

U.S. Department of Homeland Security | Science and Technology Directorate

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# WEBINAR: COUNTER-UAS SELECTION CONSIDERATIONS



Science and  
Technology



**DRONERESPONDERS**

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Office of National Laboratories, NUSTL  
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Approved for Public Release

# Speakers



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# POCs

- FEMA C-UAS Grant Program: [Frequently Asked Questions](#)
- Submission Deadline: December 5, 2025 at 5 pm ET
- Program-specific information: [FEMA-GPD-GrantPrograms@fema.dhs.gov](mailto:FEMA-GPD-GrantPrograms@fema.dhs.gov)
- NUSTL: [NUSTL@hq.dhs.gov](mailto:NUSTL@hq.dhs.gov)

Available to provide technical support: prior to the submission, before purchase and receipt of equipment, after equipment received

- FIFA 2026 Support: Federal support consolidated request form:  
<https://forms.office.com/g/TVPi2Fn46K>

Work with your Federal Coordinating Officers (FCOs)



# C-UAS Terminology & Key Concepts

# C-UAS Continuum of Events



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# C-UAS Continuum of Events



# C-UAS: Detect

**Detection:** A declaration that a sensor has a UAS or candidate target in its presence

- This declaration can be specific to the transmission of RF signals from only a GCS, only an aircraft or both
- Some systems, depending on how thresholds are configured, may report any object in its view as a detection (i.e., birds, commercial planes) or they might attempt to alert the operator of only objects it thinks are UAS

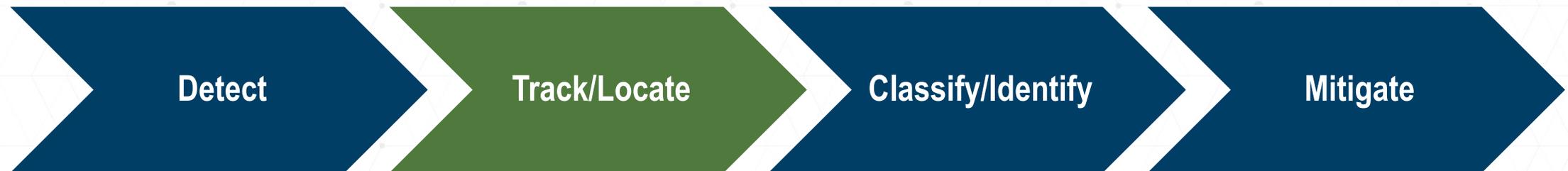


# C-UAS: Track/Locate

**Track:** A compilation of reports **over time** of where a GCS or UAV is located. Generally displayed as a line or a sequence of dots.

**Locate:** A **static** estimated report or display of where a GCS or UAV is located; for the operator, this display can take on many forms, such as:

- Heat map display
- Quadrant alert
- Circle to indicate center estimate and error
- Line of bearing



# C-UAS: Classify/Identify

**Classify/Identify:** These terms are often used interchangeably but can have different meanings for different parties (e.g., developers, operators, Department of Defense (DoD), Federal Aviation Administration (FAA))

- **Classification:** Assignment of an UAS to a high-level category, such as UAS type, group, manufacturer and/or protocol
- **Identification:** Assignment of an UAS to a more specific name or category, such as the physical/mac address of the modem, or the exact make/model and protocol of the UAS



# C-UAS: Mitigate

**Mitigate/Negate/Interdict/Neutralize:** These four terms are often used interchangeably to describe the methods used to remove or reduce the threat posed by an UAS



# C-UAS Sensor Types and Methods



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# Radiofrequency detection factors

- **Line of sight (LOS):** Sensors operate optimally when there is line of sight between the threat (GCS, UAV) and the sensors.
- **Libraries:** A set of known parameters (visual, acoustic, RF, etc.) that reliably represent a threat; systems will attempt to match their libraries against observed signals (threats) to determine if alert levels need to be elevated
- **Noise floor:** The environmental conditions that may affect a sensors ability to distinguish between an actual threat signal and surrounding signals present
- **Signal to noise ratio (SNR):** The ratio between the signal strength and the noise floor

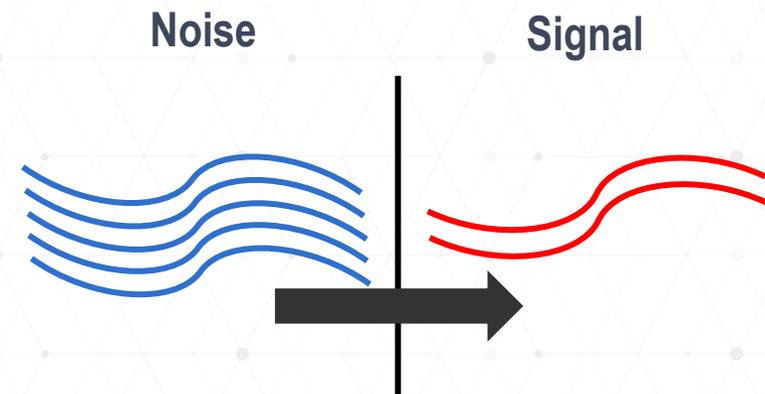
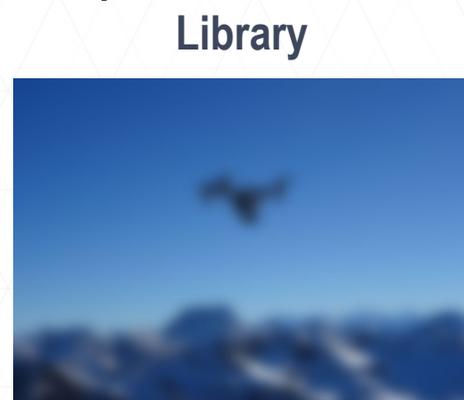


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# C-UAS Sensor Types and Methods

Most C-UAS devices will use some combination of these sensor modalities:

- Passive RF
- Radar
- Electro-optical & infrared cameras
- Acoustic sensors



Radio Frequency



Radar



EO/IR



Acoustic



- What UAS are in your RF Library?
- By what process does your system provide the location of the UAS and/or Ground Control Station?
- What is your total coverage area with a single node?



- Under ideal conditions, at what range can you reliably detect a small UAS (e.g. DJI Mavic)?
- Is the Radar FCC approved?
- How does the system classify UAS from other airborne objects (e.g. manned aircraft, birds)?

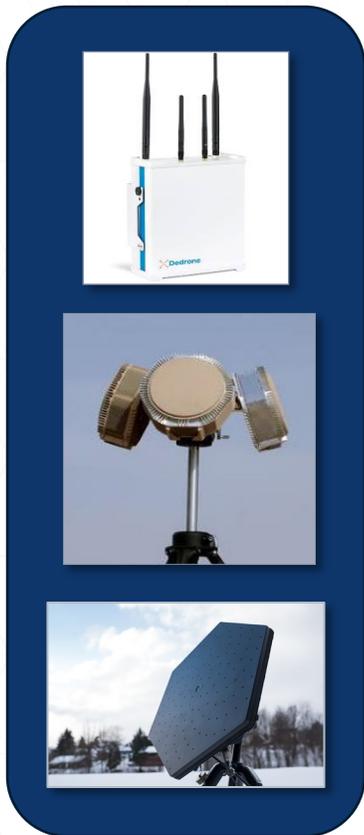


- Under ideal conditions, at what range can you reliably detect and classify a small UAS (e.g. DJI Mavic)?
- Can the camera auto track a UAS target once identified?
- Does the camera have low-light or nighttime capabilities?
- What is the optical zoom of the camera?

