

GNSS in Robotic Radiation Contamination Measurement

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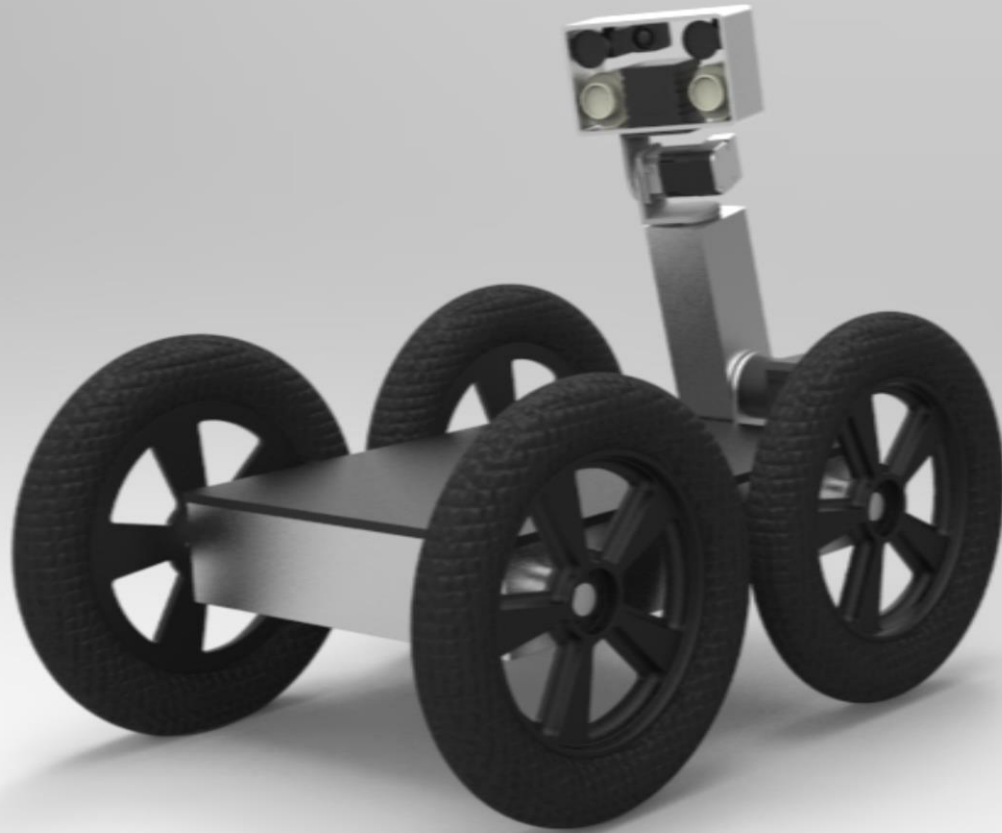


ATERSOS – Autonomous telepresence robotic system

SINGLE OPERATOR, MULTI ROBOT RECONNAISSANCE ROBOTIC SYSTEM



What is it for? Possible missions.



GENERAL RECONNAISSANCE

CBRN(E)

SEARCH FOR VICTIMS/CRIMINALS

MULTISPECTRAL MAPPING

ENVIRONMENT MEASUREMENT

AUTONOMOUS AREA GUARDING

Visual Telepresence

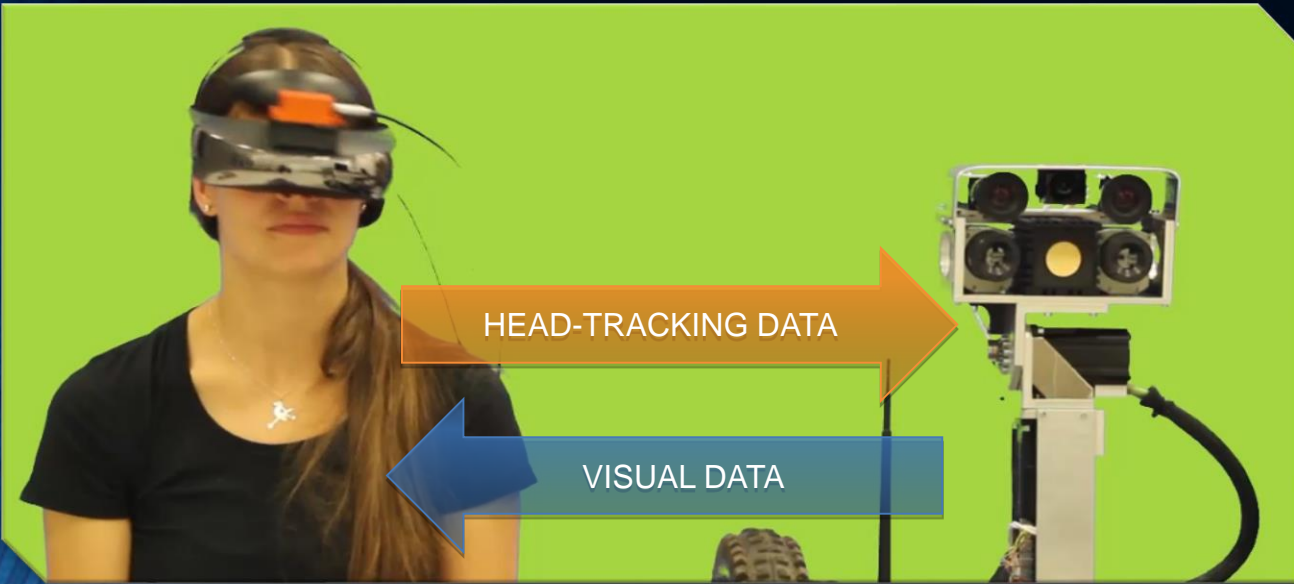


Autonomous Mode

OPERATOR SHOULD FEEL TO BE IN THE ROBOT'S PLACE

OPERATOR

ROBOT



HEAD-TRACKING DATA

VISUAL DATA

- adding autonomous functions
- return home
- 3D mapping
- autonomous area search



- increases concentration
- makes control easier and more intuitive
- better on direct sunshine

ORPHEUS ROBOTS

X1



AM



AC-P



EXP



AC2



X3



X4



X2



AC



HOPE



F1



XTA





RADIATION EXPERIMENT

ATEROS

Mission

**TERRORISTS
CAPTURED
RADIOACTIVE
MATERIAL**

**THEY WERE
STOPPED BY
CZECH ARMY**

**RADIOACTIVE
MATERIAL
ACCIDENTALLY
LEAKED**



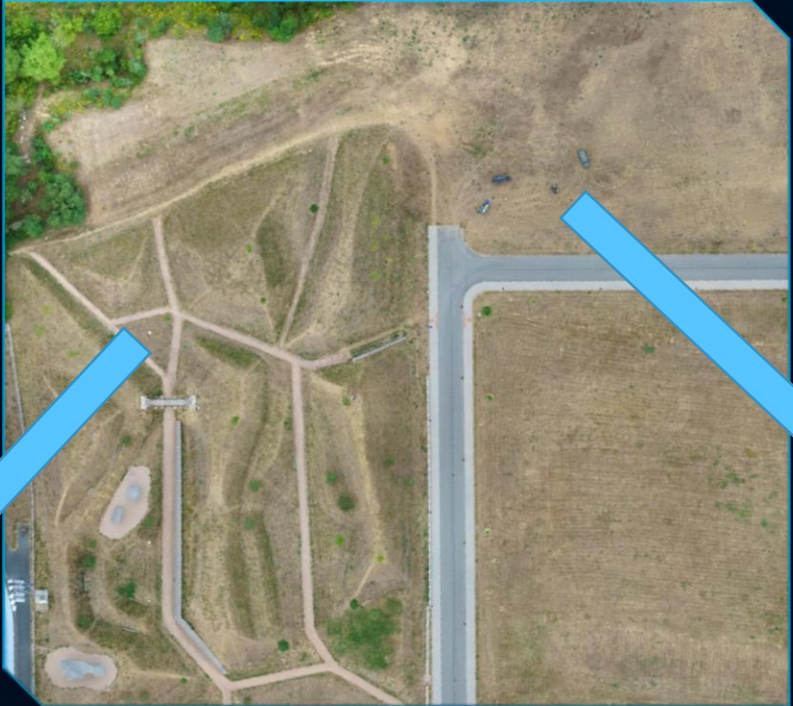
Motivation

- autonomous search for:
 - point radiation sources
 - area (surface) contamination – liquids, dust
- unknown terrain – potentially unreachable by UGVs
- combination – UAV, UGV

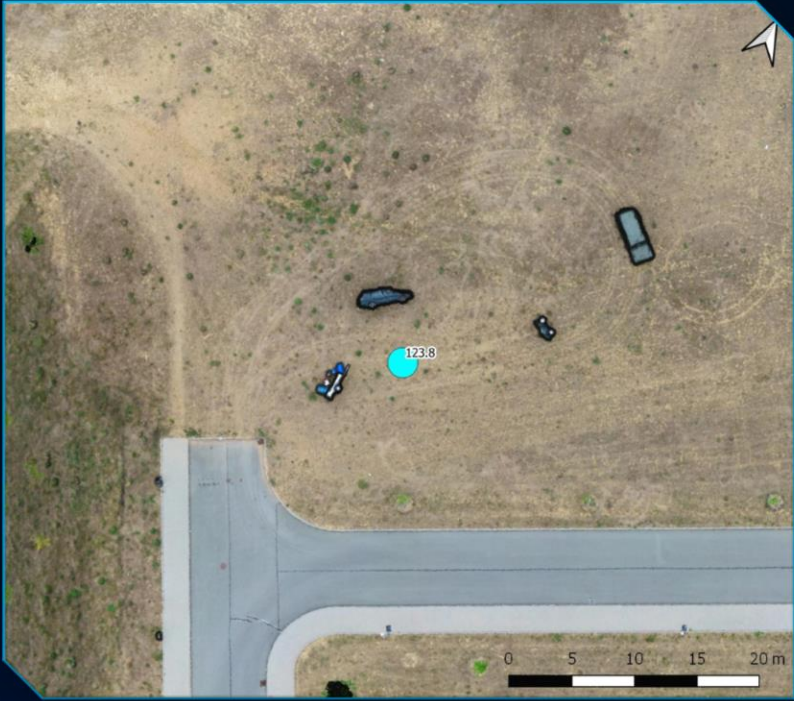
NO HUMANS IN THE HOT AREA & AUTONOMOUS OPERATION



Sources



ISO-TOPE	ACTIVITY [MBq]
Co-60	123.78
Cs-137	79.82
Co-60	24.76
Co-60	24.56
Cs-137	7.53
Cs-137	7.53
Co-60	2.95
Co-60	2.85





Cooperation

- Brno University of Technology
 - CEITEC
 - Faculty of Electrical Engineering and Communication
- Nuvia a.s.
- Czech Army, University of Defence
- Fire Rescue Service of South-Moravian Region
- VTUL

Projects:

