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Boids Cycling Boyd's Loop:

The Nexus of Artificial Intelligence and Joint Planning

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A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning and Strategy. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.

This paper is entirely my own work except as documented in footnotes.

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Abstract

The role of the commander and their intuition has remained constant while the character of war has evolved. In an operational environment increasing in velocity and complexity due to perpetual technological progress, the Joint Planning Process (JPP) suffers from path dependency, remaining an industrial era process only periodically revised to tackle increased complexity, failing to address the core analog processes while ignoring incorporation of digital possibilities. Re-envisioning JPP to incorporate advances in Artificial Intelligence (AI) and Machine Learning (ML) would invert the current method of reverse planning in theoretical hindsight from envisioned endstate to a process grounded in the present reality, searching a range of courses of action through multiple decision trees, agilely and ceaselessly synchronizing to converge the multi-domain effects required to dominate a complex adaptive system. Through this forward exploration, insights of interacting with an adapting system emerge, and commanders are able to distill complexity and think in time, making often non-intuitive decisions in the near term in order to set up a decisive winning action in the future. Man-machine teaming within JPP will not only outpace the forecasting ability of the current process but will provide a capable receptor for insights from current DoD data analytics initiatives animating the environment and adversary as adaptive agent, gaining vital insight in time, across all domains, ultimately providing a better vantage point for manifesting c*oup d'oeil* of the future.

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Chapter 1: Introduction

War is a human endeavor—a clash of wills characterized by the threat or application of force and violence, often fought among populations. It is not a mechanical process that can be precisely controlled by machines, calculations, or processes.
—Department of the Army, ADP 6-0, Mission Command

Decision making has been the centerpiece of warfare since its beginning. Decision making, and the philosophy of mission command, which enables initiative, has always depended on understanding, judgement, and action. The commander's ability to discern decisive leverage points in time and space, to achieve success is the essence of the art. Sir Rupert Smith distilled the idea, writing, "the practice of war, indeed its 'art' is to achieve an asymmetry over the opponent."[1]As warfare has evolved in scale and technology, the ability to achieve the benefit of asymmetry by understanding and acting within a complex adaptive system to gain a position of relative advantage has become the modest evolution of the commander's role.[2] Napoleon, then later Clausewitz, described the ability to expertly perceive and deduce the most appropriate action as *coup d'oeil*. *Coup d'oeil as a* type of commander's intuition has been at the heart of many battlefield successes. *Coup d'oeil* was a crucial aspect of Colonel Joshua Chamberlain's well-known decision at Gettysburg.[3] Chamberlain's estimate of the situation while positioned on the flank of the Union line, and the subsequent surprising decision to attack down the forward slope of Little Roundtop like a right wheel against the attacking Confederate Army, proved decisive in the moment and was certainly a flash of brilliant *coup d'oeil*.

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[1] Rupert Smith, *The Utility of Force: The Art of War in the Modern World, 2nd ed.* (New York, Penguin Books, 2019), 4.

[2] Alan Hastings, "Coping with Complexity: Analyzing Unified Land Operations Through the Lens of Complex Adaptive Systems Theory" (Leavenworth: School of Advanced Military Studies, 2019), 8, 17-18.

[3] Michael Howard and Peter Paret Ed, *On War* (New York, Alfred A. Knopf, 1993), 118. "Refers to the quick recognition of a truth that the mind would ordinarily miss or would perceive only after long study and reflection."; Michael Shaara, *The Killer Angels* (New York: Random House, 2010), 189-190.

While decision making has remained central, it has become more complex due to the evolution of the environment in which it occurs. The size of armies grew with industrialization, and the rate of change only increased as technology and other drivers fueled cycles of adaptation and evolution. An epoch of dispersion and decentralization occurred due to advances in the lethality of weapons of war.[4] As a response to complexity inherent in the tyrannies of distance and scale, stressing limitations in communications, the philosophy of mission command emerged.[5] Mission command creates a state of shared understanding, mutual trust, and the commander's acceptance of risk, which enables disciplined initiative for competent subordinates to act within the parameters of a mission-type order, and act within the commander's intent to accomplish the mission.[6] One of the main realizations that shepherded the mission command philosophy is that subordinate leaders could see and take opportunities in line with their commander’s intent due to their better vantage point.[7]

As leaders look to the future, mission command will become more imperative for dealing with the complexity of the future battlefield. The contemporary decision-making process will be challenged by the increasing speed and volatility of the operating environment. However, while effective mission command will become increasingly important, it will also become exponentially more challenging. The vectors of change that describe the trajectory of the operating environment lie along tempo, scale, opacity, non-linearity, and connectivity. In the last century, the acceleration of technology has been a further catalyst for change, creating the current strategic and operational environment in which “the scale, scope, tempo, and lethality of

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[4] Robert A. Johnson, “Predicting Future Warfare,” *The U.S. Army Quarterly: Parameters 44*, no. 1 (Spring 2014): 66-71. https://press.armywarcollege.edu/parameters/vol44/iss1/8.

[5] U.S. Department of Defense, Department of the Army, *ADP 6-0. Mission Command: Command and Control of Army Forces*, by Headquarters, Department of the Army (Washington D.C., 2019), vii.

[6] Department of the Army, *ADP 6-0. Mission Command*, 1-7.

[7] Ibid., 1-3.

large-scale ground combat exacerbates the dynamic and uncertain nature of war, delaying or making precise cause-and effect determinations difficult."[8] Looking to the future and the future operating environment, continuous change will contribute to both the importance of timely and effective decision making and exacerbate many of the commander's cognitive and decision-making challenges.

In the future, adversaries will be both more adaptive and dynamic, competing across all domains.[9] In the next fifteen years, and increasing over time, U.S. "adversaries in some cases will have superior, or near equal capabilities bolstered by advantages in time, space, and perception, and when employed effectively—often in a hybrid and multi-domain fashion—they can prevail over a U.S.-led force."[10] The growth of adversaries' capabilities will create mid-21st Century conditions whereby prevailing "will depend on an ability to synchronize multi-domain capabilities against an artificial intelligence-enhanced adversary with an overarching capability to visualize and understand the battlespace at even greater ranges and velocities."[11] Emerging joint doctrine wholeheartedly accepts the future conditions and is incorporating converging capabilities and actions from all domains. It reiterates that the "proliferation of advanced technologies has accelerated the speed, added complexity, and expanded the geography of warfare." [12] While operating more decentralized through mission command, it is evident that future commanders and their formations will need to achieve success on the battlefield by integrating and synchronizing effects from all domains to defeat the enemy.

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[8] Department of the Army, *ADP 6-0. Mission Command*, 1-2.

[9] U.S. Department of Defense, Department of the Army, *TRADOC Pamphlet 525-92. The Operational Environment and the Changing Character of Warfare*, by Training and Doctrine Command (Fort Eustis, 2019), 7.

[10] Ibid., 8.

[11] Ibid.

[12] U.S. Department of Defense, The Joint Staff, *JP 3-0. Campaigns and Operations: Revision Final Coordination*, by Joint Force Development (Washington D.C., 2020), 214-215.

While not completely alien to Colonel Chamberlain's intuition at Gettysburg, contemporary and future commanders face a more difficult decision-making environment. Faced with mortal danger, Chamberlain clearly accounted for both scientific calculations and psychological effects in a time constrained window of opportunity. In the future, however, commanders will await the same insight while searching for solutions to ill structured, high complexity problems extending through the six domains of air, land, maritime, information, cyber, and space. The future state of affairs poses a potential growth to complexity that will increase at an exponential rate as new technologies and applications are realized. Human learning and even the ability of the most seasoned commander to intuit will not keep pace with the advances. In contrast to the autonomy that mission command advocates to address the acceleration of the battlespace, battle winning *coup d'oeil* must be sustained into the future through improved human cognition, improvement to the decision-making process, or its *augmentation.*

While the mission command philosophy provides a near term mitigation to circumvent some of the difficulties of hierarchical decision making to gain or maintain the initiative, it does not address or eliminate the problem of complexity. The amount of existing information often exceeds the cognitive ability of leaders within the space and time the environment permits, and the brain is prone to errors.[13] The subordinate commander that attempts to exercise disciplined initiative is doing so based on their intuition, and belief in resemblance between problems. The trajectory of the future environment will further exacerbate the decision support structure provided by the commander's staff due to an increase in volatility of the future operating

[13] Dietrich Dorner, *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations* (New York: Metropolitan Books, 1996), 7-10.

environment.

The cleaving of decision competence and available support has created a widening capability gap between the analytical decision-making process, commander's intuition, and effective decision making. While Colonel John R. Boyd's *time-based theory of conflict* entailed fighter pilots "generating a rapidly changing environment," the future environment itself will likely challenge the "ability to adapt," but with Boyd's ultimate message still holding true, that "whoever can handle the quickest rate of change is the one who survives."[14] The current and future environments clearly demonstrate the need to develop more agile decision support tools that can stem the gap and regain a decisional advantage for commanders moving toward an operational environment increasing in velocity and complexity. The ability to effectively forecast several engagements ahead in an opaque and complex environment will be essential to success. Simultaneously, the ability to understand and react first in a dynamic environment capable of rapidly invalidating previous plans will be essential to seizing and retaining the initiative.[15]

The science of complexity and study of chaos have wrestled with similar problems, which provide relevant insight to the military commander's emergent challenge. Work with computer modeling and artificial intelligence has made great gains. In many games, computers have eclipsed a human's ability to make decisions. Examples include firsts in chess, go, and even games dealing with decision making based on imperfect knowledge—poker. In an expert analysis of a self-played game by AlphaGo played nine days before the match in which AlphaGo defeated reigning world champion Lee Sedol, the analysis routinely described segments of the

[14] Robert Coram, *Boyd: The Fighter Pilot Who Changed the Art of War* (New York: Little, Brown and Company, 2004), 328.

[15] Department of Defense, *Changing Character of Warfare*, 8; 6; Hastings, "Coping with Complexity," 4-6.; John Rosenberger, "The Burden our Soldiers Bear." *Combat Training Center (CTC) Quarterly Bulletin* (4QFY95): 13, 16, 22.

game as “very complicated, with both sides playing exquisite moves that we still do not fully comprehend.”[16] Its ability to combine brute force calculation and machine learning made AlphaGo not only a nearly unbeatable opponent but illuminated new ways of looking at an ancient game. In move thirty-seven of the second game, AlphaGo made a move that was “unimaginable in the more than three-thousand-year history of the game.”[17] Lee Sedol responded in game four with an equally inhuman move described by commentators as “God’s Touch,” which many attribute to insights developed when “AlphaGo pushed the boundaries of human intuition.”[18] It is clear that AI can improve human performance from engaging with it.

As a reaction to AI dominance, human-machine teams in chess have achieved a new pinnacle of decision making, combining the tactical excellence of algorithms that evaluate future moves several turns in advance with humans’ strategic ability. Examples from chess, while very applicable, are fairly pedestrian compared to the deep learning accomplished in other areas of AI and machine learning. Current US Defense efforts related to AI and decision making appear focused on big data and data analytics. Current projects such as Project Maven or Joint All-Domain Command and Control (JADC2), once fielded, will undoubtedly synthesize vast amounts of data to provide commanders even more information. Proponents believe “it’s going to inform our decision-makers, it’s going to help them make decisions that, like playing chess, are thinking about two or three moves downstream.”[19] Predictive analytics, however, cannot be

[16] Fan Hui, *AlphaGo vs. AlphaGo: Game 1: “Fighting”* (London: Google DeepMind, 2016) https://deepmind-media.storage.googleapis.com/alphago/pdf-files/english/ag-vs-ag1/AG20vs20AG20-20G120-20English.pdf.

[17] Ibid.

[18] George Zarkadakis, *Move 37 or How AI Can Change the World*, (Huffpost, November 26, 2016) https://www.huffpost.com/entry/move-37-or-how-ai-can-change-the-world_b_58399703e4b0a79f7433b675.

