

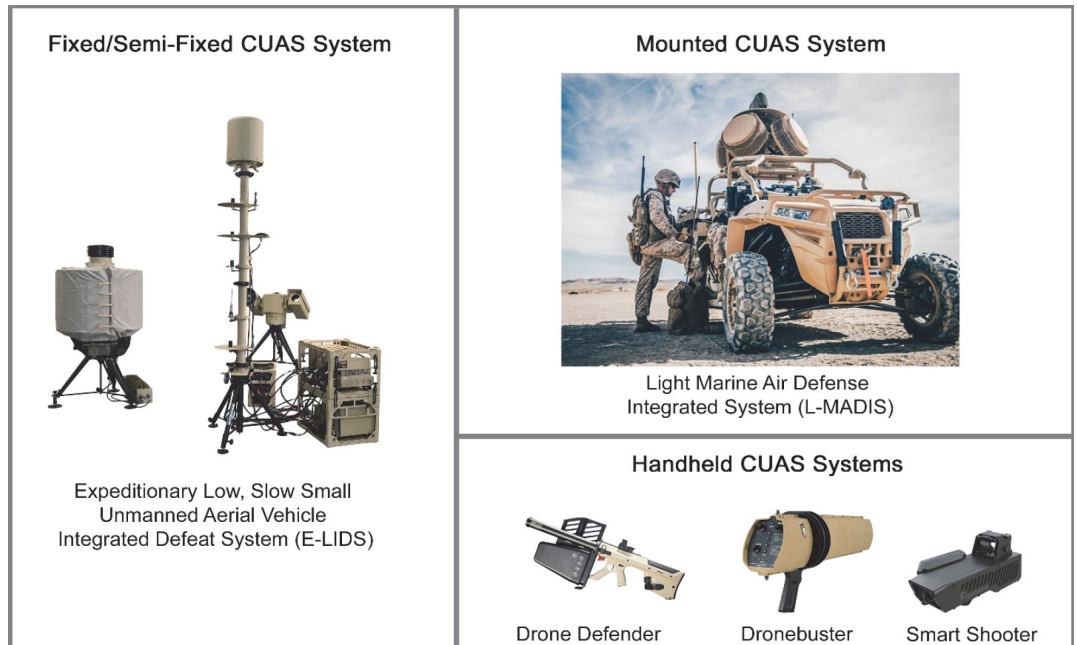
Counter-Small Unmanned Aerial Systems (UAS) Systems

Executive Summary

- In July 2019, USD(A&S) requested DOT&E's support in assessing the operational performance of a select set of counter-small unmanned aircraft systems (C-sUAS) systems as installed, integrated, and employed in an operationally representative environment.
- In collaboration with the Combatant Commands, Service representatives, and the Joint Deployable Analysis Team (JDAT) (part of Joint Chiefs of Staff/J6), DOT&E developed an assessment plan for 11 C-sUAS systems (Table 1) at 5 locations outside the continental United States (OCONUS). JDAT executed the OCONUS assessment plan between November 2019 and March 2020 under DOT&E oversight.
- DOT&E also participated in test planning, observation, and administration of two Service-led C-sUAS system tests within the continental United States (CONUS) in February and March 2020.
- In April 2020, DOT&E delivered an independent analysis of the OCONUS data to the newly formed, Army-led Joint C-sUAS Office (JCO) in support of their C-sUAS down-selection task.
- In May 2020, the SECDEF accepted the JCO recommendations to down-select from 28 fielded C-sUAS systems to 7.

System

- C-sUAS systems are designed to detect, track, identify, and defeat or disable small (Groups 1 and 2) unmanned aircraft systems (sUAS). Common methods for detecting sUAS include radars, radio frequency (RF) scanners, and electro-optical (EO) or infrared (IR) cameras. Common defeat methods include jamming the sUAS RF control or video link, jamming sUAS Global Navigation Satellite System signals, or destroying the sUAS using a kinetic mechanism, such as lasers, projectiles, or an intercepting sUAS.
- Based on inputs from USD(A&S) and U.S. Central Command, DOT&E assessed a select set of widely employed C-sUAS systems (listed in Table 1) against Group 1 sUAS. Most systems relied on RF jamming to defeat or disable sUAS.



