Underwater Explorer for Flooded Mines

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EGU2020: Sharing Geoscience Online
Discussion block/Live chat: May 8th 2020, 14:00-15:45

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

UNEXUP Overall details

- **Funding:** EIT RawMaterials
- **Context:** Direct continuation of the Horizon 2020 UNEXMIN project
- **Budget:** 3 002 020 €
- **Start date:** January 2020
- **Duration:** 36 months
- **Consortium:** 8 organizations, 6 EU countries
- **Target audiences:** Mining companies / raw materials exploration industries; Geological Surveys; water companies; any industry with an underwater structure that needs to be surveyed
- **Output:** A new raw materials exploration / mine mapping service for underground flooded mines and other flooded areas

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Project Context

UNEXMIN → UNEXUP

(2016 – 2019)

Focus on research and development of a multi-robotic platform to survey underground flooded mines and other underwater environments

Core objective: Develop a prototype for underwater exploration; Raise scientific interest

(2020 – 2022)

Focus on the commercial deployment of the technology developed in UNEXMIN, while further improving the robotic system's software, hardware and capabilities

Core objective: Upgrade the prototype; Sell an exploration service

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Consortium partners – three knowledge pillars

INESCTEC
TECHNOLOGY & SCIENCE
ASSOCIATE LABORATORY
PORTUGAL

Research

MISKOLCI EGYETEM
UNIVERSITY OF MISKOLC

Education

UNEXMIN
GEOROBOTICS

Industry

Education

4coders

Industry

LPRC
LA PALMA RESEARCH CENTRE

Industry

GeoZS
Geološki zavod Slovenije

Research

UNIVERSIDAD POLITÉCNICA DE MADRID
POLITÉCNICA

Education

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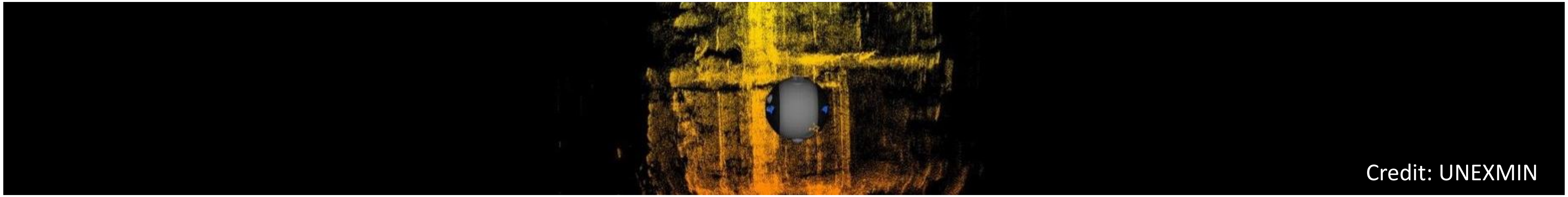
Project Context

EU dependence on the import of raw materials → ~30,000 closed mine sites in Europe → Abandoned/ underground mines contain valuable mineral resources → Most of them are now flooded* → Lack of information on status and layout

*over 11,000 already catalogued



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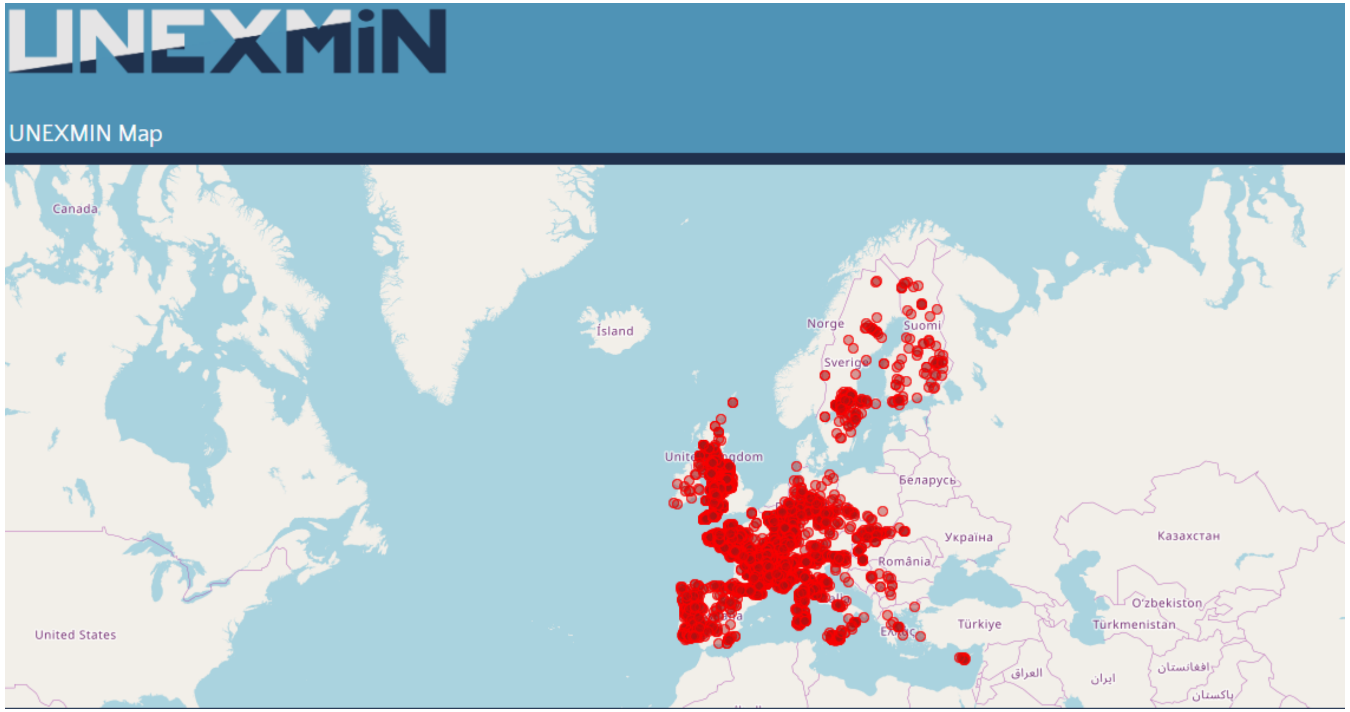
Project Context



