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ROBOMINERS Project - the future of mining

Author: Alicja Kot-Niewiadomska

Mineral and Energy Economy Research Institute
Polish Academy of Science
Division of Mineral Policy

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Project overview



- Program Horyzont2020: „Raw materials policy support actions”
- **Leader:** Centre for Automation and Robotics (CAR) of the Universidad Politécnica de Madrid (UPM)
- **Consortium:** ROBOMINERS will be implemented by a consortium of 14 partners from 11 European countries (Austria, Finlandia, Hiszpania, Belgia, Węgry, Słowenia, Polska, Wielka Brytania, Niemcy, Estonia, Portugalia)
 - 4 SMEs
 - 5 academic institutions
 - 2 Non-governmental institutions
 - 3 Governmental institutions
- **Duration** (months): 48 (2019-2023)
- **Budget:** € 7.44 mln





Aims of project



The programme aims to create a bio-inspired robot capable of mining underground mineral deposits

Within the project duration, the consortium **aims more particularly at:**

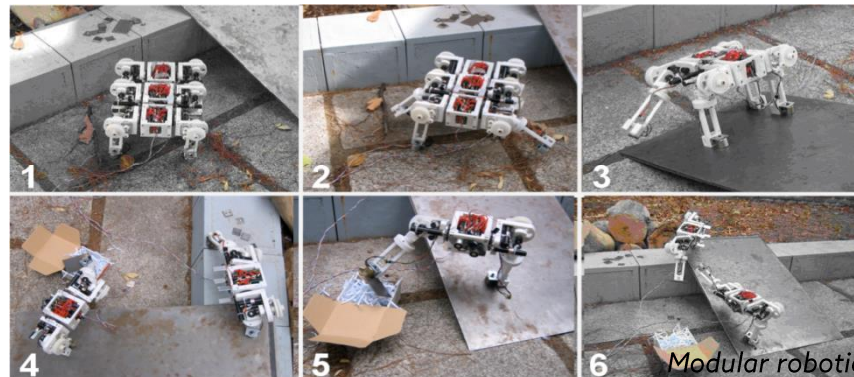
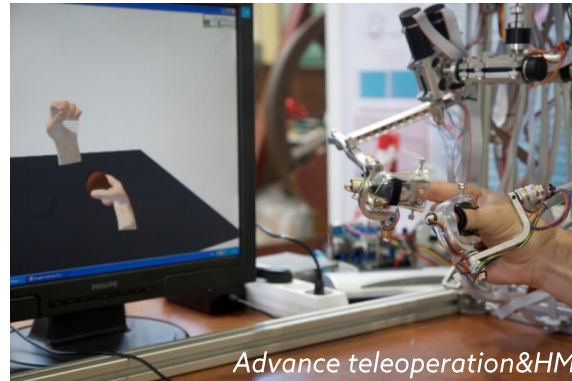
- **constructing** a fully functional **modular robot miner prototype** following a bio-inspired design, capable of operating, navigating and performing selective mining in a flooded underground environment;
- **designing a mining ecosystem** of expected future upstream/downstream raw materials processes via simulations, modelling and virtual prototyping;
- **validating all key functions** of the robot-miner to a Technology Readiness Level (TRL);
- **using the prototypes to study and advance future research challenges** concerning scalability, resilience, re-configurability, self-repair, collective behaviour, operation in harsh environments, selective mining, production methods as well as for the necessary converging technologies on an overall mining ecosystem level.



Centre for Automation and Robotics (Universidad Politécnica de Madrid)



- Resources from R&D&I projects: ≈ 3 M€/y (EC, Spanish and contracts)
- Publications: ≈ 70 journal papers/year (1/2 from Q1)
- Patents: 2,5 per year

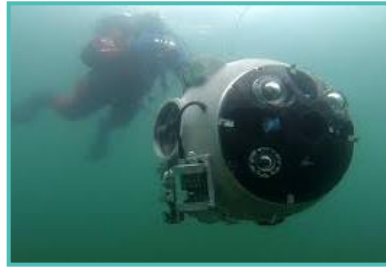




Other similar projects in last years



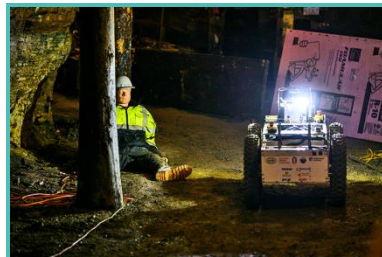
UNEXMIN – underwater explorer for flooded mines



