Radiation source localization using swarm robotics and 3D-SLAM methods

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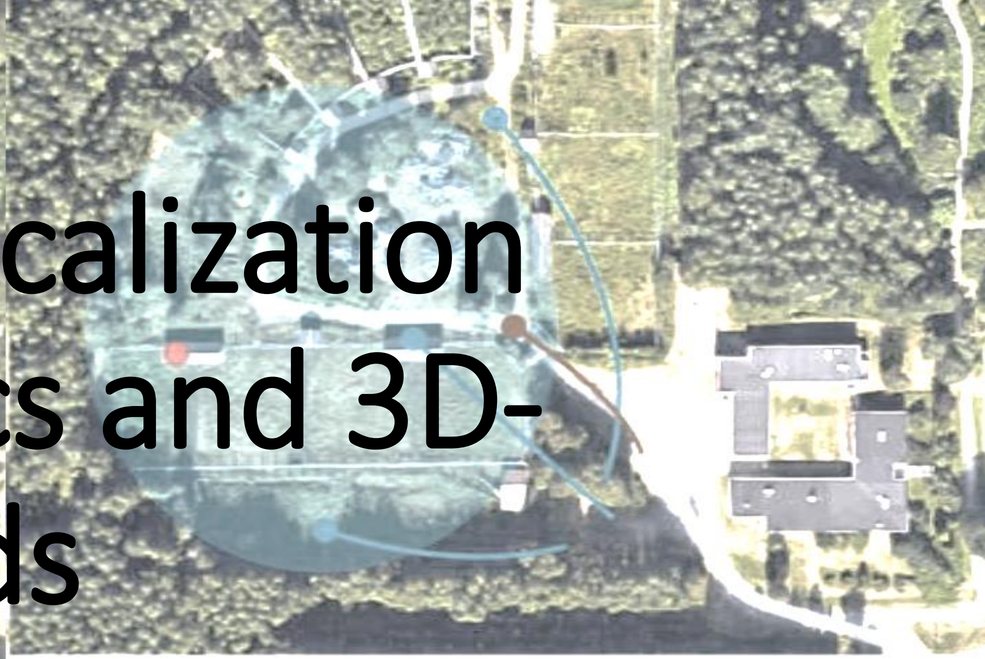
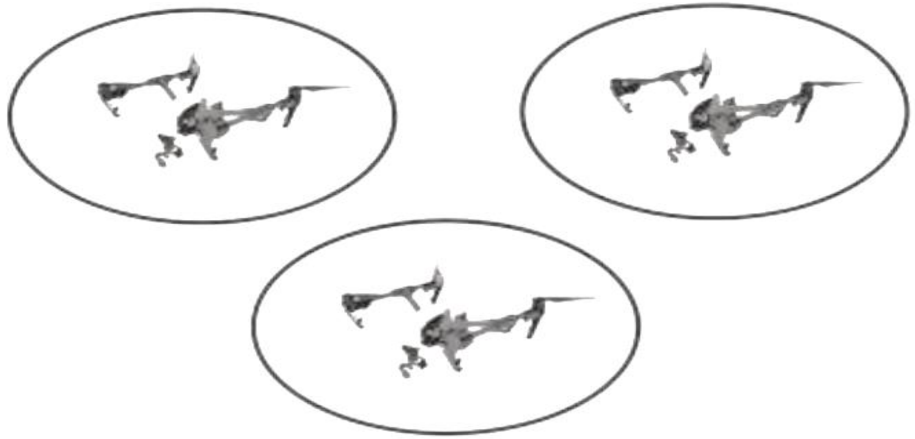




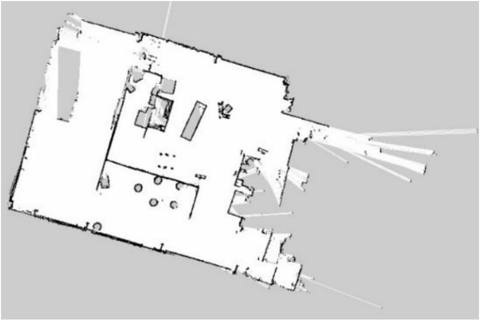
Unnamed vehicles (1/3)

