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Closing the Defense Gap Against Small Unmanned Arial Systems

December 2025

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Thesis Advisors: Dr. Robert F. Mortlock, Professor
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Department of Defense Management

Naval Postgraduate School

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ABSTRACT

The rapid proliferation of small unmanned aerial systems (sUAS) has exposed significant vulnerabilities within the U.S. Army's air defense architecture. This thesis examines how the Army can close the counter–small unmanned aerial system (C-sUAS) capability gap through scalable, cost-effective, and military occupational specialty (MOS)-agnostic solutions. Using the doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTmLPF-P) framework, the study analyzes doctrinal, organizational, and institutional factors influencing the development and employment of C-sUAS capabilities. A comparative cost-effectiveness analysis evaluates four representative systems—Stinger, Coyote, directed energy maneuver–short range air defense (DE M-SHORAD), and DRAKE—across six measures of effectiveness. The results indicate that while kinetic and directed energy systems provide precision and lethality, their high cost and limited scalability constrain force wide employment. The DRAKE electronic warfare system demonstrates the greatest operational flexibility, lowest cost per engagement, and highest potential for broad fielding. The study concludes that integrating non-kinetic systems within a layered defense framework, supported by DOTmLPF-P-driven reforms, offers the most sustainable and adaptable approach to defending against sUAS swarms in future large-scale combat operations.

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ABOUT THE AUTHOR

MAJ Kevin A. Leal served as an Army Air Defense Artillery officer for a decade before transferring to the Army Acquisition Corps as a 51A. He spent his command time leading both a Headquarters and Headquarters Battery (HHB) within a PATRIOT Battalion and was in charge of a Terminal High Altitude Area Defense (THAAD) test Battery. MAJ Leal also served in key tactical and strategic roles supporting air and missile defense operations in the PACOM, EUCOM, and CENTCOM areas of responsibility. He is currently completing a Master of Science in Defense Program Management at the Naval Postgraduate School, where his research focused on counter-small unmanned aircraft systems (C-sUAS), cost-effective air defense modernization, and layered force protection. He will then serve as an assistant product manager in the precision fire and mortars section located at Picatinny Arsenal in New Jersey.

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I would like to acknowledge that all research, analysis, and writing for this thesis were conducted prior to **July 11, 2025**. Any new programs, doctrine, or research developed after this date were not taken into account for the purpose of this study. The findings and recommendations presented reflect the information, resources, and perspectives available up to that point in time.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADA	air defense artillery
ATP	Army techniques publication
BCTs	brigade combat teams
BIT	built-in test
C2	command and control
C-IED	counter–improvised explosive device
COTS	commercial off-the-shelf
CPMR	capabilities portfolio management review
C-RAM	counter–rocket, artillery, and mortar
C-sUAS	counter–small unmanned aerial system
C-UAS	counter–unmanned aerial system
DCR	DOTmLPF-P change recommendation
DE	directed energy
DE M-SHORAD	directed energy maneuver–short range air defense
DIU	Defense Innovation Unit
DoD	Department of Defense
DOTmLPF-P	doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy
ECM	electronic countermeasure
EO/IR	electro-optical/infrared
EUCOM	European Command
EW	electronic warfare
FAAD C2	forward area air defense command and control
FM	field manual
FOC	full operational capability
FRP	full-rate production
FS-LIDS	fixed site–low, slow, small unmanned aircraft system integrated defeat system
FY	fiscal year
GMD	ground-based midcourse defense
HIMAD	high-to-medium altitude air defense

IED	improvised explosive device
IFF	identification, friend or foe
ILE	intermediate-level education
IOC	initial operational capability
ISR	intelligence, surveillance, and reconnaissance
JCIDS	Joint Capabilities Integration and Development System
JCO	Joint counter–small unmanned aircraft system office
JCREW	Joint counter radio-controlled IED electronic warfare
JIEDDO	Joint improvised explosive device defeat organization
LCMR	lightweight counter-mortar radar
LIDS	Low, Slow, Small Unmanned Aircraft System Integrated Defeat System
LPWS	land-based phalanx weapon system
LSCO	large-scale combat operations
MANPADS	man-portable air defense system
MDAP	major defense acquisition program
M-LIDS	mobile–low, slow, small unmanned aircraft system integrated defeat system
MOE	measure of effectiveness
MOS	military occupational specialty
M-SHORAD	maneuver–short range air defense
NCR	National Capital Region
NGSRI	next-generation short-range interceptor
NTC	National Training Center
OTA	other transaction authority
PACOM	Pacific Command
PME	professional military education
RCCTO	rapid capabilities and critical technologies office
RCIED	radio-controlled improvised explosive device
RF	radio frequency
SALUTE	size, activity, location, unit, time, equipment
SDR	software-defined radio
SLEP	service life extension program

sUAS	small unmanned aerial system
THAAD	Terminal High Altitude Area Defense
TRL	technology readiness level
TTP	tactics, techniques, and procedures
UAS	unmanned aerial system
vA	overall effectiveness value
XRC	extended range counter-sUAS missile

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I. IDENTIFYING THE GAP

Since 2015, the development and mass production of drones have accelerated, making the platform increasingly inexpensive and accessible (Hollenbeck et al., 2025). The use of small unmanned aerial systems (sUAS) has transformed modern warfare, with Ukraine rapidly adapting to integrate sUAS into its military strategies, while Russia has simultaneously expanded its use of one-way attack drones (Hambling, 2025). At the start of the war in Ukraine, lethal drone units began with just a single platoon in 2022 and quickly grew into a full regiment by the end of 2024, striking over 5,000 targets in a single month (Hambling, 2025). In this conflict, sUAS have been used to carry out kamikaze-style attacks on high-value targets such as tanks, vehicles, surface-to-air weapon systems, ships, and strategic bombers, which has demonstrated how a low-cost asset can have high-impact effects.

As drone warfare continues to evolve, the gap in traditional air defense systems continues to widen, and these systems are ill-suited to defend against sUAS. The following challenges in modern warfare illustrate how the inability to respond effectively to drone threats creates significant difficulties. Units have typically used Stinger missiles in traditional short-range air defense (SHORAD) systems. However, the cost disparity between using Stinger missiles and shooting down multiple sUAS reveals a clear inefficiency and unsustainability during active conflict (Missile Defense Advocacy Alliance [MDAA], 2025). Although lasers are currently in development and expected to be fielded in the future, missiles remain expensive and slow to produce, whereas drones are relatively inexpensive and easy to manufacture (Norsk, 2025). Moreover, using missiles, bullets, or even lasers to neutralize drones carries a risk of unintended collateral damage, as a missed shot may cause more harm than the drone itself.

Ukrainians and Russians are experiencing advancements in drone warfare in real time. At the beginning of 2025, Ukraine declared that one of its primary objectives was to find innovative ways to defend against swarms of Russian small sUAS (Dickinson, 2025). Although many systems are being developed to counter this threat, broad frameworks are also being established here in the United States including those developed at the Fires Center of Excellence at Fort Sill, OK, to improve procedures for tracking and reporting sUAS activity (McLain, 2025). This training, still relatively basic, is beginning to lay the foundation for future counter-small unmanned aerial system (C-sUAS) operations across the force.

A. PROBLEM STATEMENT

This study highlights the urgent need for the U.S. Army Air Defense Community to close the gap in counter-sUAS capabilities, particularly against sUAS tactics that are redefining modern combat. By examining the recent developments and challenges in the Ukrainian and Russian sUAS war, this research analyzes the importance of doctrinal adaptation, accelerated acquisition, and operational testing. Ultimately, this study aims to build upon the growing body of knowledge that can help decision-makers invest in counter-sUAS systems that will neutralize the threat and close the gap in the United States' current layered air defense systems.

B. RESEARCH QUESTIONS

This capstone research project answers the following primary and secondary research questions:

1. How can the U.S. Army close the C-sUAS capability gap through scalable, cost-effective, and MOS-agnostic solutions within its layered air defense architecture?
2. What are the comparative cost-effectiveness and scalability trade-offs between kinetic and non-kinetic C-sUAS systems?

C. RESEARCH METHODOLOGY

This study employs a qualitative research methodology structured around the doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTmLPF-P) framework complemented by a comparative cost-effectiveness analysis of key C-sUAS platforms. The DOTmLPF-P framework, widely applied in defense acquisition and capability development, enables a holistic evaluation of both materiel and non-materiel solutions to the growing threat posed by small sUAS.

The qualitative component of the research draws on an extensive review of U.S. Army doctrine, operational concepts, and institutional publications, including field manuals (FM), Army techniques publications (ATP), and capability development documents, alongside case studies from recent conflicts such as the Russia-Ukraine war that illustrate emerging sUAS employment patterns and countermeasures. These qualitative insights provide the contextual foundation for understanding organizational, doctrinal, and operational gaps within current Army air defense capabilities.

To complement this assessment, the study integrates a quantitative cost-effectiveness analysis that evaluates four representative C-sUAS systems; Stinger man-portable air defense system (MANPADS), Coyote interceptor, directed energy maneuver–short range air defense (DE M-SHORAD), and DRAKE electronic warfare (EW) system across six measures of effectiveness (MOEs): scalability, cost per shot, operational performance, military occupational specialty (MOS)–agnostic usability, mobility, and schedule to initial operational capability (IOC). Each system is analyzed through a weighted decision matrix to quantify relative performance and affordability, allowing comparison of operational value against total ownership and sustainment costs.

Combining the DOTmLPF-P framework with a cost-effectiveness model enables a multidimensional analysis that captures both institutional and economic considerations. This hybrid approach ensures that findings address not only what doctrinal or organizational adaptations are required to close the counter-sUAS gap, but also which systems offer the most scalable, sustainable, and cost-efficient path for achieving force-wide air defense coverage.

D. SCOPE AND LIMITATIONS

The scope of this thesis is confined to U.S. Army air defense systems, with a specific emphasis on C-sUAS capabilities within tactical and operational environments. While acknowledging the significant contributions of joint and interagency partners, the research focuses on the Army's ability to defend maneuver and fixed assets against the expanding sUAS threat during large-scale combat operations (LSCO). The analysis explores both materiel and non-materiel solutions, evaluating how scalable, cost-effective, and MOS-agnostic systems can be integrated across formations to enhance layered air defense coverage.

To preserve the unclassified nature of this thesis, all data used in the analysis are derived exclusively from open-source publications, official Department of Defense documents, and credible defense industry releases available prior to July 2025, which serves as the research cut-off date. Classified program data, sensitive performance parameters, and restricted acquisition details were deliberately excluded.

Additionally, the cost data presented for each system, including the Stinger, Coyote, DE M-SHORAD, and DRAKE platforms, are treated as estimates derived from open-source reporting, congressional budget documents, and defense industry statements. Because precise procurement and sustainment costs remain classified or proprietary, these estimates are used to provide relative comparisons for the purpose of cost-effectiveness analysis rather than definitive program financial valuations.

