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Research Report

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Small Uncrewed Aircraft Systems in Divisional Brigades

Requirements and Findings

The Russo-Ukrainian War that began in February 2022 has provided significant insights into the importance of uncrewed aircraft systems (UAS) across several missions. UAS have served as platforms to provide intelligence, surveillance, and reconnaissance (ISR); targeting systems for indirect fire; one-way loitering munitions (which attack by crashing into the target and exploding); and platforms that can engage targets and return to the owning unit. According to some reports from early in the conflict (summer 2022), UAS identified up to 80 percent of Ukraine's targets for indirect fire missions, and loitering munitions have had considerable publicized effects.[1] Combatants' innovation regularly adds new insights: Ukrainian and Russian UAS employment is changing rapidly, with some claiming it is reshaping modern warfare.[2]

Small uncrewed aircraft systems (SUAS) present a major opportunity and challenge for the U.S. Army. SUAS are "small, light, inexpensive uncrewed aircraft that battalion and subordinate maneuver, maneuver support, and maneuver service and sustainment units employ" (U.S. Army Futures Command, 2020, p. 1). As of this writing in 2023, units in Army divisions have only limited UAS experience and capabilities

KEY FINDINGS

- Small uncrewed aircraft systems (SUAS) present a major opportunity and challenge for the U.S. Army, and significant change is required to realize the opportunity.
- Most importantly, the Army needs a training ecosystem that supports realistic training with SUAS. Currently, units cannot train as they will need to fight, primarily because of range, airspace, and spectrum-management challenges.
- The Army's ability to create SUAS Master Trainers (MTs), the key personnel who train and certify unit trainers and operators, must also improve. Changes to increase the number of MTs will be necessary as SUAS proliferate in the Army.
- Fixing training shortfalls will require additional resources and changes in policy. The Army can solve or waive many of the obstacles it faces, but this will require Headquarters, Department of the Army attention and urgency and coordination across joint communities (e.g., the airspace and spectrum-management communities) and with the Federal Aviation Administration.
- Doctrine; Tactics, Techniques, and Procedures; and Army culture must also change to make SUAS part of how the Army operates across the board. For example, commanders and staff will need to be trained to plan for and conduct operations that use SUAS and on how to counter enemy uncrewed aircraft systems.
- How the Army purchases SUAS makes them unduly expensive, and how it treats losses in training deters unit commanders from using them. New approaches that rely on the adaptive acquisition framework, emphasize inexpensive (often commercial) SUAS, and consider SUAS as collections of Class IX parts or Class V items (for loitering munitions and first-person-view SUAS) rather than as end items could permit flexibility and facilitate both the use of SUAS in training and the replacement of large numbers of lost systems in combat.
- The Army's spectrum-management approach and available allocations cannot accommodate units' demand for spectrum to operate SUAS. However, it is possible to increase effective spectrum capacity and permit more-flexible use of the spectrum through more-dynamic frequency allocation and other measures. A tactical electromagnetic battle-management approach would not only permit better SUAS operations and training but would also bring many other benefits.
- There is a large and growing market for commercially available SUAS, many of which could have great utility to XVIII Airborne Corps units, such as by reducing costs compared with systems acquired through the Army acquisition system. Our 2023 market analysis found that 176 commercial SUAS can satisfy the XVIII Airborne Corps requirements, with 26 meeting multiple sets of requirements.

compared with their counterparts in Ukraine. For example, according to one source, Ukraine *loses* as many as 10,000 UAS per month; in comparison, U.S. Army units fly orders-of-magnitude fewer flights in the same time frame and lack appropriate training ecosystems and supporting systems (Watling and Reynolds, 2023a, p. 18).

Army units and organizations are actively experimenting with UAS and developing new approaches for using them, providing insights into the requirements for UAS at different organization levels.[3] The Army is examining its UAS requirements, and various parts of the Army are developing concepts for UAS acquisition, fielding, and use. The Maneuver Center of Excellence (MCoE) and the Aviation Center of Excellence are working to identify effective UAS solutions, and other Centers of Excellence (CoEs) are also involved.

The XVIII Airborne Corps has articulated some characteristics of SUAS that it believes it needs and is working to provide such capabilities. For example, short-range reconnaissance SUAS were fielded to infantry platoons in one Brigade Combat Team (BCT) of the 82nd Airborne Division in the second quarter of fiscal year 2023 on a trial basis, and all the division's BCTs were scheduled to receive quadcopters by the end of calendar year 2023.

SUAS capabilities are rapidly evolving, which makes the task of fielding and maintaining cutting-edge SUAS-enabled forces more challenging. This is a dynamic field in which innovation occurs quickly, both within the military and in the private sector. Many commercial UAS are capable platforms; for example, in 2020, the ScanEagle from Insitu could be outfitted with sensors that range from typical electro-optical and infrared (EO/IR) cameras, to a visual detection and ranging sensor, to a multi-mode radar with synthetic aperture radar, coherent change detection, moving-target indicator modes, and beyond-line-of-sight (BLOS) datalink (Insitu, 2020). These sensors (or similar ones) can be integrated onto a variety of other UAS platforms. Although many commercial off-the-shelf (COTS) UAS have add-on kits that provide capabilities that military units do not typically desire (e.g., agricultural sprayer kits), the ability to change payloads indicates a potential for other add-on kits of greater use to the military. Allies also field military-grade UAS that could be useful to the Army.

Project Purpose

Exploiting the many opportunities that SUAS present will require the Army to train as it will fight and overcome substantial force-integration challenges. To examine these issues, the XVIII Airborne Corps asked us to identify options for the Army to select,

Abbreviations

AAF	Adaptive Acquisition Framework
ATAK	Android Team Awareness Kit
AUVSI	Association for Uncrewed Vehicle Systems International
BCT	Brigade Combat Team
BLOS	beyond-line-of-sight
CoE	Center of Excellence
COTS	commercial off-the-shelf
CTC	combat training center
DIU	Defense Innovation Unit
DIVARTY	Division Artillery
DoD	U.S. Department of Defense
DSB	Division Support Brigade
EO/IR	electro-optical/infrared
EW	electronic warfare
FLIPL	Financial Liability Investigations of Property Loss
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HQDA	Headquarters, Department of the Army
ISR	intelligence, surveillance, and reconnaissance
LSCO	large-scale combat operations
MCoE	Maneuver Center of Excellence
MT	Master Trainer
RF	radio frequency
SDR	software-defined radio
SIGINT	signals intelligence
SUAS	small uncrewed aircraft system(s)
UAS	uncrewed aircraft system(s)
VTOL	vertical take-off and landing

field, and employ SUAS and to assess the implications of integrating additional Group 1 and 2 SUAS into divisional brigades for reconnaissance, fires, and other purposes.[4] We sought to derive implications for institutional and unit training and training support; other institutional functions needed for success, such as how SUAS are acquired and accounted for; and support functions needed for large-scale combat operations (LSCO) with a peer competitor.

