2022 Richard S. Schultz '60 Fellow Research Report

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"Artificial Intelligence and Electromagnetic Warfare: Creating New Capabilities on The Battlefield"

Introduction and Project Overview

The environment in which US warfighters operate in has fundamentally changed. Warfare as we know it today is not what it once was ten or even five years ago: operations across all five domains (sea, air, land, space, and cyber) has become increasingly complex. As the multi-domain warfighting strategy continues to grow in its popularity as the preferred playbook for modern militaries to gain and maintain control of the pace of warfare, militaries across the globe are developing a strong dependence on the electromagnetic spectrum (EMS). Militaries recognize that the EMS is a maneuver space essential for facilitating control of the battlefield in turn directly impacting the success of any military operation. The EMS is a part of the electromagnetic operational environment (EMOE) defined as a composite of the actual and potential electromagnetic radiation, conditions, circumstances, and influences that affect the employment of capabilities and the decisions of the commander. It includes the existing background radiation as well as the friendly, neutral, adversary, and enemy electromagnetic systems able to radiate within the EM area of influence. The EMS itself is a series of frequencies ranging from radio waves to microwaves, visible light, X-rays, and gamma rays that radiate electromagnetic energy. Virtually every modern weapon system including but not limited to aircraft, tanks, ships, missiles, satellites, and communication systems, rely upon the EMS to function. [See Figure 1]

Modern military forces exploit the spectrum to support operations through activities that are grouped into the following four categories: sensing, communication, attack, and deception. The United States Department of Defense (DoD) states that the EMS is the critical connective tissue that links all domains and enables multi-domain operations. The DoD has made EMS superiority a top priority as near-peer adversaries to the United States have accelerated and outpaced the United State in the development of advanced EMS capabilities and skillsets. [See Figure 2]

Furthermore, as our national security, critical infrastructure, communication, and economic complexes grow increasingly dependent on EMS functions, a significant vulnerability in the nation's defense has been exposed, one with potentially devastating
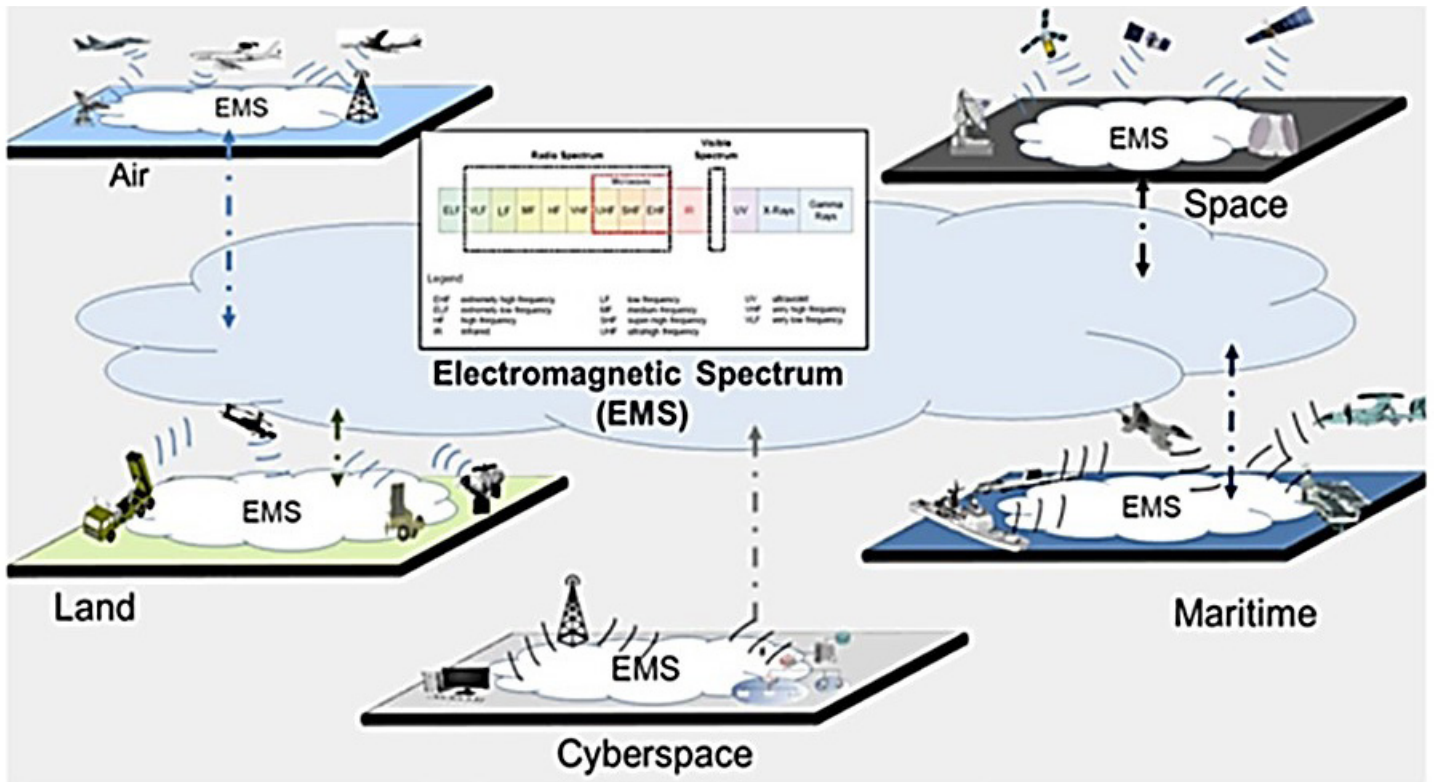

