C-UAS System – Concept and Architecture

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Secretary - EUROCAE WG-115

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Introduction

- Developing C-UAS Standards
  - Secretary of EUROCAE WG115, and RTCA 238
  - Convener of ISO TC20/SC16/WG8
  - Member ISO TC20/SC16 CAG
- Chief Technology Officer for Operational Solutions Ltd
- Founder and CEO of Nexus Nine Ltd
- 35 years experience within Aviation, Security, and Defense sectors

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C-UAS Concept

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"A C-UAS system is a comprehensive system of systems that is designed to detect, track, identify (DTI) and provide information to support mitigation of the risk posed by unmanned aircraft operating in a designated area."

- It comprises several complementary components, each with its own specific function, that collectively provide comprehensive coverage against UAS threats.

Detection	Responsible for detecting UAS within the designated area of protection.
Tracking	The C-UAS system enhances the information from the sensor(s) to provide a comprehensive real-time understanding.
Identification	The C-UAS system will correlate identity information to support the distinction between friendly and hostile UAS.
Alerting	Provides alerts to the C-UAS operator and relevant authorities when a UAS has been classified as a risk.
Mitigation	Provides a means of response in order to mitigate the UAS that is posing a threat.

C-UAS Architecture

- A C-UAS DTI system is expected to include functions for:

Detection: This function is based on one or more types of surveillance sensors, such as radar, lidar, cameras, thermal and acoustic sensors or radio-frequency detectors.

Tracking: The tracking function enhances data from the sensor(s) and provides a consolidated state vector (“track”) for the detected UAS.

Identification: This function identifies unmanned aircraft, taking into account available identity metadata, and includes this information into the track of the detected UAS.

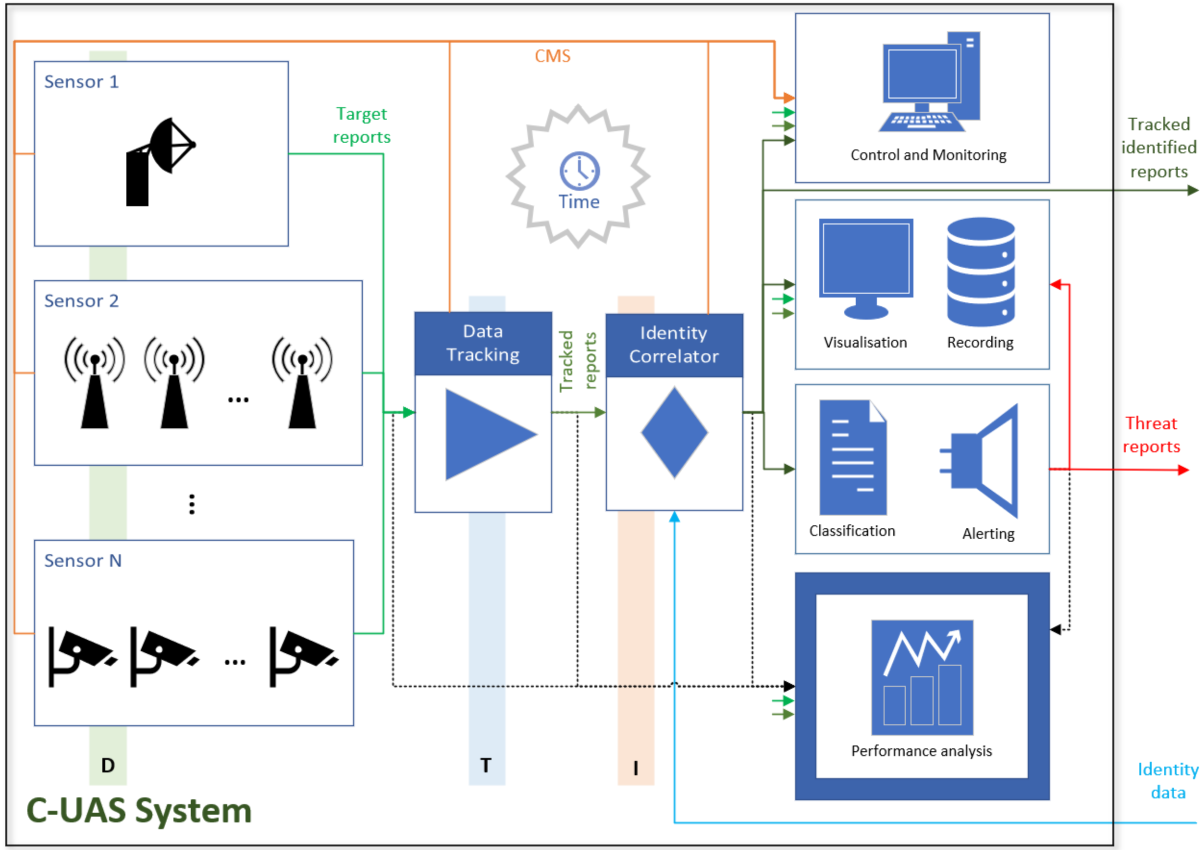
Classification: This function identifies the target reports associated with UAS and enables the sorting of the detected UAS based on their type, size, material, speed and other characteristics.

