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Counter-UAS Model-Based Systems Engineering (MBSE)

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Author Note: Michael Mauro, Preston Halvorson, Nain Vazquez, Lucas Mowry, and Carter Beck are cadets at the United States Military Academy. The team is composed of three Engineering Management Majors, one Systems Engineering Major, and one Systems Decision Sciences Major. The work created by these authors is for their Capstone project, under the direction and guidance of Lieutenant Colonel (LTC) Stephen Gillespie. LTC Stephen Gillespie, professor and director of the Systems Engineering program within the Department of Systems Engineering, is serving as the Capstone project's faculty advisor. The views, expressions, and opinions herein are those of the authors alone and do not reflect the position of the United States Military Academy, the Department of the Army, the Department of War, or MITRE.

Abstract: The project's focus is on the integration and implementation of Counter-Unmanned Aerial Systems (C-UAS) technologies at the platoon level through Model-Based Systems Engineering (MBSE) to enable experimentation. The Army's Concept Focused Warfighting Experiment (CFWE) provided a collection of C-UAS technologies that the team then screened and modeled within the Systems Modeling Language (SysML). The models and methodologies created by the MBSE Team decompose the technologies into their behaviors and components, allowing us to fully capture and understand their capabilities. The models, such as the Block Definition Diagram (BDD), decompose the overall system into its basic parts, whereas the Activity Diagram (ACT) captures the actions or behaviors of the corresponding systems. With guidance from stakeholders and our advisor, the models developed provide a clear hierarchical depiction of alternative solutions to the modern warfighting drone adversaries.

Keywords: Small Unmanned Aircraft System (sUAS), Counter UAS (C-UAS), Systems Model Language (SysML), Infantry Warrior Simulation (IWARS)

1. Introduction

1.1 Background

The rapid increase of small Unmanned Aircraft Systems (sUAS) by adversaries poses a significant threat to U.S. forces on the modern battlefield. In response, the U.S. Military is testing multiple Counter-UAS (C-UAS) technologies, including Drone Busters, M-LIDS (Mobile, Low, Slow, Unmanned Aircraft Integrated Defeat System), and Sky Views (Paulsen, 2025). Working with the Combat Focused Warfighting Experiment (CFWE), this capstone modeled four C-sUAS. The technologies are the remote autonomous integrated defense engagement rover (RAIDER), bi-spectral obscurant screening system (BOSS), detect track identify (DTI) system, and multispectral camouflage poncho. During the Russian and Ukrainian War, the Ukrainian Army established a separate branch of the military for drones called the Unmanned Systems Forces (Kirichenko, 2025). The modern battlefield is changing rapidly, and the UAS structure of various Nations' militaries must adapt to these new changes. Nations that fail to adapt to these new changes will be defeated in war. Given the fast-growing and highly lethal capabilities of enemy UAS, light infantry platoons require effective C-UAS. This capstone will model the design and implementation of C- capabilities in light infantry platoons and recommend changes to platoon-level operations utilizing Model-Based Systems Engineering (MBSE) to support the CFWE.

1.2 Army's Approach

The Army's Force Structure Transformation initiative reorganized the training and acquisitions commands into the Transformation and Training Command (T2COM), overseeing the experimentation and directorate of training for the Army (T2COM, 2025). Within T2COM, the Army Futures Command (AFC) was tasked to bridge the gap between US capabilities and near-peer threats such as the People's Liberations Army of China (PLA) through the experimentation of technologies at the CFWE (*FUTURES and CONCEPTS COMMAND*, 2026). The CFWE focuses on modernizing the Army through integrated experiments of Command and Control (C2), cross-domain fires, and analytical systems modeling and simulations from the infantry platoon level up to the theater level. Defense companies such as MITRE provide various technologies, research, and hypotheses to direct the experimentations at the CFWE to provide commanders with the necessary information to integrate these technologies with their units for increased lethality. The CFWE aims to validate the new technology's capabilities and enhance the operational efficiencies of soldiers on the battlefield while fostering collaboration amongst various armies and teams.