ENAEX – International leader in high technology initiation for blasting in mining, construction, tunneling and seismic exploration



Autonomous Robots Map and Detect Objects in Mine (**DARPA Subterranean**)



MINING-RoX – Mobile Robots (Alexander) in Underground Mining



ARIDuA – robot (Julius) can track people, robots, and machines, as well as monitor environmental conditions in mines

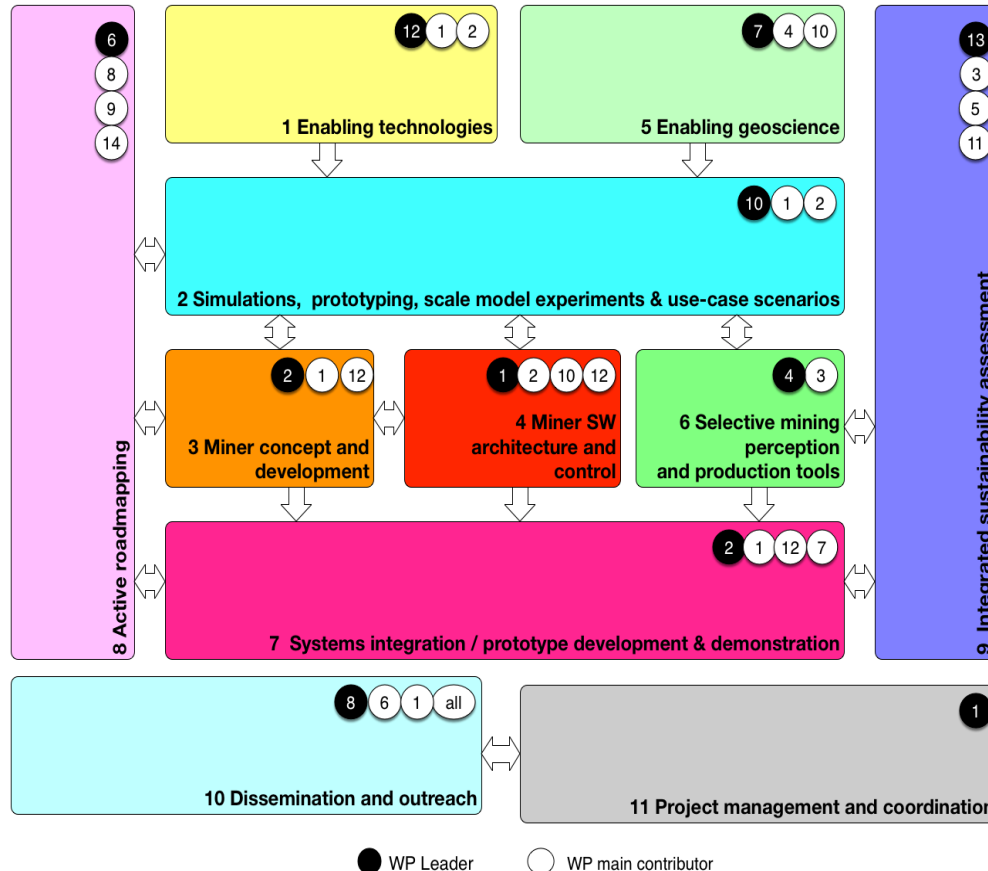


UNDROMEDA – Underground Robotic System for Monitoring, Evaluation and Detection Applications (NEW)

