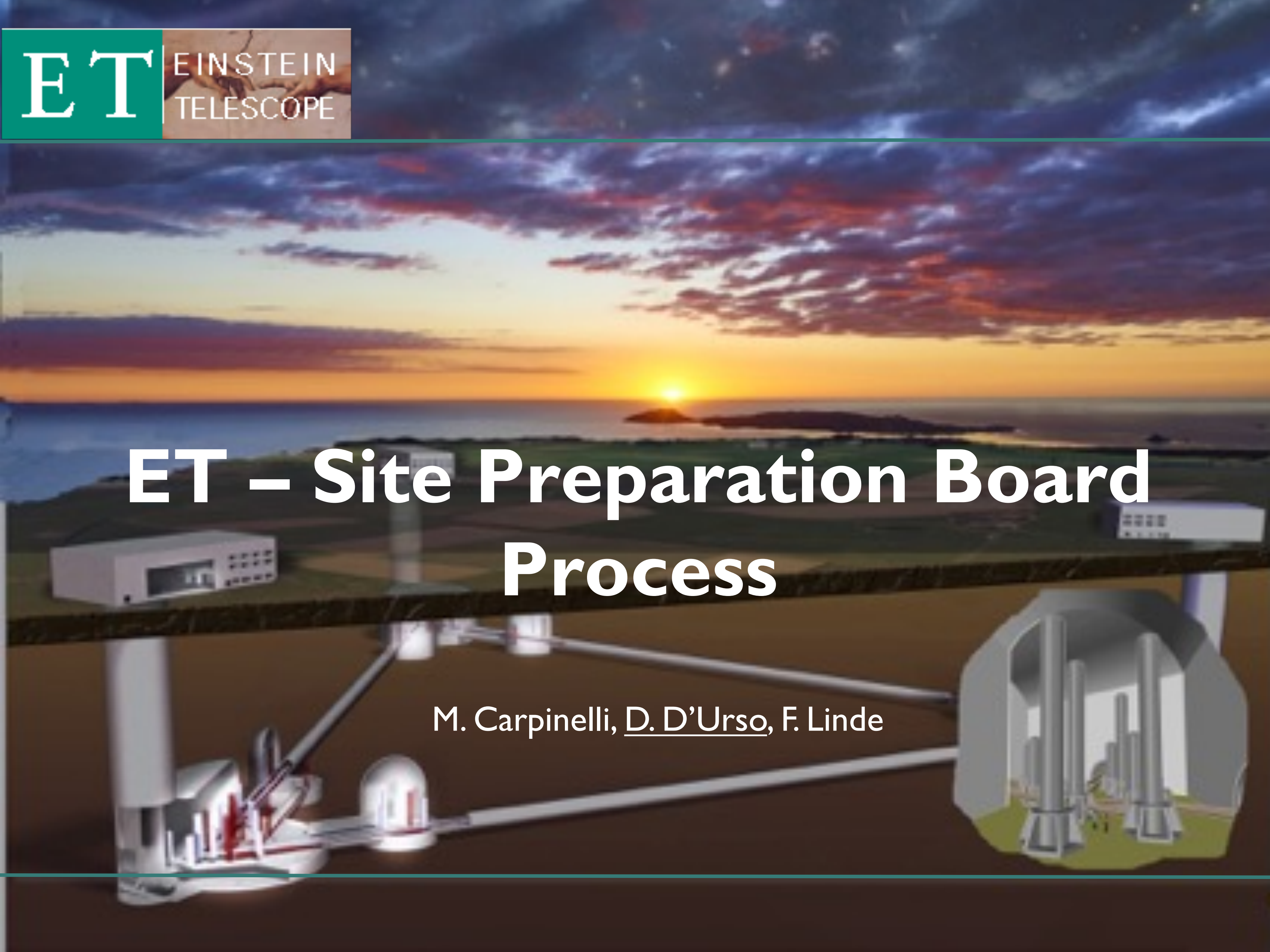

ET – Site Preparation Board Process

M. Carpinelli, D. D'Urso, F. Linde

Outline

- Site Selection @ ESFRI
- ET INFRA-DEV Proposal
- ET Organization
  - SPB Mandate
  - SPB Divisions
- SPB Activities
  - Current status
  - Timeline and future plans
- Towards the Definition of Site Selection Process
  - Scientific and technical aspects

Global Framework

ESFRI Interview: Q7

- Please provide details of the
  - strategy for funding the preparatory (Q7a) and
  - Implementation (construction) phases (Q7b)
  - procedures and timeline associated with the decision for final location of the ET (Q7c)

ESFRI Interview: Q7c

Q7c Site decision timeline and procedure

Activities are well underway. Decision and site selection procedure determined at government level

Site qualification activities in progress

- In parallel at two sites: Sardinia and Euregio Meuse-Rhine
- Working groups as part of the Instrument Science Board
- Site Preparation Board instituted to oversee the process of *e.g.* site information, data analysis
- External parties (companies): construction, budget, socio-economic aspects
- Cost of civil infrastructure will be site dependent

Risk assessment

- More than 85% of the implementation budget is in infrastructure and vacuum system
  - Vacuum system is relatively low risk
  - Infrastructure relatively modest risk (globally > 5,000 km of tunnel/year; we can select the location), and significant de-risking is ongoing (Early Contractor Involvement)

Site selection procedure in Preparatory phase

- Decision and site selection procedure will be determined at government level
- See answers to Q10

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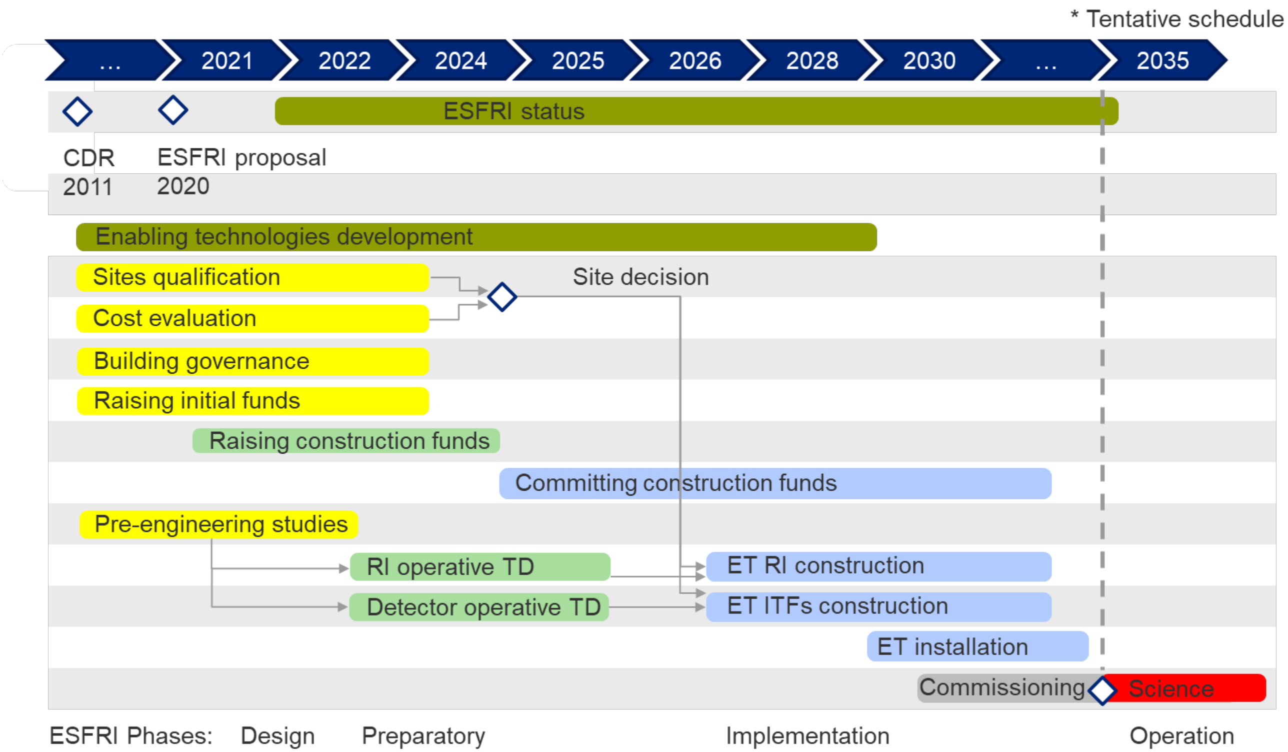
ESFRI Interview: Q9

