A sustainable design for the ET infrastructure: engineering challenges and key solutions

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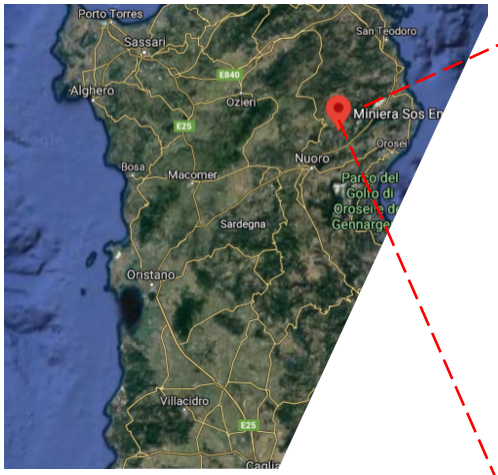
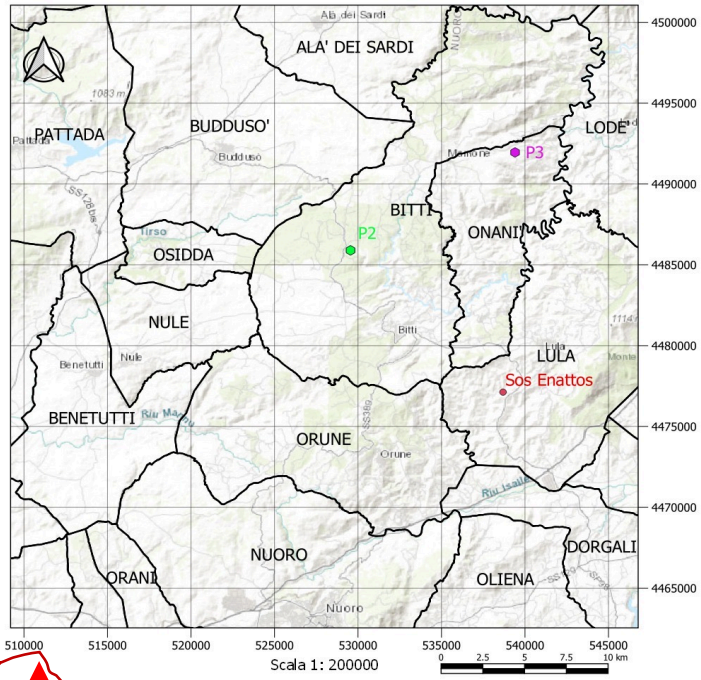
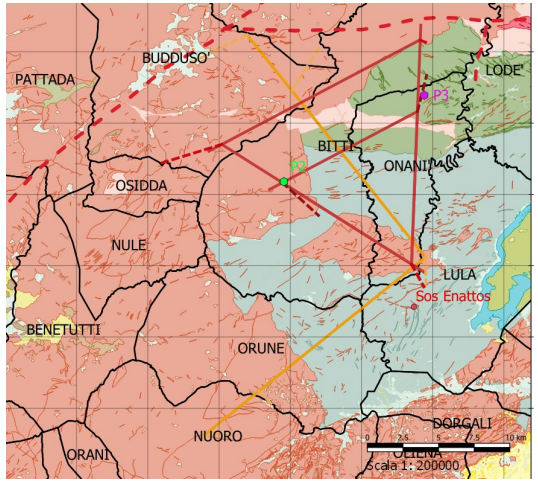
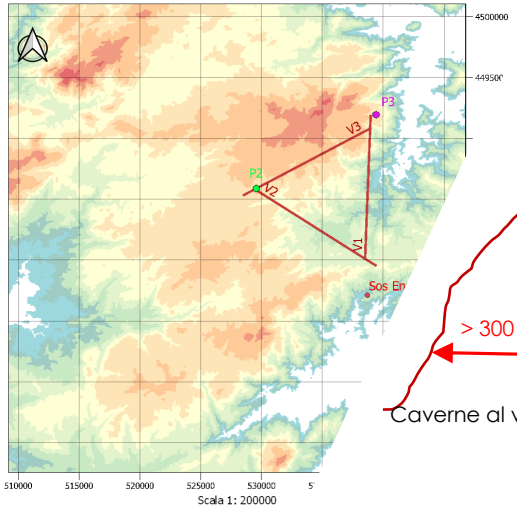
Requirements and constraints for the general framework

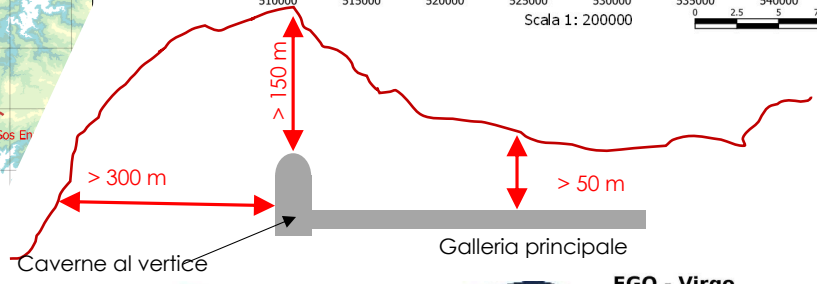
- depth and rock/soil coverage
- protected areas
- anthropogenic noise sources
- geology and rock quality
- trasport and connettivity
- envirionmental impacts











