

<b>REPORT DOCUMENTATION PAGE</b>			<i>Form Approved</i> <i>OMB No. 0704-0188</i>		
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<b>1. REPORT DATE (DD-MM-YYYY)</b> 22-04-2020		<b>2. REPORT TYPE</b> FINAL		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b> ARTIFICIAL INTELLIGENCE AT THE OPERATIONAL LEVEL OF WAR				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b>  LCDR Steven I. Davis, U.S. Navy  Paper Advisor: Professor Michael R. Croskrey				<b>5d. PROJECT NUMBER</b>	
				<b>5e. TASK NUMBER</b>	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)</b> Maritime Advanced Warfighting School Naval War College 686 Cushing Road Newport, RI 02841-1207				<b>8. PERFORMING ORGANIZATION REPORT</b> -----	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Distribution Statement A: Approved for public release; Distribution is unlimited. Reference: DOD Directive 5230.24					
<b>13. SUPPLEMENTARY NOTES</b> A paper submitted to the Naval War College faculty in partial satisfaction of the requirements of the Joint Military Operations Department. The contents of this paper reflect my own personal views and are not necessarily endorsed by the NWC or the Department of the Navy.					
<b>14. ABSTRACT</b> Artificial Intelligence at The Operational Level of War  Artificial intelligence (AI) is an emerging technology with widespread applications. The National Defense Strategy highlights the importance of AI to military operations for the United States to retain an advantage against its near peer competitors. To fully realize this advantage, it will be necessary to integrate AI not only at the tactical level, but also the operational level of war. AI can be integrated into the complex task of operational planning most efficiently by subdividing it into its component operational functions which can be processed by narrow AI. This organization reduces problems to a size which can be parsed by an AI and maintains human oversight over machine supported decision-making.					
<b>15. SUBJECT TERMS</b> Special Operations Forces and General Purpose Forces, Artificial Intelligence, Command and Control					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b> Director, MAWS
<b>a. REPORT</b> UNCLASSIFIED	<b>b. ABSTRACT</b> UNCLASSIFIED	<b>c. THIS PAGE</b> UNCLASSIFIED			31

Standard Form 298 (Rev. 8-98)

**NAVAL WAR COLLEGE**

**Newport, R.I.**



**ARTIFICIAL INTELLIGENCE AT THE OPERATIONAL LEVEL OF WAR**

**By**

**Steven I. Davis**

**Lieutenant Commander, United States Navy**

**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.**

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## **Abstract**

### *Artificial Intelligence at the Operational Level of War*

Artificial intelligence (AI) is an emerging technology with widespread applications. The National Defense Strategy highlights the importance of AI to military operations for the United States to retain an advantage against its near-peer competitors. To fully realize this advantage, it will be necessary to integrate AI not only at the tactical level but also at the operational level of war. AI can be integrated into the complex task of operational planning most efficiently by subdividing it into its component operational functions, which can be processed by narrow AI. This organization reduces problems to a size that can be parsed by an AI and maintains human oversight over machine supported decision-making.

## Introduction

AI is an emerging, transformative set of tools with the potential to aid military decision-makers. Our national strategy depends on incorporating artificial intelligence (AI) into warfare. The 2020 National Defense Authorization Act mentions AI 11 times.<sup>1</sup> The National Defense Strategy highlights the importance of capitalizing on commercial breakthroughs in AI and machine learning.<sup>2</sup> Military use of AI is a compelling way to retain national security. The creation of tools to support tactical actions, such as destroying enemy forces and navigating from one point to another have significant and visible effects that make them politically palatable in a resource-constrained environment. Their repeatability for training and testing purposes, make them quick wins for AI systems in the acquisition process. However, tactical actions are of limited scope and duration.<sup>3</sup> Integrating AI only at the tactical level ignores the decisive effects that take place at the operational level.

Operational warfare, the level where practitioners translate tactical actions into strategic effects, depends on the ability of leaders to make sound decisions. Joint Force Maritime Component Commanders (JFMCC) have the difficult task of constructing plans which will meld theater strategy and Joint Force Commander (JFC) objectives by shaping the environment through decisive naval engagements. A JFMCC aided by the rapid cognitive abilities of AI

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1. Adam Smith, “S.1790 - 116th Congress (2019-2020): National Defense Authorization Act for Fiscal Year 2020,” webpage, December 20, 2019, 2019/2020, <https://www.congress.gov/bill/116th-congress/senate-bill/1790>.

2. Jim Mattis, “Summary of the 2018 National Defense Strategy” (Washington DC: U.S. Department of Defense, 2018): 3, <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

3. *Universal Naval Task List (UNTL)*, OPNAVINST 3500.38B/MCO 3500.26A/USCG COMDTINST M3500.1B (Washington, DC: U.S. Department of the Navy, Chief of Naval Operations, 2007): 1-2, <https://www.secnav.navy.mil/doni/Directives/03000%20Naval%20Operations%20and%20Readiness/03-500%20Training%20and%20Readiness%20Services/3500.38B%20Chapter%201-2.pdf>.

would be able to develop and more thoroughly analyze courses of action (COA). These qualities will be necessary for future conflicts.

