# Better Together: Integrating Artificial Intelligence into Team Cognition

A Monograph

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On the battlefield of the future, synthetically made decisions will occur in and around those made by human beings. Artificial Intelligence (AI) will, in fact, alter the conduct of every aspect of human life. War and how people conceive of it will be no exception to this wave of change. In particular, the framework and methods in which the US Army conceives its way of warfare must adapt to incorporate the strengths of non-emotive intellect with the insight of human emotive thought. Teaming AI with human actors potentially provides a decisive advantage in military decision-making and represents a new kind of cognitive framework and methodology for successful military operations. The proliferation of AI in military applications is already in motion and the subsequent increase in the complexity of operating environments is now inevitable. The United States has an absolute responsibility to achieve and maintain dominance in military applications of AI. Not doing so assumes enormous risk and cedes initiative to enemies actively seeking positions of relative advantage.

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## Abstract

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On the battlefield of the future, synthetically made decisions will occur in and around those made by human beings. Artificial Intelligence (AI) will, in fact, alter the conduct of every aspect of human life. War and how people conceive of it will be no exception to this wave of change. In particular, the framework and methods in which the US Army conceives its way of warfare must adapt to incorporate the strengths of non-emotive intellect with the insight of human emotive thought. Teaming AI with human actors potentially provides a decisive advantage in military decision-making and represents a new kind of cognitive framework and methodology for successful military operations. The proliferation of AI in military applications is already in motion and the subsequent increase in the complexity of operating environments is now inevitable.

Just as nuclear weapons served to end World War II and subsequently deter resumption of overt major power conflict during the twentieth century, competitors expect AI to become the most significant aspect of national power in the twenty-first century. This work focuses on the culture of the US Army but is certainly applicable to other corporate cultures. If AI is to be effectively leveraged in the future, and it must be in order to address the almost certain challenges of competitor use, successful incorporation of AI tools requires analysis of existing culture and visualization of both future cultural and technical developments. The United States has an absolute responsibility to achieve and maintain dominance in military applications of AI. Not doing so assumes enormous risk and cedes initiative to enemies actively seeking positions of relative advantage.

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Any errors in this work are my own and should not reflect poorly on referenced materials or similar analysis by others.

# Acronyms

| | |
|---|---|
| AI | Artificial Intelligence |
| BO | Boundary Object |
| CAS | Complex Adaptive System |
| CTC | Combat Training Center |
| CDR | Commander |
| CM | Crisis Management |
| DES | Discrete Event Simulation |
| DSS | Decision Support System |
| EM | Electromagnetic |
| FSM | Finite State Machine |
| MBM | Multiagent-based Model |
| PD | Planning and Design |

# Illustrations

# Introduction

> Artificial intelligence is the future, not only of Russia, but of all of mankind. Whoever becomes the leader in this sphere will become the ruler of the world.
>
> — Vladimir Putin, President of the Russian Federation

On the battlefield of the future, synthetically made decisions will occur in and around those made by human beings. Despite the moral posturing of leaders in science and business who oppose the weaponization of autonomous systems, major competitors on the world stage will employ technology in new ways to increase the tempo and complexity of warfare.[1] The primary vehicle to do so will be Artificial Intelligence.

Artificial Intelligence (AI) will in fact alter the conduct of every aspect of human life. War and how people conceive of it will be no exception to this ongoing and forthcoming wave of change. In particular the framework and methods in which the US Army conceives its way of warfare must adapt to incorporate the strengths of non-emotive intellect with the insight of human emotive thought. The potential of teamed human-AI thought is practically limitless and may well be the most decisive aspect of future combat because it will likely far outpace anything seen before. This potential insight is apparent in the elevation of AI as a critical capability in both the US 2017 *National Security Strategy* and 2018 *National Defense Strategy*.

Since the original conceptualization of AI, many theorists predicted that at some future point AI-derived thought would outpace and outmaneuver human thought. Many critics of this assertion based a counterargument on the long-standing dominance of human masters over artificial competitors in complex board games. This is no longer true, from Chess to the ancient Chinese strategic game of Go.[2] The truly revolutionary innovation would see these types of

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[1] International Joint Conferences on Artificial Intelligence Organization, "Autonomous Weapons: An Open Letter from AI & Robotics Researchers," July 28, 2015, accessed October 31, 2018, https://futureoflife.org/open-letter-autonomous-weapons/?cn-reloaded=1.

[2] Andrew Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies" (Report for the Center for Naval Analyses, Arlington, VA, January 2017), iii.

thinking combined to utterly outperform either type alone. A US Army Warfighting Challenge, number 15 or Conduct Cross-Domain Maneuver, seeks to answer how to "create synergy with capabilities employed across all domains to increase relative combat power, pose enemies with multiple dilemmas, and defeat or destroy enemy forces."[3] The combined biological and artificial intellectual framework potentially provides a portion of the solution to such a problem. Teaming AI with human actors potentially provides a decisive advantage in military decision-making and represents a new kind of cognitive framework and methodology for successful military operations.

## Competition over AI Capabilities

The United States is not alone in the quest to gain leverage through military applications of AI. The two competitors generally regarded as most dangerous, China and Russia, actively seek relative advantages within the wide field of AI technologies. China possesses a coherent public strategy that seeks to integrate AI technologies within systems across all the elements of national power.[4] Tellingly, this includes aspirations to integrate AI-derived advantages into military decision-making systems at all levels of war.[5] Russia also seeks broad military applications of AI and openly admits to employing AI in multiple weapon systems.[6] The

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[3] Army Capabilities Integration Center (ARCIC), *Army Warfighting Challenges* (Fort Eustis, VA: Army Capabilities Integration Center, June 28, 2018), accessed August 25, 2018, http://www.arcic.army.mil/Initiatives/ArmyWarfightingChallenges/.

[4] Gregory Allen and Elsa B. Kania, "China Is Using America's Own Plan to Dominate the Future of Artificial Intelligence," *Foreign Policy*, September 8, 2017, accessed September 9, 2017, http://foreignpolicy.com/2017/09/08/china-is-using-americas-own-plan-to-dominate-the-future-of-artificial-intelligence/.

[5] Elsa B. Kania, "Battlefield Singularity: Artificial Intelligence, Military Revolution, and China's Future Military Power," November 28, 2017, accessed October 31, 2018, https://www.cnas.org/publications/reports/battlefield-singularity-artificial-intelligence-military-revolution-and-chinas-future-military-power.

[6] Samuel Bendett, "In AI, Russia Is Hustling to Catch Up," *Defense One*, April 4, 2018, accessed October 31, 2018, https://www.defenseone.com/ideas/2018/04/russia-races-forward-ai-development/147178/.

proliferation of AI in military applications is already in motion, and the subsequent increase in the complexity of operating environments is now inevitable.

Just as nuclear weapons served to decide conflict and subsequently deter it during the twentieth century, competitors expect AI to become the most significant aspect of national power in the twenty-first century. To this end, both Russia and China speak publicly of their desires to gain a marked advantage in applications of these technologies to counter the influence of the United States. The United States has an absolute responsibility to achieve and maintain dominance in military applications of AI. Competitors in the international system will inevitably seek to weaponize AI without trepidation over ethical concerns of application. When held to a much higher moral standard, it is imperative that the US Army develop human-AI teamed cognitive framework for effective decision-making and maintain a qualitative edge in the capability to solve problems. Not doing so assumes enormous risk and cedes initiative to enemies actively seeking positions of relative advantage. Choosing to not integrate AI tools into decision systems would be the modern equivalent of eschewing machine guns in favor of muzzle-loading muskets alone.

## Background

Proposing a shared cognitive framework for military decisionmakers and artificial assistants requires exploration of military culture and cognitive processes as well as description of existing technical solutions for artificial thought. This work focuses on the culture of the US Army but is certainly applicable to others. If AI is to be effectively leveraged in the future, and it must be in order to address the almost certain challenges of competitor use, successful incorporation of AI tools requires analysis of existing culture and visualization of both future cultural and technical developments.

## The Philosophy of Mission Command

US Army doctrine spends a great deal of time and effort to explain the concept of mission command, which is foundational to the Army's operational concept. There are three interrelated but distinct ideas within the topic of mission command: the exercise of mission command, the philosophy of mission command, and the mission command warfighting function.[7] Mission command as an action by commanders is defined as "the exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower agile and adaptive leaders in the conduct of unified land operations."[8] This definition requires commanders of units to both provide guidance to subordinates and enable execution through innovative approaches within disciplined initiative. Within the outlines of the mission described by the commander, subordinate unit commanders and leaders strive to achieve overall mission success through fulfilling their roles and seeking out opportunities to enable the rest of the organization.

