



Speaker

Akshit Saradagi, Luleå University of Technology (LTU)

Project Leader

George Nikolakopoulos, Luleå University of Technology (LTU)

Partners

ABB AB, Boliden AB

Project duration

2021-03-01 – 2023-04-30



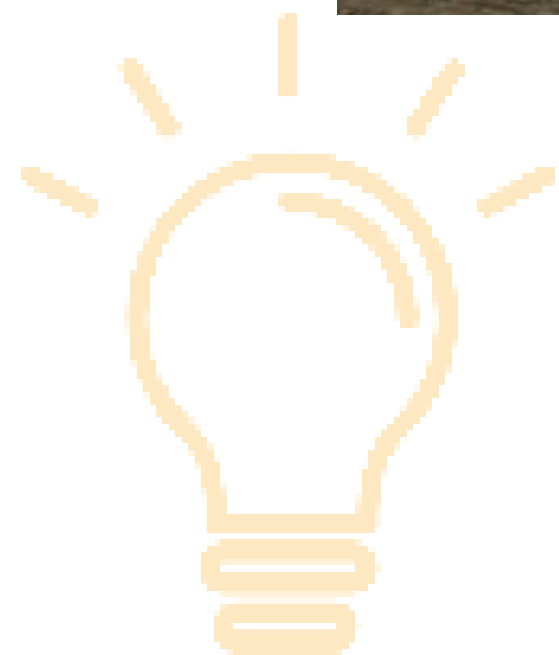
Program Day 2023

Goals of the project



Figure 1. A concept of waypoint navigation in the Aitik mine.

1. Develop Robust, Reliable advanced AI enabled Autonomy for aerial vehicles (drones)
2. Full integration of the autonomous toxic gases sensing solution with the aerial platform.
3. Integration of aerial platform with local positioning system.
4. Integration of developed solution into Aitik's infrastructure.
5. Demonstration of human-robot interaction interfaces and technical solutions.



Goals of the project

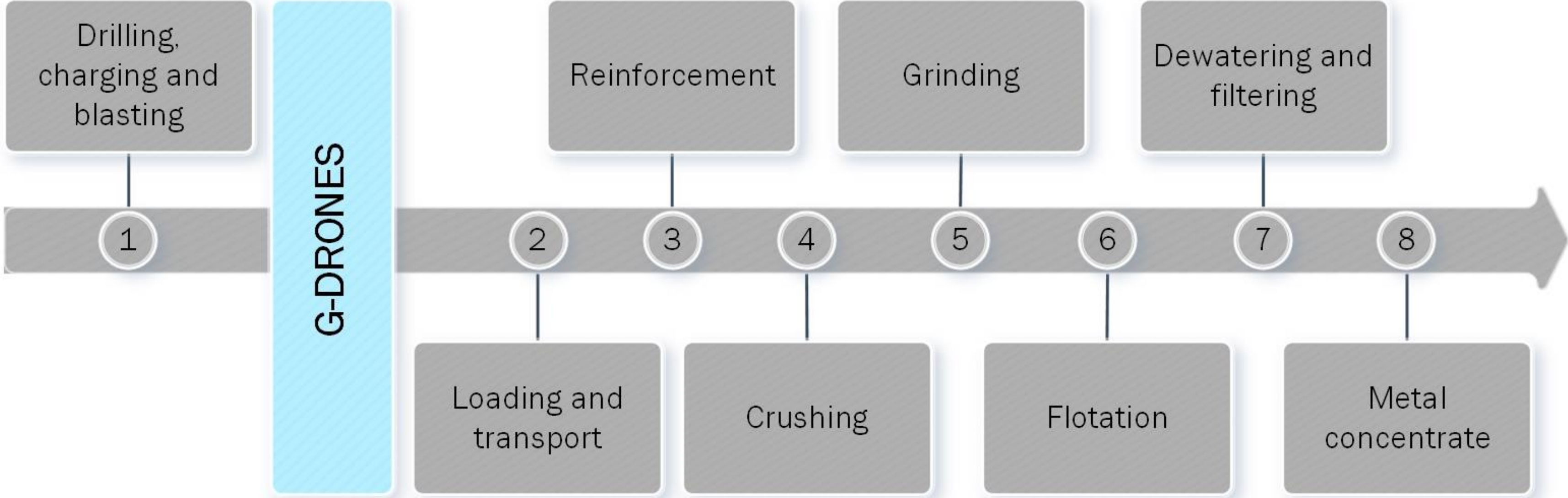
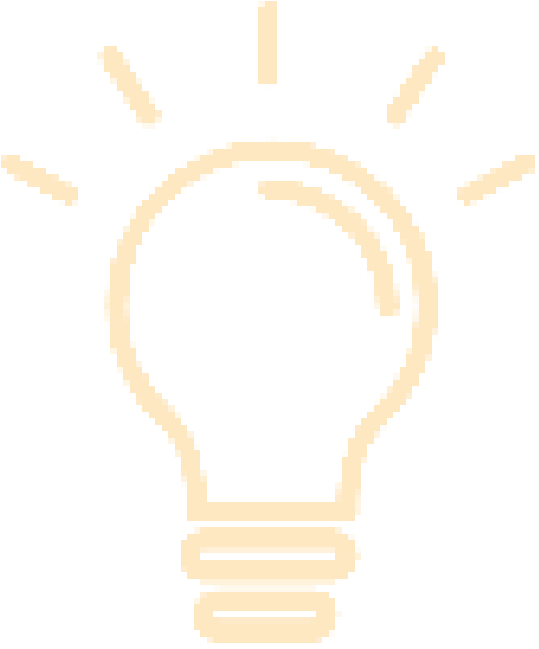


