
TECHNO
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WARFARE
IN 2035
TECHNO
WARFARE GROUP
INTELLIGENTIZED WARFARE IN 2035

Techno Warfare 2035

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About This Document

The researchers on Team Techno-Warfare Group prepared this report as a group Strategic Research Project as part of the requirements to complete the Master of Strategic Studies degree from the United States Army War College (USAWC). This document's research, analysis, and preparation were conducted from October 2022 through May 2023. This report answers a strategic question posed by Mr. Thomas F. Greco, Deputy Chief of Staff, G-2, U.S. Army Training and Doctrine Command, based on open-source information and interview with subject-matter experts.

Requirement

What will *Intelligentized warfare*[1] look like in 2035, and what skill sets will leaders need to win in this environment?

The team's findings were produced in multiple mediums, including a digital PDF version (primary) and a soft-bound book format. Multiple methodologies were used to determine key findings and convergences, including interviews with subject matter experts, scholarly publications, open-source reporting, and the Nominal Group Technique.

Analytic Confidence

Unless otherwise indicated, the analytic confidence in the findings of this report is MODERATE. The questions posed were complex, and the research timeline was relatively short due to the completing academic requirements of the USAWC curriculum. Corroboration and source reliability were consistently moderate to high. The research team worked individually and collaboratively to answer the questions and utilized several different structured analytic techniques.

[1] Intelligentized warfare is China's approach of incorporating emerging technologies such as artificial intelligence, cloud computing, big-data analytics, quantum information, the internet of things, cognitive dimension, and unmanned systems to achieve dominance. Koichiro Takagi, “The Future of China’s

Key Findings

Research Question:

What will *Intelligentized warfare* look like in 2035, and what skill sets will leaders need to win in this environment?

- Scope characteristics of warfare in 2035 that are "*intelligentized.*"
- Will the advent of *intelligentized warfare* enhance the current approach to warfare, transform the approach, or lead to a revolution in military affairs?
- Based on the projection from the previous question, might this lead to increased frequency of wars of annihilation or wars of attrition?
- Forecast beneficial Knowledge, Skills, and Behaviors (KSB) future leaders will need to operate effectively in 2035.
- What training, educational, or cognitive programs exist for future leaders?

Summarized Answer:

Intelligentized warfare, as conceptualized in *China's National Defense in the New Era* (July 2019), will highly likely (71-85%) evolve into a new type of warfare that can be best described as Techno-sentient warfare by 2035. Enabled by quantum computing and cutting-edge artificial intelligence, Techno-sentient warfare will be comprised of a fusion of space, cyber, and cognitive influence operations conducted below the threshold of armed conflict and throughout combat operations leading to systems clashes and partially automated warfare.

To prevail in this new era, it is almost certain (86-99%) leaders will need to cultivate a functional understanding of emerging technologies, master the intricacies of the artificial intelligence decision-making processes, and develop a sophisticated comprehension of big data-driven AI solutions. This expertise will be crucial for fostering trust in these consequential systems across tactical, operational, and strategic levels, empowering the leaders of 2035 to adopt a resilient mindset that prioritizes innovation.

Section 1: What will Techno-Sentient Warfare look like in 2035?

The 2019 concept of intelligentized warfare was China's approach of incorporating emerging technologies to achieve dominance in conflict without waging conventional warfare. The concept imagined information, underpinned by the Internet of things as a critical requirement, combines elements including artificial intelligence, cloud computing, big-data analytics, quantum information, and unmanned systems to directly impact or control adversaries in the cognitive domain.

Figure 1 below includes the seven key technologies associated with Intelligentized warfare on the left, and the corresponding technologies associated with Techno-sentient warfare on the

right. The transformations in these technologies, explored below, led our research team to the findings related to warfare in 2035, explored throughout sections 1 and 2 of these findings.

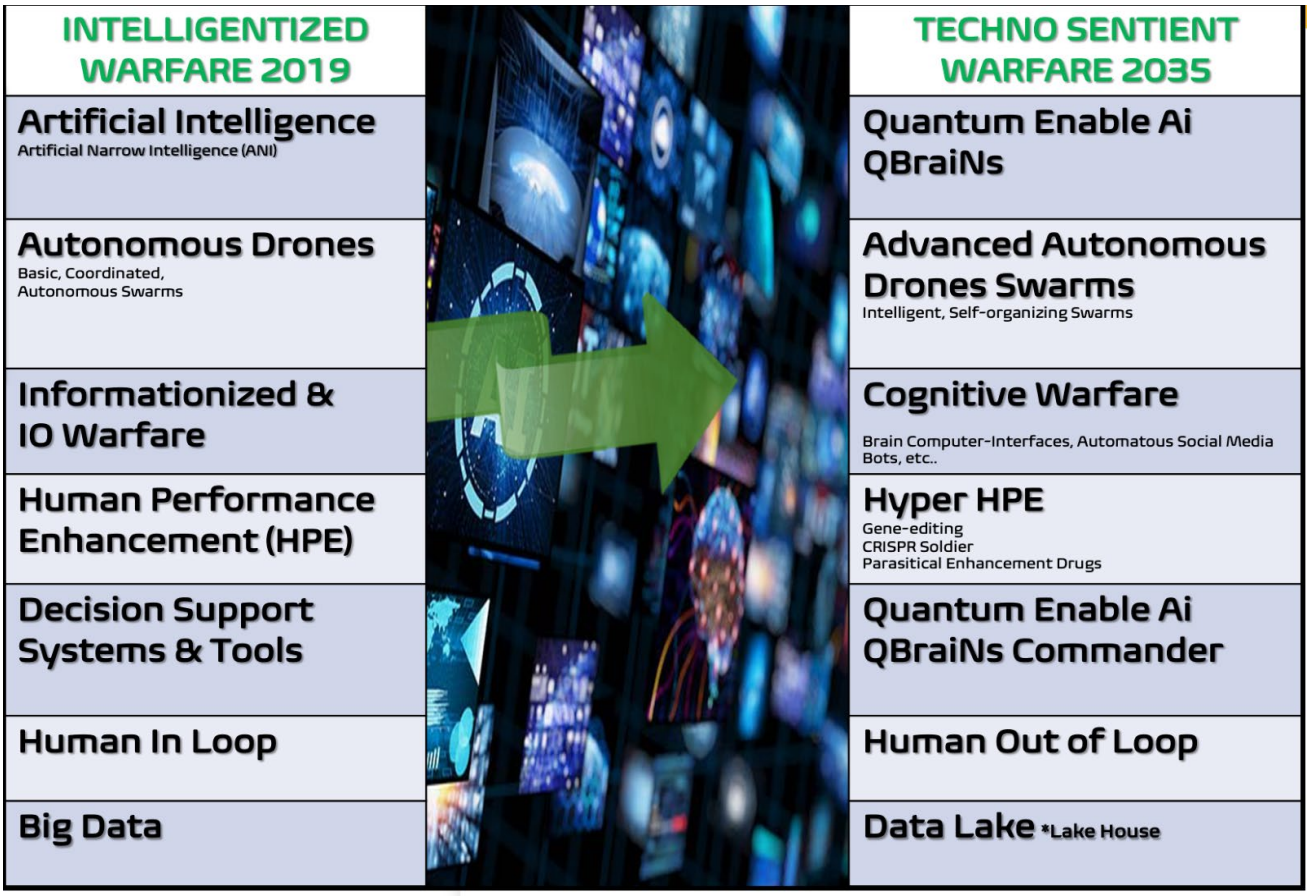

Figure 1: Key Technologies Associated with Intelligentized Warfare and Techno-Sentient Warfare

Basic Artificial Narrow Intelligence to Quantum Brain Networks (QBraiNs): Since 2019, artificial narrow intelligence (ANI) has advanced in a parabolic fashion. Increased availability of large-scale datasets has propelled unexpected AI advancements that include the development of sophisticated deep learning algorithms leading to the widespread adoption of AI in multiple industries. The advent of quantum computing promises to propel AI capabilities to new levels. Quantum computing uses principles of quantum mechanics to perform computations that traditional computers cannot. It utilizes quantum bits (qubits) that can exist in multiple states simultaneously, allowing for parallel processing and exponentially faster computations than classical computers.

Quantum Brain Networks (QBraiNs): Quantum Brain Networks (QBraiNs) is a new interdisciplinary area of study described by Cornell University as integrating knowledge and methods from neurotechnology, artificial intelligence, and quantum computing. The objective is to develop enhanced connectivity between the human brain and quantum computers for various disruptive applications. QBraiNs technology aims to use a brain-machine interface (BMI) to

create a computing platform that can help individuals analyze complex data sets and detect patterns or anomalies to support rapid decision-making in real-time.

Basic Autonomous Drones to Advanced Autonomous Drone Swarms: Autonomous drones will transition from basic functions to **Advanced Fully Autonomous Drone Swarms.** Future systems retain the ability to not only achieve specified objectives but will be able to communicate within the swarm and dynamically reorganize and form subgroups to make limited decisions using distributed algorithms.

Informationized and IO Warfare to Cognitive Warfare: Informationized and IO warfare refers to using information technology and communication networks to gain a strategic advantage in military operations by disrupting or manipulating the enemy's information systems and influencing their decision-making processes. **Cognitive Warfare** will focus on influencing and manipulating the thoughts, beliefs, attitudes, and behaviors of targeted individuals or groups using psychological tactics such as propaganda, disinformation, and other forms of brain manipulation. It aims to gain a decisive advantage over the opponent by controlling human behavior's mental and emotional aspects, otherwise known as the cognitive domain.

Human Performance Enhancement (HPE) to Hyper Human Performance Enhancement: Previous human enhancement used pharmaceuticals, nutritional supplements, and wearable technology to increase human output. As warfare transitions from Intelligentized warfare to Techno-Sentient warfare, HPE will advance to **Hyper HPE**. At the core of Hyper HPE is the application of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) technology, which relies on genome editing technology to enhance human performance.

Figure 2: Portrayal of QBraiNs CDR

Decision Support System and Tools to QBraiNs Commander: The 2019 version of decision support systems and tools relied on a laborious process, including analog procedures and a robust staff to develop options before making decisions. Team Techno Warfare Group's (TWG) research points towards a transition to what may be known as a **QBraiNs CDR**. The application of QBraiNs for commanders and essential staff will enable decisive and rapid decisions.

Human-In-The-Loop to Human-Out-Of-the-Loop: This transition highlights the anticipated need to shift from continuous human oversight in offensive and defensive systems to a forecasted need to rely upon, in some instances, automatic machine or system reactions. **Human Out of the Loop (HOOL)** operations are often synonymous with autonomous or 'full autonomy.' DOD Directive 3000.09 defines autonomous weapon systems as "a weapon system that, once activated, can select and engage targets without further intervention by an operator." When one

nation's military chooses to use HOOL operations, it may become necessary for competing nations to follow suit. Previous US Army Futures Command Gen. Murray stated that the Pentagon may have to relax rules related to defeating drone swarms since human decision-making and action is an eternity when compared to machine time.

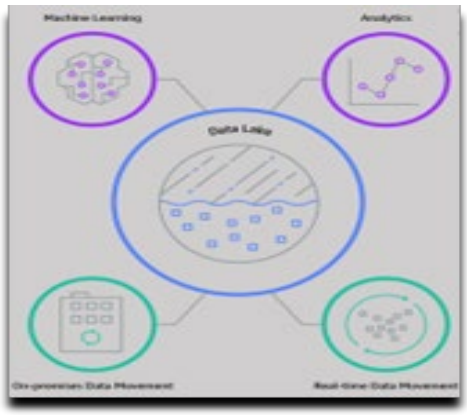

Figure 3: Data Lake Diagram

Big Data Transition to Data Lakes: The manual collection and processing of large amounts of structured and unstructured data will transition to Data Lakes. Microsoft defines Data Lakes as a repository that stores large amounts of data in its original form and can handle all data types from any source. The data is stored in staged zones for various user needs and can power big data analytics, machine learning, and predictive analytics.

Techno-Sentient Warfare: It is highly likely (71-85%) that nations with advanced technologies will employ Techno-sentient warfare by 2035. Techno-sentient warfare incorporates quantum computing and advanced artificial intelligence (in the spectrum between artificial narrow intelligence and artificial general intelligence) to augment emerging technologies supporting semi-automated warfare. The term "sentient" in Techno-Sentient Warfare refers to the AI's ability to operate autonomously, make decisions, and adapt to new circumstances; it is not necessarily inferring that the system has consciousness.

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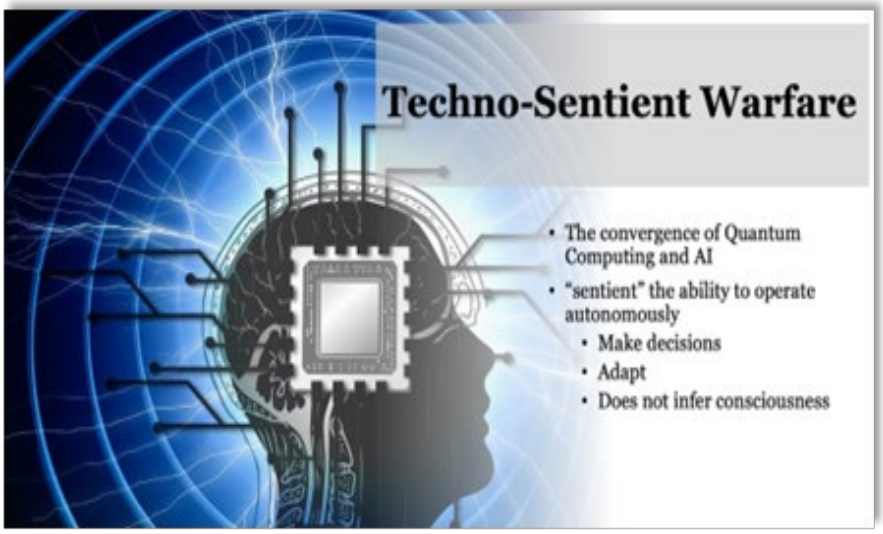


Figure 4: Techno-Sentient Warfare

In Techno-sentient warfare, systems will work with systems, communicating and cooperating, making complex decisions, adapting to changing situations with little human input, and learning from their collective experiences. As nations increase in Techno-sentient warfare proficiency,

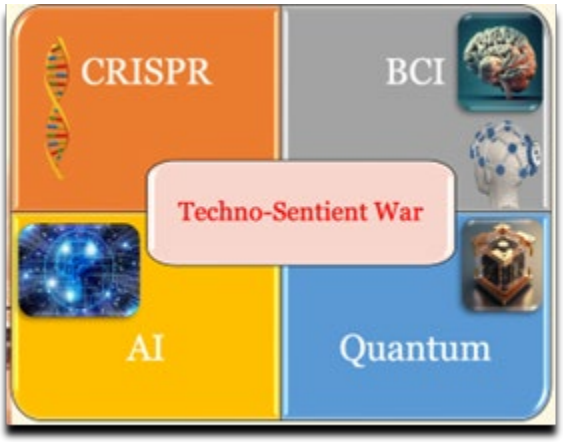
conflict will occur earlier along the competition continuum and support forces throughout combat operations. Government and military forces will increasingly operate in domains outside of the traditional land/air/maritime domains in support of national objectives while conducting accelerated competition in the "grey zone," where decreased human involvement will increase plausible deniability and reduce the risk of human casualties, thereby reducing barriers to conflict. The key to dominating Techno-sentient conflict lies in perceiving, adapting, and acting faster than the opponent to induce or reverse paralysis across the system of systems by focusing on attacking or influencing vital nodes.

Section 2: A Changing Character of Warfare

In an overview document titled “War, Strategy, and Theory,” William T. Johnson and Tami Davis Biddle describe the character of war as something that changes with time and is “highly dependent on scientific innovation, technological change, demographic shifts, trends, and changes in domestic and international political organization and national policies.” Team TWG’s research indicates that the character of warfare is almost certain (86-99%) to change before 2035. The advancement of previously described technologies suggests that the battlefield's scope will expand beyond the conventional domains. Increasingly, conflict will encompass the cyber, space, and especially cognitive domains which will blur the boundaries between peacetime and wartime. In combat, new technologies designed to enhance human performance combined with machine and robotic advancements will enable semi and fully autonomous systems to accelerate the pace of warfare. Digital communication and tracking technologies will allow dispersed operations supported by over-the-horizon kinetic strikes combined with nonphysical domain assaults to gain a positional advantage.

- The battle of systems is expected to occur before physical human engagement
- Ubiquitous computerized sensors supported by automated call-for-fire
- Enhanced humans paired with robot armies and uncrewed vehicles
- Integration of quantum computing enables the processing of complex data sets from multiple domains
- Accelerated wargaming and decision-making

Figure 5: Converging Technologies



Based on the forecasted convergence of required technologies, all referenced advancements will not be fielded to the same degree in all nations with advanced militaries. It is highly likely (71-85%) that those nations will be in a crucial transition period in 2035. Though there are various estimations on the speed of advancement of AI, chances are better or less (46-55%) that artificial general intelligence (AGI) will not be attained until 2040 at the earliest. Our research indicates that some changes will lead to revolutions in military affairs. However, advancement from artificial narrow intelligence (ANI) to artificial general (AGI) or super intelligence (ASI) will likely be the key technology that will precede a Military Revolution and expand Techno-sentient warfare to a form of automated Techno-sentient warfare.

Revolutions in Military Affairs

According to Rand Hundley in a 1999 Rand Corporation research brief, a revolution in military affairs is defined as "a paradigm shift in the nature and conduct of military operations that either renders obsolete or irrelevant one or more core competencies of a dominant player, creates one or more new core competencies in some new dimension of warfare, or does both." It is almost certain (86-99%) that the convergence of the previously described disruptive technologies will lead to the emergence of individually operated and autonomous drone swarms, resulting in a revolution in military affairs (RMA) by 2035. Gene-edited, technologically enhanced soldier capabilities are also highly likely (71-85%) to be developed to the point that it will revolutionize small squad capability in special operation units by 2035. Finally, it is highly likely (71-85%) that cognitive social media warfare will reach a level commensurate with an RMA. Coordinating the use of information, space, and cyber capabilities, state and non-state actors operating in the grey zone will seek to manipulate the thoughts and actions of targeted individuals or groups through automated psychological assaults.

Wars of Annihilation and Attrition

Wars of annihilation and attrition: The strategies of annihilation and attrition are generally attributed to the German military historian Hans Delbröck. In “The American Way of War,” Russell Weigley summarizes Delbröck’s position, describing annihilation as a strategy to defeat the enemy’s military. On the other hand, the strategy of attrition seeks to exhaust the opponent. Wars of annihilation will likely (56-70%) increase in specific instances involving nations adept at employing Techno-sentient warfare against nations employing conventional warfighting concepts. Nations that exploit technological advancements and explore operational concepts

associated with Techno-sentient warfare will possess a clear asymmetric advantage against nations using outdated technology. An appropriate comparison may be Desert Storm. Even though the Iraqi Army was billed as the fourth largest military in 1991, it lost half its might in the short battle against allied forces as it waged an outmoded war against a technologically superior force. A more recent example includes the second Nagorno-Karabakh war, where Azerbaijani forces, using information warfare and sensors tied to uncrewed and autonomous drones, decisively defeated Armenian forces mired in outdated concepts and obsolete equipment in a short 44-day war.

Wars of attrition, however, are almost certain (86-99%) for nations engaging in Techno-sentient warfare in 2035. Enhanced military operations supported by cutting-edge technology will streamline decision-making and enable quicker adaptation to changing situations – on both sides. This will accelerate warfare, but it will be difficult for one side to achieve a decisive advantage over the opposing nation. Even if fielded forces of one nation are significantly attrited, special forces and para-military units using Techno-sentient capabilities will provide the conditions for prolonged wars of attrition. Some glimpses of a combination of advanced and aging technologies continue to be used in the Russia-Ukraine war. While Russia was able to achieve a fait accompli using a combination of grey zone tactics in their annexation of Crimea in 2014, they were unsuccessful in their objectives in 2022 against an opponent that learned from the 2014 events and began incorporating tactics and new technologies into their political structure and military forces.

Section 3: What Skill Sets Will Leaders Need for Warfare in 2035?

The Army categorizes attributes into seven ‘talent domains,’ further broken down into 42 ‘talents,’ and finally into 199 measurable KSBs (Knowledge, Skills, and Behaviors). 'Knowledge' refers to facts and information that someone knows, 'Skills' refer to what someone can do, and 'Behavior' refers to how someone acts. The Techno-Warfare Group’s research indicates it is almost certain (86-99%) that leaders will need to cultivate some existing KSBs, learn new technologies, and develop new skills and behaviors for future warfare. During an interview, experts from *Shield AI* proposed that leaders must develop knowledge and skills, including cultivating a deep understanding of emerging technologies, mastering the intricacies of the artificial intelligence decision-making processes, and developing an advanced comprehension of big data-driven AI solutions. Understanding how AI is trained and makes decisions will be crucial for fostering trust in the systems we rely on in the future.

The Techno-Warfare Group identified in Figure 6 (below) the attributes (in green) listed as necessary for conflict in 2035. Next, the team compared those attributes with the list of 199 KSBs identified in the Army Talent Attribute Framework (in black). All terms could be correlated to an existing KSB except for the following (red shading): Learn from failure; Accept

failure; Human Centered Engineering; Application Program Interface; and Trust in Systems, including AI/ML.

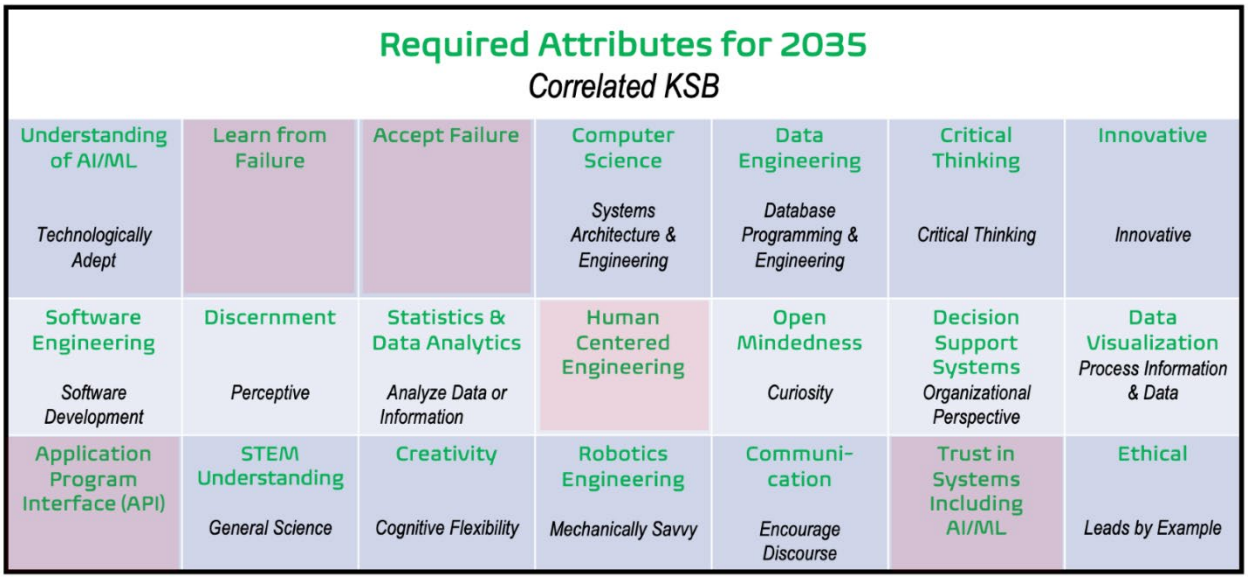


Figure 6: Attributes Required for Techno-Sentient Warfare Required for TSW

Learn from and accept failure: Failure is often a prerequisite to innovation or invention. IBM's Thomas Watson, Sr., once said, "the fastest way to succeed is to double your failure rate." The behavior associated with accepting failure and the skill associated with learning from failure will be critical in a Techno-sentient environment; it also lies counter to US Army culture. In referring to regulations that essentially override junior leader decisions, Casey Haskins wrote an article titled *A Good Answer to an Obsolete Question: The Army's Culture and Why it Needs to Change*, where she lamented "[the institutions] existed to prevent failure, and no one seemed to notice that in so doing they also prevented excellence." Innovation in a rapidly changing environment with new combinations of technologies will require trial and error, initiated from the bottom up, where eventual successful iterations can be shared seamlessly across the force.

Human-Centered Engineering: In 2021, Boston College launched a human-centered engineering program that combines liberal arts focus with a demanding engineering curriculum. The program uses design thinking at its core and emphasizes experiential learning in collaborative teams across disciplines. As technology advances in an increasingly digitized and automated world, the military needs to consider more than just the technical aspects of technological improvements. It should strive to promote and develop systems that recognize the importance of keeping humans at the intersection of technology and military applications – not just for ethical reasons but also for effectiveness.

Application Program Interface: One of the themes identified throughout Team TWG's research is the need for interdisciplinary solutions to facilitate converging technology applications.

Application Program Interface (API) skills are essential for modern and future software development because it allows developers to build complex systems by leveraging the functionality of other applications and services. Military formations often struggle to synchronize incongruent systems. The forecasted operational environment characterized by accelerated warfare will require leaders at echelon to promote and understand how to leverage systems that seamlessly exchange data, then synchronize that data with capabilities that include built-in functions and tools to integrate those features for offensive or defensive measures quickly.

Trust in systems: In Winthrop's translation of Alexis de Tocqueville's "Democracy in America," Tocqueville describes "those who cultivate the sciences among a democratic people … mistrust systems, they adhere closely to facts and study facts with their senses." Though written in 1840, Tocqueville's observations hold true today. In defining all the Army KSBs, the Talent Attribute Framework references 'trust' seven times; every time trust is used, it refers to a person or a group of people. The document never refers to a behavior that would require trust in a system. The Army should consider expanding its definition of trust in relation to the behavior or developing a new behavior centered on trust in systems.

The researched team also used the nominal group technique (NGT) to highlight existing talent areas within the Talent Attribute Framework. The team's research indicates that leaders will need to develop further the following talents to be effective in an era of Techno-sentient warfare:

Talent (Talent Domain)	**Technology Fluency** (Expertise and Personal Competence)	**Openness to Experience** (Disposition)	**Math & Science** (Expertise and Personal Competence)	**Problem-Solving** (Cognitive)	**System Thinking** (Cognitive)

Figure 7: Talents Requiring Increased Development for Techno-Sentient Warfare

1. Technology Fluency: Basic computer skills, advanced computer skills, cyber knowledge, data science, innovative technology, and being technologically adept.
2. Openness to Experience: Curiosity, innovation, intellectual efficiency, tolerance, tolerance for ambiguity, and adaptability.
3. Math and Science: Basic mathematics, advanced mathematics, general science, mathematical reasoning, mathematics knowledge, and science methods.
4. Problem-Solving: Problem solver, structured problem-solving, troubleshooting, and unstructured problem-solving.
5. Systems Thinking: Strategic thinking and systems thinking.

Current Training, Educational, or Cognitive Programs Exist for Future Leaders

DoD, universities, and civilian businesses have all explored innovative ways to educate and train their personnel to meet various needs for generations with diverse learning preferences. Figure 8 below provides an overview of the novel methods used in the assorted organizations. Starting on the left and moving clockwise around the figure, the Department of Defense operates 43 cognitive human performance enhancement programs across various research labs, including university collaborations. Military organizations have also explored the use of specific pharmaceuticals and nervous system stimulants for training and missions.

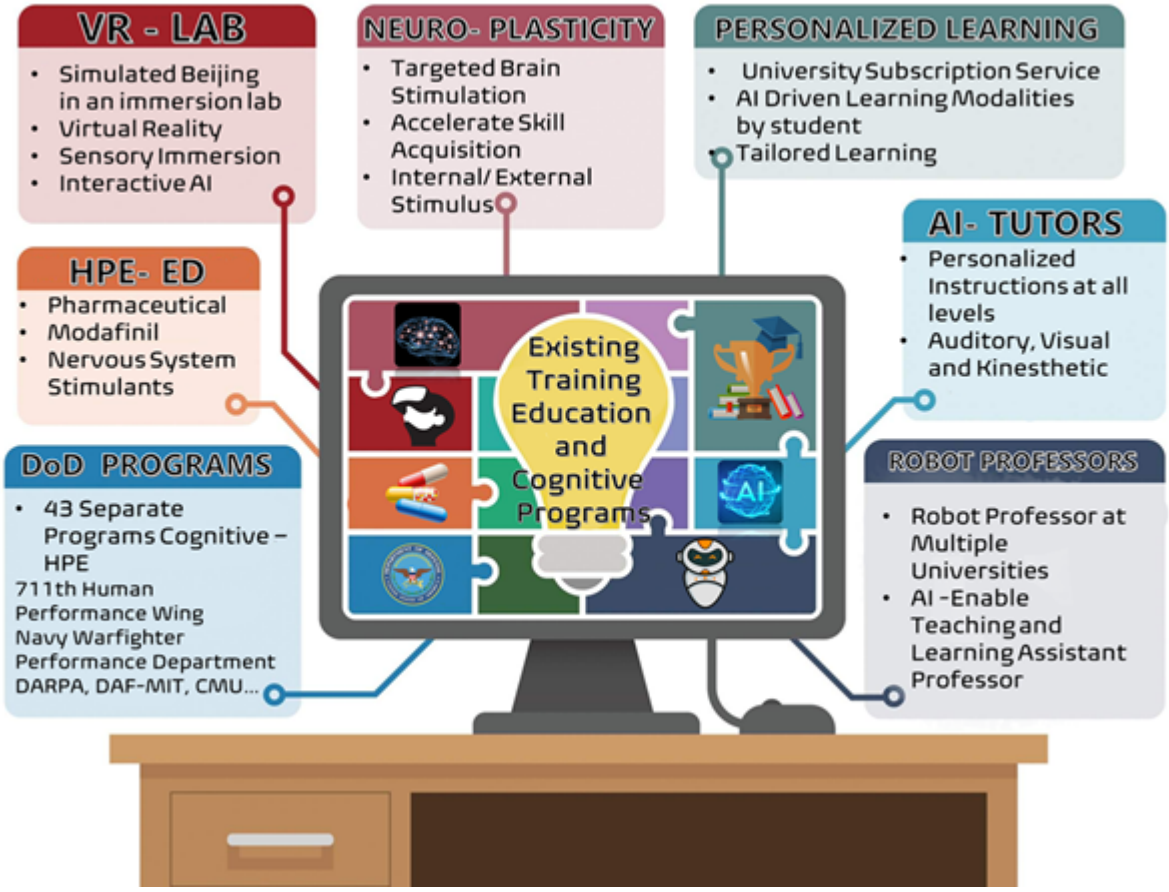


Figure 8: Current Training, Educational, and Cognitive Programs

Universities such as the Kanda University of International Studies in Japan and the Unitec Institute of Technology in New Zealand have used immersive technologies such as virtual reality (VR) and augmented reality (AR) to enhance language learning and to provide interactive education. Additionally, students at Rensselaer Polytechnic Institute in New York used their immersion lab to master Mandarin about twice as fast as their peers. Major universities such as Georgetown and MIT have explored neuroplasticity methods to accelerate skill adaptation and medical institutions have used similar methods to enhance treatment protocols to help motivate patients. Several universities are experimenting with personalized learning, including

subscription-based programs that use AI tutors and teaching assistants to facilitate interactive education, even without a human instructor. Philipps University of Marburg, Germany is the first to employ a full-time robot lecturer named Yuki. The DoD may benefit from exploring some of these disruptive education models to improve future training and education.

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Integrated Short Form Analytical Reports (ISFAR)

Almost Certain One Revolution in Military Affairs, Highly Likely Multiple Other Revolutions in Miliary Affairs, But Unlikely Military Revolution by 2035

Executive Summary

It is unlikely (31-45%) the world will witness a military revolution by 2035, but the expected convergence of specialized technologies makes a military revolution more likely within the decade following 2035. However, the convergency of a broad range of specialized technologies accelerated by artificial narrow intelligence make it almost certain that individual-operated and autonomous drone swarms will materialize into a revolution in military affairs (RMA) by 2035. Super soldier capabilities are also highly likely to be developed to the point that it will revolutionize small squad capability in special operation units by 2035. Finally, it is highly likely that cognitive social media warfare in the grey zone will influence nations at the RMA level, but below the level of conflict by 2035. The greatest obstacle to these concepts emerging over the next 12 years is the formation of deliberate operational concepts and doctrinal solidification. Despite these challenges the increasing potential of a multi-polar or bi-polar world will accelerate military adoption of these concepts.

Discussion

Revolutions in Military Affairs (RMA) and Military Revolutions (MR) historically are difficult to predict and almost always forged through experience in battle, when the need to escalate capability becomes paramount to gain a military advantage over an opponent. Not all scholars agree on every RMA and MR, but the work by MacGregor Knox and Williamson Murray entitled "The Dynamics of Military Revolution 1300-2050" provides a consolidated structure of the two concepts and is used as the framework for this forecast.[1] Figure 1 is directly from Knox and Murray's book and includes their judgment of RMAs and MRs from the Middle Ages thru the nuclear age. The definitions of RMA and MR below are a conglomeration of several scholar's descriptions but derive their core concepts from the aforementioned book.

Anticipatory RMAs of the Middle Ages and early modern era
- longbow, offensive–defensive strategy, gunpowder, new fortress architecture.

Military revolution 1: *the seventeenth-century creation of the modern state and of modern military institutions*
Associated and resultant RMAs:
- Dutch and Swedish tactical reforms, French tactical and organizational reforms, naval revolution, Britain's financial revolution;
- French military reforms following the Seven Years' War.

Military revolutions 2 and 3: *the French and Industrial Revolutions*
Associated and resultant RMAs:
- national political and economic mobilization, Napoleonic warfare (battlefield annihilation of the enemy's armed forces);
- financial and economic power based on industrialization (Britain);
- technological revolution in land warfare and transport (telegraph, railroads, steamships, quick-firing smokeless-powder small-arms and artillery; automatic weapons);
- the Fisher revolution in naval warfare: the all-big-gun battleship and battlefleet (1905–14).

Military revolution 4: *the First World War irrevocably combines its three predecessors*
Associated and resultant RMAs:
- combined-arms tactics and operations, Blitzkrieg operations, strategic bombing, carrier warfare, submarine warfare, amphibious warfare, radar, signals intelligence.

Military revolution 5: *nuclear weapons and ballistic missile delivery systems*
Associated and resultant RMAs:
- precision reconnaissance and strike; stealth; computerization and computer networking of command and control; massively increased lethality of "conventional" munitions.

Figure 1: RMAs and MRs. Source: The Dynamics of Military Revolution, 1300-2050, 17.

Revolution in Military Affairs[H] An identifiable shift in the character of war, usually (but not always) due to technological improvement(s) combined with a new operating concept.[H,H,H] The effect of the change is significant enough that it can render the previous means or method of battle less competitive or even irrelevant.[H] Figure 2 (below) portrays the traditional sequence of events leading to an RMA.

Figure 2: Designed by author, derived from RAND Research Brief (See Footnote 2) Source: Rand.org

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Drone Swarms. Militaries are almost certain (86-99%) to develop Autonomous drone swarms into new operational concepts and doctrine before 2035.[H] The video in Figure 3 (right) shows how an individual can remain on the loop in directing a robotic swarm to achieve broad objectives or even allow the swarm to operate autonomously to achieve narrow objectives.

Figure 3: OFFensive Swarm-Enabled Tactics (OFFSET) Sixth Field Experiment. Click on picture or go to: https://youtu.be/W34NPbGkLGI to view video. Source: DARPA

Expected advances in machine learning (ML) and quantum computing over the next ten years will advance this drone swarm operational concept beyond the current capability and relegate the single human operating a single platform to a level of irrelevance.[H]

Super Soldier. The combination of the following technologies makes the super soldier highly likely by 2035. Based on the forecasts, the capabilities will not be widespread by this date, but it will likely (56-70%) be sufficient to outfit multiple technically advanced military special operation forces by 2035. The highly likely forecast that light fidelity will achieve full adoption by 2035[H] will enable MicroClimate vests and Exo-skeleton advancements. The highly likely forecast that brain-computer interfaces (BCI) will be in development by 2035[H] support communication, mobile data integration, and interactive heads up displays.[M] Additionally, as China utilizes "a Military-Civil Fusion approach to biotechnology as a dual-use technology, it is highly likely (71-85%) the widespread application of Gene-related HPET will begin in 2030, particularly within military applications."[H]

Figure 4: Super Soldier capability. Click on picture or go to: https://youtu.be/r1m68B53iek to view video. Source: U.S. Army

Grey Zone Cognitive Warfare: The competition continuum may be tilting towards increased cognitive attacks aimed at influencing opponents below the level of armed conflict. Increasingly, attacks are derived from "bots" rather than humans. Two forecasts convey that it is "highly likely that artificial intelligence will use coercive persuasion to shape individual thinking through social media by 2035" and social-media bots are likely (56-70%) to begin cognitive social media warfare before 2035. These types of asymmetric attacks are highly likely to continue to occur in the cyber, space, and electromagnetic realm designed to influence adversary actions and deter kinetic military conflict.

Figure 5: Image from LTC Hatcher forecast on social media warfare

Military Revolution: A military revolution centers on an identifiable change in society that facilitates a shift in the character of war while increasing the ability of states to project power. They are more rare than RMAs and usually include a combination of multiple RMAs.[H] "Revolutions in military affairs require the assembly of a complex mix of tactical, organizational, doctrinal, and technological innovations in order to implement a new conceptual approach to warfare or to a specialized sub-branch of warfare."[3]

It is unlikely the world will witness a military revolution by 2035, but the expected convergence of specialized technologies makes a military revolution more likely within the decade following 2035. The central capability that promises to generate a profound effect on almost every other emerging technology is AI. AI improvements have accelerated at a rapid pace over the last two years, but the capability still rests within the Artificial Narrow Intelligence (ANI) band.[H]

ANI is currently enabling humans to increase efficiency, but it is unlikely to rise to the revolutionary level. Advancements to the next two progressions – Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI) – support a highly likely forecast of setting the conditions for the next military revolution. However, "chances are a little better or less (46-55%) that AI will evolve into AGI by 2040."[M] As Figure 1 RMAs and MRs points out, there are "associated RMAs" and "resultant RMAs" tied to each military revolution. The previously mentioned technologies forecasted to emerge into RMAs by 2035 will highly likely (71-85%) qualify as associated RMAs that help drive the next military revolution.

Since the development of the concepts of revolutions in military affairs and military revolutions, theorists have predicted RMAs that either never came to pass, or fulfilled evolutions in military affairs, rather than revolutions in military affairs.[H] Military organizations can be resistant to change, based on their hierarchical structure, and so the greatest obstacles to these concepts emerging over the next 12 years is the formation of deliberate operational concepts and doctrinal solidification. Despite these challenges the increasing potential of a multi-polar or bi-polar world will accelerate military adoption of RMAs to achieve or maintain a competitive advantage. Additionally sudden advancements in development of AGI could accelerate the technologies underpinning these forecasted RMAs and cause these and additional RMAs to emerge faster than anticipated.

Analytic Confidence

The analytic confidence for this estimate is *moderate*. The author used reliable sources that pointed to recently accelerated technological advancements across multiple fields, but with various estimates. Unanticipated advancements in AGI will accelerate most of the emerging technologies and could propel a MR prior to expectations. The analyst worked within a group setting to develop various technological forecasts but worked alone in converging the research and could have benefited from additional time for research and assessment.

Author: LTC Phillip B. Cain

Commercial and Defense Applications of Quantum Brain Networks, The Convergence of Artificial Intelligence, Quantum Computing, and Brain Computer Interface Technology, Likely by 2040

Executive Summary

Due to rapid technological advances, it is likely (56-70%) that the convergence of Artificial Intelligence (AI), Quantum Computing (QC), and Brain-Computer Interface (BCI) technologies will accelerate the development of Brain Computing Networks (QBraiNs) applications by 2040. QBraiNs has the potential to unlock unprecedented processing power, data analysis, and human-machine interaction capabilities, enabling more precise and sophisticated applications in fields such as healthcare, education, transportation, and the defense sector. Despite technical, ethical, and legal issues related to privacy, security, and human rights, early adoption of this technology by defense and industry competitors will likely accelerate research and development due to the potential implications for great power competition and strategic advantage for early adopters.

Discussion

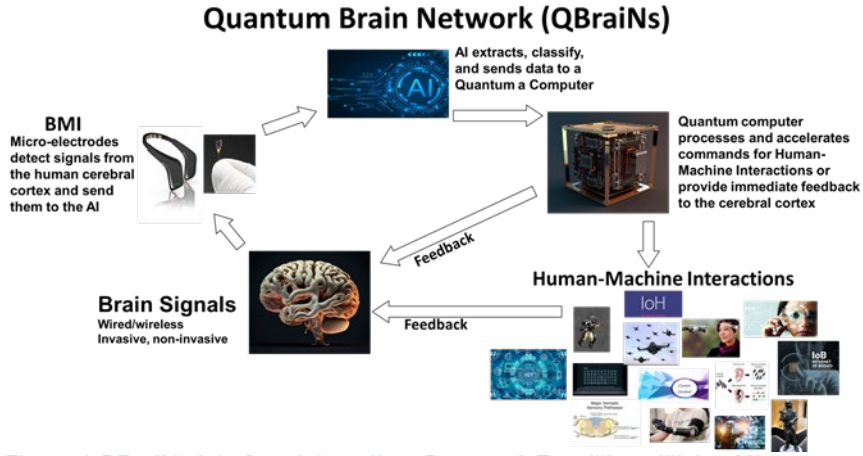


Figure 1 QBraiNs Interface Interaction. Source: A Rendition utilizing Midjourney.

QBraiNs is an interdisciplinary field that integrates principles from artificial intelligence, BCI, and quantum computing to develop enhanced connectivity between the human brain and quantum computers.[H][M] QBraiNs aims to simulate the human brain's information processing mechanism by using Brain-Machine Interface (BMI) systems (invasive or non-invasive) to establish a connection with the human brain. It then utilizes AI algorithms for data processing and analysis and quantum computing for complex calculations (see Figure 1).[H][H][M] The goal of QBraiNs is to create a computing platform that can learn from experience, adapt to new situations, analyze complex data sets, detect patterns and anomalies and make decisions in real-time.[M]

QBraiNs and BCI share a fundamental similarity in their aim to understand and replicate how the human brain processes information. QBraiNs focuses on the intersection of quantum computing and artificial neural networks for powerful AI, while BCI involves direct communication between the brain and external devices to control computers, prosthetics, or other devices. These similarities drive the acceleration of research and development in this interdisciplinary field. Due to the existing body of knowledge and techniques in BCI, *The QBraiNs Project*[H] in collaboration

with the *Human Brain Project*,[H] a scientific consortium of the European Union, and various universities, research institutions, and private companies from around the world[H] are leveraging the advances in BCI and Neurolink to accelerate QBraiNs research and development, including the development of governance addressing the ethical and dual-use technology concerns.[H H] Other collaborating institutions include the University of Oxford, the University of California, Berkeley, the Max Planck Institute for Human Cognitive and Brain Sciences, and IBM.[M] Due to this concerted global effort, it is likely (56-70%) that QBraiNs will reach commercial and defense applications by 2040.

Despite the significant efforts by the US, allies, and partners to accelerate QBraiNs by leveraging advances in BCI, China is rapidly emerging as a leader in this field due to its significant government investments in party-mandated research and development complemented by a supportive albeit non-existent regulatory environment.[H] In 2019; China produced a non-invasive chip called the "Brain Talker" which allows a person to control a computer with just their brainwaves,[M M] and forms the core of what China calls "brain control" (cognitive) warfare; an element of the overarching *Intelligentized Warfare*[1] concept dominated by China. Despite this chip's direct association with China's BCI program[M], it illustrates the feasibility of applying an existing capability to emerging technology such as QBraiNs.

QBraiNs rely on QC and AI, both facing several technological, cybersecurity, and ethical challenges. Quantum computers require extremely low-temperature environments for efficient functioning, experience qubit errors that are hard to identify and rectify, deployment and operational costs are high, and pose cybersecurity threats due to the ability to decipher encrypted data.[M H M M M] Despite these challenges, recent technological advances have mitigated most QC issues.[H M M] The use of new materials enabled the creation of more stable qubits at average temperatures. The development of governance standards and ethical frameworks and policies are addressing the ethical concerns associated with both AI and QC.[H]

Due to QBraiNs integrated AI and QC capabilities, QBraiNs has the potential to enhance the employment of future semi-autonomous and autonomous systems enabling human-in-the-loop, and human-out-of-the-loop functions greater control and predictability of use. [M H] Despite the ethical concerns pertaining the research and development of these disruptive technologies, advancements in materials technology, computer processing, and neuroscience will likely (56-70%) accelerate the growth of a safe, practical, and robust QBraiNs capability well beyond rehabilitative medical use that will not only revolutionize health, commercial and defense sectors but transform how the average individual interacts with others and their networked environment by 2040. The nation best able to adapt to the competitive environment and overwhelm its adversaries' capability to do so will be better equipped to achieve an advantage.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable based on the credibility of the respective articles and publications. While the sources tended to corroborate one another, they varied in estimated forecasts and technological challenges. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is susceptible to change due to QBraiNs nascent nature and the potential future challenges comprising technical, ethical, and legal concerns, all of which will

influence the time horizon for the development of this technology. Additional time and staffing are required to improve this estimate.

Author: LTC Fidel Arvelo[2]

Highly Unlikely the DOD Will have an Artificial Intelligence Ready force by 2035

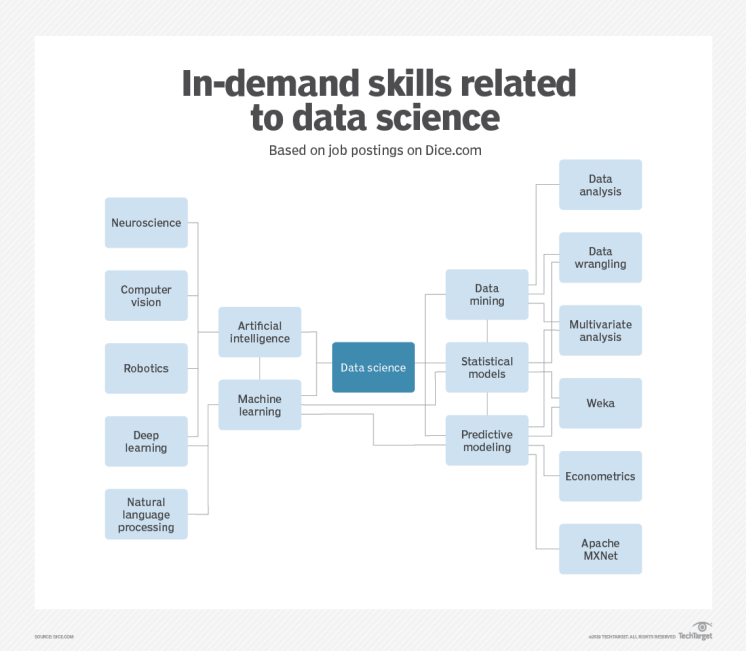
Executive Summary

Despite the Department of Defense (DOD) recruiting efforts, it is unlikely (71-85%) to be able to recruit and retain the number and caliber of experts needed for the future of Artificial intelligence (AI) warfare by 2035. Due to increasing demand in the private sector for technology-driven employment, the education needs for working with AI, the DOD structure for hiring and training personnel and the benefits and flexibility in working in the private sector, it is unlikely the DOD will meet its recruiting goals.

Discussion

The demand for AI talent is high and is likely to increase by 35% in the near future,[H] and the DOD is competing with the commercial sector for the same talent. According to the U.S. Bureau of Labor Statistics, the projected growth rate in IT is projected to grow by 15% from 2021 to 2031[H] and the median annual wage is 97,430 compared to the median wage for all occupations of 47,750.[H] The US Cyber Command Joint intelligence operations center commander said, "our bench is not deep enough" regarding adequate numbers of trained cyber professionals, not just in cyber command but across the DOD.[H] The requirements for security clearances, citizenship, physical fitness, restricted lifestyle, and lower salaries hinder hiring in the DOD.

Figure1 Basic data skill needed for working in AI https://www.techtarget.com/searchbusinessanalytics/feature/The-most-in-demand-data-science-skills-you-need Basic



An individual working in AI must possess both hard and soft skills. Hard skills like mathematics, statistics, programming languages, and computer science are essential, but soft skills such as critical thinking and problem-solving will differentiate the leaders in this field.[M] It is impossible to succeed in AI and

machine learning (ML) without a tool kit of knowledge and skills, but obtaining those skills requires education and training with experienced professionals and can be costly. See figure 1 for the most in-demand skills for success in the AI field.

The traditional military training and schooling models are insufficient to tackle the challenges of the future AI environment. Companies such as Google, Apple, and Microsoft are structured differently, encourage innovation collaboration and are better positioned to accept the risk because of their agile and responsive nature.[M] Companies that embrace innovation, encourage new ideas, embrace failure, create psychological safety, and promote diversity of thought are more successful than companies that discourage individual thought, such as the military.[M] The most innovative organizations think there is a better way to do things, collaborate beyond the organization, recognize the need for experimentation, accept failures, and empower people to voice dissenting opinions.[H]

The future of AI is dependent on the workforce of tomorrow. The DOD offers many opportunities, but the disparity between pay, benefits, and flexibility of the private sector challenges the DOD in recruiting talent. Generation Z, born between 1996 and 2010, will make up 30% of the workforce and has a preferred learning style incongruent with the military's brick-and-mortar schoolhouse.[M] Gen Z are digital natives, prefer digital formats, on-the-go mobile options, and to recruit this talent, the DOD needs to have more flexible options for hiring.[M] Bootcamps are intensive entry-level formats that are faster than earning a degree and come in a variety of format and schedules to accommodate self-paced learning.[H]

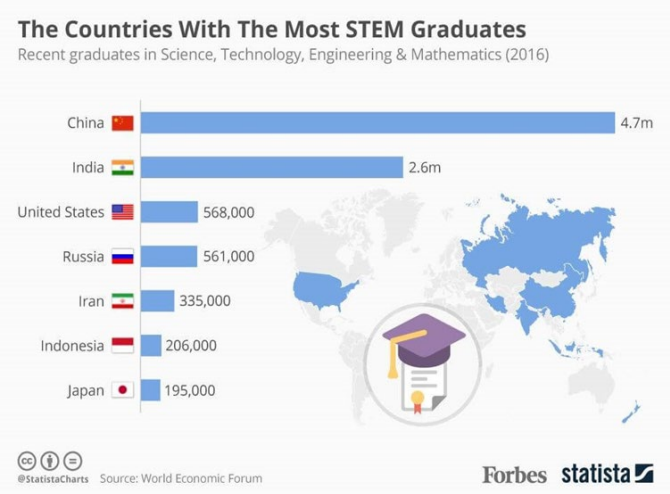


Figure 2: https://www.statista.com/chart/7913/the-countries-with-the-most-stem-graduates/

The PLA has been modernizing for over 20 years, with most AI breakthroughs occurring in the commercial sector, making civil-military integration a crucial innovative approach.[M] China and India are leading the U.S in students receiving education in Science, Technology, Engineering & Mathematics (STEM) degrees. Many students are receiving education at American Institutions, and it is unlikely the U.S. will be able to overcome those statistics.