We produced four reports in this series (see box) and this capstone report. This report provides an overview of the study; presents requirements for SUAS in brigade-size divisional units (BCT, Division Artillery [DIVARTY], and Division Support Brigade [DSB]); and includes short summaries of the other reports in this series. Although each of the reports was written as a stand-alone document, there is some overlap, and the reader may want to review them all.

Overview of Methods

We used two main research methods: interviews and a review of applicable literature. Interviews were with experts from XVIII Airborne Corps divisions and other Army stakeholders (e.g., XVIII Airborne Corps nondivisional units and staff, UAS and robotics staffs in applicable Army CoEs, acquisition officials, and DoD officials), and other government and private-sector experts. The study also builds on lessons from the Russo-Ukrainian War and other literature. The literature review focused on (1) current UAS experiences across the Army and other services (the U.S. Marine Corps in particular), (2) the conflict in Ukraine (we conducted this study from October 2022 to December 2023), (3) the recent conflict in Nagorno-Karabakh, and (4) other relevant technical and operational publications.

For the materiel requirements analysis discussed below, we used input from interviews, the literature we examined, and knowledge of Army doctrine on

Other Reports in This Series

***Small Uncrewed Aircraft Systems in Divisional Brigades: Survey of SUAS* (Putney and Ellinger, 2025).** This report provides an overview of commercial and government UAS markets to help identify both specific solutions that the XVIII Airborne Corps (and the Army) could adopt immediately and these markets' features that are worth examining and perhaps trying to influence (e.g., using the Army's purchasing power to leverage agile acquisition approaches).

***Small Uncrewed Aircraft Systems in Divisional Brigades: Options to Improve Acquisition and Accountability* (Camm, Girardini, and Kelly, 2025).** This report examines innovative approaches to acquisition and accountability that could both make SUAS more affordable and facilitate their use in training and combat. In particular, it provides suggestions that should ease the administrative burdens of training losses and reduce some commanders' concern that such losses could result in them being found financially liable, which result in some units not training with their SUAS.

***Small Uncrewed Aircraft Systems in Divisional Brigades: Electronic Warfare and Spectrum Management Considerations* (Osburg et al., 2025).** This report addresses the challenges of spectrum use, key aspects of spectrum availability in combat that the Army must ensure for SUAS to be more effective, the limitations of spectrum use in training, and electronic warfare (EW) challenges and opportunities. It proposes solutions for these challenges should the Army (and DoD) decide it needs to make better use of the available spectrum and to leverage how SUAS-based EW capabilities could affect the modern battlefield.

***Small Uncrewed Aircraft Systems in Divisional Brigades: Small UAS and Counter-UAS Training* (Phillips et al., 2025).** This report addresses training issues, including requirements for home-station training support, key Army institutional training requirements and processes, unit training, and individual training. This report also includes insights and implications for the counter-UAS mission, with an emphasis on training for the counter-UAS fight.

how LSCO will be executed and of tables of organization and equipment. Additional information about the methods is provided in Appendix A. As noted above, this is the first of five reports in this series. The other four reports, which we draw on here, each used distinct research approaches that are presented in those reports.

Organization of This Report

The remainder of this report is organized as follows. First, we discuss materiel requirements for SUAS in brigade-size divisional units. Next, we summarize insights from the other four reports in this series, focusing on (1) existing commercial and government UAS markets, (2) innovative approaches to acquisition and accountability, (3) spectrum management, and (4) training policies, practices, and infrastructure. We then present our conclusions. The report also includes two appendixes. Appendix A provides a fuller description of our methods. Appendix B offers data on SUAS capabilities and trends.

Identifying Materiel Requirements

According to XVIII Airborne Corps staff, the initial request for research support was motivated by XVIII Airborne Corps' experience as Task Force Dragon working with Ukrainian forces in 2022. In particular, Ukrainian success with SUAS indicated that U.S. forces could improve how they use SUAS. In this section, we outline requirements developed to inform potential improvements in this area.

Operational Requirements

Materiel requirements are derived from operational requirements, so we first identified operational requirements through a review of the literature and discussions with Army stakeholders. Our goal in developing these requirements was to help XVIII Airborne Corps identify COTS offerings that could help it quickly meet its needs.

Our research indicated that integrating SUAS is unlikely to create new doctrinal missions for Army forces. **Rather, their introduction to the force will change how units execute existing missions and, in some cases, who will conduct them.**[5] In general, soldiers and leaders we interviewed used their current missions as the contexts for discussions of what they needed SUAS to do on the battlefield. For example, DSB personnel discussed the need for route reconnaissance and finding locations suitable for establishing logistical resupply points; DIVARTY personnel discussed what a battery commander would need for the reconnaissance of new firing positions; and BCT personnel discussed the need to identify enemy formations and weapon systems so that they could engage them with direct and indirect fire assets. Neither the soldiers in the XVIII Airborne Corps units nor the other Army stakeholders with whom we spoke considered new missions, such as artillery units being able to identify and strike enemy targets independent from their supported maneuver units. However, this should not rule out the potential to use SUAS for new missions as SUAS innovation changes how wars are fought.

Our interviews revealed a preference for putting machines rather than soldiers in harm's way in the execution of these missions—a very important contribution. Although this does not represent new doctrinal missions, this concept does affect how missions are executed.

The one exception to this general reliance on using existing doctrinal missions to describe requirements—a reliance that is implied rather than made explicit—is that **providing Army ground units with organic air assets that can engage or assist in missions ranging from ISR to EW to strikes could shift which unit types execute them.** For example, if a maneuver battalion had a stock of loitering munitions to strike key enemy assets, it might rely less on artillery units.[6] To cite another example, if a BCT had the ability to conduct electronic sensing using UAS, it might not need to use military intelligence units and assets, which often come with the burden of the Top Secret classification that accompanies signals intelligence (SIGINT) collection.

Because requirements were mostly articulated in terms of existing doctrinal missions, **a unit's operational characteristics and ability to execute those missions—as well as expected mission, enemy, ter-**

rain, troops, and time—were interviewees' principal considerations to frame SUAS requirements.

Unit characteristics, including whether a unit is heavy or light, affect the ability to move equipment, provide energy sources for SUAS (e.g., electrical generation for battery recharging or fuel), and provide other support. Units with more lift and greater logistical capabilities could field and operate more-capable SUAS that require more such support, even if the unit's mission, and the terrain it might control or influence, would not be significantly larger than that of a similar unit with less lift and support capability. In this regard, the XVIII Airborne Corps was a particularly interesting sponsor because it contains four divisional types—heavy, with the 3rd Infantry Division; light, with the 10th Mountain Division; airborne, with the 82nd Airborne Division; and air assault, with the 101st Airborne Division. It does not include a Stryker-equipped brigade, but Stryker characteristics, with respect to SUAS support, would be similar to a heavy division.

