Infantryman with 3rd Battalion, 8th Cavalry Regiment, 3rd Armored Brigade Combat Team, 1st Cavalry Division, clears bunker September 25, 2019, during platoon live-fire training, Rodriguez Live Fire Complex, Republic of Korea (U.S. Army/Scott Kuhn)

Harnessing Artificial Intelligence and Autonomous Systems Across the Seven Joint Functions

By Brian David Ray, Jeanne F. Forgey, and Benjamin N. Mathias

Although the 2018 National Defense Strategy emphasizes technological innovation as well as the way it will change the overall character of war, the joint force is not adequately positioned to share best practices and lessons learned among key players in the artificial intelligence/autonomous systems (AI/AS) space.[1] To address this shortcoming, joint manning documents across the force should add an AI/AS cell made up of officers, warrant officers, and senior noncommissioned officers in order to effectively incorporate technological best practices across the seven joint functions. This increase of specialized staffing is similar to the approach that the Army took in 2003 at the brigade level with the creation of knowledge management as a distinct discipline

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and staff function.[2] With knowledge management, the Army sought to "help commanders drive the operations process through enhanced understanding and visualization . . . thereby enabling them to envision a set of desired future conditions that represent the operation's end state."[3]

Embracing similar new approaches and techniques in the AI/AS space is in keeping with advice offered by Rear Admiral Andrew Loiselle, the deputy director for Future Joint Force Development on the Joint Staff J7, who stated, the joint force "cannot expect success fighting tomorrow's conflicts with yesterday's weapons and equipment. Neither is modernization defined solely by hardware. It requires changes in the way we organize and employ forces."[4]

This article explores the most likely impacts of AI/AS on each of seven joint functions: command and control (C2), intelligence, fires, movement and maneuver, protection, sustainment, and information. These functions represent groups of related activities that provide commanders and staff with the ability to synchronize and execute military operations.[5] Each of the functions, which is aligned with the Joint Capability Areas and Functional Capability Boards, allows for effective assessment and investment decisions by policymakers.[6]

The Use of AI/AS in the Joint Force

The joint force is accustomed to fighting by effectively synchronizing the unique set of land, sea, and air capabilities inherent in each of the Services. In the protracted engagements of the past two decades, the joint force has fought via a set of "interconnected human-inhabited platforms that pass surveillance and targeting data across great distances."[7] However, over the next 20 years, the pace of technological change will significantly impact how the joint force plans and executes the full spectrum of its missions.[8] Rapid technological developments in five key areas (info, neuro, quantum, nano, and bio) will be primary drivers in various areas of AI and AS.[9] As the Brookings Institution's John Allen and Darrell West note, "AI will significantly impact the world's economy and workforce, the finance and health-care systems, national security, criminal justice, transportation, and how cities operate. All of this change is likely to redistribute and concentrate wealth, challenge political systems, and generate new cyber threats and defenses."[10]

Future kinetic conflicts, especially those that include near peers such as China or Russia, will likely be replete with AI/AS architectures and methods that will include engagements best characterized as a "swarm" of lethality with unprecedented "coordination, intelligence, and speed."[11] In a March 2016 budget hearing before Congress, General Joseph Dunford, then Chairman of the Joint Chiefs of Staff, stated future conflicts will likely have "an increasingly transregional, multi-domain, and multi-functional nature. . . . [F]uture conflicts will spread quickly across multiple Combatant Command geographic boundaries, functions, and domains."[12] U.S. near peers clearly understand the importance that AI/AS will have in future conflicts.

By way of example, in 2017 the Chinese government released a document titled "New Generation Artificial Intelligence Development Plan" with the stated ambition of leading the world in AI by 2030. This plan calls for a "civil-military" fusion of AI to leverage dual-use advances for applications in national defense, including support of command decisionmaking, military deduction, and defense equipment.[13] The Chinese also have an approach in this domain that is best described as "systems confrontation and system destruction warfare."[14] Seeing the strategic importance of AI, Vladimir Putin stated, "Whoever becomes the leader in AI will be the ruler of the world."[15] The United Kingdom also clearly demonstrated the importance of AI/AS with its May 2018 publication of a joint doctrine document titled *Human-Machine Teaming*. The document describes the stakes that are involved in exploring and integrating AI/AS:

> *Robots and artificial intelligence offer the potential for an inflection point in delivering military transformation and advantage. Developing the right blend of human-machine teams (i.e., the effective integration of humans and machines into our warfighting systems) is the key . . . and we should not forget that we are in a race with our adversaries to unlock this advantage. The clock is ticking as new technology capabilities accelerate. This joint concept document should be read by everyone who needs to understand how AI, robotics, and data can change the future character of conflict for us and our adversaries.*[16]

