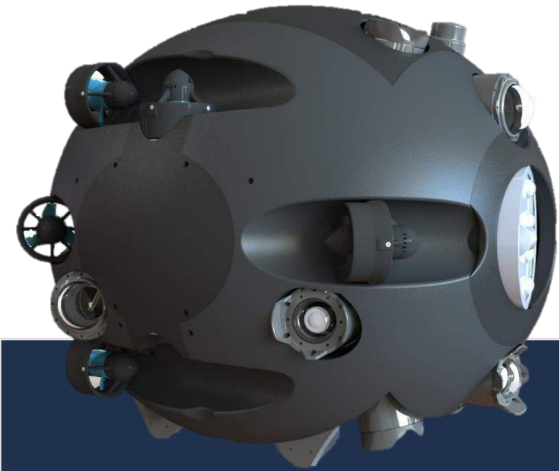

UNEXMIN

G E O R O B O T I C S



UX-1Neo - A robotic explorer
for flooded mines, caves and
tunnels

About us

The Unexmin Georobotics Ltd. (UGR) is a start-up provides surveying services for flooded underground environments. Our technology is uniquely developed to handle these harsh environments.



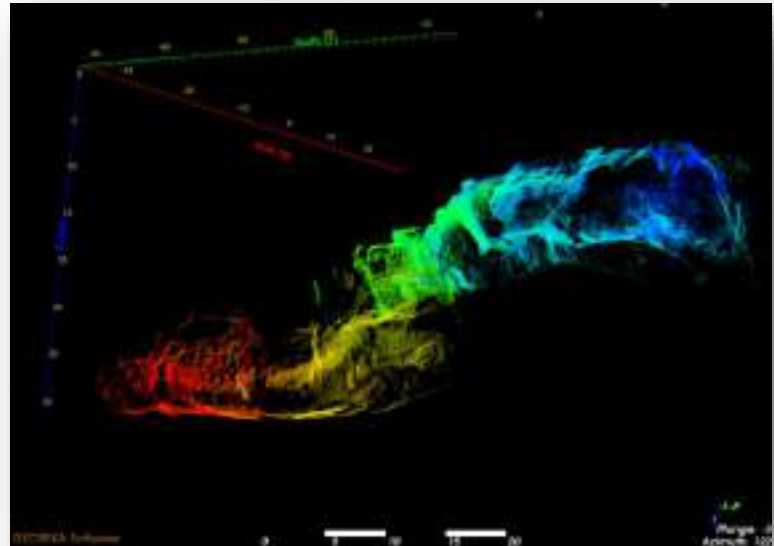
Pioneers in robotic solutions for flooded environments

About us

- Total of **5 robots**: UX1a, UX1b, UX1c, UX1-Mara, UX1-Neo
- Total of **8 different sites**: Kaatiala (Finland), Idrija (Slovenia), Urgeirica (Portugal), Ecton (UK), Molnár János (Hungary), Csór (Hungary), Solotvyno (Ukraine), South Crofty (UK)

Summary of all missions:

- Over **18 missions** in 8 different sites
- Over **80 dives**
- Over **300 hours** of diving
- More than **2 million** captured images



Our technology



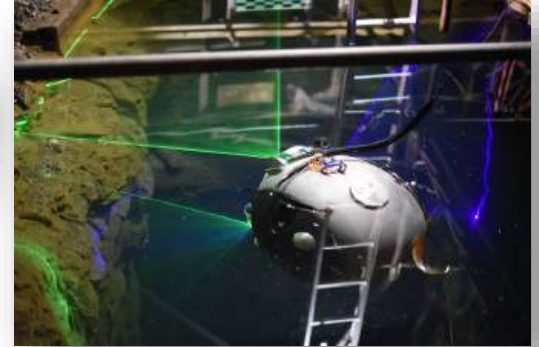
Characteristics

- **Modular**
- Swappable batteries
- Removable disk enclosure
- HDPE frame
- 10 Gb fibre optical umbilical
- **Depth: 500m (target depth: 1500m)**
- 2600 Wh
- **>8h operation**
- Dimensions: 700 x 620 mm
- Approx. Weight: <90kg



Navigational Instruments

- **Multibeam sonar**
- 2 scanning sonars
- **6 cameras with onboard processing**
- Flotation foam
- **Full 6 DOF thrusters control**
- **6 structures light system (SLS) units**
- Pressure tolerant pendulum
- Underwater connectors and cabling