Maneuver units' primary characteristic that affects their SUAS requirements is that they control or influence territory. Their missions are mostly limited to the geography they can cover with direct and indirect fire assets, including the units' ability to see what might be approaching their area of operations (noting that these units alone are not responsible for surveillance in division-centric operations). Therefore, the geography typically within a given unit's area of responsibility served as a good proxy to frame its SUAS requirements, and the range of its organic indirect fire assets approximates the range its SUAS would need to cover, with an appropriate additional loitering time factored in. This proxy was validated and reinforced in interviews with divisional and brigade personnel.

Expected **enemy** characteristics also affect SUAS requirements. Principal among these, and of greatest emphasis for this analysis, is an enemy's EW capability. Because SUAS often rely on Global Positioning System (GPS) signals for position, navigation, and timing, and because they rely on radios to communicate with the ground controller stations in their home units, spectrum availability, use, and reliance are critical issues. The ability to operate SUAS without creating connectivity conflicts for other users of the spectrum, be they communications systems, radars, or other systems, is an important consideration.

Potential Use Cases

Applying this logic to all units, from maneuver platoons through BCTs, as well as the information we derived from interviews with key stakeholders, helped us develop the results in Table 1 (reproduced from Table 1 in Putney and Ellinger, 2025). Specifically, our interviews and analysis made it clear that we needed to address four levels of unit organization—platoon, company/battery/troop, battalion/squadron, and brigade—even though our analysis focused primarily on SUAS at company/battery/troop and battalion/squadron levels (of note, BCTs used RQ-7 Shadow UAS, a Group 3 system, and platoons had small "soldier-borne" UAS of limited capability at the time of our study).

However, two other types of use cases arose in interviews and the literature—tethered UAS and UAS used for conveyance or small-scale resupply missions. Because our task was to develop options for XVIII Airborne Corps to consider purchasing, we include these types of UAS in the tables despite them not being unit types. Tethered UAS are UAS that are connected to a fixed or vehicular ground station by a tether, which provides the UAS with power and a wired communications connection. They provide ISR and serve as communications relays for smaller UAS (and potentially other assets) to extend their range. XVIII Airborne Corps units were experimenting with tethered UAS during our research period. UAS that are used for conveyance were of less importance but were still under consideration. As noted in the tables below, they provide an ability to deliver high-value items to hard-to-reach areas. As innovation continues on the battlefield, their use will no doubt expand. Therefore, we included them to provide a more complete picture of available UAS.

Table 2, adapted from Putney and Ellinger (2025), describes the key features of each of the use cases.

TABLE 1

Potential Use Cases for SUAS in XVIII Airborne Corps

Use Case Name	Use Case Description
Platoon	Soldiers need to be able to see around corners, inside buildings, and "over the next hill." May be used in constricted areas (e.g., around buildings, forests).
Company/ battery/ troop	Light infantry and others need to carry and parachute in, then see over the next hill and into defensive positions to successfully use short-range weapons—including mortars, indirect grenade launchers, and direct-fire weapons. May be used in constricted areas (e.g., around buildings, forests).
Battalion/ squadron	Support the firing of up to battalion mortar ranges and similar reconnaissance ranges. May be carried short distances and likely have transportation available.
Brigade	Support longer-range firing (e.g., Howitzers) or reconnaissance. Transportation available.
Tethered[a]	The battalion, brigade, or division needs to see a large area and provide communications relays or links.
Conveyance	The battalion, brigade, division, or other unit needs to rapidly send high-value items, such as blood, batteries, (small) weapons, or ammunition.

SOURCE: Adapted from Putney and Ellinger, 2025, Table 1.

[a] A tethered SUAS is physically connected by a tether or cord to a base station that it flies above. Typically, power and data are sent through the tether.

Insights from Across the Research

In this section, we summarize key insights from the four other reports. These reports each focus on one of four major challenges we identified during the course of our research:

- identifying SUAS that the XVIII Airborne Corps could quickly purchase and field to meet materiel requirements at the brigade echelon and below (Putney and Ellinger, 2025)
- changing policies on property accountability and acquisition strategies to ensure that units are incentivized to use SUAS in training and that the Army adopts acquisition approaches that permit it to keep pace with rapidly evolving capabilities and large losses (Camm, Girardini, and Kelly, 2025)
- overcoming limitations on available spectrum, addressing the complexities and risks of EW, and leveraging related opportunities (Osburg et al., 2025)
- adapting training policies, practices, and infrastructure to facilitate the widespread adoption of SUAS into unit training (Phillips et al., 2025).

What Commercial SUAS Are Available to Provide Capabilities for BCT Training?

Putney and Ellinger (2025) provides an overview of systems that the XVIII Airborne Corps could quickly purchase and field, as of 2023, to meet the materiel requirements for SUAS at the brigade echelon and below. To conduct this analysis, the research team searched three databases to find potential UAS for the use cases noted above: the DoD Defense Innovation Unit (DIU) Blue UAS (DIU, 2023); the Association for Uncrewed Vehicle Systems International (AUVSI) Uncrewed Systems and Robotics Database (AUVSI, undated); and Janes (Janes, 2023). We also considered systems that interviewees recommended and that we found during the literature search. We analyzed the entries in these databases and other sources and screened them to identify options for the XVIII Airborne Corps.

We found that there are many systems available on the commercial market for the XVIII Airborne Corps that meet its requirements—specifically, our market analysis found **176 SUAS that could potentially be used to satisfy the use cases discussed above** (although we note that the market changes regularly). Of these, **22 SUAS can meet or nearly meet the key features of two or more use cases.**

We also examined these systems in three tiers. The first tier includes SUAS that meet materiel requirements and regulations governing the countries that DoD entities can acquire systems and their components from. Many systems are already vetted for DoD purchase through the Blue UAS program or are programs of record, so they would be easy to

TABLE 2

Use Case Key Features and Practical Specifications

Use Case	Transport	Size	Range/ Endurance	Camera	Launch/ Recovery	Additional Characteristics
Platoon or other small unit	Can be carried by a single soldier in packs or pockets	<1 lb and smaller	• Range: at least 1 km • Endurance: at least 30 min	EO/IR camera	Either vertical take-off and landing (VTOL) or hand launch and recovery	
Company/ battery/ troop	Carried in packs or split into multiple packs	<10 lb	• Range: at least 3 km • Endurance: at least 1 hour	EO/IR	Preferred system allows VTOL	• Preferred system will allow other payloads • Preferred system sends data to the controller with Android Team Awareness Kit (ATAK) capabilities
Battalion/ squadron	Can be transported by multiple personnel or in a vehicle	10–20 lb	• Range: 7 to 10 km • Endurance: at least 1.5 hours	EO/IR	Preferred system allows VTOL	• Preferred system will allow other payloads, including EW, weapon, communication transmissions • Preferred system contains BLOS capabilities • Preferred system sends data to the controller with ATAK capabilities
Brigade	Transported by a vehicle to the use location	10–30 lb	• Range: >20 km • Endurance: at least 2 hours	EO/IR	Preferred system allows VTOL; at a long range, the system is likely to have separate launch and recovery teams and controller teams	• Preferred system will allow other payloads, including EW, weapon, communication retransmissions, and chemical, biological, radiological, and nuclear defense • Preferred system contains BLOS capabilities • Preferred system sends data to the controller with ATAK capabilities
Tethered	Transported by vehicle to the use location	<100 lb	• Must be tethered • Altitude and payload determine range	EO/IR	Requires VTOL	• Preferred system will allow other payloads, including high-quality EO/IR and communications • Sensor data should be able to be sent to multiple systems; likely has separate deployment and controller teams from other UAS in the unit • Able to accept communications retransmissions payloads
Conveyance	Transported by vehicle to the use location	<150 lb	• Range: at least 5 km • Endurance: at least 1 hour	EO/IR		• Can transport up to 50 lb • Preferred system will contain an auto-navigation option