Alerting: The alerting function reports the presence of any identified unmanned aircraft that may pose a threat in a designated area, according to the predefined alerting parameters.

Control and Monitoring: This function manages the settings and status of the C-UAS DTI system and ensures that it is functioning properly.

Recording and Visualization: This function records historical data and provides visualisation tools to observe the data.

Performance Analysis: This function monitors the system performance in real-time and provides tools to analyse the compliance with the performance requirements.



C-UAS DTI system can be treated as a "black box", allowing freedom to combine components as required, as long as the Minimum Performance Requirements are met at the reporting output interfaces.

C-UAS Performance metrics

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- The following performance metrics are considered essential in evaluating the effectiveness and efficiency of a C-UAS system to perform its function.
  - Probability of update of position
  - Accuracy of position
  - False surveillance reports
  - Delay in surveillance reports

Each performance metric can be applied to each reporting output of the CUAS system.

C-UAS Sensor Technology

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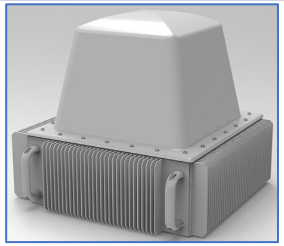
- A C-UAS DTI system uses sensors and data feeds to determine the existence, position and movement of UAS.
- Each sensor technology has certain strengths and limitations for any given situation and should be selected accordingly.
  - The use of a layered approach of dis-similar sensors to achieve the required coverage is recommended
- Data feeds are provided by co-operative UAS or related systems:
  - Remote ID is / has been mandated for many UAS operations to enable UAS to identify themselves to other stakeholders.
  - Aeroscope is a proprietary signal provided by DJI platforms that can provides limited information about the UAS.
  - Some UAS include existing aviation co-operative identification systems such as ADSB, FLARM etc
  - UTM integration can provide planned and approved current UAS activity

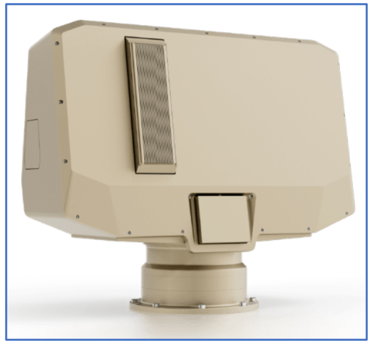
An effective CUAS system will consist of several different and complementary sensor / data feeds technologies

C-UAS RADAR Technology

- Radars transmit modulated electromagnetic waves and processes the reflected signals to detect the presence of a UAV.
- Key characteristics:
  - Typically operate in:
    - L,S band (also used for ATC),
    - X band (also used for ground movement and navigation)
    - K, W band (also used for short range ground movement)
  - Maximum range typically from 500m to 20km+
  - 2D or 3D geo localisation
  - Az /EL accuracy typically from 3° to >0.5°, and Range from 10 to 0.5m
  - Update rate from 0.3hz (mechanically rotating) to >10hz (solid state)
  - Can provide multiple detections over a wide area simultaneously
  - Cost ranges from $20k to >$1M+







