AN AUTONOMOUS UNDERWATER EXPLORER FOR FLOODED MINES

The UNEXMIN project

Norbert Zajzon coordinator

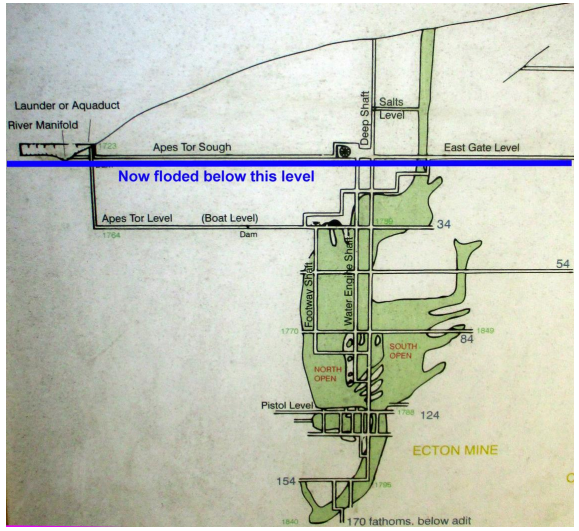
First interim meeting and Technology Appraisal Workshop

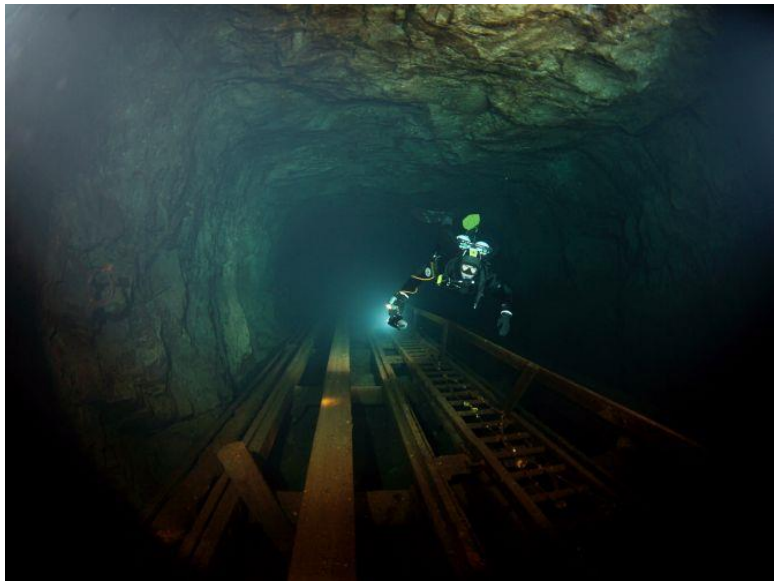
- Tampere 31st of January – 2nd of February 2017

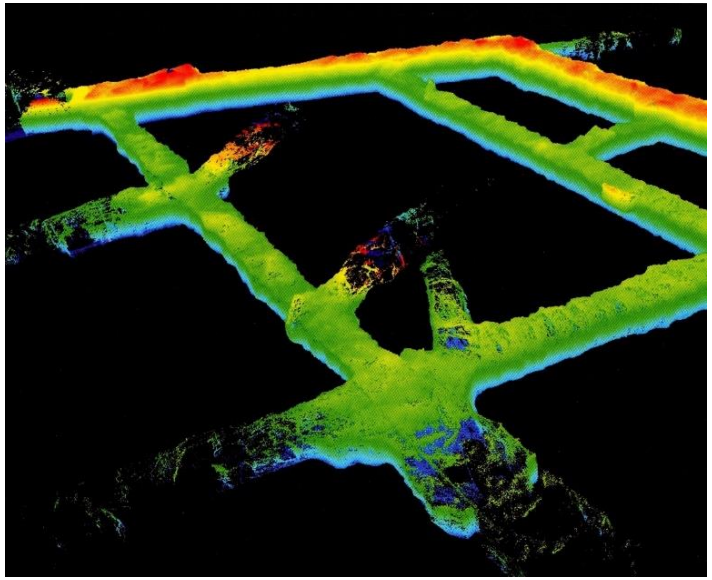
This project has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No 690008.

ABOUT THE PROJECT: CONCEPT

- There are of the order of 30,000 closed mine sites in Europe and many of them potentially contain considerable amounts of valuable mineral raw materials,
- The closure of a mine is usually more related to economics and technological challenges than to the actual depletion of mineral resources
- Often minerals which were disregarded during the operational life of the mine (such as fluorite in lead/zinc mines)
- These mines are now flooded and the last piece of information of their status and layout is decades or over a hundred years old.