Figure 2. Enhancement of the Production Cycle by G-DRONES

Impact

- Attractive, progressive and Safe workplaces
- Improved Production and Cost efficiency
- Acceptance in Mining & metals industries



Project Timeline: Project Start Date : 2021-03-01 – End Date : 2023-04-30

G-DRONES WPs and Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WP1: Project Coordination																								
T1.1 - Financial and Administration Management																								
T1.2 - Coordination and Project Management																								
T1.3 - Development of Regular Project Reports and Final Report																								
WP2 - Innovation and Dissemination																								
T2.1 - Public Visibility																								
T2.2 - Technology Exploitation Strategy and Business Plan																								
T2.3 - Dissemination and Demonstration Activities																								
T2.4 - Education and Training																								
T2.5 - G-DRONES Standardisation activities																								
WP3 - Hardware and Software Development																								
T3.1 - Base Aerial Platform design and development for Artic Conditions operations																								
T3.2 - Gas Sensor Integration on the base aerial platform																								
T3.3 - Sensor options for mining applications																								
T3.4 - Base software development																								
WP4 - Autonomous Operation Modules																								
T4.1 - Aerial Vehicle Communication																								
T4.2 - Reactive Navigation																								
T4.3 - Robust Sensor Fusion Framework for multi-sensorial localization																								
T4.4 - Overall Mission Planner Human-Machine Interface																								
WP5 - System Integration																								
T5.1 - Analysis of ABB requirements for system integration																								
T5.2 - System Preparation and Integration into ABB ecosystem at Aitik mine																								
T5.3 - Integration results analysis																								
WP6 - Field Demonstration																								
T6.1 - Demonstration of autonomous navigation in Aitik Open Pit Mine																								
T6.2 - Demonstration of autonomous gas monitoring																								
T6.3 - Full scale field trials																								

Project Results

Development activities (WP3):

- ✓ Received 3D map of the open pit at Aitik
(Width x Height x Depth: 1489 x 1404 x -435 meters)

