



AN AUTONOMOUS UNDERWATER EXPLORER FOR FLOODED MINES

DEVELOPING AN UNDERWATER ROBOTIC PLATFORM TO EXPLORE FLOODED MINES – THE STATE OF THE UNEXMIN PROJECT (MARCH 2019)

LUÍS LOPES & UNEXMIN CONSORTIUM

2ND INTERNATIONAL REAL-TIME MINING CONFERENCE

FREIBERG, GERMANY

MARCH 27TH 2019



LPRC

LA PALMA
RESEARCH
CENTRE

This project has received funding from the European Union's Horizon
2020 research and innovation programme under grant agreement No 690008.



KEY FACTS

- EU funded H2020 project (RIA: Research and Innovation Action) – GA 690008
- 12 partners / 7 countries
- 45 month duration (February 2016 – October 2019)
- Funding: 4.87 million Euros
- Major outcomes:
 - Three prototype robots: **UX-1a, b and c**
 - A company offering the UNEXMIN surveying technology to the market
 - **UNEXMIN GeoRobotics**



UNEXMIN VIDEOS

- UNEXMIN project overview
- Other videos
 - UX-1a assembly
 - Kaatiala field trials
 - Idrija field trials



A screenshot of the UNEXMIN YouTube channel page. The top navigation bar includes links for "The Project", "Inventory of Flooded Mines", "Media Corner", "Partners", and "Contact". Below this, a "Videos" section features two video thumbnails: "UNEXMIN FIELD TRIALS AT KAATIALA MINE" (6:14) and "UNEXMIN UX-1 ROBOT ASSEMBLY IN PORTO" (6:01). A sidebar on the right lists "UNEXMIN Media Corner", "News", "Press Releases", "Image Gallery", "Videos" (highlighted), "Downloads", and "UNEXMIN ID". The main content area shows the channel's profile with the name "UNEXMIN" and "21 subscribers". Below the profile, there are tabs for "INÍCIO", "VÍDEOS" (selected), "LISTAS DE REPRODUÇÃO", "CANAIS", and "ACERCA DE". A search bar labeled "Pesquisa" is also present. The video list at the bottom includes "UNEXMIN Idrija field trials video" (7:23), "UNEXMIN Fact #02 - How do UX-1 turn" (0:26), "UNEXMIN Fact #01 - The nickname of UX-1" (0:38), "UNEXMIN - Idrija tests" (2:42), and "UNEXMIN UX-1 robot assembly in Porto" (6:01). Each video entry shows a thumbnail, title, and view count.

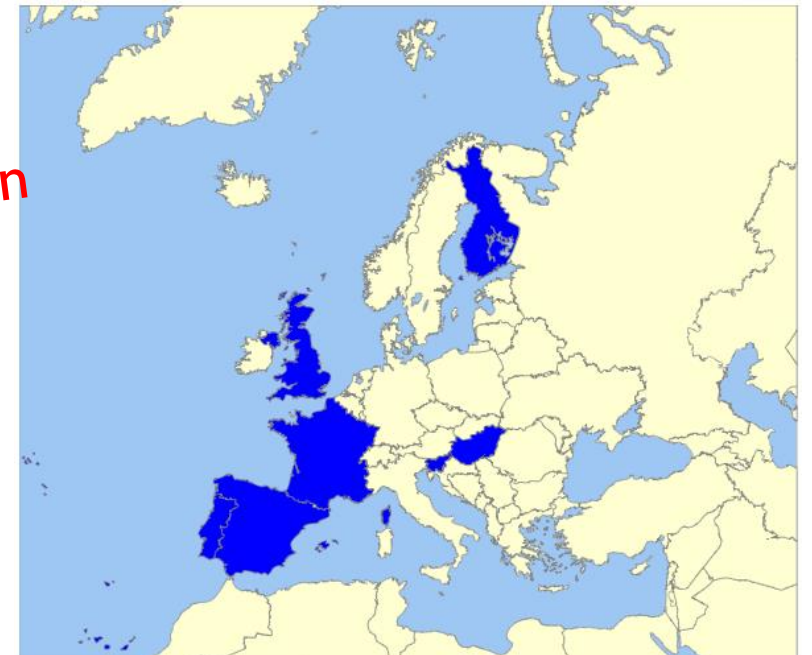
CONSORTIUM

- University of Miskolc, Hungary
 - Tampere University of Technology, Department of Mechanical Engineering Systems, Finland
 - Universidad Politécnica de Madrid, Centre for Robotics and Automation, Spain
 - INESC Tec – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Portugal
-
- Resources Computing International Ltd, UK
 - La Palma Research Centre for Future Studies, Spain
 - Geological Survey of Slovenia, Slovenia
 - European Federation of Geologists, France
 - Geo-Montan Kft, Hungary
-
- Empresa de Desenvolvimento Mineiro, Portugal
 - Ecton Mine Educational Trust, UK
 - Center za Upravljanje z Dediscino Zivega Srebra Idrija, Slovenia