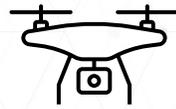


- What is the detection range of a single node under ideal and non-ideal conditions?
- How many nodes can be networked together?
- What UAS are in the acoustic library?

# Multi-modal systems



+



“Dark” drone:  
unknown RF protocol, or  
autonomous flight mode



Low radar cross section  
(RCS), but still noisy

In this example we see RF, radars, and acoustic sensors working together to provide a more **robust** and **higher confidence** detection and geolocation of a UAS to cue a camera automatically and get a **visual confirmation** of the UAS threat for an operator.

Sensor Fusion can help facilitate layered defense and automate much of the processing chain. It can also reduce false alarms.

# C-UAS Mitigation



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# What is C-UAS Mitigation?

- Mitigate – Negate – Interdict – Neutralize: These four terms are often used interchangeably
- Mitigation describes the methods used to remove or reduce the threat posed by sUAS.
- It is generally the last step in the C-UAS processing chain



# Mitigation and State and Local Law Enforcement

The Department of Justice acting through the FBI, shall deputize SLTT law enforcement or correctional facility officers in the **FBI Joint Terrorism Task Forces (JTTF)**. All SLTT JTTF personnel operating mitigation technologies purchased or supported with C-UAS Grant Program funds must:

- Have JTTF personnel **trained at, or scheduled to be trained at, the Federal Bureau of Investigation's National Counter-UAS Training Center (FBI NCUTC)**. FEMA will verify registration with the FBI to ensure compliance with this requirement.
- Include proof of registration and, where applicable, certification with their grant application and maintain this documentation for compliance purposes. Equipment not in regular use, or used for unauthorized purposes, may be subject to recovery, and the recipient may be required to return grant funds. Documentation of usage and deployment must be maintained and submitted in performance progress reports.

# C-UAS Mitigation Techniques

- **Electronic attacks**

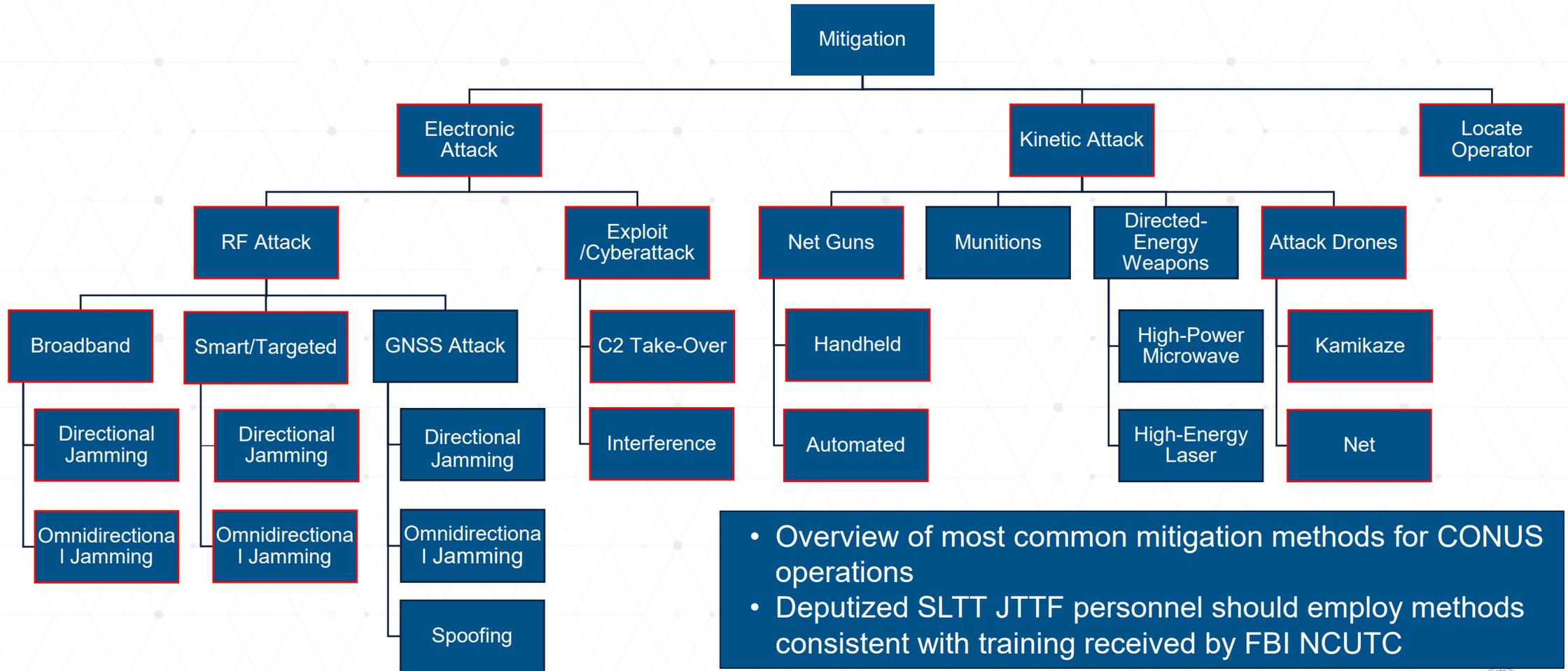
- Radio Frequency (RF)
  - Broadband Jamming
  - “Smart”/Targeted Jamming
  - ~~Global Navigation Satellite System (GNSS) Jamming and Spoofing~~
- Exploitation (Cyberattack)

- **Kinetic attacks**

- Net Guns
- ~~Munitions~~
- ~~Directed Energy Weapons~~
- Attack Drones

- **Locate Operator**

# Enumerating Types of C-UAS Mitigation



- Overview of most common mitigation methods for CONUS operations
- Deputized SLTT JTTF personnel should employ methods consistent with training received by FBI NCUTC

# Electronic Attacks

- Exploitation (Cyberattack)
- RF Attacks
  - Broadband Jamming
  - “Smart”/Targeted Jamming
  - GNSS



# Exploitation (Cyberattack/Hacking)

C-UAS that masquerade as a legitimate GCS signal through the exploitation of a weakness or bug in the communication protocol.

C-UAS can receive the communications from one participant (GCS) and prevent the other participant (aircraft) from receiving these communications. The C-UAS then has option to:

- Obtain sensitive data from the sUAS
- Eavesdrop in real-time
- Send Command & Control (C2) signals
- Augment reported telemetry information

Exploitation methods are highly dependent on the sUAS and communication protocol being exploited.

