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Evaluating Requirements for the Electromagnetic Order of Battle for U.S. Army Warfighter Exercises

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Abstract: Simulations play an integral role in Army training, allowing soldiers to experience a degree of the reality of a combat environment without posing a risk to themselves. However, the standard Army simulations do not include the ability to produce an electromagnetic order of battle (EOB) because they currently lack an established electromagnetic spectrum (EMS) layer. An EOB displays known and assumed EMS-dependent assets and the potential impact they have on the battlefield. As such, the EOB will be a critical tool for planning, preparing, executing, and assessing combat operations, including electromagnetic warfare (EW), which will play a vital role in future wars. This study uses a model-based systems engineering methodology to derive the requirements for the EOB for inclusion in Army training simulations. The research began with reviewing doctrine regarding EW, looking at the actions performed by staffs as they plan, prepare, and execute EW activities. The doctrine found that the EOB required three primary components -- EMS data assumptions, EMS mapping, and EOB overlay. The EMS data assumptions fill in gaps of information about the EMS from the simulation. The EMS mapping and EOB overlay then translate the EMS into an overlay that can be viewed on command post software, allowing the staff to conduct EW operations. This analysis derived requirements for each of these components that would be necessary for the Army to successfully train for EW operations.

Keywords: Combat Simulation, Electromagnetic Warfare, Army

1. Introduction

In modern warfare, the successful implementation of new technologies and tactics is essential for an army to emerge victorious. Among these advanced technologies, Electromagnetic Warfare (EW) holds significant promise for shaping the outcome of future wars. EW involves using electromagnetic energy to disrupt or disable an enemy's electronics and communication systems. Given the significance of EW in future conflicts, it is imperative that the U.S. Army is equipped to train in this area. Presently, there exists a significant gap in simulation training that accurately reflects realistic EW activities in support of operations. Determined in a previous iteration of this capstone, the lack of an Electromagnetic Order of Battle (EOB) is one of the primary challenges in this regard (Dorman *et al.*, 2022). The EOB displays the location and properties of friendly and enemy equipment that use the electromagnetic spectrum (EMS). This equipment includes radios, radars, and EW systems, which are critical tools for preparing and executing EW operations.

This study sets out to understand the requirements of the EOB, which integrates into future Army training simulations. The study uses a model-based systems engineering approach to derive these requirements from doctrine and subject matter experts. The study identifies the doctrinal steps a division staff performs when planning and executing a mission involving EW. It then identifies the actions performed by the EOB through this process. These actions form the basis for a series of requirements for the EOB.

2. Background

2.1. Electromagnetic Warfare

EW is a military strategy that involves the use of directed energy and electromagnetic radiation to control the Electromagnetic Spectrum (EMS) and attack the enemy. EW is divided into three domains: Electromagnetic Attack (EA), Protect (EP), and Support (ES), which play a critical role in defining training requirements for the Electromagnetic Operating Environment (EMOE) (USA CAC, 2016) magnetic, directed, or anti-radiation weapons to deny, degrade, disrupt, destroy, and manipulate enemy combat capability. While EA is an effective approach, it poses risks to troops on the ground as it discloses their location to the enemy. Airborne EA is hindered by availability and is also vulnerable to kinetic attacks. The EP domain focuses on protecting units from enemy attacks, while the ES domain provides support capabilities to enhance the effectiveness of EW operations.

Although the U.S. Army has been using EW since World War II to gain a tactical advantage on the battlefield, they have significantly increased its role in recent years. Over the last decade, the U.S. Army has invested significantly in developing EW capabilities, recognizing the critical role of EW in modern warfare (Hoehn, 2022). The Army's EW units work closely with other branches of the military and intelligence agencies to provide situational awareness and support operations across the electromagnetic spectrum (Barton *et al.*, 2023).