[19] “The Key To All-Domain Warfare Is ‘Predictive Analysis:’ Gen. O’Shaughnessy,” *Breaking Defense*, last modified on May 5, 2020, 3:23pm, https://breakingdefense.com/2020/05/the-key-to-all-domain-warfare-is-predictive-analysis-gen-oshaughnessy/.

capitalized on in the absence of an improved military decision-making framework without exacerbating the challenge of understanding the operating environment.

Scientific advances in artificial intelligence and machine learning highlight revolutionary implications for military decision making. The technology, however, must be applied to a distinctly human endeavor comprised of imperfect information about often ill-structured problems. Human beings will remain responsible for decision making in these complex situations and will remain accountable for their decisions. No amount of new technology can displace that. To be effective, the technology must aid professional practitioners who synthesize decades of experience and study to apply their intuition to decisions. To avoid wasted time or money in the acquisition process, or worse yet, abdication of a radical technological advantage, a bridge between the technology and the unique context of military decision making is required. A bridge between artificial intelligence logic and algorithms, and their potential applications in existing decision support tools to enable decision making and disciplined initiative in the future operating environment is conspicuously absent from the existing literature on military decision making and AI development. Current and past efforts have focused on education and doctrinal process, without modification for the calculation capability now resident in computers, or lifting the veil surrounding artificial intelligence, and harnessing its game-changing power.

The Joint Planning Process, a decision-making apparatus, while analytically sound, is not structured in a way that it will keep pace with the future environment. Because the pace of conflict will outweigh a staff's ability to process an analytical contribution it will force commanders to solely rely on intuition in a world in which the past may be less relevant. The commander's intuition, which pulls from studied history and decades of personal experience, is open to bias and heuristics, and they often intuit based on solutions from previous conflicts. Such analogical reasoning is inaccurate for Joint, Interagency, Intergovernmental and Multinational (JIIM) operations within a complex adaptive system, which will increasingly continue to permeate conflicts of the 21st Century.

An artificial intelligence enabled, semi-autonomous Joint Planning Process will create an understanding of the environment grounded in a framework of physical information. Course of action development will not originate from a desired endstate worked backwards applying ways and means in theoretical hindsight to create an imagined future. It will work forward from the current state. AI enabled JPP will explore forward through the possible branches of friendly and adversary decision trees, towards the environment and adversary described in step four of the Joint Intelligence Preparation of the Operational Environment (JIPOE), brought to life as adaptive agent by means of minimax style decision tree.[20] Alternative operational futures will be built through the emergence of feasibility, completed through optimization of the contributions of joint functions, inherently distinguishable, then judged by the human component of the man-machine team to be suitable and acceptable. Re-envisioned man-machine JPP will keep pace with the future operating environment, not only operating at near machine speed, but at the speed of relevance. AI enabled JPP will assist commanders to better understand the complex operating environment, act first and decisively at the edge of chaos, and provide superior vision through a thickening fog of war. In the future, AI will provide a better vantage point for generating and exploiting *coup d'oeil*.

[20] Rune Djurhuus, "Chess Algorithms Theory and Practice" (Oslo: University of Oslo, 2013), 6-12. https://www.uio.no/studier/emner/matnat/ifi/INF4130/h13/undervisningsmateriale/chess-algorithms---theory-and-practice_ver2013.pdf.

Chapter 2: Decision Making within the Joint Planning Process

No man ever steps in the same river twice, for it's not the same river and he's not the same man.
—Heraclitus

In the joint military context, commanders, while supported by their staff, ultimately use their own faculties for decision making. When commanders are conducting problem solving to formulate guidance for their staff or subordinates, they are essentially conducting "means-ends analysis, a process of searching for the means or steps to reduce the differences between the current situation and the desired goal."[1] In the process they are likely to reduce the list of differences in one of three ways: by the application of means that directly achieve the goal, by applying means to achieve a step or component of the goal, or by employing an available solution resembling a solved problem.[2] Even intuition, a sudden insightful interpretation of an event or data, works in a similar method. "Despite the apparent sudden flash of insight that seems to yield a solution to problems, research indicates that the thought processes people use when solving insight problems are best described as an incremental, means-ends analysis."[3] Leaders recognize similarities and make connections to personal and studied history that lead to insight.

The scientific explanation of intuition describes a much more algorithmic process to achieve *coup d'oeil*, fitting the very definition of "a process or set of rules to be followed in calculations or other problem-solving operations."[4] Commanders, while representing a human yet particularly practiced professional cohort of problem solvers, none the less, follow the same

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[1] Daniel Schacter, Daniel Gilbert and Daniel Wegner and Matthew Nock, *Psychology: Third Ed.* (New York: Worth Publishers, 2014), 382.
[2] Schacter et al., *Psychology*, 383.
[3] Ibid., 386.
[4] New Oxford American Dictionary, 3rd ed, s.v. "algorithm," (New York, NY: Oxford University Press, 2010), 40.

internal process of a mental algorithm. Psychologist, economist, and Nobel Laureate Daniel Kahneman explained the internal, often semi-conscious process with the description that "the mental work that produces impressions, intuitions, and many decisions goes on in silence in our mind."[5] Mathematical physicist, philosopher of science, and Nobel Laureate Roger Penrose described an unconscious development of ideas, and a conscious judging of those ideas.[6]

Rational Choice Theory, from classical economic theory, suggests "that if we are rational and are free to make our own decisions . . . we make decisions by determining how likely something is to happen, judging the value of the outcome, and then multiplying the two."[7] Rational choice theory compares multiple options based on the value of the outcome and the probability it will happen. A direct comparison is done between the product of probability and expected value. Rational choice theory shares an algorithmic process with all of the previous descriptions. While the rational choice model in itself is not sufficient to accurately predict decisions in many cases, Bart Kosko describes a more realistic variant that converges on the intuition example, as well as shares an algorithmic process in what he terms fuzzy logic. Kosko asserts that you intuitively develop a weighted average of many considerations and are inclined towards it.[8] All of the descriptions of decision making from experts across a variety of applicable fields all converge on a similar process that possess the characteristics of an algorithm.

Within the body of military scholarly work, Carl Von Clausewitz, a known proponent of *coup d'oeil*, succinctly wrote "Strategy deduces only from experience the ends and means to be examined," and was presciently close to the means-ends insight from psychology.[9] Additionally,

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[5] Daniel Kahneman, *Thinking, Fast and Slow* (New York, NY: Farrar, Straus and Giroux, 2013), 4.
[6] Roger Penrose, *The Emperor's New Mind* (Oxford: Oxford University Press, 1989), 546.
[7] Schacter et al., *Psychology*, 374.
[8] Bart Kosko, *Fuzzy Thinking: The New Science of Fuzzy Logic.* (New York, NY: Hyperion, 1993), 176.
[9] William Duggan, *Coup D'Oeil: Strategic Intuition in Army Planning* (Carlisle, PA: Strategic Studies Institute, 2005), 3, https://press.armywarcollege.edu/monographs/729/.

"Napoleon himself told us he borrowed his strategy from the campaigns of the 'great captains' he studied."[10] The examples reinforce the reliance on experience, as lived or studied. A more contemporary example, General James Mattis points out that for him, "The problem with being too busy to read is that you learn by experience . . . i.e. the hard way. By reading, you learn through others' experiences, generally a better way to do business, especially in our line of work where the consequences of incompetence are so final for young men. Thanks to my reading, . . . it lights what is often a dark path ahead."[11]

Despite their competence, commanders' reliance on individual experience and knowledge has limitations even for the most brilliant commander. The staff, staff processes, and even service and joint doctrine evolved to better enable the commander and mitigate any shortcomings. Analysis of the paired algorithmic processes of expert individual cognition in the form of the commander and the analytical staff Joint Planning Process reveals remaining gaps and liabilities that will be further exacerbated by the future operating environment in terms of the requirements for speed, and the increased complexity and adaptive nature of the environment.

Within the current process, in order to prevail against thinking and adapting enemies operating in a complex adaptive system, military commanders are enabled by their own staff process of thinking and adapting. In the joint force the process is known as the Joint Command and Staff Process. The continuous cyclic process is described in the roughly four steps of "analyze the situation and need for action; determine the course of action (COA) best suited for mission accomplishment; and carry out that COA, with adjustments as necessary, while continuing to assess the unfolding situation," and occurs over successive iterations known as the

[10] Duggan, *Coup D'Oeil*, 3.

[11] Geoffrey Ingersoll, "Too Busy to Read," Military and Defense, Business Insider, accessed April 14, 2021, https://www.businessinsider.com/viral-james-mattis-email-reading-marines-2013-5.

Joint Planning Process (JPP).[12] The Joint Planning Process is a rigorous and deliberate seven step process that enables a commander to make decisions on actions their unit will take. The process consists of the steps of Planning Initiation, Mission Analysis, COA Development, COA Analysis, COA Comparison, COA Approval, and Plan/Order Development. Step 1, Planning Initiation entails both organization of the planning group and gaining an understanding of strategic guidance. The groundwork for decision making begins with Mission Analysis in the second step.

As staffs methodically analyze the mission, the commander provides their insight and guidance to direct the staff's efforts towards providing the best available solution. During mission analysis, commanders must make their own assessment of the situation based on training and experience to give guidance to the staff. While the commander does this, the staff balances the commander's experience, providing details and analysis specific to the current situation, helping the commander understand the unique situation, and the applicability of other events or actions. The effectiveness of the step depends on many variables. The commander must be able to understand the environment, the situation occurring within it, and determine the most advantageous way of accomplishing the mission. If the commander mentally categorizes the mission in a certain way, then the unit's mission, intent and planning guidance will likely follow in that direction. As introduced earlier, "means–ends analysis and analogical problem-solving offer pathways to effective solutions, although we often frame things in terms of what we already know and already understand."[13] The tendency towards familiar frames is a manifestation of availability bias in which the decision maker bases their reasoning on examples that come to

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[12] U.S. Department of Defense, The Joint Staff, *JP 1. Doctrine of the Armed Forces of the United States*, by Chairman of the Joint Chiefs of Staff (Washington D.C., 2017), xxiii.

[13] Schacter et al., *Psychology*, 387.

mind and is connected to intuition as the third of the three previously introduced methods of means-ends reasoning. The flaw is that "things don't happen more frequently just because we can conceive of them more easily," and we "create a picture of the world using the examples that most easily come to mind."[14] At the same time, humans are often "confident even when we are wrong, and an objective observer is more likely to detect our errors than we are."[15] The objectivity check is what the staff provides in their mission analysis brief to the commander within JPP.

In psychology, a "concept refers to a mental representation that groups or categorizes shared features of related objects, events, or other stimuli. A concept is an abstract representation, description, or definition that serves to designate a class or category of things."[16] We formulate categories "in large part by noticing similarities among objects and events that we experience in everyday life."[17] Several theories exist for the development of concepts such that something could gain inclusion to a category by meeting family resemblance criteria, closeness to a prototype image, or by comparison to a previously encountered exemplar.[18] The importance to decision making is that "we use categories and concepts to guide the hundreds of decisions and judgements we make during the course of an average day."[19] If we understand categories and concepts to be our construction and understanding of something, it is first important to appreciate that it is the definition of the individual elements or factors that judgement, logic, or reason are applied to. Correctly establishing the concepts pertaining to a problem are the precursor for any meaningful or effective means-ends reasoning.

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[14] Rolf Dobelli, *The Art of Thinking Clearly* (London: Hodder & Stoughton Ltd., 2013), 35, https://justincayce.files.wordpress.com/2016/09/the-art-of-thinking-clearly-by-rolf-dobelli.pdf.

[15] Kahneman, *Thinking, Fast and Slow,* 4.

[16] Schacter et al., *Psychology,* 369.

[17] Ibid., 369.

[18] Ibid., 370-371.

[19] Ibid., 374.