2. Methodology

Our problem statement is as follows: *We want to model the design and implementation of C-UAS capabilities in light infantry platoons and recommend changes to platoon-level operations utilizing MBSE to support the CFWE.* The problem statement aims at modeling technologies to be tested at the CFWE through Systems Modeling Language (SysML) in both their design and behavior so that the CFWE can best design an optimal scenario to defend against enemy UAS. Engagements with stakeholders help identify key sticking points within the CFWE and break through limitations so that the simulations can take place to model realistic scenarios and find changes to recommend for light infantry platoons

As an initial step in a methodology, we identified technologies to support the CFWE. Our technological inputs are the Remote Autonomous Integrated Defense engagement Rover (RAIDER), BOSS system, Detect Track Identify (DTI) system, and multi-spectral camouflage poncho. The Army's transformation in contact (TIC) focus, coupled with changes to defense acquisition, necessitates a dynamic approach to understanding the integration and impact of new technologies on the force. In particular, it must understand the changes new technologies induce on tactics, techniques, procedures and unit organization. The Army is addressing this by transitioning from static, pre-planned experimentation, such as the former CFWE, to dynamic, integrated training and transformation events. This new approach necessitates a dynamic method for analyzing, documenting, and communicating changes and lessons learned in these events. The MBSE approach described in this paper provides experimenters with dynamic capabilities to see and update how organizations and operations are impacted by the integration of new technology. This enables them to clearly capture test cases and document results in a way that can be readily used to drive institutional change. Future work will expand on detailed methods to employ this during training and transformation exercises.

We used two Systems Modeling Language diagrams: Block Definition Diagrams (BDD) and Activity Diagrams (ACT). Our BDDs offer a hierarchical depiction of the technology to a level that helps us understand the system in its entirety. This helps the CFWE team understand and view the criteria they care about, such as speed, weight, and survivability within our models. As part of our inputs, our stakeholders set evaluation criteria that became part of our models. These criteria were survivability, speed, and weight. Values that were prioritized by our stakeholders were the speed of our technology to identify enemy UAS and the speed of our technology to react and employ against enemy UAS. Then, our team modeled the behavior of each system through an activity diagram. The activity diagram allows the user to understand how a technology would operate in the given scenario, as well as the interaction between the soldier and the system. The activity diagram also shows where each value is relevant throughout the actions taken in the given scenario.

The outputs of our technologies, displayed in the SysML diagrams, and their values are models that display an understanding of how each system works. Each model breaks the system into parts that need to be considered by the CFWE team and us as we develop a diagram that resembles the structure of an infantry platoon integrated with the technologies evaluated. The next output our team created from the activity and interaction models is an understanding of the possible scenarios and decisions made by soldiers with the technologies. These activity and interaction models will help scope our scenario so that we model what is needed for a platoon to defend against UAS.

Constraints and limitations in our model are that we mostly model a passive defense in our research and limit our ability to consider active defenses against enemy UAS, with the only active defense technology being the RAIDER. We are also limited to having data on the agreed-upon technologies between ourselves and the CFWE team. Many of the values needed to be assumed between us and the CFWE team to properly simulate the technology. We assume that Group 2 and above UAS assets will be dealt with at the company level. Group 2 UAS are approximately 21 pounds or heavier and have higher maximum speeds and altitudes than group one. Next, it is assumed that PLA drone assets have the same baseline resilience as suggested in open-source literature or are similar to U.S. drone capabilities. We are also assuming that technical specifications published on unclassified research platforms are reasonably accurate. Finally, we are assuming that the passive defense scenarios, as developed by the CFW team, are how the technologies will be employed.

2.1 Modeling Approach

We are modeling the complex problem of what alternatives are best suited to counter Group 1 UAS assets. Group one consists of drones that are under five pounds in weight, have a limited battery life, and a limited distance. These drones are seen as smaller unmanned aircraft compared to the other groups of UAS assets. To do this, we are using the modeling platform Magic Systems: Systems Architect. The purpose of using this system is that it is easy to understand and view, as well as its compatibility with Systems Modeling Language. The purpose of modeling this problem is to provide transparent, digestible snapshots of different technologies to show how they interact and the overall value they offer when countering UAS assets (Estefan, 24). Using this platform, we modeled four technologies: the RAIDER, the BOSS system, the multispectral camouflage poncho, and the DTI system.