Supporting the overall concept of mission command are six principles that further highlight expectations of the art of command and science of control, two of which are highly relevant to this work. The first of the two is to "Create Shared Understanding," which is collaborating and communicating across the formation to both send and receive information, clarify unknowns or misunderstandings, and to question assumptions and share perspectives in order to create a more complete perception of the operating environment throughout the enterprise.[9] Inherent in this idea is the requirement to both constantly reevaluate the status of operations in light of available information and to share updated assessments across the

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[7] US Department of the Army, *Army Doctrine Publication (ADP) 6-0, Mission Command* (Washington, DC: Government Printing Office, 2014), 1.

[8] US Department of the Army, *Army Doctrine Publication (ADRP) 6-0, Mission Command* (Washington, DC: Government Printing Office, 2012), 1-1.

[9] US Department of the Army, *Army Doctrine Publication (ADP) 6-0, Mission Command*, 3.

organization. The second principle of mission command relevant to this work is to "Accept Prudent Risk," which requires commanders to evaluate risks within their formation and chosen operational concepts, consider which are appropriate to take in order to accomplish the mission, and minimize hazards while deliberately exposing the organization to injury or loss to exploit opportunities.[10] This clearly obliges commanders to seek out the best possible understanding of relevant factors in the operating environment, to include the disposition of the enemy, and to use professional judgment and knowledge to predict future events. Better decisions made more quickly confer a significant advantage.

## AI and Simulation Concepts

Mission command is a human endeavor, executed through leadership and within the networks and systems of the organization. While the concept is fairly simple, the structure in place to support execution becomes fairly complex. This structure and the functions it provides constitute a Complex Adaptive System (CAS). CASs are systems composed of discrete component parts that demonstrate emergent behaviors that are distinct from the composite agents' behaviors, meaning these behaviors are not derived from or possessed by those agents. They seek to anticipate and adapt the behavior of the system to adequately address the challenges of the environment.[11] In essence, a CAS acts analogously to a biological body. While there are multiple components and systems within it that enable the system to function, such as the senses or the lymphatic system, the body acts at the direction of the conscious mind. These interconnected systems' components often interact nonlinearly, either through chance or by design.[12] Composite agents in a CAS continue to execute their unique functions in support of the overall system,

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[10] US Department of the Army, *Army Doctrine Publication (ADP) 6-0, Mission Command*, 5.

[11] Nathan M. Colvin, "A Complex Adaptive Systems Approach to the Future Operational Environment" (Master's Thesis, US Army Command and General Staff College, 2014), 14.

[12] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 72.

adapting or changing as required by the demands of the system.[13] Joint doctrine includes the CAS concept and emphasizes that it often applies to systems or units with lower thresholds of centralized control where subordinate units act within a common framework.[14] Military organizations operating under mission command act in the same way, making the CAS concept an extremely useful lens through which to understand and improve the underlying structure as well as the complementing functions.

Multiagent-based Models (MBM) refers to a range of techniques that enable analysis and insight into the behavior of CASs.[15] MBMs seek to understand how and why systems operate with distributed problems and distributed decision-making.[16] These models consider a wide range of characteristics within the environment and the CAS to reach an understanding of the behaviors of the system. This includes assessing to what extent the environment is knowable, how predictable the environment is, to what extent control is applicable within the environment, how the future state of the environment relates to current and previous states, and the interaction of agents within the environment.[17] MBM techniques are most effective when the CAS requiring study has a high level of heterogeneity in the sense that composite agents possess a known range of characteristics and properties, there is distributed autonomy throughout the system for agents within it, and bounded rationality applies to agents in the sense that they all cannot be fully aware of the state of the whole system and make decisions based on available data.[18] This framework emerged from AI research efforts to understand how increasingly complex systems of systems

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[13] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 76.

[14] US Department of Defense Joint Staff J-7, *Planner's Handbook for Operational Design* (Suffolk, VA: Joint and Coalition Warfighting, 2011), II-6.

[15] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 90.

[16] Gerhard Weiss, *Multiagent Systems: A Modern Approach to Distributed Modern Approach to Artificial Intelligence* (Cambridge, MA: The MIT Press, 2000), 79-80.

[17] Ibid., 82.

[18] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 90.

operate to enable better design or manipulation of these systems. It is also extremely applicable to systems of non-synthetic agents. The same techniques of modeling and analysis enable understanding and inform prediction of the behavior of human systems. The MBM is a useful derivation of the CAS concept that enables deeper understanding not only of how a friendly organization operates, but also of the propensities and possibilities for how and why an enemy organization will act in response.

The structure of assessments made through the application of logic generally divides three forms: deductive reasoning, inductive reasoning, and abductive reasoning. Deductive reasoning starts with a hypothesis derived from a universal rule that offers an explanation for why a particular event occurs, moving from the general to the specific with a definitive causal chain at the end of the process in the same way that simple mathematics produces definite answers.[19] Inductive reasoning proceeds from limited observations and seeks to provide a larger hypothesis for observed events, moving from specific to general explanation without a definitive answer.[20] Abductive reasoning starts with a set of observations known to be incomplete and seeks out the most likely rational explanation, forming an expedient and reasonable answer from information available.[21] All three forms of logical reasoning are appropriate in different situations, though all three are not possible simultaneously. AI currently demonstrates greater than human ability to make deductive assertions but generally underperforms in both inductive and abductive reasoning.[22]

MBMs provide a vehicle for the combination of the three types of logic and especially in the pursuit of iterative abductive reasoning toward the goal of refining theories for behavior

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[19] Charles S. Peirce, *Collected Papers of Charles Sanders Peirce*, ed. Charles Hartshorne and Paul Weiss, vols. 1, 2, 3, 4, 5, and 6 (Cambridge, MA: Harvard University Press, 1960), 28.

[20] Ibid.

[21] Charles S. Peirce, *Collected Papers of Charles Sanders Peirce*, ed. Arthur W. Burks, vols. 7 and 8 (Cambridge, MA: Belknap Press, 1958), 106.

[22] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 64.

explanation. This is a kind of iterative modeling, often referred to as exploratory modeling, in which the ranking of possible outcomes of a system occurs in spite of known uncertainties.[23] Exploratory modeling seeks to understand implications of change across a system and how agents within the system react as well as across the environment in which the system operates. Exploratory modeling of an MBM potentially equates to near-instant wargaming of complex scenarios to illuminate the probability of future events as well as the potential impact of those events. This results in interactive searching for possible outcomes to inform decision-making. Utilizing MBM iterations as exploratory modeling amounts to creating "generative explanations," or bottom-fed insights that emerge from the hybridized analysis of all three forms of logical process that project high-level behaviors from low-level rules and behaviors.[24] This modeling potentially provides great insight into key factors that commanders weigh to drive decisions, the dynamic of risk and opportunity. In other words, this modeling could greatly enhance the quality of information available to commanders to allow the execution of mission command.

## US Army Doctrine and Context

Commanders have a vast array of tools available to control, guide, and manage their organizations. The support staff constitute the vast majority of these tools in the form of professional Soldiers operating within the CAS of the organization. Army doctrine refers to this process, the melding of human beings and processes into a system that serves the needs of the organization, as the dual roles of the commander exercising both the art of command and the science of control.[25] The art of command refers to the management of human beings, adapting communication and motivation to the people within the organization. The science of control

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[23] Steve Bankes, "Exploratory Modeling for Policy Analysis," *Operations Research* 41 (June 1993): 435–449.

[24] Ilachinski, "AI, Robots, and Swarms Issues, Questions, and Recommended Studies," 92.

[25] US Department of the Army, *Field Manual (FM) 6-0, Commander and Staff Organization and Operations* (Washington, DC: Government Printing Office, 2014), vii.

refers to the organization of processes and information to enable the functioning of the organization. This balancing act of human and non-human elements constitutes the broad outlines of operational art. Doctrine defines operational art as "the cognitive approach by commanders and staffs—supported by their skill, knowledge, experience, creativity, and judgment—to develop strategies, campaigns, and operations and organize and employ military forces by integrating ends, ways, and means."[26] This concert of information exchange between commander and staff, humans and systems, leads the organization as a CAS to analyze the operational environment and make reasonable deductions about both the environment and the actors within it to decide on appropriate actions for the organization to take. The entire process constitutes distribution of thought, analysis, and decision-making across a CAS, which is another way of saying it constitutes something known as team cognition.