If the situation or component parts are mischaracterized, then the resulting solution will likely be illogical. Scientific experimentation provides evidence that suggests "competency on reasoning tests depends more on whether the task makes sense to participants than on their problem-solving ability."[20] Within a complex adaptive system (CAS), the level of complexity makes it more likely that without significant analysis, incorrect concepts will be formed, especially when analogy to previous conflicts or situations are formed. This is anchoring bias, in which a guess at something they are uncertain of is obtained by shifting from a certainty.[21] Similar heuristics and biases that contribute to the forming of inaccurate concepts are information bias, which is "the delusion that more information guarantees better decisions."[22] Additionally, the illusion of attention shows "that we are confident that we notice everything that takes place in front of us. But in reality, we often see only what we are focusing on."[23] Similarly, feature positive effect has shown that "we have problems perceiving non-events. We are blind to what does not exist."[24] This small sampling of human cognitive errors manifests and compounds as decision makers want more information and are incorrectly confident they can take it all in, but they are only absorbing what they focus on out of the information presented not noticing what is absent. The biases can result in a poor interpretation of the situation, and grave consequences when they occur during 21st Century modern conflict.

During the 2008 war between Georgia and Russia, Russian precedence resulted in incorrect categorization of Russia's actions leading up to the war, and flawed theoretical reasoning, which resulted in a Russian *fait accompli* when their true plan was executed. "The

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[20] Schacter et al., *Psychology*, 374.
[21] Dobelli, *Art of Thinking Clearly*, 76.
[22] Ibid., 135.
[23] Ibid., 193.
[24] Ibid., 208.

Georgians, until they were plunged headlong into the fighting, appear to have prepared only for a replay of previous confrontations in Abkhazia and South Ossetia regions in the early 1990s."[25] To their surprise, "the Russian military staged an all-out invasion, planning to totally decimate and destroy the Georgian military."[26] There was a significant amount of information available that, had commanders been looking for it, would have provided fact-based, unemotional analysis that would have alerted Georgian decision makers to the differences between the current situation and preceding conflicts, leading to more productive preparation, deterrence, and response. Challenging the heuristic developed impressions of the Russian actions would have likely revealed that "Russian authorities had been making serious preparations for war over the span of nearly one decade."[27]

In the future, the vectors of change will exacerbate the gap between the reliability of human cognition and the complex operating environment. In fact, the more recent Russo-Ukrainian War showed how both the environment of 21st Century war and a Russian aggressor evolved in just six years from the Georgian conflict. Human bias and cognitive limitations applied to a cursory understanding of a conflict often obscures underlying causes, but also highlights the inherent limitations of the current organizational and staff processes faced with the rate of change. Methods such as causal loop analysis, and cognitive maps, provide an avenue to capture and interrogate the complex interactions in a system using mathematical calculations. As the operating environment continues to become increasingly complex, AI programs using similar logic will enable deeper understanding of problems to enable reliable mission analysis even in a time constrained Joint Planning Process.

[25] Svante Cornell and Frederick Star, *The Guns of August 2008: Russia's War in Georgia*, (New York: M.E. Sharpe, 2009), 162.
[26] Cornell and Star, *The Guns of August 2008*, 162.
[27] Ibid., 50.

The third step in JPP is COA Development. A strong COA will accomplish the mission within the commander's intent, position for future operations, enable initiative, and be flexible with respect to an array of adversary and other actor actions.[28] During the mental calculations that are a major contribution to generating options within COA development, multiple options to achieve the desired end come to mind. In the event of multiple options, a process must be used to select one. The cognitive tool for reasoning is logic. Logic is defined as "reasoning conducted or assessed according to strict principles of validity."[29] Logic serves the purpose of assessing both the accuracy and suitability of the path from means to ends, and also evaluates multiple options of reaching the ends against each other to arrive at a decision. While rational choice theory seems common sensical, it is unlikely that any person on a staff is actually multiplying probability by expected value and comparing the product of multiple options.

However, Kosko proposes that fuzzy associative memory operates by recalling multiple considerations, weighing each to a varying degree while regularly judging a relative value and comparing options.[30] The quasi-mathematical process is often effective, but not easily explainable regarding why a specific conclusion was reached. Occurring within their semi-aware mental process are heuristics, used to simplify calculations, as well as some neuropsychological flaws, which impact decisions in a similar way. Rate neglect results in unknowingly disregarding distribution levels, and the law of small numbers often leads to random distribution creating a false correlation.[31]

On top of the logic flaws, other biases impact the quality of solutions, such as alternative

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[28] U.S. Department of Defense, The Joint Staff, *JP 5-0. Joint Planning,* by Joint Force Development (Washington D.C., 2017), V-20 – V-22.

[29] New Oxford American Dictionary, 3rd ed, s.v, "logic," (New York, NY: Oxford University Press, 2010), 1027.

[30] Bart Kosko, *Fuzzy Thinking: The New Science of Fuzzy Logic.* (New York, NY: Hyperion, 1993), 176.

[31] Dobelli, *Art of Thinking Clearly,* 140.

blindness, which has shown that people "systematically forget to compare an existing offer with the next-best alternative."[32] Similarly, *déformation professionelle* is the tendency to identify solutions within one's own discipline.[33] All of the biases and heuristics work to limit options that "come to mind," despite being nested within the thorough analytical process of course of action development. Despite several sub steps, the COA Development process still requires conjuring up a great deal of the solution.

Another vital aspect of COA development is the anticipation of the need to adjust the plan as it unfolds, and the development of branches or alternatives. A good COA provides flexibility, and branches and alternatives are planned contingent actions or adjustments to the plan. Doctrinally, "an alternative is an activity within a COA that may be executed to enable achieving an objective. Alternatives, and groups of alternatives comprising branches, allow the commander to act rapidly and transition as conditions change through the campaign or operation."[34] With an appreciation for basic options expressed as separate concepts, the staff makes adjustments to "best synchronize (arrange in terms of time, space, and purpose) the actions of all the elements of the force."[35] In addition to synchronization, the staff is also concerned with "integrating and synchronizing these requirements by using the joint functions of C2, intelligence, fires, movement and maneuver, protection, sustainment, and information."[36] Additionally, with the introduction of all domain operations, staffs ask themselves: "how do land, maritime, air, space, cyberspace, and special operations forces integrate across the joint functions to accomplish their assigned tasks?"[37] The integration and synchronization of the joint

[32] Dobelli, *Art of Thinking Clearly*, 159.
[33] Ibid., 201.
[34] U.S. Department of Defense, *JP 5-0. Joint Planning*, V-23.
[35] Ibid., V-24.
[36] Ibid., V-25.
[37] Ibid.

functions and domains is critical to achieving synergy and a decisive effect. Integration and synchronization are a vital portion of JPP but are also critical to adjustment decisions.

While already important in 20th Century conflict, the increasingly complex contested environment of the 21st Century amplifies the importance of adjustment decisions as it changes dynamically as a CAS. The volatility creates several meaningful impacts to the decision-making process, which will only increase in importance in the future. As Chaos Theory describes, chaotic systems are heavily dependent on starting state conditions. Like the weather, science accurately forecasts the interactions and changes at the particle level, but due to compounding reactions in various directions, positive and negative feedback loops make forecasts increasingly inaccurate over increasing amounts of time.

A pendulum is a helpful visual analogy. Calculating the path of a pendulum after it is released is a relatively simple problem, and one in which the state of the pendulum could be forecasted with relative accuracy even after several cycles of swinging forwards and backwards. Calculating the movement of a double pendulum, however, comprised of a second pendulum suspended from the first, creates exceptional dependance on the starting position, with changes to the future path magnified by very small differences in starting positions. Human forecasts of the path of the double pendulum will likely be significantly off by the time the pendulum swings back the first time.[38] The adaptive or change component of modern conflict makes a singular course of action or even forecasted branches and sequels suggest they should be viewed with the same reliability as predictions about the weather. While not a scientific proof, the old adages that "the enemy gets a vote," and "no plan survives first contact with the enemy," provide credence to the reasoning. What is most salient about the impact of operating within a CAS, is that every

[38] "Double pendulum," My Physics Lab, accessed March 24, 2021. https://www.myphysicslab.com/pendulum/double-pendulum-en.html.

action changes the problem. A commander adheres to solving their original problem possibly at their own peril, but even when they demonstrate flexibility, processing and accounting for changes, there are variables that by their and their staff's limitations are unseen or difficult to process.

The peril of vehement adherence to the original supposition is best demonstrated by the case that John Boyd used to describe his Boyd's Loop.[39] The example that led to his recognition of the OODA Loop stemmed from an analysis of air-to-air combat during the Korean War. The realization that the MiG-15 pilot's decision cycle was slower than the F-86 pilot's decision cycle, and that the delay by the MiG-15 pilot resulted in the pilot reacting to an outdated version of the problem, albeit only by seconds or fractions of a second. The inherent reaction time to a problem that has since evolved, negated other advantages such as speed.[40] Keeping in mind the purpose of mission analysis is to understand the situation and problem well enough to formulate solutions, Boyd's Loop is relevant when the environment and problem are constantly evolving and adapting, and risk wasted staff work time and man hours committed to JPP on an outdated problem.

Step four, COA Analysis and Wargame, assess developed courses of action, conducting a process to test the COA and make refinements. The assessment is only directed at the generated course of action, with no real mechanism to determine if there is a better COA in waiting. Feature positive effect would suggest that cognition is not an appropriate safeguard for arriving at the most advantageous COA, but only improving and troubleshooting what is "available" in step four. Time constraints limit the number of friendly and adversary COAs that can be

[39] William S. Lind, *Maneuver Warfare Handbook*. (Boulder, CO, Westview Press, 1985), 5-6; Observe, Orient, Decide, Act (OODA).

[40] Lind, *Maneuver Warfare Handbook*, 4-5.

analyzed, often only wargaming against the enemy's most likely COA. The staff process is open to making a subjective assessment during the fifth JPP step of COA Comparison on top of a subjective assessment made during COA Analysis in step four if they do not adequately establish measurement and evaluation criteria to ensure a necessary level of objectivity. Once the staff has compared the COAs, they present their findings and recommendation to the commander in step six, COA Approval, and finally conduct order development. As this description highlights, the planning process suffers from path dependence moving forward from COA Development and has no evidence-based mechanism to ensure that it is the best path to go down before committing, because the analysis and evaluation mechanisms are applied after the production of a small number of COAs.

The current environment and decision-making process already clearly present challenges with respect to trade-offs between time available and a comprehensive decision process. When time necessitates shortcuts, the process opens itself up to the human shortcuts it is designed to balance against. The nature of the operating environment and complex adaptive systems, as well as the nature of the mission command philosophy, all inject a degree of instability or rapid change in the environment, as do predictions about the future operating environment. All the factors increase the need of a military decision process such as JPP to reevaluate with increasing regularity, the ability to use current means as designed to achieve desired ends. Planning will increasingly become more like forecasting the weather. The all-domain approach will increase adjustment decisions, making the ability of JPP to keep pace with the changes increasingly difficult and important.

Chapter 3: Available Exemplar vs Building a Prototype – AI Enabled Understanding

We have to disobey the old logic and break its laws to transcend it.
—Bart Kosko, Fuzzy Thinking

Adaptive Systems do not lend themselves to analogical reasoning. In new situations, human cognition forms concepts from available knowledge and experience, which leads to association with past examples, driving intuition, or inductive leaps, based on analogy and experience. In this way, human cognition finds an exemplar from available sources. In contrast, computers calculate each instance and all relative, programmed variables to build a prototype of the actual situation. With the ability of a 2 GHz processor to run two billion cycles a second—computers build their prototype in real time.[1] AI is able to measure and calculate the current situation in near real time and enable commanders and staffs to elevate their understanding from anchoring on historical precedence to the connections of the current prototype. In short, AI can restore an expert glance to decision makers in a much more complex environment.

With some calculations based on the available information and data from past conflicts, it is possible to approximate the understanding of a situation that AI would have gleaned from available data. The calculations presented in this chapter are done in hindsight, but a computer program does what it is programmed to do, and with the algorithmic application of logic, it is possible to see how different parameters would have yielded different forecasts. Had Georgian leadership consulted an AI decision tool prior to the 2008 Russo-Georgian War, it would have provided insightful analysis of the evolving problem, creating decision space while providing a contrary view to the conforming perspective amongst the leadership.

