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<b>14. ABSTRACT</b> Command and Control Artificial Intelligence: AI-supported operational planning in the maritime domain.  The rising capabilities of artificial intelligence (AI) are relieving the cognitive burden on humans in diverse fields such as medicine, business, and gaming, freeing those people to focus on analysis, strategy, and refinement. Such an AI would be particularly useful in the maritime domain given the inherently mechanical nature of naval operations. The US Navy should use the same concept—use AI to augment its human commanders and staffs to reduce the cognitive burden during operational planning. This would free the human commanders and staffs to consider appropriate objectives, the acceptable level of risk, and assess the efficacy of their operations. To be effective, this AI would need the following characteristics: <u>explainability, adherence to human norms, and functionality in an unstructured environment.</u> 4419 words.					
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**NAVAL WAR COLLEGE  
Newport, R.I.**

**Command and Control Artificial Intelligence:  
AI-supported operational planning in the maritime domain**

**A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Maritime Advanced Warfighting School.**

**The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.**

**21 APR 2023**

## Introduction

Military robots are no longer just for “dirty, dull, or dangerous” tasks. Often, military research into artificial intelligence (AI) centers on development of autonomous systems—a self-driving truck, a device to find road-side bombs, or an unmanned aerial vehicle that can identify and engage a target with minimal human interaction. The intent of such systems was to keep humans safe from dangerous environments so those humans could focus on the cognitive tasks in warfare. Research and testing of these autonomous systems showed that they are often best employed when they are paired with human operators. Machines have strengths and weaknesses, just as humans do, and are best used when their strengths make up for human weakness and vice versa.

While military robots have thus far reduced the physical load to humans, research shows robots, in the form of AI, can take on much of the cognitive burden as well. OpenAI’s release of ChatGPT in November 2022<sup>1</sup> demonstrated the utility of introducing AI into areas that were seemingly impervious to computer aid.<sup>2</sup> Suddenly, a machine could relieve some of the cognitive load from doctors, businessmen, writers, etc. so those humans could focus on analysis, strategy, and refinement.

The US Navy should apply that same approach to support commanders at the operational level of war in the maritime domain—a sort of ChatGPT for operational planning. Such a command and control AI (C2AI), with a heavy reliance on human-AI pairing, would support commanders and staffs by developing courses of action that balance the operational factors of

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<sup>1</sup> Funmi Looi Somoye, “Who created Chat GPT—and who owns OpenAI?” PC Guide, March 29, 2023, <https://www.pcguides.com/apps/who-created-chat-gpt/>

<sup>2</sup> Ray Kurzweil, *The Singularity is Near* (New York: Penguin Group, 2005), 290.

time, space, and force. This would free the human commanders and staffs to consider appropriate objectives, the acceptable level of risk, and assess the efficacy of their operations. To improve the command and control in the maritime domain at the operational level of war, human naval commanders should use C2AI to build their plans. For the greatest effect, this AI should augment the commander's operational idea and be explainable, adhere to human norms, and function in an unstructured environment.

### AI and the Maritime Domain

C2 in the maritime domain is well-suited for augmentation from AI since naval combat is dependent on mechanical processes, is less susceptible to the effects of terrain, and involves relatively few maneuvering units. A naval force identifies and tracks enemy targets and then delivers ordnance through mechanical/computer systems, not individual human skills like the firing of a rifle.<sup>3</sup> Other than the final decision to execute the strike, the entire process is automated.<sup>4</sup> Additionally, given the distances and anonymity involved, there is less human psychological resistance to engaging the enemy naval forces.<sup>5</sup> Next, a naval force is less susceptible to the effects of terrain. In the land domain, an AI would have to map and model every piece of terrain, cover, and concealment in real time to develop a solution. These variables are limited to weather, sea state, and current in the maritime domain. Finally, the precise position of all ships, aircraft, and missiles are readily tracked and disseminated to friendly forces. Therefore, in many ways, developing a course of action in the maritime domain is akin to solving

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<sup>3</sup> Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: W.W. Norton & Company, Inc., 2018), 163.

<sup>4</sup> Paul Scharre, *Four Battlegrounds: Power in the Age of Artificial Intelligence* (New York: W.W. Norton & Company, Inc., 2023), 263.

<sup>5</sup> Dave Grossman, *On Killing: The Psychological Cost of Learning to Kill in War and Society* (New York: Back Bay books / Little, Brown, and Company 1995) 98.

an engineering problem and can be aided by what is effectively a high-powered calculator in the form of AI.

Naval combat's dependency on mechanical processes makes it easier to model naval engagements, producing results that are closer to expected real-world outcomes, so there is greater utility in the incorporation of AI into these models. Unlike in the land domain, in which adversaries may fire millions of rounds over the course of a single engagement, adversaries plan exchanges in naval combat to the individual missile since a single hit has the potential to put a ship out of action. Using Wayne Hughes' salvo equations as a model for planning, a naval commander can use force and counterforce to determine how to arrange a fleet and sequence an attack. In one of Hughes' examples, he demonstrates how a fleet can cut its losses in half by attacking with a portion of its fleet instead of all its ships at once.<sup>6</sup> This calculation requires no sophisticated software, just basic arithmetic. However, expanding the analysis to scouting, deception, weapon range, and multi-domain assets "more thoroughly demands... a more complicated analytical form."<sup>7</sup> Balancing the operational factors of time, space, and force for a fleet comprising different classes of ships with different armaments and sensors involves enough variables to quickly reach the limits of human cognition. Balancing and optimizing these variables is best left to AI.