The military application of autonomous systems has an array of protection and lethality possibilities (for example, unmanned vehicles and swarming weapons systems) as well as the potential to provide commanders with the ability to make decisions much more quickly and efficiently than a team of humans in a headquarters ever could. Even though AI/AS is at the forefront of thought leadership in a variety of disciplines, the Department of Defense (DOD) has neither taken a proactive approach in developing policies to govern such technology, nor has it effectively infused it into the formal acquisition process. This lack of policy guidance and adequate funding has had a limiting effect on the full military potential of AI/AS.[17] This lack of joint/synchronized exploration of AI/AS possibilities should be a significant concern. As of summer 2018, each Service still seemed to be going it alone, with the Air Force, for example, having more than 600 projects incorporating various facets of AI across multiple mission sets.[18]

The application of AI/AS in a military context has significant potential. Some researchers envision future AI/AS fights with "autonomous and uninhabited systems" that will be networked and have the ability to coordinate actions in response to events on the ground.[19] For example, swarming/coordinated action will enable synchronized attacks or defense, more efficient allocation of assets over an area, self-healing networks that respond to enemy actions, and

Airman participates in Security Forces Sustainment training at Baumholder, Germany, October 10, 2019 (U.S. Air Force/Deven Schultz)

widely distributed assets that cooperate for sensing, deception, and attack. As then–Secretary of the Army Mark Esper stated, "This technology [AI/AS] could very well change the character of warfare as we know it."[20]

In the U.S. Army War College publication *Key Strategic Issues List 2018–2020*, AI and AS are mentioned multiple times as keys areas for future research and investment.[21] Our allies in the United Kingdom also see the benefits of AI/AS for each of the joint warfighting functions with the following stated goals: "increase situational awareness, lighter physical and cognitive loads, sustainment with increased anticipation and efficiency, increased force protection, and ultimately superior maneuver options in and across all domains."[22] However, one difficulty that the United States and others will have in adopting AI/AS across any of the seven joint functions primarily concerns the challenges associated with testing and validation. In short, how can leaders be confident that a system will do what it is intended to do and nothing else beyond that, which might be detrimental to the mission? As then–Vice Chairman of the Joint Chiefs of Staff General Paul Selva stated, "In the DOD, we test things until they break. You can't do that with artificial intelligence. We're going to have to figure out how to get the software to tell us what it has learned."[23] Beyond this necessary step of analyzing what the software has learned, the more critical aspects of assessment also include deciding how to employ AI/AS within all of the generally accepted ethical, legal, and moral frameworks.[24]

Regarding the use of AI/AS in the joint force, there are currently four Joint Capability Areas envisioned for unmanned systems: battlespace awareness, force application, protection, and logistics.[25] For example, the use of robots would mean that fewer troops would be needed to defend a certain piece of terrain. This is an advantage given increasing DOD personnel costs.[26] Robots also have the capability to operate for longer periods of time without the human need for rest.[27] Moreover, unmanned systems can operate in harsh and deadly environments (for example, chemical, biological, radiological, or nuclear) with less degradation in capabilities. These and other examples provide an economy-of-force advantage that would allow joint force commanders the flexibility to allocate personnel to particular aspects of a battle plan (for example, interpretive or conceptual work) that are not conducive to or appropriate for unmanned systems.[28] An economy-of-force advantage from AI/AS would help

Figure 1. Exponential Convergence

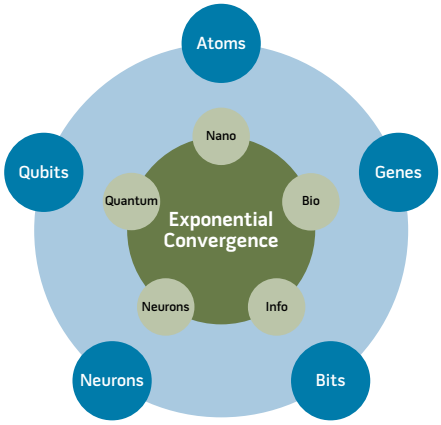
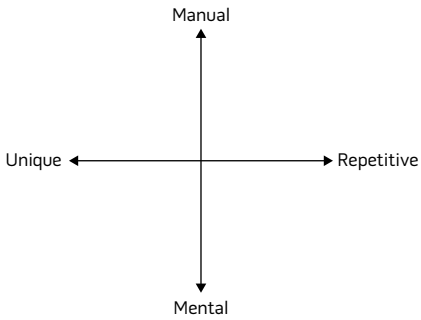


Figure 2. Tasks and Trust

The development of a useful understanding of the spectrum of tasks and their associated levels of trust requires a framework to distinguish between the nature of differing military tasks and the intendant effects upon the need for human supervision.



