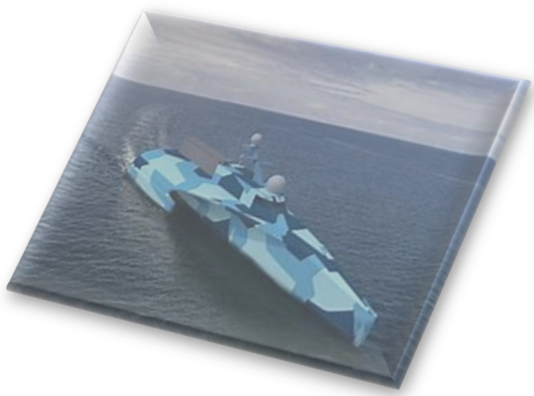

AUTONOMOUS MILITARY SYSTEMS

Defining the Requirements: Part Two

ABSTRACT

While autonomous vehicle capabilities have advanced at an incredible rate in both the civilian and military spheres, DoD struggles with clearly discerning an analytical tool useful for proposing, assessing, evaluating, and determining the requirements for the application of autonomous systems across the military. This is Part Two of a Whitepaper series, and this portion revisits the elements necessary for creating a common taxonomy for just such a process called “Standards of Autonomy in Military Application” (SAMA).

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A Taxonomy for a DoD-Wide Approach Toward Autonomous Systems Application

Standards of Autonomy in Military Application (SAMA)

The U.S. Army's Robotic and Autonomous Systems Strategy published in 2017 provided a useful framework for analysis of Army-specific warfighting priorities and discusses enumerated Army Warfighting Challenges (AWfC) which would be addressed and mitigated through RAS utilization. It is used here as a foundational framework for a more detailed analysis.

Similarly, in an effort to codify terms of reference (TOR) to eliminate confusion amongst civilian, industry, and DoD policymakers, a joint effort between the National Institute of Standards and Technology (NIST) and DoD produced the Autonomous Levels for Unmanned Systems (ALFUS) construct. This original ALFUS effort was a four-year multi-agency project that ran from 2003-2007. NIST published their Version 2.0 Whitepaper in 2008 and followed up with a supporting slide presentation in 2014. The ALFUS effort involved over 60 working group members from DoD, Academia, and Industry. It was a noble effort, but not detailed enough for DoD to properly guide its ultimate objectives for autonomous programs today, nor was it good enough to clarify requirements for software engineers or to help industry understand exactly what DoD desires.[1]

Since then, DoD has evolved and provided more refined guidance regarding AI and multi-agent control, so a taxonomy of operational level applications of service and joint AI capabilities is the next step in refining and defining critical TOR to better educate industry, civilian leadership, DoD end users, and the international community. The most recent evolution of working taxonomy concepts was JHNA's Operational-Autonomous Levels for Unmanned Systems (O-AFLUS). Synthesized in 2019, O-ALFUS capitalized on the latest evolutions in military autonomy. Since that time, the Army has continued to refine its autonomous behavior capabilities. The Army has advanced individual platform autonomy, while both the Airforce and Navy have experimented independently with groups of robotic systems operating with multi-agent autonomy. These evolutions demand we revisit the need for setting a common language to describe operational expectations for autonomous capability. If the DoD is to be able to explain to Congress what it expects to achieve with the money it spends to develop such a breakthrough technology. This cannot be a mere chart of engineering terms and algorithm codes; it must be a lexicon useful to explaining performance, constraints and limitations. The working term the author suggest for this revised taxonomy is "Standards of Autonomy in Military Application" or 'SAMA'.

As already recognized and stated, autonomy means different things to different people. Within the automotive industry (the representative leaders in ground autonomous systems), the Society of

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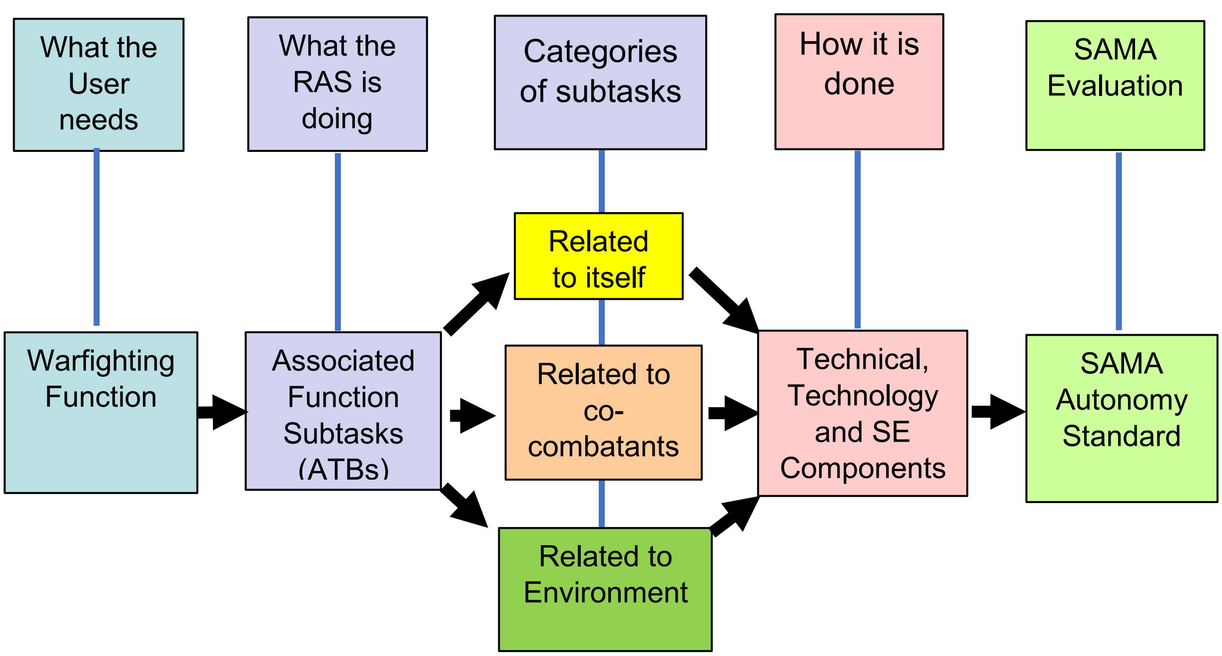
[1] John Northrup, Matt Dooley, and B.J. Hennesey, *Toward Defining Operational Autonomous Levels for Unmanned Systems,* John H. Northrup and Associates White Paper, October 22, 2019