[1] Operational Design is a notable adaptation that has introduced the development of a systemic understanding of the operational environment, however the dependency of variables remain relatively subjective, and the process time consuming.; U.S. Department of Defense, *JP 5-0. Joint Planning*, IV-1.

An AI decision tool has the ability to acquire, synthesize and account for an exponentially larger amount of data than a staff officer conducting analysis, and it can retain and continue those calculations while additional data is added, or existing data improved. Creating a structure to analyze adversary actions within an AI tool makes it possible to develop a mission analysis program that develops potential adversary courses of action and assesses a likelihood of the potential COAs based on objective analysis.

Travel time is one small example of the calculations that could rapidly become unwieldly for a staff officer yet be built upon and combined with others by computer, preventing an inferior heuristic, most likely anchoring, to creep in. These types of seemingly minor, yet relevant misunderstandings are the origin of much of the friction of war. Calculating the time required for one vehicle to travel a given distance requires only the division of distance by speed. The calculation of the time required for a military Division to travel that same distance must now introduce many more variables to develop an accurate forecast. Specifically, the number of vehicles, the number of available routes, number of march units, and serials, as well as the time in between, and the distance in between vehicles, which now leads to a calculation of: ((March Distance+(Distance Between Vehicles*0.961*Vehicles per route)) / March Rate)+(Time Between March Units *0.0278* Vehicles per route)+((Time Between Serials+0.167)*0.00556*Vehicles per route). In under fifteen lines of code, a program can be written that will ask for the required inputs and provide the calculation, most importantly highlighting the insight that it would take a division roughly ten times as long as a single vehicle to complete a 100 kilometer road march if limited to only one route.[2] In all areas where the science of warfare has generated calculations that turn data to information, AI could crystalize

[2] Division travel time was computed in a program written in Python 3 based on inputs of 5,000 vehicles, 32 Km/hr. travel speed, 2 minutes between march units, 5 minutes between serials, 100m between vehicles.

that knowledge and make it rapidly usable and available.

The JPP step that enables commanders to understand the operational environment and translate that understanding into a mission and guidance to enable the development of a course of action, is mission analysis. A key input to the mission analysis step is the Joint Intelligence Preparation of the Operational Environment (JIPOE). The JIPOE is an algorithmic four step process consisting of "Define the operational environment (OE). Describe the impact of the OE. Evaluate the adversary and other relevant actors. Determine the course of action (COA) for adversary and other relevant actors, particularly the most likely COA and the COA most dangerous to friendly forces and mission accomplishment."[3] With slight modification to the process, JIPOE can be combined with AI to provide more objective understanding of a situation and predictive analysis of likely adversary actions. The first step of JIPOE defines the parameters of the operational environment.[4]

The second step of JIPOE traditionally requires a detailed manual analysis of the different aspects of terrain, other mission variables, and the operational variables, creating map products that anticipate how the variables will impact operations. Existing computer programs are capable of rapidly analyzing terrain and could be modified to incorporate other variables. More importantly, conducting this analysis in a program or programming language that could carry into the steps of JPP by man-machine team. Without modifying the second step of JIPOE much, AI could evaluate how the operating environment dictates the integration of the seven joint functions. This analysis creates an overlapping patchwork of the potential employment of the joint functions of command and control (C2), intelligence, fires, movement and maneuver,

[3] U.S. Department of Defense, The Joint Staff, *JP 2-01.3. Joint Intelligence Preparation of the Operational Environment*, by Joint Force Development (Washington D.C., 2014), I-1.

[4] In the 2008 Russo-Georgian War the operational environment (OE) could be defined as the country of Georgia including the de facto states of Abkhazia and South Ossetia, as well as the adjacent oblasts of Russia.

protection, sustainment, and information, within a specific OE.[5] The joint functions assist in pointing towards specific COAs. This range of potential options will comprise many of the branches on the friendly and adversary decision tree to be evaluated in COA Development. The more actions observed and found to be consistent with a certain COA, the more likely the COA is the adversary's intended COA. This is a very similar mechanism as to how a computer neural network could use bidirectional associative memory to clean up a noisy picture of the environment and converge on a specific prototype of collective action.[6]

Conducting a modified second step of JIPOE in a manner similar to how AI would process the information for the situation prior to the Russo-Georgian War reveals insight into the intentions and future actions of Russia. Despite the 104th Airborne Assault Regiment redeploying to Pskov in northwest Russia at the completion of the *Kavkaz* 2008 Exercise, the 135th and 693rd Motorized Rifle Battalions (MRB) remained in the vicinity of the Mamison Pass.[7] The two MRBs were equipped with T-72 tanks, 2S3 self-propelled artillery, and a significant compliment of infantry.[8] First analyzing the capability resident in the movement and maneuver function, the MRBs' movement options consist of roughly three main routes towards Tskhinvali. These three routes were analyzed and shown as a comparison in Table 1 below.

Table 1: Russian First Echelon Movement and Maneuver – Time and Distance

	Roki Tunnel	Didi Gupta	Mt. Kazbek	Tskhinvali	Approximate Time
Central Route	45Km	85Km	N/A	99Km	3hrs. 34min.
Western Route	N/A	109Km	N/A	123Km	4hrs. 19min.
Eastern Route	N/A	N/A	141Km	359Km	11hrs. 42min.

Source: Data adapted from Author, with data from Boufesis, *The Russia-Georgian War*

[5] U.S. Department of Defense, *JP 1. Doctrine for the Armed Forces,* I-9.
[6] Kosko, *Fuzzy Thinking*, 208-211.
[7] Alexandros Boufesis, *The Russia-Georgian War of 2008: Russia's Geostrategic Ascension.* (Ann Arbor, MI: Nimble Books, 2015), 44-45.
[8] Boufesis, *The Russia-Georgian War of 2008*, 45.

of 2008.

Bridges and overpasses play a factor in the available routes for the 51-ton T-72 or 31-ton 2S3, as well as the 10-11 foot width of both and the 10 foot height of the 2S3. All three routes cross the Russian border from within North Ossetia, but only the Roki Tunnel route crosses directly into South Ossetia. Even if staged at the top of the Mamison Pass, the Roki Tunnel route is the shortest and fastest to Tskhinvali or the center of South Ossetia. Additional garrisoned forces within the operating environment included the 503rd Motorized Rifle Regiment (MRR) in Troitskoye, 136 Km from the eastern border crossing and 192 Km from the Roki Tunnel. In Khankala the 42nd Motorized Rifle Division, as well as the 50th Self Propelled Artillery Regiment were 153 Km from the eastern crossing and 220 Km from the Roki Tunnel. From both of these garrisons, the shortest route to Tskhinvali is the Roki Tunnel. The ability to capture and compare details provides some insight when captured in this way. These three options are further represented in Figure 1 below as one ply of the RSEA decision tree.

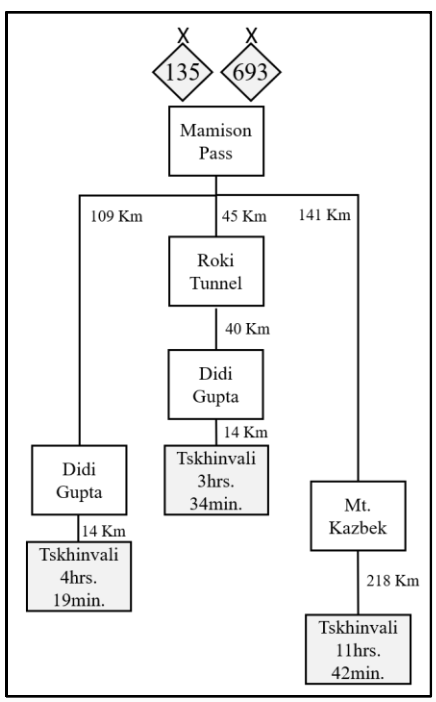

Figure 1: Russian First Echelon Forces Decision Tree. *Source:* Data adapted from Author, with data from Boufesis, *The Russia-Georgian War of 2008.*

Having looked at the disposition of forces from a movement and maneuver perspective prior to the Russian invasion in 2008, AI would have identified the use of the Roki tunnel by the 135th and 693rd MRBs as the most rational and likely because the analysis of joint functions converge on it, which was in fact what Russian forces did on August 8, 2008.[9] Traditional staff analysis, while analytical in nature, still provides meaning based on the information interpreted, but often through the unconscious use of heuristics, commonly with comparison to available past examples. An AI enabled method more objectively identifies order within information, and the similarity of that order to the prototypes of a specific action.

Analyzing the fires joint function provides its own insight, as well as begins to corroborate likely courses of action as the options and capabilities to achieve the effects from fires align with movement and maneuver options. The 135th and 693rd MRBs that remained in vicinity of the Mamison Pass following the completion of the *Kavkaz* 2008 exercise were equipped with 2S3 Akatsiya 152mm self-propelled artillery. The northern entrance of the Roki Tunnel is just outside of the maximum effective range of the 2S3's Rocket Assisted Projectile (RAP) round range from the top of the Mamison Pass. This, as well as the positioning of rocket artillery systems described subsequently, does not correlate to a prototype of a defense; reinforcing the intention of offensive operations. This comparison to a prototype will be discussed in step 3 of JIPOE.

In addition to the forces in vicinity of Mamison Pass, a rocket artillery unit equipped with BM-21s was moved to Kesatikau, only 5 Km by road, and 3 Km straight line distance to the north northeast from the north side of the Roki Tunnel. Dependent on the type of rocket, the 122mm rockets firing from a PAA in vicinity of Kesatikau could range to the northern edge of

[9] Boufesis, *The Russia-Georgian War of 2008,* 48-50.

the town of Java, 35 Km by road from the southern opening of the Roki tunnel on the center route. Conversely, from that firing position they could only range up to the Mamison Pass in the west and could not range the eastern route at all without significantly repositioning to the north and east. The location of rocket and tube artillery systems concur with the results of the movement and maneuver analysis, identifying an ability to provide effects beyond the Roki Tunnel and support movement and maneuver along the center up to the town of Java. The analysis of the fires joint function clearly points towards the central route from the Roki Tunnel. The step-by-step analysis replicating AI processing highlights the synthesis of the influence of terrain on the location and magnitude of effects that can be generated by the joint function. For the sake of length, only two of the seven joint functions were described. However, even with only two joint functions analyzed, the calculations show how AI can connect adversary actions to provide predictive analysis superior to drawing from analogy or means-ends reasoning, as the terrain and geometry are most certainly different from historical exemplars. Specific calculations are possible about the connections between units and equipment across multiple domains and the impact of the terrain on them. This specificity enables interpretation about their capability, and how changes to that disposition would affect it. This is insight. A more general staff processing of the information is not calibrated to the same level, nor are the linkages teased out, allowing the illusion of attention and feature positive effect to sustain the staff's confidence while not revealing any new information to be interpreted.

The third doctrinal step of JIPOE, evaluate the adversary, focuses on capturing the available forces of the adversary with respect to disposition, composition, and strength, and determining their doctrinal template for operations. In an AI enabled modification, the step of evaluate the adversary will be focused on the latter, as the former was analyzed in step two. The previous analysis of joint functions highlighted where the adversary was capable of achieving and even massing effects from the joint functions but does not identify the type of operation it is in support of. An understanding of the tasks and steps required to complete a variety of actions on the spectrum of conflict must be captured. Identifying the building blocks of a course of action is only a slightly different endeavor than conducting a Universal Joint Task List (UJTL) crosswalk, as there are tangible subordinate tasks that must be achieved, often roughly in order, to execute a Course of Action, and create its prototype.

Without changing the laws of physics, there are a series of physical observable actions to prepare for and conduct a military operation. Courses of action are comprised of capabilities delivered by the joint functions. Additionally, the capabilities have requirements, and many are observable. This is an ideal interface for current big data and data analytic initiatives. The identification of supporting tasks can aggregate to outline a COA that becomes increasingly clear as indicators overlap. As the program pieces together identified steps and tasks and compares them to prototypes of COAs, the likelihood of a specific COA emerges.