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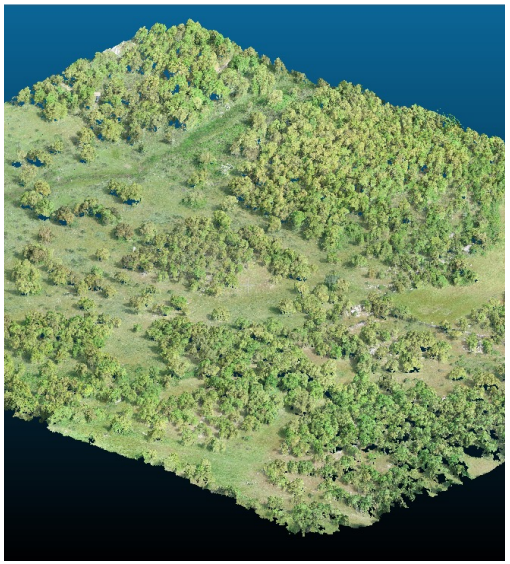
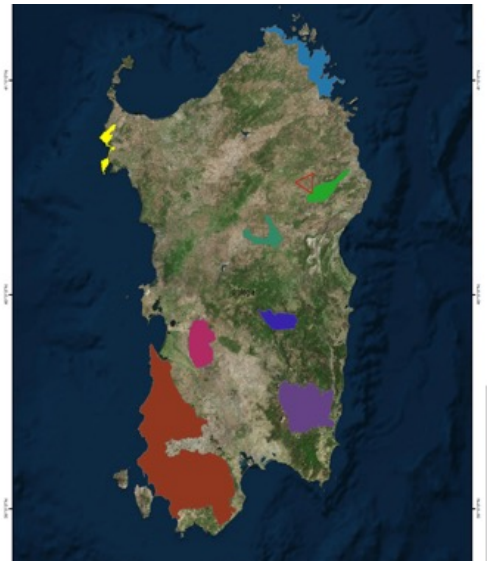
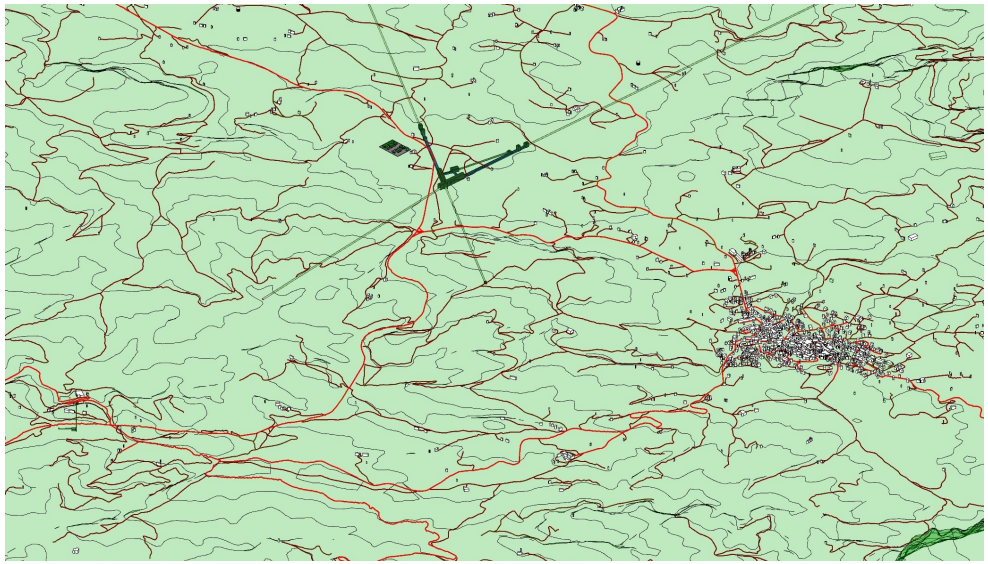




Regulatory framework

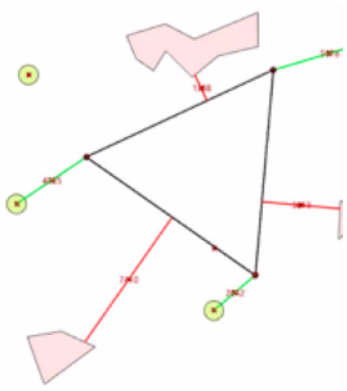
- excavation material replacement
- groundwater disposal
- environmental law
- natural park and protected areas
- contaminated waste
- involvement of private partners
- buffer zones



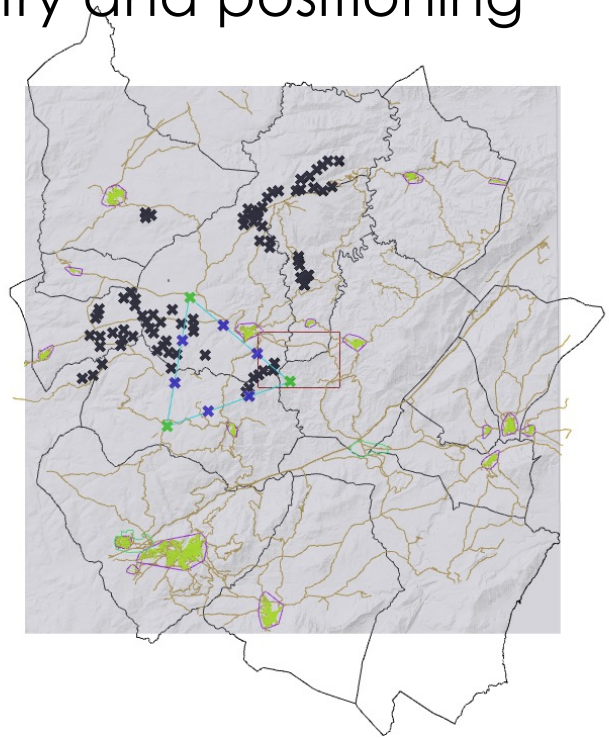
Multiple criteria decision-making for geometry and positioning