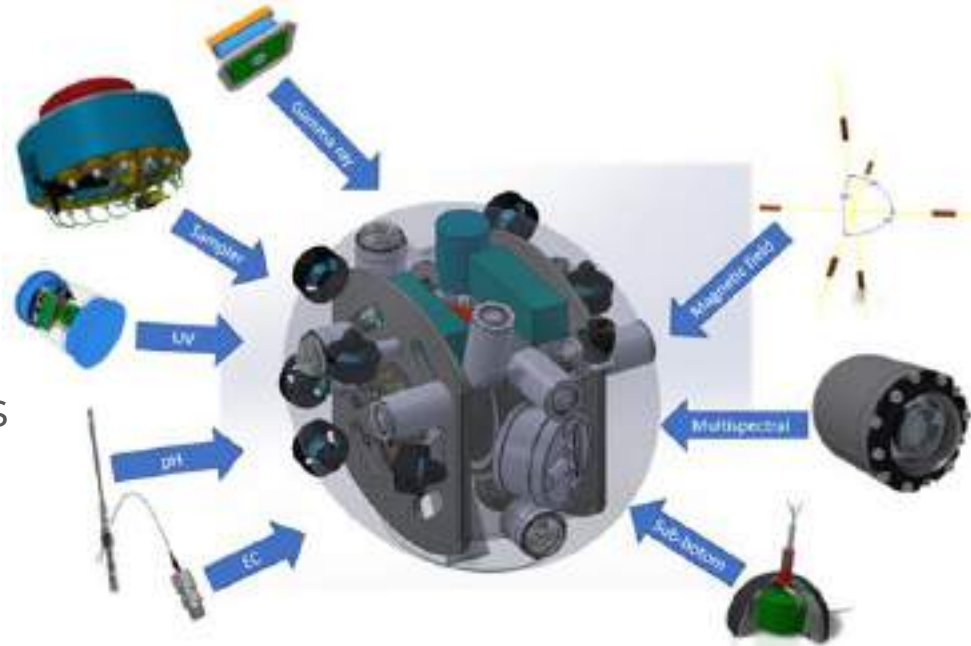


Our technology



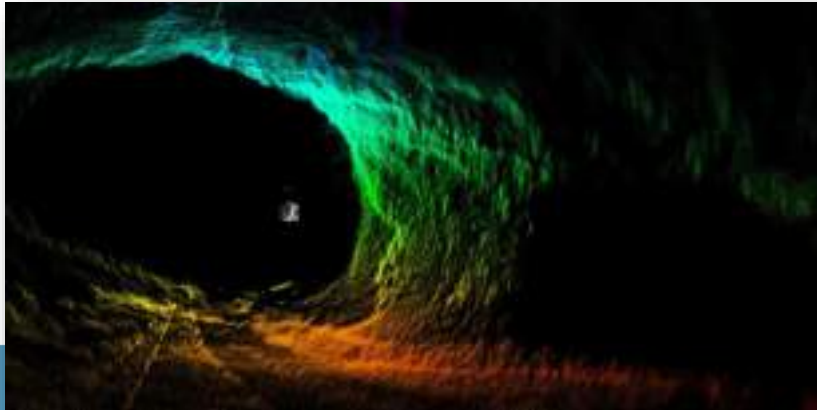
Geoscientific instrumentation

- Multi/hyperspectral imaging
- Sub-bottom sonar
- Water parameter measurements
- Water sampling
- Underwater rock sampling
- Gamma measurements
- Flux-gate magnetometer



Field work - Kaatiala Mine, Finland

- Open-pit, flooded pegmatite mine
- **Open-surface water**
- **Underwater tunnels** with high openings



Field work - Idrija Mercury Mine, Slovenia

- UNESCO World Heritage
- Underground mine
- **90% of the mine workings are flooded**
- Water surface is **176 m below the surface**
- Dirty, opaque water
- Several underwater obstacles



Field work - Urgeiriça Uranium Mine, Portugal

- Remediated, closed **uranium mine**
- Underground mine workings
- **All the tunnels and shafts are flooded**
- Water surface is 5 m below the surface
- Clear water from ~20 m depth



Field work - Urgeiriça Uranium Mine, Portugal

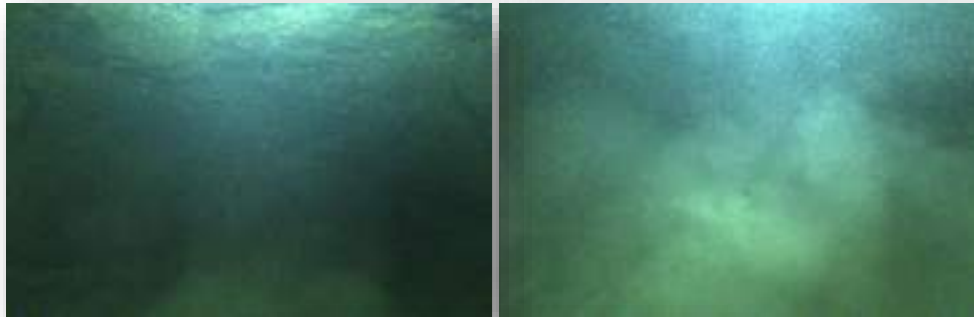


The UX-1Neo reached the bottom at 186 m
(view from down camera)



