Aerial robotics research at the ARG-SnT-UL

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Agenda

- Introduction
  - UL - University of Luxembourg
  - SnT - Interdisciplinary Center for Security, Reliability and Trust
  - ARG - Automation & Robotics Research Group
- Aerial robotics
  - Definition
  - Capabilities / Skills
  - Extending Autonomy & Safety: research activities
- Research on aerial robotics at the ARG-SnT-UL
  - Research Process
  - Aerial Robotics Platforms
  - Aerial Robotics Lab and Simulators
- Aerial Robotics Applications at the ARG-SnT-UL

University of Luxembourg (UL)

- Founded in 2003
- **Research-oriented**
- Sites: Belval Campus, Kirchberg Campus and Limpertsberg Campus
- Programmes: 14 bachelor degrees, 42 master degrees and doctoral education
- Research and academic staff: 242 professors + 850 research staff
- Students: 6,423 students
- Structure
  - 3 Faculties
    - FSTM - Faculty of Science, Technology and Medicine
    - FDEF - Faculty of Law, Economics and Finance
    - FHSE - Faculty of Humanities, Education and Social Sciences
  - 3 Interdisciplinary Research Centers
    - **SnT - Interdisciplinary Centre for Security, Reliability and Trust**
    - LCSB - Luxembourg Centre for Systems Biomedicine
    - C2DH - Luxembourg Centre for Contemporary and Digital History

UNIVERSITÉ DU LUXEMBOURG

Interdisciplinary Center for Security, Reliability and Trust (SnT)

- Founded in 2009
- 6 SnT's strategic research priorities:
  - **Autonomous Vehicles**
  - Cybersecurity
  - FinTech
  - Internet of Things
  - Secure and Compliant Data Management
  - Space Systems and Resources
- Research and academic staff: around 25 Prof. & 120 research staff & 240 PhD students
- Funding: Consumed annual income > 20 M€
  - EU/ESA (10 %)
  - FNR (39 %)
  - Partnership program (18 %)
  - UL Base Funding (33 %)
- Structure: 15 research groups
  - **Automation & Robotics Research Group (ARG)**

SnT

securityandtrust.lu

Automation & Robotics Research Group (ARG)

- Lead by Prof. Holger Voos
- Start 2012
- Research areas
  - Autonomous Vehicles and Robots
  - Distributed and Networked Automation and Control
- Team
  - 3 Postdoc researchers
  - 8 PhD students
  - Master & Undergrad students
- Partners

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SES your satellite company
Fonds National de la Recherche Luxembourg
LUXCONNECT
ispace
NVIDIA
Digital Luxembourg Leading the way towards a smart nation
SPACE RESOURCES.LU

Aerial robotics research activities

- Responsible: Dr. Jose-Luis SANCHEZ-LOPEZ
- Team
  - 2 PostDoc researchers
  - 5 PhD students
  - Master & Undergrad students

- Research goal
  - Provide aerial robots with the highest level of autonomy allowing them to perform different missions in different environments without human intervention

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Aerial robot vs RPAS/UAV

- **UAV/UAS, RPA/RPAS, Drone, …**
  - Aerial vehicle / Aircraft (e.g. multirotor) with a limited level of autonomy (i.e. self GNC)
  - Remote pilot controlling the platform (e.g. Ground Control Station)
  - Communication link (highly dependent)