Consequently, the findings and recommendations presented in this thesis should be interpreted within the limits of open-source accuracy and unclassified analysis, while still offering meaningful insight into cost-performance trade-offs, scalability considerations, and acquisition strategies relevant to Army decision-makers.

E. CHAPTER OVERVIEW

Chapter I introduces the research by defining the operational gap in defending against sUAS, presenting the problem statement, and outlining the primary and secondary research questions that guide the study.

Chapter II provides a comprehensive background of current U.S. Army air defense capabilities, the evolving structure of sUAS threats, and the Department of Defense's ongoing efforts to counter them. This chapter establishes the contextual foundation for understanding how existing systems and organizational structures address or fail to address the growing sUAS challenge.

Chapter III details the research methodology, applying the DOTmLPF-P framework to identify doctrinal, organizational, and materiel gaps while assessing potential solutions through both qualitative analysis and institutional evaluation.

Chapter IV expands upon this analysis by conducting a comparative cost-effectiveness assessment of representative C-sUAS systems; Stinger, Coyote, DE M-

SHORAD, and DRAKE, using a weighted decision matrix based on six MOEs. This chapter quantifies each system's relative affordability, scalability, and operational value to determine the most cost-efficient and sustainable solution for force-wide implementation.

Chapter V synthesizes the findings from both frameworks, providing conclusions and recommendations that address the Army's strategic, doctrinal, and acquisition pathways for closing the defense gap against sUAS across all echelons of the force.

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II. BACKGROUND

In 2020, the Department of Defense (DoD) established the Joint counter-small unmanned aircraft system office (JCO) to address the escalating threat posed by sUAS (Lushenko, 2025). The JCO identifies and prioritizes C-sUAS capability gaps in coordination with other enterprise stakeholders through the DoD capabilities portfolio management review (CPMR) process. The CPMR serves as a high-level, joint assessment of the DoD's comprehensive C-sUAS portfolio and informs decisions regarding future C-sUAS investments in both materiel and non-materiel solutions (Small UAS and counter-small UAS, 2025). Additionally, the JCO represents the joint force at the National Security Council and coordinates with federal agencies on matters of homeland defense. The JCO also collaborates with the Defense Innovation Unit (DIU) and the Army rapid capabilities and critical technologies office (RCCTO) to accelerate the delivery of critical capabilities to warfighters. The DIU's mission is to promote DoD adoption of commercial technologies, specifically those addressing the evolving sUAS threat, while the RCCTO facilitates the rapid fielding and testing of essential capabilities to meet Combatant Commanders' operational requirements (Gonzalez, 2025).

The JCO has identified four imperatives to accelerate capability development while integrating novel operational concepts to address the challenges posed by sUAS. Lushenko, 2025 describes the following: First, the JCO ensures situational awareness across the joint force. Second, it serves as the central coordinating body for all C-sUAS efforts, ensuring that requirements guide flexibly funded and sustained innovation. Third, it leverages existing acquisition authorities to accelerate C-sUAS capability development. Fourth, these efforts collectively aim to enhance support for the warfighter (Lushenko, 2025).

Recognizing that no single solution can counter the full spectrum of sUAS threats, the JCO has implemented a three-layer defense approach. According to Lushenko, the first layer employs nonlethal capabilities, such as EW, designed to confuse or disrupt sUAS systems before they can reach their targets. The second layer consists of "soft-kill" technologies, including microwave weapons and high-energy lasers, which aim to disable drones in flight. The third layer constitutes a "hard-kill" capability, relying on direct-fire weapon systems such as dismounted machine guns and interceptors like the Coyote missile according.

In addition, the JCO is partnering with the U.S. Army's Fires Center of Excellence to facilitate training initiatives at the Joint counter-small unmanned aerial University at Fort Sill, OK, and the planned National counter-unmanned Training Center at Redstone Arsenal, AL (McLain,2025). These efforts aim to ensure that military personnel, law enforcement agencies, and allied partners maintain common situational awareness of the threat environment, understand available response options, and develop mastery of relevant tactics, techniques, and procedures.

A. CURRENT ARMY AIR DEFENSE SYSTEMS

The current U.S. Army Air Defense Community is divided into two primary categories: high-to-medium altitude air defense (HIMAD) systems and short-range air defense (SHORAD) systems (Department of the Army, 2020). HIMAD systems are designed to engage long-range aerial threats such as fixed-wing aircraft, rotary-wing aircraft, cruise missiles, ballistic missiles, anti-radiation missiles, and Group 3 and larger unmanned aerial systems (UAS). Systems such as ground-based midcourse defense (GMD), Terminal High Altitude Area Defense (THAAD), Patriot, and Iron Dome are categorized as HIMAD systems.

In contrast, SHORAD systems are focused on countering close-range threats, including rockets, mortars, rotary-wing aircraft, and UASs. SHORAD platforms include the maneuver short-range air defense (M-SHORAD) system mounted on Stryker vehicles, the Avenger system, Stinger MANPADS, and counter–rocket, artillery, and mortar (C-RAM) systems (DOA, 2020).

According to the Army Air and Missile Defense Operations FM, each Avenger battery consists of two Avenger platoons and the necessary support equipment. Each Avenger system as demonstrated in Figure 1 is outfitted with eight Stinger missiles, an .50-caliber machine gun, sensor with identification, friend or foe (IFF) capabilities (DOA, 2020). Currently, there are six Avenger battalions in the National Guard that are in constant rotation to support the National Capital Region (NCR) with one battalion to provide air defense coverage for the airspace over Washington, DC. On the active component side, there are three Avenger batteries that are integrated with Patriot and Counter–Rocket, Artillery, and Mortar (CRAM) Battalions, one stationed in Fort Sill Oklahoma the other two at Fort Bragg in North Carolina (Wilson & Gardner, 2022).

Figure 1. The Avenger Weapons System Captured Firing a Stinger Missile. Source: Missile Defense Advocacy Alliance (2023).

The Stinger MANPADS employs retrofitted Stinger missiles equipped with a proximity fuze to engage and destroy UASs through either direct impact or proximity detonation. The system requires specialized training as demonstrated in Figure 2 and has been integrated with combat units to enhance their effectiveness against aerial threats (DOA, 2020).

Figure 2. The Stinger MANPADS Displayed on a Marine's Shoulder. Source: Missile Defense Advocacy Alliance (2023).

M-SHORAD serves as the division's organic air defense capability. It is designed to protect assets within a division and brigade headquarters, while also defending maneuver formations conducting decisive operations in the close area. Figure 3 shows air defense system mounted on the Stryker A1 platform and is equipped with a Stinger missile pods, Hellfire missiles, a 30mm cannon, and sensors capable of countering fixed-wing aircraft, rotary-wing aircraft, and UASs (MDAA, 2023). Currently, there are four M-SHORAD battalions: two are stationed in Europe, while the remaining two are based in the United States with one of the U.S.-based battalions serving as a test unit (Wilson & Gardner, 2022).

Figure 3. The Maneuver-Short Range Air Defense on Display. Source: Missile Defense Advocacy Alliance (2023).

C-RAM systems, as shown in Figure 4, are within the active component and are organized under the Indirect Fire Protection Capability (IFPC)/Avenger battalions. These batteries deploy at the battery level and are typically employed at the platoon level at forward operation bases. In FM 3-01 of the Arm Air and Missile Defense Operations, each C-RAM battery consists of three C-RAM platoons and the associated support equipment. A standard battery is equipped with 12 land-based phalanx weapon systems (LPWS), 20-millimeter gun systems with three Sentinel radars, six lightweight counter-mortar radars (LCMR), and three platoon engagement operations sections (DOA, 2020).

Figure 4. The Counter–Rocket, Artillery, and Mortar Shooting During a Live Fire. Source: Missile Defense Advocacy Alliance (2023).

DE-M-SHORAD is an emerging capability that utilizes the same Stryker A1 platform as M-SHORAD (shown in Figure 5.) that is retrofitted with a 50 kW-class laser (MDAA, 2023). This system is designed to provide a cost-effective, kinetic solution for countering sUAS and larger aerial threats (Gonzalez, 2025). The program aims to reduce the cost per engagement while enhancing defensive capabilities. Currently, the U.S. Army RCCTO, in collaboration with the JCO, DIU and its host unit the 4th Battalion, 60th Air Defense Artillery Regiment (4-60 ADA) has been conducting testing to evaluate the system's effectiveness against swarms of drones (Wilson & Gardner (2022).

Figure 5. The Direct Energy Maneuver-Short Range Air Defense System at the Range. Source: Gonzales (2025).

B. UNMANNED AERIAL SYSTEM

Unmanned aerial systems vary significantly in size, function, and operational capability, and they are employed by both state and nonstate actors across a wide range of military and civilian applications. As illustrated in Table 1, UAS platforms are categorized into Groups 1 through 3, which include micro, mini, and tactical systems characterized by lower altitudes, lighter payloads, and limited endurance. In contrast, Table 2 depicts Groups 4 and 5, which encompass larger strategic and theater-level platforms with extended range, endurance, and altitude capabilities.

Table 1. UAS Group. Source: Department of the Army (2023).

Group	*Weight (lbs)*	*Speed (kts)*	*Normal Operating Altitudes (ft)*	*Notes*	*Threat & COTS Examples*	*Friendly Examples*
Group 1: micro/ mini UAS	0 - 20	<100	< 1,200 AGL	Generally, hand launched commercial-off-the-shelf, radio-controlled platforms. The have limited ranges and small payload capabilities. They offer real time video. Operated within line of sight of the user They offer real time video. Operated within line of sight of the user	DJI MAVIC, Enterprise Dual	RQ-11 Raven
Group 2: small tactical	21 - 55	101 - 250	< 3,500 AGL	Small airframes with low radar cross sections provide medium range and endurance. Launched from unimproved areas with a small number of people involved. Requires line of sight to the ground control station.	SKY-09Ps	Scan Eagle
Group 3: tactical	56 – 1,320		< FL 180	Similar to Group 1 and 2 UAS, requires a larger logistical footprint. Range and endurance varies significantly among platforms.	Shahed	RQ-7B Shadow

Table 2. UAS Group. Source: Department of the Army (2023).