Source: Andrew Massie, "Autonomy and the Future Force," *Strategic Studies Quarterly* (Summer 2016), 139.

address one of General Dunford's stated concerns, namely that the joint force currently lacks sufficient capacity to meet all the combatant commands' requirements for forces.[29]

The Definition of *Autonomous* in Military Settings

When incorporating any form of autonomy in a military context, it is important to acknowledge that such a move also increases unpredictability.[30] Autonomy in the context of the human/machine interaction dynamic has three dimensions: the human-machine C2 relationship, the complexity of the decisions made by the machine, and the functions of the system that are made autonomous. DOD frequently defines *autonomy* in terms of human involvement in the execution of a machine's tasks. Systems that are marked by full human control over all the machine's core tasks are considered "human-in-the-loop" systems. Systems that have the ability to operate independently but still require humans to review decisions and intervene in the case of a malfunction are often called "on-the-loop" or "human-supervised" systems. A system that can carry out its tasks with total independence, leaving no opportunity for a human to intervene, is referred to as a "human-out-of-the-loop" system.[31] However, there are many different points of view regarding the terms used throughout the military (for example, *automation* vs. *autonomy*, *semi-autonomy*, *supervised autonomy*, *on-the-loop* vs. *in-the-loop*, and *mixed initiative*). This diversity of AI/AS phrases led to such confusion that a recent report suggested that "DOD should abandon the debate over definitions of levels of autonomy" and instead focus on developing a "method of analysis of trade-offs over multiple stakeholders and objectives."[32]

Currently, DOD has an established "spectrum of activity" for describing autonomy. Variables within the spectrum include differentiating between machines that think and machines that think and act. Figure 1 offers a visualization regarding the important distinctions between what can best be described as manual or "physical tasks" (firing a weapon, for example) vis-à-vis mental or "cognitive tasks" (for example, deciding if the target is friendly, neutral, or hostile). As one can imagine, the spectrum between the two is quite wide. Therein lies the difficulty for DOD, and by association the joint force, in deciding which scenarios and environments are conducive to the advantages of autonomous systems and which require human discernment and interaction with machines in order to accomplish the mission.[33]

Command and Control

As Joint Publication (JP) 3-0, *Joint Operations*, states, joint functions should reinforce and complement one another.[34] Integration across the other six joint functions is imperative if joint task forces are to effectively and efficiently accomplish their mission. Of the seven joint functions, C2 is the most complex and most important. For example, JP 3-0 lists 12 tasks that are part of the joint C2 warfighting function. Examples include managing risk, communicating and maintaining the status of information among and across subordinate units, assessing progress toward accomplishing mission-related tasks, and coordinating/controlling the employment of joint lethal and nonlethal capabilities. Given these important tasks, it is clear that AI/AS could play a significant role in creating efficiencies in a variety of C2 decisionmaking processes.[35] As noted by Samuel White, "Winning in the decision space is winning in the battle space."[36] Similarly, a more robust capability for commanders to effectively "understand the operating environment" was one of the 11 strategic themes of the *Decade of War* study that looked at key lessons learned in Afghanistan and Iraq.[37]

An example of how AI/AS could prove beneficial in this area includes more timely, accurate, and relevant intelligence that results in a more robust common operating picture across the joint force, something that would provide a staff with the opportunity to keep commanders better apprised of developments in the battlespace.[38] Another example of improved C2 via AI/AS is the automated analysis of more than 90,000 daily Facebook posts by the so-called Islamic State and its sympathizers, looking for actionable intelligence that even the most robust team of humans could not possibly generate in a similarly efficient manner.[39] General Dunford has described these types of scenarios as the ability of commanders to "make decisions at the speed of relevance."[40]

Andrew Massie suggests why AI/AS, and its implications for C2, are not easily reconciled:

The challenge of C2 Mission Command involves communicating intent as well as appreciation for why a task has been

Paratrooper assigned to 37th Brigade Engineer Battalion, 82nd Airborne Division, navigates wire obstacle during Blood on the Water competition at Fort Bragg, North Carolina, September 7, 2018 (U.S. Army/Ryan Mercado)

set but does not determine how it must be conducted; competent subordinates will exercise their best judgment dependent upon the circumstances. However, when delegating authority, we set bounds on the activity our subordinates undertake. Approaching one of these boundaries invokes the need to report up the chain for clarification or further guidance. Therefore, supervision is inherent in any command relationship, and will vary with circumstance and task complexity.[41]

The difficult balance is determining how to harness the speed of AI/AS in the C2 protocol *without* losing the ability to incorporate new or revised command guidance as circumstances dictate or as new opportunities present themselves on the battlefield.