Field work - Urgeiriça Uranium Mine, Portugal

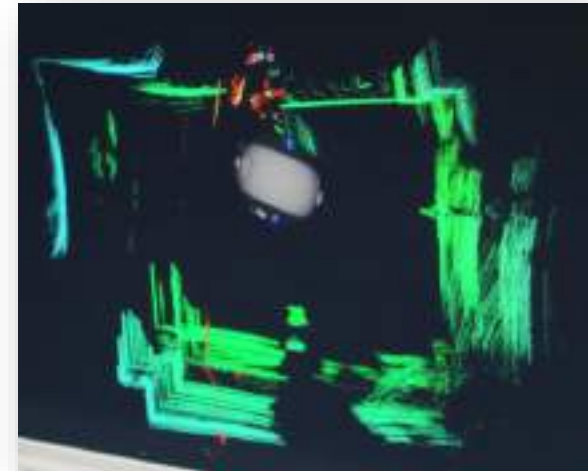
RGB cameras



*In case of **low visibility**, the robot **can** still **navigate** using **laser** and **sonar** information*



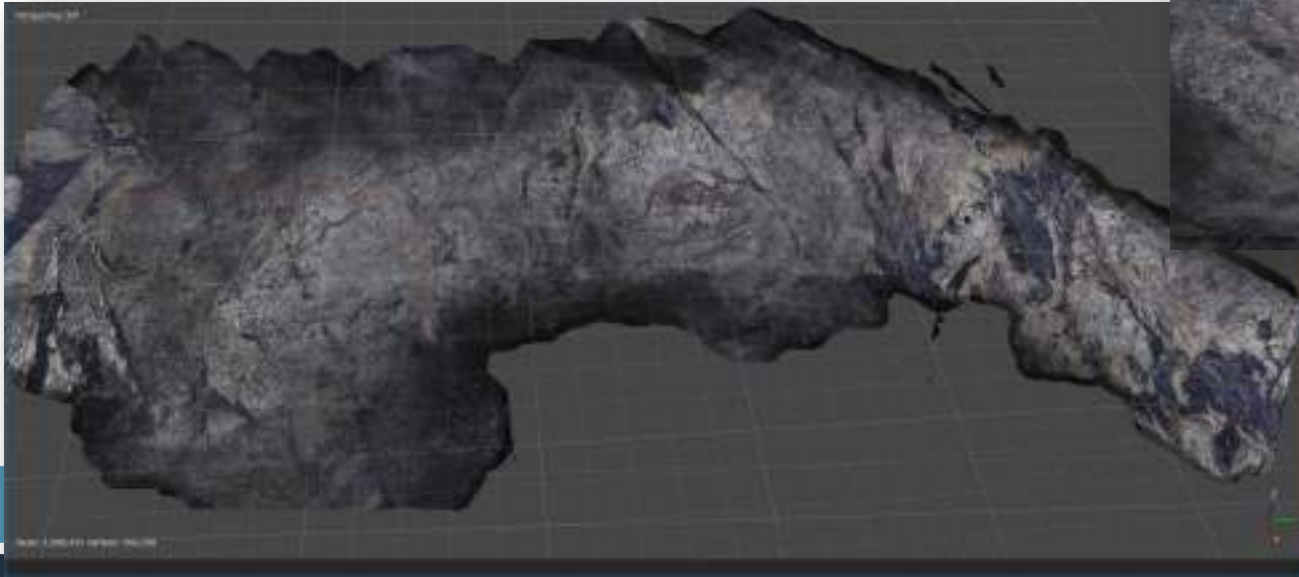
Raw data from lasers (SLS)



*The pictures show the same environment, but on the **left** seen with the **cameras**, and on the **right** with the **laser data***

Field work - Urgeiriça, Portugal - Photogrammetry example

The **2k resolution** RGB camera images can be used for **underwater photogrammetry**



