

UNEXMIN and UNEXUP Projects: Development of Submersible Robots for Survey of Flooded Underground Mines

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Abstract

A series of submersible robots have been developed in the EU-funded UNEXMIN (Horizon2020, 2016–2019) and UNEXUP (EIT Raw Materials, 2020–2022) projects, for surveying and exploration of flooded underground mines. The robots carry cameras and a range of different instrumentation to determine physical and chemical properties of wall rocks and water; there are also water samplers to allow further laboratory analysis of the water.

The first generation of robots (UX1) is designed for dives to a maximum of 500m depth, and no contact with wall rock, though they include a water sampling unit. In UNEXMIN the prototype design included a 60 cm diameter spherical pressure-hull with instrument and camera ports, and thruster manifolds on either side. A number of problems with the design were identified during trials, so in UNEXUP a complete re-design produced a modular robot (UX1-NEO) of similar shape, exterior dimensions, and instrumentation capabilities, but with considerable weight reduction as well as a new thruster configuration for improved manoeuvrability. This is the version currently being tested.

The second generation currently under development (UX2-DEEP) will be similar in appearance but is designed to dive to 1500–2000 m maximum depth and will include also a device for sampling the wall rock. Both generations include pH, conductivity, temperature and pressure sensors, gamma-ray detector, and magnetometer. Six cameras (to give all-round vision) use white light and ultraviolet sources (the latter to identify fluorescent minerals). In the first generation there was also a multi-spectral unit, but this was found difficult to use because of problems in registration of the time-sliced images when the robot was moving. This is now being replaced by a hyperspectral unit, which not only gives much more spectrometric data but also avoids the image-matching problem.

A series of trials have been carried out at mines around Europe. These include the open-pit Kaatiala mine in Finland, and underground mines: Idrija mercury mine (Slovenia), Urgeiria uranium mine (Portugal), and Deep Ecton copper mine (Staffordshire, UK). Currently a new set of trials are under way in Hungary and Ukraine. Examples are shown from Urgeirica and Ecton. In particular, extensive dives in May 2019 at Ecton yielded much new data on geology and archaeology, as well as the water which had been almost undisturbed since the mine flooded to river level in the late 1850s.

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