SOURCE: Adapted from Table 2 in Putney and Ellinger, 2025.

acquire. The second tier includes some systems from companies that sell to U.S. or other militaries, can produce in quantity, and can provide systems that the XVIII Airborne Corps could likely acquire with a reasonable amount of vetting and testing. The third tier includes systems that would likely need some modifications and testing to meet acquisition needs or are produced by companies that might not be able to immediately meet the requirements, such as production at volume, and thus would take more time and effort to acquire.

Key results of this analysis include the following:

- Of the systems that **meet all** the key features of at least one of the use cases, 26 SUAS should be easy to acquire (tier one); 22 SUAS could be acquired but would need some vetting or testing (tier two); and 55 SUAS would take more time to meet acquisition needs (tier three).
- Of the systems that **nearly meet all** the key features of at least one of the use cases, 14 SUAS should be easy to acquire (tier one); 15 SUAS could be acquired, but systems will need some vetting or testing (tier two); and 47 SUAS will take more time to meet acquisition needs (tier three).
- There are four to nine SUAS for each use case that are easy to buy and meet the key features of the use case, except for the brigade use case, for which purchasing all SUAS will take the most effort and time.

What Acquisition and Property Accountability Policies Could Make SUAS More Affordable and Facilitate Their Use?

Camm, Girardini, and Kelly (2025) examines the need to change how the Army buys and accounts for SUAS to ensure that units are incentivized to use SUAS in training and that the Army adopts acquisition approaches that permit it to keep pace with rapidly evolving capabilities and large losses. Two key points underlie this analysis. First, the XVIII Airborne Corps and the Army should expect to use SUAS in new and innovative ways and to experience large-scale losses (Watling and Reynolds, 2023a, p. 18). Second, Army units must train with SUAS in ways that approximate, as closely as possible, how they will be used in combat rather than avoid training losses, which is currently the case in many units (Camm, Girardini, and Kelly, 2025).

Acquisition and property accountability policies must change to recognize these facts and support training and combat operations. Because the Army will use and lose many SUAS in future dynamic, unpredictable military engagements, it will need to train to use them effectively and adaptively to minimize losses and thus preserve combat power. Furthermore, in such a future, the Army will need an ability to mix and match the components and payloads of SUAS to meet mission requirements and to replace them quickly when they are lost (Camm, Girardini, and Kelly, 2025).

To prepare for such a future, **the Army will need to tolerate higher levels of loss of and damage to its SUAS in training to motivate full-spectrum unit training in their effective use.** We know from interviews that many units do not use their SUAS aggressively in training (or at all) out of fear of being held financially liable for their loss. Because of this, an important part of an increased tolerance of loss will likely require a change in the application of the Army's Financial Liability Investigations of Property Loss (FLIPL) program to recognize the high value of such training relative to the cost of SUAS loss or damage during training. The Army would need to change its regulations and how it accounts for SUAS (e.g., as collections of expendable Class IX parts rather than end items), and major unit commanders would need to exercise their authority to adjust how FLIPLs are used (Camm, Girardini, and Kelly, 2025). These changes would help motivate more-realistic training with SUAS.

To prepare for the high losses expected in LSCO and to support rapid innovation, **the Army should, when possible, acquire SUAS by using the agile pathways offered by the Adaptive Acquisition Framework (AAF) and agile methods,** such as those used in the Army's Rapid Capabilities and Critical Technologies Office, Other Transaction Authority acquisitions, and Commercial Solutions Openings. In this setting, commercial SUAS and components offer the Army many advantages relative to their government-developed counterparts (see Camm, Girardini, and Kelly, 2025, for additional details).

How Can the Army Manage the Use of Available Spectrum to Ensure SUAS Effectiveness?

Osburg et al. (2025) considers how the Army might overcome limitations on available spectrum, address the complexities and risks of EW, and leverage related opportunities. The Army's inability to provide adequate spectrum for SUAS at home stations is one of the major shortfalls in its ability to create the training ecosystem necessary for realistic training, and Army units' ability to dynamically access spectrum will be critical in combat (Phillips et al., 2025). The Army's current spectrum-management approach cannot dynamically provide sufficient access to spectrum to support training requirements and combat operations, and the demands for SUAS spectrum exceed available allocations. This problem will be exacerbated in the future because of the simultaneous operation of many more SUAS and other spectrum-dependent technologies at all echelons and in a more-dynamic fashion and because of enemy use of the spectrum and EW.

However, **it is possible to increase effective spectrum capacity and permit more-flexible use of the spectrum through more-dynamic frequency allocation and other measures, such as electromagnetic battle management.** Key capabilities that the Army needs to build into SUAS and supporting systems include frequency agility, antijam waveforms, increased radio frequency (RF) power and low-latency digital RF links, non-GPS-dependent navigation capabilities, onboard processing, and increased battery capacity. **Army SUAS need better protection against threats, including from direct EW effects and kinetic targeting of platforms and operators enabled by an adversary's electronic sensing and cyber capabilities.** SUAS can support and enable EW, electronic sensing, electronic attack, SIGINT, electronic intelligence, and military deception operations.

Because the anticipated threat environment for SUAS in LSCO will likely lead to significant attrition, the Army will need to acquire SUAS in much larger quantities than currently programmed. Thus, **the EW and spectrum-management-related features discussed above also must be affordable enough for large-scale production.**

These challenges will require the Army to make changes across doctrine, organization, training, materiel, leadership, education, personnel, facilities, and policy, and the Army will need to iterate on potential solutions to ensure that they are effective.

How Can the Army Adapt Training Policies, Practices, and Infrastructure to Facilitate Widespread Adoption of SUAS into Unit Training?

