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New Generation of Counter UAS Systems to Defeat Low Slow and Small (LSS) Air Threats

MSG-SET-183 | Jacco Dominicus | April 28, 2021

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- SCI-301 and its Background
- LSS Air Vehicles as a Threat
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- C-sUAS Systems

Personal introduction

- Jacco Dominicus
- MSc in Aerospace Engineering (Delft University of Technology)
- At NLR (Netherlands Aerospace Centre) since 2001
- Defence Operations Department – Principal R&D Manager
- Team Lead for Operational Employment & Weapon System Performance (~15 persons)
- Chair of SCI-301 “Defeat of Low, Slow and Small (LSS) Air Threats”

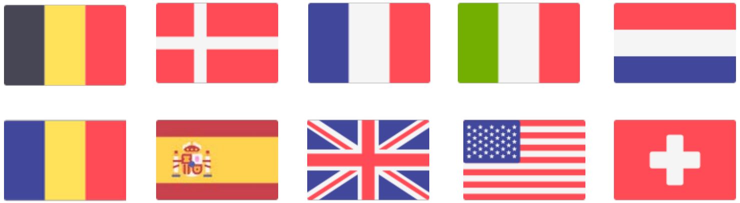
SCI-301 and its background

- NATO
- NATO STO (Science & Technology Organisation)
- NATO CSO (Collaboration Support Office)
- SCI (Systems, Concepts & Integration) Panel

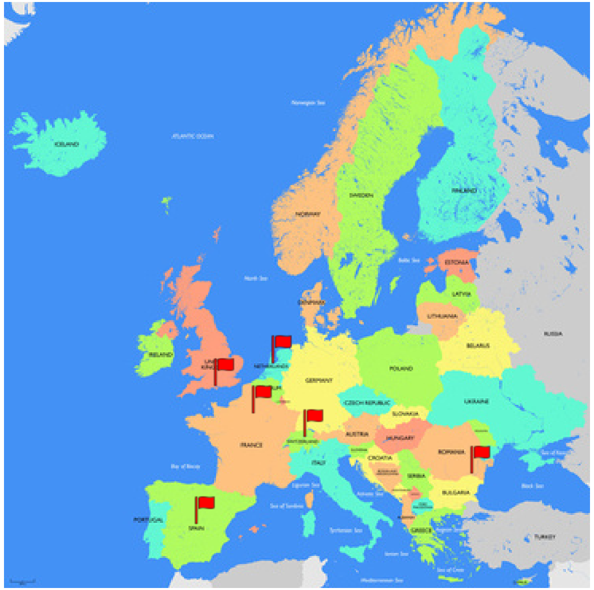
- 2010 – 2016: ET SCI-241 “Defence Against UAV Attacks”
- 2016: ET SCI-301 “Defeat of Low Slow and Small (LSS) Air Threats”
- 2017 – 2021: RTG SCI-301

SCI-301“Defeat of Low Slow and Small (LSS) Air Threats”

- TAD – Technical Activity Description
  - Assess 1st Generation C-UAS Systems
  - Propose 2nd Generation C-UAS Systems
- Participating nations:
  - Belgium, Denmark, France, Italy, the Netherlands, Romania, Spain, United Kingdom, United States
  - Switzerland
  - NATO JAPCC



SCI-301 Meeting Schedule



Meeting Schedule

1. CSO, Paris, France, June 2017
2. DSTL, Portsmouth, UK, November 2017
3. Madrid, Spain, June 2018
4. MOD, Bucharest, Romania, November 2018
5. NLR, Amsterdam, the Netherlands, April 2019
6. AFRL, Rome, New York, United States, October 2019
7. Armasuisse, Thun, Switzerland, February 2020

- Virtual meetings, April 2020 – Present

SCI-301Approach

- Four Teams:
  A. Threats Horizon Watch, Operational Analysis and Modelling & Simulation
  B. Novel Detection and Identification
  C. Future Effectors
  D. Networking and Autonomy
- Management Team Composition:
  - Chair
  - Co-Chair
  - Secretary
  - Editor-in-Chief
  - Team Leads
- Deliverables:
  - Interim report (2018)
  - C-sUAS 101 (2019)
  - Final report (Summer 2021)

LSS air vehicles as a threat

sUAS Characteristics:

- Small $\Rightarrow$ Hard to detect
- Easy to obtain (commercially available)
- Inexpensive, expendable
- Easy to modify
- Easy to operate
- Airpower (in a limited form) now available to everybody

sUAS Capabilities:

- ISR (reconnaissance, indirect fire support, etc.)
- Communications
- Weapon delivery
- Direct attack
- Collision with other air vehicles

Countering LSS air threats

- Process of countering sUAS:

1. Prevention
2. Detection/Tracking/Classification/Identification/Intent
3. Decision making
4. Intervention
5. Forensics

1. Prevention

- Regulations
  - Laws
  - Registration
  - Transponders
  - No-fly zones
  - Geofencing
- Non-proliferation?
- Intell?