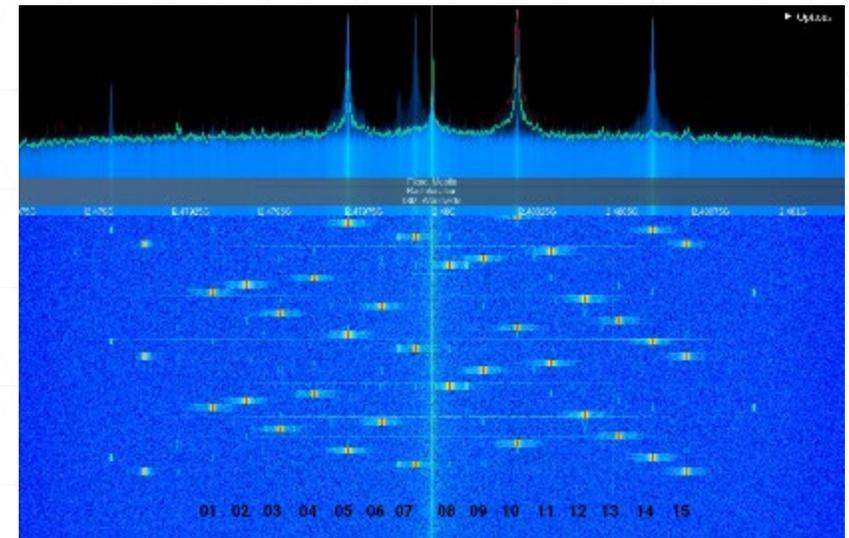
Collateral damage is very dependent on the nature of the mitigation method

- C2 take over can potentially allow a public safety officer to remotely land the aircraft in a safe area.
- Interference, depending on its nature, can lead to an aircraft crashing, landing immediately, or hovering in place.
  - Disabling operator video feed
  - Manipulating aircraft payload
  - Disabling on-board sensors
- Depending on air traffic volume of sUAS, ensuring accurate identification of the target sUAS can mitigate collateral impacts.

# RF Attacks: Broadband vs “Smart” Jamming

C-UAS that attempt to neutralize or mitigate a threat sUAS by disrupting the radio frequency link (C2 and/or telemetry) between the ground control system (GCS) and aircraft.

- **“Smart” (Targeted) RF Jamming:** An RF Jamming antenna transmits power in a manner that matches the exact modulation and frequency hopping pattern as the target sUAS but at much greater levels. This prevents the aircraft from receiving commands from the GCS and reduces collateral RF interference.
- **Broadband RF Jamming:** UAS frequencies are emitted indiscriminately from an RF jamming antenna across multiple channels of a single or multiple bands and at much greater power levels than the GCS. This prevents the aircraft from receiving commands from the GCS.



Smart RF jamming uses knowledge of the frequency hopping pattern to anticipate and “step” specific channels within a bandwidth at specific moments in time (order of milliseconds)

# Smart or Targeted RF Jamming

- Smart RF jamming systems attempt to mimic the exact frequency-hopping method and pattern used by a target sUAS and transmit at a higher power.
- This method prevents the aircraft from receiving the necessary commands from a ground controller while minimizing the RF collateral effects.
- Collateral impact depends on what bands are being jammed. **Disruptions may still occur to anyone else using those bands, but is less likely to occur, and perhaps less severe in nature than broadband jamming.**



# RF Broadband Jamming

Collateral impact depends on what bands are being jammed.

- ISM Bands (2.4 & 5.8 GHz)
  - Economic impact to the public
  - Communications impact to public
  - Critical infrastructure and public safety – Still rely on ISM bands (even though it is not a best practice)
    - C-UAS technologies, video streaming, enabling UAS
- Cellular Network
  - Economic impact to the public
  - Communications impact to public
  - Critical infrastructure and public safety – Still rely on cellular bands (even though it is not a best practice)
    - C-UAS technologies, video streaming, enabling UAS



# Kinetic Attacks

- Net Guns
- Attack Drones
- ~~Munitions~~
- ~~Directed Energy Weapons~~
  - ~~High Power Microwave~~
  - ~~High Energy Laser~~



# Net Guns and Attack Drones

Ranged weapon designed to shoot a projectile that deploys a net to ensnare a target UAS.

- **Man-portable:** aimed and fired by a human
- **Fixed or mounted:** aimed and/or fired automatically

Net guns tend to have shorter ranges. Reported ranges generally are between 0 and 300 meters.



UAS designed to chase and capture or intercept another target UAS.

- **Interceptor:** A sacrificial UAS that intends to crash into the target UAS
- **Net capture:** a UAS with an attached or deployed net system used to disable a target drone

Both types of UAS are likely to employ on-board tracking and targeting sensors to aid in their objective.



# Understanding Collateral Impacts

C-UAS operators need to understand the trade-offs between the mitigation methods employed and the potential unintended impacts to the surrounding environment

The surrounding environment will dictate the unintended impacts.

- Urban Environments
- Sports Stadiums
- Mass Gathering Events
- Airports
- Residential Areas
- Critical Infrastructure
- Prisons
- Rural Communities

# Locate Operator

The method most used by state and local first responders is to locate the ground controller and thus the operator, then request they land the target sUAS.

- Distracting and prolonging engagement (e.g., conversation) with a remote pilot could lead to delayed response and potentially erratic flight operations
- Remote pilots with malicious intent may accelerate their timetable for attack if approached by law enforcement.
- Law enforcement personnel should be cognizant of the flight path, surrounding area, sUAS payloads, and sUAS performance as they approach a remote pilot.

# C-UAS Equipment Test Results



# Counter-UAS Technologies

- Radars
- Radio Frequency (RF) Systems
- Electro-Optical Infrared (EO/IR) Cameras
- Acoustic Systems

Test and evaluation (T&E) of a counter unmanned aircraft system (C-UAS) technology is one government mechanism for evaluating this type of technology before major acquisition.

# Performance Metrics Explanation

Derived from Guidelines for Test and Evaluation of C-UAS Technologies, a joint DoD, DHS, NSC document

Metric	Question Metric Answers
Probability of Geolocation per Sortie	<b>Was the UAS geolocated at least once during a sortie?</b>
Overall Persistent Detection Rate (Without LOS Constraints)	<b>Ignoring line of sight conditions, over the entire duration (sampled at 1 Hz) of a sortie, what percentage of time did the C-UAS persistently and correctly detect the UAS?</b>
Persistent Detection Rate (With LOS Constraints)	Accounting for line-of-sight constraints and conditions, over the entire duration (seconds) of a sortie, what percentage of time did the C-UAS persistently and correctly detect the UAS?
Time to First Detection from Launch	From the moment a UAS is launched, how long did it take for the C-UAS to detect the UAS?
Time to First Geolocation within LOS	From the moment a UAS was within line of sight of the C-UAS, how long did it take for the C-UAS to detect the UAS?
Maximum Detection Range	<b>What was the maximum range at which the C-UAS detected a UAS?</b>
UAS Type Detection Count	Of the XX number types of UAS used during this event, how many were the C-UAS able to detect?
Track Accuracy	<b>On average, how accurate was the C-UAS ability to geolocate target UAS?</b>
Probability of Classification/Identification	For C-UAS that are capable of classification (i.e. aircraft type or protocol) or identification (make/model or mac address), how often did the system correctly classify/identify the UAS?

