Feasibility study on the construction of the underground infrastructure for the Einstein Telescope Project(ET) - Sardinia

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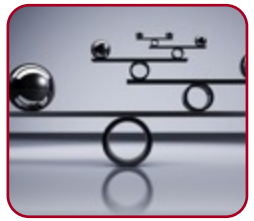
GWADW2021 Gravitational Wave Advanced Detector Workshop 17-21 May2021

On-going activities / Working groups

Geology and hydrogeology

Geodetic control network and Surface infrastructures



3D modeling

Multi-criteria-analysis to support localization

Service plants and surface facilities

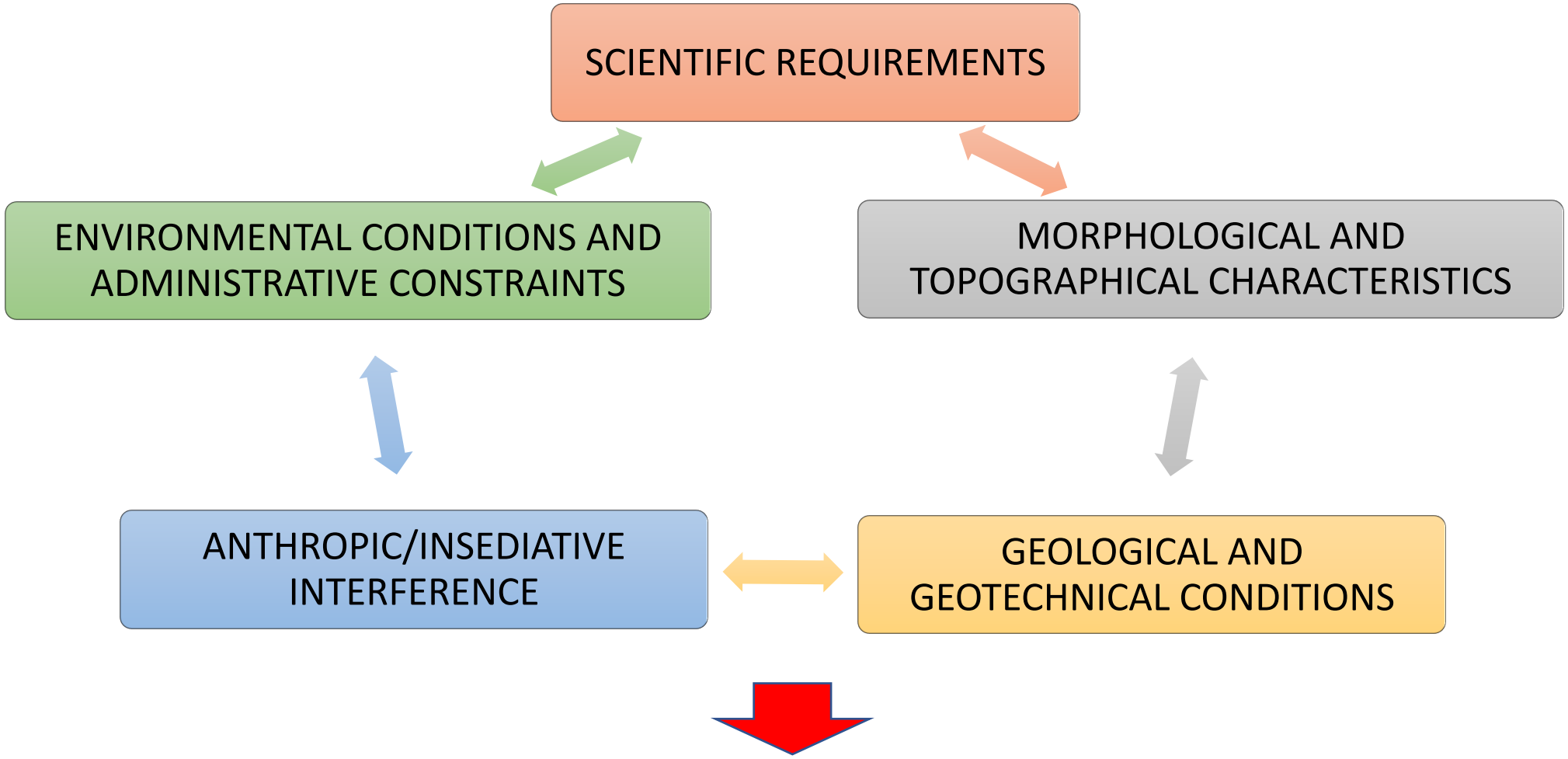
Safety and enviroment

Permissions and authorizations

Underground works and instrumental equipment (coordination with ET collaboration and other underground obs)

Technical feasibility & cost assessment

Localization



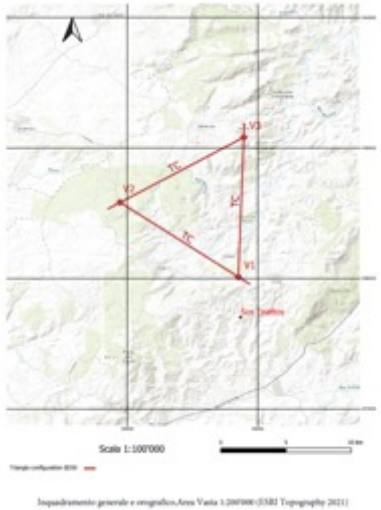
GEO-DATABASE design and development of a **GIS PLATFORM** (called **ET_GIS_S**)

ET_GIS_S

Summary table of Metadata used in cartographic products (at date)

NOME	TIPO DI DATI	FONTE	DATA CREAZIONE	RISOLUZIONE SPAZIALE	SR	URL
Database Geotopografico(DBGT10K)	Vettoriali	Sardegna Geoportale	02/10/2017	Denominatore 10000	EPSG:4326	https://www.sardegnageoportale.it/
Modelli digitali di elevazione_passo 10 m	Raster	Sardegna Geoportale	01/01/2011	Distanza 10 m	EPSG:3003	https://www.sardegnageoportale.it/
Carta Geologica di base	Vettoriali	Sardegna Geoportale	01/01/2007	Denominatore 25000	EPSG:3003	https://www.sardegnageoportale.it/
Carta Litologica della Sardegna	Vettoriali	Sardegna Geoportale	01/06/2018	Denominatore 25000	EPSG:3003	https://www.sardegnageoportale.it/
Piano Stralcio per l'Assetto Idrogeologico	Vettoriali	Sardegna Geoportale	31/01/2018	Denominatore 10000	EPSG:3003	https://www.sardegnageoportale.it/
Piani Urbanistici Comunali (PUC)(PP)	Vettoriali	Sardegna Geoportale	25/05/2015	Denominatore 10000	EPSG:3003	https://www.sardegnageoportale.it/
Piano Paesaggistico Regionale	Vettoriali	Sardegna Geoportale	01/12/2005	Denominatore 25000	EPSG:3003	https://www.sardegnageoportale.it/
Cartografia catastale	Raster	Agenzia delle Entrate	In aggiornamento		EPSG3:6706	https://www.agenziaentrate.gov.it/
Siti di Interesse Comunitario (SIC)	Vettoriali	DG Difesa dell'Ambiente - Servizio della sostenibilità ambientale e Sistemi informativi (S.A.S.I)	03/10/2019		EPSG:3003	http://intranet.sardegnaambiente.it/
Zone Speciali di Conservazione (ZSC)						
Zone Protezione Speciale (ZPS)	Vettoriali		06/19/2020		EPSG:3003	http://intranet.sardegnaambiente.it/
Fotogrammetria da Drone	Raster	Indagini	21/05/2020	Distanza 0.1 m	EPSG3:6707	
Dataset da satellite	Raster	Indagini	02/12/2020	Distanza 0.5 m	EPSG:4326	
Parchi Eolici in realizzazione	Vettoriali	Ministero dell'Ambiente	10/02/2021		EPSG:4326	https://va.minambiente.it/

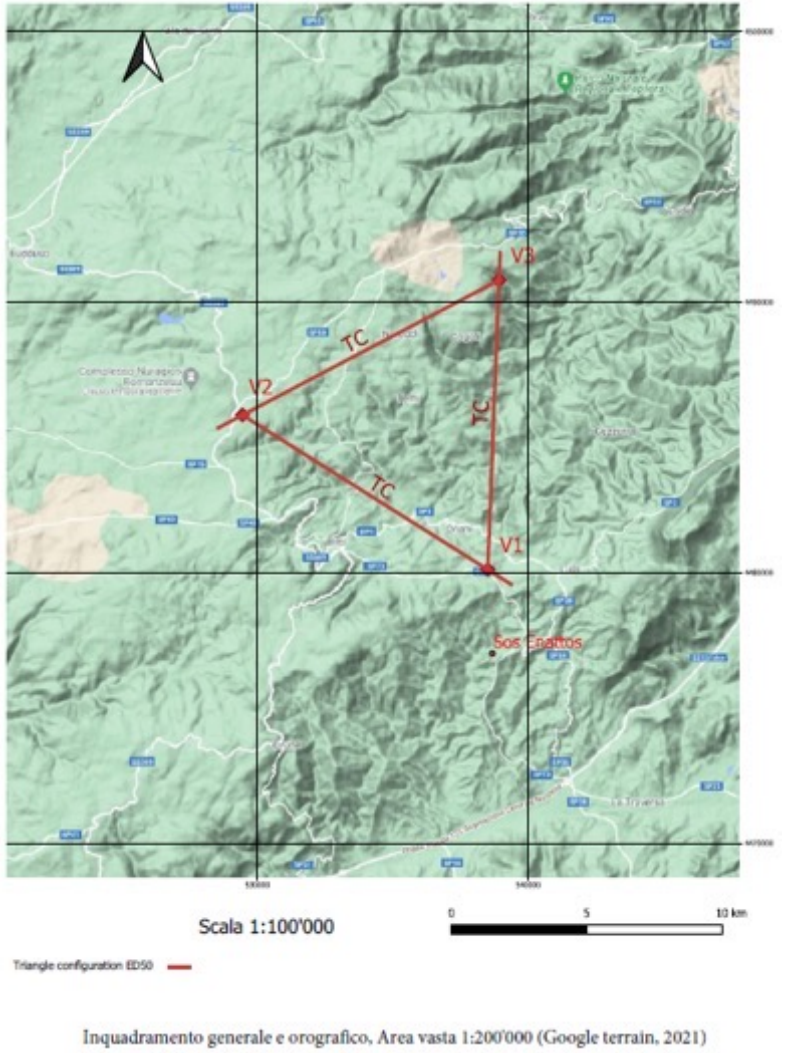
ET_GIS_S system will be integrated with maps and data acquired during the project