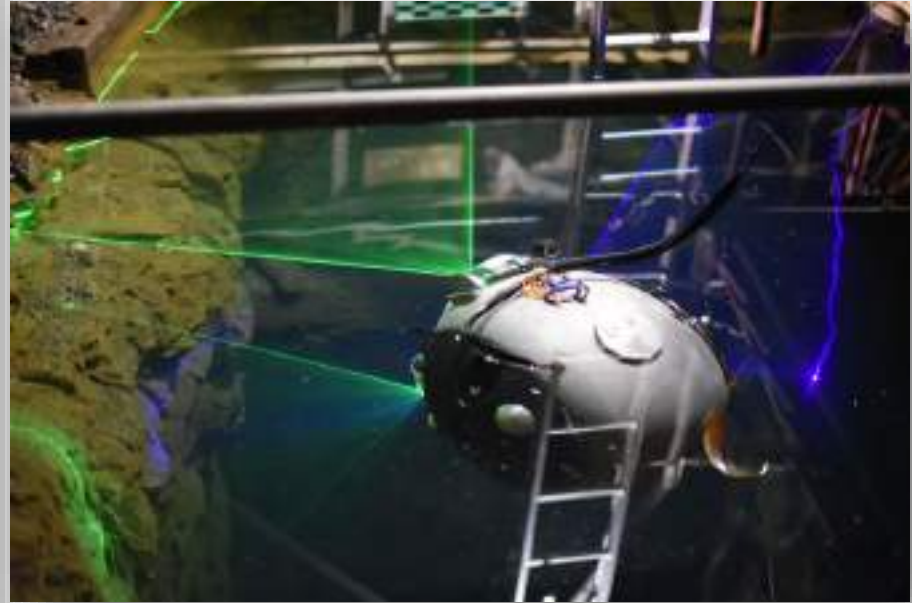
The **georeferenced photogrammetric models** can be used for detailed geological interpretation

Field work - Ecton Mine, United Kingdom

- Deep Ecton Mine was one of the most important **copper mines** in Britain in the **18th century**.
- There are large flooded workings that extend down to over -300m below river level.
- These **had not been seen since the later 1850s** after the mine pumps were turned off, until the UNEXMIN project provided information on some of the flooded workings by the use the **UX-series submersibles**.



Field work - Ecton Mine, United Kingdom

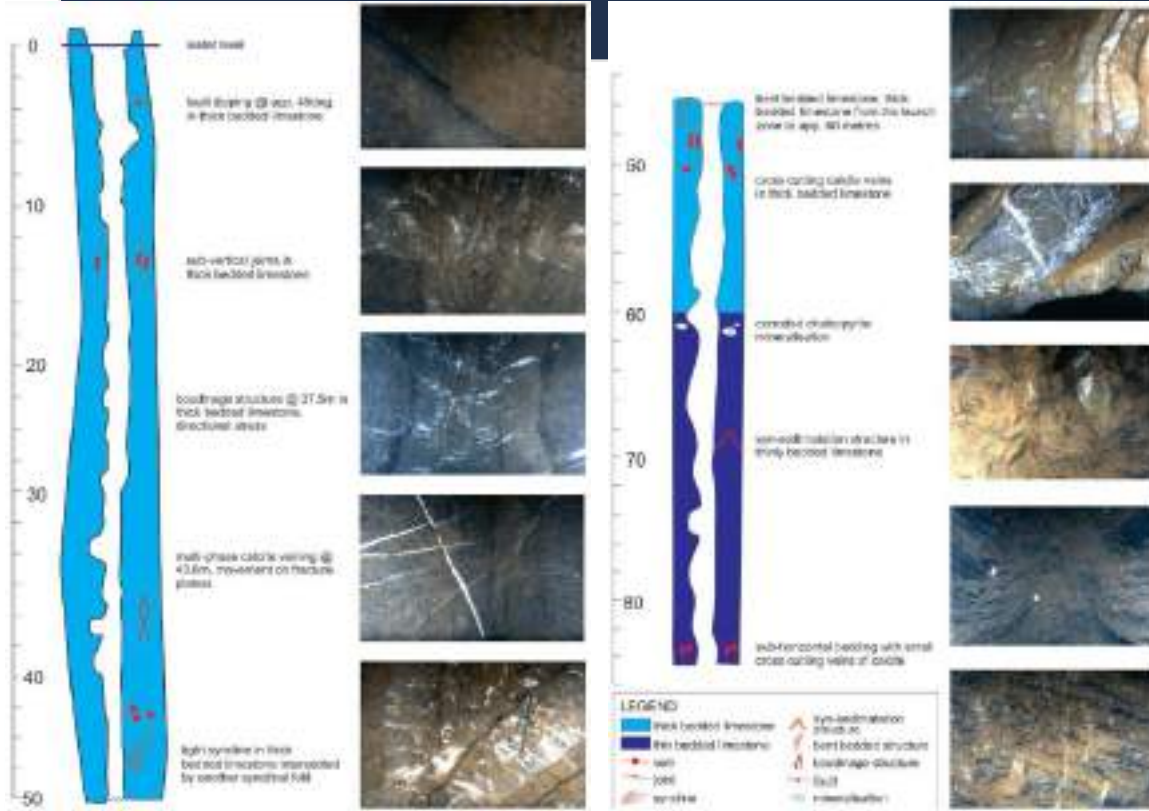


Field work - Ecton Mine, United Kingdom



Field work - Ecton Mine, UK – Geological interpretation

The **geological interpretation** was easily done after the collected data was processed



