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An AI Framework for the Department of the Navy

Larry Lewis, Diane Vavrichek

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Abstract

The Chief of Naval Operations directed the creation of a Naval AI framework for the Department of the Navy. CNA, as part of a Quick Response Project, wrote a draft framework document for the Navy based on an initial outline from the writing team. This framework document is informed by CNA research and experts, providing an evidence-based approach. The document includes DON challenges, considerations for the most vital DON applications of AI, how to link AI applications to critical DON missions, manning and organizational requirements, policy considerations, and specific actions needed to help DON be the adaptive organization it needs to be to use AI effectively and rapidly.

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Mark Geis
Executive Vice President
Center for Naval Analysis

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Executive Summary

Artificial intelligence (AI) is a transformative technology offering significant military advantages to nations that can adapt and operationalize it. This creates a double incentive for the Department of Defense (DOD), including the Department of the Navy: to capitalize on this technology both to leverage the efficiencies and operational benefits of AI, but also—in a new era of great power competition—to compete successfully to maintain a military advantage. To this end, the US government (including the military) is taking a top-down, strategically driven approach to AI. In the past year, the US issued a new executive order on AI and DOD established the Joint AI Center within the Office of the Secretary of Defense, while creating the Department of Defense Artificial Intelligence Strategy as an annex to the 2018 National Defense Strategy.

The Department of the Navy (DON) is taking its own strategic approach to the leveraging of AI for the sea services. To this end, the Chief of Naval Operations directed the creation of a Naval AI framework to establish a foundation and action plan for this strategic approach. CNA, as part of a Quick Response Project, wrote a draft framework document for the Navy based on an initial outline from the writing team. This framework document is informed by CNA research and experts, providing an evidence-based approach. The document includes DON challenges, considerations for the most vital DON applications of AI, how to link AI applications to critical DON missions, manning and organizational requirements, policy considerations, and specific actions needed to help DON be the adaptive organization it needs to be to use AI effectively and rapidly.

History shows that successful military innovation is not easy: it can take decades to overcome organizational resistance to new ideas and processes. The current environment of great power competition, in which adversaries express their intent to overtake the US using AI, means that DON does not have the luxury of time to adapt. This DON AI is a strategic first step towards making the most of AI technology and succeeding in this competition.

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Introduction

The Department of Defense (DOD) is taking a top-down, strategically driven approach to incorporating artificial intelligence (AI). AI represents a broad and revolutionary technology with a host of varied military applications—ranging from force development and management to direct applications in warfare. Recognizing the pivotal role of AI in national security, in 2018 DOD established the Joint AI Center within the Office of the Secretary of Defense and created the Department of Defense Artificial Intelligence Strategy as an annex to the 2018 National Defense Strategy. DOD further directed that each of the services develop annexes to the DOD AI strategy to describe their approach to leveraging AI. The Chief of Naval Operations (CNO) was dissatisfied with this independent approach and wanted an integrated Department of the Navy (DON) strategy to help guide the department as a whole.

In response to this, the DON recently assembled a team to develop a Naval AI strategy document, encompassing both Navy and Marine Corps priorities. The Navy Combat Identification office, part of the N2N6 team assigned to draft this plan, requested that CNA support this effort, later described as a Naval AI framework. This quick-response project directly supported the development of this framework.

The Naval process

The drafting team included N2N6, Office of Naval Research (ONR), Digital Warfare Office (DWO), Naval Research Lab (NRL), Marine Corps Warfighting Laboratory (MCWL), Naval members of the Joint AI Center, and CNA. When CNA joined the writing team, the group had already created a draft table of contents with outlined bullet points for each section. The plan was for the group to draft the framework to encompass those points over the next few months, with an estimated completion of August 2019.

The expected timeline slipped because many of the same team members were also working on an AI task from the Chief of Naval Operations (CNO) guidance on Naval superiority.[1] As a result, the team lead asked CNA to flesh out the existing outline as a first draft of the framework. At the end of the quick-response project, we provided our draft to the group, which is also included in the appendix. The framework is expected to be finalized by October. According to

[1] Chief of Naval Operations, *A Design for Maintaining Maritime Superiority—Version 2.0*, December 2018, https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf

the document itself, the intent is as follows: "This document is intended to present a flexible framework that will lay the groundwork to man, train, and equip the Sea Services for the effective adoption of AI."

CNA approach

As a member of the writing team, CNA attended meetings and made initial contributions to fine-tuning of the sections. For example, it was argued by some that there was no need for a policy section, but CNA put forward some of its research showing that there were important policy implications. However, as time moved on, the writing team was getting little writing done and the time allotted for the quick-response project (QRP) was coming to an end. CNA volunteered to use our research and expertise to flesh out to the outline and create a draft document. That draft provided content in each section and changed the overall outline, creating several new sections.