The DOD is at a disadvantage over several other countries and commercial sectors concerning the AI industry. Education, Salaries and the increasing demand for experts in this field, and the competition in the commercial market leave the U.S falling behind in this arena.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable based on the credibility of the respective articles and publications. While the sources tended to corroborate one another, they varied in their forecasts and future potential for adoption. Although the analyst

had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to enduring efforts by the scientific, educational, and commercial industries. Additional time and staffing are required to improve this estimate.

Author: COL Leslie Carlson[1]

Intelligentized Warfare Highly Likely to Use Quantum Computing, AI, and Autonomous Systems to Define The Operational Environment of 2035

Executive Summary

It is Highly Likely (71-85%) that Intelligentized warfare (IW) in 2035 will be continuously occurring, prior to, and during kinetic conflict in 2035 and beyond. IW will become "competitive conflict warfare," plausible deniability will reign supreme in future war, where AI enabled offensive and defensive measures will replace human involvement. IW will be continuous, everywhere, all-of-the-time warfare that will rely more heavily on domains outside of the traditional land, air, and maritime domains. Cyber, space, cognitive and new undefined domains will be where future wars are fought leveraging AI, quantum computing, and autonomous systems to formulate IW of 2035.

Discussion

Both the United States and China are experiencing military transformation and modernization, a process through which their militaries are becoming increasingly reliant on artificial intelligence and associated technologies, which forms the new theory of warfare as IW. Depicted in Figure 1, Chinese military leaders now believe that informationized war evolved and intelligentized warfare is the new form of war.[H] China believes that AI, in particular, will eventually enable intelligentized warfare—a more rapid, precise, and dispersed form of combat intended to paralyze enemy forces and decisionmakers.[M] China's 2019 *National Defense in the New Era Information Office of the State Council of the People's Republic of China* defines intelligentized warfare as artificial intelligence, quantum information, big data, cloud computing, and the Internet of Things and their application in the military field with the rapid development of long-range precision, intelligence, stealth, and unmanned weapons.[H] IW will generalize confrontation and competition, the limits of the battlefield will expand as the boundary between peacetime and wartime will

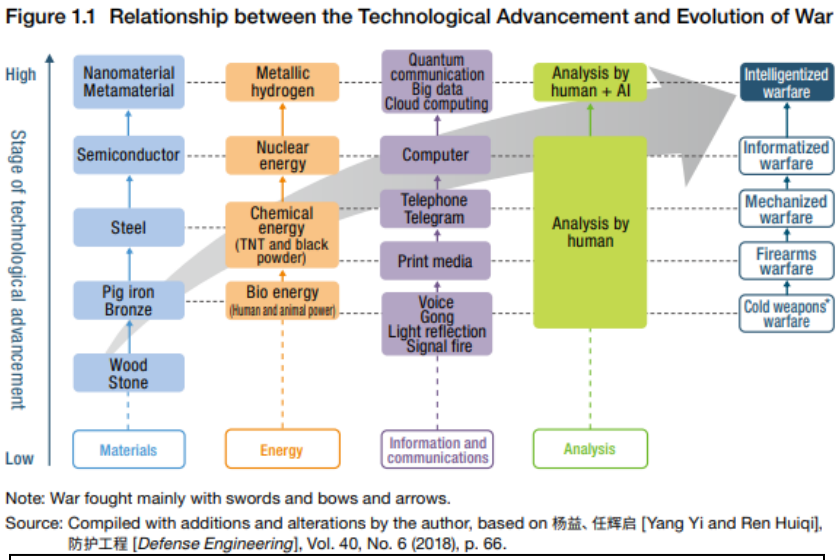


Figure 1: Technological advancements and evolution of war http://www.nids.mod.go.jp/publication/chinareport/pdf/china_report_EN_web_2021_A01.pdf

become increasingly blurred, and intelligence will penetrate into the whole process of all elements of future wars.[M] Vladimir Putin stated in a 2017 speech that "Artificial intelligence is the future, not only for Russia, but for all humankind…Whoever becomes the leader in this sphere will become the ruler of the world."[H] He was not wrong in his assertion as the major powers of the world have engaged in a race to develop and employ AI in all elements of national power, AI will drive IW in the future.

IW in 2035 outside of China's definition above will focus primarily on AI enhanced systems that should be accelerated in 2040 with quantum computing, and the use of semi-autonomous and autonomous systems with AI enhancing the interoperability of manned and unmanned systems. Warfare will become competitive conflict warfare that is continuously occurring.[H] The future of IW will continue to evolve as new technologies, new threats, and the replacement of humans by drones, robots, and potentially cyborgs.[M]. By 2035, the landscape of IW is expected to be marked by a plethora of dynamics such as robot armies launching attacks, self-driving tanks, and large-scale, computerized sensors with extended ranges.[M] Even more cutting-edge innovations, such as human enhancements, nano-technologies, advances in materials science, and high-power/density energy sources, bring into sharp relief the scope and pace of changes in IW. Technologically advanced countries will develop human out of the loop (HOOL) lethal autonomous weapons (LAWS) by 2030 and implement them in the field by 2035.[M] The adoption rate of HOOL LAWS may be influenced by complex battlefields and ethical concerns. Once a nation starts using autonomous systems, it will be challenging to stop further adoption, despite some advocating for a ban on LAWS.[H] Even if well-known scientists and celebrities advocate for the ban of LAWS, it would still be difficult or impossible to prevent further adoption once one nation starts using autonomous systems, see Figure 2 for a forecast on what the future battlefield may look like (see Annex D for full report on HOOL and LAWS). Findings from recent joint wargames stated that technological advances will significantly alter the characteristics of combat operations "resulting in a battlefield that is faster, more lethal, and distributed."[H] The recent conflict in Nagorno-Karabakh showed the world the first time that the majority of battle damage inflicted during the conflict occurred by unmanned platforms.[H] Azerbaijani unmanned aerial systems (UAS) were used to gather intelligence and carry out long-range strikes during the Nagorno-Karabakh war in 2020.[H] Azerbaijani's

Figure 2: Alarming Military Swarming Attack Drones Already in Use by Militaries
YouTube: Alarming Military Swarming Attack Drones Already In Use By Militaries - YouTube

employed smart loitering munitions that could autonomously select and attack targets without the need for real-time control by humans, against Armenian forces.[H] To further support the assertion that this trend will continue to be developed and employed a West Point Lieber Institute study stated the following about the most recent combat operations in Ukraine, "Drones have almost wholly replaced reconnaissance patrols and are used daily to drop ordnance."[H] (see Annex E for full report) All of these advancements will be further expedited by the introduction of operational quantum computing.

The ability of quantum computing to process large amounts of data will have a revolutionary impact on cryptography, machine learning, drug discovery, and material science.[H] This will have significant implications for scientific discovery, economic competitiveness, and national security, see Figure 3 for a graphic depiction of quantum computing vs. classical Computing. By leveraging the principles of quantum mechanics such as superposition, entanglement, and interference, quantum computing can attain quantum supremacy, which means surpassing the computational power of classical computers and even supercomputers to solve complex problems.[H] The *National Quantum Initiative* has established collaborative partnerships between the US, Europe, and Japan, driving progress in quantum technology research and development, the ultimate goal is to achieve full commercialization by 2040.[H] (see Annex F for full report on quantum computing commercialization) Eventually, quantum computing will help create AI systems that act in a more human-like way. For example, enabling robots to make optimized decisions in real time and more quickly adapt to changing circumstances or new situations.[M] Another application of quantum computing in the military is in the field of cryptography.[H] Quantum computers can break many of the encryption algorithms used to secure sensitive

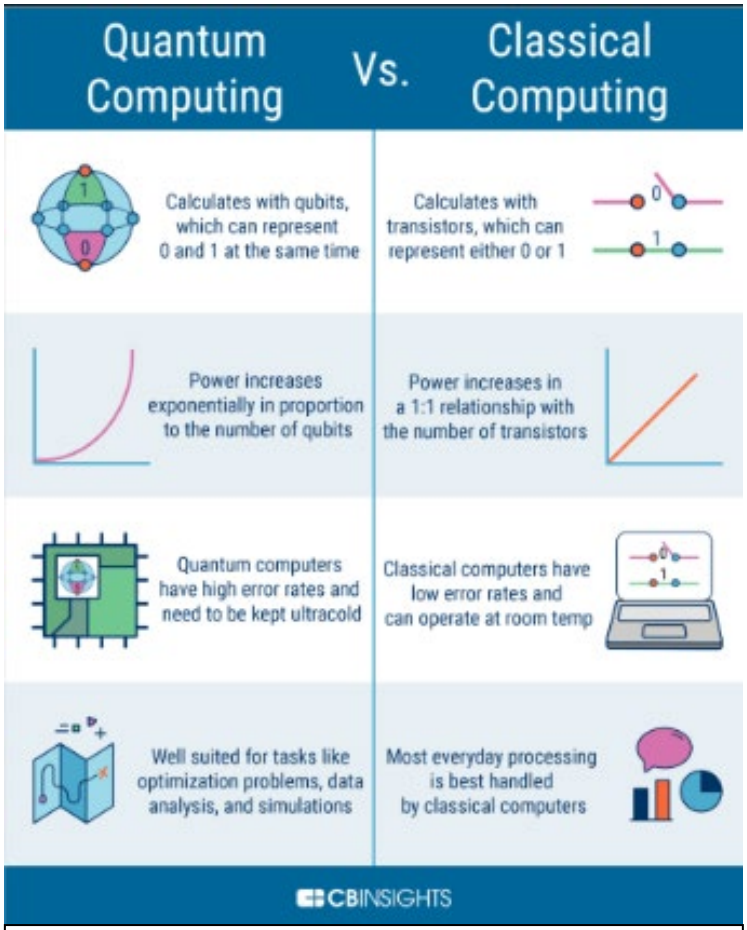


Figure 3: Quantum Computing Vs. Classical Computing In One Graphic: https://www.cbinsights.com/research/quantum-computing-classical-computing-comparison-infographic/

information, and as a result, they can be used to improve the security of military communications and data by developing new quantum-resistant encryption techniques.[M] The advancement of quantum technologies, particularly in space, will enhance data collection, processing, and exploitation capabilities through improved sensor capabilities and secure communications, but also increase the operational importance of targeting networks through disinformation, cyber- or physical attacks, which may occur well before any actual conflict, significantly affecting the cognitive domain.[M]

The battle of systems will occur before physical human engagement. Unmanned systems will replace customary reconnaissance forces as militaries strive to gain positional advantage through dispersed operations and long-range strikes to influence forward and intermediate staging locations while "cognitive strikes" focus on strategic support areas and personnel. The use of IW enables accurate energy release that can either be distributed among multiple interconnected systems or focused on a vital node, resulting in the adversary being rendered persistently paralyzed. The key to gaining an advantage lies in dominating the cognitive domain by perceiving, adapting, and acting faster than the opponent to induce or reverse paralysis across the system-of-systems.[M]

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore, given the lengthy time frame of the estimate, and the pace of technological advancements, this report is sensitive to change due to new information.

Author: LTC Samuel Meyer

Manipulating The Mind Weaponized Neuroscience is Highly Likely to Become the Dominate Cognitive Warfare Strategic Weapon by 2035

Executive Summary

Intelligentized warfare[1] is China's approach to achieving dominance by incorporating emerging technologies such as A.I., cloud computing, big-data analytics, quantum information, IoT, advances in uncrewed systems, and weaponized neuroscience. Weaponized neuroscience, a critical emerging component of intelligentized warfare, utilizes cognitive warfare to gain control over people's thoughts and actions. The modern battlefield is expanding, and the human brain may become the next battleground for the 21st century. It is highly likely (71-85%) that cognitive warfare will become the primary strategic weapon system by 2035, with China's Strategic Support Force (SSF) poised to dominate. The SSF is projected to divide cognitive operations into four categories: bilateral exchanges, biological human performance enhancement, weaponized neuroscience, and disinformation spread by autonomous social media bots. As countermeasures, Allied defense sector leaders must invest in AI-driven detection tools and cybersecurity initiatives to combat advanced AI-driven bots, secure and efficient Brain-Computer Interfaces (BCIs), and address ethical concerns surrounding the use and weaponization of neuroscience. Biological human performance enhancement and human performance enhancement drugs are also expected to augment soldiers' physical and cognitive abilities, urging defense leaders to explore their own research in ethical human performance enhancement technologies and develop strategies for confronting enhanced adversaries. The synergistic combination of these technologies will reshape the defense landscape by 2035, demanding proactive strategies from defense sector leaders to adapt, innovate, and maintain a competitive edge in this evolving environment. [H]

Discussion

Intelligentized warfare is China's approach to incorporating emerging technologies such as artificial intelligence, cloud computing, big-data analytics, quantum information, the internet of things, advances in uncrewed systems, and weaponized neuroscience to achieve dominance. [H] [H] Weaponized neuroscience is highly likely (71-85%) to become a strategic weapon system,

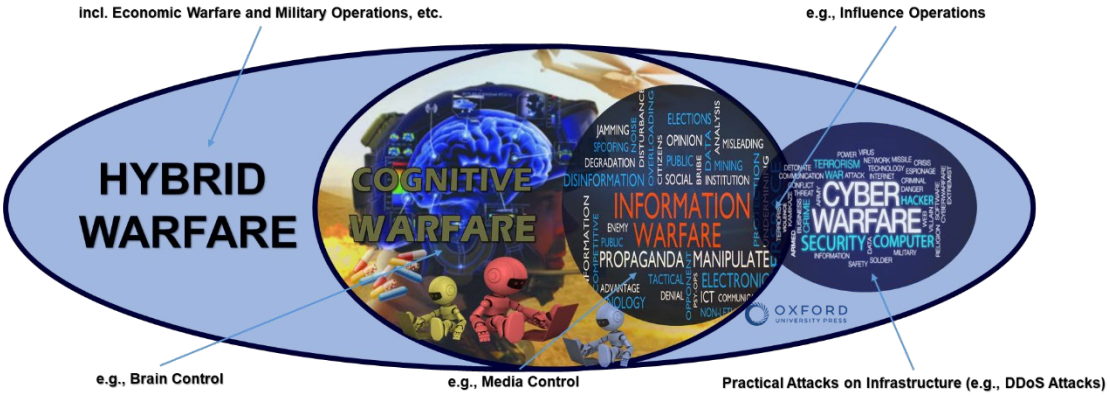


Figure 1 The conceptual relationship among cognitive warfare and other types of warfare. Revision by author [H]

specifically cognitive warfare. Cognitive warfare takes the manipulation of information and decision-makers to an unprecedented level - the brain. This type of warfare goes beyond controlling media and constituencies epistemically and emotionally; [H] focuses on using weaponized neuroscience to gain control over people's thoughts and actions. In other words, cognitive warfare is dedicated explicitly to brain control and can be integrated with other forms of warfare and emerging technological tools to enable hybrid threats. While information warfare and cyberwarfare may target individual decision-makers or infrastructure and intellectual theft, cognitive warfare takes it a step further by using neuroscience advancement and resources to achieve its goals. [H H]Cognitive warfare is the manipulation of environmental stimuli to control the mental states and behaviors of enemies and followers in active conflict (hot) war and below-conflict political tension or open hostility (cold) wars. [H] A similarly stated definition from NATO defines cognitive warfare as the weaponization of public opinion by an external entity to influence public and/or governmental policy or destabilize governmental actions and institutions. [H] Cognitive warfare manipulates people's perceptions, which are formed through their cognitive processes. Cognitive process manipulation warfare involves acquiring knowledge, interpreting information, and ultimately tailoring and controlling perception. The cognitive domain encompasses perception and reasoning, and cognitive warfare seeks to exploit this domain by influencing people's beliefs, values, and culture. The aim is to alter how individuals think and, ultimately, act. Strategic cognitive warfare seeks to control the cognitive mechanisms that shape our perceptions. As above, [H]Figure 1 exemplifies the relationships between the primary warfighting concepts. [H] Figure 2 demonstrates the primary characteristics of psychological, electronic, cyber, and information warfare incorporated within cognitive warfare. [H]
The battlefield has expanded to more than just traditional warfare domains. It now includes a

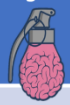
Characteristics	Psychological Warfare 	Electronic Warfare 	Cyber Warfare 	Information Warfare 	Cognitive Warfare 
Use of Mass Trends/ Data			*	*	*
Deals with Thoughts and Behaviors	*				*
Capacity for Extreme Public Reach			*		*
Interest in Circulation of information	*	*		*	*

Figure 2 demonstrates this in another way: the primary characteristics of psychological, electronic, cyber, and information warfare are incorporated within cognitive warfare. Re-envision by author [H]

potentially even more challenging terrain: the human brain. Our minds, consciousness, and perception have become essential tools in the fight for supremacy, making it a new battleground for the 21st century. This notion of the 'sixth domain' where battles occur is a true representation of the power of the human brain and its importance in modern warfare. [H M]
Conventional warfare has long been the dominant means of achieving strategic aims in the national security world. However, the technological advancements in neurotechnology and informatics make it highly likely (71-85%) a new form of strategic weapon cognitive warfare

will rise to the top. The use of brain-computer interfaces, pharmaceuticals, adaptively cognitive, social media A.I. bots, and other emerging technologies designed to enable brain control is also referred to as weaponized neuroscience. Significant advancements in technologies have opened a new frontier in the realm of warfare. Cognitive warfare will significantly impact conventional warfare in 2035. The United States and its allies will face ethical issues using these tools, whilst Russia and China will operate unrestrictedly and with impunity. [H M]

It is likely (56-70%) that by 2035, China's Strategic Support Force (SSF) is poised to dominate cognitive warfare, transforming it into the primary organizing entity for cognitive warfare operations, which is projected to be the Chinese strategic weapon of choice capable of initiating effective cognitive warfare through military threat according to the Journal of Global Security Studies. [H M] It is likely (56-70%), as this analysis suggests, that Cognitive operations may soon be divided into four distinct categories. These categories include (1) bilateral exchanges to exert influence, (2) Biological Human Performance Enhancement coupled with Genetic manipulation for military intimidation, (3) Weaponized Neuroscience, and (4) disinformation spread by Autonomous Social Media Bots. With such groundbreaking advancements, the world of cognitive operations is becoming increasingly complex and sophisticated. [H H H H]

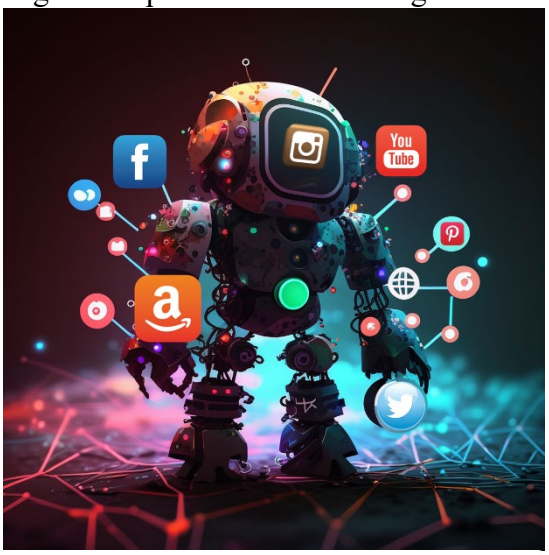


Figure 3 Autonomous social media bots are likely (70-80%) to reach a new level of sophistication by 2035 [H]

A range of cutting-edge technologies will contribute to this transformation, including Autonomous Social Media Bots, [H] Brain-Computer Interfaces (BCIs), [H] Biological Human Performance Enhancement, [H] Human Performance Enhancement Drugs, [H] and Weaponized Neuroscience. [H] Autonomous social media bots are likely (70-80%) to reach a new level of sophistication by 2035. [H] These advanced AI-driven bots will generate highly targeted disinformation campaigns, manipulating public opinion, undermining trust in institutions, and disrupting enemy morale. [H] As part of China's SSF, these bots will play a crucial role in shaping the cognitive battlespace, requiring allied defense sector leaders to invest in countermeasures such as AI-driven detection tools and cybersecurity initiatives. Brain-Computer Interfaces (BCIs) and Weaponized Neuroscience are expected to bring about a revolutionary change in military applications. Based on current trends and projections, there is a high likelihood (71-85%) of these technologies being widely adopted in defense operations by 2035. [H] These interfaces will directly connect the human brain and machines, significantly enhancing warfighter situational awareness, decision-making, and communication capabilities. Additionally, the weaponization of neuroscience will facilitate the development of advanced neuro-weapons[2], further bolstering China's SSF cognitive warfare arsenal. NATO and Allied Defense leaders must invest in R&D for secure and efficient BCIs while addressing the ethical concerns surrounding their use and the weaponization of neuroscience. Biological Human Performance Enhancement and Human Performance Enhancement Drugs are highly likely (71-85%) to be widely used by 2040. [H H] These enhancements, leveraging gene-editing technologies, advanced biological developments, and performance-enhancing drugs, will augment soldiers' physical and cognitive abilities, offering a considerable advantage in combat. When integrated

into China's SSF, these enhancements, combined with Weaponized Neuroscience, will contribute to the force's cognitive warfare capabilities, compelling defense leaders to explore their own research in ethical human performance enhancement technologies and develop strategies for confronting enhanced adversaries.

Despite advances in Allied force structure and NATO's commitment to a cognitive warfare incubator and identification of cognitive warfare as developing warfare, China's Strategic Support Force (SSF) is on track to become the organizing entity for intelligentized warfare, with cognitive warfare as its most casualty-producing weapon system. [H M] The synergistic combination of Autonomous Social Media Bots, Brain-Computer Interfaces, Biological Human Performance Enhancement, Human Performance Enhancement Drugs, and Weaponized Neuroscience will reshape the defense landscape by 2035, demanding proactive measures from defense sector leaders to adapt, innovate, and maintain a competitive edge in this evolving environment.

Analytic Confidence

The analytic confidence in this estimate is moderate. While advancements in technology are difficult to predict, the sources analyzed were generally reliable and corroborated with one another. The analyst had sufficient time but worked independently following a structured method. https://chat.openai.com/ ChatGpt 4 was leveraged to consolidate key findings and recommendations from the five consolidated Short Form Analytical Reports (SFARs) used to construct these integrated findings. This report is subject to change due to unforeseen breakthroughs or setbacks in technological development and the evolution of geopolitical dynamics. Additional time and staffing would improve the accuracy of this estimate.

Author: Lt Col Dorian C. Hatcher [3]

Short Form Analytical Reports (SFAR)

Quantum Computing Commercial Adoption Likely By 2040

Executive Summary

Due to the significant global investment and technological breakthroughs in quantum computing, it is likely (56-70%) that this technology will reach commercial adoption by 2040 despite the numerous technical challenges associated with achieving quantum supremacy.[2] Quantum computing's ability to process vast amounts of data will revolutionize fields such as cryptography, machine learning, drug discovery, and material science, with significant implications for national security, economic competitiveness, and scientific discovery.

Discussion

Quantum computing leverages the principles of quantum mechanics, (superposition, entanglement, and interference), to achieve quantum supremacy, a term used to describe the ability of quantum computers to solve problems that are beyond the capabilities of classical computers and supercomputers.[H] Unlike classical computing, which uses binary bits that can represent either 0 or 1, quantum computing achieves a state of superposition in which quantum bits (qubits) represent both 0 and 1 at the same time (click on figure 1 for a description).[H] Qubits are composed of quantum particles and are subject to quantum entanglement, which occurs when two or more qubits become correlated, meaning that the state of one qubit can affect the state of another, even when separated by a large distance. Interference occurs when qubits interact or respond to their surroundings, causing their behavior to slow and then stop, thereby enabling qubit manipulation to achieve multiple computational states.[H]

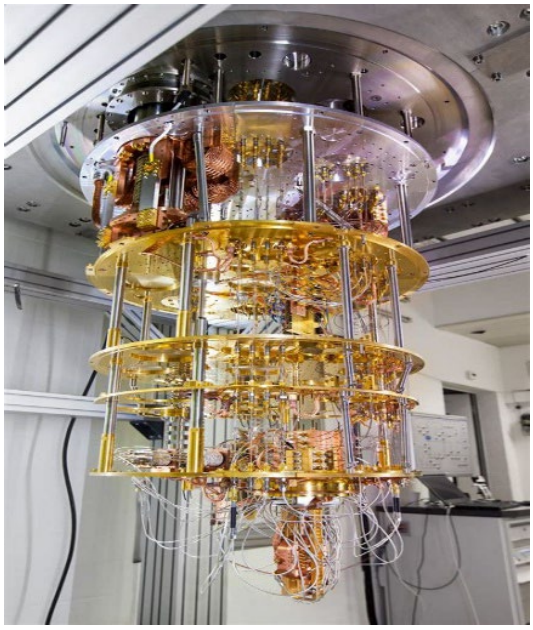


Figure 1 Quantum Computing Explained. Source: The Inner Detail. https://theinnerdetail.com/quantum-computing-explained/ Click on the Image for a short descriptive video.

As scientific progress in quantum technology accelerates, developing quantum computers has become a top priority for governments seeking the next competitive advantage in the digital age (see figure 2).[M] *Cognitive Market Research* predicts that the global quantum investment market will grow to $467 billion by 2030,[M] with the U.S. and China vying for leadership in investments, research, and development.

[2] Quantum Supremacy is a term used to describe the ability of quantum computers to solve problems that are beyond the capabilities of classical computers and supercomputers

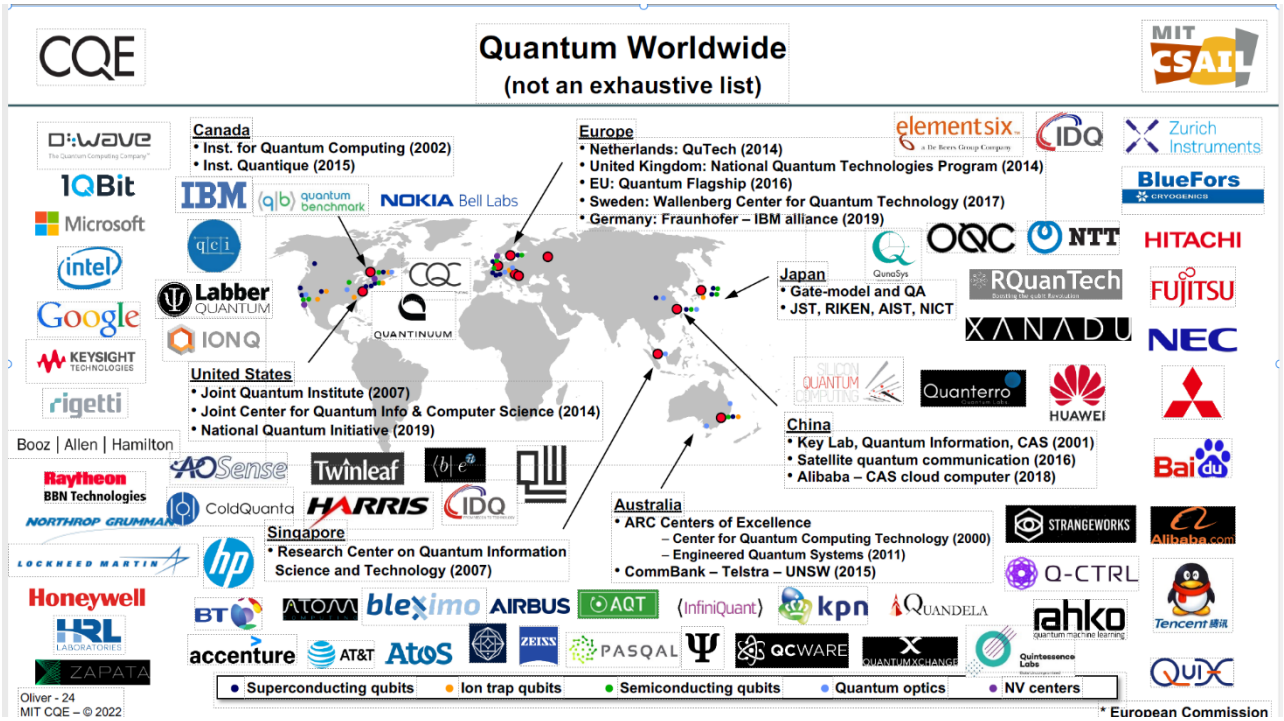


Figure 2 Quantum Worldwide. Source: MIT Computer Science and Artificial Intelligence Lab. https://cap.csail.mit.edu/sites/default/files/sessionpdfs/Oliver_Introduction%20to%20%20Quantum%20Computing.pdf (slide 24)

The U.S. and Canada pioneered the deployment of working quantum computers, with China recently becoming the third nation to deliver its "Wuyuan" quantum computer (figure 3).[MM] Furthermore, IBM is working with Mercedes-Benz, ExxonMobil, CERN, and Mitsubishi Chemical on implementing quantum computing to improve their respective processes and services in electric vehicles, data processing for the Large Hadron Collider, and improving transit routes.[M]

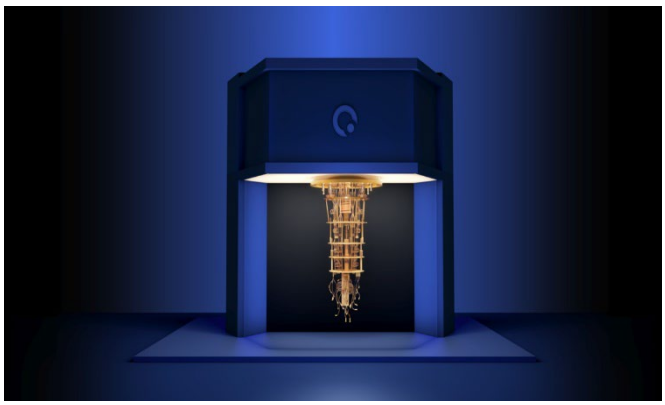


Figure 3 "Wuyuan" superconducting quantum computer Photo: Courtesy of Origin Quantum

The process of achieving quantum supremacy is a complex operation full of formidable challenges. Current quantum computing system are susceptible to extreme temperatures requiring a temperature controlled environment close to absolute zero (~ −273.15 °C) to function efficiently.[M] Another issue is that qubits, the essential components of quantum computers, are prone to errors that are very difficult to identify and rectify.[H] The cost of quantum computing is

high, with a single qubit costing up to $10,000.[M] Finally, quantum computing presents a cybersecurity threat due to its ability to easily decipher the Rivest–Shamir–Adleman (RSA) security keys of any conventionally-encrypted device, system, or network, which poses geostrategic and political implications across the commercial and defense sectors.[M] A recent example of this threat is China's claim of devising an algorithm that can decrypt the most secured encryption key (2048-bit RSA), using a 372-qubit quantum computer.[M]

Despite these challenges, leading players in the field of quantum computing continue to develop solutions to mitigate the challenges and to accelerate quantum computing at an industrial scale. Google, IBM, Microsoft, and Alibaba, have already launched commercial Quantum-as-a-Service cloud services enabling developers, researchers, and enterprises to access quantum computing resources at a rate of $1,000 to $2,000 per hour, as opposed to the $20 million to $40 million it would cost to own.[M] Google, IBM, and laboratories in Japan developed processes that mitigate the qubit entanglement error-correction process, while Australia developed a software that improves the performance of quantum-computing hardware.[HMM] InfoSys is accelerating quantum computing innovation by leveraging a hybrid approach of blending the algorithms of traditional computers with those of quantum as a bridge to making quantum computing a reality.[M] Collaborative initiatives and partnerships established through the *National Quantum Initiative* between the United States, Europe, and Japan are driving progress in quantum technology research and development aimed at achieving the ultimate objective of full commercialization by 2040.[H]

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable based on the credibility of the respective articles and publications. While the sources tended to corroborate one another, they varied in their respective forecasts. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to enduring efforts by the scientific and commercial industry to advance quantum computing at an industrial scale. Additional time and staffing are required to improve this estimate.

Author: LTC Fidel Arvelo[3]

[3] ChatGPT, and Perplexity were utilized in this estimate's research, construction, and data summarization.

Almost Certain AI will Completely Change The Character of Warfare by 2035

Executive Summary

Rapid advances in AI and technology make it Almost Certain (86-99%) that the character of warfare in 2035 and beyond will be vastly different than that of the character of warfare now. Given the current rapid advancements it is certain that the current characteristics of war could change as rapidly as overnight with the introduction of new technology and AI enhanced systems and weapons, specifically AI-powered autonomous weapons systems and drones and quantum computing will have the potential to revolutionize modern warfare, allowing military forces to operate more efficiently and effectively than ever before.

Discussion

The National Intellegence Global Trends 2040 says that "The combination of improved sensors, automation, and artificial intelligence (AI) with hypersonics and other advanced technologies will …..define the future characteristics of war in 2035 and beyond."[M] The Chairman of the Joint Chiefs of Staff General Mark Milley told the Eurasia Group Foundation on a podcast that "Today we are undergoing the most significant and most fundamental change in the character of war…being driven by technology."[H] The advent of intelligentized warfare, which refers to the use of AI, machine learning (ML), cognitive warfare, and other advanced technologies in military operations will transform the approach to warfare. In recent years a shift towards asymmetric warfare and unconventional tactics such as guerilla warfare, cyber attacks, and space and electromagnetic operations have already highlighted a notable change in the charater or war.[M] This type of warfare may not necessarily lead to either annihilation or attrition, but rather to a protracted conflict with no clear winner. This entire process is making wars knowledge-based as opposed to traditionally quantity driven – a radical shift from attrition and destruction-based approaches to one based on effects and outcomes.[M] Furthermore, advances in technology will change the nature of warfare altogether. As wars become driven by information, AI can provide or recommend valuable options to the commanders that the human brain may not be able to assess on account of the volume or decision time stress.[M] The development of autonomous weapons and the increasing reliance on AI in military decision-making will lead to wars fought largely by

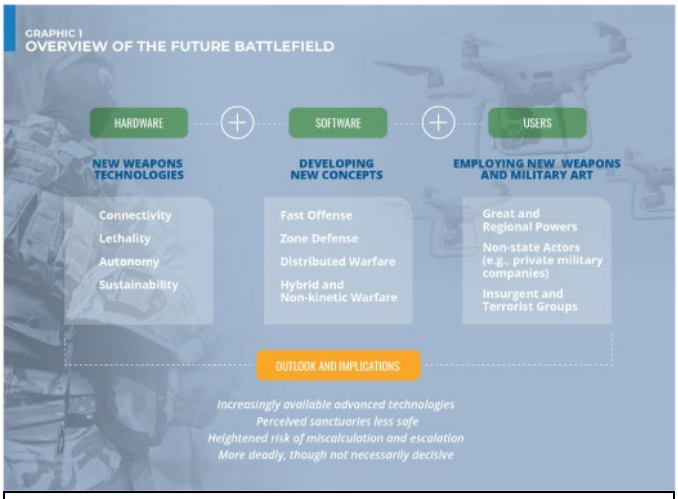


Figure 1: Overview of the future battlefield https://www.dni.gov/index.php/gt2040-home/gt2040-deeper-looks/future-of-the-battlefield

machines, with little direct human involvement. GEN Milley also stated in the same podcast that "All of those [AI, ML, robotics] technologies are converging all at the same time, and they're all coming to fruition here in the next 10 or 15 years."[M] The advent and employment of new technologies will potentially reduce the human cost of war, but it also raises ethical questions and the potential for unintended consequences. The integration of AI with traditional military operations has already upgraded logistics, administration, maintenance, training, personal management and routine activities and exercises.[M]

An *Interesting Engineering* article states that, "By 2050, the growth of distributed systems, quantum computing, 3D printing, cryptocurrencies, biotechnology, and climate change is expected to cause an even more dramatic shift [in the character of war]."[M] The future of warfare will to come down to a handful of major factors: new technologies, new threats, the obsolescence of reliance on heavy armor, and the replacement of humans by drones, robots, and potentially cyborgs.[M]. Robot armies on attack, self-driving tanks and massive, long-range, computer-enabled sensors and natural camouflage technology are just a few of the many dynamics expected to characterize warfare in 2035.[M] Even more cutting-edge innovations, such as human enhancements, nano- technologies, advances in materials science, and high-power/density energy sources, bring into sharp relief the scope and pace of changes in the character of war. Offensive technologies such as hypersonic missiles and autonomous weapons will become more prevalent, giving attackers a greater advantage in striking targets quickly and accurately. Additionally, the use of artificial intelligence (AI) in military operations will also change the character of war, allowing for more autonomous decision-making and less human control.

There will still be humans on the battlefield, but they will be supported by robotics exoskeletons are predicted to make an appearance, giving individual soldiers greater strength, endurance, and carrying capacity.[L] According to a recent report by the US Department of Defense (DoD), 2035-2050 will be the timeframe where cyborg soldiers are a regular feature of the US Armed Forces.[L]

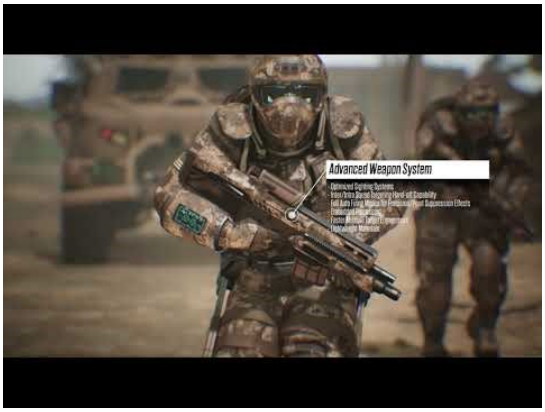


Figure 2: The Soldier of the Future
YouTube: https://www.youtube.com/watch?v=r1m68B53jek&t=190s

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore,

given the lengthy time frame of the estimate, this report is sensitive to change due to new information.

Author: LTC Samuel A. Meyer

Cognitive Social Media Warfare Dominates by 2028, Becoming Fully Autonomous Social Media Predators by 2035

Executive Summary

Rapid advances in Artificial Intelligence (A.I.) make it highly likely (71-85%) that China will develop cognitive warfare disinformation social media artificial general intelligence[4] over the next five years as opposed to operator-driven "cyborg" chatbots.[H] Widespread utilization and application of AGI Social-Media Bots are likely (56-70%) to begin between 2033 thru 2035. An adversary could use social media accounts controlled by advanced artificial intelligence, which can automatically adjust their responses to different visual and written content forms, potentially shaping society's behavior without human intervention.

Figure 1: AI rendering of Six Domains of Warfare

Discussion

Over 47 countries, including China - up from 28 countries in 2018 - already have computational propaganda and social media automation manipulation campaigns that cost tens of millions each. These campaigns were developed to execute psychological operations and manipulate public opinion over social media.[H] The engineering of public opinion over social media platforms will likely become the leading edge of computational propaganda. Computational propaganda uses technology, mainly social media, and algorithms, to manipulate public opinion and spread disinformation. It often involves using automated bots and other tools to amplify specific messages and influence online conversations.[H] Computational propaganda's evolution to cognitive warfare [5] remains an increasingly dangerous and disruptive phenomenon currently used to undermine basic democratic foundations in the cognitive domain.[M] Cognitive warfare

[4] Artificial General Intelligence (AGI) refers to the ability of machines to perform a wide range of cognitive tasks similar to those performed by humans and to adapt to new tasks without human intervention. This estimate is specific to the cognitive warfare implementation of psychological operations over social media.

[5] Cognitive warfare uses psychological and information operations to influence thoughts, emotions, and behaviors. This can include disinformation and propaganda, but it also encompasses other tactics such as psychological manipulation, influencing perceptions of reality, and disrupting decision-making processes.

often focuses on manipulating the target's decision-making process, while computational propaganda focuses on disseminating information or disinformation.[M]

In an era of constantly increasing digital news and social media consumption, artificial intelligence (A.I.), big data analytics, and sophisticated algorithms are employed to blur the lines between truth and falsehoods, negatively impacting trust in our democratic systems.[M] A.I. technologies will influence individuals on social media, providing powerful tools for governments to monitor citizens on a massive scale.[H] Adversaries use big data analytics to filter out particular topics or sentiments from online conversations. This allows governments to target specific people or groups with tailored messages while censoring perceived dissenting perspectives.[H] Through deep learning algorithms and data scraping, A.I. can use natural language processing techniques to determine which words or images elicit a given psychological response in a population segment, making it easier for regimes to manipulate public opinion.[M]

As much of the populace has turned away from traditional objective news outlets, such as newspapers, governments worldwide have widely deployed AI-driven bots for disinformation campaigns designed to manipulate public opinion and stir up conflicts among different sectors of society.[M] These malicious tactics continue to thrive as automated systems generate vast amounts of 'fake news' on social media platforms with no initially traceable source[M] making it difficult for citizens to differentiate between reliable information sources and deliberately falsified ones. For example, Russian interference in the presidential campaign of 2016 is evidence of computational propaganda.[M] These developments pose significant threats not just to democracy but also to global security, where malicious actors or hostile nations use A.I. technologies in the next evolution of computational propaganda as it transitions to unrestrained AGI-driven cognitive warfare operations with potentially devastating consequences.

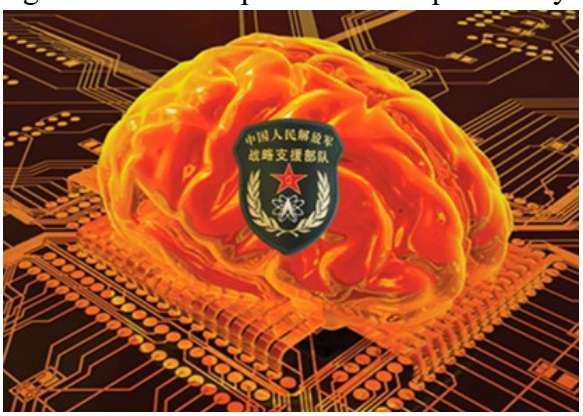


Figure 2: Creating the Strategic Support Force (SSF) centralizes PLA Space, Cyber, Electronic and Psychological warfare capabilities.

AGI-driven cognitive, social media warfare refers to using artificial general intelligence (AGI) to conduct information operations on social media platforms to influence public opinion, promote narratives, and manipulate human behavior. This type of warfare relies on AGI algorithms that can autonomously analyze social media data, generate content, and interact with users, adapting to their preferences and feedback. AGI-driven cognitive, social media warfare aims to penetrate and exploit online social networks to gain an advantage in diplomatic, military, and economic domains, alter perceptions, and ingrain a specific ideology among targeted audiences.[HH] China remains at the forefront of this cognitive warfare effort, defined by China's New Generation Artificial Intelligence Development Plan [H] and the 2019 white paper China's National Defense in the New Era that created China's operational arm for cognitive warfare, the Strategic Support Force.[H] According to PLA scientists from the National University of Defense Technology,

"conflict in the cognitive domain attempts to undermine the adversary's will and resolve, undermine perception and command capabilities to weaken fighting spirit, and manipulate decision-making."[H]

Despite most experts assuming that artificial general intelligence is over 30 years away,[M] China's accelerated research agenda makes it highly likely that it can translate into real-world advances in social media cognitive warfare. For instance, the PLA-named Tianjic chip leverages a brain-inspired architecture. Its designers claim it represents an essential bridge between computer-science-oriented and neuroscience-oriented progression toward artificial general intelligence with human-like capabilities.[M] In addition, China's unrestricted access to gene editing, transgenic monkeys, primate research, and human-computer brain interfaces leaves morally righteous countries lagging and vulnerable to widespread manipulative communication.[H] These advances and the PLA's capacity to leverage academic and commercial advancements make it highly likely that China will be the first to make the evolutionary leap to AGI-driven cognitive, social media warfare within the next five years.

Analytic Confidence

The analytic confidence for this estimate is **Moderate**. Sources generally conclude and provide examples of computational propaganda, disinformation, image manipulation, and "Fake News," which are already commonplace as adversarial cognitive warfare tactics. Most sources corroborate one another; however, significant disagreement remains on Artificial General Intelligence's future "human-like" capabilities. This estimate remains sensitive to change due to its long-time span and recent advancements and abundance (ChatGPT) of open artificial intelligence architecture. Additional time and additional staffing would help refine this estimate.

Author: Lt Col Dorian C Hatcher

Developments in Fully Implantable Brain-Computer Interfaces Transform Military Applications by 2035

Executive Summary

Rapid United States advances in Brain-Computer Interfaces (BCI), devices implanted in specific brain areas and designed to interface with external technology, make it highly likely (71-85%) that the US will dominate in developing (BCI) by 2035. Widespread utilization and application of Brain-Computer Interface remains likely (56-70%) to begin surfacing in military applications by 2035. The Brain-computer interface (BCI) industry promises to revolutionize DoD initiatives, enabling enhanced decision-making and collaboration between humans and machines. Despite advancements meant to focus on the medical device industry, BCI could unlock unprecedented possibilities for assisted human operations and significantly improved manned/unmanned combat teaming capabilities.

Discussion

As a result of Neuralink's[6] cutting-edge micron precision surgical robot (picture right), Neuralink is highly likely (71-85%) to position the United States as the global leader in Brain-Computer Interface (BCIs) industry. Neuralink surgical robot's impeccable micrometer spatial precision at six threads per minute[H] and unique scalability make it an ideal technology for BCI development since implantation is now faster and exponentially more precise than traditional methods at a reduced cost.[H] Moreover, Neuralink will attract significant investment and has already raised $363M in funding.[M] Enhancing the US dominant position Neuralink has access to top-level talent with basing in Austin, Texas and Fremont, CA, both hotbeds of medical device and the tech industry and with over 70 positions currently available.[M] Under CEO Elon Musk, Neuralink is positioned to drive the BCI industry and help to energize the growth of the industry. Neuralink surgical robot represents a significant step forward in the field of BCIs and is highly likely (71-85%) to position the United States as a leader in this critical and rapidly growing industry. The N1 Chip technology and other BCI efforts from UC Berkeley In-Ear Brain-Computer Interface,[M] Kernel Non-Invasive brain data modeling,[M] and Paradromics high data rate fully implantable 1600

[6] Neuralink Corporation is an American neurotechnology company that develops implantable brain–computer interfaces based in Fremont, California. Founded by Elon Musk and a team of seven scientists and engineers.

neuron (BCI),[M] makes it likely (56-70%) the US will transform the Brain-Computer Interfaces industry. Initially Neuralink's chip will provide treatments for spinal injuries, eyesight restoration, brain disease, epilepsy, Alzheimer's, dementia, Parkinson's, and some psychiatric disorders.[H]

The Science Behind Elon Musk's Neuralink N1 Brain Chip - Video

Crucially, the FDA's approval of Neuralink's chip as a class III medical device is a pivotal step toward launching America forward in this decisive new industry and technology.[H] As it stands, this high-risk category requires stringent regulation to proceed with market distribution. The FDA endorsement will showcase the agency's faith in Neuralink's potential benefits and their assessment that clinical data can validate safety and efficacy parameters. Additionally, the FDA must assess the N1 design, its manufacturing processes, and all post-market surveillance protocols before final approval for human trials anticipated in mid-2023.[H] Once approved, the N1 chip will be a revolutionary step forward for neuroscience and the computer-brain interface industry. Where previously a total of approximately 300 neurons were able to be mapped at once, the N1 chip allows for the mapping of over 2048 neurons, significantly eclipsing prevision mapping.[H]

Despite the significant US lead in the (BCI) industry, China is rapidly emerging as a leader in the Brain-Computer Interfaces (BCI) due to its considerable government investments in party-mandated research and development, securing over 30.4 million to a single company.[M] China boasts a vast pool of highly skillful military and civilian engineers & scientists, complemented by a supportive albeit non-existent regulatory environment, China enjoys the upper hand in unity of effort in BCI products & solutions due to direct government involvement. Furthermore, Chinese companies receive advantageous government subsidies that fuel their strategic moves forward. However, China still lags behind the US in terms of aggregate (BCI) development by slightly over a decade.[M H]

Midjourney AI Rendition of Future Space Force Guardian BCI Applications

The cutting-edge Neuralink N1 chip will revolutionize military applications through human enhancement technologies thru brain-computer interfaces (BCI).[H] Combatants can take advantage of higher performance and capabilities utilizing direct (BCI) interfaces that provide real-time battlefield insights on locations of both friendly and hostile forces.[H] This unique technology has the potential to directly activate pathways in soldiers' brains based on their chemistry for improved productivity under challenging conditions as well as greater emotional resilience against stress or anxiety using Deep Brain Stimulation (DBS).[H] The potential for future military applications remains limitless.[H]

Analytic Confidence

The analytic confidence for this estimate is Moderate. Sources generally conclude and provide examples of cogent, detailed illustrations of significant advancements in brain-computer interfaces, specifically concerning Neuralink and Elon Musk. Most sources corroborate one another; however, there remains considerable disagreement on China's ability to catch up in this industry in its current capabilities. This estimate remains sensitive to change due to its long-time span and recent advancements in Brain-Computer Interfaces. Additional time and staffing would help refine this estimate as a significant amount of scientific literature is associated with this topic.

Author: Lt Col Dorian C Hatcher [7]

[7] ChatGPT, Perplexity AI, Jasper AI, and Speechify.com ask Ai Bot were utilized in this estimate's argument research, construction, and summarization.

Widespread Autonomous Drone Swarms Use in Combat Almost Certain by 2035

Executive Summary

Private industry use of robotics combined with recent artificial intelligence (AI) advancements make it almost certain (86-90%) that autonomous drone swarms will have widespread use in combat by 2035. Despite ethical concerns and defensive systems designed to defeat drone swarms, benefits including increased situational awareness and decreased human risk will outweigh risks.

Discussion

The term "drones"[8][H] has expanded beyond unmanned aerial vehicles (UAV)[H] and include any powered unmanned, autonomous or remotely-piloted robotic device. They include unmanned surface vehicles (USV)[H], unmanned underwater vehicles (UUV)[H], unmanned ground vehicles (UGV), and a subcomponent of UGV that is referred to as subterranean (SubT)."[H] UAVs became popular in the U.S. military during the conflicts in Iraq and Afghanistan, but unmanned vehicles had prior commercial applications that increased with the advanced research and development accompanying the military use of these vehicles.[H] Commercial application includes aerial photography, shipping and delivery, information gathering, search and rescue, geographic mapping, building safety inspections, crop monitoring, law enforcement, border control, and storm tracking.[H]

Individual drone flights led to aspirations to launch multiple drones simultaneously in support of a concerted objective. In 2020, a Chinese company, Shenzhen Damoda Intelligent Control Technology Co., Ltd., dispatched a massive basic drone swarm leading to a Guinness World Record of 3,051 UAVs in support of a light display,[H] breaking the previous Russian record of 2,200 UAVs[H]. While an impressive feat, the drones were not fully autonomous and did not need to avoid obstacles in the open air. AI has enabled the recent leap from basic swarm capability in a pre-planned mission scenario to autonomous swarm missions that can navigate through obstacles and cooperate to accomplish tasks.

Figure 1: (OCT 2022) 3,051 drone display. Click on picture or go to https://youtu.be/44KvHwRHb3A Source: Guinness World Record

Elements of complexity theory[9][H] provide insights into how engineers develop algorithms to guide a drone swarm towards a common goal. Properties of self-organization including

[8] The term "drone" became almost synonymous with Unmanned Aerial Vehicles (UAV), but as remotely piloted robotic systems have become more common, the term has expanded to include all air, ground and water-born unmanned or remotely piloted vehicles. See references below.

[9] Element of complexity theory include self-organization "production of organized patterns, resulting from localized interactions within the components of the system, without any central control. Melanie Mitchell,

clustering, flocking and schooling, task allocation, and decision-making[H] illustrate how a group of individual organisms work together using simple rules.[H][10][11] Researchers have altered complexity theory concepts to develop algorithms for unmanned systems, relying on the same principles animals and insects use to coordinate actions.