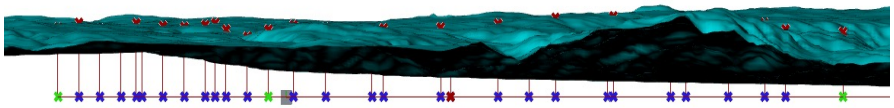
Multi-objective optimization by evolutionary solvers

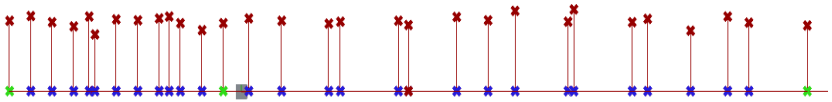
- *parametric models based on predefined variables*
- *best combination of positioning parameters to satisfy constraints.*

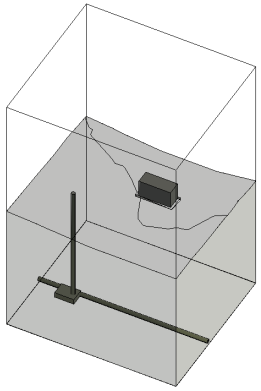


- ✓ *maximizing the distance from noisy areas, industrial zones, windmills*
- ✓ *minimizing the distance of the vertices to access roads and service areas*
- ✓ *comply geology and geotechnical constraints*
- ✓ *optimize access points*
- ✓ *calibrate the optimal depth*









Rhinoceros

grasshopper

Galapagos

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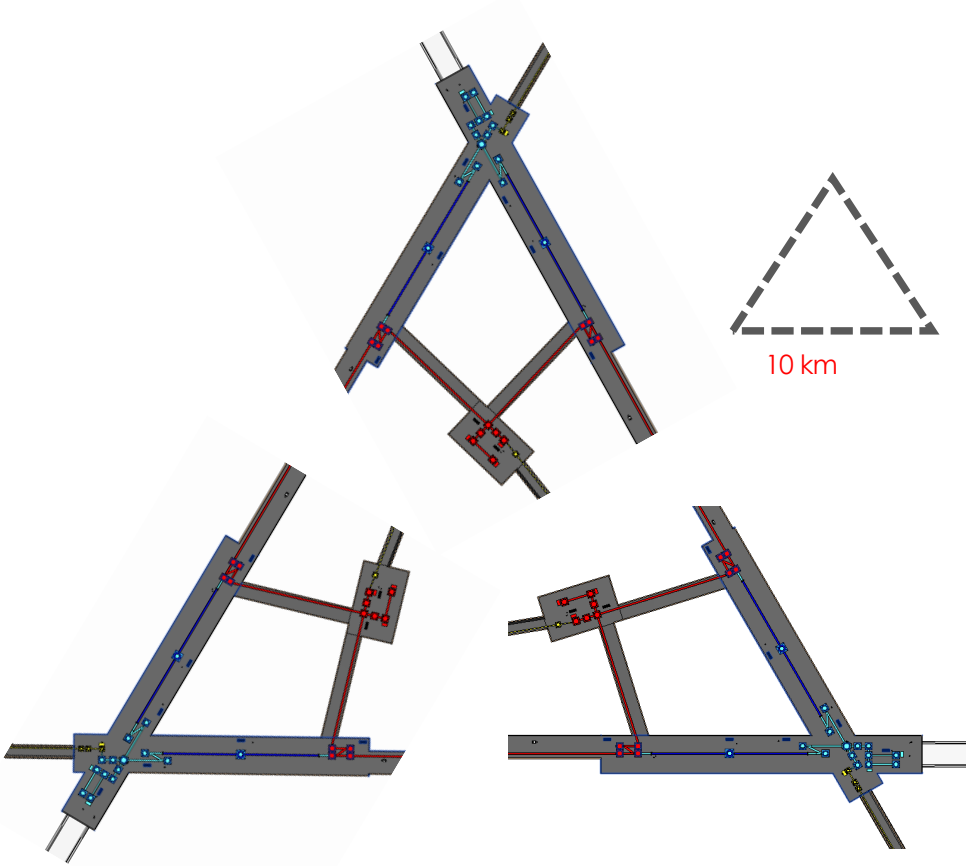
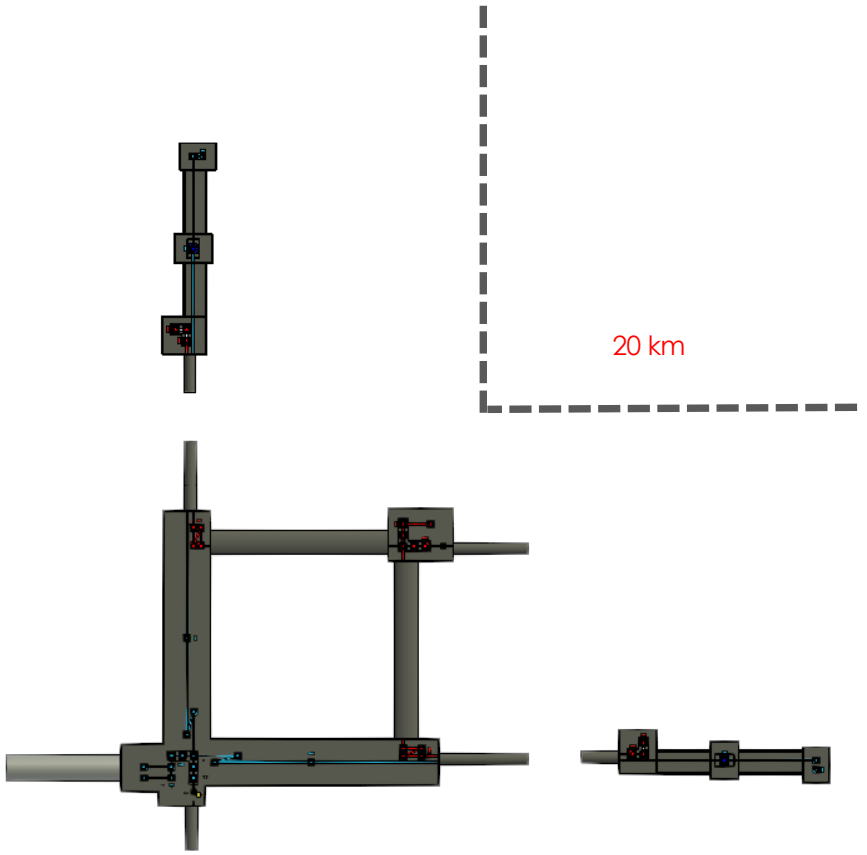
Advanced modelling for architecture and civil engineering