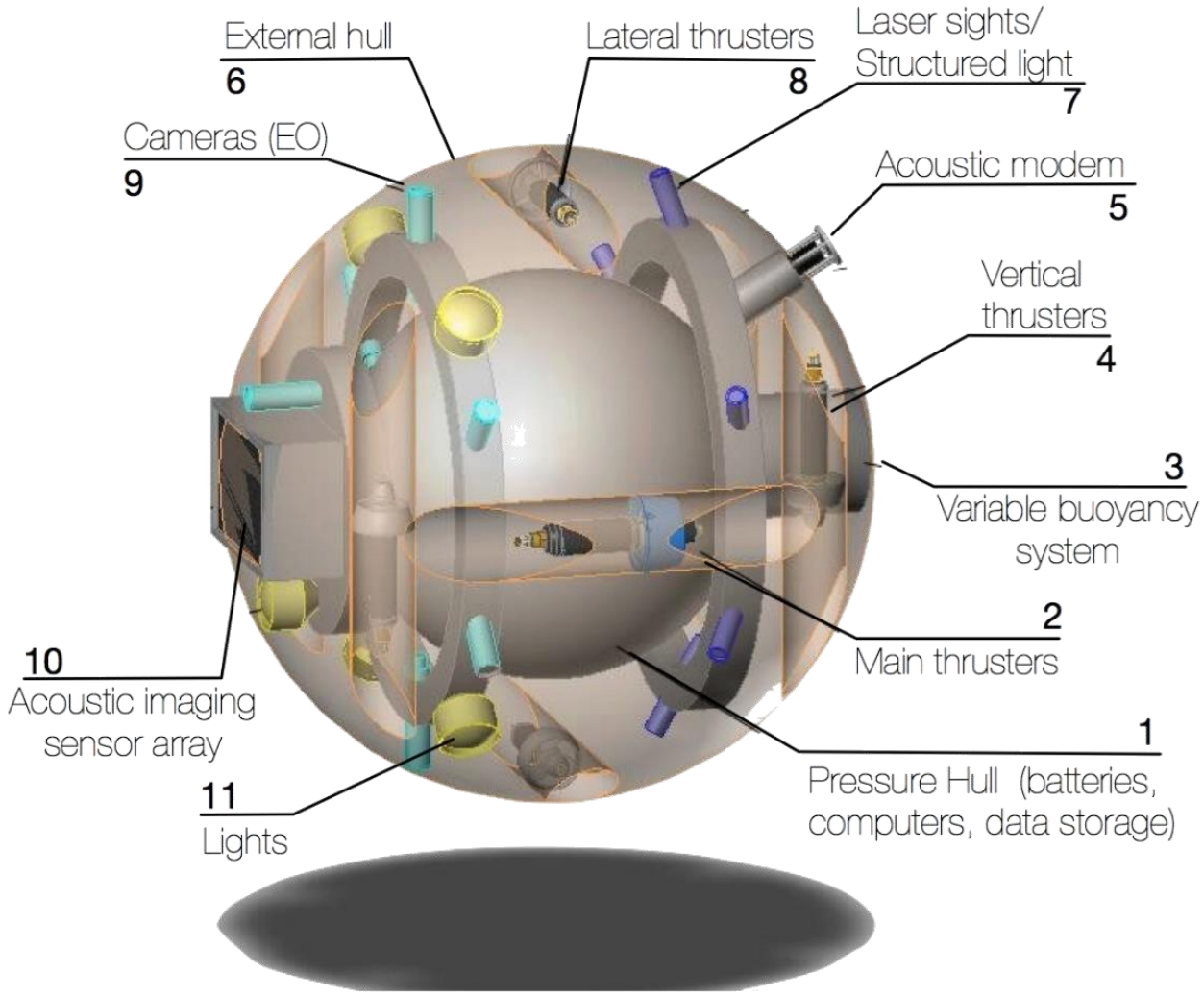
ABOUT THE PROJECT: CONCEPT

Physical Apperence

- Max operational depth: ~500m
- Shape: spherical
- Size: ~ 0.6 m diameter
- Expected weight: 112 Kg
- Neutral Buoyancy
- Power consumption: 150–300 W
- Max speed: 1–2 Km/h
- Autonomy: up to 5 hours
- Thrusters power: 2–5 Kgf

Propulsion:

- one tail thruster (2), plus two thrusters for longitudinal (sway) motion (8) Vertical
- movement (heave): based on buoyancy control (3) and vertical thrusters (4)
- Attitude control (pitch and yaw): pendulum-based (displacement of the centre of mass)



KEY FACTS ABOUT THE PROJECT

EU funded H2020 research project (RIA: Research and Innovation Action)

Grant Agreement number: 690008 (H2020-SC5-2015)

13 partners (7 countries)

45 month duration

(1st of February 2016 – 31st of October 2019)

Funding summ: ca. 4.87 million Euro

Deliverables: Three working protptype robots

Spin-off company offering the technology

ABOUT THE PROJECT: CONSORTIUM

- University of Miskolc
- Tampere University of Technology, Department of Mechanical Engineering Systems
- Universidad Politécnica de Madrid, Centre for Robotics and Automation
- Inesc Tec – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência
- Resources Computing International Ltd

Technology development

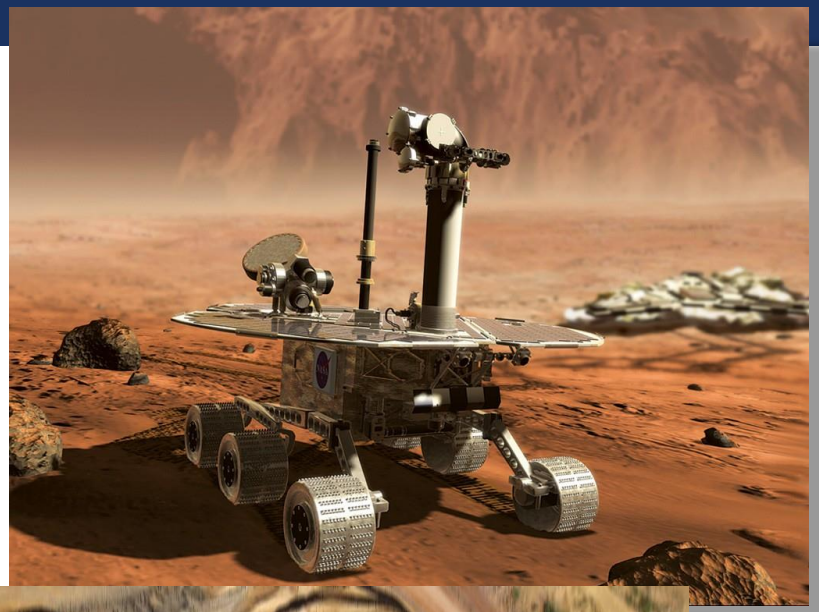
- La Palma Research Centre for Future Studies
- Geological Survey of Slovenia
- Geoplano Consultores Sa
- The European Federation of Geologists
- Geo-montan Kft

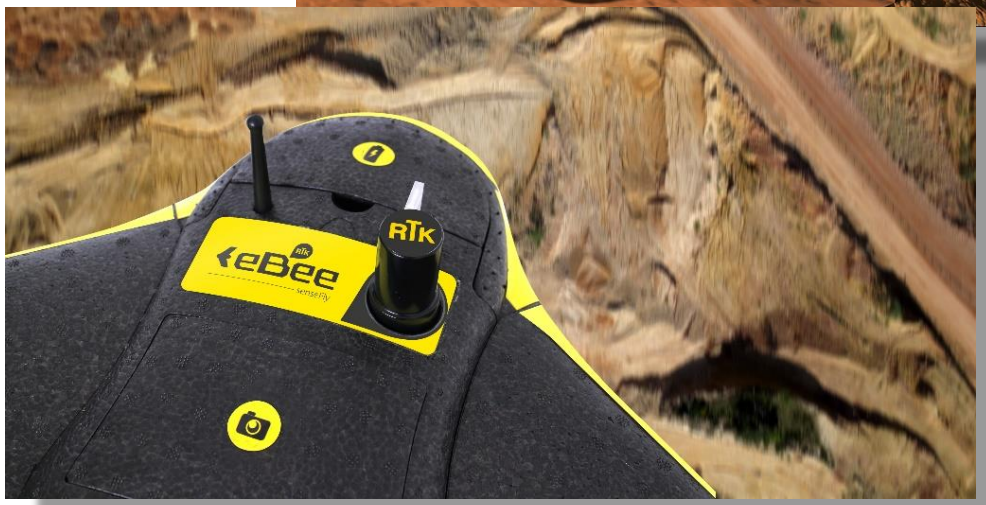
Technology exploitation

- Empresa de Desenvolvimento Mineiro
- Ecton Mine Educational Trust
- Center za Upravljanje z Dediscino Zivega Srebra Idrija