Automotive Engineers (SAE) has established their baseline definitions which consist of five levels of autonomy from drive assistance to full autonomy. NASA identifies and defines eight levels spanning from no to full autonomy and the University of South Carolina Computer Science and Engineering Department defines ten levels of autonomy to describe the transition from no to full autonomy. While these stakeholders generally agree on what 'no autonomy' and 'full autonomy' mean, they do not agree on the sliding scale that lies in between; hence the varying number of levels. Further complicating matters, these stakeholders agree there are functional subcomponents to each of their levels of autonomy and have naturally focused their functions to fit their scope. For instance, SAE has four sub functions including steering/speed, monitoring, dynamic driving, driving modes capability while NASA used observe, orient, decide, act. These subordinated functions set a taxonomy that is very specific to the stakeholder field and tasks and thus is not necessarily tailorable in their "off the shelf" form for military application.[2]

SAMA seeks to apply these previous industry, academic, and DoD efforts into an operationally and militarily useful taxonomy to assist industry capability developers, and civilian and DoD policymakers in their efforts to bridge the gap (what is colloquially known as the "Valley of Death") between research and development/demonstrations, and the end state of viable programs of record in the Planning, Programming, Budgeting, and Execution System (PPBES) process. This analysis will utilize the Joint Warfighting Functions combined with the Principles of Joint Operations, as well as domain-specific applications for Air, Land, and Maritime requirements. Future endeavors and refinements will need to add Space, Cyberspace, and Coalition dimensions in this analysis, but for now this paper will focus specifically on the traditional terrestrial warfighting domains.

At its most basic, SAMA, like O-ALFUS seeks to answer very simple questions through a logical process:



[2] Ibid., pp. 3-4

The Warfighting Function is self-evident. The Associated Function Subtasks would then be broken down into Autonomous Tactical Behaviors (ATBs) to define exactly what is sought from autonomous capabilities within that warfighting function. Those ATBs are then related to the machine itself, its integration and relation to its co-combatants or human/machine team members within U.S. units, and then to the environment/domain in which it is operating. This then provides engineers with specific behaviors and capabilities necessary from a technical, technological, and systems engineering perspective. From there, DoD decision makers and program managers can determine technology/capability prioritization, assess prototype demonstrations, and then assign the standard of autonomy desired for each capability.

SAMA Standards:

In broad terms, as with O-ALFUS, the SAMA matrix can be broken down into refined definitions of autonomy for DoD use. Unlike previous concepts, SAMA goes further in laying out more detailed levels of autonomy that permits a more granular discussion regarding exactly how much independent capability one is getting for the robots operating at that level- a critical tool for explaining to Congress and the Pentagon more precisely what they are getting for their money:

SAMA Levels	Autonomous Behavior	Description
0 Human Manual Operation	Manual	The human performs all aspects of the task including sensing the environment, generating plans/options/goals, and implementing processes
1 Human Tele-Operation of a RAS Platform	Tele-Operation	The machine assists the human with action implementation. However, sensing and planning is allocated to the human. For example, a human may teleoperate a machine, but the human may prompt the machine to assist with tasks
2 RAS Provided Operator Assist	Assisted Tele-Operation	The human assists with all aspects of the task. However, the machine senses the environment and chooses to intervene with the task. For example, if the user navigates the machine too close to an obstacle, the machine will ***automatically steer*** to avoid collision
3 RAS Subordinated Control	Batch Processing	Both the human and machine monitor and sense the environment. The ***human***, however, ***determines the goals*** and plans of the task. The machine then implements the task.
4 RAS Decision Subordinated Control	Decision Support	Both the human and machine monitor and sense the environment and generate a task plan. However, the ***human chooses*** the task plan and commands the machine to implement actions
5 RAS Human Led Shared Control	Shared Control with Human Initiative	The machine autonomously senses the environment, develops plans and goals, and implements actions. However, the human monitors the machine's progress and may intervene with new goals and plans if the machine is having difficulty, or if new directives are given
6 RAS Machine Led Shared Control	Shared Control with Machine Initiative	The machine performs all aspects of the task (sense, plan, act). If the machine encounters difficulty, it can prompt the human for assistance in setting new goals and plans
7 Human Executive Control	Executive Control	The human may give an abstract high-level goal (e.g., navigate in environment to a specified location). The machine autonomously senses environment, sets the plan, and implements action