Configurations of the instrumental apparatus

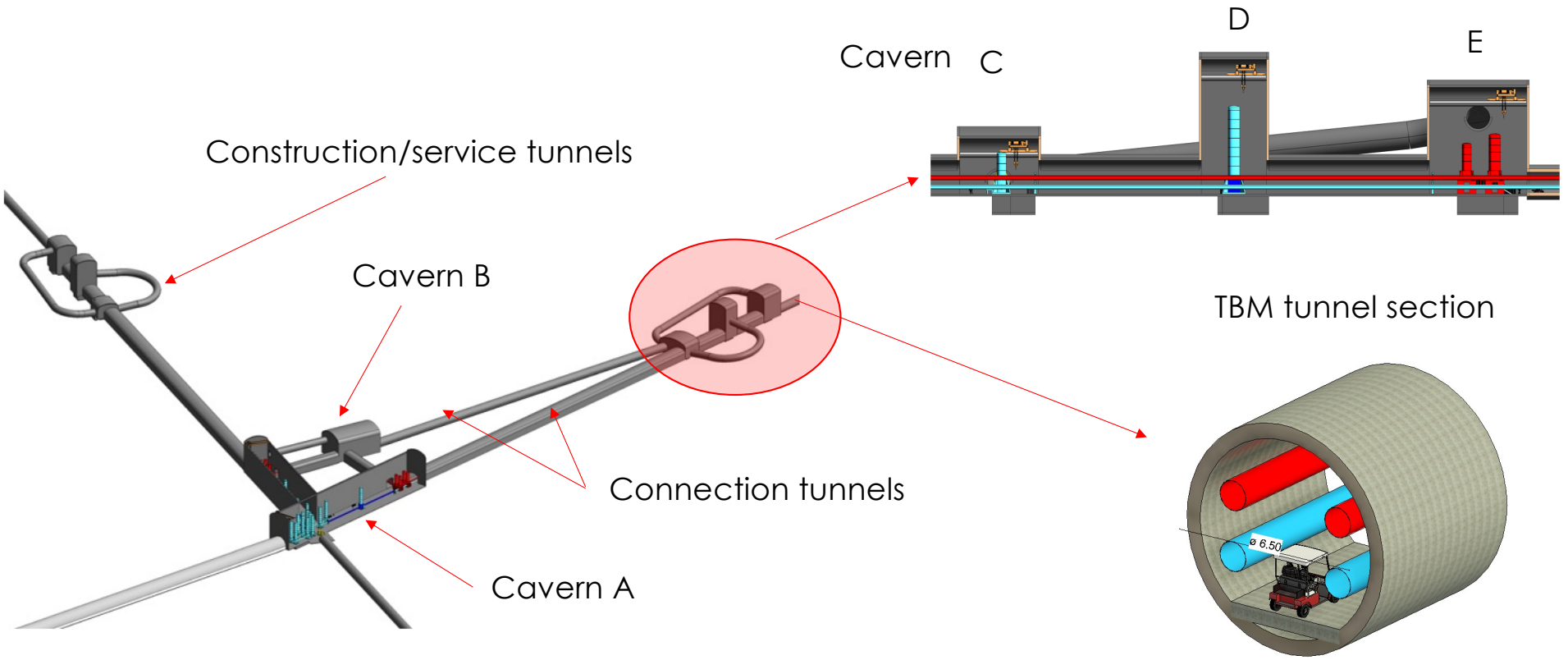


10 km

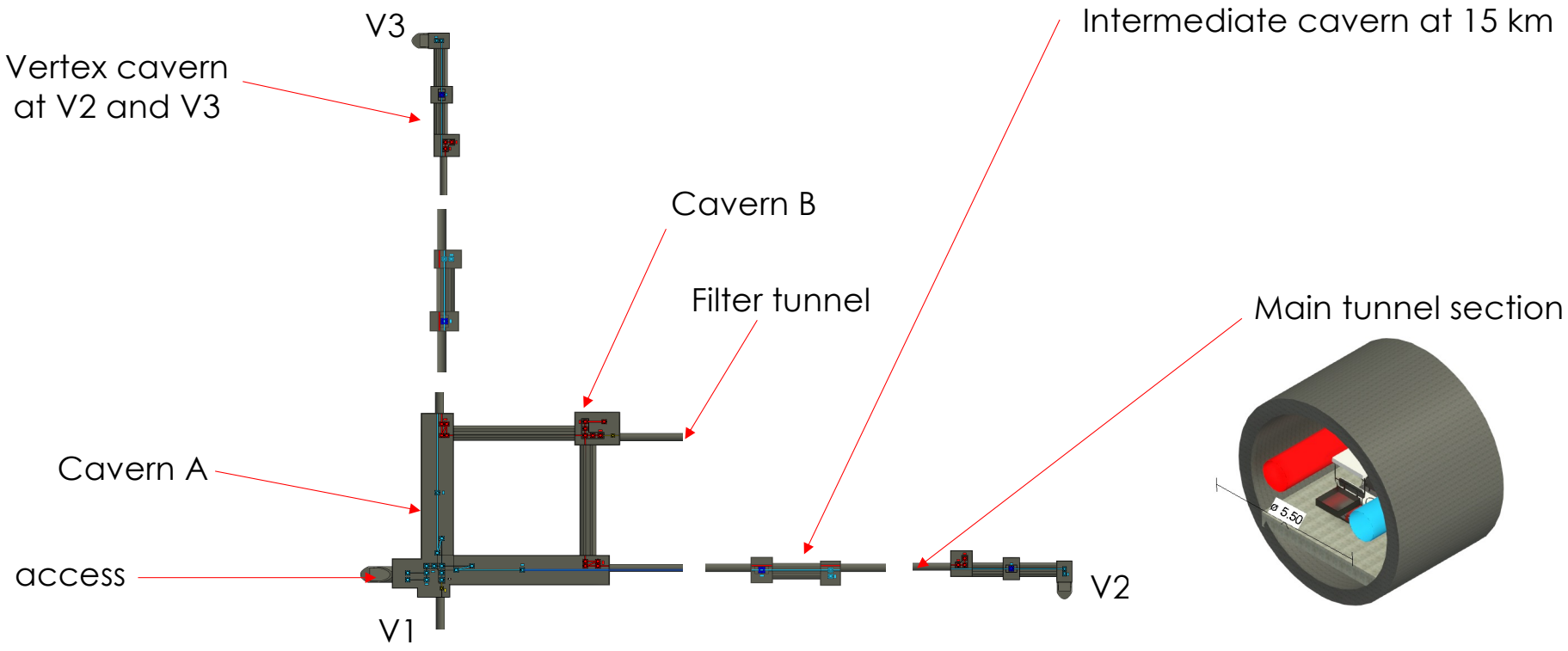


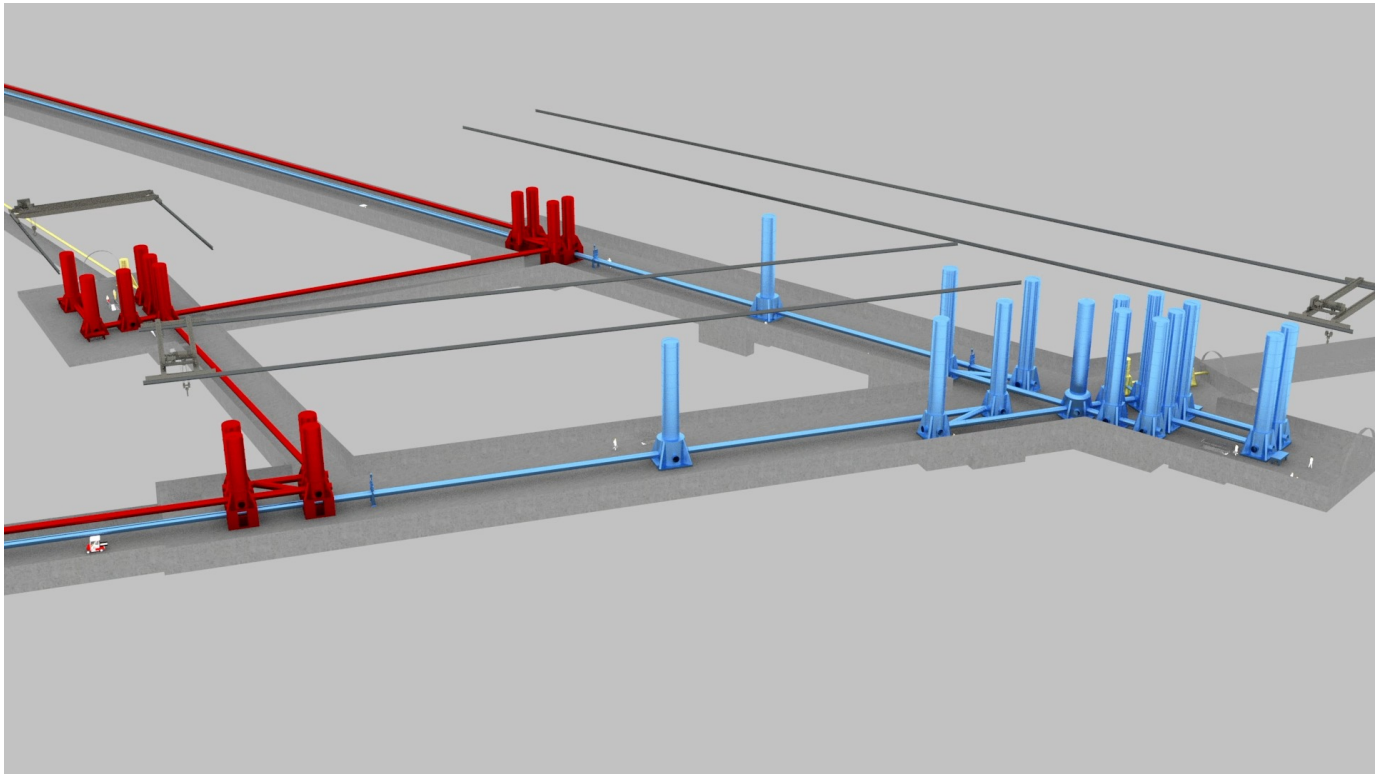
20 km

Triangle configuration



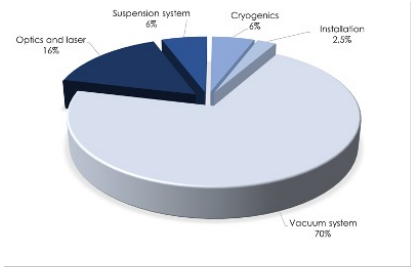