Group	***Weight (lbs)***	***Speed (kts)***	***Normal Operating Altitudes (ft)***	***Notes***	***Threat & COTS Examples***	***Friendly Examples***
Group 4: Strategic or theater	> 1,320	Any speed	< FL 180	Relatively large systems operated at medium to high altitudes. This group has extended range and endurance capabilities. Normally requires a runway for launch and recovery.	Forpost	MQ-1C Gray Eagle MQ-1A/B Predator
Group 5: Strategic	> 1,320	Any speed	> FL 180	Operates at medium to high altitudes having the greatest range, endurance, and airspeed. Requires large logistical footprint like that of manned aircraft and has a suite of optics for targeting and weaponry for engagements	Wing Loong II	RQ-4 Global Hawk MQ-9 Reaper

AGL	above ground level	ft	feet	RQ	Reconnaissance unmanned aircraft system
COTS	commercial-off-the-shelf	Kts	knots	UAS	unmanned aircraft system
DJI	Da-Jiang Innovations	lbs	pounds		
FL	flight level	MQ	American military drone		

Since their development in the 1970s, UAS technologies have undergone substantial advancements that have led to an increasingly complex operational environment, particularly as smaller UAS platforms become more difficult to detect using traditional radar systems. Current air defense radars face notable limitations in tracking low-altitude, low-radar-cross-section drones, posing significant challenges to situational awareness and threat mitigation efforts (GAO, 2023). While promising advances in detection, cyber warfare, and layered defense architectures are underway, key challenges remain. The DOTmLPF-P framework offers a comprehensive lens through which to identify and address these gaps, but successful implementation will require synchronized efforts across doctrine, training, and materiel development/acquisition.

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III. ANALYSIS

In the DoD, understanding how to address capability gaps without defaulting to the development of materiel solutions is part of the acquisition process to ensure that today's challenges can be met with creative and effective solutions. This research applies the DOTmLPF-P research framework to my research: Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy. This methodology originates from the Joint Capabilities Integration and Development System (JCIDS) and is explicitly designed to explore materiel and non-materiel solutions to operational problems and is especially relevant when capability gaps may be mitigated or solved without procuring new hardware or systems.

Additionally, the study explores how the U.S. Army can effectively integrate C-sUAS capabilities into its formations. As defined in the JCIDS Manual, the DOTmLPF-P change recommendation (DCR) is a formal JCIDS document used to recommend nonmateriel changes in response to identified capability gaps (Joint Staff, 2021). The DCR examines proposed changes across eight domains (Defense Acquisition University, n.d.):

Doctrine – The principles that guide how the military fights

Organization – The structure and arrangement of military units

Training – Modifications to institutional or operational training

materiel – Implementation of existing systems that can be fielded or commercial off the shelf (COTS)

Leadership and Education – Leader development and professional military education (PME)

Personnel – Recruiting, managing, or reskilling human capital

Facilities – Infrastructure and installation requirements

Policy – Governance, rules, and guidance impacting implementation

DOTmLPF-P analysis is particularly effective for assessing major defense acquisition programs (MDAPs), as it broadens the aperture beyond simply buying new technologies. The method is often applied during a JCIDS analysis or Functional Needs Assessments to identify holistic solutions to complex defense challenges.

A. APPLICATION OF THE DOTMLPF-P ELEMENTS

To build on this foundation, the following section applies the DOTmLPF-P framework directly to the Army's current C-sUAS posture. By evaluating each element; doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy; this analysis identifies the specific institutional gaps that constrain the Army's ability to counter the growing sUAS threat and highlights where non-materiel and materiel solutions can provide the greatest impact. The discussion begins with an assessment of existing doctrinal guidance.

1. Doctrine

This evaluation examines current doctrinal guidance, including FM 3-01: Air and Missile Defense Operations (DOA, 2020); Army techniques publication (ATP) 3-01.81: Counter–Small Unmanned Aircraft Systems Techniques (Department of the Army, 2023); and ATP 3-01.15: Multi-Service Tactics, Techniques, and Procedures for Air and Missile Defense (Department of the Army, Department of the Navy, Department of the Air Force, & Department of the Marine Corps, 2023), to assess whether existing tactics and principles effectively address the growing drone threats. FM 3-01 provides the outline of the breakdown structure of Air Defense Operations but provides limited guidance on counter–unmanned aircraft systems, and only clarifies the categorization of UAS groups. ATP 3-01.81 outlines both passive and active measures against UAS threats and goes into detail of the different types of passive measures, including camouflage, concealment, deception, dispersion, displacement, and the use of hardening and protective construction. It also covers the identification and reporting method for active measures, and broadly covers the actual active measures and refers to the units' tactics, techniques, and procedures (TTPs). ATP 3-01.15 delves slightly deeper but still provides only a superficial overview of active and passive defense measures, including a standardized reporting system across all forces. Current training doctrine emphasizes passive and active counter-unmanned aerial system (C-UAS) defense, including the implementation of a standardized reporting procedure. However, no current doctrine exists for incorporating available systems that units can reference and request to begin their training.

2. Organization

The Army relies on the air defense community to address aerial threats. Currently, most active-duty forces are structured around HIMAD systems such as Patriot and THAAD, with increasing efforts to expand M-SHORAD units to meet projected growth. In February 2024, the Army released a white paper outlining its plans to transform the force by adding four additional M-SHORAD battalions, a proposal that has been reviewed by Congress (DOA, 2024). The expansion of M-SHORAD will enhance the protection of maneuver forces against such aerial threats but will be limited to mounted systems (DOA, 2024).

3. Training

In 2022, the Fires Center of Excellence at Fort Sill, OK, announced the establishment of a C-sUAS University, which is an institution open to students from all service branches and is intended to spread the knowledge and counter the growing threat posed by sUAS; the first courses began in October 2023 (*Air Defense Artillery Journal*, 2022).

At the C-sUAS University, the Fires Center of Excellence has begun incorporating lessons learned from both the European Command (EUCOM) and Pacific Command (PACOM) into instruction on TTPs, displayed on Figure 6. Additionally, the 3rd Battalion, 2nd Air Defense Artillery (3-2 ADA) Regiment, which is tasked to host such training, has developed a specialized C-sUAS training program focused on the importance of passive air defense and timely reporting. This program is built upon four foundational pillars that clearly define its objectives and underscore its strategic significance (McLain, 2025). The 3–2 ADA program designed its curriculum to be MOS-agnostic. Rather than relying on terminology specific to the 14-series Air Defense MOS, the program uses universal military reporting frameworks, such as the size, activity, location, unit, time, equipment (SALUTE) report, to make training accessible to soldiers across all MOSs. This inclusive approach ensures that non-air defense personnel can integrate into the air defense common operating picture.

However, it is important to note that the training program does not currently include instruction on kinetic engagement systems used to neutralize enemy sUAS. To address personnel qualification and doctrinal alignment, the Office of the Deputy Chief of Staff, G-1, issued a Notification of Future Change in December 2024. This notification announced the future establishment of a C7 Skill Identifier, pertaining to Joint Installation C-sUAS Protection, which will be available across all service branches, effective October 1, 2027 (Department of the Army, Office of the Deputy Chief of Staff, G-1 [DA G1], 2024). This initiative aims to standardize training, enhance readiness, and ensure the identification and continued development of qualified personnel across installations.

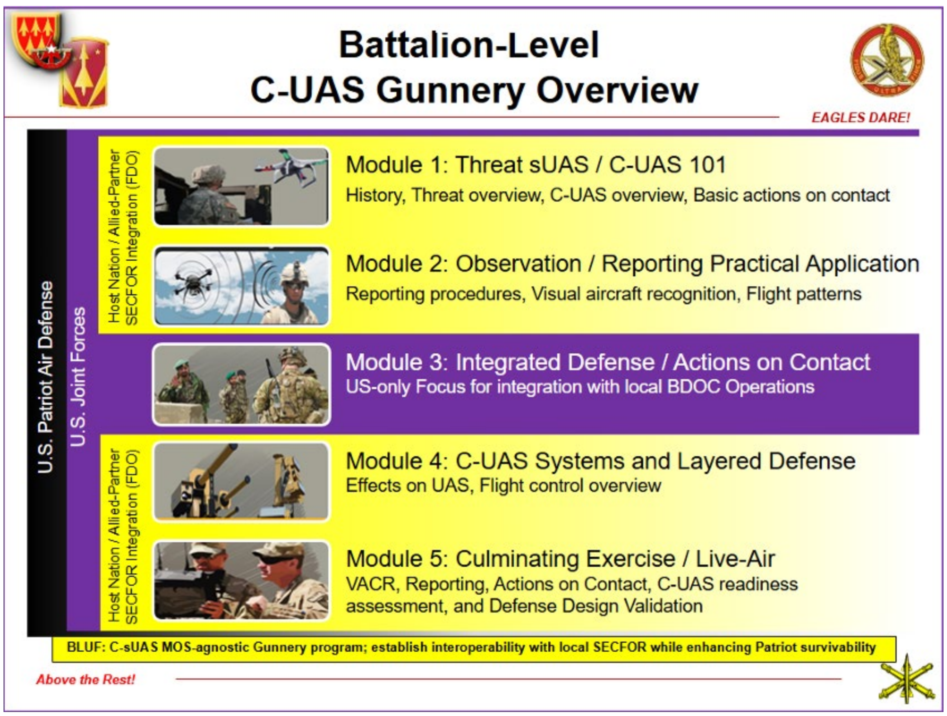

Figure 6. Fort Sill C-UAS Gunnery Overview Presented at the Fires of Excellence C-UAS Course. Source: McLain (2025).

A persistent gap in current training lies in the operational application of C-sUAS TTPs. Units often lack opportunities to practice with current systems in high-stress, scenario-based environments, which are necessary for refining responses to a sUAS threat. Additionally, units have limited availability of Red Air teams, which has hindered units' ability to realistically simulate and respond to drone swarms, which are a critical threat scenario in preparation for Large-Scale Combat Operations (Perez, 2025).

4. Materiel

The U.S. Army currently employs several emerging platforms to address the growing Counter–Small Unmanned Aircraft Systems threat. Raytheon's fixed site–low, slow, small unmanned aircraft system integrated defeat system (FS-LIDS) is one such solution (PEO, 2025). Separately, the Army is also developing and fielding the DE M-SHORAD system to provide mobile, on-the-move C-sUAS capabilities for maneuver units. Meanwhile, the U.S. Navy and Air Force employ the DRAKE system, a fielded, software-defined electronic countermeasure (ECM) platform that delivers non-kinetic UAS defeat through disruption of command links (Northrop Grumman Corporation [NGC], 2024).

Raytheon's FS-LIDS displayed in Figure 7 was originally developed to assist the U.S. Army in countering rocket, artillery, and mortar threats in Iraq and Afghanistan. The KuRFS radar has since demonstrated exceptional precision and reliability in C-UAS operations (Raytheon, 2025). When paired with the Coyote kinetic effector, the system delivers a comprehensive detect-and-defeat capability against small UAS threats. According to Raytheon, in addition to supporting the Coyote system, KuRFS is compatible with multiple weapons systems, including the LPWS, .50 caliber machine guns, 30 mm cannons, and high-energy laser platforms.

Figure 7. The FS-LIDS Demonstrating Its Fires. Source: RTX (2024).