AI must be holistically integrated across the levels of war to realize its benefits fully. Beyond local, short-duration battles, it needs to be applied to major operations and campaigns, involving entire theaters of war for months or years. Implementation at the operational level of war amplifies the synergy between sequenced engagements and synchronized operations to achieve strategic objectives. Beyond technological development, operational incorporation will spur the creation of the policy and doctrine needed to create a willingness for warfighters to use AI. As experience using AI grows, its adoption will increase. The particular AI technologies implemented to assist naval operational planning may be distinct from those used to calculate a firing solution or plot a course through denied shoal waters. Still, acceptance at the operational level will drive use in the tactical.

At the JFMCC level, a network of AI systems would provide decision-makers a decisive advantage and aligning separate artificial narrow intelligence (ANI) units focused on operational functions would realize the most significant benefit. First, ANI solutions are more suited to military problem solving than their artificial general intelligence (AGI) counterparts. Second, the nature of war drives a necessity to integrate AI at the operational level. Finally, while there are many ways it could be integrated, doing so along functional lines gives the most significant benefit. Assimilating AI not only in a technological sense, but also describing its use in policy, doctrine, and training will allow the Navy to use it to full capacity and gain an advantage against our strategic competitors.

### **What is Artificial Intelligence to the Navy?**

AI is a monolithic term, describing distinct technologies and philosophies, many of which are not applicable to military. AI is a concept which over the past 70 years, and some of its implementations have the potential to improve naval decision making. History shows that the application of new technologies is a constant challenge, as well as an opportunity. For example, an international treaty in 1899 attempted to ban weaponized aircraft, but this did not stop their use in WWI. Instead, combatants found ways to combine with other combat arms, making them a necessary element of strategy in less than a year.<sup>4</sup> Like aerial warfare, AI presents too many advantages to prevent expanded use.

Our near-peer competitors will almost certainly integrate weaponized AI into their national strategies. China's State Council plans to be the world leader in AI by 2030 and leverage it for military use.<sup>5</sup> Vladimir Putin has stated that whoever controls AI will "rule the world."<sup>6</sup> Chinese naval researchers highlight integrating intelligent military technology into Battlespace Planning and Decision Making as a key area to improve naval combat.<sup>7</sup> With its current progression, in the next decade, AI will shift the balance of power through systems that autonomously acquire large amounts of data, learn from experience, and act on that information

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4. Greg Allen and Taniel Chan, "Artificial Intelligence and National Security," Belfer Center for Science and International Affairs, accessed April 16, 2020,<sup>3</sup>

<https://www.belfercenter.org/publication/artificial-intelligence-and-national-security>.

5. China State Council, Flora Sapio, and Weiming Chen, "New Generation of Artificial Intelligence Development Plan," State Council Document No. 35 § (2017): 5-6,

<https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf>.

6. Kelley Saylor, "Artificial Intelligence and National Security," CRS Report (Washington DC: Congressional Research Service, November 21, 2019): 1

<https://crsreports.congress.gov/product/details?prodcode=R45178>.

7. Qiu Zhiming et al., "Some Thoughts on the Application of Intelligent Military Technology in Naval Combat," trans. China Maritime Studies Institute, Center for Naval Warfare Studies, U.S. Naval War College, *Air & Space Defense* 1 (2019): 1-5.

in ways unexpected by human operators.<sup>8</sup> The nation which can more quickly and effectively harness AI across the spectrum of war will have an advantage. If the Navy fails to integrate AI, or does so too slowly, it will be at a competitive disadvantage in the maritime domain and during joint operations.

Like other dual-use technologies, such as jet engines, communications equipment, and nuclear reactors, as the capability of AI increases, so does its potential for lethal use. Scholars and practitioners continue to develop competing definitions to describe its boundaries. In 1955, early AI researchers defined its purpose as solving the "problem of making a machine behave in ways that would be called intelligence if a human were so behaving."<sup>9</sup> This definition broached the problem of decision making but unnecessarily limited AI by requiring it to resemble human thought processes. Sebastian Thrun, former Director of the Stanford AI Laboratory and winner of the DARPA Grand Challenge, defines AI only as the ability for a machine to "perceive something complex and make appropriate decisions."<sup>10</sup> A 2018 definition states AI can "identify and use the right piece of 'Knowledge' at a given step of solving a problem."<sup>11</sup> The change in these definitions shows a trend from trying to copy human thought to finding new methods of critical analysis. As AI moves beyond emulating human behavior, more military applications will become apparent. Increases in performance may allow the Navy to use AI to better ascertain

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8. Kareem Ayoub and Kenneth Payne, "Strategy in the Age of Artificial Intelligence," *Journal of Strategic Studies* 39, no. 5–6 (September 18, 2016): 793–819, <https://doi.org/10.1080/01402390.2015.1088838>.

9. John McCarthy et al., "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence: August 31, 1955," *AI Magazine* 27, no. 4 (Winter 2006): 12–14.

10. Peter Warren Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin Press, 2009): 77.

11. Amit Konar, *Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain* (CRC Press, 2018): Secs. 1-2.

and react to the operational environment, but a thinking machine thrust into an environment for which it was not designed can be just as bewildered as an untrained human.

Replicating human consciousness is costly and may not serve military needs. Idealized AGI is closest to what many people envision AI to be. It would display human-like consciousness and be capable of solving a broad set of tasks.<sup>12</sup> HAL in the movie *2001: A Space Odyssey*, matches this depiction, a thinking machine that receives and responds to natural language questions. The cost of this open-ended thinking is self-programming, or the ability for a system to write instructions for itself and solve tasks not initially intended by its developers. Creating a true AGI would require yet more layers of self-programming and theoretically meta-programming, the ability to redefine its fundamental principles of operation.<sup>13</sup> When developers broaden the scope of problems an AI must handle, this increases its level of complexity and unpredictability. AGI would be costly and unreliable in operational scenarios.