In 2008, Russia's actions prior to their invasion displayed several observable components of the impending offensive operations. A modified step three of JIPOE would compare Russia's posture to doctrinal template prototypes. The comparison includes the potential offensive roles of a motorized rifle battalion, notably as an advanced guard or part of the first or second echelon.[10] An advanced guard role often includes tank and artillery augmentation.[11] The description for motorized rifle battalions in the offense further describes the typical location of the reinforcing artillery stating, "an attached artillery battalion takes up firing positions 2-4 kilometers from the

[10] Lester Grau and Charles Bartles, *The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces*, (Fort Leavenworth, KS: Foreign Military Studies Office, 2016), 129.
[11] Grau and Bartles, *The Russian Way of War*, 129.

troops on the forward edge."[12] At the brigade level, the first echelon is comprised of 2-3 battalions with reinforcements.[13] The elements of a doctrinal template for the offense correlate significantly to how the Russian forces were staged in North Ossetia in August 2008. The previously analyzed Russian forces match the description of a first echelon force of a motorized rifle brigade in the offense, as they consisted of two MRBs, an attached tank company, and an attached rocket battery. It should not be surprising that the attached rocket battery was placed consistent with doctrine, within the 2-4km planning factor, at three kilometers from the forward edge of the Roki Tunnel.

The analysis from step two pointed towards an orientation on the Roki Tunnel. The analysis of step three points towards an attack south through it. In the examples, there is no single indicator that definitively forecasts the adversary's actions, but two different perspectives of the physical world converged towards a most likely course of action. The non-binary nature of the approach is well suited to the use of the Fuzzy Approximation Theorem (FAT) for synthesis into step four of JIPOE.[14]

Placing the continuum of conflict on an x-y curve creates a medium for the doctrinal template prototype and joint function effects discussed in steps two and three to guide the most likely COA to a point on the continuum. If prototype collective actions cover a curve as patches, and each indicator by joint function is a point on the curve, then indicators begin to identify a specific patch.[15] To understand how overlapping patches determine a value, the process works much like associative memory, in that all rules fire to some degree, many to zero degree. The

[12] Grau and Bartles, *The Russian Way of War*, 129.
[13] Ibid., 138.
[14] Kosko, *Fuzzy Thinking*, 158.
[15] Ibid.

average of the rules that fired to different degrees gives a center of mass for the output.[16] Taking several different observable actions and corresponding them to values representing the continuum of conflict creates a method to forecast the adversary's intent with degrees of certainty. The continuum of conflict and degrees of certainty creates a framework that can be further built upon to include additional layers of analysis, or even incorporate the principle of machine learning. Figure 2 shows an example of the fuzzy approximation theorem created for the continuum of conflict. Actions on the y-axis correspond to a position along the continuum. Insight is generated by objectively aligning actions to elements of the competition continuum, then determining a collective center of mass for a number of inputs, creating a framework to interpret data and indicators.

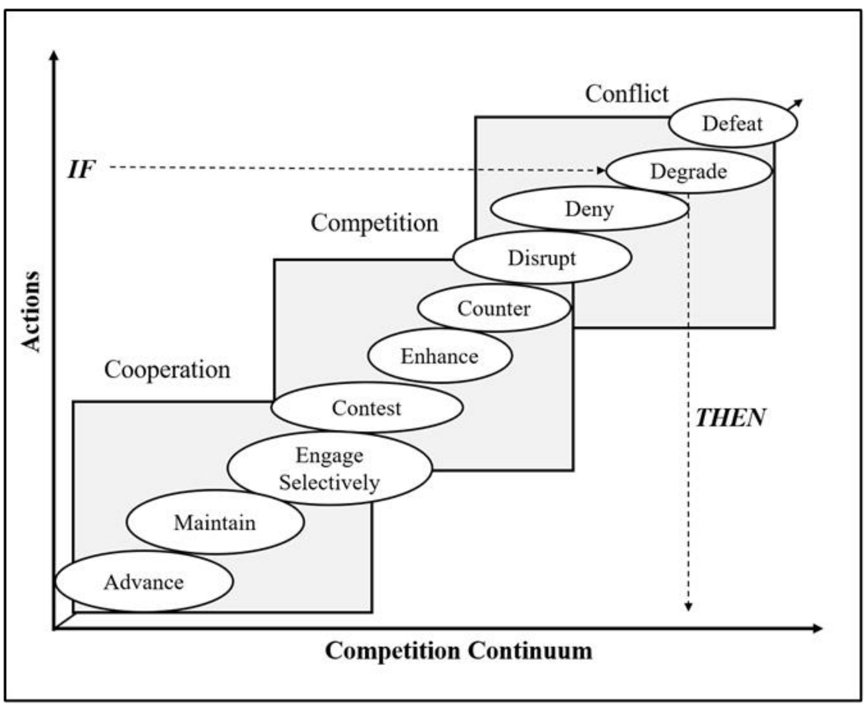

Figure 2: Conflict Continuum as Fuzzy Approximation Theorem. *Source:* Data adapted from Author, with data from Department of Defense, *JP 3-0;* Concept based on *Kosko, Fuzzy Thinking.*

[16] Ibid., 171-172.

To incorporate and exploit the potential power of a machine learning approach, historical actions as expert data points could be inputted to fine tune analysis. An important distinction between machine learning using historical precedence is the use of individual actions, preparations, or condition setting as data points, and not analogy to past conflicts in totality. One way these expert data points feed into the AI algorithm and analysis is through the use of adaptive vector quantizers (AVQ), which build upon the fuzzy system described. AVQs can fine tune the patches that govern the rule the parameters return. If the patch in general is depicted as a two-dimensional shape on an x-y axis of two variables, then a data point is a specific x-y coordinate in that square. When expert data is inputted, AVQ dots move to the data at a specific coordinate.[17] As Kosko explains, it means, "AVQ dots estimate data clusters. So they estimate fuzzy rules, since rules are patches and clusters cover patches."[18] Machine learning techniques refine the patches associated with the doctrinal templates by adding the hindsight of historical precedence. The inclusion of historical precedent better enables the identification of the appropriate prototype serving to sharpen and enhance the JIPOE step.

Past examples of Russian foreign policy in their near abroad provides many examples of real-world action and how it compared to their doctrinal templates. Russia conducted limited actions in the 1991-1992 South Ossetia War when they provided less overt military support. That exemplar biased both the Georgian leadership and the majority of the international community leading to an incorrect forecast of Russia's actions in 2008. The Georgian leadership anchored their thinking on the available example from the early 1990s when forecasting Russian actions in 2008. Looking further back to the Soviet's response to protest and uprisings in Hungary in 1956,

[17] Kosko, *Fuzzy Thinking*, 215-220.
[18] Ibid., 221.

Czechoslovakia in 1968, or Afghanistan in 1979 would yield even more expert data points. The December 1979 invasion of Afghanistan does not at first glance invite analogy to the events leading up to the 2008 invasion, but that is largely due to human cognition's draw on availability, and selective focus. An AI-enabled focus does not draw analogy from history but compares current actions to a prototype which has been refined and made more accurate by past actions.

In terms of the 1979 invasion, the size of the force entering Afghanistan was much larger, although so is Afghanistan, which is just under ten times as large as Georgia, and 172 times larger than South Ossetia. In Afghanistan, "some 300 tanks and APCs of the 360th Motorized Division, followed by a fleet of supply trucks, moved toward Kabul via the ancient Turkestan city of Mazar-i-Sharif along fast, Soviet constructed highways."[19] In all, the Soviets sent multiple divisions along three main axes. However, despite the disparity in scale between the two operations nearly thirty years apart, an MRB crossed the Amu Darya river first, serving as the advanced guard for its parent regiment, and the lead element of the 108th Motorized Rifle Division.[20] The lead echelon and its composition remained doctrinally similar, as did the requirements for fuel, ammunition, and air support. A comparison of curves for the continuum of conflict done by joint function would identify notable clusters of past data points pointing towards an attack. Figure 3 shows an example of how a single data point could be adjusted based on historical precedence. The interpretation of each data point can be adjusted based on past data. Pierre-Simon Laplace's Rule of Succession provides a starting point for this

[19] Edward Girardet, *Afghanistan: The Soviet War.* (New York, NY: St. Martin's Press, 1985), 15.
[20] Lester Grau and Michael Gress, *The Soviet-Afghan War: How a Superpower Fought and Lost* (Lawrence, KS: University Press of Kansas, 2002), 17.

adjustment based on precedence. His surprisingly simple theorem states that the probability of an event is equal to the (Past Occurrences +1) / (Past Opportunities +2).[21]

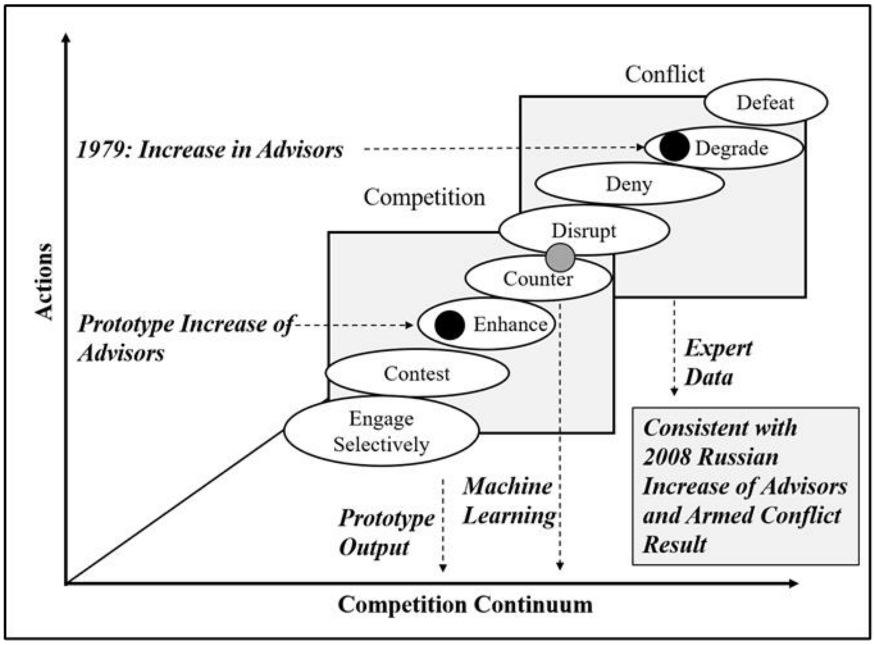

Figure 3: Expert Data Points on the Conflict Continuum. *Source:* Data adapted from Author, with data from Department of Defense, *JP 3-0; Boufesis, The Russia-Georgian War of 2008;* Concept based on Kosko, *Fuzzy Thinking.*

If only the single precedence of the 1979 Soviet invasion of Afghanistan is considered, then the probability that an increase in advisors correlates to degrading their adversary's will, and not enhancing military advantage is 66%.[22] The corresponding shift to interpretation would be interpolated to move the output of increasing advisors from the middle of competition to the overlap between competition and conflict. This shift gives the prototype equal weight as the sum of the expert data points. Adding and evaluating all available observed actions creates an

[21] Jonathan Weisberg, "Laplace's Rule of Succession" Jonathan Weisberg, https://jonathanweisberg.org/pdf/inductive-logic-2.pdf.

[22] Weisberg, "Laplace's Rule of Succession," https://jonathanweisberg.org/pdf/inductive-logic-2.pdf. With only one previous data point in which conflict resulted the calculation is (1+1)/(1+2)= 66%; Department of Defense. *JP 3-0. Campaigns and Operations: Revision Final Coordination*, 132-133.

objective method to evaluate Russia's intentions. This mechanism could also be scaled in and used for the previous analysis of joint functions for Russian first echelon forces in order to provide insight into their most likely course of action. This is not an autonomous process, but one that combines the best of man-machine team.