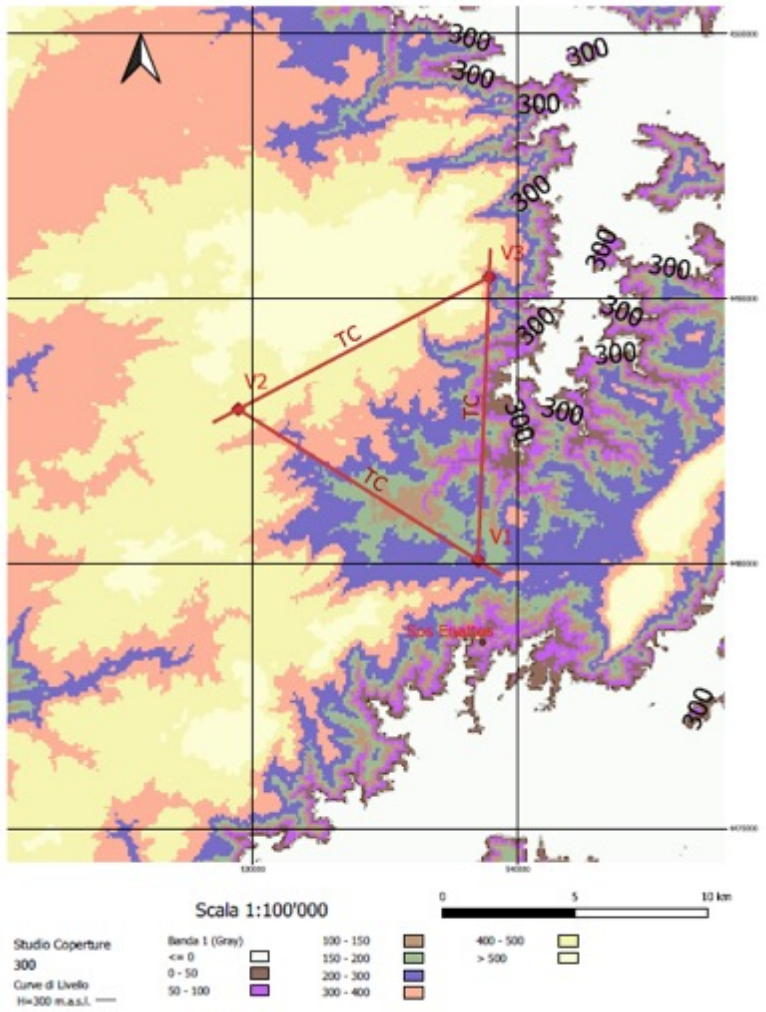
- Satellite surveys over large area (orthophotos/DTM)
- Detailed topographic surveys about the areas affected by the construction of the surface works
- Location and results of geophysical and geotechnical investigation
- Photogrammetric surveys by drone and helicopter

MORPHOLOGICAL AND TOPOGRAPHICAL CHARACTERISTICS

- definition of the most suitable areas for surface buildings and portal access
- localization of the shafts exit
- verification of the presence of minimum rock cover above and sideways to the main caverns and tunnels
- definition of the groundwater drainage system



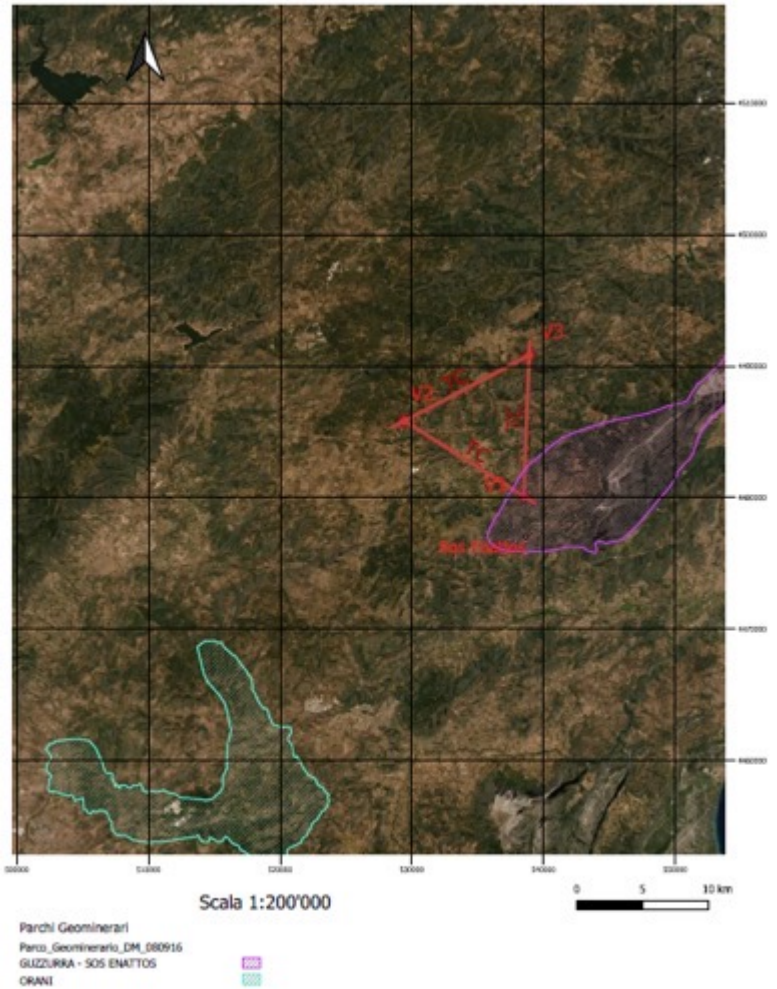
Inquadramento generale e orografico, Area vasta 1:200'000 (Google terrain, 2021)



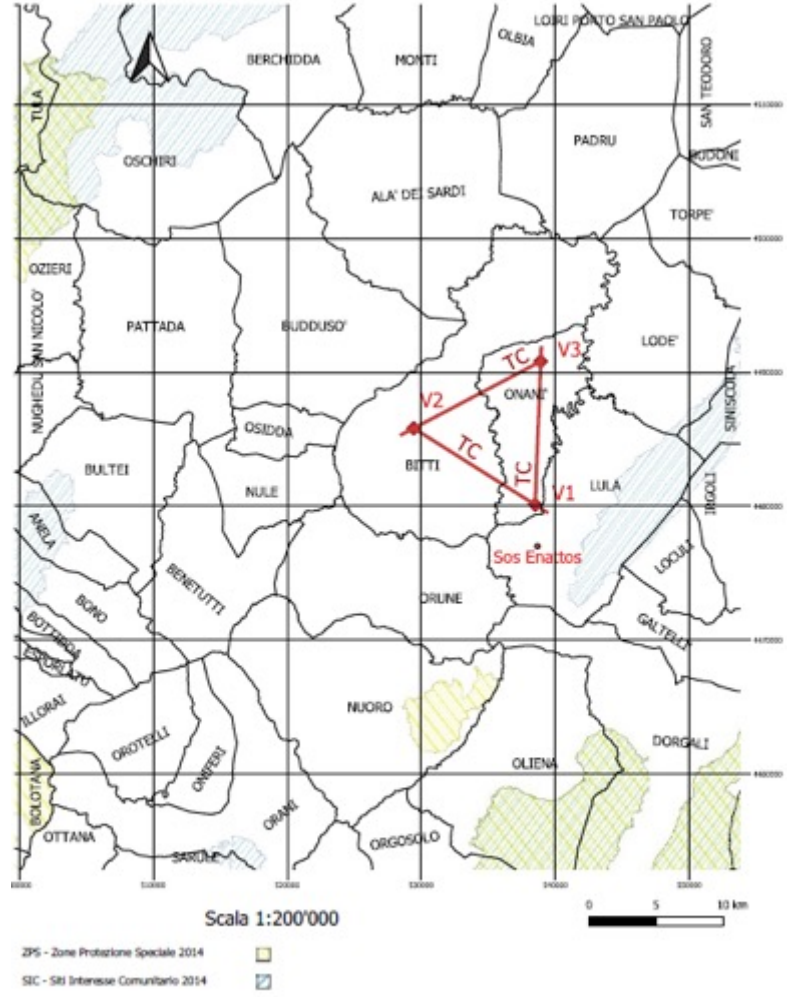
Mappa delle coperture, interferometro a quota 390 m s.l.m.