AI is also particularly well-suited to the maritime domain because so much of naval operations occurs in the global commons. Adversaries take actions every day to hide illegal

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<sup>6</sup> Wayne Hughes, *Fleet Tactics and Naval Operations, Third Edition* (Annapolis: Naval Institute Press, 2018) 279.

<sup>7</sup> *Ibid.*, 279.

fishing<sup>8</sup>, smuggling, and movement of military assets.<sup>9</sup> How can a naval commander know which of the hundreds of ships daily transiting the Straits of Malacca<sup>10</sup> to search? Parsing the manifests of all container ships to find a single container holding contraband destined for an adversary's port or making sense of automatic identification system (AIS) data to determine which ships are engaged in illegal, unreported, unregulated (IUU) fishing requires data analysis that humans alone cannot perform quickly or efficiently. AI can identify the patterns hidden in the reams of data and direct naval commanders to the appropriate target.

C2AI will be key to helping naval commanders more quickly understand the battlespace, develop executable courses of action, and make critical decisions. AI's utility is not limited to the models governing the exchange of missile salvos—it could build an entire COA in which it arrays forces with respect to time, space, and purpose.<sup>11</sup> To develop a course of action, AI should first compile a range of key inputs—sensor data, AIS data from commerce shipping, cargo manifests, weather forecasts, weapon system specifications, etc.—to develop the joint intelligence preparation of the operating environment with the human N2. Then it should consider human inputs from problem framing and mission analysis and develop a concept of operations with the staff. Finally, C2AI and the staff present multiple courses of action to the

<sup>8</sup> John Grady, "Coast Guard: Illegal Fishing Has Surpassed Piracy as a Global Threat," *USNI News*, January 19, 2023, [https://news.usni.org/2023/01/19/coast-guard-illegal-fishing-has-surpassed-piracy-as-a-global-threat?ct=\(USNI\\_NEWS\\_DAILY\)&mc\\_cid=b4f8a408f0&mc\\_eid=bf469e92d8](https://news.usni.org/2023/01/19/coast-guard-illegal-fishing-has-surpassed-piracy-as-a-global-threat?ct=(USNI_NEWS_DAILY)&mc_cid=b4f8a408f0&mc_eid=bf469e92d8)

<sup>9</sup> Gabriele Steinhauser and Benoit Faucon, "Russia Ship's Secretive South Africa Stop Prompts U.S. Questions," *The Wall Street Journal*, January 9, 2023, <https://www.wsj.com/articles/russian-ships-secretive-south-africa-stop-prompts-u-s-questions-11673265353>

<sup>10</sup> Malacca Straits, Dryad Global, accessed April 18, 2023, <https://dg.dryadglobal.com/south-east-asia-straits-of-malacca#:~:text=Over%2070%2C000%20ships%20pass%20through%20the%20straits%20annually.>

<sup>11</sup> Stephanie Rosenthal and Laura M. Hiatt, "Human-Centered Decision Support for Agenda Scheduling" In Proc. of the 19th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2020), Auckland, New Zealand, May 9–13, 2020, IFAAMAS

commander.<sup>12</sup> Just as with AI systems like ChatGPT, this should be an iterative process in which the human planners tell the AI what aspects of the COAs to modify. In the end, the human commander should have an AI-generated course of action that balances time, space, and force in a greater level of detail and in a faster time than the commander's human staff could produce on its own.

### AI-Human Teaming

A popular perception of AI is one of total autonomy in which the AI thinks, decides, and acts on its own. In reality, researchers are finding that AI is most effective in a symbiotic relationship with a human user. AI, in general and C2AI specifically, is a tool that supports human cognition and decision-making.

C2AI is not meant to replace a human commander or human staffs. One AI researcher summarizes the relationship between humans and AI in this way: "it is more meaningful to view AI as a tool for augmentation (extending human's capabilities) rather than automation (replacing them)."<sup>13</sup> AI can process vastly more data than a human, identify patterns, and consider more variables, all without becoming emotional or fatigued. For example, experiments in which AI competes against professional players of multiple types of games, from chess to strategy computer games, reveal several key advantages AI holds over humans: increased speed and scale of information processing, multitasking, precision, coordination, and long-term planning.<sup>14</sup> But it was not without its weaknesses. AI often struggled in novel situations or when events could be

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<sup>12</sup> Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York: Hachette Books, 2020), 112.

<sup>13</sup> Jarrahi, Mohammad Hossein. "Artificial Intelligence and the Future of Work: Human-AI Symbiosis in Organizational Decision Making." *Business Horizons* 61, no. 4 (2018): 577–86. <https://doi.org/10.1016/j.bushor.2018.03.007>.

<sup>14</sup> Scharre, *Four Battlegrounds*, 269.

interpreted in multiple ways.<sup>15</sup> This is why there is utility in pairing AI with humans. Human understanding of context can support the AI in situations with high levels of uncertainty or equivocality.<sup>16</sup> In this way, AI should be considered as a tool like a screwdriver—the tool can complete actions that human physiology cannot, but the human must know how and when to use it. Paired together, complementing the other’s strength while mitigating the weaknesses, humans and AI can achieve more meaningful results.<sup>17</sup>

The pairing of a human commander with C2AI must be a “human-in-the-loop” system so that the human commander has final say in operational decisions. Designers of autonomous systems must consider whether the human acts as essential operator, failsafe, and/or moral agent.<sup>18</sup> With C2AI, the human will act as all three: any C2AI COA must be selected and implemented by the human (essential operator) and the human will make the judgment if the COA is suitable (failsafe) and acceptable (moral agent).