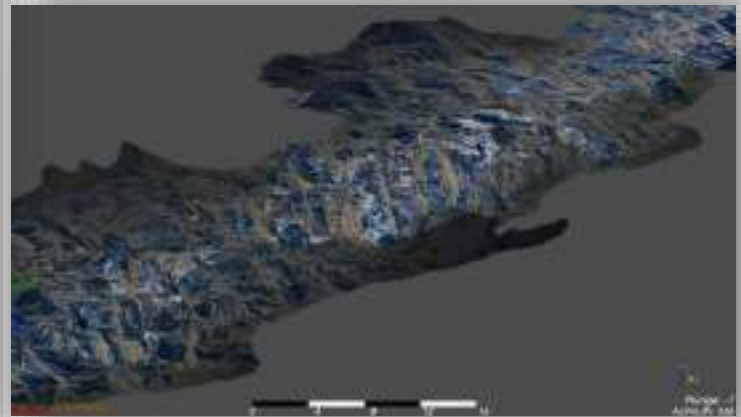
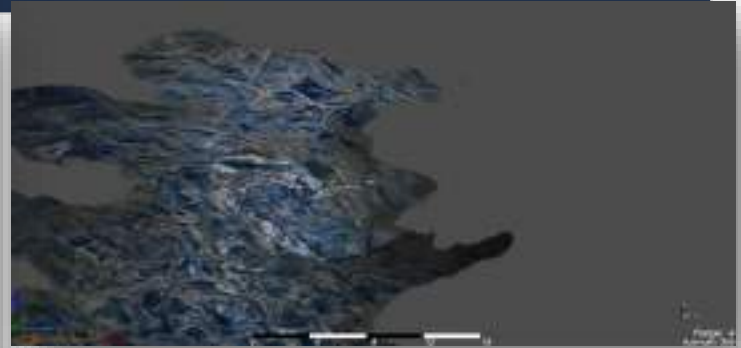
Stockwerk calcite veins on **RGB** (top) and **UV** (bottom) images



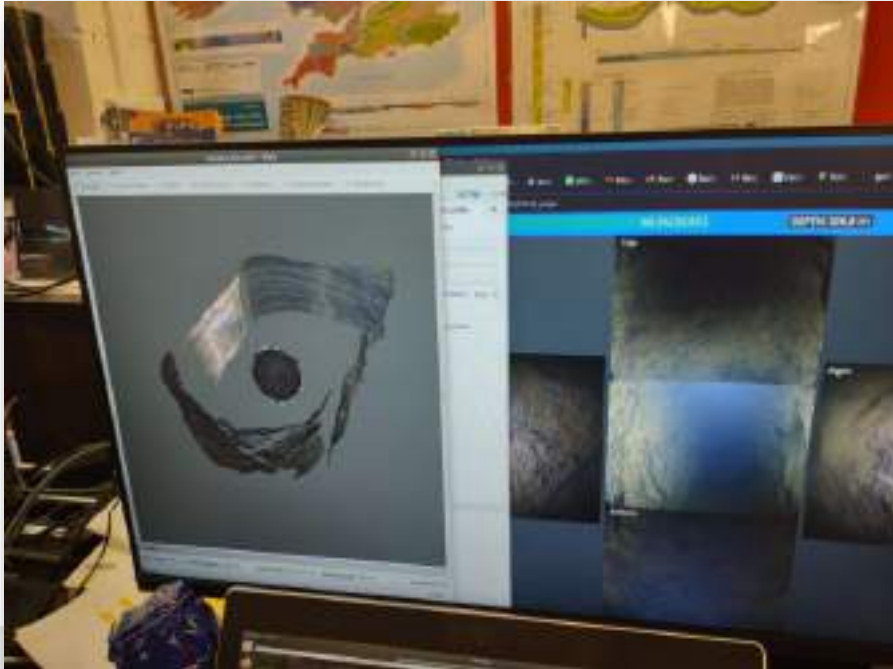
Syncline with calcitized tension cracks, winding shaft