Having recently formed a center for AI, CNA has a growing body of research on the topic. We mined this body of work for insights and fact-based observations and principles. Reports that were particularly useful for this study included the following:

- *Combat Identification: An Opportunity for Using AI in Warfighting*[2]
- *Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations*[3]
- *Research and Development Implications for Human-Machine Teaming in the U.S. Navy*[4]
- *Redefining Human Control: Lessons from the Battlefield for Autonomous Weapons*[5]
- Research on autonomy ecosystem[6]

In addition to a review of existing CNA research, we solicited insights and perspectives from analysts from different divisions to get their insights and perspectives. The goal was to get a

[2] Larry Lewis, Annette M. Matheny, Mary E. Lauer, and Stephen M. Perry, *Combat Identification: An Opportunity for Using AI in Warfighting*, CNA, DRM-2018-U-018854-Final, December 2018.

[3] Larry Lewis, *Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations*, CNA, DRM-2017-U-016281-Final, September 2017.

[4] Michael F. Stumborg, Scott B. Brauner, Christine A. Hughes, Caitlin N. Kneapler, Jason A. Leaver, Rahul I. Patel, and Colin P. Shields, *Research and Development Implications for Human-Machine Teaming in the U.S. Navy*, DRM-2019-U-019330-1Rev, March 2019.

[5] Larry Lewis, *Redefining Human Control: Lessons from the Battlefield for Autonomous Weapons*, CNA, DOP-2018-U-017258-Final, March 2018.

[6] Diane Vavrichek is leading this study for ONR. The analysis will be reflected in a forthcoming deliverable.

comprehensive contribution from CNA overall, providing a solid, evidence-based foundation for the Naval AI framework. Through a modest effort in time and resources, this effort became a proof of concept of the value CNA can provide to the Navy.

Discussion of CNA Contributions

As CNA made its draft of the AI framework, there were three different kinds of contributions made to the document:

- Nesting the Naval framework into DOD and US government guidance
- Filling gaps: Insertion of specific ideas from CNA reports
- Synthesis of multiple CNA reports for new content

We will discuss examples of each kind of contribution to the DON AI framework for this QRP.

Nesting the Naval framework

The US government has recognized how critical it is to quickly and effectively make the most of the emergence of AI as a transformative technology. The DON efforts should nest within these larger efforts to be consistent with and to fully leverage them. Three particularly important US government developments that CNA included in the DON AI framework are the AI executive order, the DOD AI strategy, and the National Institute for Science and Technology (NIST) report on AI standards.

AI executive order

The President issues executive orders to direct the federal government's operations. This functions as a tool to help focus a large bureaucracy on specific priorities. To this end, on February 11, 2019, the President issued the "Executive Order on Maintaining American Leadership in Artificial Intelligence."[7] The AI executive order (EO) cites the promise and transformative nature of AI to justify the need for executive action, with goals of the EO including both self-interest and promoting values:

> "…drive growth of the United States economy, enhance our economic and national security, and improve our quality of life."[8]

[7] White House, Executive Order 13859, Executive Order on Maintaining American Leadership in Artificial Intelligence, February 11, 2019.

[8] White House, Executive Order 13859, "Executive Order on Maintaining American Leadership in Artificial Intelligence," February 11, 2019.

> "…maintaining the economic and national security of the United States and to shaping the global evolution of AI in a manner consistent with our Nation's values, policies, and priorities."[9]

There are six explicit goals in the EO:

- Sustained enterprise investment in research and development (R&D) for AI, including US government, industry, and international partners/allies
- A push for creating AI infrastructure in government, including data, computing power, and algorithms
- A principled push for AI applications, reducing barriers to the broad use of AI but in ways that both preserve national security and promote US values
- Promoting integrity and trust in US and international standards, in order to minimize vulnerability to attacks and to promote reliability
- Building an AI-ready US workforce through apprenticeships, training, and education
- Protect critical areas of advantage in AI and related technology against strategic competitors and adversaries

The EO also calls for prioritization of applications by US departments and agencies, budgeting commitments to meet the EO goals, and the pursuit of necessary data and computing resources.

DOD AI Strategy

Recognizing the importance of AI for maintaining a military edge in a new era of great power competition, DOD developed an AI strategy in 2018 and released an unclassified summary to the public in 2019.[10] This strategy outlines key areas of DOD focus with regards to AI. The DOD AI strategy includes four lines of effort:

- Delivering AI-enabled capabilities that address key missions
- Partnering with leading private sector technology companies, academia, and global allies and partners
- Cultivating a leading AI workforce
- Leading in military ethics and AI safety

[9] White House, "Executive Order 13859, Executive Order on Maintaining American Leadership in Artificial Intelligence," February 11, 2019.

[10] Department of Defense, *Summary of the Department of Defense Artificial Intelligence Strategy*, February 12, 2019.