The DRAKE system, showed on Figure 8, is a Technical Readiness Level of 9, fielded, intelligent software defined radio (SDR) ECM solution designed to detect, identify, track, and defeat sUAS (NGC, 2024). Currently employed by the U.S. Navy, U.S. Air Force, and international partners such as Australia and New Zealand, DRAKE provides non-kinetic UAS defeat capabilities by disrupting the command link between drones and their operators. DRAKE can operate independently or integrate with command and control (C2) platforms, including the forward area air defense command and control (FAAD C2) system, allowing for layered defense configurations. Its clean radio frequency (RF) signal and flexible timing protocols are designed to avoid interference with friendly communications systems, making DRAKE suitable for deployment alongside other radar and communication platforms such as Patriot and THAAD weapon systems (Northrop Grumann, 2024).

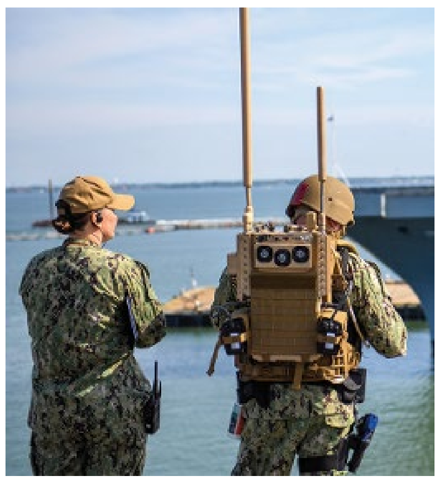

Figure 8. Navy Sailors Using the DRAKE System. Source: NGC (2024).

The system is modular and available in mounted, dismounted, and fixed-site configurations, with common hardware and software across all variants. It requires minimal operator training and features intuitive user interfaces. In addition to counter-UAS operations, the DRAKE system can be re-tasked for counter–improvised explosive device (C-IED) missions without changing its software (NGC, 2024).

5. Leadership and Education

As the Army shifts its focus from counterinsurgency operations to large-scale combat operations, there is a significant learning curve in how maneuver forces will integrate air defense assets across all echelons. Additionally, there is a notable gap in institutional knowledge within the branch regarding how air defense units support higher headquarters, as these units have often operated separately from maneuver elements in the last 2 decades.

6. Personnel

It remains uncertain whether the air defense community will have a sufficient number of qualified Soldiers to support the expanding Counter–Small Unmanned Aircraft Systems (C-sUAS) mission set and fill the project M-SHORAD units that are projected to be stood up in the coming years. The active-duty force continues to face shortages in key air defense MOS, particularly 14G (Air Defense Battle Management System Operator) and 14H (Air Defense Enhanced Early Warning System Operator).

While some National Guard units possess training in short-range air defense (SHORAD), their operational experience is limited to the legacy Avenger system, which does not fully address the requirements of the evolving C-sUAS threat environment.

7. Facilities

Yuma Proving Ground hosted a C-UAS demonstration focused on defeating Group 1 and Group 2 drones (Schauer, 2021). The site was selected due to its unique environmental and technical advantages, including expansive open terrain, stable atmospheric conditions, a dry climate, a broad and available RF spectrum, and its proximity to UAS testing operations. The co-location of the Joint Counter-UAS University, the Fires Center of Excellence schoolhouse, and the 4th Battalion, 60th Air Defense Artillery Regiment (4-60 ADA), in partnership with RCCTO, further supports C-UAS testing and training. In the summer of 2025, the 4th Battalion, 60th ADA, in collaboration with RCCTO, conducted a live-fire exercise against a swarm of Group 1–3 UASs (Gonzales, 2025). This event generated critical data to support the Army's FY2026 Enduring High Energy Laser Program, anticipated to become the Army's first directed energy (DE) program of record (Gonzales, 2025).

8. Policy

The JCIDS process acknowledges that policy alignment is often essential to enable capability development across other warfighting domains. Currently, C-UAS operations in host nations remain insufficiently addressed (Gettinger, 2025).

In summary, the DOTMLPF-P analysis reveals that while significant strides have been made in fielding capabilities like M-SHORAD and expanding C-sUAS training, challenges remain across several domains, particularly in doctrinal integration, personnel readiness, and policy alignment. Table 3 provides an overview and a side by side with conclusion and recommendations for each of the elements of the analysis. The findings underscore the need for a synchronized, multi-domain approach that not only equips units with advanced technologies but also prepares them doctrinally, organizationally, and culturally for the demands of modern air defense. As threats continue to evolve, implementing the recommendations outlined in this analysis will be critical to building a resilient and adaptive force capable of countering the full spectrum of sUAS threats.

Table 3. Conclusion and Recommendation Table

DOTMLPF-P Element	Findings	Conclusions	Recommendations
Doctrine	Existing doctrine insufficiently addresses active C-sUAS measures. Limited guidance exists beyond categorization and basic TTPs.	Doctrine needs revision to include standardized integration of kinetic C-sUAS systems and refined active defense tactics.	Update FM 3-01 and ATPs with detailed C-sUAS engagement procedures and standardized reporting and request channels.
Organization	The Army is expanding M-SHORAD battalions, but current force structure is still heavily focused on HIMAD systems.	Organizational growth is positive, but SHORAD capabilities must expand faster to match the pace of sUAS threats.	Accelerate activation of new SHORAD units and assess integration models for unmanned or semi-autonomous C-sUAS platforms.
Training	New C-sUAS University established; training is MOS-agnostic and widely accessible. Gaps in kinetic engagement training persist.	C-sUAS training is progressing, but practical application and kinetic engagement training must be included in standard curricula.	Expand Red Air simulation programs and integrate practical C-sUAS training into a combat training center CTC rotations for all units.
materiel	Multiple systems like FS-LIDS, DE-MSHORAD, and DRAKE provide layered capabilities. However, integration and affordability remain challenges.	System diversity offers promise, but current capabilities are fragmented and need better field integration and operational testing.	Standardize C2 interfaces and prioritize procurement of cost-effective and mobile systems like DE-MSHORAD and DRAKE.

DOTMLPF-P Element	Findings	Conclusions	Recommendations
Leadership and Education	Institutional knowledge on joint integration with maneuver units is limited. Shift in focus from COIN to LSCO is ongoing.	Leadership must prioritize PME updates to ensure C-sUAS concepts are taught and integrated at all echelons.	Include C-sUAS scenarios in intermediate-level education (ILE) and PME; ensure leaders across branches understand integration doctrine.
Personnel	Shortages in MOS 14G and 14H; uncertain if force can meet future M-SHORAD and C-sUAS demands despite FY25 recruitment success.	Personnel pipeline for air defense is stressed	Develop new pipeline for C-sUAS-focused personnel through skill identifiers and career tracks that would be able to attach to any type of units and not just the Army Air Defense Community.
Facilities	Live-fire testing and training supported by co-located institutions (e.g., Yuma Proving Ground, Fort Sill). Facilities are adequate for ongoing development.	Infrastructure is largely in place but may require scaling to support additional M-SHORAD units and more frequent training rotations.	Expand training access at facilities like Fort Sill and Yuma; fund additional sites to decentralize capacity.
Policy	Lack of clear C-UAS policy in host nations. JCIDS process calls for better alignment to enable implementation across domains.	Policy gaps must be addressed to enable full deployment and use of C-sUAS tools in both domestic and international settings.	Develop and disseminate joint policies that enable use of C-sUAS systems in allied host nations with clarity on legal/ROE boundaries.

B. LIMITATIONS IN CURRENT ARMY AIR DEFENSE C-SUAS SYSTEMS

Despite progress in fielding various C-sUAS technologies, the Army continues to face critical limitations. Traditional air defense systems such as Patriot and THAAD were designed to counter large, high-altitude aerial threats and lack the capability needed to effectively engage low-flying, low-signature drones, especially in swarm formations (Behling et al., 2022). HIMAD radar systems often struggle to distinguish low-signature drones from environmental clutter, leading to high false positives and delayed response times (Knight, 2019). Additionally, these systems are inherently static when deployed and require large power generators, making them vulnerable to detection by enemy intelligence, surveillance, and reconnaissance (ISR) via thermal imaging or acoustics, and have no organic capability to neutralize Group 1–3 sUAS threats. Although passive defense is encouraged, it is insufficient against coordinated attacks with a high risk of a single kinetic drone strike that can disable critical assets like missile launchers or radar systems.

M-SHORAD systems offer the ability to shoot, move, and communicate and can maneuver with maneuver forces. Personnel challenges further compound the issue. The active-duty forces lack sufficient trained air defense Soldiers, particularly in MOS 14G (Air Defense Battle Management System Operator) and 14H (Enhanced Early Warning System Operator), to meet growing C-sUAS demands. While National Guard units have SHORAD experience, they operate the legacy Avenger system, which is not as effective in interception or as cost effective. The Air Defense community is already task-saturated with responsibilities for cruise missiles, ballistic missiles, aircraft, and larger UAS threats. Expanding into sUAS defense without broader integration could strain existing manpower and capability.

Finally, current training paradigms, though improving, are underway to build a joint-reporting framework and improve communication and situational awareness. However, most Soldiers still receive limited practical exposure to C-sUAS systems. Widespread training on such systems will be needed to familiarize troops with countermeasures, and to refine TTPs and ensure readiness across all units, not just those within Air Defense.

C. OPERATIONAL THREATS POSED BY SUAS

Small Unmanned Aircraft Systems present a rapidly evolving and asymmetric threat to Army operations across both tactical and strategic domains. These systems are increasingly used for kinetic attacks, such as delivering explosives to high-value targets, and for non-kinetic missions, including surveillance, reconnaissance, and real-time target acquisition to support adversary fire support (Way, 2022).

Swarm tactics are especially concerning. By saturating detection systems and creating decision paralysis within compressed engagement windows, swarms can overwhelm even well-equipped units. This threat exposes the vulnerabilities in the current air and missile defense framework, particularly when existing systems are not designed to simultaneously track and neutralize large volumes of small, fast-moving aerial targets.

The proliferation of COTS drones lowers the threshold for adversaries to conduct effective aerial operations (Behling et al., 2022, p. 164, xxii). At minimal cost, enemies can pose significant operational risks that complicate conventional risk models and force allocation. While current sUAS systems are limited by factors such as altitude ceilings, battery life, and basic AI, technological advancements, accelerated by conflict-driven innovation such as in Ukraine, are closing these gaps.

This changing threat landscape demands a holistic and joint approach to defense. The scale and frequency of drone threats are too great for the Air Defense community to manage alone. Commanders at all levels must incorporate C-sUAS concepts into their planning, doctrine, and training. A distributed capability of drone defense, supported by joint-force doctrine, will allow for greater operational flexibility and resilience. Holistic defense will require both passive and active measures, realistic training, and widely accessible counter-drone tools that Soldiers can learn, employ, and adapt across all MOSs.