ENVIRONMENTAL CONDITIONS AND ADMINISTRATIVE CONSTRAINTS

- avoid interferences with national parks, protected areas, etc.
- avoid interferences with areas subject to usage constraints
- underground works national regulations



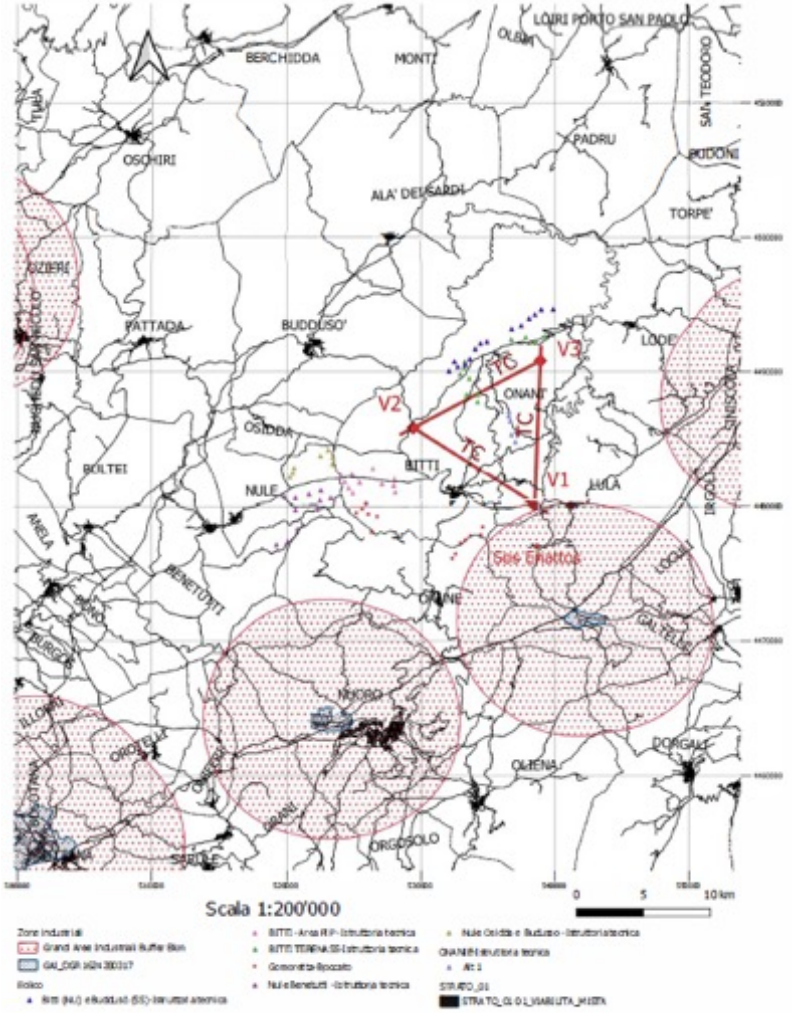
Parchi Geominerari



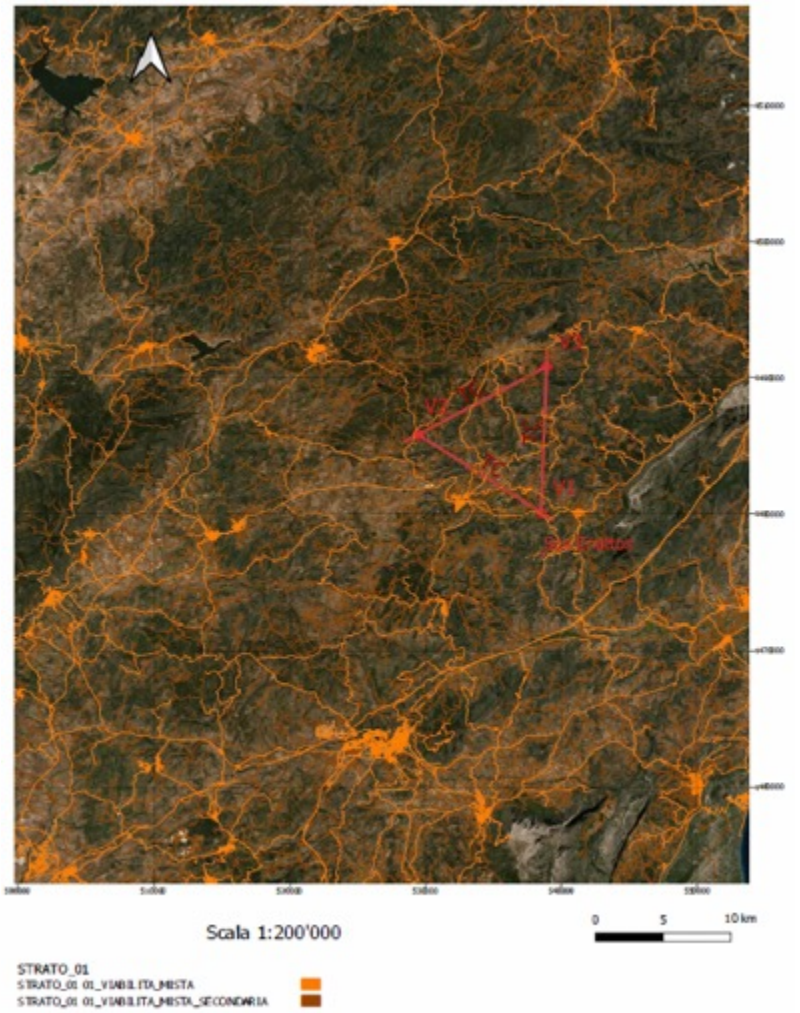
Zone di Protezione Speciale e Siti di Interesse Comunitario

ANTHROPOGENIC/INSEDIATIVE INTERFERENCE

- distance from possible sources of anthropogenic noise (industrial areas, large population centers, wind farms, etc.)
- connection to the main and secondary roads



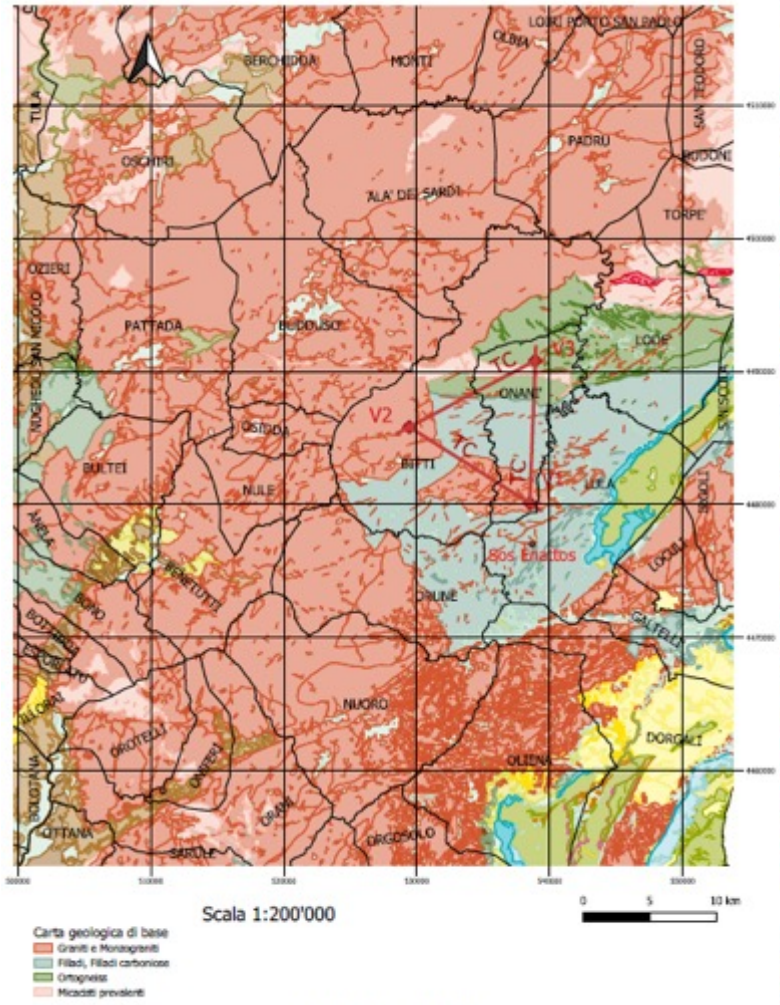
Parchi eolici e aree industriali Carta di sintesi