ROBOMINERS - Resilient Bio-inspired Modular Robotic Miners



Structure of project



WP 1 – Enabling technologies

WP2 – Simulations, prototyping, scale model experiments and use-case scenario

WP3 – Miner concept and development

WP4 – Miner SW architecture and control

WP5 – Enabling geoscience

WP6 – Selective mining perception and production tools

WP 7 – System integration/prototype development and demonstration

WP8 – Active roadmapping

WP9 – Integrated sustainability assessment

WP10 – Dissemination and outreach

WP 11 – Project management coordinator

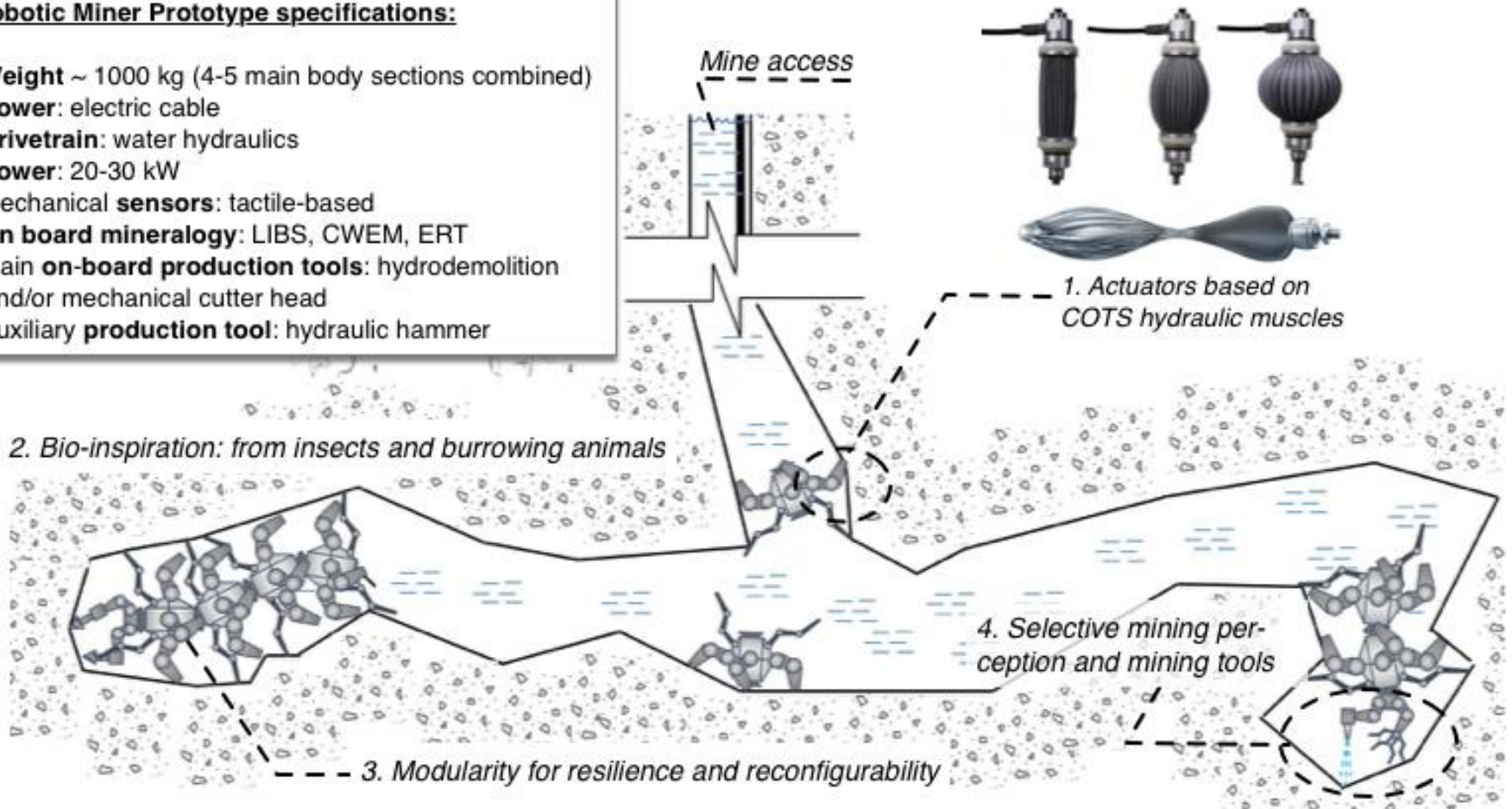


Project overview: concept

Underground mining scenario

Robotic Miner Prototype specifications:

- Weight** ~ 1000 kg (4-5 main body sections combined)
- Power:** electric cable
- Drivetrain:** water hydraulics
- Power:** 20-30 kW
- Mechanical **sensors:** tactile-based
- On board mineralogy:** LIBS, CWEM, ERT
- Main **on-board production tools:** hydrodemolition and/or mechanical cutter head
- Auxiliary **production tool:** hydraulic hammer