2.2. Warfighter Training Events and Army Training Simulations

An Army Warfighter Exercise is a large-scale military training event that evaluates the readiness of Army units to execute their missions in a simulated combat environment. These exercises challenge soldiers with a range of scenarios and missions, using a training simulation to replicate the battlefield due to limitations in training areas. The staff receives an order from the higher headquarters and must execute the Military Decision-Making Process to develop orders for their subordinate units, who then execute their assigned missions in a computer-based simulation.

The Joint Land Component Constructive Training Capability (JLCCTC) is the simulation-based training program used by Mission Command Training Program (MCTP) in executing a Warfighter Exercise. JLCCTC is a federation of simulations, with the primary Army simulation being the Warfighter Simulation (WARSIM). Through JLCCTC, WARSIM can interface with other simulation software to look at aspects outside of ground combat to include air power, logistics, and naval support. Currently, WARSIM only provides limited capabilities connected to the electromagnetic spectrum. In particular, the only piece of equipment supported in WARSIM is radar. The simulation assumes that every agent has perfect communication with each other. As such, when an EW attack occurs during a Warfighter Exercise, the trainers manually go in and turn off the effected radar systems. External to the simulation, they “white card” the trainees, giving them a white card that tells them that an EW attack has occurred and the impact on the units (Anderson *et al.*, 2021).

3. Methodology

This study follows the methodology outlined in Figure 1. Initially subject matter experts and doctrine provided insight into the staff’s actions related to EW during the training exercise. From there, the study identified the flow of information through the command post and training simulation necessary to conduct each action. The bridge between the simulation and the command post is primarily performed by the EOB; as such, this flow of information provides a series of actions performed by the EOB. In turn, these series of actions form the basis for a series of functional requirements for the EOB.

The study used Model-Based Systems Engineering (MBSE) tools to perform this analysis. MBSE is a methodology that emphasizes the use of models to capture and communicate system requirements, design, analysis, and verification activities throughout the system development process, promoting consistency and traceability between different stages of the system lifecycle. It aims to improve system quality, reduce development costs, and time to facilitate collaboration among stakeholders.

The primary MBSE tool used in the study is swimlane diagrams. An excerpt from the swimlane diagram is shown in Figure 2. In Figure 2, the activities performed by the staff during the warfighter are sequentially listed in the top swimlane. The next swimlane shows the role of the command post software in supporting the staff activities. The last two swimlanes are the combat simulation and the trainer. The middle three swimlanes are the components of the EOB, which indicate the functions performed by the EOB to bridge the gap between the command post and the simulation. The functions performed by the EOB set the basis for the functional requirements for the system.

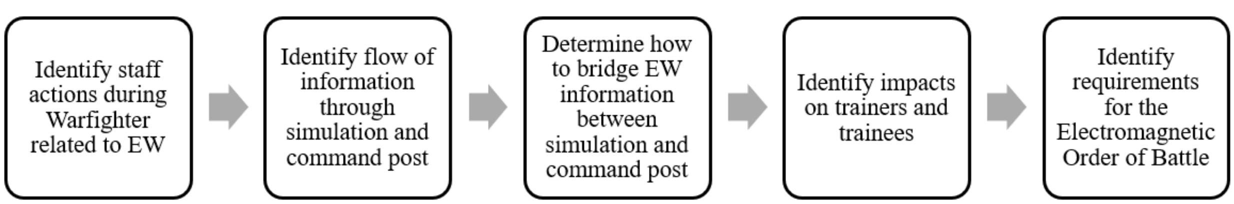

Figure 1. Methodology used in this study to determine the requirements for the EOB.