# C-UAS Radar Technologies

# Radars Tested (2021-2025)

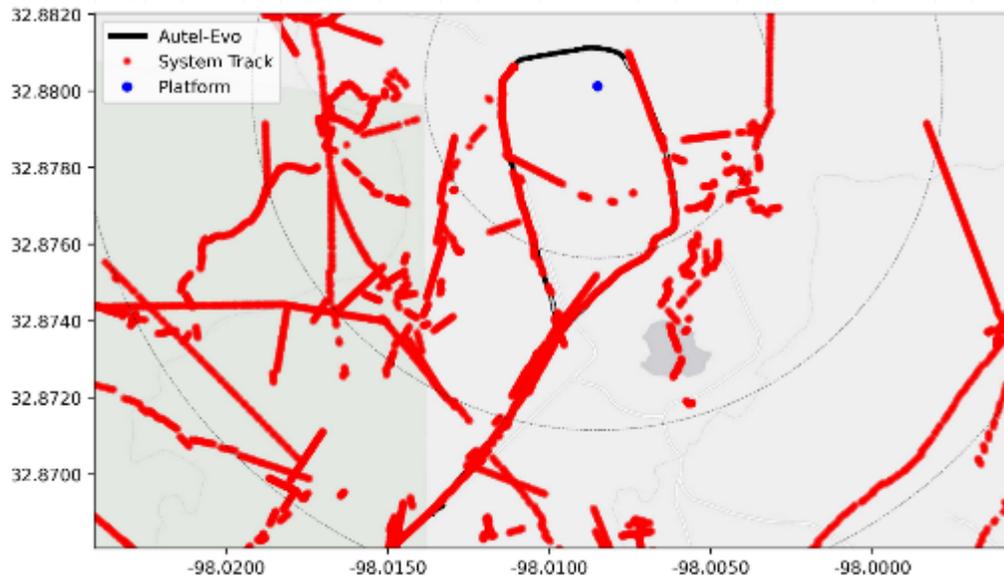
Event	Radars Evaluated
Capability Optimization Research Environment (CORE) II (2025)	<ul style="list-style-type: none"> <li>MatrixSpace</li> <li>Fortem R40</li> <li>OWL GA7360 Radar</li> </ul>
Customs and Border Protection (CBP) Border Operations (2024)	<ul style="list-style-type: none"> <li>Fortem R-30 TrueView</li> </ul>
Capability Optimization Research Environment (CORE) I (2024)	<ul style="list-style-type: none"> <li>Fortem R-30 TrueView</li> <li>Leonardo DRS RPS-42</li> <li>Numerica Spyglass Radar</li> <li>Elbit MATR-X</li> <li>SRC Gryphon R1410</li> <li>Teledyne FLIR Ranger R20SS 3DS</li> <li>Robin Radar IRIS</li> </ul>
Ridgeback (2024)	<ul style="list-style-type: none"> <li>Weibel Radar XENTA-D3</li> </ul>
Ohio State University (OSU) Swarm Test (2023)	<ul style="list-style-type: none"> <li>Robin Radar IRIS</li> </ul>
Bradford Urban Assessment (2022)	<ul style="list-style-type: none"> <li>EchoDyne EchoGuard</li> </ul>
Air Domain Awareness (2021)	<ul style="list-style-type: none"> <li>Rafael (RSGS) Leonardo RPS-42</li> <li>EchoDyne EchoGuard</li> <li>Elbit MATR-X</li> <li>Teledyne FLIR Ranger R20SS 3DS</li> <li>Fortem R-30 TrueView</li> <li>Hensoldt Spexer 2000</li> <li>SRC Gryphon R1400</li> <li>Thales Gamekeeper 16U</li> </ul>

# C-UAS Radar Detection Range

	Manufacturer	Radar Name	Detection Range Group 1 sUAS, vendor claim	Max Measured Detection Range from DHS test event	Weight (Radar Only)
<b>Short Range (0 - 2.5 km)</b>	MatrixSpace	<b>MatrixSpace Radar</b>	~ 1 km	Available	<4.5 kg
	Echodyne	<b>EchoGuard</b>	1–1.4 km	Available	1.25 kg
	Fortem	<b>R-30 TrueView</b>	2.5 km	Available	5.4 kg
	OWL (Dynetics)	<b>GroundAware 7360 3D</b>	2.5 km	Available	47.6 kg
<b>Mid-Range (3 - 5 km)</b>	Teledyne FLIR	<b>Ranger R20SS 3DS</b>	3 km	Available	17.5 kg
	Echodyne	<b>EchoShield</b>	2.8– 4.8 km	N/A	17.8 kg
	Fortem	<b>R-40 TrueView</b>	>3 km	Available	N/A
	Elbit	<b>MATR-X</b>	4.8 –6.2 km	Available	27 kg
	Leonardo DRS	<b>RPS-42</b>	5 km	Available	30 kg
	Robin Radar	<b>IRIS</b>	5 km	Available	29 kg
	Numerica/Anduril	<b>Spyglass</b>	5 km	Available	27 kg
<b>Long Range (&gt; 5 km)</b>	SRC	<b>Gryphon R1410</b>	7.7 km	Available	36.5 kg
	Weibel	<b>XENTA-D3</b>	~10 km	Available	>50 kg

# Example #1: Short Range Phased Array Radar

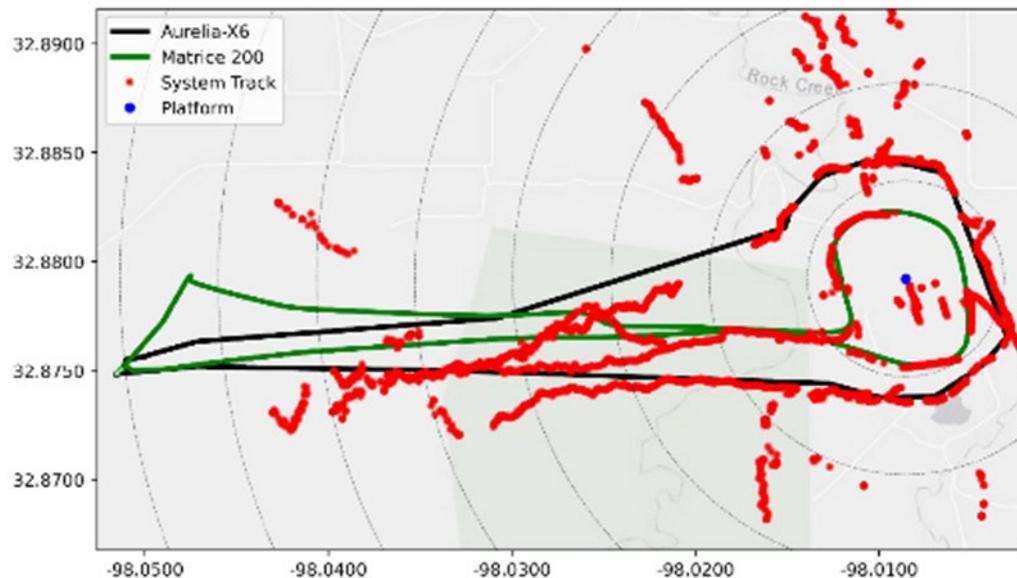
- 3D phased array radar
- Identification is performed by a machine learning model that considers factors such as micro-doppler reflections, velocity, Radar Cross Section (RCS), etc.
- Low relative cost & SWaP