- Please provide further details on the
  - business plan (Q9a)
  - timeline (Q9b)



ET EINSTEIN TELESCOPE

ET INFRA-DEV Proposal

- WP1 Coordination and Management
- WP2 Organization, Governance and Legal Aspects
- WP3 Financial Architecture
- **WP4 Site Selection**
- WP5 Project Office
- WP6 Technical Design
- WP7 Transfer of Technology
- WP8 Computing and Data Access
- WP9 Sustainable Development Stategy
- WP10 Education, Outreach and Citizen Engagement

ET INFRA-DEV: WP4

- Site Selection
  - **Site scientific evaluation**
  - Socio-economic impact
  - Legal/Financial aspects of the RI implementation

Site decision is included as well in the deliverable list ? National Representatives are the ones deputed to take the decision, aren't they ?

Would it be possible to have the decision in 3 years from now ?

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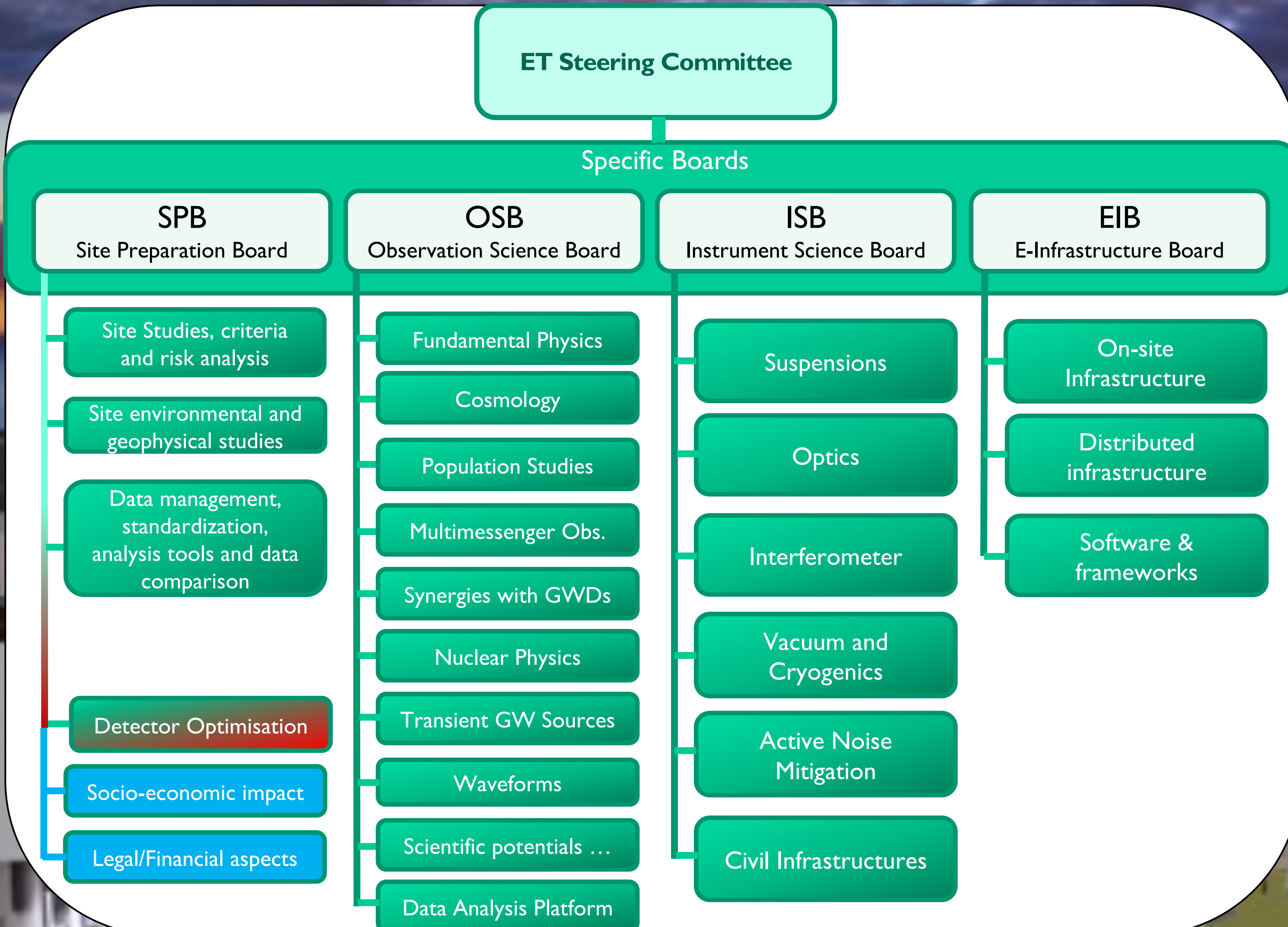
ET Organisation



SPB Mandate

- The SPB must lead the effort on the Einstein Telescope site related activities
  - coordinate the effort on site related activities
  - formulate the site specifications for ET
  - acquire the characteristics for each site and propose a procedure for site evaluation

Sites must be compliant to a series of requirements which may affect the detector sensitivity

SPB Duties

- Evaluation of technical noise generated in the infrastructure (ventilation, climate control, vacuum and cryogenic facilities, etc.)
- Risk assessment:
  - risks related to realizing the Einstein Telescope infrastructure (water level disturbances, sink holes, etc.)
  - risks for the Einstein Telescope related to possible future noise sources due to new construction projects in the region like windmill farms, roads, trains, (heavy) industries;
- Propose a procedure for site evaluation.

SBP Divisions

➢ *Site studies, criteria and risk analysis*

- Definition of criteria which candidate sites must address. Define surface and downhole measurements to be performed, for accurate noise characterization and site description in terms of geophysical, geological and geotechnical information.
- Identification of strengths, weaknesses, opportunities, and threats related to the realization of ET.
- Identification and analysis of potential (future) events that may negatively impact individuals, assets, and/or the environment. Evaluation of tolerability of the risk.

➢ *Site environmental and geophysical studies*

- Environmental studies including seismic surveys.
- Coordination of measurements to be performed (long-term, short-term, passive and active measurements).
- Geophysical and technical investigation.
- Coordination of measurements to be performed. Estimation of the environmental impact of the ET infrastructure (water level disturbances (temporary or permanent), expected sagging of surface etc.).

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SPB Divisions

- ***Data management, standardization, analysis tools and Data Comparison***
  - Definition of unique data formats for sensor data acquisition.
  - Set up of (or identify) a database to collect and to share the various data acquired at each site with all ET collaborators.
  - Definition of software tools and recipes to be used for data analysis, to allow a coherent comparison among the different measurements. These tools will be made available through a repository to all collaborators.
  - Organization of dedicated meetings to discuss methods, analysis tools and plans for surveys.
  - Comparison of data and analysis results from candidate sites.
  - Organization of dedicated periodic analysis meetings.

