UAS position tracking for sensor evaluation

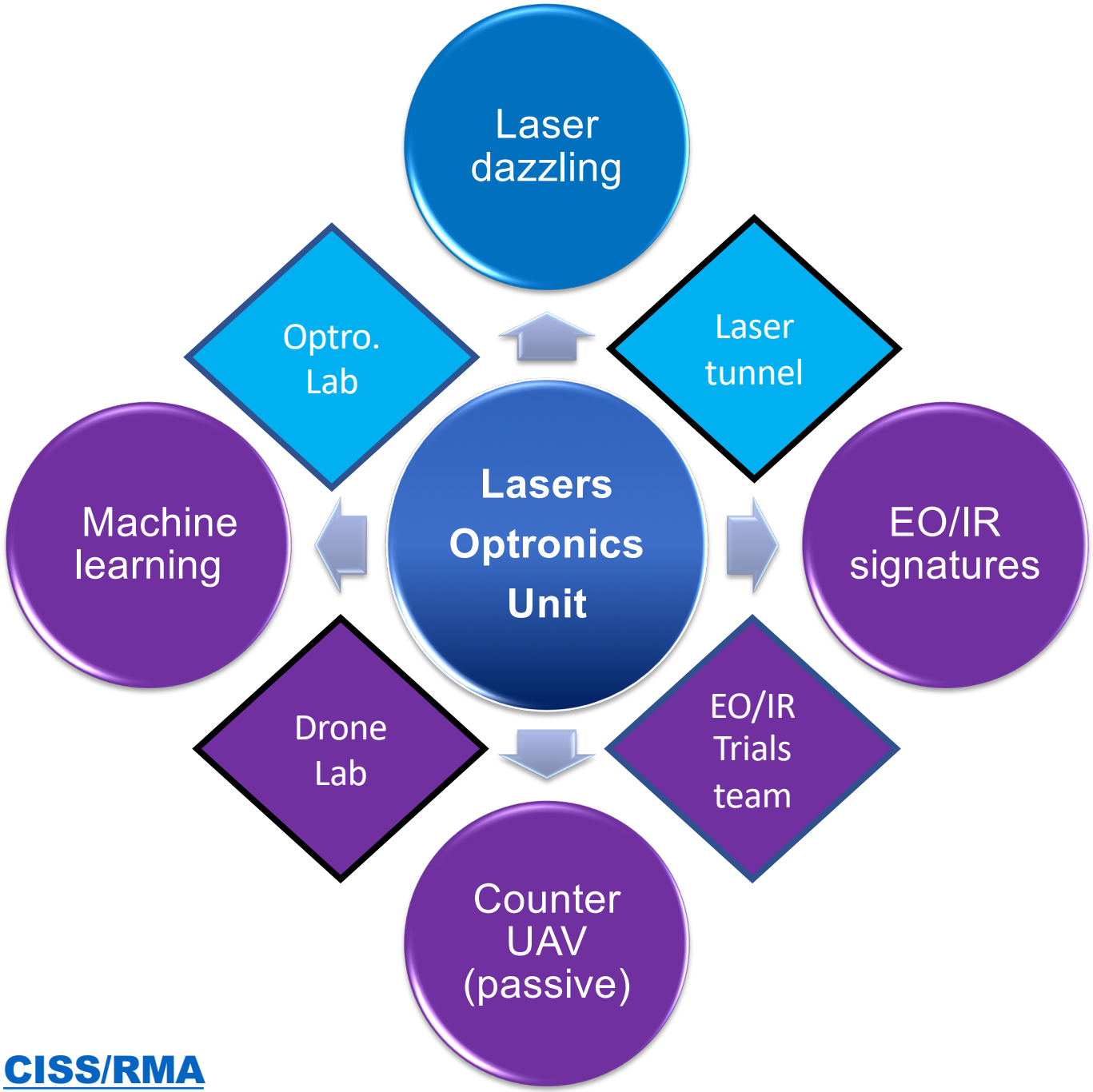
Alexander Borghgraef

Royal Military Academy
Laser and Optronics Research Unit

04/10/2022

CISS/RMA

RMA Brussels
Royal Military Academy

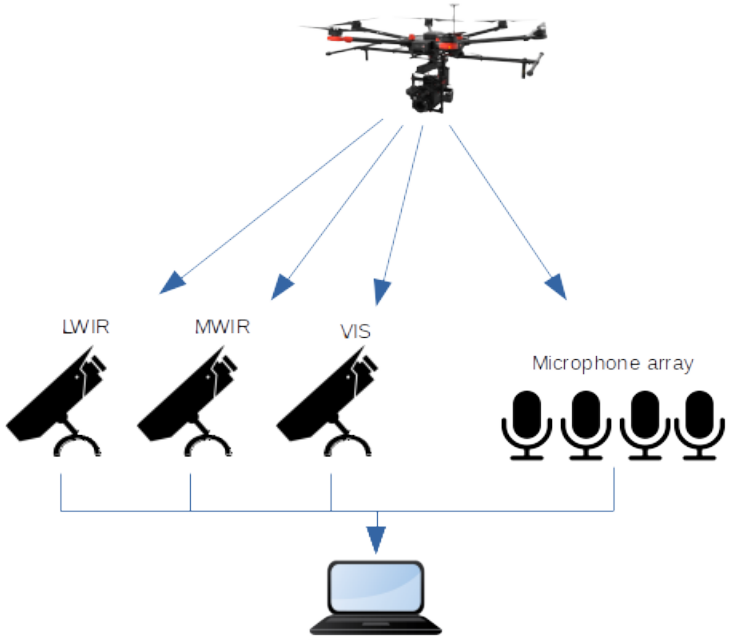


Laser & Optronics Research Unit

CISS/RMA

Royal Military Academy

UAS position tracking for sensor evaluation
