Naval War College Review

Volume 72
Number 4 *Autumn 2019*

Article 7

2019

The Future Navy—Near-Term Applications of Artificial Intelligence

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NEAR-TERM APPLICATIONS OF ARTIFICIAL INTELLIGENCE

Implementation Opportunities from Modern Business Practices

Christian H. Heller

Secretary of Defense James N. Mattis made headlines in early 2018 after stating that artificial intelligence (AI) may change the "fundamental nature of war," a groundbreaking premise that could alter the principles of warfare and centuries of military thinking.[1] War has been and is meant to be a human endeavor to achieve human ends. AI poses the challenge—or opportunity—of altering that premise. The common picture of AI in warfare raises images of self-directed drones in the sky attacking targets of opportunity at their own discretion; armies of intelligent android warriors in the fashion of *I, Robot;* or an all-powerful supercomputer dominating humankind, reminiscent of the *Terminator* and *Matrix* franchises. While these images from science fiction portray a possible distant future, just as H. G. Wells did with *The War of the Worlds,* the practical applications of AI involve intricate and redundant tasks that augment human involvement and increase humankind's own abilities and productivity. Rather than replace human participation in war and national security activities, AI supports human beings to make us better at defending the country.

This AI-augmented world is no longer a futuristic discussion. Spurred on by private business and the innovations of Silicon Valley, the world outside the Pentagon is developing new and better uses for AI at exponential rates. The Department of the Navy (DoN) needs to harness the progress of private development in the field of AI, not as an optional benefit or high-speed capability, but as an institutional imperative to maintain superiority

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Naval War College Review, Autumn 2019, Vol. 72, No. 4

Naval War College Review, Vol. 72 [2019], No. 4, Art. 7

over our nation's enemies. The numerous near-term applications of AI can be implemented today to lay the groundwork for the future of maritime forces and institutions. The first place to implement new technology is in the support functions and noncombat specialties of the Navy and Marine Corps. Current business practices can be implemented within the DoN to reduce costs, increase efficiencies, generate new capabilities, and reduce manpower requirements in noncombat roles, which would increase the number of sailors and Marines available for deployments and operations.

This article begins with a brief review of the status of AI research and development (R&D), existing capabilities, and areas in which private industry is pursuing new opportunities. Second, it will examine the current policy of the Department of Defense (DoD) toward AI implementation. Next, the article will propose nine applications from current business uses of AI wherein the technology could benefit the Navy and Marine Corps. It concludes by demonstrating that integrating AI into the DoN may be a large task, but it is not impossible. By relying on previous examples, the Navy and Marine Corps can institutionalize AI technologies and ensure our ability to respond adequately to the full range of military operations in the future.

Marine Corps lieutenant colonel Earl Hancock "Pete" Ellis's work on amphibious warfare—one of the most important maritime developments of the twentieth century—only led to success in World War II because of the years of preparation, refinement, and experimentation that the Navy and Marine Corps committed to it prior to Pearl Harbor. The same concept holds true today with AI. The groundwork for operations with AI can—and must—be laid today, or the naval forces of the nation will be left unprepared for future missions.

DEFINITIONS OF ARTIFICIAL INTELLIGENCE

The definition of artificial intelligence has changed many times since the first conference on AI at Dartmouth College in 1956, at which researchers joined together to theorize about the combination of robotics, neural networks, and programming.[2] One current definition describes AI as "an entity (or collective set of cooperative entities), able to receive inputs from the environment, interpret and learn from such inputs, and exhibit related and flexible behaviors and actions that help the entity achieve a particular goal or objective over a period of time."[3] Another states that AI is the ability to "teach computers to parse data in a contextual manner to provide requested information."[4] The many definitions of AI continue to evolve to define more-specialized subcategories of the field, but each is useful for providing guidelines and goals for researchers.

AI is a self-teaching machine. Rather than a program with set inputs and outputs that runs consistently, AI teaches itself and changes as its environment

changes. Cellular phone assistants are examples of simple AI that still require human input. For instance, Apple's Siri application can perform many activities and searches through preprogrammed procedures. However, it requires human input in the form of software updates, patches, and reprogramming as the world changes around it. In contrast, more complex AI learns these changes for itself, similar to how the human brain works. For example, if you were to wake up in a room you have never seen in a country you have never been to, your first instinct would be to ask questions, look around, and explore. AI is designed to learn from unused, unsorted, or new information in the same way. As Army lieutenant colonel Patrick Sullivan states, AI is the "ability of computers to learn from data, as opposed to being explicitly programmed."[5] AI involves far more than simple mathematics and programming, and thus, researchers require knowledge in areas such as logic, philosophy, and physics to create a self-learning device.

Structures and Types of AI

An AI system has four layers, which interact with each other to mimic human intelligence. AI itself can be imagined as the topmost layer, which absorbs, stores, and processes information to make decisions. One layer below, the AI relies on machine learning, which allows it to "learn and act without the need for human input." The third level down is deep learning, which contains the AI's ability to process images, speech, and language. Finally, the bedrock of the AI system is the neural network, which processes data. The most opportunities for new research exist in this neural-network layer. While the human brain has over one hundred billion neurons, the most advanced AI available today only has about one billion neuron equivalents.[6]

Artificial intelligence is divided into two major categories. *General AI* attempts to mimic the human brain in completely autonomous thought, while *narrow AI* is the creation of smart computers to solve complex problems.[7] General AI does not exist yet, but substantial and increasing progress in the field of narrow AI provides enormous opportunity for the eventual creation of general AI. AI, as many understand and use it today, is narrow AI. For example, narrow AI is used on most commercial passenger planes. On Boeing 777s, pilots only spend about seven minutes out of every flight manually flying the plane, while Airbus pilots manually fly about three and a half minutes of every flight.[8] IBM's Deep Blue and Watson projects are both advanced versions of narrow AI that have received much attention over the past years. Amazon's Alexa and Apple's Siri are both examples of narrow AI beginning to make regular, continuous changes to people's lives. Importantly, when examining the feasibility of the Navy and Marine Corps using AI, one must remember that an iPhone or Amazon user need not know anything about computer programming, networking, or search logics

to use these functions. The operating system is designed to function with inputs from the average user.