Ongoing Activities

- 1st ET – Site Studies and Characterization Workshop, Nuoro (Italy) 8-11 November 2021

- Geological investigations
- Geotechnical plans
- Feasibility Studies
- Seismic measurements
- NN estimation

Geological Investigations (Sardinia)

TALK'S STRUCTURE

RECAP ON:

- ❖ SARDINIA GEOLOGY AND REASONS WHY THE ET INFRASTRUCTURE SHOULD BE HERE
- ❖ PREVIOUS WORK OF SASSARI UNIVERSITY ON THE PROJECT

OUR NEW RESULTS:

- ❖ STRUCTURAL MAP ADVANCES
- ❖ FAULT CHARACTERIZATION
- ❖ MULTISCALE GEOLOGICAL CHARACTERIZATION OF BOREHOLE SURROUNDINGS BY MEANS OF:
  - STRUCTURAL GEOLOGY
  - STRUCTURAL GEOMORPHOLOGY
  - GEOELECTRICS

GENERAL CONCLUSIONS

Overall, we provide new insights on the lithological distribution and nature of contacts and fault zones, which are relevant for the prediction of mechanic behaviour of the rocks along the tunnel tracks.

Geological results:

- Preliminary structural map of the ET Sardinia area
- Definition of lithologies and structures
- Relative chronology of deformation events

ERT results:

- Recognize the thickness of altered zones above the bedrock
- identify superficial or suspended aquifers
- reconstruct the geometry of fault and fracture systems of limited extension and interconnectivity

OUR PRODUCTS

02/07/2021 "Progetto Einstein Telescope SARDEGNA" - Analisi geologico strutturale preliminare.

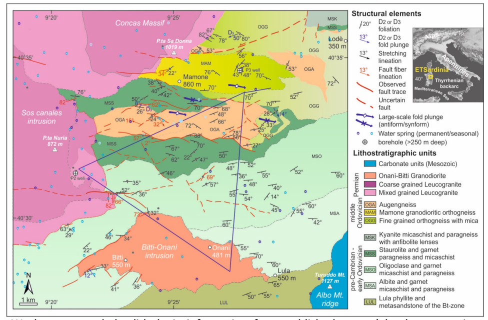
- Geological map review
- Lithological and structural characterization from new geological survey along the tunnel trace between P2 and P3 and between Bitti village and P2 borehole
- Morpho-structural and structural preliminary results

28/09/2021 "Relazione Geofisica – Prospezioni geoelettriche nel sito sardo candidato ad ospitare l'Einstein Telescope.

- ERT survey on P2 and P3 boreholes surroundings.
- Structural interpretation of tomographic lines

Beside that vulgarization at Lula

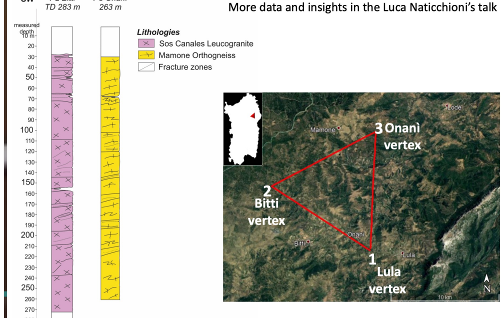
A NEW STRUCTURAL MAP



We have merged the lithologic information from published maps (also by comparing satellite images) and added new data collected in the field.

BOREHOLE COMPOSITION AND STRUCTURE

More data and insights in the Luca Naticchioni's talk



Active passive seismic survey (Sardinia)

In the framework of the Project Einstein Telescope Sos Enattos, we report the preliminary results of the active-source seismic surveys performed by the INGV team in drilling sites **P2** (labelled as Onani) and **P3** (labelled as Bitti-Mamone) in July and September 2021.

The main goal of these surveys was the reconstruction of the shallow subsurface velocity structure surrounding the two drilling sites.

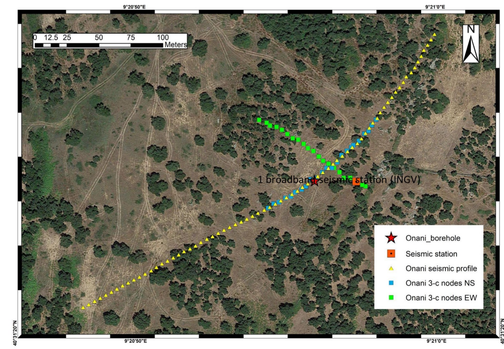
We combine **refraction tomography** and **downhole** seismic measurements.

In collaboration with the Karlsruhe Institute of Technology (**KIT**), the active-source seismic surveys were complemented by recordings operated by a 3-D nodal array.
Moreover, in one borehole (P3 site) optical fiber was installed to record seismic signals during passive and active seismic surveys.

Next steps (February - April 2022)

- High-resolution tomographic models of seismic profiles E-W and N-S from site P3 "Bitti-Mamone" + 1 vertical seismic profile from borehole P3.
  (main reasons: accurate hand-picking of first-arrival traveltimes; computational cost of best-fit models though non-linear approach)
- Joint inversion of refraction and borehole data for profile "Onani" (site P2) and for E-W profile "Bitti-Mamone" (site P3) to improve resolution depth and the imaging of possible subsurface fractured zones.
- Shallow 2-D shear wave velocity model of seismic profile P2 (from MASW).

In collaboration with KIT, analysis of active-source seismic data recorded by the 3-D nodal arrays (3-D tomography of the volume surrounding the two boreholes P2 and P3) and by optical fiber in the borehole.



Site P2: Onanì

location map and seismic surveys

Unfortunately, unfavourable local logistical conditions hampered the acquisition of two long and intersecting seismic profiles.

We thus collected and deployed:

1 high-resolution seismic profile
1 vertical seismic profile (downhole)

plus

2 linear arrays of 3-c nodes (**KIT**)
1 broadband seismic station (**INGV**)

Site P3 Bitti-Mamone
(work in progress)

1 vertical seismic profile
2 high-resolution seismic profiles

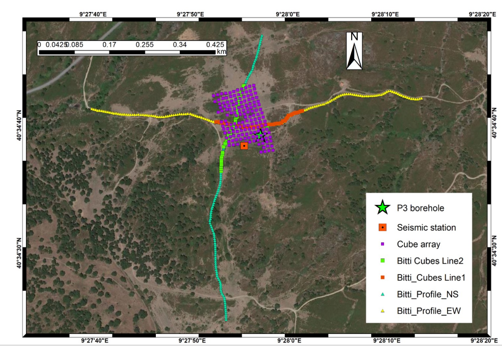
fully integrated with KIT deployments

nodal array of 153 3-D component cubes

2 linear arrays of 3-D component cubes

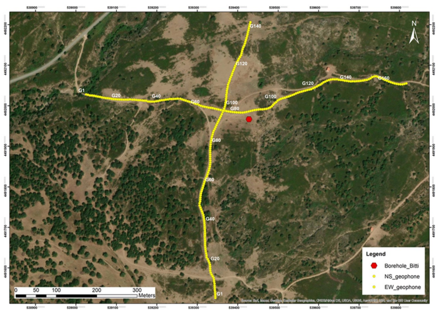
DAS vertical array

1 broadband seismic station (INGV)



Site P3 Bitti-Mamone
(work in progress)