L-shaped configuration

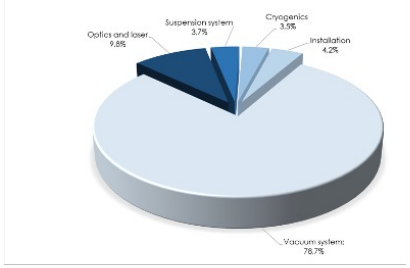


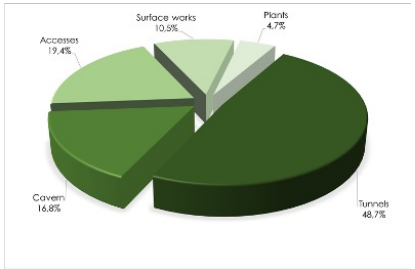


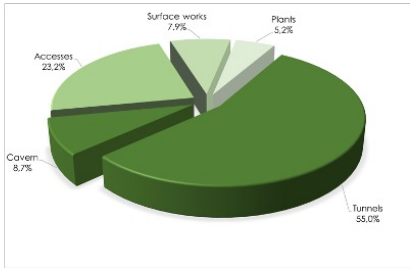
Underground infrastructure

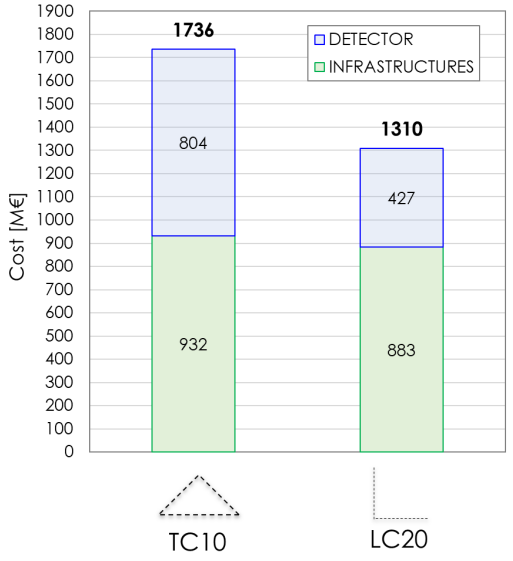
Preliminary cost assessment