Figure 1

Figure 2

consequences if it were to be exploited by our adversaries. To ensure the defense of the nation and unfettered access & maneuver within the EMS the DoD relies on electromagnetic warfare (EW). [See Figure 3]

What is Electromagnetic Warfare?

The DoD defines EW as "Military action involving the use of the EMS and directed energy to control the EMS or attack the enemy." EW is the key enabler that dictates how our forces gain advantage within the contested EMS to and achieve EMS Superiority. EW exists as a subset of a larger field of operations known as Electromagnetic Spectrum Operations (EMSO). EMSO as defined by the DoD is the coordination of military actions to exploit attack, protect, and manage the EMOE. While EW is solely focused on fighting the enemy in the EMOE, EMSO has the role of viewing the EMS from a wholistic

perspective often dealing with management and deconfliction of EMS, a duty that has grow in its importance with the utilization of the multi-domain warfighting strategy. [See Figure 4]

Electromagnetic Spectrum Management includes planning, coordinating and managing use of the EM spectrum through operational engineering, and administrative procedures. As an activity, spectrum management is a fully nested and integral part of EW. Awareness and understanding of the EMS are the foundation to conducting the operations required to gain advantage within the spectrum. Spectrum management provides awareness and helps our forces be more agile and efficient in the use of the EMS, to enable EMW activities.

However, EW has three divisions: electromagnetic protect (EP), electromagnetic attack (EA), and

electromagnetic support (ES). The division of EP involves the protection of personnel, facilities, and equipment from any effects of friendly or enemy use of the electromagnetic spectrum. The military utilized EP to perform frequency deconfliction i.e., spectrum management, electronic masking, emission control, (EMCON), and electromagnetic hardening.

EA utilizes electromagnetic energy, directed energy, or antiradiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability. Examples include decoys, EM Jamming, anti-radiation missiles, high powered lasers, electromagnetic cyberspace attack delivery, and electromagnetic pulse (EMP) weapons.