- The two exceptions were the Land-Based Phalanx Weapon System (LPWS) and Howler, which employ kinetic defeat mechanisms.
- Fixed-site systems typically use multiple methods to detect, track, and identify sUAS, including radars, RF sensors to detect the wireless signals used to control sUAS or provide video feeds, and EO/IR or visual cameras to detect the sUAS' visual or heat signature. These systems often combine these methods to provide a multi-layer capability, which requires an effective human interface and command and control capability that integrates and networks the various sensors to provide actionable information to the system operator.
 - Mobile systems generally consist of fewer components and might use only one method to detect, track, and identify sUAS.

Mission

- A unit equipped with a C-sUAS capability detects, tracks, and identifies the presence of sUAS and provides kinetic and non-kinetic means to destroy or negate the ability of the adversary sUAS to complete its mission (either intelligence, surveillance, and reconnaissance; or attack).
- Fixed-site systems provide broader defense of a base or installation and typically constitute a portion of the overall layered defense strategy.
 - Mobile systems are designed to be more agile, scalable, and maneuverable. They can be moved within a forward operating

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base to protect high-value assets or installed on mobile platforms to protect units on the move.

- Handheld or soldier-worn systems are often employed as a component of a fixed-site system to engage sUAS at short range. Some handheld systems cannot detect sUAS and

must therefore be cued to the sUAS location or rely on visual detection by the operator.

Major Contractors

- Varies by C-sUAS system. See Table 1.

C-sUAS Category	System Name	Detection Methods	Defeat Methods	Service	Major Contractor / Lead Integrator
Fixed or Semi-Fixed Systems	Counter-Remote Control Model Aircraft Integrated Air Defense Network (CORIAN) versions 1.5 and 1.8	RF	RF, GPS	Army	CACI
	Fixed Site-Low, Slow, Small Unmanned Aerial Vehicle Integrated Defeat System (FS-LIDS)	RF, radar, camera	RF, GPS	Army	SRC, Inc.
	Medusa System of Systems	RF, radar, EO/IR	RF, GPS	Air Force	SAIC
	Expeditionary-Marine Air Defense Integrated System (E-MADIS)	RF, radar, camera	RF, GPS	Marine Corps	Naval Surface Warfare Center, Crane Division
	Land-Based Phalanx Weapon System (LPWS)	Radar, EO/IR	20-mm M940 ballistic round	Army	Raytheon
Mounted or Mobile Systems	Light-Marine Air Defense Integrated System (L-MADIS)	RF, radar, cameras	RF, GPS	Marine Corps	Naval Surface Warfare Center, Crane Division
	Howler	Radar, EO/IR	Coyote UAS	Army	Raytheon
	EnforceAir	RF	RF	N/A – Israeli System	D-Fend Solutions
Handheld or Soldier-Worn Systems	Drone Restricted Access Using Known EW (DRAKE) (backpack version)	RF	RF	Navy	Northrop Grumman
	Drone Defender	RF, visual	RF, GPS	Army	DeDrone
	Dronebuster	Visual	RF, GPS	Army	Flex Force

EW – Electronic Warfare; EO – Electro-optical; IR – Infrared; RF – Radio Frequency; UAS – Unmanned Aerial System; C-sUAS – Counter-Small Unmanned Aircraft Systems

Activity

- From November 8, 2019, through March 13, 2020, JDAT executed OCONUS testing in accordance with the DOT&E-approved test plan. The JDAT team executed 281 record test sorties using 11 C-sUAS systems (listed in Table 1) across 5 U.S. Central Command locations. A DOT&E representative was part of the test team for three of the sites, and DOT&E representatives were part of the CONUS support team at JDAT. In coordination with JDAT, DOT&E approved regular test modifications required by operational realities.
- From February 28 through March 4, 2020, the Marine Corps executed the follow-on CONUS testing of the Light-Marine Air Defense Integrated System (L-MADIS) C-sUAS system at Yuma Proving Ground, Arizona. Testing consisted of 60 record test sorties.
- From March 9 – 12, 2020, the Air Force executed follow-on CONUS testing of the Medusa C-sUAS system at Edwards AFB, California. Testing consisted of 61 record test sorties.
- DOT&E representatives assisted in planning and data collection during CONUS tests. Tests were conducted in accordance with DOT&E recommendations.