[UNEXMIN Flooded Mines Database]

- Free, publicly available
- The most complete database, and growing

Data on:

- General information on the site
- Commodities
- Deposit and ore types
- Flooding condition and level

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Project Context

Complex underground layout, topology and geometry of most underground mines make it unfeasible to do any surveying by conventional, or remotely controlled equipment. Human risks and high costs, such as dewatering, are also barriers to explore flooded environments.

Human risk

Financial risk

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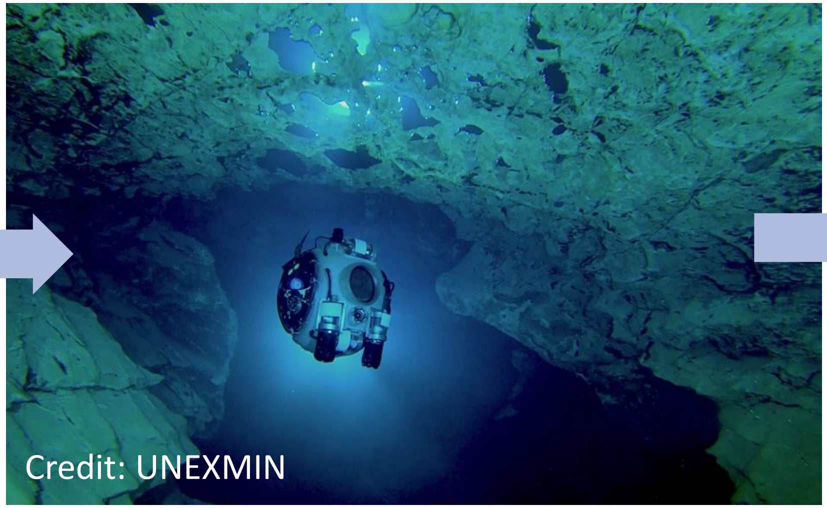
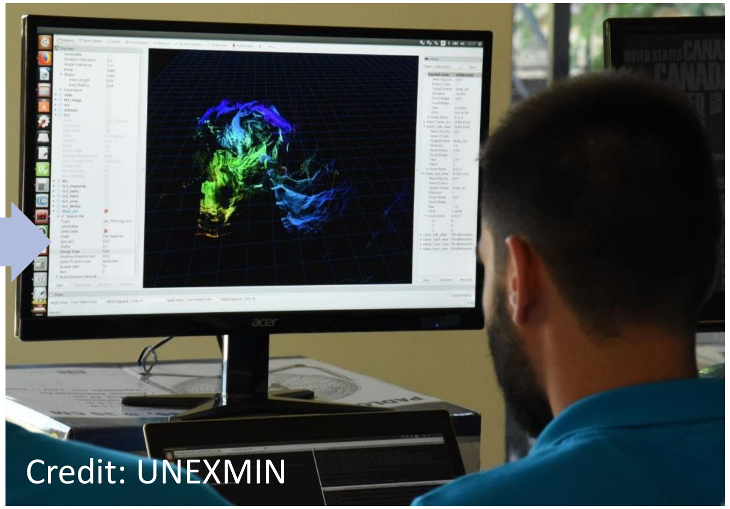
UNEXUP solution

The UNEXUP robotic platform is able to gather high-quality and high-resolution geological, mineralogical and topological data from these currently inacessible mine sites without human risks or environmental impacts. It will potentially become a game changing exploration technology for the mining industry.

Credit: UNEXMIN



Credit: UNEXMIN



Credit: UNEXMIN

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UNEXUP Objectives

- **Improve the current UX-1 system's hardware, software and limitations**
- **Build an additional, more complex robot, with further capabilities and sensors**
- **Test the robots' performance in different pilot tests**
- **Bring commercial interest to the innovative technology**

- **LAUNCH THE SERVICE INTO THE MARKET!**
  - UNEXMIN GeoRobotics Ltd. (UGR), founded by members of the UNEXMIN consortium, is the partner responsible for the commercialization strategy and business plan of the UNEXUP technology

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Work packages

- **WP0: Market strategy and business development portfolio**
  - ➢ Market analysis
  - ➢ Strategic plan for commercialization
  - ➢ Business plan development
  - ➢ Customer relations
  - ➢ Business risk management

Go-to-market and business strategies will be defined in 2020, updated accordingly during the project's lifetime