8 **Human Supervisory Control**	Supervisory Control	The machine performs all aspects of task, but the human continuously monitors the machine, environment, and task. The human has override capability and may set a new goal and plan. In this case, the autonomy would shift to ***executive control, shared control, or decision support***
9 **Pure RAS Autonomy**	Pure Autonomy	The machine performs all aspects of a task autonomously without human intervention with sensing, planning, or implementing action
10 **Cooperative Full Autonomy**	Full Autonomy – Cooperative	Fully autonomous machine system teams with a human to solve a problem. Both human and machine contribute equally to problem solving through shared sensing, planning, and implementing action. Sometimes the machine lets the human believe it was his/her decision
11 **Collaborative Full Autonomy**	11A: Full Autonomy – Collaborative Machine/Human	Human-machine teaming. A group of fully autonomous machines work together with another group of machines or humans to solve simple or complex problems.
	11B Full Autonomy – Collaborative etween Machines	Machine teaming. A group of fully autonomous machines work together with another group of machines to solve complex problems to achieve mission objectives (e.g., collaborative swarming behaviors where machine teams sense, plan, and act based on mission parameters and objectives)

Joint Doctrine Guide for Application of SAMA Standards:

A Word on Complexity:

Any attempt to discern clear levels of autonomous performance must consider the complexity of the environment. Autonomy found to be fully functional in simple scenarios with permissive environments may not function as well in scenarios with more obstacles, complex threats, and variable environmental conditions (Figure 1). Furthermore, a military commander's tolerance for operational risk and incidental

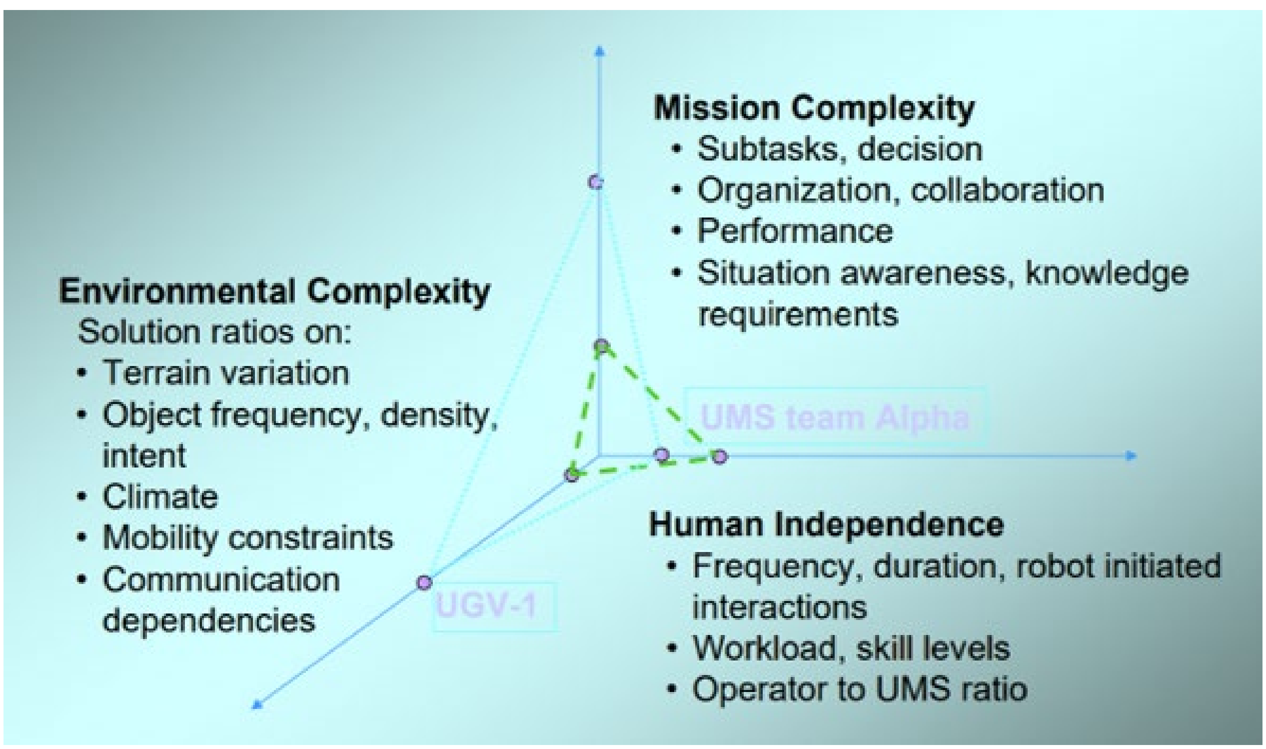


Figure 1 ALFUS Complexity Triangle

failure may be limited and thus lower the permission thresholds for freer robotic function. Any matrix depicting ascending levels of autonomy must account for this variable to be useful in explain what a robot is expected to do. SAMA calls this matrix assessment the Operational Complexity Level or 'OCL.' Like an operational risk assessment and management matrix common to most U.S. Army units, a commander simply adds this factor into where he/she places the constraints on a robotic platform's independent operation. SAMA recommend the following:

Operational Complexity Levels (OCL)

1. Low
2. Moderate
3. Challenging
4. High
5. Extreme

Autonomous Tactical Behaviors (ATBs) Defined:

ATBs, or tasks, describe discrete, individual machine actions, processes, capabilities, or procedures integral to accomplishing a mission. These coincide with the Joint Warfighting Functions of Movement and Maneuver, Fires, Command and Control, Intelligence, Information, Sustainment, and Protection. ATBs are the decomposed actions warfighters can distill from the more broadly defined warfighting functions. From a broad conceptual perspective, these functions can be augmented and facilitated/improved upon through AI-related capabilities codified in separate and discrete ATBs.[3] They useful from explaining how certain capabilities help enhance warfighting in an explicit functional domain. For example:

Command and Control:

C2 encompasses the exercise of authority and direction by a commander over assigned and attached forces to accomplish the mission. The JFC provides operational vision, guidance, and direction to the joint force. The C2 function encompasses a number of tasks, including: (1) Establish, organize, and operate a joint force HQ. (2) Command subordinate forces. (3) Prepare, modify, and publish plans, orders, and guidance. (4) Establish command authorities among subordinate commanders. (5) Assign tasks, prescribe task performance standards, and designate OAs. (6) Prioritize and allocate resources. (7) Manage risk. (8) Communicate and ensure the flow of information across the staff and joint force. (9) Assess progress toward accomplishing tasks, creating conditions, and achieving objectives. (10) Coordinate and control the employment of joint capabilities to create lethal and nonlethal effects. (11) Coordinate, synchronize, and, when appropriate, integrate joint operations with the operations and activities of other participants. (12) Ensure the flow of information and reports to and from higher authority.

