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

E-TEST TEAM

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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*

ET Tunnels
General Consideration

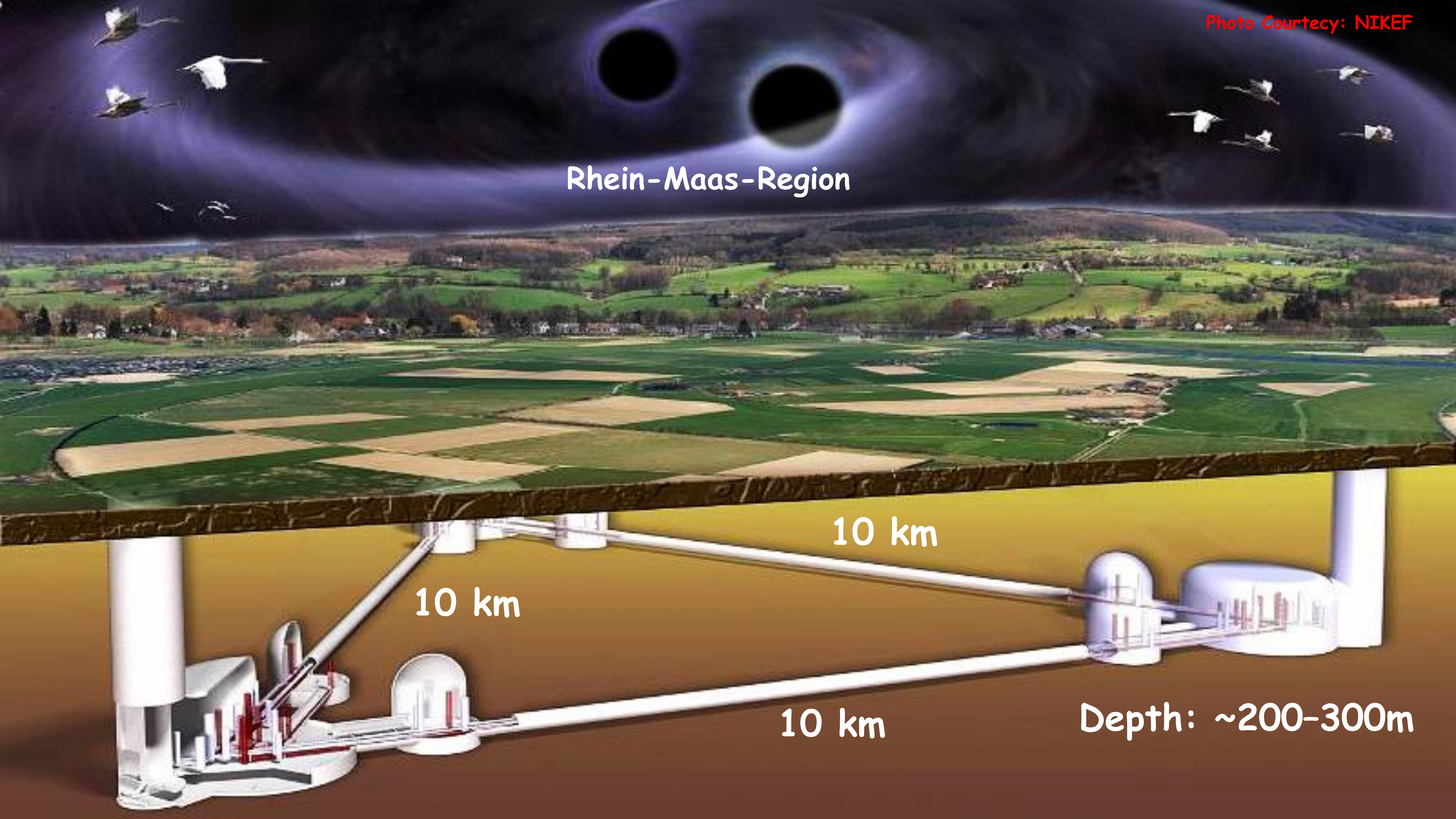