Team cognition is cognitive activity that occurs at a team level within specific cognitive framework that is the aggregate of the individual planning of team members, where a team consists of a set of people who interact dynamically, interdependently, and adaptively toward a common and valued mission by performing specific roles within the team during a limited time of membership.[27] There is a great deal of research that shows decision-making within a group or team, the inevitable outcome of team cognition within a military organization, often suffers from process loss and a resultant decrease in the quality of the collectively-made decision.[28] A major factor in the cohesiveness, productivity, and performance of teams is the degree to which shared mental models proliferate within the minds of the team members.[29] Visualizing team members as

[26] US Department of the Army, *Army Doctrine Publication (ADRP) 3-0, Operations* (Washington, DC: Government Printing Office, 2017), 2-1.

[27] Nancy J. Cooke, Jamie C. Gorman, and Jennifer L. Winner, "Team Cognition," in *Handbook of Applied Cognition*, 2nd ed., ed. Francis T. Durso, Raymond S. Nickerson, Susan T. Dumais, Stephan Lewandowsky, and Timothy J. Perfect (Chichester, UK: John Wiley & Sons, 2007), 240.

[28] Ibid., 250.

[29] Ibid., 251-53.

representative of the different senses in a body, their contributions paint a mental image of an object from the different perspectives of sight, sound, smell, taste, and touch to gain a deeper understanding of the object in question.[30] Better understanding lends itself to better decision-making. This is largely a result of the focusing influence of shared models on the process of team cognition, implying that common terms of reference and sharing of mental models to gain general awareness within the team lend themselves to better decision-making processes and eventually better decisions.

A Decision Support System (DSS) is an interactive synthetic system that seeks to enhance the judgment of a user and their action of deciding through framing, modeling, and problem-solving.[31] DSS are pervasive within many spheres of civilian use to include finance, weather forecasting, and competitive gaming.[32] Most of these systems seek to carry the metaphorical weight of calculations and data-mining that most human beings find tedious or distracting, leaving the human agent free to assess the applicability of DSS-derived recommendations or analysis. Integration of a DSS into battlefield decision-making represents a significant advantage that is currently unrealized. The field of research surrounding the DSS concept recognizes implicitly that neither human thought nor artificial thought alone meets the threshold for best-case decision support analysis in complex, imprecise, and vague problems.[33] Through dialectic interaction, however, iterative analysis of problems leads to a better understanding of these wicked problems as the human participant assesses the subjective, implicit, or tacit aspects of the task while the synthetic participant provides analysis of large

[30] Cooke et al, "Team Cognition," 257.

[31] Marek Drudzel and Roger Flynn, *Encyclopedia of Library and Information Science*, ed. Allen Kent (New York: Marcel Dekker Inc., 2002), 6.

[32] Stephen J. Banks, "Lifting Off of the Digital Plateau With Military Decision Support Systems" (Master's Thesis, US Army Command and General Staff College, 2013), 20-33.

[33] Behrouz H. Far and Guenther Ruhe, "Prescriptive Decision Support Based on Software Agent Interaction," in *Intelligent Decision Support Systems in Agent-Mediated Environments*, ed. Gloria E. Phillips-Wren and Lakhmi C. Jain (Fairfax, VA: IOS Press, 2005), 163.

groups of data and untiring reassessments of data as the process addresses the task from different angles.[34] By combining the strengths of human and synthetic cognitive partners, better cognition results.

To successfully manage the problems that CAS-classified organizations address, through the use of human decision systems and with the assistance of enabling tools such as a DSS, organizational leaders direct, guide, and participate in the management of various levels of information through what US Army doctrine refers to as the cognitive hierarchy of Data, Information, Knowledge, and Understanding.

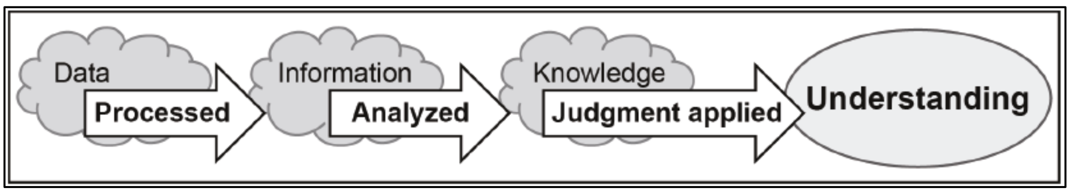


Figure 1. Achieving Understanding. *Army Doctrine Reference Publication (ADRP) 6-0, Mission Command* 2012, 2-7.

This four-tiered classification of distinct echelons of information enables assessment of the relative value of different pieces of information as they relate to the success of the mission.[35] Synthetic intelligence currently proves greatly beneficial in gathering and processing data to become information, and in some forms at providing analysis of information that informs the realization of knowledge.[36] However, no system yet realized shows significant promise in applying judgment to gain understanding. A noteworthy critique of automated information processing is that such automation can create a paradoxical dynamic in which automated recommendations seem to absolve decision-makers of responsibility while coloring those recommendations as being more akin to directives.[37]

[34] Far and Ruhe, "Prescriptive Decision Support Based on Software Agent Interaction," 163-67.

[35] John L. Morrow, "Employing Abductive Reasoning to Achieve Understanding" (Master's Thesis, US Army Command and General Staff College, 2015), 17-22.

[36] Banks, "Lifting Off of the Digital Plateau With Military Decision Support Systems," 40-47.

[37] Paul Dumouchel and Luisa Damiano, *Living with Robots*, trans. Malcolm DeBevoise (Cambridge, MA: Harvard University Press, 2017), 178.

## Outlines of Artificial and Human Cognition

Automated cognitive systems are distinct from biological systems because the majority of information that automated systems process is not typically available to the intentional user, meaning that they do not typically have to "show their work" to the human participant.[38] "Technology rarely functions along the same rhythms as humans. Information systems and machines are pushed to maintain their peak efficiency, often running twenty-four hours a day. Humans find themselves deciding whether to have their machines run at less than optimal conditions, or secede greater levels of personal decision making to maximize technological utility."[39] The perceived disparity in tasks that are extremely simple for the human brain to accomplish while being simultaneously quite challenging for AI to do is known as Moravec's paradox, a result of the brain devoting significant specialized portions of itself toward specific functions such as facial recognition or the sense of smell as opposed to solving algebra problems.[40] Nonetheless, very recent developments indicate that AI is in fact capable of both intuition and creativity in generating knowledge as opposed to merely analyzing information.[41] The implications of ignoring such capabilities are staggering. If a competitor manages to harness such potential in AI it possesses the potential to rapidly outpace the field in distributed decision-making, especially on the battlefield.

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[38] Dumouchel and Damiano, *Living with Robots*, 86.

[39] Colvin, "A Complex Adaptive Systems Approach to the Future Operational Environment," 34.

[40] Max Tegmark, *Life 3.0 - Being Human in the Age of Artificial Intelligence* (New York: Knopf, 2017), 53.

[41] Sarah Knapton, "DeepMind's AlphaZero Now Showing Human-like Intuition in Historical 'turning Point' for AI," *The Telegraph*, December 6, 2018, accessed December 6, 2018, https://www.telegraph.co.uk/science/2018/12/06/deepminds-alphazero-now-showing-human-like-intuition-creativity/.

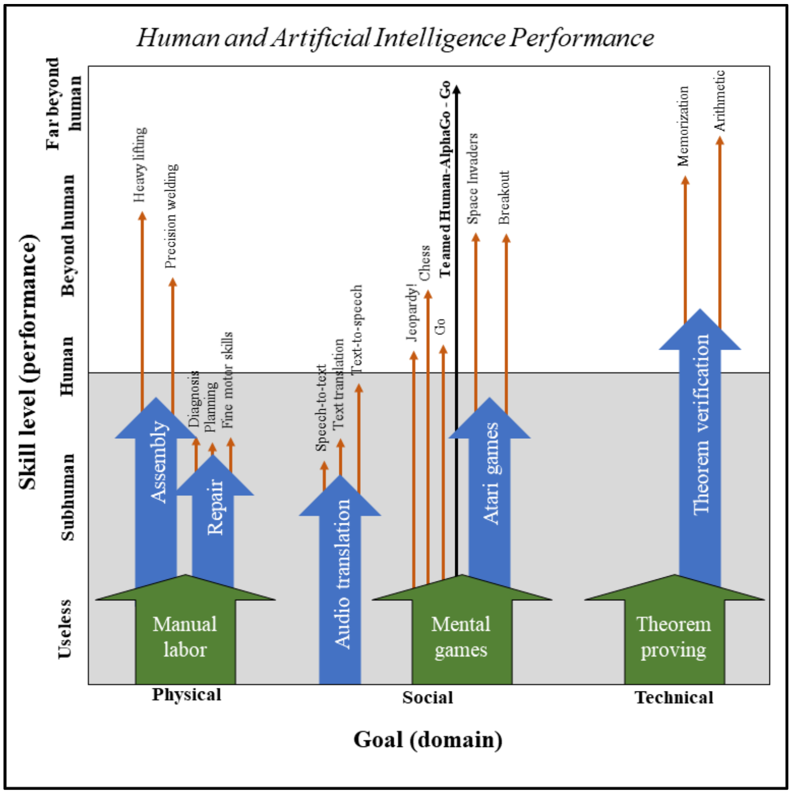


Figure 2. Human and Artificial Intelligence Performance. Adapted from *Life 3.0 - Being Human in the Age of Artificial Intelligence*, 2017, 51.