2.2 Systems Modeling Language

There are several benefits of using SysML. The main benefits to focus on, however, are that it provides clear and detailed avenues to communicate and that the Army is currently using SysML to model complex problems in the world today that integrate with mission engineering. Along the same line, the language and platform allow for easy substitution of technology to test different alternatives and change the value of those tested substitutes. There are three main pillars within SysML, and our team focused on two of these pillars to build our model. The three pillars are structure, behavior, and requirements (Delligatti, 5). We focused on the structure and behavior pillars, which are modeled by BDDs and activity models.

3. Modeling

3.1 Block Definition Diagram

The Block Definition Diagrams (BDD) provided significant advantages to the overall modeling and integration of the technologies chosen by the team within an infantry platoon. We then broke the alternatives down into various parts and values through SysML. They allow users to display the structure of something. In other words, it displays what components and values make up the block. In our problem, we made diagrams for each of the technologies that not only show what components they make but also the values that coincide with the technology. The RAIDER is broken down into different blocks, such as the radar system, the containerized weapon system, the light chassis, the mechanics, and the drivetrain. All the blocks have different value properties that help define and articulate the model. The block in blue labeled “Drone” depicts the enemy drone and shows the relationship it has to the RAIDER by using ports and comments depicting how elements recognize each other. For the other three technologies, similar diagrams are modeled, depicting each component and the value properties that correspond. The importance of BDDs is that they allow stakeholders to view the structure of their technologies as well as the assumptions and liberties the team took in designing them. These assumptions included finding comparable machines with similar battery life and diesel input to interpolate in a manner that would be accurate to the RAIDER. BDDs are the most foundational structural blocks of a model that help give the base organization and interconnectedness, allowing project teams to build upon the model to increase in complexity and depth in a problem set (Delligatti, 24).

3.2 **Activity** Diagrams

Complementary to block definition diagrams, activity diagrams do not model structure but behavior. These models allow visible depictions of how a system would respond in each scenario, developed by the CFWE team. This scenario is reacting to contact from an enemy Group 1 UAS asset while on patrol during a mission. For each technology, we modeled a response to a drone threat in the area. Each technology is broken apart into swim lanes that show which component of the technology is performing the activities. Each activity is a rounded rectangle, while each lane has a singular starting node as well as a singular finishing node with multiple activities. These specific diagrams are set up in an iterative format to show a response to a second drone or reinforcing elements. These models are important to determine the field-testing aspect of modeling. While modeling this way does not achieve the same data as a simulation, it provides a more concise and clearer picture that is easy to digest, and when paired with block definition diagrams, you can glean data that is critical to understanding the system, like how the technology would respond to a threat or certain courses of action that are possible. Activity diagrams serve as a modeling support to simulations that allows stakeholders and team members to view potential routes taken by technologies. This is crucially important in relation to the army when developing tactics, techniques, and procedures (TTPs).