- CAK III – TACR ALPHA
- Robotics for Industry 4.0



mapping UAS trajectory
planning



aerial 3D map building

DEM (digital elevation map)
building

measurement UAS trajectory
planning

aerial 3D radiation measurement



hotspot identification

UGV traversability (DEM) map
building

UGV trajectory planning

ground radiation measurement

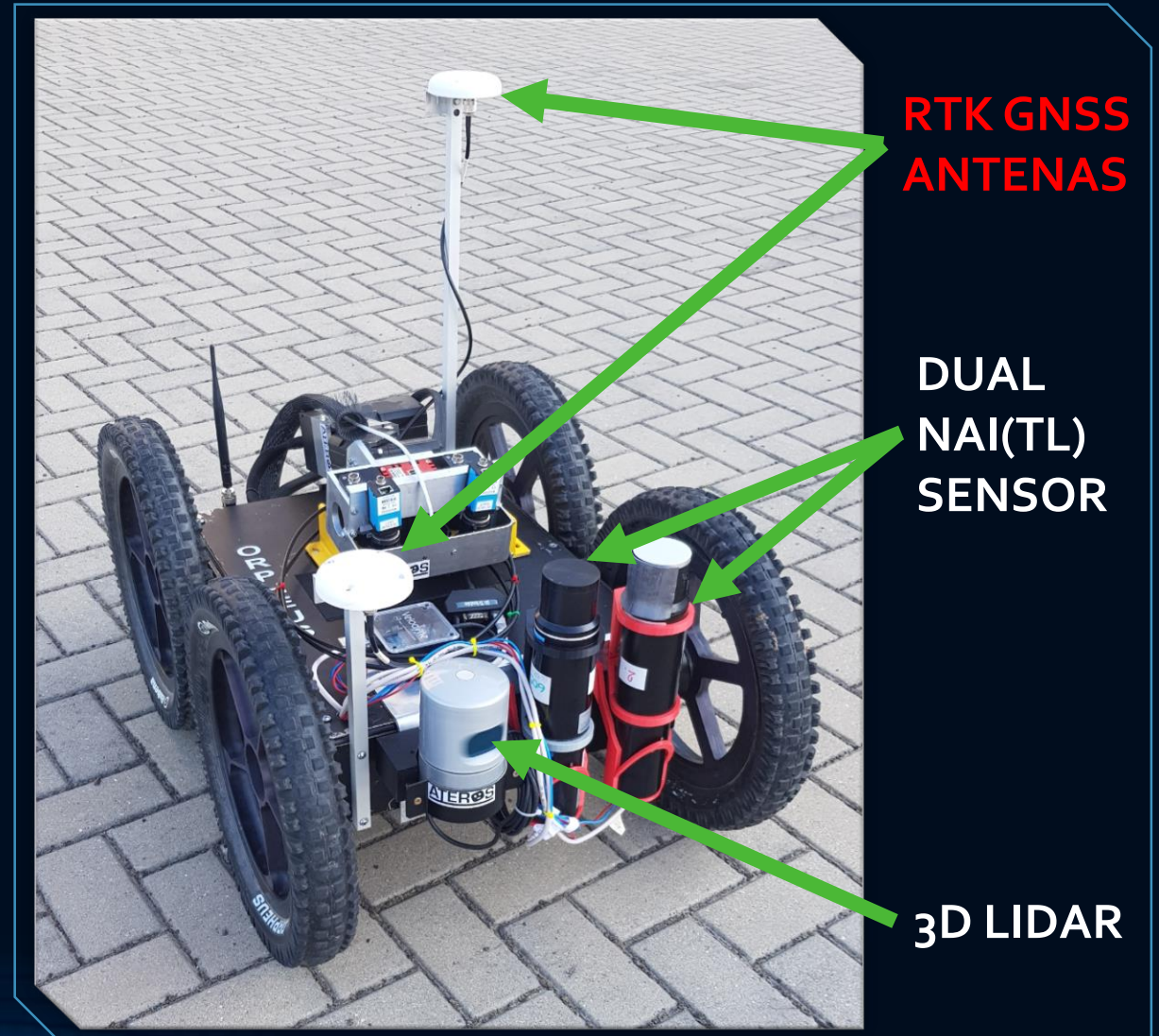


precise radiation map building



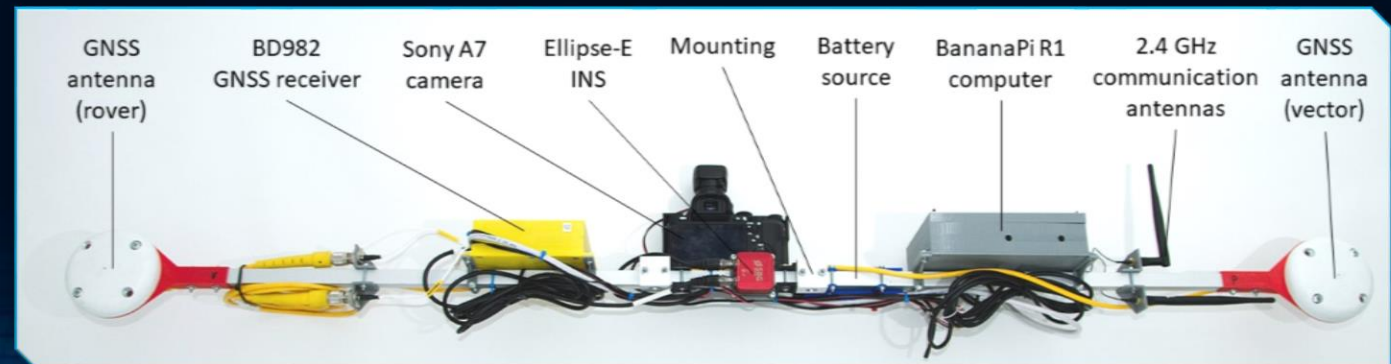
Orpheus-X4

- fully autonomous mode
- centimeter precision navigation
- **vector RTG GNSS receiver**
- two NAI(TL) 2" detectors
- rugged construction
- communication with operator's station

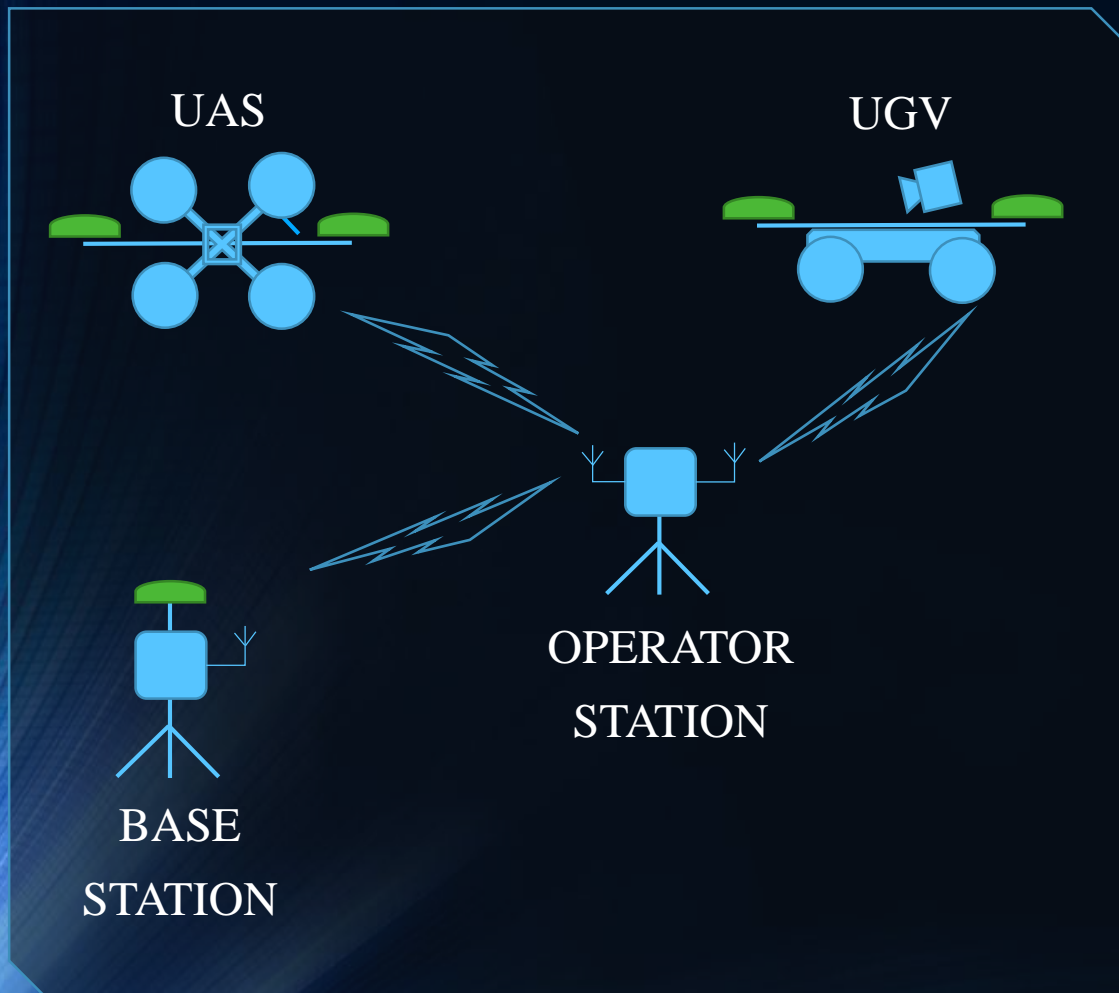


BRUS with photogrammetry & radiation module

- VTUL drone in - 2 configurations
- photogrammetry module
 - **vector RTK GNSS**
 - IMU
 - full-frame camera
 - BananaPi computer
 - communication link
 - Battery
- radiation module
 - 2" NAI(TL) detector
 - data-logger
 - GNSS receiver
 - 1 DOF laser altimeter



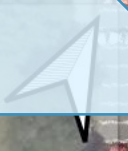
Correction data communication scheme



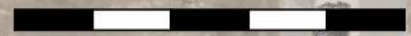
- custom RTK GNSS base station
- long communication distances
- custom datalink – 2,4 GHz
- base station is not a part of operator station
- retranslation



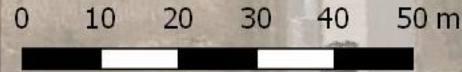
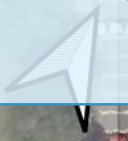
AREA OF INTEREST - CUZK ORTOPHOTO