Benefits

- Effective at detecting and tracking UAV over wide areas
- Useable in all light levels, most humidity, and rain (model dependant)
- May be able to classify detected object using track dynamics, AI and µDoppler

Considerations

- Actively transmits RF energy
- Requires spectrum management to deconflict

C-UAS Camera Technology

- EO cameras receive signals reflected or emitted from a UAV, and form an image which can be processed or interpreted by a Human.
- Key characteristics:
  - Typically operate in:
    - Visible band (daylight) with horizontal resolution typically ranging from 1280 to 3840 pixels
    - Near IR (low light) with horizontal resolution typically ranging from 704 to 2560 pixels
    - SWIR (high humidity) with horizontal resolution typically ranging from 640 to 1920 pixels
    - MWIR, LWIR (zero light) with horizontal resolution typically ranging from 640 to 1280 pixels
  - Maximum range typically from 500m to15km
  - 2D geo localisation (can be 3D if Laser Range Finder integrated)
  - Usually deployed as Visible and IR camera fitted to Pan and Tilt mount
  - Camera update rate typically 30hz to 60hz – specialist sensors exceed 100Hz
  - Typical FoV range from 11° Horizontal to <0.5° zoom lens
  - Cost ranges from $20k to $500k+





Benefits

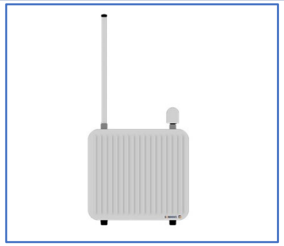
- Effective at tracking and classifying detected UAV, often using AI image recognition.
- Operates passively and discretely.
- Effective for Human interpretation, confirmation and providing evidence.

Considerations

- Requires compliance to privacy and GDPR legislation.
- Visible / Near IR band camera may not be effective in certain light levels or fog/ rain.
- IR cameras may not be effective in low temperatures or high humidity / rain.

C-UAS RF Technology

- RF Sensors receive and process electromagnetic waves emitted from the UAV or GCS in order to detect the presence of the UAS.
- Key characteristics:
  - Detection requires UAS type to be contained within library of know signals
  - Decoding relies on ESM/ cyber techniques to read the information contained within the signals
  - Typically operate in the following bands:
    - 433MHz
    - 868MHz
    - 915MHz
    - 2.4 GHz
    - 5.8GHZ
  - Maximum range typically from 300m to 15km+
  - 1D (Azimuth bearing) or 2D (Azimuth and Elevation bearing), or 3D (Geolocation if link decoded)
  - Bearing accuracy typically from 10° to >3° rms, Geolocation typically accurate to <10m
  - Update rate based on library size typical ranging from 30s to >1s.
  - Can provide multiple detections over a wide area simultaneously
  - Cost ranges from \$20k to >\$500k+



Benefits

- Effective at detecting and classifying UAS over wide areas
- Operates passively and discretely.
- Useable in all meteorological conditions
- May be able to classify detected object using RF signature or decoded data (depending on model)

Considerations

- Requires compliance to Radio, privacy, and computer misuse legislation.
- Library based system likely to require on going updates to remain effective against new threats.

C-UAS Acoustic Technology

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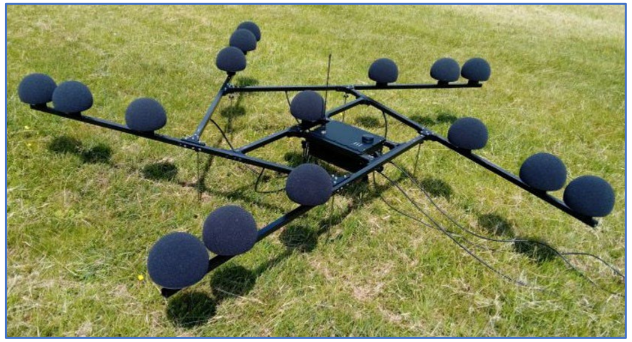
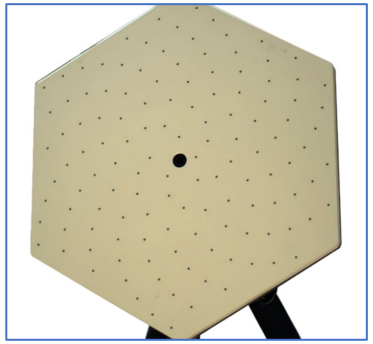
- Acoustic Sensors receive and process acoustic energy emitted by the propulsion system of the UAV.
- Key characteristics:
  - Maximum range typically from 200m to 1km
  - 2D (Azimuth and Elevation bearing)
  - Az accuracy typically <8, Elevation accuracy typically <10°
  - Update rate typically upto 10hz
  - Can provide multiple detections over a wide area simultaneously
  - Cost ranges from \$20k - \$100k