- Unmanned aerial vehicles
  - Customized octocopter DJI S1000+
  - Payload ca. 6 kg
    - Multiple cameras and a laser scanner can be used at the same time
    - Flight time approximately 25 min depending on the payload
  - Computing hardware
    - Jetson TX2 –mini computer + PIXEVIA CORE X1

Unmanned vehicles (2/3)

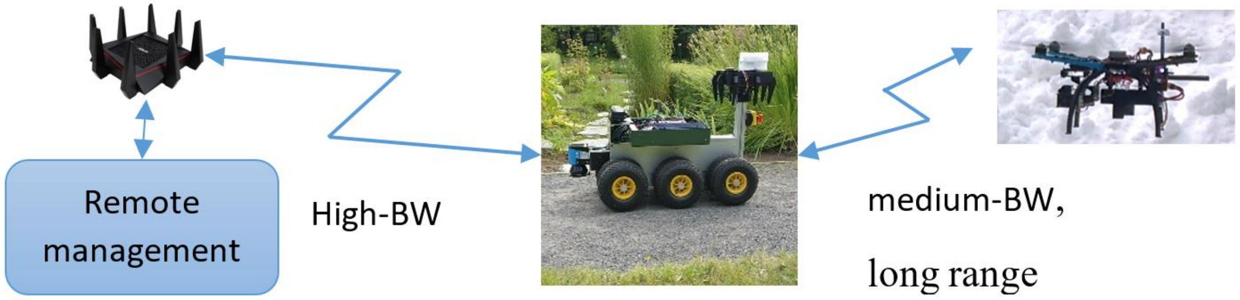
- Optional unmanned aerial vehicles
  - Quadcopter, hexacopter
    - Custom made
    - Light and agile
    - Development and testing of algorithms
    - Flight time > 15 min.
    - Mini computer
  - Commersial DJI Inspire 1
    - Remotely controlled

Unmanned vehicles (3/3)



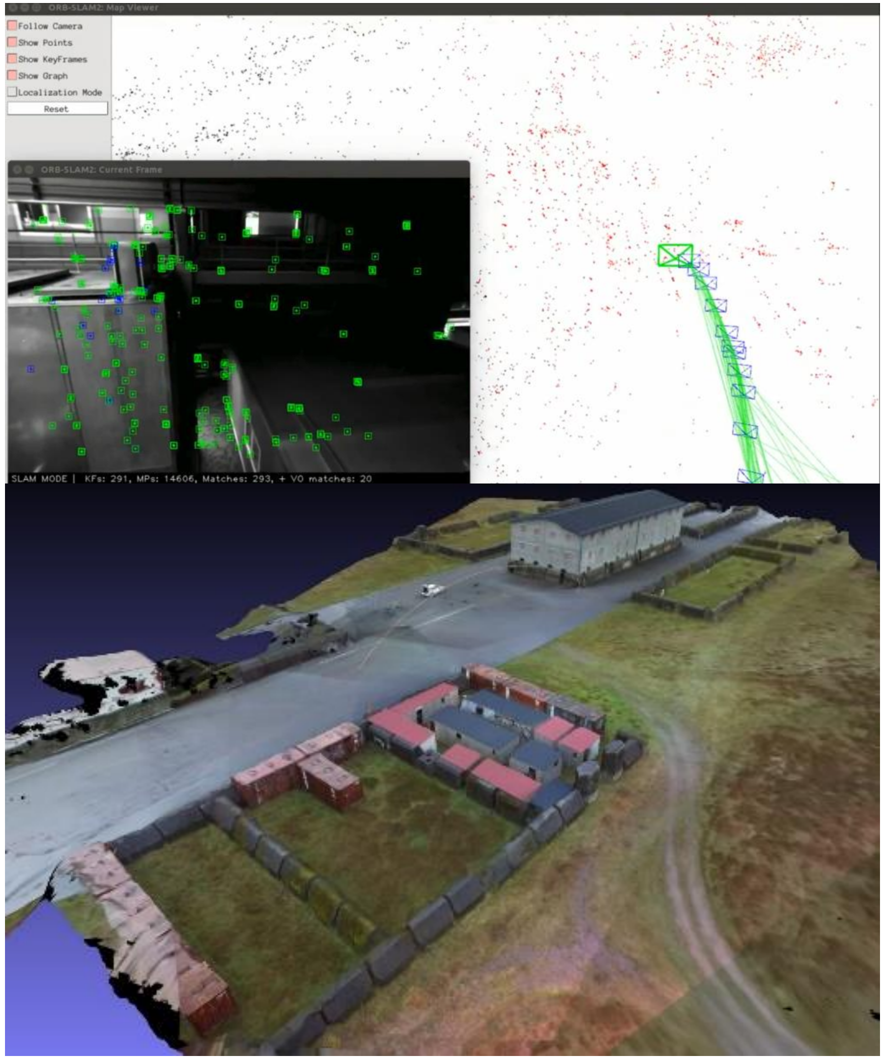
- Unmanned ground vehicle, Mörri
  - Custom made
  - Fast computer
    - 7th gen. Core-i7-prosessor
    - GPU: Nvidia Geforce GTX 1070
  - Capable of real-time high-precision 3D mapping
  - High payload
    - WiFi access point
    - Long distance radios
    - High precision measurement equipments
  - Complements the copters
    - Indoor operations
    - Very close to the radiation source in some cases