AI can also assist commanders in making decisions about distinction (that is, proper identification of friend, enemy, or noncombatant) as well as decisions that deal with the appropriate proportionality of a retaliatory strike.[42] The Air Force is currently developing the fastest jet computer processor in avionics, the Advanced Display Core Processor, that will have the ability to process 87 billion instructions per second. The result will be faster and more reliable mission data processing.[43] Another area where AI/AS could prove advantageous is military operations in complex environments such as mega-cities and subterranean operations.[44] IBM, with its Watson AI initiative, foresees AI/AS technology soon being adapted to develop tactical military plans as well as design a set of courses of action (COAs) for commanders to consider.[45]

C2 enhancements that utilize AI/AS have the following advantages: endless and faultless memory, lack of emotional investment, and potentially unbiased analyses.[46] However, autonomous systems are not capable of reasoning in the human sense.[47] Systems of this nature develop COAs (that is, reason) using a probabilities approach.[48] Accordingly, DOD Directive 3000.09, *Autonomy in Weapons Systems*, from May 2017 provides clear guidance on the C2 function with regard to the use of autonomous and semi-autonomous systems: "Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[49] In a military engagement where lethal force is directed or applied, there is a clear chain of accountability from the trigger puller to the commander who directs that the target be engaged. For autonomous weapons systems, the locus of responsibility is not so clear-cut. How to determine who "ordered" the attack and who or which entities should be held accountable

Combat medic assigned to Landstuhl Regional Medical Center, Regional Health Command–Europe secures simulated casualty during simulated attack as part of 21st Theater Sustainment Command Best Medic Competition, Baumholder, Germany, August 22, 2019 (U.S. Army/Jesse Pilgrim)

beyond the traditional chain of command present significant challenges.[50]

With these types of concerns in mind, the key position that the United States has taken in many international settings (for example, the United Nations Convention on Certain Conventional Weapons) is that lethal force can only be committed to a target when "appropriate levels of human judgment" by an individual have been taken into account. In other words, a person, not a machine, has the ultimate decisionmaking authority. Interestingly, it was clarified at the same meeting that the U.S. position was not that a human had to make every firing decision. Instead, the U.S. position is that a weapons system has to act in a manner consistent with "reasoned human decisionmaking." Specifically, the U.S. position paper argues that international humanitarian law "does not require that a weapon determine whether the target is a military objective, but rather that the weapon be capable of being employed consistent with the principle of distinction by a human operator."[51]

Intelligence

The joint intelligence process encompasses six categories of intelligence operations: planning and direction, collection, processing and exploitation, analysis and production, dissemination and integration, and evaluation and feedback.[52] If correctly established and thoroughly vetted by subject matter experts from all Services and intelligence disciplines, AI/AS tools offer a variety of opportunities and provide the potential for mitigating cognitive analyst biases (for example, availability heuristic or bandwagon effect).

Planning and direction will likely continue to be a human-driven operation, although AI/AS can provide recommendations using historical data, cultural knowledge, previous operational design, and results. As with many applications of AI/AS, the likelihood of success with the employment of these technologies is largely dependent on the quality and volume of the data available for analysis. Critical to the success of AI/AS efforts in joint intelligence will be the normalization of legacy stovepipe data segregation.

While joint collection activities could be enabled or supplemented by cognitive AI/AS systems, it is likely to take time for commanders to become comfortable with the idea of having a machine prioritize their intelligence requirements for collection and develop a supportive collection strategy. In reality, AI/AS tools have the potential to be well suited to perform as a collection manager in accordance with the four key tenets of this particular role: early identification of requirements,

prioritization of requirements, taking a multidisciplinary approach, and the tasking of available collection assets.[53] The Navy has invested heavily in AI-enabled sensors in both sea (for example, OPNAV N96 initiatives) and air (for example, sixth-generation fighter) platforms.[54]

Processing and exploitation present perhaps the most promising use of AI/AS systems in the intelligence domain. For example, during the past 10 years within the geospatial intelligence discipline, academicians and technology professionals have participated in an annual contest known as ImageNet to detect and identify certain objects within images.[55] Teams from around the world collaborate and compete to build the best exploitation programs by leveraging traditional programmatic coding, detailed algorithms, and AI/AS tools. The resulting open-source repository now contains over 14 million URLs that can be used to train image recognition AI tools, many of which have achieved a 97.3 percent accuracy rate, far surpassing average human capabilities.[56] Signals intelligence—including communications intelligence, electronic intelligence, and foreign instrumentation signal intelligence—is another discipline that presents a significant opportunity for AI/AS usage in the analysis of collected electronic signals. The use of AI/AS tools in conjunction with other disciplines, such as human intelligence, will be slower to implement.