These advances in narrow AI serve as an important bridge to the development of general AI. Advanced progress in narrow AI can be used with human-in-the-loop (HITL) systems for "expanded human potential."[9] Indeed, while AI systems have beaten world-class chess players on numerous occasions, the greatest success is achieved when an AI is paired with a human.[10] In an HITL system, human decisions and operations are advanced through integration with AI, such as in flight-simulation trainers. An HITL system requires a human user working with the AI and making decisions on the basis of AI recommendations. The system empowers human interaction with the AI, and the platform can be designed to defer some or all decision-making to human operators. In fact, many argue that combining humans and AI creates optimal decision-making outcomes.[11] Unmanned aerial vehicles and other intelligence, surveillance, and reconnaissance (ISR) platforms operate with these designs.[12] DoD believes that both HITL and human-on-the-loop systems—in which a human becomes involved to override the system when necessary—will play a role in future military applications of AI.[13]

Important developments in artificial intelligence are taking place within machine learning and deep learning, two different programming processes with different intents. *Machine learning* is the process by which a program can search through large amounts of data, learn from it, and apply it to make and recommend informed decisions. The concept can be applied to any scenario in which the AI is able to carry out a certain function with a given data set, and the AI becomes better at that function over time. Machine learning already is used in programs such as music-streaming services and data security. *Deep learning,* by contrast, is machine learning that can learn new functions and refine its existing functions without human interference. Deep learning is demonstrated best by the following example of a flashlight: "[The flashlight] could be programmed to turn on when it recognizes the audible cue of someone saying the word 'dark.' Eventually, it could pick up any phrase containing that word. Now if the flashlight had a deep learning model, it could maybe figure out that it should turn on with the cues 'I can't see' or 'the light switch won't work.'"[14]

Both deep learning and machine learning require large data sets to be effective. As explained by the layers concept earlier, AI by itself does nothing. The ongoing "big data revolution" creates more information in one day than ever has existed in the history of humankind and creates a situation in which humans are physically unable to parse through it to reach the best conclusions. Large, organized data sets combined with appropriate AI tools have the potential to refine and alter warfare and war-fighting institutions to the benefit of the wager—in this case, the Navy and Marine Corps.

Public Use Leads to DoN Application

The best examples of artificial intelligence that can apply to the DoN are those that members of the public already are using effectively. Simple AI programs are all around us. Google Maps uses AI to program the most-efficient routes for drivers. Chatbots such as Siri, Alexa, and Microsoft's Cortana are AI applications that have advanced considerably over recent years and continue to learn and refine their output to support the personalized needs of their users even better. AI can act as an "intelligent salesman," providing personalized sales recommendations to customers—also known as smart advertising. Organizations such as ride-sharing company Uber Technologies use dynamic pricing—accurately pricing a commodity or service between supply and demand.[15] More advanced AI tools that can benefit the DoN are being created every day. For example, AI engines now are able to create fake video with realistic images and sounds. One example of this was researchers at the University of Washington using AI to create a realistic but fabricated video of former president Barack Obama giving a speech.[16]

A more ambitious example by one of the most well-known AI systems provides insight into the pace of AI development. IBM's Watson has the capability to provide "personality insights" derived from various means of communication. Using linguistic analysis, Watson can determine personality characteristics from media channels such as e-mail, text messaging, and Twitter. Business uses the service to determine an individual's likely attraction to various products or services, but the Navy and Marine Corps could use it to gain insight into an individual's actions and thoughts relevant to warfare. Watson categorizes a person on the basis of what IBM calls the big five personality traits (each of which has six different specific facets), twelve different individual needs, and the values that specific individual might hold.[17] The system is remarkably accurate. During an experiment in which a famous individual's speeches and statements were played for Watson, the AI accurately provided personality profiles. For example, Martin Luther King Jr. was characterized as empathetic, self-controlled, difficult to embarrass, desiring prestige, attracted to helping others, and unconcerned about traditions.[18]

THE DEPARTMENT OF DEFENSE AND ARTIFICIAL INTELLIGENCE

DoD has made strides in the right direction with AI and other emerging technologies. AI is the topic of many discussions, roundtables, panels, and research proposals. In June 2016, the Defense Science Board (DSB), a technology advisory committee for the Secretary of Defense, published its report on the state of autonomy as a field and its future potential. The report recognized the rapid advancement of the technology and its "high-value capabilities." It recommended that DoD accelerate its adoption of autonomous systems, while also expanding the types of technologies that DoD elements have available for missions. Most

military uses for unmanned systems today involve remote human operation rather than true AI employment. Expanding the role of AI can magnify the benefits of the system. Not only does the integration of greater AI autonomy reduce casualty rates of U.S. personnel, but such systems can adopt riskier tactics; target with greater accuracy; and operate with greater endurance, range, and speed while retaining a greater level of flexibility and mobility. For perspective on how widespread these applications could be, DoD's eleven thousand unmanned aircraft currently make up 40 percent of the total number of U.S. military aircraft.[19]

The DSB's report highlights six different mission parameters to consider when determining the applicability of AI. These parameters are speed of decision-making, heterogeneity and volume of data, quality of data links, complexity of the action, danger of the mission, and required persistence and endurance. AI can be a critical component in missions with high or complex levels of these parameters, such as cyber operations; missile defense; data analysis; ISR data integration; contested communication or operations; unmanned vehicle operations, including unmanned undersea operations; air operations center activities; multimission operations; and chemical, biological, radiological, and nuclear attack cleanup.[20]

DoD's budget gives some impression of where initial inroads into AI research are heading. For 2019, the Air Force allocated $87 million to experiment with AI for wargames and field training, while the Army allocated $6.5 million for training purposes, to include simulations and virtual reality. The Navy set aside $6.5 million for similar training purposes, in addition to experimentation for combat purposes. The Navy, through its rapid prototype development program, is using $49 million to apply AI to combat systems, such as new submarine combat assets. The Marine Corps has allocated $7.1 million for an unmanned warning system to provide commanders with increased situational awareness.[21] The Army plans to field new unmanned combat systems by late 2019. The system, dubbed the next-generation combat vehicle, will be assigned to operational units in 2021. The intent is to replace both the M1 Abrams tank and the M2 Bradley infantry fighting vehicle with the new system eventually.[22]

Regardless of research and new systems, DoD policy mandates strict human oversight of any autonomous or semiautonomous weapons systems. Weapons systems "shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[23] As new hardware is developed and combined with AI, tight restrictions on the use of force are appropriate. However, as development of previous systems, such as the MV-22 Osprey, was plagued with difficulties and setbacks, so too will AI encounter training challenges—and potential fatalities.[24] These weapons systems are still years away from regular use in the DoN. Research should continue, as their impact on future warfare will be vital. But there are numerous examples of AI from industry

that can be implemented today because they are not connected to armaments, and therefore do not face the same complex ethical and policy questions as lethal autonomous assets.