Measurement system



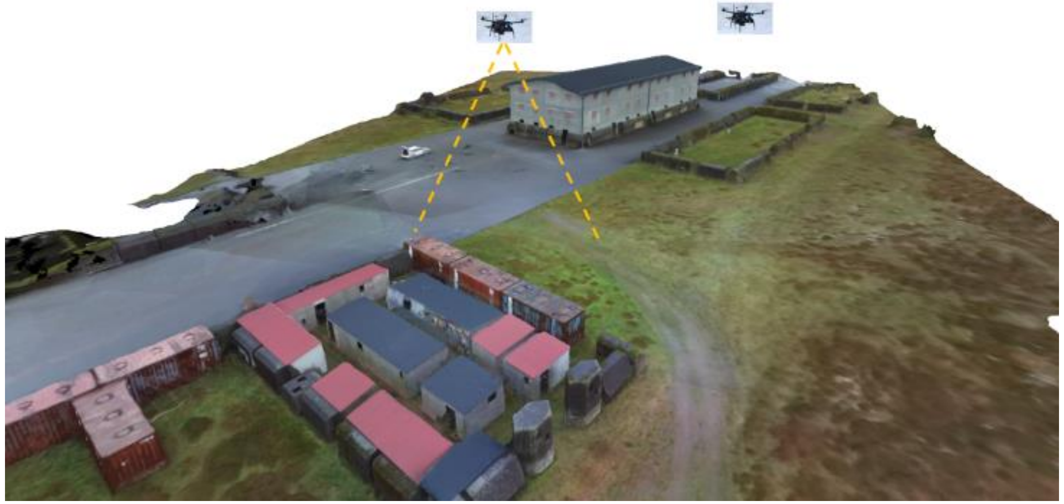
- Mörri ground vehicle
  - Communication support for the copters
  - Support for coordinating the swarm operations
    - Performs large-scale planning algorithms for the copters

Steps for locating radiation sources (1/3)