- Benefits
  - Effective at detecting and classifying UAV over relatively short range
  - Operates passively and discretely.
  - Useable in all light levels, most humidity, and rain (model dependant)
  - Classifies detected object using acoustic signature

- Considerations
  - Relatively short range requires careful deployment.

C-UAS C2 Technology

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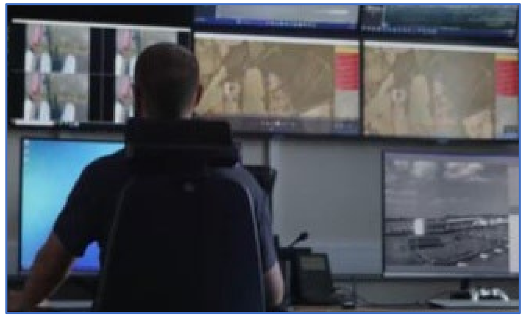

- **Data Tracking** uses correlation and fusion of data from multiple sensor sources (when available), to create the best version of the truth.
- **Classification** sorts the detected objects based on their type, size, material, speed, and other characteristics, to provide useful information for the alert function to identify potential threats.
- **Alerting** considers all the available information, including tracks, identity, and classification data, to assess when a UAS can be reported as a threat to a designated area.
- **Control and Monitoring** forms part of the UI (user interface) and enables an operator to monitor and control the system in real-time.
- **Visualisation** forms part of the UI and provides the C-UAS DTI system data in a graphical format, in real time.
- **Recording** allows the capturing and storing of data generated by a C-UAS DTI system for later analysis and review.

An effective C2 is key to achieving desired C-UAS system utility

C-UAS Standards

- EUROCAE . RTCA published document and work items:
  - ED-322 / DO-403 System Performance and Interoperability Requirements for non-cooperative UAS Detection Systems
  - ED-286 / DO-389 OSED for Counter-UAS in Controlled Airspace – currently being updated
  - ED / DO-XXX (new document) Interoperability Requirements for Counter-UAS systems

- ISO C-UAS work items:
  - ISO 16746 User Quality and Safety – guidance about the aspects to consider to specify a safe and effective C-UAS
  - ISO 16747 Manufactures Quality and Safety –guidance about the aspects to consider to design and manufacture safe and effective C-UAS components.
  - ISO 25461 Framework for detection, localization, and identification systems –guidance about generic CUAS architecture, functionality and components suitable for any user / domain audience (i.e. not use case specific)
  - ISO 25216 Categorization and classification of unmanned aircraft (UA) detection and countermeasure system - provide a means to “grade” CUAS components by functionality / performance suitable for any user / domain audience (i.e. not use case specific)

We need experts from all backgrounds to support our work, as Standards don’t write themselves!

IN CONCLUSION

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- A C-UAS system is a comprehensive system of systems that is designed to detect, track, identify (DTI) and provide information to support mitigation of the risk posed by unmanned aircraft operating in a designated area.
- A C-UAS DTI system can be treated as a "black box", allowing freedom to combine components as required, as long as the Minimum Performance Requirements are met at the reporting output interfaces.
- Each performance metric can be applied to each reporting output of the CUAS system.
- An effective CUAS system will consist of several different and complementary sensor / data feeds technologies.
- An effective C2 is key to achieving desired C-UAS system utility

Questions?

THANK YOU

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