Project overview



1. Abandoned mines (flooded mines?)

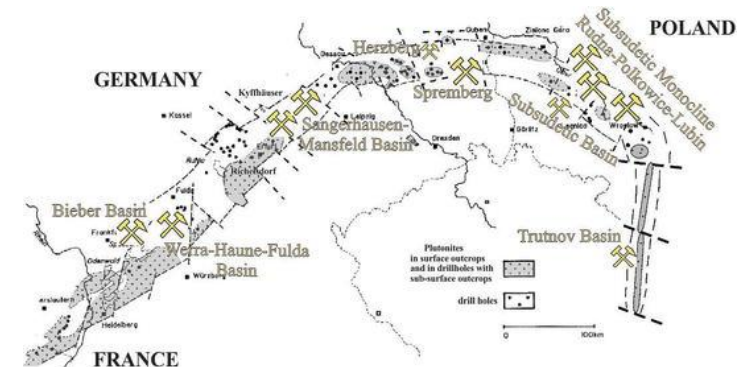
- part of **Botallack mine** that started in XVI century and closed in 1895. Engine houses are probably one of the most well known of the mining relics in **Cornwall**,
- Botallack was one of the greatest **copper** and **tin** mines in England.



Botallack Mine, Cornwall. Source: www.cornwalls.co.uk

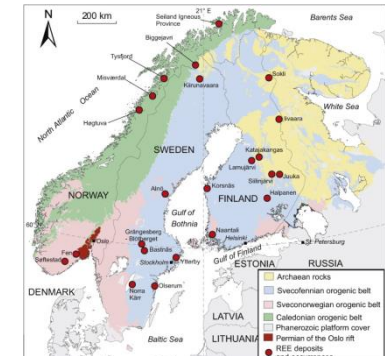
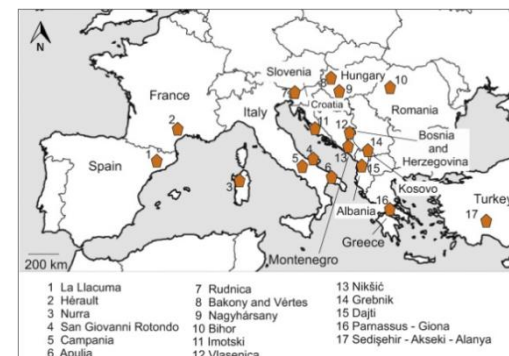
2. Ultra depth

- everything that lies **below 3000 metres** is considered „**ultra-depth**“ for conventional mining and beyond the scope of minerals prospecting in Europe,
- Kupferschiefer Formation (V, Mo, U, Ag, As, Sb, Hg, Bi, Se, Cd, Tl, Au...)



3. Small deposits

- a good example for the small deposits is the enrichment of **REE**
- high grade (1-10 wt% range) REE mineralisations are hosted by alkaline magmatic rocks, mainly by carbonatite.



Location of the enrichments of REE. Source K.M.Goodenough et al. 2016



Two big R&D subjects



1. The miner

- a modular, bio-inspired, heavy duty robot
- capable of self-reconfiguration
- equipped with selective mining tools (perception, production)



2. The mining ecosystem

- mine design and geometry
- new mining strategies
- **sustainability assessment**
- **macro economics and feasibility**
- **environmental impact, social impact**, ethical issues