Metric	Result
<b>Probability of Geolocation per Sortie</b>	<b>65%</b>
Overall Persistent Geolocation Rate (Without LOS Constraints)	22978 / 109755 21%
Persistent Geolocation Rate (With LOS Constraints)	22978 / 42459 54%
Time to First Geolocation from Launch (seconds)	Median   Mean 190   256
Time to First Geolocation within LOS (seconds)	Median   Mean 31   57
<b>Maximum Geolocation Range (meters)</b>	<b><u>4924</u></b>
UAS Type Geolocation Count	9 out of 9
<b>Track Accuracy (meters)</b>	<b>14</b>
Probability of Classification/Identification	20 / 132 11%

# Example #2: Combined Radar & Electro-Optical/InfraRed

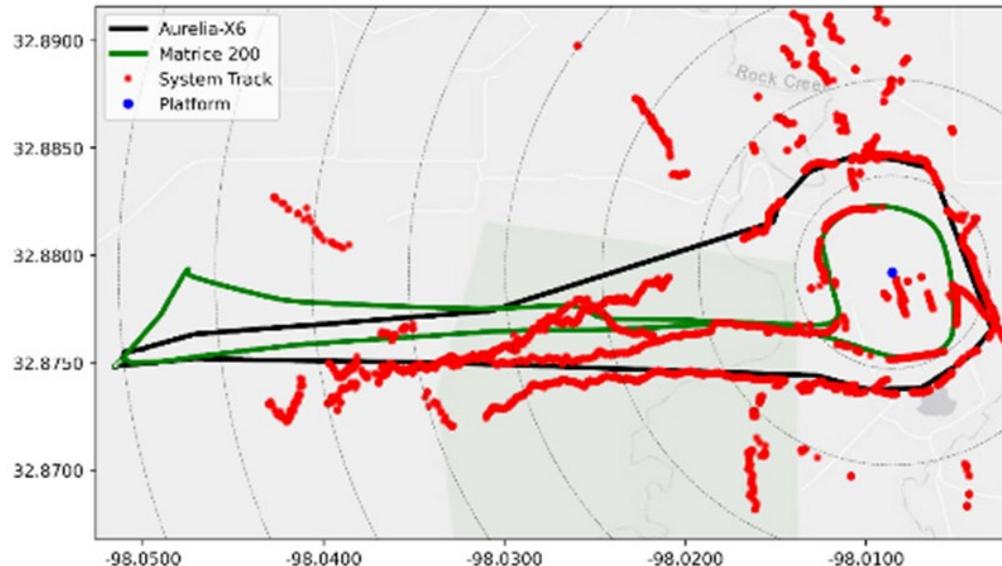
- X-band rotating radar
- 360° coverage
- Combined with an EO/IR camera with slew-to-cue capability



Metrics	Radar	Camera
Number of Detections	67	57
Number of Opportunities	112	112
<b>Probability of Detection</b>	<b>60%</b>	<b>51%</b>
Number of Classifications	66	57
Number of Classification Opportunities	112	112
<b>Probability of Classification</b>	<b>59%</b>	<b>51%</b>
Track Accuracy* (meters)	15	16
Time Tracked in Window* (seconds)	5246	2242
Time Observed in Window* (seconds)	31020	31020
<b>Probability of Track*</b>	<b>17%</b>	<b>7.2%</b>
<b>Automated Slew to Cue available</b>	<b>Yes</b>	

# Example #3: Combined RF & K-band Radar

- An omnidirectional passive RF detection sensor that provides real-time classification of drones.
- A dual-mode radar, lightweight and power-efficient, operating on a mini solar panel.



Metric	RF Results	Radar Results
<b>Probability of Geolocation per Sortie</b>	<b>73%</b>	<b>53%</b>
Overall Persistent Geolocation Rate (Without LOS Constraints)	21963 / 92137 24%	2022 / 69114 2.9%
Persistent Geolocation Rate (With LOS Constraints)	21963 / 59468 37%	2022 / 34190 5.9%
Time to First Geolocation from Launch (seconds)	Median   Mean 160   224	Median   Mean 314   367
Time to First Geolocation within LOS (seconds)	Median   Mean 3   69	Median   Mean 122   170
<b>Maximum Geolocation Range (meters)</b>	4514	1228
<b>UAS Type Geolocation Count</b>	<b>9 out of 9</b>	<b>9 out of 9</b>
<b>Track Accuracy (meters)</b>	<b>10.6</b>	<b>15.8</b>
Probability of Classification/Identification	N/A	N/A

# C-UAS RF Technologies

# NUSTL C-UAS RF Assessments

- The subsequent slides provide an overview of NUSTL's past performance results from various test events involving C-UAS RF technologies.
- The events listed on the next slide took place between 2021 and 2025.



# RF Tested (2021-2025)

Event	RF Sensor Evaluated
Capability Optimization Research Environment (CORE) II (2025)	<ul style="list-style-type: none"><li>• Axon Dedrone RF-310</li><li>• ATSC Cadence XS</li><li>• EXFO SkyHawk</li><li>• iCR Mini Banshee</li><li>• MyDefence Wolfpack</li><li>• R2 Wireless ODIN</li><li>• Sentrycs Horizon</li><li>• Skycope SkyEye and SkyMini</li><li>• Vorpal VigilAir</li></ul>
NYPD US Open (2023)	<ul style="list-style-type: none"><li>• Dedrone RF-160 &amp; RF-360</li></ul>
Bradford Urban Assessment (2022)	<ul style="list-style-type: none"><li>• Aerial Armor</li><li>• Dedrone RF-160/RF-360</li><li>• D-Fend</li><li>• Skyview</li></ul>
Air Domain Awareness (2021)	<ul style="list-style-type: none"><li>• CACI Corian</li><li>• CRFS RFEye</li><li>• Droneshield RF One</li><li>• Hensoldt SkyScan</li><li>• iCR Banshee</li><li>• Titan</li></ul>