If the international consensus in 2008 was that of a repeat of Russia's activities in the 1990s, namely employment of peacekeeping troops complimenting irregular force and political activities, then AI's analysis would have provided a lone voice of caution. [23] AI does not get a crazy hunch or intuition. AI does not succumb to the influence of personality and previous successes. AI is not concerned with social proof or herd instinct and would display their answer regardless of any form of social pressure or disagreement with the commander. AI simply calculates based on its programming and the data inputted.

Of course, an expert staff executing JPP could have achieved a similar conclusion, but not without significant study of appropriate doctrinal templates, and a thorough study of the situation and variables—if given the time, and ability to remain objective. It is likely that an average staff would not have produced the same level of objective analysis and would have provided much more subjective conclusions, especially if few unambiguous warnings were present. The analysis of each joint function using current methods is time consuming and requires additional time to compile and merge the analysis of multiple individuals in order to identify the same insights. This staff process takes hours or days, and the Russians could cross the border and be in Tskhinvali by the time the staff figured it out for themselves. The AI

[23] Bruno Coppieters Ed., *Contested Borders in the Caucasus.* (Brussels: VUB University Press, 1996), 98-101.

enabled process would take far less time to figure out and would provide a doctrinally sound recommendation of what to do about it.

Chapter 4: Backwards Planning vs Searching Forward – AI Enabled COA Development

Having a computer partner meant never worrying about making a tactical blunder. The computer could project the consequences of each move we considered, pointing out possible outcomes and countermoves we might otherwise have missed. With that taken care of for us, we could concentrate on strategic planning instead of spending so much time on laborious calculations. Human creativity was even more paramount under these conditions, not less.
—Garry Kasparov, Deep Thinking

The time it takes to assemble key staff personnel to meet, conduct working groups, and iterate and merge work product for every JPP step is considerable. The ability to condense JPP further is limited by group mechanics and workflow. Other than planning a directing a course of action, the most significant available time reduction exists when planning in a crisis. Yet, doctrine does not present an elegant way of shortening the process, only a suggestion that "when possible, planners leverage previously prepared plans as a starting point in a crisis, modifying as required to meet the operational circumstances. If no previously developed plan is suitable, then the planning begins from scratch."[1] The guidance does not provide a more streamlined process, and worse, looks to substitute a solution for a similar previously solved problem, a technique at the heart of previously discussed cognitive error. Regardless of the impetus to begin planning, once complete, the plan's shelf life becomes increasingly short, particularly for current and future conflicts. Staffs that do not adapt to the increased call for speed and agility will abdicate their relevant support to the commander and unwillingly abandon them, leaving them to make intuition-based decisions in the fog of war with no reference points to prevent disorientation and an unwarranted confidence in their intuition.

JP 5-0 provides a seven-step approach to course of action development that follows a

[1] U.S. Department of Defense, The Joint Staff, *JP 5-0. Joint Planning*, by Joint Force Development, (Washington D.C., 2020), I-13.

backwards planning construct.[2] While there are merits to the backwards planning of operations, mention of the adversary is conspicuously absent from the step. The enemy's most likely COA and most dangerous COA are listed as key inputs to COA Development in a previous table but are not overtly included in the seven-step process. If intelligence is to drive maneuver—as the saying goes, then the forecasted approach of the 135th and 693rd MRBs into South Ossetia through the Roki Tunnel and onward to Tskhinvali would have featured as either the most likely or the most dangerous enemy COA. This Russian course of action can more appropriately drive the development of a Georgian course of action, as well as incorporate existing technical capabilities. Creating a friendly COA that achieves asymmetry against the adversary and executes the actions which are most advantageous against the adversary's actions is a vital element of *coup d'oeil*. Executing it may take art, but the science of warfare can derive the plan.

Step one of the course of action development process directs the planner to "determine how much force will be needed in the theater at the end of the operation or campaign, what those forces will be doing, and how those forces will be postured geographically."[3] The technique is effective as a method to produce a course of action, but it is likely that in a complex operating environment the forecasted end state the COA was designed from will branch and alternate. In order to determine the required force, a method of measuring the adversary's combat power is required to ensure the design accounts for the required friendly combat power. There are many methods of varying complexity to determine a value to represent combat power. There are some very intricate models, such as calculating the sum of the theoretical lethality index (TLI) for each weapon system, which each consist of many factors, or the Theater Analysis Model (TAM) which also aggregates the value of all individual weapon systems, as well as modifies the value

[2] U.S. Department of Defense, *JP 5-0. Joint Planning*, III-36.
[3] Ibid.

for terrain and type of mission.[4]

An AI program can make even the most tedious systems feasible, so it is not limited by complexity which staffs are, especially when time is constrained. While this example uses the TAM, the TAM is not the point. Whatever the commander, staff, or doctrine recommends can be used. In fact, updating running estimates which occurs in step one of JPP should include confirming or updating capabilities and equations.

Breaking down the attacking Russian force in vicinity of the Mamison Pass into their component pieces, consisting of approximately 1,500 personnel, fourteen T-72 main battle tanks, and sixteen 2S3 self-propelled artillery pieces, as well as the nine BM-21 multiple launch rocket systems in vicinity of the tunnel, enables their combat power to be calculated.[5] Performing Correlation of Forces and Means (COFM) calculations on that force yields their relative combat power based on type of mission and terrain, resulting in a value of 59 when conducting a deliberate attack through the rolling terrain south of the Roki Tunnel or 50 when conducting an attack into Tskhinvali.

Table 2: Russian Forces Combat Power Calculation

System	Combat Power Value	Quantity	Mission Multiplier	Terrain Multiplier: Hill	Combat Power Attacking in Hills	Terrain Multiplier: Urban	Combat Power Urban Attack
T-72 MBT	0.80	14	1.00	0.7	7.84	0.6	6.72
BMP	0.30	82	1.00	0.7	17.22	0.6	14.76
2S3	0.90	16	1.75	0.7	17.64	0.6	15.12
BM21	1.50	9	1.75	0.7	16.54	0.6	14.18
				Overall Combat Potential Score:	**59.24**		**50.78**

Source: Data adapted from Author, with calculations based on Hogg, *"Correlation of Forces: The Quest for a Standardized Model."*

The range of combat power shown in Table 2 can inform the required combat power to

[4] David Hogg, "Correlation of Forces: The Quest for a Standardized Model" (Thesis, School of Advanced Military Studies, Leavenworth, 1993), 15-18.

[5] Boufesis, *The Russia-Georgian War of 2008*, 45.

defeat this Russian force in various potential scenarios, as well as provides an estimate for casualties based on force ratios. It is not a crystal ball, but it does represent prudent planning. As the very first quote of this paper called forth, "war is a human endeavor—a clash of wills characterized by the threat or application of force and violence, often fought among populations. It is not a mechanical process that can be precisely controlled by machines, calculations, or processes."[6] That human dimension and element of chance cannot be removed, but these calculations provide the best that analytical means-ends reasoning can provide. Table 2 begins to provide an answer to the initial COA Development question of required forces.

When the combat potential has already been modified for terrain and mission type as in the TAM method, a calculation derived from computer modeling can be used to forecast casualties based on the corresponding COFMs.[7] Once all other variables are factored in, a remaining 1:1 ratio equates to an equal distribution of casualties, with a non-linear curve that approaches 0% at a roughly 4.4:1 combat power ratio.[8] This calculation does not provide a percentage chance of "mission success," but can provide iterations of expected battle damage and casualties, which shows how the combat power is affected over time. Assumptions must be made about the loss of combat power that will result in a defeat or withdraw, but this is a great example of where human insight can be forced to provide specificity, benefitting both the process and the individual's knowledge. Table 3 provides insight into the mutual destruction a 1:1 ratio can result in, but how higher ratios can decisively tip the balance, increasing the ratio

[6] Department of the Army, *ADP 6-0. Mission Command,* 1-1.

[7] Reiner Huber et al. Ed. *Military Strategy and Tactics: Computer Modeling of Land War Problems*, (New York: Plenum Press, 1975), 113.

[8] Modifying combat potential by terrain and mission type shows where the typical force ratio heuristics of Attack at a 3:1 or 5:1 in urban operations for a 50% chance of success comes from.

with each iteration. This appreciation for the application of combat power over time provides a key insight and can inform decision making on the allocation of forces.

Table 3: The Positive Feedback Loop of Force Ratios

Russian Combat Power (CP)	COFM	Georgian Combat Power (CP)	Forecasted Results of First Engagements based on COFM	Resulting COFM	Forecasted Results of Subsequent Engagements based on Updated COFM	Final COFM
59.24	1:1	39.49	Russian CP: 29.62 (50% Strength) Georgian CP: 19.75 (50% Strength)	1:1	Russian CP: 14.81 (25% Strength) Georgian CP: 9.87 (25% Strength)	1:1
	1:2	78.98	Russian CP: 29.62 (50% Strength) Georgian CP: 71.08 (90% Strength)	1:2.4	Russian CP: 14.81 (25% Strength) Georgian CP: 66.10 (84% Strength)	1:4.5
	1:3	118.47	Russian CP: 29.62 (50% Strength) Georgian CP: 112.55 (95% Strength)	1:3.8	Russian CP: 14.81 (25% Strength) Georgian CP: 110.30 (93% Strength)	1:7.4

Source: Data adapted from Author, with data from Boufesis, *The Russia-Georgian War of 2008;* Calculations based on Hogg,*"Correlation of Forces: The Quest for a Standardized Model"*

With escalation of the situation in South Ossetia, Georgian President Saakashvili defined three objectives for the military on 7 August, 2008. He directed them "to prevent all military vehicles from entering Georgia from Russia through the Roki Tunnel; second, to suppress all positions that were attacking Georgian peacekeepers and Interior Ministry posts, or Georgian villages; and third, to protect the interests and security of the civilian population while implementing these orders."[9] As the Secretary of the Georgian National Security Council, Alexander Lomaia later testified, "the logic of our actions was to neutralize firing positions on the outskirts of Tskhinvali and try to advance closer to the Roki tunnel as soon as possible by circling around Tskhinvali."[10] This directive, and the logic that underpinned the Georgian military response provides a helpful contrast to the continued development of the AI enabled COA.

[9] Cornell and Star, *The Guns of August 2008*, 169.
[10] Ibid.

The previously analyzed Russian forces from Table 1 and 2 account for the first echelon forces which would attempt to enter Georgia through the Roki Tunnel. The forces described as firing on Georgian forces and villages, were operating in vicinity of Tskhinvali and consisted of Ossetians aided by the Russian and Ossetian "Peacekeeping" battalions, which were increased in number to 830 Soldiers, approximately 300 mercenaries, and more substantial artillery.[11] Because of their considerable infantry, and different mission and terrain of hastily defending from the urban center of Tskhinvali, their combat potential through the same method used previously, is calculated at 60.

Given the locations of the Georgian second, third, fourth, and fifth Infantry Brigades, as well as a separate tank battalion in Gori, their distances to Russian forces, or key terrain can be calculated. Additionally, the corresponding combat power of Russian forces in vicinity of the Roki Tunnel and Tskhinvali can be recorded, and goal programming can be used to mathematically optimize the combat power routed from each Georgian brigade location to either the Roki Tunnel or Tskhinvali to meet favorable force ratios, while minimizing the overall distance travelled, which minimizes both time and fuel consumption.

```
Georgia Attack Routing.py
Combat_Power_Committed_from_2D_BDE_Roki_Tunnel = 67.0
Combat_Power_Committed_from_3D_BDE_Tskhinvali = 67.0
Combat_Power_Committed_from_4TH_BDE_Roki_Tunnel = 12.0
Combat_Power_Committed_from_4TH_BDE_Tskhinvali = 55.0
Combat_Power_Committed_from_5TH_BDE_Tskhinvali = 67.0
Combat_Power_Committed_from_IND_TANK_BN_Tskhinvali = 42.0
Total combat power miles = 58364.0
```

Figure 4: Results of Combat Potential Optimization Python Program. *Source: Original program by author.*

[11] Cornell and Star, *The Guns of August 2008*, 73-74.