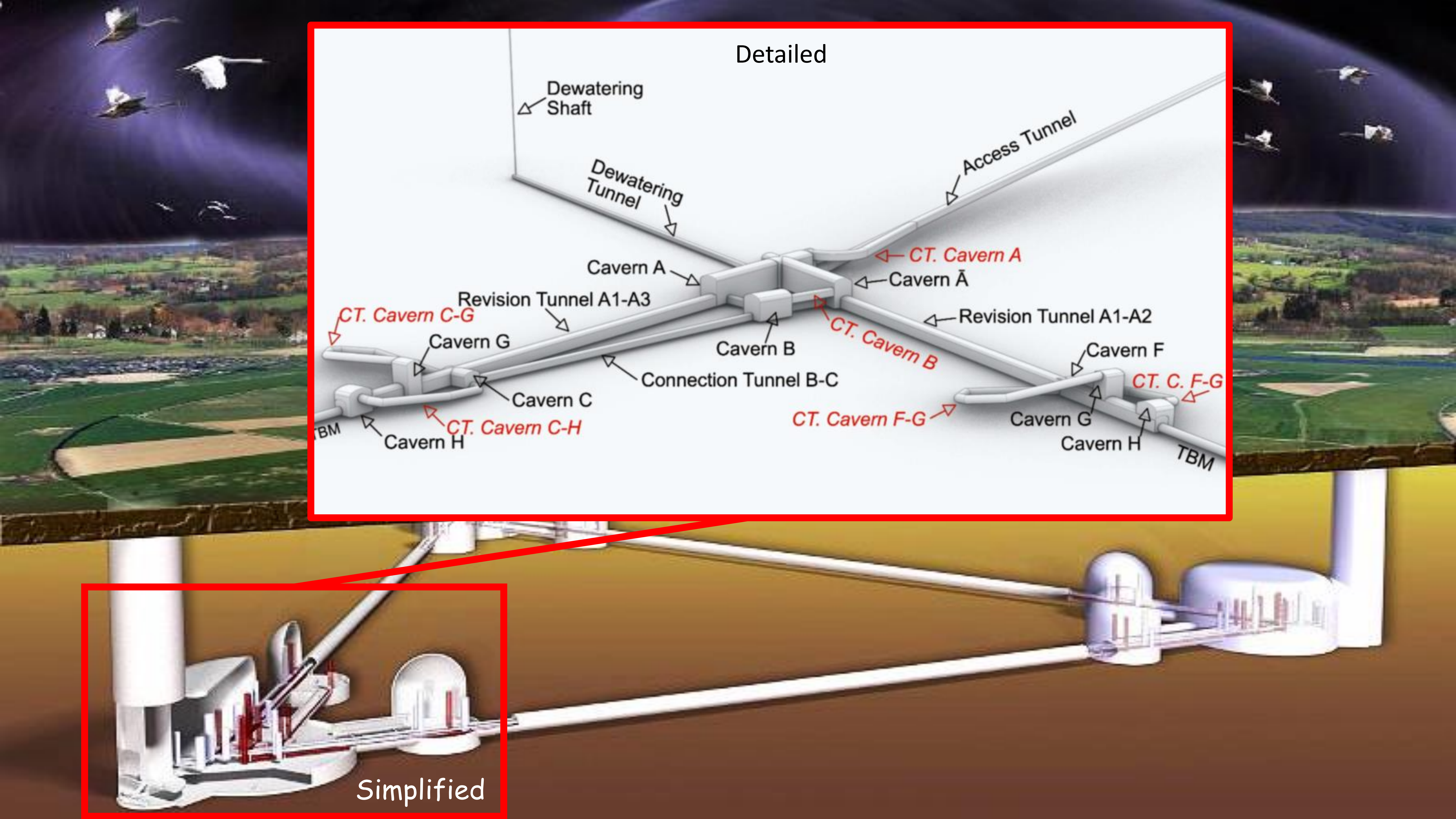
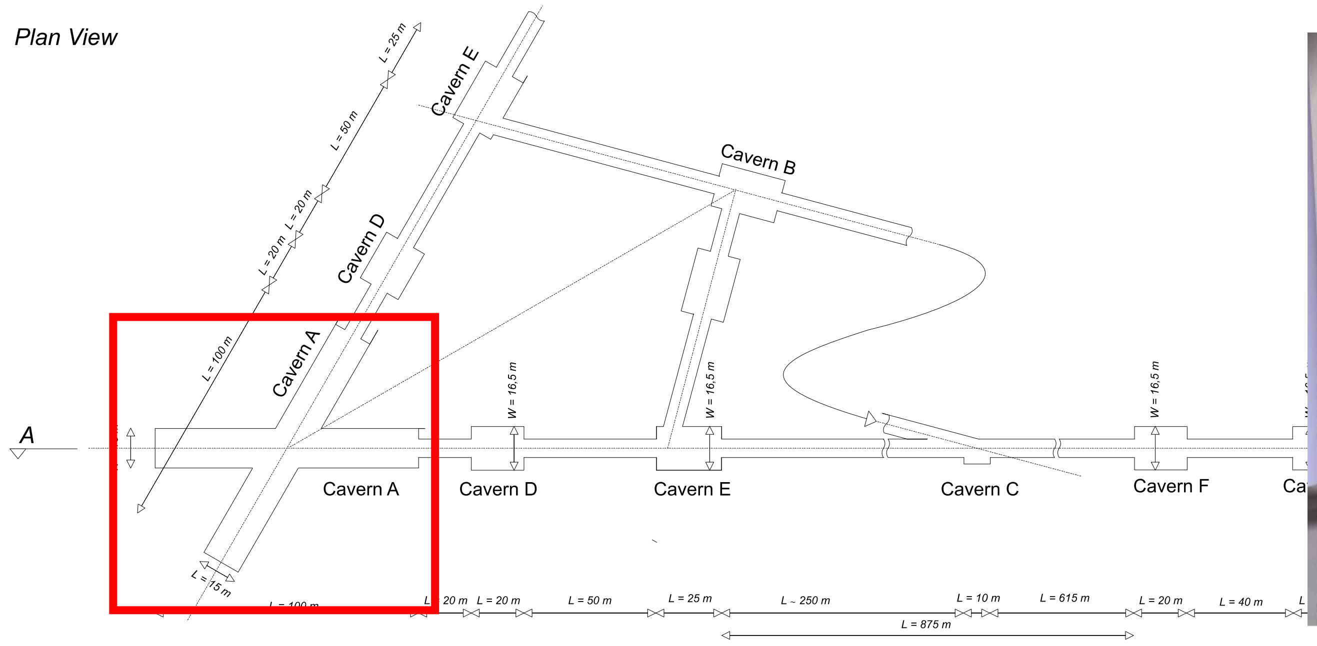
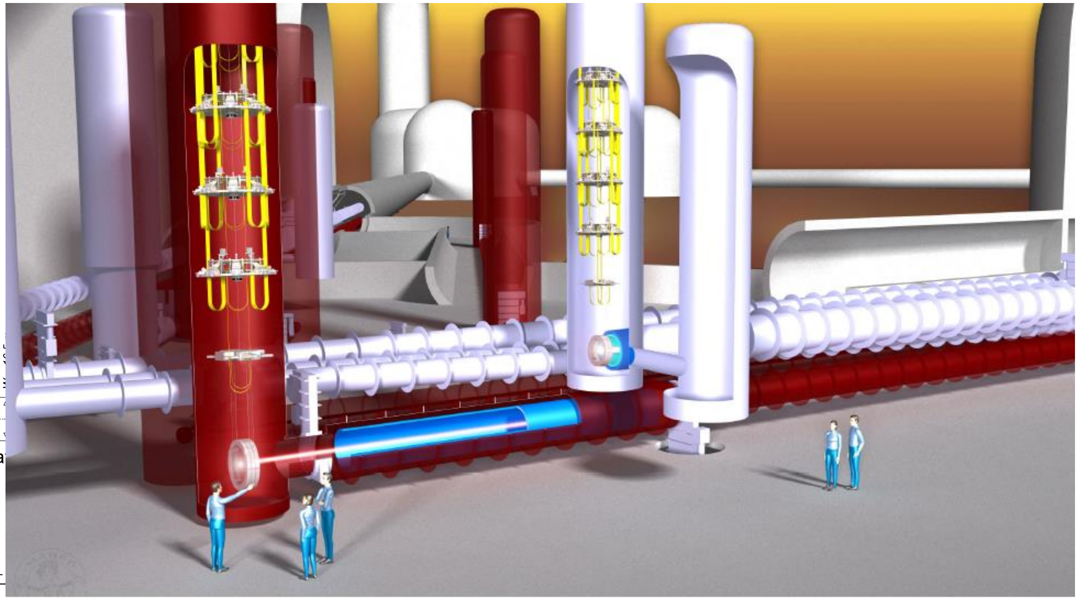