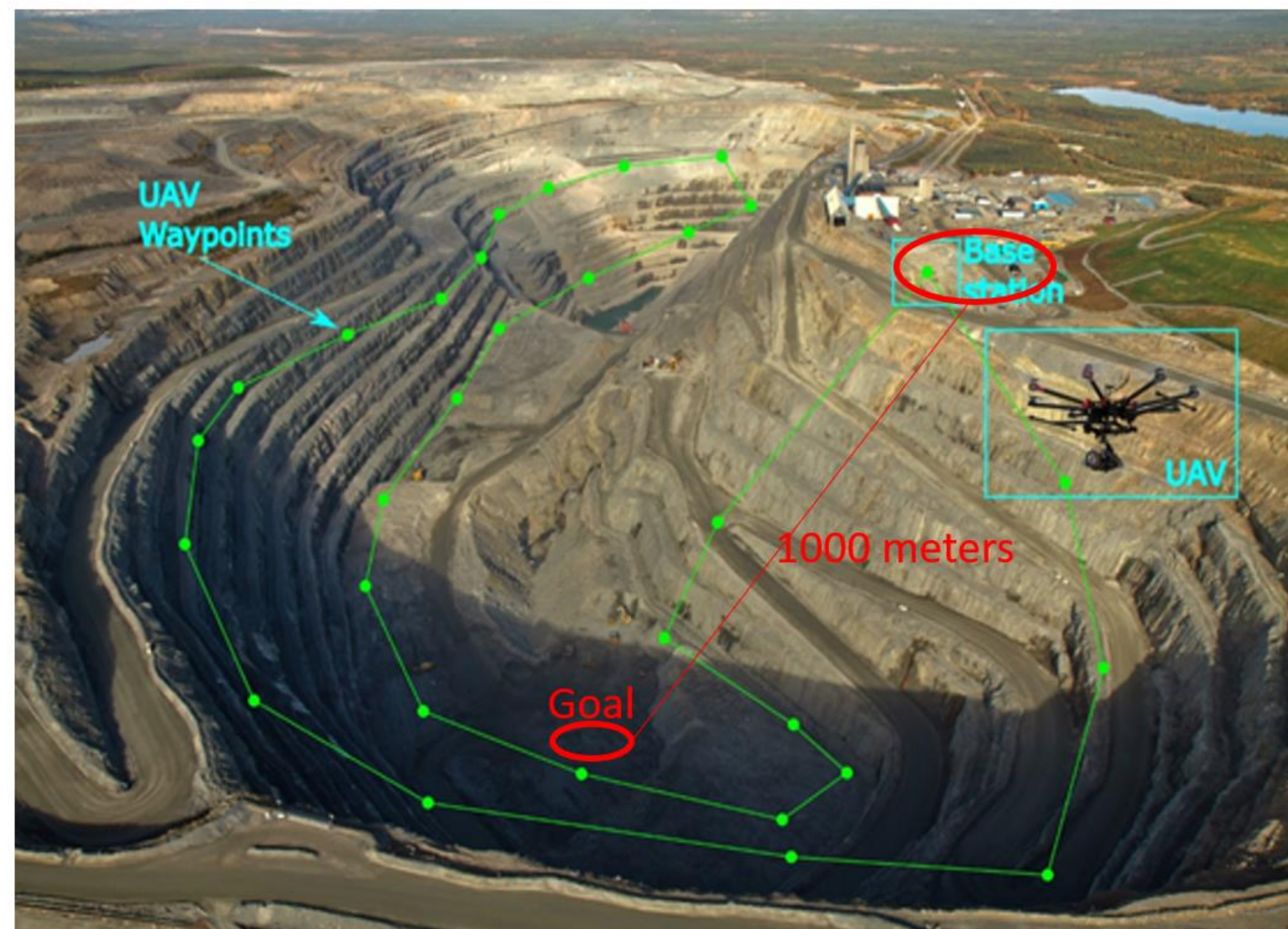


Figure 3. A concept of waypoint navigation

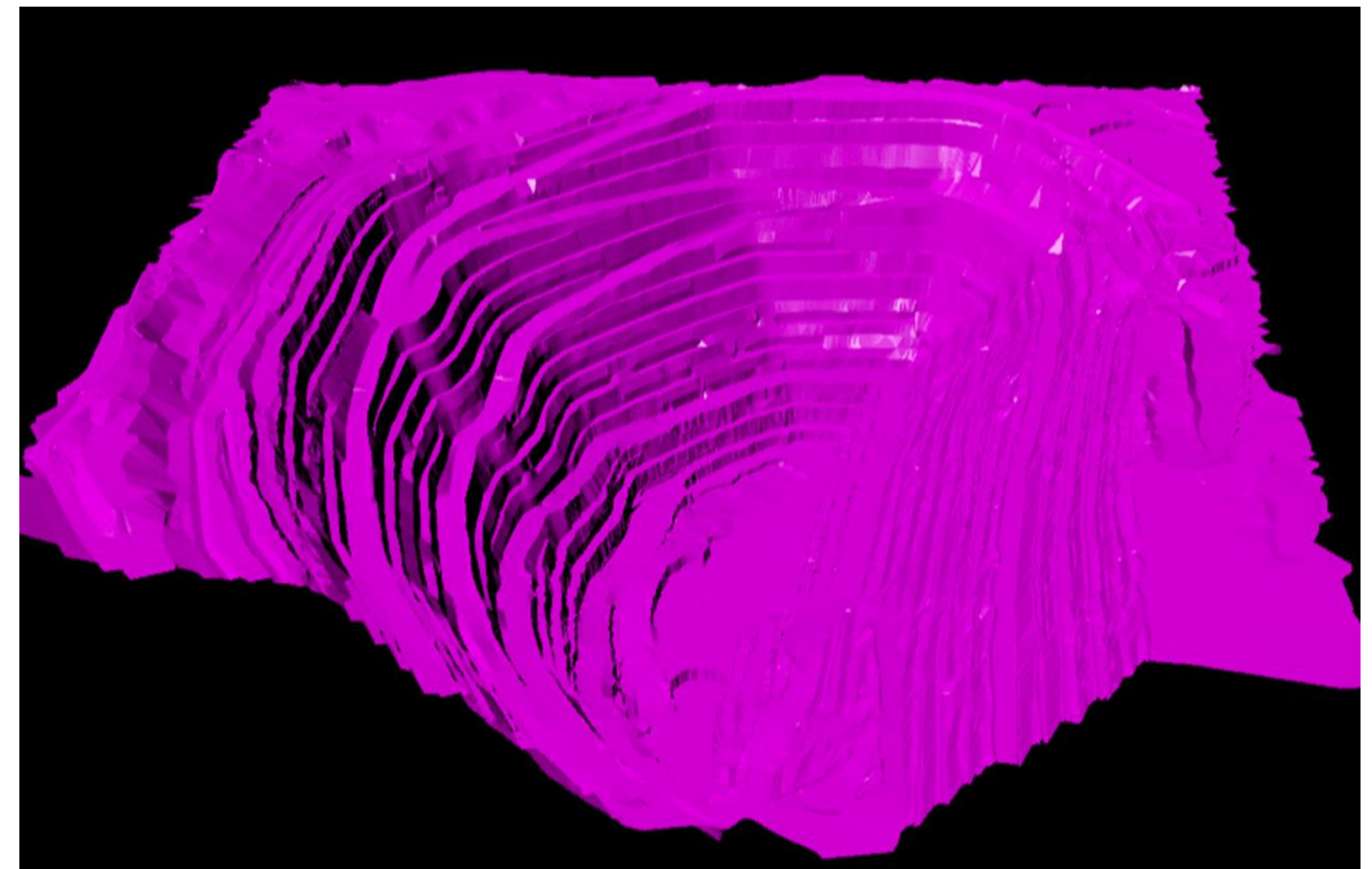


Figure 4. 3D map of the open pit in mesh format

Project Results

Development activities (WP3):

- ✓ Estimated aerial platform characteristics
- ✓ Selected aerial platform: DJI Matrice 300
- ✓ Conceptual design of the aerial platform with integrated onboard computer (LTU-NUC) is implemented.
- ✓ Overall system architecture is designed
- ✓ LTU-NUC is successfully integrated with aerial platform