Key stakeholders

ABOUT THE PROJECT: BACKGROUND, CONCEPT AND APPROACH





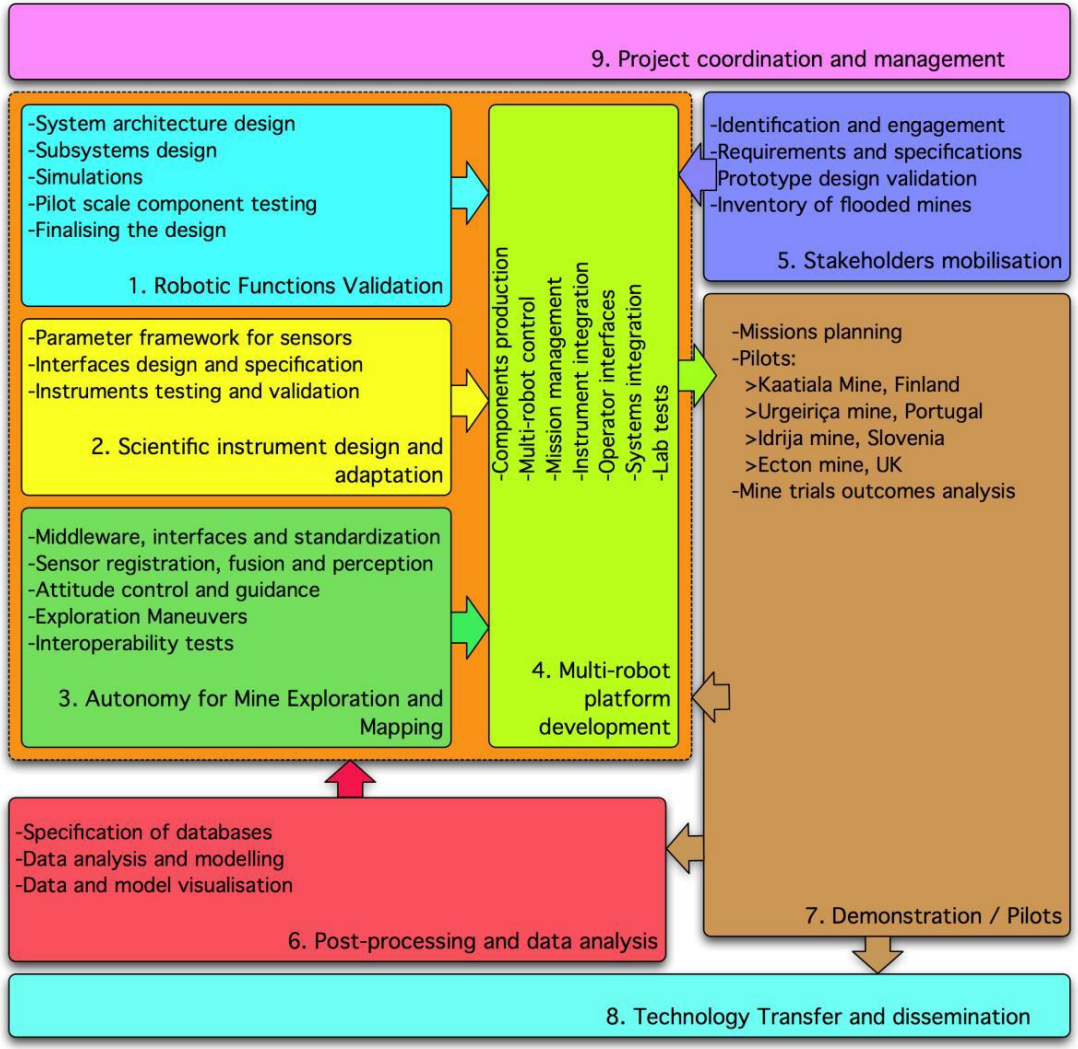
ABOUT THE PROJECT: GOALS

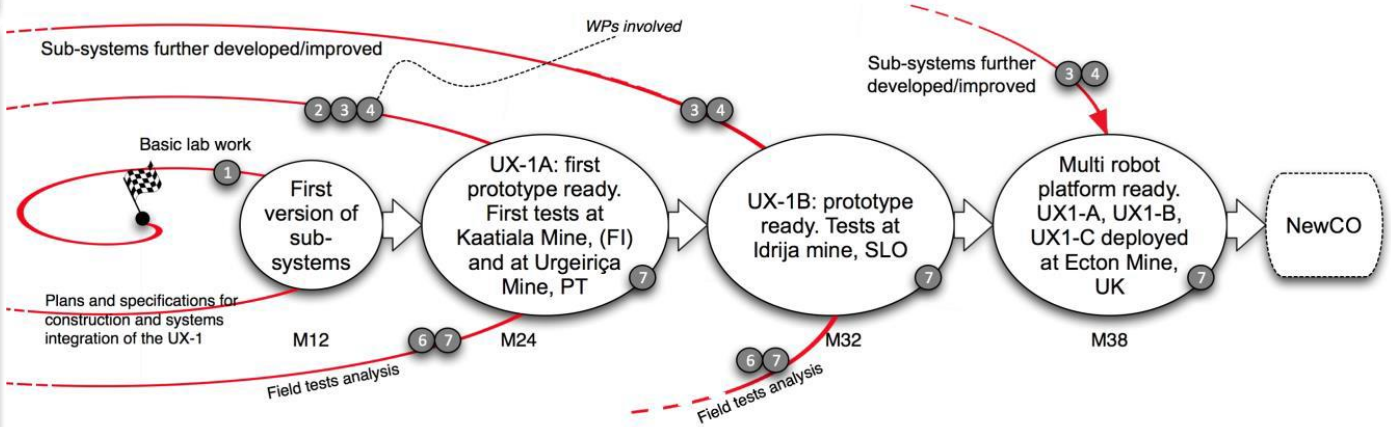
- The project will use cutting edge science and technology from deep sea robotics to develop a *fully autonomous robotic surveying* solution for mapping abandoned and flooded deep mines. *Major technical challenges* are related to the harsh environment, mine depth and the need for autonomous navigation and mapping of semi-structured environments, while at system level the *major focus will be on robustness and dependability.*

Specific goals

- Design and build a multi-platform robotic Explorer for autonomous 3D mapping of flooded deep mines
- Demonstrate the operation of the prototype at a set of representative pilot sites
- Develop an open-source platform for technology transfer and further development
- Develop a research roadmap in support of further technology development
- Develop commercial services for exploiting the technology

