Proceedings of the Annual General Donald R. Keith Memorial Conference
West Point, New York, USA
April 24, 2025
A Regional Conference of the Society for Industrial and Systems Engineering

Simulating Infantry Platoon Counter Unmanned Aerial Systems to Increase Combat Effectiveness

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Author Note: CDTs Nick Brown, David Garcia, John Goetz, Connor Kling, and Wesley Rockefeller conducted this research as their capstone project for their majors in the Department of Systems Engineering (DSE) at the United States Military Academy (USMA). The cadets will commission as 2nd Lieutenants in the U.S. Army in May 2025. Lieutenant Colonel Stephen Gillespie served as their capstone advisor. The MITRE Corporation sponsored this capstone project and U.S. Army Futures and Concepts Center served as their primary operational stakeholder. The views expressed herein are those of the authors and do not reflect the position of the United States Military Academy, the Department of the Army, or the Department of Defense.

Abstract: Small Unmanned Aerial Systems (sUAS) present significant threats to light infantry platoons, necessitating innovative countermeasures to ensure soldier survivability. This project employs a systems-based process to determine the most effective method to counter sUAS (C-sUAS) for a light infantry platoon and recommends changes to platoon-level operations to facilitate this method. It explores various tactics and emerging technological innovations designed to mitigate UAS. The analysis uses the Infantry Warrior Simulation to model and evaluate the impact of these C-sUAS measures on platoon survivability. Results indicate that both shotguns and sUAS jammers increase platoon combat effectiveness against enemy drones; however, shotguns present a fratricide risk and additional training. The analysis recommends employing jammers with organic platoon weapons for C-sUAS, with an emphasis on developing clear fire control measures to mitigate fratricide risk. This guidance may evolve as tethered drones, largely immune to jamming, become more prevalent.

Keywords: Unmanned Aerial System (sUAS), counter-sUAS (C-sUAS), Infantry Warrior Simulation (IWARS)

1. Introduction

1.1 Background

Recent conflicts such as the Russo-Ukrainian war demonstrate that small Unmanned Aerial Systems (sUAS) are highly lethal on the modern battlefield. The U.S. Army maintains is capability to engage large, high-flying UAS via air-defense systems (Headquarters, Department of the Army, 2023). However, the authors' personal experiences in military training such as Reconnaissance and Surveillance Leaders Course (RSLC) and at the Joint Readiness Training Center (JRTC) demonstrate gaps in the Army's Counter sUAS (C-sUAS) capabilities. Specialized reconnaissance units use thermal blankets to evade detection from the thermal cameras commonly equipped on drones. Some Special Forces teams at JRTC resort to seeking cover under the nearest tree. In the 82nd Airborne, Commanders instruct their formations to hastily disperse, engage sUAS with rifles and machine guns, and seek cover and concealment (LTC Ryan, interview, n.d.). These Techniques, Tactics, and Procedures (TTPs) are outpaced by the prevalence of small offensive drones on the modern battlefield. Implementation of optimal TTPs, weapons, and modernized C-sUAS technology may improve the combat effectiveness of small, dismounted units. This capstone seeks to determine the most effective method for a light infantry platoon to counter enemy sUAS and recommend changes to platoon-level operations to facilitate this method.

1.2 Methodology

This research used the Systems Decision Process (SDP) to understand and define the problem and then design and assess potential solutions. The SDP is a four-phase approach for systems engineering that involves Problem Definition, Solution Design, Decision Making, and Solution Implementation with a special emphasis on stakeholder values and understanding the environment (Patrick J. Driscoll et al., 2024). This involved understanding and defining the problem using a value modeling approach as described in section 1.3 below. It then focused much of the solution design on simulating a dismounted infantry platoon countering UAS with various methods as described in section 2. Outside of the simulation it assessed impacts of various solutions related to requisite Soldier training and the physical load Soldiers would carry to implement CUAS solutions. It then synthesized the various analyses using statistical analyses to quantify the impact of potential solutions based on simulation and analysis results and provides recommendations.

Key Constraints include requirements for the project to be open sourced and simulated in IWARS. Key limitations of the parameters we decided to measure in IWARS are as follows; fixed number of infantry personnel, fixed initial Blue starting point, fixed engagement threshold, fixed red drone capability – to identify the most important ones.