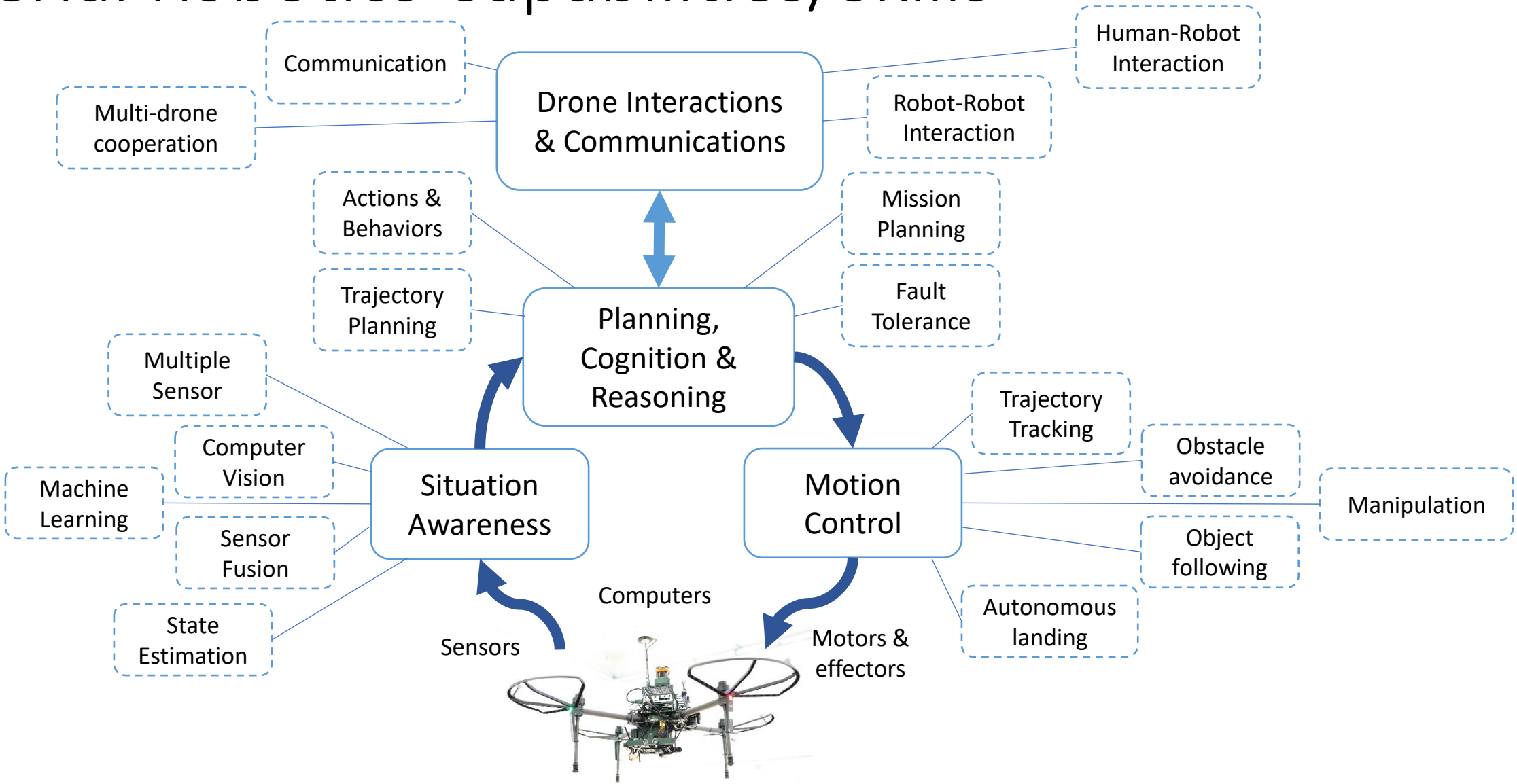
- **(Autonomous) Aerial robot**
  - Aerial vehicle / Aircraft (e.g. multirotor) with a high level of autonomy (e.g. artificial intelligence) thanks to advanced sensing and computing
  - No need for remote pilot controlling the platform (e.g. Ground Control Station)
    - Only sparse (i.e. non dedicated) supervision
    - Punctual high-level mission commands
  - Independent of communication link