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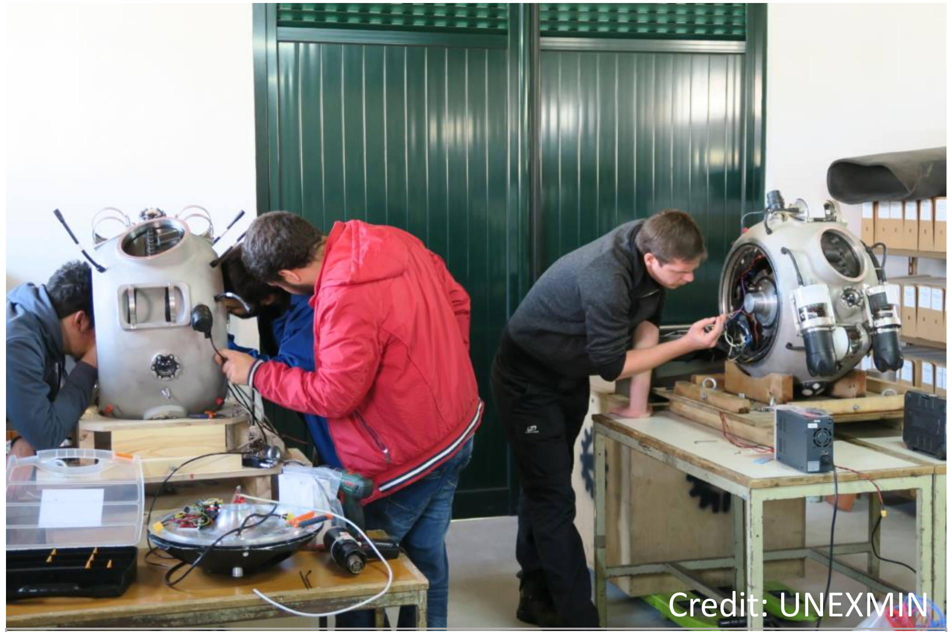
Work packages

- **WP1: Technology upscaling and development**
  - Commercial upscaling of UX-1 prototypes
  - Development of a modular deep water prototype
  - Further development of scientific instrumentation and tools
  - Extending robot exploration capabilities
  - Ground control station and ground support systems
  - Post-processing software upgrades
  - Testing UX-1's components



- End of 2020: UX-1 Upscaling;
- In 2021: New, more complex robot;
- 2022: Additional funcionalitites, higher operational level

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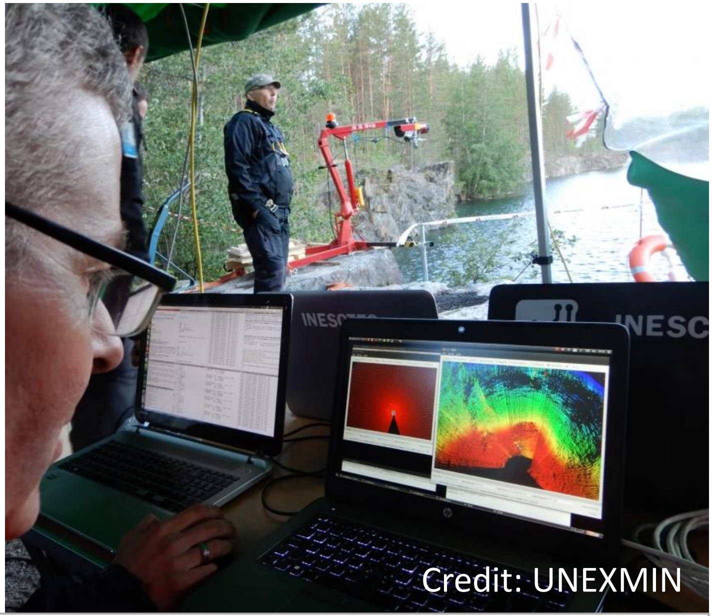
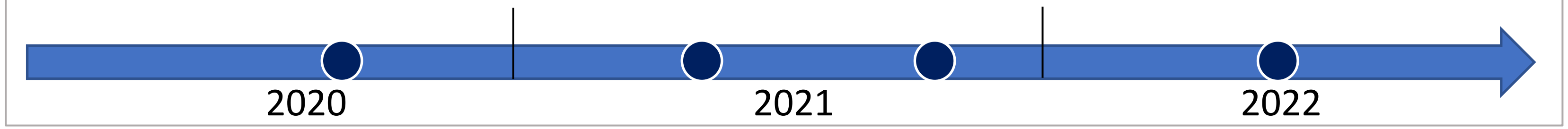
Work packages

- **WP2: Pilots**
  - Pilot selection
  - Field trial preparations
  - Field trial reports
  - Operations improvement
  - Geoscientific evaluation



Initial plan: 4 trials



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Work packages

- **WP3: Project management**

Project management will guarantee that the project's tasks, deliverables and outcomes are met in due time throughout the project, in line with the description of work, and in accordance with EIT RawMaterials guidelines.