1.3 Problem Definition and Value Modeling.

Stakeholder Analysis: Key stakeholders for this project include our sponsors at MITRE, FCC and Army Futures Command (AFC), the U.S. Army Maneuver Capability Development Integration Directorate (CDID), and, importantly, potential users of any CUAS systems such as maneuver officers and non-commissioned officers (NCOs). Throughout the project we met with them and iteratively defined and refined the problem through meetings, interviews, and surveys. This resulted in the following problem statement and value model to assess the value of any potential solution.

Problem Statement and Value Model: Determine the most effective method for a light infantry platoon to counter enemy small UAS and recommend changes to platoon-level operations to facilitate this method. The fundamental objective of the capstone is maximizing the combat effectiveness of the platoon. The qualitative value model captures key aspects of this problem as discussed with stakeholders.

Table 1: Value Model

Function	**Defeat Enemy UAS**	**Survive Enemy UAS**		**Maintain Lethality**	**Maintain Unit Maneuverability**
Objective	Maximize probability of defeating enemy UAS	Minimize Casualties (Enemy Fire)	Minimize Casualties (Friendly Fire)	Minimize ammunition usage	Minimize system training time
Value Measure	# of enemy UAS destroyed	# of enemy fire casualties	# of friendly fire casualties	# of rounds expended	# of Hours spent training
Assessed by	Simulation	Simulation	Simulation	Simulation	Training Model
Global Weight	.23	.28	.16	.14	.19

Global Weights: We developed swing weights through surveying 30 West Point faculty members with infantry backgrounds, including Captains, Majors, and senior NCOs, who ranked the five value measures in terms of significance. We normalized these swing weights to determine global weights which helped us assess how important each value measure is.

2. Simulation

The IWARS is an agent-based combat simulation developed to represent infantry combat operations. It enables users to depict operations, to include tactics and decision making, weapon and equipment characteristics and performance data, and weather and terrain data (Mittal, 2024). It was originally developed for and used by various U.S. Army labs and analysis centers. Its capabilities enable studying and assessing the impact of varying a light infantry platoon's reaction to UAS using a variety of equipment and techniques.

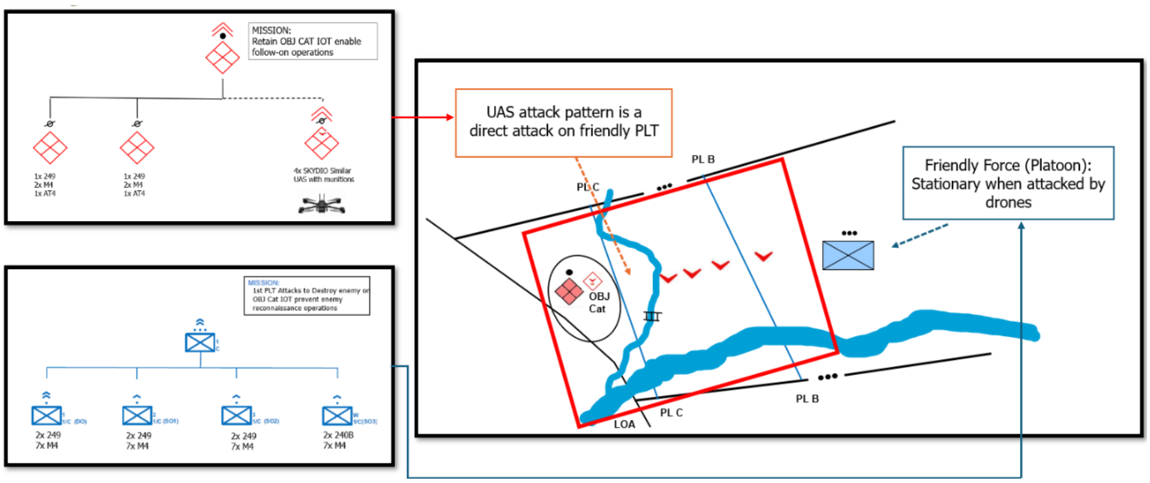

Figure 1: Simulation Situation

2.1 Simulation Scenario

In IWARS, we developed a simulation where an organic infantry platoon attacks to seize objective CAT in order to enable follow on Blue Operations in the AO. Upon movement, the Platoon contacts four enemy UAS about 500 meters from Objective with no cover or concealment provided by the terrain or weather as is shown in Figure 1. The enemy mission is to retain Objective Cat. Key Enemy weapon systems are four Skydio UAS and will be described in further depth in section 2.3.