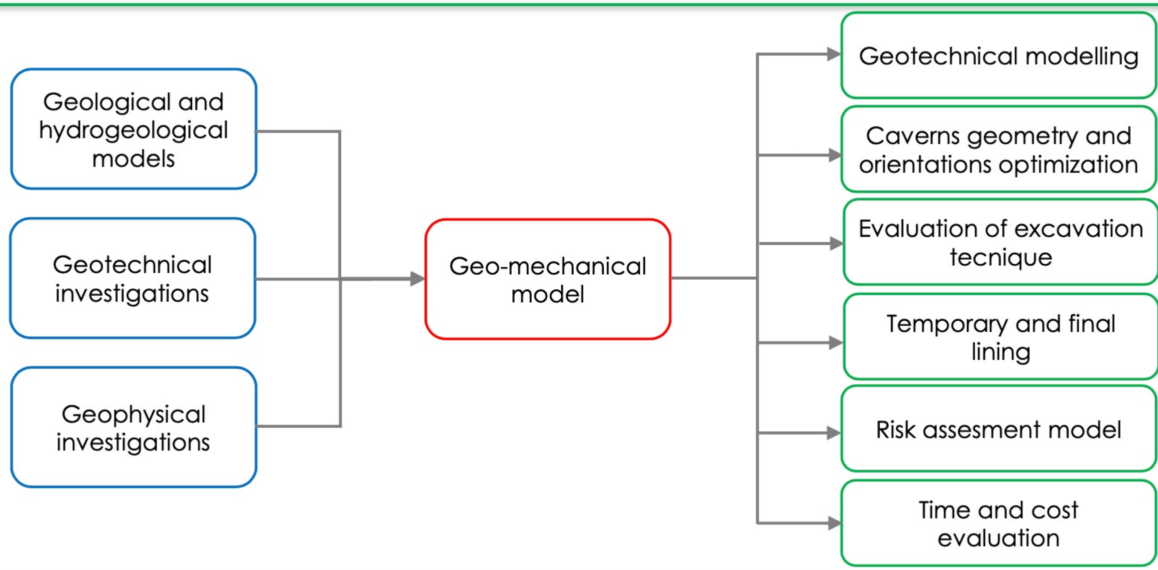
Vertical Seismic Profile	
Source	IVI-Minivib
N° Sources	112
Maximum depth	240 m
Acquisition interval	2 m



Geophysical characterization of the shallow subsurface in sites P2 and P3 from high-resolution active-source seismic profiling and downhole data: preliminary results Active seismic survey Teams

Geotechnical Issues and Plan

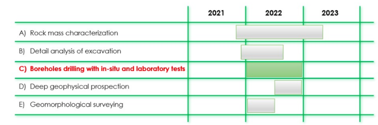
MAIN OBJECTIVES



GEOTECHNICAL INVESTIGATION PROGRAM

C) Boreholes drilling with in-situ and laboratory tests

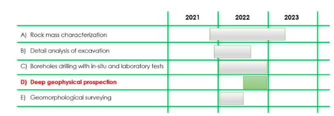
- Execution of n. 2 boreholes with core recovery up to depth of about 250 m from ground level
- Water tests on boreholes
- Geophysical logs and acoustic camera BHTV
- Cores collection for laboratory tests
- Laboratory tests (density, waves measurements, UCS, triaxial tests, deformability tests, indirect tensile tests, etc.)



ET - Site Studies and Characterization, 8-11 Nov 2021, Nuoro (Italy)

D) Execution of deep geophysical prospection to obtain information for 3D geological and geotechnical models.

It is planned to carry out at lest two orthogonal profiles in correspondence of the two boreholes described in the previous slide in order to have the possibility of calibrate the results of geophysics in function of the information acquired from the borehole excavation



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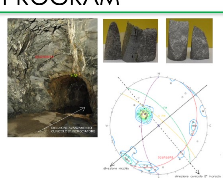
GEOTECHNICAL INVESTIGATION PROGRAM

A) Rock mass characterization

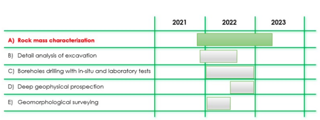
FIRST PHASE:

- Geo-structural surveys;
- Collection of samples for laboratory tests;
- Laboratory tests (density, waves measurements, UCS, triaxial tests, deformability tests, indirect tensile tests, etc.)
- Geo-mechanical model of different units



SECOND PHASE:

- Update of the geo-mechanical model on the basis on the information collected during the boreholes excavation (see next slide).



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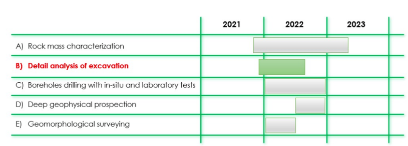
Geotechnical INVESTIGATION PROGRAM

B) Specialist study for the analysis of mechanical excavation (TBM)

- Open or Shielded tunnel boring machine
- Number of boring machine (time and cost estimation)
- Study the interference with local tunnel enlargement (service cavern, emergency exit)



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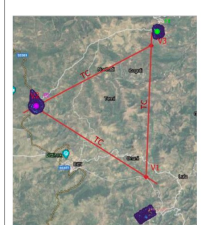
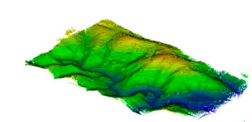
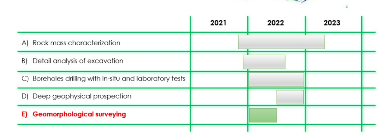
E) Execution of UAV surveying in areas of interest such as access/emergency exit portals, shaft exits, surface infrastructure zones, etc., in support to geostructural characterization.







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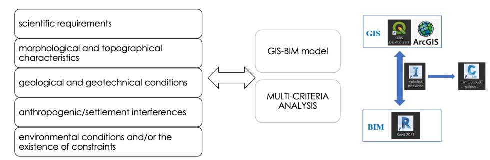
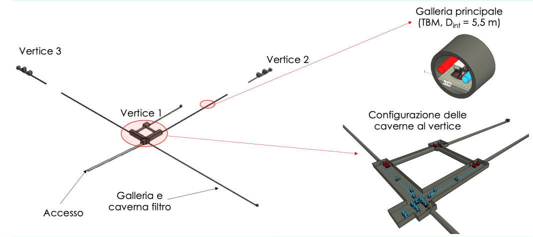
Feasibility Studies – ET Layout

- adopted approach for optimizing the infrastructure localization based on a GIS-BIM and multi-criteria analysis
- collection and managements of the main requirement and constraints
- triangle Reference Solution (TC)
- L-configuration hypothesis (LC)
- comparative cost-benefit analysis for the two configurations

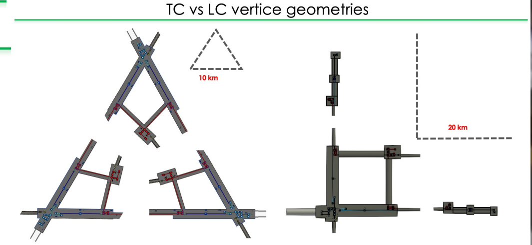
methodology for localization



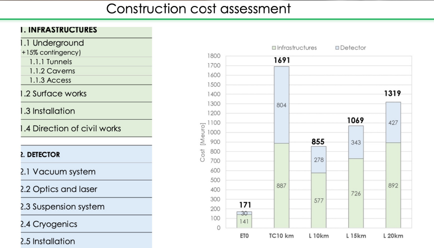
Layout LC_20km



TC vs LC vertice geometries



Construction cost assessment



consideration

- For the CT the realization of 3 distinct interferometers involves the realization of a more coplex system of caves and tunnels at the 3 vertices
- The LC can be extended to lengths longer than 20 km
- The costs for the construction of the infrastructure are comparable (TC has more caves, a larger but shorter main tunnel diameter and fewer exits/entrances).
- LC realization times may be shorter than CT (longer tunnels (TBM) but less complex caverns (D&B)

Feasibility study for ET Infrastructure for Sardinia site: location optimization, GIS-BIM three-dimensional modelling, multicriteria analysis M. Marsella

Seismic Measurements (Sardinia)