- **WP4: Communication, dissemination and outreach**
  - ➢ Communication and dissemination management
  - ➢ Outreach support toolkit
  - ➢ Increasing market interest

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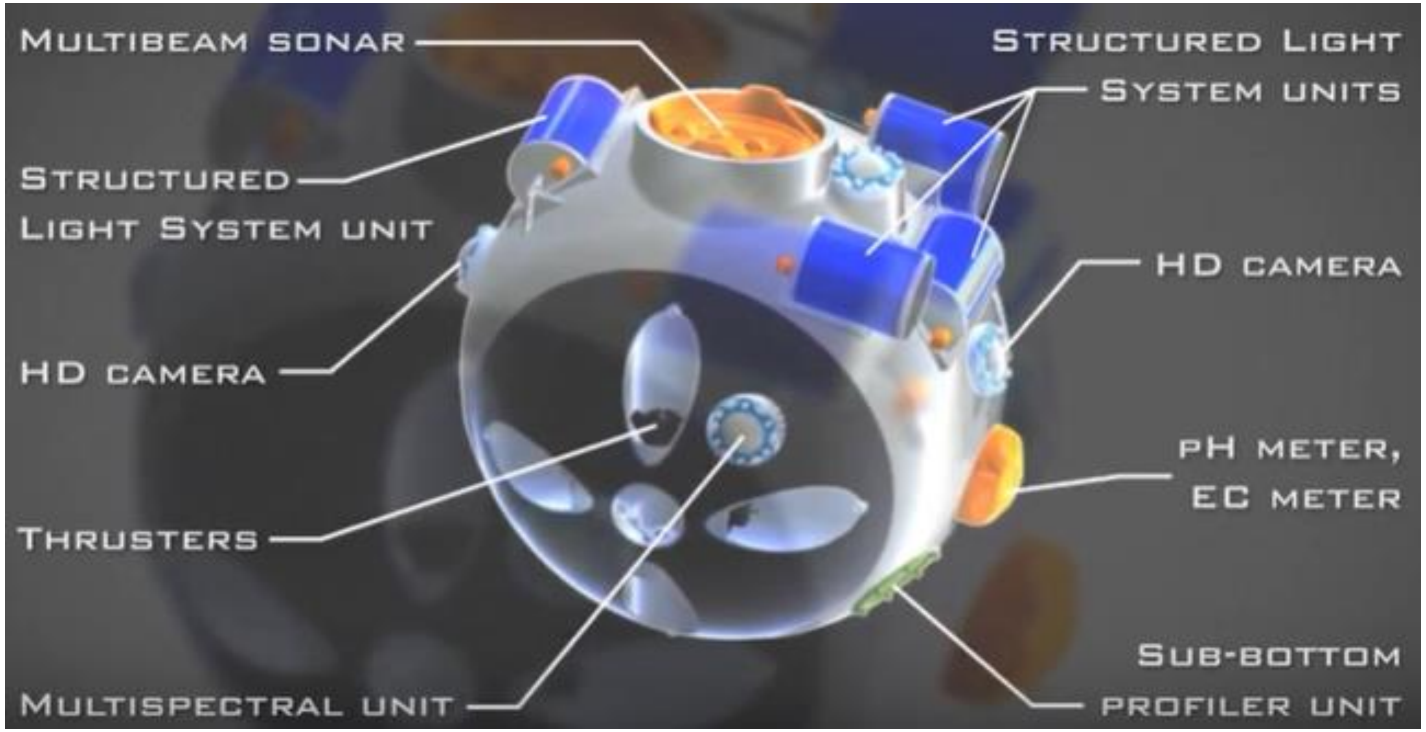
Current UX-1 robot

- Maximum operation depth: 500m
- Spherical shape
- Diameter: 0.6m
- Weight: 112Kg
- Power consumption: 250-400W
- Maximum speed: 1-2Km/h
- Autonomy: up to 5 hours
- Neutral buoyancy
- Navigational Instruments
- Geoscientific Instruments



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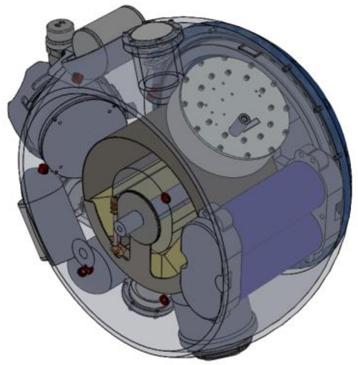
UX-1 Navigational Instrumentation

- Pressure hull
- Computer
- Batteries
- Thrusters

+

- Multibeam and scanning sonars
- Digital cameras (5)
- Structured light projectors
- Doppler velocity sensor (DVL)
- Inertial Navigation System (INS)
- Scanners and lasers