People employed in safety-critical occupations, such as the military, work in complex systems embedded within a large socio-technical system.[42] Four important features characterize such workplaces:

1) Human-safety requires the combined human-machine system to be operated correctly
2) The task demands imposed on the human operator are primarily cognitive
3) The social aspect refers to the need for efficient communication and collaboration between team members to accomplish goals
4) Systems are embedded within a natural, event-driven, dynamic, and therefore not fully predictable real-time environment

The design of human-system interaction should seek optimal mutual cooperation; this requires team members to operate from common ground or a common frame of reference of the actual situation, which is the result of merging crew members' perceptions and their situational

[42] Bernd Lorenz and Raja Parasuraman, "Automated and Interactive Real-Time Systems," in *Handbook of Applied Cognition*, ed. Francis T. Durso et al., Second Edition (Chichester, UK: John Wiley & Sons, 2007), 413-417.

assessment, which leads to effective decision-making and coordinated action.[43] Human intuition tends to underperform in prediction in comparison to algorithms, even amongst experts operating within their fields of expertise.[44] Additionally, experts faced with scientific evidence of algorithmic predictive superiority express distrust and incredulity, expressing a culturally driven aversion to changing how they value information.[45] The momentum required to overcome such cultural aversion is essential to effective utilization of AI in military decision-making and will only occur as a result of applied leadership and demonstrated efficacy by paired decision-makers.

An ideal venue for testing and improving such pairings already exists within US Army training cycles in the form of the Combat Training Centers (CTCs). Designed to push rotational training units past the point of failure in the pursuit of improvement through gaining new knowledge, the utility of an AI decision assistance tool would actually increase over the course of each rotation because of the generative knowledge that a learning system creates naturally. In other words, the more decisions a learning decision assistance tool participates in, the better it gets at both deciding and predicting. The relatively contained but complex environment of a CTC provides an ideal generative knowledge source through instrumentation data collected and the inputs of training cadre into after action reviews and feedback to units. Every rotation the data set and both analytic and predictive ability of the AI tool would improve even as the generative knowledge of effective interfacing with different rotational unit leaders would as well. Once a sufficiently capable modeling tool emerges from this process, interacting with the best available data from other training events and actual conflicts continues the generative knowledge accumulation and capacity building. While the tool will by no means achieve perfection, the increased predictive ability it provides will greatly enhance human military decision-making. This

[43] Lorenz and Parasuraman, "Automated and Interactive Real-Time Systems," 431.

[44] Daniel Kahneman, *Thinking Fast and Slow* (New York: Farrar, Straus and Giroux, 2011), 223-227.

[45] Ibid., 227-229; Phililp E. Tetlock and Dan Gardner, *Superforecasting: The Art and Science of Prediction* (New York: Broadway Books, 2015), 20-23.

capacity for growth is the fundamental advantage that this form of decision assistance tool has over others, an inherent ability to improve and be immediately applicable. It is not hyperbole to assert that a learning system can vastly improve any learning organization. The process of trying, failing, analyzing, adjusting, and trying again is the exact model used by forecasters with proven rates of extreme success in both accuracy and consistency.[46]

An existing tool that appears ready-built as a foundation for a military decision assistance tool is Discrete Event Simulation (DES). DES is arguably the most widely used operational research technique in practice. Most DESs model systems are queuing networks, meaning that they analyze actions by the entities within a system as the entities pass from one decision to another, reassessing the state of the system and potential outcomes that branch from each decision.[47] This type of modeling is ideal for clearly defined systems as well as for modeling that occurs without constraints on time required to model. A DES simulation can exhaustively predict the probability of outcomes given enough time for analysis. This aspect of DES is not ideal for rapid decision-making but would be useful for analysis and planning prior to events in extremis. However, DESs can also analyze sets of discrete instantaneous events.[48] The ability to analyze sets of simultaneously changing data allows a DES to model the real world and not just a virtual one. A direct application of this potential is a DES variant called a Finite State Machine (FSM). An FSM is a computation model that maps a starting state for a system and how inputs change that state, enabling analysis of extremely complex and otherwise incomprehensible systems.[49]

[46] Tetlock and Gardner, *Superforecasting: The Art and Science of Prediction*, 273.

[47] Sally Brailsford, "Theoretical Comparison of Discrete-Event Simulation and System Dynamics," in *Discrete-Event Simulation and System Dynamics for Management Decision Making* (Chichester, UK: John Wiley & Sons, 2014), 108.

[48] J. B. Evans, *Structures of Discrete Event Simulation: An Introduction to the Engagement Strategy*, Ellis Horwood Series in Artificial Intelligence (Chichester, UK: Ellis Horwood Limited, 1988), 38-40.

[49] K. Choi Byoung, Kang DongHun, and Kyu Choi Byoung, *Modeling and Simulation of Discrete Event Systems* (Chichester, UK: John Wiley & Sons, 2013), 256-259.

The FSM application breaks free of the usual limitations of modeling and especially DES-type simulations by executing multilayered analysis simultaneously in sets and not as single variables or actors alone. To fully apply an FSM to military decision-making requires insight into how both humans and simulations actually think.

Human consciousness is the product of thought-models, the emergent output of interaction between instinct, curiosity, and knowledge accumulated over a lifetime.[50] These mental models, the foundational block upon which consciousness rests, are imperfect but sufficient simulacra of reality.[51] So too are the models that simulation employs. A common critique of using AI to analyze complex systems or predict future events is that the programmers' biases will weaken the model by making it imperfect and by extension not useful. There are no perfect models, whether in the minds of man or within the bounded realities of artificial thought. This does not mean that artificial models are not useful but requires the understanding that they are in fact often imperfect, just as human judgment is. The major advantage that artificial thought has over human thought is the ability to recursively improve at a very rapid pace through generative knowledge growth and exposure to vast amounts of data and simultaneous events that humans cannot engage with instantaneously. The primary obstacle to human and artificial collaboration, then, is the bandwidth of thoughts exchanged. Human cognition is best when focused on single events and often that very act of concentrating drowns out other stimuli.[52] Since artificial thought can assess multiple sets of data simultaneously in contrast to human, the potential for artificial communication to overload the human partner is extremely high. The key to effective communication is defining appropriate forms and volumes of shared information.

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[50] Evans, *Structures of Discrete Event Simulation: An Introduction to the Engagement Strategy*, 11.

[51] Tetlock and Gardner, *Superforecasting: The Art and Science of Prediction*, 80.

[52] Kahneman, *Thinking Fast and Slow*, 23-24.

Communication between artificial and human partners requires the use of boundary objects (BOs). Not unique to this form of communication alone, BOs enable communication across communities of practice and domains, both disciplinary and organizational.[53] Their function is to translate ideas between groups that think differently, and the creation and management of BOs is fundamental to maintaining coherence across intersecting fields of thought.[54] Though originally a social science construct, BOs are essential to artificial and human cognitive teaming. The shared cognitive framework necessary to function effectively in such a team is in fact the outline of requisite BOs. Just as doctrine provides shared mental models for military professionals to communicate from, common terms and definitions between artificial and human partners will act as BOs to enable better decision-making.

## The Roles of AI Tools

When considering how AI should enhance military decision making there are four roles or functions within two domains that are appropriate.[55] The first domain is procedural decision-making where structures drive outcomes. Any AI tools in this domain would either enable decision automation, such as prescribed reactions to specific stimuli, or support the routinization of decisions by outlining recommended actions and seeking resolution. Decision automation is the subject of much debate and controversy, and not just in terms of military application, because of ethical considerations about systems classified as "human-out-of-the-loop" and the risk of unintended consequences resulting from rapid automated activity. This work will not address decision automation because it is not yet apparent that the inherent risk of automated actions is

[53] Steffen Bayer, Tim Bolt, Sally Brailsford, and Maria Kapsali, "Models as Interfaces," in *Discrete-Event Simulation and System Dynamics for Management Decision Making* (Chichester, UK: John Wiley & Sons, 2014), 26.