The AI strategy also addresses the role of the newly formed Joint AI Center (JAIC), which include the following:

- Delivering AI capability in critical areas (National Mission Initiatives, including Project Maven, predictive maintenance, cyber automation, humanitarian aid/disaster relief, and automating administrative tasks)
- Promoting AI infrastructure for DOD (e.g., data foundation, common tools and architecture, common standards)
- Supporting service initiatives (described as Component Mission Initiatives, complimentary to the JAIC's National Mission Initiatives)

We also noted the strategy's specific policy commitments in the areas of workforce and AI safety and ethics when the drafting of the DON framework.

NIST AI Standards

One of the objectives of the AI EO is to "ensure that technical standards minimize vulnerability to attacks from malicious actors and reflect Federal priorities for innovation, public trust, and public confidence in systems that use AI technologies; and develop international standards to promote and protect those priorities." In the pursuit of that objective, the EO calls for the National institute of Standards and Technology (NIST), reporting to the Secretary of Commerce, to "issue a plan for Federal engagement in the development of technical standards and related tools in support of reliable, robust, and trustworthy systems that use AI technologies." In response, NIST created an AI standards action plan for the federal government. It identifies nine specific types of AI standards that are needed: concepts and terminology, data and knowledge, human interactions, metrics, networking, performance testing and reporting methodology, safety, risk management, and trustworthiness (including attributes such as accuracy, explainability, resiliency, safety, reliability, objectivity, and security).[11] As DON adjusts its processes, systems, and infrastructure to better leverage AI, nesting its standards within the larger US government enterprise will help promote efficiency, security, and ethical use of data and AI applications.

Filling gaps

A second contribution to the AI framework was filling in best practices and recommendations from existing CNA analysis. We provide two examples. First, in the section on partnerships, we

[11] NIST, *U.S. Leadership in AI: A Plan for Federal Engagement in Developing Technical Standards and Related Tools, Prepared in response to Executive Order 13859*, August 9, 2019.

provided paragraphs on the following aspects of working with partners, including the following:

> In an age where industry and academia are leading the government in AI research and development, we must adapt to maximize our ability to collaborate to effectively use the best technologies available. While we build AI capacity within DON, the Department will monitor key AI developments in industry and academia and build agile processes to leverage them. DON will foster relationships with industry and academia to promote cooperation, dialogue, mutual understanding, and trust.
>
> Allies are one of the Naval enterprise's great strengths. We will be deliberate in working together with allies to promote a strong AI alliance. This will involve making the most of collective resources, ensuring interoperability, and pursuing complimentary capabilities to strengthen our security and better address emerging threats. We will work with our allies at all stages: planning and requirements; CONOPS, system, and policy development; experimentation; and multilateral training.[12]

Both of these paragraphs are derived from CNA analysis and recommendations in the Third Offset report.[13] That analysis also built on previous CNA research. For example, the recommendations for working with allies is based on our analysis of US Marine Corps forces working with the UK in Helmand Province, Afghanistan, where the two forces worked together for the first time since before World War II. That analysis identified missed opportunities and best practices for preparing to work with allies, which is relevant to the development and use of AI.[14]

Another example is in the "Linking AI to Mission" section. The first paragraph reads as follows:

> The Naval enterprise will utilize a problem-driven approach as it adopts AI, asking: what are the critical problems facing the Naval force? What problems are suitable for applying the technology of AI, given its requirements and limitations? We are not adopting AI for its own sake, but in order to advance the Naval mission. Technology has repeatedly transformed warfare, but historically, successful disruptive innovation on the battlefield has come out of an initial focus on the problems that need to be solved; technology then becomes the enabler of innovative thinking.[15]

[12] The full draft document is contained in the appendix.

[13] Larry Lewis, Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations, CNA, DRM-2017-U-016281-Final, September 2017.

[14] Alexander Powell, Larry Lewis, Catherine Norman, and Jerry Meyerle, Summary Report: U.S.-UK Integration in Helmand, CNA, DOP-2015-U-011259-Final, February 2016.

[15] The full draft document is contained in the appendix.

We derived the approach, and particularly the highlighted questions, from the CNA report on combat identification.[16] In that report, the Navy asked CNA if AI could be used in a particular application to promote the combat identification process in the context of air and missile defense. The answer is yes, and the report documents a way to move in that direction with a simple application of AI to better identify commercial airliners (thereby simplifying the air picture and helping to focus limited identification resources on still-unidentified aircraft). But the report also provided a framework for the Navy to make such decisions in general. This framework fit well into the Naval AI framework in this section.