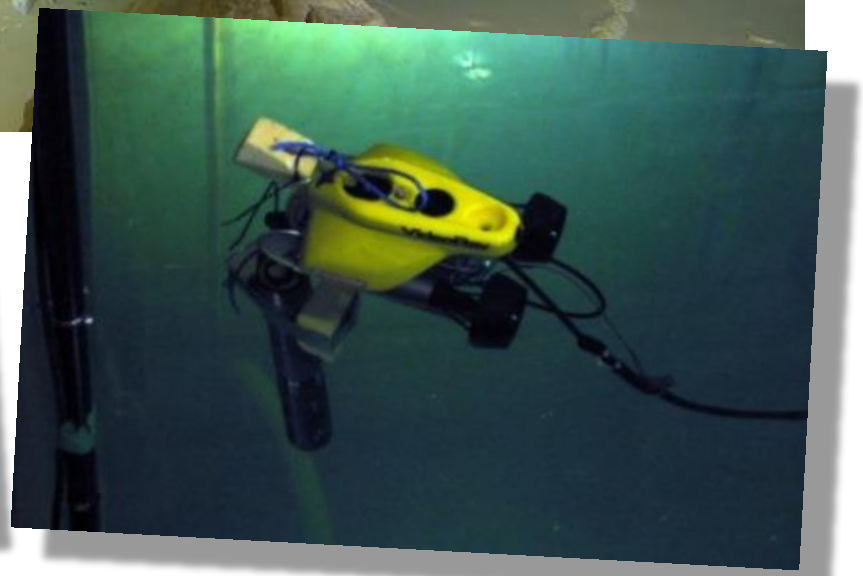
ABOUT THE PROJECT: APPROACH



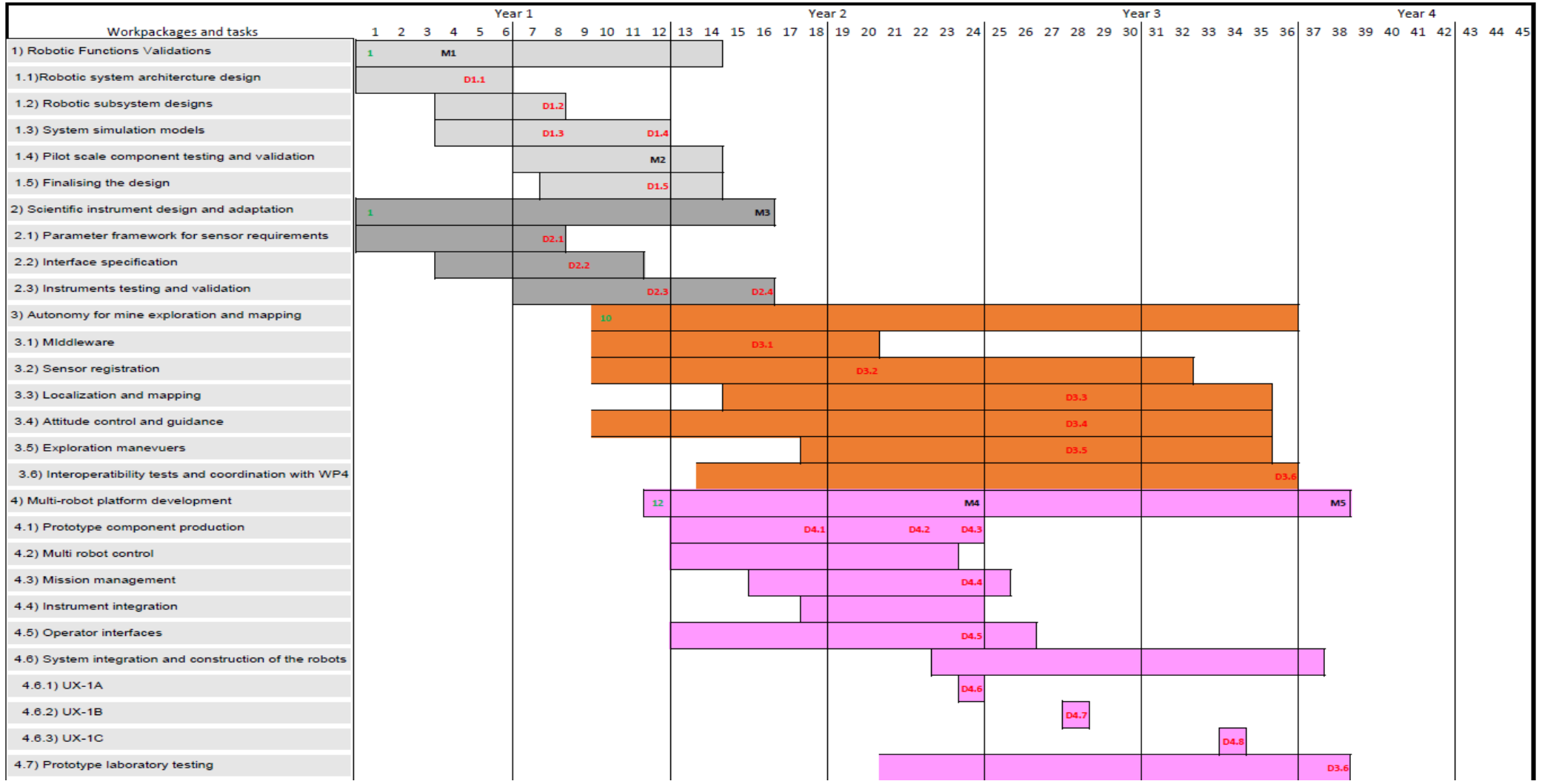


ABOUT THE PROJECT: APPROACH

- Cave exploration
- Ambulance
- Monitoring of nuclear facilities
- Monitoring of large diameter pipelines
- ….
- ….
- ….
- ….
- Looking ahead