Chapter III examined the Army's counter–small unmanned aircraft systems posture through the DOTmLPF-P framework, identifying the institutional, doctrinal, and operational factors that shape the service's ability to counter the rapidly evolving sUAS threat. The analysis showed that while the Army has made progress in select areas, such as establishing the C-sUAS University, expanding SHORAD formations, and fielding early materiel solutions, significant gaps remain in doctrinal clarity, training standardization, personnel capacity, and policy alignment. These systemic shortfalls illustrate why no single solution can resolve the C-sUAS challenge and why both materiel and non-materiel approaches must be considered together. The findings from this chapter directly inform the need to evaluate specific capability options not only on their tactical performance but also on their scalability, affordability, and suitability for MOS-agnostic employment across the force.

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IV. COST EFFECTIVENESS ANALYSIS

This chapter conducts a comparative cost-effectiveness assessment of multiple C-sUAS alternatives through a structured decision framework grounded in six MOEs: scalability, cost per shot or engagement, performance against swarms, MOS-agnostic usability, mobility, and schedule to IOC. These MOEs were selected to capture both the operational relevance and programmatic viability of each system within the Army's layered air defense enterprise. Each option is analyzed based on its cost per engagement, estimated unit cost, and overall effectiveness value (vA), which is derived through the weighted aggregation of the six MOEs. Unweighted scores represent the baseline performance of each system across individual criteria (with rated scores from 1 to 5 with a higher scores being better in that criteria), while weighted scores incorporate the assigned MOE multipliers to quantify each factor's relative importance within the decision-making process.

Scalability, assigned the highest relative weight of 0.30, represents the Army's ability to produce, distribute, and sustain a given system widely across the force. This factor acknowledges that even the most capable system provides limited strategic value if it cannot be fielded at scale to meet operational demands. Cost per shot or engagement (weighted at 0.25) reflects overall affordability and long-term sustainability by comparing the average expense of neutralizing targets such as the difference between missile expenditures and DE power consumption. Performance against swarms (0.20) assesses a system's effectiveness against multiple simultaneous Group 1–3 UAS threats, emphasizing precision, engagement rate, and endurance under high-volume conditions.

The MOS-agnostic criterion (0.15) measures the degree of specialization required for Soldiers to operate the system effectively. Systems that can be employed by a broader range of personnel without extensive air defense training are inherently more sustainable and adaptable to large-scale combat operations. Mobility (0.07) evaluates the ability of each system to operate while mounted or dismounted, providing flexibility across terrain and maneuver elements. Finally, schedule to IOC (0.03) considers the projected timeline for a capability to reach fielded and operational status, represented on the decision matrix in Table 4. Although scalability remains the top priority, this analysis accounts for all programmatic risks and trade-offs among cost, performance, and readiness factors.

The four representative systems are assessed within this framework: the Stinger MANPAD, the Coyote interceptor, the DE M-SHORAD system, and the DRAKE EW system.

Table 4. Decision Matrix

Decision Matrix														MOE Scores (higher is better)	
C-UAS Platforms		Cost ($/Round)	Estimated Mounted Unit One-Time Cost ($)	Estimated Unit Dismounted (Portable) One-Time Cost ($)	Estimated Unit Fix Site One-Time Cost ($)	Estimated Cost of sytsem and 100 rounds	Effectiveness v(A)	Scalability (MOE 1)	Cost per Shot (MOE 2)	Operational Performance (MOE 3)	MOS Agnostic (MOE 4)	Mobility (MOE 5)	Schedule to IOC (MOE 6)	Unweighted	Weighted
								0.3	0.25	0.2	0.15	0.1	0.03		
Stinger (Kinetic)	unweighted														
	weighted														
Coyote (Kinetic)	unweighted														
	weighted														
Direct Energy (Non Kinetic)	unweighted														
	weighted														
DRAKE System EW (Non Kinetic)	unweighted														
	weighted														

A. STINGER MANPAD (KINETIC) MOE EVALUATION

Scalability: The Stinger system demonstrates moderate scalability within the Army's current and projected force structure. The FIM-92 Stinger is a fully fielded, mature MANPADS with long-established production lines, logistic support channels, and sustainment infrastructure that enable continued procurement and export to allied nations (Gettinger, 2025). However, industrial capacity remains constrained, with U.S. manufacturing limited to roughly several dozen to low hundreds of missiles per month, which slows replenishment following major transfers such as the 500 systems Germany and 200 systems the Netherlands supplied to Ukraine (Palowski, 2024). Recent DSCA approvals for 940 FIM-92K Block 1 missiles valued at $780 million underscore FYs of funding and prioritization (Palowski, 2024). At the tactical level, scalability is further limited by training throughput, as non-air-defense personnel require extensive certification to maintain proficiency, a gap observed during National Training Center (NTC) rotation 25–02 when brigade combat teams (BCTs) struggled to manage decentralized MANPADS gunnery programs (Rodriguez, 2025). Therefore, the Stinger received a scalability score of 4, reflecting its mature production line, established logistics base, and long-standing global fielding, though still constrained by slow industrial replenishment of missiles.

Cost per Shot / Engagement: Each Stinger missile costs approximately $480,000 per round, making it among the most expensive short-range interceptors in the Army inventory (MDAA, 2024). This high per-shot cost generates an unfavorable cost-exchange ratio when engaging inexpensive commercial or small tactical UAS, a challenge repeatedly cited in Congressional Research Service analyses and Army cost-effectiveness reviews (Gettinger, 2025). The combination of high per-shot cost and limited magazine depth reinforces the system's role as a precision, high-value interceptor rather than a cost-efficient swarm-defeat tool. Cost of the MANPAD Grip holder is not specified but is included in the overall weapon cost (MDAA, 2024). Accordingly, the Stinger was assigned a cost-per-shot score of 1 because its $480,000 per-missile expenditure creates the worst cost-exchange ratio of all systems when defeating inexpensive Group 1–2 drones.

Operational Performance: The Stinger missile provides reliable single-target precision, using on-board infrared homing guidance to autonomously track and destroy low-altitude aircraft and Group 1–2 UAS after launch (DOA, 2020). However, its limited ammunition capacity (one or two missiles per soldier) prevents sustained engagements against multiple simultaneous targets. Current doctrine classifies Stinger teams as a component of layered air defense rather than a stand-alone solution for large-scale swarm attacks (DOA, 2020). As of 2025, the Army's follow-on programs, including the next-generation short-range interceptor (NGSRI) and extended range counter-sUAS missile (XRC), are in development to increase rate of fire and engagement envelope specifically for swarm defense (Gettinger, 2025). For this reason, the Stinger received an operational performance score of 1*,* as it delivers reliable single-target lethality but cannot sustain engagements against multiple drones or swarms due to its very limited magazine depth and slow re-engagement cycle.

MOS-Agnostic Ease of Use: The Stinger system was deliberately reintroduced into maneuver formations "to provide an organic air-defense capability to soldiers outside the Air and Missile Defense Community" (Gettinger, 2025). FM 3-01 outlines procedures allowing maneuver Stinger teams to conduct independent engagements under established weapons-control statuses, typically weapons tight for rotary-wing aircraft and weapons free for low, slow, and small UAS (DOA, 2020). In practice, however, recent CALL assessments at the NTC found that non-dedicated Stinger teams lacked standardized training and certification oversight, forcing BCTs to rely on ad-hoc gunnery programs (Rodriguez, 2025). The absence of a unified evaluation framework, coupled with limited Master Gunner billets and oversight from higher ADA headquarters, constrains true MOS-agnostic employment at scale. Thus, the Stinger earned a MOS-agnostic score of 2.5*,* acknowledging that maneuver forces can employ it doctrinally, but significant training, certification, and gunnery oversight requirements limit true broad-spectrum usability.

Mobility: The Stinger remains one of the Army's most mobile air-defense assets, employable as a man-portable, dismounted, or vehicle-mounted system (DOA, 2020). It can be fired from shoulder launchers, tripods, or integrated mounts such as the Avenger (currently being phased out) turret, or enabling use across light, Stryker, and armored formations (Palowski, 2024). Its minimal power and maintenance requirements allow teams to displace rapidly and reposition near critical assets in alignment with brigade maneuver schemes, providing point or area coverage without significant logistical burden (DOA, 2020). As a result, the Stinger received a mobility score of 4*,* given its proven ability to operate dismounted, vehicle-mounted, or tripod-mounted with minimal infrastructure or power requirements.

Schedule to IOC: According to Gettinger (2025), the Stinger has been fully operational since the early 1980s and continues to function as the baseline short-range interceptor within the Army's and Marine Corps' layered air-defense architectures. Gettinger further notes that ongoing sustainment efforts, including the service life extension program (SLEP), have modernized seekers and propulsion systems, extending the missile's serviceability into the late 2020s. He also highlights that successor efforts, most notably the NGSRI, are currently in a prototype competition between Lockheed Martin and Raytheon Technologies and are not expected to reach IOC until approximately FY2028, with full-rate production (FRP) projected later in the decade. Consequently, Gettinger concludes that the Stinger will retain full operational status and remain the Army's primary, ready counter-UAS and SHORAD interceptor for the near-term transition period (Gettinger, 2025). Therefore, the Stinger received a Schedule to IOC score of 4*,* reflecting its long-standing operational status, sustained modernization through SLEP upgrades, and continued role as the Army's primary short-range interceptor while successor programs remain years from IOC.

B. COYOTE COUNTER-UAS SYSTEM (KINETIC) MOE EVALUATION

Scalability: The Coyote system demonstrates moderate scalability, reflecting its flexible integration within the Low, Slow, Small Unmanned Aircraft System Integrated Defeat System (LIDS) architecture, but also revealing structural limits in production and force-wide implementation. The LIDS family includes both FS-LIDS and Mobile-LIDS (M-LIDS) configurations, each employing a mix of radar, electro-optical/infrared (EO/IR) sensors, FAADC2, and Raytheon's Coyote interceptors for layered defense against Group 1–3 UAS (Gettinger, 2025; PEO Missiles and Space, 2025). The Coyote Block 2+ interceptor can be deployed from either fixed or mobile platforms, demonstrating design modularity and interoperability within the broader LIDS-Family-of-Systems (RTX, 2024). As of FY2025, the Army requested $280.1 million in procurement funding for five M-LIDS (single-vehicle Stryker configuration) and six FS-LIDS systems, along with $117.4 million for Coyote interceptors, quantities that represent limited initial fielding rather than broad Army-wide distribution (Gettinger, 2025). Additionally, production objectives for 6,000 kinetic and hundreds of non-kinetic Coyote interceptors between FY2025 and FY2029 indicate long-term scaling goals but underscore the current shortfall between demand and available manufacturing output. While the M-LIDS Increment 2.1 consolidation to a single Stryker vehicle improved mobility and reduced footprint, this optimization is still limited to small procurement batches and select unit fielding (Gettinger, 2025). Therefore, the Coyote system received a scalability score of 3, reflecting its growing fielding across LIDS formations and strong modularity, but limited by high platform cost and modest interceptor production capacity.