Synthesis of multiple CNA reports

At other times, we considered the findings and observations of several CNA reports and through synthesis created new content and observations. One example is the "AI Applications and Human Machine Teaming" section. That section discusses the two basic types of AI and autonomy as described by the Defense Science Board ("in motion" and "at rest"), and ONR describes three general applications of AI for DON (autonomy, decision aids, and optimization). There was also interest in human-machine teaming, as DOD overall has stressed the belief that the combination of man and machine will be the "killer app" that will give the US a military edge over adversaries, based on the quality and training of its personnel.

CNA has analyzed various components of these issues, including considerations for autonomous systems, elements of human control, and tasks relevant to human-machine teaming. To support the AI framework, we connected the DON AI applications to the general Defense Science Board distinction of "in motion" and "at rest" and then analyzed human-machine teaming considerations for each of the applications.[17] We then connected those to the Observe-Orient-Decide-Act (OODA) loop observations in CNA's human-machine teaming analysis.[18] The result is a way to think analytically about human-machine teaming requirements for different kinds of DON AI applications.

Thinking proactively about human-machine teaming is important because effective human-machine teaming does not just happen: it takes deliberate consideration of the strengths of

[16] Larry Lewis, Annette M. Matheny, Mary E. Lauer, and Stephen M. Perry, *Combat Identification: An Opportunity for Using AI in Warfighting*, CNA, DRM-2018-U-018854-Final, December 2018.

[17] Larry Lewis, *Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations*, CNA, DRM-2017-U-016281-Final, September 2017; Larry Lewis, Redefining Human Control: Lessons from the Battlefield for Autonomous Weapons, CNA, DOP-2018-U-017258-Final, March 2018.

[18] Michael F. Stumborg, Scott B. Brauner, Christine A. Hughes, Caitlin N. Kneapler, Jason A. Leaver, Rahul I. Patel, and Colin P. Shields, *Research and Development Implications for Human-Machine Teaming in the U.S. Navy*, DRM-2019-U-019330-1Rev, March 2019.

both man and machine, and tailoring of interfaces and functions to account for human factors. The shootdown of a USN F/A-18 by a PATRIOT missile in Iraq in 2003 serves as one of many historic examples (another is the USS *Vincennes* destroying a civilian Iranian airliner) of the dangers of automation and system design not leading to appropriate human judgment. Accordingly, DON will need to take steps to avoid risks and maximize the strengths of its personnel and AI technology when marrying them together. Specific steps recommended in the framework include that the DON "draw on technical expertise, an understanding of cognitive processes, and cultivating appropriate trust in AI-enabled systems through design as well as substantial training opportunities and demonstrations in real world conditions. Areas of focus will include system design, training, and concept development."

The "Adapting for AI" section also synthesizes findings from multiple CNA reports. This section combines work on historical best practices for military innovation from the autonomy ecosystem study for ONR (the deliverable is still being written but the analysis was available within CNA) with recommendations for changing DON institutional processes in the Third Offset report.[19] The former provides a perspective on how successful innovation requires key institutional steps, while the latter provides ways for DON to move and adapt faster. Together they provide the DON with a blueprint for adapting to better use AI.

[19] Larry Lewis, *Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations*, CNA, DRM-2017-U-016281-Final, September 2017.

Summary and Conclusions

Department of the Navy leadership has recognized the decisive and significant ways that AI can change the Naval enterprise, offering opportunities for greater efficiencies and political-military advantages in a new era of great power competition. At the same time, peers and other potential adversaries have signaled their commitment to this technology, creating a new competition of time. The development of the Naval AI framework is intended to help DON to move rapidly and effectively in light of the twin imperatives of benefits and competition.

CNA's Quick Response Project dedicated CNA resources to the drafting of this framework. Taking and adapting the overall table of contents and outline from the Naval writing team, CNA created a draft document based on three sources: considerations from US government guidance (the US Executive Order, the DOD AI strategy, and the NIST report on AI standards), filling in gaps from existing CNA analysis, and synthesis based on the CNA body of work on AI and autonomy. By including CNA analysis and experts across different divisions, the project aimed to provide a comprehensive contribution from CNA overall. The result is an evidence-based foundational draft for the Naval AI framework that the writing team can finalize and take forward.

Appendix: Draft Naval AI Framework

DEPARTMENT OF THE NAVY AI FRAMEWORK

IMPERATIVE

Artificial intelligence (AI) is transformative to the character of war. AI can be used to **reduce risk** to Sailors and Marines, **increase mission effectiveness**, and **gain efficiencies**; AI can also lead to new, revolutionary tactics and strategies that are **disruptive and decisive** against adversaries. In addition to the imperative to leverage technology to be more effective and gain efficiencies, this era of Great Power Competition creates additional urgency to leverage the technology of AI. It is clear that other countries are aggressively seeking to capitalize on technological opportunities in AI. In the absence of prompt action to address AI across the Naval institution, the Navy and Marines could cede overmatch at sea and sacrifice critical efficiencies and capabilities across the enterprise.