Field work - Ecton Mine, UK – 3D modelling

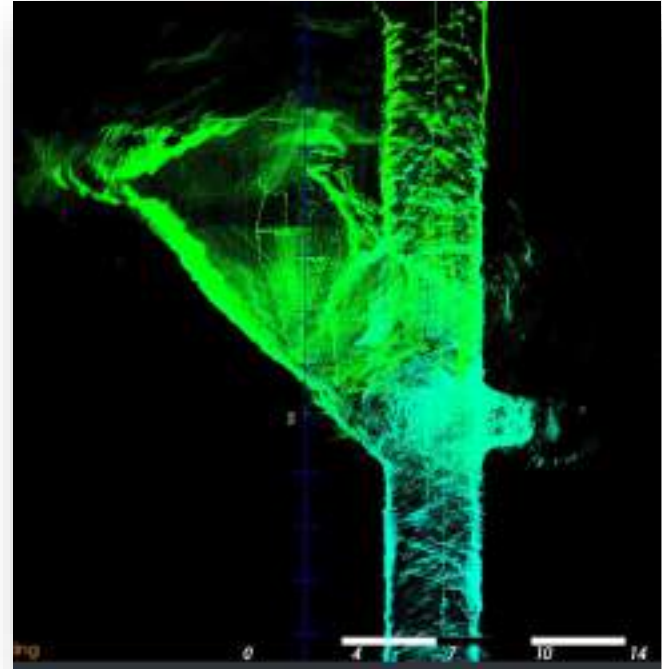
Detailed, **high-resolution photogrammetric models** from the flooded parts of the mine



Field work - Ecton Mine, UK – 3D modelling



In case of good visibility, **laser** and **sonar** based **3D point clouds** can be created **simultaneously** and the **immediate result** can be observed **during the dive**



Field work – Csór freshwater well, Hungary

- **Primary water source** of Székesfehérvár, Hungary
- **5 cm accuracy 3D map** is required to be able to lower a new equipment to the bottom of the well
- The **water pumps were working constantly** during the work
- **Human contact with water was prohibited**
- One-day mission
- ~66 m depth



Field work – Csór freshwater well, Hungary



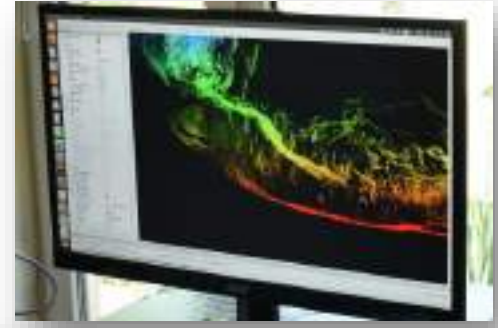
After the special disinfection the UX-1Neo robot obtained the precise 3D map of the well

Field work – Molnár János cave, Hungary

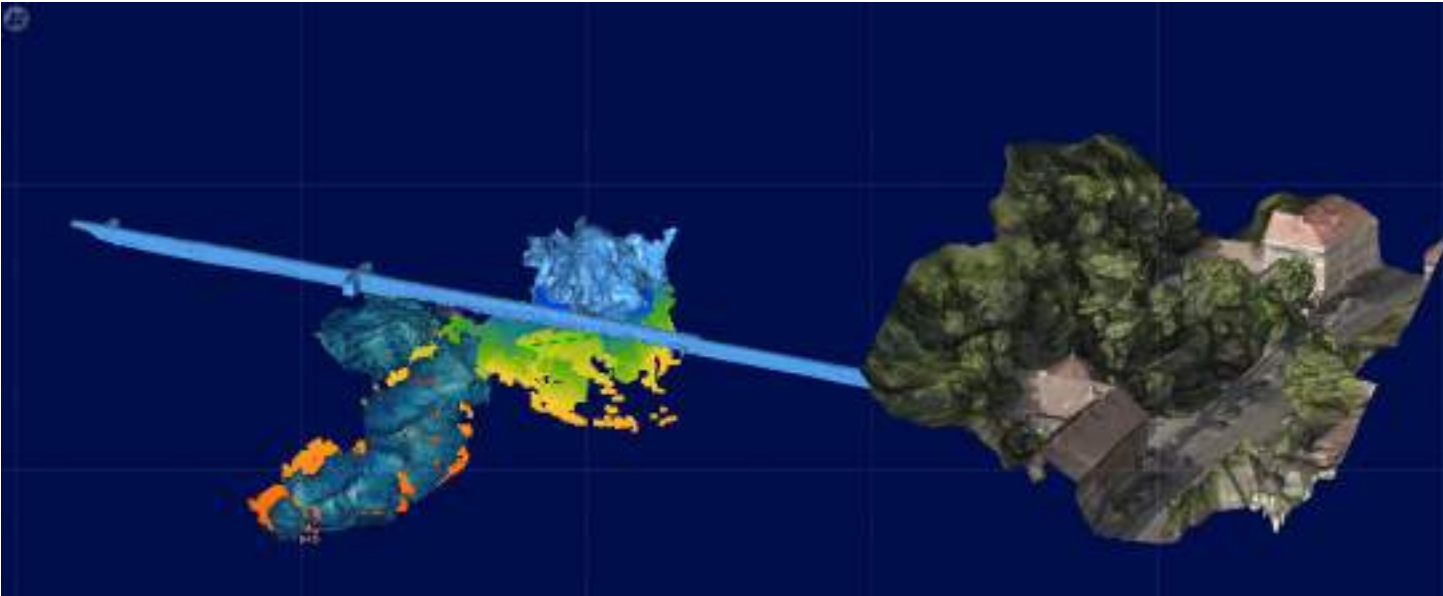
- The Molnár János Cave is a **thermokarstic** water-filled **cave system**
- The **deepest** sections reach **100 metres**, while the **total length** of explored sections is currently **5.5 kilometres**
- The cave is well-known for cave-divers due to the **warm** (20-28 Celsius degrees), **crystal clear water**. There are **no strong currents** within the cave, the water flows very slowly.