Analysis and production are also good candidates for the integration of AI/AS tools. Currently, the "Chinese People's Liberation Army is developing algorithms that enable data fusion, enhance intelligence analysis, and support command decisionmaking."[57] Today's intelligence teams are faced with an increasing flow of information and data through a variety of sensors and sources. Technological advances have continued to accelerate that flow, but human analysts have not been able to keep pace with these increases. There is undeniable risk associated with the integration of AI/AS tools into analytical processes. As with any cognitive or machine-learning solution, it will take time as well as a variety of learning situations to hone analytical capabilities and build a sufficient level of confidence with AI/AS-developed products. Processes must be put in place to vet analytical data, especially those created prior to achieving an acceptable level of confidence with joint products. In the end, though, if the joint force does not find a way to streamline and automate a portion of the intelligence analysis function, commanders will continue to be deprived of volumes of potentially actionable intelligence.

Within the dissemination and integration function, AI/AS will enable the former, but the latter is required to enable AI/AS usage. Standard dissemination is one of the most straightforward intelligence functions to automate, while ad hoc disseminations will likely continue to involve human effort. As previously cited, integration with large, consistent, normalized datasets will require successful AI/AS intelligence integration. That said, there are also security implications associated with collapsing a variety of data sources or networking a greater number of intelligence, surveillance, and reconnaissance assets. Since every sensor within an automated system has the potential to be exploited in a variety of ways (for example, jamming, intercepting, hacking, or spoofing), integrating these tools into a more comprehensive network has the potential of increasing vulnerability.[58]

While AI/AS tools have the ability to objectively evaluate and provide feedback regarding the quality and effectiveness of intelligence reports and products, the more critical and impactful evaluation of the quality and effectiveness of intelligence is likely to come from the human engaged in conflict. If commanders do not trust and act on intelligence products produced with the assistance of AI/AS tools, it will not matter how efficient the processes have become.

Fires

JP 3-0 lists eight key considerations when employing fires: targeting, joint fire support, countering air and missile threats, interdiction, strategic attack, global strike, limiting collateral damage, and nonlethal capabilities.[59] As AI/AS are developed, it is important for the programmers to work closely with commanders to ensure this breadth of employment options is taken into account. In 2005, as the AI/AS sector was gaining traction, a senior leader at U.S. Joint Forces Command commented on the significant benefits of automated weapons systems: "They don't get hungry. They're not afraid. They don't forget orders. They don't care if the guy next to them has just been shot. Will they do a better job than humans? Yes."[60] In 2019 and beyond, the implications of AI/AS in the fires domain are even higher, with Bruce Jette, Assistant Secretary of the Army for Acquisitions, Logistics, and Technology, offering the following observations:

There are a number of public organizations that have gotten together and said, "We don't want to have AI tied to weapons." But time is a weapon. If I can't get AI involved with being able to properly manage weapons systems and firing sequences then, in the long run, I lose (in the time domain). Let's say you fire a bunch of artillery at me, and I can shoot those rounds down, and you require a man in the loop for every one of the shots. There are not enough men to put in the loop to get them done fast enough.[61]

While those statements are true in most respects, they are observations that only look at AI/AS technology as an asset. The liabilities of technology must also be considered. Commanders and the U.S. Government must still be held accountable for actions taken by AI/AS. DOD Instruction 3000.09 directs that autonomous weapons must be able to "complete an engagement in a timeframe consistent with commander and operator intentions and, if unable to do so, terminate engagements or seek additional human operator input before continuing the engagement."[62]

Given this directive, the crafting of rules of engagement for multiple scenarios, as well as establishing the appropriate boundaries for how DOD will utilize AI/AS technologies, will be quite challenging. For example, when programming an

Four unmanned remotely operated high-speed maneuvering surface targets move to blocking positions on James River during Office of Naval Research–sponsored demonstration of autonomous swarmboat technology, Newport News, Virginia, August 13, 2014 (U.S. Navy/John Paul Kotara)

autonomous weapons system (AWS) for a multitude of scenarios, at some point the weapon will only be effective and/or safe to employ in a small number of instances, calling into question its benefits vis-à-vis its costs. If an AWS cannot be programmed to meet the "reasonable commander standard" (that is, properly weighing the likely collateral damage vis-à-vis the potential military advantage), it is highly unlikely that a senior military leader will conclude that the potential advantages of an AWS are worth the risk.[63]