INTENT

This document is intended to present a flexible framework that will lay the groundwork to man, train, and equip the Sea Services for **the effective adoption of AI.** The Department of the Navy (DON) seeks velocity in its adoption of AI—speed and direction. In historical examples of successful military innovation, success was not a function of technology, but rather effective leadership managing institutional adaptation based on key ideas. In other historical cases, needed innovation was significantly delayed because leaders and the institution failed to adapt. Because of the imperatives for AI adoption, DON leadership is committed to pursuing this goal through the leveraging of historical best practices; strategic investments in capabilities, processes, and workforce; appropriate risk-taking in technology development; partnering in industry and elsewhere; and more, as described below.

CHALLENGES

To deliver AI-enabled capabilities at requisite speed and scale requires the Navy to adapt—to organize, train, and equip in new ways commensurate with the pace and nature of AI technology and based on new warfighting concepts. Key challenges include:

- Technical complications for operational use: AI raises intrinsic challenges for verification, validation, and traceability.
- A different development environment: research and development is increasingly dominated by the commercial sector, with technological advances at a rapid and accelerating pace. DON will need to adapt in order to more quickly acquire and operationalize state of the art technology.

- Managing return on investment: considering effectiveness or efficiency gained versus time and money.
- The difficulty of institutional adaptation: change will require deliberate management by senior leaders and initiative at all levels.
- Mitigating a lack of standardization: the lack of interoperability and common standards for infrastructure, software baselines, networks, and data will challenge the ability to implement AI solutions at scale across the Department.
- Harnessing DON data: making needed data available and exploitable for needed capabilities.

The need for fast advances: capable and motivated competitors see AI as an opportunity to outpace and gain a military advantage over the US.

FIRST PRINCIPLES

The Department must observe and adhere to a set of best practices, or first principles, in order to ensure impactful and successful AI development and delivery; adherence will not only advance AI adoption, but also create opportunity space for a host of other emerging technologies (e.g., robotics, additive manufacturing, hypersonics, biotechnology, and advanced materials).

Waiting on DWO input. They were assigned to lead this section.

Potential principles from CNA strategic approach document:

- *Create policy and resourcing for data collection, storage, sharing, and use in AI applications.*
- *Update intelligence and intelligence requirements for data needed in planned AI applications.*
- *Address ethical and legal issues such as bias mitigation in the collection of data for AI training.*
- *Develop test-and-evaluation processes appropriate for non-deterministic and adaptive systems.*
- *Combine iterative development, experimentation, and assessment to accelerate learning and improvements.*
- *Consider "AI ready" characteristics in systems and standards that allow periodic AI updates.*
- *Develop robust training and education to cultivate appropriate trust of AI-enabled systems.*
- *Analyze human-machine teaming to best divide labor between warfighters and AI systems.*
- *Become an effective fast follower of critical developments in the tech industry.*

- *Develop policy for operational AI applications, including use-of-force decisions, to improve AI safety.*
- *Develop export policy for AI systems, encouraging interoperability with allies while protecting critical technologies*

TERMS OF REFERENCE

An important facet of successful AI pursuit will be **a widely accepted and understood definition of AI** accompanied by a meaningful **AI Taxonomy** for the Department in order to set a datum of language and understanding. Progress in AI to date involves technology that function in limited, well-defined contexts such as strategy games, language translation, self-driving vehicles, and image recognition—so-called "narrow AI." This contrasts with the notion of "general AI"—i.e., hypothetical future technologies that can function as a human can in dynamic, undefined contexts, potentially with far better performance than humans are capable of. This strategy focuses on narrow AI and how the Naval enterprise can make best use of that technology in its missions.

DON will use AI definitions, taxonomies, and standards developed collectively by the US government, consistent with the February 11 2019 Executive Order, "Executive Order on Maintaining American Leadership in Artificial Intelligence," and with the National Institute for Standards and Technology's (NIST) "U.S. Leadership in AI: A Plan for Federal Engagement in Developing Technical Standards and Related Tools."[20]