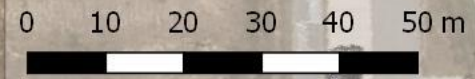
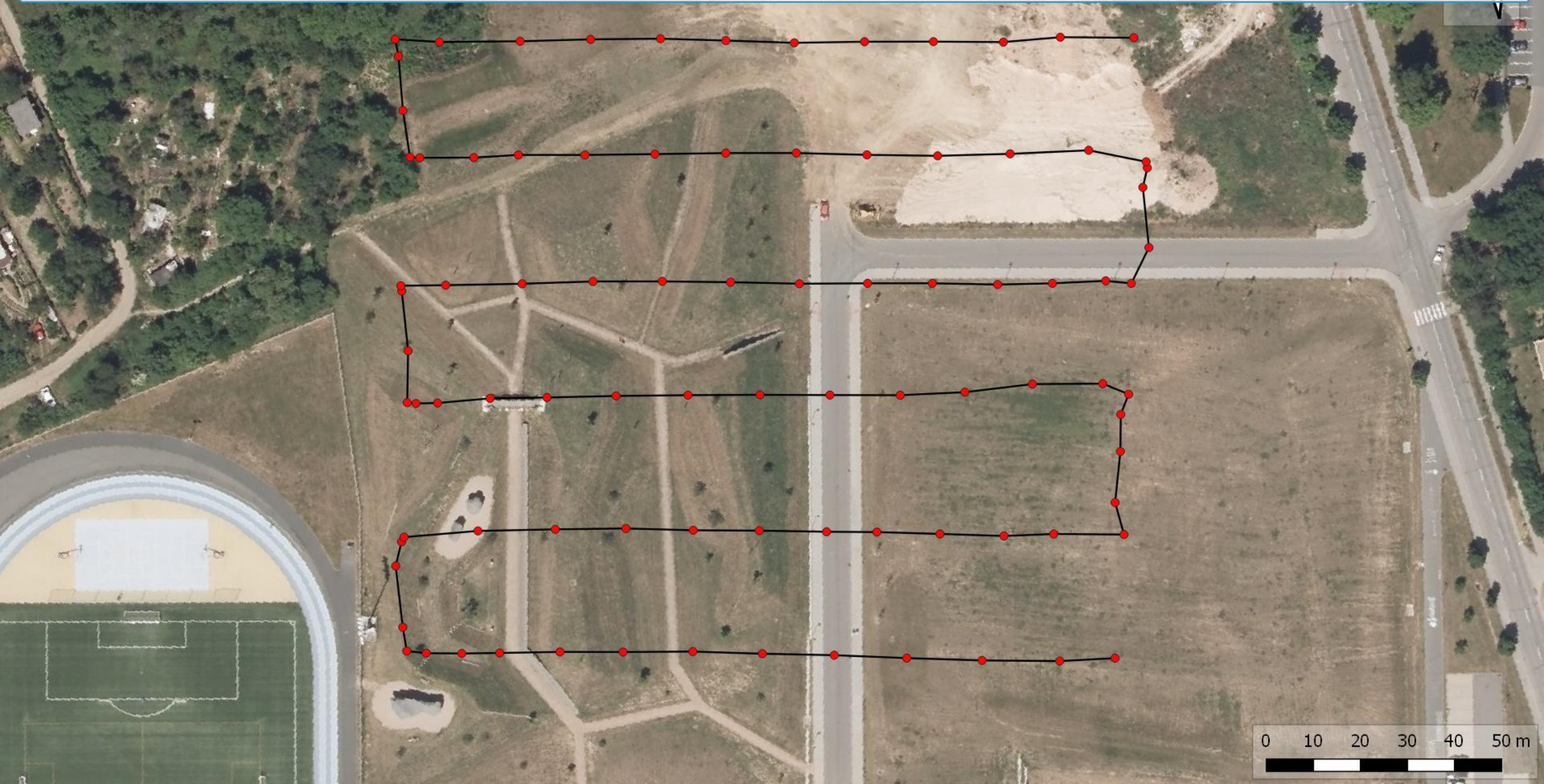
0 10 20 30 40 50 m



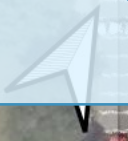
UAV TRAJECTORY FOR THE AERIAL PHOTOGRAMMETRY



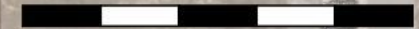
REAL UAV TRAJECTORY AND PHOTO POSITIONS



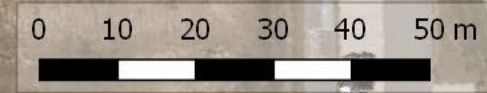
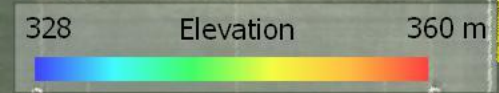
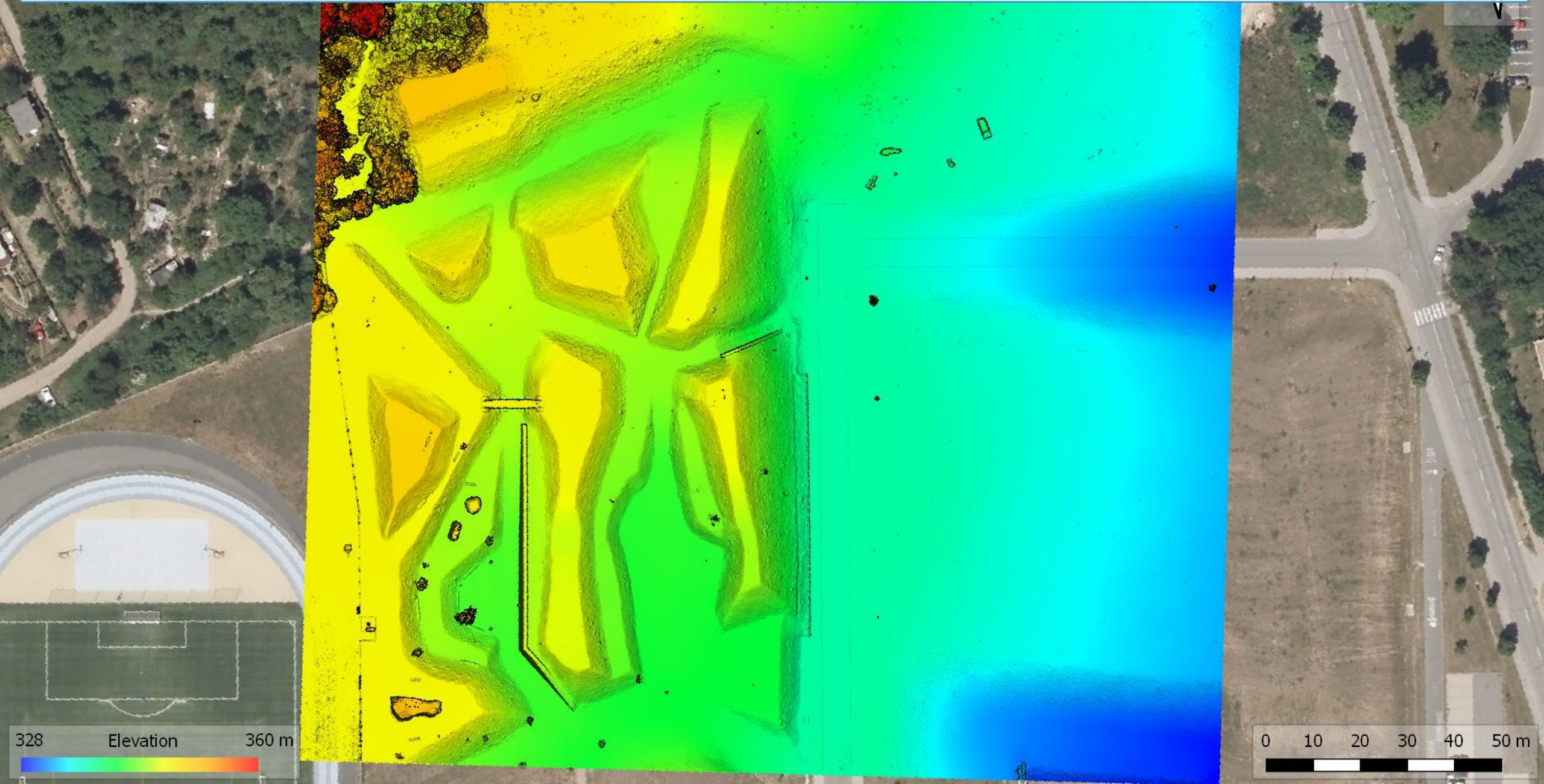
UAV-BASED ORTHOPHOTO