The UAV Threat



CISS/RMA

RMA Brussels
Royal Military Academy

UAS position tracking for sensor evaluation
The SET260 Trial

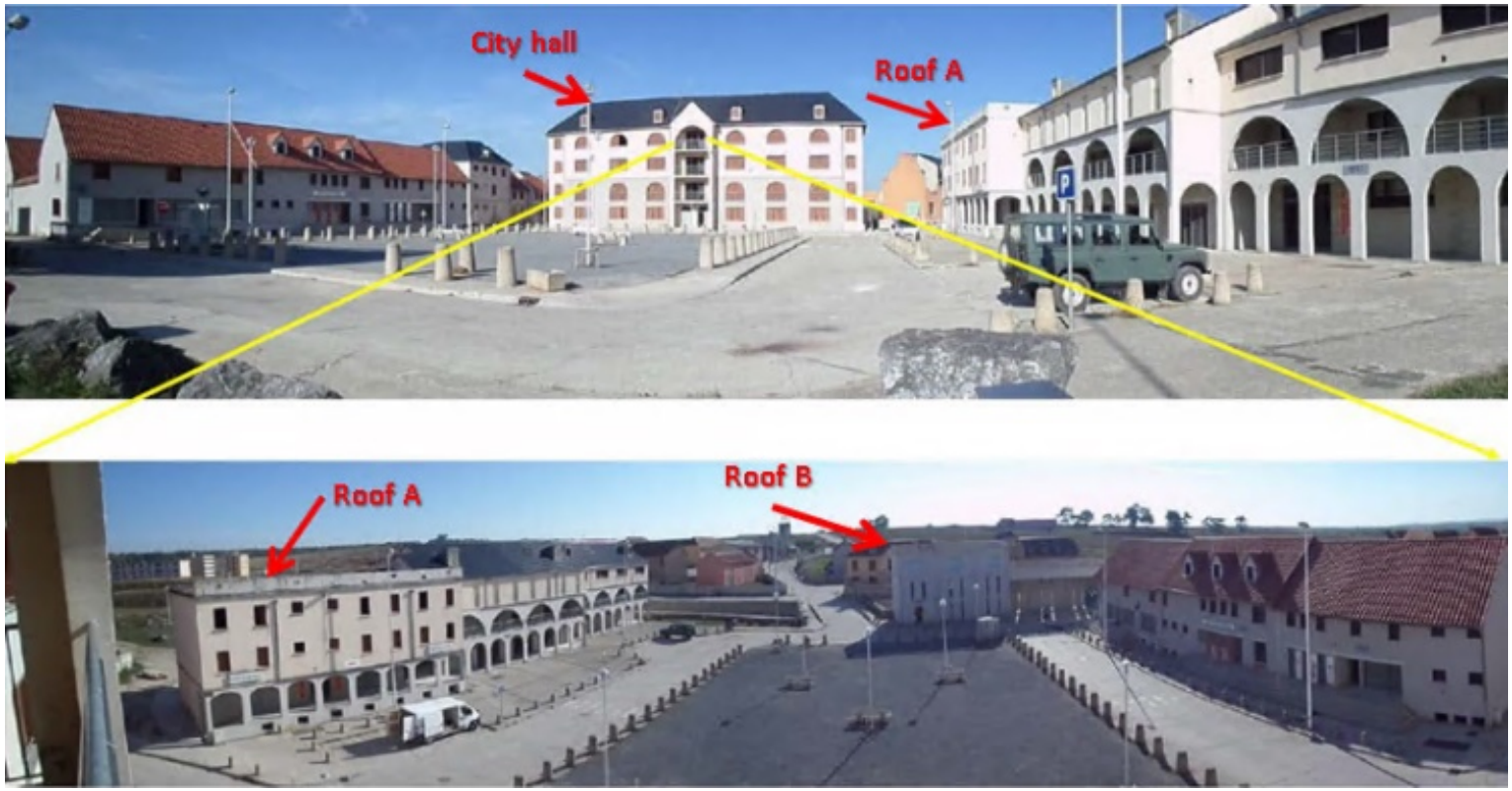
CENZUB Trial

- Collaboration between 9 NATO countries
- Collecting UAV signatures in urban background
- Wide range of active and passive sensors
- Successful organization of a large scale trial

