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Maneuver Robotics & Autonomous Systems (MRAS): Enabling Future Capability

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ABSTRACT

The Army Operating Concept and the Cross Domain Maneuver Concept describe more capable Brigade Combat Teams that can operate semi-independently across wide areas on the future battlefield. Robotics and Autonomous Systems can increase capabilities of Brigade Combat Teams by increasing situational awareness, facilitating movement and maneuver, improving protection, extending a small unit's area of operations, and sustaining the force with increased distribution, throughput, and efficiency. Army industry partners, in concert with Army labs, must provide the affordable technologies that can provide these autonomous and semi-autonomous operational capabilities to the future force. While acknowledging that there must be significant technology development to realize this vision, this concept paper aims to take a realistic look at enabling Brigade Combat Teams with third-offset capabilities by 2035.

INTRODUCTION

The Army Operating Concept TRADOC Pamphlet 525-3-1, "Win in a Complex World," for the first time focuses on all three levels of war: tactical, operational, and strategic. The environment in which the Army will operate is unknown. The enemy is unknown, the location is unknown, and the coalitions involved are unknown. It emphasizes the criticality of land forces in shaping security environments, deterring conflict and consolidating gains. It further emphasizes the integration of advanced technologies with skilled Soldiers and well-trained teams to maintain differential advantages over adversaries. In recognizing technologies with the most potential for military application, autonomous and semi-autonomous operational capabilities may increase lethality, improve protection, and extend Soldiers' and units' reach and endurance. Additionally, power saving and generation technologies may reduce sustainment demand and strategic lift requirements.

CAPABILITIES

Building the future force links warfighting challenges with required capabilities. Forced entry, combined arms maneuver and establishing and maintaining wide area security require Army formation designs capable of deploying rapidly and operating to achieve missions in multi-domain battle. The *Force 2025 Maneuvers, published in 2014,* developed concepts, operational and organizational plans to achieve the vision of the Army's force in the then-defined near- (2014-2020), mid- (2020-2030), and far- (2030-2040) terms and translates big ideas (such as logistics demand reduction and integration of robotics and autonomy-enabled systems) into technology focus areas. One such focus area, autonomy-enabled systems, can serve as force multipliers at all echelons from the squad to brigade combat team. Future robotic technologies and Unmanned Ground Systems (UGS) will augment Soldiers and increase unit capabilities, situational awareness, mobility, and speed of action. Additionally, future maneuver forces require the capability to maneuver and survive in close combat against enemies operating with robotic and autonomous systems unmanned air and ground systems.

ROBOTIC EMPLOYMENT IN MANEUVER

The Army must address Army Warfighting Challenges (AWfC), or enduring first order problems, the solutions to which will improve current and future force combat effectiveness. The eleventh AWfC, Conduct Air-Ground Reconnaissance and Security Operations, calls on Robotics and Autonomous Systems (RAS) to support. Unmanned Aerial Systems (UAS) have already demonstrated the potential to generate accurate targeting locations for precision fires and the ability to report battle damage assessments. By employing next generation sensors and shooters, RAS achieve real-time integration and optimization of targeting data for a range of fires

applications. RAS fuse data from all joint, national, and multinational sensors from space to subterranean to achieve real time integration and optimization of targeting data. RAS enable forces to move accurately and quickly track and defeat targets, match targets with effects, and coordinate capabilities.

TRADOC Pamphlet 525-3-6, "The U.S. Army Cross Domain Maneuver Concept (CDMC)," expands on the ideas presented in the U.S. Army Operating Concept. It describes how Army maneuver forces generate overmatch across all domains, the electromagnetic spectrum, information environment, and human perception. Army maneuver forces also integrate reconnaissance and security operations, maneuver sensors, and long- range capabilities into positions of advantage, integrate intelligence and operations, defeat enemy cross-domain capabilities, and transition from shaping operations to close combat. The CDMC also recognizes the role of unmanned air and ground systems and robotics in future maneuver.[1] The CDMC further notes that when multiple subordinate formations operate dispersed and potentially out of mutual supporting range, higher-level commanders integrate capabilities across domains, echelons, and formations to conduct