NEAR-TERM AI APPLICATIONS FOR THE NAVY AND MARINE CORPS

By examining current business uses of AI, we can discern many prospects for implementing it to support the Navy and Marine Corps. Future autonomous weapons systems and combat technologies aside, the near-term applications of AI can make the Navy and Marine Corps more responsive, flexible, and deadly. Since narrow AI—which exists throughout industry, as mentioned in the previous sections—is simply the composition of "machine-learning solutions that target a specific task," the technology can be applied to a range of functions, especially in routine noncombat processes.[25] These near-term AI applications can reduce costs, free up manpower to support new units, and lay the requisite groundwork for the full-scale adoption of complex AI systems in the next decade. Currently functioning AI systems can be used to support administration, personal productivity, planning, logistics, crisis response, training, intelligence, force protection, and force structure. This section will examine each of these possibilities by applying current private industry practices to DoN functions.

Administration

Administration is one of the primary support functions within the Navy and Marine Corps that can be revolutionized through AI. Numerous companies already use AI to assist with information-input management, which involves processing "incoming mail, e-mails, invoices, spreadsheets, presentations, PDFs, and other documents." The system benefits from the digitization of information in the modern age. AI can help with the preprocessing of information (i.e., who needs this information and how does it reach them) as well as the maintenance, categorization, and later use of it. One example is an insurance provider in Germany that uses IBM's Watson to identify topics from e-mails and letters and route them to the correct internal departments within the organization. Global logistics companies are using AI to assist with internal functions such as accounting, human resources, and information technology. AI can work with robotic, rules-based processes, such as filling in forms and accessing data, to be a force multiplier for administrative work. Accounting and professional services firm Ernst & Young estimates that 65 percent of human resources rules-based processes can be automated using a combination of AI and robotics.[26] Because both the Navy and Marine Corps are inundated with documents and correspondence, AI can have a direct impact on their efficiency.

The use of AI to provide customer support and feedback is prevalent in private business. Fast-food restaurant chain Taco Bell has a virtual customer representative usable via online collaboration tool Slack, and HP's Print Bot AI is available through social media platform Facebook Messenger.[27] Even more impressive, Print Bot was developed in only three weeks.[28] Disney released a Miss Piggy chatbot prior to the release of its updated *Muppets* television show to spark interest and garner reviews.[29] Companies such as Cogito combine AI and behavioral science to provide real-time guidance for customer representatives to help foster better interactions and relationships.[30] For the services, such guidance could streamline administrative interactions, especially for deployed forces or among different commands. Digital representatives from Navy or Marine Corps headquarters or a deployed unit's parent command could be seconds away with answers and insight. The technology also has the potential to provide better communication with partners, support bilateral and multilateral operations, and foster more-effective mission outcomes.

The automation of human tasks by AI systems expands beyond user interaction. The development of computer vision technology holds promise for areas such as administration, but also intelligence (discussed later in this article). AI-based computer vision can learn from documents, images, and videos to record patterns and adapt output measures.[31] AI is already capable of generating written reports for news agencies. News outlets such as the Associated Press (AP), Fox, and Yahoo use platforms from Automated Insights to write stories about earnings reports and sports recaps.[32] Its main AI-writing platform, called Wordsmith, is a natural-language-generation platform that turns data into written comprehensive text. The program allowed the AP to publish twelve times more stories in a specific topic area with fewer errors and greater efficiency.[33] The computing and technology company NVIDIA uses Wordsmith to streamline its reporting procedures and turn data into usable forms. The information is used to create instantaneous, comprehensive reports that team leaders can use to drive decision-making.[34] As a final example, social media giant Facebook built DeepText in 2016 to read and understand human communication in text form. The program reached "near-human accuracy" at the pace of thousands of Facebook posts every second and can be used in twenty different languages.[35]

AI data-analysis capabilities can free administrative sections from performing certain work and reduce manning requirements, while still accomplishing the same tasks. Since AI can learn to standardize documents, accomplish repeated tasks, and analyze data much faster than humans can, AI is suited to support perfectly the administration functions of the DoN. The list of possibilities for DoN implementation is almost endless: processing command check-ins and checkouts, facilitating awards write-ups and processing, executing search and

creation of policies and orders, authorizing travel, routing lists, disseminating white papers, and many more. Units teach new administrative clerks to accomplish these relatively routine tasks, but an AI mechanism can learn and perfect them in a shorter period.

One potentially overlooked administrative area of AI influence is energy usage. DoD spent over $15 billion on energy in 2015.[36] Even minimal reductions in facilities' consumption (such as air-conditioning and electricity) can have monumental cost savings. In one example, the Marine Corps Resident Energy Conservation Program implemented a network of centrally tracked energy usage monitors to reduce residential unit energy consumption by 12–15 percent and save $4 million.[37] AI-controlled large-scale heating and cooling systems on DoN installations could save tens of millions of dollars annually. In private residences, the Nest Learning Thermostat program is an example of AI drastically reducing energy costs for consumers by reducing heating bills by up to 12 percent and cooling bills by 15 percent.[38]

Personal Productivity

Increases in the daily personal productivity of DoN personnel can reduce man-hour requirements and generate institutional efficiency at the individual level. Existing AI platforms already can organize, write, and disseminate correspondence for their users.[39] Advances in speech recognition also hold enormous promise for personal productivity. Speech-recognition capabilities can be used for authentication, instructions, planning, production, and coordination.[40] Hours spent creating and editing documents, approving forms, passing documents through checklists, and sharing information vertically and horizontally could be reduced each day. These additional free hours could allow for greater productivity at the individual level and greater opportunity for responsibility at the unit level. At the most positive extreme, never again would a Marine or sailor be refused the opportunity to attend a training school or advanced instructional course because his or her presence at work was indispensable. The AI, which had been tracking that individual's work for months, would be able to slide into his or her place for the duration of the absence.