For the 4th Infantry Brigade, which is recommended to split combat power between objectives, a second optimization can be run to determine the quantities of different combat systems by joint function to each objective and can be followed by travel time calculations based on formation sizes as discussed previously. What results is a rational choice solution grounded in doctrine and formed through the type of calculations reserved for adjudicating wargames in the later JPP step of COA Analysis.

```
Systems to Objectives - Georgia Attack Routing.py
Status: Optimal
Combat_Power_Committed_from_4TH_Armor_Tskhinvali = 13.0
Combat_Power_Committed_from_4TH_Artillery_Roki_Tunnel = 13.0
Combat_Power_Committed_from_4TH_Infantry_Tskhinvali = 42.0
```

Figure 5: Recommended Split Task Organization of 4th Brigade. *Source: Original program by author.*

```
March Time.py
Enter Distance in Km: 287
Enter Speed in Kmph: 32
Enter Number of Routes: 2
Enter Number of Vehicles: 126
Enter Vehicle Spacing in m: 50
Select Calculation 1-Simple March Time, 2-Convoy March Time
Choose operation 1 or 2: 2
Time to Close 287 Km with 126 vehicles = 9.20 hours
```

Figure 6: Results of Time Analysis to Objectives. *Source: Original program by author.*

This output is similar to analyzing data to create information. Merging these component pieces of information can create knowledge, which the commander or staff can apply wisdom to. Instead of possessing an element of un-explainability, as intuition would inject, this approach is explainable, and can be modified with specific commander's planning guidance.[12] In this case,

[12] The desired and acceptable range of COFMs is a great example of potential commander's planning guidance.

the effectiveness of armor, infantry and artillery in both the attack and defense, as well as hills and urban terrain were factored into the optimization, and the output prioritized artillery to the Roki Tunnel. This recommendation while originating algorithmically, abides by human military judgement which would recognize the comparative difficulty of employing artillery in a city, as well as the relative advantage of infantry.

The types of calculations that are ordinarily reserved for the later step of COA analysis are applied in the development of the COA in this modification. As Kasparov described the benefits of teaming with a computer, so too can humans apply operational art to a concept that has already incorporated the science. The level and complexity of the calculations that assist in generating the COA can be improved based on industry best practices.

The outputs of the man-machine developed COA can be compared to what the Georgian National Security Council articulated about their general course of action. This AI-enabled recommendation would have provided a more formidable force to the Roki Tunnel simultaneous to the commitment of Georgian forces towards Tskhinvali. It is likely that an earlier and more significant commitment of forces to a defense in vicinity of the Roki Tunnel would have significantly disrupted the invading Russian forces, which were already canalized, as well as prevented them from moving their rocket systems within range of Tskhinvali, and ballistic missile batteries through the tunnel to range further into Georgia, which proved to be the *coup de grace* for Georgian forces.[13]

The modified method thus far has established a way to develop the “next move” based on an appreciation for friendly and adversary combat power by location, how that combat power is affected by mission type and terrain, and the time relationship between forces both during

[13] Cornell and Star, *The Guns of August 2008*, 174.

movement, and maneuver in contact.

These examples of ground forces must naturally extend to the application of combat power and effects from all domains. This technique enables simultaneous analysis of individual domains and provides a mechanism for the integration of cross-domain effects. Sorties of close air support may be integrated into the ground domain to provide a better combat power ratio at key locations and times in the ground fight. Additionally, air-to-air combat calculations can be carried out with ground- based air defense assets being factored into the air-to-air calculations. This creates a multi-dimensional framework for combat operations conducted within and across domains and provides a method for synchronizing convergence. As conditions in one domain change, the impact on other domains and operations can be carried through. This creates multi-domain breadth to the framework. With the core COA developed, the joint functions of protection, sustainment, command and control, and information can algorithmically identify the best integration of their function. With sufficient detail with respect to the breadth of the COA, the explanation can now turn to depth.

In order to create a COA at the operational level that has depth in both time and space, it must forecast several engagements ahead to achieve positions of relative advantage and seek to achieve a defeat mechanism that translates to success. Whereas the previous processes have largely been creations of algorithmically linking existing military doctrine or scholarship, they struggle to make the leap beyond immediate decisions and create operational art. For this, existing artificial intelligence provides applicable examples.

The minimax used in chess AI scores all board dispositions two moves ahead, action and reaction, and then compares the scores based on the program.[14] The one with the worst score is

[14] Rune Djurhuus, "Chess Algorithms Theory and Practice", 6-12.

pruned as an option. Having eliminated the worst future option two moves ahead, the best remaining option is selected. The pruning and eliminations process prevents a scenario where one could take a low value piece in the immediate move but would then lose a high value piece on the next move. The algorithm repeats the process based on each subsequent move. In many programs, the algorithm analyzes many more moves ahead, exponentially adding board dispositions to evaluate and rank potential moves.[15] To ease calculations on the computer, a process known as alpha-beta pruning can remove branches when it becomes clear that they will not be the best option and stop evaluating them. Based on the demonstrated ability to valuate military formations based on their correlation of forces and means, it is possible to see how even simple chess AI methodology could form the basis for developing operational art.

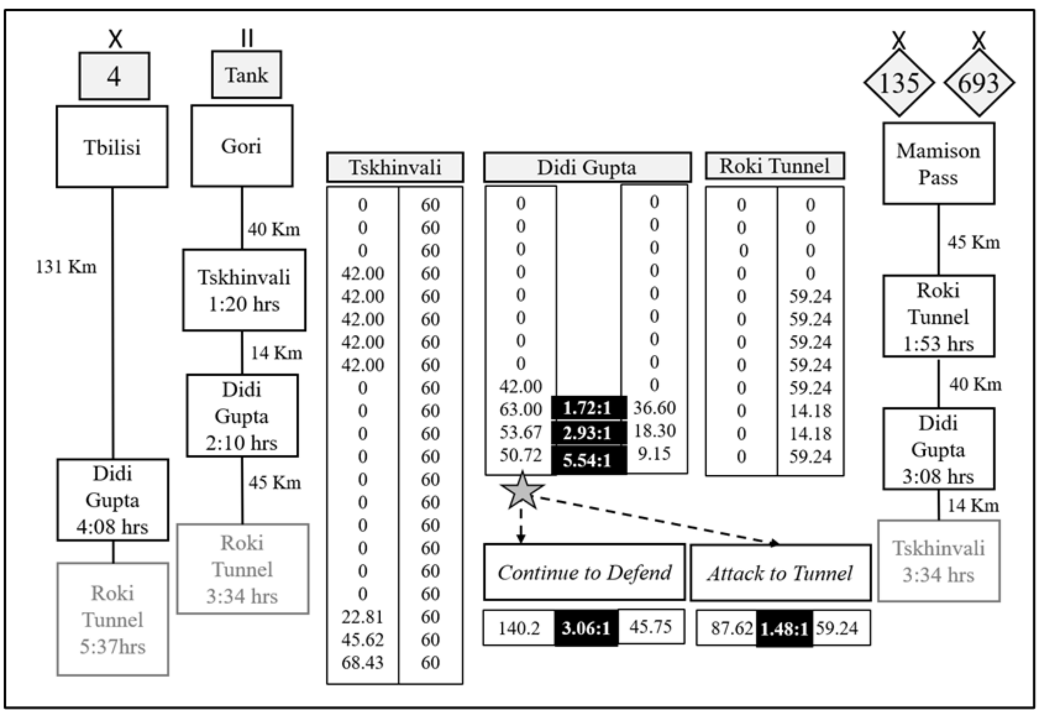

Figure 7: Combined Russo-Georgian Decision Tree. *Source:* Data adapted from Author, with data from Boufesis, *The Russia-Georgian War of 2008.*

[15] Bart Selman, "Foundations in Artificial Intelligence." (Ithaca, Cornell University), 21-50. http://www.cs.cornell.edu/courses/cs4700/2014fa/slides/CS4700-Games1_v5.pdf.

When using a decision tree and the minimax algorithm for chess AI, the program appraises the board for most, or all, alternative futures and generates a comparable value. For each option, there is a specific disposition of white and black game pieces on the board. The disposition can be scored for each side, resulting in assignment of a number score. For example, the remaining white pieces are worth 30 points and black pieces are worth 40. This specific disposition is valued at -10 for the white player. In addition to the aggregated value of pieces, modifiers for positions are also often used. The method of valuating the remaining pieces for each side is very similar to the TAM calculations of combat power previously used to analyze the Russian and Georgian forces. Instead of values for individual chess pieces, combat power of military formations would be considered. The mechanism design creates an attritional focus, preserving friendly combat power and removing the opponent's, prioritizing based on value. The remarkable trait that emerges from what looks very mechanical at first, is the creation and linking of favorable force ratios in time and space, which achieve asymmetry to heavily attrit the adversary and preserve friendly combat power. In short, it verges on operational art, and may even be said to generate *coup d'oeil*. When multiple Georgian COAs are compared in this fashion, a different distribution of Georgian forces emerges as most advantageous due to variations in travel time towards the Roki Tunnel, and how engagements down their respective decision trees were forecasted to progress.

If the AI-enabled COA development process continues to search further ahead, the 503rd MRR in Troitskye and the 42nd MRD and 50th Self Propelled Artillery Regiment in Khankala, are Russian combat power in the OE that are considered for commitment further along the decision tree in Minimax fashion prior to the earlier decision of allocating forces between the Roki Tunnel and Tskhinvali. Once an understanding of forces in time and second and third order effects emerge, it highlights a non-intuitive decision to attack towards the Roki tunnel due to forecasted actions with respect to Russian second echelon forces further in the future. The original disposition of Georgian forces could not get to the Roki Tunnel in time to defend should the Russian forces commence movement at the same time. A modification to this disposition was able to defend in vicinity of Didi Gupta, keeping Russian forces canalized in the hills, and was able to defeat the Russian attack. This defense could withstand the 503rd MRR from the Russian second echelon, but not the 42nd Motorized Rifle Division, which would be on the heels of the 503rd. Because of this, the Georgian defense needed to counterattack to the tunnel prior to the 503 MRR's arrival in order to close the tunnel if they were to accomplish their mission. With these connections emerging from the complexity, Georgian leadership could think in time and generate *coup d'oeil*.

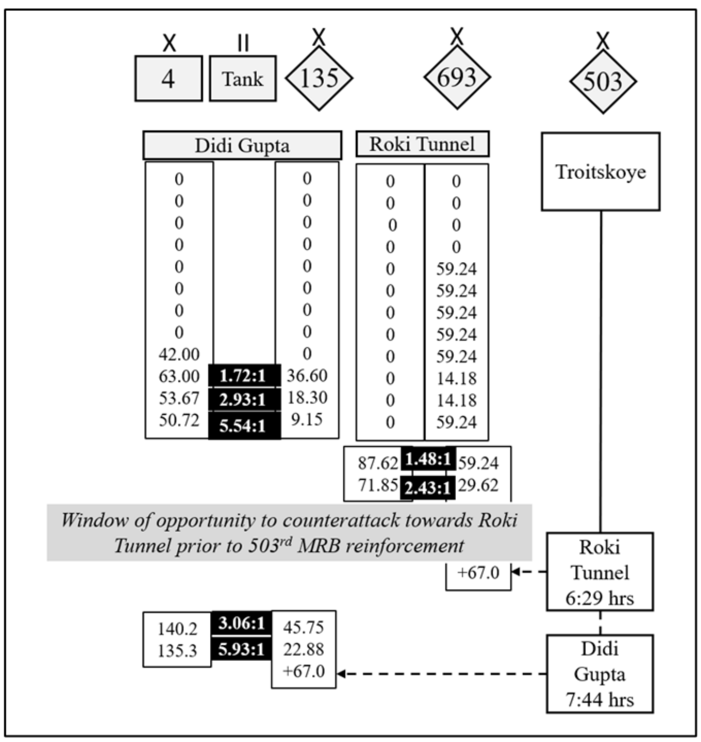

Figure 8: Decision Tree Evolution. *Source:* Data adapted from Author, with data from Boufesis, *The Russia-Georgian War of 2008.*

The algorithmic process for establishing available COAs goes a long way to mitigate the gap created by insufficient time while introducing a level of academic rigor to JPP that may have otherwise amounted to little more than subjective assessment with all the implicitly unknown dangers buried within such an assessment.