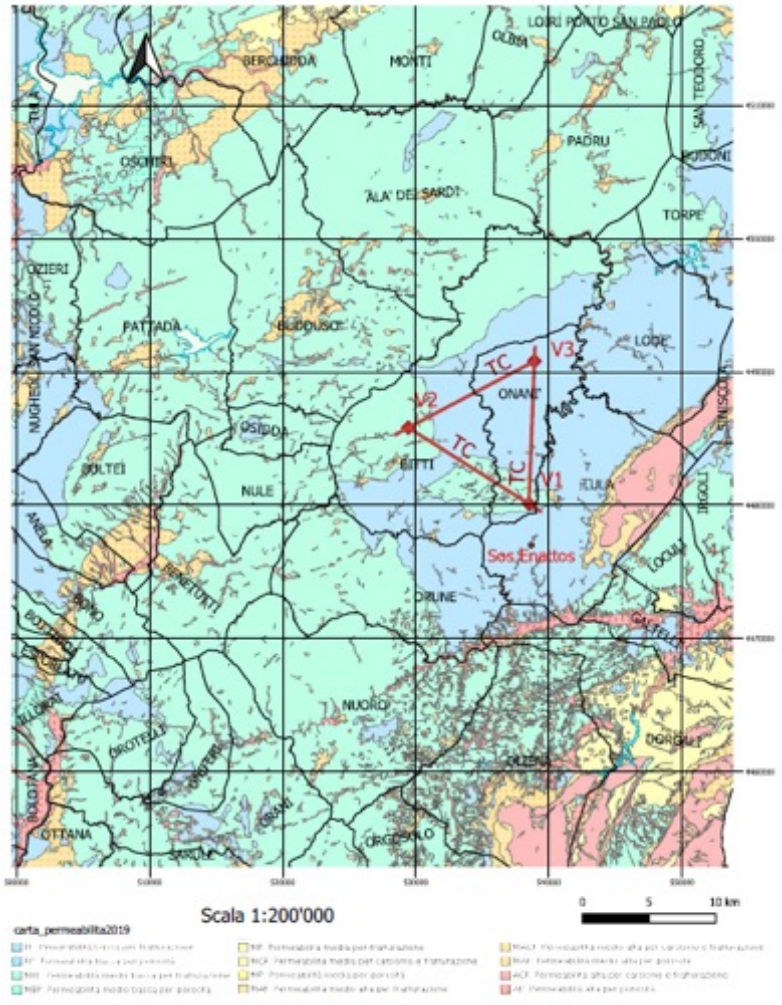
Carta delle infrastrutture viarie

GEOLOGICAL AND GEOTECHNICAL CONDITIONS

- positioning and orientation of the main caverns
- positioning of the ventilation and service shafts

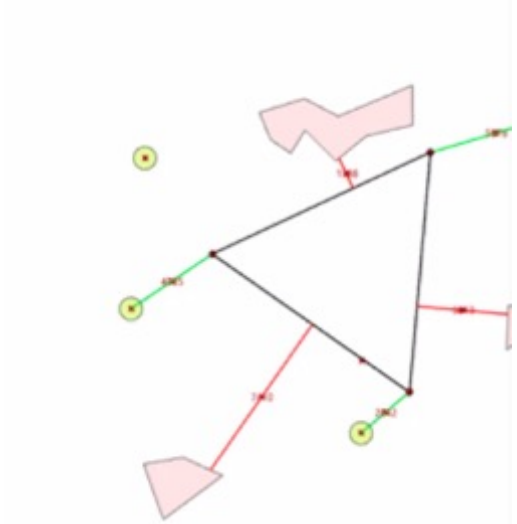


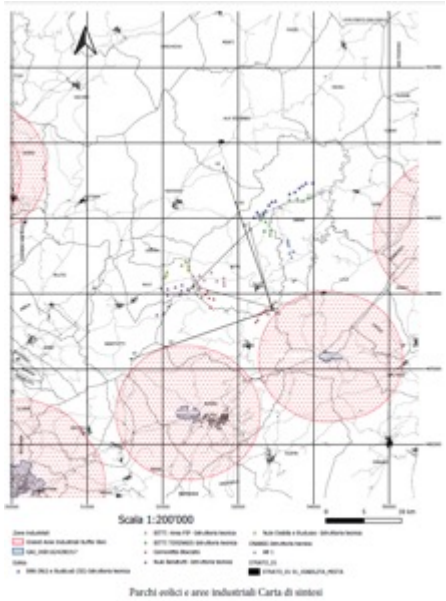
Carta Geologica 1:25'000

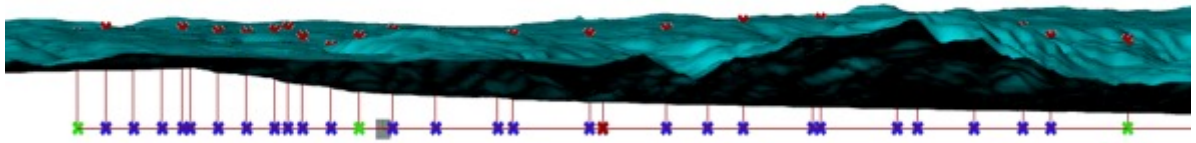


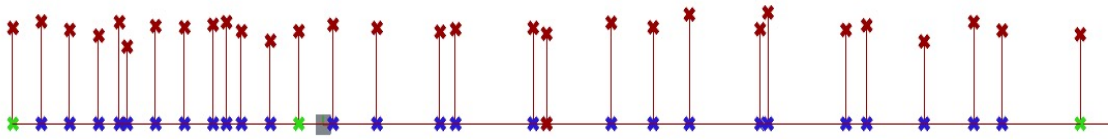
Carta della Permeabilità dei substrati della Sardegna 1:25'000

Multicriterial Analysis









Subgroup 1 : Multiple criteria decision-making tor geometry and positioning (Wissam Wahbeh - FHNW).

Integration between GIS tools and multi-policy analysis allows decision-making to be incorporated into a geographic system. The main advantages are organizing, managing and integrating the large amount of geographical data to process and model the preferences of decision-makers.

Relevant quantitative limiting factors to be compliant with scientific requirements maximizing the distance from noisy areas, industrial zones, windmills, etc.

- minimizing the distance of the vertices to access roads and service areas, etc.
- comply geology and geotechnical constraints.
- optimize access points.
- calibrate the optimal depth.

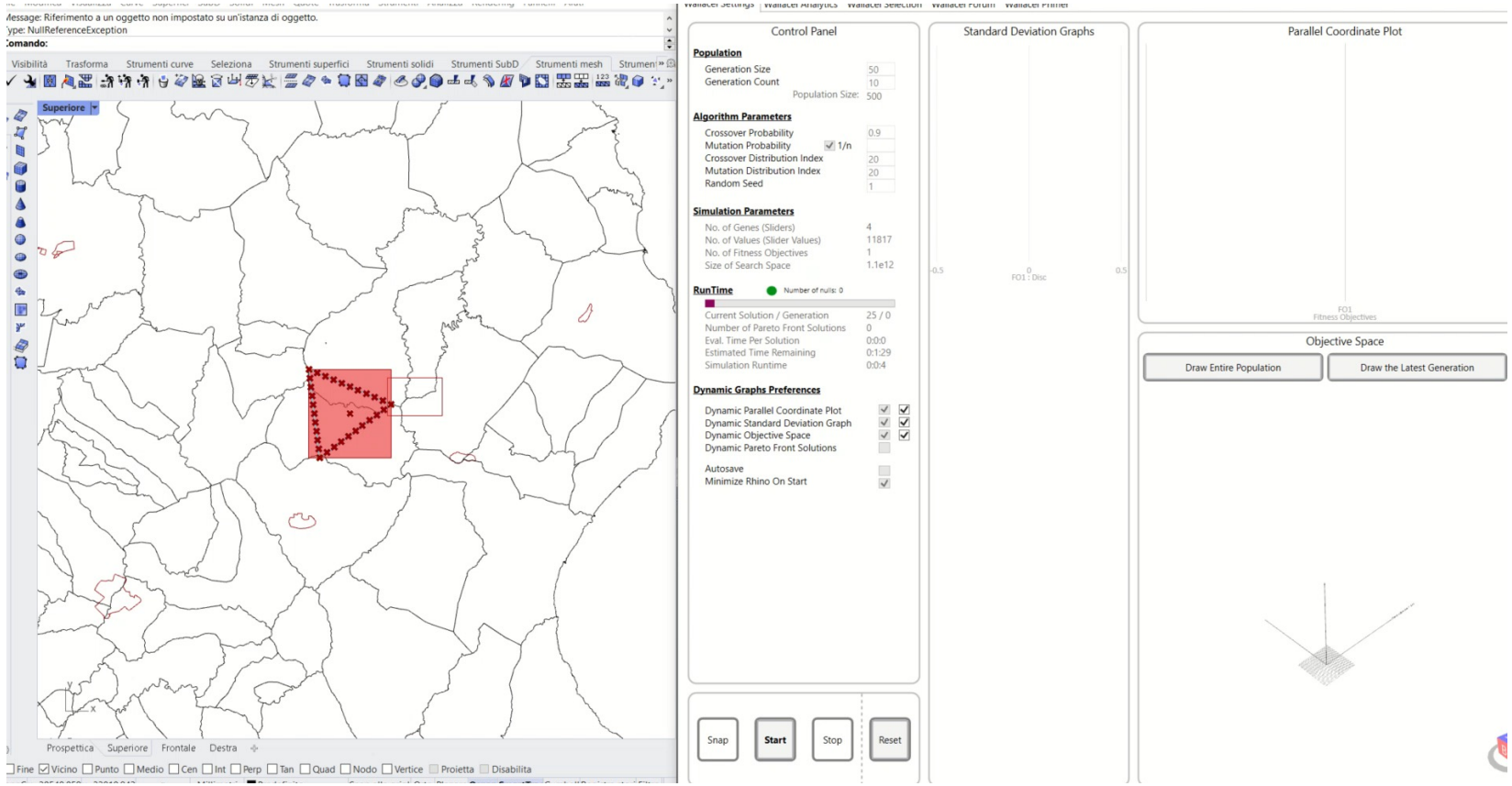
Multicriterial Analysis

a commercial 3D computer graphics and computer-aided design (CAD) application software developed by Robert McNeel& Associates.

graphical algorithm editor integrated with Rhino's 3-D modeling tools (graphic parametrization)

Galapagos created by David Rutten provide a generic IA platform for the application of Evolutionary Algorithms available in Grasshopper

Wallacei -Multi-Objective Evolutionary Optimization.