- JDAT and the Services conducted the OCONUS and CONUS tests using adversarial Red Teams flying a range of realistic fixed- and rotary-wing sUAS flight profiles. Testing considered both single and multiple sUAS threats with a focus on commercial off-the-shelf Group 1 sUAS weighing less than 20 pounds.
- In April 2020, DOT&E completed and delivered an independent analysis of OCONUS and CONUS test data to the JCO in time to support their C-sUAS down-select analyses and comeback brief to the SECDEF.
- In May 2020, the SECDEF accepted the JCO recommendations to down-select from 28 fielded C-sUAS systems to 7. Services will sustain previously fielded systems until replacement systems are available, but will not conduct additional research, development, test, and evaluation on the non-selected systems.

Assessment

- OCONUS and CONUS testing were adequate to assess C-sUAS system capability to detect, identify, track, and

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prevent an adversarial force from accomplishing sUAS reconnaissance or attack missions.

- Group 2 UAS were not available in the time frame needed to support testing. Group 3 UAS were considered to be outside the scope of OCONUS and CONUS test efforts at the time of testing. Additionally, swarm UAS threats were not utilized as a potential threat.
- Software tools currently installed on threat sUAS systems for security reasons introduced test limitations that might have affected the observed C-sUAS performance.
- OCONUS testing occurred on systems as installed, integrated, and operated at each location. The rules of engagement (ROE) and tactics, techniques, and procedures (TTPs) for employing C-sUAS systems varied by system and location. ROEs and TTPs at certain locations might have adversely affected C-sUAS system performance. For example, lengthy ROE hinder timely engagements.
- CONUS testing occurred at the test ranges using the advanced versions of the Medusa and L-MADIS C-sUAS systems as compared to those assessed OCONUS. CONUS testing permitted a greater degree of control to assess the effect of test conditions that could not be systematically varied during OCONUS testing and offered a less cluttered RF environment to the C-sUAS system operators. Approvals to use some C-sUAS defeat capabilities within the United States can take up to 6 months to obtain so, in the interest of time, CONUS testing could not include the full spectrum of C-sUAS defeat mechanisms.
- C-sUAS detection capabilities were adequate for most systems. Engagement (defeat) continues to be a challenge. A system-of-systems approach to C-sUAS yielded the highest performance.
- Reliability and maintainability shortfalls degraded the capability of some C-sUAS systems. In addition, for several systems, operators indicated that they had limited training and experience on the system.
- The details of the C-sUAS system performance across the kill chain are classified and available on request.

Recommendations

The Army-led JCO should:

1. Monitor Services' plans to execute operationally representative assessments of C-sUAS system performance

prior to fielding. An operationally representative assessment should include trained operators (including military members when deployed with military operators), Red Teams trained to fly realistic and unpredictable threat flight profiles, and a range of electromagnetic spectrum environments (spanning rural to dense urban environments) and environmental conditions (including coastal, urban, maritime, and forested).

2. Develop a set of standardized measures of performance, measures of effectiveness, operational assessment protocols, ROEs, and TTPs for use in C-sUAS system operational assessments to enable meaningful performance comparisons across C-sUAS and to enable measures of progress in C-sUAS performance over time.
3. Include Group 2 and 3 UAS and swarm UAS threats in future operational assessments. Future range upgrades should consider installing optical and RF tracking systems to execute simultaneous tracking of multiple targets and instrumentation. This is needed in order to quantify the significance of the effect on individual elements, as well as potential interactions between elements within a swarm. Test ranges will also need to maintain (and potentially expand in the future) sufficient operational space to support the increasing performance and ranges of UAS, particularly for the larger Group 3 UAS.
4. Ensure that operators are sufficiently trained before conducting testing and deployment, and that their training and Military Occupational Specialty (where applicable) properly represents operational users.
5. Explore options to reduce timelines for waivers and authorization needed to employ a full spectrum of C-sUAS defeat mechanisms in operational assessments to maintain pace with the evolving sUAS threat.
6. Investigate alternative software tools for protecting sUAS information during testing that do not adversely affect the ability to accurately evaluate C-sUAS performance.

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