Phillips et al. (2025) focuses on the Army's need to adapt its training policies, practices, and infrastructure to facilitate the widespread adoption of SUAS into unit training. The Army is the premier ground combat force in the world because it adheres to the theory that the Army achieves excellence by training as it will fight—i.e., under conditions that are as close as possible to those expected in combat. Currently, there are significant roadblocks to conducting such training at scale. These include limits on home-station training-management systems' ability to manage the risk of orders-of-magnitude more SUAS flights in the home-station training area than can be accommodated today, spectrum-allocation issues that might be more challenging than spectrum use in combat because of the need to deconflict with civilian spectrum usage, airspace-management issues that need to adequately account for the safety of civilian and military aircraft, and acquisition and accountability policies that hinder SUAS training in real ways (as discussed below).

Furthermore, there is evidence that units are not using SUAS in training or are doing so inadequately. At combat training centers (CTCs), most BCTs rely on larger Group 3 UAS during training and operations, yet companies and battalions fail to use SUAS to optimize ISR. Observations from the CTCs and the Russo-Ukrainian War indicate that effective combined arms maneuvers that integrate SUAS require

- operators to be experts who can use advanced techniques and understand how they fit in airspace management, ground maneuver, and fires schemes

- company-grade and field-grade leaders who can use tactics to maximize the operational value and survivability of SUAS
- battle staff who are quick and efficient at planning intelligence collection and managing airspace
- well-rehearsed air-net and fires-net “kill chains” for mission execution.

The Army also faces an institutional challenge in producing units that can effectively use SUAS. The 2023 training pipeline for SUAS operators was insufficient in terms of basic qualification throughput and preparing expert operators and, unless changed, will be overwhelmed when the Army starts fielding SUAS in greater numbers.

Part of the solution is to train the trainer, i.e., units need battalion Master Trainers (MTs) who can qualify as company unit trainers, and units need a routine battle rhythm for maintaining and developing expertise. However, the SUAS MT course requires refinement to increase throughput and to better prepare MTs to assist commanders in implementing SUAS training plans.

Effective SUAS integration with combined arms maneuver at the battalion level and below requires more than operator proficiency: **SUAS also need to be integrated into most missions.** However, our interviews revealed that few units move beyond basic operator-level proficiency or plan for the integration of SUAS in combined arms operations. Units are not training realistically at home station for the combined arms maneuver employment of SUAS, primarily because of range-control constraints, airspace-management and spectrum limitations, and accountability policies that deter SUAS use (noted above). Furthermore, unit SUAS training plans lack training models that leaders could easily adopt or adapt to execute a step-by-step program to train individual and collective SUAS employment.

Tactics for SUAS employment are rapidly evolving, but the Army lacks a mechanism, repository, or forum for operators, leaders, and units to share Tactics, Techniques, and Procedures and standard operating procedures. **Battalion and BCT staff require training and decision aids in airspace and risk management to accommodate more SUAS in the airspace** while still employing rotary and fixed-wing aviation, fires, and other capabilities across warfighting functions. Finally, **counter-UAS training needs to be integrated across echelon collective training,** which includes creating Opposing Force UAS assets.

The Army can solve or waive many of the obstacles to train the way it fights, but this requires Headquarters, Department of the Army (HQDA) attention and urgency. These issues can be resolved only with coordination across the joint communities (e.g., for airspace and spectrum management). These are Army- and DoD-level problems that corps, division, and brigade commanders alone cannot fix.

Conclusion

UAS are changing the way wars are fought. Ukrainian and Russian soldiers are innovating constantly, and the way SUAS are employed, supported, and attacked have changed significantly in the 15 months from when this work began (October 2022) to when it concluded (December 2023).

The XVIII Airborne Corps recognized this shift early and has pressed hard to keep up with changes on the battlefield. However, significant institutional hurdles hamper its and the Army’s ability to change, train, and adapt.

Tactics for SUAS employment are rapidly evolving, but the Army lacks a mechanism for leaders and units to share Tactics, Techniques, and Procedures.

Key challenges are

- identifying SUAS that the XVIII Airborne Corps could quickly purchase and field to meet materiel requirements at the brigade echelon and below
- changing policies on property accountability and acquisition strategies to ensure that units are incentivized to use SUAS in training and that the Army adopts acquisition approaches that permit it to keep pace with rapidly evolving capabilities and large losses
- overcoming limitations on available spectrum, addressing the complexities and risks of EW, and leveraging related opportunities
- adapting training policies, practices, and infrastructure to facilitate the widespread adoption of SUAS into unit training.

In this report, we have examined these challenges and presented both discrete solutions, such as systems that can be quickly purchased to fill requirements and changes to how SUAS are accounted for, and approaches to addressing challenges that could evolve as needed, such as mechanisms for securely sharing lessons learned, concepts for changing how spectrum is managed and how EW is fought, and graduated use of the AAF for acquiring SUAS from commercial sources and through programs of record. We examine these challenges and potential solutions in greater detail in the four companion reports. Taken together, this series is intended to influence not only how the Army approaches SUAS systems but also how it supports training, how it acquires and accounts for rapidly changing technical equipment such as SUAS, and what it needs to effectively employ them.

Taken together, this series is intended to influence how the Army supports training with SUAS, how it acquires and accounts for SUAS, and what it needs to effectively employ them.

Yet, this is a rapidly evolving area, and it will be critical for the XVIII Airborne Corps and the Army to adapt rapidly as well. Operational and institutional agility will be necessary if the Army is to dominate on future battlefields. In the months and years ahead, it will be important to gather lessons learned from experimentation, training, and operations (including in Ukraine and perhaps other combat zones), to analyze these lessons, and to innovate aggressively.

Appendix A. Research Approach

Interviews

To develop this series, we conducted interviews and examined applicable literature. Interviews were with experts from XVIII Airborne Corps divisions and other Army stakeholders (e.g., XVIII Airborne Corps nondivisional units and staff, UAS and robotics staffs in applicable Army CoEs, acquisition officials, and DoD officials), and other government and private-sector experts.

We conducted interviews with soldiers in group and individual settings. We met with XVIII Airborne Corps staff officers and division staff officers from each of the XVIII Airborne Corps subordinate divisions. At the brigade level, we interviewed groups from each brigade's staff and groups of operators from at least one BCT in each of the subordinate divisions, two divisional artilleries, and one DSB. At the recommendation of the XVIII Airborne Corps Commanding General, we also met with the commanders and staff from two maneuver battalions who have been particularly innovative in their approach to using SUAS. We interviewed representatives from relevant CoEs, especially with the MCoE, which was the SUAS proponent in 2023, including two trips to Fort Benning.[7] We also held several meetings with other key stakeholders, such as the 75th Ranger Regiment and U.S. Army Special Operations Command, and met with an assortment of stakeholders at the 2023 UAS conference held at Fort Novosel. In addition, we spoke with representatives from DIU, Program Executive Office Aviation, various other vendors, and the Army's UAS Project Management Office.

We asked interviewees not only about UAS technical requirements (e.g., range, loitering time, payload, desired sensor and communications capabilities, ease of replacement if lost) but also about requirements to address the questions raised in some of the reports mentioned above (e.g., requirements for sustainment, constraints in the training environment, and agility of the acquisition system).