Cost per Shot / Engagement: According to Gettinger (2025), the unit cost of the Coyote interceptor is approximately $129,538, based on the DoD's FY2025 budget justification documents. While this cost is considerably lower than traditional surface-to-air missiles, Army officials have acknowledged that it is not always cost-effective against low-cost, expendable drones (Gettinger, 2025). The DoD's 2024 Counter-UAS Strategy specifically identifies reducing the "cost imbalance between unmanned systems and countermeasures" as a key objective. Despite these challenges, the Coyote offers an intermediate-cost solution that balances affordability and performance, particularly when deployed as part of a layered defense network rather than as a stand-alone interceptor. Accordingly, the Coyote was assigned a cost-per-shot score of 3.5, as its $129K interceptor cost is far lower than Stinger but still too expensive to sustainably counter cheap, mass-produced drones.

Cost per Platform: Based on Dardine (2025), the $1 billion U.S.–Qatar defense agreement for 10 FS-LIDS and 200 Coyote Block 2 interceptors provide insight into the program's current cost structure and scalability limitations. Assuming each interceptor costs approximately $130,000, the total missile expenditure would represent roughly $26 million of the contract value, leaving approximately $974 million allocated to the ten FS-LIDS platforms and associated support. This equates to an estimated $97.4 million per fully equipped system, inclusive of hardware, integration, training, and sustainment. These figures underscore the system's high technical sophistication and modularity but also highlight the cost barriers to mass production and fielding across the Army's force structure. Consequently, while the FS-LIDS demonstrates production maturity and exportability, its current unit cost profile reinforces a moderate scalability rating, as widespread deployment would require significant industrial capacity growth and sustained procurement investment.

Operational Performance: Operational testing and field reports indicate that the Coyote Block 2+ interceptor provides strong performance against small, maneuvering UAS threats. PEO Missiles and Space (2025) describe the system as a low-cost, turbine-engine-powered effector capable of high-speed engagements with a rapid time-to-target. The missile employs KuMRFS family radars for command-and-control guidance until its onboard seeker takes over for terminal homing, culminating in the detonation of a low-collateral, forward-firing blast-fragmentation warhead. Complementing this, RTX (2024) reports that the Coyote's radar can detect targets as small as a 9 mm bullet, with a low false-alarm rate, and has demonstrated the ability to track swarms of more than 30 UAS simultaneously. These data points illustrate a mature capability set combining precision, reliability, and swarm-defeat capacity suitable for operational deployment. For this reason, the Coyote earned an operational performance score of 4*,* due to its high-speed maneuvering capability, precision seeker, and demonstrated effectiveness against multiple Group 1–3 threats.

MOS-Agnostic Ease of Use: Ease of integration and operator accessibility are significant factors influencing fielding speed and sustainment costs. RTX (2024) emphasizes that the Coyote system is fully interoperable with the FAADC2 architecture and existing Syracuse-developed EW suites. The Coyote can be incorporated into division-level air defense formations with minimal additional manpower requirements, aligning with the Army's goal of scalable, MOS-agnostic systems (PEO Missiles and Space, 2025). Although the Coyote system's modular design and intuitive interface enable broader interoperability, its operations are synchronized through air defense command-and-control processes managed by PEO Missiles and Space (PEO Missiles and Space, 2025); therefore, personnel outside the ADA branch would require specialized training to effectively coordinate with ADA units and integrate into the FAADC2-controlled air defense network (RTX, 2024). As a result, non-ADA personnel would need targeted instruction on air defense communications protocols, engagement authority procedures, and radar cueing integration to operate within established ADA command structures (Gettinger, 2025). This additional training requirement could slow cross-branch adoption and reinforces that the system is primarily optimized for employment within the air defense enterprise (PEO Missiles and Space, 2025; RTX, 2024). Thus, the Coyote system received a MOS-agnostic score of 2, since its employment requires dedicated specialized operators working through FAAD C2, making cross-MOS adoption difficult.

Mobility: Mobility is another defining strength of the Coyote system. The M-LIDS configuration enables mobile, on-the-move protection for brigade-level formations, while FS-LIDS provides point defense for fixed facilities such as command posts or airfields. As detailed by PEO Missiles and Space (2025), the Coyote Block 2+ interceptor employs a rail-launched, turbine-engine design that enables compact launcher configurations and supports rapid system repositioning for flexible deployment across both fixed and mobile platforms. Dardine (2025) corroborates that the system's fixed-site and mobile variants ensure full spectrum coverage from maneuver to static defense. This dual-mode employment enhances survivability and operational reach, allowing the Army to tailor deployment to tactical or strategic requirements. As a result, the Coyote was assigned a mobility score of 3*,* reflecting its dual-use employment in both mobile (M-LIDS) and fixed-site (FS-LIDS) architectures, though constrained by platform size and sensor dependencies.

Schedule to IOC: The Coyote system and the broader LIDS family of systems have achieved a high level of operational maturity, indicating that the capability has effectively reached and surpassed its IOC milestone. PEO Missiles and Space (2025) reports that the system has been fielded and tested extensively, with sustained operational deployments dating back to 2019. Dardine (2025) further notes that FS-LIDS units are now in export production, demonstrating an established industrial base capable of full-rate manufacturing and long-term sustainment. The system's integration into international contracts such as the U.S.–Qatar agreement and its continuing domestic procurement underscore that the Coyote has transitioned well beyond prototype status and is now in the production and deployment phase of its life cycle, meeting Army objectives for timely fielding and operational readiness. As a result, the Coyote system received a Schedule to IOC score of 5*,* as it is fully fielded, combat-proven, exported internationally, and already in sustained production under the Army's FS-LIDS and M-LIDS programs, representing the highest maturity level among kinetic C-UAS options.

C. DE M-SHORAD (NON- KINETIC) MOE EVALUATION

Scalability: The DE M-SHORAD system exhibits moderate scalability potential within current Army air defense formations. Its use of the existing Stryker A1 chassis and reliance on standard Ethernet-based command-and-control architecture support integration with other battlefield sensors and air defense systems, providing a foundation for future expansion (U.S. Government Accountability Office [GAO], 2023). However, scalability remains constrained by the system's high electrical-power and cooling requirements, which limit rapid proliferation across units (GAO, 2023). The Army's 2019 other transaction authority (OTA) contract for four prototype systems totaled $203 million (Heininger, 2019). While the specific per-unit cost was not stated, this investment level indicates that initial prototypes remain cost-intensive and complex to replicate, thereby reducing near-term scalability. Sustainment challenges, including the need for clean-room maintenance of optical components, further restrict the system's suitability for widespread field deployment (GAO, 2023; Heininger, 2019). Looking ahead, standardization of power-generation and thermal-management modules is expected to improve modularity and support broader brigade-level scalability, enabling DE systems to transition from prototype demonstration to operational fielding (Gettinger, 2025). Accordingly, DE M-SHORAD received a scalability score of 2*,* as its prototype cost, high power/cooling demands, and complex sustainment requirements prevent near-term mass fielding.

Cost per Shot / Engagement: DE M-SHORAD excels in affordability per engagement, with each laser shot costing roughly $1–$10, representing a revolutionary reduction compared with kinetic interceptors such as the Stinger ($480,000) or Coyote ($129,000; GAO, 2023; MDAA, 2024). This near-zero marginal cost after power generation enables deep magazines and sustained operations without resupply, significantly improving cost-effectiveness during swarm engagements. For this reason, the system earned a cost-per-shot score of 5*,* the highest possible, because each laser engagement costs only $1–$10, making it by far the most economical per-shot system.

Cost per Platform: The DE M-SHORAD currently remains in limited prototype and evaluation stages, and therefore lacks an officially published production unit cost. However, credible estimates can be derived from Army contract data and supporting industry disclosures. According to the U.S. Army (Heininger, 2019), an initial OTA agreement valued at $490 million funded four Stryker-mounted DE prototypes, yielding an approximate upper-bound prototype cost of $120 million per vehicle, inclusive of research, integration, and testing expenses. As the system transitions into early production, costs are expected to decrease substantially as manufacturing efficiencies and subsystem maturity improve.

Performance Against Drone Swarms: The 50-kilowatt high-energy laser has proven capable of defeating multiple small UASs and Group 3 drones in live-fire testing (Feickert, 2025). It provides precision engagement with minimal collateral damage, making it effective in swarm scenarios where missile interceptors would be cost-prohibitive. Yet, operational deployments in CENTCOM (Feb 2024) revealed performance degradation in dusty and humid environments, underscoring the need for adaptive optics and improved cooling under sustained fire (Feickert, 2025; GAO, 2023). Thus, DE M-SHORAD received an operational performance score of 3.5*,* demonstrating high accuracy and effectiveness against drones, though degraded in heavy dust, humidity, or atmospheric turbulence.

MOS-Agnostic Ease of Use: Automation through EO/IR cueing and integrated tracking reduces operator workload and engagement time (GAO, 2023). The interface aligns with existing air-defense C2 architectures, simplifying integration for trained Soldiers. The DE M-SHORAD system will almost certainly fall under the ADA community's portfolio, adding another complex layer to an already saturated mission set. As the Army's sole branch responsible for defending against aerial threats, from ballistic missiles to sUAS, the ADA force structure remains heavily weighted toward HIMAD systems such as Patriot and THAAD. The introduction of DE M-SHORAD extends ADA responsibilities downward into the short-range and tactical C-sUAS fight, thereby expanding coverage requirements across both maneuver and fixed formations (Feickert, 2025). This shift increases the community's operational and personnel burden, as each DE platform requires trained crews, maintenance support, and integration within existing FAAD C2 networks. Accordingly, it received a MOS-agnostic score of 1, as its operation requires highly trained ADA crews, advanced technical maintenance, and specialized C2 integration far beyond maneuver-unit skillsets.

Mobility: Mounted on the Stryker A1 chassis, DE M-SHORAD maintains full maneuverability with armored formations (Feickert, 2025). It can move, shoot, and communicate alongside maneuver forces, offering protection to forward elements. The trade-off lies in the laser's substantial power and cooling footprint, which may restrict endurance in extended, high-tempo operations (GAO, 2023). For this reason, DE M-SHORAD earned a mobility score of 3, benefiting from the Stryker chassis maneuverability while constrained by its large power-generation and cooling subsystems.

Schedule to IOC: Prototype testing began in FY2021 under RCCTO, with user assessments running through FY2024 (Feickert, 2025). The Army intends to select a vendor for its enduring high-energy laser design in FY2025 and target a production decision by FY2026, placing IOC in the mid-to-late 2020s (Gettinger, 2025). This timeline reflects steady progress but lags behind mature non-kinetic options already fielded. Accordingly, DE M-SHORAD received a Schedule to IOC score of 1, reflecting that the system remains in prototype status, has not yet entered production, and is multiple years away from achieving an operational fielding decision. Despite successful demonstrations, its technical complexity, ongoing RCCTO testing, and delayed transition timeline place it far behind other mature C-UAS options in terms of near-term availability.