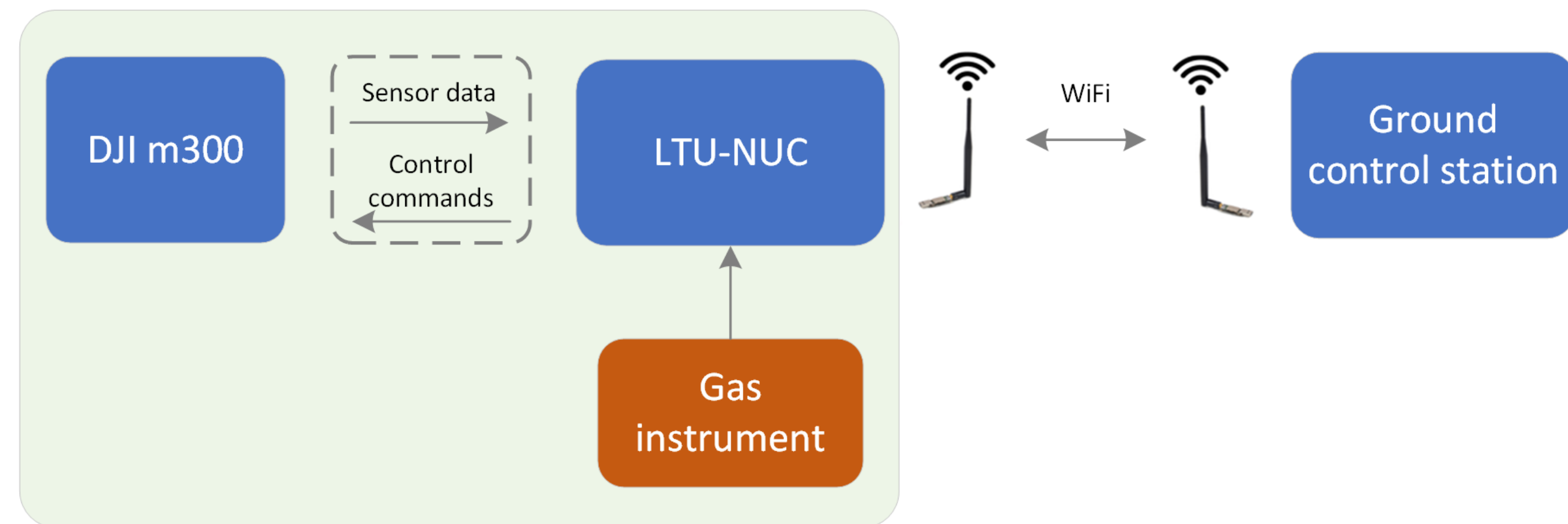


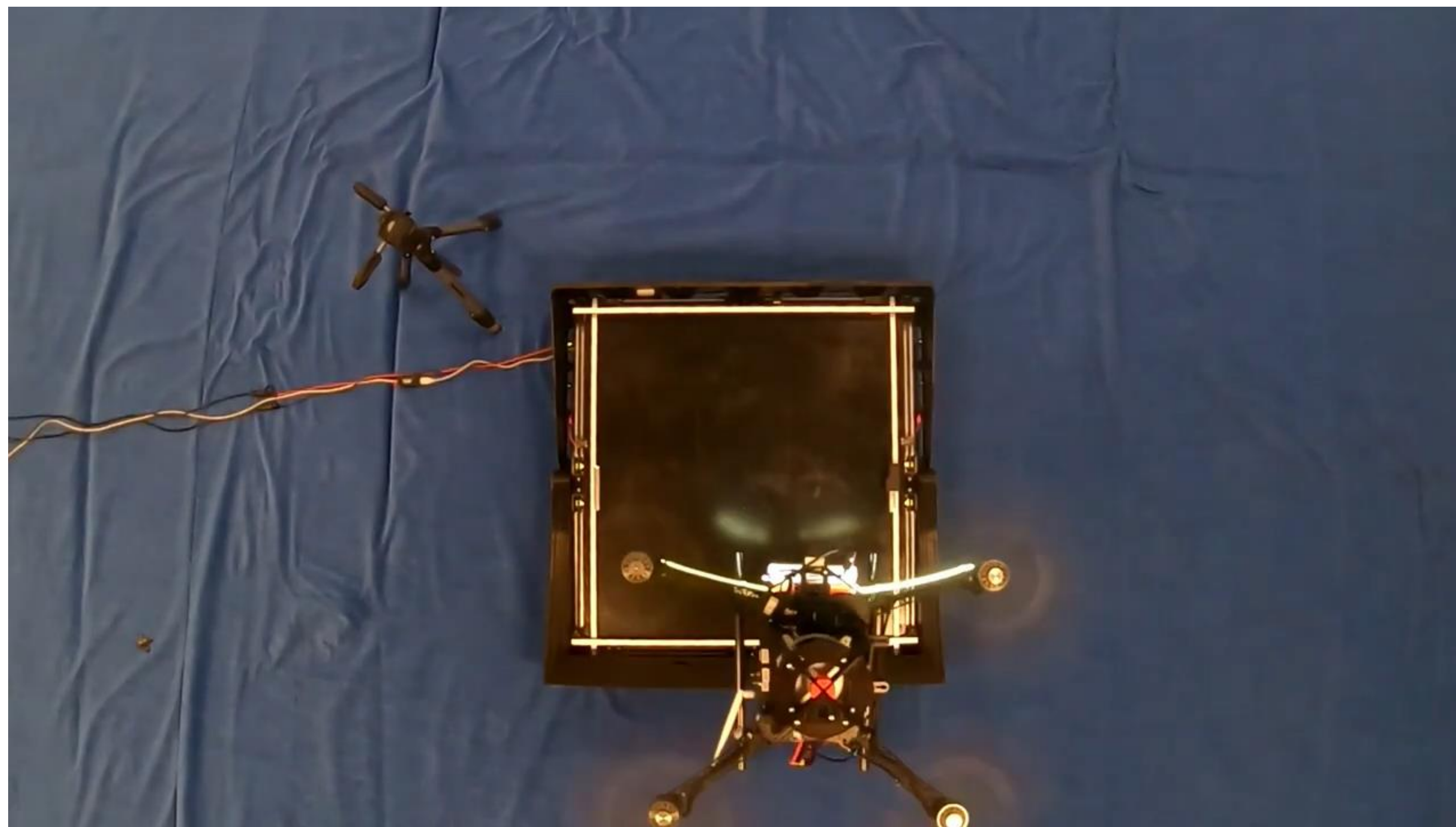
Figure 5. Overall system architecture

Project Results



Figure 6. From *CAD design of LTU-NUC aerial system to evaluation tests at Aitik*