[1] CDMC Paragraphs 2-2a (1), b-2a(4), and E-3c

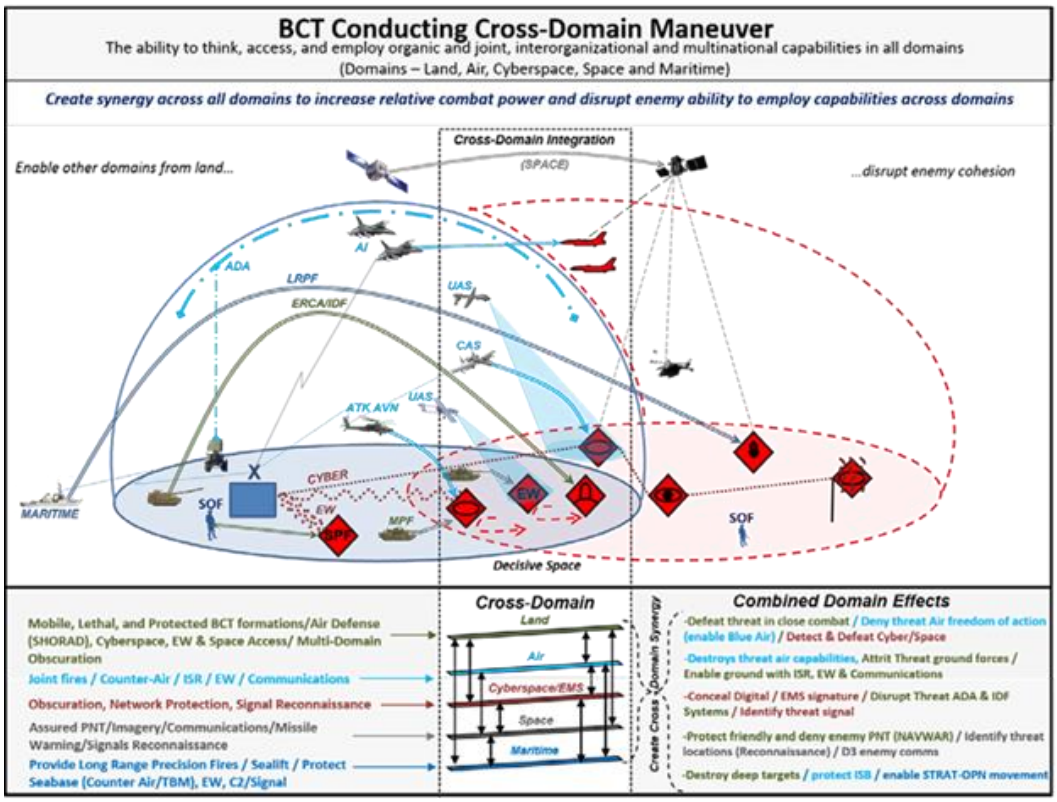
continuous reconnaissance and provide security over wide areas between subordinate maneuver forces. Capabilities requiring integration include providing a dedicated reconnaissance force, employing unmanned aerial and ground platforms, robotics and sensors, or a combination of all.

The CDMC contains an entire Robotics Appendix (E), *Unmanned Systems*, to focus on the multiplying effects and outcomes sought as systems begin demonstrating opportunities for leaner and more effective protection, lethality, and survivability. The CDMC calls for prioritizing research on autonomous UGS, supporting parallel technology efforts in persistent power supply, and upgrading Army information network and sensor capabilities- all considered critical in the far-term. Once refined, these supporting technologies allow teams of UGS and unit-level small UAS to work together and expand the operational reach and situational awareness of commanders, under the umbrella concept of maneuver RAS (MRAS). The use of leaner robotics compared to current manned platforms will increase the capabilities of the force and help the force become more agile with increased strategic mobility.

As the Army becomes more technically focused and network enabled over the next decade, robots offer additional opportunities to establish and extend the Army information network capabilities to the individual Soldier. Beyond that, rapidly deployable MRAS capable of connecting mission command systems will allow for mission command on-the-move and the rapid transition to offensive operations after initial entry into a theater of operations. MRAS then allows commanders to retain the initiative during high-tempo, decentralized operations. Expendable MRAS platforms will provide commanders the ability to take operational risks previously unimaginable.

Autonomous UGS have the potential to increase commanders' situational understanding in urban environments through reconnaissance and mapping of subterranean systems. Teams of UGS and UAS will execute intelligence, surveillance, and reconnaissance based on tasks given by a single operator. These teams will conduct adaptive, persistent intelligence, surveillance, and reconnaissance for extended durations in areas inaccessible by humans.

Unmanned systems will extend area security operations and increase mission duration, thereby enabling manned systems to focus on other missions within the maneuver unit. Autonomous



capabilities can enhance protection by allowing unmanned systems to operate in areas difficult for humans to access, where threats demand greater standoff for manned teams, or where the duration of the operation exceeds reasonable human capability.