Field work – Molnár János cave, Hungary



Field work – Molnár János cave, Hungary



Complex 3D model were obtained from the first part of the cave:

- Underwater photogrammetry
- Aerial photogrammetry
- Laser point cloud
- Sonar point cloud
- Aerial LiDAR

Solotvyno, Ukraine

- Commercial field trial
- Risk of catastrophic saltwater contamination of River Tisza
- Investigate stability and water conditions within the mines
- Dives in shafts 9 & 10 with the UX1-Neo robot
- Dives in lakes 7 & 8 and shaft 10 with Water Chemistry Unit



Shaft 9



Shaft 10



**Small
Lake**



Lake 7

Lake 8

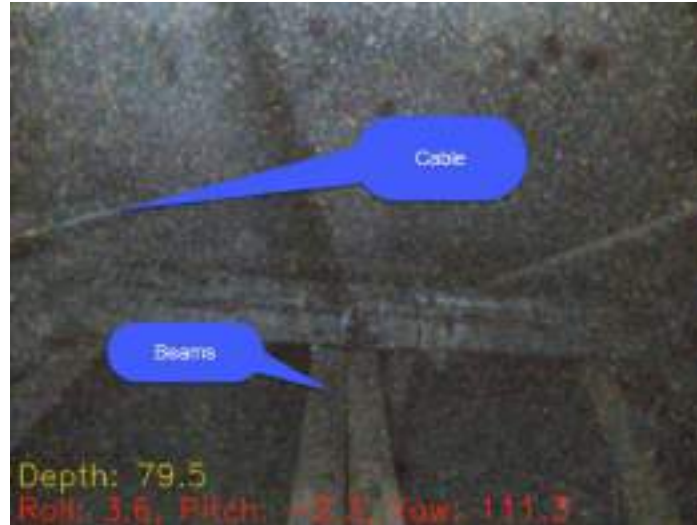


Solotvyno, Ukraine



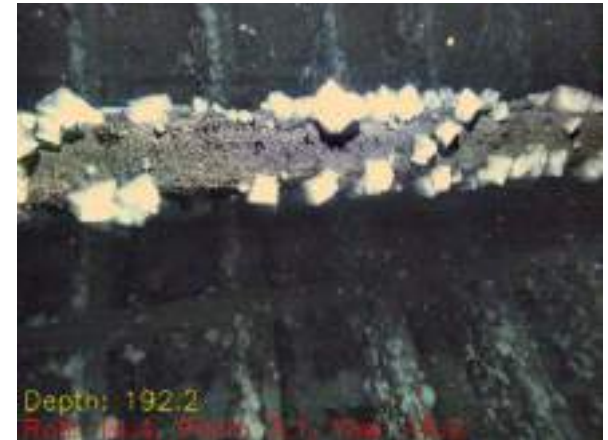
Solotvyno, Ukraine

- **Shaft 9**
 - Dive to 80m
 - Low visibility
 - Many obstacles
- **Shaft 10**
 - Dive to ~450m
 - Better visibility
 - No obstacles
 - Saturated brine