Project Results

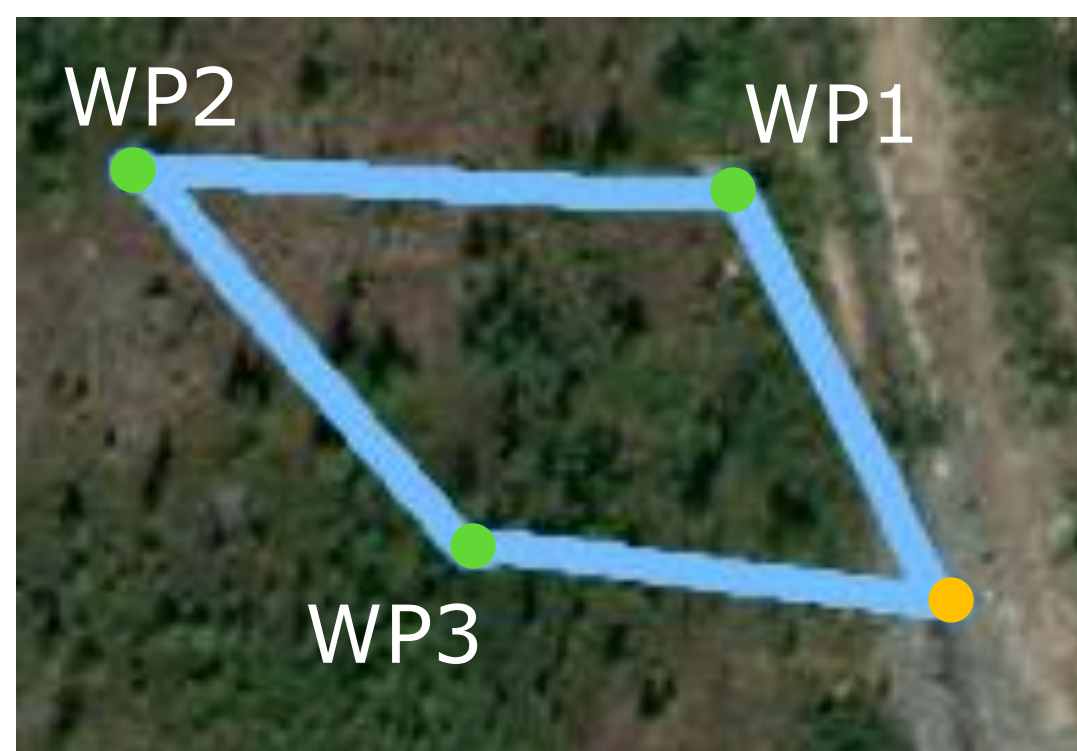


Video 1. Drone capsule demonstration

Project Results

Development activities (WP3):

✓ Autonomous drone navigation



● Start/Finish location

Figure 7. Flight path configured for autonomous mission execution



Video 2: Autonomous drone navigation over a set of user-defined waypoints (WPs)

Project Results

Development activities (WP3):

- ✓ Autonomous drone navigation



Project Results

Development activities (WP5):

- ✓ Gas instrument is selected: Dräger X-am® 5000
- ✓ Full integration of Dräger X-am 5000 with LTU-NUC



Figure 8. *Communication diagram with X-am 5000 for online gas measurements registration*

GUI

Path GUI - by frank20a

File View Help

RAI G-DRONES

Point 1
Point 2
Point 3
Point 4
Point 5
Point 6

Mission Control

Start/Send Stop

Pause Resume

Cruise Speed: 5m/s

Alt. 10m Heading 112°

Latitude Longitude

65.61841 22.1341

Zoom 16

Reload Map

Select, rearrange, delete waypoints

Mission & in-flight controls

Waypoint manipulation

Project Results

Development activities (WP6):

- ✓ Autonomous drone navigation



Figure 10. Full-scale mission flight path with assigned WPs for gas measurements.

Project Results

Development activities (WP6):