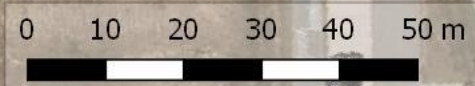
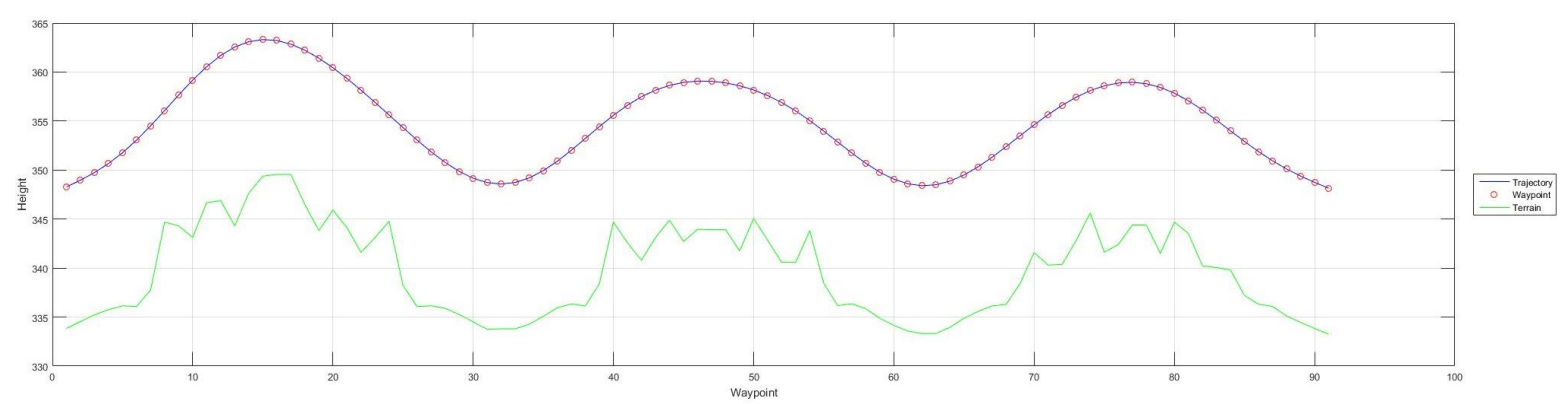
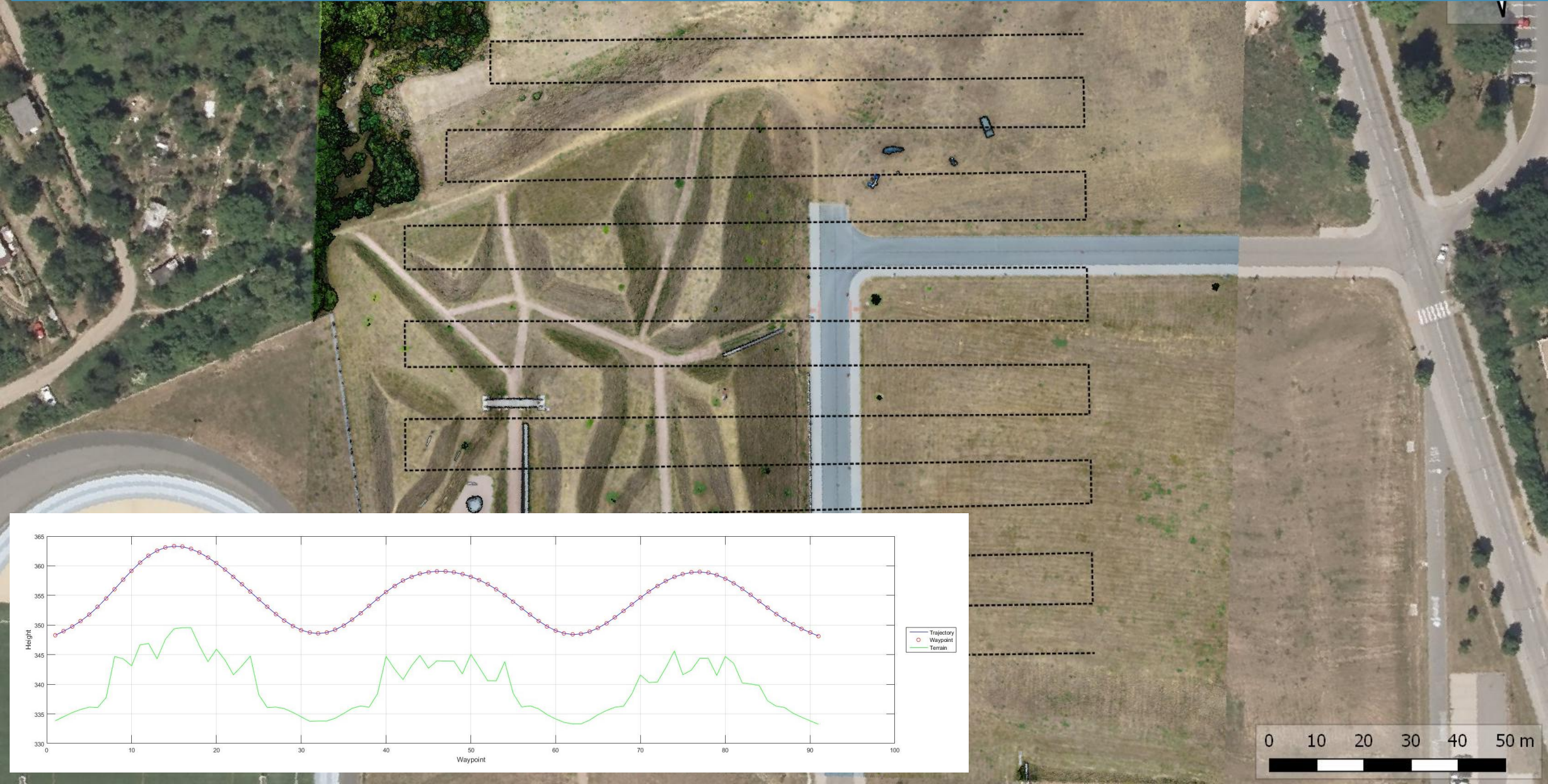
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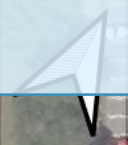
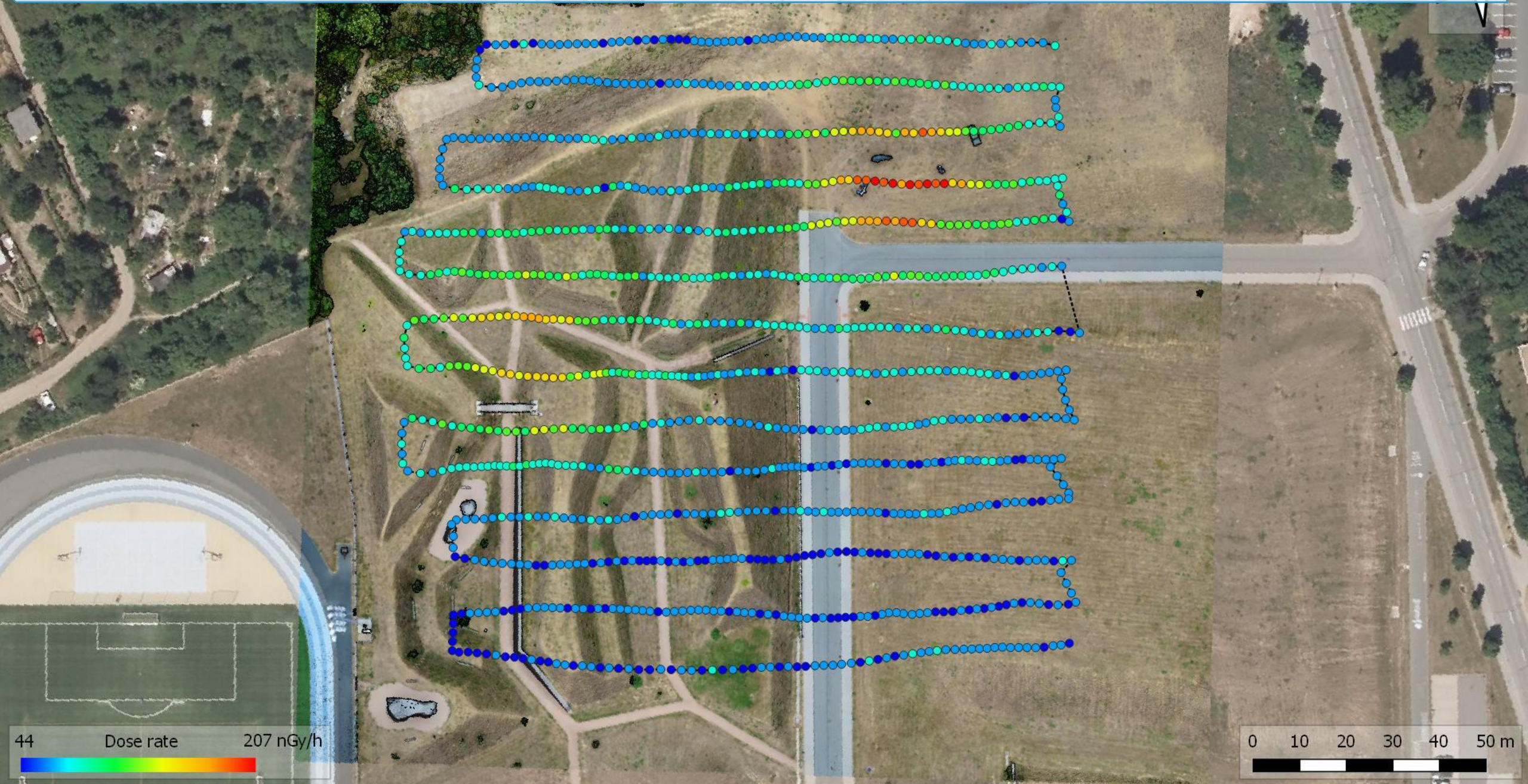
UAV-BASED ELEVATION MODEL & GRADIENT MAP



UAV TRAJECTORY FOR THE RADIATION MAPPING – ADJUSTED BY THE TERRAIN MODEL



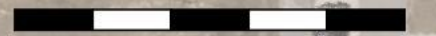
IONIZING RADIATION DOSE RATE MEASURED FROM THE UAV



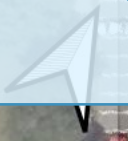
44 Dose rate 207 nGy/h



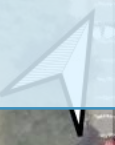
0 10 20 30 40 50 m



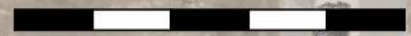
AUTOMATICALLY SELECTED CONTAMINATED AREAS



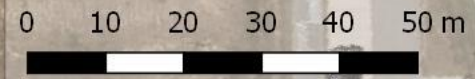
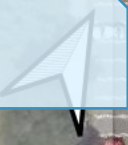
ADJUSTED AREAS BY THE OBSTACLE MAP



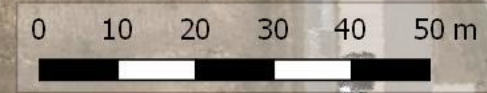
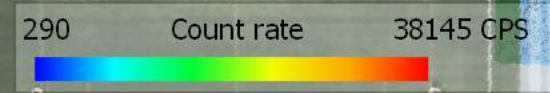
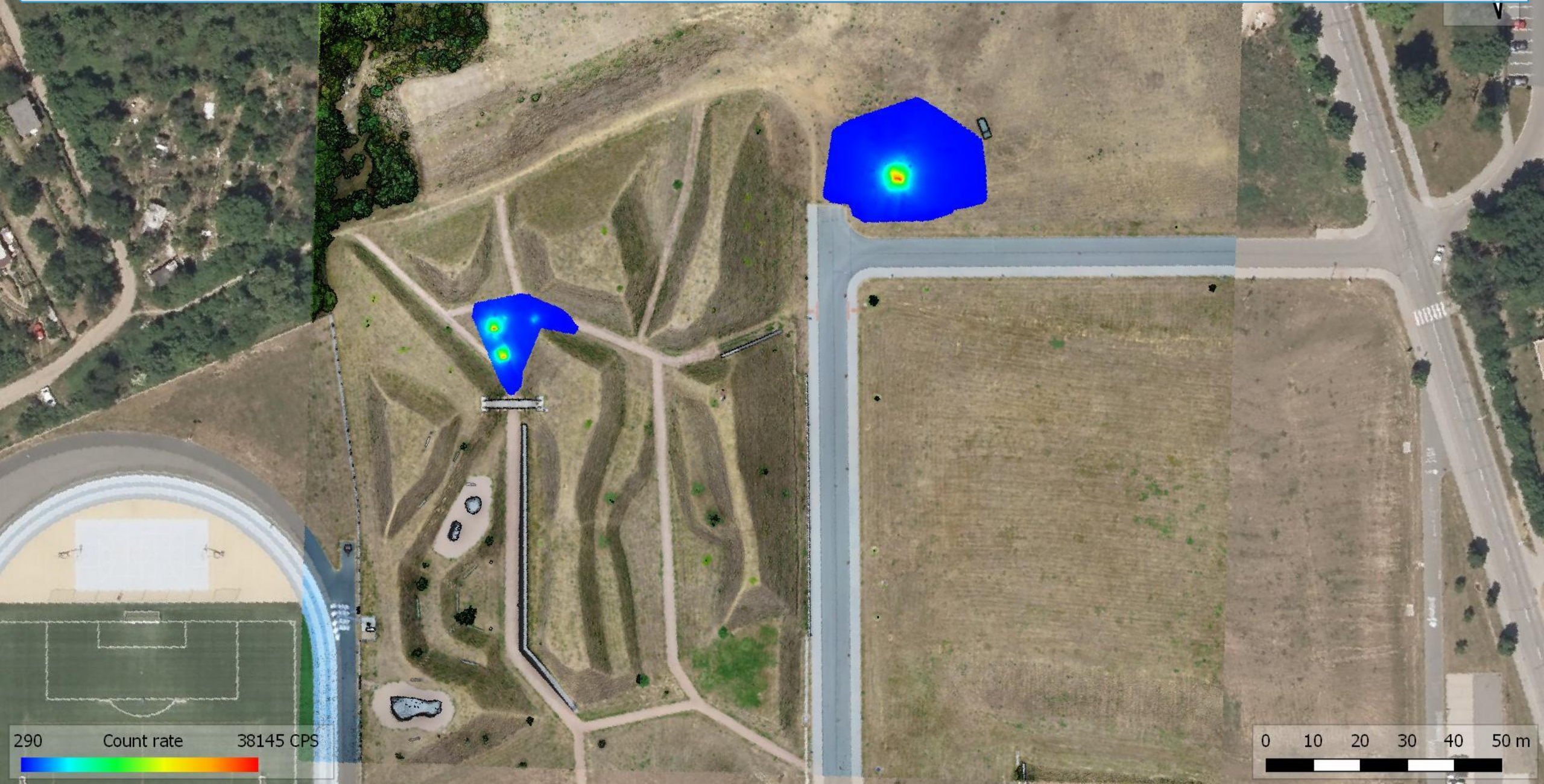
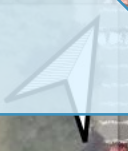
0 10 20 30 40 50 m