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[3] Joint Chiefs of Staff, *Joint Publication 3-0: Joint Operations, Appendix A, Principles of Joint Operations,"* Washington, DC: June 18, 2022, pp. III-1 – III-39

The benefit of AI-enabled C2 will be profound. In addition to being the engine to drive JADC2, AI will (1) expand the number of echelons and units commanders will be able to coordinate in the operational environment; (2) prepare and modify orders and guidance at the speed of relevance due to AI's enhanced capability to aggregate data and improve the timeliness of decision making; (3) more rapidly assign and, perhaps more importantly, reassign tasks as the situation develops; (4) better prioritize and allocate/re-allocate resources; (5) better manage risk through real time domain awareness and autonomous systems updates; (6) ensure the timely transmission of battle updates and reports to higher headquarters; (7) maintain persistence and the initiative against the enemy, overwhelming their decision making and ability to react to multiple vectors of attack across all warfighting domains.

Information:

The information function encompasses the management and application of information and its deliberate integration with other joint functions to change or maintain perceptions, attitudes, and other elements that drive desired behaviors and to 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 JFCs the ability to integrate the generation and preservation of friendly information while leveraging the inherent informational aspects of military activities to achieve the commander's objectives and attain the end state.

Here, AI can perform not only critical military information requirements, but also assist the commander in achieving not only military but political objectives and end states as well. Using AI-enabled information analysis, the joint force can monitor and discern patterns within enemy communications and data streams while simultaneously monitoring internet, social media, news, and other commercial data streams in an effort to confound enemy actions while simultaneously gaining unprecedented understanding of the social and political ramifications of military operations. Non-AI related information dominance has been recently witnessed in the Ukrainian conflict with Ukraine gaining the advantage in this important domain. AI-enabled information dominance will be even more dramatic.

Additionally, AI-enabled information operations will enhance: military deception through low-cost and attritable swarming techniques of robotic and autonomous systems; operational security through advanced reconnaissance and scouting machines and multi-vector approaches against enemy positions; cyber offensive and defensive operations through autonomous cyber capabilities; and AI monitoring, jamming, and frequency re-allocation in the electronic warfare domain while providing communication and operational capabilities in electronically denied or degraded EW environments.

Intelligence:

Understanding the OE is fundamental to joint operations. The intelligence function supports this understanding with analysis of the OE to inform JFCs about adversary capabilities, COGs, vulnerabilities, and future COAs and to help commanders and staffs understand and map friendly, neutral, and threat networks. Using the continuous JIPOE analysis process, properly tailored JIPOE products can enhance OE understanding and enable the JFC to act inside the enemy's decision cycle. Intelligence activities and *assessments also occur while defending the homeland within the guidelines of applicable regulations and laws.*

Using AI to aggregate multiple intelligence data streams to provide timely information to decision makers is key to maintaining situational awareness and the initiative on the battlefield. Additionally, AI-enabled vehicles will be able to loiter over, under, and in advanced reconnaissance positions on the battlefield to provide a common operating picture to units and the commander while providing recommendations for force and capabilities allocation and reallocation, thus maintaining pressure on enemy action and reaction decisions and times.

Fires:

To employ fires is to use available weapons and other systems to create a specific effect on a target. Joint fires are those delivered during the employment of forces from two or more components in coordinated action to produce desired results in support of a common objective. Fires typically produce destructive effects, but various other tools and methods can be employed with little or no associated physical destruction.

AI-enabled fires from all warfighting domains, perhaps simultaneously, will confound the enemy's cognitive ability to defend or respond tactically, will demoralize the enemy and keep them on their heels under a persistent barrage of multi-vector fires which create effects in the physical *and* cognitive domains. Overwhelming force means not only firepower, but fires for effects in the operational environment from multiple vectors to achieve military and political objectives. AI-enabled capabilities will be able to synchronize and coordinate fires from the strategic down to the tactical levels of war in a near-seamless and timely manner.

Movement and Maneuver:

This function encompasses the disposition of joint forces to conduct operations by securing positional advantages before or during combat operations and by exploiting tactical success to achieve operational and strategic objectives. This function includes moving or deploying forces into an OA and maneuvering them to operational depths for offensive and defensive purposes. It also includes assuring the mobility of friendly forces.

From strategic movement of forces from the U.S. or in space, to the tactical maneuver of units to gain positional and cognitive advantage over the enemy, AI-enabled capabilities will play a critical role in streamlining actions, reducing manpower and manhours for deployment and employment concerns, and providing the situational awareness and informational advantage necessary for tactical success. AI capabilities will greatly reduce the tremendous amount of time and energy required for the development of the time-phased force deployment data (TPFDD) necessary for force and transportation feasibility analysis, and force generation and mobility requirements for deployment using autonomous systems (ships, trucks, aircraft, and data). Similarly, maneuver will be greatly enhanced through the use of robotic scouts and reconnaissance, the fusing of ground, aerial, seaborne, and space sensors, and the data aggregation capability AI will provide.