Scientists from the EPFL University in Switzerland have learned from these basic characteristics of self-organization and improved upon these simple rules with more advanced control techniques including "model predictive control" that incorporate an internal model using individual drone dynamics to avoid problems such as traffic jams.[H] These improvements allowed EPFL drone swarms to successfully navigate cluttered surroundings without impacting each other or any of the barriers in the testing environment.

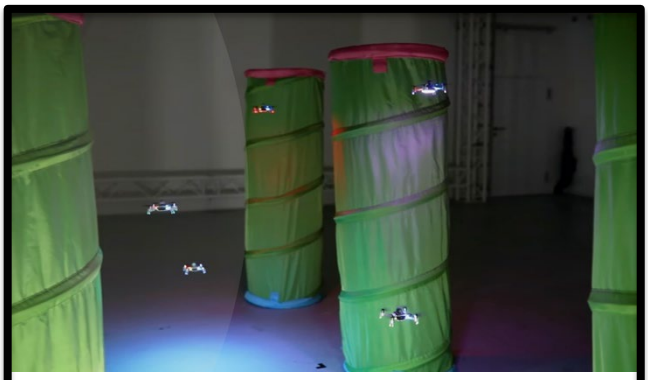


Figure 2: (MAY 2021) Switzerland EPFL University testing drome swarms in cluttered areas. Click on picture or go to: https://youtu.be/cAXUKNGpMG4 to view video. Source: https://actu.epfl.ch/news/helping-drone-swarms-avoid-obstacles-without-hitti/

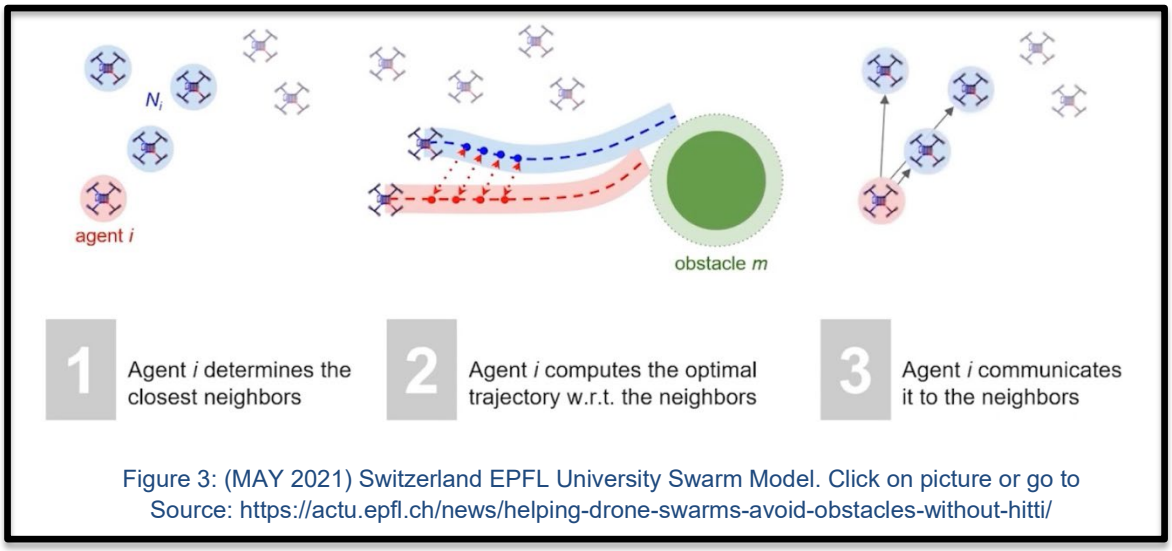


Figure 3: (MAY 2021) Switzerland EPFL University Swarm Model. Click on picture or go to Source: https://actu.epfl.ch/news/helping-drone-swarms-avoid-obstacles-without-hitti/

"Introduction to Complexity" (video of Santa Fe Institute Lecture 7.0 Introduction, Fall 2014), *Complexity Explorer,* accessed November 3, 2014, http://www.complexityexplorer.org.

[10] The ability of a school of fish to dodge a predator or flock of birds to instantly change direction may appear as if a single entity is directing the movement. In actuality, individual animals interact in various ways until a pattern emerges. Peter Miller, *The Smart Swarm: How Understanding Flocks, Schools, and Colonies Can Make Us Better at Communicating, Decision Making, and Getting Things Done* (New York, NY: Penguin Group, 2010), xix.

[11] Author studied principles of complexity theory and elements of self-organization in support of a prior Monograph. Phillip B. Cain, *Understanding Social Media and Mass Mobilization in the Operational Environment*, May 2015.

Engineers at the Massachusetts Institute of Technology (MIT) have increased the communication ability by developing a scheduling algorithm called "WiSwarm," tailoring a wireless network to handle high loads of data from multiple sources, prioritizing and relaying the freshest data.[H] Drone swarms have varying levels of complexity depending upon their capabilities, function, and task. Table 1 below lists swarms by levels of complexity progressing from the least to most complex. Researchers or militaries have proven the use of swarms through the first three levels of complexity[M] and have experimented with level four and possibly five.[12][M]

Increasing Levels of Complexity of Drone Swarms

1)	**Basic Swarm:** composed of a group of drones that can perform simple tasks such as formation flying, but each drone operates independently without any coordinated behavior.	
2)	**Coordinated Swarm:** capable of performing more complex tasks through communication and coordination; each drone has a specific role to play, and the can execute tasks such as search and rescue, surveillance, and delivery.	 swarm
3)	**Autonomous Swarm:** ability to make decisions and carry out tasks without intervention; drones are equipped with advanced sensors and algorithms that them to detect and avoid obstacles, plan routes, and adapt to changing environments.	 human enable
4)	**Intelligent Swarm:** capable of learning and adapting to new situations; drones machine learning algorithms to improve their performance over time and can communicate with other drones to share knowledge and coordinate behavior.	 use
5)	**Self-organizing Swarm:** ability to dynamically form subgroups and reorganize itself in response to changing conditions; drones use distributed algorithms to make decisions and can function even if some drones are lost or malfunctioning.	

Evidence of military use

Military experimentation

Possible experimentation

Table 1: Abbreviated information from OpenAi ChatGPT answer to following question asked on March 18, 2023: "What are the different levels of complexity for autonomous drone swarms?" Source: https://chat.openai.com

Overview Video of Drone Swarm Use in Various Militaries

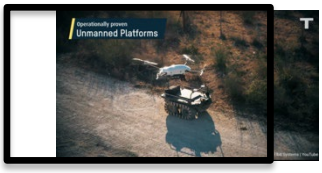


Figure 4: (OCT 2022) The linked YouTube video provides an thorough overview of various nation's drone swarm technology. Click on picture or go to: https://youtu.be/2m_3xJKSsbI to view video.

[12] Reference figures and videos below. 2) Coordinated swarm video: May 2022 Chinese researchers tested an autonomous swarm in a dense forest using an AI algorithm, successfully navigating through unprogrammed obstacles. 3) Israel Legion-X autonomous networked combat system, managed by a "human-on-the-loop" via a tablet. Drones in the air and ground can communicate with each other, sharing real-time information in support of the mission. 4) DARPA's The OFFensive Swarm-Enabled Tactics (OFFSET) drone swarm works in phases to isolate an area and classify items of interest and hazards for the swarm commander.

Figure 8: (NOV 2021) German defense firm showcases new air defense system, capable of attacking a swarm of drones. Click on picture or go to: https://youtu.be/pb5_F4_Eod8 to view video. Source: https://defence-blog.com/german-defense-firm-showcases-new-air-defense-system/

Militaries have acknowledged the growing threat of kamikaze drones and drone swarms and have developed various systems using standard munitions, flak[H], missiles,[H] and microwave energy weapons[H] to defend against such an attack.[H] Despite the advances in defensive systems, the current technology does not allow these systems to work seamlessly with separate tactical systems and cannot be everywhere on the battlefield at once. Air defense assets are a high demand/low density organization in most militaries and are not fielded in sufficient supply to protect all tactical units.[H]

Another hurdle to fielding autonomous drone swarms stems from international groups. The International Committee of the Red Cross has lobbied governments to prevent "slaughterbots"[13] and other drone swarms from being fielded in militaries, so far with limited success.[H] One issue that could gain traction in limiting the numbers of drones within each swarm includes an argument from a UC Berkley professor who suggested that large autonomous drone swarms could rise to a level to be characterized as a weapon of mass destruction (WMD).[H] Even if successful in attributing WMD status to vast swarms, there is a remote chance (1-15%) that groups using ethical arguments will be successful in preventing nations from developing increasingly capable drone swarms.

Analytic Confidence

The analytic confidence for this estimate is *high*. Adequate time was provided to the analyst who found reliable, corroborating sources. The analyst worked alone and, in a group-setting, soliciting expert information from a leading company in the AI field.[14] Given the recent AI advancements improving autonomous system functions, improvements are highly likely (71-85%) to continue at an exponential rate rather than a steady rate.

Author: LTC Phillip B. Cain

[13] "Slaughter bots" Stewart Sugg used this term to characterize autonomous drones armed with facial recognition software that would enable the swarm to hunt and kill specific enemy virtually risk free. https://youtu.be/9fa9lVwHHqg

[14] Shield-AI Interview (Annex TBD).

Autonomous Drone Swarms Will Almost Certainly Emerge Into a Revolution in Military Affairs Before 2035

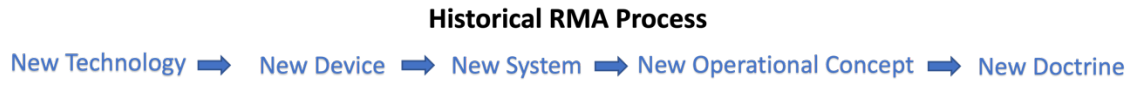
Executive Summary

Growing military threats in concert with receptive military/associated organizations combined with advancing technologies make it almost certain (86-99%) that autonomous drone swarms will lead to a revolution in military affairs (RMA) before 2035. Obstacles in the RMA process include impractical application, mistaken or incomplete operational concepts, or cultures that are resistant to change. Despite these challenges, recent growth in artificial intelligence and supporting technologies along with the concerns of being outpaced by opposing militaries will accelerate adaptation of the autonomous drone swarm capability.

Discussion

The concept of revolutions in military affairs (RMA) derive from Soviet military theorists and expanded upon by modern historians.[H] Various definitions exist, but the majority of sources describe an RMA as an identifiable shift in the character of war, usually (but not always) due to technological improvement(s) combined with a new operating concept.[H,H,H] The table below details the sequence of events that have led to an RMA.

Figure 1: Historical RMA Process designed by author, derived from RAND Research Brief on *"Past RMSs, Future Transformations: What Can History Tell Us About Transforming the U.S. Military?"* https://www.rand.org/content/dam/rand/pubs/research_briefs/1999/RB7108.pdf Source: Rand.org



The effect of the change is significant enough that it can render the previous means or method of battle less competitive or even irrelevant.[H] Due to dominant nations' satisfaction with their preeminence, RMAs are most often not derived from a dominant power, but from a rising power.[H] A Military revolutions (MR) is different than an RMA. They are more rare and usually includes multiple RMAs combined with systematic changes in society that not only adjust the character of war but also increase the ability of states to project power.[H] Williamson Murray and MacGregor Knox identified five MRs and associated RMAs in their book titled "The Dynamics of Military Revolution, 1300-2050."[15] Figure 2 below contains a portion of Table 1.1 from their book, listing MRs 2 and 3 along with the associated and resultant RMAs.

[15] MacGregor Knox, Williamson Murray, "The Dynamics of Military Revolution, 1300-2050," Cambridge University Press, Cambridge, UK, 2001, 17.

Military Revolutions 2 and 3: The French and Industrial Revolutions

Associated and Resultant RMAs:

- National political and economic mobilization, Napoleonic warfare (battlefield annihilation of the enemy's armed forces)
- Financial and economic power based on industrialization (Britain)
- Technological revolution in land warfare and transport (telegraph, railroads, steamships, quick-firing smokeless-powder small-arms and artillery; automatic weapons)
- The Fisher revolution in naval warfare: the all-big-gun battleship and battlefleet (1905-14).

Figure 2: Military Revolutions 2 and 3 from Table 1.1. Revolutions in military affairs and military revolutions. Source: The Dynamics of Military Revolution, 1300-2050, 17.

In 1999, the RAND Corporation produced a research brief titled, "Past RMAs, Future Transformation: What Can History Tell Us About Transforming the U.S. Military?" In that document, the authors produced a table outlining a checklist on how the U.S. Military might bring about a successful RMA.[M] In analyzing the Figure 2 (right), one might assess that with the rise of China's economic and military power, DoD's current situation has changed; the U.S. Executive branch and DoD now view China as the "Pacing Threat".[H,H,H] Concern of China's experimentation with possible RMAs has heightened U.S. awareness and spurred the U.S. Defense Advanced Research Projects Agency (DARPA) to capitalize on new technology and experiment with innovative concepts to include Persistent Close Air Support (PCAS) and Kinetic Integration Lightweight Software Individual Tactical Combat Handheld (KILSWITCH),[H] Offensive Swarm-Enabled Tactics (OFFSET),[H] Manufacturing Experimentation and Outreach (MENTOR2)[H] Machine Common Sense (MSC) program,[H] Space Power Conversion Electronics (SPCE) program,[H] and many others.[H]

RMA Checklist	DoD's Current Situation
A fertile set of enabling technologies	Yes
Unmet military challenges	Yes, but may not be compelling enough
A receptive organizational climate	Maybe, but not in all Services
Support from the top	Yes, but not in all Services
Mechanisms for experimentation (to discover, learn, test, and demonstrate)	Yes, but may not cover entire spectrum and may not encourage risky experiments
A challenge to someone's core competency	Not so far
A focus on a definite thing or short list of things	Not so far
Positive ways of responding to successful experiments (in terms of doctrine, acquisition, and force structure)	This could be a problem: The DoD "system" often has difficulty responding positively to risky new ideas

Figure 3: RMA Checklist from RAND Research Brief. https://www.rand.org/content/dam/rand/pubs/research_briefs/1999/RB7108.pdf Source: Rand.org

Disruptive technologies that have the potential to follow the historical RMA process and eventually produce a new operational concept and doctrine include autonomous systems, ubiquitous sensors, advanced manufacturing, quantum science, robotics, machine learning, cyber, space, information, and brain-computer interface.[M] Recent exponential advancements of AI carries the potential to positively impact several of these emerging technologies, thrusting them beyond the system phase and into the operational concept phase over the next several years. An existing technology where the U.S. has transitioned from new technology thru new doctrine (see Figure 1) during the last 20 years is the unmanned aerial system (UAS). UAS gave rise to unmanned drone platforms capable of navigating on and under the sea, on land, and subterranean. The convergence of drones with advancing technologies[H] has led to autonomous drone swarm capability that is almost certain to materialize into an RMA before 2035,[H] Autonomous drone swarms maturing into intelligent and self-organizing swarms, facilitated by advancing AI algorithms and machine learning, will allow drone swarms to share knowledge and coordinate behavior within the swarm – without human input – and possibly even dynamically reorganize itself into subgroups in response to changing environmental conditions and enemy activity (See SFAR: Autonomous Drone Swarms). A single human operator capable of deploying an autonomous drone swarm and monitoring mission execution using virtual reality capability will be more than an enhancement to current operations – it will be a new way of employing a capability that will leave the single drone operated by a single human less relevant or irrelevant in the future.[H]

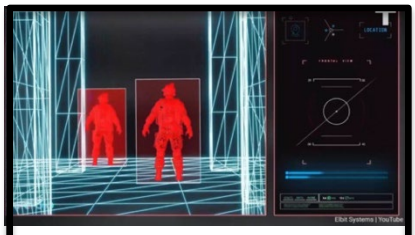


Figure 4: "The Terrifying Rise of AI Drone Swarms. Click on image or go to https://youtu.be/2m_3xJKSsbI.

Over the last several decades, theorists have envisioned possible RMAs that have not come to fruition.[H] Obstacles in the RMA process including impractical application, mistaken or incomplete operational concepts, or cultures that resist change can preclude an RMA from materializing.[H] Despite these challenges and decades of false starts in AI, recent growth and improving technologies along with the concerns of being outpaced by opposing militaries[M] will accelerate adaptation of one or more RMA by 2035.

Analytic Confidence

The analytic confidence for this estimate is *high*. The author used reliable sources that pointed to recently accelerated technological advancements across multiple fields. There was adequate time, but the analyst worked alone using and unstructured method. Furthermore, given the recent economic challenges and inflation following the pandemic, unforeseen incidents could preclude systems from being adopted at scale.

Author: LTC Phillip B. Cain

Artificial Intelligence Highly Likely to Use Coercive Persuasion to Shape Individual Thinking Through Social Media by 2035

Executive Summary

The advancements in Artificial Intelligence (AI) data gathering, bots, and advanced computing technology are highly likely (71-85%) to provide the capability to analyze personal information and manipulate a person's views through social media and the internet. The use of coercive persuasion has become more sophisticated with the use of social media and digital technology.

Discussion

In modern warfare, technological advancements have paved the way for new and innovative combat methods. But as the U.S. looks toward the future, this emerging threat can potentially change the nature of war. Brainwashing (from the Mandarin word *xi nao*: *wash brain*) or coercive persuasion, as it is also called, is highly likely (71-85%) to be employed by China through social media to influence and change the behaviors and beliefs of individuals.

The term brainwashing came into existence in the 1950s, and its meaning has evolved. It has raised new concerns about psychological warfare and manipulating the mind with artificial intelligence and computer data mining.[M] Coercive persuasion is a psychological technique used to manipulate an individual's beliefs, thoughts, and behavior.[H] Brainwashing has been used throughout history, from the Wu-Chu wars, WWII, Vietnam.[H] One of the most well-known events of brainwashing in warfare occurred during the Korean War when POWs were subjected to physical and emotional abuse and signed confessions for crimes they did not commit.[H]

Figure 1: *https://smist08.wordpress.com/2020/10/09/brainwashing-by-social-mediaUsers Dopamine is released when using social media, and can change the chemical in the brain.*

The emergence of new technology, the global reach of the internet, and the use of social media have made it easier than ever to spread disinformation and sway public opinion due to the inability to censor propaganda in a free democracy. Social media is the most popular activity globally, with over 4.26 billion people using it, and projected to increase to 6 Billion in 2027.[H] When an individual receive a

text, message, or like on Facebook or Twitter, the brain releases dopamine along a reward pathway that makes us feel good. As this reward is delivered randomly when someone receive these messages, this dopamine-triggering behavior becomes routine.[H] Overuse of the internet causes internet addiction, creating neurological, psychological, and social problems such as isolation, loneliness and negative emotions.[M] Artificial Intelligence (AI) algorithms designs analyze vast amounts of data on individuals' behavior, preferences, and interests and then tailor personalized content that is more likely to appeal to them.[M]

Adult judgments are malleable to group pressure, and less than one-third of people studied can resist this.[M] Just being part of a group influences judgment, perception, and pressure.[M] The internet and social media have positive and negative effects, and every trigger and stimulus leaves traces in the brain.[H][H] Using neurofeedback, rhythmic sound, or flashing lights, the neural activity of the brain can be modified.[M] AI uses various information-processing techniques, including natural language processing, machine learning, and data mining. The future of AI in social media is analyzing individual personality traits, likes, interests, and political affiliations and targeting those traits to sway personal thoughts and behaviors in a different direction. For example, AI can use Facebook likes and digital footprint data to determine intelligence, political view, personality, happiness, and more.[H] It is highly likely that by 2035, AI will be able to analyze this data and target individuals to sway political views or beliefs and even elections. Attitudes are formed through direct experience or the persuasion of others and can be changed through operant or classical conditioning.[H] Through the use of repetition, sounds, music, and colors, advertisers have been using techniques similar to brainwashing to build associations in the brain to retain information it would not normally retain. With the assistance of AI and social media, individuals will be targeted through a more narrow scope to sway beliefs and values through subliminal messages.[M] Operant conditioning can reinforce or discourage a belief or idea by making it a positive or negative experience.[H] The conditioned thoughts or positive behaviors are repeated, and negative ones diminished.[H] Neuroscientists are using brain imaging combined with artificial intelligence and machine learning to analyze the complex electrical activity of the brain. They can decipher what a person is thinking and feeling. The ability to examine and change the electrical activity in the brain promises to do for the brain what biochemistry did for medicine.[M]

Figure 2: https://www.semanticscholar.org/paper/Artificial-Intelligence-in-Social-Media

Social Media brainwashing is a complex and multifaceted technique; not all people are susceptible. A whole population does not need to be persuaded, only those with the opposing view that need to be changed, as it is highly likely there are those that already hold the wanted views or ideology.

Coercive persuasion in modern warfare is a controversial and often morally questionable practice. While it can effectively achieve political objectives, it is important to recognize its ethical implications and ensure that it is used within the bounds of international law and human rights. However, certain governments worldwide have fewer restrictions on these activities and will use them to achieve the intended goals.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to the advent of new technology and access to personal information systems.

Author: COL Leslie M. Carlson[16]

[16] ChatGPT, Perplexity AI, were utilized in this estimate's argument research and construction.

Chances Are a Little Better or Less That Artificial Narrow Intelligence Will Evolve to Artificial General Intelligence by 2040

Executive Summary

Despite the rapid advancements in Artificial Intelligence (AI) natural language processing, computer vision, robotics, and machine learning, chances are a little better or less (46-55%) that AI will evolve into Artificial General Intelligence (AGI) by 2040. Factors such as ethical and responsible use, the lack of a regulatory body, and the semiconductor shortage represent challenges that will affect its deployment and adoption.

Discussion

At the core of the artificial intelligence field is the notion of the next AI evolution consisting of machines capable of understanding and learning any task that a human can do. [M] Enter AGI, a type of AI in the mid-variant between Artificial Narrow Intelligence (ANI) and Artificial Super Intelligence (ASI),[H] with the ability to think abstractly, reason, solve problems, and understand complex concepts.[17] (See figure 1)

The

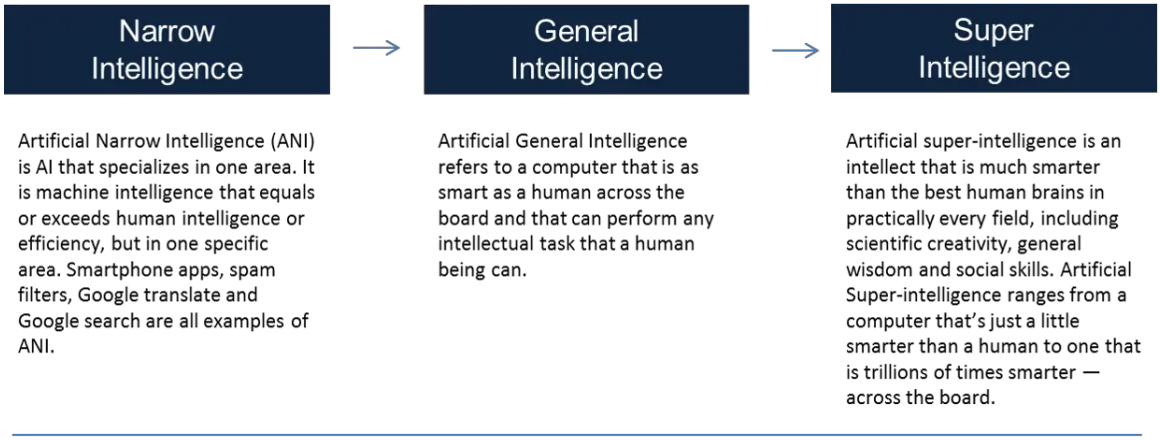


Figure 1: Progression of Artificial Intelligence.
Source: https://cio-wiki.org/wiki/File:Artificial_Intelligence_Progression.png

development of Artificial General Intelligence (AGI) remains highly uncertain, with experts providing widely varying estimates on when AGI will become a reality. Some experts predict that AGI could be achieved within the next few years, while others believe that it is decades away, and some question whether it will ever be achieved at all. [M M H M H] This significant disparity in probability estimates has been demonstrated in several research studies, including those published by Our World in Data[H] and AI Multiple.[H] (Select Figure 2 for an expanded view). The uncertainty surrounding AGI's

[17] As defined by ChatGPT3 on 23 January 2023.

development has important implications for the future of AI research and underscores the need for careful consideration of its potential risks and benefits.

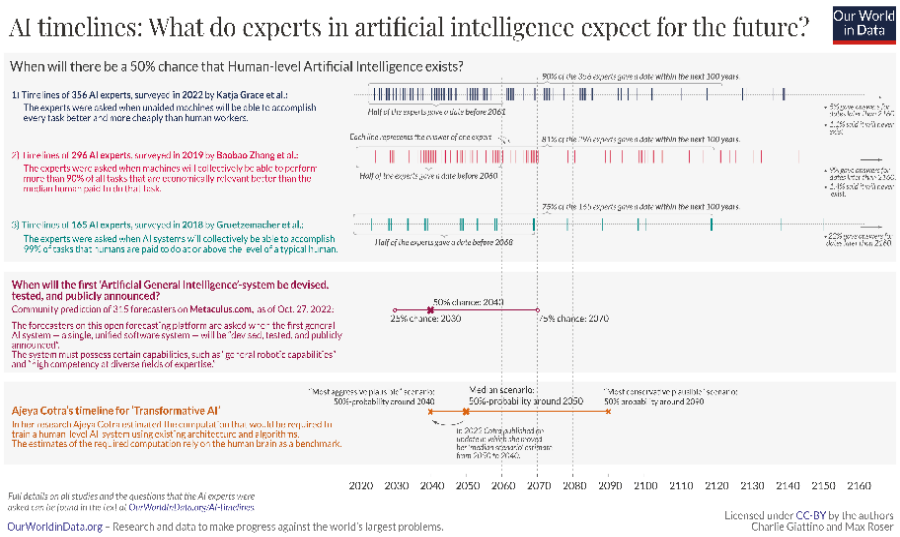


Figure 2: AI Timelines: What do experts in artificial intelligence expect for the future? Click on the picture or the following source: https://ourworldindata.org/ai-timelines

Significant challenges will likely influence the realization of AGI within the next 20 years. One of the primary concerns is the absence of a regulatory body overseeing AI development[H] to address AI's inability to assume human qualities that emphasize empathy, ethics, and morality.[MM] Many efforts across the civilian industry and government are attempting to address this issue. One of the most prominent efforts is the *Blue Print for an AI Bill of Rights, published by the White House in 2022,* which provides guidelines for designing and implementing automated systems that uphold democratic values and safeguard individual liberties and personal information.[H] But despite the myriad efforts, experts argue that chances are a little better or less (46-55%) that any form of AI will fully be adopted in the next decade due to the lack of consensus on defining common ethical standards.[ML]

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable, with some having high quality and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore, given the lengthy time frame of the estimate, this report is sensitive to change due to advances in AI research and development.

Author: LTC Fidel Arvelo[18]

[18] ChatGPT, You.com, and Perplexity were utilized in this estimate's research, construction, and data summarization.

Developed Nation Militaries Highly Likely to Conduct Over 50% of Operations in a Decentralized or Distributed Mode by 2035

Executive Summary

Emerging and disruptive technologies (EDT)[H] leading to pervasive reconnaissance and rapid long-range strike capability make it highly likely (71-85%) that most developed nations[H][19] will increase training for non-centralized operations during the next 7 years with over 50% of planned large scale combat operations (LSCO) occurring in a decentralized or distributed mode by 2035. Distributed[H] or decentralized operations[H] are broadly defined as operations that are dispersed from a core area (additional description below). The risk of mass casualties from precision fires will likely (56-70%) force even authoritarian or less developed militaries to increase their reliance on non-centralized operations to increase unit survivability.

Discussion

Militaries will likely trend towards non-centralized operations for two main reasons: to increase effectiveness and minimize casualties.[M] Various factors will determine the rate at which militaries will shift away from centralized operations. Those factors include, but are not limited to:

- ☐ Persistent reconnaissance
- ☐ Unmanned systems
- ☐ Robotics
- ☐ Precision long-range fires
- ☐ Fast strike capability
- ☐ Artificial intelligence & machine learning
- ☐ Effective communication networks
- ☐ Digital unit identification

Figure 1: Developed by author.

Recent findings from U.S. Army joint wargames state that technological advances will alter the character of combat operations "resulting in a battlefield that is faster, more lethal, and distributed."[H] The characteristics from this recent study were prevalent in the 2020 conflict between Armenia and Azerbaijan[M][20] and align with the U.S. Army's[H] and China's[H] anticipation of future warfare. During the 2020 Nagorno-Karabakh war, Azerbaijani unmanned aerial systems (UAS) provided intelligence and enabled long-range strikes[H] against Armenian forces while using smart loitering munitions that could select and attack targets without real-time control by humans."[H][21] This recent conflict between militaries of "developing nation" status[H] supports the increasing lethality supported by persistent reconnaissance, AI, and quick strike capability. This conflict also serves as the first time wherein almost all the battle damage inflicted during the conflict occurred by unmanned platforms.[H] The trend continues, as the West

[19] In addition to high level of prosperity, all developed countries have several characteristics in common, to include fully industrialized, technologically advanced, and manufacturing-based economies.
[20] One of the lessons identified by the author included "warfare is accelterated: roboticization and automation mean battles will be increasingly executed faster than ever before."
[21] "Without real time control by humans" also known as human-out-of-the-loop (HOOL).

Point Lieber Institute's study indicates, through their characterization of ubiquitous drones in the current conflict in Ukraine: "Drones have almost wholly replaced reconnaissance patrols and are used daily to drop ordnance."[H]

Network System Characteristics

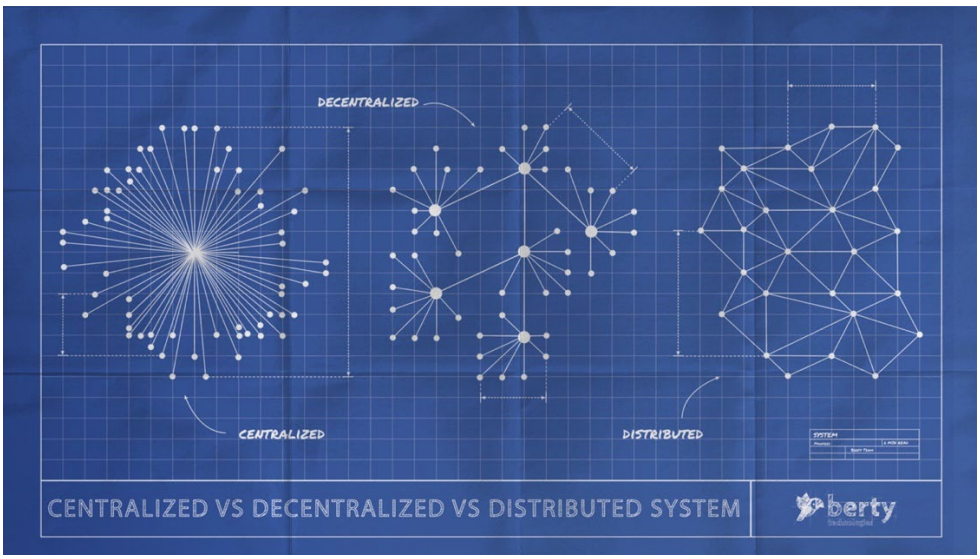


Figure 2: Berty image based on Paul Baron's memorandum in the RAND Corporation "On Distributed Communications" developed for the U.S. Air Force in August 1964.
Source: https://berty.tech/blog/decentralized-distributed-centralized/

Figure 2 provides a graphic representation of the following system types: 1) Centralized system – depends upon a central node that directly serves all nodes; 2) Decentralized system – the overall behavior of the system relies on the aggregate of the individual node decisions; 3) Distributed system – relies on separate nodes for communication and synchronization over a common network.[H] In military use, dispersed systems (decentralized and distributed) carry less risk of mass casualties from individual adversary strikes. Distributed systems require the highest levels of technical advancement to prevent cyber intrusion and fratricide but would be the most resilient to emerging threats.

Despite tendencies of authoritarian regimes and nations with amateur non-commissioned officer corps to demand centralized control, their militaries will need to shift towards non-centralized operations to limit the risk to force. Recent trends indicate and increasing likelihood of mass casualty events by adversaries using systems designed to observe and strike while maintaining limited human risk. Militaries that rely on centralized control may prefer to use other methods to reduce risk such as enhanced camouflage technology[MH] or constant battlefield displacement.

Analytic Confidence

The analytic confidence for this estimate is *high*. Each source was highly credible, and no credible sources indicated an opposite trend towards centralized operations. The analyst worked alone using an unstructured research method but had sufficient time. The trend in the estimate is unlikely to change, even over the next 15 years. However, the rate of the shift remains contingent on technology advances, training, equipment, and doctrine – all of which will vary within individual countries and militaries.

Author: LTC Phillip B. Cain

China Will Likely Outpace The United States in Machine Learning by 2035

Executive Summary

Due to restrictions in the United States on personal data collection and the time it takes to develop machine learning, China will likely (56%-70%) outpace the U.S. in machine learning by 2035. China has unlimited access to its population's data and has invested in machine learning for the past ten years, while large data companies like Facebook and Google have placed further restrictions on access to their data for weapon development or physical harm to humans, making it unlikely (31-45%) the US will be able to outpace China.

Discussion

Machine learning is a subset of artificial intelligence that can learn and improve by looking at examples or large amounts of data. The machine learning algorithm's performance improves as it is exposed to more data over time,[M,] and can learn and identify patterns without explicit instructions.[M] For example, to teach a machine to identify a particular type of dog and differentiate it, the program needs large amounts of data and pictures of all kinds of dogs for the device to learn to distinguish between a wolf and a husky.

Figure 1: Large amounts of data are needed for machine learning https://www.analyticsinsight.net/top-10-machine-learning-tools-2021/

The military use of machine learning is essential to U.S. weapons systems and decision-making tools for leaders. Predictive analytics machine learning analyzes historical and existing external data to find patterns or behaviors and can forecast with significant accuracy.[MH] Through pattern recognition, the military can use this forecasting algorithm to detect changes in the number of troops, vehicle movement, and intensity of communications systems and predict areas that are likely to be attacked. In addition, machine learning algorithms are being developed for autonomous systems like drones and vehicles. UAV's patrol border areas, identify threats, and can operate independently based on real-time data it receives.[M]

Cybersecurity solutions recognize a pattern and plan the correct response, whether the response is human-controlled or machine instructed to quarantine corrupt files.[M] Network securities use

machine learning to identify the patterns of users, data, equipment, systems, and networks and to distinguish abnormal from ordinary.[H]

Machine learning requires large amounts of data to train and improve its accuracy hence, access to data is crucial.[H] Organizations make independent choices about who may use their data and for what purposes. Data has inherent value and may or may not be shared or sold. Moreover, there are regulatory restrictions on data sharing and privacy concerns.[H] Concerns about trust, safety, and lack of control over the use of available data currently hamper large-scale data sharing[H] Finally, decision support systems analyze large amounts of data and possible solutions and propose the best course of action faster than humans.[H] This support system still leaves the ultimate decision to a human.

China does not have the privacy regulations of the United States, so it can quickly obtain the large amount needed to improve machine learning. In addition, China has the world's largest population and more internet users than the United States providing more data from machine learning and research development.[M] The Chinese government collects and provides access to large amounts of data on its population through social media, Wiebo, health, information systems, satellite imagery, sensors, and portable data platforms such as WeChat.[H]

Many large tech partners such as Google, IBM, and Microsoft have instituted ethical principles about data sharing:

- Google has stated it will not develop "Weapons or other technologies whose principal purpose or implementation is to cause or directly facilitate injury to people or technologies that gather or use the information for surveillance violating internationally accepted norms. At the same time, Google clarified that it would still seek defense contracts. "While we are not developing AI for use in weapons," CEO Sundar Pichai wrote, "we will continue our work with governments and the military in many other areas."[M]

- IBM has created an ethics board since there is not significant legislation to regulate AI practices. There is no real enforcement mechanism to ensure that ethical AI is practiced.[H] The Board was established as a central, cross-disciplinary body to support a culture of ethical, responsible, and trustworthy AI throughout IBM.[H]

- Microsoft believes artificial intelligence is the defining factor of our time but ethical standards must keep humans in the loop. Microsoft is looking for solutions that can benefit everyone, not just particular population cohorts.[H]

Comparison between general-purpose ethical codes and military ones conclude that as long as humans retain enough control and stay in the loop, moral responsibility is retained independently

of the potential use of artificial intelligence technology. To obtain the large amounts of data needed, the military must assure the tech companies that a human will always be in the loop to prevent unintended catastrophic events; otherwise, data sharing will continue to be a challenge.

Machine Learning has the potential to significantly improve military operations and provide a strategic advantage in the next conflict. Still, due to the time it takes for machine learning and the large amount of data it consumes, the US will likely fall behind China in the full development of that resource by 2035.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to the advent of new technology and access to personal information systems. [22]

Author: COL Leslie M Carlson[23]

[22] Ganesh Atkale, "Emerging Technology News: The Role of Artificial Intelligence and Machine Learning in the Military.," *Emerging Technology News* (blog), October 10, 2018, 5, https://ganeshatkale.blogspot.com/2018/10/the-role-of-artificial-intelligence-and.html.Ganesh Atkale, "Emerging Technology News: The Role of Artificial Intelligence and Machine Learning in the Military.," *Emerging Technology News* (blog), October 10, 2018, 5, https://ganeshatkale.blogspot.com/2018/10/the-role-of-artificial-intelligence-and.html.

[23] ChatGPT, Perplexity AI, were utilized in this estimate's argument research and construction.

Highly Likely That China Becomes Leader in Military Applications of Biological Human Performance Enhancement by 2030

Executive Summary

With rapid advances in Chinese Human Performance Enhancement Technologies (HPET) and the cooperation of a complicit regulatory environment, it is highly likely (71-85%) that China will lead the world in developing CRISPR Cas9, Gene Editing, and Gene Doping technological capabilities by 2030. Utilizing a Military-Civil Fusion approach to biotechnology as a dual-use technology, it is highly likely (71-85%) the widespread application of Gene-related HPET will begin in 2030, particularly within military applications. These advancements promise incredible outcomes such as eliminating diseases, improved strength levels & vision, and decreased fatigue all contributing to enhanced overall human capability.[H]

Discussion

China's recent advances in Human Performance Enhancement Technologies (HPET) include gene editing, gene doping, and CRISPR, which can enhance human physical and cognitive abilities. [H] In particular, Chinese scientists have made advancements in gene editing using CRISPR-Cas9 technology. This technology has the potential to modify genetic traits and alter phenotypes[24].

CRISPR is a revolutionary gene editing tool that allows scientists to precisely target specific sections of DNA and make edits at will. By doing so, they can enhance particular characteristics or even remove undesirable traits. For example, researchers at Shanghai's Institute for Advanced Medicine have used CRISPR to successfully improve the production of red blood cells in mice with anemia.[H] The potential applications for this technology range from practical medical treatments to radical military use, such as creating "super soldiers" with enhanced physical or cognitive abilities.[H]

Dr. Joy Zhang, a world-renowned specialist in gene editing governance from Kent University Canterbury, warns that China might be prone to "regulatory negligence" regarding genetic engineering following a controversial claim five years ago of a Chinese scientist producing the first-ever gene-edited babies.[M] Newly established Chinese regulatory guidance on the importance of ethical supervision of gene editing is inadequate. Specifically, there is no clear indication of how or if the newly established regulations apply to the Chinese private and

[24] Phenotypes refer to an organism's observable physical, behavioral, and physiological characteristics resulting from the interaction between its genotype (the genetic makeup of the organism.)

military sectors.[H] John Radcliffe, the former Director of National Intelligence, has already indicated that China is working to build “super soldiers”[H] “There are no ethical boundaries to Beijing's pursuit of power," wrote Director Radcliffe.[H]

China’s national strategy of military-civil fusion endeavors a superior biotechnology program[M] focused on gene editing and HPETs to create specific traits, such as high intelligence or reptilian night vision in Chinese soldiers.[H][M] However, this remains a complex and delicate undertaking. As these desired features are influenced by many genetic locations with only minute impacts on the specific outcome, reaching their desired result without introducing dangerous side effects remains an ambitious task that lies more than five to ten years away.[H] Over the next five years, scientists anticipate enhanced precision in editing DNA to repair any damage to a sequence. While particular challenges may linger, tremendous progress is expected in searching for new genetic repair solutions.[M]

Figure 2: Conceptualized Gene-edited Warrior

Recent advancements in CRISPR Cpf1 enzyme gene editing have been integrated into China's military programs, which are focused on surpassing the military power of the United States. Given the favorable regulatory environment in China with limited ethical restrictions, the country is highly likely (71-85%) to become a leader in Gene-related HPET.[M] Notably, the most-frequent author of articles on CRISPR published in 2016 or later is the Chinese Academy of Science.[H] China initiated twice as many CRISPR trials in a three-year period as the United States.

China remains at the forefront of HPET research and development due to its increasingly sophisticated laboratory capabilities and substantial investment in cutting-edge science and technology initiatives.[M] China is expected to continue to outpace the United States in the future,

Figure 3: Conceptualized Chinese Super Soldier

which mandates clear regulations to ensure that all involved parties apply technological advancements responsibly and ethically in China and abroad.[H] The United States must monitor the progress of Chinese HPE innovation by actively tracking critical indicators such as program launches, government grants, joint ventures, conferences, patents, and publications and assessing related applications, breakthroughs, and setbacks to anticipate the ever-evolving landscape of Chinese biological and technological " super soldier" advancement.[H] Gene editing could play a significant role in the execution of China's Intelligentized Warfare concept by enabling the country to create genetically modified soldiers with enhanced physical and cognitive abilities. By manipulating the genomes of soldiers, it may be possible to increase their resistance to fatigue, improve their reflexes, enhance their abilities to process sensory information, and more.[H] These modifications could give Chinese soldiers a significant advantage in combat situations, allowing them to operate more effectively and with greater speed and accuracy. Chinese military researchers are already exploring the possibilities of creating genetically modified soldiers, and their advances could potentially alter the dynamics of warfare in the future.[M]

Analytic Confidence

The analytic confidence for this estimate is High. All sources generally conclude and provide examples of cogent, detailed illustrations of significant advancements in Chinese Human performance enhancement technologies, specifically concerning gene editing and the civil-military fusion between Chinese academic institutions and the military. To determine the full extent of Chinese gene editing research, ongoing analysis of the National Institute of Health database is required as trials closely related to the Chinese Registry but lacking a Chinese identifier may be present. The majority of sources concur that China's permissive regulatory environment provides an advantage to its military and allows limited oversight of China's current scientific capabilities. This estimate remains sensitive to change due to its long-time span and recent advancements in CRISPR Cas9 and Cpf1 enzyme gene editing. Additional time and staffing would refine this estimate due to the volume of associated scientific literature.

Author: Lt Col Dorian C Hatcher [25]

[25] ChatGPT, Perplexity AI, Jasper AI, Google Translator, and Speechify.com ask Ai Bot were utilized in this estimate's argument research and construction.

Light Fidelity Highly Likely to Achieve Full Adoption by 2035

Executive Summary

Due to its capabilities and the increasing global financial investments and interests in Li-Fi technology, it is highly likely (71-85%) that Li-Fi will be fully adopted by 2035. Despite Wi-Fi's current dominance as the standard for wireless connectivity on the Internet of Things (IoT) spectrum, Light-Fidelity (Li-Fi offers significant advantages in terms of security, bandwidth, and speed, making it a transformative technology for connectivity and communication across various industries, including the defense and commercial sectors.

Discussion

Li-Fi) is a wireless communication technology that transmits data between devices via light, infrared, and near-UV spectrum waves.[H] It works by modulating the intensity of light emitted by a light source, such as an LED bulb, at a very high frequency imperceptible to the human eye. This modulation encodes digital information, such as a video or a webpage, onto the light waves, which are then received and decoded by a photodetector in the receiving device, such as a smartphone or a computer (see Figure 1).[M] Because Li-Fi operates in the light spectrum bandwidth (about 10,000 times greater than the radio-wave spectrum used by Wi-Fi), Li-Fi can send data up to 100 times faster than Wi-Fi and 14 times faster than WiGig.[26][M]

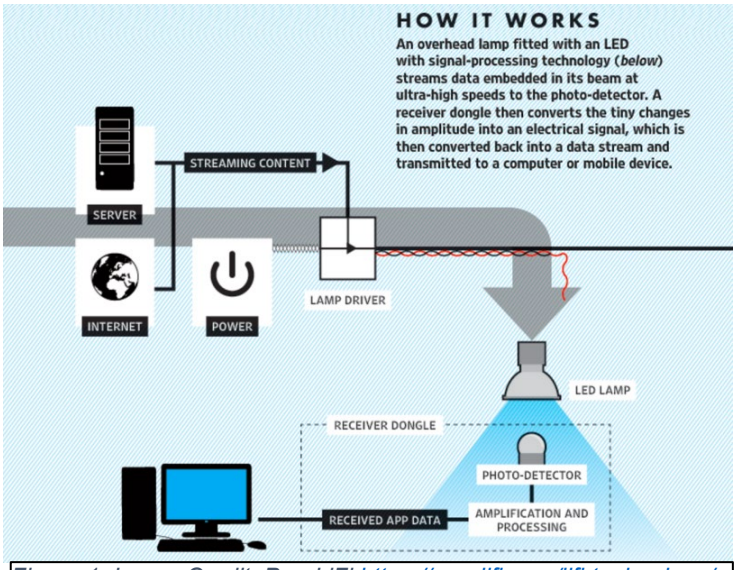


Figure 1: Image Credit: PureLiFi https://purelifi.com/lifi-technology/

Given society's heavy reliance on visible light sources such as bulbs and lamps, the integration and utilization of LiFi technology for wireless Internet connectivity presents unparalleled advantages that will highly likely (71-85%) influence its full adoption.[M] Li-Fi, in its current stage, aims to complement and provide relief to the already congested radio spectrum used to provide Wi-Fi connections. The number of IoT devices worldwide is forecast to reach more than 29 billion in 2030.[MM] This demand for wireless internet access is in danger of overloading the bandwidth supplied by Wi-Fi, a term known as "spectrum crunch", where the demand for wireless communication services exceeds the available radio frequency spectrum.[27]

[26] WiGig is a wireless technology that uses the 60 GHz frequency band to provide high-speed data transfer rates between devices. It is also known as IEEE 802.11ad and is an extension of the Wi-Fi wireless networking standard.
[27] https://www.techopedia.com/definition/29483/spectrum-crunch

Li-Fi provides enhanced security compared to Wi-Fi due to its data transmission, which cannot penetrate walls, making it resistant to signal hacking, thereby, highly advantageous for environments that require stringent privacy measures, such as hospitals, government buildings, and the defense industry.[M] Li-Fi is a more reliable option than Wi-Fi, especially in environments such as hospitals or airplanes, where radio frequency interference can disrupt Wi-Fi signals. Additionally, Li-Fi's ability to penetrate water facilitates communication in underwater environments, making it suitable for marine research and exploration.[M]

Figure 2: Li-Fi adopted by the U.S. Navy
https://youtube.com/clip/UgkxCMICKZDIpuCBFRcgdKmWCe6er-KPUfr I

Many sectors have already adopted Li-Fi technology. The DoD is currently experimenting with Li-Fi technology because of its potential to enhance communications resiliency in an increasingly complex world of Anti-Access Area Denial (A2/AD) systems and cyber-attacks.[M] In 2021, the U.S. Army signed a $4.2 million contract with *pureLiFi* to deliver a secure wireless data transmission system in Africa and Europe employing Li-Fi.[MMM] The U.S. Navy is also incorporating Li-Fi to enhance ship-to-ship, ship-to-shore communications and underwater operations (select the image in figure 2 for a descriptive video).[Hhttps://allhands.navy.mil/Stories/Display-Story/Article/1840622/li-fi-technology-in-the-us-navy/]

In the aerospace and education sectors, France, in partnership with *Oldecomm*, leads the global effort to incorporate a light-based wireless internet system on commercial flights and in schools.[M] In 2021, *Kyocera SLD* began providing Seattle-based avionics data networking company *Spectrum Networks* with components to build Li-Fi into airplanes.[M] In the same year, *Airbus* incorporated Li-Fi into its corporate jets.[MH]

In the commercial sector, the Kingdom of Saudi Arabia is integrating Li-Fi technology into "*The Line*," the country's 100-mile-long intelligent city project.[M] Citing cyber security, Holland's *World Forum The Hague* installed Li-Fi as a resiliency measure.[M]

Li-Fi technology faces drawbacks such as high deployment costs, a limited ecosystem restricting implementation at scale, susceptibility to external light interference, limited signal range, and

line-of-sight requirement, which may necessitate multiple systems for larger spaces.[M] Despite these challenges, it is highly likely (71-85%) that Li-Fi will achieve full adoption by 2035 due to the increasing global interest and the continuous efforts pursued in the scientific and commercial sectors to improve Li-Fi technology. *Kyocera SLD* developed a 100-Gbps laser-based Li-Fi system that mitigates the signal range and light source interference challenge.[M] A research fellow in electronic and electrical engineering at Glasgow's University developed a technology called "reconfigurable intelligent surfaces" that mitigates line-of-sight limitations while enhancing secure communications.[H] To expand interoperability across the ecosystem, *pureLiFi* produced a "light antenna module" for embedding into consumer devices,[MM] and Taiwan's Getac Technology Corporation made a tablet incorporating *pureLifi* module as proof-of-concept (see figure 3).[M]

Figure 3: Getac launches its first ruggedized tablet with built-in Li-Fi capability (courtesy Pixabay) https://purelifi.com/purelifi-shows-

Despite Li-Fi technology's slow progression since its inception in 2011, the market is anticipated to acquire a valuation of approximately USD 116.96 billion by the end of 2030 due to its potential to improve industries such as the IoT, Lighting-as-a-Service (LaaS), intelligent transport systems, smart cities and the medical sector.[H]

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable based on the credibility of the respective articles and publications. While the sources tended to corroborate one another, they varied in their forecasts and future Li-Fi potential for adoption. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to enduring efforts by the scientific and commercial industry to advance Li-Fi technology at scale. Additional time and staffing are required to improve this estimate.

Author: LTC Fidel Arvelo[28]

[28] ChatGPT, You.com, and Perplexity were utilized in this estimate's research, construction, and data summarization.