The March 2017 U.S. Robotic and Autonomous Systems (RAS) Strategy highlights advanced RAS development and addresses challenges in five capability objectives to guide technology development and employment of UGS and UAS in support of dismounted formations that easily translate toward mounted formations:

1. Increase situational awareness;
2. Lighten the Soldiers' physical and cognitive workloads;
3. Sustain the force with increased distribution, throughput, and efficiency;
4. Facilitate movement and maneuver; and,
5. Protect the force.

Autonomous unmanned systems integrated into combat formations allow the maneuver force from squad to the brigade combat team to reduce force density in conditions of uncertainty and enable freedom of movement and action. Next Generation Combat Vehicles will incorporate autonomous systems both on and off the platform. MRAS must assist in operating, targeting, protecting, and maintaining on-board systems. In short, MRAS requirements nest in virtually all ground Science and Technology (S&T) investment areas.

REQUIRED TECH ADVANCEMENT

Between now and FY25, (S&T) investments are sought for remote and close proximity autonomous robotic unmanned ground and aerial systems that provide intuitive alert interfaces for danger awareness and avoidance, afford greater situational awareness, recognize threats, and automatically recognize and track targets for human engagement. Unmanned systems in the mid-term, 2025 through 2035, should respond to digital and verbal commands and act as members of the squad or crew. They must also provide accurate verbal and written language translation unobtrusively and aid cognition of various crew tasks. Autonomous unmanned systems, given sufficient levels of artificial intelligence, will function as members of the formation executing tasks as well as providing oversight for subordinate systems, also known as unmanned-unmanned teaming (UUT). This capability will allow leaders to employ unmanned systems for critical and complex tasks such as establishing a self-emplacing mesh communication network, or reconnoitering and mapping subterranean infrastructures – an emerging focus area. Unmanned systems in the far-term, 2035 and beyond, should increase formation combat effectiveness and reduce their sustainment burden by implementing purpose-built solutions derived from lessons learned in the near- and mid-terms.

Over the next twenty-five years, four technology advancements are essential to allow the fastest and most cost effective achievement of the RAS capability objectives: common control, autonomy, artificial intelligence (AI) and cyber protection; all of which will begin to change how the Army operates by steadily integrating autonomous systems into combined arms maneuver. In addition to advancements of common control, autonomy, and AI, the Army requires government-owned architecture, interoperability, common control interfaces, common platforms, and modular payloads as well as software and hardware to realize cost-savings. Making common MRAS platforms and control interfaces translates to cheaper life cycle costs, the potential for faster upgrades to support innovation, and accelerated capability development. Expeditionary focused doctrine notes that decreasing the Soldier-to-robot controller ratio can provide significant gains in unit effectiveness and situational understanding. Component/payload modularity facilitate MRAS integration in different mission sets without requiring unique chassis (reducing the requirement for capital

assets). For example, in one mission a medium UGS carries extra supplies, and in the next mission employs a chemical, biological, radiological and nuclear (CBRN) sensor payload, while in a third mission it emplaces a surveillance asset. Finally, cyber protection and assured control, or **mission assurance**, are critical for effective RAS development and employment. Mission assurance, defined as the actions taken to achieve mission resiliency and ensure the continuation of mission essential functions and assets under all conditions and across the spectrum of threats and hazards, obviously allows units a much higher probability of mission success. The ability to assign tasks to UGS and passively control or over-watch multiple assets simultaneously is critical. This requires development of suitable autonomous or semi- autonomous behaviors to lessen Soldier cognitive loads further than current UGS.

Vignette: Urban Operations (2025)

Squads and platoons equipped with small RAS in urban terrain make contact on their own terms, thus reducing the need for formations to maintain the traditional 6:1 attacker-to-defender ratio commonly associated with conventional urban combat operations. Squad Multipurpose Equipment Transports carry supplies and small unit enablers, such as additional weapons, power generation, and other ground robots. These capabilities enable Soldiers and tactical units to avoid threats, maneuver and clear objectives efficiently, and initiate contact under favorable conditions. Platoons and squads will use these systems to aid in reconnaissance missions across three dimensions (surface, supersurface, and subsurface) and to protect Soldiers. UAS sensors loitering overhead work with UGS platforms on the ground to provide enhanced situational awareness to human teammates in order to create better tactical options for small unit leaders.