E-mail, the lifeblood of communication in the modern military, could benefit from the implementation of AI. Google's machine-learning capabilities for e-mail already can sort incoming and outgoing message traffic into different categories by subject and importance.[41] Google's Allo technology went a step further by suggesting responses for the user, on the basis of previous conversations and preferences. Allo tied into Google Assistant, which can provide local suggestions, Internet search results, travel directions, and answers to questions that appear naturally in the user's conversation. Google Assistant also can learn

from the user's preferences and needs to assist with tasks such as purchasing airline tickets.[42]

These information-processing AI systems can be tailored for specific industries. AI platforms are used in the health-care industry to process doctors' notes, reports, and patient files and compare those inputs to research studies and clinical databases to diagnose patients and propose treatment paths.[43] If such systems are capable of diagnosing and providing treatment for kidney failure and cancer, the same systems can be used for managing schedules, operations, training plans, and unit development. Digital personal assistants also could be used within and among commands to better exchange information, schedule meetings, plan agendas, and coordinate efforts.

Planning

The first unofficial rule of planning in the military is to ask the question: "What did they do last time?" Many leaders at all levels of command express frustration over lack of coordination between departments, inadequate duty turnover, and loss of long-term knowledge when vital personnel retire or redeploy. AI poses a solution in the form of a robust search function. Google has nearly perfected search techniques using a process called RankBrain. The AI remembers what other users asked for before and the eventual end locations of their searches. It then applies that knowledge to the next search having similar inputs.[44] When tasked with a new planning assignment—whether it be for range training, an exercise, or a full operation—it is likely that similar activities have been planned previously. AI presents an opportunity to harness years of institutional knowledge from parts of the Navy or Marine Corps that the searcher never may have known existed, all by saying, "I'm planning something like X-Y-Z involving A-B-C. Has this been done before?" Not only can the AI return useful options for aiding the planners, but it also can compile them automatically into a convenient format for easy mental ingestion. Leadership principles across the services call for the one-third–two-thirds rule of planning: one-third of the time for the leader, two-thirds of the time for the subordinate units. AI could transform this into a one-tenth–nine-tenths rule.

AI systems, in conjunction with humans, can support risk management and financial planning. Data analytics company FICO uses AI to assess individuals' credit scores and determine the level of risk they represent. FICO has used such systems for over twenty-five years for credit decisions, fraud prevention, and cyber security.[45] Wealthfront, an automated financial management and investment service, manages billions of dollars using AI.[46] BlackRock, one of the world's largest investing firms, uses artificial intelligence for "heavy cognitive lifting . . . to tease out patterns that might remain obscure to human eyes and brains."[47] Such

capabilities could save millions of dollars from the DoN budget by determining inefficiencies, identifying discrepancies, managing accounts, and providing more-exact financial estimates for mission planning.

The general area of suppliers and contracts provides opportunities for additional cost savings. Private companies are using AI to assist with conducting negotiations and drawing up contracts. SAP CoPilot, an AI with a chatbot-style interface, supports a business as a digital assistant to interpret documents and act on behalf of the user. The system then can provide the user with information and options in a simple manner. The platform has the potential "to help users make informed decisions based on complex data analysis that's done in real-time."[48] Deloitte, one of the world's largest tax accounting and consulting firms, partnered with Kira Systems to develop an AI that can analyze thousands of tax documents.[49] The software then structures the information in a usable form that identifies the most important clauses and segments.[50]

The most arduous step of military planning—orders development—could be streamlined with AI. Writing hundred-page documents with a nearly limitless number of annexes, appendices, and tabs has plagued staff officers since at least the Byzantine Empire in the tenth century.[51] In only three weeks, Booz Allen Hamilton (BAH) developed its prototype Tabletop Commander program, which can process an entire operations order and convert it into a "visually pleasing, realistic" interface for the recipient to use.[52] The service could be especially helpful for amphibious ready groups (ARGs) and Marine expeditionary units (MEUs) operating in constantly changing environments.

Logistics

Transportation, logistics, and supply capabilities stand to benefit most immediately from advances in AI. Google Maps provides the most basic example of the harnessed power of AI by using location and transportation data from thousands of smartphones to plan optimal transport routes. Uber also uses such programs to determine the most-exact arrival times, travel times, and pickup locations. Commercial and logistics aircraft harness AI for use in mechanical processes such as autopilot and route planning, to mitigate disruptions.[53] Tesco, a Britain-based multinational grocery store, uses AI to manage its own logistics chain and help its customers. After the company's creation of a massive "data lake," an AI system now routes drivers, manages stock levels, and controls customer-integration applications. The system can track frequently purchased items and usage of those items and plan restock times, so as to maintain uninterrupted flows of products for both retail stores and their customers.[54] Ocado, the world's largest online-only grocery store, uses similar technology to manage its own stocks as well as the systems for several large online retail businesses.[55]

In the logistics industry, courier and parcel company DHL Express and IBM collaborated on a project exploring the current and future uses of AI. AI and logistics are natural partners since "the network-based nature of the industry provides a natural framework for implementing and scaling AI," which helps amplify "the human components of highly organized global supply chains." Some companies, such as Leverton, use AI to process and classify thousands of contracts, clauses, policies, and signatures, allowing documents with hundreds of pages to be completed in a fraction of the time necessary for human processes. DHL uses forecasting AI to analyze fifty-eight parameters and assist with proactively mitigating air freight travel delays. DHL has used an intelligent-routing AI called SmartTruck for over a decade to feed real-time travel information to its drivers. Furthermore, the company uses AI to manage its supply chain, ensure continuity, and minimize problems arising from poor labor practices and material shortages.[56]

Managing infrastructure is easier with AI. Engie, a French electrical company, uses AI-driven image processing, along with a drone fleet, to monitor infrastructure throughout its regions.[57] The company uses this technology to focus on high-value assets, such as gas and wind turbines, to monitor their status and predict maintenance cycles, which results in better efficiency and profitability.[58] The DoN could use these capabilities for monitoring vehicles, fleets, buildings, bases, and operational areas.