Development teams

*Exploitation
Geological
interpretation*

*Internal
stakeholders*



CONCEPT AND APPROACH

Dependence on the import of raw materials



30,000 closed mine sites in Europe



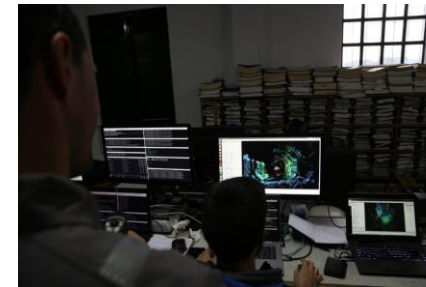
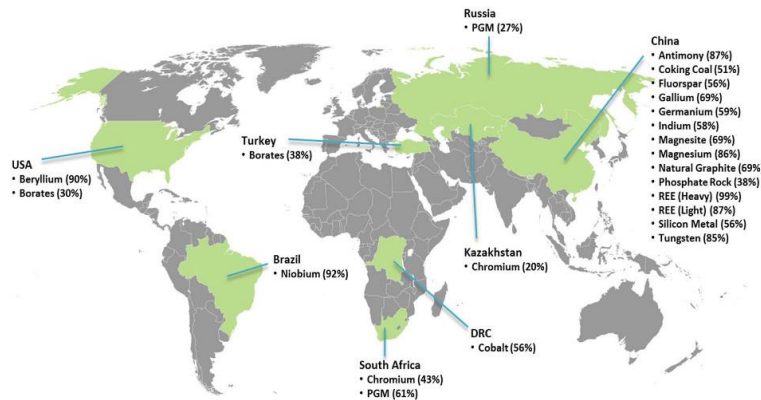
Abandoned deep underground mines are becoming interesting



Most of them are now flooded



Lack of information on status and layout



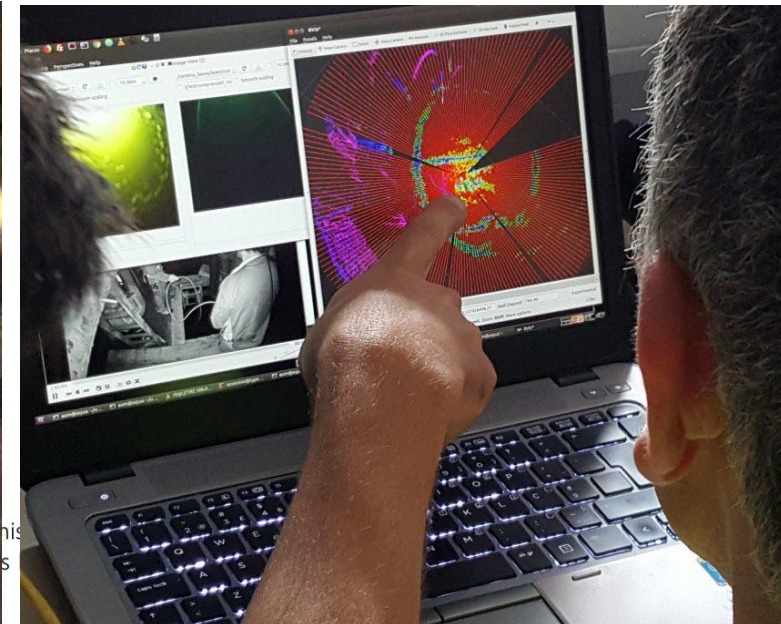
PROBLEM!