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SUMMARY

Sos Enattos

- At depth ~110 m: factor ~10 attenuation for F < 0.07 Hz and F > 1 Hz, partially consistent with Rayleigh waves*;
- Tough geological materials (Vp > 4000 m/s, Vs > 2000 m/s)
- No stratigraphic site effects
- At 110m depth: ~NLNM over the 2-5 Hz frequency band
- Microseism band (0.1-1 Hz) correlated with wave climate in the western Mediterranean Sea
- Measured noise amplitude must be considered as an upper bound, since anthropogenic activities at the mine are still ongoing;
- For the (crucial) 2-10 Hz frequency band:
  - * Spectral ratios with the surface stations < 1 and the detailed analysis of glitches indicate the existence of local disturbances, likely due to human operations

SUMMARY - II

P2 and P3 corners: At depth 250-m, the 2-10 Hz noise is among the lowest ever observed on the Earth

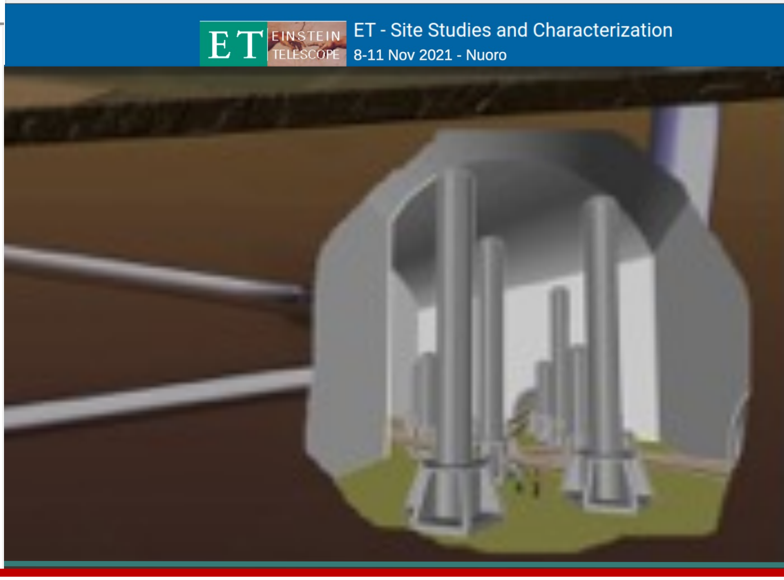
HOMEWORK:

- Improve assessment of PATH EFFECTS:
- Attenuation, Anisotropy
- Account for transient (Glitches)

This Talk:

A summary of the passive seismic data analysis

1. The Sos Enattos site
   - Single-station & underground measurements
   - Small-aperture array
   - velocity models
2. The P2 and P3 corners: borehole spectra
3. Summary, and some considerations



A summary of seismic data analyses at the ET candidate site in Sardinia (Italy) G. Saccorotti

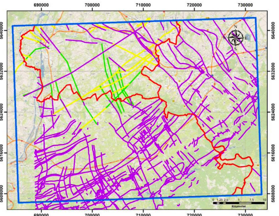
Geological Investigations (EMR)

Main Objectives - WP T4

- **3D Cross-Border Open Geological Model**
  - Evaluation and incorporation of existing geological data sets
  - Implementation of new boreholes
  - Active and passive seismic survey
- **ET-Design**
  - Feasibility study and optimal positioning of the ET triangle
  - Extensive multi-disciplinary in-situ and laboratory testing campaign
  - Assessment of regional fracture characteristics by outcrop analogue studies

Geological Structures in the EMR Region

- Structure set A
  - Running NE – SW
  - Originate from Late Paleozoic orogeny
  - Affects only Paleozoic rocks
- Structure set B
  - Running NW-SE
  - Origin in Devonian, reactivated several times
  - Affects all rocks
- Information about large-scale structures from literature & maps
- Local information on small-scale features by outcrops & drill-core data

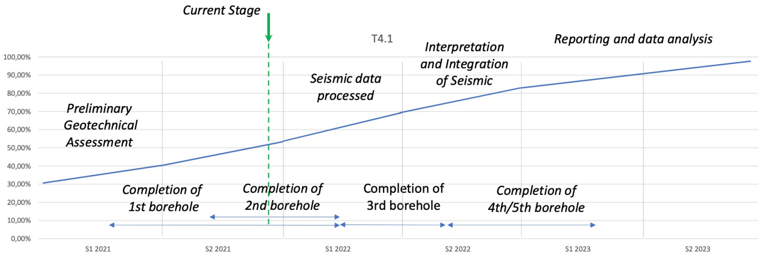


First Step - Surface Investigations

- Surface investigation of outcropping rocks provides
  a. The possibility to get a first approximating technical data source by in-situ and laboratory testing
  b. derive possible formations of special interest for further investigation

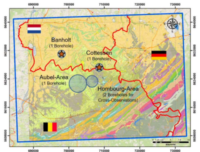
(© Raphael Burchartz)

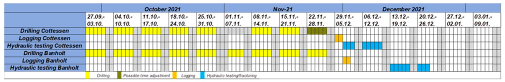
Preliminary Forecast of T4.1 Cross-border Open Geological Model



Second Step - Drilling Campaigns

- Two currently ongoing drilling campaigns shall give information about the actual rock conditions/properties down to a target depth of 250 m
- Different borehole tests will be performed as well as core logging and mechanical tests on the core material



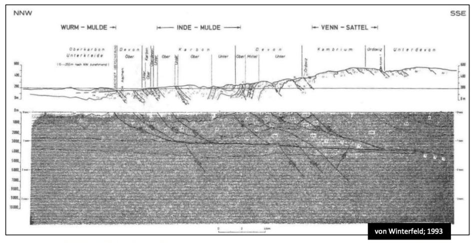


Geological Field Investigations, Drilling Programs and Geophysical Logging

Active passive seismic survey (EMR)

Why use seismic investigations & how it is done

- **2D or 3D information on subsurface**
  - Rock layering
  - Structures in the subsurface
- **Active seismic campaign**
  - 2D lines
  - Using vibro-seis trucks
- **Passive seismic campaign**
  - Battery-driven geophones

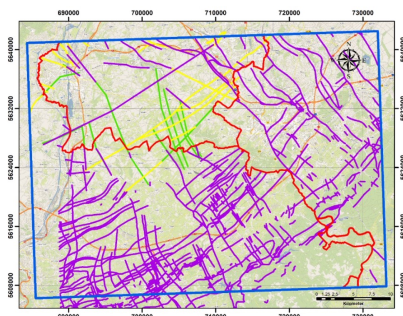


Status & challenges of active seismic survey

- **Status**
  - Tender is published and currently open
  - Permitting phase started
    - Contact with local authorities
    - Check for environmental requirements and UXOs
- **Challenges**
  - Meeting requirements in 3 regions
  - Potential loss of signal due to strong impedance contrast between Cretaceous soft-rock and Paleozoic hard-rock
  - Finding time slot that is in accordance to natural protection of animals

Active and passive seismic investigations

- **2D Active seismic survey**
  - Lines in high angle to existing geological structures
  - Follow existing infrastructure
- **Passive seismic campaigns**
  - Clusters of geophones in an area
  - Geophones record for ca. 2 months
  - Use of any passive input signal
    - Earthquakes in the Eifel mountains
    - Traffic, windmills, etc.