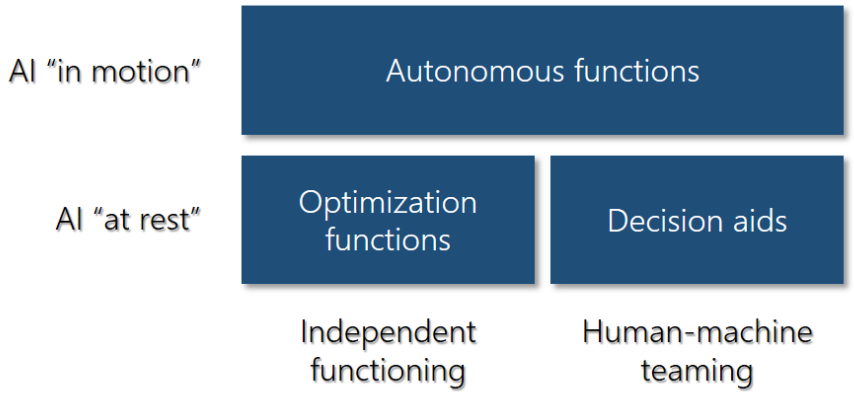
AI APPLICATIONS AND HUMAN MACHINE TEAMING

DON can pursue a range of AI applications. In general, these applications can be characterized as either "at rest" or "in motion" capabilities. "At rest" capabilities are systems that "operate virtually, in software, and include planning and expert advisory systems," while "at rest" capabilities "have a presence in the physical world and include robotics and autonomous vehicles."[21] There are two types of "at rest" applications particularly suited to the Naval AI enterprise: decision aids and optimization functions. Each of these types of applications carry their own considerations for how they are used: independently or using human-machine teaming, as shown in Figure 1.

Figure 1. Human Machine Interactions for Different AI Applications

[20] White House, Executive Order 13859, Executive Order on Maintaining American Leadership in Artificial Intelligence, February 11 2019; NIST, U.S. Leadership in AI: A Plan for Federal Engagement in Developing Technical Standards and Related Tools, Prepared in response to Executive Order 13859, August 9 2019.

[21] Defense Science Board, Summer Study on Autonomy, Department of Defense, June 2016.



Autonomous functions can include navigation, sensor or weapon allocation, the provision of logistics or communications capabilities, or the use of lethal force. The effectiveness of these functions can be enhanced by leveraging AI. They can substitute for—possibly in dull, dirty, or dangerous tasks—and can save manpower requirements or provide rapid response time in tasks where time is of the essence. Alternately they can be used in concert with humans, such as an autonomous wingman or logistics vehicle. In addition to these benefits, autonomous functions can also carry risks—for example, friendly fire, civilian casualties, and accidents such as inadvertent escalation, as well as reduced effectiveness in environments which they are not designed or programmed for. It will be imperative that DON sufficiently mitigate these risks.

Decision aids combine the strengths of machines with the strengths of humans: leveraging technology's ability to process vast quantities of data and filtering or finding patterns to leverage the human ability to gain understanding and apply context. In complex and demanding settings, a human-machine team can exceed the performance of either individually. Optimizing the performance of the human-machine team requires deliberate consideration of both technical system performance and human factors.

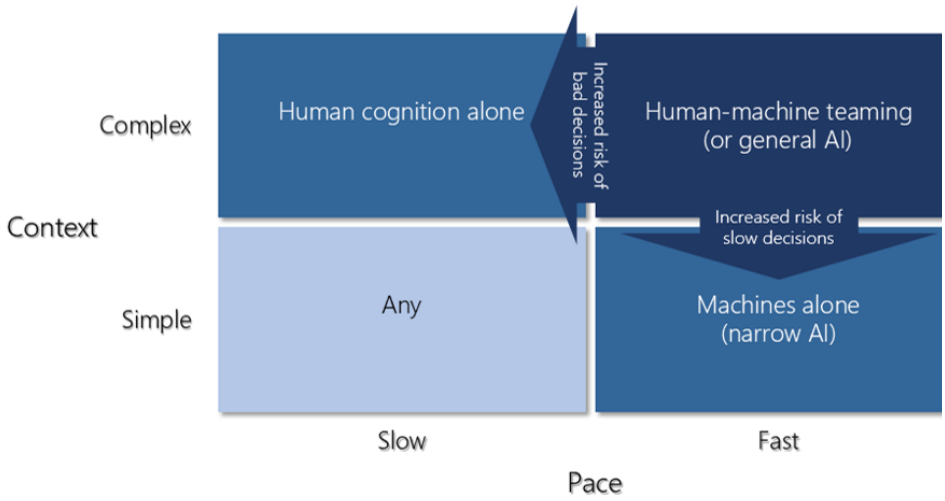
AI can also be used to perform **optimization functions**. For example, AI can leverage large quantities of data and identify patterns in order to contribute to improved and predictive maintenance, help identify candidates for recruitment, and improve the performance of existing systems (e.g., improved tracking in an air defense system). These functions do not make independent decisions about physical actions and they do not interact with humans on a real time basis, but they make real contributions to Naval systems and processes being more effective and efficient.

We expect that some of the greatest advantages for DON operations will be associated with human-machine teaming applications of AI. Therefore we will prioritize and be intentional with developing such applications in such a way as to get the best from

technology and humans as they work together. To do this, we will draw on technical expertise, an understanding of cognitive processes, and cultivating appropriate trust in AI-enabled systems through design as well as substantial training opportunities and demonstrations in real world conditions. Areas of focus will include system design, training, and concept development.