Autonomous aerial robots

- Aerial Robot = UAV/RPAS/drone + advanced payload + AI

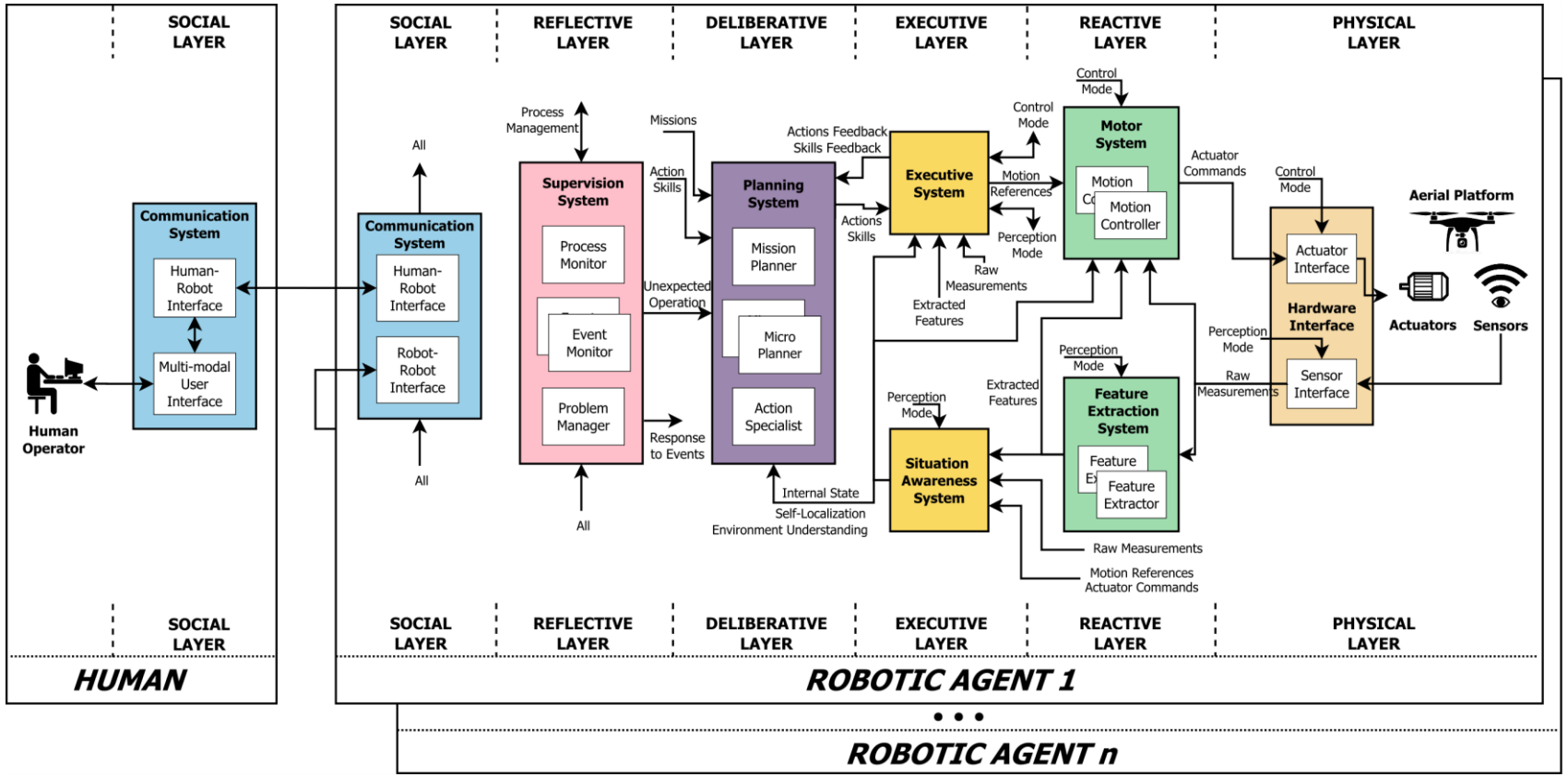
- Why?
  - Simplification of use
  - Reduction of cost of operation
  - Scalability: Deployment of fleets
  - Range of operation: BLOS Flights
  - Increase in security and safety
  - Enable new applications
  - Applications based on 4 Ds:
    - Dull, Dirty, Dangerous And Dear

Aerial Robotics Capabilities/Skills



Extending Autonomy & Safety: research activities

- PhD thesis, 2017: Aerostack system architecture



Extending Autonomy & Safety: research activities

- BEST-RPAS - Robust Emergency Sense-and-Avoid Capability for Small Remotely Piloted Aerial Systems
  - Funding body: FNR-CORE 2015 Call
  - Starting date: 1 Feb 2016
  - Duration: 4 Years

- SAFEMUV - Safe Airframe Inspection using Multiple UAVs
  - Partners:
    - SnT-UL, Luxembourg
    - Hochschule Bonn-Rhein-Sieg, Germany
    - University of York, UK
  - Funding body: University of York - Assuring Autonomy International Programme (AAIP) – Demonstrators 2019
  - Starting date: 1 May 2020
  - Duration: 18 Months

- 5G-Sky – Interconnecting the Sky in 5G and Beyond - A Joint Communication and Control Approach
  - Funding body: FNR-CORE 2019 Call
  - Starting date: 1 April 2020
  - Duration: 4 Years