While the timeline for implementation of AGI always seems to be a decade away, other varieties of AI exist today and avoid AGI's complications. Government acquisition experts define ANI as one used to solve pre-defined tasks or provide limited scope expertise.<sup>14</sup> A definition of AI from the 2019 National Defense Authorization Act closely matches ANI: "A set

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12. Ben Goertzel, "Artificial General Intelligence: Concept, State of the Art, and Future Prospects," *Journal of Artificial General Intelligence*; Vienna 5, no. 1 (2014): 1–48, <http://dx.doi.org.usnwc.idm.oclc.org/10.2478/jagi-2014-0001>.

13. Kristinn R. Thórisson et al., "Editorial: Approaches and Assumptions of Self-Programming in Achieving Artificial General Intelligence," *Journal of Artificial General Intelligence*; Vienna 3, no. 3 (2012): 1, <http://dx.doi.org.usnwc.idm.oclc.org/10.2478/v10229-011-0017-1>.

14. "Artificial Intelligence: Emerging Opportunities, Challenges, and Implications for Policy and Research" (Washington, DC: U.S. Government Accountability Office, June 26, 2018): 2, <https://www.gao.gov/products/GAO-18-644T>.

of techniques, including machine learning, that is designed to approximate a cognitive task."<sup>15</sup> These definitions remove the need for AI to mimic humans, linking it solely to problem-solving.

ANI would excel at solving naval tasks over AGI. Removing the need to simulate consciousness frees resources for solving specific tasks. Like logic-controlled systems, ANI can operate in a specific domain without user intervention if given appropriate sensor data. ANI differs from logic-controlled systems in that they can modify their responses based on outcomes, rather than having reactions hard-coded by a programmer.<sup>16</sup> It does this through a set of techniques collectively called machine learning, which links inputs and outcomes to rewards.<sup>17</sup> So while designers may give ANI a small set of tasks, it will gradually improve its execution of them. Training an AI to perform general tasks with many criteria takes massive amounts of time and computational power. More specific tasks will generate faster improvement. Machine learning would allow the Navy to train AI to perform useful actions, like determining threat levels at sea and planning communications windows, but places limits on their complexity. ANI provides the speed, accuracy, and repeatability required for military tasks, provided designers set their boundaries appropriately.

### **Why Integrate Artificial Intelligence at the Operational Level of War?**

The speed of AI cognition brings an undeniable advantage to warfighting. AI can evaluate the outcome of a decision faster than a human. An AI tested against human fighter

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15. Mac Thornberry, "115th Congress (2017-2018): John S. McCain National Defense Authorization Act for Fiscal Year 2019," Pub. L. No. H.R. 5515, 1697 (2018), <https://www.congress.gov/bill/115th-congress/house-bill/5515/text>.

16. Christopher Paul et al., "Improving C2 and Situational Awareness for Operations in and Through the Information Environment" (RAND Corporation, November 1, 2018): 97-98, <http://search.proquest.com/docview/2139447592?pq-origsite=summon>.

17. Sean Gerrish, *How Smart Machines Think* (Cambridge, MA: MIT Press, 2018): 18.

pilots was able to control a simulated aircraft 250 times faster than its human counterparts. It could intrinsically counter firing solutions and transition between offensive and defensive actions easily.<sup>18</sup> When a pilot only needs to choose between speed, altitude, pitch, yaw, weapon selection, and the contributing factors equally limited, enemy relative bearing, velocity, and weapons loadout, an AI can easily exceed the ability of a human to observe, orientate, decide, and act. Errors corrected through feedback widen the advantage in each shortened cycle.<sup>19</sup> Within each repetition of the decision cycle, a contender assisted by AI moves into a slightly better position than her competition, bringing her inevitably closer to victory. However, AI's benefits extend beyond encounters between individual units.

AI would allow decision-makers to investigate more solutions to complex operational problems and look more profoundly into the effects of these solutions. The operational level of war consists of campaigns, each designed to achieve one of the theater strategic objectives nested under the national objective assigned to a combatant commander.<sup>20</sup> A JFMCC bridges tactical actions distributed throughout time and space to meet theater objectives using detailed planning. To meet the challenge of planning distributed maritime operations in a joint environment, the CNO's Design for Maritime Superiority states a requirement for AI-powered analytic decision

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18. "Artificial Intelligence; New Artificial Intelligence Beats Tactical Experts in Combat Simulation," *Defense & Aerospace Week*, July 13, 2016, <https://search-proquest-com.usnwc.idm.oclc.org/docview/2114666465/fulltext/7DE340F07E3E47ADPQ/1?accountid=322>.

19. Robert Szeligowski, "Cognifying the OODA Loop: Improved Maritime Decision Making" (Newport, RI, Naval War College, 2018): 27, <https://apps.dtic.mil/dtic/tr/fulltext/u2/1057893.pdf>.

20. Milan N Vego, *Joint Operational Warfare: Theory and Practice* (Newport, R.I.: Naval War College, 2009): II-18.

support tools from the unit to the fleet level.<sup>21</sup> This requirement recognizes that to remain competitive, future methods for solving the complex problem of sequencing the tactical actions of a joint force in a multipolar environment will require more than human ingenuity. A JFMCC equipped with AI to assist in the decision-making process will generate a strategic advantage by creating increased continuity between battles and engagements.