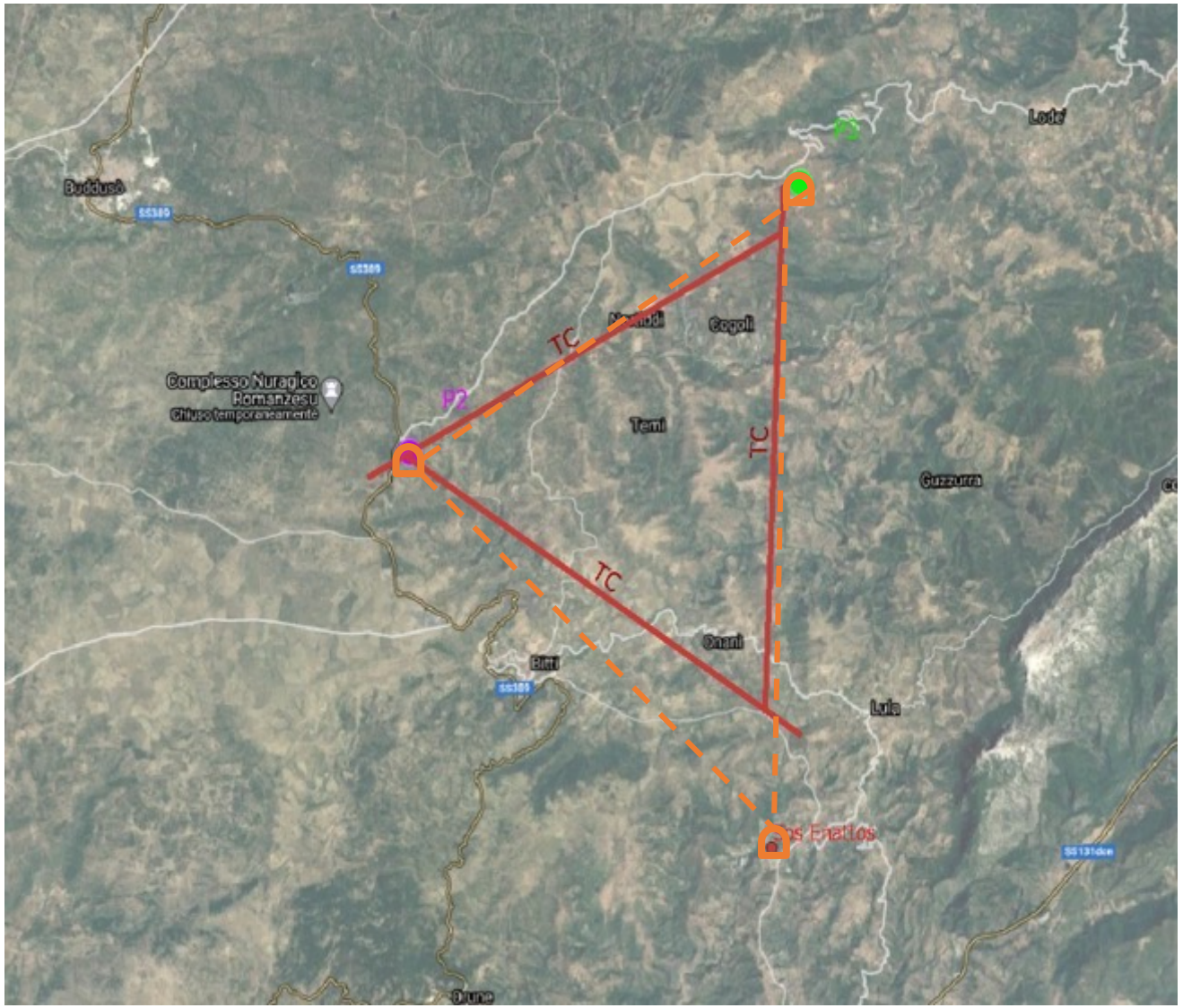
Multi-objective optimization by evolutionary solvers

- Creation of parametric models based on predefined variables within predefined limits.
- The solver find the best combination of input parameters(position coordinates and rotation) to satisfy constraints.

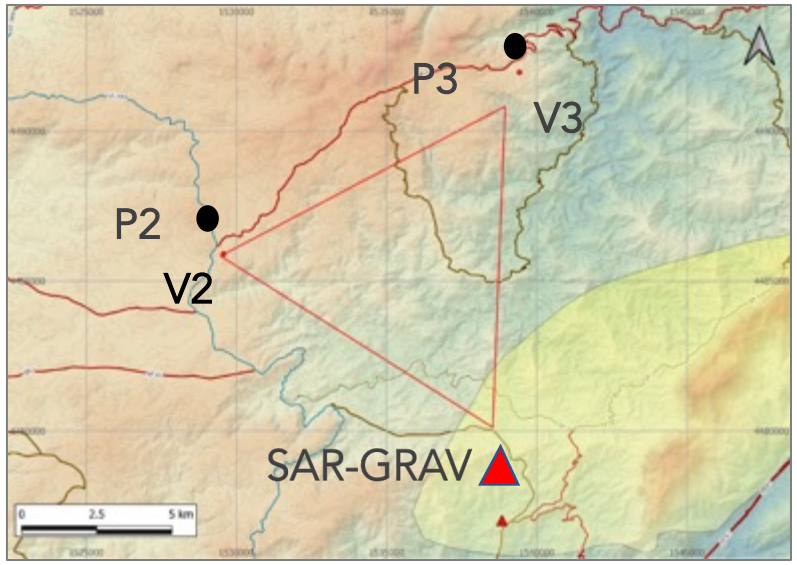
Geodetic reference system

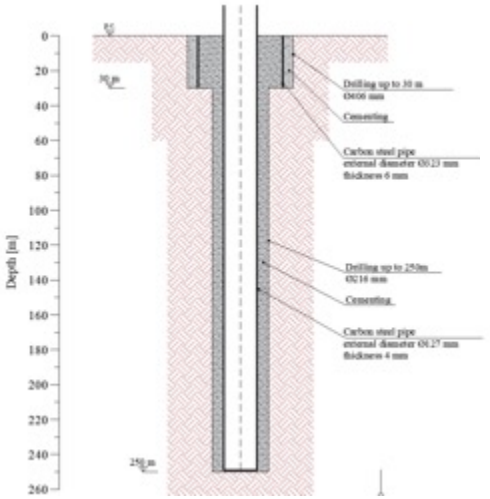
Design and materialization of a Primary Geodesic Control Network consisting of reference vertices established with GNSS methods and secondary points and its subsequent measurement for the determination of coordinates and their accurateness:

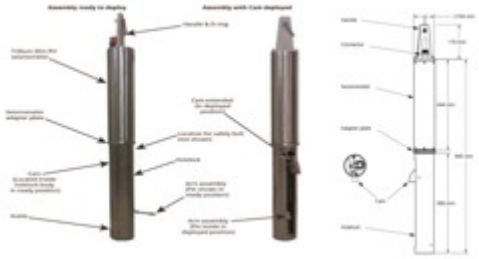
- design of the geometric configuration network, through in situ inspections and numerical simulations;
- study of local geoid for the definition of corrective factors on topographic measures;
- installation of 3 GNSS permanent stations for the classification and control of Datum transformations.