Protection:

Preserves the joint force's fighting potential in four primary ways. One way uses active defensive measures that protect the joint force, its information, its bases, necessary infrastructure, and LOCs from an enemy attack. Another way uses passive defensive measures that make friendly forces, systems, and facilities difficult to locate, strike, and destroy by reducing the probability of, and minimizing the effects of, damage caused by hostile action without the intention of taking the initiative. The application of technology and procedures to reduce the risk of friendly fire incidents is equally important. Finally, emergency management and response reduce the loss of personnel and capabilities due to isolating events, accidents, health threats, and natural disasters.

Uncrewed systems utilizing various levels of AI for the conduct of their missions inherently raise the protective measures necessary for security of the units engaged in battle. From uncrewed logistics convoys, to uncrewed defensive systems to provide anti-air, anti-missile, and other protective measures, to uncrewed scout and reconnaissance vehicles, and the military deception uncrewed swarming systems can provide, AI-enabled capabilities will reduce the number of personnel exposed to enemy fires.

Sustainment:

Sustainment is the provision of logistics and personnel services to maintain operations through mission accomplishment and redeployment of the force. Sustainment provides the JFC the means to enable freedom of action and endurance and to extend operational reach. Sustainment determines the depth to which the joint force can conduct decisive operations, allowing the JFC to seize, retain, and exploit the initiative. The sustainment function includes tasks to: (1) Coordinate the supply of food, operational energy (fuel and other energy requirements), arms, munitions, and equipment. (2) Provide for maintenance of equipment. (3) Coordinate and provide support for forces, including field services; personnel services support; health services; mortuary affairs; religious support (RS); postal support; morale, welfare, and recreational support; financial support; and legal services. (4) Build and maintain contingency bases. (5) Assess, repair, and maintain infrastructure. (6) Acquire, manage, and distribute funds. (7) Provide common-user logistics support to other government agencies, international organizations, NGOs, and other nations. (8) Establish and coordinate movement services. (9) Establish large-scale detention compounds and sustain enduring detainee operations.

As mentioned above, sustainment is one of the many areas where AI-enabled systems can dramatically enhance joint force capabilities and timeliness through greater automation while minimizing personnel exposure to enemy action. As with the Amazon example earlier in this paper, that company is leading the way in robotic logistics and drone deliveries. The Department of Defense can learn from their lead and embrace similar approaches to military operations. Of most immediate impact, the integration of AI into the assistance of monitoring and reporting maintenance functions, using predictive analytics and predictive maintenance, will streamline what is otherwise a time, cost, and – in its most extreme implication – human life intensive endeavor. AI analysis can greatly reduce maintenance error or the loss of human life by predicting impending failure of critical vehicle systems. AI can generate supply chain demands ahead of need, based on predictive pattern memory and granular analysis of system supply and delivery needs.

In terms of discreet ATBs in support of the Joint Warfighting Functions, the following could be applied to autonomous machines as representative examples:

- **Move:** Position administratively in its operational environment per mission parameters
- **Maneuver:** Move tactically in its operational environment, loiter awaiting a target, seek an advantageous position against a threat
- **Reconnoiter/Detect:** Find, identify, classify, and prioritize potential targets
- **Calculate:** Process necessary targeting data
- **Track:** Maintain contact with detected targets
- **Select Munition/Payload:** Select appropriate payloads to manipulate its environment or the proper munitions to engage threats
- **Engage:** Deliver lethal or non-lethal effects, either LOS, BLOS or NLOS
- **Communicate:** Communicate with both human and machine co-combatants
- **Control:** Manage or control other entities as when operating in a team or swarm
- **Manipulate:** Interact with its environment, (e.g. twist a door knob, or remove obstacles)
- **Refine Position/Micro-Adjust:** Make small adjustments to its orientation or posture
- **Request Guidance:** Stop and request further instructions from a human
- **Assess/Reason/Adapt:** Assess, reason, understand, learn and adapt to its changing environment, (e.g. how does it think and modify its actions)
- **Survive:** Protect itself from environmental or enemy threats
- **Sustain/Replenish:** RAS repair and replenish themselves
- **Sacrifice:** Decide to protect other co-combatant unit human team members by sacrificing itself

Similarly, these ATBs can serve as related subtasks to the Principles of Joint Operations and the Universal Joint Task List (UJTL). The Principles of Joint Operations encompass:

Mass

In order to achieve mass, appropriate joint force capabilities are integrated and synchronized where they will have a decisive effect in a short period of time. Mass often must be sustained to have the desired effect. Massing effects of combat power, rather than concentrating forces, can enable even numerically inferior forces to produce decisive results and minimize human losses and waste of resources

The U.S. went away from quantity in favor of exquisite technological quality in the prosecution of its warfighting aims, but as the old saying goes, quantity has a quality all its own, especially in attrition-style warfare. What AI can bring to this principle is the merging of both; to whit, a "return of Mass to the battlefield." AI harnessed to battlespace management and assisting in command and control of maneuver and fires, for both crewed and uncrewed assets, will accelerate and enhance lethality. Many of the strategies DoD has created herald AI-enabled platforms' ability to provide long-range ISR, decoy or deception, distributed all-domain swarming, etc. This mass, coupled with the relatively cost-effective nature of those high-tech platforms should they be lost in the prosecution of their missions, will better preserve military end strength normally associated with crewed platforms conducting the same missions.