D. DRAKE (NON-KINETIC) MOE EVALUATION

Scalability: The DRAKE system demonstrates high scalability across the joint force due to its mature production status, modular design, and multi-variant flexibility. According to Northrop Grumman (2024), the Joint counter radio-controlled IED electronic warfare (JCREW)/DRAKE family has achieved technology readiness level (TRL) 9, reached full operational capability (FOC), and entered FRP under the Naval Sea Systems Command Program of Record (PEO USC PMS-408). Operational since 2017, the system is already deployed by the U.S. Navy, U.S. Air Force, and coalition partners including Australia and New Zealand (Northrop Grumman, 2024). Additionally, Gettinger (2025) explains that DRAKE evolved from the JCREW program, a legacy system proven scalable during Iraq and Afghanistan operations under Joint improvised explosive device defeat organization (JIEDDO), confirming that DRAKE benefits from an established industrial and doctrinal base. These combined attributes give DRAKE one of the highest scalability ratings among non-kinetic C-sUAS systems. Accordingly, DRAKE received a scalability score of 4, reflecting its TRL 9 maturity, FRP status, multi-service adoption, and modular variants that enable force-wide distribution.

Cost per Shot / Engagement: DRAKE's cost per engagement is near zero, as its jamming effects require only a portable electrical power rather than expendable munitions. Northrop Grumman (2024) notes that the system provides independent detection and selective jamming capability with virtually unlimited magazine depth, while requiring only minimal power consumption and maintenance. Compared with kinetic interceptors such as the Stinger ($480,000 per missile) and Coyote ($129,000 per interceptor), DRAKE offers a favorable cost-exchange ratio for countering low-cost drones (Gettinger, 2025; MDAA, 2024). Its SDR architecture enables reusable emission control hardware, reducing life cycle costs. The ability to conduct repeated engagements without resupply makes DRAKE the most cost-efficient of all systems evaluated in this study. For this reason, DRAKE earned a cost-per-shot score of 5, as RF disruption incurs virtually zero marginal cost, allowing unlimited engagements without consumables.

Cost per Platform: The following figures are estimates only, no source publishes a definitive per-platform DRAKE price, and are derived from a component-level, bottoms-up cost decomposition and analogy to fielded EW and counter-UAS systems. The dismounted (man-portable) DRAKE kit is estimated at $25,000–$150,000 per kit, with a best (midpoint) estimate of $87,500; this range reflects component analogies and cost drivers described in GAO (2023) and Heininger (2019). The mounted (vehicle-integrated) DRAKE installation is estimated at $500,000–$2,500,000 per vehicle, with a best estimate of $1,500,000, reflecting added costs for multi-band transmitters, antenna arrays, power conditioning/cooling, vehicle modifications, and integration and sustainment cost trends from Gettinger (2025), PEO Missiles & Space (2025), and RTX (2024).

Operational Performance: The system provides high operational performance through advanced detection and selective disruption of enemy UAS command links. Gettinger (2025) describes DRAKE as capable of detecting, tracking, locating, identifying, and defeating UAS threats by exploiting their radio-frequency (RF) communications. Northrop Grumman (2024) adds that the system delivers layered protection against both radio-controlled improvised explosive device (RCIED) and sUAS, with the ability to conduct selective jamming or operate in coordination with C2 networks such as FAAD C2 to achieve a comprehensive C-sUAS and Couter-IED defense. Each unit records engagement events for post-mission intelligence analysis and features a built-in test (BIT) function with a "Go/No-Go" indicator for fault isolation (Northrop Grumman, 2024). These features enhance situational awareness and system reliability. The system's performance against drone swarms, achieved through synchronized multi-node jamming, is a direct outcome of its networking capability, allowing multiple DRAKE units to share threat data in real time (Northrop Grumman, 2024). Collectively, these capabilities establish DRAKE as one of the most operationally reliable non-kinetic C-sUAS platforms in the joint inventory. Thus, DRAKE received an operational performance score of 4*,* due to its ability to detect, track, and selectively jam UAS command links, including synchronized multi-node suppression against swarms.

MOS-Agnostic Ease of Use: DRAKE was intentionally engineered for simple operation and minimal specialized training. Northrop Grumman (2024) specifies that its intuitive user interface, automated threat recognition, and built-in fault diagnostics enable Soldiers outside the ADA community to employ the system effectively. The design supports operation by personnel trained in basic EW procedures, aligning with the Army's initiative to make C-sUAS systems MOS-agnostic and scalable across formations. Integration with FAAD C2 and other joint networks allows DRAKE operators to function within existing command architectures without extensive re-training (Northrop Grumman, 2024). Because of these characteristics, DRAKE achieves a high

MOS-agnostic score, emphasizing accessibility and reduced manpower requirements relative to kinetic systems that demand dedicated ADA operators (Gettinger, 2025). Accordingly, DRAKE was assigned a MOS-agnostic score of 5*,* reflecting its intuitive user interface, low training burden, automated threat recognition, and suitability for employment by non-ADA Soldiers.

Mobility: DRAKE's architecture enables multi-configuration employment for dismounted, mounted, and fixed-site operations (Northrop Grumman, 2024). The backpack-mounted variant supports maneuver elements conducting mobile missions, while vehicle-mounted and static versions provide area defense for convoys, airfields, or command posts. All configurations share common hardware and software, ensuring interchangeable components and simplified sustainment (Northrop Grumman, 2024). Because it can accompany maneuver units with minimal logistic burden and operate in austere environments, DRAKE earns a very high mobility rating, surpassing larger platform-dependent systems such as DE M-SHORAD (Gettinger, 2025). Its open-architecture hardware and software enable rapid updates, while common components across mounted, dismounted, and fixed-site variants reduce sustainment and logistics complexity (Northrop Grumman, 2024). As a result, DRAKE earned a mobility score of 5, as it is fully deployable in mounted, dismounted, and fixed-site configurations with a minimal logistical footprint.

Schedule to IOC: DRAKE has already achieved IOC and entered sustained fielded service. Northrop Grumman (2024) reports that the system has been operational since 2017, delivering long-term afloat and ashore protection for U.S. and allied forces. It reached FRP under a Naval Sea Systems Command Program of Record, confirming its maturity and logistical readiness. Gettinger (2025) corroborates that DRAKE's rapid transition from its JCREW counter-IED lineage to a full counter-UAS capability demonstrates a high degree of acquisition agility and operational readiness. Consequently, DRAKE receives the highest possible score for IOC, outperforming emerging prototypes like DE M-SHORAD still awaiting production decisions. For the reason that the DRAKE system achieved FRP under a naval program of record, and is already fielded by the Navy, Air Force, and allied partners, making it the most mature non-kinetic option, DRAKE received a Schedule to IOC score of 5.

The decision matrix shown in Table 5 compares the four representative C-sUAS platforms; Stinger, Coyote, DE M-SHORAD, and DRAKE against the six weighted MOEs: scalability, cost per shot, operational performance, MOS-agnostic usability, mobility, and schedule to IOC. Each criterion was assigned a relative weight to reflect operational and acquisition priorities, with scalability (0.30) and cost per shot (0.25) carrying the greatest influence due to their importance in determining force-wide affordability and fielding potential. As indicated in the weighted totals, DRAKE achieved the highest vA score (4.65), outperforming other systems largely because of its low operational cost, high scalability, and flexible deployment across mounted, dismounted, and fixed configurations (Gettinger, 2025; Northrop Grumman, 2024). The Coyote system followed with a total score of 3.325, reflecting strong kinetic performance and integration potential but limited scalability due to high platform costs (Dardine, 2025; PEO Missiles & Space, 2025). Both Stinger and DE M-SHORAD scored comparably lower (2.545 and 2.55, respectively), with Stinger constrained by high per-shot cost and limited magazine depth, and DE M-SHORAD affected by sustainment complexity and immature production scalability (GAO, 2023; Heininger, 2019). Overall, the analysis highlights that while kinetic systems remain valuable for precision and lethality, non-kinetic solutions, particularly modular EW systems like DRAKE, offer the most cost-effective and scalable approach for countering Group 1–3 drone threats in large-scale operations.

Table 5. MOE Evaluation

	Decision Matrix						MOE Scores (higher is better)	
C-UAS Platforms	Scalability (MOE 1)	Cost per Shot (MOE 2)	Operational Performance (MOE 3)	MOS Agnostic (MOE 4)	Mobility (MOE 5)	Schedule to IOC (MOE 6)	Unweighted	Weighted
	0.3	0.25	0.2	0.15	0.1	0.03		
Stinger (Kinetic)	4	1	1	2.5	4	4	16.5	
	1.2	0.25	0.2	0.375	0.4	0.12		2.545
Coyote (Kinetic)	3	3.5	4	2	3	5	20.5	
	0.9	0.875	0.8	0.3	0.3	0.15		3.325
Direct Energy (Non Kinetic)	2	5	3.5	1	3	1	15.5	
	0.6	1.25	0.7	0.15	0.3	0.03		2.55
DRAKE System EW (Non Kinetic)	4	5	4	5	5	5	28	
	1.2	1.25	0.8	0.75	0.5	0.15		4.65

As summarized in Table 6, the estimated cost of system and 100 Rounds, the relative cost structures of each C-sUAS platform demonstrate significant variation between per-engagement expenditures and average system acquisition costs. To provide a normalized comparison across all systems, this analysis multiplies the cost per round by 100 engagements and averages the available mounted, dismounted, and fixed-site platform estimates to determine a representative system cost.

Table 6. Cost Comparison Analysis Based on System and Engagement Expenditures

Decision Matrix							
C-UAS Platforms		Cost ($/Round)	Estimated Mounted Unit One-Time Cost ($)	Estimated Unit Dismounted (Portable) One-Time Cost ($)	Estimated Unit Fix Site One-Time Cost ($)	Estimated Cost of sytsem and 100 rounds	Effectiveness v(A)
[redacted]							
Stinger (Kinetic)	unweighted	$480,000	N/A	N/A	N/A	$ 48,000,000	2.545
	weighted						
Coyote (Kinetic)	unweighted	$129,000	$ 97,400,000	N/A	$ 97,400,000	$ 110,300,000	3.325
	weighted						
Direct Energy (Non Kinetic)	unweighted	$ 10	$ 120,000,000	N/A	N/A	$ 120,001,000	2.55
	weighted						
DRAKE System EW (Non Kinetic)	unweighted	$ -	$ 1,500,000	$ 87,500	$ 1,500,000	$ 1,029,167	4.65
	weighted						

The Stinger (Kinetic) system exhibits the highest ammunition expenditure relative to its platform cost. At an estimated $480,000 per missile, the total cost for 100 rounds equals $48,000,000. As shown in Table 6, the Stinger lacks a dedicated platform cost entry across mounted, dismounted, or fixed-site configurations, consistent with its classification as a man-portable weapon system (Gettinger, 2025; MDAA, 2024). Therefore, the overall cost burden is concentrated in missile procurement and sustainment rather than hardware acquisition. This cost profile highlights the limited scalability of kinetic interceptors when confronting inexpensive or expendable drone threats.