Alternative systems—human “on-the-loop” or human “out-of-the-loop”—rely more on the AI than on the human interaction. An “on-the-loop” system is one in which the human is not the essential operator but can act as a failsafe. This is suitable when events happen too fast for humans to control and requires “supervised autonomy,” e.g. a missile defense system that will fire automatically unless a human tells it not to fire.<sup>19</sup> An “out-of-the-loop” system is most suitable in communications-degraded environments in which direct control of the system by a human is impossible, such as an unmanned aerial vehicle navigating to its destination when

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<sup>15</sup> Ibid. 272.

<sup>16</sup> Jarrahi, “*The Future of Work*”

<sup>17</sup> Clive Thompson “AI Shouldn’t Compete With Workers—It Should Supercharge Them,” *WIRED*, October 13, 2022, <https://www.wired.com/story/ai-shouldnt-compete-with-workers-it-should-supercharge-them-turing-trap/>

<sup>18</sup> Scharre, *Army of None*, 322.

<sup>19</sup> Ibid., 326.

something severs the control link.<sup>20</sup> In this case, the human is neither the essential operator nor failsafe, and the human's moral agency is limited to the design of the system well before implementation. While it is necessary for the navy to have a combination of systems that are "on-the-loop" and "out-of-the-loop," only an "in-the-loop" design is appropriate for C2AI because it allows for the human to be the essential operator, failsafe, and moral agent.

An "in-the-loop" system enables the best synergy of the strengths of the human and the AI. After his famous 1997 loss to the chess-playing AI Deep Blue, chess grandmaster Gary Kasparov heralded a new age of chess that he called "centaur chess," in which AI would provide in-game advice to its supported human player.<sup>21</sup> But if the AI was smart enough to defeat the best chess player in the world, what could the human possibly provide the AI? The answer is context. AI is susceptible to misinterpreting the environment and a human can redirect the AI when this happens.<sup>22</sup> AI can iterate thousands of possible moves with thousands of variables in a way that a human brain cannot, but this computation takes time. A human who recognizes the context of the situation can direct the AI to analyze a certain category of moves to speed the process along and then quickly distinguish between the multiple options the AI suggests.<sup>23</sup>

Evidence of the benefits of this teaming also appear in AI-augmented cancer diagnosis. Whereas AI trained to find tumors in scans can process thousands of images of similar scans in a way that humans cannot, the human doctor can understand the context of the patient's medical

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<sup>20</sup> Ibid., 329.

<sup>21</sup> Mike Cassidy, "Centaur Chess Shows Power of Teaming Human and Machine," Huffpost, December 6, 2017, [https://www.huffpost.com/entry/centaur-chess-shows-power\\_b\\_6383606](https://www.huffpost.com/entry/centaur-chess-shows-power_b_6383606)

<sup>22</sup> Bradley Martin et al., *Advancing Autonomous Systems: An Analysis of Current and Future Technology for Unmanned Maritime Vehicles* (Santa Monica: RAND Corporation 2019) e-book

<sup>23</sup> Tyler Cowen, "What are humans still good for? The turning point in Freestyle chess may be approaching," *Marginal Revolution*, November 5, 2013, <https://marginalrevolution.com/marginalrevolution/2013/11/what-are-humans-still-good-for-the-turning-point-in-freestyle-chess-may-be-approaching.html>

history, the variables that affect how lab techs took the scan, and other medical conditions that produce similar symptoms. When presented with radiological scans, the error rates for human doctors and AI diagnosing alone were 3.5 percent and 7.5 percent, respectively. When the AI analyzed the image first and then made a recommendation to the human doctor, the human/AI team's error rate fell to 0.5 percent.<sup>24</sup>

When applied to naval warfare, the AI can optimize the positioning of assets to maximize the effects of scouting, anti-scouting, firepower, and counterforce, while the human commander can optimize the plan through the selection of objectives, limitations, and the desired end-state of the operation. The combination of the computational power of the AI with the content-derived intuition of the human is the reason why C2AI must be an "in-the-loop" system.

### Characteristics of C2AI

To support the decision making of naval commanders, C2AI should be operable in an unstructured environment, explainable to the human user, and conformable to human norms, with an understanding of when to break them. These three characteristics will ensure that C2AI provides utility to the commander in the chaos and uncertainty of war.

C2AI must be able to operate in the unstructured, uncertain environment that is part of the unchangeable nature of war. Despite impressive AI victories over chess grandmasters<sup>25</sup> and 9p go champions<sup>26</sup>, these mediums offer a poor analogy of war. According to game theory, chess and go, while complex, are still games of perfect information since the players know what moves are possible, the exact moves the opponent already made, and the conditions for victory.

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<sup>24</sup> Jarrahi, "The Future of Work," 579.

<sup>25</sup> Cassidy, "Centaur Chess Show Power of Teaming Humans and Machine"

<sup>26</sup> Greg Kohs, *AlphaGo*, Deep Mind Technologies Limited 2017

However, war is defined not only by its complexity, but also by uncertainty.<sup>27</sup> Therefore, game theory would define war as a game of incomplete information. In these games, players may have no knowledge of payoffs, the identity of other players, what moves are possible, how actions and outcomes are linked, and what the opponent(s) know or don't know.<sup>28</sup>

The limited and ever-changing information available for an environment and enemy makes accruing the data which C2AI requires to develop a solution a seemingly impossible task. Since war is a game of incomplete information, it is impossible for either a human, AI, or human-AI team to determine with certainty what the enemy will do next. But the world is inherently probabilistic. Therefore, C2AI must use "predictive analytics" to mitigate uncertainty and advise the human based on the probability of an event occurring.<sup>29</sup> Just as the best human planners can hope to develop the enemy's most *likely* course of action, so too will C2AI with predictive analytics. By using probability and data-driven statistical inference,<sup>30</sup> C2AI can present the most likely scenario for the human's consideration.