CISS/RMA

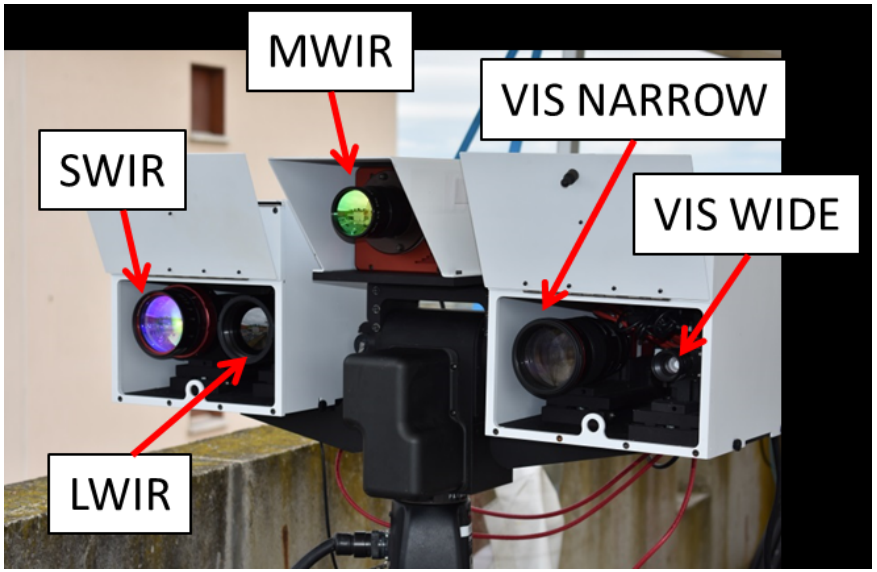
RMA Brussels
Royal Military Academy

UAS position tracking for sensor evaluation
The SET260 Trial: Locations



UAS position tracking for sensor evaluation
The SET260 Trial: Locations

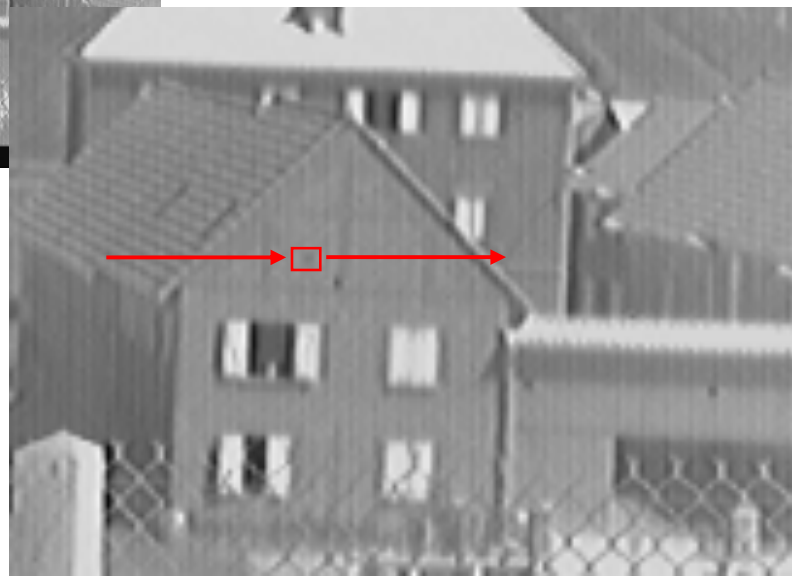
UAS position tracking for sensor evaluation
The SET260 Trial: Sensors