ES is the division of EW tasked with "sensing" and building situational

Air Domain EMS Dependencies
* Radars
* Laser guided weapons
* Command guided munitions
* Radar guided munitions
* Anti-radiation munitions
* ID Friend or Foe Signaling
* Terrestrial RF communications
* SATCOM
* Passive RF/IR/EO sensors
* Positioning, navigation and timing receiver
* Ground based radars, EO/IR sensors

Maritime Domain EMS Dependencies
* RF and Laser guided weapons
* Command guided munitions
* Radar guided munitions
* Anti-radiation munitions
* Blue force tracker
* Terrestrial RF communications
* SATCOM
* Laser communications
* Passive RF/IR/EO sensors
* Positioning, navigation and timing receiver
* High power laser systems

Land Domain EMS Dependencies
* Radars
* EI/IR/RF/Laser guided weapons
* Command guided munitions
* Radar guided munitions
* Anti-radiation munitions
* ID Friend or Foe Signaling
* Terrestrial communications
* SATCOM
* Passive RF/IR/EO sensors
* Positioning, navigation and timing receiver
* High power laser systems

The EMS overlaps all the physical domains and the information environment

Space Domain EMS Dependencies
* EO/IR/RF sensors
* RF communication transponders
* Synthetic Aperture Radar
* Ground based radars
* Ground based ladar systems
* Satellite telemetry and control links

Cyber Domain EMS Dependencies
* Terrestrial and SATCOM RF command and control links
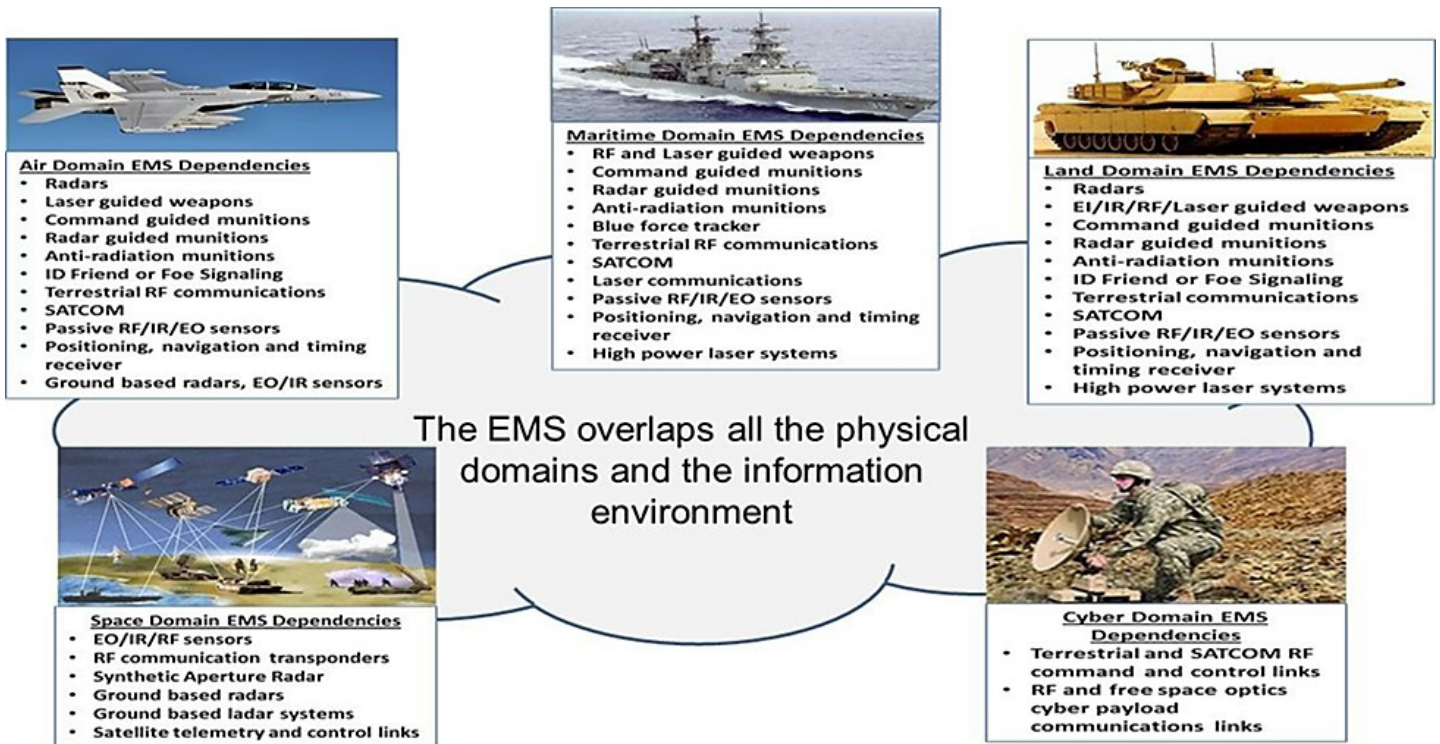* RF and free space optics cyber payload communications links