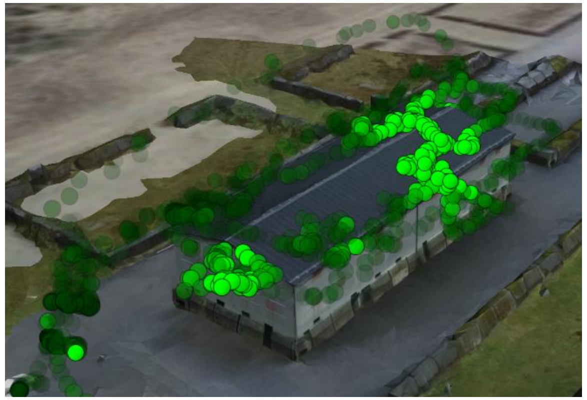
- 1. Mapping by the copter
  - Real-time mapping of interest points for the navigation map
    - GPS is not mandatory
    - Metric coordinates are obtained by means of an optical flux sensor
  - Simultaneous collection of image data for 3D reconstruction
    - High resolution 3D model
    - The radiation measurements are accurately positioned in the 3D reconstruction of the site

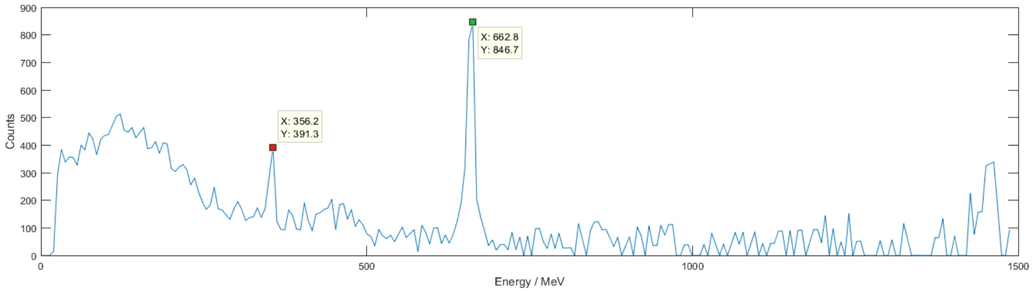
Steps for locating radiation sources (2/3)



- 2. Location of the radiation source
  - On several platforms simultaneously
  - Real-time location based on the common navigation map using the camera image
  - The common navigation algorithm instructs the copter flight controllers
  - On-board functions
    - Positioning
    - Obstacle avoidance and automatic flight

Steps for locating radiation sources (3/3)





- 3. Visualization of measurement data on a 3D map
  - Either in reconstruction or in a real-time map
    - Reconstruction is of a better quality but can not be done in real time
- On the left: data collected in NKS-B Nordum NEXUS 2017 in Sweden
  - GPS positioning

Aerosol number concentration around strong radioactive sources:

Technology and first results

Institute for Atmospheric and Earth System Research

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Aerosolic particles:

- Drones provide a versatile platform to determine spatio-temporal variability of atmospheric aerosol particles
- Finding aerosol sources
- Tracking pollution transport

Challenges:

- Weight, sampling, electricity requirements
- Rapid movement of the drone (flooding optics)
- Detection efficiency