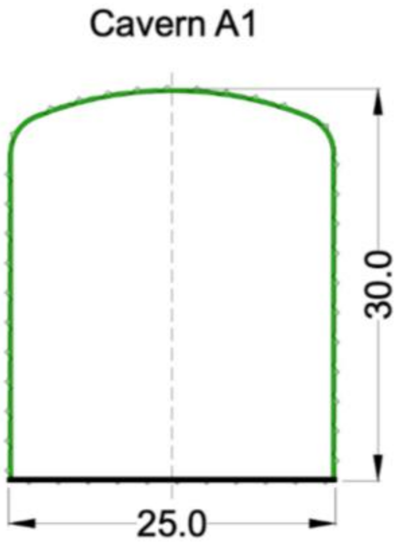
Photo Courtecy: NIKEF
Rhein-Maas-Region
10 km
10 km
10 km
Depth: ~200–300m


Detailed
Dewatering Shaft
Dewatering Tunnel
Access Tunnel
CT. Cavern A
Cavern A
Cavern Ā
Revision Tunnel A1-A3
CT. Cavern C-G
Cavern G
Cavern B
CT. Cavern B
Revision Tunnel A1-A2
Cavern F
CT. C. F-G
Connection Tunnel B-C
Cavern C
CT. Cavern C-H
Cavern H
TBM
CT. Cavern F-G
Cavern G
Cavern H
TBM
Simplified

Source: Einstein gravitational wave telescope – Conceptual Design Study

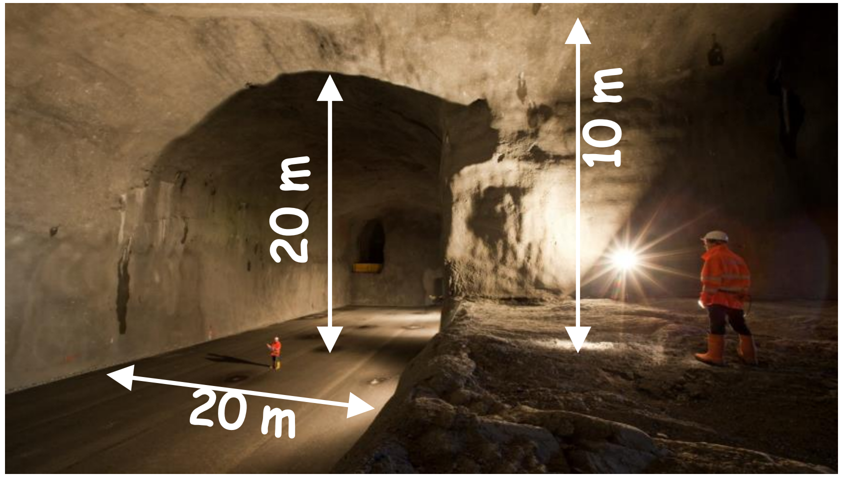






Main Caverns *("vertex stations") to host the cryogenic infrastructure and laser injection systems*