Figure 3

awareness of the EMOE. ES achieves this by the use of probing tactics that search for, intercept, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic energy for the purpose of immediate threat recognition, targeting, planning and conduct of future operations. Most data and information collected from ES nodes compliments intelligence gathered from SIGINT collection methods. Together the three disciplines of EW enable U.S armed forces to accurately characterize the EMOE, have freedom of maneuver across the EMS, and deny the adversary's ability to access the EMS all while protecting and enabling friendly use.

Challenges that face the EW community

While the benefits of EW are clear, challenges do exist, and they are only becoming more prevalent. At the current state of the EMS workforce EMS professionals have highly technical skillsets,

but due to operating in siloed communities across the DoD they lack the operational synergy necessary to coordinate and enable joint warfighting. Given that EW professionals make up the majority of the EMS workforce this is problematic, especially as the key to future success in warfare relies on all/multi-domain combat operations, operations that are dependent on the EMS. Apart from the lack of synergy in joint warfighting, EW operators are currently assessing how to deal with an increasing congested and contested EMS. Sensing and charactering the EMS has become more difficult than ever before due to the sheer number of devices and systems that populate the EMS. EW operators are having to invest more time and energy into characterizing the EMS by using tradition ES methods that are currently yielding subpar results. A similar story is seen in the EA and EP divisions as the sheer vast expansion of EMS in the modern age has made maneuvering and

operating within the EMOE a complex task. With the operational duty of an EW operator having grown in the past ten years, and the tools at the disposable of an EW operator to fulfil tasks and objectives associated with that duty mainly staying the same, a critical problem has exposed itself. How can the DoD develop warfighting strategy and doctrine that is heavily dependent on the EMS and operations withing the EMOE without properly equipping the warfighters responsible for coordinating military actions that are directly aimed at controlling the EMS and engaging the enemy within the EMOE? Luckily, a solution to the problem does exists and it starts with one of the fastest growing technologies on the planet, Artificial Intelligence (AI).

Solutions

AI is the new buzzword found in virtually every industry and business on the planet. It will change they many industries function,

including the defense industry. AI will transform the battlespace and dictate the pace at which warfighting operations are conducted for many years to come. Harnessing and moreover understanding this technological advancement is critical to ensuring the defense of the nation in a world that continues to become more technologically sophisticated. It is envisioned that AI will be involved in every aspect of the DoD's functions and actions from planning military operations and developing autonomous weapon systems, to creating more efficient/effective training and recruitment strategies. The DoD defines AI as "the ability of machines to perform tasks that normally require human intelligence". While this definition is broad in scope it does the field of AI justice as the capabilities of AI do just that, "perform task that normally would require human intelligence". Many common tasks that AI perform include pattern recognition, reasoning, prediction, or acting. These four tasks can and do directly address the current challenges that

EW operators are facing. Given the mass expansion the EMS has seen in recent years, an expansion that will only continue to grow in the coming decades, EW operators are stretched to their operational limits due to the sheer amount of EMS data they have to interact with and process on a daily basis.