MAIN OBJECTIVE

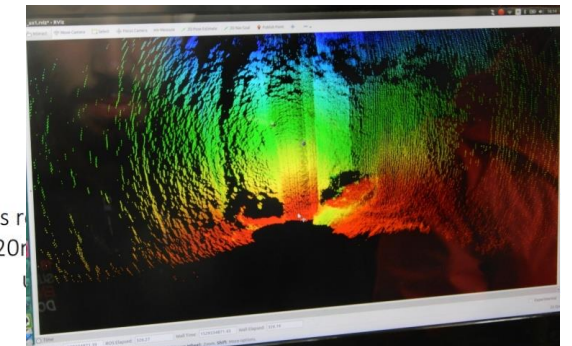
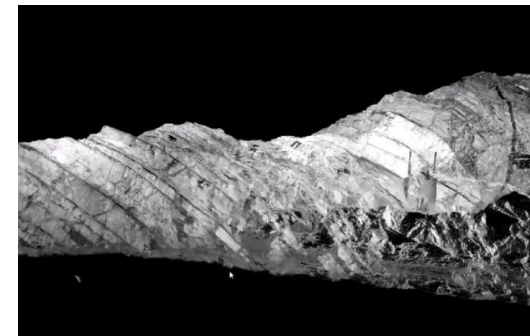
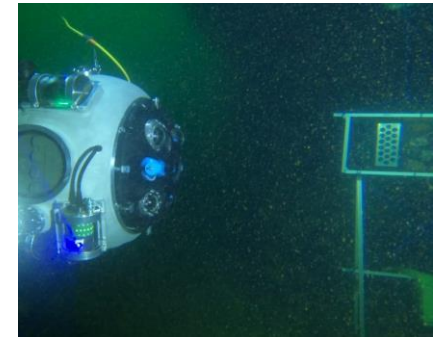
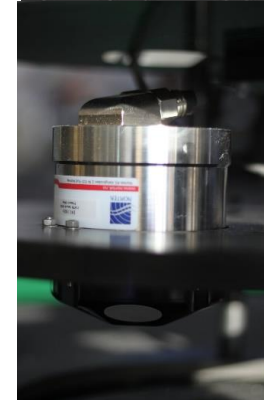
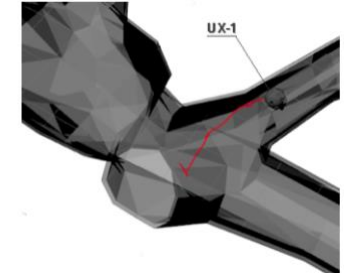
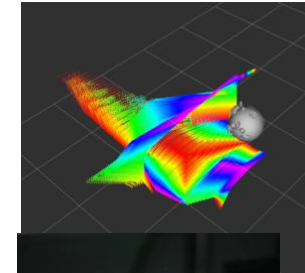
UNEXMIN is developing a new robotic platform – 3 robots: **UX-1a, b, c** – for the autonomous exploration and mapping of flooded underground mines. The platform uses non-contact & non-damaging methods to collect valuable geological, mineralogical and spatial data.

Currently, these data cannot be obtained in any other way without major costs (i.e. dewatering) or associated risks (e.g. sending human explorers).



WORK PACKAGES

- WP1: Robotic functions validation (finished)
- WP2: Scientific instrument design and adaptation (finished)
- WP3: Autonomy for mine exploration and mapping
- WP4: Multi-robot platform development
- WP5: Stakeholder mobilisation
- WP6: Post-processing and data analysis functions
- WP7: Demonstration/Pilots
- WP8: Dissemination, technology transfer and exploitation