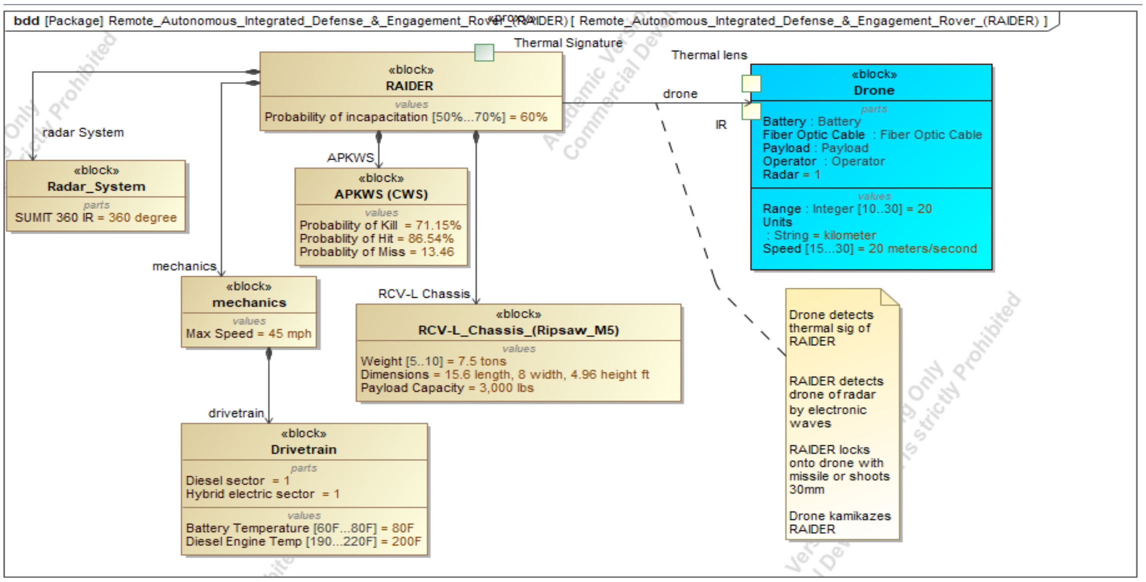

Figure 1 RAIDER Block Definition Diagram

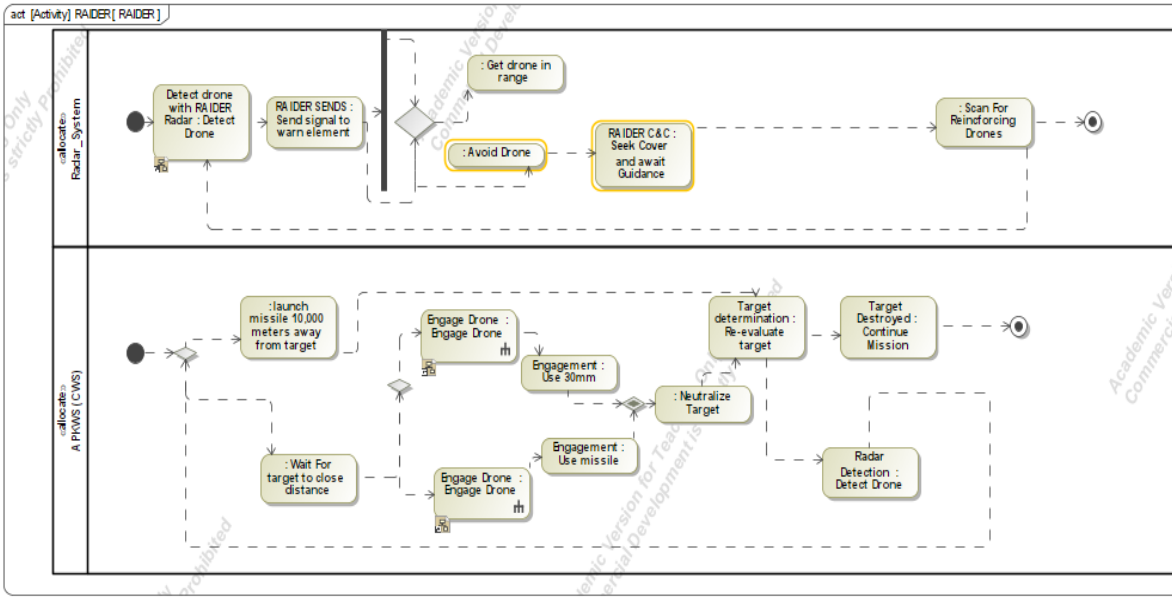

Figure 2 RAIDER Activity Diagram

3.3 Interaction of Models

The BDD and activity diagrams are related to each other. Each activity can trace back to a certain block, which is displayed in the Allocation Matrix (Table 1). The first column represents the activity that is happening, shown in (Figure 2). The second column displays what that activity type is or who owns it. Excluding the first row, everything in column one is an activity, all of column two says behavior, showing that the activity is a type of behavior that the technology is doing. Columns three and four say where the activity is allocated from and to. This is where you can see how the BDDs and ACTs physical structure is traced to activities. As previously mentioned in section 2.2, each ACT has swim lanes, column three shows the allocation to which lane the activity appears, if applicable, which helps with tracing and organization to see what components are responsible for what tasks. This carries over all technologies and diagrams. For example, the "re-evaluate target" activity is allocated to the Containerized Weapon System (CWS) swim lane, while the situation assessment is allocated to the activity poncho diagram and other blocks, as well as the CWS swim lane, showing that both technologies use the same activity in similar manners. The "Allocated from" column shows where that activity is related to other activities. This is important to see the sequence of events that are occurring throughout the ACT in a cleaner, more organized way. The importance of this allocation matrix is traceability. Developing a matrix like the one shown in Table 1 allows the stakeholders and team to see where all the parts of all the models developed are traced back to. This is important for a couple of reasons, but mainly for experimentation. If the team needed to switch out a block or activity to capture results for different or updated technology, we could look at the matrix and see the effects it would have on the model as a whole. In doing so, it allows for flexibility, ease of testing, and modeling alternatives to see what the best solution is when plugged into a simulation.