DoD Highly Unlikely to Successfully Compete With Civilian Sector to Recruit And Retain Talent For AI-driven operations by 2035

Executive Summary

Despite the ability of the Department of Defense (DoD) to recruit some AI experts, it is Highly Unlikely (16-30%) that it will be able to attract and retain the number and caliber of experts necessary for AI-driven future warfare by 2035. Although DoD offers many opportunities for advancement, there will be fewer opportunities for AI talent compared to other industries, making it more difficult to retain top talent in the long term. A survey of 254 U.S. AI PhD graduates revealed that 76 percent held jobs in either academia or the private sector, and only 31 percent would consider a government job.[M]

Discussion

A report published in 2021 by the National Security Commission on AI (NSCAI), argues that the "greatest impediment to the United States being AI-ready by 2025" is not a lack of technology or funds but, rather, the "alarming talent deficit" within the DoD and Intelligence Community.[HH] AI experts are in high demand in the private sector, which can offer more attractive salaries and benefits packages in the civilian sector than the DoD. There is a significant demand for AI talent across many different industries. According to a report by Gartner, AI's global revenue was $51.5 Billion in 2021 and witnessed growth to $62.5 Billion in 2022 at a Compound Annual Growth Rate (CAGR) of 21.3% during 2021-2022.[M] The demand for AI talent is high, and the private sector is willing to pay top dollar for skilled AI professionals. This competition and unbalance in resources make competing for the DoD with the private sector for the same talent pool difficult. Fortune Business Insights stated that the global AI market could rise to $360 Billion by 2028 at a CAGR of 33.6% from 2021 to 2028.[M] The U.S. Bureau of Labor Statistics states that overall employment in computer and information technology occupations is projected to grow 15 percent from 2021 to 2031, much faster than the average for all occupations; this increase is expected to result in about 682,800 new jobs over the decade.[H] In addition to new jobs from growth, opportunities arise from the need to replace workers who leave their occupations permanently. Approximately 418,500 openings each year, on average, are projected to come from growth and replacement needs.[H] The median annual wage for this group was $97,430 in May 2021, which was higher than the median yearly wage for all occupations of $45,760.[H] Figure 1 shows that the average salary for an artificial intelligence

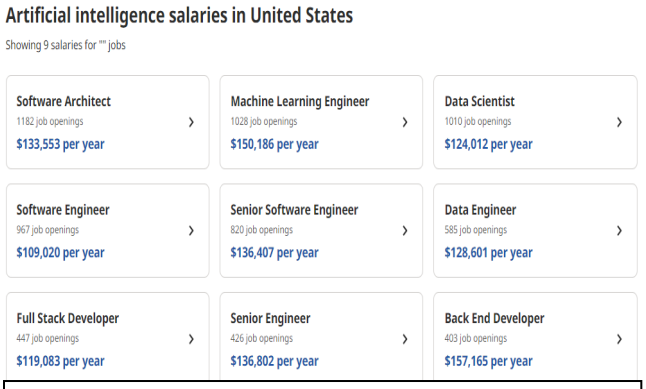


Figure 1: AI Salaries in the United States. https://www.indeed.com/career/salaries/artificial%20intelligence

programmer ranges from $100,000 to $150,000, salaries are significantly higher for AI engineers, averaging $171,715 with the top 25% earning above $200,000.[M] Talent.com states that based on 1596 salaries of different types of AI-focused and enhanced jobs that the average AI salary in the United States is $149,512 per year or $71.88 per hour, with entry-level positions start at $115,000 per year while most experienced workers make up to $203,341 per year.[H] While the DoD offers many opportunities for advancement, there are fewer opportunities for AI talent compared to other industries. In addition, the competition makes it difficult for the DoD to retain top talent long-term. Nevertheless, the demand for AI skills is high as organizations recognize this technology's potential to improve their operations. Those who can utilize AI skills effectively will be in high order and will be able to find jobs in various sectors. Figure 2 shows the 2023 payscale for General Schedule (GS) employees within the DoD. The DoD faces significant challenges competing with private companies for AI talent recruitment. The disparity in entry-level pay between the public and private sectors highlights that private companies have the financial resources to offer higher salaries, bonuses, and other incentives that are often beyond the reach of government agencies. An example is a GS-10's initial pay at entry is $53,990, all of the AI entry level jobs listed in figure 2 above average $80K more than that. As a result, the DoD will be challenged to attract and retain top AI talent, especially at the entry-level. In addition, the upward promotion potential at private companies is generally much more extensive, as these companies often provide more rapid advancement opportunities based on merit, skillset, and overall job performance. Conversely, the DoD typically follows a more rigid promotion process subject to government regulations and bureaucratic procedures, which can be frustrating for ambitious AI professionals seeking quick career advancement. A recent Concil on Foreign Relaions articale highlight the fact that, "Hiring and retaining diverse, tech-savvy talent is the keystone not only for U.S. leadership in AI but also solidifying U.S. ability to innovate and compete — both economically and militarily."[H] The article went on to say that, "DoD should undertake a number of initiatives to attract AI and machine learning talent, and an essential component is actively contributing to the field."[H] The National Security Commision On Artificial Intelligence (NSCAI) final report explains, "the biggest obstacle hindering the recruitment of digital talent is…the perception, and too often the reality, that it is difficult for digital talent in government to perform meaningful work, with modern computing tools, at the forefront of a rapidly changing field."[H] The DoD must change its culture and its policy and paractice to demonstrate that it is a center of excellence by actively contributing relevant work and research to the field.

SALARY TABLE 2023-GS
INCORPORATING THE 4.1% GENERAL SCHEDULE INCREASE
EFFECTIVE JANUARY 2023

Annual Rates by Grade and Step

Grade	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	WITHIN GRADE AMOUNTS
1	$ 20,999	$ 21,704	$ 22,401	$ 23,097	$ 23,794	$ 24,202	$ 24,893	$ 25,589	$ 25,617	$ 26,273	VARIES
2	23,612	24,174	24,956	25,617	25,906	26,668	27,430	28,192	28,954	29,716	VARIES
3	25,764	26,623	27,482	28,341	29,200	30,059	30,918	31,777	32,636	33,495	859
4	28,921	29,885	30,849	31,813	32,777	33,741	34,705	35,669	36,633	37,597	964
5	32,357	33,436	34,515	35,594	36,673	37,752	38,831	39,910	40,989	42,068	1,079
6	36,070	37,272	38,474	39,676	40,878	42,080	43,282	44,484	45,686	46,888	1,202
7	40,082	41,418	42,754	44,090	45,426	46,762	48,098	49,434	50,770	52,106	1,336
8	44,389	45,869	47,349	48,829	50,309	51,789	53,269	54,749	56,229	57,709	1,480
9	49,028	50,662	52,296	53,930	55,564	57,198	58,832	60,466	62,100	63,734	1,634
10	53,990	55,790	57,590	59,390	61,190	62,990	64,790	66,590	68,390	70,190	1,800
11	59,319	61,296	63,273	65,250	67,227	69,204	71,181	73,158	75,135	77,112	1,977
12	71,099	73,469	75,839	78,209	80,579	82,949	85,319	87,689	90,059	92,429	2,370
13	84,546	87,364	90,182	93,000	95,818	98,636	101,454	104,272	107,090	109,908	2,818
14	99,908	103,238	106,568	109,898	113,228	116,558	119,888	123,218	126,548	129,878	3,330
15	117,518	121,435	125,352	129,269	133,186	137,103	141,020	144,937	148,854	152,771	3,917

Figure 2: SALARY TABLE 2023-GS (opm.gov)

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore, given the lengthy time frame of the estimate, this report is sensitive to change due to new information.

Author: LTC Samuel A. Meyer

Highly Unlikely That The Department of Defense (DoD) Will Realize an AI Educated Force by 2025

Executive Summary

Despite the DoD's efforts to accelerate AI education across the enterprise, it is unlikely (16-30%) that the DoD will realize a total educated force by 2025 due to the disparate efforts piloted by the service components, the size of the population to educate, and the lack of a comprehensive program to manage, recruit and retain talent. However, due to significant financial investments, the continued partnership with academia and private industry, and efforts by the services in identifying and retaining talent, it is likely (56-70%) that DoD will realize an AI-educated force by 2035.

Discussion

In response to Section 256 of the *National Defense Authorization Act (NDAA)* for Fiscal Year (FY) 2020 (P.L. 116-92)[H] the Joint Artificial Intelligence Center (JAIC) published the *Department of Defense (DOD) Artificial Intelligence Strategy*[H] with the objective to accelerate AI capability at scale by 2025.[29] Originally designed for educating service members in relevant occupational AI fields, DoD elected to expand this mandate to cover the Total Force (to include the Active Component, Reserve Component, and civilian employees). Recognizing that building an AI workforce will require much more than highly educated, deep technical experts, the JAIC identified six archetypes: Lead AI, Drive AI, Create AI, Employ AI, Facilitate AI, and Embed AI (see figure 1). The archetypes are divided into three main categories: leaders, developers, and users, according to their roles and areas of expertise. Concentrations within archetypes provide tailored learning depending on AI-related roles in addition to a common foundation. This strategy forms the common framework for the DoD Service components to tailor programs based on their unique missions and operational needs.

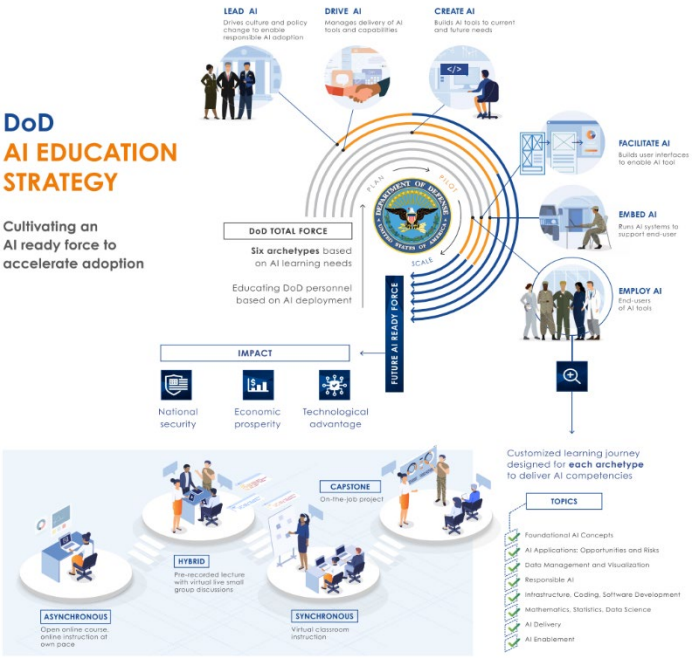


Figure 1: DOD AI Education Strategy (press Ctrl+Click to follow link)

[29] The National Security Commission on AI (NSCAI) calls for an AI ready force by 2025, while the AI Educations Strategy presupposes a window of 5-7 years from the date of publication in 2020.

With an AI readiness target of 2025, and AI competitiveness by 2027,[30][MM] the Departments of the Air Force (USAF) and Space Force (USSF), partnered with the Massachusetts Institute of Technology, to pursue an education model thru online asynchronous and synchronous courses and in-person activities focused on educating the senior leadership.[31][M] Simultaneously, the USAF is piloting distance learning modules through the Digital Air University to target the "Drive AI' and 'Create AI' archetypes.

Figure 2: Air Force Col. Tucker Hamilton dons a virtual reality headset to assist Capt. Kyle McAlpin in collecting data for the Department of the Air Force/MIT AI Accelerator's project, Objective Performance Prediction and Optimization Using Physiological and Cog Cognitive Metrics. Photo courtesy of the DAF/MIT AI Accelerator.

The U.S. Army AI Intelligence Task Force partnered with Carnegie Melon University in Pittsburg, PA. for its first two-year Master's degree pilot program in Data Analytics and Data Engineering.[32][MH] The U.S. Navy has concentrated efforts on AI systems research and development at the expense of defining the training and education for operators and maintainers of AI systems.[M] Instead, the Navy's focus is to develop Sailors and Marines through partnerships with community colleges and distance learning programs on IT and Cybersecurity technology making it unlikely to meet the AI Education Strategy objectives by 2025.[MM]

The DOD recognizes that, as it progresses toward an AI-educated force, it is highly likely that people will be the hardest challenge due to. For instance, some experts argue that despite the efforts to educate the 'Lead AI' archetype (primarily senior officers and civilian executives), much of the total force resides in the 'Employ AI' archetype (end users of AI). Therefore, unless the focus is on the entire workforce simultaneously, the goal to scale AI readiness across a population comprising 3.5 million military and civilian personnel by 2025, is highly unlikely (16-30%).[33][MM] But, as the distance learning programs evolve and achieve full implementation across services it is likely that the DOD will reach its goal. The DOD acknowledges that it currently lacks a mechanism to manage and track its AI talent[M] and that it is not postured to compete with the civilian sector to attract and retain such talent. To tackle these issues, the DOD is collaborating with the private sector to create and deploy of AI technology that can assist with identifying and assessing personnel with the requisite skills.[MM] Encouraging initiatives like AI Talent 2.0,[M] and an AI-driven app offer potential solutions to these challenges.[M] [MM]

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[30] USAF and USSF projection based on both NSCAI and JAIC timelines.

[31] In October 2022, USAF began its first 'Lead AI' archetype accelerator two year Master's program comprised of 200 senior officers, non-commissioned officers, and civilians in senior leadership roles.

[32] 20 Army officers and 5 civilians began their AI master's program in August 2020.

[33] The 3,475,888 Total DoD Personnel is made up of 2,586,825 Military Personnel and 889,063 DoD Civilians. DoD Active-Duty members make up 51.6% of Total Military Personnel.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to the advent of new technology and as the assessments and recommendations from the various pilot programs become available and are implemented. To improve the estimate and provide recommendations for how to reach a significant number of learners at scale most efficiently, additional time and staffing is required.

Author: LTC Fidel Arvelo[34]

[34] ChatGPT, and Perplexity were utilized in this estimate's research, construction, and data summarization.

Human Out of The Loop Autonomous Weapon Systems Almost Certain to be Fielded in Multiple Militaries by 2035

Executive Summary

Advances in unmanned systems, Artificial Intelligence (AI), and machine learning make it almost certain (86-99%) that technically advanced countries will develop functional human out of the loop (HOOL) lethal autonomous weapons (LAWS) by 2030 and will field HOOL LAWS by 2035. Complex battlefields and ethical concerns will affect the rate of adoption, but it will be highly likely (71-85%) that static defensive weapons that have limited time to identify and engage incoming threats will be fielded prior to LAWS designed for search and attack. Once one nation fields autonomous systems, it will be difficult or impossible to prevent further adoption, despite well-known scientists and celebrities advocating for banning LAWS.

Discussion

The wars in Iraq and Afghanistan made unmanned aerial systems (UAS) popular, but remotely piloted vehicles (RPV) were just the beginning.[H] Technology has enabled advancement from remotely piloted, to semi-autonomous, to human-supervised systems, and will highly likely lead to fully autonomous vehicles and systems employed on the battlefield. As society has slowly warmed up to the promise of safer and more efficient travel with fully autonomous systems[H], LAWS have been met with more resistance.

To mitigate concerns, militaries have developed processes designed to keep humans in some level of control of the process or execution, as seen below in Figure 1. Human in the loop (HITL) and human on the loop (HOTL) systems have allowed humans to keep an appropriate level of control, based on the weapon system type and application. The advent of machine learning (ML) combined with HITL functions have increased reliability in semi-autonomous systems and resulted in increased trust in human- supervised operations through three primary ways: 1) Humans providing feedback to ML algorithms allow the machine to learn and improve predictions; 2) Humans helping to verify the accuracy of predictions made by the ML algorithm; 3) Humans helping improve ML algorithm performance by suggesting or implementing changes.[M] Improved algorithms and accuracy is not the only concern. Researchers suggest human-like sensibilities are necessary for ethically sound decisions in combat.

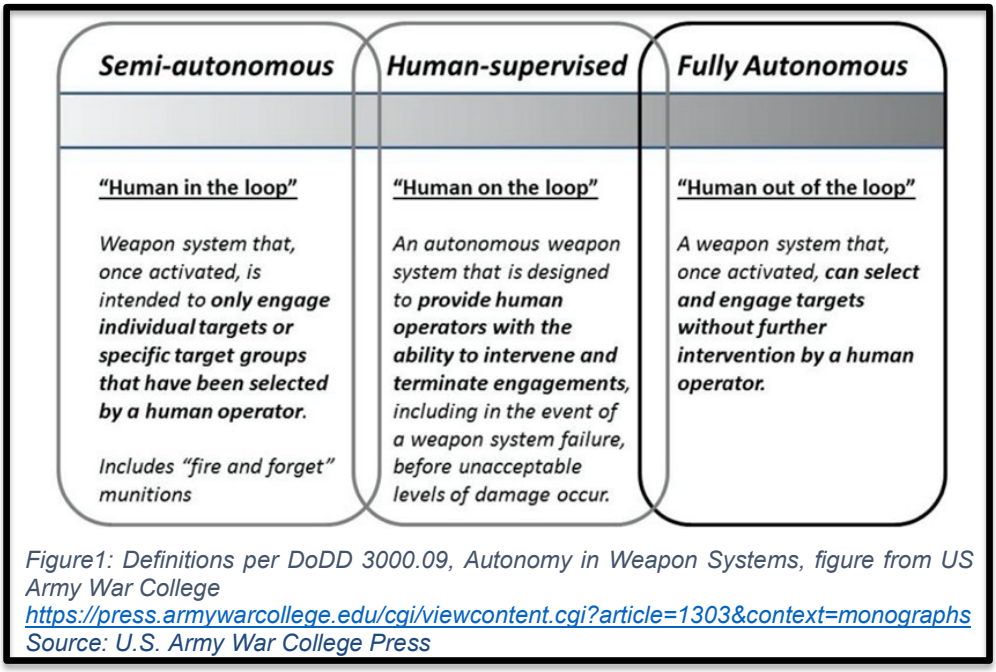


Figure1: Definitions per DoDD 3000.09, Autonomy in Weapon Systems, figure from US Army War College
https://press.armywarcollege.edu/cgi/viewcontent.cgi?article=1303&context=monographs
Source: U.S. Army War College Press

While some international progress has been made in advancing the ethical development of LAWS, the U.S. Department of Defense (DoD) has led the way; they recently published an updated directive establishing the policy, guidelines, and a working group for developing and using autonomous and semi-autonomous functions in weapon systems. DoD Directive 3000.09 developed ethical principles that include reasonable, equitable, traceable, reliable, and governable requirements related to systems that use AI.[H] Noted in a podcast enabled *AI with AI* entitled "Up, Up, and Autonomy!," the absence of definition or policy in countries like China and Russia mean those countries have more leeway related to the application of their autonomous systems.[H]

Adversary or potential adversary nations like Russia and China have been funding AI research. Figure 2 highlights the fact that most of the AI research the U.S. military conducts is highly related to autonomous operations. Russia and Israel have been keeping pace with autonomous advancements, and are perhaps the only nations claim to having employed them in a limited fashion in combat.[L,H] Dmitry Rogozin, the former Director General of Roscosmos and the Head of the Special Military Advisory Group stated that Russia would be employing their "Marker" robot in response to NATO tanks,

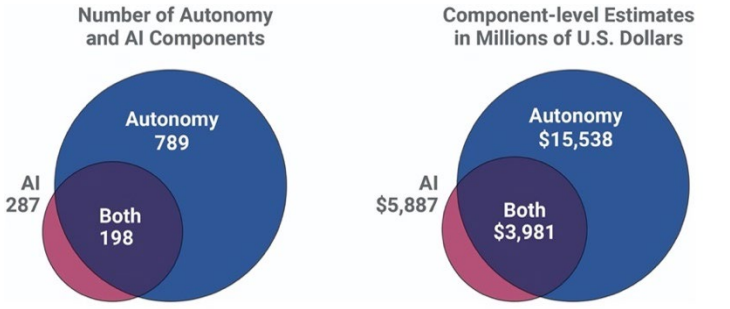


Figure 2: Most of the U.S. military S&T research related to AI also related to autonomy (component-level estimates, FY2018-FY2020).
https://www.academia.edu/60139399/U_S_Military_Investments_in_Autonomy_and_AI_A_Strategic_Assessment
Source: Department of Defense FY2020 Budget Estimates, RDT&E Justification Books of the U.S. Army, Navy, Air Force, and DARPA.

claiming the vehicle can recognize enemy equipment in daylight or infrared and attack without human input.[L] China's People's Liberation Army (PLA) is "actively pursuing AI-enabled systems and autonomous capabilities in its military modernization across services and for all domains of warfare."[H] However, obstacles such as short-falls in the technical workforce, engineering experience, and advanced semiconductors are impairing China's ability to advance as quickly as they would like.[H]

Russia previously touted the use of their Uran-9 UGV in Syria in 2018 for reconnaissance and combat duty, but ultimately acknowledged its failure, stating the system was better suited for stationary guard duty while under human supervision.[35][H] Fully autonomous self-driving cars have also continued to fall short of promises by automakers.[H] Even with these public failures, competitors have noticed the benefits of these advancements and fear of falling behind the competition compels companies to commit even more resources towards development. Additionally, Pentagon officials have stressed the need to keep humans in the loop, but leaders like U.S. Air Force GEN O'Shaughnessy has advocated to move the military towards HOTL to maintain relevance with incoming threats.[36][M] The fear of inadequate defenses against threats such as hypersonic missiles or drone swarms make it highly likely that static weapons designed for defensive measures will be adopted first, followed by offensive systems. Competitor nation threats will influence military decision-makers around the globe to maintain relevance with potential threats, which means other technically advanced nations[H] will likely (56-70%) move towards HOOL operations.

Despite over 30,000 signatures in an open letter[H] on autonomous weapons, including well-known scientists and celebrities such as Steven Hawking and Elon Musk advocating against autonomous weapons,[M] the United Nation's Group of Governmental Experts (GGE) on autonomous weapons systems (AWS) have not come to a consensus on regulation or restrictions[H] and nations have continued investing in companies for the purpose of developing technology to enable autonomous operations.[H]

Analytic Confidence

The analytic confidence for this estimate is *high*. Adequate time was provided to the analyst who used reliable, corroborating sources. The analyst did work alone using an unstructured method, but current rudimentary experimentation in combat, support the analytical confidence level. Given the speed of advancements of the supporting elements of autonomous operations, it

[35] "Russian military tested the Uran-9 UGV in Syria, which led to a very public admission that such technology is essentially not ready for direct combat and is better suited for stationary or guard duties under direct operator supervision."
[36] GEN Terrence J. O'Shaughnessy spoke of the challenge of defending against hypersonic missiles, stating the following: "By leveraging a cloud architecture, big data analytics, edge computing, artificial intelligence, and machine learning, this network should sense a threat from one node and engage it precisely and expeditiously from another across vast distances and across all domains."

is possible that a few nations could begin employing effective systems using HOOL LAWS prior to 2035.

Author: LTC Phillip B. Cain

Innovative and Specialized Approaches to Learning and Training Highly Likely to be Required for Competitive Organizations by 2033

Executive Summary

Increasing complexity in the world make it highly likely (71-85%) that businesses and military organization will change the way they educate, train, and conduct operations during the next seven years, with major changes being implemented by 2033. Militaries will still highly likely maintain their rigid, hierarchical structure, but they will likely (56-70%) need to adjust their culture and adopt innovative educating and training models from successful business to preserve their competitive edge. Some of the common characteristics of innovative organizations include viewing flawed ideas as building blocks, prioritizing transparency and trust, providing opportunities for collaboration, encouraging risk-taking, and normalize constructive dissent.

Discussion

Traditional business and training models are not irrelevant. There is still a need to know when to use linear thinking and how to apply it.[H] Linear thinking is described as "a systematic and analytical thought process that follows a known step-by-step progression similar to a straight line. Linear thinkers view a problem as a process with a set starting point that follows a sequence of connected series, ultimately leading to a solution.[H]" The Cynefin Framework in Figure 1 (left) provides a useful model in knowing when to use standard, linear thinking, and when to use a non-standard approach. As you move counterclockwise from the lower right corner of the framework, the level of complexity increases, and so does the need to use non-linear, innovative thinking.

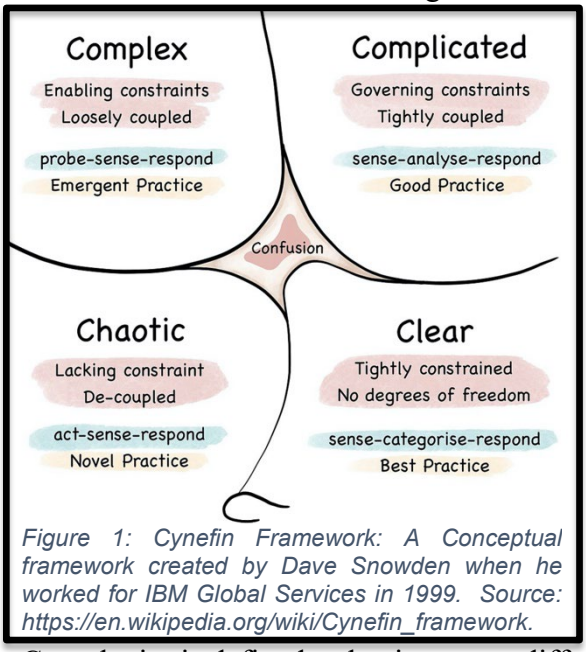
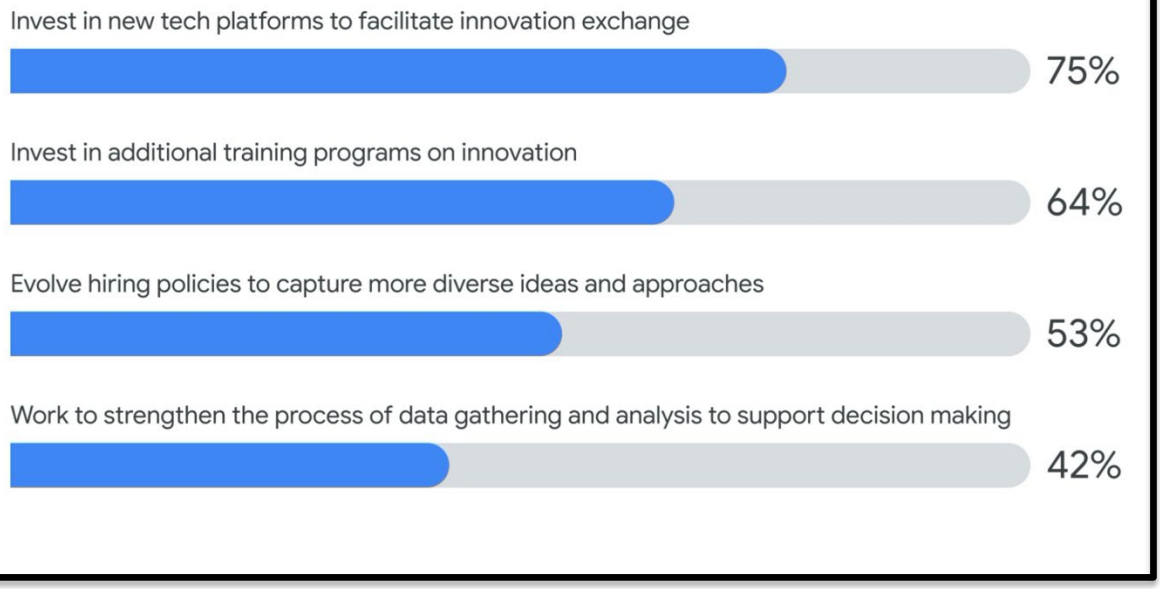


Figure 1: Cynefin Framework: A Conceptual framework created by Dave Snowden when he worked for IBM Global Services in 1999. Source: https://en.wikipedia.org/wiki/Cynefin_framework.

Complexity is defined as having many different parts connected or related to each other in a complicated way.[H] As the number of parts (or nodes) increases, so often do the number of connections, indicating an increasing complexity.[H] Traditional models of training and schooling were developed to accommodate a less complex environment and may be insufficient to tackle the challenges presented by the future environment.[H] In a 2022 worldwide survey of post-2000 incorporated companies with around 1,000 people, researchers found those businesses plan to take the following actions over the next five years to boost innovation:

Figure 2: Actions businesses are taking in the next five years to boost innovation. Source: https://cloud.google.com/executive-insights/everyone-wants-a-culture-of-innovation-report-what-does-it-look-like-report.



Innovative businesses adapt to increasing complexity by taking advantage of emergent properties or even positioning their companies to lead the development of emergent discoveries. An article by Noubar Afeyan and Gary P. Pisano published in the Harvard Business Review suggest that emergent discovery "requires a culture in which people, particularly leaders, in an organization are comfortable broaching seemingly infeasible ideas… a culture that views 'flawed' ideas not as dead ends but as building blocks and considers the evolution of ideas to be a collectively shared responsibility."[H] Figure 2 (below) conveys the emergent discovery process, as described in the article.

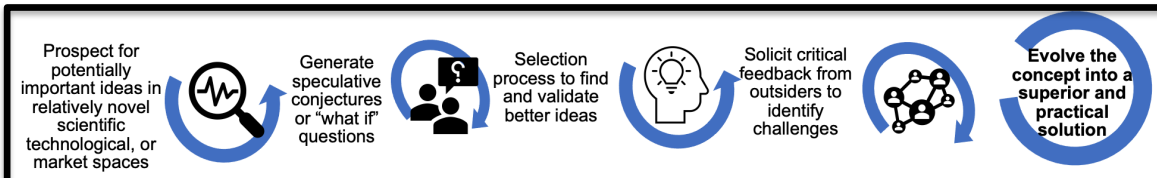


Figure 3: Author-generated image based on the Emergent Discovery Process as detailed in "What Evolution Can Teach Us About Innovation."
Source: https://hbr.org/2021/09/what-evolution-can-teach-us-about-innovation?registration=success

Contemporary companies widely known for taking advantage of emergent discoveries through innovate business practices include Google, Apple, Amazon, and Microsoft. While these companies possess different management structures,[M37] they contain some similar characteristics that may indicate how military organizations may position themselves to take advantage of the forthcoming changes, due in large part to reverberations of AI and increasing complexity.[38]

[37] The author describes the Apple business design as structured, Amazon as unstructured, and Google as open.

[38] *[Automated Assessment (truncated) from AI platform Unrestricted Intelligence] "AI has the potential to revolutionize the way organizations operate, from streamlining processes to providing more accurate and*

Business cultures that prioritize transparency and trust while providing opportunities for collaboration and risk-taking are better positioned to innovate because of the agile and responsive nature these characteristics produce.[H] Working outside of a primary field is also important. Google is famous for their "20% rule" that requires employees to spend at least 20% of their working hours on pet projects[H], reinforcing the "Medici Effect.[H39]"

At the individual level, senior-level leaders that embrace innovation often encourage new ideas, embrace failure, create psychological safety, and promote diversity in thought.[M] At the managerial level, instilling confidence in employees' ability to come up with fresh solutions, encouraging cooperation over competition, and learning from other firms are characteristics that help inspire innovation.[M]

There is no single business model that enables innovation. However, while the chain of command in a hierarchical organization is efficient, it can be detrimental to innovation. David Burkus points out that the very structure that enables decision-making and order-issuing stifles creative ideas. He states that "creative ideas that come from the middle or lower levels of a hierarchy have to work their way up through a series of managers, each with the power to veto but each lacking the power to implement."[M] This impediment to innovation is noted in a number of studies, including an article entitled "Don't Let Hierarchy Stifle Innovation, published in the Harvard Business Review. In that article Timothy Clark suggests three steps to neutralize side effects of hierarchy and encourage cultural flatness. Those steps corroborate with the suggested elements of innovation mentioned earlier and include: 1) Grant irrevocable participation rights; 2) Practice exploratory inquiry; 3) Normalize constructive dissent. Despite the hierarchical nature of military organizations leading to the highly likely forecast that they will maintain their rigid structure, advanced nations will likely need to adopt emerging educating and training models such as those discussed in this paper to preserve their competitive edge.

Analytic Confidence

The analytic confidence for this estimate is *high*. Sources were reliable and while the sources identified differing views on how successful organizations innovate, they agreed on several core characteristics. There was adequate time, but the analyst worked alone and could not entertain the plethora of articles dedicated to innovative organizations. Given the exponential growth of new websites and applications derived from the OpenAI system, it is easy to determine that changes are likely to occur, but difficult to forecast exactly how organizations will respond to emergent characteristics of the system.*Author: LTC Phillip B. Cain*

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timely insights. AI can be used to automate mundane tasks, allowing employees to focus on more complex tasks. AI can also be used to provide more accurate and timely insights, allowing organizations to make better decisions. AI can also be used to provide more personalized training and education, allowing organizations to better prepare their employees for the future."

[39] "Medici Effect" by Frans Johansson, who argues that "innovation comes from diverse industries, cultures, and disciplines when they all intersect, bringing ideas from one field into another."

Military Leaders Must Acquire New Skill Sets to be Effective in Rapidly Advancing Data Centric Environment in 2035

Executive Summary

It is almost certain (86-99%) military leaders will need to develop new skill sets to effectively manage new data driven AI enhanced technologies and strategies. Key skills military leaders will need now and in 2035 are understanding of data analytics, data engineering, ability to use/leverage machine learning, application program interface understanding, and data visualization skills to effectively communicate data-driven decisions. Currently leaders lack the requisite skills at scale to be effective in future intelligentized warfare. Future military operations will be characterized by the increased use of data-driven systems, machine learning, and intelligentized warfare.

Discussion

Candice Frost, commander of the U.S. Cyber Command's Joint Intelligence Operations Center (JIOC) said “our bench is not deep enough” when it comes to having an adequate number of trained cyber professionals in critical roles, not just at Cyber Command and the DOD, but across the entire federal government.[H] This highlights the current gap in capability and skills required to shape the future force and modernize. Military leaders must have a deep understanding of data analytics and the skills to leverage data to gain strategic advantages on the battlefield. Candice Frost went on to say that “Our future AI systems can’t just be created monolithically. They've got to come in different flavors and understandings, and that is done by having a workforce that sees things from different perspectives.”[H] Military leaders will need to be able to interpret and analyze large volumes of data, draw insights from it, and use those insights to make informed decisions. A recent Government Accountability Office (GAO) report highlighted the next key steps in Defense’s ongoing effort to improve its software ecosystem. Recommendations from the report touched on cultivating a strong workforce to address ongoing gaps in critical software modernization knowledge as well as upskilling employees to become more comfortable in Agile and DevSecOps fundamentals to address those gaps.[M] This report comes as Defense, along with other federal entities, are looking toward updating their software with emerging technologies, particularly artificial intelligence to address the future enviroment. The report identified the need to “develop a department-wide strategic workforce plan for DOD’s software workforce—including strategies tailored to address gaps in the critical skills and competencies—will help position DOD to execute next steps in this planning process and achieve future software modernization goals.”[H]

As the world becomes increasingly complex, organizations will need leaders who are able to make decisions quickly and efficiently.[M] Specific skills that leaders should possess include: Data engineering, data engineers design, build, and optimize systems for data collection, storage, access, and analytics at scale.[H] The DoD collects and analyzes vast amounts of data from various

sources. Data engineering skills are necessary to ensure that the data is efficiently and effectively processed, managed, and analyzed to support data-driven decision-making and enhance AI driven Machine Learning (ML). ML is a subfield of AI that involves teaching machines to learn from data without being explicitly programmed, ML algorithms identify patterns and trends in data and use them to make predictions and decisions.[H] ML is used to build predictive models, classify data, and recognize patterns, and is an essential tool for many AI applications.[H]

See figure 1 for a graphic depiction of Application programming interface (API) development, is "a set of rules that enable different applications to communicate each other…It acts as an intermediary layer that processes data transfers systems."[H] API is an important subset of understanding data and data visualization skills, "data visualization is the graphical representation of information and data, using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data."[H] Additionally, API provides an excellent means to present data to non-technical audiences without confusion. This skill is critical for the military to have leaders at all echelons (and ranks) with the knowledge and tools to rapidly convert terabytes of data generated from a broad array of sources ranging from battlefield sensors to captured enemy material to publicly available information into intelligence — and, ultimately, successful operations.[M] Leaders must be skilled in data visualization software, data analysis software, and database management systems and possess strong analytical skills to interpret the insights generated by big data analytics tools and use this information to make data-driven decisions. Findings from *Big Data And National Security: A Guide For Australian Policymakers,* stated that "Advances in the scale, application, and commercial uses of data significantly outpace regulation of the big data landscape."[M] Technical and analytical capabilities that are essential for the functioning of societies are increasingly concentrated in the hands of a small number of commercial entities, and the skills are lacking in the operational and strategic levels of the DoD.[M] Data is remodeling society's relationship with government, changing participation in the economy and access to services, as well as challenging trust in social, commercial, and government institutions.[M] Big data is also redefining national security and the way nations protect individual rights and freedoms.[M] If analyzed and processed effectively data can be used to outpace an adversary's decision-making processes and also offer the ability to challenge or deny an adversary's situational awarenes.[H]

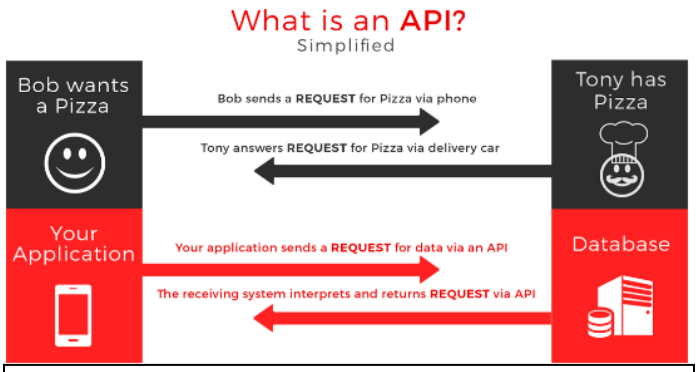


Figure 1: What is an API. https://coresolutions.ca/blogs/core-web/the-real-reason-api-s-are-the-greatest

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method.

Author: LTC Samuel A. Meyer

PLA Likely to Have a Better Trained Artificial Intelligence Force Than the United States DoD in 2035

Executive Summary

The PLA will likely (56-70%) have a better-trained AI force, despite United States DOD and military initiatives to recruit and train talent. China has made significant investments in artificial intelligence (AI) development and has become a major player in the industry.[M] With China's large pool of talent, a growing number of AI companies, and government strategy to lead AI development, the United States will likely lose the AI race without the collaboration of academia, research institutes, industry, and the US tech giants.

Discussion

The future of AI is dependent on the workforce of tomorrow. With diverse artificial intelligence innovations, the future force must be well-equipped to learn new skills and stay adept with the change and innovation that comes with AI. In AI and technology, the only thing constant is change. The DOD acknowledges the importance of "formal education, awareness, training, commercial partnerships, and on-the-job learning"[H] and the value of working with the academic, commercial, and industrial base for training but has not yet succeeded in building an adequate AI workforce.[H] Both the PLA and the DOD have focused on employment demand and talent training that is needed by industry and the DOD.[HH]

The PLA has been modernizing for more than 20 years and has been described as a half-mechanized, half-informationized force with most AI breakthroughs occurring in the commercial sector, which has made the civil-military integration a crucial innovative approach.[M]
In China's vision of future warfare, AI will dominate the battlefield, and humans are almost obsolete.[M] Xi Jinping has stated that for AI "development is the number-one priority, talent is the number-one resource, and innovation is the number-one driving force."[H]

An individual working in AI must possess both hard and soft skills. Hard skills like mathematics, statistics, programming languages, and computer science are essential, but soft skills such as critical thinking and problem-solving will differentiate the leaders in this field.[M] It is impossible to succeed in AI and machine learning (ML) without a tool kit of knowledge and skills. Below are a few of the essential computing skills for success in the AI field: (See figure one for goals of an artificial intelligence)

- Mathematics: Linear Algebra, calculus, and statistics are necessary for understanding the algorithms and models used in AI, and a strong foundation is required for designing, implementing, and using machine learning.[H]
- Programming Skills: Fluency in programming languages such as Python, Java, R, and C++[M] are necessary for developing applications and implementing algorithms. Python is the most common command program used in AI and ML, is open source and continually changing.[MH]
- Cloud Computing: Large data management is at the basis of AI. The cloud provides secure storage for vast amounts of data where it maintains the storage servers, infrastructure, and network while maintaining the security of the data and ensuring the user has access to the data when needed.[MH]

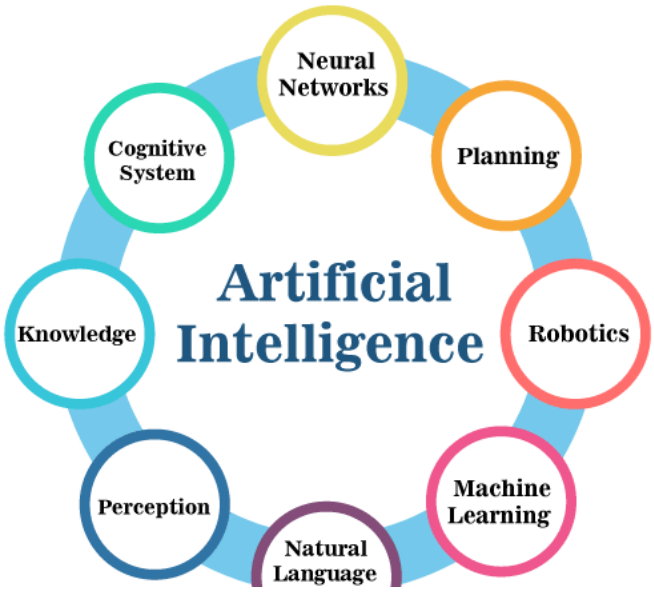


Figure 1: https://www.javatpoint.com/goals-of-artificial-intelligence Special traits or abilities that researchers expect an intelligent system to exhibit is similar to the skills needed to work in artificial intelligence.

- Machine Learning: ML teaches a system to classify and predict something.[M] A deep understanding of a broad set of algorithms, such as supervised and unsupervised learning for developing models, is necessary.[M] Deep Learning and Neural Networks are subsets of machine learning.[H]
- Natural Language Processing: NLP is the study of how computers can understand and process human language and is needed for language translation systems and voice assistants.[M]

Being good at coding and programming is not the only skill needed. People involved in AI must have critical thinking and problem-solving skills. In the ever-changing technology of AI, creative solutions and the perseverance to see complex, time-consuming projects through are as important as any knowledge-based skill.[M] AI projects require teamwork from commercial, industrial, and military disciplines. It is a rapidly evolving field of study, and those who work in it need to have a passion for learning and staying up to date with the latest advancements.[M]

China has achieved significant progress in a new generation of AI theories and technologies, and the industry has entered the first echelon of AI technology and is optimizing new applications in different domains.[M] China established new educational systems and constructed campuses focused on big data and AI learning. China is mandating AI education in the high school curriculum and for AI companies to train university students.[H] China draws on its large population for talent. As many as 16% of the STEM graduate students in the United States are Chinese citizens.[H]

The industry has a global talent shortage, and the DOD does not have the power to hire the experienced talent needed to develop a workforce with AI capabilities across a broad range of needs so they must train their force. The DOD prioritizes education and training to improve its capabilities but is falling behind the private sector. [H] The DOD and Military requirements for clearance, citizenship, lower salaries, dress codes, and restrictive work environments make the DOD a less competitive employer.[M]

Figure 2: A tug of war between army and industry or AI talent https://madsciblog.tradoc.army.mil/192-new-skills-required-to-compete-win-in-the-future-operational-environment.

Generation Z (people born between 1996 and 2010) will make up 30% of the workforce by 2030, so building the next generation of talent should be a top priority. Gen Z has preferred learning styles and has grown up as digital natives[H], preferring digital formats and on-the-go mobile options, and desires to be in a collaborative learning environment

The DOD and PLA are major players in AI development and have different strengths and approaches. While China has made significant progress in recent years, the US DOD is falling behind as both countries continue to invest heavily in AI research and development.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is sensitive to change due to the advent of new technology and access to personal information systems.

Author: COL Leslie M. Carlson[40]

[40] ChatGPT, Perplexity AI, were utilized in this estimate's argument research and construction.

Advances in India's Artificial Intelligence Development Are Likely to Surpass The United States New Development by 2035

Executive Summary

India is making rapid advances in the development of artificial intelligence and is likely (56-70%) to meet or surpass that of the United States new development by 2035. India, as an ally, is likely to share the technology with the United States and its allies in peacetime. But are unlikely to do so during a conflict. The interdependent relationships of India to Russia and China could mean that India could chose to share technology with these countries, furthering the likelihood of capability overmatch.

Discussion

India has quickly become a leader in AI, which is of direct interest to the US. US-India relations are a priority, given India's power and combined with the uncertainty regarding Russia and China. There are about 170 AI related startups in India and have received investment of 36 million dollars.[H] In contrast, more than 1,000 U.S. companies have also set up operations in India, employing one million people. More than three-quarters of working nonresidents in the U.S. are from India. Most are in IT, with an especially high-profile presence in Silicon Valley. Indians are also heavily represented as students and professors at America's elite universities, especially in STEM fields.[H] India's AI market was valued at $3 billion in 2020, or 1% of the global market, and is expected to grow at a rate of 20% over the next five years, second only to China.[H]

One indicator of AI growth is the number of research articles published related to AI. The United States has historically been the leader in AI-related research output, but from 2016 to 2019, China produced more AI-related papers than any other nation, India was third. To become a dominant AI power, India is improving the quantity and quality of its AI research.[M]

Figure 1: *Companies such as Google, Facebook and Amazon are investing in startup companies that are developing innovative technologies.* *https://onpassive.com/blog/economic-growth-artificial-intelligence-india/*

Another key metric is government expenditure on AI. These expenditures in India surged by 109.6%, or US$665 million, in 2018. In addition, AI expenditure is expected to continue to surge

at a compounded annual growth rate (CAGR) of 39%, reaching US$11,781 million by 2025.[M] According to a Brookings Study, the U.S. is 94th percentile for technology and research and 96th percentage for investment India is in the 57th percentile in technology and research and 78th percentile in Investments.[H] To improve this performance, India must develop tech partnerships, which depends on investment and education. Microsoft's research and development campus is located on the outskirts of New Delhi and many of the largest U.S. investors in India are leaders in the development and application of AI and related technologies. This includes IT-focused firms such as Microsoft, Google, e-tailers Amazon and Walmart, and aerospace giants Boeing and Lockheed.[M] It is highly likely (71-85%) that in the next 20 years India will be the next Silicon Valley.

The Biden administration plans to prioritize federal funding for U.S. research and development on AI and other advanced technology.[H] In New Delhi, India unveiled new military devices and projects that included 75 new AI products meant for the Indian armed forces and for civil use. Among the prototypes was a Trishul missile system capable of detecting human movement and engaging targets at 300 meters with 100% accuracy.[M]

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another but the level of evidence varied from anecdotal evidence to comparative case studies. There was adequate time, but the analyst worked alone and did not use a structured method. Given the unknowns of the political and operational environment, this report is sensitive to change due to new information and situations in the international community.

Author: COL Leslie M. Carlson

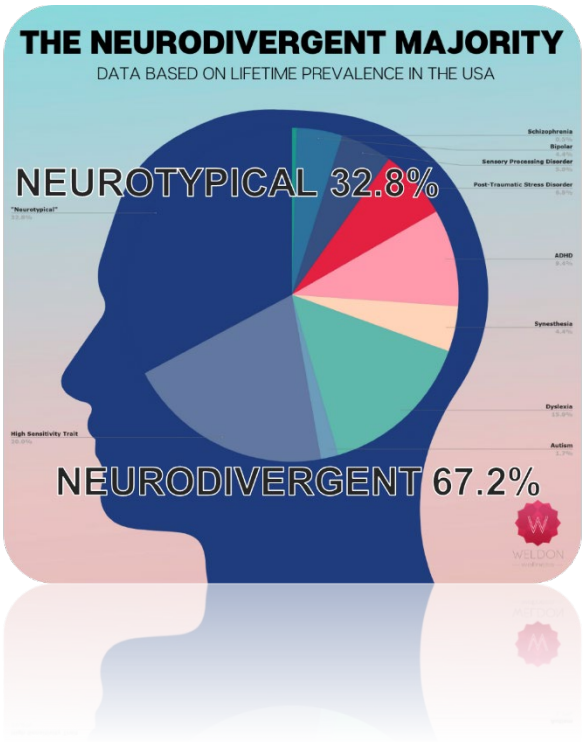
U.S. Military Highly Likely to Remain Behind Commercial Industry And Universities on Implementation of Innovative Training, Educational, or Cognitive Programs for Future Leaders by 2035

Executive Summary

The United States military is highly likely (86-99%) to lag behind the commercial industry regarding training, educational, or cognitive programs for future leaders by 2035. The United States Department of Defense (DoD) has encountered significant obstacles in keeping up with technological advancements in education, such as accelerated learning, A.I. tutors, personalized learning, and gamification learning. Moreover, the DOD has yet to consistently integrate visual, auditory, and kinesthetic learning modalities into their professional military leader education,[H] and there is a high likelihood (71-85%) that this trend will continue. This predicament is partly due to the entrenched bureaucratic and hierarchical structure of the military, making it challenging to implement quick and responsive changes to meet emerging requirements or technological advancements. Its focus on tradition and history can hinder innovation.[HM]

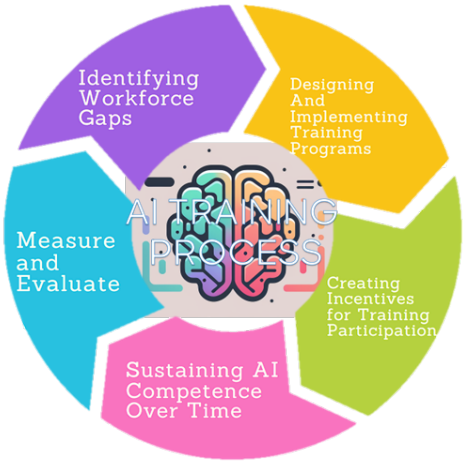
Discussion

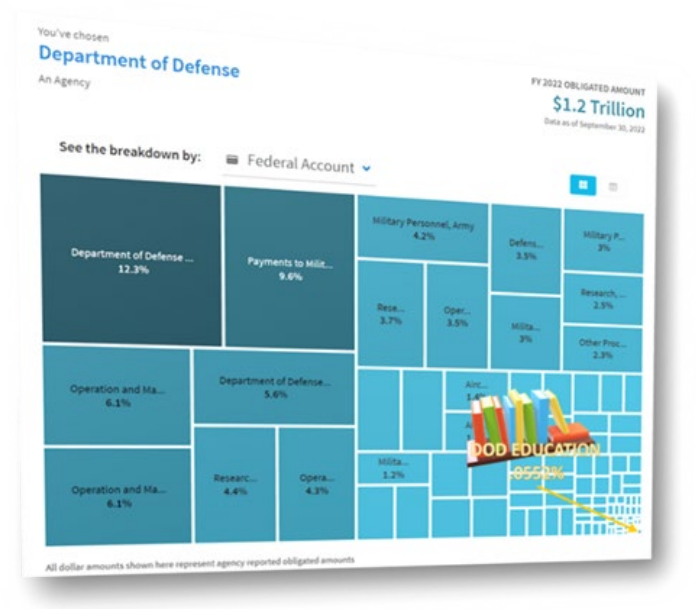
Despite the Defense Department's efforts to keep up with technological advancements in education, such as A.I. tutors, data-enhanced decision processes, personalized learning, and gamification learning, DoD continues to face significant obstacles.[H] The Department of Defense has yet to consistently integrate visual, auditory, and kinesthetic learning modalities into its professional military education, further hindering progress, and has no current accommodations to support the neurodivergent[41].[H] Common strengths among the neurodivergent population include pattern recognition, analysis, visualization, problem-solving, memory, and achieving a state of hyperfocus to complete a project—skills that are advantageous in many career fields within the DoD.[H]



[41] Neurodivergent is an umbrella term that covers a variety of cognitive diagnoses, including (but not exclusive to) autism spectrum disorder, attention deficit disorder (ADD) and attention-deficit/hyperactivity disorder (ADHD), dyslexia, dyscalculia, and Tourette's syndrome.