Height of 30 m required for main suspension systems + vacuum envelopes



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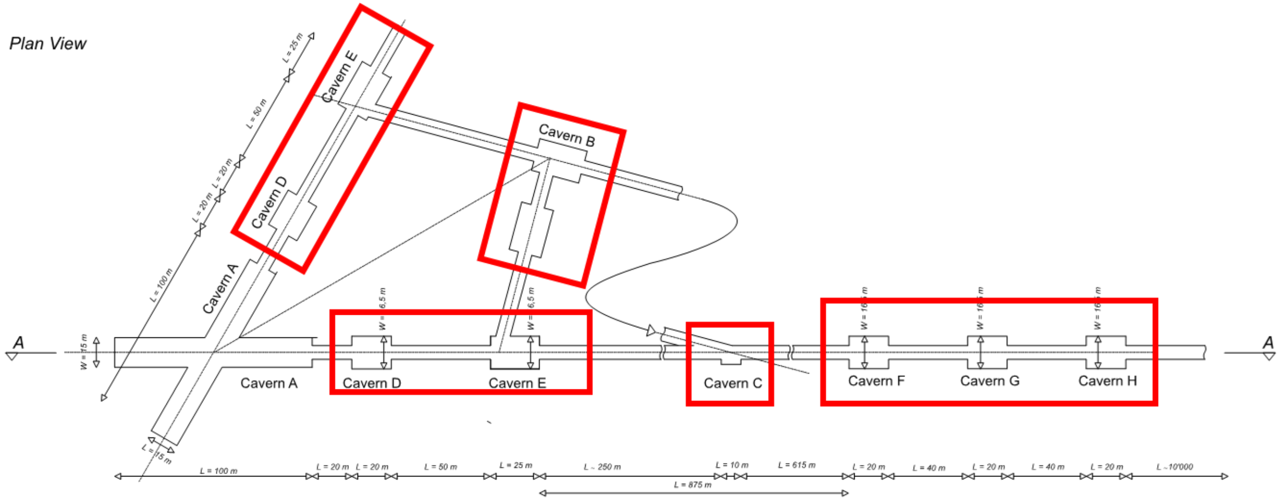
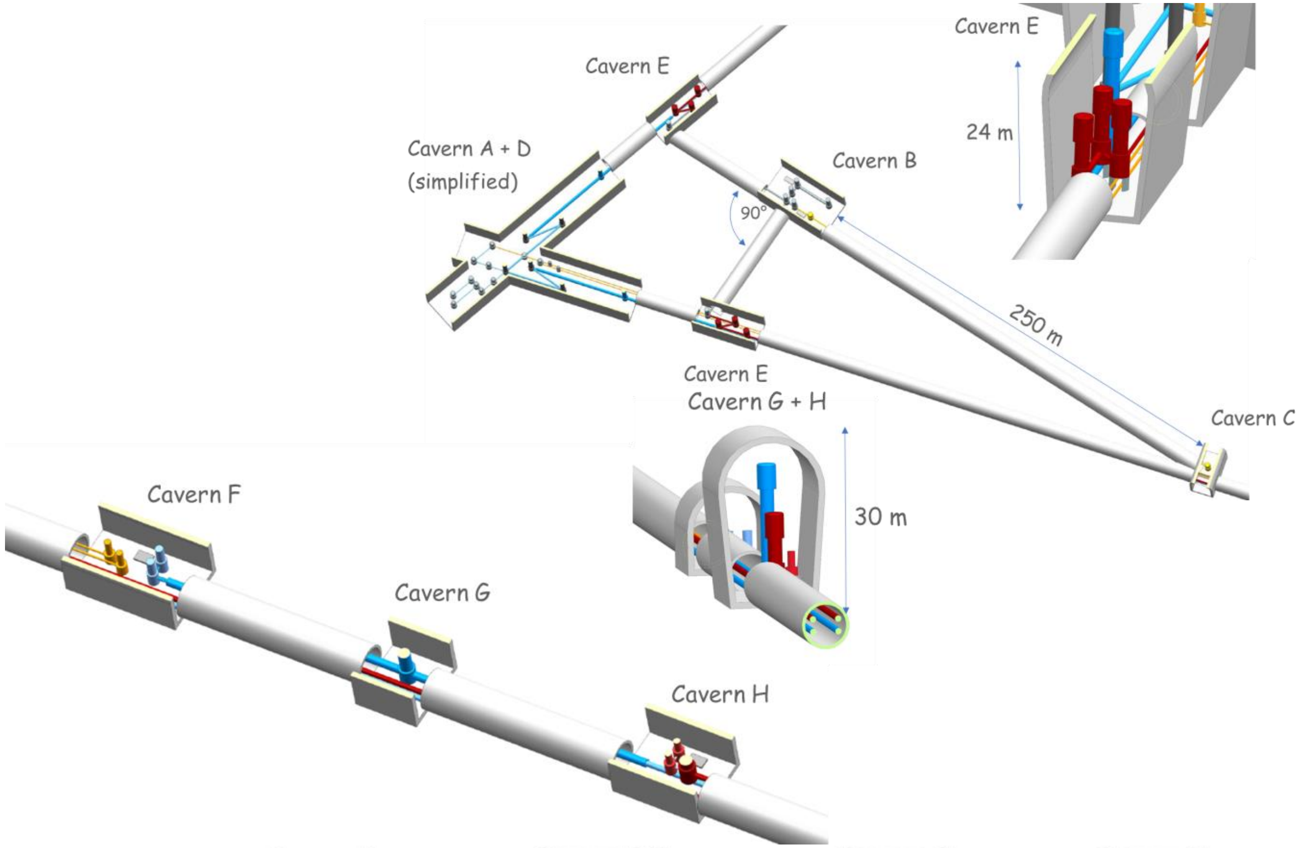
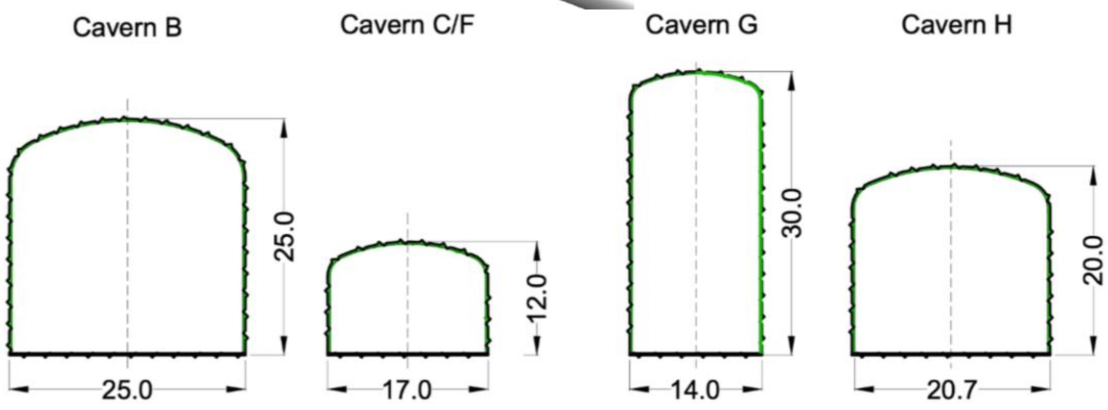
Source: Einstein gravitational wave telescope – Conceptual Design Study