Table 1 Allocation Matrix

Name	Owner	Allocated to	Allocated from
RAIDER	Behavior	RAIDER Remote_Autonomous_Integrated_Defense_&_Engagement_Rover_(RAIDER)	RAIDER
Re-evaluate target	Behavior	APKWS (CWS)	Target Destroyed
Scan For Reinforcing Drones	Behavior	Radar_System	
Seek Cover and await Guidance	Behavior	RCV-L_Chassis_(Ripsaw_M5)	
Send a signal to warn element	Behavior	Radar_System	
situation assessment	Behavior	Activity Poncho; Continue Mission(context APKWS (CWS)); Engage Drone ;Wait For target to close distance(context APKWS (CWS)) ;HQ WPNS	radio to higher
Target Destroyed	Behavior	Target Destroyed; Re-evaluate target(context APKWS (CWS)); Neutralize Target ;Remote_Autonomous_Integrated_Defense_&_Engagement_Rover_(RAIDER)Drone	Target Destroyed

The SysML model elements of these technologies can be mapped to the inputs of a constructive simulation. This mapping is not a perfect one-to-one match as modeling data does not always directly correspond with simulation inputs. To demonstrate this utility, we conducted an integration exercise where we mapped SysML model elements to simulation inputs. Value properties from the BDD correspond to the IWARS database constructing capabilities, for example, the properties of the RAIDER's probabilities of kill maps to IWARs database probabilities of incapacitation. Complementarily, the ACT diagrams map to the IWARs mission planner. Both the ACTs and BDDs provide value in analyzing different technological aspects from different perspectives. We were able to come together as a team and write synchronization reports that provided further discourse on the strengths and weaknesses of each technology. These reports also provided the team with a better understanding of how the technologies would act in the given CFWE scenario of reacting to drone contact. This information was used to build upon ACT diagrams and give further accuracy to soldier actions when simulating. In doing so, results were interpreted and cleaned to provide recommendations for optimal solutions for the CFWE team's problem.