[54] Allesandro Mongili and Giuseppina Pellegrino, *Information Infrastructure(s) : Boundaries, Ecologies, Multiplicity* (Cambridge, UK: Cambridge Scholars Publishing, 2014), xxix.

[55] Sally Brailsford and Leonid Churilov, *Discrete-Event Simulation and System Dynamics for Management Decision Making*, ed. Brian Dangerfield (Chichester, UK: John Wiley & Sons, 2014), 348–352.

reasonably manageable. Decision routinization support, however, appears to be a very reasonable role for AI to play in advising military commanders. The second domain for AI application is critical thinking. Two roles for AI in this domain are that of system modeling for improvement and providing unique insights to inform human analysis. System modeling for improvement appears highly relevant to both internally and externally focused advice for military commanders. Providing insight for consideration also appears extremely valuable for military planning, though not necessarily for crisis management. Evaluation of AI tool applicability will focus on these two domains and the three appropriate roles in describing potential integration into current and future operations.

## Methodology

This work employs the Schwartz Model, also known as Alternate Futures Analysis, to postulate four possible futures of human-AI cognitive teaming defined by two decisive environmental factors.[56] Two of the four worlds, the most dangerous possible world for the United States and the most appropriate for justifying the need for employing AI, will undergo further analysis to explain how the US Army must prepare itself to succeed in future complex environments. Recommendations for methods and principles of combined decision-making result from this analysis as well as for areas of further study and implications for US Army leadership.

In considering the employment of AI tools in any role, there is an implicit corollary that consideration of counter-AI operations is necessary to fully understand the interaction of friendly and adversarial actors. This work acknowledges that further exploration is necessary to appreciate what might constitute counter-AI operations, what gaps and seams emerge from the interaction of AI-influenced actors, and how the addition of AI integration on both sides affects the complexity of actors' behavior. The underlying assumption within this work is that these things are knowable and capable of being analyzed, but that such analysis is beyond the scope of this monograph.

[56] Peter Schwartz, *The Art of the Long View: Planning for the Future in an Uncertain World* (New York: Doubleday, 1991).

This work will also not explore the ethical and moral implications of combining AI and human decision-making. It assumes that competitors will attempt to do so regardless of any ethical or legal implications of subsequent acts, and that combining types of thought does not inherently create ethical challenges. To quote US Army doctrine, “Commanders, staffs, and subordinates ensure their decisions and actions comply with applicable United States, international, and, in some cases, host-nation laws and regulations.”[57] US Army actions that follow any type of thinking, biological alone or teamed with AI, will always occur within the legal and ethical framework of the Law of Armed Conflict and require no additional framing.

## Analysis

The two selected Schwartz model dynamics, or most significant contextual factors, are organizational complexity and environmental complexity. Organizational complexity is highly relevant because it enables evaluation of applicability and potential requirement across the range of future force structures for the US Army. More complex organizations require greater effort to synchronize and manage, especially in combat. Environmental complexity reflects expected changes not only in technology and global social structure but also in current and future competitors’ framework for employing force against US interests. More complex environments present unpredictable challenges and tend to have emergent properties that are mostly unforeseeable. For the purposes of this analysis, low complexity means equal to or lower than current levels while high complexity means a noteworthy increase from current levels; this is not to imply that the current range of operating environments is simple but only to acknowledge that the roles of AI tools are currently mostly undefined and AI is not integrated across the vast majority of possible military applications, and therefore an argument must be made to justify integrating them based on necessity vice simplicity.

[57] US Department of the Army, *Field Manual (FM) 6-0, Commander and Staff Organization and Operations*, vi.

This approach acknowledges the interactive complexity of these systems and accounts both for organizational systems approaches to manage complex structures of systems, which reduces decision-makers spans of control and enables effective management, as well as for scientific and technological progress which provides a deeper understanding of the physical world and more effective interaction within the cognitive and digital domains. Upon considering these two continua of complexity there are four resultant possible futures: World 1 as "Forrest Gump" on the low end for both factors, World 2 as "Genghis Khan" with low organizational complexity but high environmental complexity, World 3 as "Desert Storm" with high organizational but low environmental complexity, and World 4 as "Fighting Cancer" with high complexity for both.

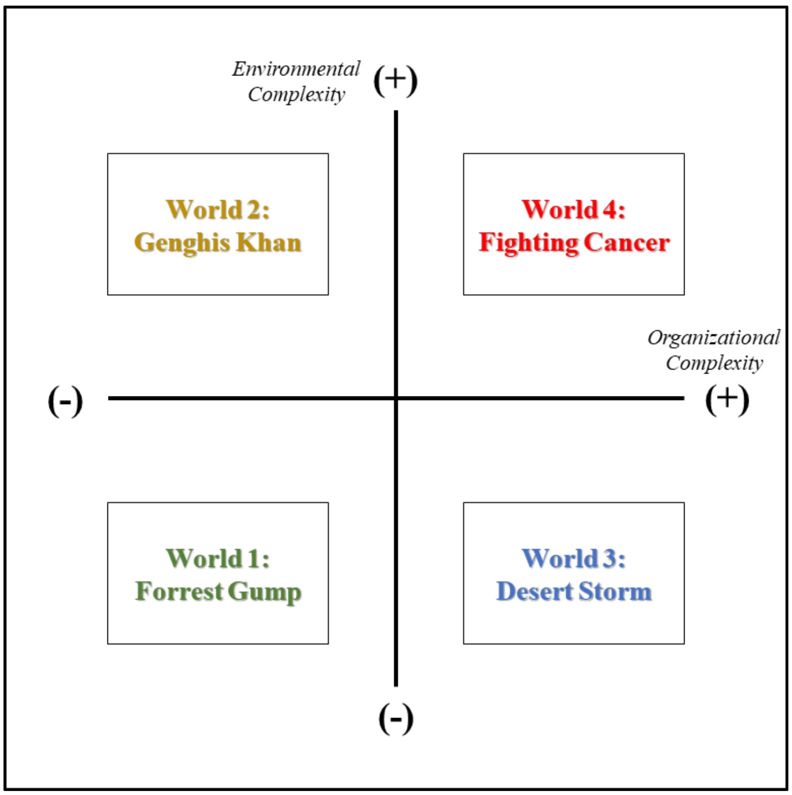


Figure 3. Four Possible Future Worlds. *Created by author*.

The two worlds least appropriate for analysis in this work are Forrest Gump and Desert Storm because both worlds appear quite manageable without the need for AI tools to address their challenges. Forrest Gump, named for the simplistic eponymous film character, is the simplest and least threatening potential future and therefore investment into military AI tools seems unlikely.

Desert Storm, named for the highly synchronized military campaign where complex organizations fought in a relatively simple environment, presents similarly negligible challenges as Forrest Gump and again does not require AI assistance to find solutions to military problems since there is great precedent for managing complex organizations without the need for AI tools, despite the fact that such tools are extremely helpful for such a task.

The most challenging world, as well as the most dangerous for the United States and partners, is Fighting Cancer. Named to evoke the understood complexity of both selecting effective procedures and the uniqueness of each form of the disease, this world shows that the hybridization of human and synthetic intelligence is most important to provide a distinct relative advantage; the focus of AI assistance is internal to enable better shared understanding and situational awareness within friendly military organizations. The less challenging but still highly appropriate world for considering AI application is Genghis Khan. Named after the famous conqueror who led relatively homogenous forces to subdue numerous complex and distinct civilizations, this world shows how the operating environment requires greater adaptivity despite friendly actor organization relative simplicity; the focus of AI assistance is external to assess competitors and the environment to predict future change. In both selected worlds, the fusion of human and artificial thought provides a distinct asymmetric advantage impossible to achieve by either human or artificial agents alone and an advantage that appears absolutely requisite for protecting US and partner interests. The difference in AI application during analysis will be the anticipated primary utility of roles for tools, internal or external. While both focuses are undoubtedly useful in either world, analysis will distinguish them as previously stated in pursuit of a deeper understanding of how that use informs requisite cognitive framework.