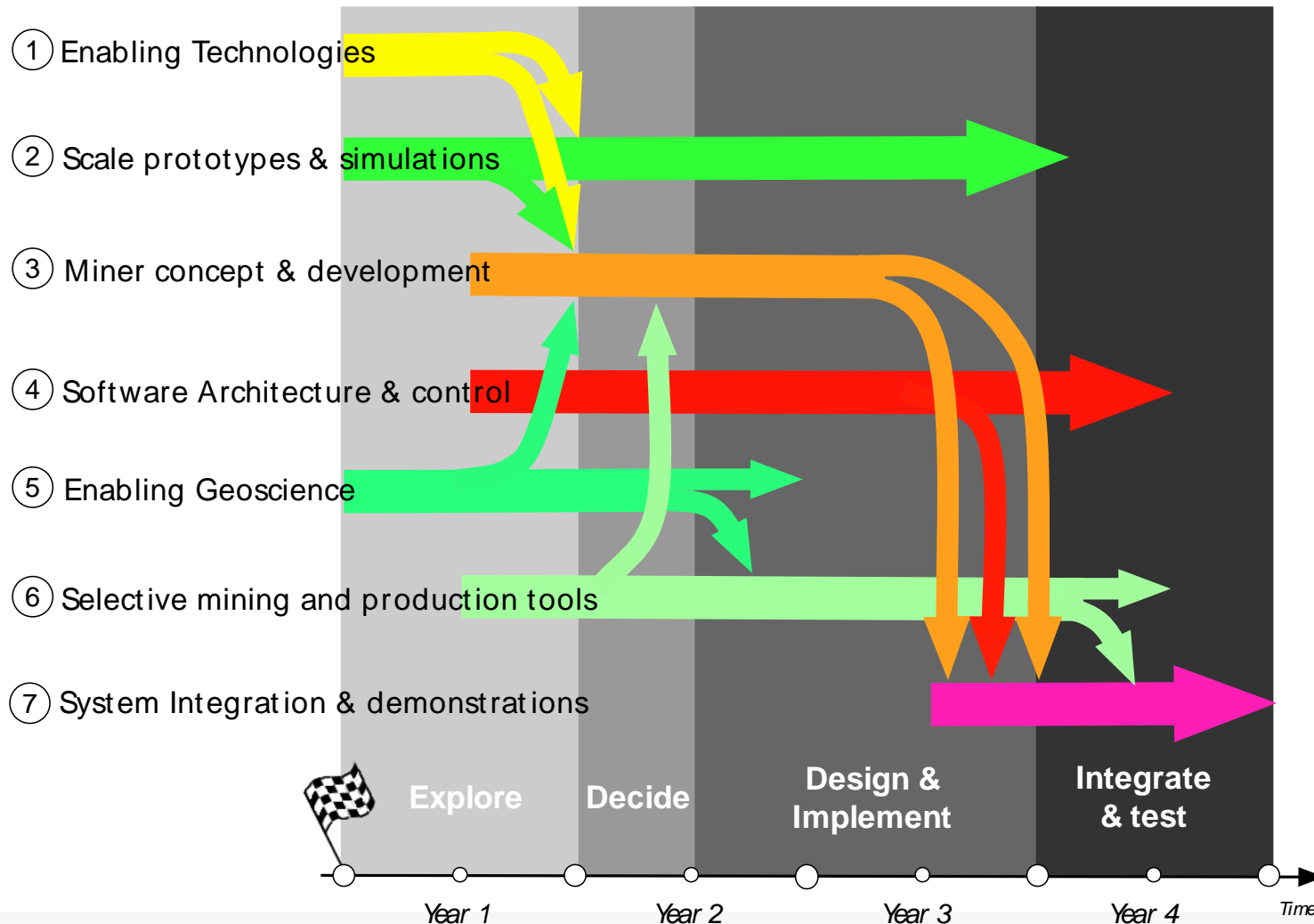




Project overview: timeline - miner



Need to integrate different disciplines → need of a common language

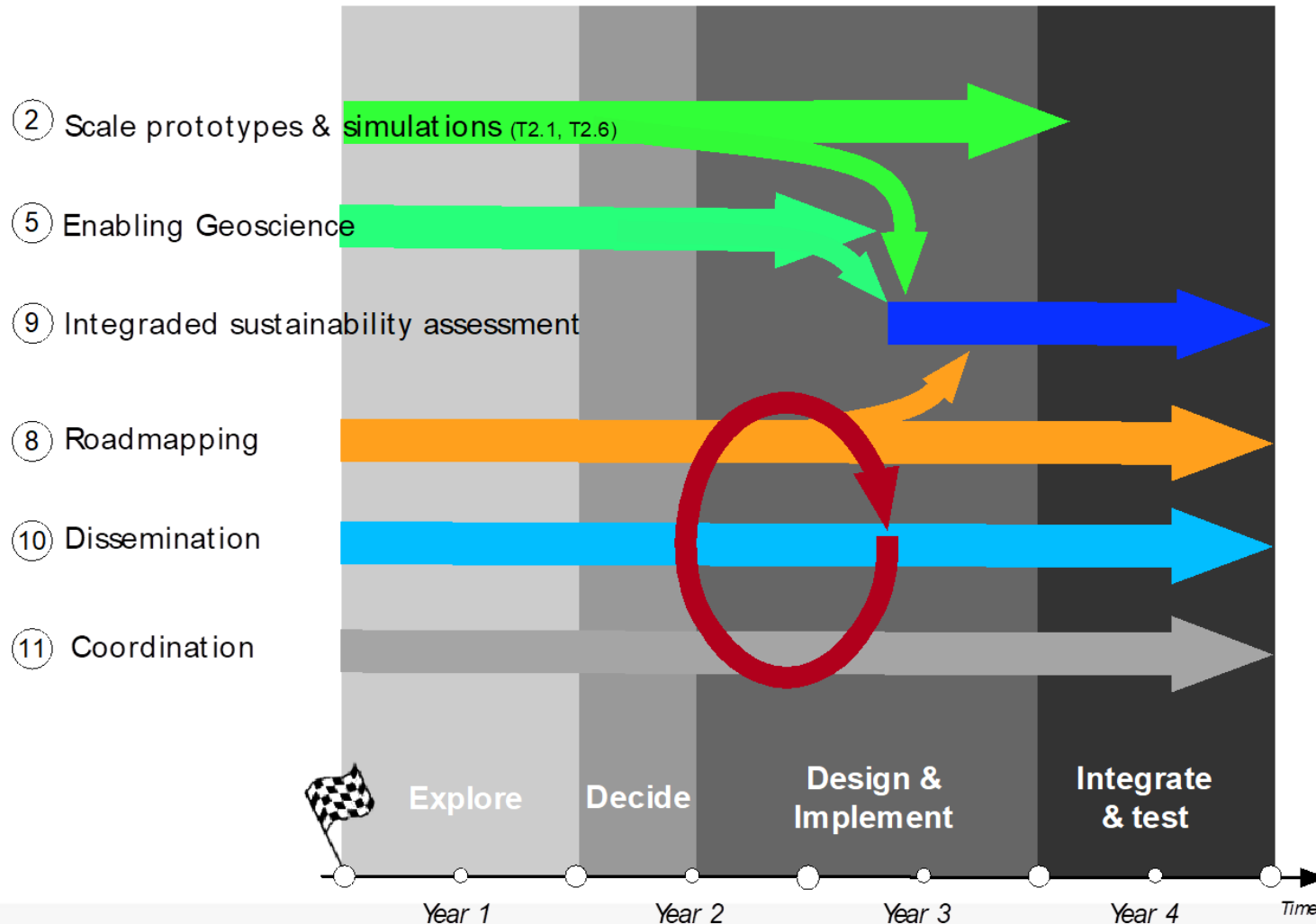




Project overview: timeline – mining ecosystem



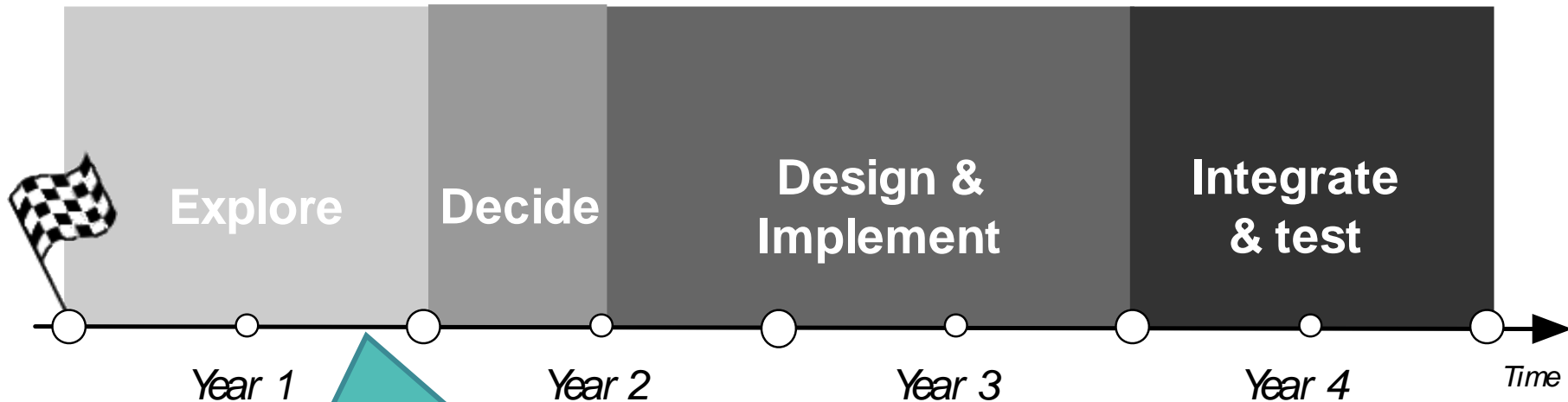
Need to integrate different disciplines → need of a common language





Current state

12 /18



T2.1 – Conceptualization of mine geometry and mining models

T3.1 – System requirements

T4.1 – Software Architecture design

T6.1 – Perception & mineralogy concept



Thanks for your attention



Alicja Kot-Niewiadomska
a.kn@min-pan.krakow.pl