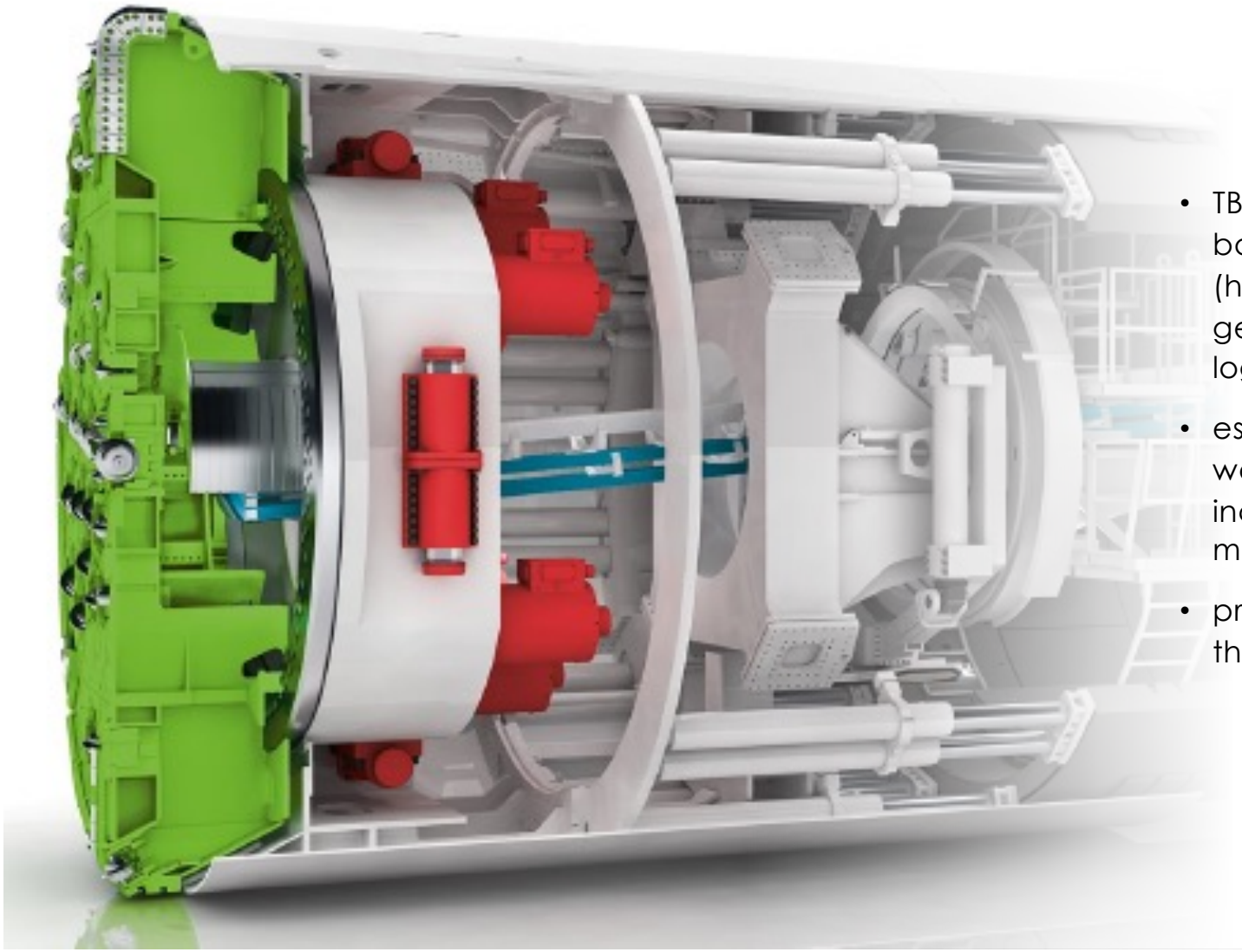






excavation technologies

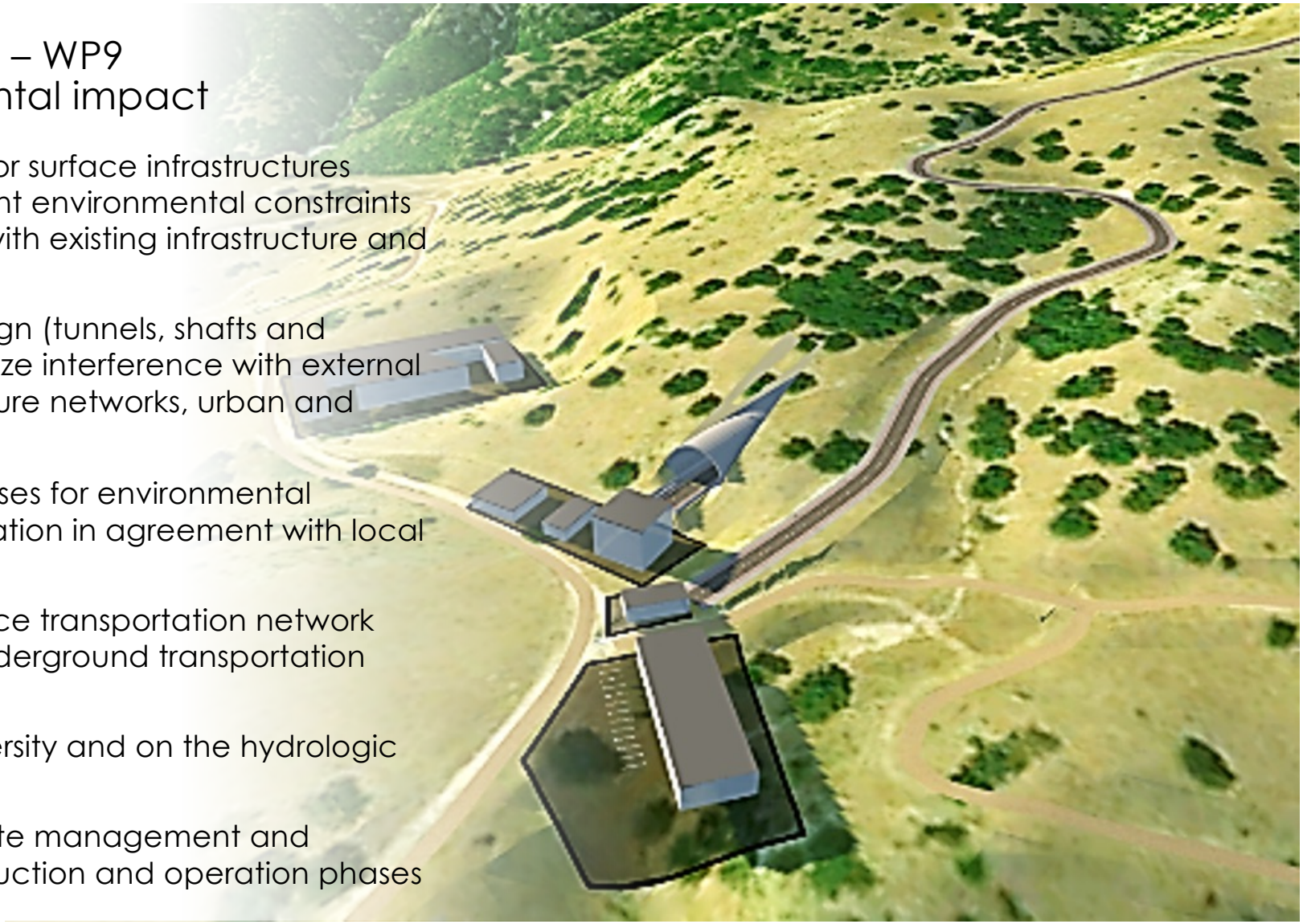
- evaluation of the most suitable in relation to the geometric, hydrogeological and geotechnical characteristics of the route
- assessment of the risks and solutions necessary to mitigate them;
- forecasting of excavation performance related to the technologies identified
- support to the definition of the investigations necessary for the experimental determination of the input parameters of the forecast models