Literature Review

In addition to interviews and discussions with soldiers and Department of the Army and DoD civilians, we examined the literature on current UAS experiences across the Army and other services (the U.S. Marine Corps in particular), the ongoing (as of 2023) conflict in Ukraine, the recent conflict in Nagorno-Karabakh, and other relevant technical and operational publications.

Much of the literature search focused on specific topics in the four companion reports in this series. This literature included numerous policy and reporting documents and many news reports that covered UAS operational tasks. Doctrine and training manuals, technical manuals, and other Army and DoD documents and directives (e.g., range regulations, range-use databases, airspace-management memorandums of understanding between DoD and the Federal Aviation Administration) were also considered. Datasets on commercially available UAS were also important, as was a systematic review of relevant Army and Joint doctrine and strategies, SUAS operator manuals and payload-specification documents, and lessons-learned reports from recent conflicts and major training events.

We also reviewed reports and briefings that were recommended by the experts we interviewed as part of the research. Official DoD documents were critical. These included regulations, handbooks, and other formal guidance relevant to DoD acquisition, capability-requirements determinations, and materiel accountability. Documents relevant to relatively new ways that DoD could acquire commercial goods and services, and ways to acquire them more quickly, were particularly helpful. We also reviewed documents specific to individual DoD acquisitions. Recent RAND reports relevant to DoD acquisition policy, especially reports with a special emphasis on agile and other nontraditional means of acquiring goods and services from commercial sources, were also important. We also reviewed classified literature and reports.

Appendix B. SUAS Capabilities and Trends

One of the challenging aspects of this research project has been the rapidity with which SUAS and their uses are changing. Indeed, the changes that took place between just October 2022, when this project started, and December 2023, when our research concluded, are immense.

A key factor in understanding SUAS needs and limitations is technical—how does what is needed compare with what is possible? In this appendix, we present some of the more important of these trends. Two RAND reports (Wilson et al., 2020; Pernin et al., 2021) provide additional insights into related trends.

Launch Mode

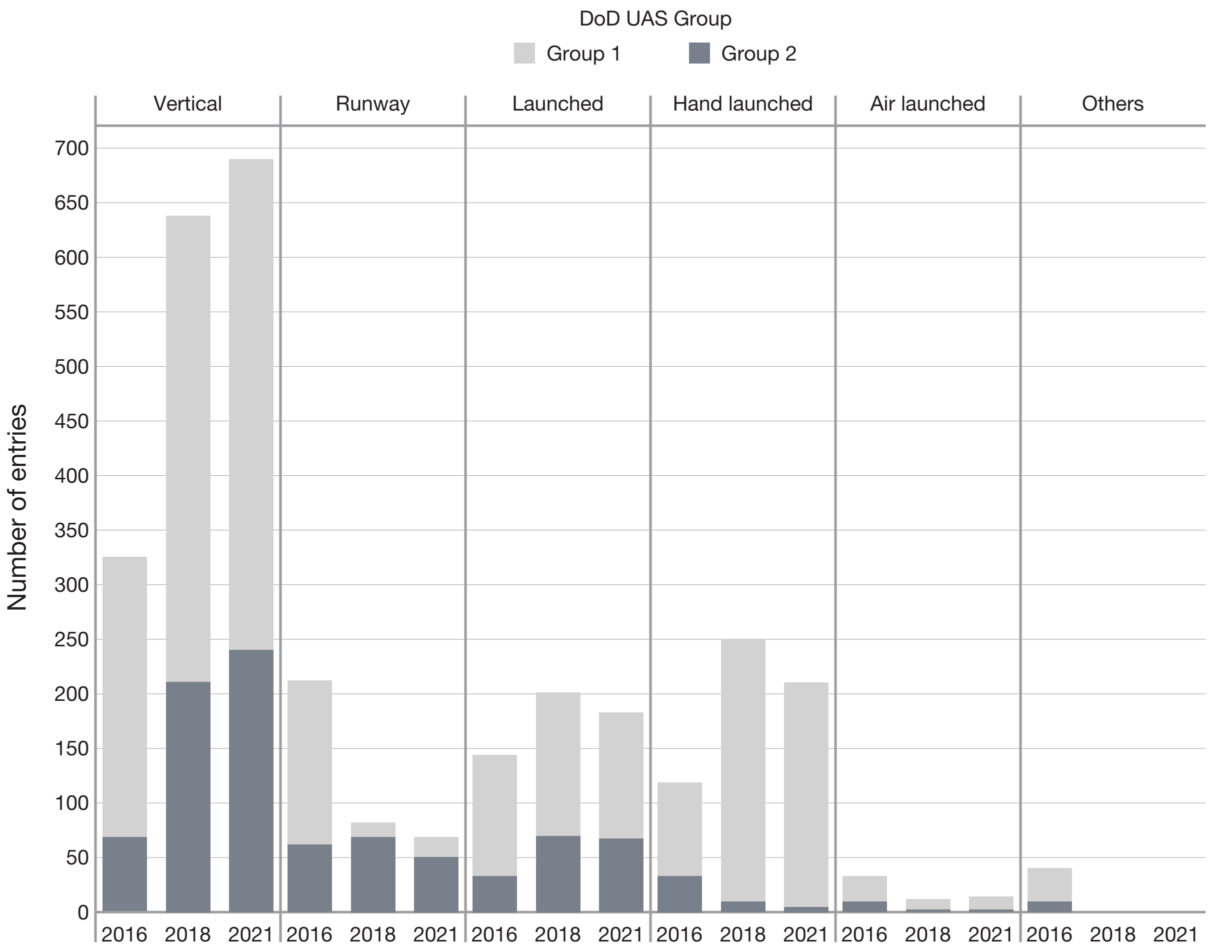
For tactical applications, VTOL improves operational flexibility and avoids the need for runways or cumbersome launch and retrieval systems, such as catapults and nets. However, because of physics-based limitations, VTOL vehicles generally have shorter range, shorter endurance, or lower payload capacity than runway- or catapult-launched vehicles of the same general size and mass. Figure B.1 shows the increase in the number of VTOL-capable SUAS from 2016 to 2021.

Examples of UAS launch modes are as follows:

- vertical: quadcopters, such as the RQ-28A Skydio model, which some Army units are fielding in 2023
- runway: fixed-wing UAS, which are often larger than SUAS (e.g., RQ-7 Shadow)

FIGURE B.1

Number of Commercially Available SUAS, by Launch Mode and Group (2016, 2018, 2021)



SOURCE: Features data from AUVSI, 2021.

- launched: UAS that are often propelled from a tube or rail device, such as the Switchblade loitering munition
- hand launched: small, fixed-wing drones, such as the RQ-11 Raven
- air launched: a current area of focus for Army Aviation, with its Air Launched Effects efforts; an example is the eBee TAC, which is on the DIU Blue UAS list
- other: all other UAS; for example, lighter-than-air vehicles (blimps).