There is a high likelihood (71-85%) that this trend will continue. In contrast, industry is consistently leaning forward to cultivate an AI-ready workforce. Organizations like the Carnegie Mellon University Software Engineering Institute have outlined a process to grow an AI-ready DoD workforce. The process includes identifying workforce gaps, designing and implementing training programs, creating incentives for personnel to participate in training, and sustaining A.I. competence over time.[HM]





To invest in its leadership, the military must adopt a more active and technology-driven role in keeping pace with technological advancements in education, despite the DoD's current investment in Advanced Research encompassing 36 different programs from five different laboratories.[HM] It is highly likely (86-99%) that the DoD will continue to fail in the educational implementation of new technology due to structural competing requirements and a significant lack of funding.[H] The Department of Defense spends approximately $6.9 billion on education annually, less than 1% of its overall budget (FY22).[H]

In an attempt to capture the imagination and financial backing of Gen. Z and beyond, industry and universities are leaning forward on innovations that could astronomically improve learning and significantly lower costs.[M] Universities are researching new techniques for accelerated learning, visual, auditory, and kinesthetic modalities, and personalized learning. Corporations and universities are identifying innovative approaches with A.I. teaching assistants, College by Subscription, and virtual reality that are best practices in commercial education while learning from industry leaders, and these Real-world benefits are being integrated into education today.[M] Students in the


A simulated Beijing in an immersion lab at Rensselaer Polytechnic Institute in Troy, N.Y., where students can learn Mandarin Chinese.

immersion lab mastered Mandarin about twice as fast as their counterparts in conventional classrooms, stated Shirley Ann Jackson, the president of Rensselaer Polytechnic Institute.[M] The use of A.I. in education is also expected to increase significantly, potentially transforming how military personnel are trained. According to Bryan Fendley, Director of Academic Computing at the University of Arkansas, Monticello, AI could automate the grading process, provide personalized feedback to students, and even develop tailored learning plans based on the individual's strengths and weaknesses.[M] While A.I. will likely (56-70%) never fully replace human instructors. It could serve as a valuable addition within DOD, enhancing the learning experience for military personnel.

DoD is working to emphasize workforce development more, particularly as they face challenges in attracting and retaining highly skilled personnel.[M] This includes investing in training and development programs to enhance the skills of existing personnel's skills and attracting and recruiting new talent. According to a study by the RAND Corporation, the military should focus on developing an "agile, adaptive, and responsive" workforce that can quickly respond to emerging threats and challenges, and it's not.[H]

The commercial industry has made considerable progress in developing and implementing training, educational, and cognitive programs. One key factor that contributes to this progress is the ability of the commercial industry to attract and retain top talent.[H] Commercial companies are known for offering competitive salaries, benefits, and opportunities for career growth, which has allowed them to attract some of the best and brightest minds in the industry.[M] In contrast, the U.S. military is bound by strict regulations regarding pay and promotion, which makes it challenging to attract and retain top talent and, in most cases, has not even determined mission-critical occupations.[H] The military is constantly battling to prioritize its investments to ensure they are effectively meeting national strategic objectives while balancing talent management, new and emerging technologies, and programs necessary to maintain the readiness of existing capabilities.[H] Despite military officers spending more than 1/4 of their career in Professional Military Education, the DoD must prioritize intuitive and inventive workforce development and training programs, recognizing that investing in personnel is critical to maintaining a strategic competitive advantage. Changes in military formations can significantly impact the education of military leadership. According to Defense News, the Army is considering changes to its formations to enhance its capabilities to respond to emerging threats. These changes involve incorporating smaller, autonomous units capable of operating independently. Additionally, deploying uncrewed systems and other new technologies will

U.S. soldiers assigned to the 82nd Airborne 3rd Brigade Combat Team train with the Integrated Visual Augmentation System during Project Convergence 2022. Army spent 1.3Bn in RDT&E to make soldiers less lethal. [M]

enable the Army to respond faster and more efficiently operational.[M] Strategically, these new initiatives will have little effect on the future of DoD education and could hinder commanders' ability to adapt to changing situations due to a lack of familiarity or trust with these emerging capabilities.

Despite the DoD developing new multidomain force structures and having an existing institutional PME educational structure, it continues struggling to implement any educational innovation identified across industry.[M] Changes to instruction and doctrine and advances in new concepts are hampered by overclassification, debilitating staffing processes, and institutional apathy that simply waits out the innovators.[M] Therefore, it remains highly likely (86-99%) that the U.S. military will continue to lag behind the commercial industry in implementing innovative training, educational, or cognitive programs as it prioritizes funding on gadgets over education and investments in its human capital.

Analytic Confidence

The analytical confidence of this estimate is **moderate** and accounts for confirmation bias. Numerous and extensive sources were available that appeared reliable based on the high credibility of the publications. The hypothesis includes the possibility that the Department of Defense has numerous programs focused on this effort and accounts for anchoring bias. The analysis worked alone using a structured method, but given more time and additional personnel resourcing would increase the confidence of this estimate. This estimate remains sensitive to emerging information and future technologies.

Author: Lt Col Dorian C Hatcher [42]

[42] ChatGPT, Perplexity AI, Jasper AI, Google Translator, and Speechify.com ask Ai Bot were utilized in this estimate's argument research and construction.

Unlikely That China Will Outcompete the United States in Advanced Chip Resources by 2035

Executive Summary

Despite this disparity in manufacturing, it is likely (56-70%) the United States will be able to have a stable supply of advanced microchips by 2030 using Taiwan TMSC technology.[M] Taiwan is the number one producer of semiconductors in the world. It produces 65% of the world's semiconductors and almost 90% of the most advanced chips smaller than 10 nanometers.[HMM]

Discussion

Semiconductors are critical components that power any electronics from smartphones to car brake sensors.[M] The world's telecommunications infrastructure and all modern weapons systems rely on these complex chips.[H] Recent shortage of semiconductors was due to increased demand for electronics during the Covid-19 pandemic.[M]

The microchip manufacturing process involves hundreds of steps, taking up to four months from design to production. It is not the raw material that would cause a shortage of chip, as silicones are produced by reacting silicon, one of the earth's most common elements.[H] The chip-making process needs tightly controlled cleanrooms, air quality, and temperature control. It requires a highly technical machine called an extreme ultraviolet (EUV) lithography tool only produced by ASML in the Netherlands. Each of the EUV machines requires over 40 Freight containers to ship and costs 150 million dollars.[M] The silicone material is layered with information, chips can have up to 100 layers, The size of the features printed on the chip varies depending on the layer.[M] Moore's Law predicts that the density of transistors able to fit on a chip would double approximately every two years has thus proven correct, and today's microchips contain billions of transistors.[M] Due to the manufacturing requirements, the EUV machines' availability, and the time-consuming set up, it takes several years and technical experience to start the manufacturing process.

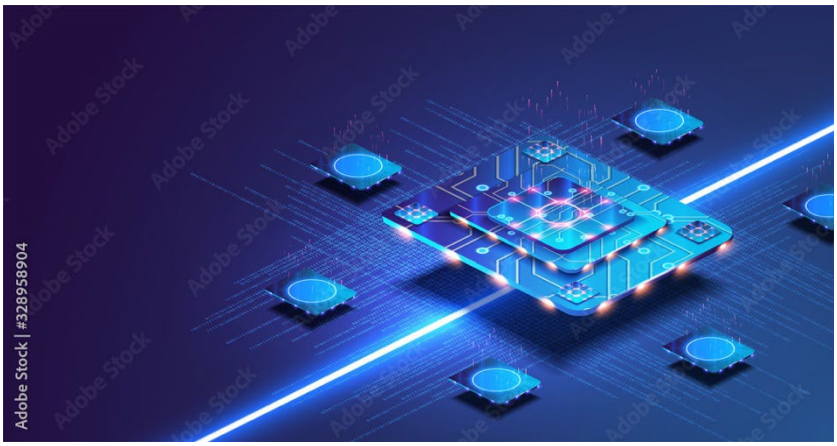


Figure 1: Futuristic microchip processor with lights

Taiwan makes 65% of the world's semiconductors, China produces 5%, the U.S. 10%, with South Korea, Japan, and the Netherlands make up the difference.[M] Taiwan's Semiconductor

Manufacturing Company (TSMC)website states it plans on building a second chip fabrication facility in Arizona that will begin manufacturing 4nm chips in 2024 and 3nm chips in 2026.[M] The United States has 7 of the top microchip manufacturers but does still not have the advanced chip capabilities that Taiwan does.[M] Intel, is just starting to produce its first below 7nm [M] chipmaker, while the TSMC has been doing this since 2016.[M] TSMC will also receive American chip subsidies linked to pledges not to further expand in China under the recently passed CHIPS and Science Act of 2022.[H]

Semiconductor Manufacturing International Corps (SMIC) China's largest chip manufacturer, stands as China's rival to TSMC but does not have the technology necessary to make Microchips smaller than 10nm due to the United States barring the sale of the EVU lithography from the Dutch.[M]

If China seizes Taiwan, the microchip factories could be controlled by China, or destroyed in a conflict. China could decide to limit access for the U.S. and its allies to advanced chips, crippling, American technological, economic, and our military advantages.[M] If it were destroyed, the world could experience a catastrophic economic crisis and collapse the electronic supply chains the world runs on.[H] If China feels it is better off just trading with Tawain than losing the advantage of a steady chip flow, then the status quo will remain.[H]

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore, given the lengthy time frame of the estimate, this report is sensitive to change due to new information.

Author: COL Leslie M. Carlson

Unlikely That DoD Will Use Artificial Intelligence to Make Autonomous Ethical Decisions in The Next 15 Years

Executive Summary

Even though the United States military has made significant progress experimenting with the use of Artificial Intelligence (AI) and Machine Learning (ML) in enhanced situational awareness, target recognition, and decision-making, it is unlikely (31-45%) that it will be able to use those advancements to make autonomous ethical decisions regarding kinetic operations, specifically autonomous weapons in an offensive capacity in any capacity by 2038. Due to the lack of flexibility within AI, ethical decision-making often requires flexibility and the ability to adapt to changing circumstances. AI systems lack this flexibility, because they are programmed with a fixed set of ethical rules or principles.

Discussion

A Competition Policy International article states that "AI notoriously fails in capturing or responding to intangible human factors that go into real-life decision-making — the ethical, moral, and other human considerations that guide the course of business, life, and society at large."[H] AI-enabled warfare will not hinge on a single new weapon, technology, or operational concept; rather, it will center on the application and integration of AI-enabled technologies into every facet of warfighting functions and principles.[M] AI will also create opportunities for more advanced processes that would operate more akin to a network, fusing multiple sensors and platforms to manage complex data flows and transmitting actionable information to human operators and machines across all domains.[H] The increasing use of AI technologies in weapon systems has generated important questions regarding whether such systems are lawful, safe, and ethical.[H] If society removes the human from the equation and fail to regulate ethical AI, there is risk making detrimental errors in crucial, everyday processes.[M] Many of the military uses of AI will complement, rather than supplant, the role of humans.[M] The overwhelming preponderance of research shows that the

Figure 1: An AI-Ready DoD by 2025: Warfighters enabled with baseline digital literacy and access to the digital infrastructure and software required for ubiquitous AI integration in training, exercises, and operations. https://reports.nscai.gov/final-report/chapter-3/

United States military will be able to harness multiple aspects of AI and ML in the future, but the ability to remove the human dimension from most decision making applications or outputs of AI and ML remove the ethical decision making ability that is required, a human must remain in the loop in any use of artificial intelligence.[M] If the Department of Defense (DoD) begins to rely on machines to make decisions when the technology is "good enough," the risk is amplified biases, risk first amendment rights and fail to regulate some of the most crucial decisions.[M] As departments and agencies rely more heavily on machines, a central guiding principle across national security scenarios is the continued centrality of human judgment.[H]

Humans may be able to outsource an ever-growing number of rote tasks and decision-making responsibilities to machines in the future, but there remains little evidence to support that the AI progression will be trusted to make ethical autonomous ethical decisions in the next 10-15 years. Figure 2 shows the many areas where AI will be face ethical dilemmas. Artificial already intelligence is many an ingrained part of industries, and only its capabilities will Despite grow from here.[L] the fact that the Defense Innovation Board has identified ethical a critical decision-making as component of successful AI and Machine Learning systems, the board does not necessarily generate actionable controls to limit ethical risk on individual projects.[M]

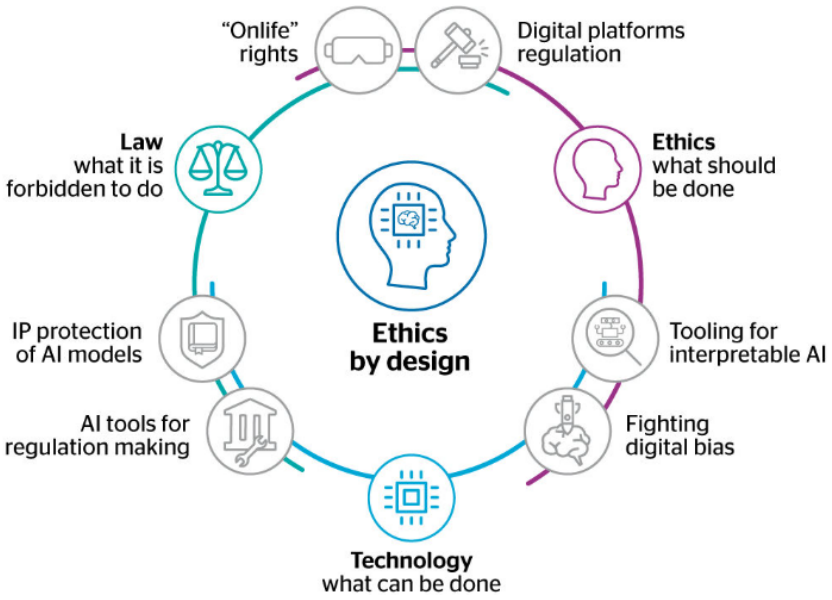


Figure 2 AI ethics by design. https://devopedia.org/ethical-ai

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method.

Author: LTC Samuel A. Meyer

US Military Almost Certain to Lag Behind China in Intelligentized Warfare by 2030

Executive Summary

China's strategic support force is positioned to almost certainly (93-99%) surpass the United States military in Intelligentized Warfare by 2030. Due to the U.S. primary focus on large-scale ground combat operations, the DoD has underestimated the importance of operational concepts and innovative force structures within the Gray zone of the competition continuum. China's dominance in Intelligentized warfare stems from its innovative doctrine, radical force structure changes, and the utilization of civilian-military fusion to revolutionize its military operations. As China's global stature grows, its perceptions and assessments evolve with its leader's interests. Despite the United States' reputation as the world's most advanced military, complacency could result in the U.S. falling behind China in intelligentized warfare by as early as 2027, with a likelihood of 93-99%.[HM]

Discussion

China's People's Liberation Army (PLA), in late 2015, created a strategic vision of a future battlefield environment dominated by artificial intelligence, cognitive warfare, and weapons autonomy.[H] They call this type of warfare "intelligentized warfare."[43] China's military leadership did not transfer their space program, cyber warfare, cognitive warfare, and electronic warfare to one of the existing services but, instead, created an entirely new organizational framework: the Strategic Support Force.[H] The amalgamation of these efforts has required establishing a new and distinct type of organization, which has proffered a revolution in Chinese military affairs.[M] Intelligentization is a unique concept China introduced to the world, which utilizes the machine speed and processing power of artificial intelligence to revolutionize military planning, operational command, and decision-support warfare doctrine.[H] By combining artificial intelligence, cognitive

Figure 1 Midjourney AI Conceptualization of SSF capabilities in 2030 invading Taiwan

[43] Intelligentized warfare is China's approach of incorporating emerging technologies such as artificial intelligence, cloud computing, big-data analytics, quantum information, the internet of things, cognitive dimension, and unpiloted systems to achieve dominance.
Koichiro Takagi, "The Future of China's Cognitive Warfare: Lessons from the War in Ukraine | Hudson," July 22, 2022, https://www.hudson.org/national-security-defense/the-future-of-china-s-cognitive-warfare-lessons-from-the-war-in-ukraine

warfare, machine learning, and human-machine collaboration, China has developed a highly sophisticated intelligentized warfare doctrine that employs advanced physical force structures within the Strategic Support Force to further Xi Jinping's political gains. This doctrine encompasses technologies such as intelligent communication networks, brain science initiatives, and combat robotics.[H] This poses a significant challenge for the United States, as DoD struggles to adopt these advanced technologies or concepts or even update their existing systems and force structure accordingly.[M] China's establishment of the Strategic Support Force (SSF) has given them a military space and information-warfare organization that is vastly different from those handling similar missions for the United States and its allies. By integrating space, cyber, cognitive warfare, and electronic warfare, China has created a unique force structure that will fully realize intelligentized warfare capabilities by 2030, with plans to test these capabilities in Taiwan.[HM] As a result the Council on Foreign Relations and senior U.S. intelligence analyst believe, "the cognitive domain will become another battle domain next to the land, sea, air, space, electromagnetic, and cyber domains of warfare." [HM] "According to a DoD Report on Military and Security Developments Involving The People's Republic of China, "PLA strategists have affirmed that new technologies will accelerate the speed and intensity of future warfare. They advocate that A.I. operationalization is critical to enhancing information processing speed and quality, enabling more accurate decision-making and creating a strategic advantage against potential adversaries." [HH] In addition, the DoD report reveals that Chinese leadership has set an ambitious goal for military modernization by 2027, coinciding with the 100th anniversary of the PLA's founding. This goal involves achieving the "integrated development of mechanization, informatization, and intelligentization."[HH] of its forces. This powerful statement highlights China's determination to become the world's dominant military force, leaving the rest of the world struggling to keep up with its advanced and intelligentized military capabilities.

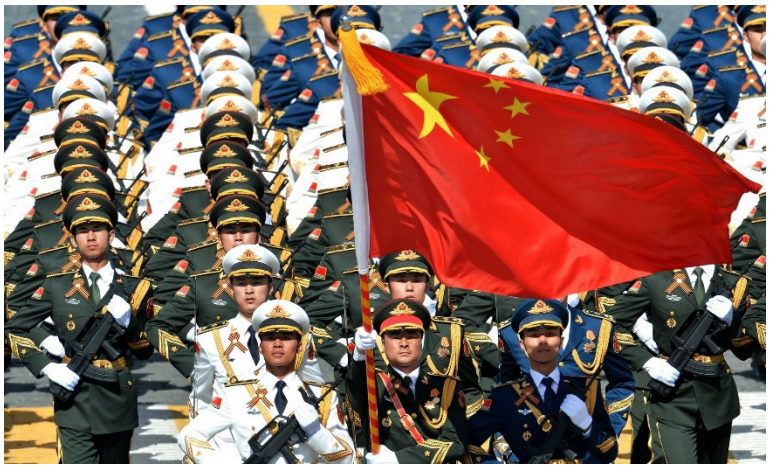


Figure 2 Joint Soldiers of the PLA Strategic Support Force Stand in Formation

Figure 2: Changes in US Doctrine identify a future that some consider as science fiction and well behind strategic competitors.

Despite recent institutional training and new doctrine publication changes [HM] in the United States, the Department of Defense (DoD) leaders required to prepare, defend, and fight an Intelligentized war are alarmingly underprepared. The DoD has not provided the necessary training to address these critical gaps in knowledge, understanding, and expertise.[HM] This leaves the United States without it's own version or counter to the Strategic Support Force, no intelligentized warfare doctrine, and no future forces program or equipped to handle intelligentized warfare as a multi-domain operational problem in the future. This lack of preparation and response to China's advanced intelligentized warfare capabilities is a glaring weakness that must be urgently addressed if the free world is to retain a competitive and effective advantage and deterrence in the global military landscape.

Analytic Confidence

The confidence level for this estimate is High, as multiple sources have provided examples of significant advancements in Chinese intelligentized warfare, particularly regarding the strategic support force and the integration between Chinese academic institutions and the military. Ongoing analysis of open-source reporting and classified reporting is needed to fully understand the extent of China's intelligentized warfare capabilities. Most sources agree that China's intelligentized warfare provides a critical advantage to its military. However, this estimate remains subject to change due to the long-time span and rapid technological advancements in intelligentized warfare. This estimate can be refined further with additional time and staffing, given the volume of scientific literature associated with intelligentized warfare.

Author: Lt Col Dorian C Hatcher [44]

[44] ChatGPT, Perplexity AI, Jasper AI, Google Translator, Midjourney AI and Speechify.com ask Ai Bot were utilized in this estimate's argument research and construction.

Wars and Conflicts in 2035 Will Almost Certainly be Characterized as AI-Enhanced Attritional Warfare

Executive Summary

Due to rapid advancements in AI, it is Almost Certain (86-99%) that future wars and conflicts in 2035 and beyond will focus on attrition over annihilation. Due to the lack of proven future warfighting concepts, warfare will remain an exercise in national attrition. The nation that can mobilize its forces and bring them to bear on an enemy over time will prevail.[H] This concept has been true through both world wars, Iraq, Afghanistan, and the war in Ukraine, and it will continue to be true for future wars.

Discussion

The fusion of traditional military skills and tactics with Artificial Intellgence (AI) and Machine Learning (ML) technology is driving the evolution of a new doctrinal concept of war that is based on rapid and accurate decisions, deployments and destruction of the adversary's ability and will to fight – instead of one based merely on the targeting of enemy armament and arsenal.[M] The key potential effect of AI and ML technologies on warfare is the ability to conduct more precise targeting, resulting in a shift towards a focus on attrition rather than annihilation. Attrition is defined by the merriam-webster dictionary as, "the act of weakening or exhausting by constant harassment, abuse, or attack."[H] Wars of attrition look more like grey zone warfare and other actions that remain below the level of armed conflict. Annihilation is defined defined by the merriam-webster dictionary as, "the state or fact of being completely destroyed or obliterated."[H] Wars of annihilation would be considered "total war" or likely to be some form of nuclear warfare. With advanced sensors, data analytics, and autonomous systems, militaries can identify and target specific high-value targets more accurately and quickly than ever before. AI is also expected to empower autonomous and high-speed weapons to carry out

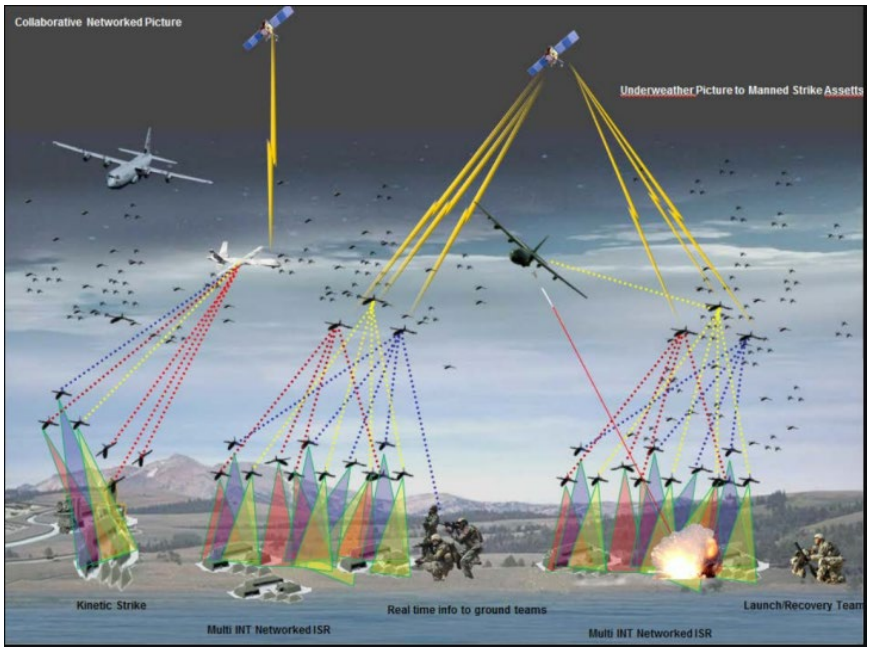


Figure 1: Artist's concept of a drone swarm battlefield
U.S. Air Force / Via defenseinnovationmarketplace.mil

collaborative attacks.[M] In the future actors will focus on both offensive and defensive operations focused on reducing their own speed of attrition while increasing that of their opponent.[M]

The ongoing war in Ukraine demonstrates that the latest warfighting technology, such as drones, cyber capabilities, and HIMARS (High Mobility Artillery Rocket System), fuel destructive battles of attrition.[H] AI is better equipped than humans to explore the exposure-manipulated speed of attrition concept, which is the most basic, irreducible dynamic of combat.[M] Combat exposure, or the degree of a military unit's stealth, is determined by two factors: the physical presence of the unit in the enemy's range of fire, and the enemy's knowledge of the unit's exact location within that range, both will be enhanced by AI.[M] AI-driven combat systems have the potential to impact military strategy by improving knowledge about the combat environment, including the opponent's location, enabling quick decision-making and faster movements, thereby decreasing one's own exposure and increasing the opponent's.[M] The intensity and speed of combat exposure and attrition will become faster, and will destroy combat resources more quickly and in higher quantities, making wars costlier for the defeated.[M] A military could, theoretically, be broken by attrition—at least long enough for its adversary to establish facts on the ground.[M] The National Security Commission on Artificial Intelligence final report stated that "AI will compress decision time frames from minutes to seconds, expand the scale of attacks, demand responses that tax the limits of human cognition. Human operators will not be able to defend against AI-enabled cyber or disinformation attacks, drone swarms, or missile attacks without the assistance of AI-enabled machines."[H] Not all actors will be able to afford and be willing to fight wars. Therefore, future wars will focus more on attrition, with a greater emphasis on sustained engagement and the gradual weakening of the enemy's capabilities, in contrast, a war of annihilation would seek to destroy the enemy's military and civilian infrastructure, often through rapid and decisive military action. Actors with limited resources or those facing adversaries with superior conventional military capabilities will be forced to resort to cheaper and more resilient capabilities to suit their specific needs and situations that will include guerrilla warfare, asymmetric warfare, limited cyber warfare, and the use of unmanned systems such as drones. All of these capabilities will most likely operate independently of each other, and the effects of their employment would be diminished until such a time that the actor could invest in AI-driven capabilities to mass affects and attrit their enemies' forces.

Figure 2: Artist's concept of Convergence Concept https://www.behance.net/gallery/97114175/CONVERGENCE_CONCEPT

Analytic Confidence

The analytic confidence for this estimate is *moderate*. Sources were generally reliable and tended to corroborate one another. There was adequate time, but the analyst worked alone and did not use a structured method. Furthermore, given the lengthy time frame of the estimate, this report is sensitive to change due to new information.

Author: LTC Samuel A. Meyer

Widespread Use of Human Performance Enhancement Drugs Across The Commercial Industry And Defense Sectors is Highly Likely by 2040

Executive Summary

Despite the ethical and safety concerns regarding Human Performance Enhancement (HPE) drugs, it is highly likely (71-85%) that HPE drugs will reach widespread use by 2040, due to the prevalence of drugs in areas such as sports and the military and the persistent drive to enhance human performance to gain a competitive advantage.

Discussion

Human performance enhancement (HPE) refers to the use of various techniques, methods, and tools that are designed to improve and optimize human physical and mental abilities.[H] One method employed for centuries is the use of drugs. From caffeine and nicotine to amphetamines and steroids, people have turned to various substances to improve their physical abilities, mental focus, and memory retention (see Figure 1).[M] In recent years, technological advancements in HPE technologies, such as Brain-Computer Interfaces, Clustered Regularly Interspaced Short Palindromic Repeats, Physical Brain Stimulation, and Genetic Modifications[H] have gained widespread attention in academic, professional, and defense sectors, with the potential to enhance our physical and mental capabilities beyond what was previously thought possible.[H] But these HPE technologies are still in their early stages of development and require more research before their full potential can be realized. Due to the nascent nature of this technology coupled with the relatively simpler and more predictable regulatory pathway for drug approval, scientists and researchers are placing greater emphasis on the pharmaceutical development of stimulants and cognitive enhancers[45] such as amphetamine, methylphenidate, or modafinil, and Nootropics[46][HH] (smart drugs), the use of which is steadily transitioning from the medical treatment of illnesses and cognitive disorders to becoming more common to sustain physical and cognitive competitive advantage, especially in the defense sector.

Figure 1: How Performance Enhancing Drugs became Part of our Work Life. Source: https://forbes.co.il/e/drugs-are-the-new-coffee-how-performance-enhancing-drugs-became-part-of-the-work-life/

[45] Cognitive enhancers encompass a wide range of drugs, including prescription medications for attention deficit disorders and pharmacological compounds for cognitive enhancement.

[46] Nootropics, also known as “smart drugs,” are a diverse group of medicinal substances whose action improves human thinking, learning, and memory, especially in impaired functions.

Figure 2: Blue Eagle. Source: https://www.kondomkungen.se/blue-eagle-power-pills

China has heavily invested in its military capabilities in recent years, explicitly focusing on the technological aspects of HPE[MM] as the backbone of intelligentized warfare.[47] Despite the technical advantages of this new domain in warfare, the People's Republic of China (PRC) recognizes that technologies are mere tools in the hands of warfighters and is incorporating HPE drugs to sustain a competitive advantage.[M] One such drug is the "Night Eagle," (see Figure 2), which allegedly aims to complement physical endurance and stamina, enabling Soldiers' peak performance capable of outlasting and outperforming their adversaries in the most challenging combat situations for four consecutive days.[M]

A meta-analysis by the Army Aeromedical Research Lab and the European College of Neuropsychopharmacology found that modafinil and dextroamphetamine improved cognition, alertness, and judgment with fewer side effects than caffeine.[MH] The U.S. Air Force has used dextroamphetamine (Dexedrine) since at least the late 1980s to sustain alertness in aircrews on long missions and has authorized the use of modafinil (Provigil) (see Figure 3), a newer stimulant that is commonly used to treat narcolepsy and promote alertness in shift workers, for use in multi-seat fighter and bomber crews.[M] Modafinil is currently under review by the Army for approval and, according to the *Leaders Guide to Soldier Crew and Endurance,* updated in January 2015, will soon be approved for use in the Army and Navy.[M] The Special Operations Command is studying the integration of HPE drugs as a complement to their Hyper-Enabled Operator[48] concept,[MMHM] aiming to enhance the operator's physical strength and endurance, thus expanding the combat capability in places they are ill-equipped to inhabit naturally, such as high altitudes and underwater.[H]

Figure 3: Modafinil - The Time Shifting Drug. Source: https://newatlas.com/go/3574/

Despite the myriad of studies affirming the effects of increased productivity and improved performance, there are significant ethical and safety concerns among the scientific community

[47] Intelligentized warfare refers to the distinctive Chinese concept of applying AI's machine speed and processing power to military planning, operational command, and decision support.

[48] The Hyper Enabled Operator (HEO) is a SOF professional empowered by technologies that accelerate tactical decision-making by increasing situational awareness and reducing cognitive workload.

due to the potential long-term effects on physical and mental health, and the ambiguous regulatory policies.[HHM] Some studies have found an increased risk of death and a wide variety of cardiovascular, psychiatric, metabolic, endocrine, neurologic, infectious, hepatic, renal, and musculoskeletal disorders,[HHH] while assessing that the benefits are relatively modest, primarily limited to improvements in recall, inhibitory control, and sustained attention.[HM] Other studies raise the potential problems with inequality due to the drugs perceived competitive advantage which can in turn lead to widening gaps in quality of life, education, and income.[H] To address the ambiguity of regulatory policies, ethical frameworks have emerged at the national and international levels to guide the development and implementation of HPE technologies and drugs rooted in the principles of bioethics, risk assessment, human dignity; harm minimization, autonomy, and consent; fairness and justice; accountability and transparency; privacy; proportionality; broad societal implications; and compatibility with international legal frameworks.[M]

Due to the active research on human performance enhancement, from sports-related studies to worker enhancement to military applications, coupled with the formulation of ethical and regulatory policies across technologically advanced countries and regions worldwide, the widespread use of HPE drugs is highly likely by 2040.

Analytic Confidence

The analytic confidence in this estimate is *moderate*. Sources were generally reliable based on the credibility of the respective articles and publications. While the sources tended to corroborate one another, they varied in their forecasts and adoption. Although the analyst had sufficient time, the analyst worked independently without following a structured method. Furthermore, this report is susceptible to change due to associated technical challenges, ethical concerns, and policy and legal developments regarding HPEs, all of which will influence the time horizon for the widespread use of HPE drugs. Additional time and staffing are required to improve this estimate.

Author: LTC Fidel Arvelo[49]

[49] ChatGPT, You.com, and Perplexity were utilized in this estimate's research, construction, and data summarization.

Annex A: Terms of Reference

Terms of Reference:
Preparing for Intelligentized Warfare in 2035

For:

Mr. Thomas F. Greco
Deputy Chief of Staff, G-2
U.S. Army Training and Doctrine Command

By:
Team Techno Warfare Group (TWG)
USAWC

December 7, 2022

Terms of Reference:
Preparing for Intelligentized Warfare in 2035

Requirement:

What will *Intelligentized warfare*[1] look like in 2035, and what skill sets will leaders need to win in this environment?

- Scope characteristics of warfare in 2035 that are "intelligentized."
- Will the advent of intelligentized warfare enhance the current approach to warfare, transform the approach, or lead to a revolution in military affairs?[2]
- Based on the projection from the previous question, might this lead to increased frequency of wars of annihilation or wars of attrition?
- Forecast beneficial Knowledge, Skills, and Behaviors (KSB) future leaders will need to operate effectively in 2035.
- What training, educational, or cognitive programs exist for future leaders?

Methodology:

Team TWG aims to research and evaluate information via several methods, including but not limited to data collection from open-source, primary, and credible periodicals/journals and interviews with academics, subject matter experts, political scientists, military strategists, and international analysts. The team may further identify and recommend changes if applicable.

The team aims to complete this project in four steps. The team will be flexible to exploit opportunities and manage potential challenges:

- *Step 1:* Conduct the following efforts in parallel. Define/Model the problem. Begin data Collection, Dissemination, and Analyzation (November - February 2023).
    - Forecast intelligentized warfare in 2035.
    - Examine and calculate China's perspective.
    - Forecast and study Russia's perspective.
    - Estimate and assess the U.S. and its partner's perspective.
    - Investigate advanced joint all-domain warfare to include cognitive warfare, AI-driven decision-making, and autonomous or semi-autonomous systems technologies.[3]
    - Execute mindmap of the problem.[4]
    - Interview subject matter experts, for example, COL Takagi Koichiro (Japanese Defense Force).
    - Team TWG agree on an answer to the previously stated question, "will the advent of intelligentized warfare enhance the current approach to warfare, transform the approach, or lead to a revolution in military affairs?".

- *Step 2:* Conduct the following efforts in parallel. Analyze and refine the problem model (February – March 2023).
    - Synthesize, analyze and refine the problem set by evaluating the research findings.
    - Synthesize, analyze and refine critical Knowledge, Skills, and Behaviors for evaluation as most beneficial in intelligentized warfare training.

- *Step 3:* Conduct the following efforts in parallel. Compile and execute production (March -April 2023).
    - Compile a comprehensive report including team findings, recommendations, and imagined futures.
    - Including briefs, graphics, and other enhancements as defined by the team.

- *Step 4:* Out-brief vital stakeholders with the finalized product (April -May 2023).

Challenges:

- *Final Product.*
  - The team will primarily use unclassified, open-source information to support an unclassified final product.

- *Classroom environment.*
  - This project is in addition to the research team's regular U.S. Army War College requirements.

- *Possible Futures.*
  - There are endless possibilities for exploring potential future conflicts. The team must scope the operational environment to focus on the "*Intelligentized*" and *"Technological"* aspects so that it remains beneficial for the client.

- *Budget.*
  - Limited Funds are available for printing, research, and travel to accomplish project objectives
  - While the research team is open to TDY for critical research options, missed classes will need approval by the appropriate faculty.
  - The estimate must be completed by Mid-April 2021.

- *Specific challenges based on the question.*
  - Our team lacks expertise in economics, acquisition, and cognitive science concentrations. The team will overcome this challenge by consulting outside industry and academic sources or residents within the U.S. Army War College academics.
  - Research on adversaries will likely require translation with no Chinese or Russian linguists on the research team.

Resources:

- *Personnel.*
  - The team consists of five personnel, Colonels and Lieutenant Colonels, with a wealth of experience in counterinsurgency, combat deployments, forensic exploitation, protection, military police, laboratory science, nursing, medical, attack aviation, logistics, space, School of Advanced Military Studies and Joint planning, and explosive ordnance disposal.
  - The team can leverage personal relationships with domestic and international colleagues, government laboratories, DARPA, medical infrastructure, intelligence exploitation architecture, justice and law enforcement, government, academic, and other institutional State and federal entities.

- *Institutional.*

- Access to the USAWC Library, a wealth of proprietary databases, numerous SMEs across AWC faculty, a wargaming division in CSL, and SMEs in data science and S&T.
- Open-source websites and print media such as books, brochures, journals, magazines, and newspapers.

- *Money*.
  - Funds are available for limited TDY in case of meeting with an individual, think tank, or attending a relevant convention.

- *Recommended outreach by the client*.
  - "Mad Scientist" Podcast; China expert on TRADOC G2 staff; COL (RET) Steve Banach, Director, Army Management Staff College; Mr. Lee K. Grubbs (TRADOC G2) can connect with other people, "think tanks," etc. (lee.k.grubbs.civ@mail.mil).

Administration:

Team TWG will provide Mr. Tom Greco, D/CoS G2, TRADOC, with the final product in Adobe Portable Document Format.

- Team TWG will prepare a draft report and submit it for peer/faculty review before the official presentation to the decision-maker in April 2023.

- The research team comprises (all phone numbers are personal cell):

  - Team Point of Contact:
  Samuel Meyer, samuel.meyer.mil@armywarcollege.edu;
  734-660-2739

  - Alternate Team Point of Contact:
  Dorian Hatcher, dorian.hatcher.mil@armywarcollege.edu;
  770-826-7750

  - Team Members:
  Leslie Carlson, leslie.carlson.mil@armywarcollege.edu;
  303-817-0392

  - Phillip Cain, phillip.cain.mil@armywarcollege.edu;
  813-857-3698

  - Fidel Arvelo, fidel.arvelo.mil@armywarcollege.edu;
  210-204-8635

Annex B: Interview with Shield AI

Interview with COL(R) Jason Davis and COL(R) John Cochran, Shield AI

About Shield AI:

- **What We Do:** Our mission is to protect service members and civilians with intelligent systems."
- **Our Story:** As a Navy SEAL, Shield AI co-founder Brandon Tseng experienced firsthand problems where intelligent autonomy could have made life-saving differences. He asked himself what does the military of 2030 look like and what role does autonomy play. The answer – AI pilots powering every military asset: aircraft, drones, ships, satellites and submarines. The lack of software and AI engineering talent from large defense primes presented an opportunity to start fresh and build the aerospace and defense technology company of the 21st century focused on AI pilots. And in 2015, alongside cofounders Ryan Tseng, and Andrew Reiter – Shield AI was founded to bring the best of AI and autonomy technology to the DoD and our allies to protect service members and civilians.

Team Techno Warfare Group Present: LTC Matthew Rasmussen (Project Advisor), COL Leslie Carlson, LTC Samuel Meyer, LTC Fidel Arvelo, Lt Col Dorian Hatcher, LTC Phillip Cain

Truncated notes of key topics below. COL(R) Jason Davis gave permission for recording; full transcript available upon request.

In response to question about limitations that would prevent fully autonomous, unmanned systems in the US military.

- US Army DOTMLPF-P (Doctrine, Organization, Training, Materiel, Leadership and Education, Facilities and Policy) is a necessary evil to align and scale new systems, but the process slows the innovation process.
- From a doctrine perspective, the Army often views AI with a narrow lens, focused on decision assistance and decision making, but it does not necessarily look how we may be able to use AI on the edge. Several commercial companies are focusing their expertise in those various areas, but no single company is currently proficient in all ways that AI might be employed. (Analogy using different automakers that are specialized in specific types of vehicles- TESLA is trying to build the best autonomous driver, while Shield AI is trying to build the best autonomous pilot). If DoD searches for one vendor that is able to support all types of AI integration, it could hinder the DoD from capitalizing on the best AI support in each area of AI.
- The culture in DoD will limit the "realm of the possible" for AI use. (Analogy of how the Army transitioned to using horses with the advent of the truck. Initially put horses on trucks and drove them around instead of using trucks in a different way).

- How might the DoD benefit from using AI in various echelons? AI-supported decision-making, computer AI support for maneuver systems for air vehicles or other systems, other individual systems that may be augmented by AI support? Might the DoD be constricted to thinking about existing formation AI support, instead of a new type of formation?
- The cost of AI talent will also be prohibitive for the Army, as it is competing against commercial companies that are paying top dollar to attract talent. A top AI engineer coming out of Carnegie Mellon with just a bachelor's degree is pulling about $300K a year. The DoD has a huge challenge attracting talent because they just don't have the compensation mechanisms as the civilian sector. The DoD has great research labs, and they have the ear of the senior leaders, but they will continue to struggle to attract the best talent.
- Innovations must also align with our national interests and values. Current ethical guidelines are likely to slow down the DoD.
- Policy between different services currently limit what rank can operate an unmanned system. There are other factors for unmanned aerial systems that revolve around weight, if the system needs a runway, and if the system operates in controlled airspace. What happens when there is an “AI-agent” at the helm? Will the DoD need to structure various restrictions for AI systems based on what type of task it is accomplishing- from tactical task involving friendly support reconnaissance that is enemy-based?
- The acquisition process could also prove to be a barrier to progress in AI-related systems. Funds are programmed out five years, but AI technologies are progressing so fast, that the system could be obsolete in five years, so flexibility in our acquisition process needs to improve.
- The US-process is more transparent than our adversaries and more restrictive, so in an environment where emerging technologies are rapidly changing, our process puts us at a disadvantage related to our adversaries. The DoD labs are lacking in some resident expertise, but in comparison, our near-peer adversaries don’t have the same issue, and so they are ahead of the US in many respects.
- Another issue that could be a detriment to progress with AI is ignorance about what is currently possible with AI across the department of defense, and what is in the realm of the possible over the next four years.
- Culture among different age groups is an interesting challenge. Those that have not grown up with systems in support may find it difficult to believe a machine may be able to execute tasks better than humans (Compare a COL that may not trust AI to pilot a 737, whereas the younger generation does not have the same proclivities).
- Autonomy is limited by setting boundaries to ensure that appropriate left and right limits are established, much like soldiers or subordinate units are given restrictions, restraints, and constraints during their planning. This means giving specific guidelines, such as "do not proceed beyond phase line spring" or "you may use this level of munition in this area, but you must obtain my approval first." These limitations ensure that autonomy is exercised within a certain framework and that decisions are made in a way that aligns with overall objectives.

In response to what type of skills or attributes leaders will need in the future environment.

- Educating senior leaders will be critical to enable thinking outside the box in how the DoD might employ AI.
- Senior leaders will need to advocate for the resources required to get the technological capability that we think we will need. In labs, it is often the case that the necessary expertise to accomplish certain tasks does not exist.
- The goal is to act as a filter for the results of the data fusion process, allowing for further filtering if necessary. Rather than teaching a leader in 2035 how to perform data fusion, the focus is on teaching them how to identify gaps in the fused data.

In response to the question about training simulation for AI enabled platforms and systems.

- You wouldn't send untrained soldiers to war, it is important to train agents (AI systems) before sending them out. This allows their behaviors to develop over time. Therefore, we focus on reinforcement learning model and reinforcement learning training to ensure that agents are properly prepared for their tasks.
- A 31 year pilot fighter pilot can be created in about 6 months and unlike. In the past, we used methods such as blunt force trauma to learn. However, an agent trained using reinforcement learning can remember what it learns and apply it to different scenarios. By using a blend of reinforcement learning and heuristic algorithmic models, with an 80:20 split, we can create a set of heuristic behaviors that allow the agent to respond appropriately to certain task conditions. This means that the agent can perform effectively in a variety of situations and learn expeditiously faster than humans.

In response to the question about possibilities and projected future use of AI enabled platforms and systems.

- Before a flora assault, there are sensors equipped with hive mind or AI technology located 300 miles ahead. These sensors communicate with each other through a mesh network or JADC 2 and relay information about what they are seeing and the behaviors they are executing. This enables them to conduct a screen, providing reports about the size and type of radar or other features they encounter. The sensor collects data, which is then relayed back to the passive AI system within the flora. Although the technology for fully autonomous aircraft is still in development and may not be ready for use within your career or the careers of your lieutenants, it is not feasible to send human pilots into a flora that is fully automated. The aircraft may have one pilot instead of two, but it is the passive AI system on the flora that controls the aircraft rather than the pilot.
- The passive AI system on the flora uses its trained behaviors to determine the best route for ingress that has the lowest chance of being detected by enemy sensors and penetrating the IADS. Although the system could fly aircraft, it has been instructed not to do so. The AI system uses information gathered by completely uncrewed systems located far ahead of the flora, which sense radar energy and determine its direction and intensity. Based on this data, the AI system calculates the probability of detection, which enables it to determine the optimal route to take.

- Because we're (U.S.) platform centric, the future is bending metal around software and that metal may not look like anything we've ever seen before, but that software.
- You nailed it when you mentioned the idea of relieving the pilot from both the mental and physical burden. The AI systems that we are designing, as well as other industries, are primarily focused on enhancing the current human capabilities. We are not looking to entirely replace humans, but rather reduce the need for 10 humans to only one, while also minimizing risk.

In response to the question about autonomy and trust.

- The level of trust between the pilot and the AI system is significant. If the pilot does not trust the AI system, they will not activate it.
- We do a significant amount of work in simulation at the outset to develop our autonomy. As the level of complexity and capability of the autonomy system increases, and the trust in it grows, the pilot in the F35 aircraft is able to delegate many of their tasks to the system. In an ideal scenario, the autonomy system is fully capable of flying the aircraft.

In response to the question about partners and allies and other companies that may be ahead of the U.S. in fielding AI driven systems and platforms.

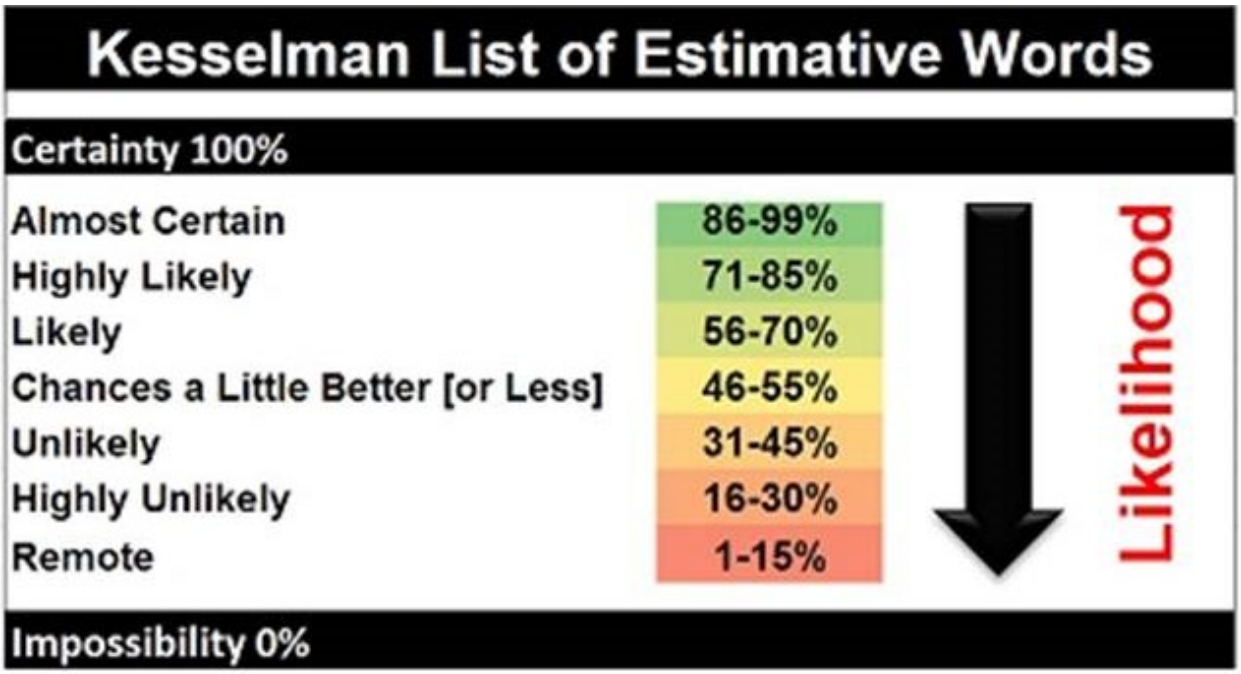
- Australians, South Korea, Isreal are all doing well. It's probably that's a country to investigate if you want to do actual deeper dive and put that into your report and then.
- Other competitors within space uh for shield AI. Uh, I think Palantir and Epesi do a great job of decision-making support, right? So the overall and it's just there are established they've got all those, they've got data for days and they can just mine it and build out decision trees.

In response to the question about what the DoD could do better.

- Senior leaders, we need to invite cutting it in, just cutting-edge industry.
- The DoD lacks knowledge on almost everything related to it (AI)- from budgeting, to acquiring, testing, evaluating, and even classifying it.

Johnny Cochran

Annex C: Kesselman List of Estimative Words



Annex D: Trust Scale and Website Validation

Trust Scale and Web Site Evaluation Worksheet
(Updated OCT 2013)

Piece of Evidence #:												Score:	Trust Scale:
Criteria	**Tips**	**Value**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**Y or N**	**0**	**15-20 High**
Content can be corroborated?	Check some of the site's facts	2											**11-15 Moderate**
Recommended by subject matter expert?	Doctor, biologist, country expert	2											**6-10 Low**
Author is reputable?	Google for opinions, ask others	2											**5-0 Not Credible**
You perceive site as accurate?	Check with other sources; check affiliations	1.5											
Information was reviewed by an editor or peers?	Science journals, newspapers	1.5											
Author is associated with a reputable org?	Google for opinions, ask others.	1.5											
Publisher is reputable?	Google for opinions, ask others.	1.5											
Authors and sources identified?	Trustworthy sources want to be known	1											
You perceive site as current?	Last update?	1											
Several other Web sites link to this one?	Sites only link to other sites they trust	1											
Recommended by a generalist?	Librarian, researcher	1											
Recommended by an independent subject guide?	A travel journal may suggest sites	1											
Domain includes a trademark name?	Trademark owners protect their marks	1											
Site's bias in clear?	Bias is OK if not hidden	1											
Site has professional look?	It should look like someone cares	1											
Total		**20**											

19 Dec 2001: The criteria and weighted values are based on a survey input from 66 analysts. For details see: http://daxrnorman.googlepages.com/analysis. Edited for simplicity by Kristan J. Wheaton, OCT 2013
3 Feb 2012: Excel Spreadsheet which adds auto-sum was produced by Bill Welch, Deputy Director, Center for Intelligence Research Analysis and Training, Mercyhurst College.
26 Jan 2013: Trust Scale and Web Site Evaluation Worksheet is in the PUBLIC DOMAIN.