However, A solution exists in machine learning, a subfield of AI that specializes in developing cognitive systems that learn and reason on their own without human programming. The field of machine learning makes this possible by applying a learning algorithm to datasets thus in turn training an AI model to "learn" knowledge. This process negatives the need for a human programmer as machine learning systems can learn parameters, rules, or objectives from the data. In relations to EW, cognitive machine learning systems can and should be developed around three focal concepts, situation assessment, decision making, and reasoning. Situation assessment involves a

system observing, characterizing, and understanding the environment in which it exists. Decision making entails a cognitive system making or recommending decisions based on a set of operational objectives and rules that it learns from a database. Reasoning covers learning from prior experiences, extracting key lessons and concepts from those experiences, and applying them to future experiences in an attempt to increase system accuracy and proficiency overall. Together the three form a continuous cognition loop, one that can be applied to EW activities in the form of providing a decision advantage to EW operators at the strategic, theater, and tactical levels of military operations. AI Situation assessment functions directly correlate to ES, while decision making functions map directly to EA and EP. Reasoning functions aid the EW operator by presenting key recommendations that increase the EW operator's efficiency in the conduct of EW operations.
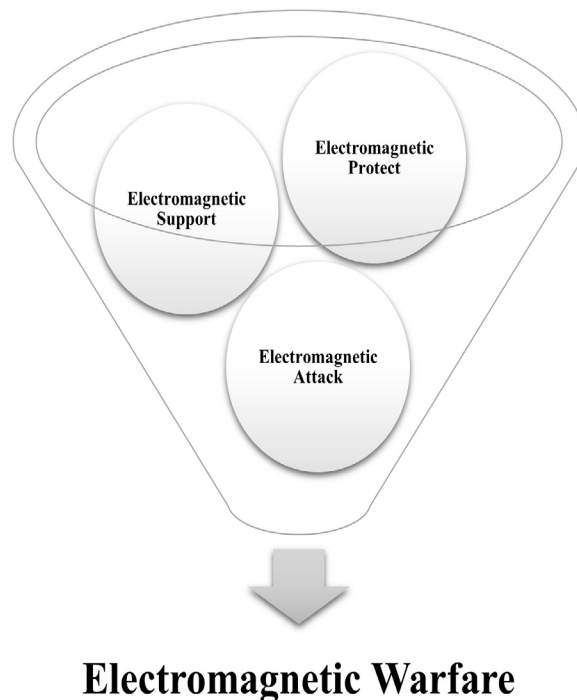

Electromagnetic Support

Electromagnetic Protect

Electromagnetic Attack

Electromagnetic Warfare

Figure 4

Conclusion?

Through the power of human-machine teaming (EW operators working in conjunction with a cognitive system) the challenging work load that EW operators face due to their in-demand skillsets and the exponential growth of the EMS can and will be radically reduced by the utilization of a cognitive system. This key intersection between AI and EW will enable the DoD and its warfighters to obtain and maintain control of the EMS, the first step in establishing control of the battlespace and dictating the of pace of warfare now, and in the future.

Author Biography

Gabriel Williams is a Norwich Senior from Suffolk, Virginia. He attended Hampton Roads Academy where he was captain of the track and field. Discovering early on that he thoroughly enjoyed the field of government and politics Gabriel chose to attend Norwich University as a Political Science major, planning to work in the government sector or Intelligence Community upon graduation. At Norwich Gabriel co-founded the Norwich University Boxing Program and made history this past year as the he was a part of the first Norwich boxing team to ever compete in the National Collegiate Boxing Association. As a member of the Corps of Cadets Gabriel thoroughly enjoys working with the rook class as he was cadre staff his junior year and is an officer in a cadet training company this year. Outside of Norwich Gabriel has had internship and contracting experiences in the Department of State and Department of Defense.

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The Richard S. Schultz '60 Symposium Fellowship was established in 2017 as an endowed fund in honor of "Dick" by his wife of fifty years, Myrna L. Schultz, their children Marni and Alan, and his classmates and friends.

The fellowship enables Norwich undergraduates, from any academic discipline, the opportunity to pursue areas of inquiry and experiences that will promote and expand their understanding of the past and how it impacts the present and future. Through research, travel, and inquiry the Schultz Fellow and faculty advisor will offer perspectives for us to face the future with better understanding and confidence.

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