Forecast of active seismic survey

- **S2 2021**
  - Closing Tender and awarding of tender to successful bidder
- **S1 2022**
  - Acquiring seismic data by contractor
  - Processing of seismic data by contractor (depends on data acquisition)
- **S2 2022**
  - Processing of seismic data by contractor (if still required)
  - Data analysis and interpretation of seismic data
  - Integration with further data sets (e.g. boreholes, near-surface geophysics) for data analysis
- **S1 2023**
  - Reporting

Hydrogeophysical characterization (EMR)

Content

- Groundwater in the EMR region
- Groundwater pumping in the EMR region
- Conceptual model
- Challenges faced for the modeling
  - Boundary conditions
  - Simplified geological model
  - Input parameters
- Further goals
  - Sensitivity analysis
  - Model calibration
  - Local model

Further goals

- Development of the sensitivity analysis and the calibration
- Preparation of the local model and calibration of the local model
- Estimation of the volume to drain and pump during the building and the operation
- Assessment of the impacts on surface/groundwater interactions, existing pumping wells, land subsidence

Challenges faced for the modeling

- **No geological model was available**
- At the scale of the regional model, many geological features have limited influence on the hydrogeology
- **Boundary conditions are key features to simulate the groundwater flows**
  - River level data are easy to collect and allow to apply realistic constrain on the groundwater level
  - Geological formation with very low hydraulic conductivity are natural boundaries where no flux are exchanged
  - When no other data is available the groundwater level is prescribed using available data

Challenges faced for the modeling

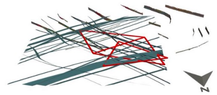
- **Hydraulic conductivity is not only defined by the geology**
  - Porosity, fractures, alteration, depth,…
  - These conductivities have to be optimized based on piezometric data (calibration)
  - However, the data available are limited and focused on shallow aquifer
- **Groundwater flow and levels are also influenced by**
  - R=P-E-R
  - Pumping and injection
  - All this stresses need to be taken into account on a large scale and with the limited data available in each country

Groundwater flow modeling for the EMR region Mathieu Veeckmans

EINSTEIN TELESCOPE

Geological modeling (EMR)

Geological modeling in E-Test



Goal: Find the optimal position for the Einstein Telescope in the subsurface

- Collect & homogenize available data
- Understand tectonic setting
- Preliminary geological models
- Conduct further geophysical exploration
- Refine geological models
- Simulate and plan tunneling

Geological modeling: Challenges & Opportunities

Challenges:

- Quantify error of model input
- Reduce overall uncertainty
- Model different geological interpretations
- Maximize information from available data

Opportunities

- Evaluate model quality and geological interpretations
- Maximize information gain from exploration methods

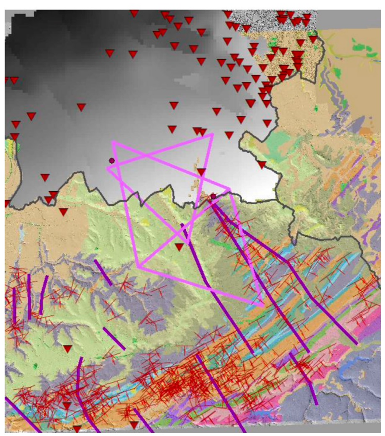
Model input

Main sources of information:

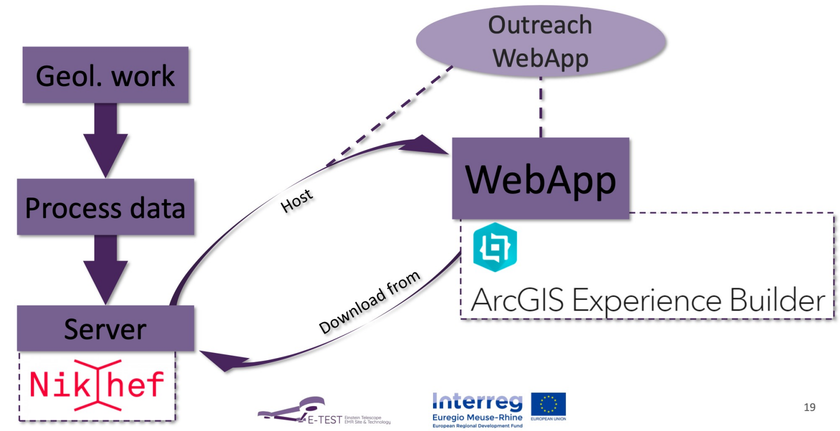
- Boreholes
- Maps (orientations and surface points)
- Profiles
- Seismic interpretations

Soon to be acquired:

- Additional boreholes
- 2D seismic
- Passive seismic
- Geophysical methods



Simplified workflow (How could this work?)

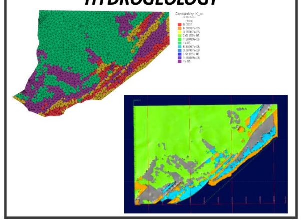


Geotechnical Campaign (EMR)

Overview

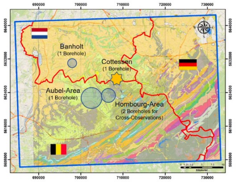
- ***ET Tunnels General Consideration***
    - *Current Cavern & Tunnel Layouts*
    - *Caverns, Tunnels and shafts Construction*
    - *Dewatering Tunnels*
    - *Surface Installations*
    - *Environmental Considerations*
- ***EMR Site***
    - *Boundary Conditions*
    - *Ongoing works*
    - *Preliminary Tunnel Design*
    - *Forecasts*

HYDROGEOLOGY

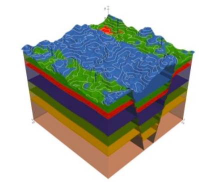


Courtecy: Univesity of Liege

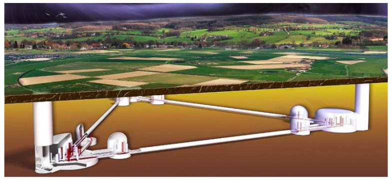
IN-SITU & LAB TESTING



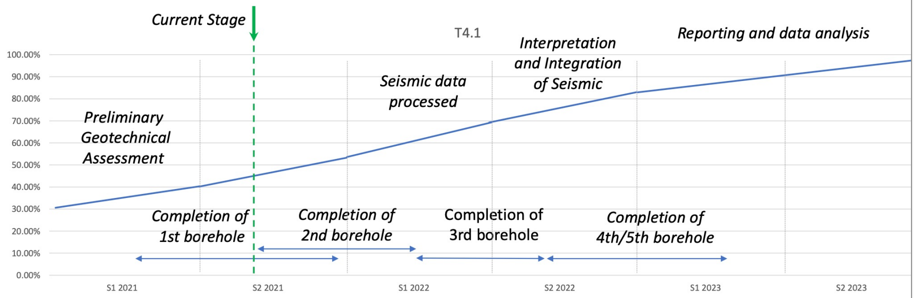
GEOLOGICAL & STRUCTURAL MODELLING



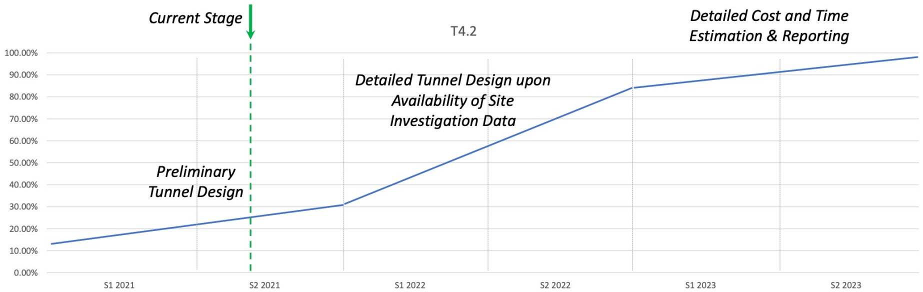
ET TUNNEL DESIGN



Forecast – Site Investigation



Forecast – Final Optimization & Tunnel Design



Geotechnical Characterization Campaign for Design of ET Underground Infrastructures - Tunnelling Aspects and Challenges P. Hamdi

ET EINSTEIN TELESCOPE Seismic Measurements (EMR)