# C-UAS RF Detection Range

Manufacturer	System Name	Detection Range Group 1 sUAS (Optimal Under Test), Vendor Claim	Max Measured Detection Range	Weight
Aerial Armor	Aerial Armor	50 km	Available	
DroneShield	DroneSentry-X MK2	4 km	N/A	
Axon	Dedrone RF-310	2–5 km	Available	
D-Fend	EnforceAir	5 km	Available	
Skyview	MPV2	5 km	Available	2.5 kg
BlueHalo	Titan	5+ km	Available	
Axon	Dedrone RF-310	2–5 km	Available	
MyDefence	Wolfpack	6 km	Available	5 kg
ATSC	Cadence XS	6 km	Available	
CRFS	RFEye	7 km	N/A	2.4 kg
EXFO	Skyhawk	4–8 km	Available	12 kg
DroneShield	RFOne MKII	8 km	N/A	
Axon	Dedrone RF-560	8–10 km	Available	
iCR	Mountain Banshee	10 km	N/A	
iCR	Mini Banshee	10 km	Available	8 kg
R2 Wireless	ODIN	12 km	Available	
Vorpai	VigilAir	4 –6 km (20 km)	Available	40 kg
Sentrycs	Horizon	25 km	Available	
Skycops	SkyEye	7+ km (35 km)	Available	9.5 kg
Skycops	SkyMini	7+ km (35 km)	Available	9.5 kg

# C-UAS Equipment Selection Considerations Tool

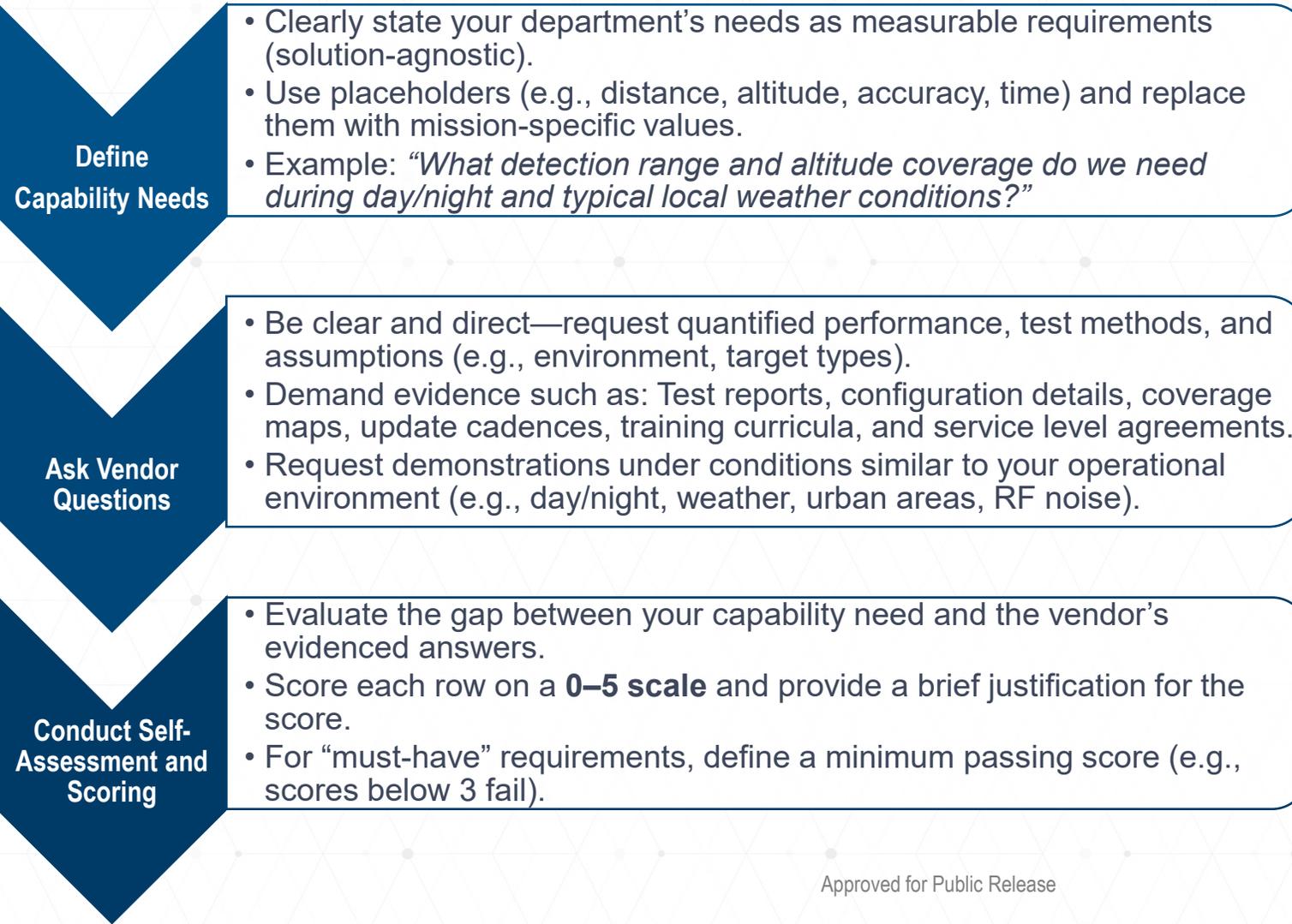


[NUSTL Home Page](#),  
Resources → C-UAS T&E Materials

# Purpose and Overview

- This tool helps first responder agencies make evidence-based, vendor-neutral decisions when acquiring counter-unmanned aircraft systems (C-UAS) detection systems.
- It aligns your mission needs with what vendors can reliably deliver and turns that into a consistent score you can compare across vendors.
- This set of rubrics is a starting point—not an exhaustive or prescriptive list.
- It is configurable:
  - You can choose to add or remove categories, questions and line items.
  - You can assign weights to whole categories or specific questions
  - Mark “knockout” criteria (e.g., any vendor with a score of 0 on a must-have item is removed from consideration).