The potential roles of and interplay between man and machine in warfighting are framed in Boyd's Observe-Orient-Decide-Act (OODA) loop for military operations, giving insight into how to best use the strengths and mitigate weaknesses of both man and machine. The three DON applications of AI contribute in different ways to the OODA functions. For example, autonomous functions are best suited for tasks that can be satisfied either prior to deployment by humans or during deployment by machine functions. For decision aids, consideration of the strengths of humans and machines in each of the OODA loop functions can enhance the performance of the human-machine team. This is particularly valuable in settings that are complex and where decisions need to be made quickly, as shown in Figure 2. The "Orient" stage can rely on uniquely human skills associated with evaluating context, so human-machine teaming enhancements are particularly relevant.

Figure 2. AI Applications and Operational Contexts



CORE OBJECTIVES

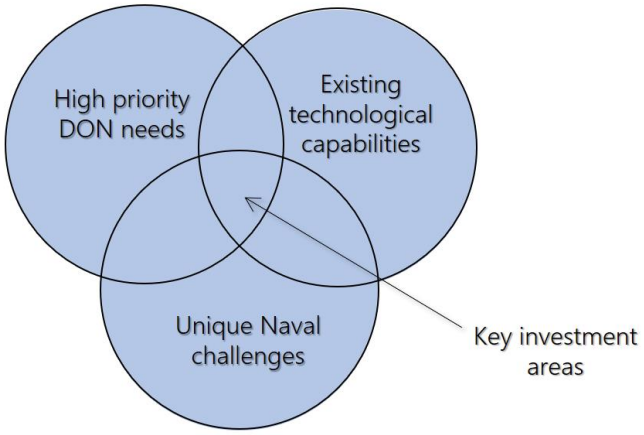
The Department of the Navy (DON) is focused on six core objective areas to foster the effective adoption of AI: linking AI to mission, AI infrastructure, managing AI, adapting for AI, partnerships, and policy. These areas are described next.

LINKING AI TO MISSION

The Naval enterprise will utilize a problem-driven approach as it adopts AI, asking: **what are the critical problems facing the Naval force? What problems are suitable for applying the technology of AI, given its requirements and limitations?** We are not adopting AI for its own sake, but in order to advance the Naval mission. Technology has repeatedly transformed warfare, but historically, successful disruptive innovation on the battlefield has come out of an initial focus on the problems that need to be solved; technology then becomes the enabler of innovative thinking.

Opportunities for applications of AI include reducing risk to sailors and marines; taking radical approaches to warfare that are disruptive and revolutionary; making incremental advances to current effectiveness; and improving the efficiency of administrative capabilities, tools and processes. In a resource-limited environment, DON will prioritize AI investments by focusing on the nexus of: high-priority Department needs, existing technological capabilities, and unique DON challenges, see Figure 3. In addition to investments in the key Naval investment "sweet spot," we will also implement a set of mission-focused Naval AI initiatives focused on identifying and developing such AI applications, with an initial focus on: improving the defenses of US and partner forces, aiding humanitarian assistance missions, reducing unintentional harm and collateral damage, informing manpower decision making, and improving efficiency through business applications. Some such efforts have already been initiated in alignment with the CNO's Design 2.0 priorities.[22]

Figure 3. Key DON AI Investment Areas



[22] Chief of Naval Operations, A Design for Maintaining Maritime Superiority—Version 2.0, December 2018, https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf

AI INFRA-STRUCTURE

AI development requires a rich infrastructure of data, tools, and networks to produce AI capability at speed and scale that can be implemented across a wide range of technically varied Naval systems and platforms. This includes a foundation of shared data that is robust and exploitable; moreover, some data and intelligence requirements will need to be changed to enable AI applications. This foundation also includes reusable tools, frameworks, and standards. For this, we will leverage efforts from whole-of-government (e.g., IC, NIST, DHS) as well as industry and academia. In some cases, capabilities developed by these partners may be able to be used directly or adapted to meet DON needs; in other cases, DON will require tailored DOD/DON solutions. The foundation for our AI infrastructure will also rely on edge and cloud services to provide expeditionary and enterprise-level networking capabilities based on Naval mission requirements.

We will scale up the Naval AI infrastructure and refine requirements incrementally by drawing from findings and feedback from demonstrations, pilot projects, and learning from the experiences of operating forces. We will also draw from technological advances by industry, academia, and other nations. Naval computing infrastructure acquisition decisions and the Naval data strategy will be designed to capitalize on exponentially increasing computing power and data storage options becoming available at decreasing prices.

ADAPTING FOR AI

Agile experimentation and management mechanisms within an adjusted organizational structure will be needed to rapidly adapt. This includes taking an **iterative approach** that identifies needs and possible solutions, assesses risk, informs policy, and translates to changes at strategic, operational, and tactical levels**.** The Naval enterprise needs to adapt to ensure that practical, effective AI solutions are available to Naval operational forces and institutions.