ABOUT THE PROJECT: GANTT



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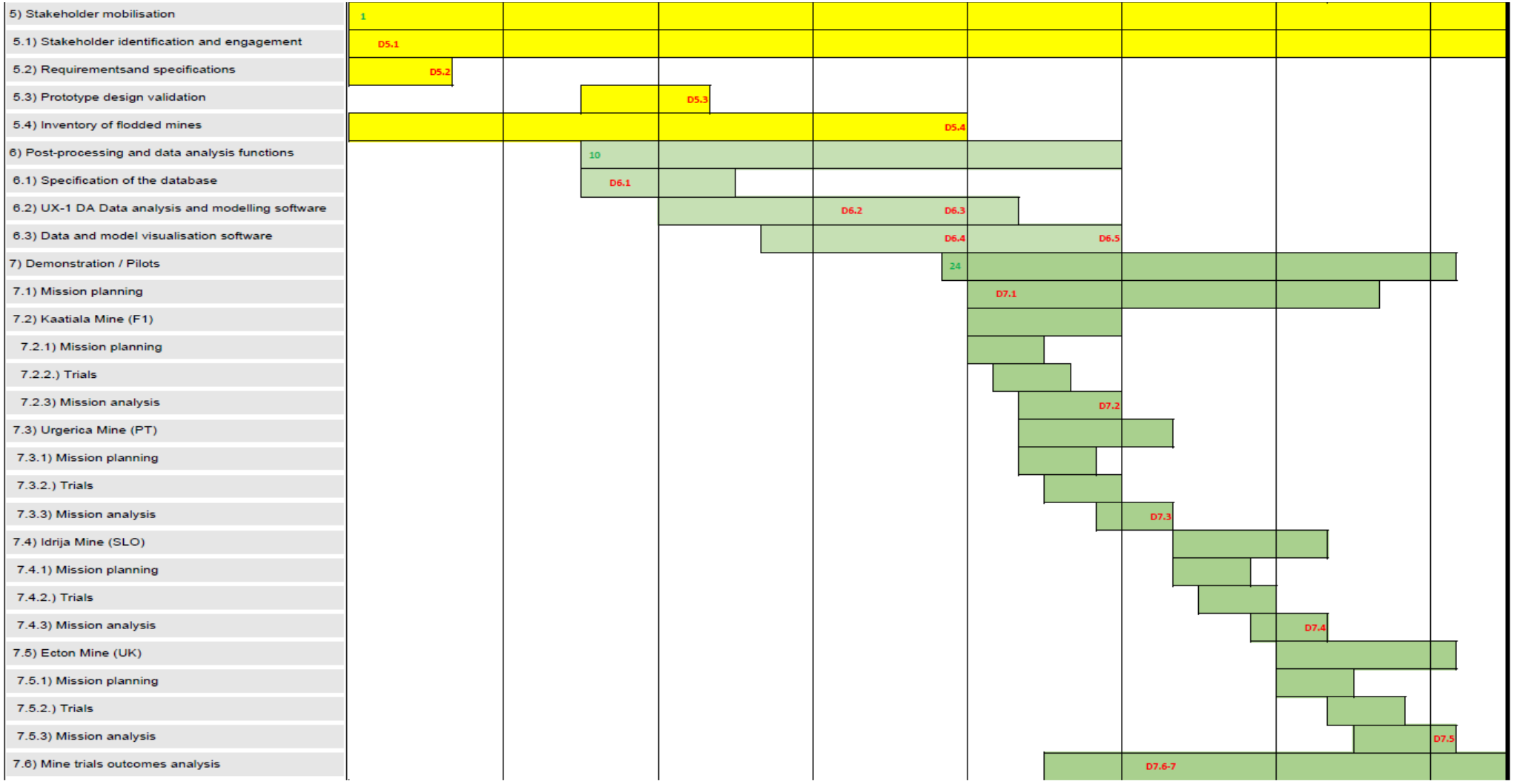
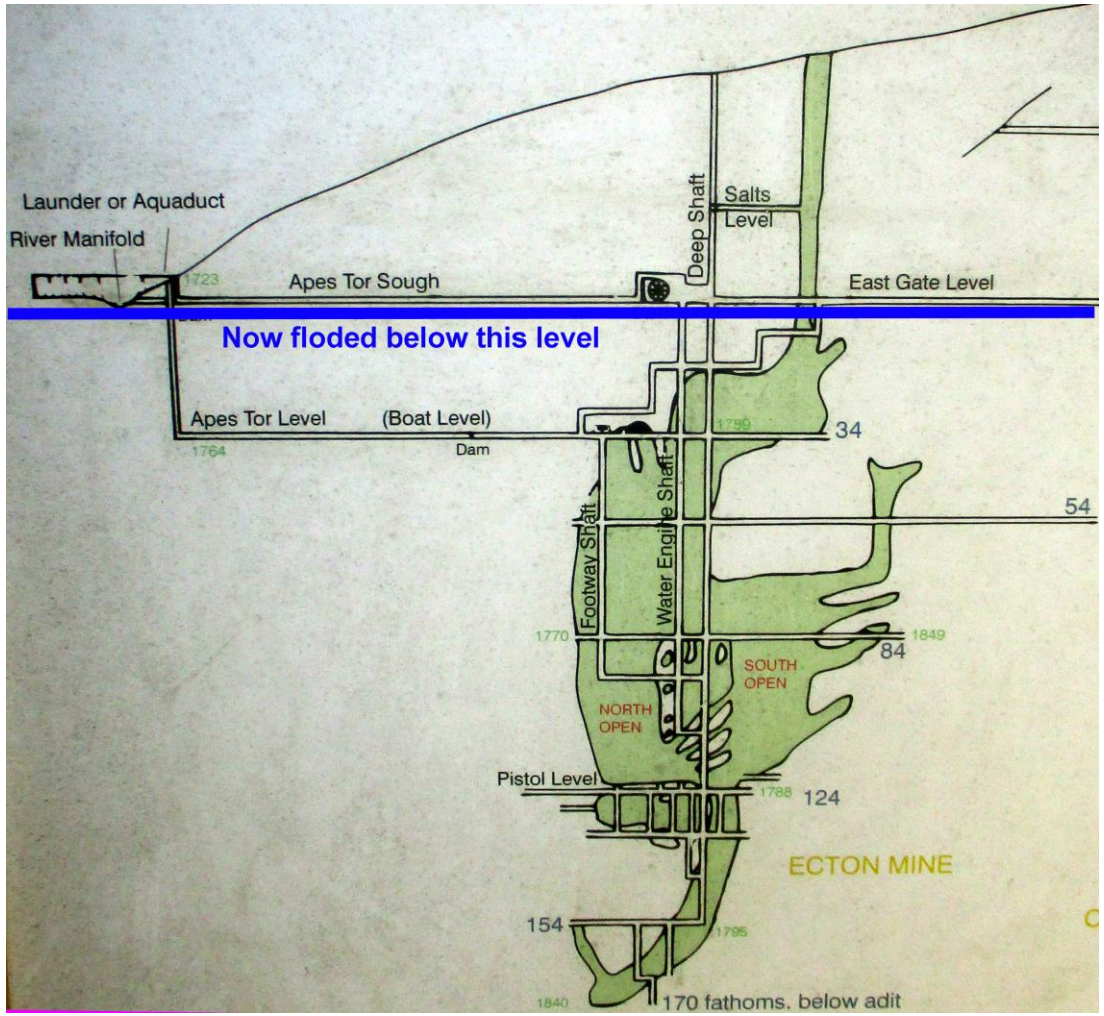


ABOUT THE PROJECT: GANTT

8) Dissemination	1								
8.1) Dissemination management		D8.3-4							
8.2) Dissemination support services	D8.1		D8.2-6		D8.13-14	D8.7	D8.5		D8.5
8.3) Leveraging technology transfers and dialogue				D8.8				D8.10	
8.4) Research roadmapping						D8.9		D8.16	
8.5) Busines economics and exploration results				D8.11		D8.12			D8.15
9) Project management	1								M6
9.1) Project coordination		D9.1	D9.3		D9.5		D9.5		D9.5
9.2) Project management	ME1	ME2	ME3	ME4	ME5	ME5	ME6	ME7	ME8
9.3 Risk management and conflict resolution			D9.2						
9.4) Intelectual property rights management				D9.4					