Operational decision-making is more complex and can have a more significant impact than tactical decisions. The nature of war amplifies the effects of campaigns where "armies have been destroyed by strategic operations without the occurrence of pitched battles."<sup>22</sup> The limited impact of battles causes their outcomes to be potentially recoverable, where defeat at the operational level can lead to loss of a war. Planning for campaigns and major operations requires the ability to anticipate over long periods and comprehend intangible objectives.<sup>23</sup> Compared to a strike group, a JFMCC is responsible for more units, threatened by more adversaries, and often constrained by the requirements of a coalition. Compared to the tactical level, operational decisions involve more factors and have harder to determine interrelationships. While AI would benefit the tactical level of war with faster decisions, incorporating it at the operational level of war would produce more significant benefits through better decisions with broader impact.

AI can lead decision-makers towards optimal solutions when presented with many that are merely suitable, feasible, or complete. Operational warfare often presents ill-structured

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21. John Richardson, "A Design for Maritime Superiority" (U.S. Navy, Chief of Naval Operations, December 2018): 10,

[https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design\\_2.0.pdf](https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf).

22. Antoine Henri baron de Jomini, *The Art of War* (Lippincott, 1862): 178.

23. *Joint Operations*, Joint Publication 3-0 (Washington, DC: U.S. Department of Defense, Joint Chiefs of Staff, 2018): xii,

[https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3\\_0ch1.pdf?ver=2018-11-27-160457-910](https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_0ch1.pdf?ver=2018-11-27-160457-910).

problems. These sorts of issues defy a common approach. They may have better or worse solutions, but seldom entirely right or wrong ones. Describing complex problems usually presupposes an already visualized solution.<sup>24</sup> Individual naval engagements are complicated, but not necessarily ill-structured. Opponents could fire hundreds of weapons in the space of minutes,<sup>25</sup> but commanders can predict success by each side's sensor range, the range of their armaments, and who can fire and return fire most quickly and for the most prolonged duration.<sup>26</sup> Scaling naval combat to an operational problem breaks the structure of what success means. Destroying more ships over many engagements with fewer missiles, denying the adversary access to an area while introducing the least risk to the fleet, or winning by other means could all define success. With AI, it is feasible for staff to quantitatively determine the outcomes of many more COAs than can be done with even the most talented team. However, since exploring the solution to an ill-structured problem predetermines which criteria are most relevant, operational issues must be appropriately creatively narrowed to be solved by an AI. AI must then be interactively teamed with human experts to be effective.

Command is one of the most human dependent activities in war. It is a process of arbitration between the commander, his staff, and the units above and below. Field Marshal Slim described five qualities a commander needs to navigate this process: willpower to resist the

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24. Michael Hoffmann and Jason Borenstein, "Understanding Ill-Structured Engineering Ethics Problems Through a Collaborative Learning and Argument Visualization Approach," *Science and Engineering Ethics*; New York 20, no. 1 (March 2014): 261–76, <http://dx.doi.org.usnwc.idm.oclc.org/10.1007/s11948-013-9430-y>.

25. Toshi Yoshihara and James Holmes, *Red Star over the Pacific: China's Rise and the Challenge to U.S. Maritime Strategy*, Revised second edition (Annapolis, Maryland: Naval Institute Press, 2018): 82.

26. Wayne P. Hughes, *Fleet Tactics and Coastal Combat*, Second edition (Annapolis, Maryland: Naval Institute Press, 2000): chap. "The Great Constants."

adversary and reluctance of his staff; judgment, especially in employing subordinates; flexibility of mind and adaptation; knowledge of his force, allies, and adversaries; and integrity focused on honesty with subordinates.<sup>27</sup> These qualities dictate how well a commander can frame a problem and use the resources at his disposal to meet the objectives given to him. While some of these qualities are inherently human, AI can amplify others.

Set ways of thinking do not encumber AI. A staff officer may not have the mental flexibility to construct new solutions to current problems, and the commander might not have the willpower to compel them to think harder. AI, devoid of biases, weighs each problem independently and will construct new solutions when directed.<sup>28</sup> AI trained to find what a commander deems relevant can highlight what is needed to build knowledge. AI draws a commander's attention away from processing data and allows her to focus more on the fundamentally human task of judging what is essential to inform subordinates and accomplish assigned objectives.

AIs do not rely on the same mental heuristics as humans to simplify their thinking. When given an insurmountable quantity of data to look through in a limited amount of time, a person is likely to choose what they see first, and that which is most familiar. This process creates results that are satisfactory but not optimal.<sup>29</sup> For the type of data AI is trained on, it can explore more possibilities in parallel than the human mind. Humans will often make the rational decision only to investigate outcomes which are most likely and closest to their natural mode of thinking. AI

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27. Edward P. Egan, *Field Marshal William J. Slim: The Great General and the Breaking of the Glass Ceiling* (Carlisle Barracks, Pennsylvania: U.S. Army War College, 1993): 12-13.

28. Geoffrey B. Grooms, "Artificial Intelligence Applications for Automated Battle Management Aids in Future Military Endeavors" (Thesis, Monterey, CA, Naval Postgraduate School, 2019): 10, <https://calhoun.nps.edu/handle/10945/62722>.