✓ Full scale mission

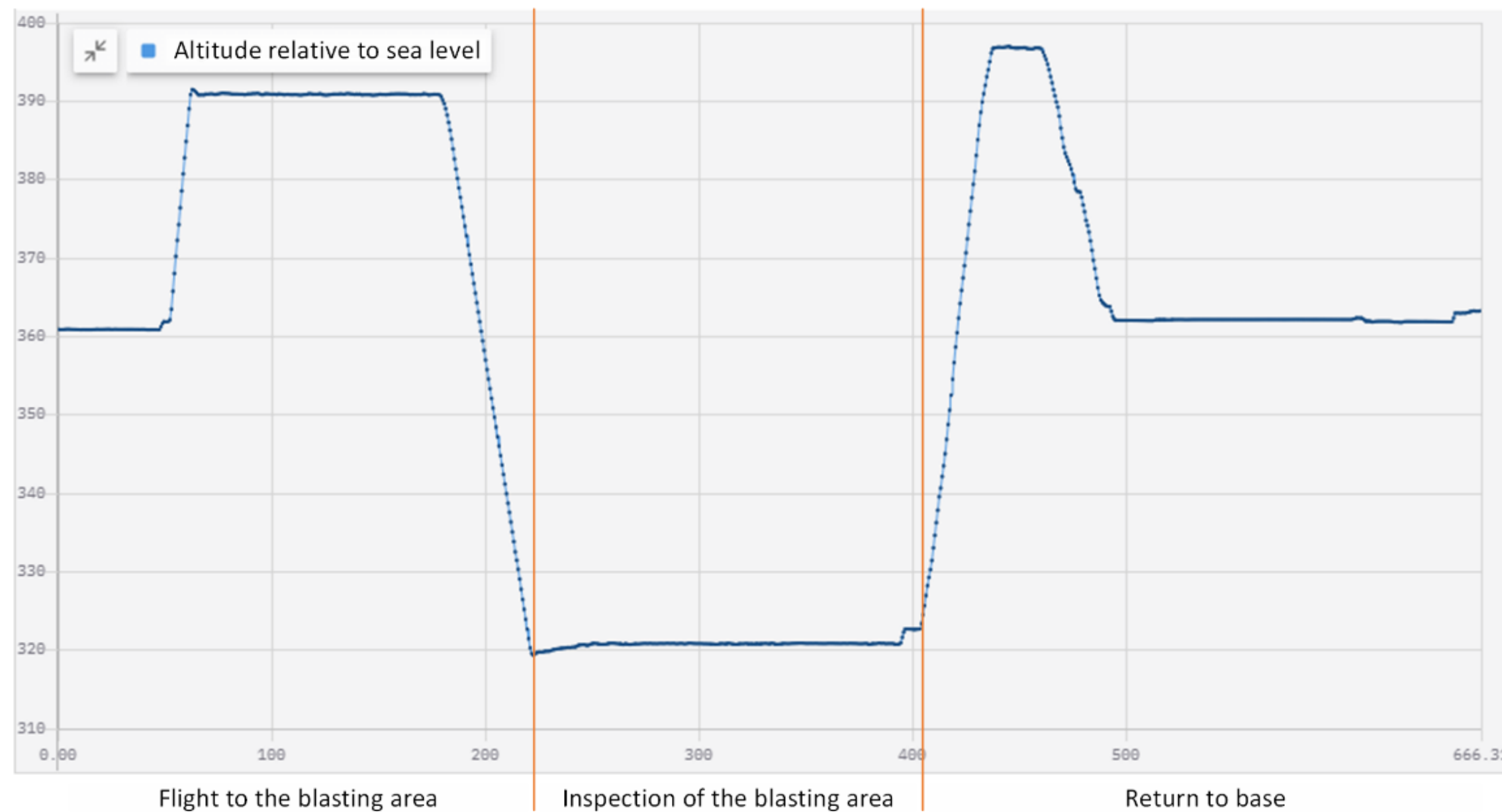


Figure 11. Flight altitude relative to the sea level

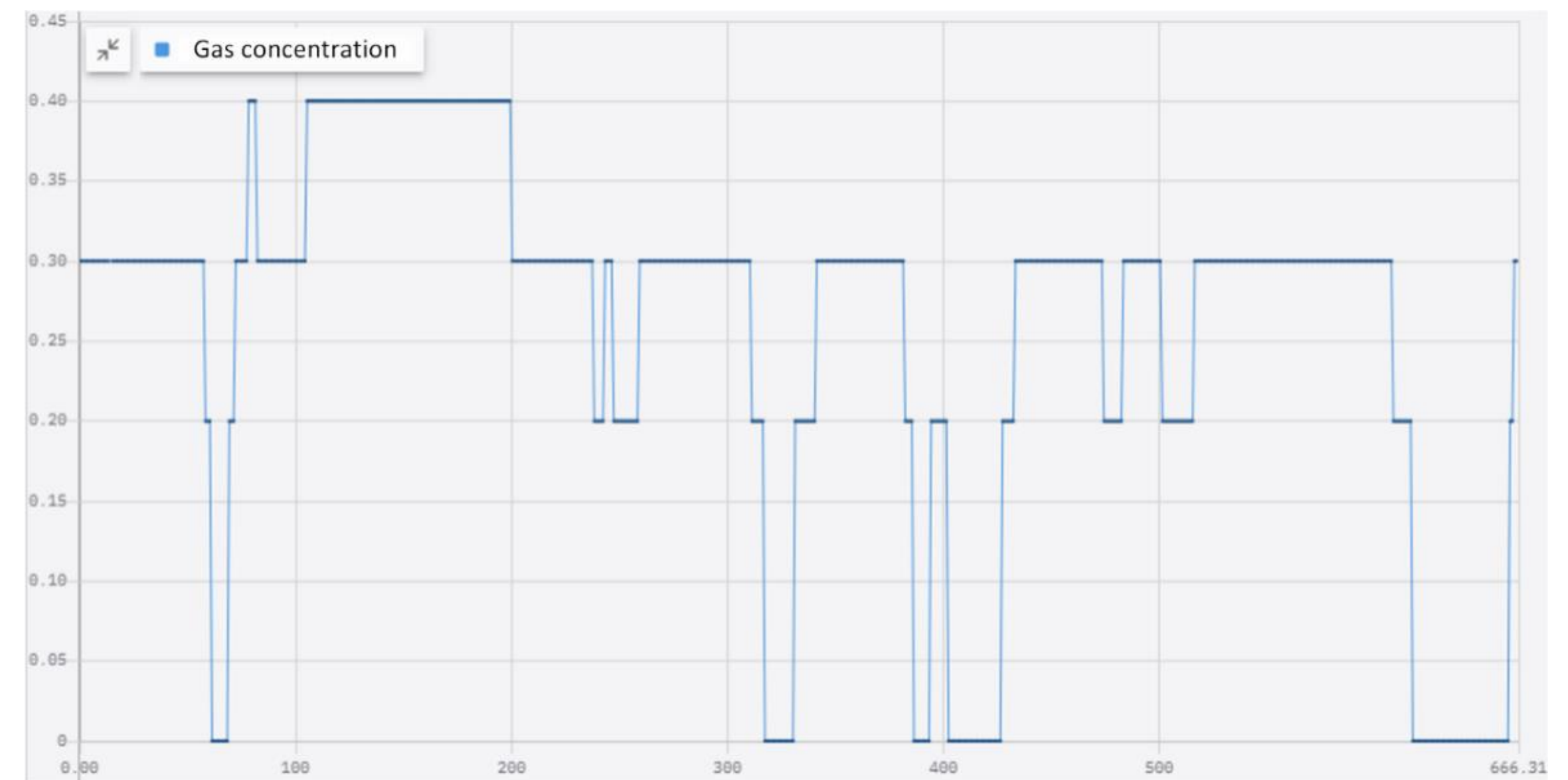


Figure 12. Gas concentration levels during the inspection mission after blasting.

Project Results

- Project coordination and dissemination activities (WP1, WP2):



Autonomous drones carrying out dangerous mining work

The vision is that in the mines of the future, machines will do all the work. To realize this vision, you must develop an essential element – something else that can perform dangerous tasks efficiently and independently.

Figure 13. Project press release

G-DRONES

Speaker
Anton Koval, Luleå University of Technology

Project leader
George Nikolakopoulos, Luleå University of Technology

Partners
ABB AB, Boliden AB

Project duration
2021-03-01 – 2023-02-28

ROBOTICS TEAM ABB BOLIDEN

Figure 14. Project presentation at Swedish Mining Innovation day 2021

G-DRONES was presented at Swedish Mining Innovation day

Last week, Swedish Mining Innovation's annual Program day was held as a digital event. During the day, current information was presented on what is happening along the entire value chain, everything from the program's major strategic investments to updates from ongoing pre-studies and full-scale and pilot projects. Almost a hundred people had registered for the event, and they dropped in and out during the digital project buffet. If you missed the Program day, or want to see one of the presentations again they are available below.

Boliden Aitik

Intro
Aitik, strax söder om Gällivare i Norrbotten, är Sveriges största koppargrubbrott. Här bryts kop

Just nu pågår ett arbete med självkörande drönare för gasmätning i Aitik. Projektet sker tillsammans med Luleå tekniska universitet och ABB. Syftet är att förbättra arbetsmiljön och öka säkerheten.

Internet of things, Industrin 4.0, är här för att stanna. Något Tony Normark, digitaliseringskoordinator i Aitik, är högst inblandad i.