In a way, C2AI can operate in uncertainty by treating the enemy like the weather. Weather patterns are classically chaotic systems that defy precise analysis due to their complex nature (meaning that tiny changes to initial conditions may result in vast changes to outcomes). To overcome this, meteorologists train their AI systems on heuristics, or rules-of-thumb, which rely on decision rules that are "usually qualitative rather than quantitative."<sup>31</sup> The human operators fully recognize that a heuristic model is "not guaranteed to result in a correct solution

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<sup>27</sup> United States Marine Corps, *Warfighting* (Quantico: Headquarters Marine Corps, 1997) 73

<sup>28</sup> Jonathan Levin, "Games of Incomplete Information," Stanford University, February 2002, <https://web.stanford.edu/~jdlevin/Econ%20203/Bayesian.pdf>

<sup>29</sup> Jarrahi, "*The Future of Work*," 580.

<sup>30</sup> *Ibid.*, 580.

<sup>31</sup> Robert G Hoffman et al., *Minding the Weather*, (Cambridge: The MIT Press, 2017), 289.

or inference but often does work satisfactorily.”<sup>32</sup> It is unlikely that computer models will ever be powerful enough to fully predict a weather system’s behavior, but the AI has become an indispensable tool for the meteorologist.<sup>33</sup> With these models, meteorological AI “outputs are useful and, some would say, necessary input for the forecaster’s process of forming a mental model and generating a sensible forecast.”<sup>34</sup> Uncertainty will never go away completely, but the C2AI must be able to use available information to derive probabilistic solutions and then rely on the human’s intuition to make a best choice regarding them.

To enable the naval commander to make that choice, C2AI must present its proposed solutions in an understandable and explainable way. In its tournament against a 9p go champion, the go playing AI AlphaGo played a move that confounded the analysis of go experts. AlphaGo’s engineers could determine that only one in ten thousand human players would have made the same move but had no means of explaining how AlphaGo’s logic arrived at that move.<sup>35</sup> If this were to happen with C2AI, a human commander could dismiss a potentially decisive action as an error because the AI could not explain why it made that suggestion. While autonomy in analysis is a goal of C2AI, the second component of optimized human-AI interaction is the “manner in which information is exchanged between the human and the robot.”<sup>36</sup> While it is unnecessary for the human using C2AI to understand what is occurring at a programming level, C2AI must be able to explain all aspects of its proposed solution in plain

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<sup>32</sup> Ibid., 289.

<sup>33</sup> Ibid., 335.

<sup>34</sup> Ibid., 333.

<sup>35</sup> Kohs, *AlphaGo*.

<sup>36</sup> Michael A. Goodrich and Alan C. Schultz, “Human-Robot Interaction: A Survey,” *Foundation and Trends in Human-Computer Interaction* vol. 1, no 3 (2007), 221

language.<sup>37</sup> A human user should receive an explanation from C2AI that revises that user's mental model which in turn improves the task performance.<sup>38</sup>

Multiple studies into human-AI teaming found that the type of interaction between the AI and the human played as great of a role in the outcome as the capabilities of the AI. A well-designed interface improves “the interaction time required for intent and/or instructions to be communicated to the robot, the cognitive or mental workload of an interaction, the amount of situation awareness produced by the interaction (or reduced because of interruptions from the robot), and the amount of shared understanding or common ground between humans and robots.”<sup>39</sup> Just as clear communication is necessary for the interaction between humans, so it is for the interaction between humans and AI.

The final characteristic of C2AI is that it must adhere to norms and know when it is permissible to deviate from them. Examples of these norms are proper weapon-to-target match, respect for the physical limitations of human servicemembers, use of doctrinal language, and accounting for logistics. Unconstrained AI can often result in “alien” outcomes<sup>40</sup> that may satisfy a requirement but do so in an unacceptable way.<sup>41</sup> In one infamous example, a program called Eurisko overwhelmed all competitors in a computer-based naval war game by developing a strategy that was simultaneously adherent to the ruleset and “socially horrifying.”<sup>42</sup> The solution

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<sup>37</sup> For example, the AI could explain that by positioning a DDG inside the threat ring of enemy land-based strike aircraft to fire a TLAM, the DDG can sail at 30kt out of the combat radius of counter-attacking enemy jets before those jets are scrambled and reach the DDG's firing position.

<sup>38</sup> Gunning, David, and David W Aha. “DARPA's Explainable Artificial Intelligence (XAI) Program.” *The AI Magazine* 40, no. 2 (2019): 44–58. <https://doi.org/10.1609/aimag.v40i2.2850>.

<sup>39</sup> Goodrich and Schultz, “*Human-Robot Interaction: A Survey*,” 221.

<sup>40</sup> Scharre, *Four Battlegrounds*, 266.

<sup>41</sup> The discussion of the ethics of fully autonomous systems or the ethics of AI is beyond the scope of this paper.

<sup>42</sup> Malcom Gladwell, “How David Beats Goliath,” *The New Yorker*, May 11, 2009, <https://www.newyorker.com/magazine/2009/05/11/how-david-beats-goliath>

produced by Eurisko was novel, but it was also completely unrealistic if applied to the real world. Therefore, C2AI must understand three important categories: prescriptions, prohibitions, and permissions.<sup>43</sup> Put another way, C2AI must take the human user's inputs of objectives, limitations, and rules of engagement to produce COAs that are acceptable and suitable in addition to feasible, distinguishable, and complete. AI will not understand the value of human life or the costs of reconstituting combat power unless humans explicitly train it to consider these components. But trying to program all human norms into an AI will "quickly lead to a computational explosion,"<sup>44</sup> so again there is an imperative for a human "in-the-loop" system. By adhering to basic professional norms, C2AI can create COAs that are suitable and acceptable to the human commander.