29. Singer, *Wired for War*, 358.

has the knowledge, resources, and lack of bias to consider results that are optimal but would go unexplored by humans in favor of more straightforward scenarios.<sup>30</sup> A seasoned leader has the intuitive sense to realize when better alternatives exist to the current plan. AI provides the advantage of developing and analyzing COAs, which the burden of time would prevent under other circumstances.

### **How to Operationally Integrate Artificial Intelligence in the Maritime Domain?**

The best current application of AI for maritime operations is to break complex maritime operational problems into subproblems, have them solved by ANI, and combined into COA recommendations. AIs which solve small problems require less training data, have more straightforward logic and can be chained together to solve more significant problems. Rodney Brooks, former Director of the MIT AI Laboratory, argued that creating symbolic representations of dynamic environments is difficult or impossible. However, task-specific agents can act intelligently with enough sensor data and, more importantly, interact coherently.<sup>31</sup> By chaining together simple activities, with a low risk of failure, more complicated problems could be solved. Multiple simple actions can be run in parallel at a low cognition layer and have their outputs combined to feed complex activities at higher tiers.<sup>32</sup> This structure has the advantage of allowing military engineers to develop and train AI to solve tractable problems first. Functions that are more challenging to AI developers can retain human-only decision methods until they

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30. Dumitru Minzarari, "From Deception to Attrition: AI and the Changing Face of Warfare," *War on the Rocks*, February 18, 2020, <https://warontherocks.com/2020/02/from-deception-to-attrition-ai-and-the-changing-face-of-warfare/>.

31. Rodney A. Brooks, "New Approaches to Robotics," *Science* 253, no. 5025 (September 13, 1991): 1227.

32. Rodney A. Brooks, *Cambrian Intelligence: The Early History of the New AI*. (Cambridge, Mass.: MIT Press, 1999): chap. "Intelligence Without Representation", <http://www.books24x7.com/marc.asp?isbn=0262024683>.

generate the expertise to solve them. Rather than waiting for a complete system, a partial system would provide an interim marginal advantage.

Given that AI can best solve problems by breaking them into smaller decisions, the question remains on how to divide them. One model for restating operational tasks is to split them into operational functions: command and control (C2), communications, intelligence, fires, movement and maneuver, protection, and sustainment. These operational functions provide the basis for conducting effective operations.<sup>33</sup> They provide the ways for an operation to employ means to achieve its ends. Therefore, it is natural to use AI alongside the decision-makers who decide how to implement these functions to meet objectives.

As applied to maritime operational war, the decision support system at the lowest layer would be composed of activities that sense the environment: detection of ships, aircraft, and submarines; fuel levels; weather; and other objective battlespace data. By restricting external input to specific, low-level tasks, the system would minimize the risk of adversarial examples or data designed to manipulate automated systems negatively.<sup>34</sup> The middle level would integrate outputs from the lower level with operational objectives and factors, such as limitations in time, space, and force, to provide solutions to problems along with operational functions. With less threat of adversarial data injection at the upper layers, these systems could use deep learning. Deep learning, a subset of machine learning, does not require as highly formatted data as other forms, but can be more computationally expensive and prone to deception.<sup>35</sup> Deep learning

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33. Vego, *Joint Operational Warfare*, III-8.

34. Christopher Paul et al., “Improving C2 and Situational Awareness for Operations in and Through the Information Environment” (RAND Corporation, November 1, 2018): 80, <http://search.proquest.com/docview/2139447592?pq-origsite=summon>.

35. Ahmed Hosny et al., “Artificial Intelligence in Radiology,” *Nature Reviews* 18, no. 8 (August 2018): 500–510, <http://dx.doi.org.usnwc.idm.oclc.org/10.1038/s41568-018-0016-5>.

would increase human interaction at this layer and expose more complex relationships. The highest level would apply C2 processes to the other six operational functions to produce operational recommendations. Each functional AI in the middle layer would feed suggestions both to other functional AI and the apex C2 layer. The middle layer ANIs make sense of complex data and scope recommendations for adjacent units and the C2 function.

Middle layer AI would promote better allocation of collection assets if integrated into the intelligence cycle of planning and direction, collection, processing, analysis, and dissemination. Adjudicating requests for limited collection assets to meet operational and tactical information needs is a JFMCC concern.<sup>36</sup> During collection planning, AI could use known adversary tracks, locations, individuals, and organizations to define and prioritize named areas of interest (NAI). During execution, AI could drive collection routes based on priority in the same way corporations have used it for delivery route planning to reduce labor, fuel, and maintenance costs.<sup>37</sup> Collection planners could reduce the risk of counter-detection by adding the location and range of adversary surveillance sites. At the C2 level, commanders and intelligence officers could use collection achievement results to justify more JFMCC collection assets and COA modifications. This methodology applies to other functions.

AI could improve sustainment in environments with shifting force dispositions and uncertain adversary presence. Conflicting requirements complicate decisions on how to use limited logistic assets to meet warfighter demands.<sup>38</sup> The lower survivability of logistic units

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36. U.S. Department of the Navy, Chief of Naval Operations, “Intelligence Support to Naval Operations,” 4–6.

37. “Optibus Adds Intelligent Route Planning Capabilities to Its Market-Disrupting Mass Transport Platform,” *PR Newswire*, February 26, 2019, <https://search-proquest-com.usnwc.idm.oclc.org/docview/2185854367?pq-origsite=summon>.