## World 4: Fighting Cancer

World 4, Fighting Cancer, is a probable future in which both US Army organizations and operating environments are more complex than at present. Army units must perform acceptably across an extensive range of mission sets and utilize increasingly complex structures and technology in order to be effective. Mission sets reflect the currently envisioned range of military operations, but the primary difference being in frequency of execution or incidence. Increasing incidence necessitates increased operational tempo during training, preparation, mission execution, and any possible recovery. The theaters in which operations occur are also more complex than those in which the majority of conventional operations currently take place. In addition to humanitarian assistance operations within megacities at the low end of the spectrum for the use of force, units must execute security assistance in close proximity to potentially hostile competitor forces near international borders and counterinsurgency operations against hostile nation-state backed separatists in complex and only moderately accessible terrain such as Southeast Asia. At the high end of the spectrum, units conduct large scale combat operations in extremely remote locations such as the African continent against threats that include competitor military organizations, autonomous weapons, nonstate actor threats, weaponized information environments, weapons of mass destruction, and contested or enemy dominated networks. All of these mission sets include a range of participants from host-nation security forces, coalition partners and allies, and non-governmental and intergovernmental actors.

In order to meet the demands of these divergent and competing roles for military organizations across myriad conditions, organizations will expend enormous energy to maintain awareness of internal conditions to share information and allocate resources as required. The broad mission set necessitates a balance of general personnel and equipment capable of meeting the demands of a wide range of tasks as well as diverse groups of specialized personnel and equipment focused on extremely challenging tasks or special roles. The heterogeneity of personnel and supporting equipment presents a dilemma for unit leaders in appropriately employing the range of tools efficaciously and in concert with other actors while in competition with hostile forces. Competitors will seek to not only disrupt and deny communications but to coerce leaders into making bad resourcing decisions and alienating other friendly actors.

## The Role of AI Tools in Crisis Management

The potential benefit of AI in this world is to enable both communications to maintain situational awareness and to assist in creating shared understanding by assessing the current and potential future states of the organization. The role of the AI in this environment is not to function with full autonomy but instead to serve as an extremely well-informed advisor to the commander on the state of the organization itself. This role is a function of the ability of the echeloned AI instances, paired with commanders, to rapidly communicate with each other during times of available communication and to batch messages and queries when communication is not possible. Without resorting to significantly technical analysis, this requires robust localized storage of data and leveraging of the vastly-faster-than-human tempo of communications between machine actors in order to overcome the challenge of disrupted communications. An example from popular culture that illustrates the value of such an advisor is the AI character Cortana in the Halo video game, book, and movie universe. Cortana and other AI characters constantly provide insight and analysis to the human protagonists, highlighting critical information found during constant analysis of available data and enabling decision-maker situational awareness. Current operations require the processing of enormous amounts of information, and often a major limiting factor to operational tempo is the speed at which information turns to knowledge through staff processes. This critical human limitation, that of limited focus and synthesizing information, could be significantly mitigated through the addition of an AI tool for crisis management (CM) and rapid communication.

This CM tool requires the previously explored MBM style of system architecture, distributed across the formation to commanders at all echelons and constantly communicating to refine analysis. The ultimate goal for the tool is to create a DSS built on team cognition that rapidly assesses available data and information and proposes relevance and action to commanders. The ability of the tool instances to rapidly synchronize perspectives and locally store snapshots of other teams informs the analysis of each paired set far faster than any organization synchronization meeting or battle rhythm event could, especially in light of the expected disruption of the electromagnetic (EM) spectrum and traditional communications methods. Instead of a forward commander within an adversarial bubble of communications disruption waiting for a window of traditional voice communications or for a text-based message to return dialogue from their higher commander, the CM tools organically inform both commanders through burst communications and enable more rapid execution of mission command by synchronizing the intent and situational awareness of each actor. This is the greatest potential of the CM tool in communications, to significantly boost organizational shared understanding.

Another significantly important capability of an appropriate CM tool is to monitor human partners' biological status to understand how brain chemistry impacts their immediate decision-making. This type of monitoring is currently at the end of the research phase and moving toward implementation, but the critical gap in proposed employment is the actual monitor.[58] Human monitors require real-time or nearly-real-time data, training, and expertise to assess the mental state of the people they observe; AI monitors, however, require no additional personnel and possess the ability to rapidly communicate important factors through a distributed network to the relevant commander for action. Figure 4 depicts the ideal dispersal of CM tool instances and the relationship between each instance to human commanders and other AIs. The distributed nature of the tools enhances communication between the human commanders and enables both procedural decision-making and critical thinking. Enhancing the commanders' understanding of both the state of friendly organizations and the other humans within them falls under the traditional umbrella of the art of command while enhancing the science of control. Two venerable

[58] Research, Development, and Engineering Command (RDECOM) Public Affairs, "Future of Army Sensors," January 20, 2015, accessed December 5, 2018, https://www.army.mil/article/140651/Future_of_Army_Sensors/; Jane Benson, "Natick Leads First-of-Its-Kind, Soldier-Readiness Study," May 23, 2018, accessed December 5, 2018, https://www.army.mil/article/205789/natick_leads_first_of_its_kind_soldier_readiness_study.

military philosophers whose thoughts on warfare stand the test of time speak to the importance of this aspect of warfare. Carl von Clausewitz's famous paradoxical trinity included the concept of passion as a major determinant in the character of war.[59] Thucydides' equally famous triptych identified fear as a primary factor in why and how warfare occurs.[60] The addition of an AI tool to enable CM provides a commander a significant advantage in mastering the passion of both their organization and themselves through acknowledgment and management, balancing the costs and benefits of fear. This act of balancing risk and reward is the essence of operational art, and a more informed perspective enables more deft harmonization. An effective CM tool that enables better understanding of both internal systems and personnel within the decision-making architecture assists better decision-making by harnessing the power of deductive logic and tireless AI cognition.

[59] Carl von Clausewitz, *On War*, ed. Michael Howard, trans. Peter Paret (Princeton, NJ: Princeton University Press, 1976), 89.

[60] Thucydides, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War*, ed. Robert B. Strassler, trans. Richard Crawley (New York: Free Press, 1998), 58.

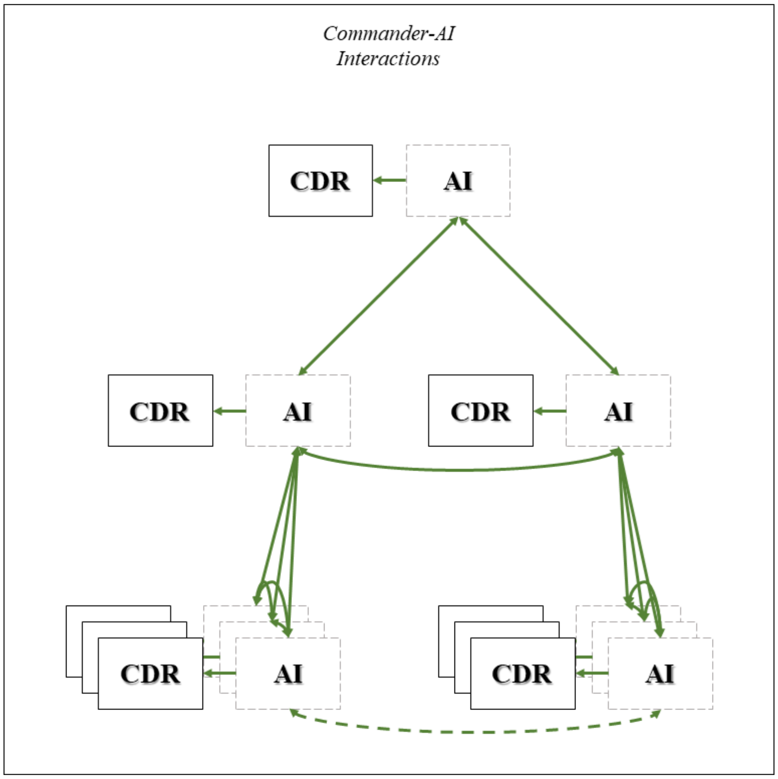

Figure 4. Commander-AI Interactions. *Created by author*.