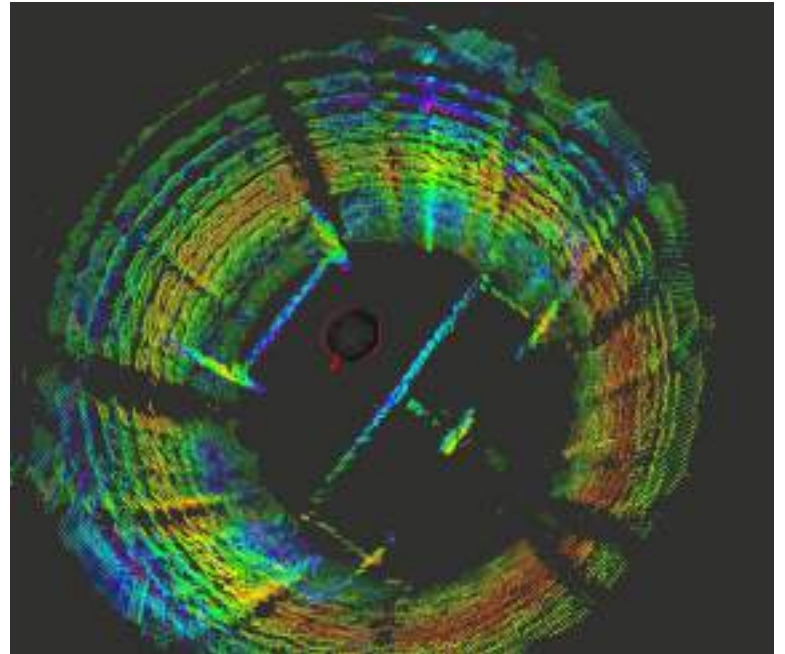
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Solotvyno, Ukraine

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Solotvyno, Ukraine

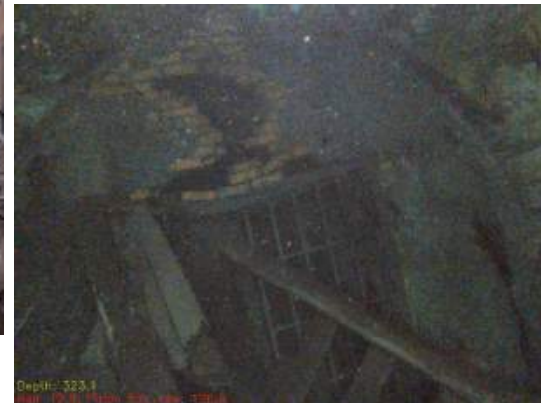
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Access blocked in the Shaft 10 at ~306m



Applications of our technology

- Raw materials exploration
- Create and/or update geological models
- Make decisions on exploitation
- Water reservoirs surveying
- Cave system exploration
- Cavity measurement (e.g. salt mines)
- Geological Surveys
- Cultural Heritage sites investigation
- Risk evaluation
- Environmental monitoring



Safety protocols

- Safety instructions and protocols for field trials are available
- They comply with the Safety legislation of the country and the company for which the trials are carried out

Approval/notes
for safe making and safe execution of works during the use of the lift robot in an underground mine

1. **OPERATOR (OPERADOR LADRO)** shall ensure, insofar as it is reasonably practicable, the health, safety, and welfare of work of all people affected by the work being conducted by **SGS**.
2. All personnel shall take reasonable care to protect his or her health and safety and the health and safety of other personnel who may be affected by his, her or someone's actions.
3. When safety measures and the person responsible for health and safety at work will be used in conjunction with the L&E on safe making and safe execution of works during the test of the **L&E** robot in the Mine before the work begins.
4. By signing the instructions, employees on the L&E confirm that they understand and agree with all the safety rules specified in the instructions.
5. Everyone working on the mine site will read all these rules.
6. A worker may refuse to perform any particular act or series of acts at a place of employment if the worker has reasonable grounds to believe that the act or series of acts is seriously dangerous to the worker's health or safety or the health or safety of other personnel at the place of employment and sufficient steps have been taken to satisfy the worker.
7. All work at a place of employment is sufficiently and competently supervised and supervised ensure personnel work safety.
8. **SGS** shall develop a training program for personnel to ensure that they are adequately trained to carry out their duties safely.
9. At the end of every shift, the direct supervisor records all observed information immediately or in another form that can be communicated quickly. This information would be relevant to the health and safety of personnel that was observed during the shift. The direct supervisor signs and dates this information after the ending of the beginning of the shift. The receiving direct supervisor reads any entry made from the previous shift and acknowledges the entry on their last shift by recording it in their shift of the previous shift (including it).
10. When it is not reasonably practicable to ensure the health and safety of workers by

Thank you!

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