Movement and Maneuver

JP 3-0 states that the objective of movement and maneuver is to gain positional advantage to accomplish both operational and strategic goals. This is done primarily through five key tasks: deploying forces within the operational area (OA), maneuvering to achieve the advantage, providing constant ability to mobilize over terrain or obstacles without delay, delaying or stopping the enemy, and controlling significant areas in the OA.[64]

In the area of movement and maneuver, an autonomous system such as a robot has certain advantages over a human. For example, a robot has no instinctual need for self-protection that could slow an advance. A robot does not have the emotions that could otherwise distract/impair a warfighter's judgment (for example, frustration, fear, revenge, or rage). Conversely, robots have no innate appreciation for the sanctity of human life or feelings such as compassion or mercy.[65] One example of new AI/AS technology in the movement and maneuver domain is the Navy's new unmanned underwater vehicle, which is capable of operating for 5 months at a time without maintenance or refueling.[66] The space domain has also seen similar use of unmanned vehicles with the Phantom Express and X-37B platforms, both of which provide enhanced and efficient maneuver capability.[67]

Even with these promising examples, there is still an open question on the best way that AI/AS can be utilized within the joint function of movement and maneuver. Unmanned aircraft and ground platforms are already utilized in the Middle East for resupply missions. The Army recently accelerated its Automated Ground Resupply program and plans to have 70 self-driving supply trucks operational by 2020.[68] The future challenge is finding ways to enable these systems to "autonomously predict, plan, track, and optimize resupply demands from military users."[69] This idea of interconnected autonomy will allow troops to focus more on the mission instead of using precious time planning how they will maneuver from one place to another across the battlespace.

Protection

JP 3-0 describes protection as a function that encompasses traditional force protection and protection of health and other activities that preserve/conserve the force. Of the seven joint functions, protection is one of the more complex. For example, JP 3-0 lists 15 tasks/components that are part of the protection warfighting function. Examples include providing air/space/missile defense; protecting U.S. civilians and contractors authorized to accompany the force; conducting operations security, cyber defense, and cyber security; providing chemical, biological, radiological, and nuclear defense; establishing capabilities and measures to prevent friendly fire incidents; and securing and protecting combat and logistics forces, bases, joint security areas, and lines of communication. And while those components of force protection seem on the surface straightforward and appropriate, JP 3-0 also includes additional aspects of force protection that are broader in nature and not easily or narrowly defined, such as health protection.[70] To ensure overmatch against near peers, force protection is one of five key lines of effort envisioned by the Army Training and Doctrine Command for integrating new technologies into future organizations, the other four being increasing situational awareness, lightening Soldiers' workloads, sustaining the force, and facilitating movement and maneuver.[71]

JP 3-0 provides a taxonomy of four broad areas that provide a useful approach for analyzing the methods by which the joint force could effectively utilize AI/AS to enhance force protection: active defensive measures, passive defense measures, the application of technology to reduce fratricide, and a more robust and rapid response to various types of emergencies (for example, accidents or natural disasters).[72] In the area of active defensive measures, the key focus is on protecting information, military installations/assets, and lines of communication from enemy destruction and/or disruption. There has been significant progress in the use of unmanned automated systems to execute resupply missions. The benefits of letting machines do the "dull, dirty, and dangerous" work of resupply so troops can focus on more complex aspects of the mission have been pointed out.[73] Commenting on a Marine amphibious exercise, Colonel Daniel Sullivan stated, "Going forward, the first one in the room should never be an air breather. It should be a robot with a lethal capability."[74] In congressional hearings, Senator Gary Peters (D-MI) offered the following telling observation: "In the Iraq War we lost more Soldiers in logistics operations than we did in combat." To mitigate loss of life, especially in resupply and logistics, one promising AI/AS concept is "leader/follower." This solution envisions personnel in a lead vehicle with multiple unmanned trail vehicles moving along the same general route based on the electronic signal from the lead vehicle.[75]

In the area of passive defensive measures, JP 3-0 stresses the importance of taking proactive/precautionary steps to make it more difficult for a hostile force to locate and engage personnel, assets/facilities, and various systems (such as communications). One could imagine the use of deep learning systems (machines that are programmed to discern when certain types of attacks are likely/imminent) conducting analysis quicker than could be expected by human monitoring and/or reaction.[76] Other examples where deep learning systems could prove beneficial include cyber defense and electronic warfare attacks. Autonomous systems also provide an advantage in defensive postures to "select and engage incoming enemy" indirect fires (for example, mortars, artillery shells, and rockets). An autonomous system designed to provide a rapid and robust "counter-battery" response against the origin of an attack provides commanders with additional time to focus on second- and third-order decisions given that the initial response to the attack was "automatically initiated" with speed and accuracy. Israel uses this type of force protection approach with its Iron Dome defenses.[77]