# Approach and Categories



# Sample Questions

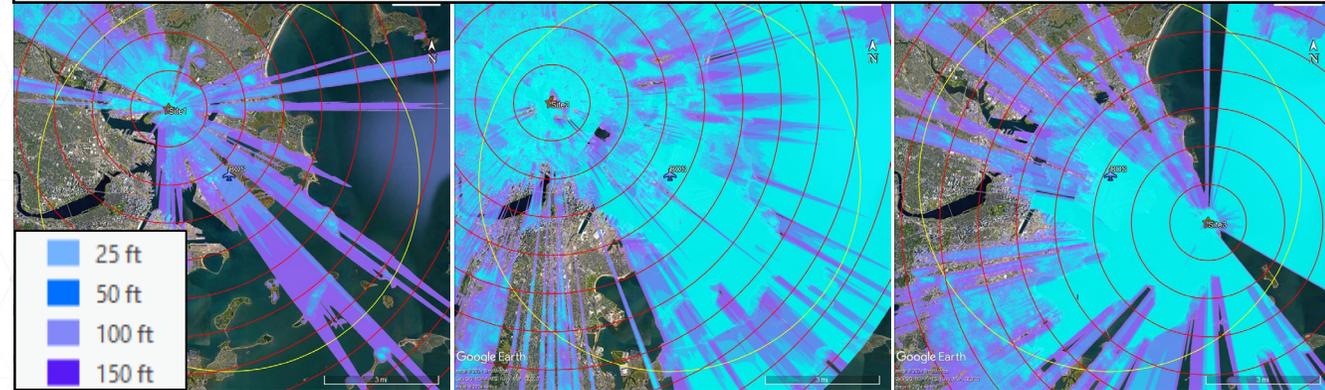
Category	Question or Statement	Documented Answer	Score (0-5)
<b>Capability needs</b>	Which specific UAS types (multirotor, fixed -wing, VTOL) and weight/size classes must our C-UAS reliably detect in our area of operations—and which can be deprioritized or out of scope? Document the thresholds (e.g., <250 g, 250 g–2 kg, >2 kg), representative examples, and any mission- specific- exceptions.		
<b>Vendor Questions</b>	What UAS types and sizes does the system reliably detect, and what does it not detect?		
<b>Self-assessment</b>	The system detects the UAS types and sizes we care about in our environment.		
<b>Capability needs</b>	Which system functions must be configurable to align behavior with our standard procedures and guidance, and what default settings and safeguards should be in place for operators?		
<b>Vendor Questions</b>	Which functions inspect or log message contents, and can they be disabled or configured to meet policy?		
<b>Self-assessment</b>	Content inspection and logging controls align with our procedures and guidance.		
<b>Capability needs</b>	What open interfaces do we require for data access and system control, and which common data formats must be supported (for example, web services, message bus, file export, machine-readable text)? Document the specific endpoints or feeds, the actions we need to perform, and the data schemas we will accept.		
<b>Vendor Questions</b>	What open interfaces are provided for data access and control, and which data formats are supported?		
<b>Self-assessment</b>	Interfaces and formats support our integration requirements without custom workarounds.		

# NUSTL Deployment Planning & Support

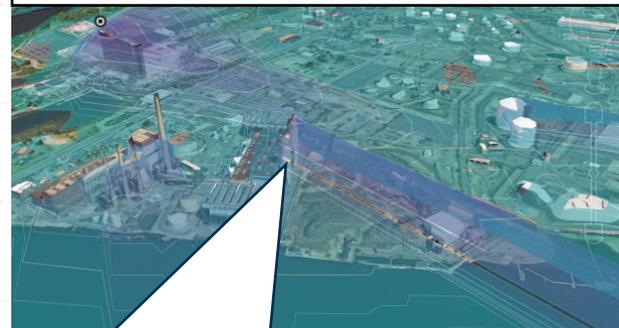
# Sensor Placement Support: LOS Analysis

- **Map-based analysis:** Important for effective sensor deployment and deconfliction between onsite operators.
- **Limitations of DTI Sensors:** Most C-UAS detect, track, and identify (DTI) sensors require line-of-sight (LOS) to function properly, which can be obstructed by terrain, vegetation buildings and other structures.
- In urban areas sensor installation site accessibility, security and presence of numerous types of obstructions complicate sensor deployment.
- Detailed LOS analysis using high-resolution LiDAR height maps (Digital Surface Models or DSMs) is critical for selecting sensor sites with optimal coverage.
- NUSTL assists in sensor site selection using advanced internal modeling tools.
- **LiDAR Data:** NUSTL sources, converts, and combines recent LiDAR data from several government, other platforms
- Results are exported as files compatible with Google Earth and ArcGIS Pro for visualization and operational planning. Reports and analysis are tailored to meet specific operational requirements.

What a difference proper sensor placement makes:  
Comparison of viewsheds of different sensors for the same area



3D shadow in KML format



3D shadow of smokestack demonstrating obstruction of view for targets at certain altitudes

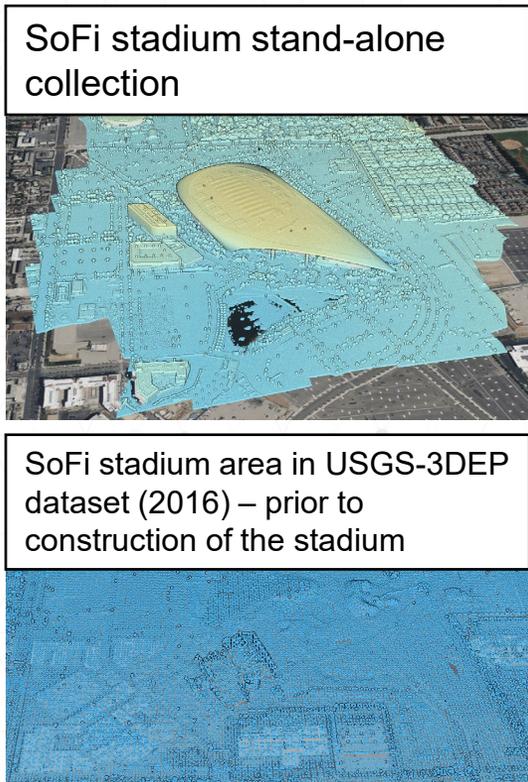
Importing/consolidation of relevant height map data



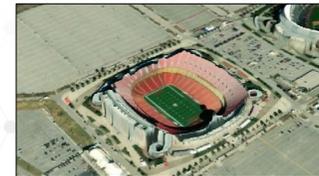
SoFi stadium

# Combining Recent LIDAR Data

- Current high-resolution height maps are critical for accuracy LOS calculation
- The availability of LiDAR varies in availability and recency
- To create current maps for analysis combination of various sources is necessary



Seattle, WA  
Lumen Field



Kansas City, MO  
Arrowhead Stadium



Boston, MA  
Gillette Stadium



East Rutherford, NJ  
MetLife Stadium



San Francisco, CA  
Levi's Stadium



Dallas, TX  
AT&T Stadium



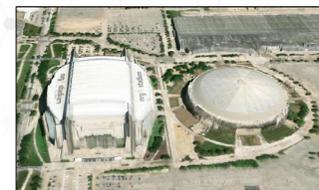
Atlanta, GA  
Mercedes Stadium



Jersey City, NJ  
Liberty State Park



Inglewood, CA  
SoFi Stadium



Houston, TX  
NRG Stadium



Miami, FL  
Hard Rock Stadium



Philadelphia, PA  
Lincoln Financial Field

# Sensor Placement Support: Reverse LOS Analysis

- Identifies potential installation sites by analyzing wide-area coverage.
- Starts with hypothetical target locations that must be visible, finds regions with most visible target location
- Results in small regions (mostly rooftops) as candidate sites
- Effective for finding sites in a large area with intent of covering multiple venues

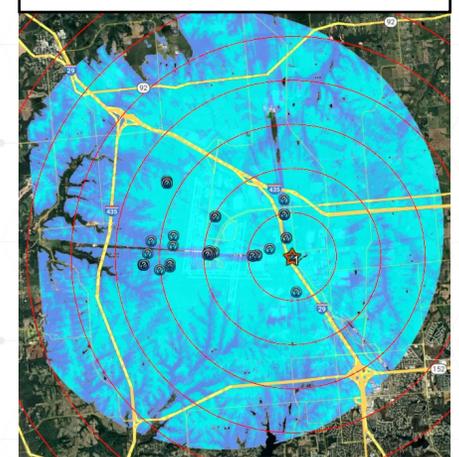
Counting LOS to a group of test points in the ROI yields heatmap highlighting candidate sites in wide area