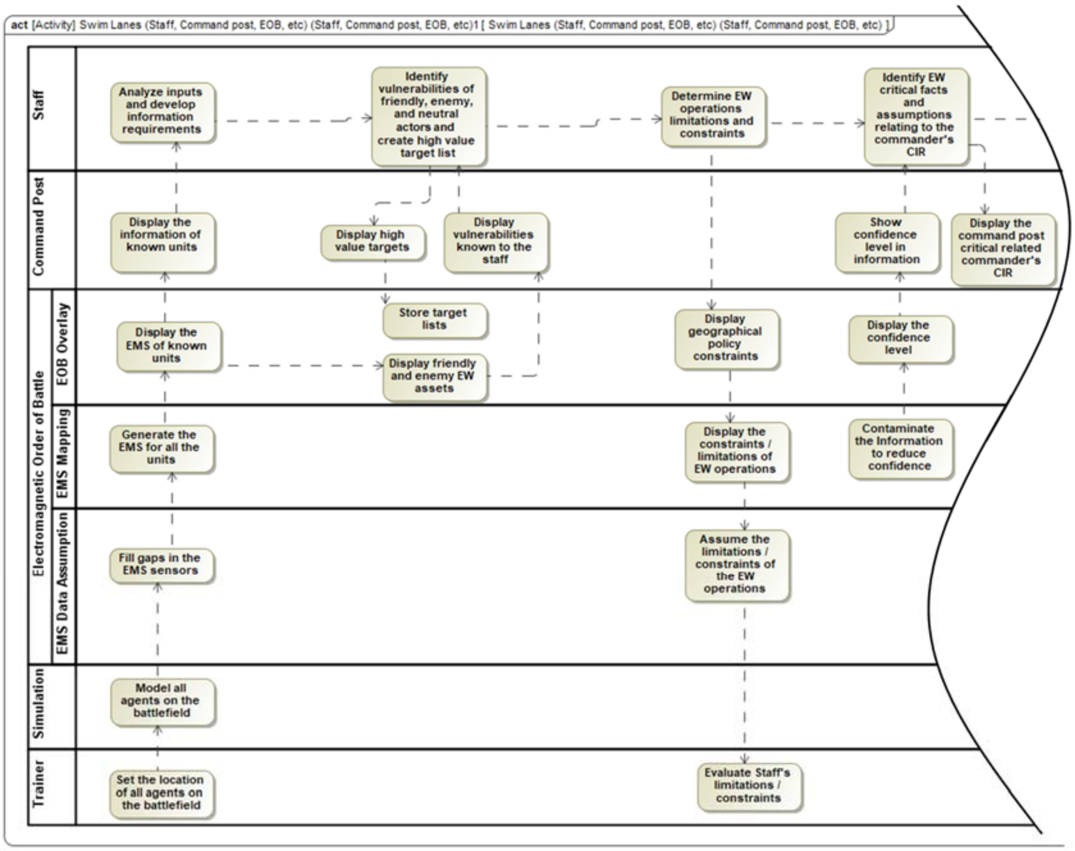

Figure 2. Swimlane diagram used for determining actions performed by EOB during a training exercise.

4. Components of the EOB

Figure 3 depicts the role that the EOB plays bridging the simulation and the command post. These roles ware based on a gap analysis performed in a previous study (Barton et al., 2023). External to the EOB are the actors (trainers and staff & commander), the simulation, and the command post. Starting with the trainers, these actors run the simulation and control the training environment. The simulation encompasses all units, equipment, effects, and the battlefield environment, while the command post shows only information known to the staff and commander that is being trained. In doing so, this mimics a realistic combat environment since the friendly units must operate with limited information about the battlefield. Therefore, the command post represents the perspective of the friendly units on the battlefield. The commander and staff conduct mission planning, preparation, and execution utilizing the command post interface, and they will communicate with the trainers about friendly actions. The trainers then ensure the friendly actions are inputted into the simulation and update the entire environment based upon the friendly actions. In response, the command post will reflect the updated friendly actions and the information revealed because of those actions.

The EOB works to bridge the information gap between the simulation and the command post. In particular, it takes the simulated battlefield from the simulation and provides an overlay to the command post that displays the information known to the staff. The EOB consists of three main components: EMS data assumptions, EMS mapping, and the EOB overlay. The EMS data assumptions block fills gaps in knowledge about the EMS that is not captured in the simulation. For example, it would model a radio in every combat vehicle and assign each radio a frequency and power level. Then the EMS mapping block maps out the EMS for a given timeframe based on the locations of agents and the information provided from the EMS data assumptions block. Finally, the EOB overlay displays the known assets related to the EMS on the battlefield at a physics-based level. The more in-depth descriptions of the functional requirements of these components are in the following section.