DON will need to reorganize and create new leadership and organizational structures to address the institutional requirements of leveraging AI as they are identified. This can include DON-level management of data and information requirements, down to changes to tactical unit staff structures to reflect increasing use of and partnering with autonomous systems. As unity of command is a DON principle, we will also need to identify who is responsible for rapid and effective progress in AI overall, and for assessing progress towards that goal.

We will move forward in the near term by identifying and pursuing AI priorities through the consideration of diverse perspectives together with rapid experimentation that incentivizes appropriate risk-taking. Following historical best practices, we will create innovation groups to spearhead intellectual development in different mission areas and for addressing specific, high-priority problems with AI. The innovation groups will

combine intellectual thinking, operational experience, doctrine and training communities, technology SMEs, and opportunities for experimentation.

We will ensure that the knowledge and lessons gained through these practices—experimentation, prototyping, training, and so on—is leveraged to refine capabilities, requirements, tactics, and operating concepts and to learn faster, including from failure. We will also explore ways to develop, field, and upgrade capabilities more rapidly when needed, including manning, training for, and sustaining those capabilities. Such efforts will include a focus on getting significant input and feedback from operating forces and refining the verification and validation process to address the distinctive features of AI.

WORKFORCE

DON will **draw from leading AI expertise resident in US companies and academic institutions** to solve demanding and pressing national security challenges. We will explore new ways to involve this outside expertise, including rotational assignments and collaborative projects.

DON must also **develop an AI-ready workforce** in order to effectively develop, manage and employ AI solutions. We will build a technical workforce capable of developing AI solutions by addressing training, career pipeline structures, and promotion and retention policies. For the effective management and employment of AI, training and education will be tailored across the Naval enterprise to ensure AI literacy at the senior leader, commander, and operator levels. We will also offer professional development opportunities to build needed capabilities, such as data scientists and engineers, to combine operational and technical expertise in our workforce.

PARTNER-SHIPS

Strong partnerships are essential for the successful adoption of AI by DON. **We will partner with industry and academia, allies, and the other branches of the US Government** in our leveraging of AI.

In an age where industry and academia are leading the government in AI research and development, we must adapt to maximize our ability to collaborate to effectively use the best technologies available. While we build AI capacity within DON, the Department will monitor key AI developments in industry and academia and build agile processes to leverage them. DON will foster relationships with industry and academia to promote cooperation, dialogue, mutual understanding, and trust.

Allies are one of the Naval enterprise's great strengths. We will be deliberate in working together with allies to promote a strong AI alliance. This will involve making the most of collective resources, ensuring interoperability, and pursuing complimentary capabilities to strengthen our security and better address emerging threats. We will work with our allies

at all stages: planning and requirements; CONOPS, system, and policy development; experimentation; and multilateral training.

Finally, the US government has signaled the priority of AI in its 2019 Executive Order and DOD AI strategy. Accordingly, DON will nest its approach with these larger efforts, and likewise leverage both DOD and whole-of-government efforts and relationships to further its effective adoption of AI.

POLICY

While AI stands to provide the Navy broad and significant advantage, its use can also raise legal, safety, and ethical issues. The Naval enterprise is committed to carrying out its missions **legally, safely, and ethically**; it will pursue these goals as it adopts AI with existing and new policy and legal mechanisms. For example, DON currently has legal and ethical review and safety processes in place that apply to operations and weapons systems. On top of these measures, we will develop and refine policy as needed to proactively address AI-specific areas where legal, ethical, and safety issues could potentially arise. Additional policies may include: new privacy considerations, checks against inadvertent bias, additional criteria for legal weapon reviews, additional validation and verification measures for AI-enabled systems, ethical requirements for training data used in machine learning applications, and policy guidance on system development and operational usage of AI-enabled capabilities (akin to DODD 3000.09). We will also actively contribute to DOD-wide policy.

SUMMARY

DON will prioritize the effective adoption of AI within the Naval enterprise, as we recognize that this is an imperative for outmatching adversaries and offers opportunities including reducing risk to mission and risk to forces, improving Naval decision making, and improving efficiency. DON will employ an approach to AI adoption that is rapid, problem-driven, and includes a focus on identifying and mitigating risks, with the commitment to mission, law, safety and ethics that marks the professionalism of the Navy and Marine Corps.

Abbreviations

AI	artificial intelligence
CNO	Chief of Naval Operations
DOD	Department of Defense
DON	Department of the Navy
DWO	Digital Warfare Office
EO	executive order
JAIC	Joint Artificial Intelligence Center
MCWL	Marine Corps Warfighting Center
NIST	National Institute of Science and Technology
NRL	Naval Research Laboratory
ONR	Office of Naval Research
OODA	Observe-Orient-Decide-Act
QRP	Quick Response Project
R&D	research and development

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