Once courses of actions are developed and analyzed, they are compared during the step of COA Comparison. During the step, the COA's ability to accomplish the mission while maximizing elements of the commander's directed evaluation criteria are measured and compared, and ultimately inform the commander's selection of a course of action.[16] COA Analysis often utilizes a variety of calculations to assist in evaluating the results of the actions within the COA. While doctrine specifically states that "COA comparison is subjective and should not be turned into a strictly mathematical process," it does seek to "inform the commander why one COA is preferred over the others in terms of the evaluation criteria and the risk."[17] The algorithmic approach to COA development described in this chapter is informed by calculations normally reserved for COA Analysis. There is often not time available to develop multiple COAs, then wargame all developed COAs, then apply COA evaluation criteria, then identify a recommended COA. With AI enabled JPP, COA Analysis and Comparison are baked in, and takes maximal advantage of available technology, all before a conventional staff could gather the tools.

Taking the implications of AI enabled JPP even further, AI could complete JPP semi-autonomously following the first iteration, conducting the full JPP process near continuously, without fatigue, incorporating every new development. A continuous AI run JPP would provide feedback about the current positions and actions of forces. Near real time feedback would enable

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[16] U.S. Department of Defense, *JP 5-0. Joint Planning*, V-42.
[17] Ibid., V-45.

the tracking of subordinate units with respect to current operations, control measure compliance, and progress. Second, near continuous JPP is able to anticipate branches by evaluating what COA should be executed based on the current conditions, and even forecast the setup of future decisive engagements as conditions change. It will fight the enemy and not the plan. An AI enabled process would have the benefit of integrating resources for any emerging COA, synchronizing and optimizing effects from all domains, making the transition to a new branch plan more feasible. Such an ability would make incredible progress towards enabling forces to rapidly adapt in order to thrive at the edge of chaos in a volatile future environment.

Chapter 5: Assessment and the Way Ahead

I won't let you beat me unfairly - I'll beat you unfairly first. —Ender's Game

The inherent nature and trajectory of conflict results in an environment that will further challenge decision making with respect to both tempo and complexity. The Joint Planning Process (JPP) enables decision making through a linear process that forms a symbiotic relationship between commander and staff. Informed commanders must engage with the process and steer it as their understanding of conditions requires. In return, JPP provides an analytical guiderail to individual judgement and intuition, which can be used artfully and with agility. The relationship of persons and process is not a straitjacket; final judgement always belongs the commander.

Without the aid of JPP, commanders are subject to a myriad of heuristics and biases. Their very experience, study, and intuition can prove misleading when dealing with problems existing in a complex adaptive system. The commander's problem is exacerbated as the future operating environment will rapidly outpace the process of a staff run JPP, leaving its analytical findings and recommendations outdated or irrelevant. Without a course correction, the unaided commander will forge ahead alone on their instincts as JPP lags. An analysis of cognition and commander's intuition within decision making reveals where the process draws its strength but also highlights where evolutionary biology has not kept pace with the explosion of technology, increasingly leaving room for error. The shortcomings will be exacerbated as the environment continues to evolve towards one of increasing speed, complexity, and volatility.

Artificial intelligence tools in other sectors already demonstrate their aptitude for the task of providing quick, consistent, and accurate calculations. The iPhone map application already provides multiple routes and recommends an adjustment decision when traffic patterns change.

To be of value, AI does not need to operate autonomously or replicate a sentient conscious being. AI only needs to bridge the widening gap between the suitability of the current planning and decision tools and the effectiveness of human cognition in complex adaptive systems. Complex calculations with more variables are not always more accurate. "One of the deepest truths of machine learning is that, in fact, it's not always better to use a more complex model, one that takes a greater number of factors into account . . . they might make our predictions dramatically worse."[1] A modest improvement to handling complexity, even one that merely reduces cognitive burden that leads to errors, will assure a decisional advantage over unaided commanders. Integrating AI into the Joint Planning Process will ensure that the process not only moves at near machine speed but, most importantly, at the speed of relevance.

With currently available open-source software and a standard laptop, tools to enable staffs to better model and understand the current environment and adversary can be developed to aid in JIPOE through Mission Analysis. Building algorithms to capture knowledge and create understanding of connections can be done now by self-taught staffs that feel incentivized or motivated to begin integrating AI. Burgeoning programming warfighters can seek technical assistance from data scientists hired across DoD organizations and echelons. Such initiative from within the force would enable Python or another programming language to become a *lingua franca*, such as Excel and PowerPoint have become. Staff's officers could code and run portions of a JPP program now, developing tools that increase staff speed and agility. Authoring programs will build trust and understanding, be explainable, and of course exceed the mental calculations of the commander it supports in several facets. It also has the added benefit of ensuring that the staff doesn't feed the commander data, but synthesizes it into information or knowledge for the

[1] Brian Christian and Tom Griffiths, *Algorithms to Live By: The Computer Science of Human Decisions*. (New York, NY: Henry Holt and Company, 2016), 155.

commander's consumption. In a complex operational environment, understanding of connections must be synthesized into insight and must emerge within the staff process, because commanders will not register the signal amidst all the noise, but will recognize and understand it when it is teased out. In order to update military planning doctrine from industrial age process to information age process, JPP must merge the calculation and analysis capability of computers with the wargaming calculations of the Cold War era, which either lie semi-dormant in the modern staff, or veiled within the niche black boxes of third-party wargame simulations.

The Course of Action Development step through the COA Analysis and COA Comparison steps must be merged and modified to take advantage of the speed, power, and insights of current AI capabilities. COA Development must be more firmly rooted in the outputs of JIPOE. While JIPOE is doctrinally a key input to mission analysis, that thread can be lost in mission analysis where strategic direction and the dissection of higher documents can overshadow it. Increased JIPOE focus prevent anchoring on the desired endstate, and not on the present conditions. Backwards planning can make unjustified means-ends leaps, unwittingly aligning too many tenuous connections only ending in the vicinity of the present conditions. The Georgia case clear exhibits the dangers of those tendencies, where the science and operational art did not get sufficient consideration. The staff and leadership intuition was wrong, and their initial plan was flawed, likely because it considered a static problem and not how it would evolve. One does not need to look very far down the decision trees of the 2008 Russo-Georgian War to see the difference between likely results of sequential commitment to Tskhinvali and the Roki Tunnel, and how the size and timing of committed forces would change the outcome. Looking further ahead into the problem than the existing situation would have revealed very different outcomes precipitating from different starting state conditions. Missing the insight of how two very different conflicts would unfold based on control of the Roki Tunnel, with overall ground combat force ratios changing rapidly with time, the Georgians didn't place the decisive importance of the opportunity to defend the south opening of the Roki Tunnel. Emphasis on defending the south opening would have changed the early balance in favor of Georgia, gaining and preserving an asymmetric advantage for much longer. The short-term focus on Tskhinvali did not take into account the much less dynamic situation there, and the comparatively small difference in rapid commitment of Georgian forces there. The ability to forecast multiple alternative futures and choices enables the team developing the COA or the commander to not just think in three dimensions but in time. Understanding time, given its increasing rarity, and having the tools to work with and through it, may be the greatest advantage AI provides.

The COA development process can identify the most advantageous branches and prune the others, selecting both on suitability, feasibility, and acceptability. Joint functions can be simultaneously allocated and optimized to complete the COA. With a fuller understanding of the joint functions, human practitioners can take a doctrinally sound, feasible COA, and apply their knowledge and experience to turn science to art.

The incorporation of AI, to be successful and sustainable, will need long term cultural development. Introducing and championing computer programming at the junior staff levels would undoubtedly result in the development of novel programs and AI from the bottom up and a level of use, understanding, and trust that could not be thrust into the force. Throughout his experience with freestyle chess tournaments in which man-machine teams competed, what became clear is that "skill at manipulating and 'coaching' their computers to look very deeply into positions effectively counteracted the superior chess understanding of their Grandmaster opponents and the greater computational power of other participants."[2] By introducing AI thinking into junior officer ranks, it will cultivate the foundational skill set, and create far more competent staffs. Just as Lee Sedol, the most dominant player of his time learned from his experience with AlphaGo, staffs will better master their craft. Additionally, the specificity required in programming will drive understanding through study and commitment to specific equations, calculations, and capabilities. Looking deeply into positions is exactly the competence that would translate to success for a staff. Fostering programming competency and its applications will identify the junior leaders in the force capable of innovation and the application of technology to achieve a winning decisive asymmetry. These future Enders will shepherd AI thinking into the military.

In a twist of irony, these shepherds of AI will intuitively identify and substitute solutions to similar previously solved problems, the very problem with intuition in a complex environment. What is different is that they will see the structure of solved programming problems in the context of the military problem in front of them. They may recognize how the Minimax algorithm could apply to Course of Action Development, or how goal programming could help better understand and achieve asymmetry in movement and maneuver. They may find insight to decisions to exploit success or consolidate through the application of upper confidence bounds. The most advantageous concept of support may lie in solutions to the knapsack or traveling salesman problems. Intelligence fusion may best be accomplished with the logic that governs smart appliances. Such connections and leaps provide existing coding solutions to optimize performance in complex and adaptive systems, and will lead to solutions that exceed individual performance, as well as crystalize that knowledge for others. If military experts can

[2] Garry Kasparov, *Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins*. (New York, NY: PublicAffairs, 2017), 246.

express how they come to expert judgements, then a replication of expert judgement can be created for man-machine team, as computer programs do what they are programmed to do.

Throughout the research, it has become clear that the number of applicable connections couldn't be explored within the scope of this paper, nor the best models and calculations be determined with certainty. A compromise of effectiveness and simplicity was struck as a vehicle to convey the concept. If for example, it is believed that Bayesian inference would be more accurate than Laplace's Rule, then that better calculation can be easily substituted without changing the overall recommendation. With limitations in mind, it is not imperative that each algorithm produce an exact number. As in correlation of forces and means, what is important, is the relation between forces, regardless of whether it is measured in statute or metric. The pyramids were not built with modern engineering, but on good measure. Certainty will never be possible by machine, or human calculation, but good measure can be consistently reached. It is possible to ensure that it isn't a fair fight.

Understanding the inherent limitations of cognition and JPP in the current and future environment led to deeper insights about the underlying reasons that underpin military doctrine, heuristics, and aphorisms, which emerged from the calculations, the ability to animate them in space and time, and the emergence of connections. Kosko revealed a similar enlightenment that "science tracks math. Induction tracks deduction."[3] However, the present environment is one still skeptical of the possibilities, through an over estimation of human cognition competence and equal ignorance of artificial intelligence, written off as something too complex to wield, too far off, or too sci-fi.

We find ourselves in a similar situation as the focus of an Isaac Asimov short story, *The*

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[3] Kosko, *Fuzzy Thinking*, 276.

Feeling of Power. In the story, a technician in the future inductively reasons out basic mathematics, a long-forgotten skill, from the answers produced by his pocket computer. Their discovery changes the relationship of man to machine after they demystify computers and are able to understand where the calculations come from. In the future operating environment, we will need the power of computers, but also the power of wielding them, and understanding the origin of their answers, knowing it is doing what the operator programmed it to do. We will "have in our hands a method for going beyond the computed, leapfrogging it, passing through it. We will combine the mechanics of computation with human thought; we will have the equivalent of intelligent computers, billions of them. I can't predict what the consequences will be in detail, but they will be incalculable."[4]

[4] Isaac Asimov, "The Feeling of Power", if, February 1958, 4. https://archive.org/details/TheFeelingOfPower/The%20Feeling%20of%20Power.

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