Annex E: List of Integrated Short Form Analytic Report References Almost Certain One Revolution in Military Affairs, Highly Likely Multiple Other Revolutions in Miliary Affairs, But Unlikely Military Revolution by 2035

Revolution in Military Affairs on JSTOR
https://www.jstor.org/stable/j.ctt809jk
The Dynamics of Military Revolution, 1300–2050
https://digital-commons.usnwc.edu/nwc-review/vol56/iss2/16/
Why the U.S. Needs a Revolution in Military Affairs/ Foreign Affairs
https://www.foreignaffairs.com/united-states/new-revolution-military-affairs
Revolution in Military Affairs-An Appraisal
https://ciaotest.cc.columbia.edu/olj/sa/sa_apr00kak01.html
The Maturing Revolution in Military Affairs
2011.06.02-Maturing-Revolution-In-Military-Affairs1.pdf (csbaonline.org)
The New Revolution in Military Affairs War's Sci-Fi Future
https://www.foreignaffairs.com/united-states/new-revolution-military-affairs
How LiFi can transform wireless networks
https://www.itp.net/infrastructure/networking/how-lifi-can-transform-wireless-networks
Brain-Computer Interfaces U.S. Military Applications and Implications, An Initial Assessment
https://www.rand.org/pubs/research_reports/RR2996.html
The Soldier of the Future
https://www.youtube.com/watch?v=rlm68B53jek
Technological Approaches to Human Performance Enhancement
https://www.rand.org/pubs/research_reports/RRA1482-2.html
Revolution in Military Affairs vs Military Revolution
https://smallwarsjournal.com/jrnl/art/revolution-military-affairs-vs-military-revolution-emergence-drones-and-robotics-driver
Weak AI is a building block to its sophisticated successors
https://dataconomy.com/2022/06/17/artificial-narrow-intelligence/
AI Ethics And The Geopolitical Wrestling Match Over Who Will Win The Race To Attain True AI
https://www.forbes.com/sites/lanceeliot/2022/08/15/ai-ethics-and-the-geopolitical-wrestling-match-over-who-will-win-the-race-to-attain-true-ai-or-agi/?sh=3414e26b7536
Commercial and Defense Applications of Quantum Brain Networks, The Convergence of Artificial Intelligence, Quantum Computing, and Brain Computer Interface Technology, Likely by 2040
https://www.rand.org/pubs/research_reports/RRA1482-4.html

Commercial and Defense Applications of Quantum Brain Networks, The Convergence of Artificial Intelligence, Quantum Computing, and Brain Computer Interface Technology, Likely by 2040

China's Strategic Support Force: A Force for a New Era
https://ndupress.ndu.edu/Media/News/Article/1651760/chinas-strategic-support-force-a-force-for-a-new-era/
Future war studies community and the Chinese Revolution in Military Affairs
https://academic.oup.com/ia/articleabstract/96/5/1327/5876629?utm_source=share&utm_medium=member_android&utm_campaign=share_via
Artificial Intelligence Task Force Welcomes Inaugural Class of AI Scholars | Article | The United States Army
https://www.reuters.com/technology/elon-musk-says-expects-neuralink-begin-human-trials-six-months-2022-12-01/
Artificial Intelligence Task Force Welcomes Inaugural Class of AI Scholars
https://www.army.mil/article/237258/artificial_intelligence_task_force_welcomes_inaugural_class_of_ai_scholars
Journal of Medical Internet Research An Integrated Brian-Machine Interface Platform With Thousands of Channels
https://www.jmir.org/2019/10/e16194/
Brainwave Authentication And Brain-Computer Interface Using In-Ear EEG – BioSENSE | UC Berkeley
https://biosense.berkeley.edu/portfolio/brainwave-authentication-and-brain-computer-interface-using-in-ear-eeg/
Li-Fi Technology: What it is, How it Works and its importancehttps://techresider.com/technology/li-fi-technology/
https://techresider.com/technology/li-fi-technology/
Li-Fi Market Is Predicted To Hit USD 116.96 Billion at a CAGR of 31.60% by 2030 - Report by Market Research Future (MRFR)
https://www.globenewswire.com/news-release/2023/03/08/2623432/0/en/Li-Fi-Market-Is-Predicted-To-Hit-USD-116-96-Billion-at-a-CAGR-of-31-60-by-2030-Report-by-Market-Research-Future-MRFR.html
An approach to interfacing the brain with quantum computers: practical steps and caveats
https://arxiv.org/pdf/2201.00817.pdf
In-Depth Guide to Quantum Artificial Intelligence in 2023 (aimultiple.com)
https://research.aimultiple.com/quantum-ai/
Brain-Computer Interfaces: U.S. Military Applications and Implications, An Initial Assessment RAND
https://www.rand.org/pubs/research_reports/RR2996.html
Worries about developments in AI | Pew Research Center
https://www.pewresearch.org/internet/2021/06/16/1-worries-about-developments-in-ai/

The PLA and China's Rejuvenation
https://www.rand.org/pubs/research_reports/RR1402.html
An Integrated Brain-Machine Interface Platform With Thousands of Channels
https://www.jmir.org/2019/10/e16194/
In-Depth Guide to Quantum Artificial Intelligence in 2023
https://research.aimultiple.com/quantum-ai/
Pentagon Seeks Proposals for AI Talent 2.0 Procurement Vehicle
https://www.govconwire.com/2022/12/pentagon-seeks-proposals-for-ai-talent-2-0-procurement-vehicle/
Experts Doubt Ethical AI Design Will Be Broadly Adopted as the Norm Within the Next Decade
https://www.pewresearch.org/internet/2021/06/16/experts-doubt-ethical-ai-design-will-be-broadly-adopted-as-the-norm-within-the-next-decade/
Chinese companies ramp up for emerging BCI technology, ready for larger market
https://www.globaltimes.cn/page/202211/1280640.shtml
US Army invests $4.2 million in large-scale LiFi deployment
https://www.cablinginstall.com/wireless-5g/article/14202283/us-army-invests-42-million-in-largescale-lifi-deployment
Paradromics Raises $20MM in Seed Funding Led by Prime Movers Lab to Advance Brain Computer Interfaces
https://www.paradromics.com/news/paradromics-raises-20mm-in-seed-funding-led-by-prime-movers-lab-to-advance-brain-computer-interfaces
Did China Break The Quantum Barrier?
https://www.forbes.com/sites/arthurherman/2023/01/10/did-china-break-the-quantum-barrier/?sh=aa461994600f
Army War College Futures Program studies emerging issues
https://www.army.mil/article/257548/army_war_college_futures_program_studies_emerging_issues
New research suggests our brains use quantum computation
https://phys.org/news/2022-10-brains-quantum.html
Brain-Computer Interfaces Are Coming. Will We Be Ready?
https://www.rand.org/blog/articles/2020/08/brain-computer-interfaces-are-coming-will-we-be-ready.html

Highly Unlikely the DOD Will have an Artificial Intelligence Ready force by 2035

How the Rise of Artificial Intelligence Could Impact Job Trends
https://emeritus.org/blog/ai-and-ml-rise-of-artificial-intelligence/
Computer and Information Technology Occupations
https://www.bls.gov/ooh/computer-and-information-technology/home.htm

DOD's Cyber Mission Depends on Skilled Workforce, Streamlined Tech, Officials Say
https://www.nextgov.com/cybersecurity/2023/03/dods-cyber-mission-depends-skilled-workforce-streamlined-tech-officials-say/383459/
DOD AI Education Strategy
https://nwcfoundation.org/wpcontent/uploads/2021/02/2020_DoD_AI_Training_and_Education_Strategy_and_Infographic_10_27_20.pdf
Everyone wants a culture of innovation. So what does it look like?
https://cloud.google.com/executive-insights/everyone-wants-a-culture-of-innovation-report-what-does-it-look-like-report
Breaking-down-the-barriers-to-innovation
https://hbr.org/2019/11/breaking-down-the-barriers-to-innovation
Training future AI talent means understanding Gen Z
https://community.hpe.com/t5/the-cloud-experience-everywhere/training-future-ai-talent-means-understanding-gen-z/ba-p/7173809 - .ZEuNl3bMK5c
What is Gen-Z
https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-gen-z
Coding Course vs. Coding Bootcamp
https://www.bestcolleges.com/bootcamps/guides/coding-course-vs-coding-bootcamp/
The PLA And Intelligentized Warfare – Analysis
https://www.eurasiareview.com/02122022-the-pla-and-intelligentized-warfare-analysis/

Intelligentized Warfare Highly Likely to Use Quantum Computing, AI, and Autonomous Systems to Define The Operational Environment of 2035

Chinese Debates on the Military Utility of Artificial Intelligence
https://warontherocks.com/2020/06/chinese-debates-on-the-military-utility-of-artificial-intelligence/
China's National Defense in the New Era
http://www.gov.cn/zhengce/2019-07/24/content_5414325.htm
Intelligent warfare, where is the change
http://www.81.cn/jfjbmap/content/2020-01/21/content_252681.htm
Whoever leads in AI will rule the world': Putin to Russian children on Knowledge Day
https://www.rt.com/news/401731-ai-rule-world-putin/
The Future of Competition: U.S. Adversaries and the Growth of Irregular Warfare
https://www.csis.org/analysis/future-competition-us-adversaries-and-growth-irregular-warfare
Life in 2050: A Glimpse at Warfare in the Future
https://interestingengineering.com/innovation/warfare-in-2050-what-to-expect
Get Ready for Robot Armies: What War Will Look Like in 2035
https://nationalinterest.org/blog/reboot/get-read-robot-armies-what-war-will-look-2035-180321

The Future of Competition: U.S. Adversaries and the Growth of Irregular Warfare
https://www.csis.org/analysis/future-competition-us-adversaries-and-growth-irregular-warfare
Experts Doubt Ethical AI Design Will Be Broadly Adopted as the Norm Within the Next Decade
https://www.pewresearch.org/internet/2021/06/16/experts-doubt-ethical-ai-design-will-be-broadly-adopted-as-the-norm-within-the-next-decade/
Army Multi-Domain Transformation Ready to Win in Competition and Conflict
https://api.army.mil/e2/c/downloads/2021/03/23/eeac3d01/20210319-csa-paper-1-signed-print-version.pdf
What the United States Military can Learn from the Nagorno-Karabakh War
https://smallwarsjournal.com/jrnl/art/what-united-states-military-can-learn-nagorno-karabakh-war
The Use of Drones in the Nagorno-Karabakh Conflict
https://defense.info/air-power-dynamics/2021/06/the-use-of-drones-in-the-nagorno-karabakh-conflict/
The Future of Competition: U.S. Adversaries and the Growth of Irregular Warfare
https://www.csis.org/analysis/future-competition-us-adversaries-and-growth-irregular-warfare
Ukraine Symposium- Data-Rick battlefields and the Future
https://lieber.westpoint.edu/data-rich-battlefields-future-loac/
Quantum Computing Vs. Classical Computing In One Graphic
https://www.cbinsights.com/research/quantum-computing-classical-computing-comparison-infographic/
What is quantum computing?
https://www.ibm.com/topics/quantum-computing
National Quantum Initiative Supplement to the President's FY 2023 Budget
https://www.quantum.gov/wp-content/uploads/2023/01/NQI-Annual-Report-FY2023.pdf
How Quantum Computing Will Transform These 9 Industries
https://www.cbinsights.com/research/quantum-computing-industries-disrupted/
Technological Innovation for Future Warfare
https://www.nato-pa.int/download-file?filename=/sites/default/files/2022-11/025%20STCTTS%2022%20E%20rev.1%20fin%20-%20THE%20FUTURE%20OF%20WARFARE%20-%20FRIDBERTSSON%20REPORT.pdf
Report on Military Applications for Quantum Computing
https://news.usni.org/2021/05/27/report-on-military-applications-for-quantum-computing
Chines Debates on the Military Utility of Artificial Intelligence
https://warontherocks.com/2020/06/chinese-debates-on-the-military-utility-of-artificial-intelligence/

Manipulating The Mind Weaponized Neuroscience is Highly Likely to Become the Dominate Cognitive Warfare Strategic Weapon by 2035

Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation

https://demtech.oii.ox.ac.uk/research/posts/challenging-truth-and-trust-a-global-inventory-of-organized-social-media-manipulation/
New Tech, New Concepts: China's Plans for AI and Cognitive Warfare
https://warontherocks.com/2022/04/new-tech-new-concepts-chinas-plans-for-ai-and-cognitive-warfare/
The Future of China's Cognitive Warfare: Lessons From the War in Ukraine
https://warontherocks.com/2022/07/the-future-of-chinas-cognitive-warfare-lessons-from-the-war-in-ukraine/
Visualization and knowledge production in international relations: The role of emotions and identity
https://journals.sagepub.com/doi/abs/10.1177/1755088219830117?journalCode=iptb
How China's Cognitive Warfare Works: A Frontline Perspective of Taiwan's Anti-Disinformation Wars
https://academic.oup.com/jogss/article/7/4/ogac016/6647447?login=false
Cognitive warfare and the use of force
https://www.stratagem.no/cognitive-warfare-and-the-use-of-force/
Cognitive Warfare: An Attack on the Truth and Thought
https://www.innovationhub-act.org/sites/default/files/2021-03/Cognitive Warfare.pdf
The Missing Domain of War: Achieving Cognitive Overmatch on Tomorrow's Battlefield
https://mwi.usma.edu/missing-domain-war-achieving-cognitive-overmatch-tomorrows-battlefield/
How China's Cognitive Warfare Works: A Frontline Perspective of Taiwan's Anti-Disinformation Wars
https://academic.oup.com/jogss/article/7/4/ogac016/6647447?login=false
Cognitive warfare: Why disinformation is Russia's weapon of choice in the war on Ukraine
https://www.ctvnews.ca/world/cognitive-warfare-why-disinformation-is-russia-s-weapon-of-choice-in-the-war-on-ukraine-1.5797222
Countering cognitive warfare: awareness and resilience
https://www.nato.int/docu/review/articles/2021/05/20/countering-cognitive-warfare-awareness-and-resilience/index.html
The Missing Domain of War: Achieving Cognitive Overmatch on Tomorrow's Battlefield
https://mwi.usma.edu/missing-domain-war-achieving-cognitive-overmatch-tomorrows-battlefield/
Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation
https://demtech.oii.ox.ac.uk/research/posts/challenging-truth-and-trust-a-global-inventory-of-organized-social-media-manipulation/
An Integrated Brain-Machine Interface Platform With Thousands of Channels
https://www.jmir.org/2019/10/e16194/
Technological Approaches to Human Performance Enhancement
https://www.rand.org/pubs/research_reports/RRA1482-2.html

Developments and challenges in human performance enhancement technology
https://www.sciencedirect.com/science/article/pii/S2590093521000394 - bib70
Weaponizing the Brain: Neuroscience Advancements Spark Debate
https://www.nationaldefensemagazine.org/articles/2017/5/11/weaponizing-the-brain-neuroscience-advancements-spark-debate
Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation
https://demtech.oii.ox.ac.uk/research/posts/challenging-truth-and-trust-a-global-inventory-of-organized-social-media-manipulation/
Technological Approaches to Human Performance Enhancement
https://www.rand.org/pubs/research_reports/RRA1482-2.html
Developments and challenges in human performance enhancement technology
https://www.sciencedirect.com/science/article/pii/S2590093521000394 - bib70
Countering cognitive warfare: awareness and resilience
https://www.nato.int/docu/review/articles/2021/05/20/countering-cognitive-warfare-awareness-and-resilience/index.html

Annex F: List of SFAR References

1. Quantum Computing Commercial Adoption Likely By 2040

What is Quantum Computing? | IBM
https://www.ibm.com/topics/quantum-computing
How Quantum Computers Work (thoughtco.com)
https://www.thoughtco.com/what-is-a-quantum-computer-2699359
What is Quantum Computing? | SEEQC
https://seeqc.com/quantum-computing
Here's what it will take to win the quantum computing arms race | Fortune
https://fortune.com/2022/09/02/quantum-computing-cryptography-companies-arms-race/
Quantum Computing Market Size to Reach $4.67 billion by 2030! Quantum Computing Market Report 2023, Market Size, Share, Growth, CAGR, Forecast, Revenue (cognitivemarketresearch.com)
https://www.cognitivemarketresearch.com/quantum-computing-market-report
Chinese scientists make quantum leap with first practical use computer | South China Morning Post (scmp.com)
https://www.scmp.com/news/china/science/article/3208568/chinese-scientists-make-quantum-leap-first-practical-use-computer
Quantum Computing: Current Progress and Future Directions | EDUCAUSE
https://er.educause.edu/articles/2022/7/quantum-computing-current-progress-and-future-directions#fn5
Has Quantum Computing Finally Arrived? - Techopedia
https://www.techopedia.com/the-challenge-of-quantum-computing/2/32537
The State of Quantum Computing with Professor Peter Shor & Professor William Oliver | CSAIL Alliances (mit.edu)
https://cap.csail.mit.edu/engage/spotlights/state-quantum-computing-professor-peter-shor-professor-william-oliver
1 million qubit quantum computers: moving beyond the current “brute force” strategy | SEEQC
https://seeqc.com/blog/1-million-qubit-quantum-computers-moving-beyond-the-current-brute-force-strategy
Chinese Researchers Claim to Break Encryption Using Quantum Computers | News | Communications of the ACM
https://cacm.acm.org/news/268461-chinese-researchers-claim-to-break-encryption-using-quantum-computers/fulltext
Did China Break The Quantum Barrier? (forbes.com)
https://www.forbes.com/sites/arthurherman/2023/01/10/did-china-break-the-quantum-barrier/?sh=441b16e24600
13 Companies Offering Quantum-as-a-Service (quantumbusinessnews.com)
https://www.quantumbusinessnews.com/infrastructure/13-companies-offering-quantum-as-a-service
Quantum computing use cases—what you need to know | McKinsey
https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/quantum-computing-use-cases-are-getting-real-what-you-need-to-know
Google says error correction will lead to useful quantum computers | New Scientist
https://www.newscientist.com/article/2360977-google-says-error-correction-will-lead-to-useful-quantum-computers/

China develops key equipment for chip manufacturing - Global Times
https://www.globaltimes.cn/page/202301/1283282.shtml
Making Quantum Computing a Reality (hbr.org)
https://hbr.org/2022/04/making-quantum-computing-a-reality
National Quantum Initiative Supplement to the President's FY 2023 Budget
https://www.quantum.gov/wp-content/uploads/2023/01/NQI-Annual-Report-FY2023.pdf

2. Almost Certain AI will Completely Change the Character of Warfare by 2035:

Office of the Director of National Intelligence - Global Trends (dni.gov)
https://www.dni.gov/index.php/gt2040-home/gt2040-deeper-looks/future-of-the-battlefield
Episode 14: How the War in Ukraine Ends — None Of The Above (noneoftheabovepodcast.org)
https://www.noneoftheabovepodcast.org/episodes/s4ep14
Asymmetrical Warfare: Today's Challenge to U.S. Military Power | Foreign Affairs
https://www.foreignaffairs.com/reviews/capsule-review/2003-05-01/asymmetrical-warfare-todays-challenge-us-military-power
AI Technology In Military Will Transform Future Warfare-Manish Kumar Jha , Amit Das - BW Businessworld
https://www.businessworld.in/article/AI-Technology-In-Military-Will-Transform-Future-Warfare/13-08-2021-400525/
Life in 2050: A Glimpse at Warfare in the Future | IE (interestingengineering.com)
https://interestingengineering.com/innovation/warfare-in-2050-what-to-expect
Get Read for Robot Armies: What War Will Look Like in 2035 | The National Interest
https://nationalinterest.org/blog/reboot/get-read-robot-armies-what-war-will-look-2035-180321
CCDC CBC-TR-1599, Cyborg Soldier 2050: Human/Machine Fusion and the Implications for the Future of the DOD - Articles of Interest - US Army Mad Scientist - APAN Community
https://community.apan.org/wg/tradoc-g2/mad-scientist/m/articles-of-interest/300458
https://www.youtube.com/watch?v=r1m68B53jek&t=190s

3. Cognitive Social Media Warfare Dominates By 2028, Becoming Fully Autonomous Social Media Predators By 2035

DemTech | Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation (ox.ac.uk)
https://demtech.oii.ox.ac.uk/research/posts/challenging-truth-and-trust-a-global-inventory-of-organized-social-media-manipulation/
New Tech, New Concepts: China's Plans for AI and Cognitive Warfare - War on the Rocks
https://warontherocks.com/2022/04/new-tech-new-concepts-chinas-plans-for-ai-and-cognitive-warfare/
Opinion | Chatbots Are a Danger to Democracy - The New York Times (nytimes.com)
https://www.nytimes.com/2018/12/04/opinion/chatbots-ai-democracy-free-speech.html
The Danger of Fake News in Inflaming or Suppressing Social Conflict | Center for Information Technology and Society - UC Santa Barbara (ucsb.edu)
https://www.cits.ucsb.edu/fake-news/danger-social
Computational Propaganda: Bots, Targeting And The Future : 13.7: Cosmos And Culture : NPR

https://www.npr.org/sections/13.7/2018/02/09/584514805/computational-propaganda-yeah-that-s-a-thing-now
新时代的中国国防_白皮书_中国政府网 (www.gov.cn)
http://www.gov.cn/zhengce/2019-07/24/content_5414325.htm
Minds at War: China's Pursuit of Military Advantage through Cognitive Science and Biotechnology > National Defense University Press > News Article View (ndu.edu)
https://ndupress.ndu.edu/Media/News/News-Article-View/Article/2053585/minds-at-war-chinas-pursuit-of-military-advantage-through-cognitive-science-and/
The Future Of Artificial General Intelligence (forbes.com)
https://www.forbes.com/sites/forbestechcouncil/2021/07/16/the-future-of-artificial-general-intelligence/?sh=304f86f3ba99
Towards artificial general intelligence with hybrid Tianjic chip architecture | Nature
https://www.nature.com/articles/s41586-019-1424-8

4. Developments in Fully Implantable Brain-Computer Interfaces Transform Military Applications by 2035

From Novel Technology to Novel Applications: Comment on "An Integrated Brain-Machine Interface Platform With Thousands of Channels" by Elon Musk and Neuralink - PubMed (nih.gov)
https://pubmed.ncbi.nlm.nih.gov/31674923/
Journal of Medical Internet Research - An Integrated Brain-Machine Interface Platform With Thousands of Channels (jmir.org)
https://www.jmir.org/2019/10/e16194/
Neuralink - Funding, Financials, Valuation & Investors (crunchbase.com)
https://www.crunchbase.com/organization/neuralink/company_financials
Neuralink Jobs & Careers - 101 Open Positions | Glassdoor
https://www.glassdoor.com/Jobs/Neuralink-Jobs-E1616853.htm?filter.countryId=1
Brainwave Authentication And Brain-Computer Interface Using In-Ear EEG – BioSENSE | UC Berkeley
https://biosense.berkeley.edu/portfolio/brainwave-authentication-and-brain-computer-interface-using-in-ear-eeg/
Brain Startup Wants to Read Your Mind With a Helmet - Bloomberg
https://www.bloomberg.com/news/articles/2020-05-05/brain-startup-wants-to-read-your-mind-with-a-helmet#xj4y7vzkg
Paradromics
https://www.paradromics.com/news/paradromics-raises-20mm-in-seed-funding-led-by-prime-movers-lab-to-advance-brain-computer-interfaces
Watch The Science Behind Elon Musk's Neuralink Brain Chip | Currents | WIRED
https://www.wired.com/video/watch/wired-news-and-science-the-science-behind-elon-musks-neuralink-brain-chip
Elon Musk expects Neuralink's brain chip to begin human trials in 6 months | Reuters
https://www.reuters.com/technology/elon-musk-says-expects-neuralink-begin-human-trials-six-months-2022-12-01/
Chinese companies ramp up for emerging BCI technology, ready for larger market - Global Times
https://www.globaltimes.cn/page/202211/1280640.shtml

China's nonhuman primate advantage in brain-computer interface research. (slate.com)
https://slate.com/technology/2021/11/china-brain-computer-interface-research-nonhuman-primates.html
Minds at War: China's Pursuit of Military Advantage through Cognitive Science and Biotechnology > National Defense University Press > News Article View (ndu.edu)
https://ndupress.ndu.edu/Media/News/News-Article-View/Article/2053585/minds-at-war-chinas-pursuit-of-military-advantage-through-cognitive-science-and/
Brain-Computer Interfaces: U.S. Military Applications and Implications, An Initial Assessment | RAND
https://www.rand.org/pubs/research_reports/RR2996.html
Brain-Computer Interfaces Are Coming. Will We Be Ready? | RAND
https://www.rand.org/blog/articles/2020/08/brain-computer-interfaces-are-coming-will-we-be-ready.html
Journal of Medical Internet Research - An Integrated Brain-Machine Interface Platform With Thousands of Channels (jmir.org)
https://www.jmir.org/2019/10/e16194/

5. Widespread Autonomous Drone Swarms Use in Combat Almost Certain by 2035

Drone - Wikipedia
https://en.wikipedia.org/wiki/Drone
Unmanned aerial vehicle - Wikipedia
https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
Unmanned surface vehicle - Wikipedia
https://en.wikipedia.org/wiki/Unmanned_surface_vehicle
Unmanned underwater vehicle - Wikipedia
https://en.wikipedia.org/wiki/Unmanned_underwater_vehicle
DARPA Subterranean Challenge (subtchallenge.com)
https://www.subtchallenge.com/
Future of Drones: Applications & Uses of Drone Technology in 2021 (businessinsider.com)
https://www.businessinsider.com/drone-technology-uses-applications
Future of Drones: Applications & Uses of Drone Technology in 2021 (businessinsider.com)
https://www.businessinsider.com/drone-technology-uses-applications
https://www.youtube.com/watch?v=44KvHwRHb3A&feature=youtu.be
3,051 drones create spectacular record-breaking light show in China | Guinness World Records
https://www.guinnessworldrecords.com/news/commercial/2020/10/3051-drones-create-spectacular-record-breaking-light-show-in-china
Complexity Explorer
https://www.complexityexplorer.org/ "Element of complexity theory include self-organization production of organized patterns, resulting from localized interactions within the components of the system, without any central control. Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute Lecture 7.0 Introduction, Fall 2014), Complexity Explorer, accessed November 3, 2014"
AD1001253.pdf (dtic.mil)
https://apps.dtic.mil/sti/pdfs/AD1001253.pdf
https://www.youtube.com/watch?v=cAXUKNGpMG4&feature=youtu.be

New “traffic cop” algorithm helps a drone swarm stay on task | MIT News | Massachusetts Institute of Technology
https://news.mit.edu/2023/new-traffic-cop-algorithm-drone-swarm-wireless-0313
Israel Rolls Out Legion-X Drone Swarm For The Urban Battlefield (forbes.com)
https://www.forbes.com/sites/davidhambling/2022/10/24/israel-rolls-out-legion-x-drone-swarm-for-the-urban-battlefield/?sh=9e187f14f49c
China’s Swarms of Smart Drones Have Enormous Military Potential – The Diplomat
https://thediplomat.com/2018/02/chinas-swarms-of-smart-drones-have-enormous-military-potential/
https://www.youtube.com/watch?v=2m_3xJKSsbI&feature=youtu.be
German defense firm showcases new air defense system (defence-blog.com)
https://defence-blog.com/german-defense-firm-showcases-new-air-defense-system/
US Army air defense planners take on rising drone threats (defensenews.com)
https://www.defensenews.com/land/2022/11/28/us-army-air-defense-planners-take-on-rising-drone-threats/
US Army Buys Directed Energy Weapon System to Counter Drone Swarms (thedefensepost.com)
https://www.thedefensepost.com/2023/01/24/epirus-counter-drone-microwave/
https://www.youtube.com/watch?v=zKnxz91SLsk&feature=youtu.be
Too Much Demand and Not Enough Supply – Missile Defense Advocacy Alliance
https://missiledefenseadvocacy.org/alert/too-much-demand-and-not-enough-supply/
https://www.youtube.com/watch?v=pb5_F4_Eod8&feature=youtu.be
www.icrc.org
https://www.icrc.org/en/document/what-you-need-know-about-autonomous-weapons
Swarms of Mass Destruction: The Case for Declaring Armed and Fully Autonomous Drone Swarms as WMD - Modern War Institute (usma.edu)
https://mwi.usma.edu/swarms-mass-destruction-case-declaring-armed-fully-autonomous-drone-swarms-wmd/

6. Autonomous Drone Swarms Will Almost Certainly Emerge into a Revolution in Military Affairs before 2035

Thinking about revolutions in warfare (Chapter 1) - The Dynamics of Military Revolution, 1300–2050 (cambridge.org)
https://www.cambridge.org/core/books/abs/dynamics-of-military-revolution-13002050/thinking-about-revolutions-in-warfare/B1ED01C9F1B8143B14CEE11B64FD5933
Revolution in Military Affairs on JSTOR
https://www.jstor.org/stable/j.ctt809jk
Why the U.S. Needs a Revolution in Military Affairs | Foreign Affairs
https://www.foreignaffairs.com/united-states/new-revolution-military-affairs
Revolution in Military Affairs-An Appraisal (columbia.edu)
https://ciaotest.cc.columbia.edu/olj/sa/sa_apr00kak01.html
Past RMAs, Future Transformations: What Can History Tell Us About Transforming the U.S. Military? (rand.org)
https://www.rand.org/content/dam/rand/pubs/research_briefs/1999/RB7108.pdf
2011.06.02-Maturing-Revolution-In-Military-Affairs1.pdf (csbaonline.org)

https://csbaonline.org/uploads/documents/2011.06.02-Maturing-Revolution-In-Military-Affairs1.pdf
Past Revolutions, Future Transformations: What Can the History of Revolutions in Military Affairs Tell Us About Transforming the U.S. Military? | RAND
https://www.rand.org/pubs/monograph_reports/MR1029.html
Revolution in Military Affairs vs Military Revolution: The Emergence of Drones and Robotics as a driver in Societal Change | Small Wars Journal
https://smallwarsjournal.com/jrnl/art/revolution-military-affairs-vs-military-revolution-emergence-drones-and-robotics-driver
Past Revolutions, Future Transformations: What Can the History of Revolutions in Military Affairs Tell Us About Transforming the U.S. Military? | RAND
https://www.rand.org/pubs/monograph_reports/MR1029.html
The US Thinks China Is a 'Near-Peer' Threat. Does China Agree? (airandspaceforces.com)
https://www.airandspaceforces.com/china-near-peer-us-pla-military/
Biden-Harris Administration's National Security Strategy.pdf (whitehouse.gov)
https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf
NDS Fact Sheet (defense.gov)
https://media.defense.gov/2022/Mar/28/2002964702/-1/-1/1/NDS-FACT-SHEET.PDF
Infantry overhaul: How DARPA's new experiments could shake up ground warfare - The Washington Post
https://www.washingtonpost.com/news/checkpoint/wp/2015/03/30/infantry-overhaul-how-darpas-new-experiments-could-shake-up-ground-warfare/
OFFSET Swarms Take Flight in Final Field Experiment (darpa.mil)
https://www.darpa.mil/news-events/2021-12-09
Manufacturing Experimentation and Outreach (darpa.mil)
https://www.darpa.mil/program/manufacturing-experimentation-and-outreach
AI Improves Robotic Performance in DARPA's Machine Common Sense Program
https://www.darpa.mil/news-events/2022-22-06
SPCE Program to Push Beyond Power Limitations in Space (darpa.mil)
https://www.darpa.mil/news-events/2022-10-07
Opportunities (darpa.mil)
https://www.darpa.mil/work-with-us/opportunities
Why the U.S. Needs a Revolution in Military Affairs | Foreign Affairs
https://www.foreignaffairs.com/united-states/new-revolution-military-affairs
Why the U.S. Needs a Revolution in Military Affairs | Foreign Affairs
https://www.foreignaffairs.com/united-states/new-revolution-military-affairs
Revolution in Military Affairs vs Military Revolution: The Emergence of Drones and Robotics as a driver in Societal Change | Small Wars Journal
https://smallwarsjournal.com/jrnl/art/revolution-military-affairs-vs-military-revolution-emergence-drones-and-robotics-driver
How one person can control a swarm of 130 robots | Popular Science (popsci.com)
https://www.popsci.com/technology/drone-swarm-control-virtual-reality/
Artificial Intelligence in Military Operations: Technology, Ethics and the Indian Perspective | Manohar Parrikar Institute for Defence Studies and Analyses (idsa.in)

https://idsa.in/idsacomments/artificial-intelligence-in-military-operations-india_rspanwar_310118

7. Artificial Intelligence Will Highly Likely Use Coercive Persuasion to Shape Individual Thinking Through Social Media by 2035

Attitude Formation (SOCIAL PSYCHOLOGY) - iResearchNet
https://psychology.iresearchnet.com/social-psychology/attitudes/attitude-formation/
14769178.pdf (mit.edu)
https://dspace.mit.edu/bitstream/handle/1721.1/83028/14769178.pdf
Dark Persuasion: A History of Brainwashing from Pavlov to Social Media on JSTOR
https://www.jstor.org/stable/j.ctv1prsst3
The True Story of Brainwashing and How It Shaped America | History| Smithsonian Magazine
https://www.smithsonianmag.com/history/true-story-brainwashing-and-how-it-shaped-america-180963400/
Effects of Social Media on the Brain (northropgrumman.com)
https://now.northropgrumman.com/this-is-your-brain-on-instagram-effects-of-social-media-on-the-brain/
Are Social Networking Sites Controlling Your Mind? - Scientific American
https://www.scientificamerican.com/article/are-social-networking-sites-controlling-your-mind/
AI-powered personalization: The key to unlocking ecommerce growth | VentureBeat
https://venturebeat.com/ai/ai-powered-personalization-the-key-to-unlocking-ecommerce-growth/
The Future of Brainwashing in Neuroscience and Social Media - Yale University Press
https://yalebooks.yale.edu/2023/02/17/the-future-of-brainwashing-in-neuroscience-and-social-media/
Brainwashing by Social Media: A Threat to Freedom, a Risk for Dictatorship - PMC (nih.gov)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9597644/
Internet Addiction: A Brief Summary of Research and Practice - PMC (nih.gov)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3480687/
Private traits and attributes are predictable from digital records of human behavior | PNAS
https://www.pnas.org/doi/full/10.1073/pnas.1218772110
Brainwashing-Style Techniques in Advertising (azcentral.com)
https://yourbusiness.azcentral.com/brainwashing-techniques-advertising-8941.html
Attitude Formation (SOCIAL PSYCHOLOGY) - iResearchNet
https://psychology.iresearchnet.com/social-psychology/attitudes/attitude-formation/
Operant Conditioning: What It Is, How It Works, and Examples (simplypsychology.org)
https://www.simplypsychology.org/operant-conditioning.html
Mind Reading and Mind Control Technologies Are Coming - Scientific American Blog Network
https://blogs.scientificamerican.com/observations/mind-reading-and-mind-control-technologies-are-coming/

8. Chances Are a Little Better or Less That Artificial Narrow Intelligence Will Evolve to Artificial General Intelligence By 2040

Artificial General Intelligence: The Future Of Decision AI (datatechvibe.com)
https://datatechvibe.com/ai/artificial-general-intelligence-the-future-of-decision-ai/

https://www.siliconaiandcybersecurity.com/post/ani-agi-asi-the-3-types-of-artificial-intelligence
File:Artificial Intelligence Progression.png - CIO Wiki (cio-wiki.org)
https://cio-wiki.org/wiki/File:Artificial_Intelligence_Progression.png
Separating Science Fact From Science Hype: How Far off Is the Singularity? (futurism.com)
https://futurism.com/separating-science-fact-science-hype-how-far-off-singularity
Date of Artificial General Intelligence | Metaculus
https://www.metaculus.com/questions/5121/date-of-artificial-general-intelligence/
www.alignmentforum.org
https://www.alignmentforum.org/posts/AfH2oPHCApdKicM4m/two-year-update-on-my-personal-ai-timelines
AI Ethics And The Geopolitical Wrestling Match Over Who Will Win The Race To Attain True AI (forbes.com)
https://www.forbes.com/sites/lanceeliot/2022/08/15/ai-ethics-and-the-geopolitical-wrestling-match-over-who-will-win-the-race-to-attain-true-ai-or-agi/?sh=2fc7c93f7536
AI timelines: What do experts in artificial intelligence expect for the future? - Our World in Data
https://ourworldindata.org/ai-timelines#the-forecast-by-ajeya-cotra
When will singularity happen? 1700 expert opinions of AGI [2023] (aimultiple.com)
https://research.aimultiple.com/artificial-general-intelligence-singularity-timing/
Worries about developments in AI | Pew Research Center
https://www.pewresearch.org/internet/2021/06/16/1-worries-about-developments-in-ai/
AI ethics: Understanding biased AI and associated ethical dilemmas | Data Science Dojo
https://datasciencedojo.com/blog/ai-ethics-biased-ai/
Top 10 biggest ethical dilemmas in AI (isahit.com)
https://www.isahit.com/blog/top-10-biggest-ethical-dilemmas-in-ai
Blueprint for an AI Bill of Rights (whitehouse.gov)
https://www.whitehouse.gov/wp-content/uploads/2022/10/Blueprint-for-an-AI-Bill-of-Rights.pdf
Experts Doubt Ethical AI Design Will Be Broadly Adopted as the Norm Within the Next Decade | Pew Research Center
https://www.pewresearch.org/internet/2021/06/16/experts-doubt-ethical-ai-design-will-be-broadly-adopted-as-the-norm-within-the-next-decade/
1906.06668.pdf (arxiv.org)
https://arxiv.org/ftp/arxiv/papers/1906/1906.06668.pdf

9. Developed Nation Militaries Highly Likely to Conduct Over 50% of Operations in a Decentralized or Distributed Mode by 2035

2022 STCTTS REPORT - FUTURE OF WARFARE (nato-pa.int)
https://www.nato-pa.int/download-file?filename=/sites/default/files/2022-11/025%20STCTTS%2022%20E%20rev.1%20fin%20-%20THE%20FUTURE%20OF%20WARFARE%20-%20FRIDBERTSSON%20REPORT_0.pdf
Developed Countries | Encyclopedia.com
https://www.encyclopedia.com/finance/encyclopedias-almanacs-transcripts-and-maps/developed-countries

Distribute Definition & Meaning | Dictionary.com
https://www.dictionary.com/browse/distribute
Decentralized Definition & Meaning | Dictionary.com
https://www.dictionary.com/browse/decentralized
REPORT OF THE NATIONAL DEFENSE PANEL - NSL Archive (navalsubleague.org)
https://archive.navalsubleague.org/1998/report-of-the-national-defense-panel
20210319-csa-paper-1-signed-print-version.pdf (army.mil)
https://api.army.mil/e2/c/downloads/2021/03/23/eeac3d01/20210319-csa-paper-1-signed-print-version.pdf
317. Top Attack: Lessons Learned from the Second Nagorno-Karabakh War | Mad Scientist Laboratory (army.mil)
https://madsciblog.tradoc.army.mil/317-top-attack-lessons-learned-from-the-second-nagorno-karabakh-war/
The Army Plans Its Warfighting Future (csis.org)
https://www.csis.org/analysis/army-plans-its-warfighting-future
New Tech, New Concepts: China's Plans for AI and Cognitive Warfare - War on the Rocks
https://warontherocks.com/2022/04/new-tech-new-concepts-chinas-plans-for-ai-and-cognitive-warfare/
The Use of Drones in the Nagorno-Karabakh Conflict | Defense.info
https://defense.info/air-power-dynamics/2021/06/the-use-of-drones-in-the-nagorno-karabakh-conflict/
The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense (csis.org)
https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense
List of 152 developing countries (worlddata.info)
https://www.worlddata.info/developing-countries.php
What the United States Military Can Learn from the Nagorno-Karabakh War | Small Wars Journal
https://smallwarsjournal.com/jrnl/art/what-united-states-military-can-learn-nagorno-karabakh-war
Ukraine Symposium – Data-Rich Battlefields and the Future LOAC - Lieber Institute West Point
https://lieber.westpoint.edu/data-rich-battlefields-future-loac/
Comparison - Centralized, Decentralized and Distributed Systems - GeeksforGeeks
https://www.geeksforgeeks.org/comparison-centralized-decentralized-and-distributed-systems/
New Active and Dynamic camouflage technologies and materials to protect troops and tanks – International Defense Security & Technology (idstch.com)
https://idstch.com/technology/electronics/new-active-and-dynamic-camouflage-technologies-and-materials-to-protect-troops-and-tanks/
Better camouflage is needed to hide from new electronic sensors | The Economist
https://www.economist.com/science-and-technology/2023/03/29/better-camouflage-is-needed-to-hide-from-new-electronic-sensors

10. China Will Likely Outpace the United States in Machine Learning by 2035

Artificial Intelligence vs Machine Learning: 15 Interesting Facts To Know (ubuntupit.com)
https://www.ubuntupit.com/artificial-intelligence-vs-machine-learning/
Predictive Analytics vs. Machine Learning (techtarget.com)
https://www.techtarget.com/searchenterpriseai/feature/Machine-learning-and-predictive-analytics-work-better-together
Top 10 Machine Learning Tools 2021 (analyticsinsight.net)
https://www.analyticsinsight.net/top-10-machine-learning-tools-2021/
7 Key Military Applications of Machine Learning | by Nicholas Abell | Medium
https://medium.com/@nqabell89/7-key-military-applications-of-machine-learning-9818dfa2ea86
How machine learning is used in Cybersecurity? [in 2021] (malicksarr.com)
https://www.malicksarr.com/how-machine-learning-is-used-in-cybersecurity/
Responsible-data-sharing-in-AI.pdf (nlaic.com)
https://nlaic.com/wp-content/uploads/2020/10/Responsible-data-sharing-in-AI.pdf
China has more internet users than any other country | Pew Research Center
https://www.pewresearch.org/fact-tank/2013/12/02/china-has-more-internet-users-than-any-other-country/
Big Ideas From Recent Trends in China's Data Governance – The Diplomat
https://thediplomat.com/2023/01/big-ideas-from-recent-trends-in-chinas-data-governance/
3 Years After the Maven Uproar, Google Cozies to the Pentagon | WIRED
https://www.wired.com/story/3-years-maven-uproar-google-warms-pentagon/
AI Ethics | IBM
https://www.ibm.com/topics/ai-ethics
What is Microsoft's Approach to AI? | Microsoft Source
https://news.microsoft.com/source/features/ai/microsoft-approach-to-ai/

11. Highly Likely That China Becomes Leader in Military Applications of Biological Human Performance Enhancement by 2030

Technological Approaches to Human Performance Enhancement | RAND
https://www.rand.org/pubs/research_reports/RRA1482-2.html
With its CRISPR revolution, China becomes a world leader in genome editing | Science | AAAS
https://www.science.org/content/article/its-crispr-revolution-china-becomes-world-leader-genome-editing
China's new human gene-editing rules worry experts - BBC News
https://www.bbc.com/news/science-environment-64857311?at_medium=RSS&amp%3Bat_campaign=KARANGA
China Is National Security Threat No. 1 - WSJ
https://www.wsj.com/articles/china-is-national-security-threat-no-1-11607019599
China has done human testing to create biologically enhanced super soldiers, says top U.S. official (nbcnews.com)
https://www.nbcnews.com/politics/national-security/china-has-done-human-testing-create-biologically-enhanced-super-soldiers-n1249914
China's Military Biotech Frontier: CRISPR, Military-Civil Fusion, and the New Revolution in Military Affairs - Jamestown
https://jamestown.org/program/chinas-military-biotech-frontier-crispr-military-civil-fusion-and-the-new-revolution-in-military-affairs/

We Don’t Own the Night Anymore - Modern War Institute (usma.edu)
https://mwi.usma.edu/we-dont-own-the-night-anymore/
Scientists discover new system for human genome editing with potential to increase power and precision of genome engineering | Broad Institute
https://www.broadinstitute.org/news/scientists-discover-new-system-human-genome-editing-potential-increase-power-and-precision
From Novel Technology to Novel Applications: Comment on "An Integrated Brain-Machine Interface Platform With Thousands of Channels" by Elon Musk and Neuralink - PubMed (nih.gov)
https://pubmed.ncbi.nlm.nih.gov/31674923/
Building national laboratories to meet China's development challenges | National Science Review | Oxford Academic (oup.com)
https://academic.oup.com/nsr/article/3/3/387/2236605?login=false
China's testing 'biologically enhanced' super soldiers on their own troops, says DNI Ratcliffe | American Military News
https://americanmilitarynews.com/2020/12/chinas-testing-biologically-enhanced-super-soldiers-on-their-own-troops-says-dni-ratcliffe/

12. Light Fidelity Highly Likely to Achieve Full Adoption by 2035

Forget Wi-Fi, Li-Fi Will Redefine Wireless Communications in Future (psmarketresearch.com)
https://www.psmarketresearch.com/blogs/li-fi-technology
Li-Fi Technology: What it is, How it Works and its importance - Tech Resider
https://techresider.com/technology/li-fi-technology/
LiFi Technology - pureLiFi
https://purelifi.com/lifi-technology/
What is Li-Fi? The fast wireless technology explained (trustedreviews.com)
https://www.trustedreviews.com/explainer/what-is-lifi-2932109
How LiFi can transform wireless networks - ITP.net
https://www.itp.net/infrastructure/networking/how-lifi-can-transform-wireless-networks
IoT connected devices worldwide 2019-2030 | Statista
https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/
Why the Next Generation of Wireless Devices Needs LiFi - Lighting Design & Specificaition (lightingdesignandspecification.ca)
https://www.lightingdesignandspecification.ca/led-technology/2921-why-the-next-generation-of-wireless-devices-needs-lifi/
What is Li-Fi? What are its Pros, Cons & applications? (circuitstoday.com)
https://www.circuitstoday.com/li-fi
Signify Li-Fi reports for duty with the U.S. military | LEDs Magazine
https://www.ledsmagazine.com/connected-ssl-controls/article/14277048/signify-lifi-reports-for-duty-with-the-us-military
US Army invests $4.2 million in large-scale LiFi deployment | Cabling Installation & Maintenance
https://www.cablinginstall.com/wireless-5g/article/14202283/us-army-invests-42-million-in-largescale-lifi-deployment
US Army comes back for more Li-Fi | LEDs Magazine

https://www.ledsmagazine.com/connected-ssl-controls/article/14222101/us-army-comes-back-for-more-lifi
https://youtube.com/clip/UgkxCMICKZDIpuCBFRcgdKmWCe6er-KPUfr I
LiFi in education: shedding light on teaching - Oledcomm
https://www.oledcomm.net/blog/news/lifi-in-education-shedding-light-on-teaching/
How KSLD hit blazing Li-Fi speeds | LEDs Magazine
https://www.ledsmagazine.com/connected-ssl-controls/article/14233699/how-ksld-hit-blazing-lifi-speeds
Airbus scores a LiFi win for a trio of corporate jets | PaxEx.Aero
https://paxex.aero/airbus-corporate-jet-lifi-entertainment-screen/
Entertainment - ACJ Smart LiFi Monitor | Airbus Corporate Jets
https://www.acj.airbus.com/en/acj-care/acj-care-for-mros/enhanced-onboard-experience/entertainment-acj-smart-lifi-monitor
Towards smart sustainable cities using Li-Fi technology: geo-location infrastructure utilizing LED street lights - PMC (nih.gov)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9454865/
Citing security, The Hague's conference center deploys Li-Fi (UPDATED) | LEDs Magazine
https://www.ledsmagazine.com/connected-ssl-controls/article/14198756/citing-security-the-hagues-conference-center-deploys-lifi
How KSLD hit blazing Li-Fi speeds | LEDs Magazine
https://www.ledsmagazine.com/connected-ssl-controls/article/14233699/how-ksld-hit-blazing-lifi-speeds
2104.02390.pdf (arxiv.org)
https://arxiv.org/pdf/2104.02390.pdf
pureLiFi shows laptop powered by Gigabit LiFi speeds at Mobile World Congress - pureLiFi
https://purelifi.com/purelifi-shows-laptop-powered-by-gigabit-lifi-speeds-at-mobile-world-congress/
Tablet maker embeds Li-Fi | LEDs Magazine
https://www.ledsmagazine.com/connected-ssl-controls/article/14186636/tablet-maker-embeds-lifi
Li-Fi Market Is Predicted To Hit USD 116.96 Billion at a (globenewswire.com)
https://www.globenewswire.com/news-release/2023/03/08/2623432/0/en/Li-Fi-Market-Is-Predicted-To-Hit-USD-116-96-Billion-at-a-CAGR-of-31-60-by-2030-Report-by-Market-Research-Future-MRFR.html

13. DoD Highly Unlikely to Successfully Compete With Civilian Sector to Recruit and Retain Talent For AI-driven operations by 2035

Career Preferences of AI Talent - Center for Security and Emerging Technology (georgetown.edu)
https://cset.georgetown.edu/publication/career-preferences-of-ai-talent/
How The Department of Defense Can Remedy The Talent Deficit Harming U.S. Technological Competitiveness (cfr.org)
https://www.cfr.org/blog/how-dod-can-remedy-talent-deficit-harming-us-technological-competitiveness
2021 Final Report - NSCAI
https://www.nscai.gov/2021-final-report/

What are the Most In-demand Skills in Artificial Intelligence in 2023? - Great Learning (mygreatlearning.com)
https://www.mygreatlearning.com/blog/most-in-demand-skills-in-artificial-intelligence/
Artificial intelligence salaries in United States | Indeed.com
https://www.indeed.com/career/salaries/artificial%20intelligence
Artificial Intelligence (AI) Market to Hit USD 360.36 (globenewswire.com)
https://www.globenewswire.com/news-release/2021/09/16/2298078/0/en/Artificial-Intelligence-AI-Market-to-Hit-USD-360-36-Billion-by-2028-Surging-Innovation-in-Artificial-Internet-of-Things-AIoT-to-Augment-Growth-Fortune-Business-Insights.html#:~:text=Pune%2C%20India%2C%20Sept.%2016%2C%202021%20%28GLOBE%20NEWSWIRE%29%20--,a%20CAGR%20of%2033.6%25%20between%202021%20to%202028.
Computer and Information Technology Occupations : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics (bls.gov)
https://www.bls.gov/ooh/computer-and-information-technology/home.htm
14 Artificial Intelligence Careers & Job Outlook [2023] (sandiego.edu)
https://onlinedegrees.sandiego.edu/artificial-intelligence-jobs/
Artificial Intelligence Salary in USA - Average Salary (talent.com)
https://www.talent.com/salary?job=artificial+intelligence
How The Department of Defense Can Remedy The Talent Deficit Harming U.S. Technological Competitiveness (cfr.org)
https://www.cfr.org/blog/how-dod-can-remedy-talent-deficit-harming-us-technological-competitiveness

14. Highly Unlikely That the Department of Defense (DoD) Will Realize an AI Educated Force by 2025

untitled (congress.gov)
https://www.congress.gov/116/plaws/publ92/PLAW-116publ92.pdf
2020 Department of Defense Artifical Intelligence Education Strategy and Infographic (nwcfoundation.org)
https://nwcfoundation.org/wp-content/uploads/2021/02/2020_DoD_AI_Training_and_Education_Strategy_and_Infographic_10_27_20.pdf
Air Force, Space Force pursue AI readiness by 2025 (c4isrnet.com)
https://www.c4isrnet.com/artificial-intelligence/2023/01/10/air-force-space-force-pursue-ai-readiness-by-2025/
Air Force Targets AI Readiness for 2025, AI Competitiveness by 2027 (governmentciomedia.com)
https://governmentciomedia.com/air-force-targets-ai-readiness-2025-ai-competitiveness-2027