However, there are times in which human users will find breaks with norms to be advantageous. The "alien" playstyle of an AI, if it is still acceptable and suitable, can present the enemy with unexpected problems and force them into a "rapidly deteriorating situation with which they cannot cope."<sup>45</sup> The unexpected move played by AlphaGo (described above) so unnerved its human opponent that he had to call a recess and walk away from the table to calm down.<sup>46</sup> In tests against professional players of the computer game *Starcraft II*, the AI overwhelmed the cognitive capacity of its human opponents by quickly pivoting between extremely aggressive and conservative play.<sup>47</sup> During the Alpha Dogfight exhibition, the AI-controlled fighter jet defeated its human opponents with tactics the humans thought to be

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<sup>43</sup> Bertram F. Malle, Paul Bello, and Matthias Scheutz. 2019. Requirements for an Artificial Agent with Norm Competence. In Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society (AIES '19). Association for Computing Machinery, New York, NY, USA, 21–27. <https://doi.org/10.1145/3306618.3314252>

<sup>44</sup> *Ibid.*, 23.

<sup>45</sup> US Marine Corps, *Warfighting*, 73.

<sup>46</sup> Kohs, *AlphaGo*.

<sup>47</sup> Scharre, *Four Battlegrounds*, 271.

impossible and against which they were unprepared to defend.<sup>48 49</sup> The AI was not consciously or unconsciously constrained by past experiences or by professional and cultural norms but instead approached each situation anew. The point to take from these examples is that AI created a decisive advantage by deviating from the accepted or understood norms. As the old joke goes: “professional soldiers are predictable, but the world is full of amateurs.” In this way, C2AI can break from norms to find or create advantages that are bold, unexpected, and difficult for the enemy to counter.

### Counterarguments and rebuttals

Some may argue that the use of C2AI for naval warfare is untenable because the AI is highly vulnerable to enemy interference. No amount of AI can solve an operational problem without accurate data on the location and disposition of enemy vessels. To gather the necessary information on the enemy, the navy would have to rely on a vast array of manned and unmanned sensors. A vulnerability in these sensors emerges due to “edge computing”—the equipment comes loaded with the necessary software to complete its tasks even if the enemy or environment severs its control link. The routine loss or capture by the enemy of this reconnaissance equipment (e.g., unmanned aerial vehicles) in future conflicts will provide the adversary with access to the

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<sup>48</sup> Scharre, *Four Battlefields*, 266.

<sup>49</sup> “Alpha Dogfight Trials Foreshadow Future of Human-Machine Symbiosis,” *DARPA*, October 26, 2020, <https://www.darpa.mil/news-events/2020-08-26>

network on which the AI “lives.”<sup>50 51</sup> In this way, it is unlikely that the navy will be able to prevent the enemy from directly influencing C2AI.

The data set on which the AI relies is also vulnerable. Creation of AI datasets are laborious endeavors, which are often subcontracted to third parties of which there are no established security best practices.<sup>52</sup> Through “data-poisoning” attacks, adversaries can potentially corrupt the deep learning datasets AI requires to function. One AI researcher assessed that poisoning as little as 0.01 percent of deep learning datasets is enough to adversely affect models.<sup>53</sup> If the dataset on which C2AI is founded is already small due to the availability of enemy data, it will only take a minimal enemy incursion to negatively affect the entire AI.

However, access to data is becoming increasingly easy in the modern world and C2AI should be able to tap into the open-source internet-of-things. The efforts of the Navy’s Task Force 59 are necessary to find information on enemy capabilities but are equally important to harness the ubiquitous coverage of the ocean by satellites. Using open-source information, it is already possible to locate and track warships at sea.<sup>54</sup> Furthermore, it is in the interest of every sea-going nation to collect environment information on the ocean. For example, the private company Saildrone is developing and deploying unmanned sailing vessels to collect “metocean

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<sup>50</sup> Marcus Comiter, “Attacking Artificial Intelligence: AI’s Security Vulnerability and What Policymakers Can Do About It,” Harvard Kennedy School Belfer Center for Science and International Affairs, August 2019, <https://www.belfercenter.org/publication/AttackingAI>

<sup>51</sup> Brandi Vincent, “Navy’s Task Force 59 reaches full operational capability as it works to build a ‘digital ocean’ of connected assets,” *DEFENSECOOP*, January 10, 2023, <https://defensescoop.com/2023/01/10/navys-task-force-59-reaches-full-operational-capability-as-it-works-to-build-a-digital-ocean-of-connected-assets/>

<sup>52</sup> Comiter, “Attacking Artificial Intelligence”

<sup>53</sup> Danny Palmer, “The Next Big Threat to AI May Already be Lurking on the Web,” *znet*, March 2, 2023, <https://www.zdnet.com/article/the-next-big-threat-to-ai-might-already-be-lurking-on-the-web/>

<sup>54</sup> H I Sutton, “Satellites Track Chinese Aircraft Carrier at Sea,” *Forbes*, April 23, 2020, <https://www.forbes.com/sites/hisutton/2020/04/23/satellites-track-chinese-aircraft-carrier-in-south-china-sea/?sh=d26303b2f075>

data” on current sea conditions.<sup>55</sup> Using privatized information sources is not new for the intelligence community, but an advantage is that AI can compile and sort all the data much faster than an entire trained section of intelligence servicemembers. Additionally, the vulnerabilities to the data sources are a known vulnerability and DARPA is working towards a solution that works “at scale” as more AI-powered systems become operational.<sup>56 57</sup> As new systems become available their critical vulnerabilities become exposed, and, as always, friendly forces take actions to protect those vulnerabilities.