Satellite Caverns *to host input test masses (low & high frequency) and vacuum vessels*

- *High frequency injection cavern (B)*
- *High frequency filter cavity cavern (C)*
- *Low frequency interferometer cavern (D)*
- *High frequency interferometer cavern (E)*
- *End of filter cavity (F)*
- *Low Frequency End-Test-Mass (G)*
- *High Frequency End-Test-Mass (H)*

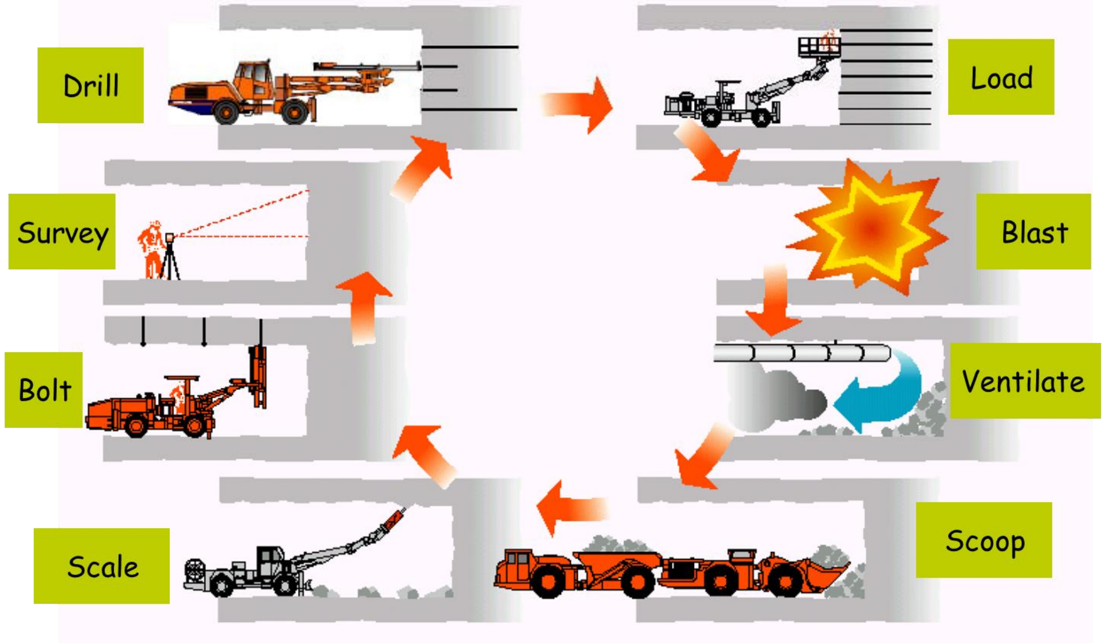


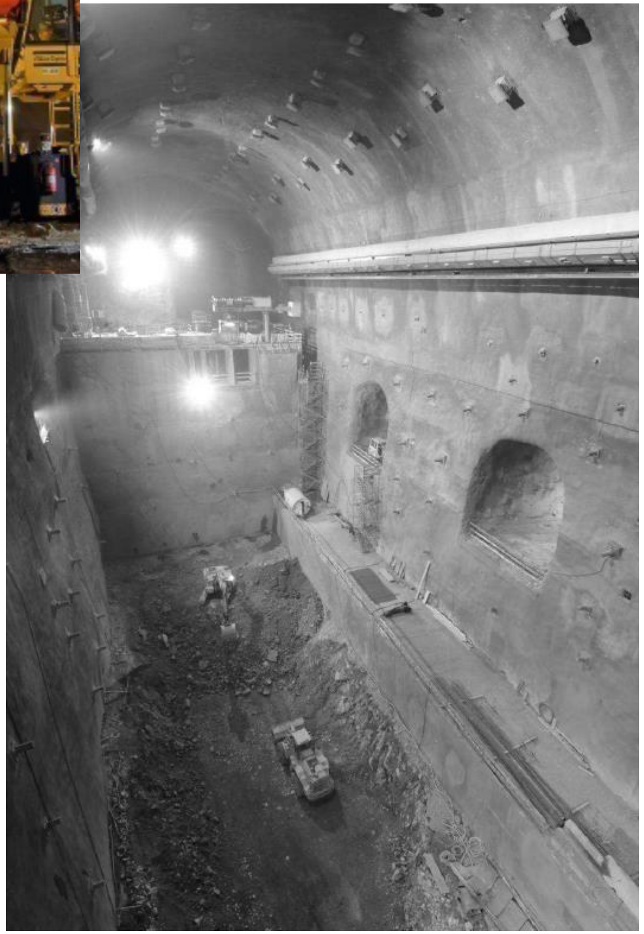




Caven Construction

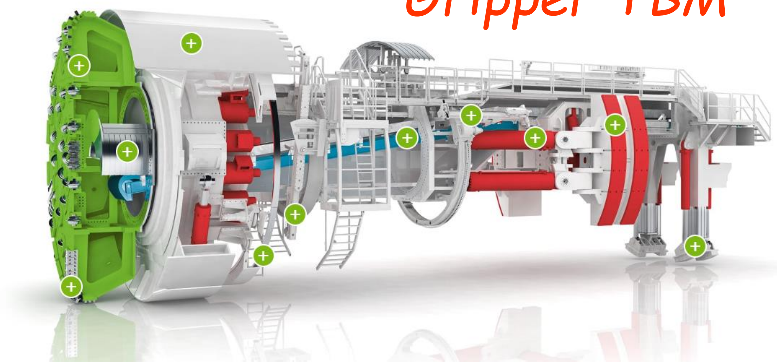
- *All caverns, tunnels and galleries in the vicinity of the access structures are excavated by Drill and Blast*