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Research process on aerial robotics

1. Identify of an **open challenge** / research topic
2. Create a **project proposal & research plan** based on background knowledge and preliminary studies
3. Study the **state of the art** and related works
4. **Propose an aerial robotic solution + AI methods** (algorithm / theory / methods)
5. **Implement the AI methods**
6. **SITL Simulate** & collect data & analyze & evaluate & improve
7. **Implement the aerial robotic solution**
8. Test in controlled **aerial robotics testbed** & collect data & analyze & evaluate & improve
9. Test in **emulated realistic environment** & collect data & analyze & evaluate & improve
10. Test in **real environment** & collect data & analyze & evaluate & improve
11. Extract **conclusions**
12. **Publish / Patent / Commercialize**

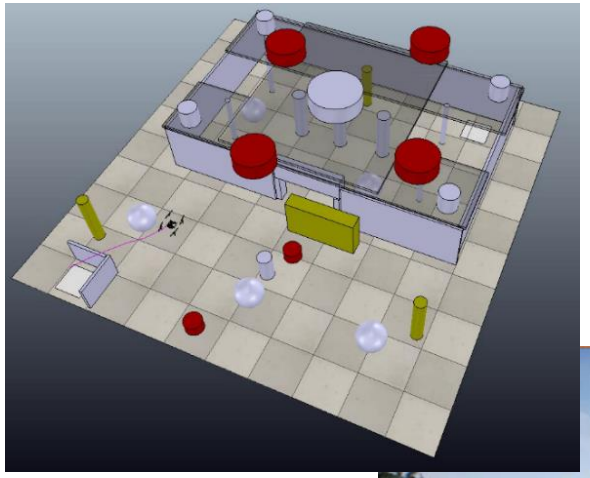
Aerial Robotics Platforms

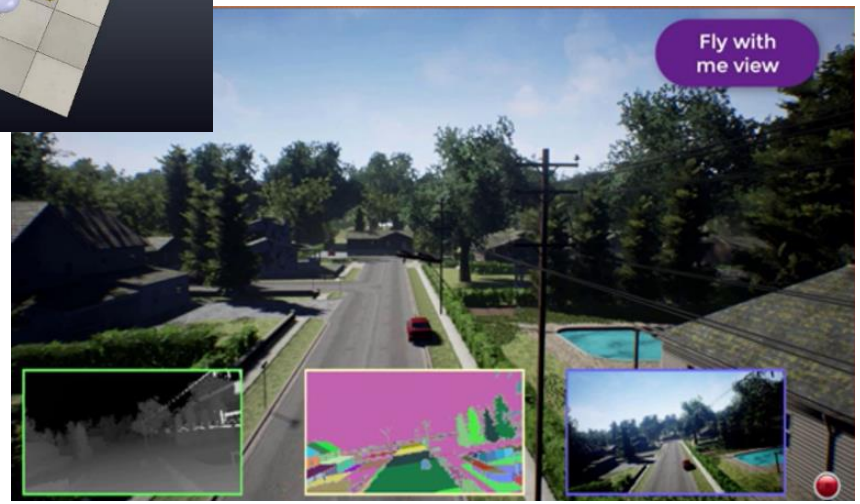
- Different multirotor Aerial Platforms
  - Size: from 10 cm to 1.2 m
  - MTOW: 1 to 20 kg
  - Payload: from 0.2 kg to 8 kg
  - Endurance: from 10 mins to unlimited
  - Commercial: AscTec, Parrot, DJI, ...
  - Self-designed and built
- Extra sensors
  - Cameras, LIDARs, RGB-D, …
- Extra computers
  - CPUs, GPUs, uProcessors
- Extra effectors
  - Manipulator arms
- Extra
  - Tethered cable