If the first argument against C2AI focuses on the technical aspects of AI, the second focuses on its cultural aspects: namely, one of trust. Despite recent advances in, and much media coverage of, large language models such as ChatGPT, those systems pale in comparison to the capabilities of the human brain. Users often report disappointing results when they use such AI to plan a travel itinerary<sup>58</sup>, draw a human hand<sup>59</sup>, or write a factually accurate report.<sup>60</sup> If current AI trained on massive datasets cannot match the performance of humans, then future AI needs the same capabilities of the human brain—it must be artificial general intelligence (AGI). However, many AI researchers argue that the development of AGI is impossible because human

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<sup>55</sup> “Ocean Data”, Saildrone, <https://www.saildrone.com/solutions/ocean-data>

<sup>56</sup> “AI Next Campaign,” DARPA, accessed April 18, 2023, <https://www.darpa.mil/work-with-us/ai-next-campaign>

<sup>57</sup> Bruce Draper, “Reverse Engineering of Deceptions (RED),” DARPA, accessed April 18, 2023, <https://www.darpa.mil/program/reverse-engineering-of-deceptions#:~:text=The%20Reverse%20Engineering%20of%20Deceptions,or%20other%20information%20deception%20attacks>.

<sup>58</sup> Jacob Passy, “Don’t trust an AI chatbot with all your travel plan just yet,” *The Wall Street Journal*, March 9, 2023, <https://www.wsj.com/articles/ai-chat-gpt-bing-travel-flights-hotels-b717148e>

<sup>59</sup> Phil Edwards, “Why AI art struggles with hands,” Vox, April 4, 2023, <https://www.youtube.com/watch?v=24yjRbBah3w>

<sup>60</sup> Kif Leswing, “Microsoft’s Bing A.I. Made Several factual errors in last week’s launch demo,” CNBC, February 14, 2023, <https://www.cnbc.com/2023/02/14/microsoft-bing-ai-made-several-errors-in-launch-demo-last-week.html#:~:text=Investing%20Club-,Microsoft's%20Bing%20A.I.,in%20last%20week's%20launch%20demo&text=In%20showing%20off%20its%20chatbot,numbers%20for%20Gap%20and%20Lululemon>.

knowledge is “tacit” and “therefore cannot be articulated and incorporated in a computer program.”<sup>61</sup> If AI can’t reliably perform basic tasks, why should commanders trust it in a situation that could determine the outcome of a war?

Even with recent advances, AI will never replicate the human brain’s capabilities for creativity and originality. The data sets used to train AI are not “in the world,” meaning that it is impossible to include all the interrelated and interdependent facts and experiences that shape a human brain.<sup>62</sup> It is by finding connections between these interrelated and interdependent facts that the human mind is able to create something new.<sup>63</sup> Therefore, a human commander with a well-trained staff may dismiss recommendations from AI because they, as humans, recognize that their collective training, experience, and understanding of other humans is greater than AI and so they “know better.” This is not just a matter of luddism—even “digital natives” experience cognitive overload when employing new technology in realistic training scenarios and fall back on their own knowledge and experiences.<sup>64</sup> Regardless of the advances in technology, war is still a human endeavor, and no amount of AI will replace the human mind’s role in it.

However, people accept new technology when exposure to it demonstrates its value. Pilots initially resisted automatic flight control, which forced engineers to devise a means for pilots to “trust and submit to machine autonomy in the appropriate circumstances.”<sup>65</sup> Those same

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<sup>61</sup> Fjelland, Ragnar. “Why General Artificial Intelligence Will Not Be Realized.” *Humanities & Social Sciences Communications* 7, no. 1 (2020): 1–9. <https://doi.org/10.1057/s41599-020-0494-4>.

<sup>62</sup> Ibid.

<sup>63</sup> John R. Boyd, “Destruction and Creation,” essay in *Boyd: The Fighter Pilot Who Changed the Art of War*, by Robert Coram (New York: Back Bay Books / Little, Brown, and Company, 2002) 451.

<sup>64</sup> Lionel Beehner and John Spencer, “Even Realistic Video Games Like Call Of Duty Won’t Help Us Win Wars,” *WIRED*, January 5, 2018, <https://www.wired.com/story/even-realistic-videogames-like-call-of-duty-wont-help-us-win-wars/>

<sup>65</sup> Timothy P. Schultz, *The Problem with Pilots* (Baltimore: John Hopkins University Press 2018) 179.

pilots were also aware of human physiological limitations in the cockpit and learned through exposure that instrumentation and automation could overcome those limitations. In time, they accepted the “erosion of their customary form of control and adopt[ed] new skills if they believed doing so would expand the aircraft’s capabilities and enhance their professional standing.”<sup>66</sup> Those same conditions will exist with C2AI and will be exposed through training and force-on-force exercises.<sup>67</sup> Revisiting Freestyle Chess from above, American grandmaster Hikaru Nakamura initially dismissed the notion of pairing human players with AI claiming his abilities are “better than [chess AI] six out of seven days of the weak.” However, he changed his opinion after losing to freestyle chess players with amateur chess ratings.<sup>68</sup> In another example, during simulated force-on-force testing of a C2AI-like software, researchers observed that the team augmented with AI succeeded 78 percent more often against the human-only team.<sup>69</sup> US servicemembers hate to lose. When exposure demonstrates that AI provides a decisive advantage, the same detractors of AI will adopt it or become irrelevant.