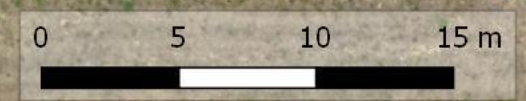
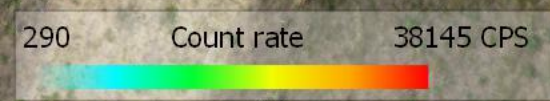
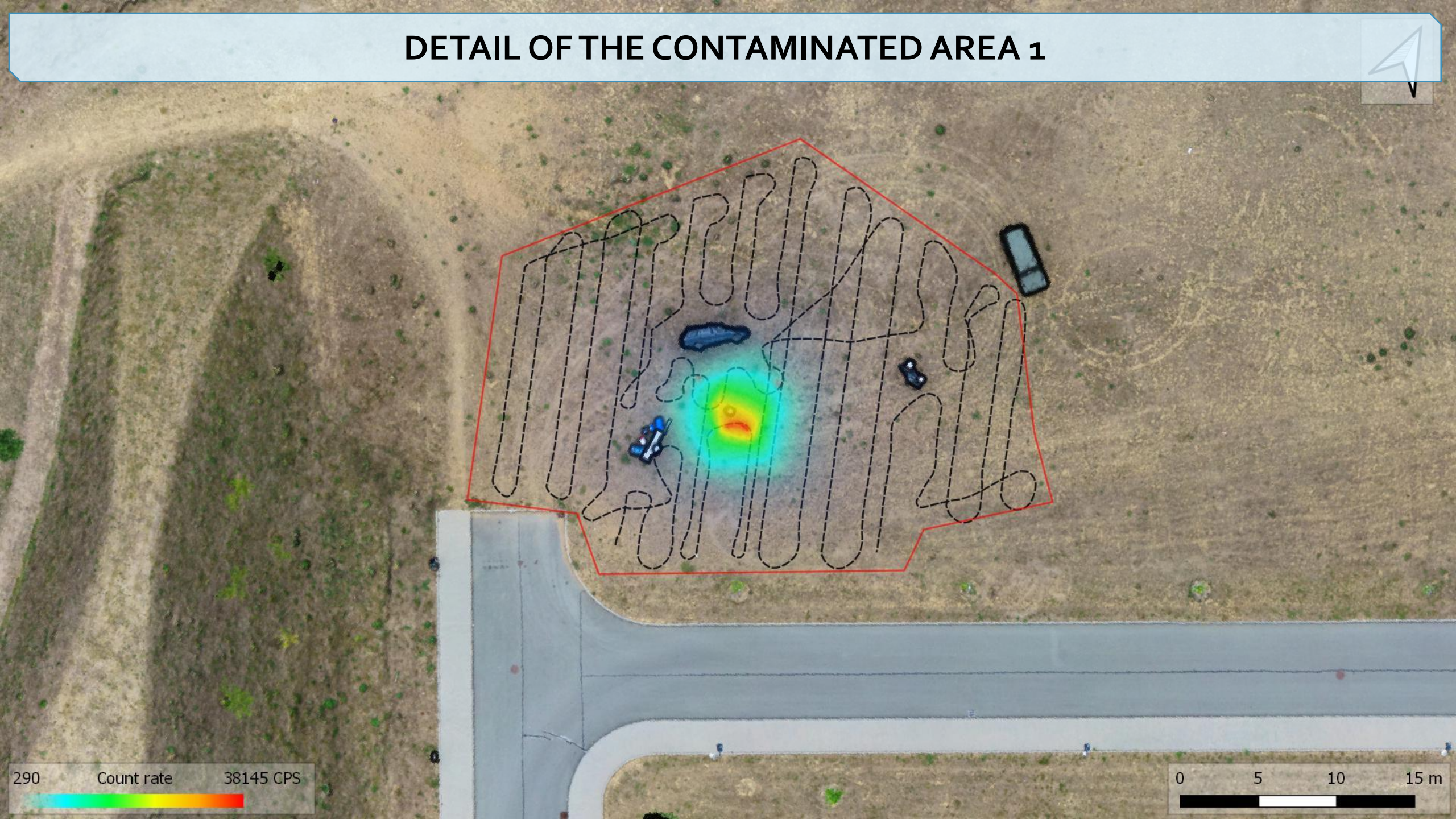
UGV TRAJECTORY FOR THE TERRESTRIAL IONIZING RADIATION MAPPING



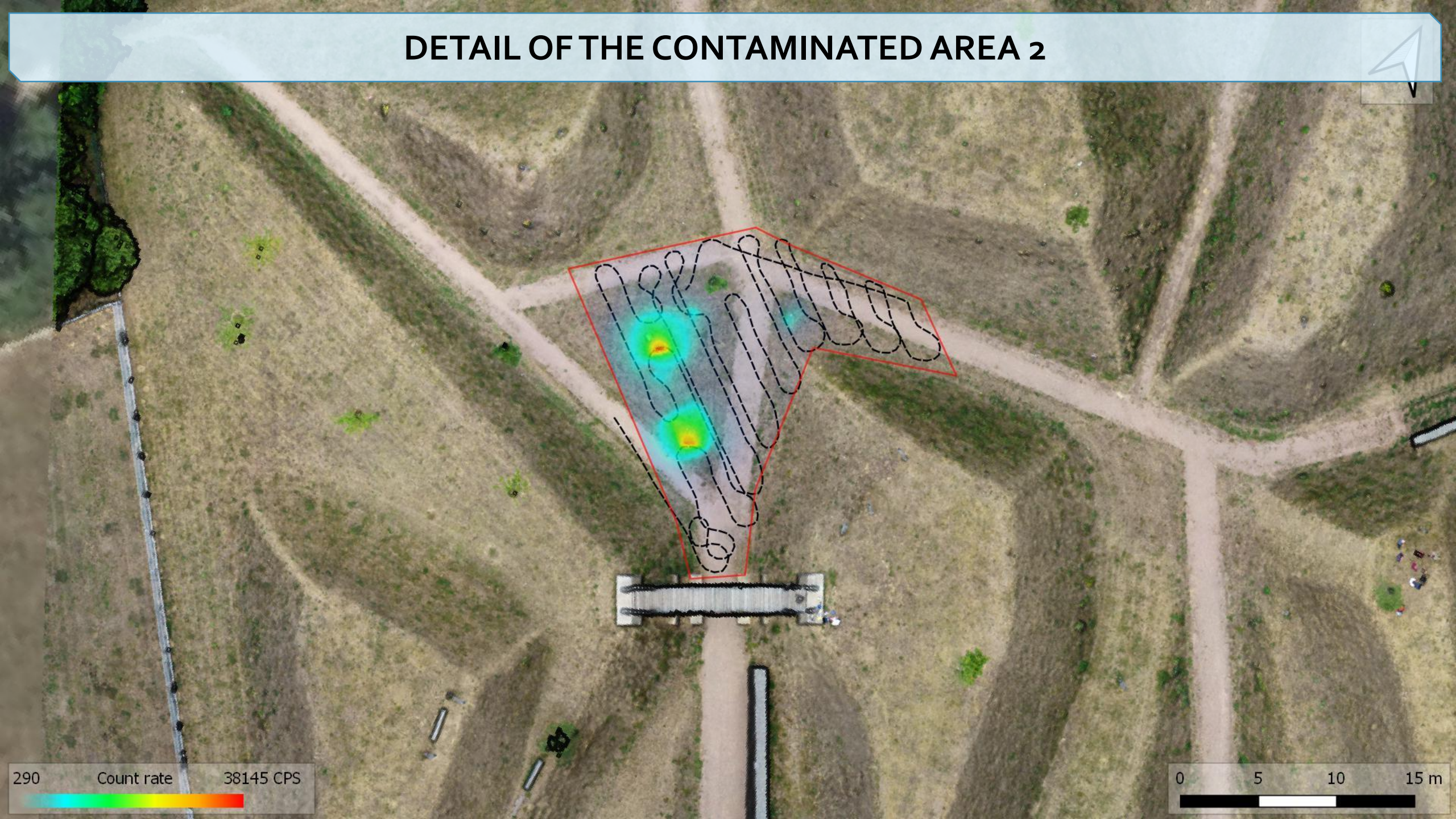
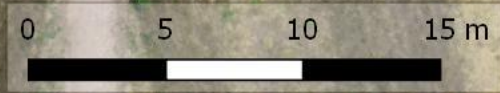
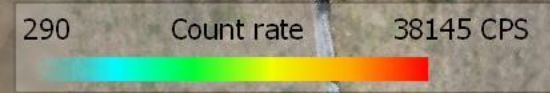
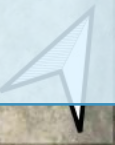
INTERPOLATED UGV-BASED IONIZING RADIATION MAP



DETAIL OF THE CONTAMINATED AREA 1

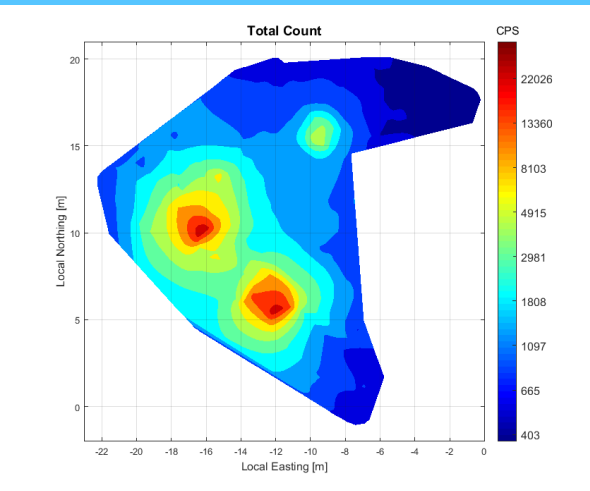
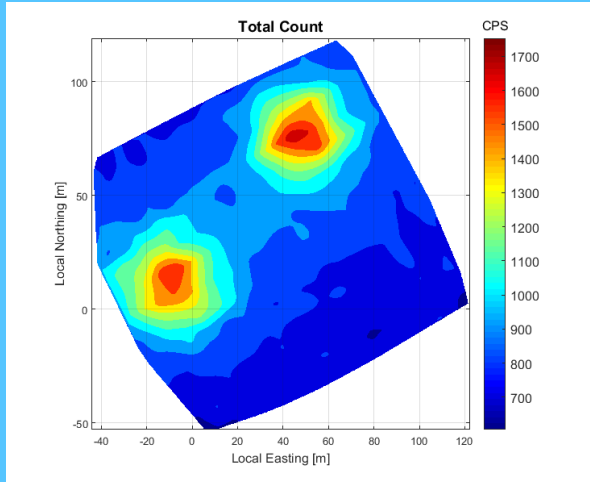