Seismological inputs for Newtonian noise modeling

Single station parameters

- Three component power spectral density (PSD) estimate
- Horizontal – Vertical spectral ratio (HVSR)
- Rayleigh wave ellipticity (Hobiger et al, 2009)

Array studies

- Beamforming (Lacoss et al 1969)
  - Azimuthal distribution of noise sources
  - Surface wave phase velocity
  - Wave types and surface wave modes
- Seismic interferometry (Wapenaar et al, 2004)
  - Station pair correlation attributes
  - 3D distribution of subsurface velocity
  - Identification of body-wave contribution (medium aperture arrays)
- Simultaneous measurements of underground seismic noise (200-250 m depth)

Geological modeling

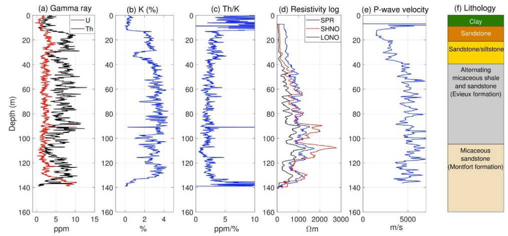
- 1D S-wave model (small aperture passive seismic)
- P-wave velocity model (1D-2D-3D) (active seismic)
- Density, Quality factor (borehole logging and inversion, Anderson et al 1965)

NN estin

How far we got at the EMR site?

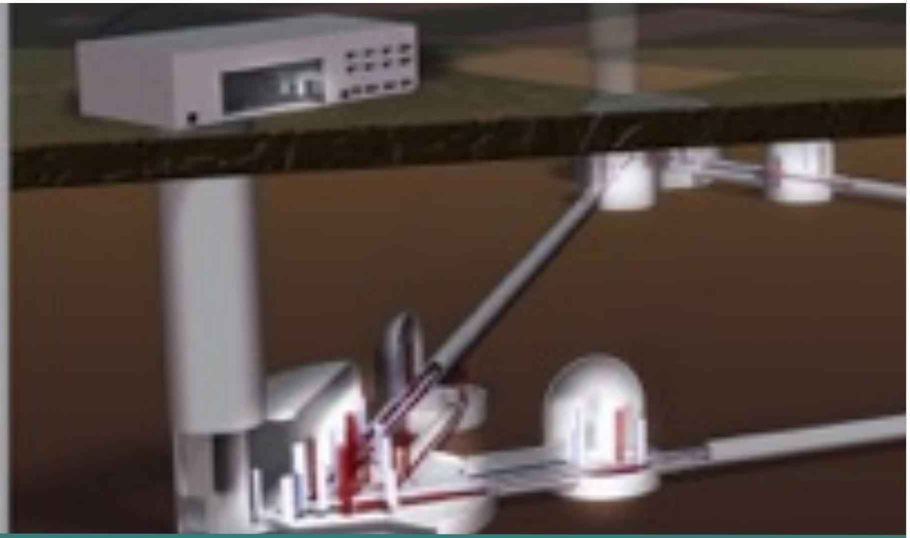
Small Aperture array studies at Terziet at the 260 m deep borehole site

- Surface and underground single station analysis - PSD surface/underground, underground attenuation, HVSR, body wave background
- Beamforming – noise direction, Rayleigh wave phase velocity, wave types
- 1 D geological model up to depths of 200 m
- 2D P-wave model – active seismic studies (2018)
- Borehole logging up to 140 m depth – Gamma ray, sonic, resistivity
- Underground noise studies at a depth of 250 m



Ongoing investigations

- Two medium-aperture array data acquired – spanning approximately 10x10 sq km
- Data analysis in progress – Beamforming, seismic interferometry, identifying surface- and body-wave contributions
- More 3-component seismic noise measurements to follow
- Two new boreholes at Cottesen and Banholt in progress



Future and ongoing studies

Dedicated small aperture array studies at future borehole sites for beamforming and correlation studies between surface array and underground seismic noise

Correlation between underground stations as a function of distance and frequency (body wave or surface wave)

Deploy medium aperture arrays with minimum separation of about 300 m

- Perform seismic interferometry for 3D subsurface model estimation
- Identify the fast-propagating body-wave background (greater sensor separation is preferred)

Perform 3-component seismometer studies at the borehole sites to identify the polarization of the seismic wave and quantify the SH-Love wave contribution

Perform gamma-ray, resistivity and sonic logging at borehole sites

- Estimation of density of subsurface formation
- Estimation of the quality factor of the subsurface from logging

Relevant publications:

- **Surface and underground seismic characterization at Terziet in Limburg - the Euregio Meuse-Rhine candidate site for Einstein telescope**, Soumen Koley, Maria Bader, Johannes van den Brand, Xander Campman, Henk Jan Bulten, Frank Linde and Bjorn Vink, 2021 IOP Publishing Ltd https://doi.org/10.1088/1361-6382/ac2b08
- **Newtonian-noise characterization at Terziet in Limburg - the Euregio Meuse-Rhine candidate site for Einstein Telescope** Maria Bader, Soumen Koley, Johannes van den Brand, Xander Campman, Henk Jan Bulten, Frank Linde and Bjorn Vink, 2021 IOP Publishing Ltd https://doi.org/10.1088/1361-6382/ac1be4

Seismological observations at the Euregio-Meuse-Rhine candidate site for Einstein Telescope S. Koley

Newtonian Noise

- Dedicated session to summarize the status of NN modeling and application to both site, starting from the experience in current detectors.
- NN estimation needs detailed knowledge of seismic spectra, anisotropy of seismic field, Rayleigh-wave dispersion, topography, geology
- Shared tools already available for user analysis

ET site-characterization workshop

Summary

	Required/recommended input	Purpose
Analytical models	Seismic spectra, Rayleigh-wave dispersion	Estimate NN spectra in simple geological/topographic settings, and for simple seismic fields
Simplest numerical models	Seismic spectra, anisotropy of seismic field, Rayleigh-wave dispersion, topography, geology	Estimate NN spectra in geological/topographic settings weakly different from flat/homogeneous
Correlation-based models	Two-point spatial correlations, topography, geology	Estimate NN spectra in complicated geological/topographic settings
Dynamical FEM simulation	Information about seismic sources, geology, topography	Study specific phenomena relevant to NN estimation and cancellation
Bayesian methods	Two-point spatial correlations, geology, topography, information about seismic sources	NNC design

Courtesy of J. Harms

Next steps

- Set-up a regular meeting (next general workshop in 6 months)
- Definition of software tools and recipes to be used for data analysis
- Organization of dedicated meetings to discuss methods, analysis tools and plans for surveys.
- Comparison of data and analysis results from candidate sites.
- Organization of dedicated periodic analysis meetings.
- Define the ”best practices” for measurements:
    - Numbers and sensitivity of instruments
    - Minimal duration of data taking
    - Recommended setup
    - Borehole design and setup and so on…

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Next steps

- follow-up of NN discussions
- Continuing the characterization campaign in terms of geology, hydrogeology and geotechnical measurements
- Continuing civil engineering studies.
- **Reliable risk assessment** on technical and scientific aspects

Would it be worthwhile to involve a private company with a huge experience in underground construction ?

How? As a Collaboration ?

Do we need a Consortium to do it ?