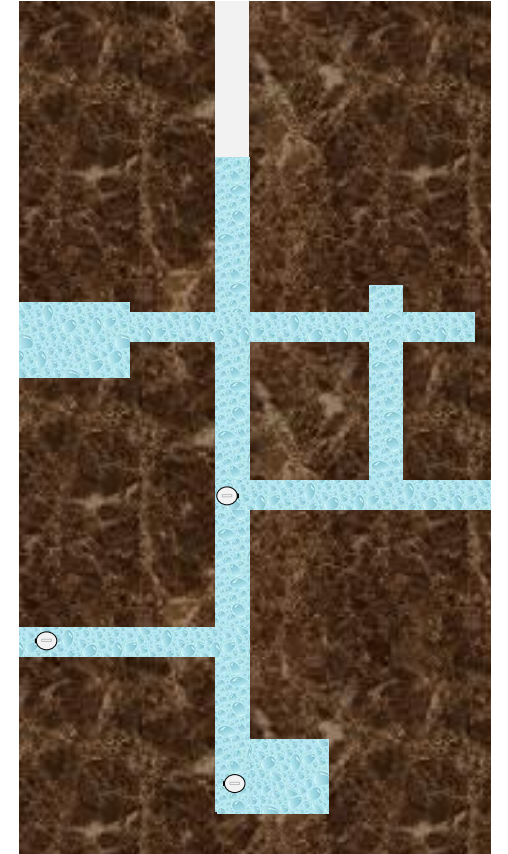


THE BEGINNING: DEFINING UX-1 CHARACTERISTICS

- Shape: Spherical
- Size: ~0.6 m diameter
- Weight: ~110 Kg
- Neutral buoyancy
- Number of subsystems: 6
- Maximum operational depth: ~500m
- Maximum speed: 1–2 Km/h
- Autonomy: up to 5 hours
- Power consumption: 250-450W

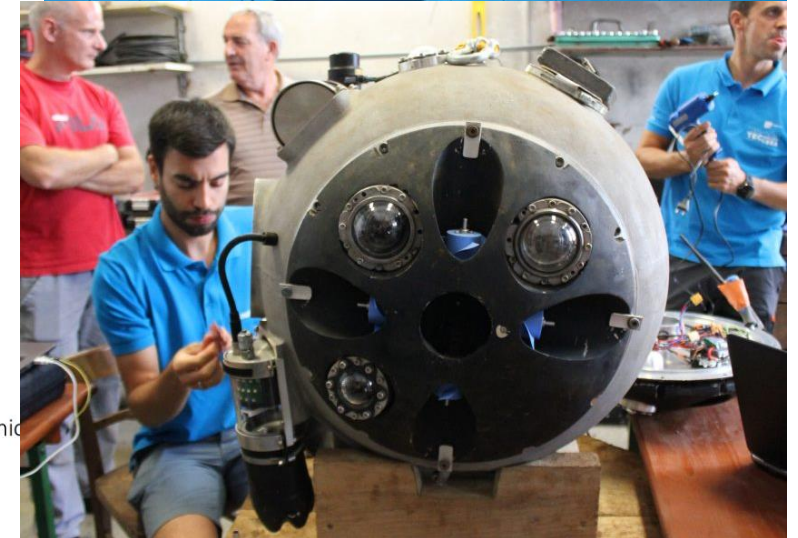
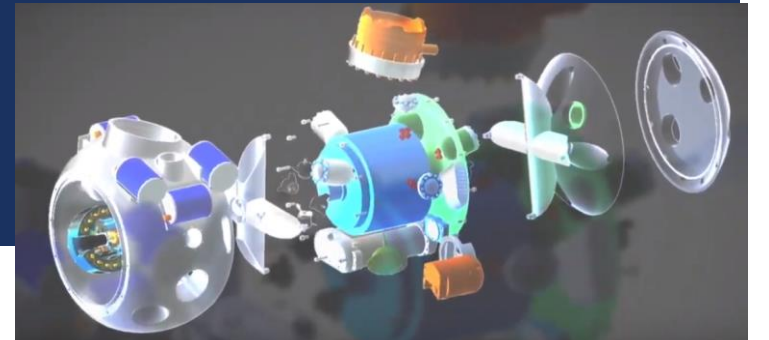