Objective

The purpose of military operations is to achieve the military objectives that support attainment of the overall political goals of the conflict. This frequently involves the destruction of the enemy armed forces' *capabilities and their will to fight. The objective of joint operations not involving this destruction might be more difficult to define; nonetheless, it too must be clear from the beginning. Objectives must directly, quickly, and economically contribute to the purpose of the operation. Each operation must contribute to strategic objectives. JFCs should avoid actions that do not contribute directly to achieving the objective(s).*

The beginning of any mission analysis is to understand the operational environment using the tenets of JP 2-01.3, Joint Intelligence Preparation of the Operational Environment. This four-step process (Define the Operational Environment; Describe the Impact of the Operational Environment; Evaluate the Adversary and other Relevant Actors; and Determine Adversary and other Relevant Actor Courses of Action) aids in understanding the political, military, economic, social/cultural, infrastructure, informational, and geographic/meteorological realities surrounding the enemy's capabilities, location, will, etc. This creates shared understanding across the joint force to better enable knowledge of the political and military objectives required for successful military operations.

There are numerous applications in this realm where AI would be of tremendous benefit.

- Data aggregation to better and more rapidly inform analysis of the operational environment
- Aiding in decision-making to assist commanders and their staffs in understanding the complexities of the operational environment to better develop courses of action for attainment of the objective
- JADC2/All-Domain Operations where the AI enabled network (or the internet of military things, or IoMT) would empower autonomous systems, decision-makers, and the joint force in order to bring massed effects onto the objective with speed and relevance
- In the case of political objectives, AI, through the use of informational, cyber, space, intelligence, and other non-kinetic means, may serve as a powerful deterrent to prevent adversaries from advancing toward open conflict

Offensive

Offensive action is the most effective and decisive way to achieve a clearly defined objective. Offensive operations are the means by which a military force seizes and holds the initiative while maintaining freedom of action and achieving decisive results. The importance of offensive action is fundamentally true across all levels of war.

In the future operating environment, gaining the initiative will mean the difference between victory or defeat. In the compressed timelines of hypersonic, algorithmic, and informational warfare, the battlespace geometry of the past measured in weeks, days, or hours will be compressed into minutes, seconds, and nanoseconds. He who sees first, understands first, and acts with precision and appropriate force will win. Comprehending, assessing, deciding, and then acting within this milieu will easily and rapidly overwhelm human cognition. Only a properly conceived application of AI capabilities and its attendant ability to process information at the speed of light will ensure the initiative can be sustained in offensive operations.

Surprise

Surprise can help the commander shift the balance of combat power and thus achieve success well out of proportion to the effort expended. Factors contributing to surprise include speed in decision-making, information sharing, and force movement; effective intelligence; deception; application of unexpected combat power; OPSEC; and variations in tactics and methods of operation.

As previously mentioned, AI and autonomous systems can assist with military deception, distributed operations to overwhelm an enemy's understanding and decision-making, provide flexible force allocation and delivery of effects across all the warfighting domains, and allow for assessment and reassessment based on data feeds and relevant enemy actions to recommend alternative force allocations or courses of action in real time.

Economy of Force

Economy of force is the judicious employment and distribution of forces. It is the measured allocation of available combat power to such tasks as limited attacks, defense, delays, deception, or even retrograde operations to achieve mass elsewhere at the decisive point and time.

Another central idea behind JADC2/All-Domain warfare. See Surprise above.

Maneuver

Maneuver is the movement of forces in relation to the enemy to secure or retain positional advantage, usually in order to deliver—or threaten delivery of—the direct and indirect fires of the maneuvering force. Effective maneuver keeps the enemy off balance and thus also protects the friendly force. It contributes materially in exploiting successes, preserving freedom of action, and reducing vulnerability by continually posing new problems for the enemy.

AI will help accelerate the clock speed of ground maneuver forces. U.S. forces will operate inside the "OODA loop" (Observe, Orient, Decide, Act) of their enemies, as AI will enable commanders to understand the location and disposition of enemy forces early. From there, commanders will be able to see the battlefield with greater clarity and thus exploit enemy weaknesses. With AI assistance, forces will move to positions of advantage faster than their enemies, engage and destroy targets of their choosing, and exploit breakthroughs and pursuit of fleeing forces with greater security and confidence. A unit so equipped with AI will be like fighting an opponent who seemingly knows what you are going to do two moves before you do.

Unity of Command

Unity of command means that all forces operate under a single commander with the requisite authority to direct all forces employed in pursuit of a common purpose. During multinational operations and interagency coordination, unity of command may not be possible, but the requirement for unity of effort becomes paramount. Unity of effort—the coordination and cooperation toward common objectives, even if the participants are not necessarily part of the same command or organization—is the product of successful unified action.

This is the driving premise behind all-domain operations and JADC2. As mentioned above, if AI were to be utilized within the JADC2 framework, then data aggregation between sensor platforms, sense-making, and decision-making would all take place much more quickly and efficiently facilitating speed of relevance actions in the time and space compressed battlefield of the future. Similarly, autonomous systems within the operating area would more quickly sense, detect, identify, target, and respond to threats than their human counterparts.

Simplicity

Simplicity contributes to successful operations. Simple plans and clear, concise orders minimize misunderstanding and confusion. When other factors are equal, the simplest plan is preferable. Simplicity in plans allows better understanding and execution planning at all echelons. Simplicity and clarity of expression greatly facilitate mission execution in the stress, fatigue, fog of war, and complexities of modern combat, and are especially critical to success in multinational operations.

If clarity is the essence of simplicity, then adequate information is the essence of clarity. AI-enabled analysis and decision tools will distill otherwise chaotic and overwhelming data streams into clear analyses which will provide the clarity necessary for decision-makers and commanders to transmit their intent to subordinate or coalition forces. Complexities and the fog of war will always be a factor in warfare – AI is no magical panacea – but sound implementation, concepts, exercises, and adoption of AI capabilities will help mitigate the scope and impact of these realities.

Security

Security enhances freedom of action by reducing friendly vulnerability to hostile acts, influence, or surprise. Security results from the measures taken by commanders to protect their forces. Staff planning and an understanding of enemy strategy, tactics, and doctrine enhance security. Risk is inherent in military operations. Application of this principle includes prudent risk management, not undue caution.