In the mid-term of the RAS Strategy, primary focus lies on improvements in situational awareness, Soldier load reduction, sustainment, and maneuver. The Army improves the ability to develop and sustain understanding through human-machine collaboration, advanced RAS, and swarming capabilities. To facilitate cross-domain movement and maneuver, the Army will introduce unmanned combat vehicles designed to function and maneuver across variable and rough terrain under combat conditions. In the far-term of the RAS Strategy, the Army displaces its antiquated autonomous systems and fields new purpose-built autonomous UGS and UAS developed through commercial research and S&T investments made in the near- and mid-terms. Studies and lessons learned from near- and mid-term initiatives inform new organizational designs that fully incorporate autonomous systems.

Deputy Defense Secretary Bob Work's remarks found in "Third Offset Strategy Bolsters America's Military Deterrence," states with regard to people and machines, "Other capabilities are advanced human-machine combat teaming such as with manned and unmanned systems working together, network-enabled autonomous weapons, and high-speed weapons like directed energy, electromagnetic rail guns and hypersonics." "All of those things will be injected into the sensor grid, into the C4I grid, into the effects grid and the logistics and support grid, allowing a big performance impact," he said, noting that the third offset and its effect on a range of military capabilities is not just about the technology.

AFFORDABILITY

Common control is the ability for one common software package to control an array of ground and air systems, and is critical for maximizing management of multiple and varied MRAS. Common control also overcomes operational limitations (data sharing / encryption / range / transferring control of platforms and payloads), while realizing cost savings and simplifying sustainment through compatible display units, batteries, and radios. The Army requires government-owned open architecture, interoperability, common platforms, and modular payloads to fully realize cost-savings and faster upgrades. Transferring autonomous technology to current Army systems also improves affordability by reducing the costs of new start programs and avoids unnecessary integration and training costs. Organizations within the RAS community offer the capabilities, resources, and expertise to pursue and achieve MRAS capabilities. Those critical to accomplishing the MRAS end state are: RDECOM, TRADOC, and DOD labs, academia, and commercial robotic vendors in the U.S. industrial base. The Army leverages commercial research whenever possible to reduce costs and increase capabilities. Through interoperability standards in the near-, mid-, and far-terms, the Army and other Joint partners, efficiencies in commonality of design and interface to the user, cost will drive down.

PATH FORWARD

Pursuing MRAS potentially allows the Army to improve the combat effectiveness of the maneuver force in significant ways. However, the path to achieving the capabilities described in this paper is neither short nor simple. Full realization of these capabilities require technology developments that are revolutionary – not simply evolutionary. Relying on the inevitable, gradual advancement of technology over time is insufficient. Development of the necessary technology requires a carefully planned strategic approach to both steer and drive advances through funded development activities.

For example, the current MRAS plan for the Robotic Combat Vehicle (RCV) aims to have S&T development completed by 2023, including a variety of semi-autonomous capabilities, as well as eventual advancement to fully autonomous operation by 2035. The objective of a fully autonomous weaponized platform functioning as an integral part of the combat formation is important and achievable, but will require significant development and investment by both the Army and industry to close the remaining technology gaps. Moreover, an extensive amount of testing will be expected (likely far more than any traditional manned fighting vehicle) in order to not only verify the performance of the system, but to also build confidence and trust in the autonomous behavior of the system as well as refine doctrinal concepts and tactics, techniques, and procedures. It is important that the Army leverage a strategy of jointly funded development, while formulating concrete intermediate goals and objectives in order to drive both the Army and industry to success.

Early funding of technology is critical for the development, maturation, and procurement of effective MRAS. The current Strategic Portfolio Analysis Review (SPAR) is well postured to align priorities and resources to achieve the objectives within the RAS Strategy. Additionally, as the MRAS Initial Capability Document (ICD) seeks Army Requirements Oversight Council (AROC) approval, Army leaders should well consider realignment of 6.1 – 6.3 Research Development Test & Evaluation (RDT&E) funds and priorities. Similar S&T working groups and approval boards should do the same. Collaborative innovation venues and processes must continue to evolve, providing routine and frequent opportunities for the Army and industry to work together to develop RAS capabilities. The Army must continue to facilitate adjustments in the Army S&T

community to keep pace with rapid evolution of RAS, computer processing power, and software.

Lastly, the anticipated fiscal environment in the near and mid-term limits the Army's ability to develop new major combat systems. While the AOC helps decision-makers understand how Army forces must fight and win in the future, the concept is only a starting point in the debate to garner the resources necessary to deliver the needed future capabilities.

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