*End-user and
project partners
requirements*



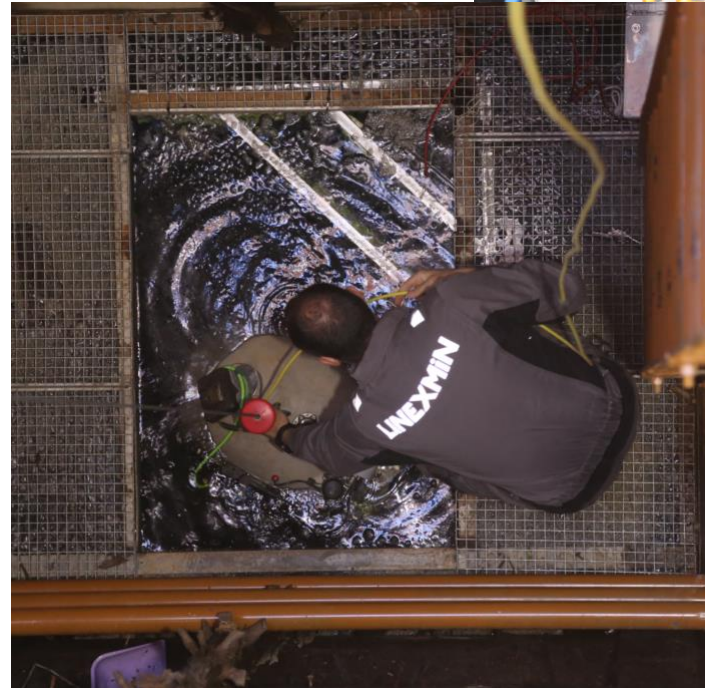
THE PAST: 2016, 2017, 2018

- Validation and simulation of basic robotic functions
- Design, testing and adaptation of scientific instruments
- Navigation, perception and 3D mapping tools and tests
- Development of post-processing and data analysis tools
- Construction of the first UX-1 prototype (April 2018)
- Field trials at the Kaatiala (June 2018) and Idrija (September 2018) mines

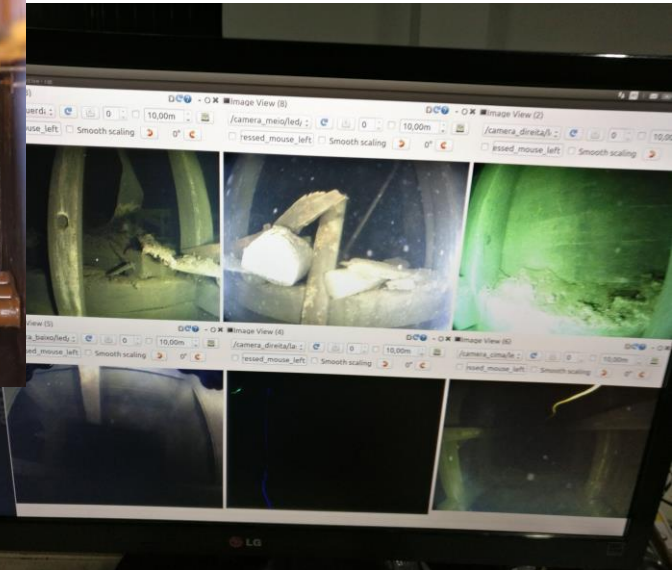


THE PRESENT: JANUARY – MARCH 2019

- Assembly of the second prototype UX-1
- Post-processing and data analysis from Kaatjala and Idrija field trials
- Autonomy tests
- First part of the field trials at the Urgeiriça mine, PT
- Laboratory work



This pro
Union's Hor



AND THE FUTURE! – MARCH – OCTOBER 2019

- Second part of Urgeiriça field trials (April)
- Ecton mine field trials (May)
- Final conference to showcase project's results (September)
 - Robotics
 - Raw materials
 - Policy



Come and meet the team and the project results!



UNEXMiN

UNDERWATER EXPLORER FOR FLOODED MINES

@UNEXMIN

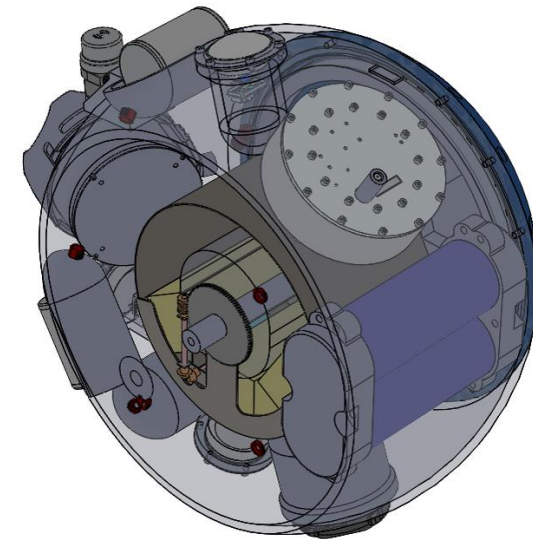
WWW.UNEXMIN.EU

UX-1 INSTRUMENTATION

- Pressure hull
- Computer
- Batteries
- Acoustic cameras
- Thrusters
- DVL (Doppler Velocity Log)
- INS (Inertial Navigation System)
- Scanner and lasers