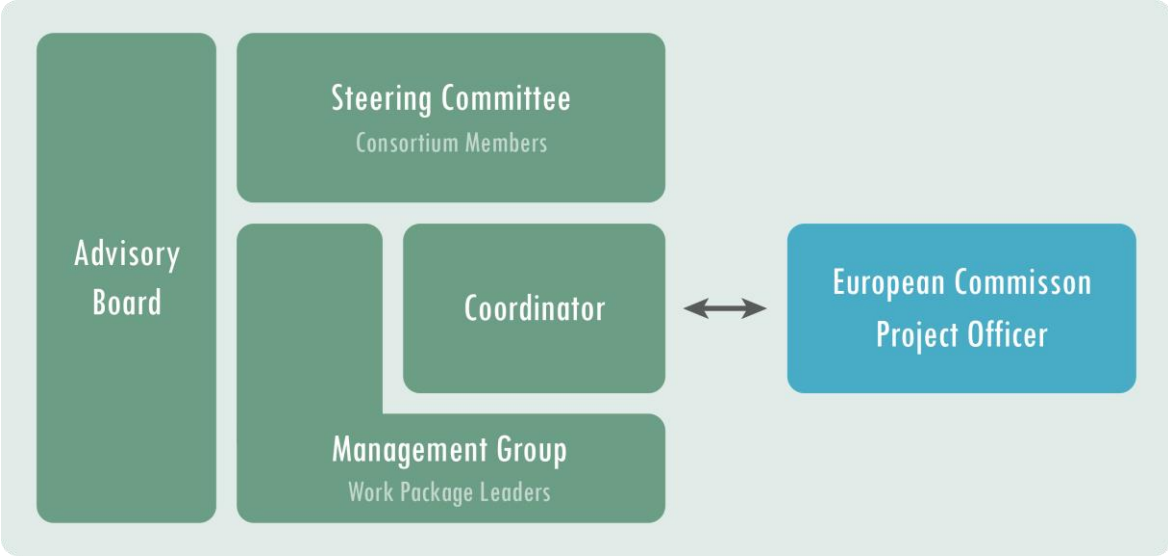
Test-sites

- **Kaatiala, Finnland**
- **Urgeiriça, Portugal**
- **Idrija, Slovenia**
- **Ecton-mine, England**



ABOUT THE PROJECT: WP9 – COORDINATION AND MANAGEMENT

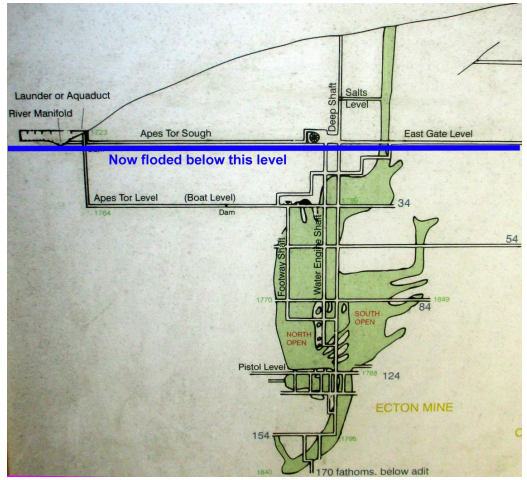
- **GOVERNANCE STRUCTURE**
  - **The Commission - The Coordinator**
    - **Project Steering Committee**
    - **Management Group**
    - **Advisory Panel**
- **TOOLS**
  - **Meetings and Online Meetings – Contact List**
  - **UNEXMIN Drive, Discussion board (Freeforum), UNEXMIN Groups, Basecamp**
  - **Templates and Helps and Guidelines**
  - **Action Plan**

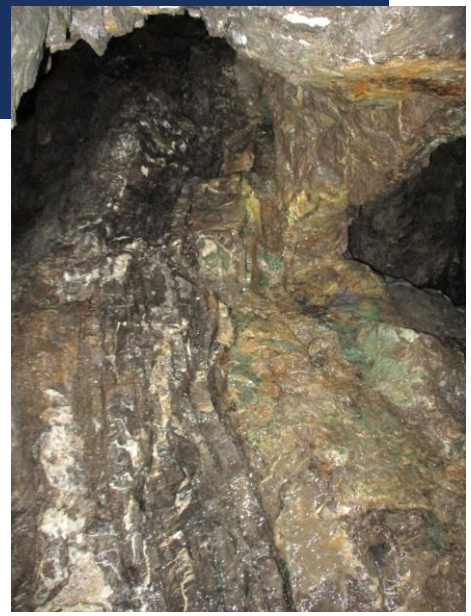


„NewCO"

KICK-OFF MEETING
18–19th of February 2016, Miskolc

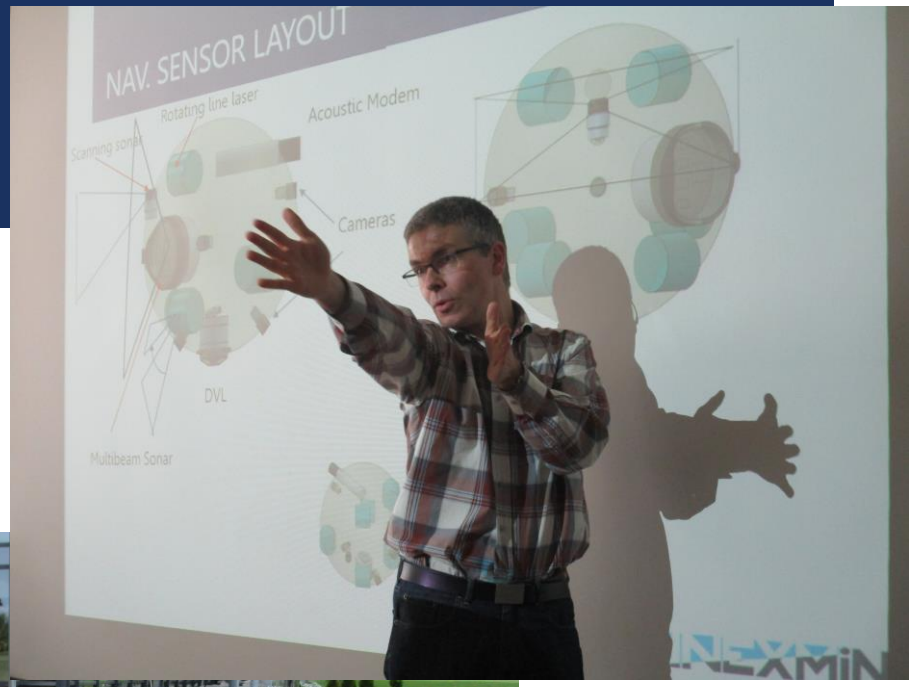
TEST-SITE VISIT
2–3rd of May 2016, Ecton-mine