Field trials in Lakiala 21.8.2018

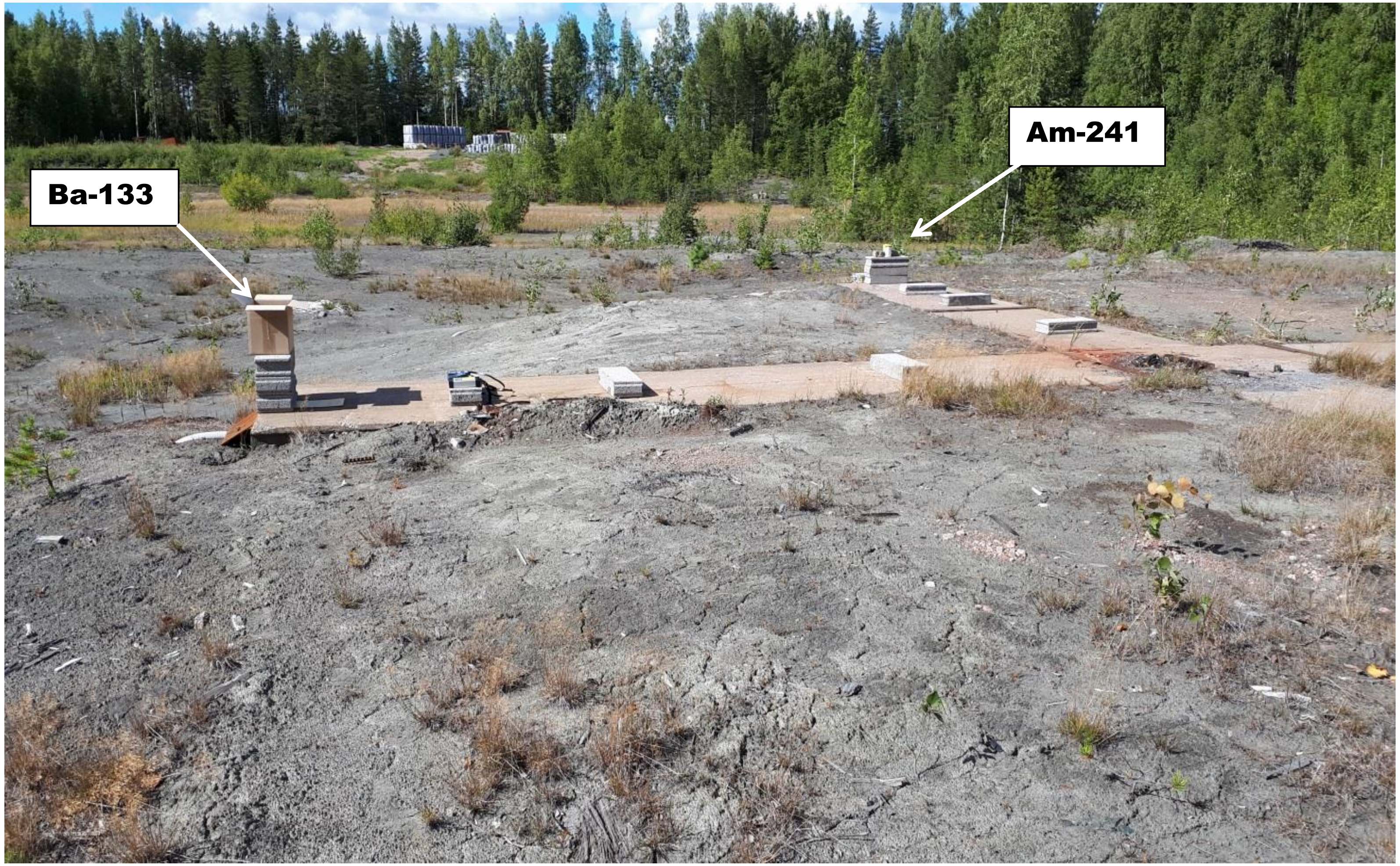
- Mapping of radiation intensity and fine particle density in the vicinity of radiation point sources
- Real world data for developing and testing location algorithms
- Testing the equipment and data collection
- Goals: 2D and 3D maps of radiation intensity and fine particle density
- The following sources were utilized:

Nuklidi	Activity 21.8.2018
Am-241	185 MBq
Ba-133	180 MBq
Cs-137	66 GBq

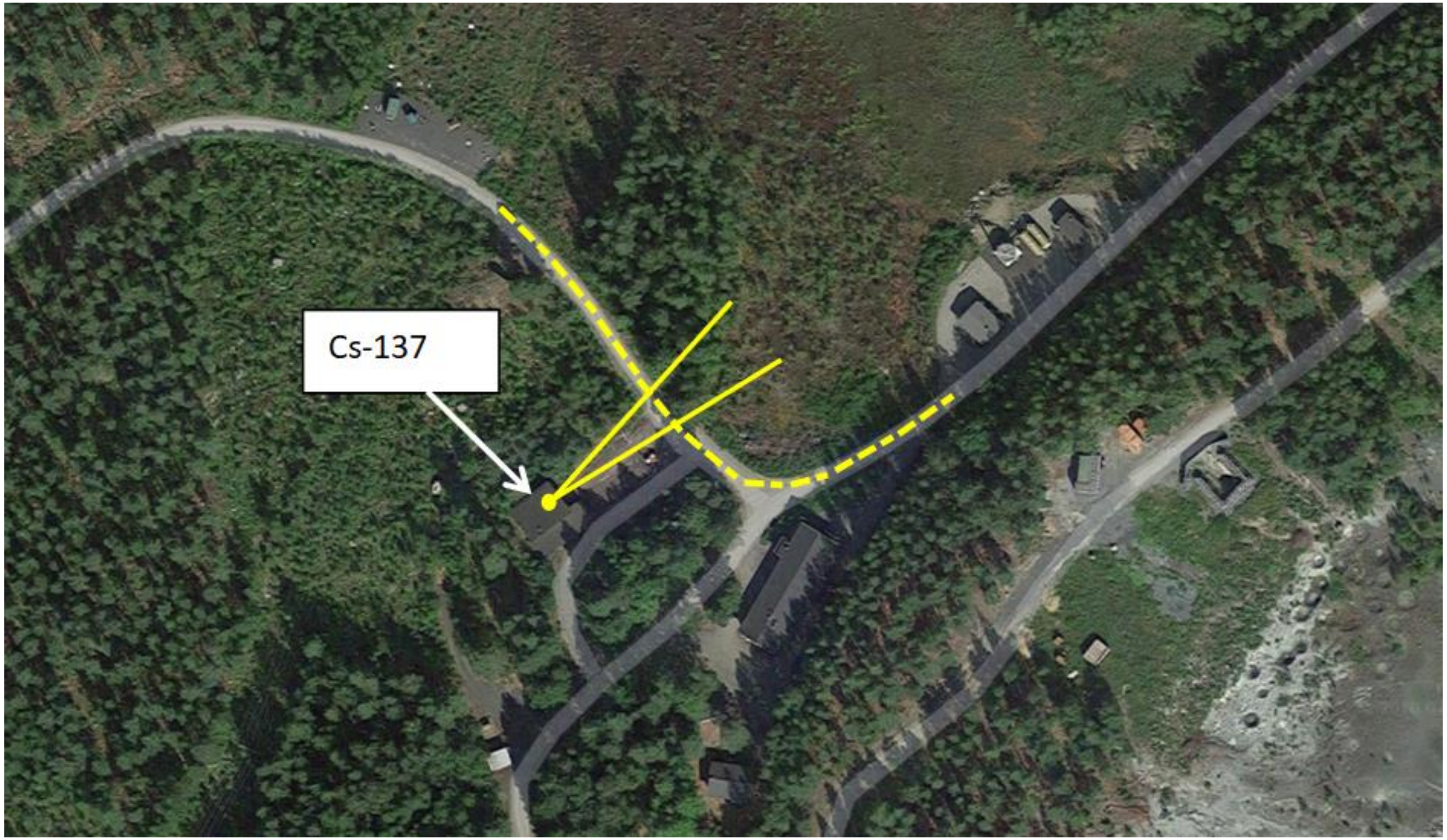
Octocopter equipped with CPC (condensation particle counter) and Kromek radiation sensor used in Lakiala measurements

Lakiala measurement area and location of radiation sources

Radiation sources were placed over a concrete "cross"



The collimated Cs-137 radiation source is located in the building and measurements were made above the street (dashed line)



Tests with radiation sources:

- Test flights in Lakiala, Finland, August 2018
- Variability in aerosol concentration
    - Co-incidence correction not taken into account
    - Detection efficiency needs to be tuned towards smaller sizes
- Data processing on-going to connect GPS location data with aerosol data and Kromek (radiation intensity)