2.3 UAS Platforms

We represented two kinds of UAS that an infantry platoon may encounter kamikazes and bombers. The Skydio X2D is prototypical of these as used in the Russo-Ukrainian war (Gabrielson, n.d.). We assessed that bombers fly at an altitude of 90 meters above ground level at a speed of 20 meters per second over Blue personnel and drops one hand grenade. We assessed that Kamikazes flies at a speed of 20 meters per second and will fly directed into Blue personnel and detonate one hand grenade (Zafra et al., 2024) (M Sjostrom, interview, n.d.). The grenades that they drop have stochastic properties in terms of probabilities to kill Blue units. The path they take and elements they target are fixed.

2.4 Counter UAS Platforms

To assess various CUAS solutions, we researched existing, prototyped, and proposed CUAS solutions from the US Army and from observations on the Russo-Ukraine war. For each of the following solutions, we assessed how a platoon performed equipped with the CUAS system and without it. While there are certainly other possible solutions or methods for CUAS operations, these were the most common and possible to assess within the resources available for the study.

Organic IN Weapon Carbines: Organic Infantry (IN) Weapon Carbines, standard among US Army Infantry Platoons, use 5.56x45mm ammunition, with 31 per platoon. Organic IN Weapons were easy to implement and are likely the first thing to be used to counter UAS as current technology stands. Operator inaccuracy is represented through a variable named “aim bias” in shooting a targets with an Organic IN Weapon.

Shotguns: Shotguns, primarily 10-gauge with 3-½" magnum shells and tungsten/steel loads, are equipped with extra full chokes, with three per platoon. Shotguns are a kinetic option that is being increasingly considered and implemented on the battlefield due to its effectiveness against small, flying, fast moving targets that are difficult to hit with a singular projectile (*M500 Shotgun*, n.d.). Operated “aim bias” is similarly represented with shotguns as Organic IN Weapons and shotgun shells are randomly dispersed in a cone. They are placed throughout the movement formation – one per squad, not including the weapons squad.

Jammers: Jammers, specifically "Hedgehog" backpack systems, have a 150-300m range , two-five hour battery life, and 60-70% effectiveness, with two per platoon. Jammers are a non-kinetic option that has already shown heavy use in recent conflicts at higher echelons with some consideration to bring to lower echelons. They are speculated by experts to be the best passive method to counter UAS (Pomerleau, 2023). In simulation, they are given fixed radius of 200 meters and use logic that either stops enemy drones in place or doesn’t at set percentage (65%). Jammers are placed towards the front and back of the formation so that the radii cover all Blue forces. Assume one battery with three to five hours of use – the simulation assumes the mission occurs within the timespan of a single battery's life.

4. Simulation Results

4.1 IWARS Outputs and Statistical Analysis

We simulated every combination of the four aforementioned factors, Drone Type, Organic IN Weapon Usage, Shotguns, and Jammers at two levels each with a 2^4 factorial design. We replicated each treatment combination 100 times. This allows us to analyze every individual alternative's impact on the value measures and their interaction effects. The figures below show how each important factor significantly impacted the relevant measurement with a boxplot. This shows both the median and distribution of results for each factor. A significant disparity between medians (such as the median observed value at one level being the same as the other levels 25th or 75th percentile) would indicate that there is a likely statistically significant impact of that treatment.