Maintenance and supply networks can benefit from the implementation of AI regulation systems to support human decision-making. General Electric (GE) uses smart sensors networked with AI throughout its equipment to detect issues and minimize downtime.[59] In the span of fifteen years, GE has progressed from monitoring equipment for failure using gauges and human intuition to using advanced AI that can predict failures in advance. GE harnessed the ability of online training programs to expand data-analytics training to members of its workforce of three hundred thousand.[60] The restaurant facilities management company ServiceChannel uses AI to monitor real-time inputs from its 1,500 facilities and one hundred thousand team members to determine the status of equipment, repairs, and ongoing operator functions.[61] Data points from over seventy million maintenance transactions compose the core inputs into the company's "decision engine," which helps managers make choices regarding pricing and assets.[62] Siemens monitors systems with its MindSphere, which tracks tool and drivetrain status and predicts when preventive maintenance will need to be completed.[63] These systems could reform military supply and maintenance structures monumentally, for both ground and aviation assets, especially at a time when aircraft maintenance issues continue to make monthly headlines.[64] For direct aircraft applicability, GE and Infosys already use AI-powered applications on a platform

called Predix to predict when landing gear on commercial planes will need repair and refitting.[65]

Travel-booking website Expedia incorporates different programs and databases into a single, centralized channel, which provides insight into additional uses of machine learning. Expedia's platform hindrance was an "unbounded computer science problem" because of the constant change in the inputs to its central system from other sites. Expedia uses an algorithm that has been tracked against human actions and purchases to predict optimal outcomes, and has perfected itself over years. One of the main challenges it faced was how to process inputs in different languages for its multinational business. For example, if a user in Spain is searching Expedia in Spanish for flights in Japan, how does the internal AI system search travel platforms in Japanese? The system's ability to overcome these difficulties illuminates potential in the Navy for interfacing with global supply and logistics systems as well as with partners and allies for overseas operations. Just as Expedia handles continuous changes in the inputs to its system, so could DoN logistics-planning and global tracking systems benefit from constant evaluation of hundreds of isolated, changing conditions.[66]

Crisis Response

AI systems already are helping organizations respond to humanitarian disasters and emergencies. According to the National Oceanic and Atmospheric Administration, fifteen events caused over $22 billion in damage within the United States alone in 2017.[67] Even nominal increases in disaster response efficiency or accuracy can result in immense economic and human benefits. AI systems are used to collect data in time sequences to track changes in disaster-stricken areas for generating damage claims and publishing images for media outlets and first responders to use.[68] Artificial Intelligence for Digital Response (AIDR) won the 2015 Open Source Software System Challenge for its application of AI to emergencies and humanitarian crises.[69]

The AIDR platform uses AI to sort through and categorize thousands of social media messages per minute into different categories for action, such as medical needs or sheltering.[70] AIDR then can help disaster-relief managers direct their efforts to the areas most desperately in need of aid, as well as to apply the correct types of aid (e.g., food supplies, medical assistance, heavy lift via helicopters) to the areas where they are required. AIDR was used in Nepal during 2015 to categorize requirements on the basis of urgent needs, infrastructure damage, and resource-deployment needs. Similar applications of AI were used in Chile during the 2015 earthquake near the city of Illapel. AI triggered evacuation warnings and disaster alerts to move thousands of citizens away from the affected areas. Other AI-driven systems hold promise for crisis response and military application in

general. 1CONCERN is a mapping tool used to create a "common and comprehensive picture during emergency operations," and to date it has analyzed almost eleven million structures and covered over thirty-nine million people.[71]

Often, in times of disaster when public services and infrastructure fail, social media platforms are the most accurate and most answerable form of information for on-the-ground aid workers. Social media can assist experts in conducting initial damage estimates, determining which populated areas were hardest hit, and helping rescuers locate victims. The ability of AI to sort through thousands of videos, pictures, and posts helps response teams map out disaster sites, provide early warnings of new disasters, and verify reports in real time.[72] In military terms, the combination of AI, social media, and drones could create a "common and complete picture for emergency operations centers," thus aiding and amplifying a commander's command-and-control capabilities.[73]

Training

Military training evaluations are notorious for their lack of reality. Existing AI capabilities for the creation of data—photographs, videos, written text, and three-dimensional displays—can magnify the efforts of existing small opposing forces (OPFOR) and simulated enemy forces often called Red Cell sections.[74] Training events involving communication, such as calls for fire, close air support, casualty evacuation requests, and execution checklists, can be made randomized, realistic, and challenging. Realistic and immersive decision-making exercises, information-processing evolutions, and instructional methods can be created and refined whenever needed. An OPFOR AI learns when students begin to exhibit predictable patterns and where continuous mistakes are made, and simultaneously refines the training evolution to address those problems.

WalkMe, a software training platform, uses AI to develop customized learning plans for users to take advantage of their talents and learning styles.[75] The AI system guides the learner through the new software and adapts the speed and depth of instruction to the learner's abilities. WalkMe AI uses predictive analytics, which employs hundreds of different measurements collected in real time, to determine the chances that a user will continue a program or stop.[76] Such programs could be used to enhance professional education and training such as distance and resident professional military education programs and military occupational specialty (MOS) training. The system also could be used for general force readiness to encourage Marines and sailors to focus on fitness training and health programs while away from work.