Autonomous systems will increasingly be able to perform tasks normally performed by human crewed systems. From defensive measures to protect rear area posts, or formations of units converging on an objective, to supply, reconnaissance, surveillance, medical evacuation, etc., autonomous vehicles and capabilities will remove scores of personnel from vulnerable or otherwise risky endeavors allowing for more focus on force protection and offensive operations.

Restraint

A single act could cause significant military and political consequences; therefore, judicious use of force is necessary. Restraint requires the careful and disciplined balancing of the need for security, the conduct of military operations, and the national strategic end state. For example, the exposure of intelligence gathering activities, such as interrogation of detainees and prisoners of war, could have significant political and military repercussions and should be conducted with sound judgment. Excessive force antagonizes those parties involved, thereby damaging the legitimacy of the organization that uses it while potentially enhancing the legitimacy of the opposing party.

This could arguably be the most potentially problematic principle when employing AI-related systems. Without a human in or on the loop to adjudicate target recommendations, there exists the possibility fully autonomous systems might erroneously engage targets, or otherwise misread or misinterpret actions in the operating area resulting in engagements inconsistent with the LOAC and IHL principles.

This is one area where concepts of operation which detail the types, numbers, and environments in which AI systems are to be utilized is critical.

Perseverance

Perseverance involves preparation for measured, protracted military operations in pursuit of the national strategic end state. Some joint operations may require years to reach the termination criteria. The underlying causes of the crisis may be elusive, making it difficult to achieve decisive resolution. The patient, resolute, and persistent pursuit of national goals and objectives often is essential to success. This will frequently involve diplomatic, economic, and informational measures to supplement military efforts.

Robots do not sleep. They do not require sustenance (other than charging and periodic maintenance). They do not possess emotions or distractions from home during long deployments which could compromise their mission execution. In other words, AI-enabled capabilities are the ultimate persistence and presence options for sustained military operations. Long-term loitering, concealed long-term reconnaissance or intelligence gathering, or passive placement until sensing enemy movement and then reacting to contact, these are all possibilities on the future battlefield where the limitations and psychological stresses normally associated with human operators are obviated and replaced by robotic team members who can dispassionately "stand the watch."

Legitimacy

Legitimacy, which can be a decisive factor in operations, is based on the actual and perceived legality, morality, and rightness of the actions from the various perspectives of interested audiences. These audiences will include our national leadership and domestic population, governments, and civilian populations in the operational area, and nations and organizations around the world.

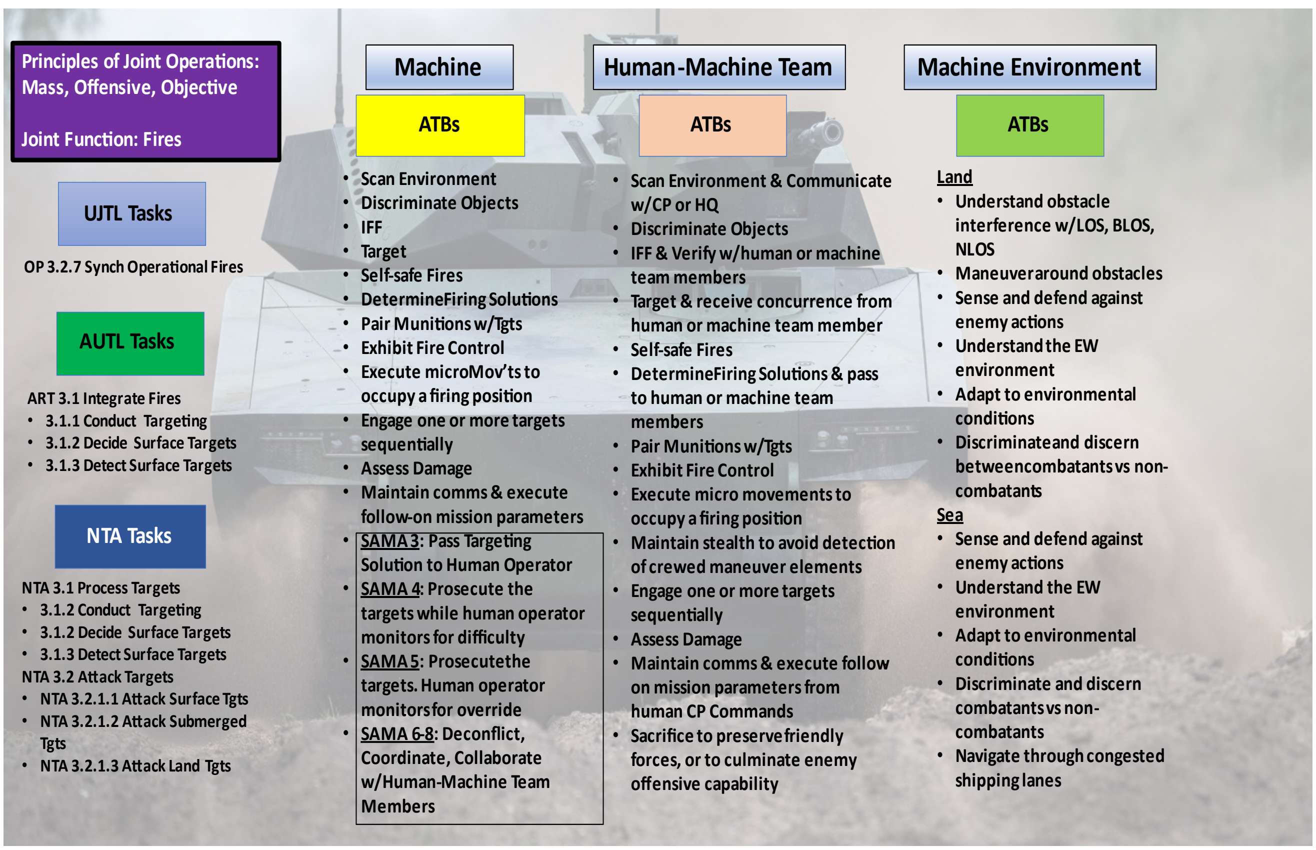
Committed forces must sustain the legitimacy of the operation and of the host government, where applicable. Security actions must be balanced with legitimacy concerns. All actions must be considered in the light of potentially competing strategic and tactical requirements, and must exhibit fairness in dealing with competing factions where appropriate. Legitimacy may depend on adherence to objectives agreed to by the international community, ensuring the action is appropriate to the situation, and fairness in dealing with various factions. Restricting the use of force, restructuring the type of forces employed, and ensuring the disciplined conduct of the forces involved may reinforce legitimacy.