Aerial Robotics Lab & Simulators

Simulators

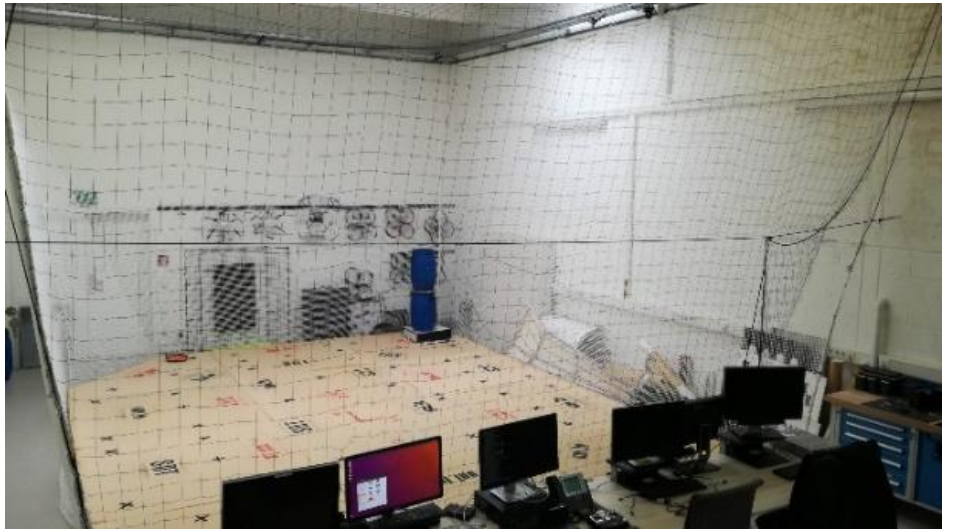
- Software-In-The-Loop (SITL) simulation





Flight Arena

- Dimensions: 5.5 x 5.0 x 4.5 m (WxLxH)
- Motion capture system:
  - 8 OptiTrack cameras
  - Under mm precision @ 200 Hz



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Aerial Robotics Applications

Airframe Inspection

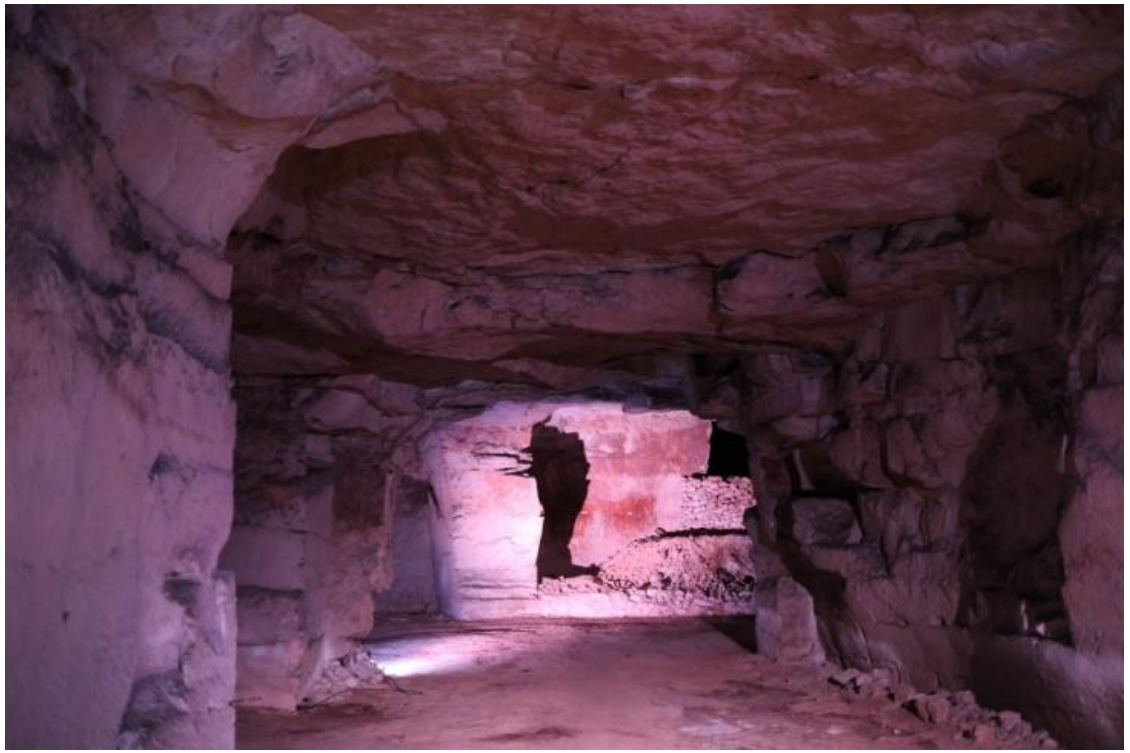
Funded by FNR-PoC – AFI
Partner: Cargolux