Sensor setups

- Multiple wavelength bands aimed at the same target
- Manual tracking/static setup with predefined FOV
- Remote controlled tracking on pan-tilt platform
- Automatic positioning via tracking algorithm (requires detection)

UAS position tracking for sensor evaluation
The SET260 Trial: Difficulties



Results (RMA)

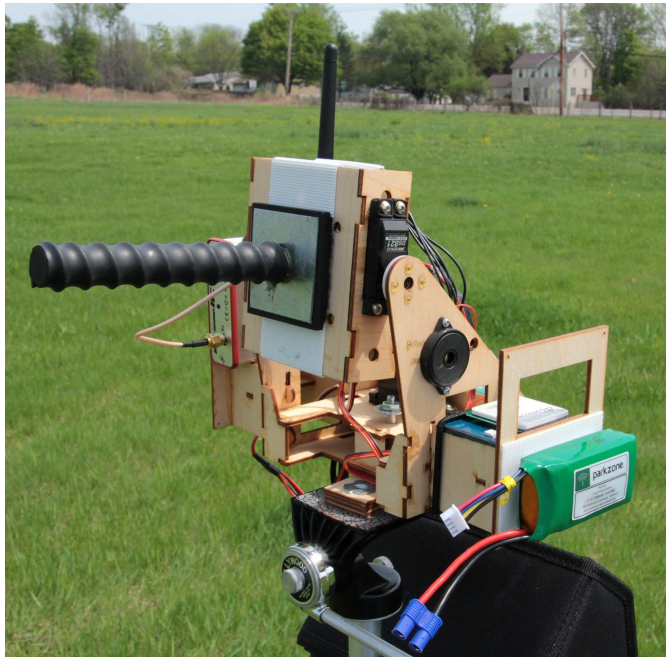
- UAV against a textured urban background are very hard to detect in wide-angle static images
- In video footage, movement allows for detection
- Movement-based detection allows for track analysis
- **Problem**: hard to assess sensor performance prior to applying tracking algorithm
- Operator had to use prior knowledge to determine target's presence (flight times, pilot in view, movement of target…)

UAS position tracking for sensor evaluation
Trial Range Automation

Problem and requirements

- Ground truth on the presence of the UAV within the FOV of the evaluated sensor requires
  - Knowledge of position of UAV at time t
  - Knowledge of position and attitude of the sensor platform at time t
- Trial automation goes further: sensor is pointed towards broadcasted UAV target position at all times
- Open source solution: no dependence on the ‘walled garden’ of UAV industry leaders such as DJI, which make access to flight information hard to obtain
  - Ardupilot and PX4 provide OSS solution
  - MAVLink protocol contains all flight information
  - Ardupilot AntennaTracker build can be applied as a sensor tracking station