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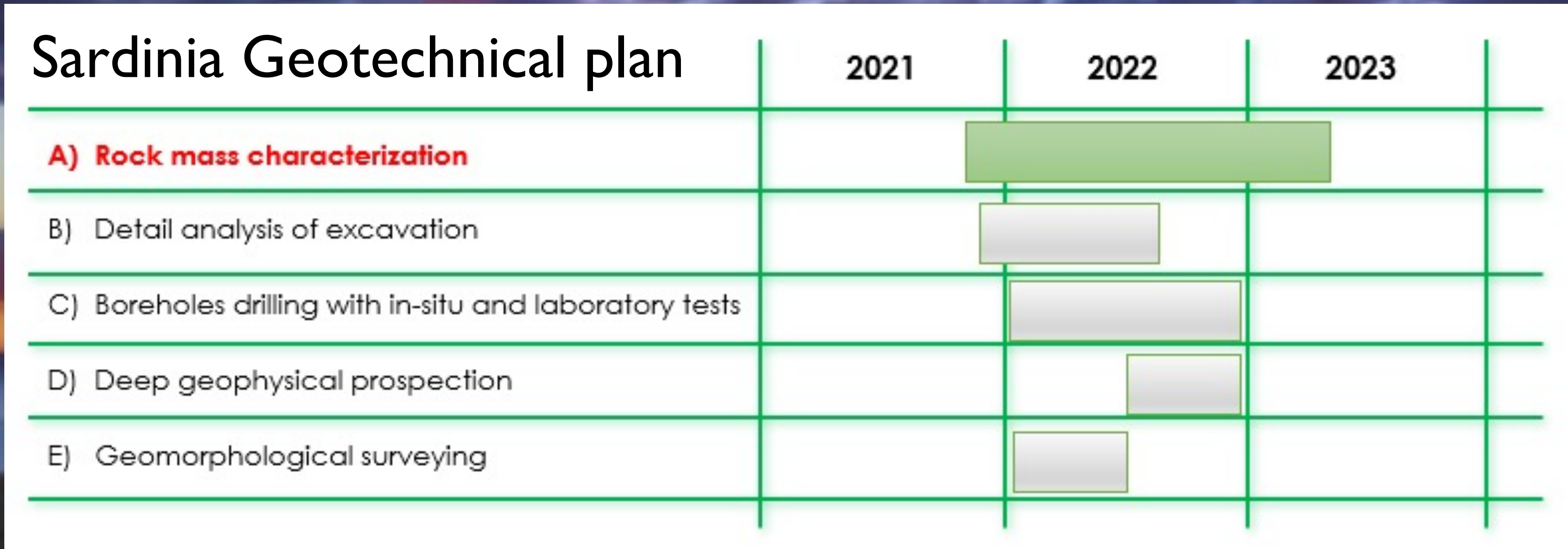
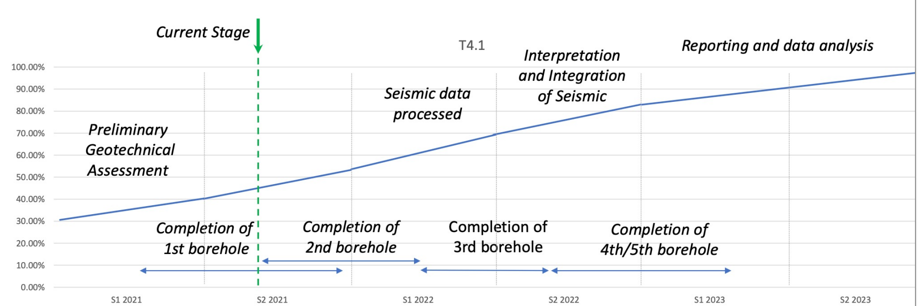
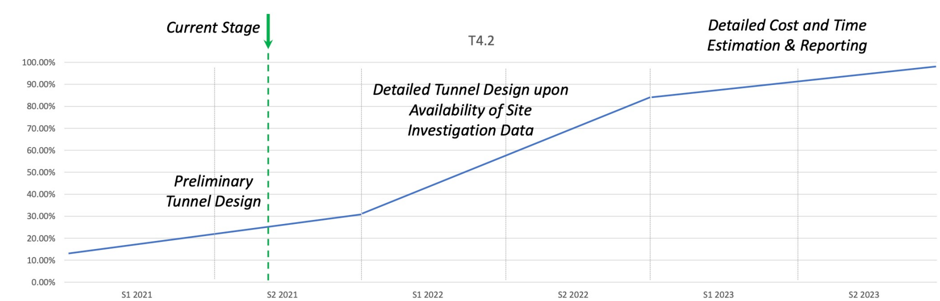
Timeline



Forecast – Site Investigation



Forecast – Final Optimization & Tunnel Design



EMR Geotechnical campaign

E-TEST

Interreg Euregio Meuse-Rhine

European Regional Development Fund

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Towards the Site Selection Process

Models
- Transfer function of seismic filtering
- NN models
- Transfer function for magnetic noise

Inputs
- Seismic noise
- Acoustic noise
- Magnetic noise
- Wind measurements

Noise budget computation and glitches

Outputs
- Sensitivity curves
- Glitchness
- Duty cycles

Towards the Site Selection Process

The ET site selection is a complex procedure that must take in account different aspects:

- Science aspects:
  - compatibility of the noise levels of the site with the first target sensitivity of ET and its possible evolutions
  - non Gaussian noise sources: glitches
  - duty cycle (seasonal, day/night and glitch effects)
  - Localisation and orientation

Towards the Site Selection Process

- Technical aspects:
  - Geology
  - Hydrogeology
  - Geo-technical properties
- Geographical aspects:
  - Travels and transportations: Roads, ports, airports
  - Parks and restricted access area
- Social aspects
  - Lodging
  - Social life of the people working at the site
  - Impact on the local community
- Financial and Political aspects
  - Money, organisation, countries, ….

Towards the Site Selection Process

Science aspects

- Define the performance indicators: ET sensitivity curve?
  - ❑ Cut in frequency: What should be the cut-in frequency? 2Hz?
  - ❑ Non-stationary noise: How to handle correctly and in a standard way the day/night and the seasonal effects? What about the duty cycle? (Earthquackes, Glitches, Technical noises)
  - ❑ Three vertices, do we use the noisest one ?
  - ❑ Vision: the infrastructure should be capable to host evolution beyond the initial ET sensitivity

Technical Aspects

- Geology: How to compare geology in a quantitative way of interest for ET?
  - Rock and soil layers?
  - Faults
- Hydrogeology:
  - How to quantify the hydrogeology and what is the impact?
- Geo-technical properties for the construction of the ET underground infrastructures

Should we commit a comparison study to a "third" company?

Inputs

- Seismic noise
  - common indications for the seismic measurements
- Newtonian Noise
  - common way to reconstruct the underground properties and structures, need for NN estimation
- Magnetic noise
  - Surface? Borehole ? Cavern? Frequency range?
- Localization and orientation
  - Depth compatible with the seismic measurements?
  - Mapping on a common GIS
  - Localisation of the vertices
  - Distance and amplitude of the main noise sources (wind mills, cities, ….)

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Conclusions

- Site Selection critical point @ESFRI, dedicated WP in the ET INFRA-DEV Proposal, dedicated board within ET Organization
- SPB duties and mandate
  - coordinate the effort on site related activities
  - formulate the site specifications for ET
  - acquire the characteristics for each site and **propose a procedure for site evaluation**
- INFRA-DEV WP
  - **Site scientific evaluation**
  - Socio-economic impact
  - Legal/Financial aspects

Conclusions

- Ongoing activities:
  - 1st ET – Site Studies and Characterization Workshop, Nuoro (Italy) 8-11 November 2021
  - Geological investigations
  - Geotechnical plans
  - Feasibility Studies
  - Seismic measurements
  - NN estimation
- Next steps
  - Regular meeting
  - Data/tools standardization and comparison among site
  - Site Evaluation parameter definition (science and technical aspects)
- Timeline: the 23/24 is a reliable time window?

Conclusions

- Detector layout: still too many possibilities on the table
- Infrastructure design and risk assessment
  - iterative process
  - Science Goals and technical aspects
  - Time to interact with private companies with a large experience in underground construction ?