✓Navigation
✓Control
✓Autonomy
✓Mapping
✓Interpretation
✓Evaluation



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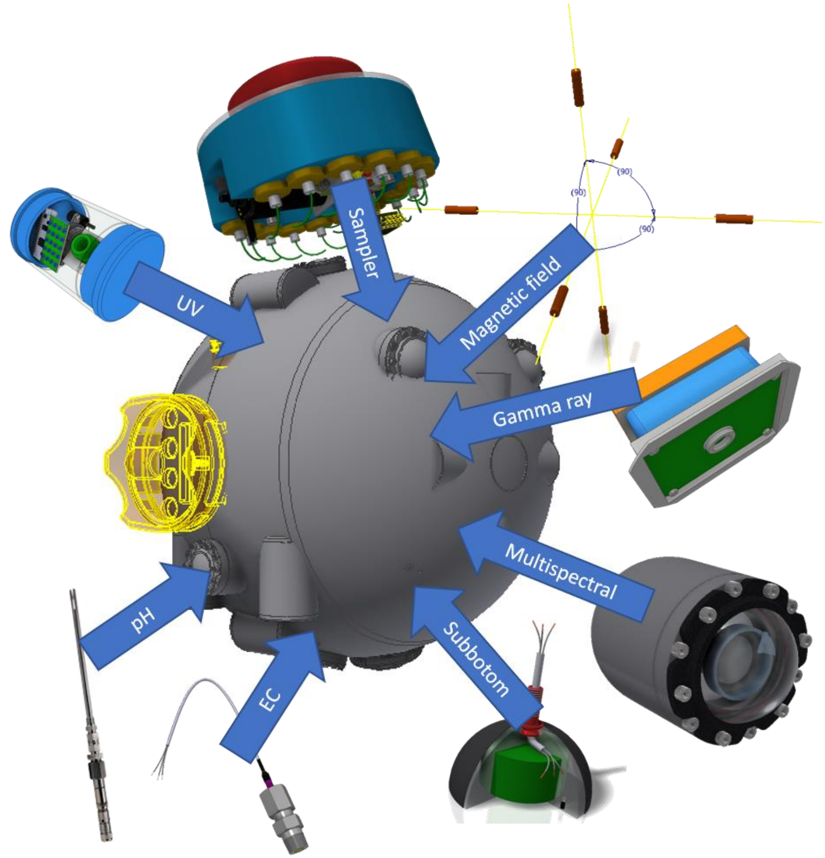
UX-1 Geoscientific Instrumentation

- pH and electrical conductivity units
- Temperature and pressure sensors
- Water sampler
- Magnetic field units
- Gamma-ray counter
- Sub-bottom profiler
- Multispectral camera
- UV-fluorescence camera

✓ Water sampling
✓ Geophysical methods
✓ Mineral identification

VALUABLE GEOSCIENTIFIC DATA



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Additional robot – at later stages of UNEXUP

The robot will share the same frame as the upscaling version of the current UX-1, with additional extensions

- To be ready in 2021, further improvement in 2022
- Heavier vehicle
- Higher depths ~1500m
- Additional scientific payload
- More challenging missions

Extending exploration capabilities

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Field Trials during the UNEXMIN project

5 Missions | 9 steps:

1 – Setting the site to conduct the dives safely (access to launch zone, setting the platform, etc)

2 – Arrival of the technical team, the robot and all equipment necessary for the tests

3 – Setting up the control room, launch site, communication and cameras

4 – Safety inductions at the site. Familiarization with the site's safety rules

5 – Teams are divided between the control room and the launch site

6 – Conducting surveying missions according to daily schedule, taking into account the specific mission's objectives

7 – Daily de-briefing regarding the day's tests that were carried out that day and plans for next

8 – Packing up and sending the equipment to the next location. Team members leave the site

9 – Data post-processing and preparing a geological report, a virtual reality model of surveyed parts of the mine (point cloud), videos from UX-1 cameras and extracting other useful geoscientific materials for mine exploration

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Field Trials during the UNEXMIN project

1) Kaatiala Mine, Finland (June 2018) - Pegmatite mine, open-pit and small underground part

- ✓ UX-1 was successfully tested in a real life environment
- ✓ Two test sites: shallow part, and deep part of the quarry
- ✓ Navigational and ballast systems were tested and worked well
- ✓ Depth control system tested and proved to be working
- ✓ 2-hour long dives approximately
- ✓ Maximum depth of about 30 meters
- ✓ Successful mapping of old underground drive
- ✓ MSU camera and LED synchronisation were successfully tested outside the water*

*not tested on any dive, one of the control board was broken by accident

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Field Trials during the UNEXMIN project

2) Idrija Mine, Slovenia (September 2018) - Mercury mine, UNESCO World Heritage site

- ✓ Movement, control and 3D mapping to explore shafts in confined environments
- ✓ Total of 11 dives within the span of two weeks
- ✓ Fully autonomous dive of the robot to the depth of about two meters
- ✓ UX-1 reached the bottom of the shaft at 26,2 m and mapped the entire area
  - Approximately two hours, 1.5h for the descent to the bottom of the mine and approximately 0.5h for the return to the surface
- ✓ The pendulum system was tested with dives at different pitches (0° and 90°)
- ✓ The multispectral camera unit has been proven to be working well
- ✓ The robot has proven to be working well in very challenging environments

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Field Trials during the UNEXMIN project

3) Urgeiriça Mine, Portugal (March/April 2019) - Uranium mine in granite pegmatite

- ✓ Total of 18 dives
- ✓ Maximum depth reached at 106,5 meters
- ✓ Mine's main shaft as well as side tunnels have been explored and mapped
- ✓ Video footages, point clouds of the shaft and side tunnels
- ✓ Multispectral images and UV fluorescence lights of the rock wall
- ✓ Focus on debugging the software and improving hardware to eliminate problems and correct open issues
- ✓ All key success factors were achieved, making this trial a successful one