DETAIL OF THE CONTAMINATED AREA 2

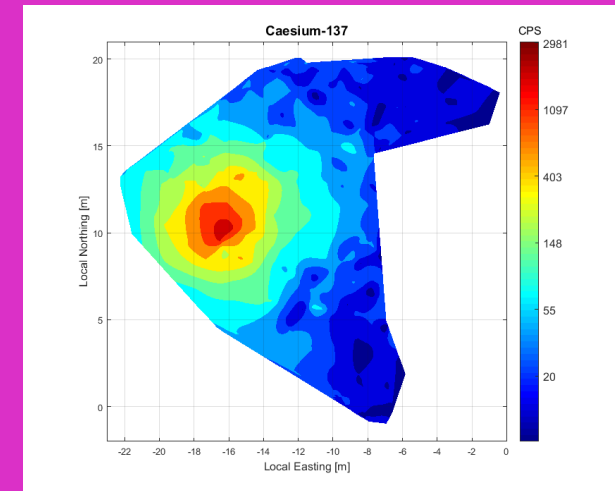
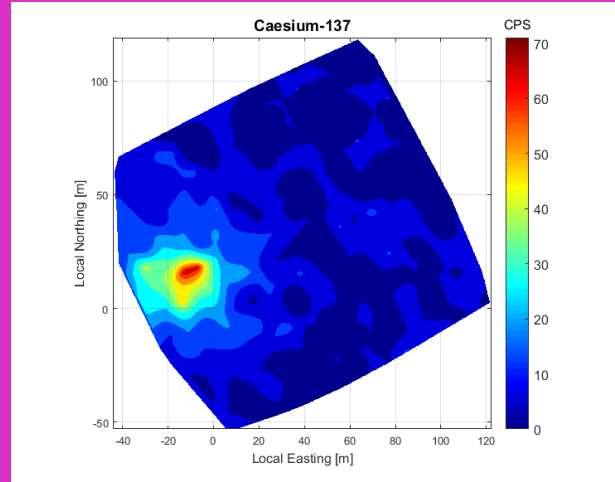


Results

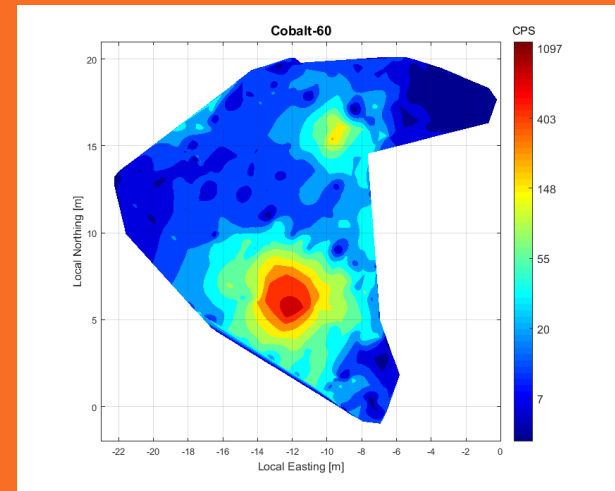
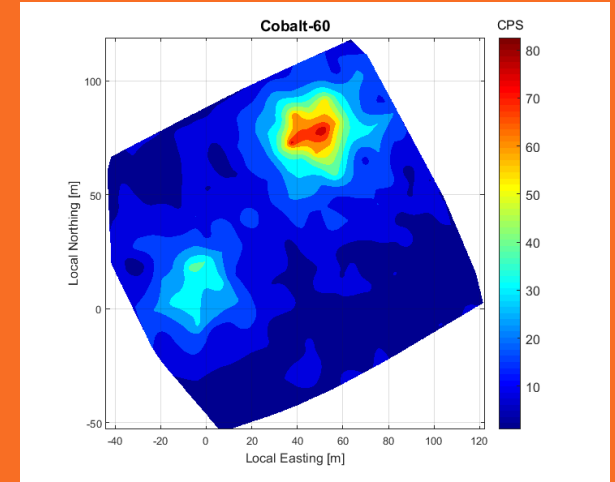
TOTAL COUNT