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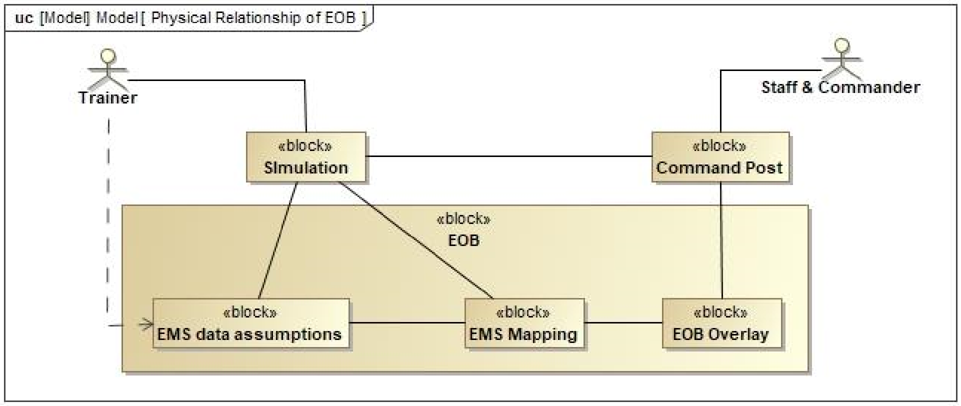

Figure 3. The role of the EOB in interfacing the simulation and command post during a training exercise.

5. Functional Requirements

5.1. EOB Data Assumptions

The EOB must have a strong depiction of the battlefield's EMS for both friendly and enemy forces. However, WARSIM does not currently account for many of the assets that use the EMS on the battlefield, such as the radios that are present in every tank. As such, the EOB must include a component, the EOB data assumptions block, which is able to fill these gaps in knowledge by making the appropriate assumptions. This portion of the EOB will likely use a combination of constants, assumptions, and machine learning to determine the capability and location of EW assets.

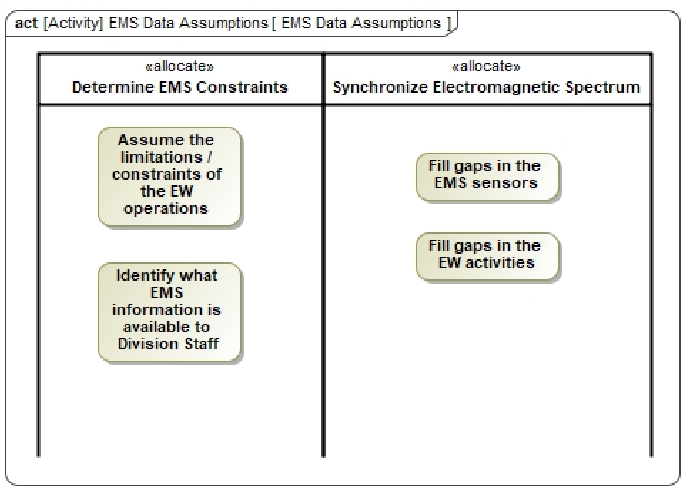

Figure 4. The functions performed by the EOB related to filling gaps in information about the EMS.

The functions performed by the EOB data assumption block are highlighted in Figure 4. At the top level, this block must be able to synchronize the EMS while accounting for its constraints. The EMS constraints are separated by the limitations and constraints of the EW operations and the EMS information available to the division staff. The synchronization of the EMS can be performed by filling the gaps of the EMS sensors and EW activities. These functional requirements are important and vital for the operation to be complete. The output from the EOB data assumption block is a description of every electromagnetic transmitter on the battlefield, to include radios, radar, and EW systems.