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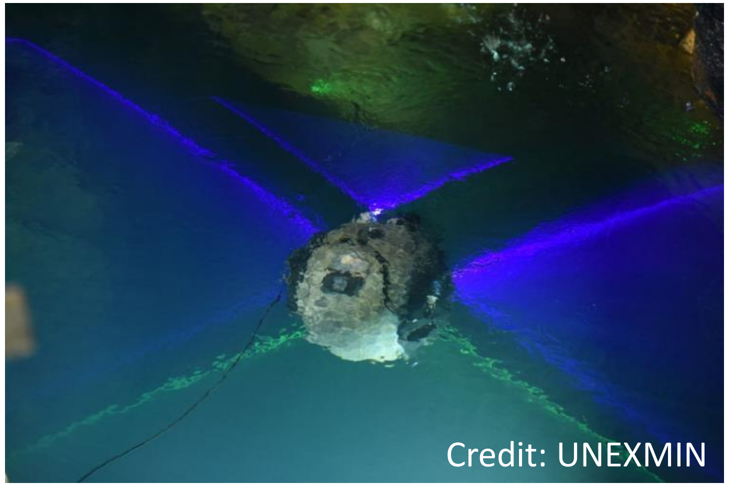
Field Trials during the UNEXMIN project

4) Ecton Mine, UK (May 2019) - Cu–Zn-Pb mine flooded in 1858 and never previously resurveyed

- ✓ Up to 125m depth. Total of 10 dives, in 3 shafts
- ✓ Two robots to navigate and acquire data from the mine (UX-1a and UX-1b)
- ✓ The data collected include video footage and point clouds
- ✓ The control systems were successful in maintaining the desired depth during the dive
- ✓ Data processing provided rapid access to high resolution videos from all five cameras, for LED ‘white’ illumination and for ultraviolet illumination
- ✓ 3D models constructed from sonar and SLS data showed the size and shape of mined pipe workings
- ✓ During the Ecton test period the robots successfully collected data from MSU, EC and pH meter and subbottom profiler. UX-1b also collected water samples with Water Sampler Unit



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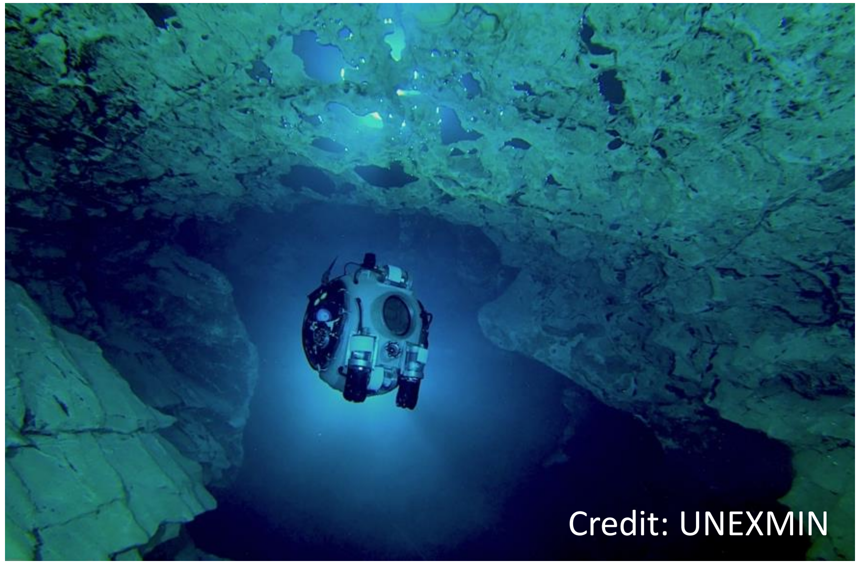
Field Trials during the UNEXMIN project

5) Molnár János cave, Hungary (June/July 2019)

- ✓ Cave system reaches up to a length of 6km, with sections up to 100m depth
- ✓ Selected location to test and improve the prototype’s autonomy
- ✓ New testing environment for the project team and the UX-1 robots
- ✓ 10 autonomous navigation missions were successfully achieved