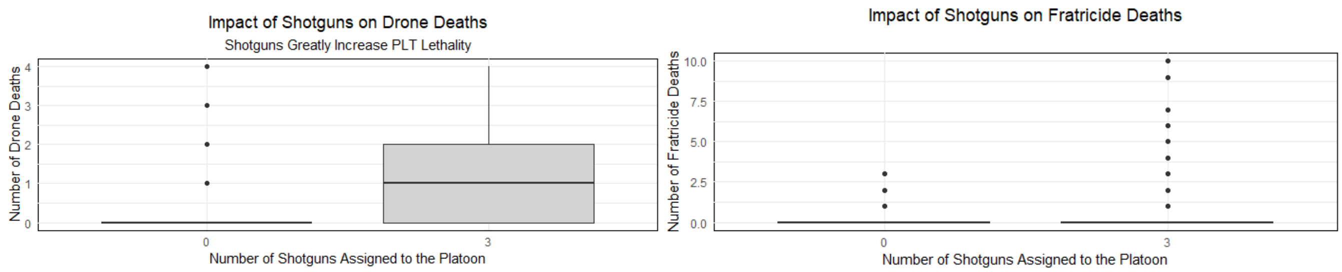

Figure 2: Impact of Shotguns

Blue Fratricide from Shotguns: Across all runs and for every treatment, the median number of fratricide deaths was zero, though, when it did occur, it occurred in high numbers with upwards of 10 Soldiers killed by fratricide. Shotguns increase the number of high-fratricide events due to fire discipline issues or close-range engagements. Figure 2 is a statistical representation of the effect of shotguns on Blue fratricide. The key takeaway from this figure is engaging drones with three C-sUAS shotguns increases the frequency of high fratricide events. This is likely due to their high projectile spread and the inability to accurately decipher what lies beyond their target drone.

Drone Deaths (Maximizing Red UAS Defeat): Shotguns greatly increase platoon lethality against drones as can be seen in figure 2. Where we add shotguns to the simulation, the number of drones destroyed increase at a rate that is statistically significant as can be seen in figure. The figure shows a lower quartile that is equal to or greater than the upper quartile of drones destroyed count when shotguns aren't implemented.

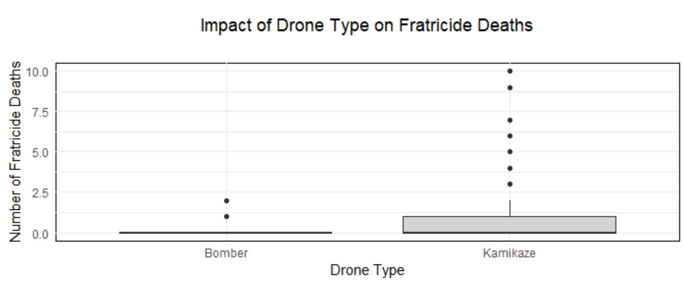

Figure 3: Red Drone Type on Blue Fratricide

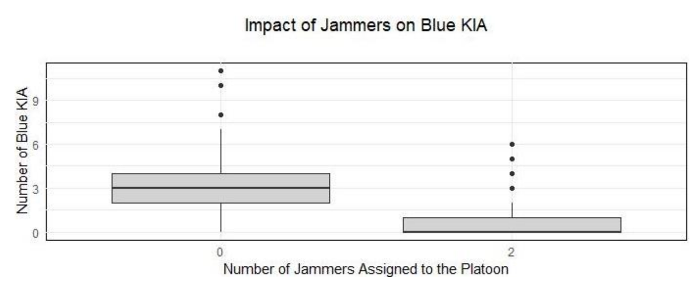

Figure 4: Jammer Impact on Blue KIA

Deaths Due to Enemy UAS (Minimizing Blue KIA): Figure 3 shows that Kamikaze drones result in an increased amount of high fratricide events. This makes sense due to the low altitude that Kamikaze drones fly. As time increases, the distance from the kamikaze drone to the Blue forces decreases, thus increasing the likelihood of a friendly fire incident.

Jammers on Blue Survivability: Figure 4 shows that jammers significantly increase survivability. With zero jammers, the mean Blue KIA is three soldiers. With two jammers, this number decreases to zero. The upper quartile of counts when jammers are present is less than the lower quartile of counts when jammers aren't – meaning jammers have a statistically significant impact of Blue survivability.