5.2. EMS Mapping

After the EOB data assumption block fills all relevant information gaps, all electromagnetic assets on the battlefield are recorded. As such, the EOB would be able to build the EMS of the battlefield. The map would include the frequency and power of every transmitter and identify the location and frequencies of every receiver. The mapping will be able to determine if the signal is able to be transmitted from the transmitter to receivers operating at the same frequencies. It would also account for the effects of terrain, weather, and EW systems on the EMS. For example, radio waves cannot travel through a mountain or dense foliage. Meanwhile, jamming equipment would fill saturate an area with radio frequency noise so that a signal would not be detected.

As shown in Figure 5, the functions that comprise the EMS Mapping can be separated into determining the effects on EW operations, generating the EMS, and contaminating the information. The first function relates primarily to EW systems and the impact that they would have on the EMS. The second function relates to developing the EMS and establishing the parameters for all the transmitters and receivers, accounting for terrain, weather, and the effects of EW systems. The third function contaminates the information to account for the "fog of war."

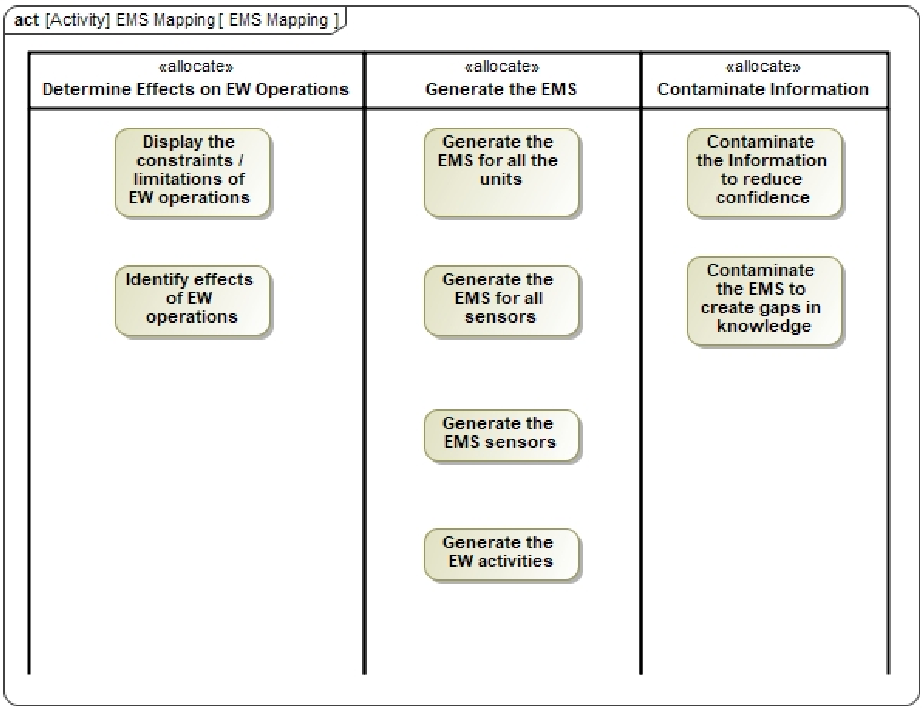

Figure 5. The functions performed by the EOB related to mapping the EMS.

5.3. EOB Overlay

The final block of the EOB is arguably the most important, in that it comprises the EOB overlay. The EOB overlay visually represents the EMS of the battlefield generating an overlay that can be viewed on the command post systems. This overlay must be intuitive enough for commanders to understand but also detailed enough for staff to be able to perform the relevant analysis.

Figure 6 displays the functional requirements for the EOB Overlay. They are broadly categorized into identify operation effects, determine EMS mapping, identify blue/red capabilities, generate the EMS sensors, and export data. These requirements strive to create an overlay that accurately displays EMS information for an operation to be displayed on the Command Post. The first four categories contain requirements focused on the location and types of EW assets and EMS effects on the battlefield. They ensure that it accurately provides the commander and staff with the necessary information to make real-time decisions during training events. Additionally, the ability to communicate relevant information to lower echelons is vital to mission success. Therefore, the EOB overlay must display relevant information to maximize the value to the command and staff and be able to export this data to increase compatibility.