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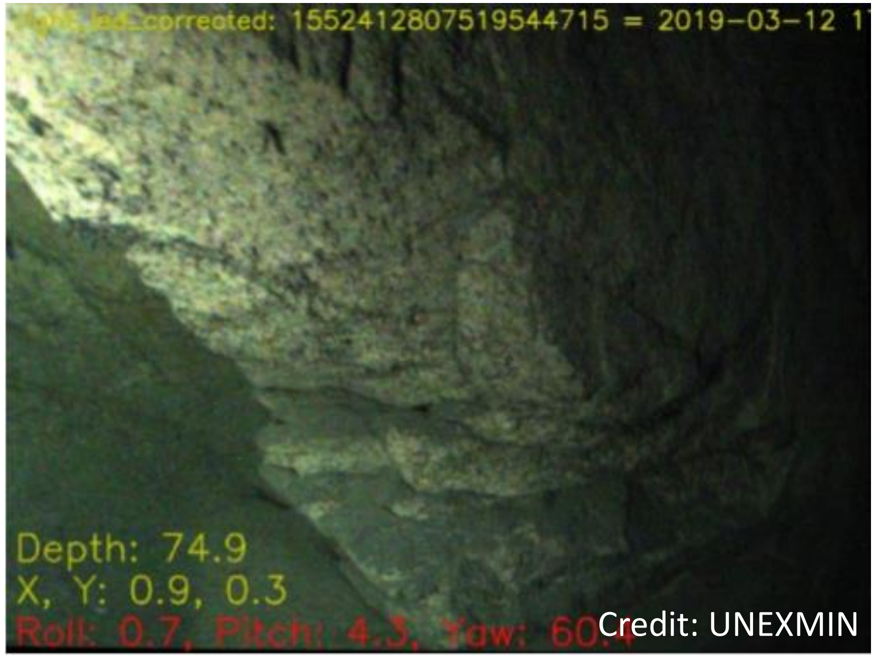
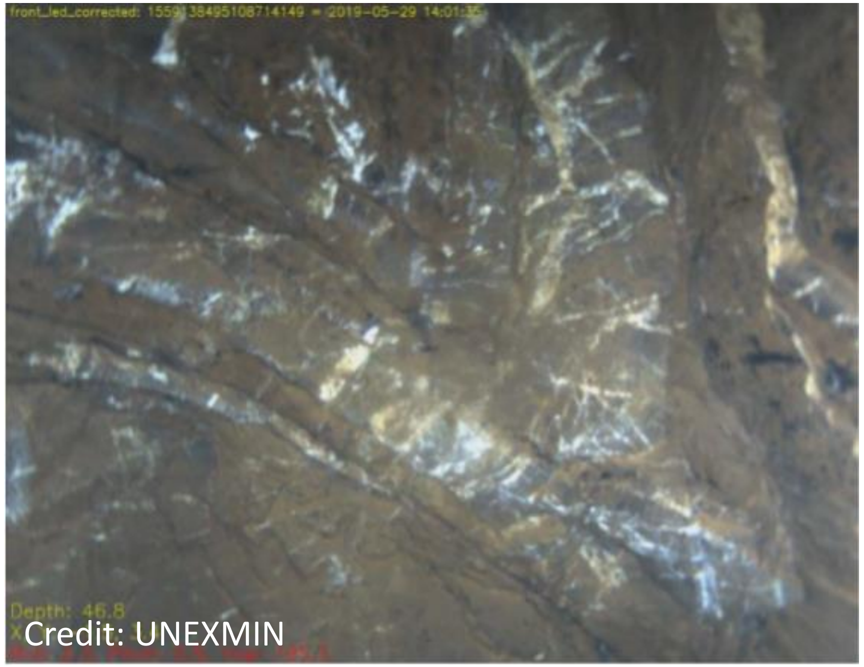
Practical outcomes

Rock type information - Urgeiriça mission.



Granite with veinlets of black mineral, possibly pitchblende

Structural geology information - Ecton Mine mission.



Syncline fold in thickly bedded limestone

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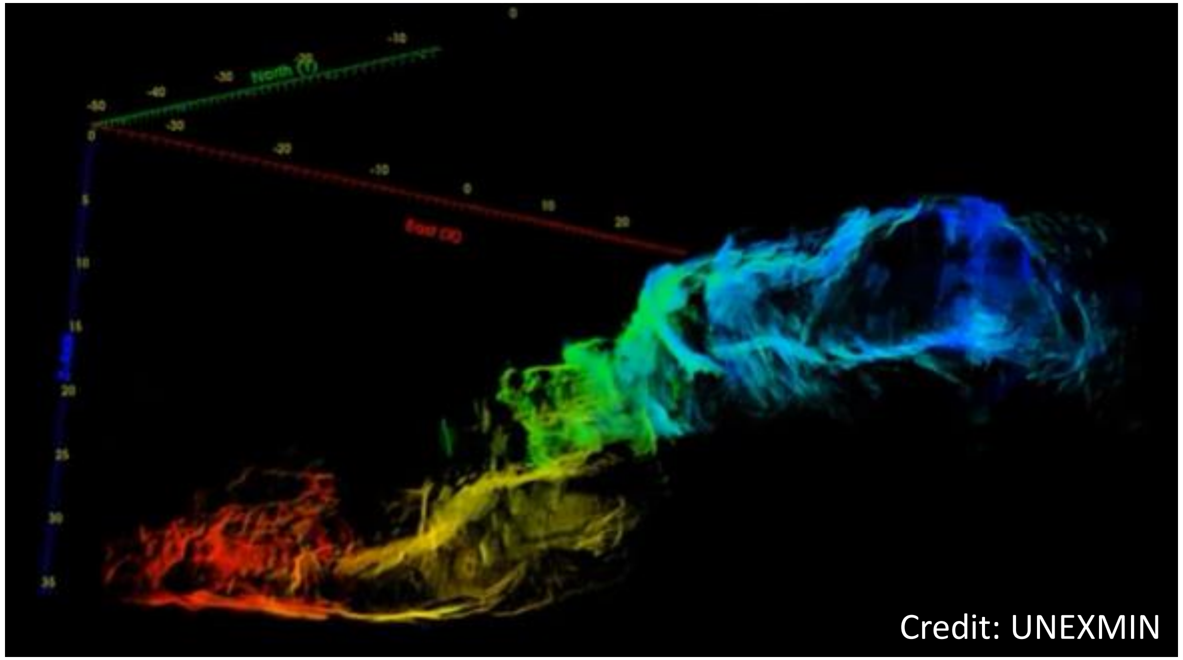
Practical outcomes

3D Mapping - Molnár János cave mission.



Post-processed data collected from the dives.

Mineralization information - Ecton Mine mission.

Multiple generations of calcite veining.