UAS position tracking for sensor evaluation
Trial Range Automation



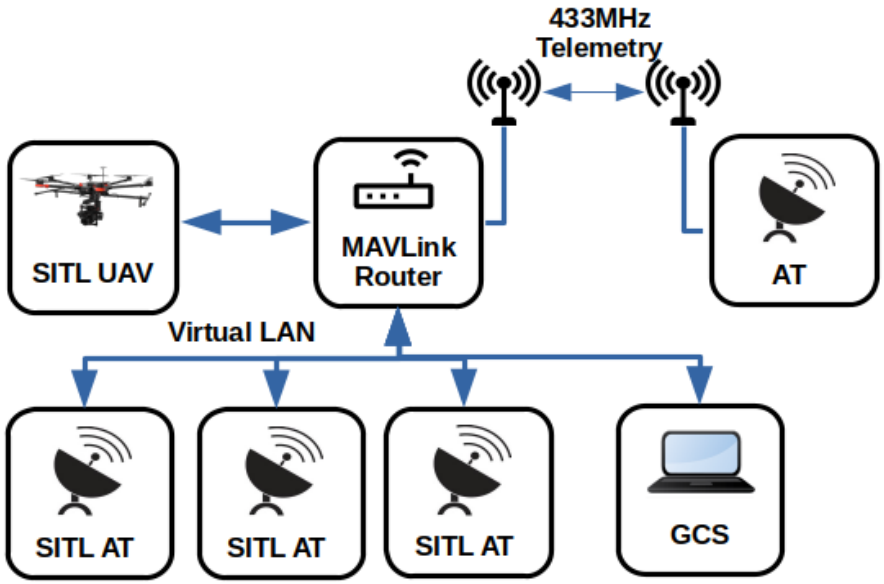
Architecture

- UAV: remotely piloted aircraft, multicopter or fixed wing, controlled by Ardupilot flight controller via MAVLink telemetry link
- GCS: Mission Planner ground control station, to be used by the pilot to operate the craft, and a trial manager to follow up on ongoing flights.
- Antenna tracker: range extending device designed to point directional telemetry radio towards UAV at all time, here co-opted to serve as a tracking station to point to be evaluated sensors at target.
- Router: network device passing on MAVLink telemetry from UAV and trackers to each other and the GCS
- UAV tracking module: optional module to integrate non-compatible drones into the framework

UAS position tracking for sensor evaluation
Trial Range Automation: Simulation

Simulated architecture

- SITL: Software-In-The Loop, simulation software for all devices compatible with Ardupilot.
- One UAV, one tracker, one GCS
  - Define SITL outputs pointed towards GCS
  - UAV outputs pointed towards antenna tracker
- One UAV, multiple SITL trackers, one GCS
  - UAV and trackers point output towards router
  - Router sends MAVLink from all VM towards GCS
  - Router sends UAV MAVLink telemetry to all trackers
- Mixed simulation – real hardware scenario
  - MAVLink router connects to serial 433MHz telemetry device, which bridges the distance to real antenna tracker setup



UAS position tracking for sensor evaluation
Trial Range Automation: Simulation

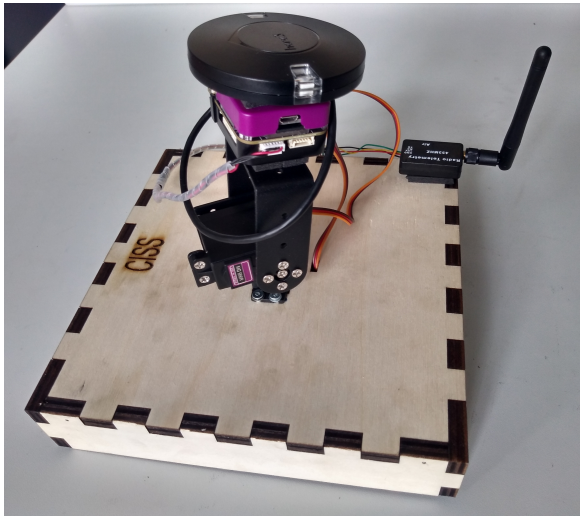
Simulated CENZUB Trial

- CENZUB city centre images from Google Maps
- One multicopter SITL instance, two trackers placed on real trial positions
- MAVLink router connects UAV VM with both trackers, and all three SITL instances with the Mission planner GCS
- All three displayed in GCS
- Operator uploads waypoints to SITL UAV, and executes flight
- Both trackers are seen to follow the drone while it follows the waypoints