– Det är häftigt att få vara med och utveckla tekniken och få se möjligheterna. Hjälpa till att ge verktyg till de olika verksamheterna, säger han.

Att använda drönare i Aitik är inget nytt. I dag använder man drönare bland annat till att besikta truckflak och för att se in i kvarnarna när det är repstopp i anrikningsverket.

Ett bra verktyg, som förbättrar arbetsmiljön.

Projektet med gasmätning startades av Mikael Burck, avdelningschef på elavdelningen, tillsammans med ABB och LTU som bygger själva systemet. Tony Normark blev inbjuden för att integrera drönaren i systemen.

– I stället för att köra in i ett gasmoln efter sprängning och veva ned rutan för att mäta så vill vi att en drönare gör det i stället. Vi vill undvika att människor får i sig giftiga gaser, säger Tony Normark.

I början av sommaren gjordes ett test med manuell flygning och drönaren lyckades registrera mätdata. Dessutom visades höga värden så området fick stängas av. Under hösten gjordes ett till test då drönaren flog autonomt över området.
– Då hade vi ställt in att den skulle flyga runt på området, avvakta några minuter, och sen flyga vidare till andra ställen. Det testet fungerade också.

Förhoppningen är att i mars göra ett slutligt fälttest där hela konceptet testas av tillredningen. Om allt fungerar som det ska så ska personalen därefter utbildas.
Luleå tekniska universitet ABB

Right now, work is underway with self-propelled drones for gas measurement in Aitik. The project is done together with Luleå Technical University and ABB. The aim is to improve the working environment and increase safety.

Internet of things, Industry 4.0, is here to stay. Something Tony Normark, digitization coordinator in Aitik, is highly involved in.
- It is cool to be involved in developing technology and see the possibilities. Help provide tools to the different business... See more

Photos

Figure 15. BOLIDEN news about the project

Thank You for your attention!

**Mining innovation for a
sustainable future**