38. *Navy Warfare Publication 4-0M* (Washington, DC: U.S. Department of the Navy, Chief of Naval Operations, 2011): 2-3.

drives decisions on whether it is preferable to bring them into areas denied by adversary defenses or draw combat craft away from objectives. AI could use the availability of military and civilian transportation, prepositioned stocks, and provider responsiveness to formulate solutions for ship and aircraft needs. Businesses use AI to accurately predict demand and discern purchasing patterns that affect transportation and warehousing.<sup>39</sup> Sustainment AI could use a variation of this process to plan the staging of material at Advanced Logistics Support Sites (ALSS) or Forward Logistic Sites (FLS). It could determine how and when to use shuttle and station ships for movement on to strike groups.<sup>40</sup> Machine learning would use fuel, food, and weapons stocks, threat rings, readiness levels, and repair times to train sustainment AI. Sustainment ANI could provide quantitatively more efficient solutions than done by humans alone and feed them to other functional areas and the C2 upper layer.

The C2 layer would arbitrate decisions from the lower layers and provide a unified recommendation. Like the commander of a military organization, it would amalgamate the advice of its lieutenant AIs. Earlier stages of the AI process use sensor data and other objective information to orient the commander; deciding on a course of action requires building an understanding of the battlespace, a higher level of appreciation.<sup>41</sup> Variability and ambiguity of the battlespace would make AI elements in this layer the most difficult to develop. Ultimately, the system would act as a trusted agent, condensing the amount of information for which the commander was responsible. Condensed information eases the burden of doubt for a time-

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39. Rupa Dash et al., “Application of Artificial Intelligence in Automation of Supply Chain Management,” *Journal of Strategic Innovation and Sustainability*; West Palm Beach 14, no. 3 (2019): 43–53.

40. *Navy Warfare Publication 4-01.2* (Washington, DC: U.S. Department of the Navy, Chief of Naval Operations, 2007): 7-9.

41. *Naval Doctrine Publication 6* (Washington, DC: U.S. Department of the Navy, Chief of Naval Operations, 1995): 17.

constrained decision-maker working, allowing her to issue more timely orders to subordinate units

Figure 1 illustrates a proposed architecture for a system based on these principles. Using adversary prediction as an example, many single-purpose ANI would combine raw sensor and unit reporting data at the lowest layer. It would assess the most likely position of enemy units. Corporations analyze the sentiment of reviews, social media, and forum postings to determine product satisfaction.<sup>42</sup> Similarly, this system would determine adversary intentions through public rhetoric and clandestine reporting. It would evaluate current and historical weather patterns to assess climate impacts on enemy operations. These three inputs and other information would be used by functional intelligence ANI to form assessments of adversary COAs. Likewise, fires nodes would use enemy composition, JFC priorities, and the predicted availability of munitions to generate targeting guidance. The middle layer nodes would pass their assessments laterally to refine adjacent recommendations, such as force protection levels. The independent functional recommendations would also feed directly to the C2 layer to create overall courses of action.

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42. Brian Keith Norambuena, Exequiel Fuentes Lettura, and Claudio Meneses Villegas, “Sentiment Analysis and Opinion Mining Applied to Scientific Paper Reviews,” *Intelligent Data Analysis* 23, no. 1 (February 20, 2019): 191–214, <https://doi.org/10.3233/IDA-173807>.