Heatmap highlights small regions typically building roofs



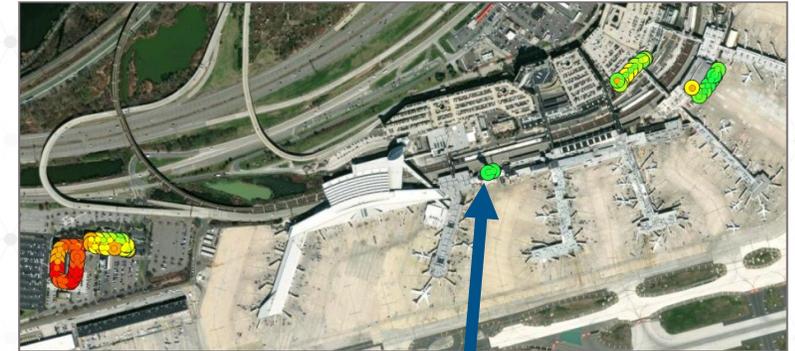
Example coverage from a candidate site



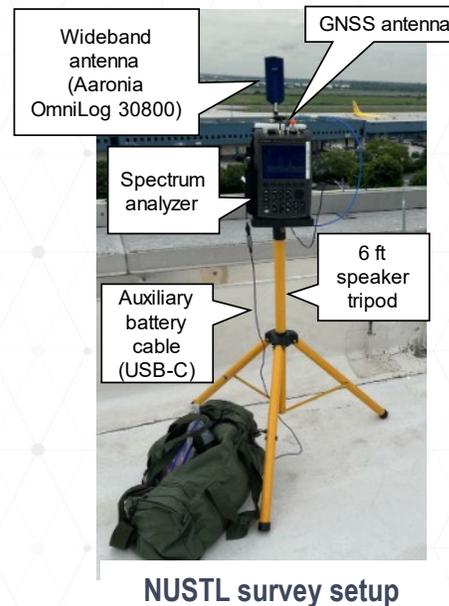
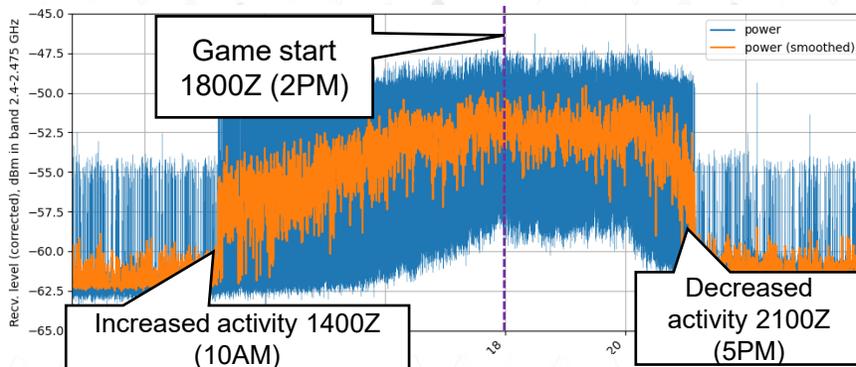
# Sensor Placement Support: RF Surveys

- Passive RF-based C-UAS sensors are affected by background RF interference, impacting range and localization precision.
- Avoiding sites near strong RF transmitters improves sensor performance.
- NUSTL developed tools and procedures to measure RF noise and activity levels relevant to C-UAS sensors.
- Background RF activity can increase dramatically during mass gathering events if sensors are placed within the venues hosting the crowds, close to cellular base stations or other transmitters (Wi-Fi, point-to-point radio link etc.)

Color-coded interference level map (green-yellow-red)

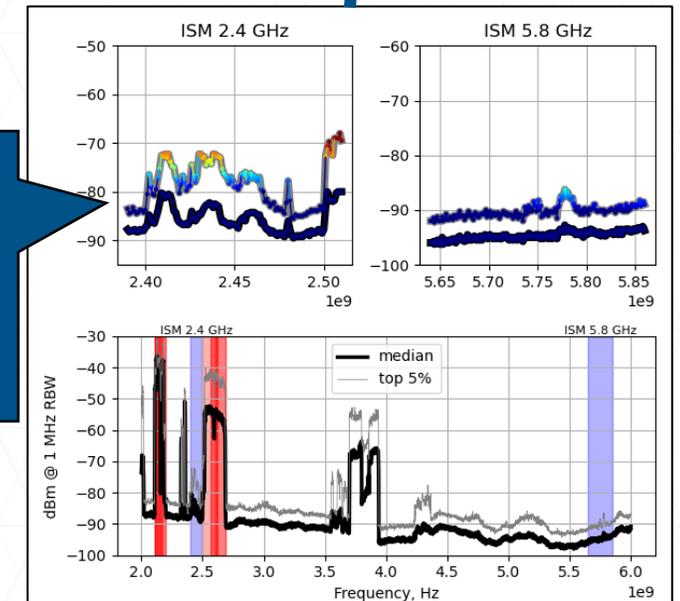


Typical RF interference levels during a mass gathering for a receiver located within a stadium: Increase of 10 dB shown here likely reduces the sensor range to about 30%



NUSTL survey setup

Median and top 5% levels colored by severity of interference



# Q&A

[ SCIENCE AND TECHNOLOGY DIRECTORATE ]

# Engage with us:



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[www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory](http://www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory)



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# ACRONYMS

- C2 – command and control
- C-UAS – counter-unmanned aircraft systems
- CBP – U.S. Customs and Border Protection
- DOD – Department of Defense
- COPC – Cloud Optimized Point Cloud
- CORE – capability optimization research environment
- DSM – digital surface model
- DJI – Shenzhen Da-Jiang Innovations Sciences and Technologies Limited
- DTI – detection, tracking, identification
- DTIM – detection, tracking, identification, mitigation
- EO/IR – electro-optical / infrared
- FAA – Federal Aviation Administration
- FCC – Federal Communications Commission
- FEMA – Federal Emergency Management Agency
- GHz – GigaHertz
- GNSS – Global Navigation Satellite System
- Hz – Hertz
- KMZ – Keyhole Markup Language Zipped
- JTTF – Joint Terrorism Task Forces
- LiDAR – light detection and ranging
- LoS – line of sight
- N/A – not applicable
- NCUTC – National Counter-UAS Training Center
- NUSTL – National Urban Security Technology Laboratory
- NYPD – New York City Police Department
- RCS – radar cross section
- RF – radio-frequency
- S&T – Science & Technology Directorate
- SNR – signal to noise ratio
- sUAS – small unmanned aircraft system
- T&E – test and evaluation
- Z – Zulu time, or Coordinated Universal Time