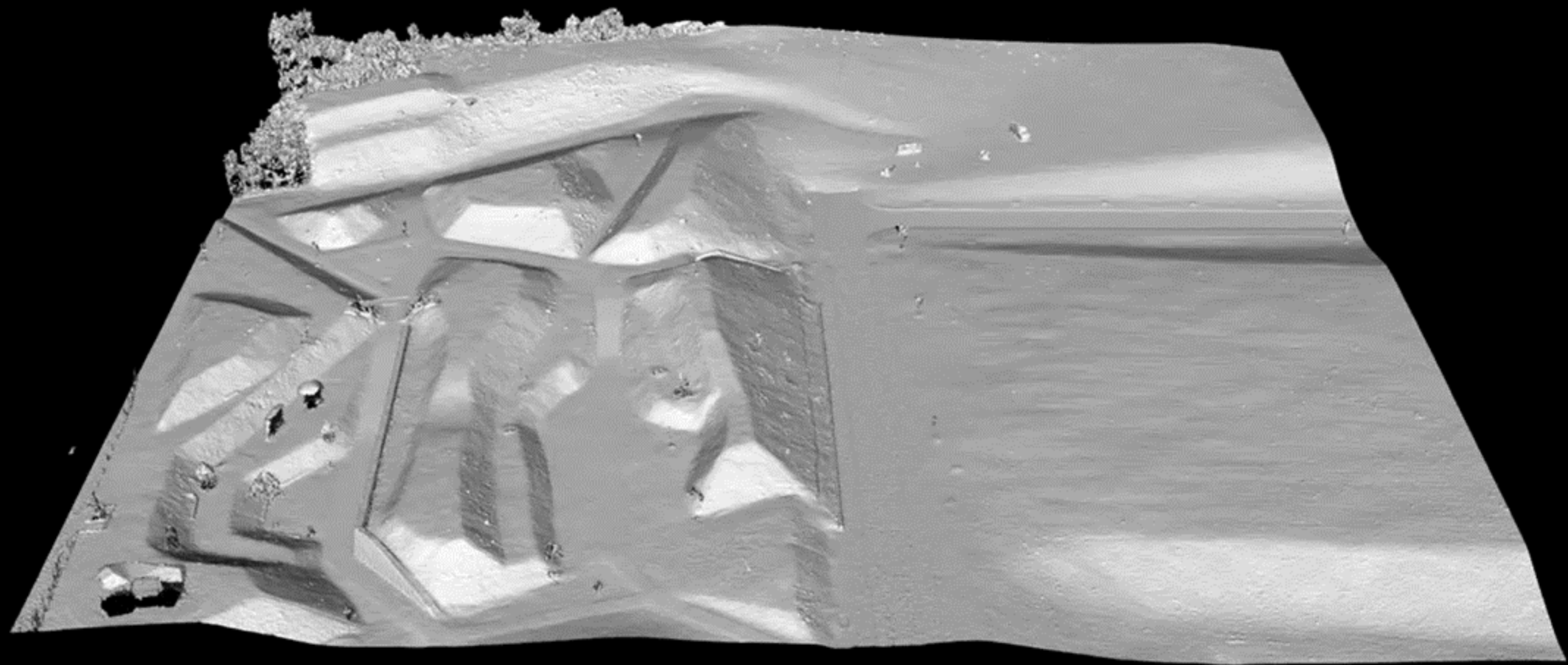


CAESIUM-137

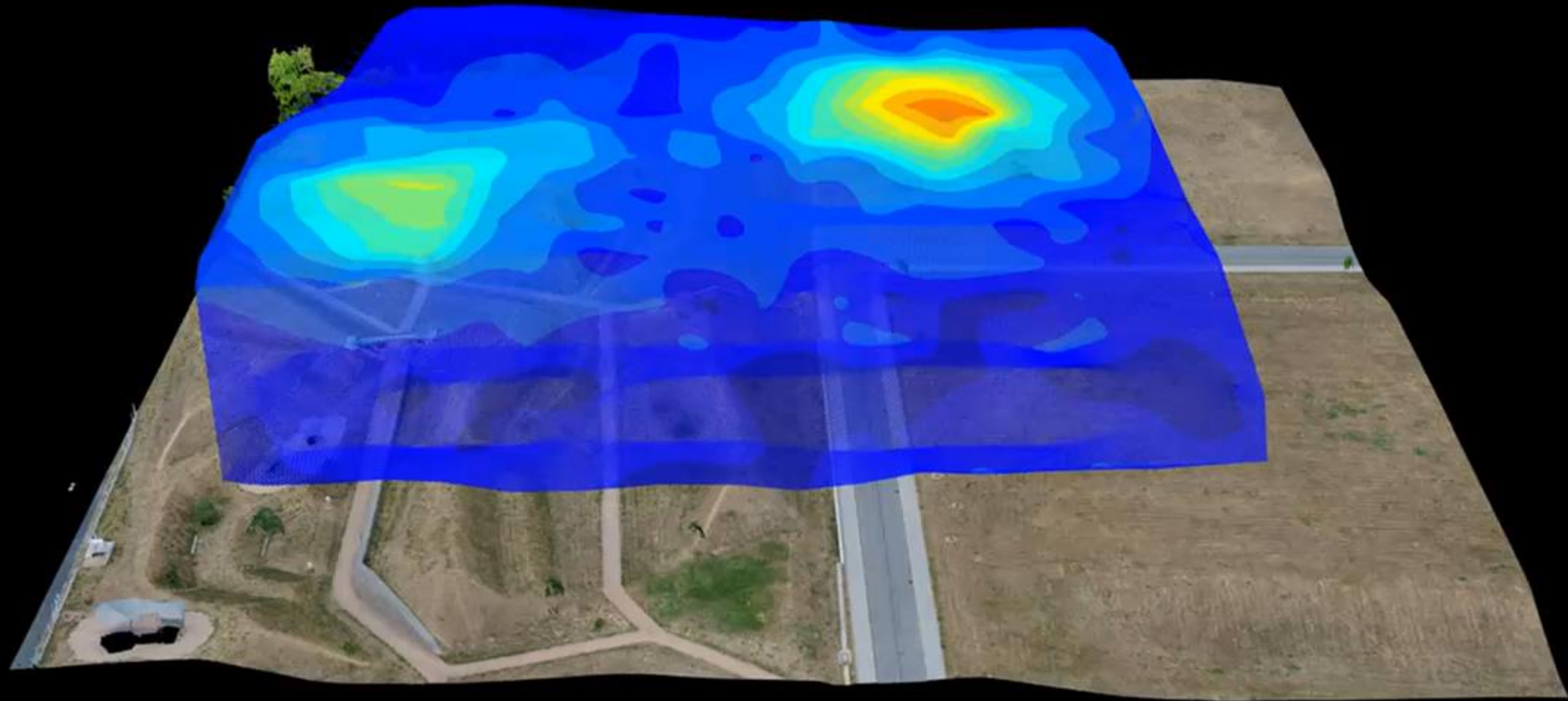


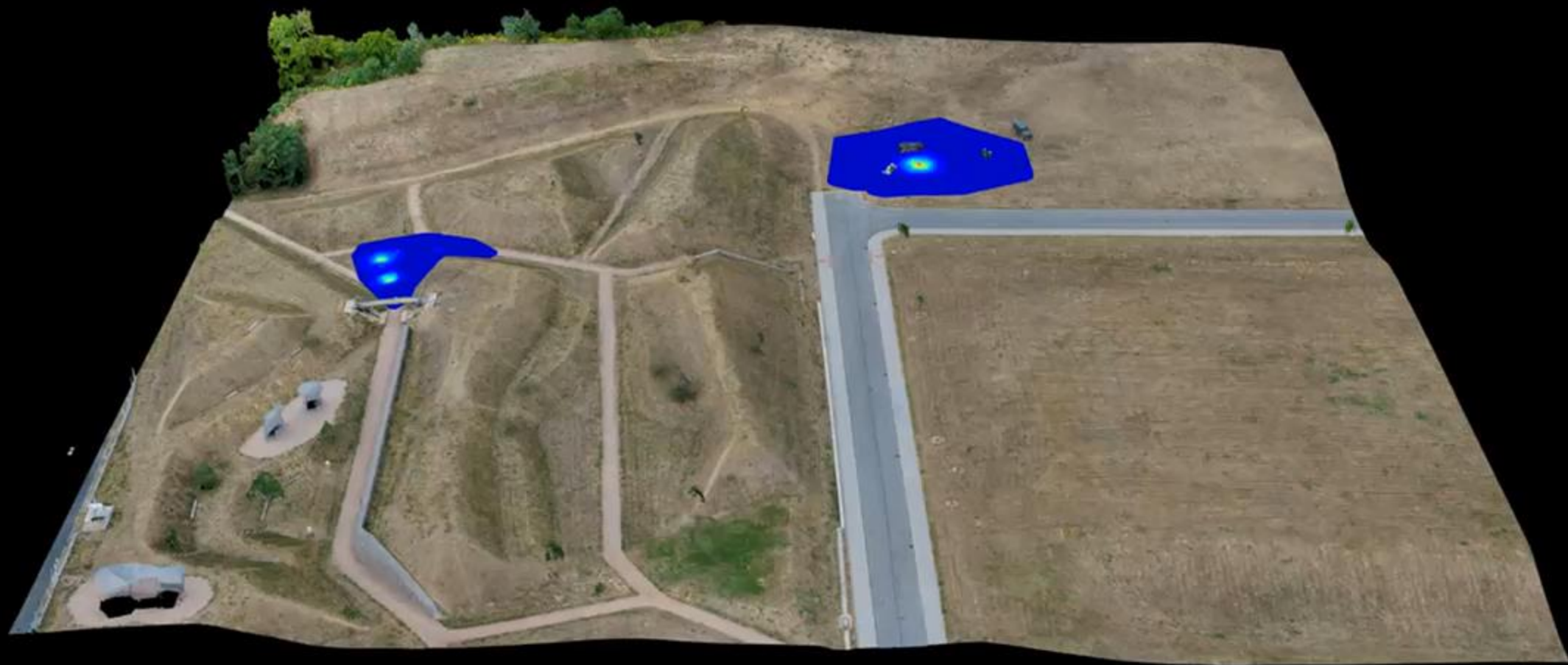
COBALT-40

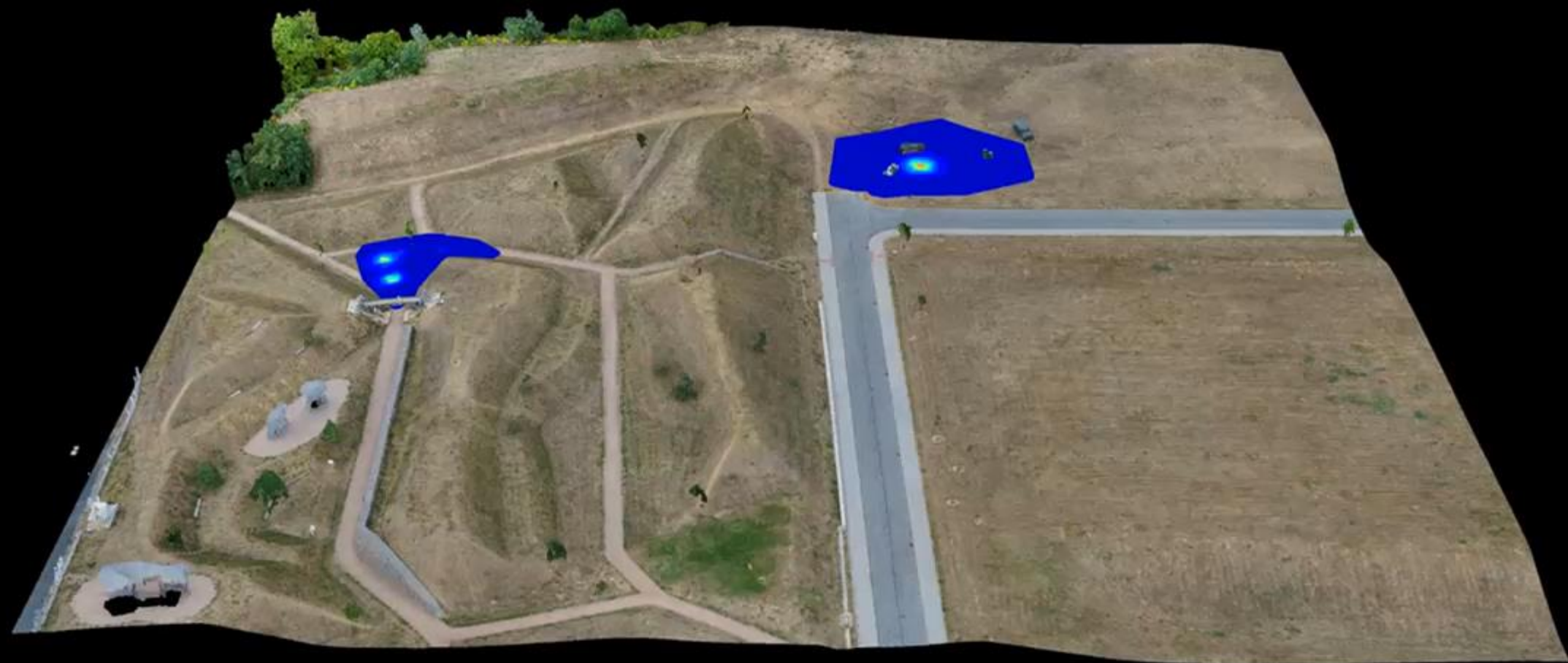






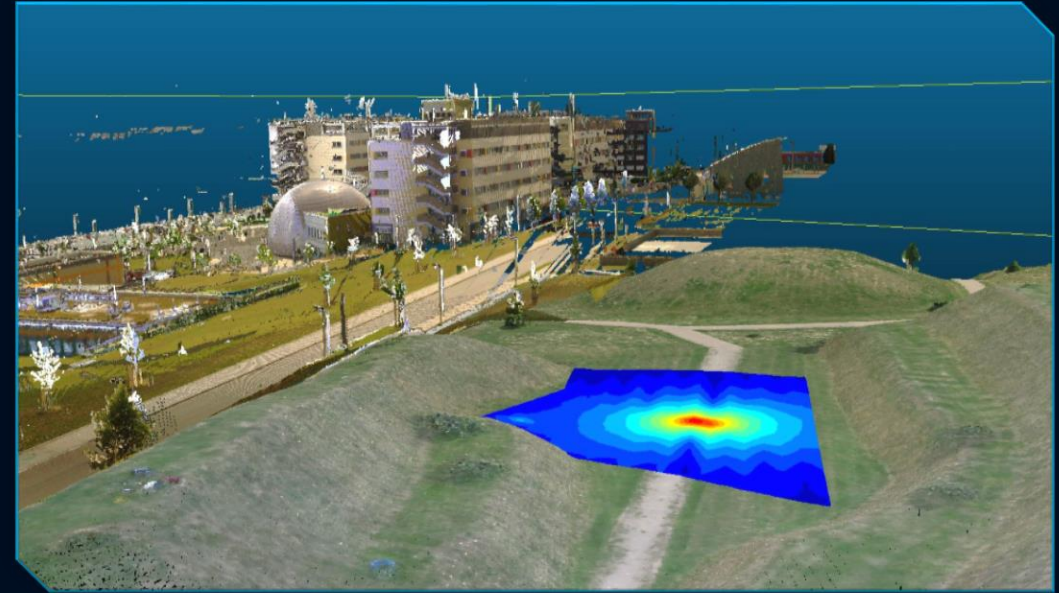




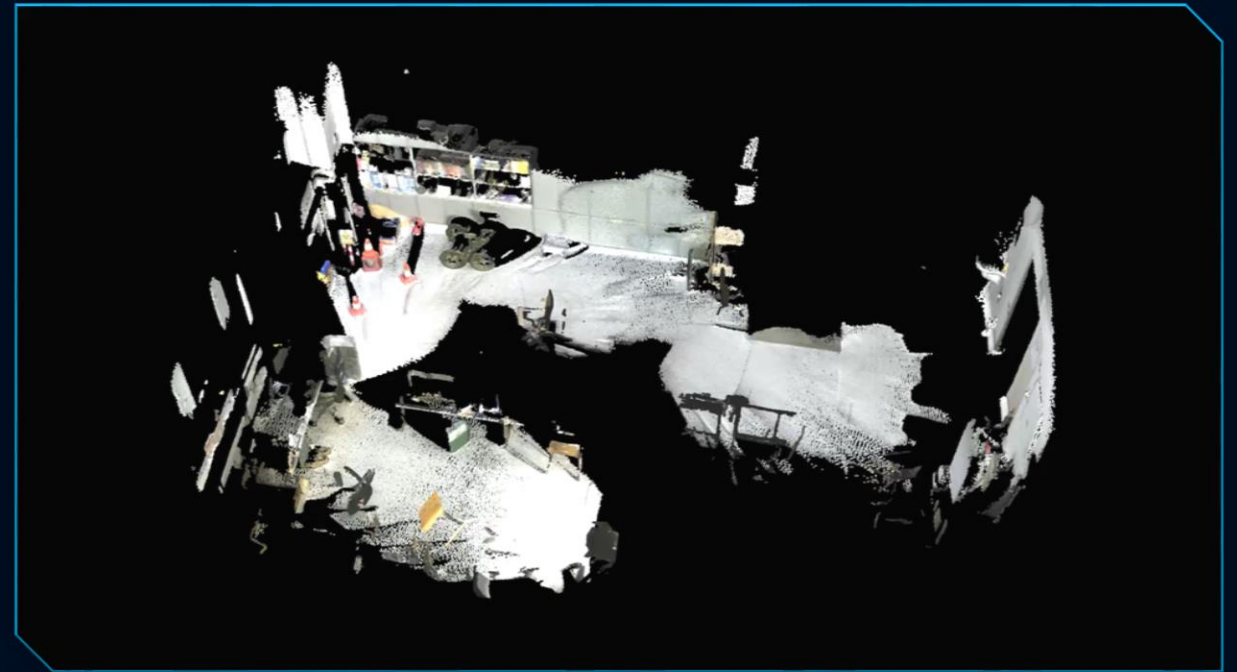


Results & Future Plans

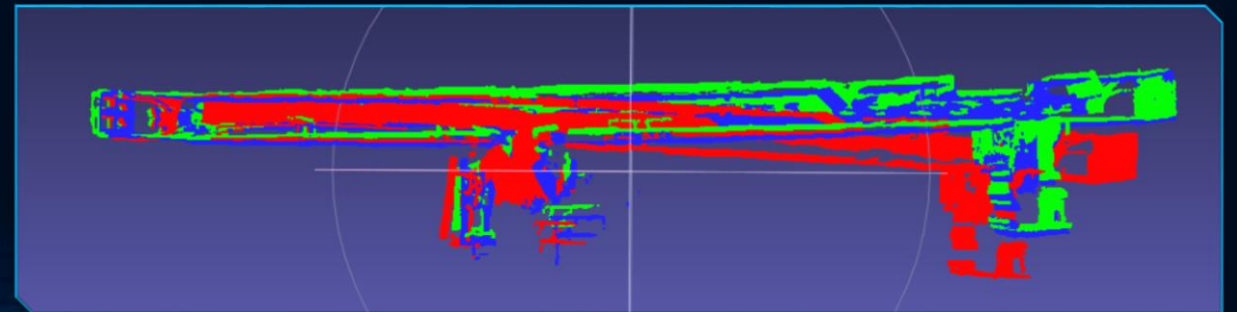
- hot areas successfully identified
- achievable sources found and localized
- autonomous obstacle avoidance
- RTK navigation of drone
- combination with telepresence