Video game developers have been leaders in AI research for years as they have made more-realistic, more-exciting challenges. Series such as *Call of Duty* and *Far Cry* contain advanced enemy AIs that can make decisions on how to interact with their environment and employ tactics with the best chance of success.[77]

Consultants from BAH predict that AI and data science will create a new wave of immersive training opportunities for the military. The company's eight hundred data scientists, including some hired from firms such as Nintendo and Disney, are working on different training projects. Two examples of these projects are to turn dense operational and training manuals into easily accessible forms and to create digital C-130 gunship trainers from thousands of real pictures.[78]

At the 2017 conference of the National Training and Simulation Association (NTSA) in Florida, AI industry experts and military officials discussed applications of AI for military training. NTSA president and rear admiral James Robb (USN, Ret.) discussed one potential option: the use of big data and AI to collect data from exercises and process it to "replay, improve performance, and give feedback to trainees." Tony Cerri, a director at U.S. Army Training and Doctrine Command, proposed that the combination of AI and big data for simulation could be "an unbeatable advantage for not only the nation but our DoD and where we're trying to go."[79] Because the battlefields and combat scenarios of the future will be increasingly complex and difficult to navigate, the potential to use AI for crafting "realistic, intelligent entities in immersive simulations" can provide the advantage the Navy and Marine Corps need, especially for operations in the contested littorals where future battles will be fought.[80]

Intelligence

Intelligence-collection systems already are overwhelming institutional capacity for sorting and analysis. Future intelligence operations will provide even more data points from which it will be progressively difficult to "discern the truth." The current U.S. Intelligence Community collects more data in one day than its entire workforce ever could analyze. Military deception (i.e., lying) will become easier for both allies and adversaries.[81] Locating an enemy's critical assets and high-payoff targets will become increasingly problematic with each passing year. In the realm of intelligence collection, much research and work already have focused on new "swarm" techniques to eliminate an adversary's ability to hide.[82] In response, Paul Scharre from the Center for a New American Security explains that "ultra-cheap 3D-printed mini-drones could allow the United States to field billions—yes, billions—of tiny, insect-like drones." AI, combined with new collection platforms, can streamline intelligence operations. Bruce Schneier from Harvard University contrasts emerging collection capabilities to those of the "exceptionally paranoid" East German secret police. While one out of every 166 citizens of East Germany was a spy, corporations today can use digital surveillance to track billions of people with minimal staff.[83] Organizations such as Facebook and Google, as well as global marketers and political consultants, already employ such techniques.

AI assistance to intelligence also can be applied to tracking and targeting. Private institutions such as the Zoological Society of London (ZSL) are using

these capabilities. ZSL uses a Google Cloud machine-learning program to track animals using cameras and image analysis. The cameras and AI use the motion of both animals and humans to identify threats from poachers. ZSL analysts previously had to sort and document all information manually, activities now done by AI. The AI exploits approximately 1.5 million different images and also is adapting its system to document conservation details in categories such as geographic regions and environmental impacts.[84]

AI has led to growth in imagery analysis. The consulting firm Accenture awarded online social network Pinterest its 2017 Technology Vision award for its use of AI. Pinterest uses AI to run its image-recommendation system, which discovers items similar to what the user is trying to find. In 2017, Pinterest introduced Pinterest Lens, which uses photos that users take of objects both online and in the real world and then helps them "identify, buy or create" such items. Pinterest Lens is a bold step that attempts to bridge the divide between the digital and physical worlds.[85] Such technology could be applicable in both data collection and analysis for the Navy and Marine Corps. For instance, a collection element could photograph an object from a distance and both the team in the field and the staff in the rear could benefit from an instantaneous match to the hostile platform and its capabilities.

Just as AIs can be programmed to learn from tax documents and contractual agreements to sort out details, the same AIs can be programmed to sort through operations orders, databases, mission briefs, status-of-forces agreements, DoD policies, planning doctrine, and historical records to generate ideas and propose courses of action for commanders. Intelligence preparation of the battlefield can be nearly instantaneous. While military operations never duplicate themselves, they often remain similar. Maritime intelligence, an ever-complex and unbounded realm, still displays patterns. For example, ships move through prescheduled cycles of maintenance, training, and operations. On-site monitoring of how these cycles apply to adversarial nations requires maintaining a high force presence in contested areas, but AI engines with large-scale data sources can guide the application of scarce DoN assets for efficiency and cost while still meeting the ISR needs of the fleet.[86]

Force Protection

AI-centered computer-vision technology could be used for security and base access. Providing base security constitutes a major use of manpower on naval installations. AI could augment gate-security guards by providing approval or denial for both vehicles and individuals. The system could assess the risk applicable to new persons requesting access, determine access approvals, and increase security measures on an installation as needed, depending on internal and external threats. Photo and speech recognition can provide an additional security

layer when deciding on access.[87] One 2015 estimate stated that digital assistants for businesses would be able to know individual customers by both voice and face by the end of 2018.[88] Security applications likely will follow in stride.

The Transportation Security Administration is implementing AI to improve the efficiency and effectiveness of screening methods in U.S. airports significantly. The Dynamic Aviation Risk Management Solution will be used to customize security levels for individuals, as determined by their "risk categorization" and flight patterns. The long-term goal is a "tunnel" that registers and screens individuals as they walk through en route to their gates.[89] A similar system could streamline base and facility security to a level requiring little, if any, human involvement.

Mobile and roaming robotic collection platforms can harness AI for force protection. Roomba, the basic room-cleaning vacuum robot, uses a combination of AI and sensors that are "capable of scanning the room size, identifying obstacles, and remembering the most efficient routes and methods." This AI capability could be used for roaming bases and rear security areas to free up manpower for offensive operations or other needs of the commander. AI security programs could combine roaming AI-instructed sensors with home security–style camera systems such as BuddyGuard and predictive incident-analysis software such as Deep Sentinel to provide comprehensive force-protection measures for naval forces, both in garrison and when deployed in operating environments.[90]

Force Structure

AI has numerous applications for force structure and personnel management within the DoN. For recruiting and force preservation, AI could provide early warning to units and commanders about at-risk personnel. Fama is an AI-based company that screens public personas on social media platforms to detect violent or racist tendencies. An estimated 43 percent of private employers already screen potential candidates' and employees' social media accounts for such traits.[91] In the Navy and Marine Corps, this kind of system could be used for force-preservation, recruiting, and transition programs. The system also could be used for intelligence purposes, to identify key nodes and leaders of networks.

Artificial intelligence is reworking human resources and staffing structures in the civilian world; military organizations could see a similar major benefit from this type of AI. IBM is working to create a new AI platform that answers new employees' most important questions and streamlines the onboarding process so that new employees are more productive. Such a tool would provide immense benefits to sailors and Marines who change responsibilities and are assigned new duties as often as every few months. AI also is being used internally to "track, analyze, manage, and protect" top talent within firms.[92] Enhancing the internal experience within an organization can reduce turnover, retain institutional

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knowledge, and create a more content workforce. Both the Navy and Marine Corps could benefit from a better employee experience to increase reenlistment rates, especially in critical MOSs and difficult billets.