Boreholes P2 and P3







Nanometrics Trillium 120 Slim Borehole

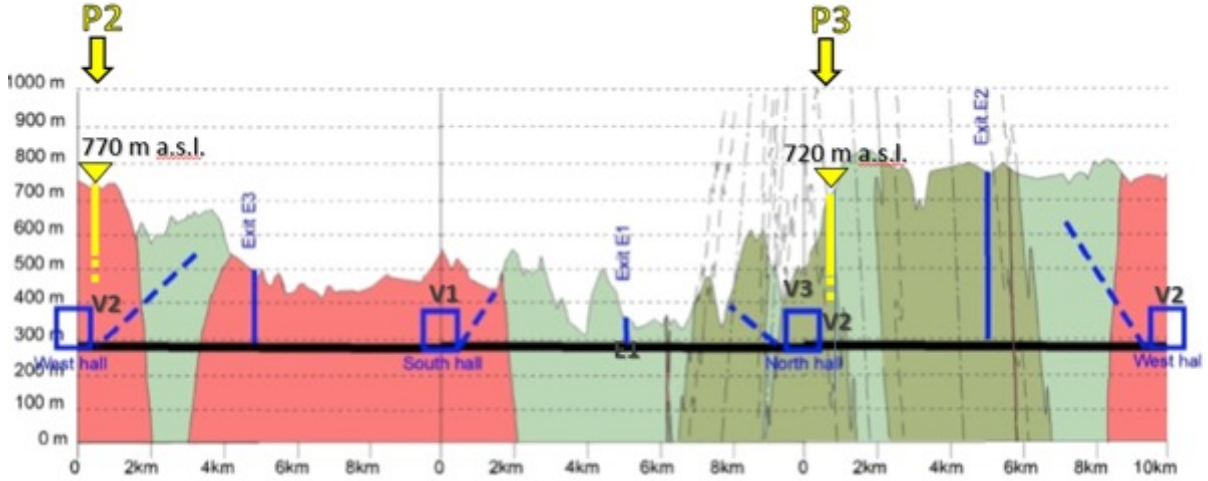
Intrusive complex

Granodiorites and monzogranites

Metamorphic basement

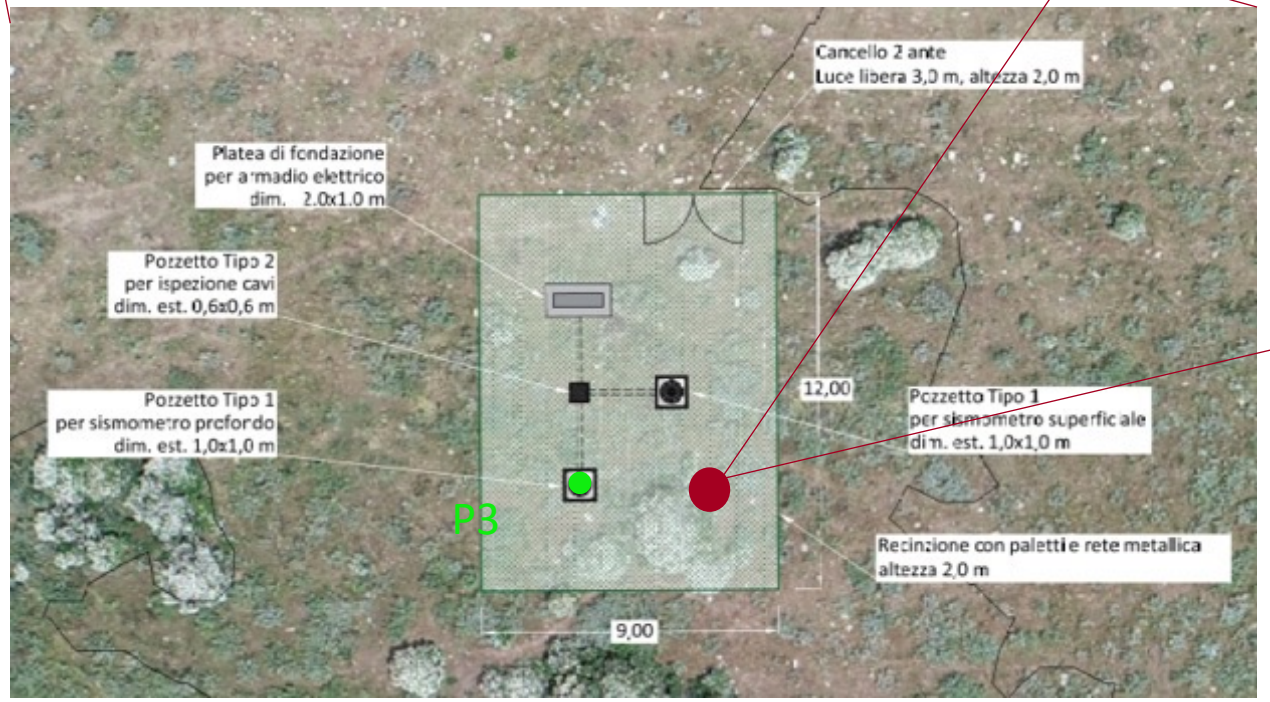
Orthogneiss

Phyllites, micaschist and paragneiss



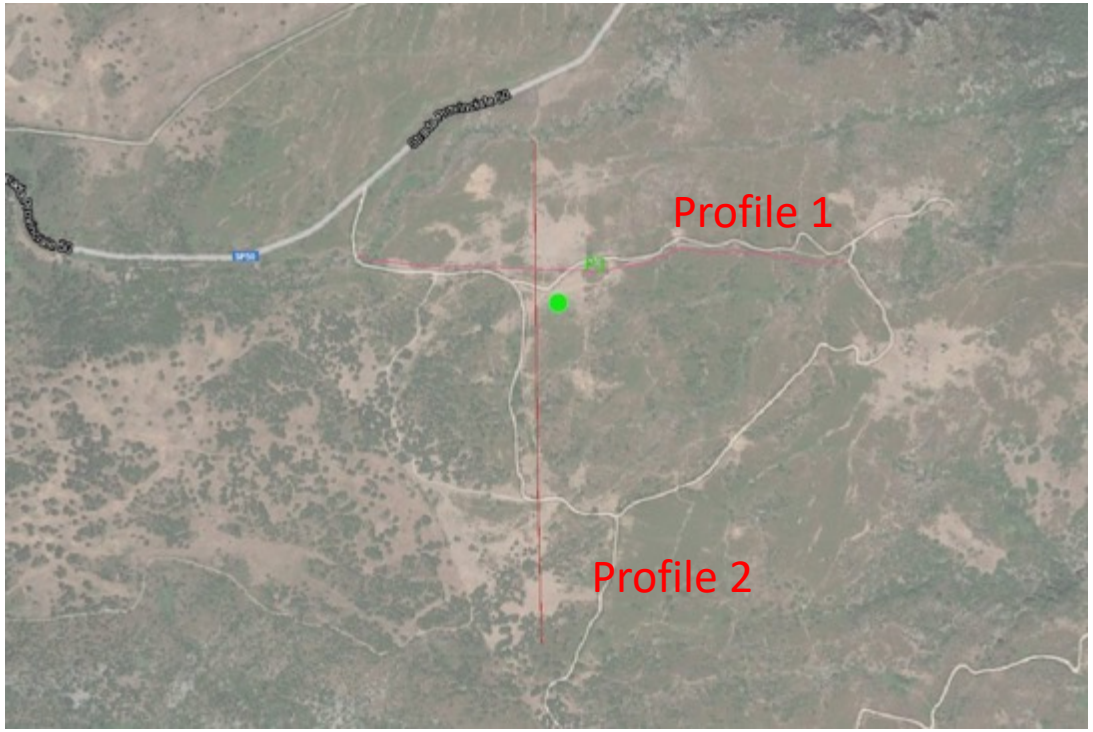
two seismometers at about a depth of 250 m (potentially up to 300 m) at ET V2 and V3.

Boreholes P2 and P3



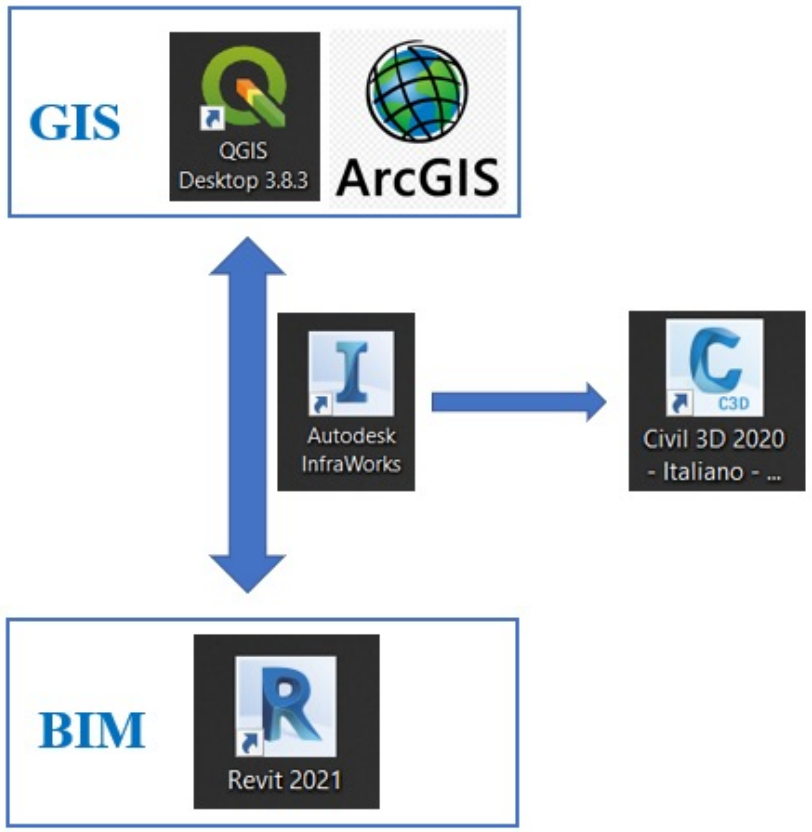
Borehole P3

- Excavation almost **completed** (up to 285 m)
- Geophysical logs and acoustic camera (BHTV) **ongoing**
- Borehole completion is expected at July-August 2021
- Surface geophysical investigation planned for July 2021