Aerial Robotics Applications

Infrastructure Inspection (e.g. bridges, buildings, …)

Aerial Robotics Applications

Mine Inspection



Funded by EU-INTERREG - GRONE

Aerial Robotics Applications

Surveillance (of data centers)

SnT Partnership with LuxConnect

Aerial Robotics Applications

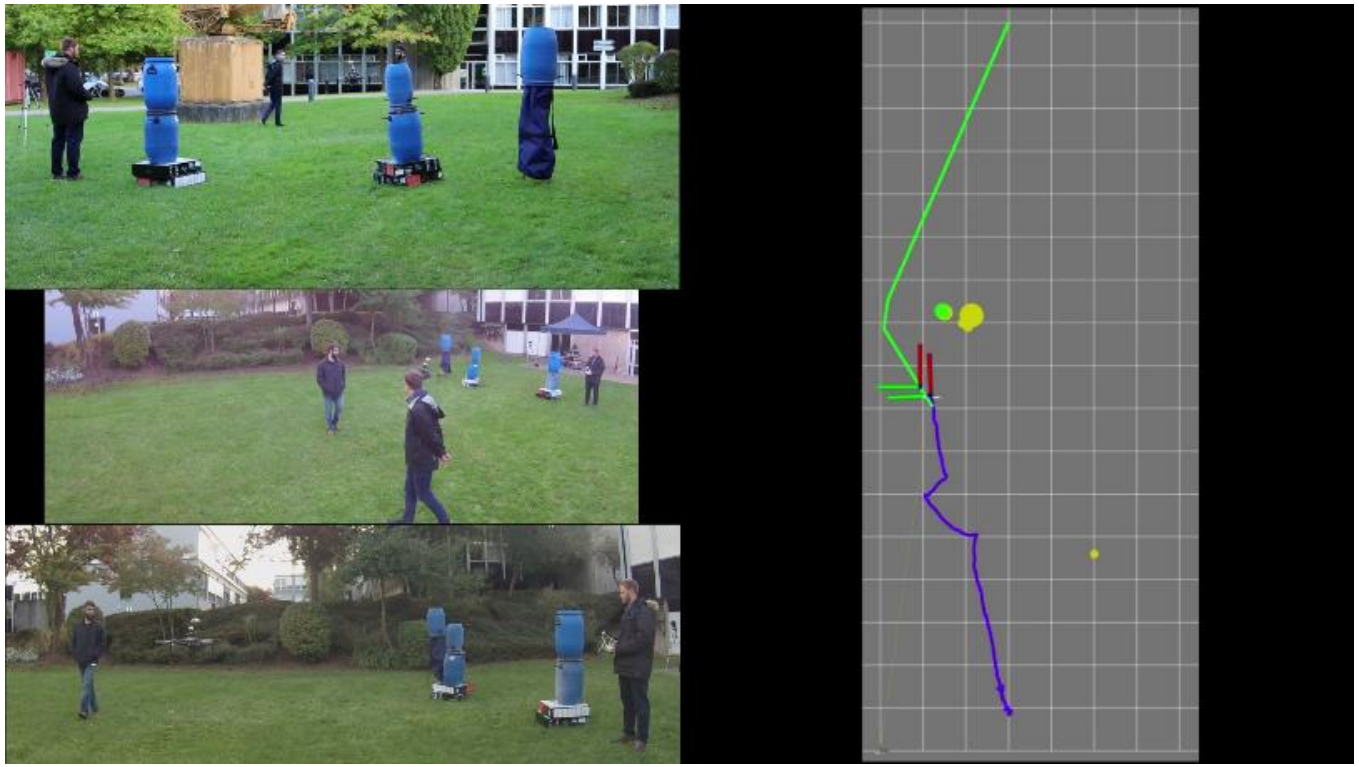
Applications

- Search and Rescue
- Autonomous take-off and landing on moving vehicles
- Improvised Explosive Detection and Deactivation
- Anti-drone aerial robot

SnT Partnership with Army of Luxembourg

Aerial Robotics Applications

Navigation in populated environments with both static and dynamic obstacles (e.g. cities)



Applications:

- Smart cities
- Emergency assistance
- Delivery
- Photography and filming
- Service Robots
- Personal Assistance

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