Automatic Stabilization

A combination of on-board sensors and a full-authority on-board flight controller keeps the SUAS inside its safe flight envelope, including when it hovers. In contrast with traditional remote-controlled airplanes, the operator no longer has to actuate individual control surfaces in real time to control the vehicle's course and maintain its stability. Related technology has been relatively mature for years, but improvements in control algorithms and sensors have led to increased performance.

Autonomous Navigation

An on-board positioning subsystem, in combination with a mission-level controller, guides the vehicle along a desired route. This route is usually defined by the operator by means of waypoint coordinates, but recent advances in sensors and software allow some SUAS to pick the best route to their destinations (see “Visual Navigation” and “Autonomous Collision Avoidance”).

Visual Navigation

Although almost all current SUAS have a built-in Global Navigation Satellite Systems (GNSS) receiver that provides three-dimensional positioning—and in some cases attitude—data to the navigation computer, this mode of operation is vulnerable to scenarios in which there is no GNSS signal, such as inside buildings, during subterranean operations, or when encountering enemy jamming. In those cases, navigation using visual references from cameras on the SUAS that feed into image processing software can augment or replace GNSS-based navigation.

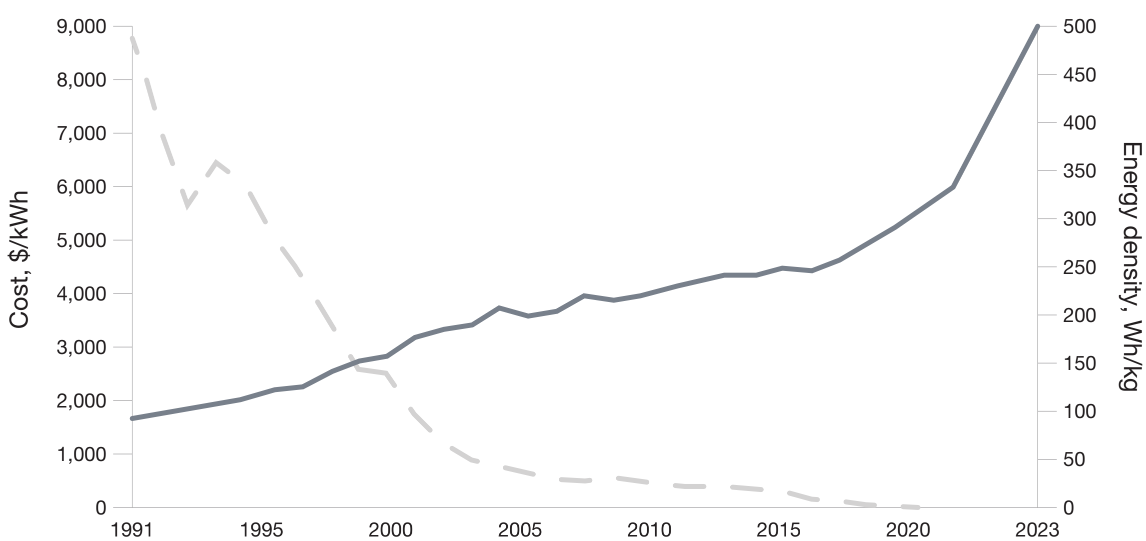
Autonomous Collision Avoidance

Part of navigating any vehicle involves avoiding collisions with other objects. In uncrewed vehicles, this is done through a combination of one or more of on-board sensors, terrain databases, and on-board processing. All three capabilities benefit from the increase in computing power and the decrease in size, weight, and power—and cost—that has shaped the marketplace over the past several decades. Autonomous collision avoidance reduces the need for operator-in-the-loop flying and thus the requirements on the SUAS communication system. Implemented correctly, it can also reduce the likelihood of in-flight collisions and thus increase the chance of mission success.

Extended Battery Life

Advances in chemistry over the past few decades have led to batteries with higher energy densities and lower costs (Figure B.2; Crabtree, Kócs, and Trahey, 2015), both of which have greatly benefited SUAS endurance and performance. Design features such as field-swappable battery packs and rapid chargers also contribute to increased effective endurance, which, in turn, enables longer flight times and ranges.

FIGURE B.2
Battery Cost and Energy Density Since 1990



SOURCE: Adapted from Walter, Butler-Sloss, and Bond, 2024.

NOTE: The dashed line shows battery cost, and the solid line shows battery energy density. kWh = kilowatt-hour; Wh/kg = Watt-hour per kilogram.

Increased Payload Capacity

Advances in structural and aerodynamic design and manufacturing, propulsion efficiency, and battery capacity combine to afford SUAS with higher payload capacity. Figure B.3 shows the substantial average payload capacity increase for SUAS from 2016 to 2018 to 2021. Increased payload capacity, coupled with the decreasing mass of payloads, greatly increases SUAS capabilities.

Increased Robustness with Respect to Weather

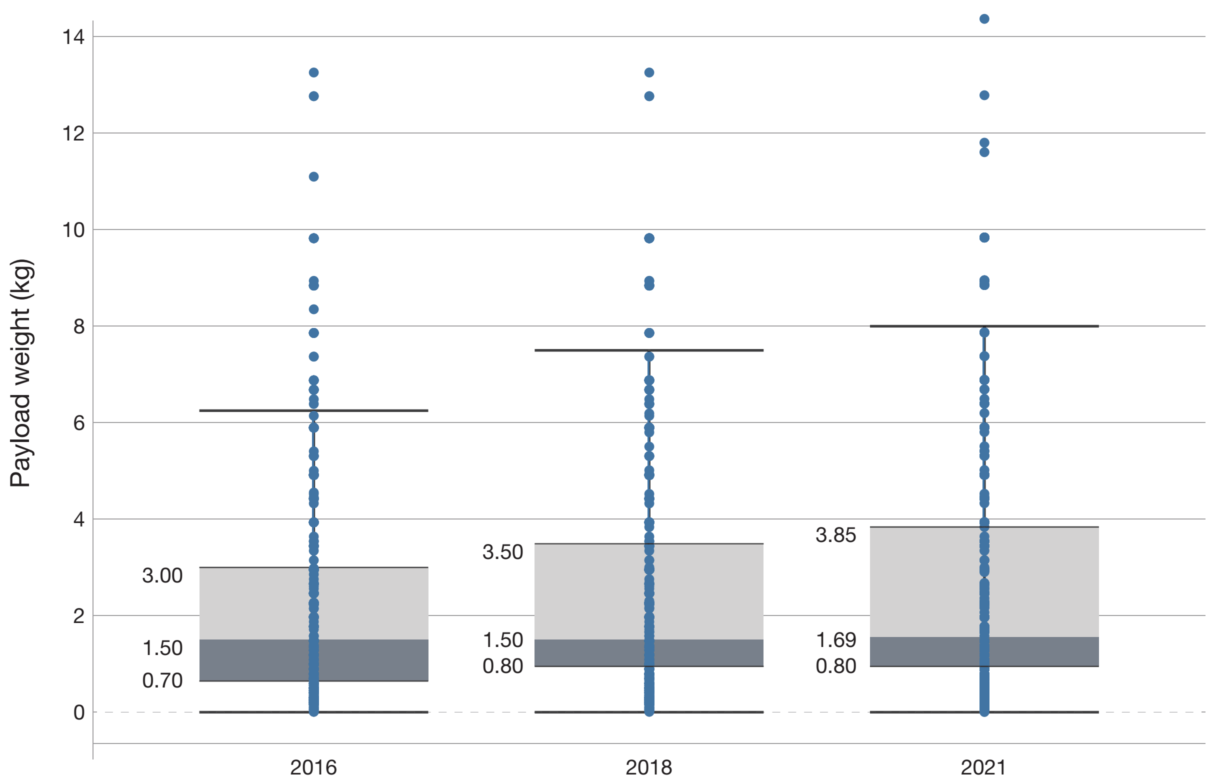
Despite the importance of Army units being able to fight during all kinds of weather, the first SUAS that the Army fielded could not be operated in the rain, above relatively low wind speeds, or below relatively mild temperatures (HQDA, 2008). With the increased performance of propulsion and stabilization systems, improved battery chemistries, and advances in structural designs, the most-recent SUAS designs on the commercial market have expanded that envelope, with some COTS SUAS being waterproof to the degree that they can land on and launch from water (SwellPro, undated).