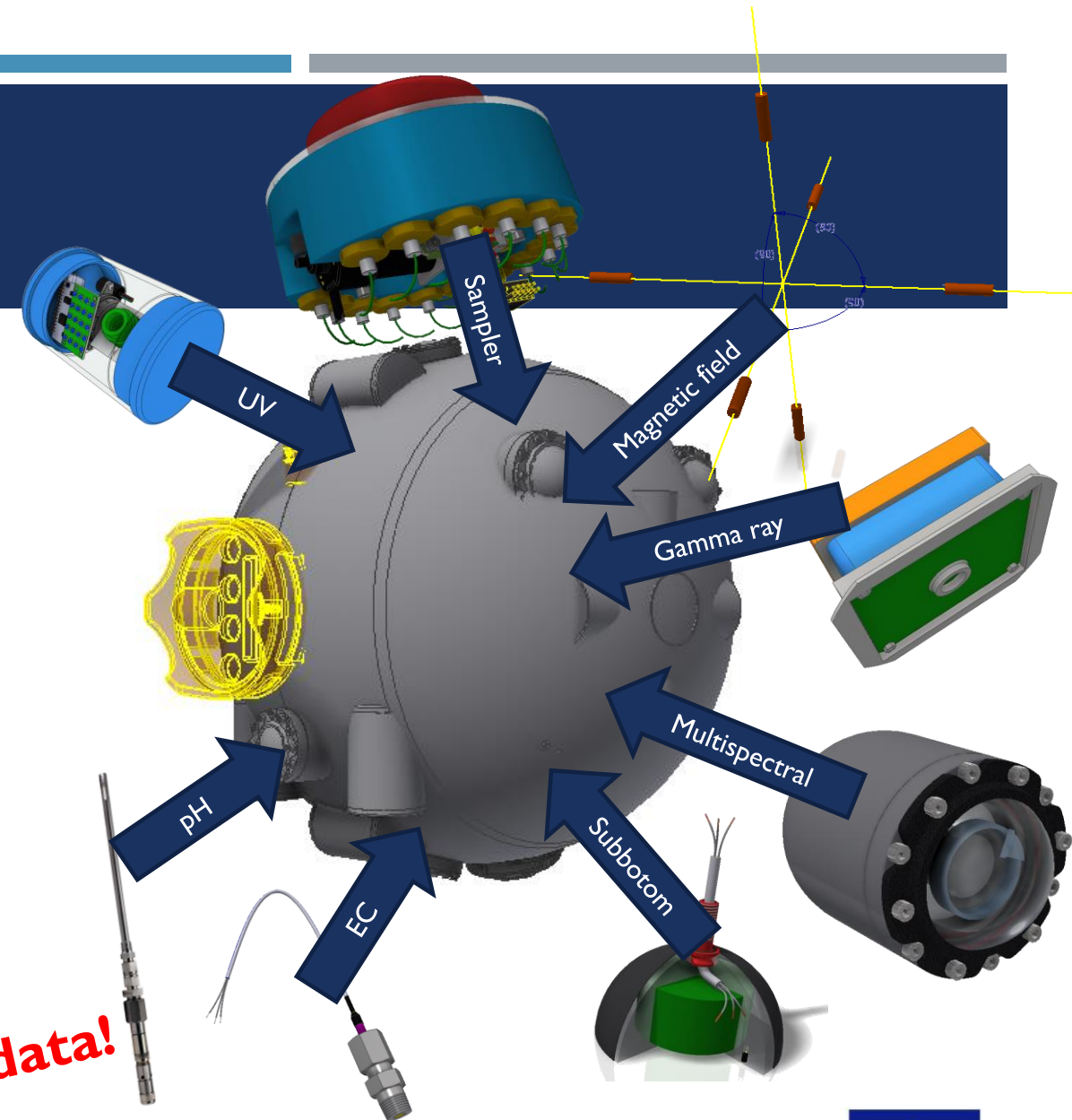
Navigation
Control
Autonomy
Mapping
Interpretation
Evaluation



SCIENTIFIC INSTRUMENTS

- pH and EC units
- Water sampler
- Sonar
- Magnetic field unit
- Gamma ray counter
- Sub-bottom profiler
- UV-light
- Multispectral camera

Water sampling
methods
+
Geophysical
methods
+
Mineralogical
methods
=
Valuable
geoscientific data!