DAF-MIT AI Accelerator tackles the challenge of cultivating and growing a world-class AI workforce through education > ONE AFRL / TWO SERVICES > Article Display
https://www.afrl.af.mil/News/Article-Display/Article/3205047/daf-mit-ai-accelerator-tackles-the-challenge-of-cultivating-and-growing-a-world/
Artificial Intelligence Task Force Welcomes Inaugural Class of AI Scholars | Article | The United States Army

https://www.army.mil/article/237258/artificial_intelligence_task_force_welcomes_inaugural_class_of_ai_scholars
CMU Partners with U.S. Army To Grow Data Science and AI Expertise
https://www.cmu.edu/news/stories/archives/2020/september/army-partners-grow-data-science.html
Preparing Sailors for the Age of AI | Proceedings - April 2022 Vol. 148/4/1,430 (usni.org)
https://www.usni.org/magazines/proceedings/2022/april/preparing-sailors-age-ai
Navy releases education strategy with focus on tech | FedScoop
https://fedscoop.com/navy-education-strategy/
Marine Corps' new education strategy focuses on tech-driven 'continuous' learning | FedScoop
https://fedscoop.com/marine-corps-technology-education-doctrine/
LinkedIn
https://www.linkedin.com/pulse/employ-ai-archetype-most-important-workforce-group-dod-dunbar/
Chapter 1: Total Force Personnel – 2021 Demographics Dashboards (militaryonesource.mil)
https://demographics.militaryonesource.mil/chapter-1-total-military-force
The DOD's Hidden Artificial Intelligence Workforce (georgetown.edu)
https://cset.georgetown.edu/wp-content/uploads/The-DODs-Hidden-Artificial-Intelligence-Workforce.pdf
How the DoD is using AI to unearth talent in the military reserves (eightfold.ai)
https://eightfold.ai/blog/dod-ai-military-reserves/
Pentagon Seeks Proposals for AI Talent 2.0 Procurement Vehicle - GovCon Wire
https://www.govconwire.com/2022/12/pentagon-seeks-proposals-for-ai-talent-2-0-procurement-vehicle/
AI-Powered App Aims to Discover Talent in Guard, Reserve > U.S. Department of Defense > Defense Department News
https://www.defense.gov/News/News-Stories/Article/Article/3027956/ai-powered-app-aims-to-discover-talent-in-guard-reserve/
AI Task Force taking giant leaps forward | Article | The United States Army
https://www.army.mil/article/225642/ai_task_force_taking_giant_leaps_forward
Army applying AI to personnel data in new ways | DefenseScoop
https://defensescoop.com/2022/11/02/army-applying-ai-to-personnel-data-in-new-ways/

15. Human Out of the Loop Autonomous Weapon Systems Almost Certain to be Fielded in Multiple Militaries by 2035

Combat drones: We are in a new era of warfare - here's why - BBC News
https://www.bbc.com/news/world-60047328
autonomous-systems-ebook.pdf (stanford.edu)
https://online.stanford.edu/sites/default/files/2020-08/autonomous-systems-ebook.pdf
Human-in-the-Loop: What is it and why it matters for ML (clickworker.com)
https://www.clickworker.com/customer-blog/human-in-the-loop-ml/
Autonomous Weapon Systems: A Brief Survey of Developmental, Operational, Legal, and Ethical Issues (armywarcollege.edu)
https://press.armywarcollege.edu/cgi/viewcontent.cgi?article=1303&context=monographs
DoD Directive 3000.09, "Autonomy in Weapon Systems," January 25, 2023 (whs.mil)
https://www.esd.whs.mil/portals/54/documents/dd/issuances/dodd/300009p.pdf

AI with AI: Artificial Intelligence with Andy Ilachinski: Up, Up, and Autonomy! on Apple Podcasts
https://podcasts.apple.com/us/podcast/ai-with-ai-artificial-intelligence-with-andy-ilachinski/id1320968109?i=1000599080273
Lethal Autonomous Weapons Systems and the Dehumanisation of War (youngausint.org.au)
https://www.youngausint.org.au/post/lethal-autonomous-weapons-systems-and-the-dehumanisation-of-war
Russia Threatens To Unleash 'Combat Robot' To Burn Ukraine's US & German-Origin Abrams & Leopard 2 Tanks (eurasiantimes.com)
https://eurasiantimes.com/russia-threatens-to-unleash-combat-robot-to-burn-ukraines-us/
“AI weapons” in China's military innovation (brookings.edu)
https://www.brookings.edu/wp-content/uploads/2020/04/FP_20200427_ai_weapons_kania_v2.pdf
Bureaucrat’s Gambit: Why is Dmitry Rogozin Sending Russian Uncrewed Ground Vehicles to Ukraine—and Does it Matter? - Modern War Institute (usma.edu)
https://mwi.usma.edu/bureaucrats-gambit-why-is-dmitry-rogozin-sending-russian-uncrewed-ground-vehicles-to-ukraine-and-does-it-matter/
Why Fully-Autonomous Cars Won't Be A Common Sight On The Roads Anytime Soon (hotcars.com)
https://www.hotcars.com/why-fully-autonomous-cars-wont-be-common-sight-soon/
AI needs humans 'on the loop' not 'in the loop' for nuke detection, general says | FedScoop
https://fedscoop.com/ai-should-have-human-on-the-loop-not-in-the-loop-when-it-comes-to-nuke-detection-general-says/
These Countries Have the Most Technological Expertise | U.S. News (usnews.com)
https://www.usnews.com/news/best-countries/rankings/technological-expertise
Autonomous Weapons Open Letter: AI & Robotics Researchers - Future of Life Institute
https://futureoflife.org/open-letter/open-letter-autonomous-weapons-ai-robotics/
Lethal Autonomous Weapons & Info-Wars: A Scientist’s Warning | by Synced | SyncedReview | Medium
https://medium.com/syncedreview/lethal-autonomous-weapons-info-wars-a-scientists-warning-cc95798bc302
Autonomous Weapons Systems: UN Expert Talks Facing Failure - Stiftung Wissenschaft und Politik (swp-berlin.org)
https://www.swp-berlin.org/10.18449/2022C43/
U.S. Military Investments in Autonomy and AI: A Budgetary Assessment - Center for Security and Emerging Technology (georgetown.edu)
https://cset.georgetown.edu/publication/u-s-military-investments-in-autonomy-and-ai-a-budgetary-assessment/

16. Innovative and Specialized Approaches to Learning and Training Highly Likely to be Required for Competitive Organizations by 2033

Linear Thinking in a Nonlinear World (hbr.org)
https://hbr.org/2017/05/linear-thinking-in-a-nonlinear-world
Linear Thinking: The Ultimate Guide | MindManager
https://www.mindmanager.com/en/tips/linear-thinking/

Explore the complexity of definition and meaning | Collins English Dictionary (collinsdictionary.com)
https://www.collinsdictionary.com/dictionary/english/explore-the-complexity-of
Complexity Explorer
https://www.complexityexplorer.org/explore/glossary/391-complex-system
https://www.oecd.org/education/school/43023606.pdf
https://www.oecd.org/education/school/43023606.pdf
What Evolution Can Teach Us About Innovation (hbr.org)
https://hbr.org/2021/09/what-evolution-can-teach-us-about-innovation?registration=success
3 Types of Innovation-Structured [Apple], Unstructured [Amazon] & Open [Google] – Trak.in – Indian Business of Tech, Mobile & Startups
https://trak.in/tags/business/2011/08/08/innovation-types-structure-open-apple-google-amazon/
Becoming an innovative organization (microsoft.com)
https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RWV4hg
20 Takeaways From Google Innovation Culture | SurveySparrow
https://surveysparrow.com/blog/20-takeaways-from-google-innovation-culture-thatll-blow-your-minds/
The Medici Effect - Wikipedia
https://en.wikipedia.org/wiki/The_Medici_Effect
Everyone wants a culture of innovation. So what does it look like? | Google Cloud
https://cloud.google.com/executive-insights/everyone-wants-a-culture-of-innovation-report-what-does-it-look-like-report
Why Hierarchy Stifles Creativity | Psychology Today
https://www.psychologytoday.com/us/blog/creative-leadership/201403/why-hierarchy-stifles-creativity

17. Military Leaders Must Acquire New Skill Sets to be Effective in Rapidly Advancing Data Centric Environment in 2035

DOD's Cyber Mission Depends on Skilled Workforce, Streamlined Tech, Officials Say - Nextgov
https://www.nextgov.com/cybersecurity/2023/03/dods-cyber-mission-depends-skilled-workforce-streamlined-tech-officials-say/383459/
DOD's IT Modernization Efforts Need Data Analytics, Workforce Upskilling - Nextgov
https://www.nextgov.com/it-modernization/2023/04/dods-it-modernization-efforts-need-data-analytics-workforce-upskilling/385001/
GAO-23-105611, Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts
https://www.gao.gov/assets/gao-23-105611.pdf
11 Skills Leaders of the Future Will Need | Leaderonomics
https://www.leaderonomics.com/articles/leadership/skills-leaders-future-need
What is a data engineer? An analytics role in high demand | CIO
https://www.cio.com/article/222004/what-is-a-data-engineer.html
Difference Between Machine Learning and Artificial Intelligence - GeeksforGeeks
https://www.geeksforgeeks.org/difference-between-machine-learning-and-artificial-intelligence/
What is an Application Programming Interface (API)? | IBM
https://www.ibm.com/topics/api

What Is Data Visualization? Definition & Examples | Tableau
https://www.tableau.com/learn/articles/data-visualization
The Army Needs Full-Stack Data Scientists and Analytics Translators - War on the Rocks
https://warontherocks.com/2020/02/the-army-needs-full-stack-data-scientists-and-analytics-translators/
Big data and national security: A guide for Australian policymakers (lowyinstitute.org)
https://www.lowyinstitute.org/publications/big-data-national-security-guide-australian-policymakers
Big Data, new epistemologies and paradigm shifts - Rob Kitchin, 2014 (sagepub.com)
https://journals.sagepub.com/doi/full/10.1177/2053951714528481
Secrecy, sovereignty and sharing: How data and emerging technologies are transforming intelligence — United States Studies Centre (ussc.edu.au)
https://www.ussc.edu.au/analysis/secrecy-sovereignty-and-sharing-how-data-and-emerging-technologies-are-transforming-intelligence

18. PLA Likely (56-70%) to Have a Better Trained Artificial Intelligence Force Than the United States DoD in 2035

CAMPAIGN_FOR_AN_AI_READY_FORCE.PDF (defense.gov)
https://media.defense.gov/2019/Oct/31/2002204191/-1/-1/0/CAMPAIGN_FOR_AN_AI_READY_FORCE.PDF
2020 Department of Defense Artifical Intelligence Education Strategy and Infographic (nwcfoundation.org)
https://nwcfoundation.org/wp-content/uploads/2021/02/2020_DoD_AI_Training_and_Education_Strategy_and_Infographic_10_27_20.pdf
Artificial Intelligence Industry Talent Development Report (2019-2020 Edition) - Center for Security and Emerging Technology (georgetown.edu)
https://cset.georgetown.edu/publication/artificial-intelligence-industry-talent-development-report-2019-2020-edition/
The PLA And Intelligentized Warfare – Analysis – Eurasia Review
https://www.eurasiareview.com/02122022-the-pla-and-intelligentized-warfare-analysis/
China’s Scary Vision of Future Warfare: Humans Are Obsolete | The National Interest
https://nationalinterest.org/blog/buzz/china%E2%80%99s-scary-vision-future-warfare-humans-are-obsolete-119996
Skill-Sets Required To Survive In An AI-Driven World (analyticsindiamag.com)
https://analyticsindiamag.com/skills-required-to-survive-in-an-ai-driven-world/
Most Important Skills Required For IT Professionals in AI and Machine Learning - IMC Grupo
https://www.imcgrupo.com/most-important-skills-required-for-it-professionals-in-ai-and-machine-learning/
Best Artificial Intelligence Certification Courses Online - Great Learning (mygreatlearning.com)
https://www.mygreatlearning.com/artificial-intelligence/courses
What is Cloud Storage? - Cloud Storage Explained - AWS (amazon.com)
https://aws.amazon.com/what-is/cloud-storage/
Predictive Analytics vs. Machine Learning (techtarget.com)

https://www.techtarget.com/searchenterpriseai/feature/Machine-learning-and-predictive-analytics-work-better-together
AI vs. Machine Learning vs. Deep Learning vs. Neural Networks: What's the Difference? | IBM
https://www.ibm.com/cloud/blog/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks
Sorting Out AI Job Titles, Skills, and Career Paths | Transforming Data with Intelligence (tdwi.org)
https://tdwi.org/articles/2020/08/11/adv-all-sorting-out-ai-job-titles-skills-career-paths.aspx
Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017) (stanford.edu)
https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/
Estimating the Number of Chinese STEM Students in the United States - Center for Security and Emerging Technology (georgetown.edu)
https://cset.georgetown.edu/publication/estimating-the-number-of-chinese-stem-students-in-the-united-states/

19. Advances in India's Artificial Intelligence Development Are Likely to Surpass the United States New Development by 2035:

Artificial Intelligence: way forward for India | Srivastava | Journal of Information Systems and Technology Management (tecsi.org)
https://www.tecsi.org/jistem/index.php/jistem/article/view/2965/681
U.S. Needs to Balance Dependency on India for IT Services (usnews.com)
https://www.usnews.com/news/best-countries/articles/2021-05-18/us-needs-to-balance-dependency-on-india-for-it-services
U.S. Needs to Balance Dependency on India for IT Services (usnews.com)
https://www.usnews.com/news/best-countries/articles/2021-05-18/us-needs-to-balance-dependency-on-india-for-it-services
National AI Policy/Strategy of India and China: A Comparative Analysis | RIS | Research and Information System for Developing Countries
https://www.ris.org.in/en/node/3368
Economic Growth of Artificial Intelligence in India - ONPASSIVE
https://onpassive.com/blog/economic-growth-artificial-intelligence-india/
www.ibef.org
https://www.ibef.org/research/case-study/india-s-artificial-intelligence-revolution
U.S.-India Artificial Intelligence Cooperation | Adapt & Advance: A Refreshed Agenda for U.S.-India Relations | CSIS
https://www.csis.org/blogs/adapt-advance-refreshed-agenda-us-india-relations/us-india-artificial-intelligence
AI, Quantum R&D Funding to Remain a Priority Under Biden - WSJ
https://www.wsj.com/articles/ai-quantum-r-d-funding-to-remain-a-priority-under-biden-11604944800
Indian Army gets ready for future wars! To adopt AI for crucial ops | The Financial Express
https://www.financialexpress.com/defence/indian-army-gets-ready-for-future-wars-to-adopt-ai-for-crucial-ops/2591845/

20. U.S. Military Highly Likely to Remain Behind Commercial Industry and Universities on Implementation of Innovative Training, Educational, or Cognitive Programs for Future Leaders by 2035

The 3 Learning Styles: Visual, Auditory, Kinaesthetic (staffordglobal.org)
https://www.staffordglobal.org/articles-and-blogs/education-articles-and-blogs/3-main-learning-styles/
DoD's 2021 China Military Power Report: How Advances in AI and Emerging Technologies Will Shape China's Military | Council on Foreign Relations (cfr.org)
https://www.cfr.org/blog/dods-2021-china-military-power-report-how-advances-ai-and-emerging-technologies-will-shape
The PLA and China's Rejuvenation: National Security and Military Strategies, Deterrence Concepts, and Combat Capabilities | RAND
https://www.rand.org/pubs/research_reports/RR1402.html
Data-Enabled Approaches for Enhancing the Air Force Transformational Capability Pipeline | RAND
https://www.rand.org/pubs/research_reports/RRA952-1.html
Our Research (darpa.mil)
https://www.darpa.mil/our-research
Special Operations as an Innovation Laboratory - War on the Rocks
https://warontherocks.com/2020/02/special-operations-as-an-innovation-laboratory/
Government Spending Explorer | USAspending
https://www.usaspending.gov/explorer/agency
How Technology Is Changing the Future of Higher Education - The New York Times (nytimes.com)
https://www.nytimes.com/2020/02/20/education/learning/education-technology.html
How Could Artificial Intelligence Shape the Future of Higher Education? #DLNchat | EdSurge News
https://www.edsurge.com/news/2018-03-29-dlnchat-how-could-artificial-intelligence-shape-the-future-of-higher-education
Every branch of the U.S. military is struggling to meet its 2022 recruiting goals, officials say (nbcnews.com)
https://www.nbcnews.com/news/military/every-branch-us-military-struggling-meet-2022-recruiting-goals-officia-rcna35078
Preparing Potential Senior Army Leaders for the Future: An Assessment of Leader Development Efforts in the Post-Cold War Era | RAND
https://www.rand.org/pubs/issue_papers/IP224.html
How Google Attracts the World's Best Talent | Fortune
https://fortune.com/2014/09/04/how-google-attracts-the-worlds-best-talent/
WATCH: Austin and Milley testify on Defense budget in Senate hearing | PBS NewsHour
https://www.pbs.org/newshour/politics/watch-live-austin-and-milley-testify-on-defense-budget-in-senate-hearing
US Army adopts new multidomain operations doctrine (defensenews.com)
https://www.defensenews.com/land/2022/10/10/us-army-adopts-new-multidomain-operations-doctrine/
All that Glitters is Not Gold: Overcoming the US Military's Pro-Innovation Bias - Modern War Institute (usma.edu)

https://mwi.usma.edu/glitters-not-gold-overcoming-us-militarys-pro-innovation-bias/

21. Unlikely That China Will Outcompete the United States in Advanced Chip Resources by 2035

TSMC Announces Expansion Plans for Highly-anticipated Arizona Fab - News (allaboutcircuits.com)
https://www.allaboutcircuits.com/news/tsmc-announces-big-expansion-plans-for-anticipated-arizona-fab/
Taiwan Is Caught in a Great Game Over Microchips - The New York Times (nytimes.com)
https://www.nytimes.com/2022/08/29/technology/taiwan-chips.html
How Intel plans to be top chipmaker again, beating TSMC and Samsung (cnbc.com)
https://www.cnbc.com/2021/11/06/how-intel-plans-to-catch-up-to-samsung-and-tsmc-with-44-billion-of-new-global-chip-fabs.html
How Silicon Chips Rule the World - The New York Times (nytimes.com)
https://www.nytimes.com/2022/09/09/business/silicon-markets-china-taiwan.html
Race for Semiconductors Influences Taiwan Conflict (voanews.com)
https://www.voanews.com/a/race-for-semiconductors-influences-taiwan-conflict-/6696432.html
Advanced Microchip Production Relies On Taiwan [Infographic] (forbes.com)
https://www.forbes.com/sites/katharinabuchholz/2023/01/13/advanced-microchip-production-relies-on-taiwan/?sh=1409cb9c371d
Factbox: Chinese chipmakers caught in U.S.-China tech spat | Reuters
https://www.reuters.com/technology/chinese-chipmakers-caught-us-china-tech-spat-2023-01-31/
2 charts show how much the world depends on Taiwan for semiconductors (cnbc.com)
https://www.cnbc.com/2021/03/16/2-charts-show-how-much-the-world-depends-on-taiwan-for-semiconductors.html
The $150 Million Machine Keeping Moore's Law Alive | WIRED
https://www.wired.com/story/asml-extreme-ultraviolet-lithography-chips-moores-law/
The U.S. Has a Microchip Problem. Safeguarding Taiwan Is the Solution. - The Atlantic
https://www.theatlantic.com/international/archive/2022/10/taiwan-microchip-supply-chain-china/671615/
How microchips are made | ASML
https://www.asml.com/en/technology/all-about-microchips/how-microchips-are-made
The 10 Largest Chip Manufacturers in the World and What They Do - History-Computer
https://history-computer.com/the-10-largest-chip-manufacturers-in-the-world-and-what-they-do/
The Battle of the World's Most Advanced Microchips | Small Wars Journal
https://smallwarsjournal.com/jrnl/art/battle-worlds-most-advanced-microchips

22. Unlikely That DoD Will Use Artificial Intelligence to Make Autonomous Ethical Decisions in The Next 15 Years

AI Isn't Ready to Make Unsupervised Decisions (competitionpolicyinternational.com)
https://www.competitionpolicyinternational.com/ai-isnt-ready-to-make-unsupervised-decisions/#:~:text=AI%20Isn%E2%80%99t%20Ready%20to%20Make%20Unsupervised%20Decisions%20CPI,parameters%2C%20and%20variables%20involved%20are%20beyond%20human%20comprehension.
Chapter 3 - NSCAI Final Report

https://reports.nscai.gov/final-report/chapter-3
Creating Cross-Domain Kill Webs in Real Time (darpa.mil)
https://www.darpa.mil/news-events/2020-09-18a
Chapter 4 - NSCAI Final Report
https://reports.nscai.gov/final-report/chapter-4
Protecting The Human: Ethics In AI (forbes.com)
https://www.forbes.com/sites/deanstoecker/2021/06/10/protecting-the-human-ethics-in-ai/?sh=5cc7651f4707
Artificial Intelligence, Real Risks: Understanding—and Mitigating—Vulnerabilities in the Military Use of AI - Modern War Institute (usma.edu)
https://mwi.usma.edu/artificial-intelligence-real-risks-understanding-and-mitigating-vulnerabilities-in-the-military-use-of-ai/
Chapter 7 - NSCAI Final Report
https://reports.nscai.gov/final-report/chapter-7
Understanding 3 Major Artificial Intelligence Ethical Issues - ReHack
https://rehack.com/data/ai/understanding-3-major-artificial-intelligence-ethical-issues/
Project Governance for Defense Applications of Artificial Intelligence > 960th Cyberspace Wing > Article Display (af.mil)
https://www.960cyber.afrc.af.mil/News/Article-Display/Article/2848035/project-governance-for-defense-applications-of-artificial-intelligence/

23. US Military Almost Certain to Lag Behind China in Intelligentized Warfare by 2030

The PLA and China's Rejuvenation: National Security and Military Strategies, Deterrence Concepts, and Combat Capabilities | RAND
https://www.rand.org/pubs/research_reports/RR1402.html
DoD's 2021 China Military Power Report: How Advances in AI and Emerging Technologies Will Shape China's Military | Council on Foreign Relations (cfr.org)
https://www.cfr.org/blog/dods-2021-china-military-power-report-how-advances-ai-and-emerging-technologies-will-shape
China's Strategic Support Force: A Force for a New Era > National Defense University Press > News (ndu.edu)
https://ndupress.ndu.edu/Media/News/Article/1651760/chinas-strategic-support-force-a-force-for-a-new-era/
The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations | RAND
https://www.rand.org/pubs/research_reports/RR2058.html
future war studies community and the Chinese revolution in military affairs | International Affairs | Oxford Academic (oup.com)
https://academic.oup.com/ia/article-abstract/96/5/1327/5876629?redirectedFrom=fulltext&login=false
新时代的中国国防 白皮书 中国政府网 (www.gov.cn)
http://www.gov.cn/zhengce/2019-07/24/content_5414325.htm
Accelerating the Defense Department's AI Adoption | Council on Foreign Relations (cfr.org)
https://www.cfr.org/report/accelerating-defense-departments-ai-adoption

Milley: China Wants Capability to Take Taiwan by 2027, Sees No Near-term Intent to Invade - USNI News
https://news.usni.org/2021/06/23/milley-china-wants-capability-to-take-taiwan-by-2027-sees-no-near-term-intent-to-invade
199. “Intelligentization” and a Chinese Vision of Future War | Mad Scientist Laboratory (army.mil)
https://madsciblog.tradoc.army.mil/199-intelligentization-and-a-chinese-vision-of-future-war/
DoD's 2021 China Military Power Report: How Advances in AI and Emerging Technologies Will Shape China’s Military | Council on Foreign Relations (cfr.org)
https://www.cfr.org/blog/dods-2021-china-military-power-report-how-advances-ai-and-emerging-technologies-will-shape
DOD Releases 2021 Report on Military and Security Developments Involving the People’s Republic of China > U.S. Department of Defense > Release
https://www.defense.gov/News/Releases/Release/Article/2831819/dod-releases-2021-report-on-military-and-security-developments-involving-the-pe/
U.S. Army Training – U.S. Army Training and Doctrine Command
https://www.tradoc.army.mil/2021/07/22/u-s-army-training/
Army War College Futures Program studies emerging issues | Article | The United States Army
https://www.army.mil/article/257548/army_war_college_futures_program_studies_emerging_issues

24. Wars and Conflicts in 2035 will Almost Certainly be Characterized as AI-Enhanced Attritional Warfare

Attrition and the Will to Fight a Great Power War (af.edu)
https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-13_Issue-4/Moore.pdf
AI Technology In Military Will Transform Future Warfare-Manish Kumar Jha , Amit Das - BW Businessworld
https://www.businessworld.in/article/AI-Technology-In-Military-Will-Transform-Future-Warfare/13-08-2021-400525/
Attrition Definition & Meaning - Merriam-Webster
https://www.merriam-webster.com/dictionary/attrition
Annihilation Definition & Meaning - Merriam-Webster
https://www.merriam-webster.com/dictionary/annihilation
7 Key Military Applications of Machine Learning | by Nicholas Abell | Medium
https://medium.com/@nqabell89/7-key-military-applications-of-machine-learning-9818dfa2ea86
From Deception to Attrition: AI and the Changing Face of Warfare - War on the Rocks
https://warontherocks.com/2020/02/from-deception-to-attrition-ai-and-the-changing-face-of-warfare/
Time for the West to think about how to engage with defeated Russia (brookings.edu)
https://www.brookings.edu/articles/time-for-the-west-to-think-about-how-to-engage-with-defeated-russia/
AI: A GAME CHANGER FOR FUTURE WAR FIGHTING (linkedin.com)
https://www.linkedin.com/pulse/ai-game-changer-future-war-fighting-wg-cdr-tarun-gupta/
The American Way of War in the Twenty-First Century: Three Inherent Challenges - Modern War Institute (usma.edu)

https://mwi.usma.edu/american-way-war-twenty-first-century-three-inherent-challenges/
Full-Report-Digital-1.pdf (nscai.gov)
https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf

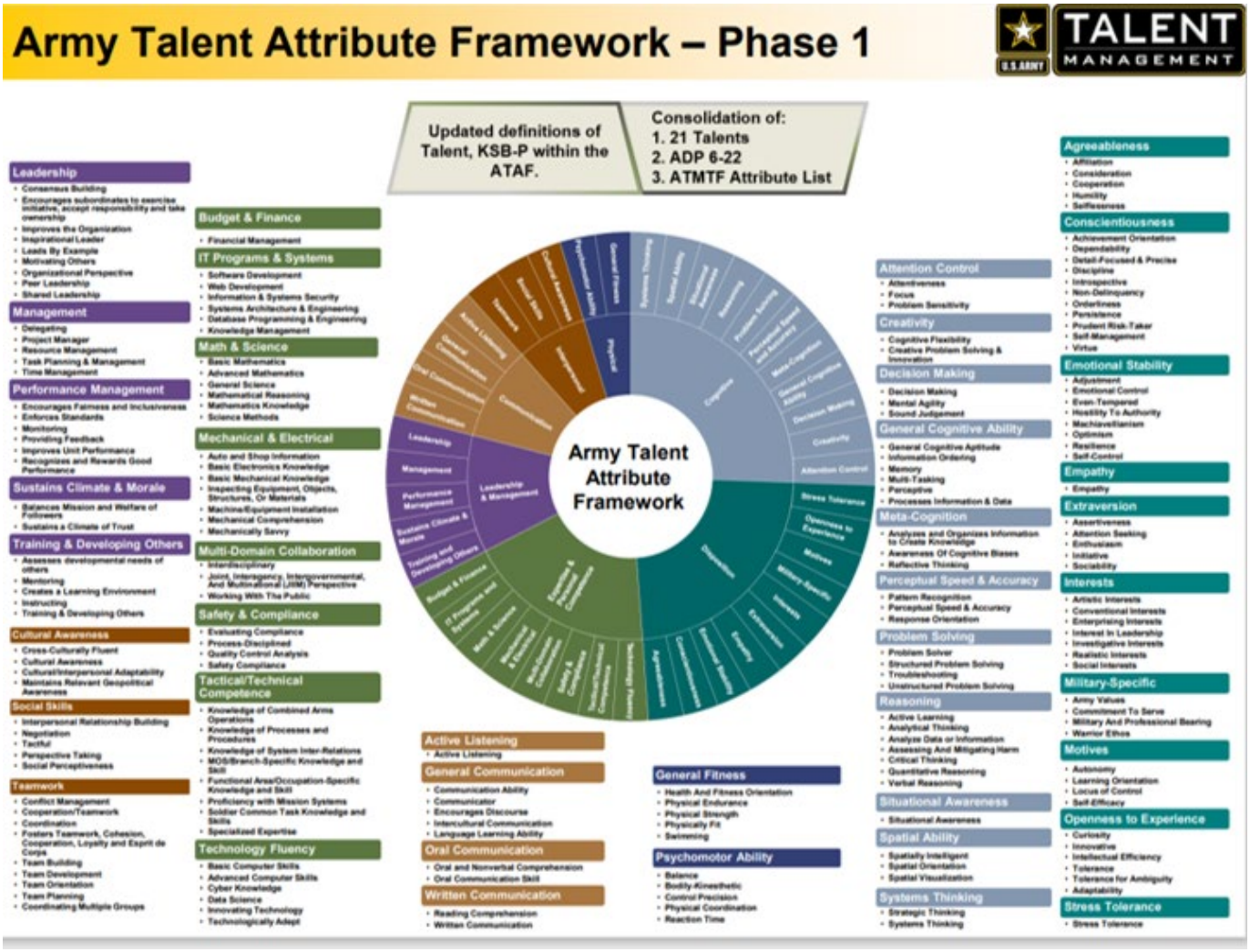
25. Widespread use of Human Performance Enhancement Drugs Across the Commercial Industry and Defense Sectors is Highly Likely by 2040

Developments and challenges in human performance enhancement technology - ScienceDirect
https://www.sciencedirect.com/science/article/pii/S2590093521000394#bib70
Home - Human Enhancement Drugs Network
https://humanenhancementdrugs.com/
Technological Approaches to Human Performance Enhancement | RAND
https://www.rand.org/pubs/research_reports/RRA1482-2.html
Nootropic - an overview | ScienceDirect Topics
https://www.sciencedirect.com/topics/neuroscience/nootropic
Nootropics as Cognitive Enhancers: Types, Dosage and Side Effects of Smart Drugs - PMC (nih.gov)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9415189/
LTC HATCHER SFAR #2 Brain Computer Interface v4.docx - Google Docs
https://docs.google.com/document/d/1dnkZLcM5zuAUw4O1ZXRJ5peJBPJqfWf_/edit
LTC HATCHER SFAR #3 China Human Preformance Enhancment v5.docx - Google Docs
https://docs.google.com/document/d/1jQpS3DVRikDtKTRUqGLjv6NLdaMtlEMu/edit
Weaponizing Biotech: How China's Military Is Preparing for a 'New Domain of Warfare' - Defense One
https://www.defenseone.com/ideas/2019/08/chinas-military-pursuing-biotech/159167/
Medicine developed for Chinese Army to fight sleep - The Korea Times
http://www.koreatimes.co.kr/www/news/special/2011/10/182_96829.html

Human Performance Enhancement | Center for a New American Security (en-US) (cnas.org)
https://www.cnas.org/publications/reports/human-performance-enhancement-1
How effective are pharmaceuticals for cognitive enhancement in healthy adults? A series of meta-analyses of cognitive performance during acute administration of modafinil, methylphenidate and D-amphetamine - ScienceDirect
https://www.sciencedirect.com/science/article/abs/pii/S0924977X20302145
SOCOM's 'Hyper Enabled Operator' concept progresses (sofrep.com)
https://sofrep.com/news/socoms-hyper-enabled-operator-concept-progresses/
SOCOM leaders want to reduce the load on operators to create 'hyper-enabled' operators (c4isrnet.com)
https://www.c4isrnet.com/artificial-intelligence/2019/09/20/socom-leaders-want-to-reduce-the-load-on-operators-to-create-hyper-enabled-operators/
Performance and image enhancing drugs use in active military personnel and veterans: A contemporary review - Whyte - 2021 - TRANSLATIONAL SPORTS MEDICINE - Wiley Online Library
https://onlinelibrary.wiley.com/doi/full/10.1002/tsm2.186
Adverse Health Consequences of Performance-Enhancing Drugs: An Endocrine Society Scientific Statement | Endocrine Reviews | Oxford Academic (oup.com)

https://academic.oup.com/edrv/article/35/3/341/2354633?login=false
Ethical Human Augmentation in the Military - A Comparison and Analysis of National and International Frameworks, Regulation, and Approval Processes | Research Square
https://www.researchsquare.com/article/rs-1826964/v1

Annex G: Army Talent Attribute Framework



Annex H: Presentation

TECHNO-SENTIENT WARFARE 2035

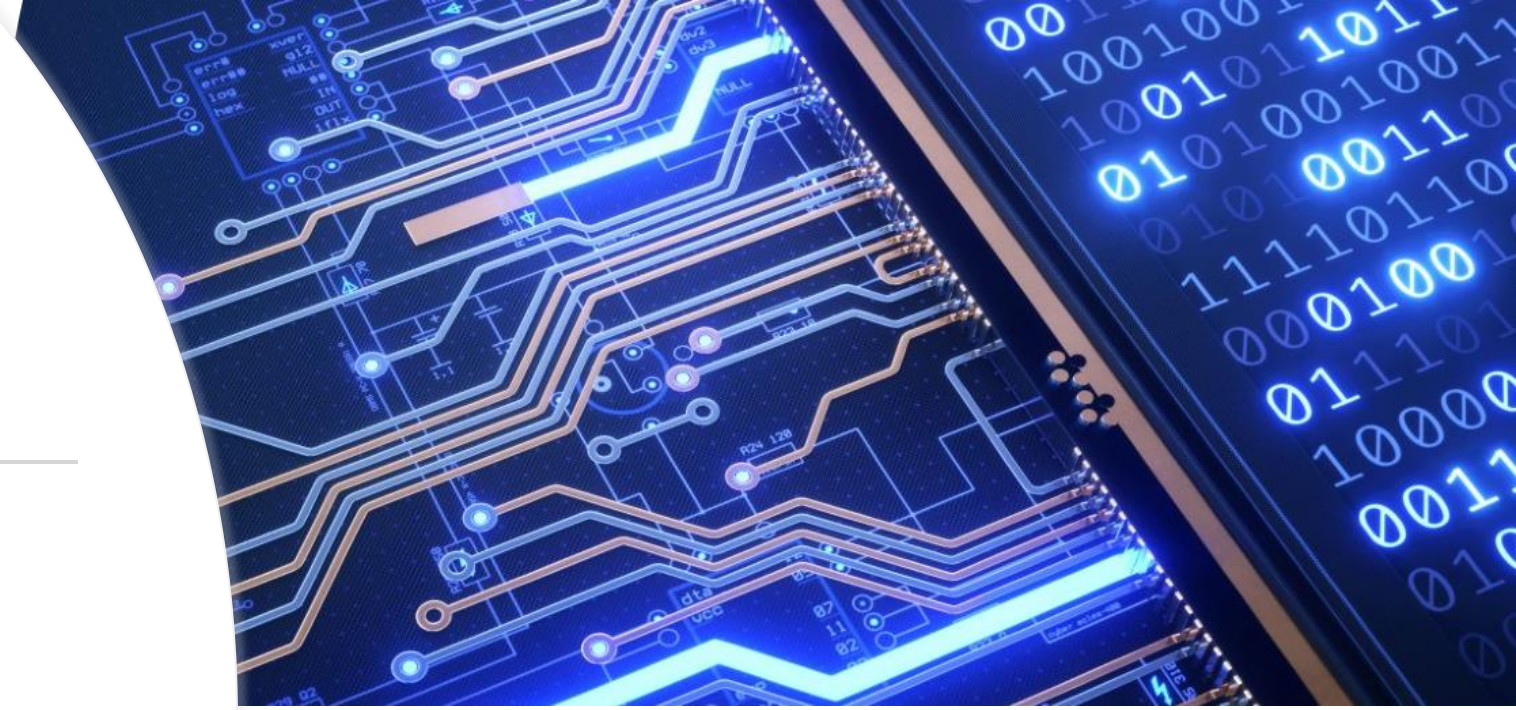
Army War College Academic Year 2023

Futures Seminar

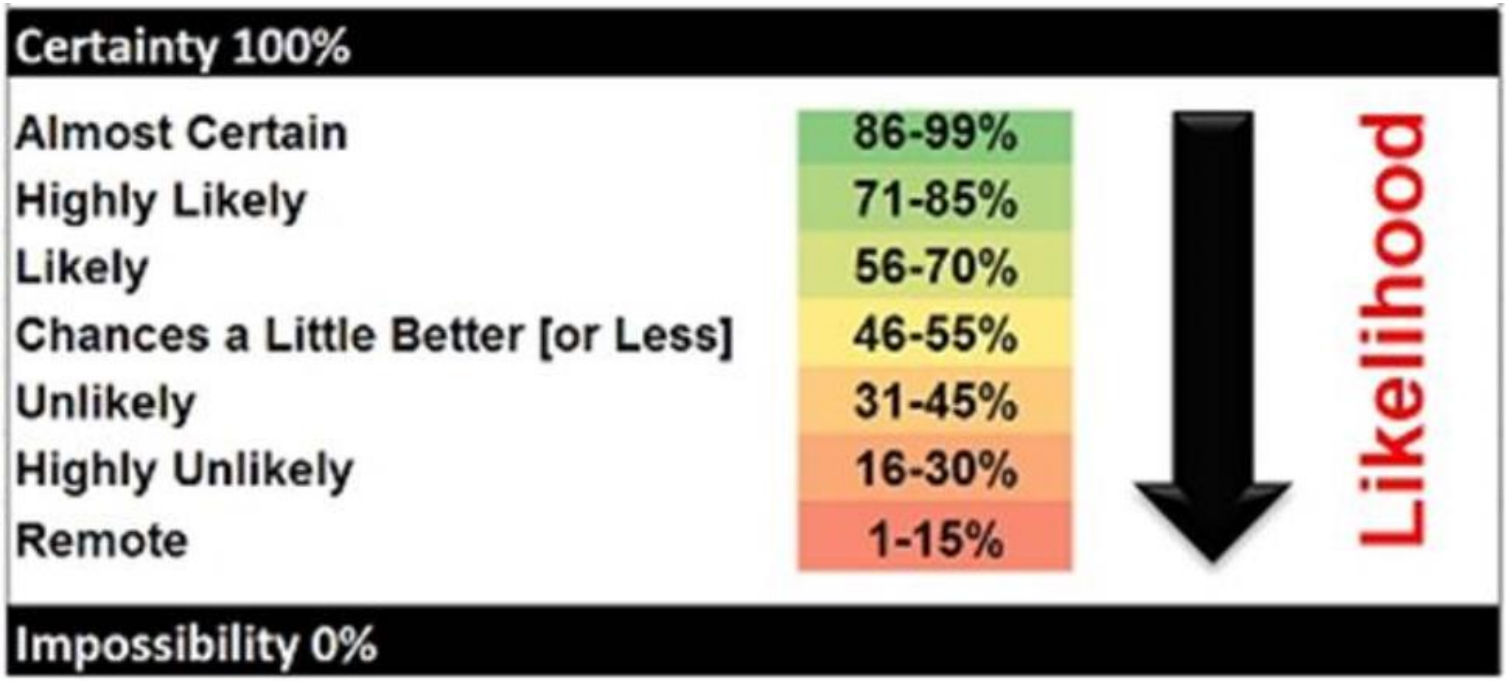
2 May 2023

TECHNO WARFARE GROUP

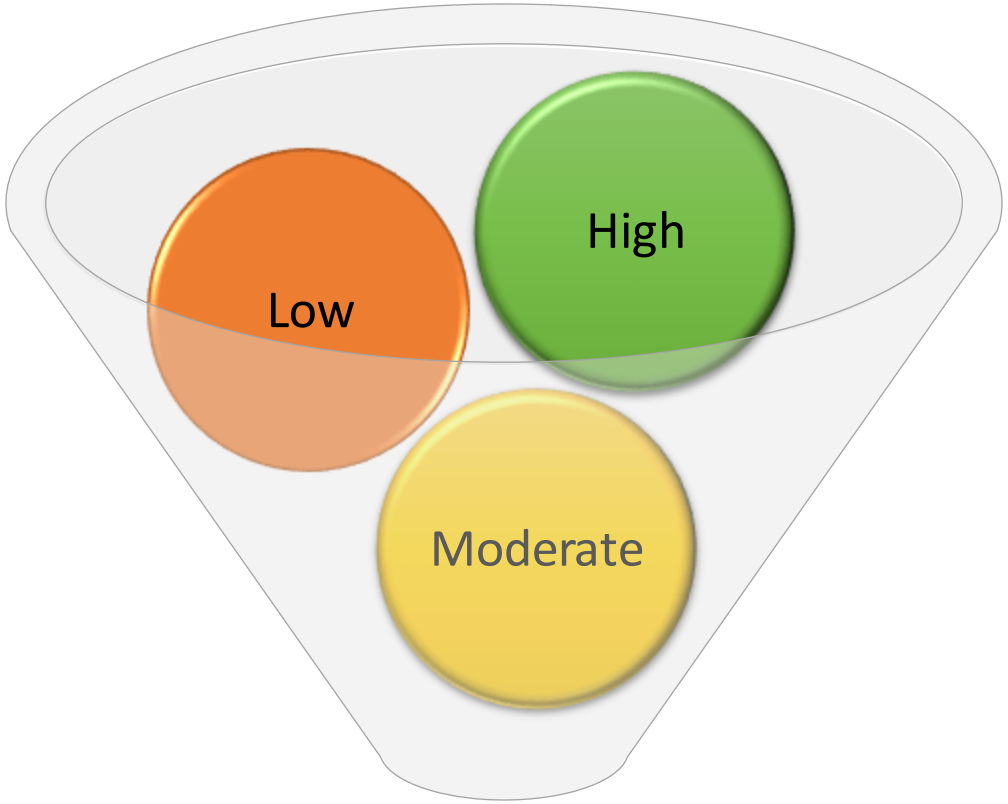
- COL Leslie Carlson, USAR Nurse Corps
- Lt Col Dorian Hatcher, US Space Force
- LTC Samuel Meyer, US Army Military Police Corps
- LTC Fidel Arvelo, US Army Explosive Ordnance Disposal
- LTC Phillip Cain, US Army Aviation



KESSELMAN ESTIMATIVE WORDS OF PROBABILITY



ANALYTICAL CONFIDENCE



Moderate

TERMS OF REFERENCE (TOR)

What will Intelligentized warfare look like in 2035, and what skill sets will leaders need to win in this environment?

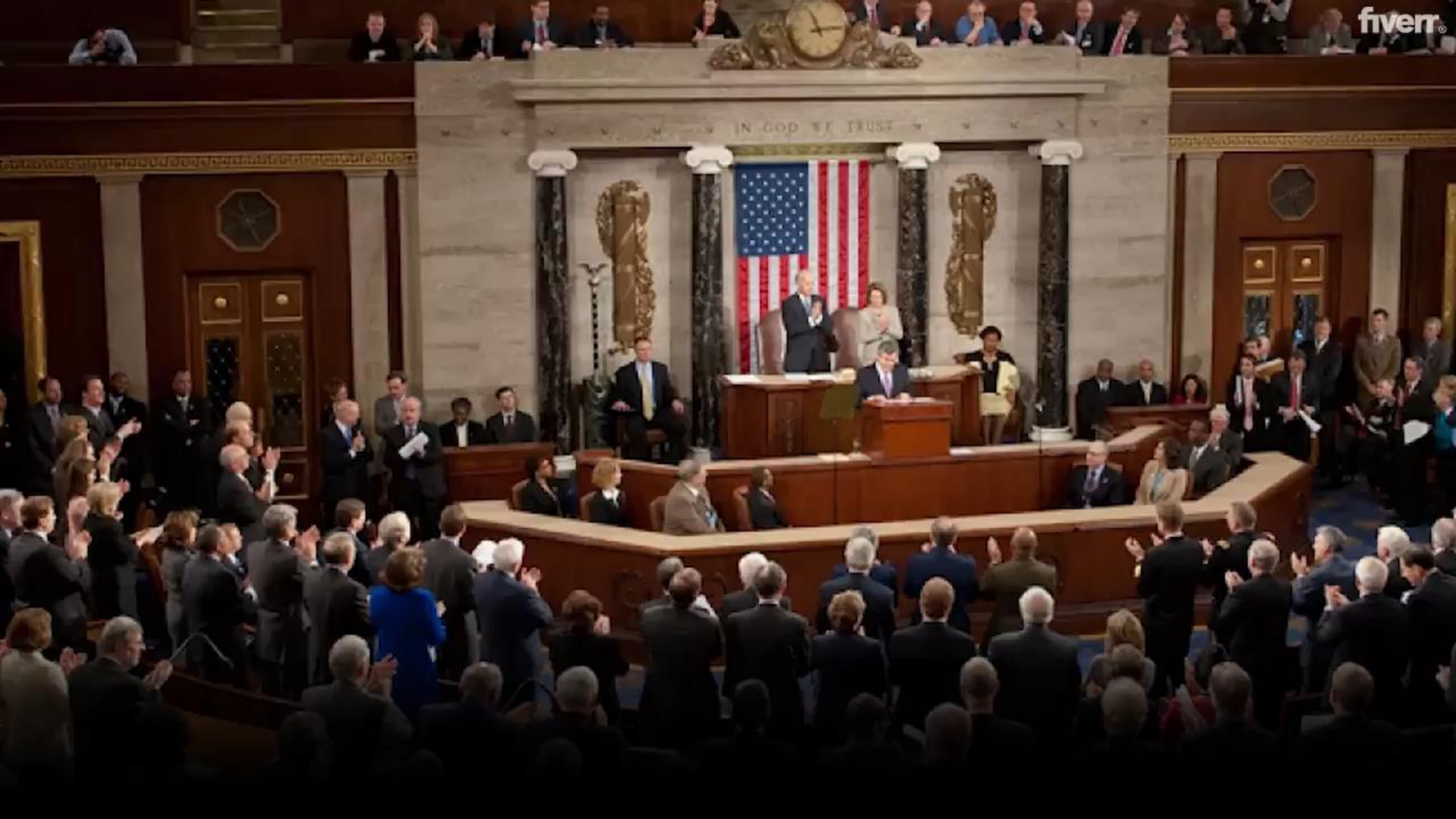
• Scope characteristics of warfare in 2035 that are "intelligentized."

• Will the advent of intelligentized warfare enhance the current approach to warfare, transform the approach, or lead to a revolution in military affairs?

• Based on the projection from the previous question, might this lead to increased frequency of wars of annihilation or wars of attrition?

• Forecast beneficial Knowledge, Skills, and Behaviors (KSB) future leaders will need to operate effectively in 2035.

• What training, educational, or cognitive programs exist for future leaders?


IN GOD WE TRUST

What will *Intelligentized warfare* look like in 2035, what skill sets will leaders need to win in this environment?

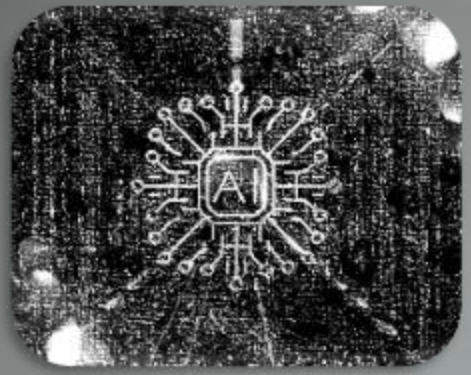
- **Intelligentized warfare** evolves to **Techno-Sentient Warfare (TSW)**
- Quantum Computing
- Artificial Intelligence
- Fusion of cognitive influence operations

What will *Intelligentized warfare* look like in 2035, **and what skill sets will leaders need to win in this environment?**

- **Leaders** cultivate a functional understanding of emerging technologies
- Develop comprehension of Big-data driven AI
- New and adaptive mindset prioritizing innovation

Key Findings: What does it look like

INTELLIGENTIZED WARFARE 2019		TECHNO SENTIENT WARFARE 2035
Artificial Intelligence Artificial Narrow Intelligence (ANI)		**Quantum Enable Ai QBraiNs**
Autonomous Drones Basic, Coordinated, Autonomous Swarms		**Advanced Autonomous Drones Swarms** Intelligent, Self-organizing Swarms
Informationized & IO Warfare		**Cognitive Warfare** Brain Computer-Interfaces, Automatous Social Media Bots, etc..
Human Performance Enhancement (HPE)		**Hyper HPE** Gene-editing CRISPR Soldier Parasitical Enhancement Drugs
Decision Support Systems & Tools		**Quantum Enable Ai QBraiNs Commander**
Human In Loop		**Human Out of Loop**
Big Data		**Data Lake** *Lake House



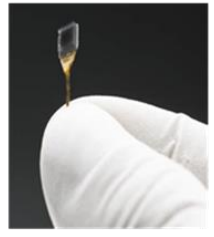
Artificial Narrow Intelligence

Quantum Brain Networks (QBraiNs)

… knowledge and methods from neurotechnology, artificial intelligence, and quantum computing to develop enhanced connectivity between the human brain and quantum computers.

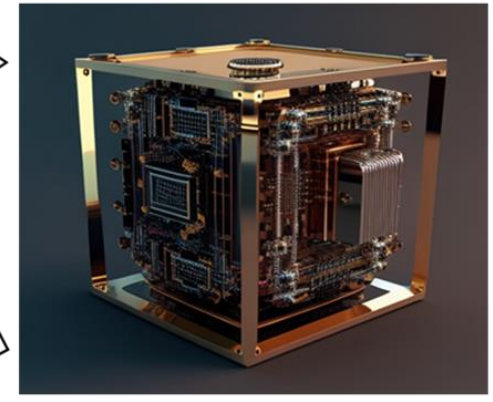
Quantum Brain Network (QBraiNs)

Micro-electrodes detect signals from the human cerebral cortex and send them to the AI



BMI

AI extracts, classify, and sends data to a Quantum a Computer



Quantum computer processes and accelerates commands for Human-Machine Interactions or provide immediate feedback to the cerebral cortex

Feedback

Human-Machine Interactions

Feedback

Brain Signals

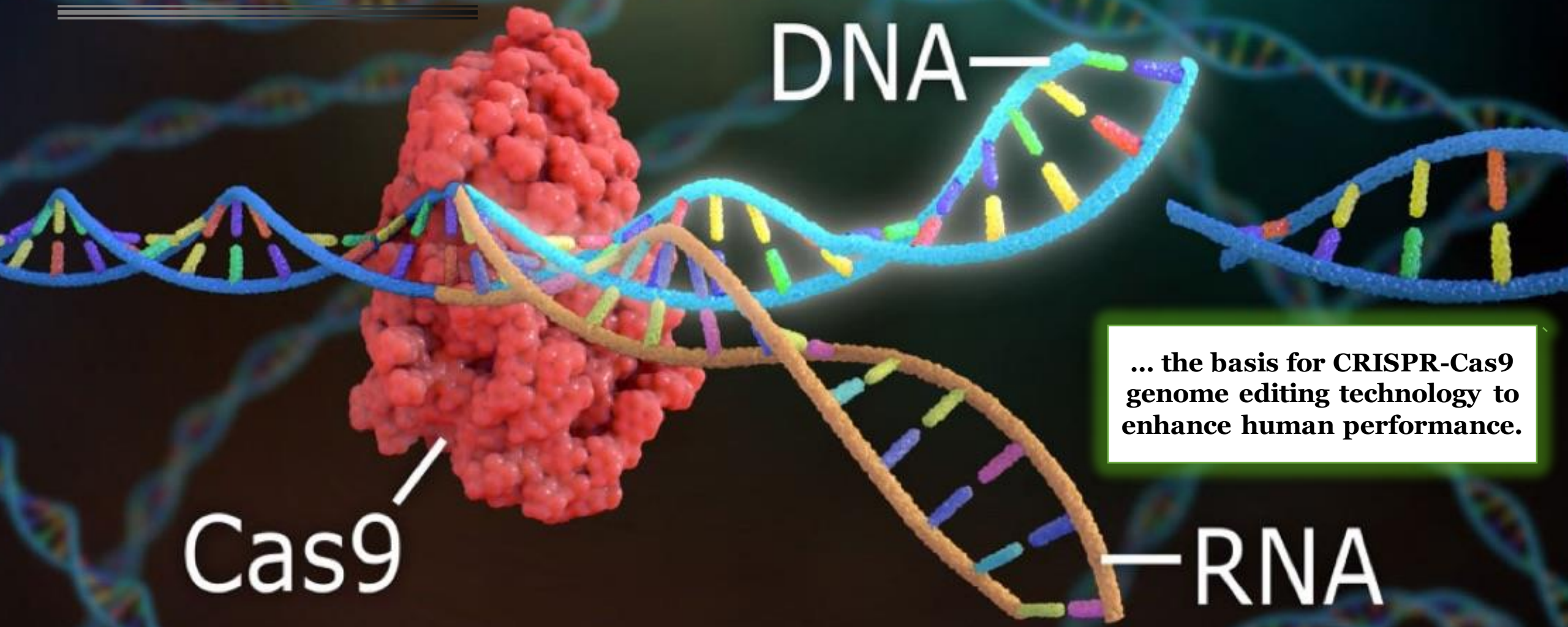
Wired/wireless
Invasive, non-invasive

Informationized Warfare

- **Influencing and manipulating thoughts, beliefs, attitudes, and behaviors**
- **Gain a decisive advantage by controlling the mental and emotional aspects of human behavior**
- **Conducted through various channels and forms of communicationw**

HPE

Hyper Human Performance Enhancement



… the basis for CRISPR-Cas9 genome editing technology to enhance human performance.