## Fighting Cancer scenario

If a CM tool enhances the ability of a commander to balance the human elements of warfare, a potential scenario set within the Fighting Cancer world illustrates the impacts of integrating AI decision assistance tools into military organizations. In this world, an adversarial nation-state initiates a forceful annexation of parts of a smaller border state friendly to the United States and partners using local criminal organizations and separatist groups with covert support by special and general-purpose military forces. In response, the United States and coalition partners provide direct military assistance to the friendly state to include on-ground advisory teams, air support, and intelligence fusion to protect major population centers and reestablish security within the original international boundary. After a lengthy period of relative calm following the initial open conflict, adversary forces appear poised to return to the offensive. Pursuing deterrence of new conflict, a US Army division mobilizes and deploys to bolster the friendly state security and military forces. Adversarial forces, including special operations forces and criminal elements, conduct low-scale disruption operations to delay this buildup of friendly combat power. These disruptions include manipulation of seaport and airport control systems, traffic light management systems in the interior of the friendly state, targeted messaging against civilians and security personnel working with the United States, and ambushes attributed to criminal elements along roads serving as lines of communication for US and friendly state military organizations. The highly disrupted state of EM communications makes traditional command and control structures, enabled through FM radio and satellite platforms, nearly impossible to maintain. On top of adversary actions, there are also large groups of internally displaced persons between the now-disputed border and major friendly state cities that are in urgent need of humanitarian assistance while still potentially containing hostile personnel hiding within the much larger innocent population. In short, this is a particularly wicked problem for a current US military organization to solve with available means.

The initial major advantage that an AI CM tool provides is in direct communication between tool instances that informs each paired commander. A disrupted EM spectrum makes long-distance voice and real-time text communications unreliable, but AI tools make maximum use of communication systems' uptime through burst transmissions and synchronizing information at speeds well beyond that of human beings alone. This provides the unique ability to communicate in a disrupted EM spectrum environment, and with adequate shielding and robust and dependable architecture, such as that provided by blockchain systems, the CM tool network provides a foundation to reestablish communications even after such catastrophic events as electromagnetic pulse weapon use. The result is that even if the division commander is unable to directly communicate with subordinate commanders continuously, the brigade commanders receive constant updates through their paired CM tool as well as provide updates. Integration of CM tools into the shared communication forums ensures rapid transmission of crisis events as fast possible and enables faster tempo in execution. The other major benefit of the CM tool is to alleviate mental strain on the commanders by reducing the number of tasks they must focus on, thereby decreasing the risk of task saturation inhibiting human cognition.

These tools greatly enhance decision routinization since echeloned understanding of situations occurs very rapidly despite the disruption of traditional communications. System modeling for improvement is not a feasible role for a CM tool as the focus of the tool is on maintaining stability in the system rather than improving it over time; it would, however, provide unique insight to commanders both on the physical state of the organization conducting operations and the mental state of other commanders. A CM tool represents a significant combat power multiplier for complex military organizations in complex operating environments.

## World 2: Genghis Khan

World 2, Genghis Khan, is a probable future in which operating environments are more complex than at present but US Army organizations are not. Likely levels of future Army organizations' complexity are a function of structure and systems, where nested systems reduce overall complexity by simplifying spans of control and creating complementary roles that spread workload and focus requirements. Army units in this world must also perform acceptably across an extensive range of mission sets as in World 4 with equal increases in frequency of operations. The theaters in which operations occur are also similarly more complex, and again all of these mission sets include a range of participants from host-nation security forces, coalition partners and allies, and non-governmental and intergovernmental actors. The relative simplicity of Army organizations enables prioritization of AI resources toward external factors and actors instead of internal elements and agents. Competitors still seek to disrupt communications and create friction between friendly actors.

### The Role of AI Tools in Planning and Design

The potential benefit of AI in this world is to enhance analysis and enable the acceptance of prudent risk by informing risk assessments through rigorous simulation. The role of the AI in this environment is to inform Planning and Design (PD) efforts with greater understanding of operating environments by detailing the likelihood of events in bounded realities across different sets of conditions. This PD tool acts as a digital red team partner by checking the validity of assumptions, providing facts, and strengthening analysis through enhancing understanding of both probable outcomes and possible risks. An example from popular culture that illustrates the value of such an advisor is the predictive modeling of Isaac Asimov's character Hari Seldon in his Foundation series of books. Heavily implied to be the equivalent to modern day algorithmic prediction applied to human activity, these models predict future events through estimates of probability and propose actions to increase or decrease the likelihood of outcomes in an effort to save galactic civilization. A current DARPA project seeks to create a causal model that illuminates underlying factors and influences in social domains that contextualize irregular and hybrid conflicts.[61] This tool appears ideally suited to assist planning at the strategic level, but not necessarily at operational and tactical levels.

An appropriate planning tool for operational and tactical commanders and staffs built around an MBM platform ensures widespread information gathering and maximizes the availability and utility of the tool. Distributed parallel analysis by multiple sets of AI-Human teams results in a vast array of insights from multiple perspectives and purposes, informing the overall organization through collaboration and emergent understanding. Since planners have more time to consider the contextually driven factors that affect operations than those executing the plan, an FSM-derived tool is appropriate as the iterative and recursive analysis of an FSM requires more time than immediate assessments. The two major purposes of the PD tool are to prove or disprove foundational assumptions and to both iteratively and recursively simulate potential future outcomes. This process will rigorously explore both he probably outcomes and

[61] Dr. Joshua Elliott, "Causal Exploration of Complex Operational Environments (Causal Exploration)," n.d., accessed October 22, 2018, https://www.darpa.mil/program/causal-exploration.

less likely but more disruptive potential outcomes in pursuit of an informed view of the spaces in which operations occur and how may change. Clausewitz identified probability as another major factor that determines the character of war, and Thucydides' highlighted the influence of interest in causing or changing warfare.[62] Thucydidean interest is in essence calculating of the range of possible outcomes and identifying the desirable ones, or the weighing of probabilities and risks to determine what best serves an enterprise. Planners must acknowledge uncertainty while striving to predict future events, and AI based tools provide a significant advantage in enabling improved assessments through abductive logic and deeper understanding of both propensities and potentialities.

As with current operations, often a major limiting factor to the effectiveness of planning is the time available to analyze the situation and predict potential and likely outcomes. The primary difference in planning and decision-making while conducting operations is the mental distance and potential objectivity available to planners by not being subject to the tyranny of the present. Despite this seeming advantage for planners, artificial planning timelines are pervasive in order to ensure planning outputs meet the needs of the bureaucracy to share information at appropriate times. The addition of an AI planning tool that both informs and critiques planning efforts could do much to greatly alleviate this critical limitation, that of limited time to rigorously examine the operating environment and make reasonable predictions.

[62] Clausewitz, *On War*, 89; Thucydides, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War*, 58.

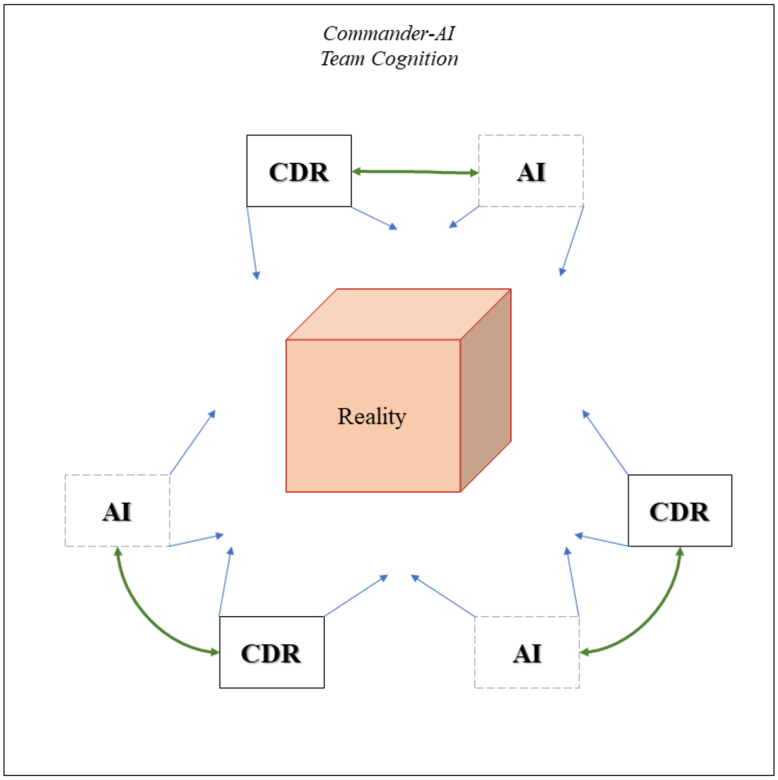

Figure 5. Commander-AI Team Cognition. *Created by author*.