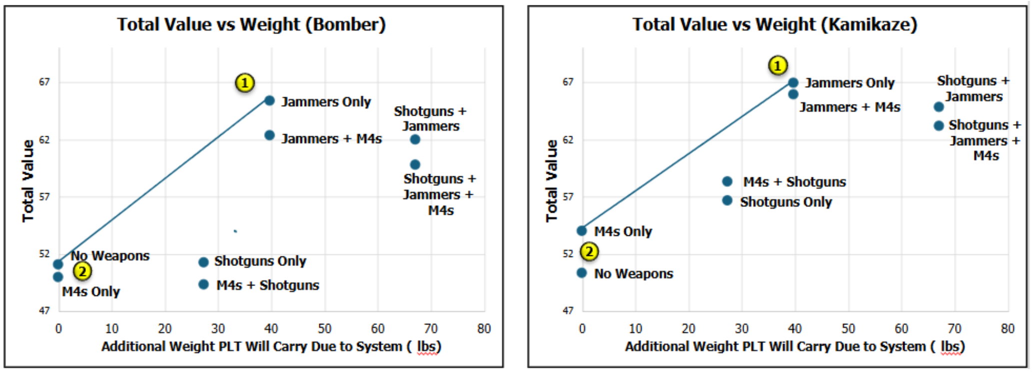

Figure 3: Total Value vs Weight by UAS type

4.3 System Weight Analysis

In our system weight analysis, we determined the weight of each alternative from in-depth stakeholder surveys, interviews with Subject Matter Experts, and personal training experience. We did not include weight as one of our value measures. We chose to do this so that we could see the impact of weight on total value. Using the data from the simulation, we calculated the total value for each alternative and then plotted the corresponding weight of the alternative to determine the optimal solution, depicted in Figure 3. Shotguns weigh about 7 pounds unloaded (*PEO Soldier | Portfolio - PM SL - M500 Shotgun*, n.d.), rounds weigh 5.5 pounds for a basic unit load of organic IN weapon ammunition (*MAS Handbook 2021*, 2021), jammers weigh about 20 pounds (Pomerleau, 2023). These are important to a light infantry platoon because of requirements to be highly maneuverable. In our model, the Infantry Organic Weapons only alternative and Jammers only alternative are the most effective. They are on the pareto frontier, meaning they offer the most value with the least weight. This can be seen in Figure 3. On both models – referring to point 2's in figure 3, we can see that while providing little value, Organic IN Weapons are extremely light. We also see that, referring to point 1's in figure 3, while they are heavy, Jammers provide the most value. Shotguns are too heavy and don't provide enough value to be an optimal solution, however, these charts show that they have an increased effectiveness against kamikaze drones.

5. Conclusions

5.1 Recommendation

We recommend that light infantry platoons be equipped with and engage sUAS with two jammer backpacks and organic weapons. However, infantry platoons must implement TTPs which limit fratricide while engaging kamikaze drones with rifles and machine guns. Utilizing these weapons alongside jammers will provide more value than jammers alone if fratricide is avoided. We determined that the benefit from the platoon engaging drones at rapid rates of fire outweighs the cost of the ammunition lost. We do not recommend implementing shotguns into infantry platoons for C-sUAS purposes. Shotguns increase the platoon's ability to destroy drones. However, value gained does not justify the increased weight gained, training time, and fratricide risk.

ISBN: 97819384969-9-8

5.2 Future Work

Future works should simulate more complex environments with exponentially more interacting factors to simulate the most realistic possibilities such as integrating additional units, fires, and complex terrain. This is only feasible through restructuring the simulation as it exists now to become a more modular system which can implement additional factors. IWARS, in its current form, cannot accommodate such a complex system. Therefore, we need a new, agent-based simulation software which can be catered to the modern battlefield. This includes creating an extensive list of modern assets as they are being used today. Since we can track battlefield developments in real time through the media, we can track how emerging technologies, such as robotic mounted C-UAS systems and tethered drone tactics, evolve in realistic scenarios. By creating a system which can add these emerging technologies, in a plug and play style, we can see how they will change the battlefield dynamic and adjust our equipment and TTPs accordingly. Additionally, our simulation used unclassified data from extensive, publicly available sources. However, if classified capabilities could be utilized for range and effectiveness of shotguns and jammers, as well as the capabilities of emerging drone technologies, a future project group may represent these findings in the simulation to a more accurate degree.

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