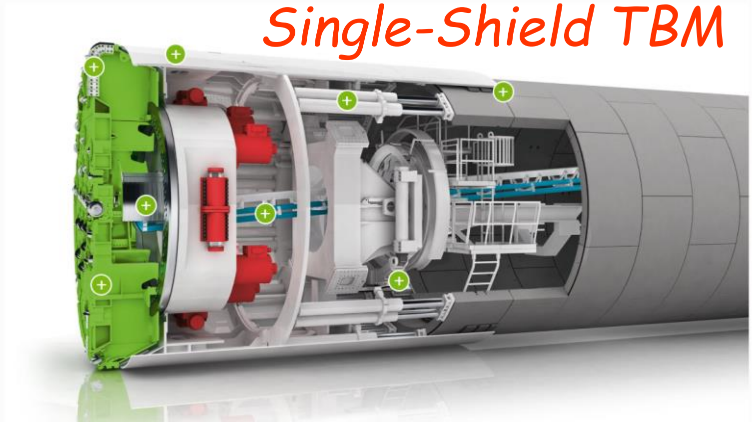




10 km Tunnels

- *Internal clearance profile of $Ø_{int}$ = 6.5 m (vacuum lines)*
- *TBM-O → 30 cm of shotcrete*
  - *more prone to water inflow (local measures possible)*
  - *Possible post excavation grading*
  - *$Ø_{exc}$ = 7.3 m (→ 1.3 mill. m³ excavated material)*
- *TBM-S/DS → 30 cm concrete lining*
  - *„watertight“ lining*
  - *Bigger deviation range*
  - *$Ø_{exc}$ = 8.4 m (→ + 400.000 m³ excavated material)*
- *Choice between 2 & 3 parallel working TBMs (cost & time)*