Modularity

Tailoring the configuration of an SUAS to a mission's needs enables operational flexibility and can reduce acquisition costs, training requirements, and storage volume. Some higher-end COTS SUAS are designed to offer modular payloads, allowing the user to swap between daylight and night-vision cameras, for example, or to attach illuminators or loudspeakers, cargo-drop devices, or any other payload package that conforms to the SUAS payload attachment interface and is within acceptable weight and volume ranges

FIGURE B.3

Payload Capacity of Group 1 and Group 2 UAS (2016, 2018, 2021)



SOURCE: Features data from AUVSI, undated.

NOTE: Shaded areas of the box plots show the medians (e.g., 1.50 kg for 2016), lower quartiles (e.g., 0.70 kg in 2016), and upper quartiles (e.g., 3.00 kg in 2016).

(DJI, undated; SwellPro, undated). Modular battery packs of different sizes also facilitate trading between endurance and payload mass capacity as needed.

Customizable Control Software and Hardware

Most COTS SUAS can be controlled using third-party devices, such as cellular phones or mobile tablet computers, as long as the SUAS manufacturer's software is installed on them. This enables adapting the control-station hardware to operational needs, and it facilitates mission planning and sharing sensor feeds via other software installed on the control device.

Radio Frequency Agility

Most UAS require an RF link between the vehicle and its operator during a mission. This of course requires related hardware (transceiver, antenna, etc.), which adds to volume, mass, and power requirements. It also provides a point of attack for enemy jamming, and the emitted RF energy makes the system vulnerable to detection. Furthermore, any spectrum use has to be deconflicted with friendly forces and other restrictions on spectrum availability, complicating operations. A key development that can mitigate these issues are software-defined radios (SDRs), which can transmit and receive on a broad range of frequencies and waveforms and can be updated and controlled via software. This greatly facilitates adapting SUAS control links to the battlefield's dynamic electromagnetic environment. Modularity plays a role here as well, because antennas may have to be swapped out by the user prior to take-off to match the frequencies that the SDR will use for a given mission. Related improvements include the automatic selection of optimum frequencies prior to each mission, thus reducing the operator's workload and training requirements.

Customization

Army acquisition processes tend to take many years (see Camm, Girardini, and Kelly, 2025, for more on the subject), and thus systems are likely to be at least partially outdated once they start being fielded. Giving units and users the ability to customize the SUAS in their inventories via local three-dimensional printing or other approaches would allow them to take advantage of the latest technological and operational developments and to adapt existing systems to emerging missions and requirements.

Automated Flexible Mass Production

On the other side of the production scale spectrum from three-dimensional printing, advances in automated manufacturing could be leveraged to create the large numbers of SUAS that the Army will likely need for future LSCO. This also aligns with the DoD Replicator initiative, launched in 2023, that aims for the fielding of massive quantities of uncrewed systems in the years to come (DoD, 2023). In particular, automated mass production is now flexible enough to accommodate building SUAS variants as needed and to incorporate new features or changes based on operational feedback.

Notes

1 See, for example, Deveraux, 2022. The claim that Ukrainian forces used UAS to identify 80 percent of indirect fire targets comes from the XVIII Airborne Corps sponsor in discussions for why this project was needed.

2 See, for example, Ignatius, 2024. With respect to reshaping modern warfare, see Trofimov, 2023.

3 There are numerous examples of Army units and organizations experimenting with drones. For example, the 82nd Airborne Division stood up a company—Gainey Company—for the purpose of experimentation. One platoon of Gainey Company focuses on SUAS, as indicated by interviews we conducted with 82nd Airborne Division staff and Gainey Company personnel. Similarly, the Maneuver Capabilities Development and Integration Directorate at Fort Benning has a robotics section that builds and experiments with drones.

4 UAS are frequently categorized into five groups by a combination of maximum take-off weight, maximum altitude, and maximum speed (see, for example, Harbaugh, 2018). UAS with the smallest combinations are in Group 1 (e.g., what the typical civilian consumer might purchase), and those with the largest are in Group 5 (e.g., Global Hawk). A listing of the groups and U.S. Department of Defense (DoD) definitions can be found in Annex C of the *Counter–Small Unmanned Aircraft Systems Strategy* (DoD, 2021). According to this source, Group 1 UAS weigh less than 20 pounds and fly below 1,200 ft above ground level and at speeds of less than 100 knots; Group 2 UAS weigh less than 55 pounds and fly below 3,500 ft above ground level and at speeds of less than 250 knots.

5 Introducing SUAS, however, creates new tasks for units and soldiers as they execute these major doctrinal missions. We discuss these new mission-essential tasks in the fourth report of this series, *Small Uncrewed Aircraft Systems (sUAS) in Divisional Brigades: Small UAS and Counter-UAS Training* (Phillips et al., 2025).

6 This is so, even as an enormous number of indirect fire missions in Ukraine are possible because of the ubiquity of SUAS to do ISR and target identification.

7 The Army has designated the Aviation CoE the proponent for all UAS since then.

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About This Report

This report documents research and analysis conducted as part of a project entitled *Unmanned Aircraft Systems (UAS) to Support Fires at Division, Brigade Combat Team (BCT), and Battalion Addendum*, sponsored by XVIII Airborne Corps. The purpose of the project was to assess the implications of integrating additional Group 1 and 2 uncrewed aircraft systems (UAS) for reconnaissance, fires, and other purposes below the division echelon. We derived implications for institutional and unit training and training support and for other institutional functions needed for success, such as how small UAS (SUAS) are acquired and accounted for, and support functions needed for large-scale combat operations with a peer competitor.

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