In the area of applying technology to reduce fratricide, AI/AS technologies have tremendous potential for the joint force as well as potential hazards. It is possible to envision scenarios in which AI/AS can provide much more effective early identification in protecting civilians as well as combatants from friendly fire incidents (for example, more precise targeting or minimizing collateral damage).[78] In the area of developing a more robust and rapid response to emergency scenarios, the key for the joint force will be adopting AI/AS technology and applying it to respond with COAs that enhance survivability as well as isolating the negative impacts that result from accidents, biological hazards, and natural disasters.[79]

Sustainment

JP 4-0, *Joint Logistics*, defines *sustainment* as "the provision of logistics and personnel services necessary to maintain and prolong operations." The logistics portion of sustainment includes the core functions of deployment and distribution, supply, maintenance, logistical services, operational contract support, engineering, and health services.[80] Among the seven joint functions, sustainment operations present some of the most likely quick wins for employment of AI/AS technologies.

The integration of AI/AS analytical tools provides a significant advantage for dealing with large datasets and complicated algorithms. The Air Force already uses the Automatic Logistics Information System, which has automated the transmission of logistics data (for example, fuel consumption and engine diagnostics) to free up pilot attention for a greater focus on combat.[81] Since planning for deployment and distribution relies heavily on large volumes of data and algorithms, AI/AS implementation could provide a tangible improvement for the joint force. By leveraging automated solutions to track information such as unit basic load status, supply orders, warehousing stock, distribution channels, and transportation schedules, a joint logistics command would be well positioned to service both peacetime and wartime requirements.

Highly automated vehicles (HAVs) are currently in use, with many experts suggesting that the adoption of autonomous vehicles will soon become commonplace in military as well as civilian settings. One of the

Marines with Headquarters Battalion, 3rd Marine Division, provide security for convoy during Samurai 2-20 on Camp Hansen, Okinawa, Japan, December 10, 2019 (U.S. Marine Corps/Kallahan Morris)

primary challenges associated with the widespread adoption of HAVs in sustainment and logistics operations is the ethical issues associated with "training" vehicles—how to teach the AI/AS technology to effectively evaluate potential accidents. The Army recently invested nearly $50 million in the Autonomous Ground Resupply Program to leverage AI/AS with the goal of saving lives as well as economy of force.[82] The joint force may want to build on this initial implementation of HAV technology in relatively self-contained environments (for example, moving materials on and off ships and aircraft) before implementing a more robust program. In this rollout, the joint force could partner with civilian freight agencies that are already moving forward with test programs. The legalities of leveraging HAVs in an international environment, and the related liabilities, would have to be fully researched by the Judge Advocate Corps before this option is rolled out in various countries.

The network-based nature of private sector logistics provides a natural framework for implementing and scaling AI for complex military supply chains.[83] In June 2018, the Army awarded a predictive maintenance contract to Uptake, a company that analyzes millions of hours of data from diesel engines and other major components to predict imminent equipment failures. The goal of this trial program is to identify ways to streamline logistics and help untether the warfighter from traditional supply lines.[84]

While the most common AI/AS-enabled personnel services and processes relate to recruitment, hiring, onboarding, and financial management, there are a multitude of rules-based, repetitive human resources tasks that can be automated to provide more time for value-added functions.[85] For example, AI/AS tools have the potential of assisting joint force leaders with talent and succession planning programs in an unbiased manner. Automation techniques could also be used to offer a preliminary evaluation of promotion packets and offer suggestions on personnel management, such as setting the optimal rate for retention bonuses.

The Services have each undertaken efforts to more effectively attract, manage, and retain talent. "Cultivating workforce talent" is highlighted in the 2018 National Defense Strategy, along with the clarification that it will require the inclusion of new capabilities and an openness to updating practices, not just the addition of new technology.[86] Following the Air Force's September 2017 Workforce Summit, Michael Parker stated, "Talent management information technology must transform to function in today's digitally connected world."[87] Simultaneously, the Navy's Sailor 2025 initiative as well as the Army's Talent Management Task Force seek to "improve and modernize personnel management."[88]

In another sustainment initiative, the Army is poised to implement the Integrated Personnel and Pay System–Army, which will allow the tracking of individual Soldier and civilian skillsets across all three components: Active, Army Reserve, and Army National Guard.[89] Personnel management has the unique ability to be both an enabler

F/A-18E Super Hornet assigned to Stingers of Strike Fighter Attack Squadron 113 launches from flight deck of aircraft carrier USS *Theodore Roosevelt*, Arabian Gulf, February 5, 2018 (U.S. Navy/Spencer Roberts)

of the future of AI/AS within the joint force—through focused recruitment and talent management programs—and a consumer of AI/AS capabilities. While each of the Services is becoming more analytical and objective regarding evaluations and promotions, having positioned themselves to use AI/AS functions in a Service-specific manner, if DOD would merge these sources of talent data, the joint force would have a robust source of the information from which to staff future teams.