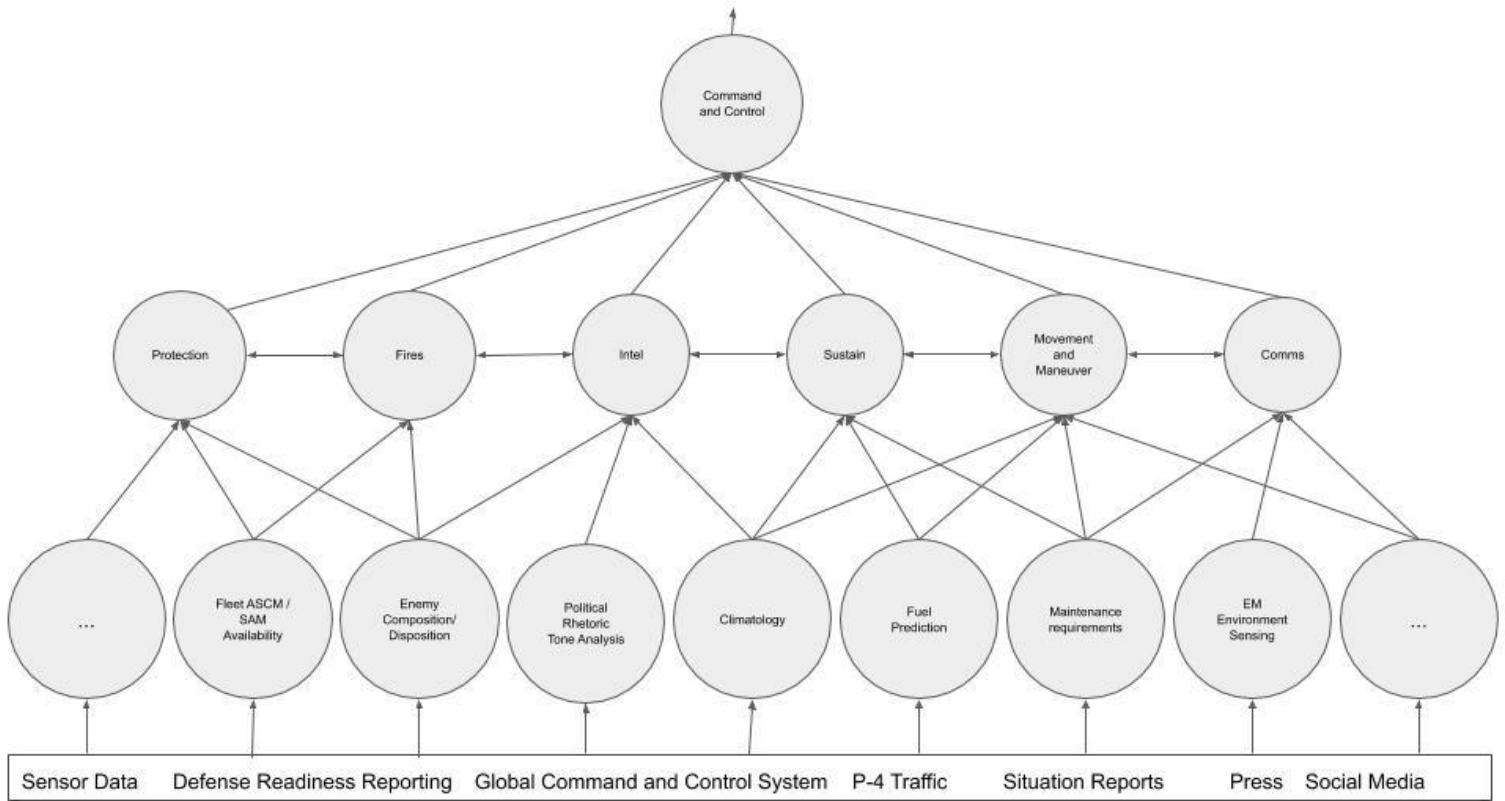


Figure 1. Proposed Architecture for Maritime Artificial Intelligence System. Illustration generated by the author.

### **Counterargument: A Case for Artificial General Intelligence**

In contrast to the concept for several narrow AIs working in parallel to provide recommendations, some might argue for a single AGI to make decisions for the commander. Sensors and data feeds can push all of the data into one consciousness, which makes all decisions simultaneously, instead of dividing the data stream into its components for ANI and recombining the outputs for upper layers. Decision-making using the AGI method would avoid the abstraction that results from using an assessment rather than the raw data. Intermediate processes would not calculate and simplify assessed enemy COAs, ranked target lists, and predetermined RAS points to generate input to a plan. Instead, it would simultaneously use all of the raw adversary and

environmental data. Removing the barriers between operational functions would eliminate the inefficiencies from them not being completely aligned.

However, the limitations of AGI would make this system ineffective. The quest to construct a system which fully implements cognition has been slow. It can be characterized by many projects which only claim to apply narrow cognitive abilities with tightly controlled conditions. The ability to switch between different sorts of tasks is limited, requiring different sets of parameters or decision models.<sup>43</sup> For example, products demonstrate the ability of speech comprehension, but they are challenging to retrain to read and understand a warning order. Also, in comparison to task-specific ANIs, the data fed into an AGI is broader and less well-groomed. Dirtier data increases the possibility of malicious input deceiving an AGI.<sup>44</sup> The multi-domain battlespace, shifting threat environment, and often vague set of constraints a JFMCC operates in are difficult for an AGI to comprehend. Other aspects of AGI make them ill-suited to decision-making.

A single AGI isolates humans from the decision-making process, where a system composed of several narrow ANIs retains some interaction. A human subject matter expert can vet the output of each ANI before moving to the next decision-making layer. They are unable or challenged to do this with a holistic, opaque AGI. Removing the human from the decision-loop creates an opportunity for things to go awry when conditions are unclear.<sup>45</sup> Questions of

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43. Iuliia Kotseruba and John K. Tsotsos, “40 Years of Cognitive Architectures: Core Cognitive Abilities and Practical Applications,” *Artificial Intelligence Review* 53, no. 1 (January 1, 2020): 17–94, <https://doi.org/10.1007/s10462-018-9646-y>.

44. Christopher Paul et al., “Improving C2 and Situational Awareness for Operations in and Through the Information Environment” (RAND Corporation, November 1, 2018): 96 <http://search.proquest.com/docview/2139447592?pq-origsite=summon>.

45. Wilson Wong, *Emerging Military Technologies: A Guide to the Issues*, Recent Titles in Contemporary Military, Strategic, and Security Issues (Santa Barbara, Calif: Praeger, 2013): 93.

suitability and feasibility aside, AGI may have trouble developing acceptable COAs. That is, while they may be able to outline plans which accomplish objectives within the constraints of time, space, and force, they may not account for ethical, humanitarian, or other hard to quantify costs. It may be possible to transfer responsibility for the decision to a machine. Still, it is unlikely Navy leadership will write a policy to assign accountability to AI, especially when the cost can be as high as the loss of human lives.<sup>46</sup> Each place where a human interacts with the data fed into and decision produced by an AI gives plausibility to this accountability. A system constructed of multiple narrow AIs retains these touchpoints.

### **Conclusion**

AI augments the decision-making abilities of humans. The values and thresholds set by designers limit the recommendations given by procedural logic tools. In contrast, AI continually refines the relationship between its inputs and its decisions. More importantly, it may see relationships between observables that a human observer would not. If there is sufficient trust in the system and understanding by the commander of an AI's methodology, it lessens the need for him to process what is inconsequential. A commander with this capability has an advantage over his competitors in the rate he can make decisions and how effectively those decisions integrate the copious data and complex relationships at the operational level of war. AI may be easier to implement for tactical effects, but it would be decisive for winning campaigns.