The Coyote (Kinetic) exhibits a dual cost profile in which both hardware and munitions are significant program drivers. Based on the values in Table 6, one hundred Coyote interceptors cost $12.9 million (100 × $129,000), while the average platform/ integration cost (mounted and fixed variants) is $97.4 million, yielding a combined system-plus-100-rounds cost of $110.3 million. This aggregation shows that Coyote's acquisition burden is dominated by the integrated LIDS package, radar, launcher, sensors, and C2, rather than the missiles alone, and it underscores that fielding Coyote at scale requires both appreciable missile inventories and a large upfront investment in platform and integration hardware (PEO Missiles & Space, 2025; Gettinger, 2025).

The DE M-SHORAD system reverses the pattern seen in kinetic weapons. The laser's per-engagement cost is estimated at $10, resulting in only $1,000 for 100 shots, which is dramatically cheaper than the ammunition costs associated with the Stinger ($48 million for 100 rounds) or Coyote ($12.9 million for 100 rounds). However, this extremely low per-shot cost is balanced by a very high initial acquisition and integration expense, approximately $120 million per Stryker-mounted platform. In essence, the DE M-SHORAD provides a powerful long-term cost advantage because it can engage numerous targets at minimal additional expense, but its high initial fielding cost makes it the most expensive system to deploy in the near term (GAO, 2023; Heininger, 2019).

The DRAKE system offers the most cost-efficient profile in Figure 9. Because it defeats UAS through radio-frequency disruption rather than expendable interceptors, the marginal cost of each engagement is effectively zero; therefore, 100 engagements incur zero expense. Averaging the documented platform estimates for mounted ($1.5 million), dismounted ($87,500), and fixed-site ($1.5 million) configurations produces an approximate mean system cost of $1.03 million (Gettinger, 2025; Northrop Grumman, 2024). Practically, this means a relatively small one-time hardware investment buys persistent, reusable defeat capability with minimal logistics burden and virtually unlimited "magazine" depth, yielding the most favorable cost-exchange ratio of the options analyzed. Dismounted units are inexpensive enough to be distributed widely across the force. At an estimated $87,500 per kit, the dismounted DRAKE configuration is affordable for equipage at company and battalion levels, enabling broad, rapid fielding without major procurement or sustainment burdens (Gettinger, 2025; Northrop Grumman, 2024). Because the system requires minimal logistics (small power needs, limited maintenance) and little specialized training, it can be integrated into unit authorizations or issued as an expeditionary kit to maneuver elements, substantially increasing the Army's distributed C-sUAS coverage. In short, the low unit price for the dismounted variant supports a scalable, MOS-agnostic approach to force protection that buys near-unlimited engagement capacity for a relatively modest one-time investment.

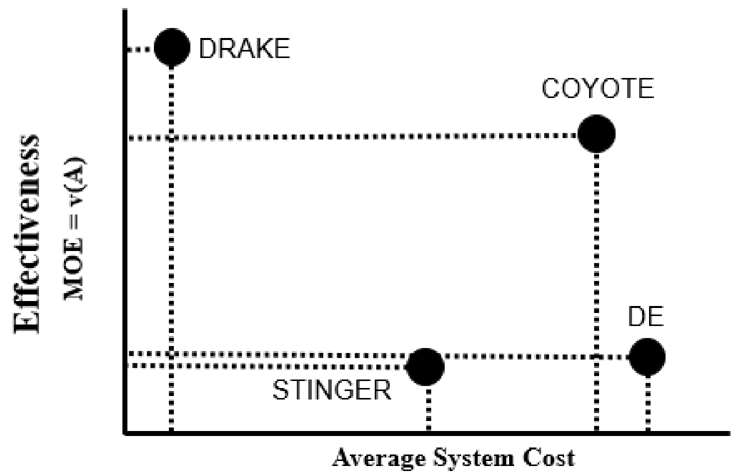

Figure 9. Cost Effective Analysis Chart

The analysis presented in Figure 9 clearly identifies the DRAKE system as the superior and most comprehensive solution among all C-sUAS alternatives evaluated. While kinetic systems such as the Stinger and Coyote demonstrate proven lethality, they remain constrained by unsustainable ammunition costs ($48 million and $12.9 million per 100 rounds, respectively) making them impractical for large-scale or sustained operations. Likewise, the DE M-SHORAD platform offers exceptionally low per-shot costs but demands a prohibitive $120 million initial investment per system, restricting near-term scalability and affordability across the Army. In contrast, the DRAKE system decisively outperforms all competitors by combining negligible engagement costs, affordable platform pricing (averaging $1.03 million across mounted, dismounted, and fixed-site variants), and true force-wide scalability. Its modular design enables flexible employment, from dismounted kits costing only $87,500 per unit for maneuver formations, to mounted and fixed variants that can protect convoys, higher-level headquarters, and critical infrastructure. This adaptability allows DRAKE to provide a base layer of protection across every echelon, effectively bridging the current air defense gap in the maneuver forces. In summary, DRAKE dominates the cost-effectiveness and operational flexibility spectrum, offering the most realistic path to deliver persistent, distributed, and affordable C-sUAS protection across the entire Army force structure. By combining low life-cycle costs, minimal training requirements, and near-unlimited engagement capacity, DRAKE represents not just an incremental improvement, but a transformational capability, the most practical, scalable, and sustainable solution to meet the Army's growing air defense demands against Group 1–3 drone threats.

V. CONCLUSION AND RECOMMENDATIONS

This research examined how the U.S. Army can close the growing capability gap in countering small unmanned aerial systems through scalable, cost-effective, and MOS-agnostic solutions. Using the DOTmLPF-P framework and a comparative cost-effectiveness analysis, the study evaluated institutional limitations alongside four representative materiel options to determine how the Army can enhance its layered air defense architecture in large-scale combat operations.

A. RESEARCH QUESTIONS AND SUMMARY FINDINGS

This study addressed one primary and one secondary research question to assess the Army's path toward a more integrated, sustainable, and distributed C-sUAS capability. The findings across Chapters III and IV provide a consolidated answer to these questions and establish the analytical foundation for the strategic implications and recommendations that follow.

1. Primary Research Question: How can the U.S. Army close the C-sUAS capability gap through scalable, cost-effective, and MOS-agnostic solutions within its layered air defense architecture?

Summary of Findings: The analysis shows that the Army cannot close the C-sUAS gap through a single system, branch, or technology. Instead, closing the gap requires a layered and distributed defense model that extends responsibility beyond the air defense branch and empowers maneuver units with simple, MOS-agnostic capabilities. The DOTmLPF-P analysis identified persistent gaps in doctrine, organizational structure, and personnel capacity that constrain the effectiveness of existing C-sUAS initiatives. Addressing these limitations requires updated doctrine emphasizing active drone defense, broader access to training, and force-wide integration of affordable, scalable non-kinetic systems. The subsequent cost-effectiveness analysis demonstrated that non-kinetic solutions, particularly the DRAKE electronic warfare system, provide the most viable baseline layer for wide-area protection, while kinetic interceptors remain critical for precision engagements but cannot be fielded at scale due to cost and ammunition constraints. Together, these findings reinforce that closing the C-sUAS gap demands a balanced approach combining scalable non-kinetic tools, selective kinetic precision, and institutional modernization across all DOTmLPF-P domains.

2. Secondary Research Question: What are the comparative cost-effectiveness and scalability trade-offs between kinetic and non-kinetic C-sUAS systems?

Summary of Findings: The comparative analysis across four representative systems; Stinger, Coyote, DE M-SHORAD, and DRAKE revealed clear distinctions between the lethality, cost, and scalability of kinetic and non-kinetic approaches. Kinetic systems offer proven engagement reliability but carry prohibitively high per-shot costs and limited magazine capacity, making them inefficient against low-cost, high-density sUAS threats. Directed-energy systems promise extremely low cost per engagement but require significant power, cooling, and sustainment infrastructure and remain years from IOC. Non-kinetic EW solutions, particularly DRAKE, achieved the highest overall effectiveness and scalability due to negligible per-engagement cost, multi-configuration flexibility, MOS-agnostic employment, and full-rate production maturity. These findings indicate that while kinetic systems have enduring value for high-priority targets, non-kinetic systems form the most sustainable and scalable foundation for Army-wide C-sUAS defense, especially in LSCO environments characterized by dense UAS employment.

B. STRATEGIC IMPLICATIONS

The findings show that Army air defense modernization must move beyond platform-centric procurement toward a layered, distributed defense model that combines kinetic precision with non-kinetic volume defense. The sUAS threat, characterized by low cost, high density, and rapid technological adaptation, demands a paradigm shift in how protection is conceptualized and resourced.

Non-kinetic systems such as DRAKE enable the Army to achieve persistent coverage without overburdening the ADA force structure. By equipping maneuver units with MOS-agnostic, portable C-sUAS tools, commanders at every echelon can contribute to a distributed protection network (Northrop Grumman, 2024). This approach would transform air defense from a specialized function into a shared responsibility embedded across the operational force.

From a strategic standpoint, integrating cost-effective non-kinetic systems into the Army's broader layered air defense architecture supports deterrence, resilience, and sustainability in future LSCO environments. It also aligns with the DoD Counter-UAS Strategy (2024) objective to reduce the cost imbalance between drones and countermeasures (Gettinger, 2025).

C. CONCLUSION

The findings of this capstone research project demonstrate that the U.S. Army can close the defense gap against small unmanned aerial systems not through a single high-end weapon, but through a deliberate combination of scalable non-kinetic systems and adaptive doctrine. Among all systems evaluated, the DRAKE system stands out as the most cost-effective, operationally flexible, and field-ready solution to provide force-wide C-sUAS coverage.

Adopting a layered approach, with DRAKE providing distributed non-kinetic suppression at the tactical level, DE M-SHORAD delivering precision energy defense at the operational level, and kinetic interceptors like Coyote and Stinger reserved for high-value engagements, creates a sustainable and resilient defense architecture.

Ultimately, the success of future C-sUAS efforts will depend not only on technology, but on the Army's ability to institutionalize adaptable doctrine, expand training beyond traditional ADA units, and resource scalable, cost-efficient capabilities. Doing so will enable every formation from brigade to platoon to participate in air defense, ensuring that the Army maintains tactical overmatch and operational survivability in the drone-dominated battlefields of the future.

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