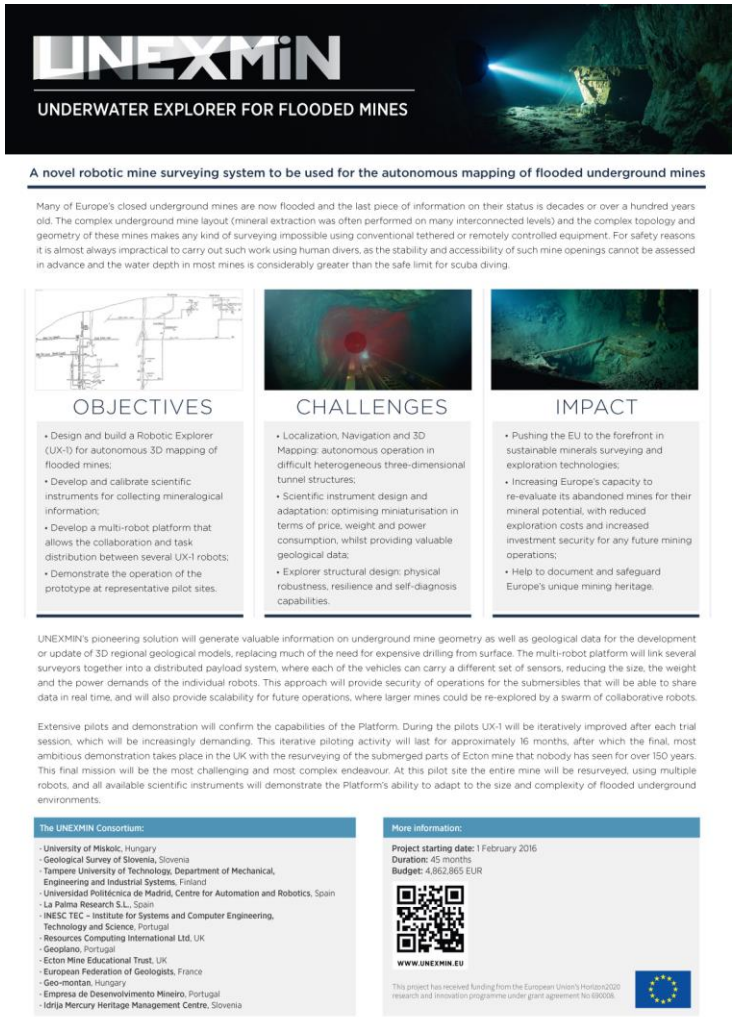


SCIENTIFIC METHODS TESTING
13rd of April, 18th of May 2016, Rudabánya

End-user Requirement Specification Workshop 24–26th of May 2016, Tampere



Exchange of best practices on mining policies and technologies: challenges in the current state of the global economy 28–29th of June 2016, Brussels


UNEXMiN

UNDERWATER EXPLORER FOR FLOODED MINES

A novel robotic mine surveying system to be used for the autonomous mapping of flooded underground mines

Many of Europe's closed underground mines are now flooded and the last piece of information on their status is decades or over a hundred years old. The complex underground mine layout (mineral extraction was often performed on many interconnected levels) and the complex topology and geometry of these mines makes any kind of surveying impossible using conventional tethered or remotely controlled equipment. For safety reasons it is almost always impractical to carry out such work using human divers, as the stability and accessibility of such mine openings cannot be assessed in advance and the water depth in most mines is considerably greater than the safe limit for scuba diving.

OBJECTIVES

- Design and build a Robotic Explorer (UX-1) for autonomous 3D mapping of flooded mines;
- Develop and calibrate scientific instruments for collecting mineralogical information;
- Develop a multi-robot platform that allows the collaboration and task distribution between several UX-1 robots;
- Demonstrate the operation of the prototype at representative pilot sites.

CHALLENGES

- Localization, Navigation and 3D Mapping: autonomous operation in difficult heterogeneous three-dimensional tunnel structures;
- Scientific instrument design and adaptation: optimising miniaturisation in terms of price, weight and power consumption, whilst providing valuable geological data;
- Explorer structural design: physical robustness, resilience and self-diagnosis capabilities.

IMPACT

- Pushing the EU to the forefront in sustainable minerals surveying and exploration technologies;
- Increasing Europe's capacity to re-evaluate its abandoned mines for their mineral potential, with reduced exploration costs and increased investment security for any future mining operations;
- Help to document and safeguard Europe's unique mining heritage.

UNEXMIN's pioneering solution will generate valuable information on underground mine geometry as well as geological data for the development or update of 3D regional geological models, replacing much of the need for expensive drilling from surface. The multi-robot platform will link several surveyors together into a distributed payload system, where each of the vehicles can carry a different set of sensors, reducing the size, the weight and the power demands of the individual robots. This approach will provide security of operations for the submersibles that will be able to share data in real time, and will also provide scalability for future operations, where larger mines could be re-explored by a swarm of collaborative robots.

Extensive pilots and demonstration will confirm the capabilities of the Platform. During the pilots UX-1 will be iteratively improved after each trial session, which will be increasingly demanding. This iterative piloting activity will last for approximately 16 months, after which the final, most ambitious demonstration takes place in the UK with the resurveying of the submerged parts of Ecton mine that nobody has seen for over 150 years. This final mission will be the most challenging and most complex endeavour. At this pilot site the entire mine will be resurveyed, using multiple robots, and all available scientific instruments will demonstrate the Platform's ability to adapt to the size and complexity of flooded underground environments.

The UNEXMIN Consortium:

- **University of Miskolc**, Hungary
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- **Ecton Mine Educational Trust**, UK
- **European Federation of Geologists**, France
- **Geo-montan**, Hungary
- **Empresa de Desenvolvimento Mineiro**, Portugal
- **Idrija Mercury Heritage Management Centre**, Slovenia

More information:

Project starting date: 1 February 2016
Duration: 45 months
Budget: 4,862,865 EUR

WWW.UNEXMIN.EU

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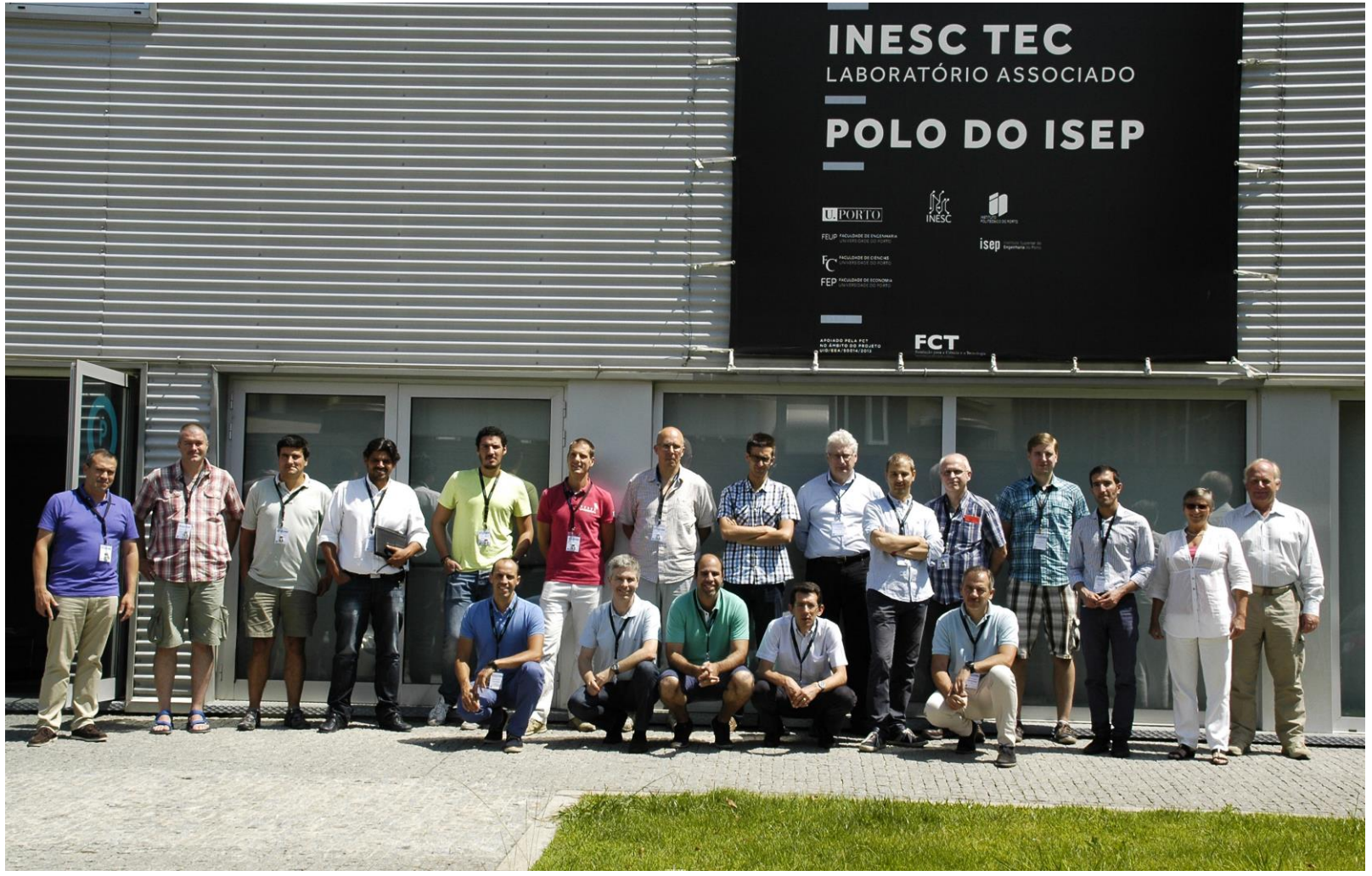
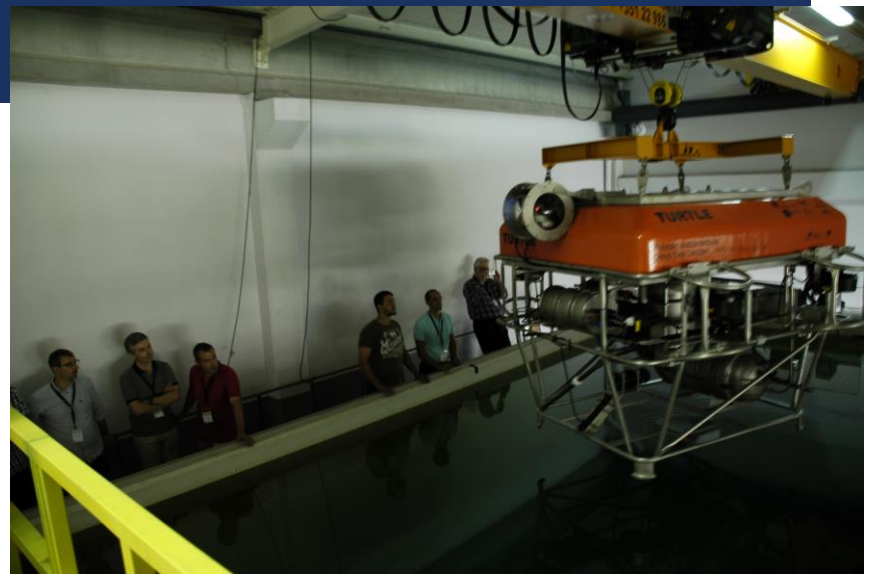
Follow-up workshop I, and Steering Committee Meeting 28–29th of July 2016, Porto





Workshop week (about open- / closed-frame design)
5–9th of September 2016, Tampere

Follow-up workshop II
25–26th of October 2016, Madrid

Dissemination

- Website
- Broschure
- Press-release
- Articles
- EFG newsletter
- EGU 2017 (other confs)
- Youtube-video (soon)

WWW.UNEXMIN.EU

The UNEXMIN Consortium:

- **University of Miskolc**, Hungary
- **Geological Survey of Slovenia**, Slovenia
- **Tampere University of Technology, Department of Mechanical, Engineering and Industrial Systems**, Finland
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The UNEXMIN Consortium is developing a novel robotic mine surveying system to be used for the autonomous mapping of flooded underground mines.

The multi-robot platform will link several surveyors together into a distributed payload system, where each of the vehicles can carry a different set of sensors, reducing the size, the weight and the power demands of the individual robots. This approach will provide security of operations for the submersibles that will be able to share data in real time, and will also provide scalability for future operations, where larger mines could be re-explored by a swarm of collaborative robots.

The technology developed by UNEXMIN will increase Europe's capacity to re-evaluate its abandoned mines for their mineral potential, with reduced exploration costs and increased investment security for any future mining operations. By retrieving data from historical sites that are currently inaccessible it will also help to document and safeguard Europe's unique mining heritage.

Already submitted deliverables

- 23 deliverables till 31st of January 2017
  - 20 (18) deliverables on time
  - 3 deliverables are delayed
    - D1.3 Control and propulsion system functional simulators
      - Delay was caused by the microcontrollers of the thrustres
      - One month delay was asked, and approved by PO. New deadline was kept
    - D2.3 Laboratory test reports of instrumentation units
      - Delay is caused by recent changes in public procurement laws in Hungary
      - Two months delay was asked (+multispectral unit), and partially approved by PO (needs further SC statement)
    - D8.8 Technology Appraisal Workshop
      - Delay approved till 10th of February 2017
- 2 Milestones till 31st of January 2017
- **D1.4 and D1.5 deliverables → Milestone 2 !!!**

Thank you for your attention!

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