Organizationally, an AI would best support decision-making as an integrated system of systems. Limiting each subsystem to a specific function would reduce the number of datasets and potential outcomes it would need to consider. The reduction would limit the amount of training

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46. William C. Martel, ed., *The Technological Arsenal: Emerging Defense Capabilities* (Washington, D.C: Smithsonian Institution Press, 2001): 230–31.

required to make it functional. Additionally, segmenting the system reduces the possibility of the entire system collapsing from misunderstood input, adversary cyber-attack, or simple bugs. Finally, in a partitioned arrangement, an initial operating capability can be achieved when each subsystem reaches a minimal level of capacity rather than waiting for the completion of the whole. Aligning the subsystems by doctrinal operational function provides parallelism with the military decision-making process. The commander's advisors can interpret the decision reached by the component in their functional area and validate it or refine it through training. These middle layer systems reduce the uncertainty and simplify the information used by upper-level networks to generate courses of action.

This paper described C2, intelligence, and sustainment AI nodes due to their overall importance as warfighting functions and clarity of implementation. These areas are already receiving AI development resources, and prioritizing them at an early stage for maritime applications would yield high rewards for low risk. However, other operational functions and low-level intelligence nodes should receive attention to synchronize their development with the first efforts. While designers develop new functional nodes, humans can substitute for the decisions which finished nodes would feed to other components. This stopgap would balance minimal functionality for an initial operating capacity with longer-term development requirements.

Commanders rely on subordinates to provide recommendations for making decisions. Trust relieves them of the burden of viewing and cognitively processing all of the information they have available to them. In contrast to human subordinates, where a universal education and experience provide insight into the decision-making process, devices trained using machine learning techniques operate as black boxes. Researchers are developing explainable AI

techniques with models and interfaces which explain decisions to human users, but such systems present tradeoffs between problem complexity, performance, and the amount of insight they can provide.<sup>47</sup> While the information used to train them is known, there is no flowchart to explain the way they deliver their conclusions. The path they take to reach a conclusion loses transparency when leaders add more inputs. Each step in the ability to solve complex problems without supervision increases uncertainty.

A commander necessarily increases his risk when he depends on AI for decision support. When he issues an order based on the recommendation of AI, he accepts liability for explaining the soundness of its methodology in the event of a negative outcome. Simulation and documentation can provide insight into the cases where AI might provide an invalid COA. However, doctrine and policy change will be necessary to draw the line between failure from chance and that from improper use of an AI COA. Operational risk management is the methodology for documenting the assumption of risk. Doctrine and policy should document when a commander should accept the risk of using an AI decision and what the consequences are for doing so improperly. Navy policy should not provide carte blanche for handing decision-making to AI, but describe the limits of authority commanders can delegate to it. Like other warfighting tools, when policy sets the limits of liability for using AI, commanders will be willing to accept the risk of it.

### **Recommendations**

First, take advantage of joint AI resources to modify standard components for Navy specific problems. The scarcity of engineers skilled in the development of military AI systems

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47. Gunning, David and David Aha. "DARPA's Explainable Artificial Intelligence (XAI) Program." *The AI Magazine* 40, no. 2 (2019): 44-58.

will limit the development of new systems. The DoD Strategy for AI specifies the creation of common tools, frameworks, and standards for decentralized development and experimentation.<sup>48</sup> Use these ready-made components to create low-level systems and standard interfaces for all of the subsystems of the AI decision net. Focus Navy resources on the procurement and implementation of middle and upper-level systems for maritime specific decision-making. Avoid technologically fascinating but ineffective solutions and maintain the objective of solving maritime problems by integrating functional area experts with the design teams.

Second, create and maintain databases of operational data that can be ingested through machine learning to train naval AI. Implement techniques and technologies which can read and centrally aggregate reports of elemental operational data, such as fuel states, missile loadouts, at the maritime operation centers (MOC). Develop methods to record and qualitatively score the results of operational decisions, such as changes in adversary posture, casualty repair rates, and public responses to operations. Databases linking inputs to operational decisions and outcomes will accelerate the development of systems meeting real-world standards.

Third, integrate the use of AI into policy and doctrine. Doctrine should codify areas where AI can be integrated into decisions making at the operational level of war. Explicitly, capstone Naval Warfare Publications for intelligence, operations, fires, logistics, planning, and communications should state where and how AI would generate an advantage in the decision-making process. Joint Publications describing Joint Maritime Operations should specify how to parse JFC requirements to JFMCC AI systems. If DoD and Navy policy characterized the

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48. “Summary of the 2018 Department of Defense Artificial Intelligence Strategy” (Washington, DC: U.S. Department of Defense, February 12, 2019): 3, <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

amount of liability a commander incurred by integrating decision recommendations from an AI, they could take calculated risks when using it. Equipping commanders and operators with the tactics, techniques, and procedures to use AI will speed its adoption in the fleet.

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[com.usnwc.idm.oclc.org/docview/2114666465/fulltext/7DE340F07E3E47ADPQ/1?accountid=32](https://search-proquest-com.usnwc.idm.oclc.org/docview/2114666465/fulltext/7DE340F07E3E47ADPQ/1?accountid=32)  
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