Military recruiting stands to benefit as well. Personal advertisement targeting, such as that conducted by digital marketing firms, can focus a recruiter's efforts to minimize wasted time.[93] AI recruiters in the business community are being applied to correlate employees with their best-suited positions, providing the right benefits, work locations, and development opportunities.[94] Navy and Marine Corps recruiting is a manpower-intensive affair; Navy Recruiting Command involves more than six thousand personnel who are taken away from forward positions in the fleet to perform these important duties.[95] AI not only could decrease the number of personnel necessary but also could reduce costs and help recruiters to be more efficient by targeting strategically chosen candidates. Dynamic-pricing tools can work for both recruiters and career planners.[96] If one candidate needs a bonus of only five thousand dollars to enlist while another needs twenty thousand dollars, AI can adapt those amounts to save money and target the right recruits. If money is not a factor, AI can help recruiters identify a candidate's motivations and appeal to those incentives.

IMPLEMENTATION

Successful implementation of AI into the Navy and Marine Corps cannot be outsourced fully. AI systems and the databases they use are inherently specific to the institutions that incorporate them. AI development leaders and the technology community favor collaboration and open-source platforms, but development from within minimizes vulnerabilities that may appear in the systems. This developmental process must pursue two mutually beneficial paths: in information and technology, and regarding personnel. AI only can reach its maximum effectiveness when the right people are paired with the right data. The more data available for the system to learn, the faster and more efficient the system will be. For successful implementation and growth, the DoN needs military specialists with knowledge of AI, human-AI collaboration, AI-database interworking, AI ethics and policy, and specific subcategories of AI, such as machine learning and deep learning.

Database compilation is a long-term process that should begin today; however, many tools and processes are available now and can be replicated. Various organizations specialize in providing AI support to new and existing businesses by applying specialized expertise to the customer's needs. For example, Techcode's Global AI+ Accelerator offers consulting services to start-ups and established businesses. The company's general manager explains that advances in AI are disrupting core organizational coordination and control processes such

as scheduling, resource allocation, and reporting.[97] Microsoft offers AI tools for developers and information professionals to harness the power of their data. Microsoft Azure lets businesses such as Geico, Heineken, and Adobe empower their already-existing applications and data services with the benefits of AI. The benefit of a prepackaged system such as Azure is its dependability through Microsoft, on which the DoN already relies for other applications. The platform is designed specifically to support various operating systems, programming languages, and databases, and it helps businesses to build custom applications for their specific needs.[98]

Implementing this change in an organization of the size and complexity of the DoN is not impossible. The utility of Azure and its process have been verified. The global shipping firm Maersk adopted Azure for five of its data centers, which led to performance improvement and risk reduction. Previously, Maersk had stored its massive amounts of data in five locations on three continents, each of which had minimal capacity for growth. Performance lagged and employee productivity was reduced severely. The outdated system also suffered from security concerns. The firm set a twelve-month timeline for relocating its data centers and their 14.4 million files, which amounted to an "impossible mission that nobody had done before."[99] But the actual process took only six months and alleviated the company's dependence on vulnerable, unreliable, failing hardware.

Amazon also rebuilt itself around artificial intelligence beginning in 2014. Amazon already used simple AI in areas such as its shipping schedules and warehouse management, but recent advances in computer vision, speech, and language processing allowed it completely to revamp twenty years of institutional structure in a way that "require[d] skills that [Amazon's] team didn't possess, tools that hadn't been created, and algorithms that no one had thought of yet." To design its flagship AI product, Alexa, Amazon worked backward with few restrictions. Blueprints included features that did not exist at the time but would be created along the way.[100] Similarly, with internal expertise, external guidance, willpower from leadership, and a plan of action, AI systems could become ingrained throughout the DoN within a few years.

IBM's Watson provides a top-tier AI system with targeted personnel support and guidance. IBM helps its customers identify the areas where Watson will be most beneficial, then provides specialist support to guide the process along the way. The primary drawbacks to this approach are the time and scale required. Fortunately, the DoN is not dependent on profit margins for its success, and the Navy and Marine Corps are already natural trailblazers in their industries. While the institution certainly faces unique challenges, the process is feasible and the challenge worth tackling. An article in the *Harvard Business Review* proposes gradually implementing AI with small projects and "low hanging fruit."[101]

Companies pick a specific program in which the value is the greatest. This approach could work for the services by initially applying the system to a specific command that would benefit the most, such as an ARG/MEU team, a supply depot, a maintenance facility, or a logistics center. To avoid complications with classifications and multiple systems, AI's initial targets should avoid intelligence units until the organization overcomes early implementation problems.

Finally, internal expertise from within the DoN for implementation of these programs will be necessary, since commercial applications are not tailored for military needs yet. The Army's science and technology community has discovered this situation in its research. Army researchers found that their needs for AI, such as autonomous convoys in rough environments, manned-unmanned teams for ISR targeting, and intelligence analysis, are not yet "of significant interest" to private companies.[102] Ultimately, these business applications provide not a specific solution but rather inspiration and a roadmap that the DoN can use to implement AI strategically throughout its departments.

COSTS AND TRADE-OFFS

Research and development within the Pentagon is often a zero-sum game: if one project benefits, another is hindered. Advances for AI will suffer a similar fate, and the DoN will need to make necessary trade-offs to compensate as it advances. Estimating the lifetime cost for a possible capability still in its infancy—almost certainly inaccurately—would lead to the termination of any accountant involved. Regardless, comparing current investments in AI research with DoD budgets, similar defense contracts, and previous platform procurements can serve as a minimal starting point in building a frame of reference.

In 2017, the U.S. government invested over $7 billion in AI, big data, and cloud storage and computing.[103] Roughly $2.4 billion of the sum went to AI and its largest segments: learning and intelligence, advanced computing, and AI systems.[104] For reference, the president requested $3.2 billion for the Marine Corps alone in fiscal year 2019 (FY19) and $194.1 billion for the entire DoN, both increases from the previous fiscal year. The total DoN budget can be narrowed further to examine the $18.6 billion requested for research, development, test, and evaluation fund (RDT&E) allocations, which includes $750 million for advanced technology development, $891 million for applied research, and $4.3 billion for advanced component development and prototypes.[105] If, at a minimum, the Navy procured 25 percent of DoD's total AI investments, it could imply that only 3.2 percent of the DoN's RDT&E funds went toward AI and associated technologies.[106] Without increases in funding, other naval research projects would need to be trimmed (or sacrificed) to allocate money to AI. The tricky balancing act is ensuring that

cuts are made without impacting the actual weapons and assets that AI would enhance.