CISS/RMA

Royal Military Academy

UAS position tracking for sensor evaluation
Trial Range Automation: Architecture



Hardware implementation

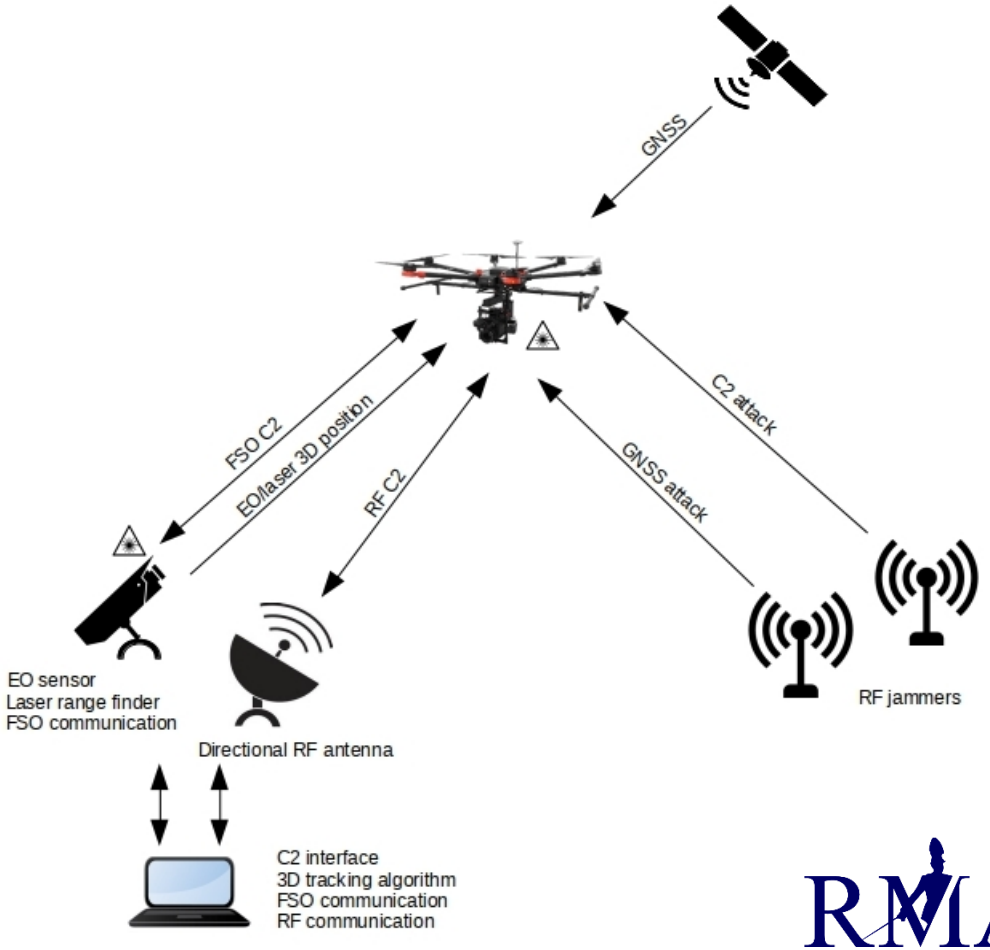
- **Initial test:** connect SITL network via serial 433MHz telemetry module to ArduPilot based antenna tracker.
- **Real-world application**: FLIR pan-tilt unit carrying multiple sensors, steered by computer translating MAVLink commands into the PTU's API

UAS position tracking for sensor evaluation
Conclusions and Future Work

- Our experiences during the CENZUB C-UAS trial organized by SET-260 showed that an automated method of keeping track of ground truth would greatly benefit the annotation and post-processing of data, and the evaluation of sensor systems.
- We developed a simulation of a trial setup using scantily documented features of the open source Ardupilot architecture,
- Method will be adapted to be implemented within the framework of several projects RMA is involved in:
  - DAP21-7: Defence study on the use of laser based techniques to augment C2 and navigation in RF denied environments
  - COURAGEOUS: EU study developing and demonstrating methodologies for the evaluation of CUAS technologies

Future work:
Laser Based Command and Navigation for UAS in RF-Denied Environment

- **RF attacks on UAS operation:**
  - GNSS attack
  - C2 attack
- **Counter**:
  - Cooperative 3D tracking of UAV using EO sensor and rangefinder
  - Re-establishing telemetry/C2 using Free Space Optical Communication
- **Civilian application**:
  - Tracking of high value UAV (organ transport e.g.)
  - Backup C2 in case of emergency (or aggression)



Future work: COURAGEUS

COURAGEOUS

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR MIGRATION AND HOME AFFAIRS

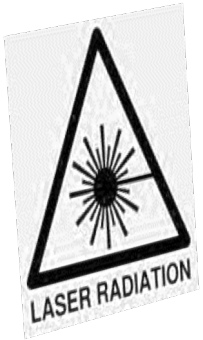
Directorate D: Law Enforcement and Security
Unit D.2 : Counter-Terrorism

European Programme for counter UAS systems testing

- Identify a set of relevant standard scenarios based on current threats;
- Develop C-UAS system functional and performance requirements and metrics;
- Develop a testing methodology;
- Carry out performance testing of individual sensors and integrated systems;
- Ensure that testing results are shared in a responsible manner between all relevant competent authorities in different affected sectors.

RMA Royal Military Academy Brussels
TNO
POLICE LËTZEBUERG
UNIVERSIDAD DE SEVILLA
INTERPOL
ROMÂNIA SERVICIUL DE PROTECȚIE ȘI PAZĂ
HELLENIC POLICE
KEMEA
WAT Military University of Technology
Estonian Police and Border Guard Board
GOBIERNO DE ESPAÑA MINISTERIO DEL INTERIOR

Point of contact for further information



Alexander Borghgraef

Laser Optronics Research Unit
CISS Department
Royal Military Academy
Renaissance avenue 30
1000 Brussels

E-mail: alexander.borghgraef@mil.be