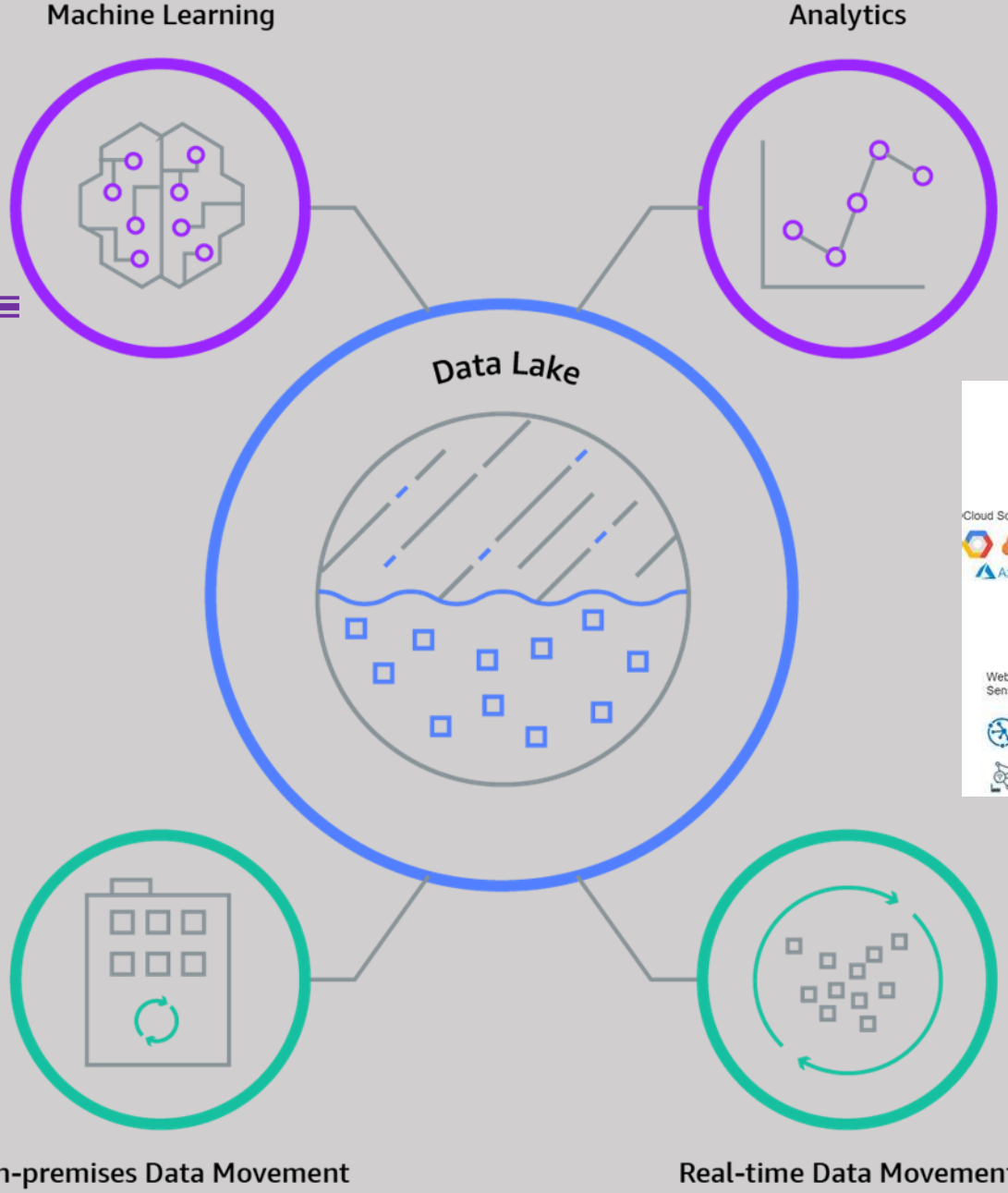
Decision Support Matrix/Tools

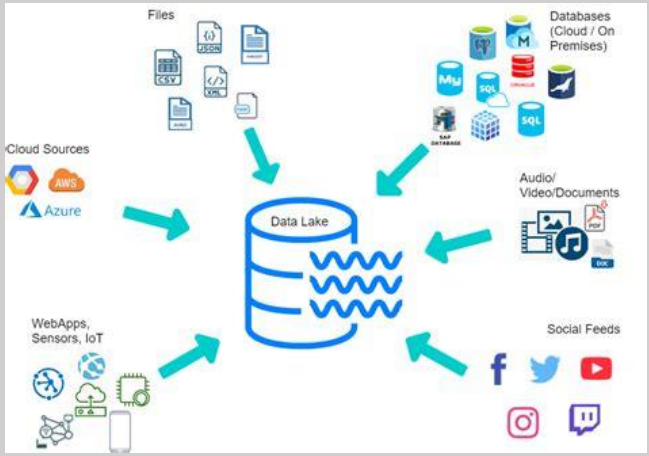
QBraiNs Commander

… refers to enabling rapid, decisive, and actionable decisions

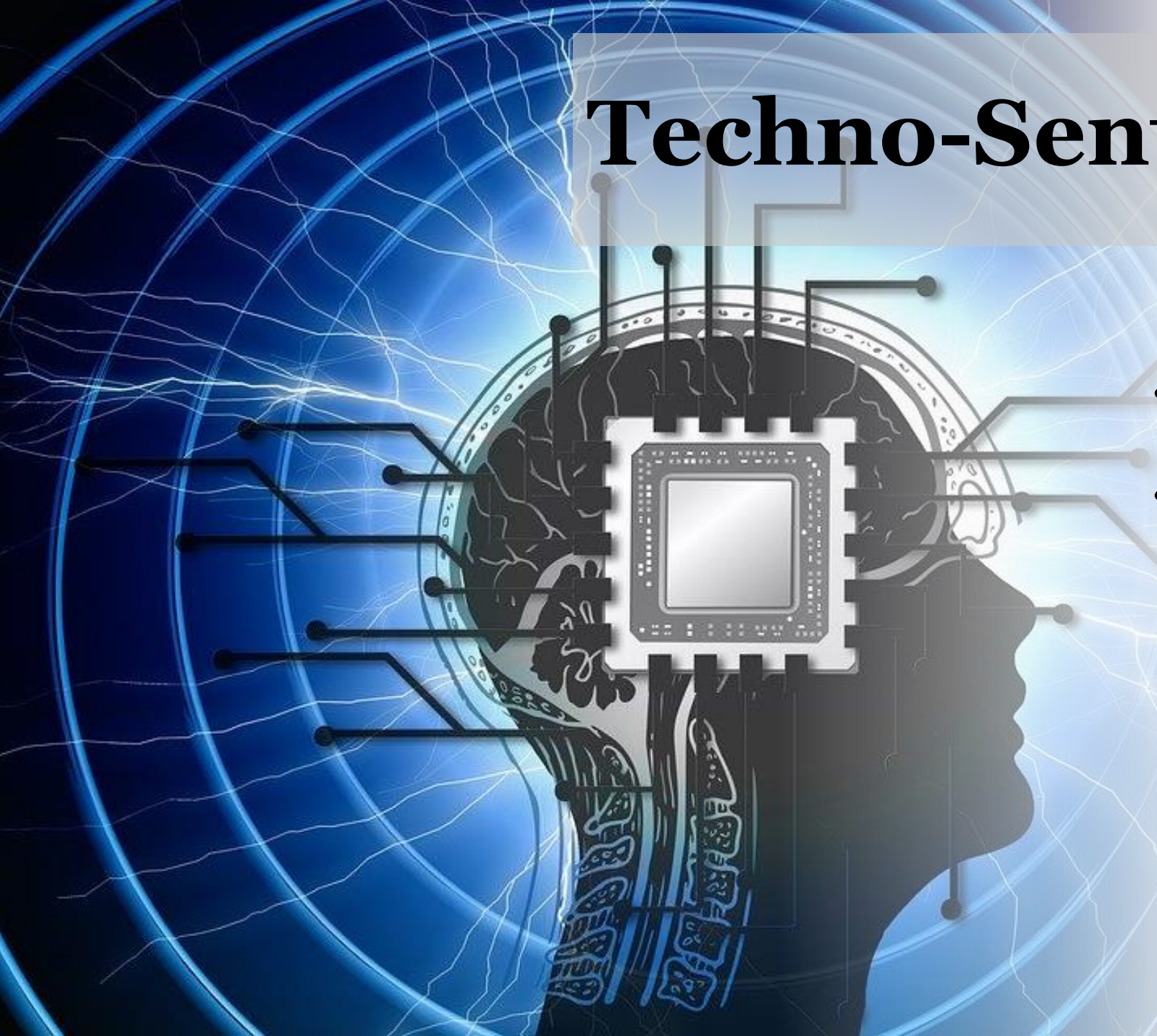
Data Lakes

- Large amount of data in the original form
- Source agnostic
- Powers ML and predictive analytics.





Techno-Sentient Warfare



- The convergence of Quantum Computing and AI
- “sentient” the ability to operate autonomously
  - Make decisions
  - Adapt
  - Does not infer consciousness

Techno-Sentient Warfare

- Systems will work with systems
- Conflicts occur earlier across the competition continuum
- Conflicts in the “grey zone” increase
- Keys to dominate:
  - Perception, adaptation, speed, autonomous

Techno-Sentient Warfare → Character of Warfare

A Changing Character of Warfare

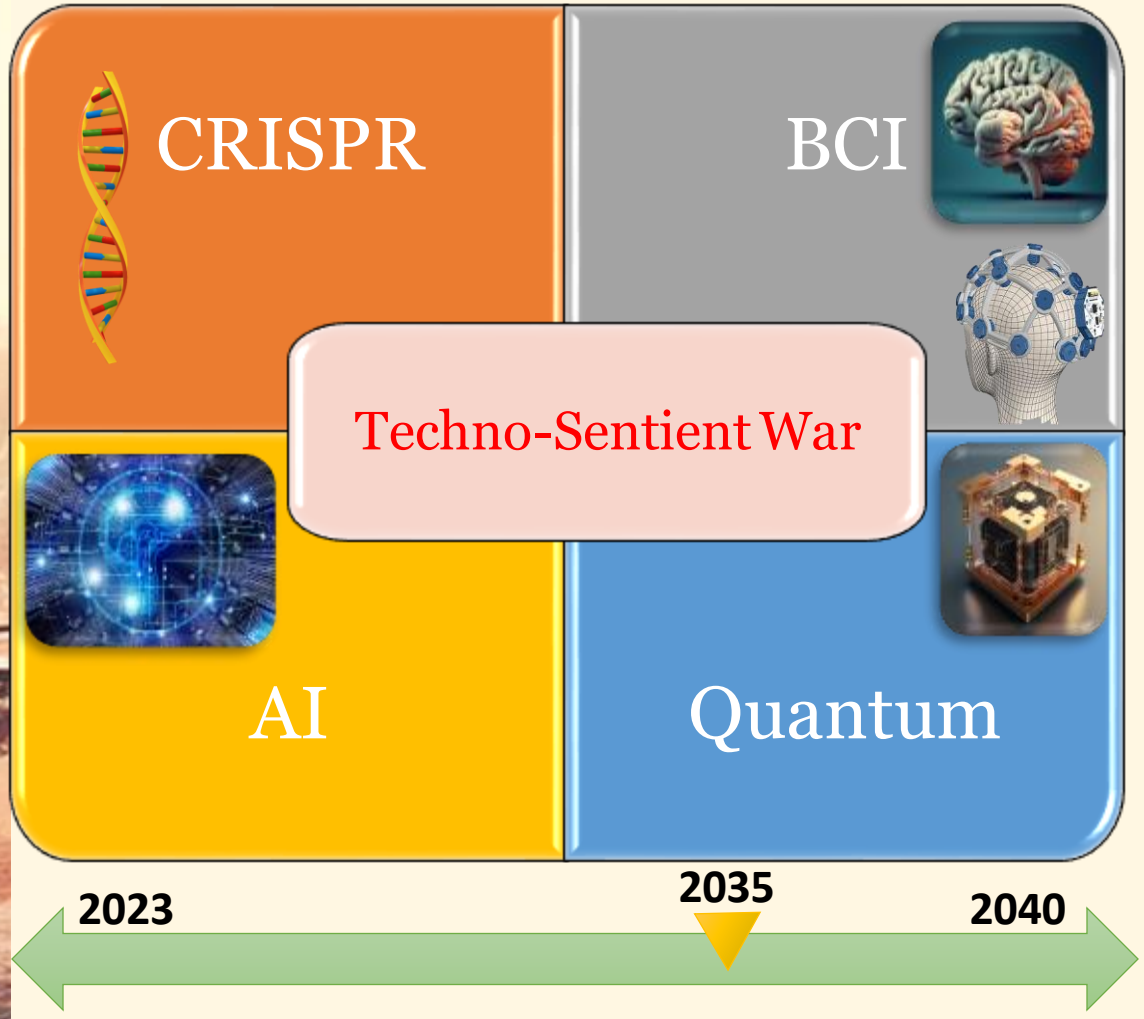
- Almost certain (86-99%) that character of warfare will change before 2035
- Increased competition in non-physical **domains** (cyber, air, space, land, maritime, cognitive).
- The **boundaries** between peacetime and wartime blur
- Increased reliance on uncrewed systems

"Highly dependent on scientific innovation, technological change, demographic shifts, trends, and changes in domestic and international political organization and national policies."

A Changing Character of Warfare

- The battle of systems before physical human engagement
- Ubiquitous computerized sensors supported by automated call-for-fire
- Enhanced humans paired with robots and uncrewed vehicles
- Integration of quantum computing
- Accelerated wargaming and decision-making

Technology Convergence

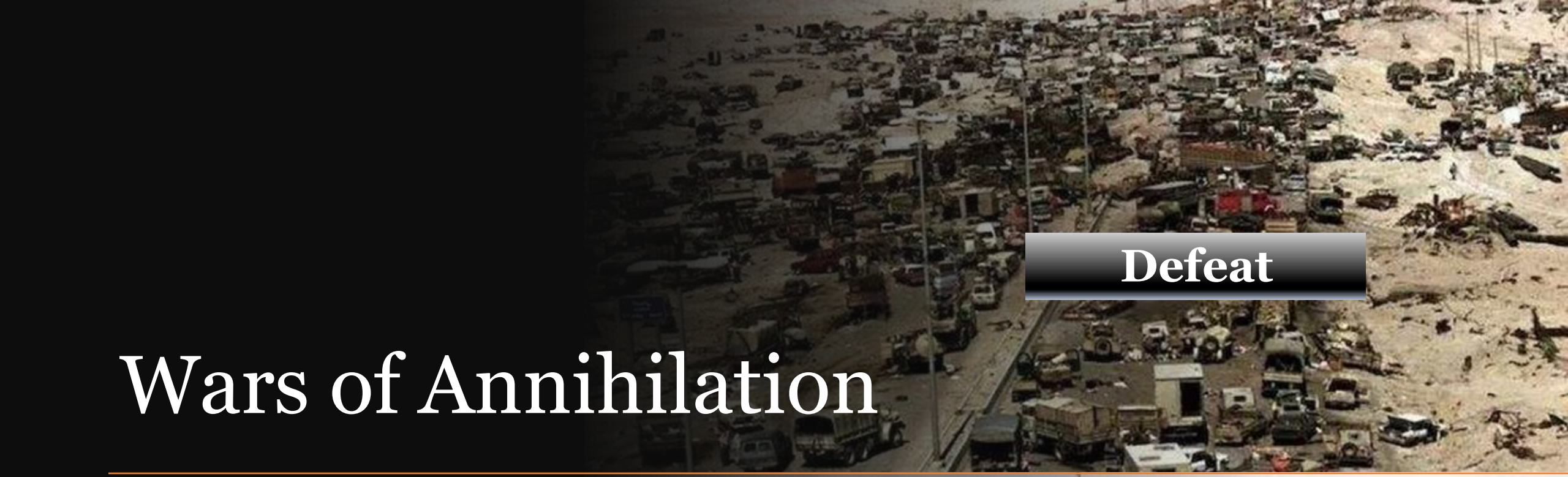


Revolution in Military Affairs

Associated RMAs

- **Individual-operated or autonomous drone swarms (Almost Certain)**
- **HPE Soldier (Exoskeleton, Drugs, BCI (Highly likely)**
- **Cognitive Social Media Warfare (Highly Likely)**

Wars of Annihilation and Attrition



Defeat

Exhaustion

Wars of Annihilation

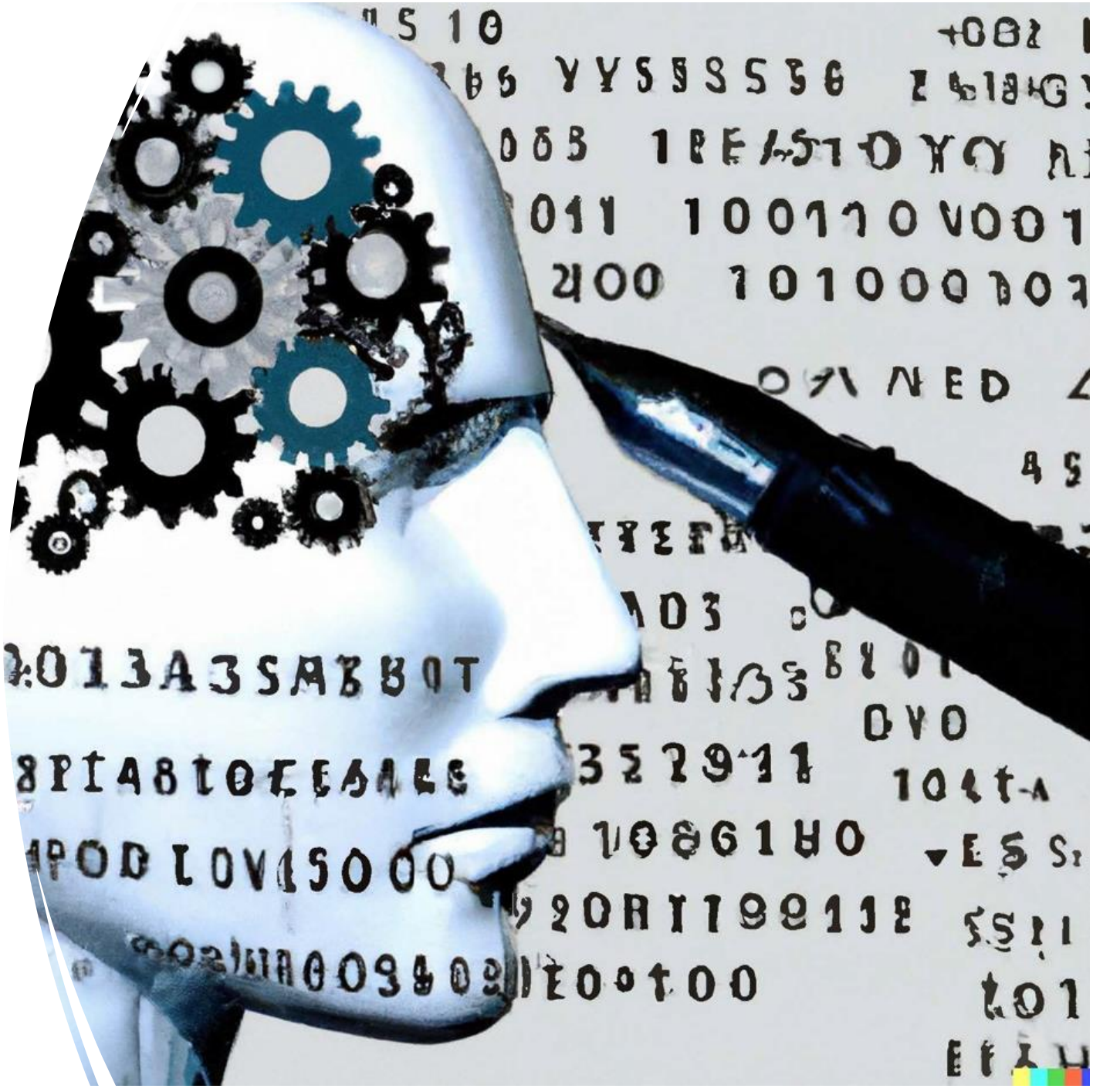
- Likely (56-70%) to increase in instances with countries using Techno-sentient warfare against conventional forces.
  - Desert Storm
  - Second Nagorno-Karabakh War

Wars of Attrition

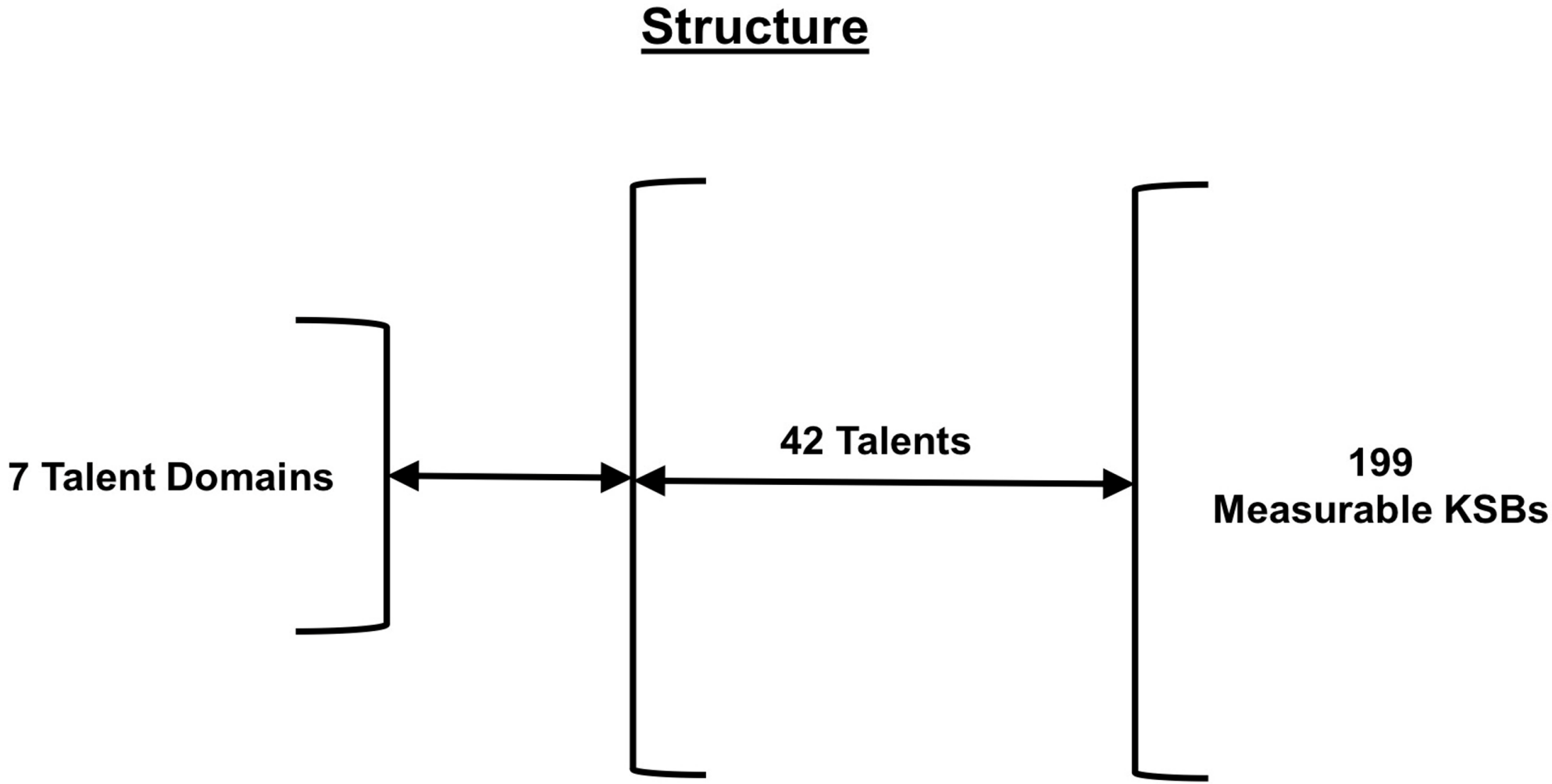
- Almost certain (86-99%) for near-peer adversaries engaging in Techno-Sentient Warfare
- Difficult to achieve a decisive advantage
- Techno-Sentient capabilities wielded by paramilitary units or special forces will provide conditions for prolonged wars of attrition

Techno-Sentient Warfare

KSBs



Techno-Sentient Warfare KSBs



While some existing KSBs overlap with TSW, it is highly likely that leaders require additional KSBs not present in today's military structure

STEM Understanding

Software Engineering

Understanding of AI/ML

Robotics Engineering

Human Centered Engineering

Data Engineering

Learn from Failure

Accept Failure

Decision Support Systems

Application Program Interface (API)

Discernment

Communication

Critical Thinking

Statistics & Data Analytics

Trust in Systems

Open Mindedness

Ethical

Computer Science

Innovation

Data Visualization

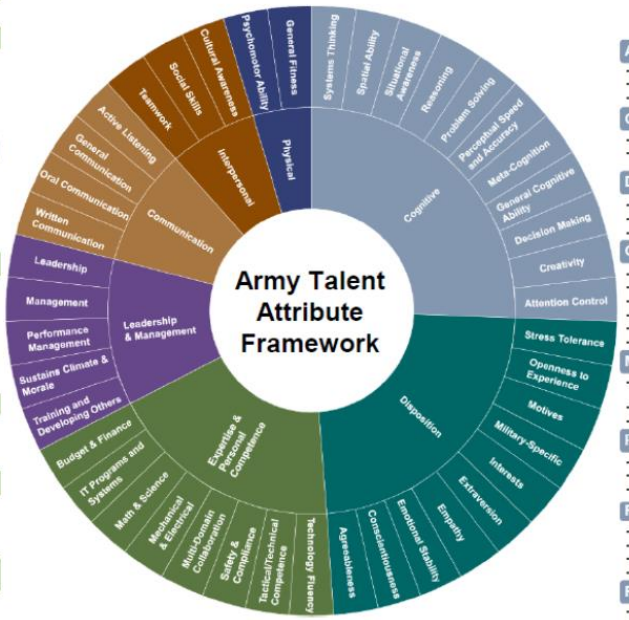
Creativity

Army Talent Attribute Framework – Phase 1

TALENT MANAGEMENT

Updated definitions of Talent, KSB-P within the ATAF.

Consolidation of:
1. 21 Talents
2. ADP 6-22
3. ATMTF Attribute List



Leadership
- Consensus Building
- Encourages subordinates to exercise initiative, accept responsibility and take ownership
- Improves the Organization
- Inspirational Leader
- Leads By Example
- Motivating Others
- Organizational Perspective
- Peer Leadership
- Shared Leadership

Management
- Delegating
- Project Manager
- Resource Management
- Task Planning & Management
- Time Management

Performance Management
- Encourages Fairness and Inclusiveness
- Enforces Standards
- Monitoring
- Providing Feedback
- Improves Unit Performance
- Recognizes and Rewards Good Performance

Sustains Climate & Morale
- Balances Mission and Welfare of Followers
- Sustains a Climate of Trust

Training & Developing Others
- Assesses developmental needs of others
- Mentoring
- Creates a Learning Environment
- Instructing
- Training & Developing Others

Cultural Awareness
- Cross-Culturally Fluent
- Cultural Awareness
- Cultural/Interpersonal Adaptability
- Maintains Relevant Geopolitical Awareness

Social Skills
- Interpersonal Relationship Building
- Negotiation
- Tactful
- Perspective Taking
- Social Perceptiveness

Teamwork
- Conflict Management
- Cooperation/Teamwork
- Coordination
- Fosters Teamwork, Cohesion, Cooperation, Loyalty and Esprit de Corps
- Team Building
- Team Development
- Team Orientation
- Team Planning
- Coordinating Multiple Groups

Budget & Finance
- Financial Management

IT Programs & Systems
- Software Development
- Web Development
- Information & Systems Security
- Systems Architecture & Engineering
- Database Programming & Engineering
- Knowledge Management

Math & Science
- Basic Mathematics
- Advanced Mathematics
- General Science
- Mathematical Reasoning
- Mathematics Knowledge
- Science Methods

Mechanical & Electrical
- Auto and Shop Information
- Basic Electronics Knowledge
- Basic Mechanical Knowledge
- Inspecting Equipment, Objects, Structures, Or Materials
- Machine/Equipment Installation
- Mechanical Comprehension
- Mechanically Savvy

Multi-Domain Collaboration
- Interdisciplinary
- Joint, Interagency, Intergovernmental, And Multinational (JIIM) Perspective
- Working With The Public

Safety & Compliance
- Evaluating Compliance
- Process-Disciplined
- Quality Control Analysis
- Safety Compliance

Tactical/Technical Competence
- Knowledge of Combined Arms Operations
- Knowledge of Processes and Procedures
- Knowledge of System Inter-Relations
- MOS/Branch-Specific Knowledge and Skill
- Functional Area/Occupation-Specific Knowledge and Skill
- Proficiency with Mission Systems
- Soldier Common Task Knowledge and Skills
- Specialized Expertise

Technology Fluency
- Basic Computer Skills
- Advanced Computer Skills
- Cyber Knowledge
- Data Science
- Innovating Technology
- Technologically Adept

Active Listening
- Active Listening

General Communication
- Communication Ability
- Communicator
- Encourages Discourse
- Intercultural Communication
- Language Learning Ability

Oral Communication
- Oral and Nonverbal Comprehension
- Oral Communication Skill

Written Communication
- Reading Comprehension
- Written Communication

General Fitness
- Health And Fitness Orientation
- Physical Endurance
- Physical Strength
- Physically Fit
- Swimming

Psychomotor Ability
- Balance
- Bodily-Kinesthetic
- Control Precision
- Physical Coordination
- Reaction Time

Attention Control
- Attentiveness
- Focus
- Problem Sensitivity

Creativity
- Cognitive Flexibility
- Creative Problem Solving & Innovation

Decision Making
- Decision Making
- Mental Agility
- Sound Judgement

General Cognitive Ability
- General Cognitive Aptitude
- Information Ordering
- Memory
- Multi-Tasking
- Perceptive
- Processes Information & Data

Meta-Cognition
- Analyzes and Organizes Information to Create Knowledge
- Awareness Of Cognitive Biases
- Reflective Thinking

Perceptual Speed & Accuracy
- Pattern Recognition
- Perceptual Speed & Accuracy
- Response Orientation

Problem Solving
- Problem Solver
- Structured Problem Solving
- Troubleshooting
- Unstructured Problem Solving

Reasoning
- Active Learning
- Analytical Thinking
- Analyze Data or Information
- Assessing And Mitigating Harm
- Critical Thinking
- Quantitative Reasoning
- Verbal Reasoning

Situational Awareness
- Situational Awareness

Spatial Ability
- Spatially Intelligent
- Spatial Orientation
- Spatial Visualization

Systems Thinking
- Strategic Thinking
- Systems Thinking

Agreeableness
- Affiliation
- Consideration
- Cooperation
- Humility
- Selflessness

Conscientiousness
- Achievement Orientation
- Dependability
- Detail-Focused & Precise
- Discipline
- Introspective
- Non-Delinquency
- Orderliness
- Persistence
- Prudent Risk-Taker
- Self-Management
- Virtue

Emotional Stability
- Adjustment
- Emotional Control
- Even-Tempered
- Hostility To Authority
- Machiavellianism
- Optimism
- Resilience
- Self-Control

Empathy
- Empathy

Extraversion
- Assertiveness
- Attention Seeking
- Enthusiasm
- Initiative
- Sociability

Interests
- Artistic Interests
- Conventional Interests
- Enterprising Interests
- Interest In Leadership
- Investigative Interests
- Realistic Interests
- Social Interests

Military-Specific
- Army Values
- Commitment To Serve
- Military And Professional Bearing
- Warrior Ethos

Motives
- Autonomy
- Learning Orientation
- Locus of Control
- Self-Efficacy

Openness to Experience
- Curiosity
- Innovative
- Intellectual Efficiency
- Tolerance
- Tolerance for Ambiguity
- Adaptability

Stress Tolerance
- Stress Tolerance

Required Attributes for 2035

Correlated KSB

Understanding of AI/ML *Technologically Adept*	Learn from Failure	Accept Failure	Computer Science *Systems Architecture & Engineering*	Data Engineering *Database Programming & Engineering*	Critical Thinking *Critical Thinking*	Innovative *Innovative*
Software Engineering *Software Development*	Discernment *Perceptive*	Statistics & Data Analytics *Analyze Data or information*	Human Centered Engineering	Open Mindedness *Curiosity*	Decision Support Systems *Organizational Perspective*	Data Visualization *Process Information & Data*
Application Program Interface (API)	STEM Understanding *General Science*	Creativity *Cognitive Flexibility*	Robotics Engineering *Mechanically Savvy*	Communi-cation *Encourage Discourse*	Trust in Systems Including AI/ML	Ethical *Leads by Example*

TSW REQUIRED ATTRIBUTES IN 2035

Accept Failure

Learn from Failure

Human-Centered Engineering

Trust in Systems, Including AI/ML

Application Program Interface (API)

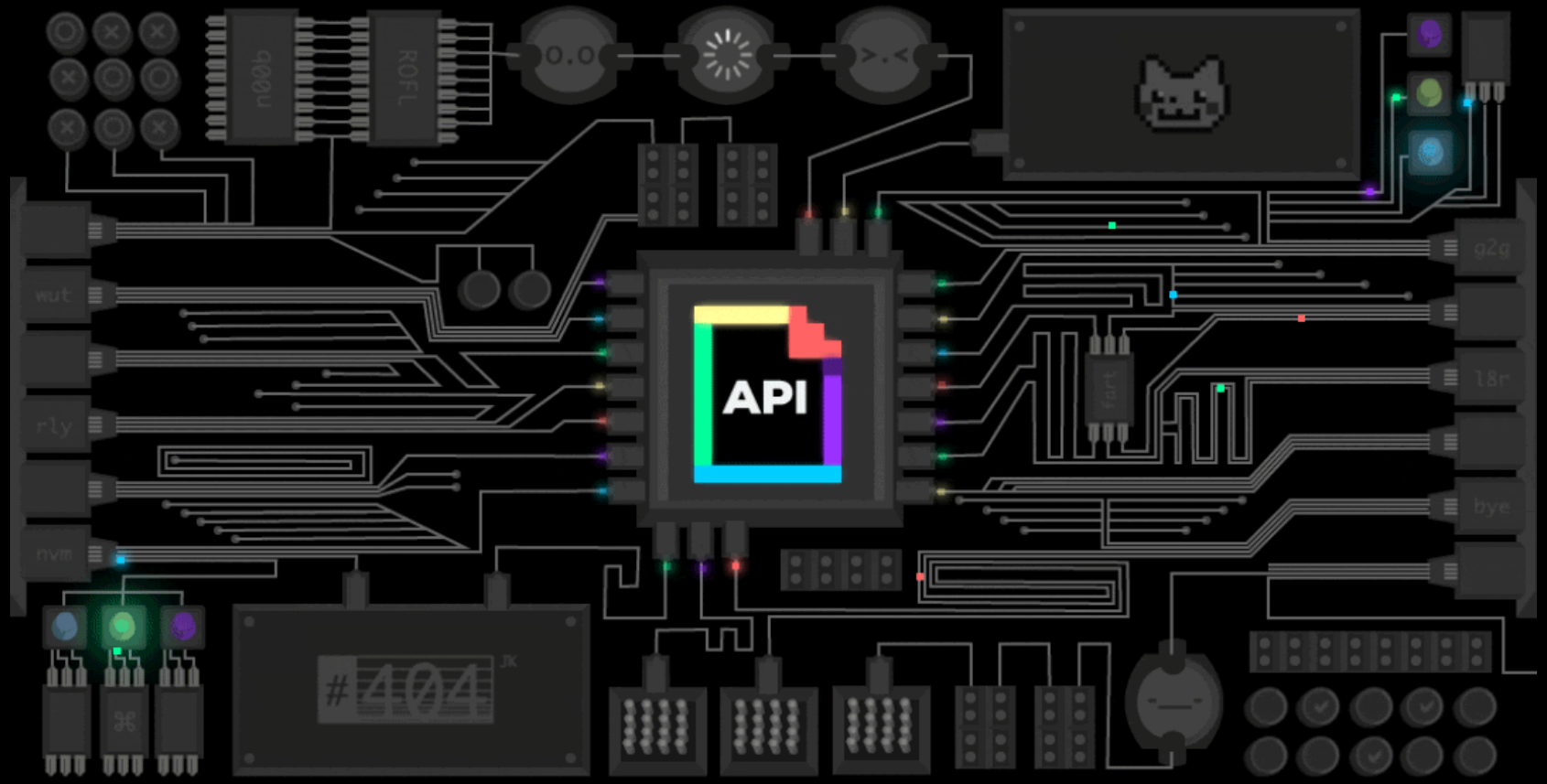
Learn from and Accept Failure

The institutions “existed to prevent failure, and no one seemed to notice that in so doing they also prevented excellence.”

The military should strive to promote and develop systems that recognize the importance of keeping humans at the intersection of technology and military applications

Human-Centered Engineering

Application Program Interface

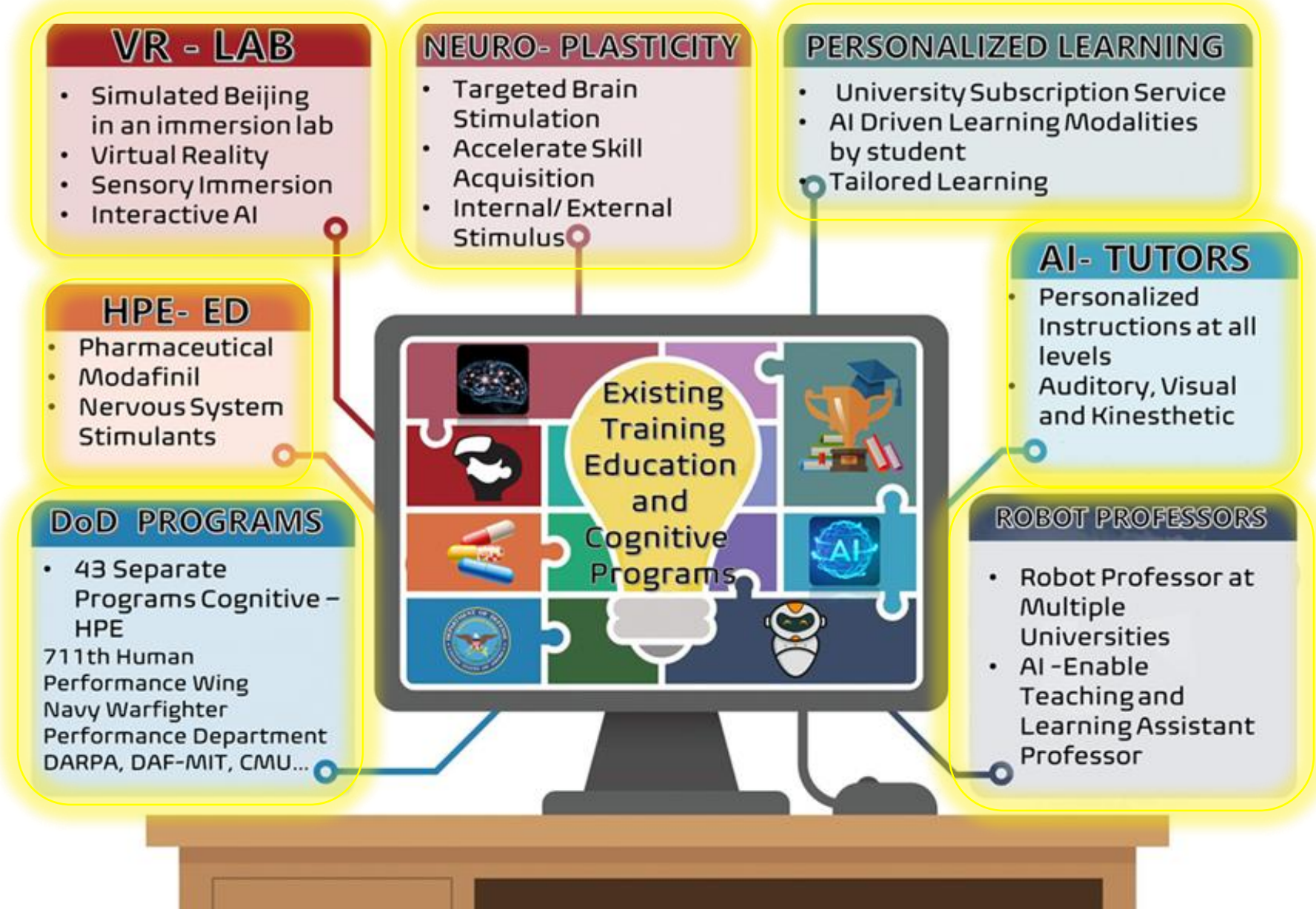


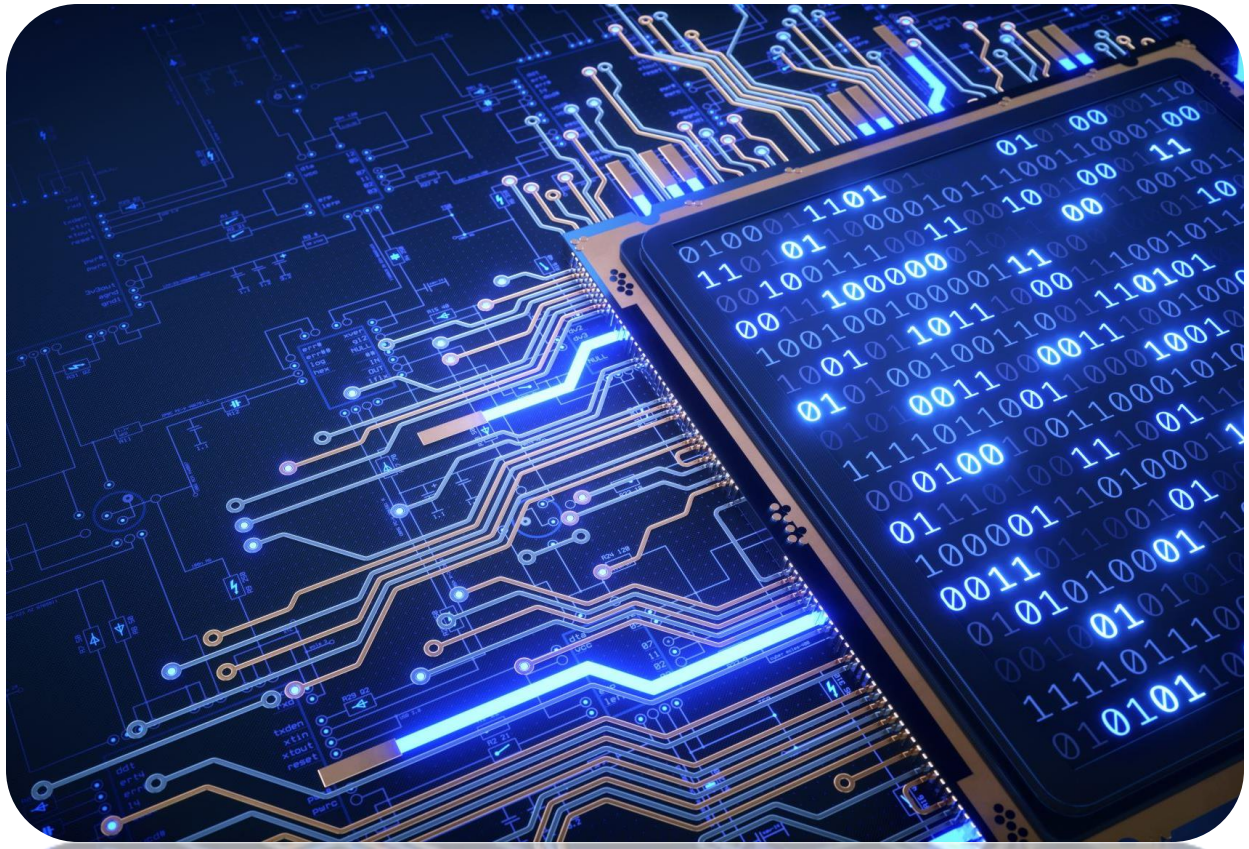
Leaders, at echelon, need to promote and understand how to leverage systems that seamlessly exchange and synchronize data to quickly integrate those features for offensive or defensive measures.

The Army Talent Attribute Framework references ‘trust’ seven times; every time trust is used in reference to a person or a group of people – the document never refers to a behavior that would require trust in a system

Trust-in-Systems Including AI/ML

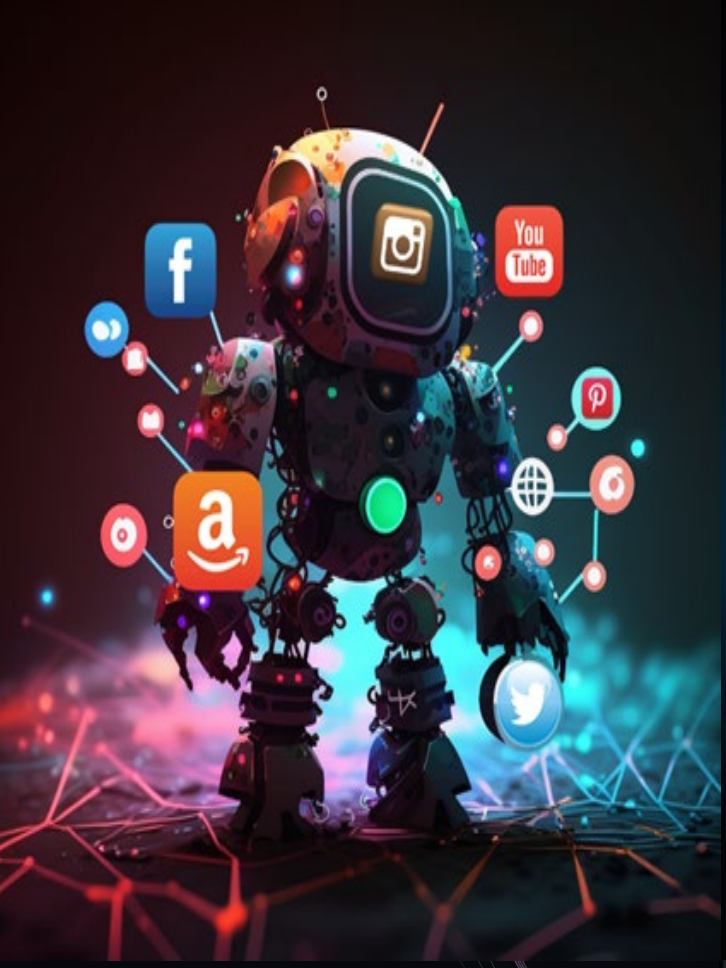
Existing Training, Educational, and Cognitive Programs





TECHNO-SENTIENT WARFARE 2035

Discussion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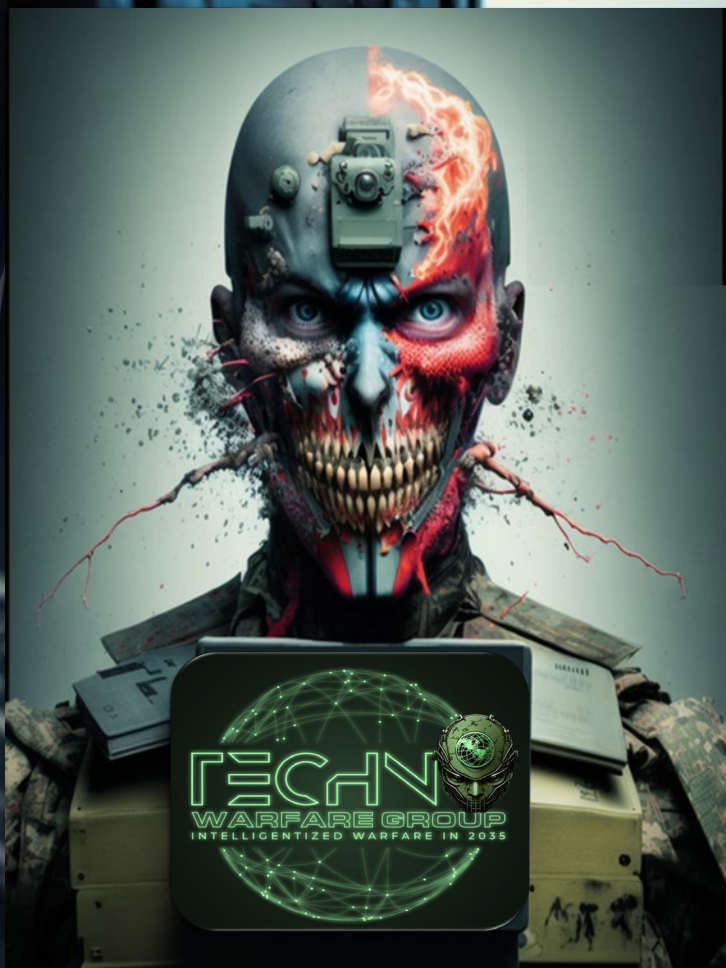
TECHN
WARFARE GROUP
INTELLIGENTIZED WARFARE IN 2035