4. Conclusion

4.1 Recommendation

Modeling the RAIDER, BOSS, DTI, and multispectral poncho allows the stakeholders at the CFWE to understand how the technology interacts with other parts of the light infantry platoon system, as seen in Table 1. This influences the way the army and stakeholders think about these technologies when implementing new TTPs and experimentation. The Army uses SysML to solve complex problems, so providing models in a common language provides critical understanding and applicable integration to mission engineering concepts, such as quantifying the efficacy of alternative approaches when conducting a mission (Office of the Under Secretary of Defense for Research and Engineering, 12). The model provides alternative approaches and structural value properties, so stakeholders can deliberate on what best fits the mission. The models are the results of this capstone and the information they provide, such as, structure and characteristics that can introduce a baseline for simulation. Models give valuable traceability information as seen for the Allocation Matrix (Table 1). This allows stakeholders to trace back to the smallest detail and level if they want to change something while conducting experiments, based on the hypothesis of what is the best way to engage Group 1 UAS assets while not giving up speed or overbearing weight. Overall, the models provide recommendations on how the technologies should be structured and organized in a platoon, as well as a base framework on how the technologies would act in the occurrence of a drone attack. The team was able to model four technologies for the CFWE; however, there is not one single technology that is the optimal solution, based on the results from the models and simulations run. The combination of technologies usually yields the best results when looking for specific mission threads such as soldier survival. We recommend using a combination of the technologies we modeled, for example, the BOSS system and the poncho, as well as running simulations on the specific mission thread that you are trying to accomplish. The models we made provide a starting point for simulating as a foundational basis, as well as possible TTPs and actions to take with activity diagrams.

4.2 Future Work

For future work, we could use different technologies. There are over a hundred technologies that can be used by other branches of the Army. We restricted ourselves to technologies that light infantry units could use. We could alter the number of each technology in a platoon as well. Another change to the model could be the assumptions made. We assumed that the light infantry platoons would use the technology in a stable climate with no weather effects. This is highly unlikely in a practical setting. We assumed the terrain type is unrestricted terrain. We could model the platoons in heavily restricted terrain. Changing the terrain could alter the results of the model and lead to another outcome. We were also restricted to public information only, so the team could not model classified technologies that exist. Another major variable that future work could cover is the other enemy drone types. We used Group 1 UAS, but there are more lethal and capable enemy UAS.

5. References

Aidanweeks19956. (2024, August 16). *Why Use MBSE? Key Benefits and How It Improves Effectiveness*. Systems Engineering. https://www.schoolofsystemsengineering.com/post/why-use-mbse

Ametrine. (n.d.). Multispectral signature management: Fundamental concepts. Ametrine. (n.d.). Poncho Elite technical capabilities (USMA)

Armor, Stryker, Infantry, Robotics: The Maneuver CDID. (2023, May). Www.army.mil. https://www.army.mil/article/266269/armor_stryker_infantry_robotics_the_maneuver_cdid

Army taps Textron's Ripsaw M3 for Robotic Combat Vehicle program, sources say—Breaking Defense. (n.d.). Retrieved January 21, 2026, from https://breakingdefense.com/2025/03/army-taps-textrons-ripsaw-m3-for-robotic-combat-vehicle-program-sources-say/

Assistant Secretary of War for Mission Capabilities(2025). *Mission Engineering.* USWR&E*, https://ac.cto.mil/wp-content/uploads/2023/11/MEG_2_Oct2023.pdf*

Delligatti, L. (2013). *SysML Distilled*. Addison-Wesley.

Dzyne technologies—Counter uas. (n.d.). DZYNE Technologies. Retrieved March 12, 2026, from https://dzyne.com/counter-uas/

Estefan, J. A. (2008). *Survey of Model-Based Systems Engineering (MBSE) Methodologies.*

FUTURES AND CONCEPTS COMMAND. (2026). Www.army.mil. https://www.army.mil/FuturesandConceptsCommand

Kirichenki, D. (2025, October). *Ukraine's drone war lesson for Europe: Technology is nothing without training*.

Madni, A. (2013). Model-Based Systems Engineering: Motivation, current status, and research opportunities. *Wiley*, 19.

Paulsen, D. (2025). *Counter-unmanned aerial systems (C-UAS) training and implementation at the National Training Center* (Publication No. 25-1093). Center for Army Lessons Learned.

Ripsaw® M5—Modular autonomous ground vehicle with scalable armor. (n.d.). *Defense Advancement*. Retrieved January 21, 2026, from https://www.defenseadvancement.com/company/textron-systems/ripsaw-m5/

T2COM. (2025). Www.army.mil. https://www.army.mil/t2com

UkraineAlert. https://www.atlanticcouncil.org/blogs/ukrainealert/ukraines-drone-war-lesson-for-europe-technology- is-nothing-without-training/