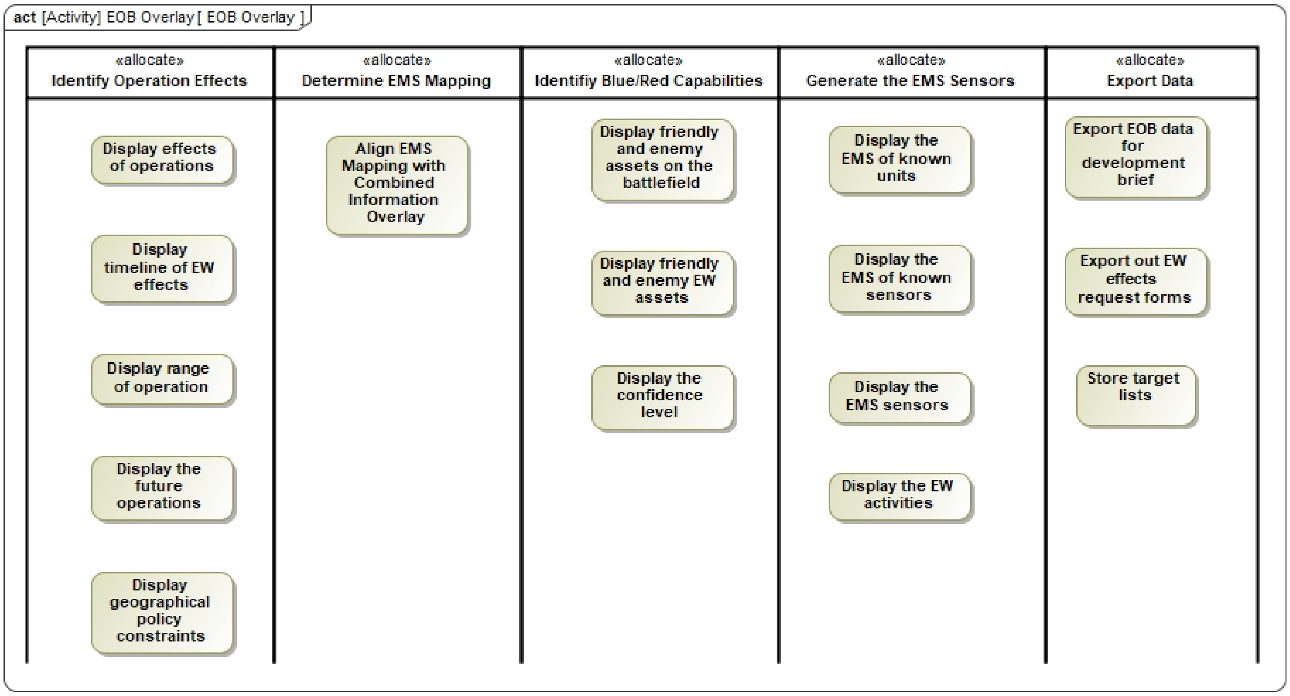

Figure 6. The functions performed by the EOB to display the EOB overlay for the command post software.

6. Conclusion

Over the last two decades, the United States military has emphasized counterinsurgency and extremism. As new electronic devices emerge on the battlefield, the U.S. is currently behind on its framework and training operations. The U.S. Army needs an EOB to allow for military training and planning at the division level. In particular, the EOB must connect the current Army simulations and command post software, providing the staff with resources to conduct realistic EW training. This study identified the three primary components of the EOB are EMS data assumptions, EMS mapping, and EOB overlay. The EMS data assumptions address discrepancies involving information about the EMS of the battlefield by accounting for the presence of assets and the asset's capabilities. EMS mapping requires that the EOB determines the effects on EW operations, generates the EMS, and contaminates the information. The most vital component of the EOB, EOB overlay component, needs to visually represent the EMS information available to the U.S. forces. The need for such a system is imperative to allow commanders and staff to prepare themselves for the unforgiving environment of a multidomain battlefield.

7. References

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