Future Plans - Obstacle Avoidance



- necessary for more autonomy
- 3D map is known but may change during mission

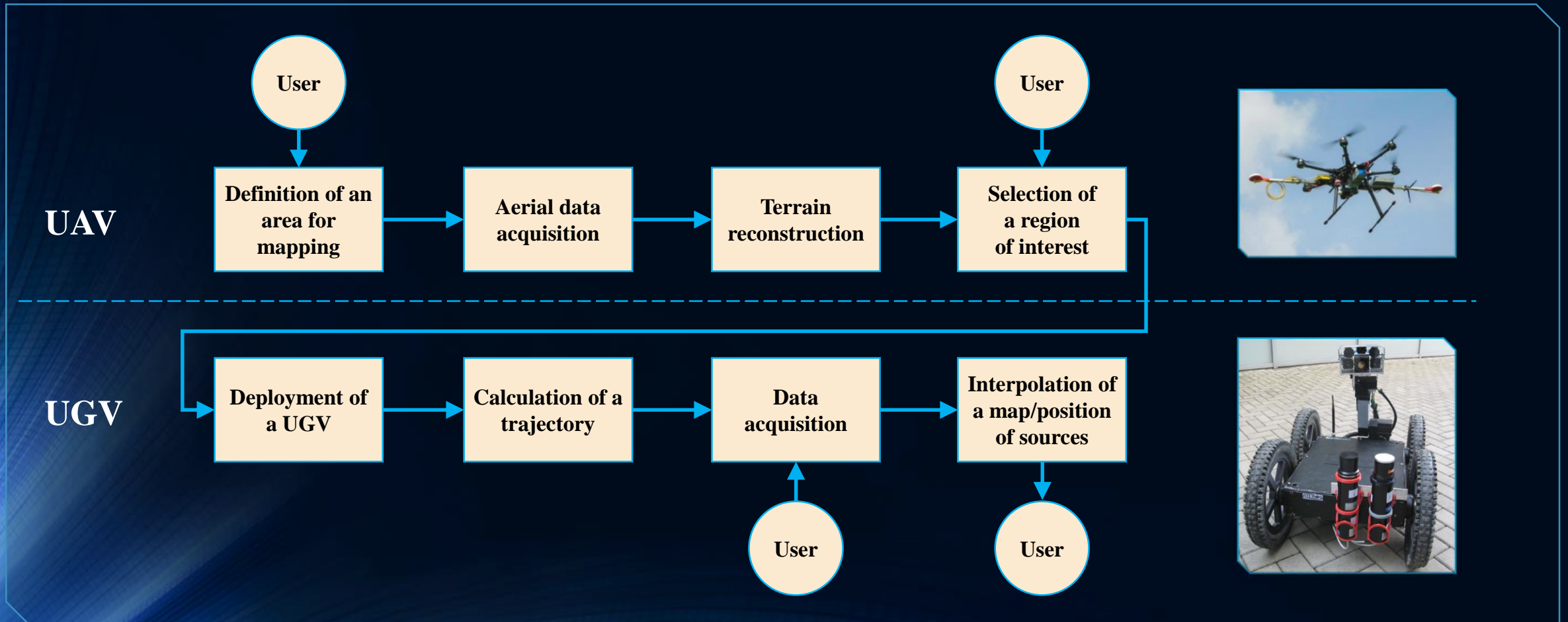


Radiation Field Measurement

- cooperation with:
 - SURO,
 - NUVIA,
 - VVU Brno,
 - SUJEB
- CAK + TACR EPSILON project



Sequence of tasks

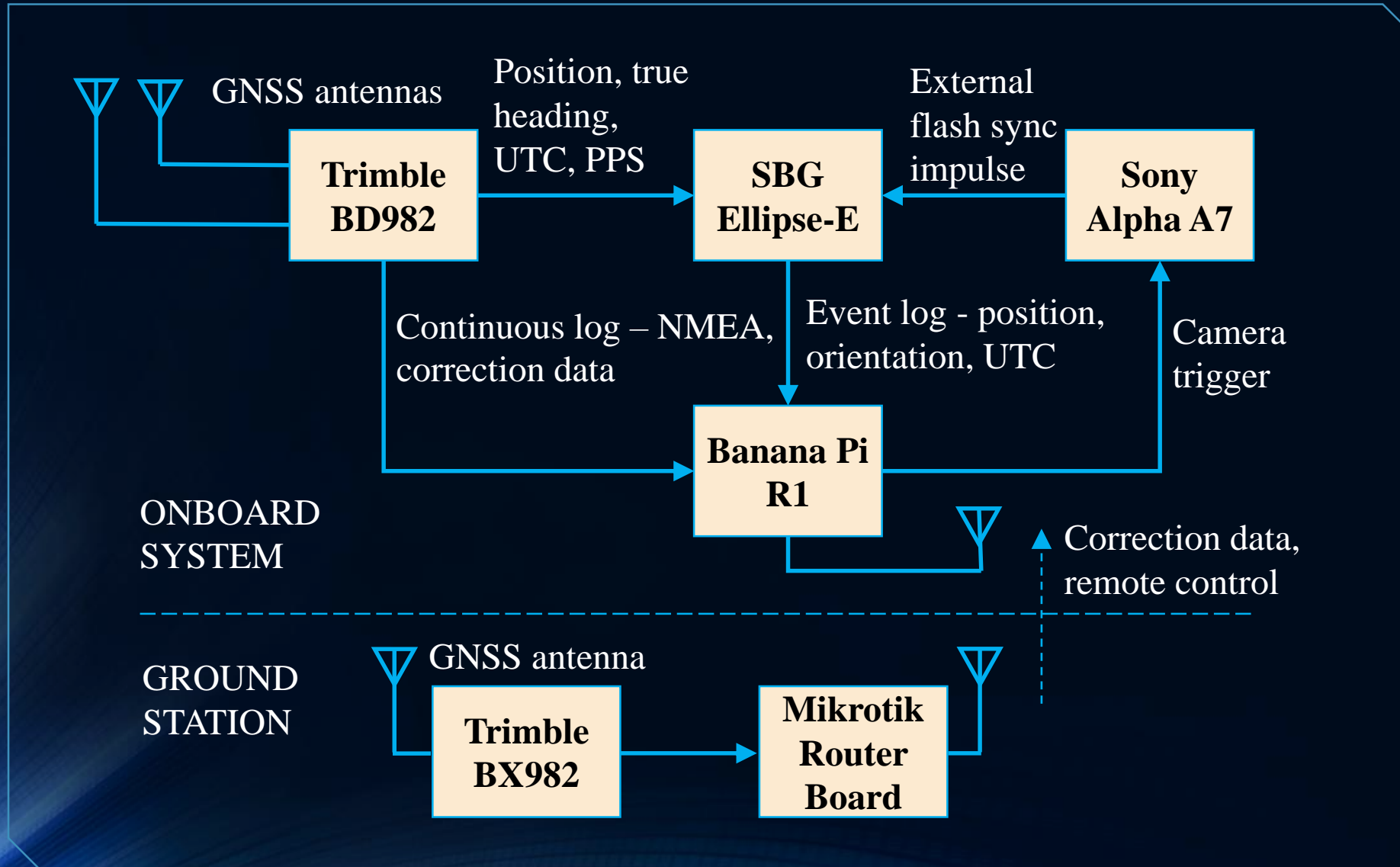


UAV – DJI S800

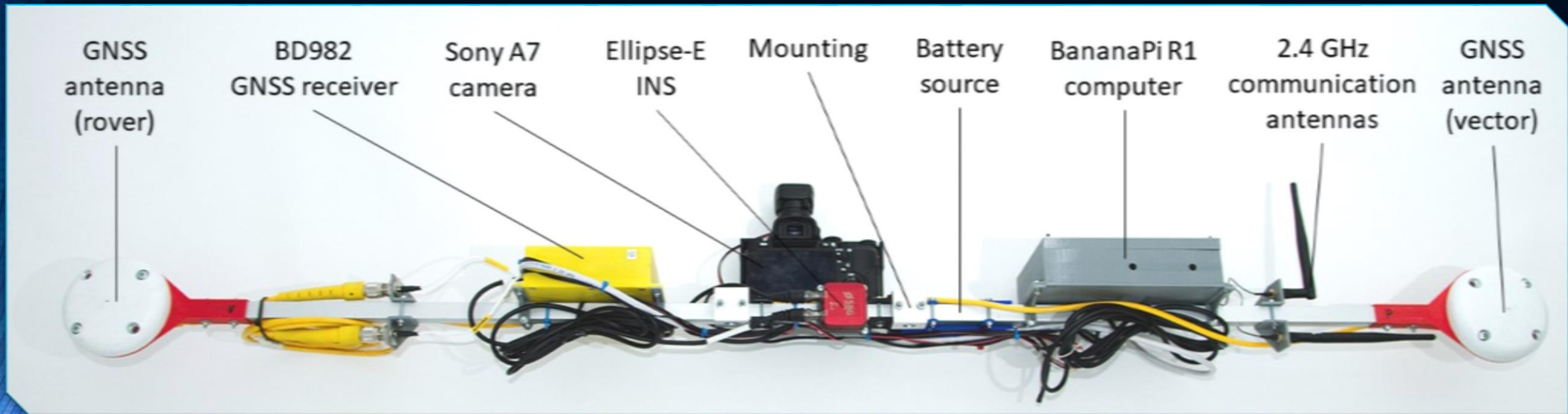
- Used for aerial photogrammetry
- Equipped with custom multi-sensor system
 - Digital camera
 - GNSS receiver (RTK) with two antennas
 - Inertial navigation system
 - Facilitates direct georeferencing of aerial imagery
- Enables to create up-to-date orthophoto and digital elevation model (DEM)



UAV – Interconnection of components



UAV Photogrammetry and Self-loc Module



UGV – Orpheus-X3

- Four-wheeled mid-size civil reconnaissance robot
- Self-localization module (RTK GNSS, INS, odometry)
- Navigation module
- Gamma radiation detection system
 - A pair of 2-inch NaI(Tl) detectors
 - Lead diaphragm
 - Counting electronics (spectrometric)
- Controlled by the on-board PC



UGV – Interconnection of components