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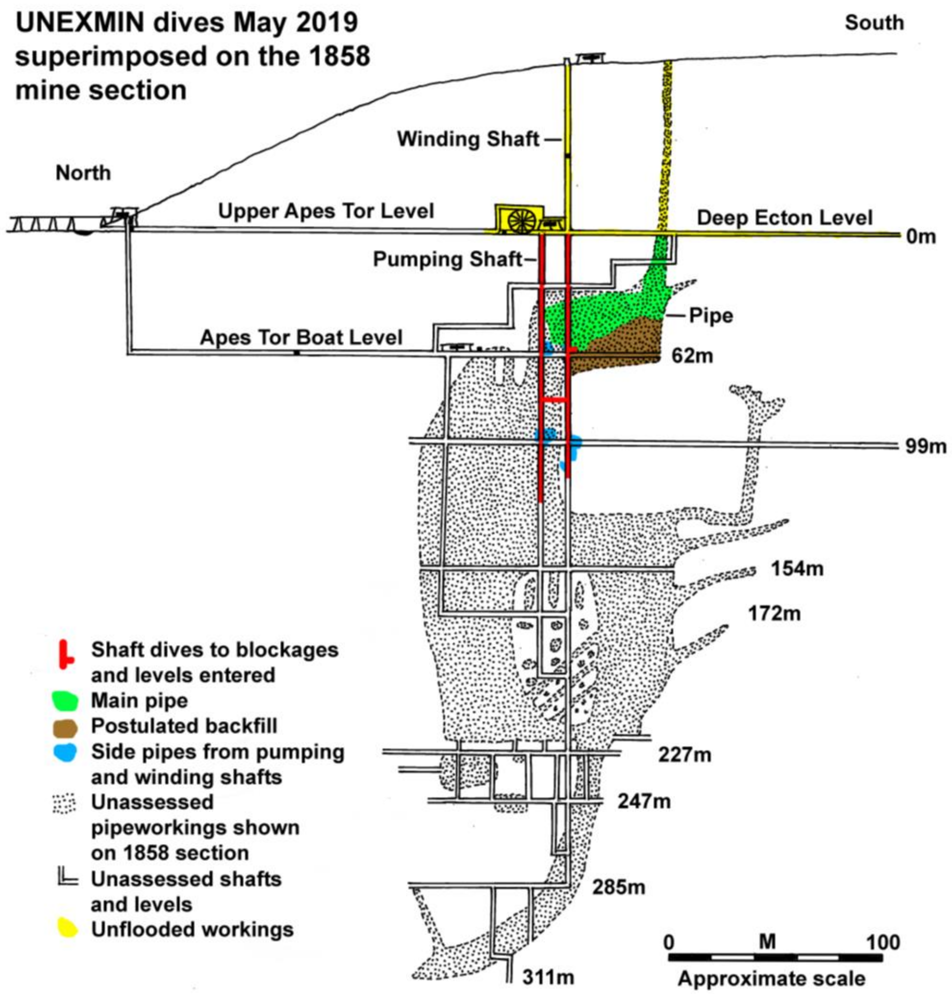
Practical outcomes



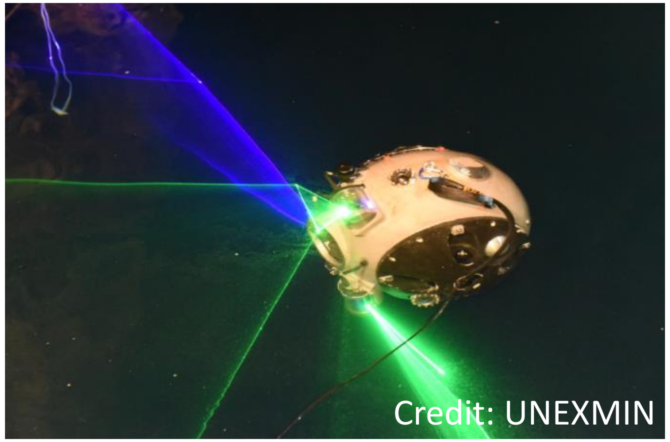
Archeological information – UNEXMIN dives May 2019 at Ecton Mine

- Dives were concentrated on the two main shafts and the upper parts of the massive “pipeworkings” in the mineral deposit
- The main pumping shaft was explored to about -125m to a blockage, while the winding shaft was choked at a little under -115m. These are sunk through bedrock, where the bedding was often near-vertical, with many anticlinal and synclinal folds also seen.
- Both shafts had levels leading off their sides at various depths, some connecting the two shafts, others going elsewhere. In the pumping shaft there were various substantial timbers, thought to be for helping retain the now-removed rods and pipes, the entrances to some of the levels and also ladders.
- Other features here included three complex groups of mineral workings in ‘side pipeworkings’ and a ‘level’ at or just below the underground canal horizon with a walled ‘dam’ at its entrance.

The approximate extent of passages explored during the UNEXMIN dives undertaken in May 2019 at Deep Ecton Mine, superimposed on the schematic 1858 mine section, with recorded depths of levels (the scale of the 1858 drawing is only approxumateas it shows the lower parts of the workings at a slightly larger scale tan those parts above).

Application of the UNEXUP Technology

- **Mineral exploration**
  - First stages of exploration
  - Create and/or update geological models at local/regional level
  - Make decisions on exploitation
- **Geological studies**
  - Geological Surveys
- **Surveying of underwater structures**
  - Cultural Heritage sites
  - Risk evaluation
  - Environmental monitoring
  - Cave exploration



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Learn more and stay tuned!

Website

https://www.unexmin.eu/unexup/

Social Media

More videos

UNEXMIN 3-minute promo video
UNEXMIN - Ecton field trials
UNEXMIN UX-1 robot assembly in Porto
UNEXMIN - Idrija tests
UNEXMIN Project overview

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Thank you!

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