Borehole P2 excavation is expected to start at

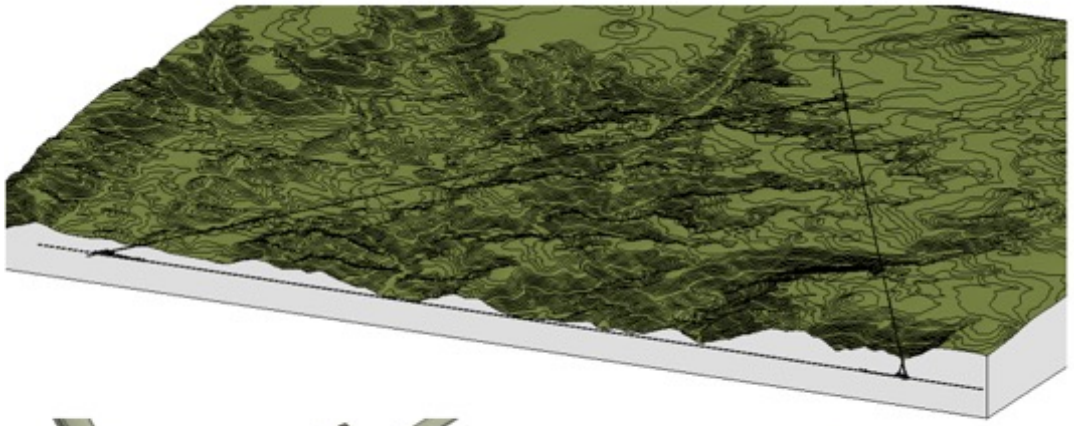
July-August 2021

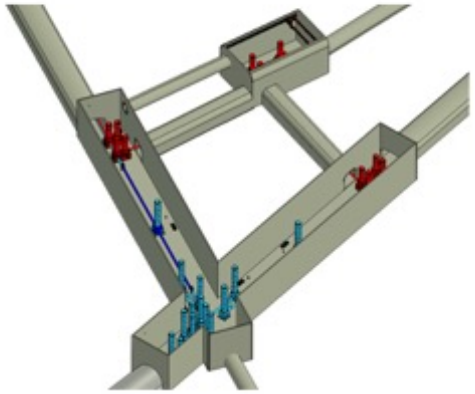


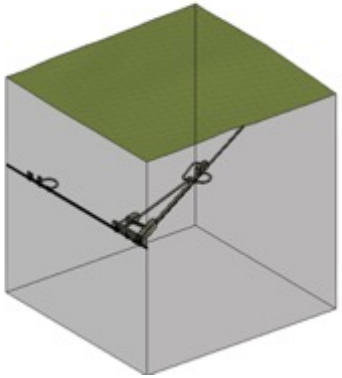
In order to represent, evaluate and configure civil works on the surface and underground, a three-dimensional GIS-BIM model has been implemented, integrating the ET_GISS system with a model of the works realized in the Building Information Modeling (BIM) field.

The integration was carried out with the Autodesk Infraworks program and the BIM model with the REVIT software.

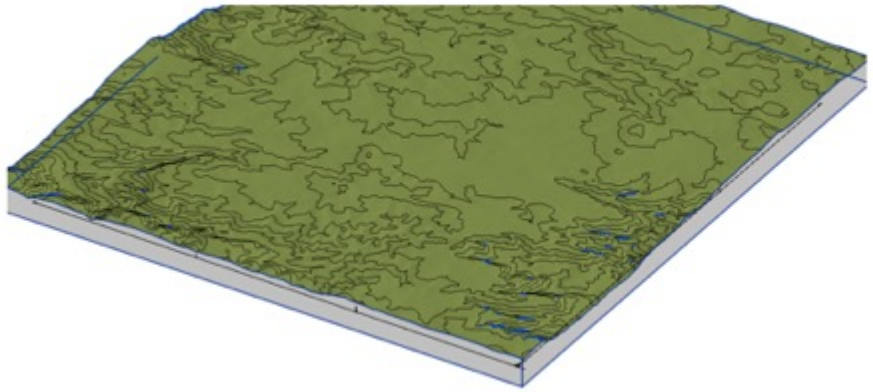
Triangle configuration (L=10km)

