international community to regulate or ban these technologies due to ethical concerns. The major concern is about lethal autonomous weapon systems (LAWS). The 2022 U.S. defense policy on LAWS defines it as "a special class of weapon systems that use sensor suites and computer algorithms to independently identify a target and employ an onboard weapon system to engage and destroy the target without manual human control of the system." DoDD 3000.09 defines LAWS as "weapon system[s] that, once activated, can select and engage targets without further intervention by a human operator." These systems are categorized as fully autonomous weapons that operate without human involvement, autonomous weapons that require human oversight, and semi-autonomous with varying degrees of human oversight but possessing "fire-and-forget" capability.[32]

Meanwhile, concerns over the ethical implications of LAWS have led to international appeals for regulation or bans, with more than 30 countries calling for legal controls on "killer robots." Amnesty International's Secretary General Agnès Callamard warned of the deeply worrying development of autonomy in weapons and said that "These machines risk automating killing,

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31. U.S. Department of Defense, Deputy Secretary of Defense Kathleen Hicks Keynote Address: 'The Urgency to Innovate' (As Delivered), DOD Speech, August 28, 2023. https://www.defense.gov/News/Speeches/Speech/Article/3507156/deputy-secretary-of-defense-kathleen-hicks-keynote-address-the-urgency-to-innov/

32. Congressional Research Service, Defense Primer: U.S. Policy on Lethal Autonomous Weapon Systems, In Focus, CRS, February 1, 2024. https://crsreports.congress.gov/product/pdf/IF/IF11150

treating it as a technical undertaking which raises human rights risks as well as humanitarian, legal and ethical concerns. Autonomous machines will make life and death decisions without empathy or compassion."[33]

Milrem Robotics THeMIS combat vehicles. (Image Credit: Milrem Robotics)

Fully autonomous weapons raise questions about accountability and adherence to international humanitarian law. Stop Killer Robots, a global coalition of more than 160 organizations working to address autonomy in weapons systems, emphasized the need to protect humanity, saying that "These 'killer robots' could be used in conflict zones, by police forces, and in border control. A machine should not be allowed to make a decision over life and death. Let's act now to protect our humanity and make the world a safer place."

China supports a ban on the use of fully autonomous lethal weapons systems despite advancing its AI capabilities in military domains. Speaking at the first UN debate on AI risks in July 2023, Zhang Jun, China's permanent representative to the UN, urged all countries to maintain responsible defense policies, reject the use of AI for military dominance or territorial aggression, and prevent any misuse of AI weaponry. Stressing the importance of peaceful AI use, he emphasized the need for human oversight in all AI-equipped weapon systems.

Target recognition and tracking

AI-driven systems enhance precision and minimize collateral damage by detecting, tracking, and identifying potential targets. These systems integrate data from various sources to provide comprehensive situational awareness, allowing for rapid analysis, timely decisions, and actionable insights.

AI's image and video analysis capabilities can revolutionize target identification, as demonstrated by the integration of an AI-enabled target recognition prototype with a U.S. Army M1 Abrams tank. This prototype, known as ATLAS (Advanced Targeting & Lethality Aided System), aids soldiers in locating and classifying enemy vehicles more efficiently. ATLAS "uses cutting-edge sensing technologies and machine-learning algorithms to automate manual tasks during passive target acquisition, allowing crews to engage three targets in the time it would normally take for them to engage one," according to the U.S. military's Defense Visual Information Distribution Service (DVIDS).

One of the most difficult tasks on the battlefield is forecasting where the enemy will attack next. The U.S. Army's Artificial Intelligence Task Force (AITF) is working on a project called

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33. Amnesty International, More than 30 countries call for international legal controls on killer robots, February 24, 2023. https://www.amnesty.org/en/latest/news/2023/02/more-than-30-countries-call-for-international-legal-controls-on-killer-robots/

Members of CMU's NREC set up equipment during the data collection event at Fort Hunter Liggett, on January 13, 2020. The partnership between CMU and the AITF focuses on modernizing the Army and its processes, through AI, by giving Soldiers the proper tools needed to succeed on the future battlefield. (Image Credit: U.S. Army/Artificial Intelligence Task Force)

Aided Threat Recognition from Mobile Cooperative and Autonomous Sensors (ATR-MCAS). This program utilizes drones, AI, and machine learning to predict enemy attacks and enhance battlefield operations. The drones identify the enemy weapons systems, such as tanks, then pass on the sightings of the identified threats to the AI which "identify, classify, and geo-locate entities, obstacles, and potential threats, generating a "common operating picture" (COP) of the battle zone for the soldier.[34] This COP is then processed by an AI-enabled decision support agent for recommendations. This dynamic approach improves interoperability across ground and air systems, enhancing warfighters' situational awareness and decision-making capabilities on the battlefield, and keeping them safer and smarter on the battlefield.

The ATR-MCAS system enhances ground warfare missions such as route reconnaissance, screening, and target verification, offering increased situational awareness and faster decision-making for soldiers. Its adaptable design boosts soldier lethality and survivability by enabling swift target identification and tracking.

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34. Patrick Ferraris, Aided Detection on the Future Battlefield, Army Artificial Intelligence Task Force, DVIDS, January 24, 2020. https://www.dvidshub.net/news/360225/aided-detection-future-battlefield/

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