2. Detection/Tracking/Classification/Identification/Intent

Means of detecting:

- Passive RF
- Active RF (i.e. Radar)
- Acoustic
- EO/IR
- LiDAR
- Others

Challenges:

- Small signatures
- Desire to detect at range (short timelines)
- Not only detection is required, but much more
- Detect, track, etc. multiple threats concurrently (no saturation)
- Low false alert rate (no false positives or negatives)
- Manpower requirements
- Desire to locate the UAS operator

3. Decision Making

Once a sUA (or more) has been detected, what to do depends on:

- The intention of the drone(s)
  - What type of drone is it?
  - What payload does it carry?
  - Where is it now and where is it going?
  - Who operates the drone?
  - Where is it operated from?
- The effects that one wants to achieve
- The effectors available
- An assessment of what happens when no intervention is performed
- An assessment of our intended action
- An assessment of the risks involved with the intervention

3. Decision Making

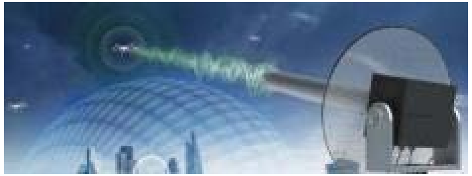
- Timelines for decision making are often short
- Rules Of Engagement (ROE) must be adhered to
- Good Common Operational Picture (COP) must be provided to decision makers
- Decision Support tools might provide assistance
- Automation?
  – Humans in-the-loop
  – Humans on-the-loop
  – Fully automated?
  – “Meaningful Human Control”
- Integration with current Command & Control systems and structures

4. Intervention

Desired or achievable effect not always to bring the drone down. Other effects may be:

- Monitor
- Deceive
- Deter
- Distract
- Deceive
- Disturb
- Delay

- Deny
- Take over control
- Capture
- Neutralise
- Degrade
- Destroy
- Go after the operator



4. Intervention

Effectors:

- RF Jamming & Spoofing
- GNSS Jamming / Spoofing
- Nets
- Jet streams
- Projectiles
- Lasers
- High Power Microwaves
- High intensity ultrasound
- Birds of prey
- Others...

Location:

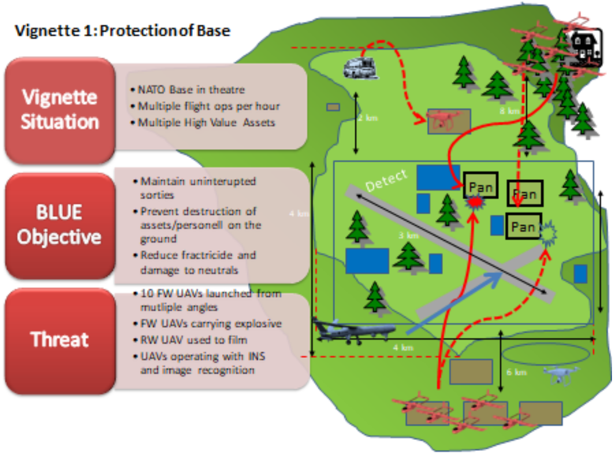
- Ground-based
  - Fixed
  - On a vehicle
- Hand-held
- On a drone (“hunter-killer drone”)

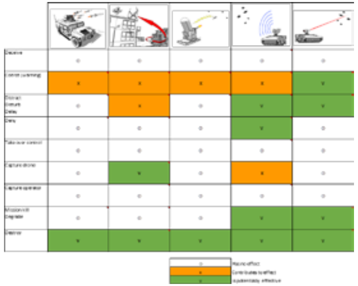
5. Forensics

- Assess effectiveness of intervention
- Assess effectiveness of adversary drone operation
- Determine:
  – What drone was used
  – How it was operated
  – Who operated it
  – Location where it was launched
  – What was its mission
  – What did it observe
  – What is now at risk
  – Etc.

SCI-301 Approach

- Six vignettes:
  1. Protection of Base
  2. Protection of Heavy Manoeuvre Force
  3. Armoured Manoeuvre
  4. Dismounted Forces
  5. Ship Navigating Narrow Strait
  6. Urban Warfighting
- Current systems were benchmarked against these vignettes
  – For Detection
  – For Effectors





0^{th} Generation C-sUAS Systems

- Existing Air Defence Systems
  - Ground based:
    - Small arms (machine guns, etc.)
    - MANPADS (Man Portable Air Defence Systems)
    - AAA (Anti-Aircraft Artillery)
    - Ground Based Air Defence Systems (GBAD): Radars, Missiles, etc.
  - Airborne:
    - Helicopters (e.g. Apache)
    - Fighter aircraft (e.g. Eurofighter, F-16)
- Pros:
  - Already acquired and in service
- Cons:
  - Not designed for sUAS as a target ⇒ may not be effective
  - Expensive & limited in numbers