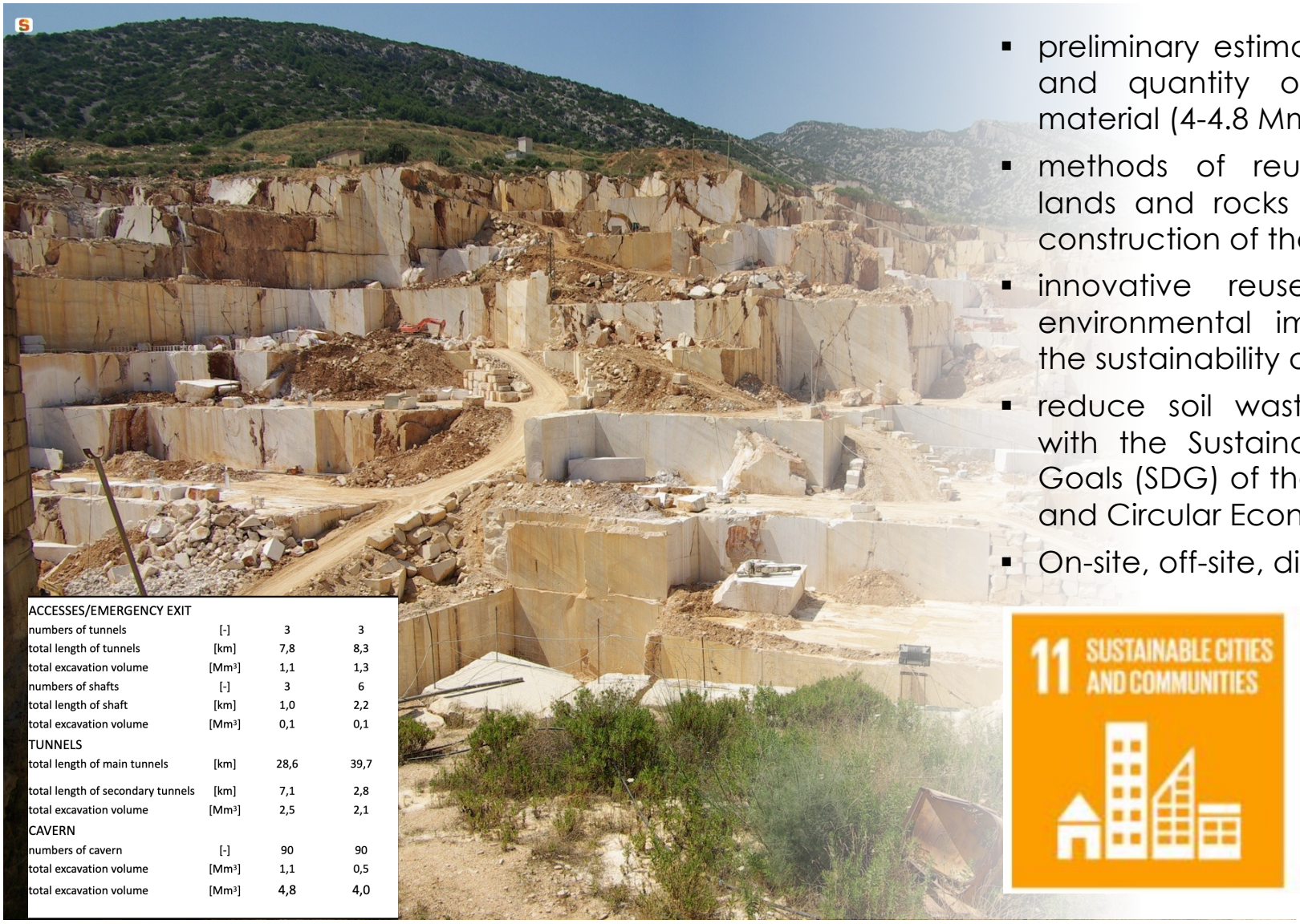


- TBM performance forecasting based on ground conditions (hydrogeological and geotechnical characterization), logistics and cost/benefit.
- estimation of feed rates and wear of excavation tools, including useful life based on mineralogical analysis
- predictive models suitable for the state of art knowledge

INFRADEV – WP9
ET environmental impact

- layout concepts for surface infrastructures taking into account environmental constraints and connection with existing infrastructure and service plants
- underground design (tunnels, shafts and caverns) to minimize interference with external surface infrastructure networks, urban and natural areas
- integrated processes for environmental assessment evaluation in agreement with local regulations
- optimize the surface transportation network and design an underground transportation system
- impact on biodiversity and on the hydrologic cycle
- approach for waste management and recycling for onstruction and operation phases





ACCESSES/EMERGENCY EXIT			
numbers of tunnels	[-]	3	3
total length of tunnels	[km]	7,8	8,3
total excavation volume	[Mm³]	1,1	1,3
numbers of shafts	[-]	3	6
total length of shaft	[km]	1,0	2,2
total excavation volume	[Mm³]	0,1	0,1
TUNNELS			
total length of main tunnels	[km]	28,6	39,7
total length of secondary tunnels	[km]	7,1	2,8
total excavation volume	[Mm³]	2,5	2,1
CAVERN			
numbers of cavern	[-]	90	90
total excavation volume	[Mm³]	1,1	0,5
total excavation volume	[Mm³]	4,8	4,0

- preliminary estimates on the quality and quantity of the excavated material (4-4.8 Mm3)
- methods of reuse of excavated lands and rocks resulting from the construction of the work
- innovative reuses with reduced environmental impact to improve the sustainability of the project
- reduce soil waste, in compliance with the Sustainable Development Goals (SDG) of the UN 2030 Agenda and Circular Economy Action Plan
- On-site, off-site, disposal

INFRADEV – WP9 – minimize ET carbon footprint

- Evaluate budget of power consumptions (instruments, service plants, computing facilities) and transportations (commuting, supplies, travels)
- Promote responsible energy consumption (efficiency of all devices,optimized design, recovering, etc.)
- Foreseen production on site (e.g., by arrays of solar panels) or provided by external suppliers