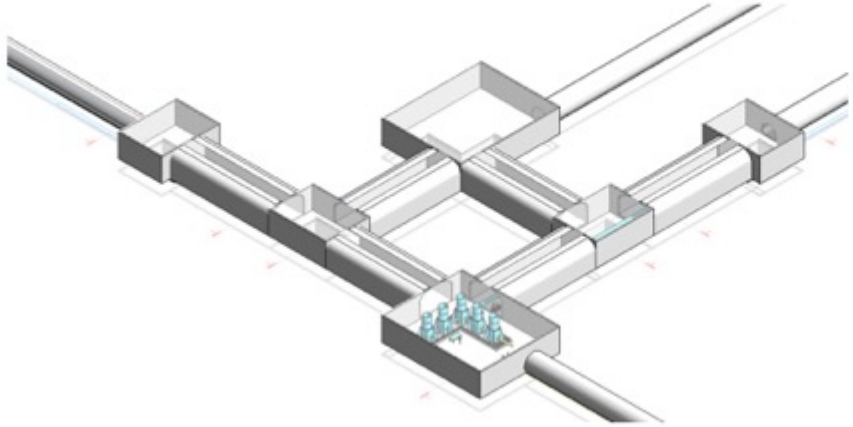


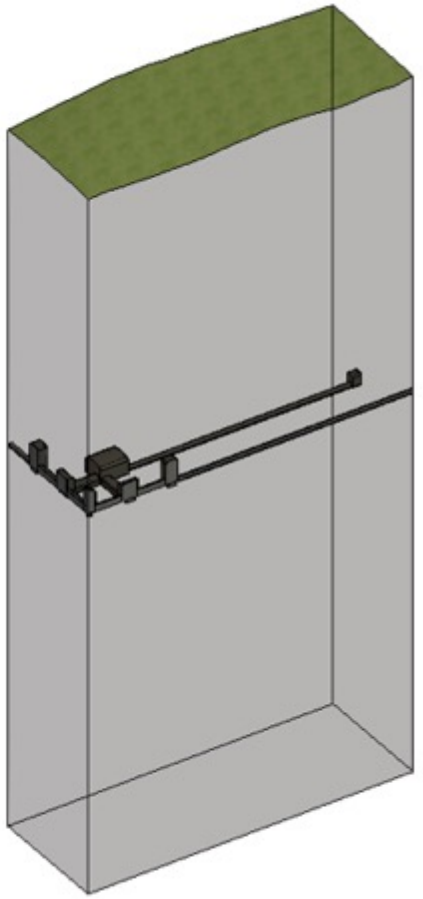




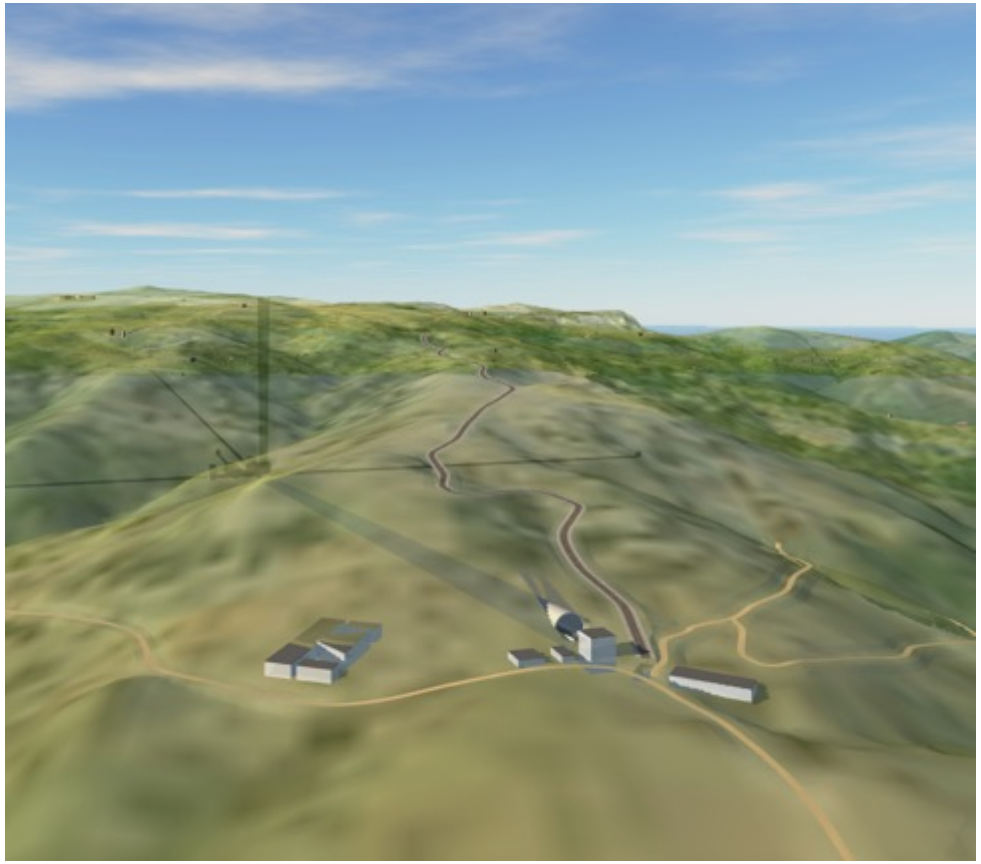
Option L configuration

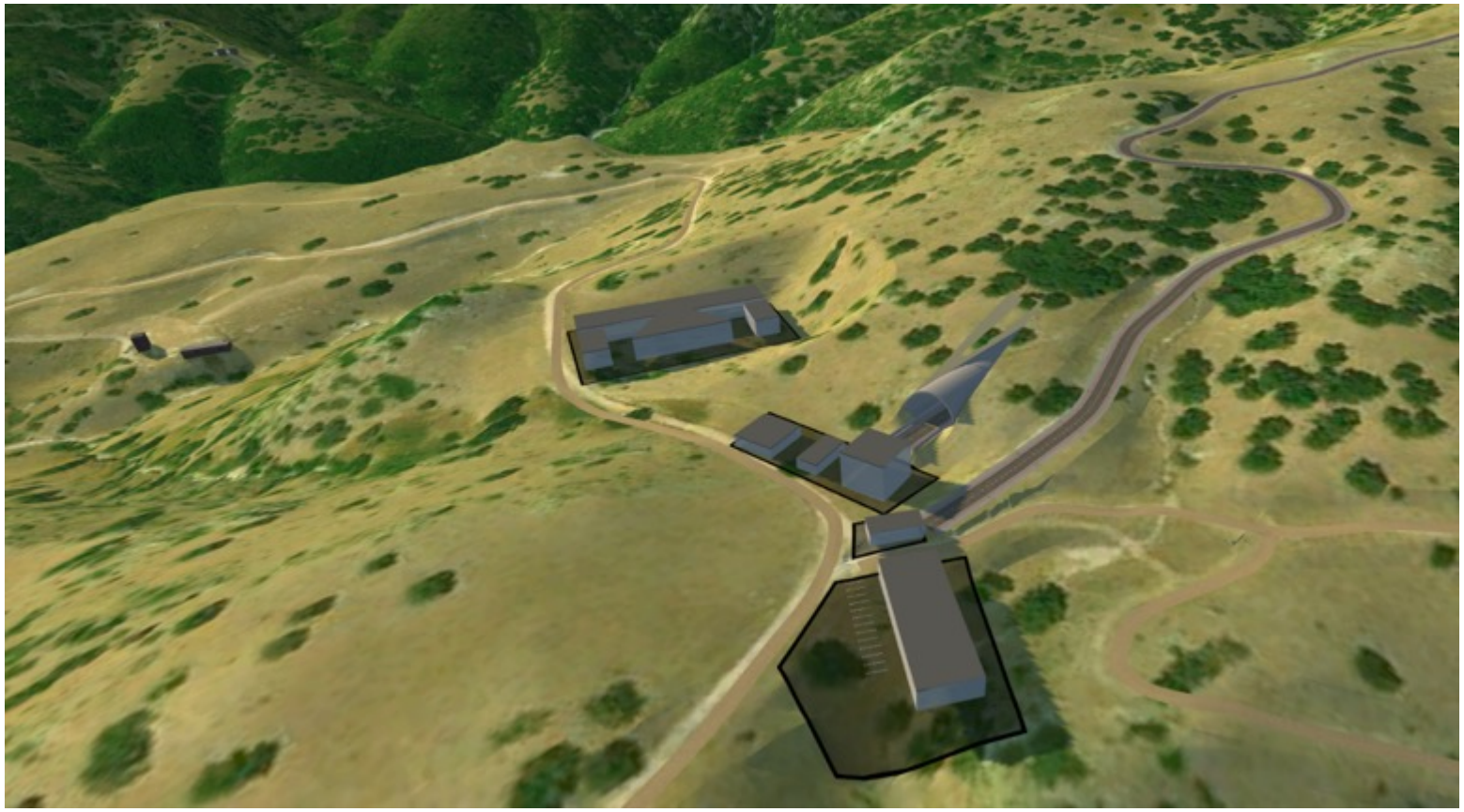




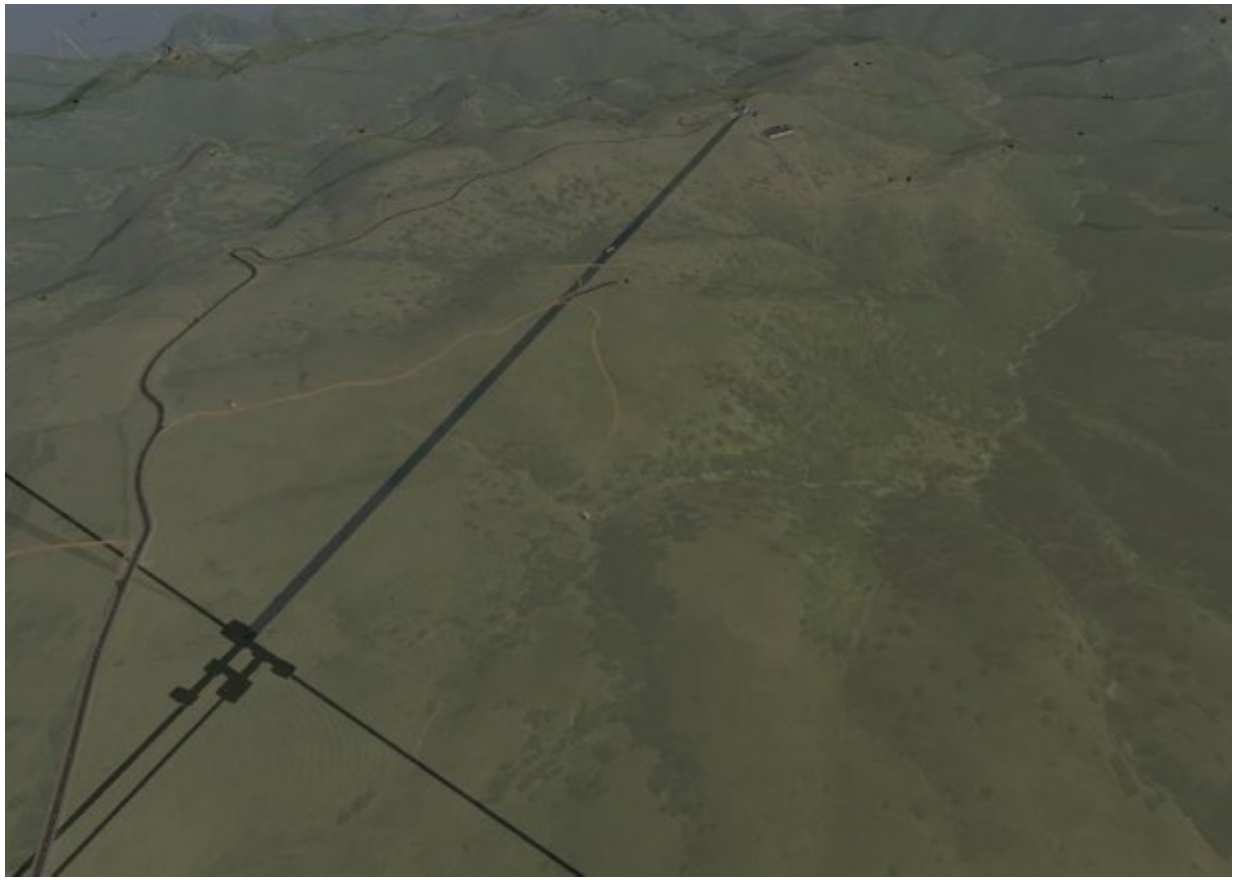


3D GIS-BIM Modelling





GIS-BIM model (Infraworks), Satellite image overlaid on three-dimensional works related to vertex 1 (northward view)



GIS-BIM model (Infraworks), Satellite image overlaid on three-dimensional works related to vertex 1 (southward view).

Technical feasibility assessment

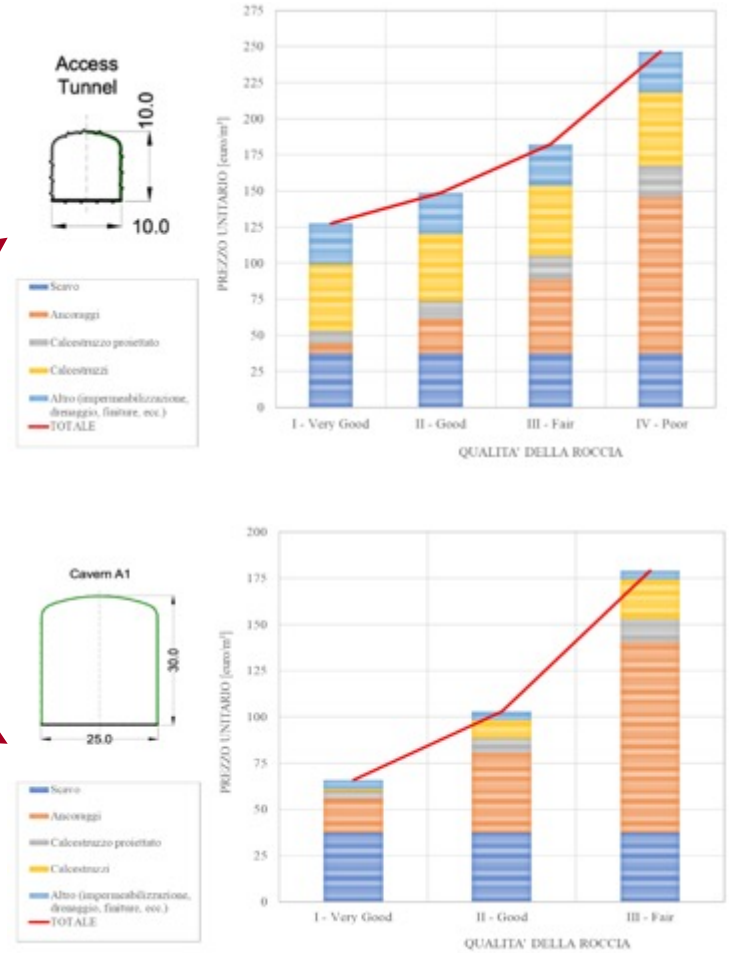
TECHNICAL FEASIBILITY STUDY OF INFRASTRUCTURE ⟷ COST AND TIME ESTIMATE

Preliminary estimates of the costs of works by **parametric unit prices** definition :

- type of work (access and construction tunnels, shaft, main and secondary caverns, etc.)
- rock quality and excavation technology.

Cost-benefit analysis of the different design scenarios, such as**:**

- selection of the optimal elevation of the infrastructure;
- selection of the number and type of caverns and accesses (tunnels, shafts).



THANK FOR THE ATTENTION