The fiscal uncertainties of congressional budgets lead to funding challenges for AI and other new R&D technologies. For instance, while the FY19 budget request included large percentage increases for each service, no new major systems received allotments for acquisition. The Pentagon's request focused on the continued production and refinement of existing capabilities because of the fear that budget increases will not remain high and consistent for years to come.[107] Instead of starting new projects that can be defunded at any time, decision makers erred toward consistency and meeting current mission requirements—an understandable and sensible position. Unfortunately, a focus on current systems means a failure to allocate sufficient efforts toward capabilities for conducting future conflict.

Previous and existing defense contracts also provide insight into the costs of new technologies. The Army's Logistics Support Activity signed a thirty-three-month, $135 million contract with IBM in 2017 to support equipment readiness with predictive analytics from its Watson platform.[108] The Army also signed a $62 million deal with IBM to build, manage, and operate a "private Army cloud data" system.[109] Palantir and Raytheon made national headlines with the award of a ten-year, $876 million contract for an Army intelligence platform, DCGS-A Increment 1.[110] In 2018, BAH signed with the Navy a five-year, $92 million contract ($18.4 million per year) for "cybersecurity, technical, and program management."[111] Standing out among these contracts is BAH's enormous ten-year, $17.5 billion ($1.75 billion per year) contract with the Defense Information Systems Agency to provide a "globally accessible enterprise information infrastructure."[112]

If AI technology in its broadest form is applied to military capabilities, perhaps the best estimation of cost is that of the military platforms and the assets with which Washington projects power. Upgrades to the M1A1 battle tank since 2005 have cost U.S. taxpayers over $4 billion ($438 million per year) through 2018.[113] The DoN is paying $4.3 billion for its next aircraft carrier, USS *John F. Kennedy*.[114] The Navy, Air Force, and Marine Corps combined signed a $1.4 billion sustainment contract for the F-35 in 2018.[115] None of these sums includes the initial research, design, testing, and implementation costs of new capabilities, but they still emphasize the sustained, multibillion-dollar investments required to field unsurpassed American military technology.

Finally, the greatest cost of AI development may be measurable not in dollars spent or the other projects DoN cancels, but rather in the way AI could reshape the world in which the Navy and Marine Corps operate. AI experiments have

demonstrated their worst possible results by teaching themselves both racism and sexism in separate cases.[116] AI also could make it easier for governments and organizations to enforce prejudicial and discriminatory policies on a supranational scale.

AI can be a great force for human development, or it can be a medium through which to act out the worst instincts of humankind. The DoN surely will encounter and respond to both possibilities. On a global historical scale, past periods of industrial revolution and technological advance created stark changes to the balance of power and altered international competition. The development of AI likely will lead to a similar international outcome in which winners reap benefits. The Center for a New American Security breaks down the "key elements of national power" for the world of AI: owning large amounts of useful data, having a large AI-capable human talent pool, harnessing computing resources, creating organizations aligned to take advantage of AI, enlisting public-private cooperation, and being willing to act on AI and its potential. The United States, China, and Russia stand ahead of the pack in terms of these elements, but other technology leaders, such as Israel, Singapore, and South Korea, are not far behind.[117] If these nations achieve usable AI integration for economies and militaries, the rest of the world may be left behind for decades.

The economic boom from countries that harness AI will increase the gap further. The mutual relationships between economic and military power will be "the clearest national security consequence" of the development of AI.[118] Economic gaps will grow wider as AI becomes mainstream for private business. PricewaterhouseCoopers estimates that the economic boon from AI will be $3.7 trillion for the United States and $7 trillion for China, while only $0.9 trillion for Southeast Asia, $0.7 trillion for southern Europe, and $0.5 trillion for Latin America.[119] A lack of economic growth in areas where the Navy and Marine Corps already operate, exercise, and work to develop host-nation capacity may mean that Washington should prepare a long-term plan for multidecade partnerships in these unstable regions.

The presence of artificial intelligence in the war zone is close at hand, and the decades of U.S. technological superiority are coming to an end.[120] This shift should be embraced. China aims to have an AI industry worth $150 billion by 2030. A single technology center in Beijing's suburb received $2.1 billion of investment.[121] In comparison, total Pentagon spending on advanced technology in 2017 was $7.4 billion, only a portion of which went to AI.[122] Investments in R&D are important, but implementation should begin sooner rather than later. While Russian spending on AI remains comparatively low, President Vladimir V. Putin has recognized the field's importance for the future of world affairs,

stating: "Whoever becomes the leader in this sphere will become the ruler of the world."[123] The failure of the United States to invest in this technology—specifically within its expeditionary maritime forces—could mean a dramatic shift in world power.

Autonomous war-fighting machines are still years away, as are the operational applications of swarm techniques, autonomous wingmen for pilots, and general AI.[124] However, the adoption of AI in the model of current business practices offers the Navy and Marine Corps three main benefits. First, if the DoN begins collecting and compiling data now, it will have larger databases from which AI can learn, and larger databases usually result in more-effective AI systems. This process will be time-consuming—the sooner we can begin, the better. Second, fewer DoN personnel will be restricted to the noncombat sector if support functions are transferred to AI. This development frees up manpower for use in new specialties, additional combat units, and forward deployments around the world. Finally, the sooner the DoN can expose average Marines and sailors to AI, the more familiar and comfortable they will become with the technologies. In the future, when the full capabilities of AI are harnessed and implemented throughout the services, the fighting force will be ready to embrace them. As noted earlier, the use of Siri does not require any understanding of computer programming or speech-recognition techniques. It does, however, require the use of an iPhone and its associated applications. A flattening of the AI learning curve means maritime forces will suffer fewer disruptions to their operations and can maintain requirements more effectively over the coming years. The business sector's AI applications provide the best starting points from which the Department of the Navy can accomplish this integration.

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