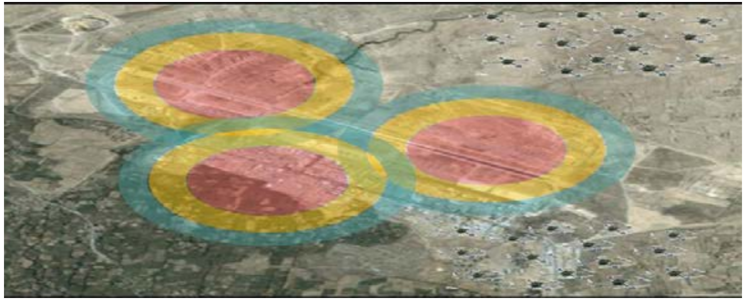

1^{st} Generation C-sUAS Systems

- Many RF-Based (>75%):
  – RF (datalink) Detection
    - Based on libraries of threats
    - Direction sensitive sensors for localisation
    - TDOA (requiring multiple antennas)
  – RF Jamming Effectors
  – RF Spoofing Effectors
- Pros:
  – Works against most commercially available drones
- Cons:
  – Possibility to manipulate the datalink
  – Future 5G systems will be a challenge
  – No capability to detect and effect autonomous drones

1st Generation C-sUAS Systems

- Radar & EO/IR Based Systems
  - Radar for initial detection
  - EO/IR sensor for further investigation
    - Eliminate false positives (e.g. birds)
    - Classification
    - Identification
  - Effector often RF jamming
- Current systems manpower intensive to operate
  - One operator per sensor

1st Generation C-sUAS Systems



Limitations:

- Sensing modalities lack range, probability of positive identification and accurate tracking
- Current systems still rely on man-on-the-loop RoE decision making and execution $\Rightarrow$ slow to react and respond
- Most current systems are not integrated in C2 infrastructure
- Many systems are incapable of addressing sUAS swarms of any type, or otherwise easily saturated
- Vendors are still focused on proprietary systems and not on modular systems that can be integrated with other solutions
- Current systems are expensive and do not address collateral damage risks

2^{nd} Generation C-sUAS Systems

- RF Detection & Effectors
  - Basis for UAS protection
  - Trend towards more sophisticated systems (better localisation, spoofing, taking over control, etc.)
- Radar & EO/IR combinations
  - AESA Radars / Millimeter wave radar / Multi-static / Passive / Micro-doppler
  - Automated detection
  - Complement with other sensors, e.g. Acoustic & LiDAR
  - Sensor fusion, e.g. by means of AI/ML

2nd Generation C-sUAS Systems

- Preparation
  - Intell
  - Planning
  - Training of personnel and AI algorithms
  - Laydown plan for detectors & effectors
  - Integrate and coordinate with others
- Decision Support
  - Common Operational Picture
  - Prioritisation of threats
  - Advice on effectors (desired effect & associated risk)
  - Autonomy:
    - Human-in-the-loop
    - Human-on-the-loop
    - Fully autonomous?

2nd Generation C-sUAS Systems

- Interoperability & integration
  - Standalone systems versus integrated systems
  - Make use of non-organic sensors and command & control (C2) systems
  - Standardisation
- Effectors
  - Multiple effectors per system
  - Matching effectors with the target and the threat

2nd Generation C-sUAS Systems

- Cost effectiveness
  - Classic systems and effectors are often expensive
  - Many are needed for sufficient coverage
  - Threats are cheap and expendable, may come in large numbers
  - Low-cost effectors needed, such as miniature hit-to-kill projectiles
- Directed Energy Weapons (DEW)
  - High Power Microwaves (HPM)
    - Damage electronics on their targets
    - Somewhat directional
    - Limited in range
  - High Energy Lasers (HEL)
    - Damage effect by local intense heating
    - Very directional
    - Operational systems
  - DEW Systems may be expensive, but low cost per shot

2^{nd} Generation C-sUAS Systems

- Saturation
  - System saturation
  - Operator saturation
  - Number of threats that can be detected and tracked
  - Number of threats that can be engaged
- Point Defence, Defence at Range & Area Defence
  - Range limitations are causing short timelines
  - Longer range detection and effectors are needed
- Hunter-killer drones
  - Can provide area defence
  - Serve both detection and effector role

2^{nd} Generation C-sUAS Systems

- Training
  - “Red Air”
  - Live-Virtual-Constructive (LVC)
  - Modelling & Simulation
- Upgradability
  - Keep pace with rapid threat developments
- R&D and Production
  - Research programs needed
  - Large industry geared towards making complex and expensive systems
  - Smaller industry has smaller R&D budgets and no experience in producing to military standards

2nd Generation C-sUAS Systems

- Acquisition processes
  - Many NATO country’s acquisition processes are not adequate to rapidly acquire new systems

2nd Generation C-sUAS Systems

Ultimate Goal: Deterrence

What deters?

- Operator must fear that operating the drone will endanger or otherwise negatively influence his life
- Operator must feel that operating the drone is futile or there is a high chance of losing valuable assets

How to achieve:

- Go after the operator
- Be extremely effective in your C-UAS efforts

Not easy to accomplish!

Conclusions

- Need something better than 1st Generation C-sUAS Systems
- No silver bullet available
- Collaboration is the key to success
- Need to address the hard challenges
  - Detection limitations
  - Positive identification / determine intent
  - ML/AI/Autonomy for rapid response, decision making, defeat determination & action
  - Innovative effectors
  - Integrated system-of-systems

Questions

¿?

Dedicated to innovation in aerospace

Fully engaged

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