### Recommendations

Regardless of current performance issues, AI is now a part of everyone’s lives and should be integrated into C2 of the maritime domain. The US Navy should develop C2AI and field it to commanders who lead multiple maneuver units, e.g., destroyer squadron commanders, carrier strike group commanders, and fleet commanders. These commanders should in turn integrate C2AI into their staffs and conduct regular, detailed training with the system. Furthermore, the navy should integrate C2AI into professional military education at all levels to develop the

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<sup>66</sup> Shultz, *The Problem with Pilots*, 170.

<sup>67</sup> Brose, *The Kill Chain*, 125.

<sup>68</sup> Tyler Cowen, *Average is Over*, (New York: Dutton, 2013)

<sup>69</sup> Vlad Yagnis, “The Status of STILLMAN,” e-mail message to author, December 30, 2022

familiarity and trust of servicemembers in the system. Over time, the navy will expose C2AI to novel situations to evolve its capabilities. Just as a ship operating without radar is unthinkable today, so it will be with commanders and staffs planning operations without C2AI.

### Conclusion

C2AI does not make a human commander or human staff obsolete. Instead, it can enable them to be more effective, creative, and responsive. Naval combat's inherently mechanical processes are well-suited to AI analysis since it can integrate and evaluate many more variables than human planners can. As AI advances, the US Navy must integrate AI into the command and control of the maritime domain to facilitate rapid analysis and free up commanders to focus on critical decisions such as selecting operational objectives that support strategic objectives, considering the acceptable level of risk, and assessing the effects of the operations. This will require the navy to create AI that analyzes all aspects of the operating environment and provides clear, understandable, and actionable recommended courses of action to the commander.

## Bibliography

- “AI Next Campaign,” DARPA, accessed April 18, 2023, <https://www.darpa.mil/work-with-us/ai-next-campaign>
- “Alpha Dogfight Trials Foreshadow Future of Human-Machine Symbiosis,” *DARPA*, October 26, 2020, <https://www.darpa.mil/news-events/2020-08-26>
- “*Ocean Data*”, Saildrone, <https://www.saildrone.com/solutions/ocean-data>
- Beehner, Lionel and John Spencer, “Even Realistic Video Games Like Call Of Duty Won’t Help Us Win Wars,” *WIRED*, January 5, 2018, <https://www.wired.com/story/even-realistic-videogames-like-call-of-duty-wont-help-us-win-wars/>
- Boyd, John R. “Destruction and Creation,” essay in *Boyd: The Fighter Pilot Who Changed the Art of War*, by Robert Coram. New York: Back Bay Books / Little, Brown, and Company, 2002.
- Bradley Martin et al., *Advancing Autonomous Systems: An Analysis of Current and Future Technology for Unmanned Maritime Vehicles*. Santa Monica: RAND Corporation 2019 e-book
- Brose, Christian *The Kill Chain: Defending America in the Future of High-Tech Warfare*. New York: Hachette Books, 2020.
- Cassidy, Mike “Centaur Chess Shows Power of Teaming Human and Machine,” *Huffpost*, December 6, 2017, [https://www.huffpost.com/entry/centaur-chess-shows-power\\_b\\_6383606](https://www.huffpost.com/entry/centaur-chess-shows-power_b_6383606)
- Comiter, Marcus “Attacking Artificial Intelligence: AI’s Security Vulnerability and What Policymakers Can Do About It,” Harvard Kennedy School Belfer Center for Science and International Affairs, August 2019, <https://www.belfercenter.org/publication/AttackingAI>
- Cowen, Tyler “What are humans still good for? The turning point in Freestyle chess may be approaching,” *Marginal Revolution*, November 5, 2013, <https://marginalrevolution.com/marginalrevolution/2013/11/what-are-humans-still-good-for-the-turning-point-in-freestyle-chess-may-be-approaching.html>
- . *Average is Over*. New York: Dutton, 2013

- Draper, Bruce “Reverse Engineering of Deceptions (RED),” DARPA, accessed April 18, 2023, <https://www.darpa.mil/program/reverse-engineering-of-deceptions#:~:text=The%20Reverse%20Engineering%20of%20Deceptions,or%20other%20information%20deception%20attacks>
- Dryad Global, *Malacca Straits*, accessed April 18, 2023, <https://dg.dryadglobal.com/south-east-asia-straits-of-malacca#:~:text=Over%2070%2C000%20ships%20pass%20through%20the%20straits%20annually.>
- Edwards, Phil “Why AI art struggles with hands,” Vox, April 4, 2023, <https://www.youtube.com/watch?v=24yjRbBah3w>
- Gladwell, Malcom “How David Beats Goliath,” *The New Yorker*, May 11, 2009, <https://www.newyorker.com/magazine/2009/05/11/how-david-beats-goliath>
- Goodrich, Michael A. and Alan C. Schultz, “Human-Robot Interaction: A Survey,” *Foundation and Trends in Human-Computer Interaction* vol. 1, no 3 (2007), 221
- Grady, John “Coast Guard: Illegal Fishing Has Surpassed Piracy as a Global Threat,” *USNI News*, January 19, 2023, [https://news.usni.org/2023/01/19/coast-guard-illegal-fishing-has-surpassed-piracy-as-a-global-threat?ct=t\(USNI\\_NEWS\\_DAILY\)&mc\\_cid=b4f8a408f0&mc\\_eid=bf469e92d8](https://news.usni.org/2023/01/19/coast-guard-illegal-fishing-has-surpassed-piracy-as-a-global-threat?ct=t(USNI_NEWS_DAILY)&mc_cid=b4f8a408f0&mc_eid=bf469e92d8)
- Grossman, Dave *On Killing: The Psychological Cost of Learning to Kill in War and Society*. New York: Back Bay Books / Little, Brown, and Company, 1995.
- Gunning, David, and David W Aha. “DARPA’s Explainable Artificial Intelligence (XAI) Program.” *The AI Magazine* 40, no. 2 (2019): <https://doi.org/10.1609/aimag.v40i2.2850>
- Hughes, Wayne *Fleet Tactics and Naval Operations, Third Edition*. Annapolis: Naval Institute Press, 2018
- Jarrahi, Mohammad Hossein. “Artificial Intelligence and the Future of Work: Human-AI Symbiosis in Organizational Decision Making.” *Business Horizons* 61, no. 4 (2018): 577–86. <https://doi.org/10.1016/j.bushor.2018.03.007>.
- Kohs, Greg *AlphaGo*, Deep Mind Technologies Limited 2017.
- Kurzweil, Ray *The Singularity is Near* New York: Penguin Group, 2005.
- Lawless, W.F., Ranjeev Mittu, Donald Sofge, Laura Hiett “Artificial Intelligence, Autonomy,