Genghis Khan scenario

A potential scenario set within the world of Genghis Khan illustrates the probable decisiveness of AI decision assistance tools in planning and executing large scale ground combat. An adversary nation-state leverages financial pressure and trade agreements to secure permission for a large forward military base near a strategic location on the African continent within a country that the United States has friendly but not favorable relations with. Over time this adversarial base grows to represent a significant amount of combat power greater than or equal to the host-nation. Upon receiving backlash from a newly elected leader who favors improved relations with the United States and partners, the adversary state declares the recent election invalid on behalf of the opposing party and imposes martial law as an extension of requested assistance. A civil struggle results with adversary military forces aiding authoritarian revanchists seeking to retain control of the seat of government. Adversary military force levels increase, not only suppressing the population of the state but now also threatening neighboring states, major sea lines of communication for global trade, and undersea internet service cables. These adversarial forces possess current peer level technology and personnel but have not yet integrated AI tools into their command and control structure, though they employ autonomous weapons platforms. The United States and coalition partners begin planning to intervene with military force. A multinational task force, built around a US Army corps but including partner brigades and battalions, prepares to conduct a forcible entry into the state to eject adversary military forces and reestablish the rule of law.

Time is of the essence when forces seek to conduct a forcible entry since all the time taken to prepare for and execute such an operation provides the opposing force opportunities to establish and improve defensive fortifications and systems. Planners must assess the enemy disposition, predict likely and possible enemy deployments of forces, and consider enemy reactions to possible friendly courses of action. Every step of this process requires significant critical analysis, which can only improve with the addition of AI planning tools. Data sets to support AI planning tools exist in the form of analysis done by the intelligence community and military intelligence organizations, as well as the requisite modeling and simulation data sets and corresponding algorithms that underpin such a tool. The most current assessment of operating environments and actors combined with the generative-knowledge based modeling tool results in informed and synthesized analysis through employing an AI PD tool.

A military modeling tool simulates the likelihood of proposed enemy courses of action, providing deeper insight into the probabilities of enemy forces conducting specific actions and sets of actions like employing banned weapon systems or choosing preemptive attacks on friendly staging locations. These simulations create a robust understanding of potential branches in enemy decisions and highlight indicators of deviations from the most likely outcomes. Human-analyst base assumptions must prove feasible through simulation as well, with points of contention between human and synthetic analysts decided by the commander’s intuition and professional judgment. Simulation also informs expectations for partner forces’ performance and participation, managing unrealistic projections of the joint multinational enterprise. This PD tool also improves military deception operations by robustly improving understanding of how enemy forces react to different situations, creating opportunities to seize initiative by forcing them to commit forces to unimportant tasks and assisting friendly force asymmetry.

The major advantage that the AI PD tool provides is the ability to create exquisite intelligence through simulation. It enables understanding of a much larger swathe of possible futures and considers the emergent properties of interaction between friendly, adversarial, and environmental actors. In essence, it creates a map of possible futures and greatly assists navigating around hazards. With respect to assessing the utility of such a tool, decision routinization benefits greatly as a mapped future and corresponding indicators of trajectory greatly simplify the task of understanding current and future events and guides decision making toward desired outcomes. System modeling for improvement also benefits greatly from use of this tool, as the simulations inform expectations of organization performance and indicate what factors can increase such performance. Unique insight is absolutely an output of tool use, since it generates exquisite intelligence and vastly improves available information from which to make decisions by exhaustively analyzing potential futures from multiple viewpoints and confirming or invalidating assumptions. An AI PD tool represents a decisive advantage for successful operations in complex operating environments.

## Conclusions and Recommendations

While the two proposed worlds are distinct for the purposes of illustration, in reality they are merely left and right limits for understanding the types of threats to the United States and partners in the conceivable future. In point of fact, it is quite possible that the scenarios from both worlds occur simultaneously in the near future and present the rational actors of the international order with significant dilemmas. The utility of dividing them for narrative in this work lies in illustrating the advantages gained by integrating AI tools into current operations for the purpose of managing crises and into planning operations for purpose of generating exquisite intelligence and producing a map of potential futures to assist in navigating complex environments. These dual applications of AI absolutely should not occur distinctly but simultaneously and in a structurally intertwined manner in the form of data sharing. The CM tool benefits greatly from access to the mapped future of the PD tool, and deviation discovered by the CM tool provides refinement and feedback to the PD tool mapping process. The dialectic interaction improves both, just as the punctuated equilibrium of challenge and response in dialogue between AI and commander improves cognition. This work proposes that these applications are in actuality two sides of the same AI tool coin and benefit greatly from each other. Integrating AI into decision-making presents the opportunity to build a cognitive machine gun equivalent of highly efficient, accurate, and rapid assessment.

Consideration of the utility of the tools and team cognition informs potential shared cognitive framework to improve military decision-making, whether in the context of current or future operations. The Fighting Cancer scenario illustrates the importance of assessing risk as required within the philosophy of Mission Command. Army doctrine defines risk as the probability and severity of loss linked to hazards, which lends itself to analysis by artificial intelligence.[63] The tools proposed in this work calculate both probability in the forms of continuities and possibilities as well as severity in the form of impacts on the complex system analyzed. These calculations enhance a commander's ability to assess risk and serve as the first major component of shared cognitive framework. The Genghis Khan scenario highlights the value of understanding and continuously assessing assumptions. Assumptions function to fill in gaps in available information and enable forward movement during military planning and operations, with the caveat that they are in essence an abductive assessment and not validated as

[63] US Department of the Army, *Army Training Publication (ATP) 5-19, Risk Management* (Washington, DC: Government Printing Office, 2014), Glossary-3.

fact.[64] The tools proposed in this work fundamentally function as abductive tools that enable formation of better assumptions as well as rapidly highlighting invalid assumptions when new information becomes available. The critical element in this portion of the shared cognitive framework is distinguishing in both the artificial and partnered human mind which assessments are factual and which are abductive assumptions. Both scenarios illuminate the impacts of time on decision-making, how the tempo of the process constrains cognition and the tempo of operations drives conditions in the system. Army doctrine defines tempo as is the relative speed and rhythm of military operations over time with respect to the enemy.[65] The proposed tools both inherently calculate tempo by assessing the complex systems and comparing friendly actors to unfriendly actors as well as reducing the time taken to conduct analysis and enabling higher operational tempo through reducing the cognitive workload of human team members. Taken together, these three concepts of risk, assumption, and tempo underpin the critical elements of shared cognitive framework for AI-human team cognition.

Two major obstacles to synthetic-organic team cognition are the cultural resistance of Army leaders and the structural framework of military decision-making. First and foremost, it is critical that leaders observe and interact with AI tools consistently and build confidence in and acceptance of their ability to increase awareness and enable better decision-making. Tropes about fallible or hostile machines will almost certainly accompany introduction of AI tools, but cynicism about potential effectiveness must be countered and tempered by demonstration of enabling capability and comparison to human only teams. There is a danger that a healthy and reasonable skepticism of AI tools as a silver bullet will unproductively override willingness to innovate and effectively employ them. Overcoming this will require significant emphasis from senior leaders and eventual validation by subordinates. Secondly, the structural placement of

[64] US Department of the Army, *Army Training Publication (ATP) 2-01.3, Intelligence Preparation of the Battlefield* (Washington, DC: Government Printing Office, 2014), 6–7.

[65] US Department of the Army, *Army Doctrine Publication (ADRP) 3-0, Operations*, 2–7.

these tools is likely to have significant effects on how quickly they demonstrate their worth. A seemingly natural venue to begin integration of AI tools is in the CTC environment and during the large simulations that occur at Warfighter exercises for larger headquarters. Initial tools may prove less useful below the battalion level, but almost certainly will enhance military planning at the battalion and above if incorporated into iterations of design, the military decision-making process, or the joint planning process. While throughout this work depiction of tools focuses on direct relationships with commanders, it may prove more useful during initial introduction to have the direct relationship be with certain members of the staff to include the executive officer or chief of staff, the operations officer, and the intelligence officer. As with all military organizations the personalities and capabilities of individuals within the organization must drive adjustment of systems and tools in balance with requirements.

Friction, imperfection, and skepticism will almost certainly define initial integration of AI tools into military organizations. Acknowledging this likelihood and the challenging nature of the task does not invalidate the need to do so. Nearly every innovation in human history faced the same obstacles, especially when pursued within large and culturally conservative bureaucracies. The US Army currently presses forward on many fronts of cultural and organizational change in the face of challenges from hostile international competitors, and ceding ground in the fight to integrate AI tools is akin to doubling-down on horse cavalry at the onset of mechanized warfare. There is no desirable prize for second place in war, and the potential advantages of AI in decision-making represent a significant advantage over actors who do not harness that advantage. It is time to become better together by embracing AI tools and changing the tempo of warfare.

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