The healthcare component of sustainment has already seen success with AI/AS and stands poised for even more. Recovery Engagement and Coordination for Health, a Veterans Administration (VA) program that uses AI to analyze veteran health record data, had proactively identified nearly 7,000 veterans at risk of suicide as of March 2018, thereby allowing for quick and effective intervention.[90] IBM is partnering with the VA—and with myriad civilian medical research entities—in the area of cancer treatment.[91] With the number of new cancer diagnoses between one million and two million annually, medical assessments are a tremendous area of opportunity for expanded AI/AS usage, particularly in remote and/or deployed environments where it is not always possible for a full range of specialists to be on location.

Whether the focus is logistics, personnel management, or healthcare services, the sustainment function is primed for incremental AI/AS enhancements. Additionally, this is a key integration area where the joint force could and should partner with civilian and interagency organizations for the more robust and effective systems.

Information

With the 2017 release of JP 1, *Doctrine for the Armed Forces of the United States*, information was added as the seventh joint function, the first addition of a joint warfighting function in 20 years.[92] JP 1 defines the *information joint function* as follows:

The information function encompasses the management and application of information and its deliberate integration with other joint functions to influence relevant actor perceptions, behavior, action or inaction, and support human and automated decision making. The information function helps commanders and staffs understand and leverage the pervasive nature of information, its military uses, and its application during all military operations. This function provides [joint force commanders] the ability to integrate the generation and preservation of friendly information while leveraging the inherent informational aspects of all military activities to achieve the commander's objectives and attain the end state.[93]

Brigadier General Alexus Grynkewich, who served on the Joint Staff as the J39 Director of Global Operations, stated, regarding the addition of this seventh joint function, "The elevation of information in joint doctrine . . . underscores the [DOD] focus on how to adapt in order to more effectively use the military instrument of national power in a changing strategic environment."[94] Building on this idea, the DOD publication *Strategy for Operations in the Information Environment* states

that information could possibly be the decisive factor in successful future military operations.[95] Secretary Mattis likewise understood the importance of this newly designated joint function when, as a commanding general, he stating, "Capturing perception is the new high ground in today's conflicts."[96] General John Hyten, then commander of U.S. Strategic Command, stated, "The military that figures out how to control information will be the most powerful military on the planet."[97] The importance of information as a joint function was also highlighted in *Joint Operating Environment 2035: The Joint Force in a Contested and Disordered World*. This document includes the following prediction: "Advanced information technologies will lead to new and faster ways to form, build, and maintain cohesion and common purpose among members of a group. Consequently, it will become easier to mobilize and expand groups and ideas, irrespective of geographic proximity."[98] In support of this prediction, the most recent National Security Strategy, as well as the 2018 National Defense Strategy, frequently cite myriad threats to national security that are likely to stem from the use of information as a weapon by U.S. adversaries.[99]

Artificial intelligence and automated systems hold tremendous promise for improvements across each of the seven joint functions. As Andrew Massie noted, "At its core, our ability to harness autonomy is a test of our ability to trust machines, and therefore delegate authority for decision making and action."[100] DOD took action with the June 2018 directive establishing the Joint Artificial Intelligence Center.[101] The joint community would be wise to build on this new initiative and timely directive by adding AI/AS planning and integration cells on joint manning documents to ensure that the benefits of lessons learned, both within and outside the military, are fully leveraged across the joint force. But this is just a part of what should be a much bolder approach to AI/AS investment across DOD and the joint force. Time is of the essence. In recent congressional testimony, DOD officials reported that China spent $12 billion in 2017 on AI and plans to spend at least $70 billion by 2020.[102] By comparison, current U.S. expenditures are one-tenth of those planned by the Chinese. By taking a bold and integrative approach in the AI/AS space, DOD and the joint community will put themselves in position to take advantage of the advice offered by Paul Schare, author of *Robotics on the Battlefield*: "The winner of this revolution will not be who develops these technologies first, or even who has the best technologies, but who figures out how to best use them."[103] **JFQ**

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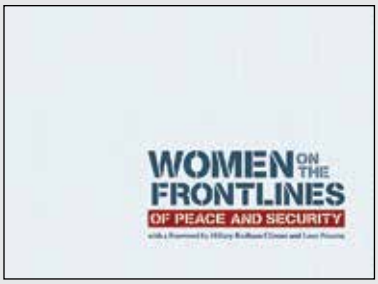

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