and Human-machine Teams: Interdependence, Context, and Explainable AI” AI Magazine, Fall 2009

Leswing, Kif “Microsoft’s Bing A.I. Made Several factual errors in last week’s launch demo,” CNBC, February 14, 2023, <https://www.cnbc.com/2023/02/14/microsoft-bing-ai-made-several-errors-in-launch-demo-last-week-.html#:~:text=Investing%20Club-,Microsoft's%20Bing%20A.I.,in%20last%20week's%20launch%20demo&text=In%20sh,owing%20off%20its%20chatbot,numbers%20for%20Gap%20and%20Lululemon.>

Levin, Jonathan “Games of Incomplete Information,” Stanford University, February 2002, <https://web.stanford.edu/~jdlevin/Econ%20203/Bayesian.pdf>

Malle, Bertram F., Paul Bello, and Matthias Scheutz. 2019. Requirements for an Artificial Agent with Norm Competence. In Proceedings of the 2019 AAI/ACM Conference on AI, Ethics, and Society (AIES '19). Association for Computing Machinery, New York, NY, USA, 21–27. <https://doi.org/10.1145/3306618.3314252>

Metz, Cade “A Mystery AI Just Crushed the Best Human Players at Poker” WIRED, January 31, 2017, <https://www.wired.com/2017/01/mystery-ai-just-crushed-best-human-players-poker/>

Palmer, Danny “The Next Big Threat to AI May Already be Lurking on the Web,” zdnet, March 2, 2023, <https://www.zdnet.com/article/the-next-big-threat-to-ai-might-already-be-lurking-on-the-web/>

Passy, Jacob “Don’t trust an AI chatbot with all your travel plan just yet,” *The Wall Street Journal*, March 9, 2023, <https://www.wsj.com/articles/ai-chat-gpt-bing-travel-flights-hotels-b717148e>

Ragnar, Fjelland “Why General Artificial Intelligence Will Not Be Realized.” *Humanities & Social Sciences Communications* 7, no. 1 (2020): 1–9. <https://doi.org/10.1057/s41599-020-0494-4>.

Robert G Hoffman et al., *Minding the Weather*, (Cambridge: The MIT Press, 2017), 289

Rosenthal, Stephanie and Laura M. Hiatt, “Human-Centered Decision Support for Agenda Scheduling” In Proc. of the 19th International Conference on Autonomous Agents and

- Multiagent Systems (AAMAS 2020), Auckland, New Zealand, May 9–13, 2020, IFAAMAS
- Scharre, Paul *Army of None: Autonomous Weapons and the Future of War*. New York: W.W. Norton & Company, Inc., 2018.
- . *Four Battlegrounds: Power in the Age of Artificial Intelligence*. New York: W.W. Norton & Company, Inc., 2023.
- Schultz, Timothy P. *The Problem with Pilots*. Baltimore: John Hopkins University Press 2018.
- Singer, P. J. *Wired for War: The Robotics Revolution and Conflict in the 21<sup>st</sup> Century*. New York, Penguin Books, 2009.
- Somoye, Funmi Looi “Who created Chat GPT—and who owns OpenAI?” *PC Guide*, March 29, 2023, <https://www.pcguides.com/apps/who-created-chat-gpt/>
- Steinhauser, Gabriele and Benoit Faucon, “Russia Ship’s Secretive South Africa Stop Prompts U.S. Questions,” *The Wall Street Journal*, January 9, 2023, <https://www.wsj.com/articles/russian-ships-secretive-south-africa-stop-prompts-u-s-questions-11673265353>
- Sutton, H I “Satellites Track Chinese Aircraft Carrier at Sea,” *Forbes*, April 23, 2020, <https://www.forbes.com/sites/hisutton/2020/04/23/satellites-track-chinese-aircraft-carrier-in-south-china-sea/?sh=d26303b2f075>
- Thompson, Clive “AI Shouldn’t Compete With Workers—It Should Supercharge Them,” *WIRED*, October 13, 2022, <https://www.wired.com/story/ai-shouldnt-compete-with-workers-it-should-supercharge-them-turing-trap/>
- United States Marine Corps, *Warfighting* (Quantico: Headquarters Marine Corps, 1997)
- Vincent, Brandi “Navy’s Task Force 59 reaches full operational capability as it works to build a ‘digital ocean’ of connected assets,” *DEFENSECOOP*, January 10, 2023, <https://defensescoop.com/2023/01/10/navys-task-force-59-reaches-full-operational-capability-as-it-works-to-build-a-digital-ocean-of-connected-assets/>
- Yaknis, Vlad “The Status of STILLMAN,” e-mail message to author, December 30, 2022