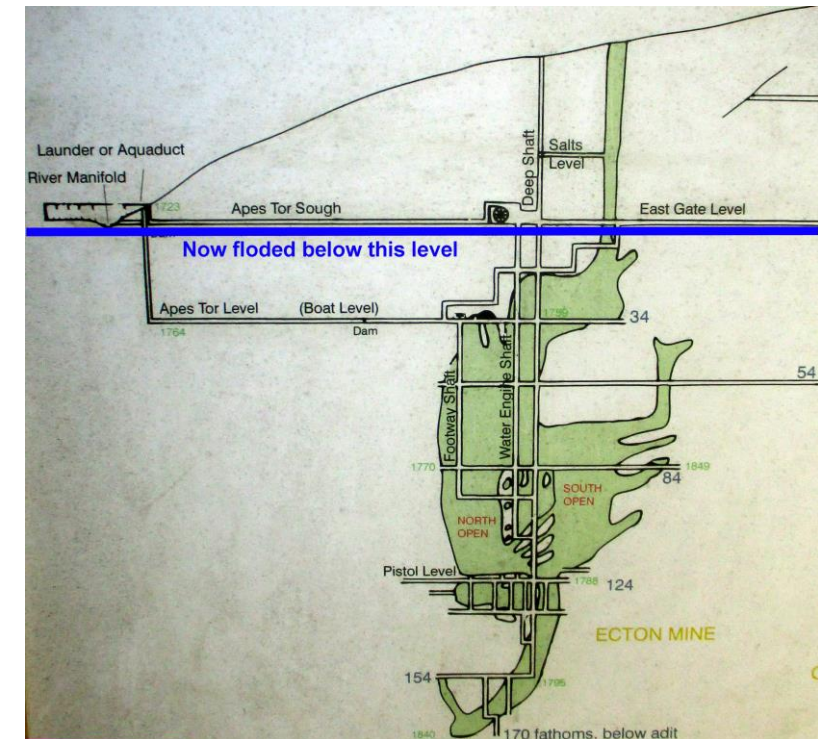


FIELD TRIALS

- **Kaatiala, Finland (June 2018; first prototype)**
 - Pegmatite mine
 - Open-pit mine with underground part
 - Robot recoverable by divers
- **Idrija, Slovenia (September 2018)**
 - Mercury mine
 - UNESCO World Site Heritage
- **Urgeiriça, Portugal (March/April 2019; second prototype)**
 - Uranium mine
 - Totally flooded
- **Ecton, UK (May 2019; multi-robotic platform)**
 - Cu – (Zn-Pb) mine (MVT)
 - National Heritage Site

Nobody has seen it for more than 160 years!

More difficulty:
layout,
geometry,
topology,
missions



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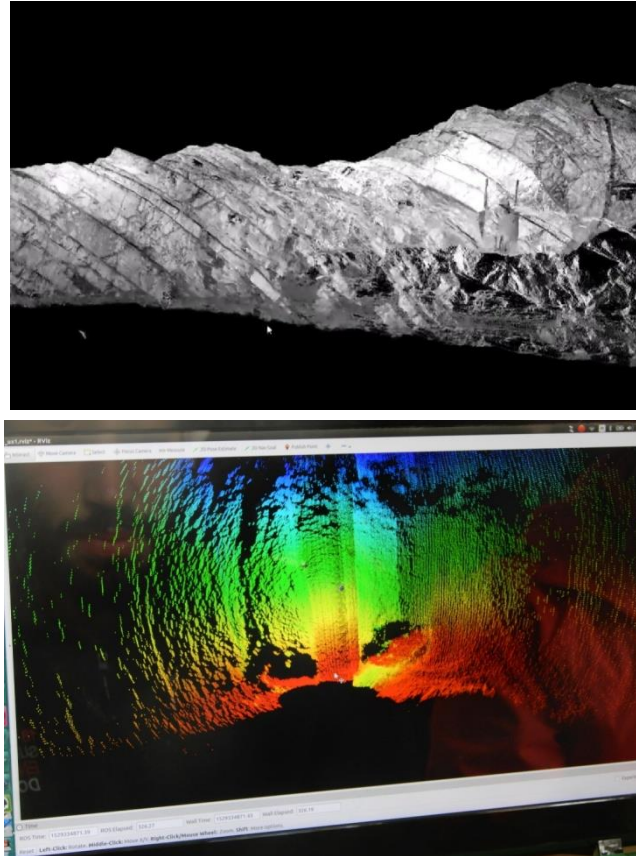
OTHER PROJECT ACTIVITIES

- Data processing: 3D models, vídeos, etc
- Interaction with stakeholders
 - Robotics
 - Raw materials
 - Technology developers
- Communication and dissemination
 - Project development
 - Project results