This can be considered in the context of restraint described above. While drone strikes in the past have raised questions about the legitimacy of U.S. actions abroad, the use of AI-related systems in future contexts will likely be even more vociferously questioned and denounced. Again, this will require the Department to engage in departmental, public, and international transparency using detailed rules of engagement, concepts of operation highlighting the types of AI-enabled capabilities and where, when, and how they will be employed (to the extent national security allows), to ameliorate doubt. If AI can be shown to statistically guarantee greater precision in targeting and lethal application than human controlled assets alone, there may an opportunity to show AI as an improvement to managing collateral damage. Again, it is the fog of war that so often leads to unintended death and destruction. AI may help clear battlefield uncertainties in specific use cases where humans alone might make more mistakes.

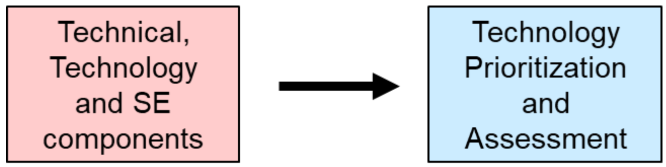
SAMA Task Analysis

From these broad doctrinal analyses of AI-related systems' utility in joint operations, the UJTL can serve as a detailed guide for mapping ATBs to UJTL tasks. From there, the individual services can utilize their respective universal task lists to further decompose those ATBs into domain-specific behaviors. A representative mapping of UJTL tasking for synchronizing operational fires will incorporate possible ATBs as they relate to the machine itself, the team members with whom the machine is working, and the environment/domain within which the machine will be operating.

In the diagram below, the Principles of Joint Operations and Joint Functions are listed first, followed by the UJTL for synchronizing operational fires. The Army and Navy UTLs are then nested under that UJTL. The respective ATBs are then listed as they apply to the machine itself, the machine as it relates to its human-machine team members, and then as the machine relates to its environment. In the Machine ATB, some notional SAMA standards are proposed for the various gradations of autonomy to illustrate how SAMA can be integrated into concepts of operation as well as tasks and purpose depending upon technology/system viability and end user/commander comfort levels with the system.



Once this decomposition of tasks is completed at the service, joint, and DoD levels, engineers will have a better understanding of how to identify the different autonomous capabilities required, the technology needed to achieve those capabilities, and the components required to begin prototyping the desired systems.



- Once end-user expectations for RAS capabilities are clarified, those detailed and doctrinally supported expectations are socialized with industry engineers
- Engineers then identify and work toward the appropriate hardware and software technology solutions. These technology solutions may be prioritized based on importance in response to competitive advantage, urgency due to service needs, or utility based on multiple applications across the Department
- Technologies are then assessed based on feasibility, readiness, and integration, interface, interoperability, or other implications (I4) beneficial to joint force fielding of these capabilities
- This net assessment then accomplishes two important functions:
    1. Contributes to the SAMA standards of autonomy in military application.
    2. Prioritizes the capabilities and the technology most needed across the joint force.

SAMA standards are assessed by evaluating all the contributing autonomous technologies that, when working together, deliver an associated function or subtask. This assessment requires three different perspectives and a coordinated decision between engineers, end-users, leadership, and policymakers.

Operational tasks are assessed as either go or no-go based upon both employability and deployability. From there, developmental test and evaluation (DTE) and operational test and evaluation (OTE) informs the technology readiness level for proposed systems.

Putting it all together, doctrinal concepts as well as joint and service task lists provide the detailed analytical framework through which ATB requirements are ascertained. This can then be fed to system engineers and system developers to produce vehicles and capabilities based upon those requirements. When prototypes are ready, DTE and OTE utilize engineering and end-user insights to determine system viability in the achievement of those ATBs in the performance of their service-related tasks. This dialogue, when coupled with the I4 considerations, helps developers and users determine the overall viability of the proposed systems/capabilities. In other words, the SAMA taxonomy provides a disciplined and detailed analytical framework to bridge the gap between development efforts and procurement and fielding requirements.

Conclusion

The US Department of Defense is committed to fielding operationally useful autonomy however it is challenged to explain what the government is getting for its money in terms Congress and Senior Military Leaders can understand. After 14 years of grappling with the need for a common taxonomy and lexicon for autonomy, the blistering pace of technology advancement in this field demands a solution the community of practice can use. Without a macro-level strategic view of how these new capabilities can be incorporated, why these new capabilities are necessary, what these new capabilities ought to do, where these capabilities should be employed, when they should be utilized, and who should be responsible for their development and use, the DoD will continue to struggle to explain its intent for autonomy. There must be a better way. The SAMA matrix offers a path to clearer understanding of operational battlefield autonomy.