POST-PROCESSING AND DATA ANALYSIS

- Multi-spectral data calibration and interpretation
- Sonar data display
- Geomechanics: identification of rock falls
- Structural geology
- Point-cloud data processing and modelling
- Detection/correction of 'noisy' spatial data



VIRTUAL REALITY

Stereoscopic rendering of 3D data for viewing in standard VR headsets:

- Interaction with the data, such as marking points of interest for later study



ENHANCEMENT OF 3D MODELS



Curvature analysis to
enhance geometric
features

3D DISPLAY OF VERY LARGE POINT CLOUDS



3D rendering of very large point clouds

Fly-through videos also capture the point cloud geometry

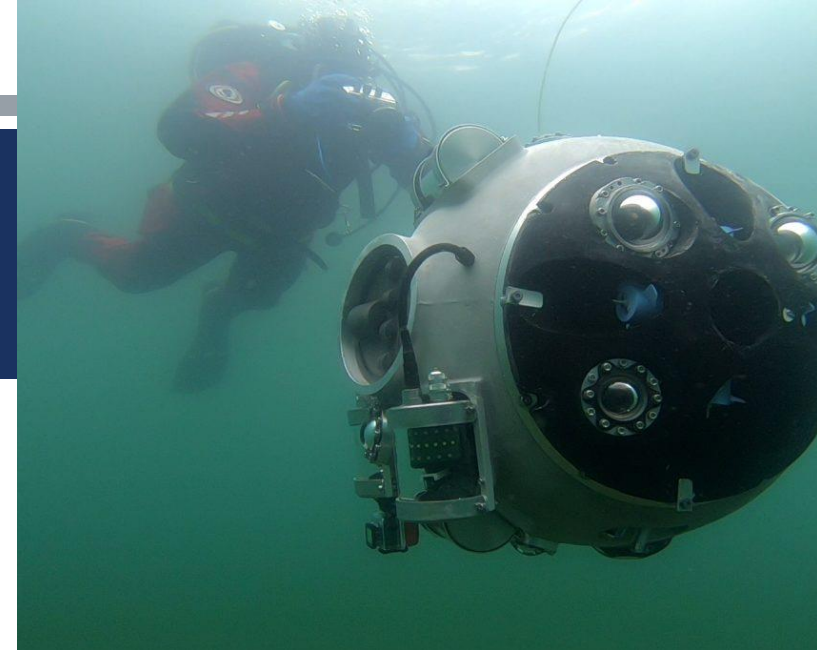
Ecton Mine Faro laser survey

APPLICATIONS FOR THE TECHNOLOGY

- **Mineral exploration**

- First stages of exploration (after sampling, before drilling)
- Create and/or update geological models at local/regional level
- Make decisions on exploitation

- Water reservoirs
- Cultural Heritage sites
- Risk evaluation
- Environmental monitoring
- Cave exploration
- Etc...



FUTURE PLANS

Offer the technology as a service with UNEXMIN GeoRobotics!

- Continue to develop instruments/sensors
- Develop new sensors
- Modifications to UX-1 series
 - Bigger depth range
 - Smaller dimensions
- UX-2 series
 - Sampling
 - Other collection tools and robotic capabilities



Information on:

- Commodities
- Deposit type
- Ore type
- Flooding condition

8174 mines

Free & publicly available

Most complete
database on flooded
mines... and growing!

SAVE THE DATE: UNEXMIN FINAL CONFERENCE

- **Date**
 - 26th September 2019
- **Venue**
 - Royal Belgian Institute of Natural Sciences
 - Vautierstreet, 29 | 1000 Brussels | Belgium
- **More information and registration**
 - Registration will open by 29 April 2019
 - To pre-register, send an email to alberto.sanchez@eurogeologists.eu.
 - Link: [Save the date!](#)



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Gracias
Obrigado
Merci



Kiitos

Thank you



Köszönöm

Hvala

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LEARN MORE ABOUT UNEXMIN

- **Website:** www.unexmin.eu
 - [Information on the project](#)
 - [Images](#)
 - [Brochures](#)
 - [Posters](#)
 - [Presentations](#)
- **Social media:** [Facebook](#) – [Twitter](#) – [LinkedIn](#) – [YouTube](#)
- **Videos:** Search “UNEXMIN”
- **Mail:** luislopes@lapalmacentre.eu

Questions?