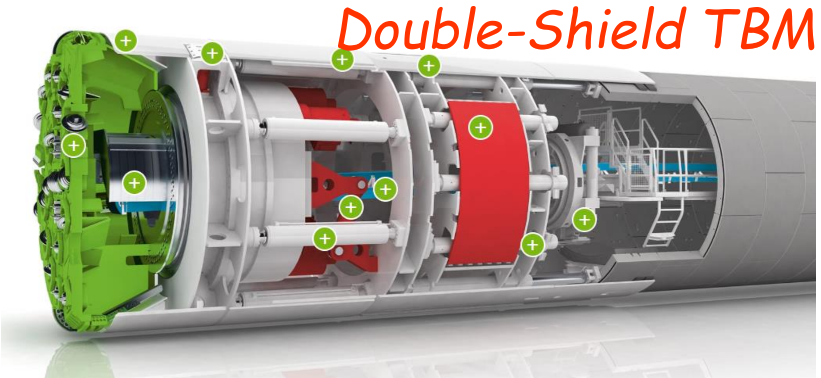


Photo Courtesy: Herrenknecht AG

Tunnel with Segmented Lining

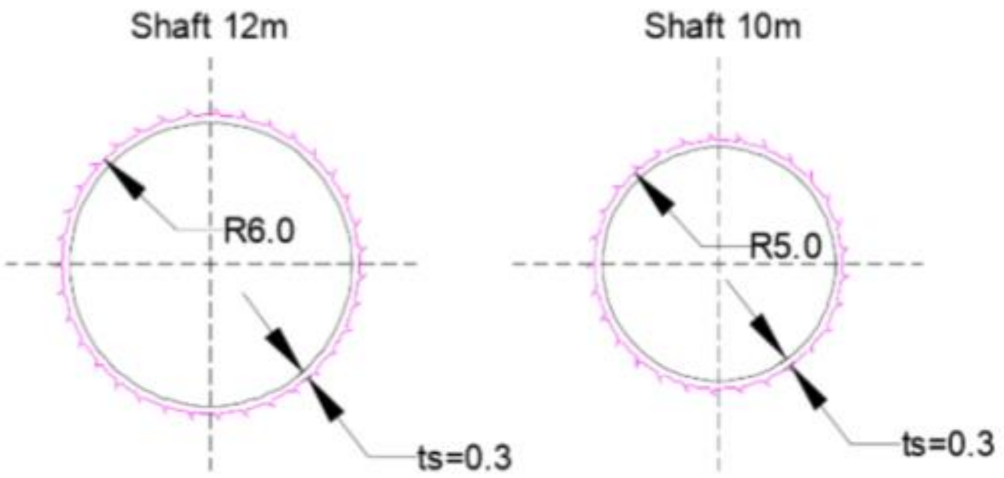
Shotcrete Lined Tunnel

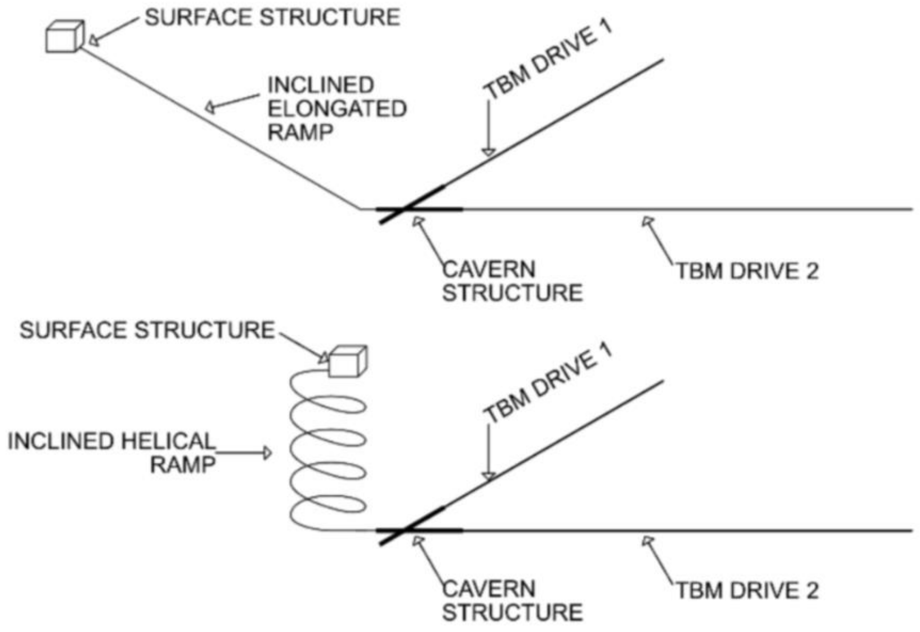
Courtecy: Implenia AG

Courtecy: Implenia AG

Shafts

- *Requirements:*
    - *Main items for laboratory equipment simplified as pill shaped (5.5 length; Ø 4m)*
    - *Vacuum pipes (20 m long; Ø 1.4 m)*
    - *Lowering parts of TBM (Ø 12 m → without TBM Ø 10 m)*
- *Inclined (10% grade → 2500 m length + safety areas) or vertical (250 m down)*
- *Decision making on the best practice for the access area depends on environmental, logistical (linking roads), geological/-hydrogeological aspects.*





Shafts

- *Conventional shaft sinking sources on a cycle of blasting, skip based mucking of the excavation material and immediate lining of the shaft.*
- *Due to the installation of various guiding rails and transportation pipes and the ventilation system, a prefabricated segmental lining is recommended in favor of a shotcrete lining system.*

Courtecy: Implenia AG

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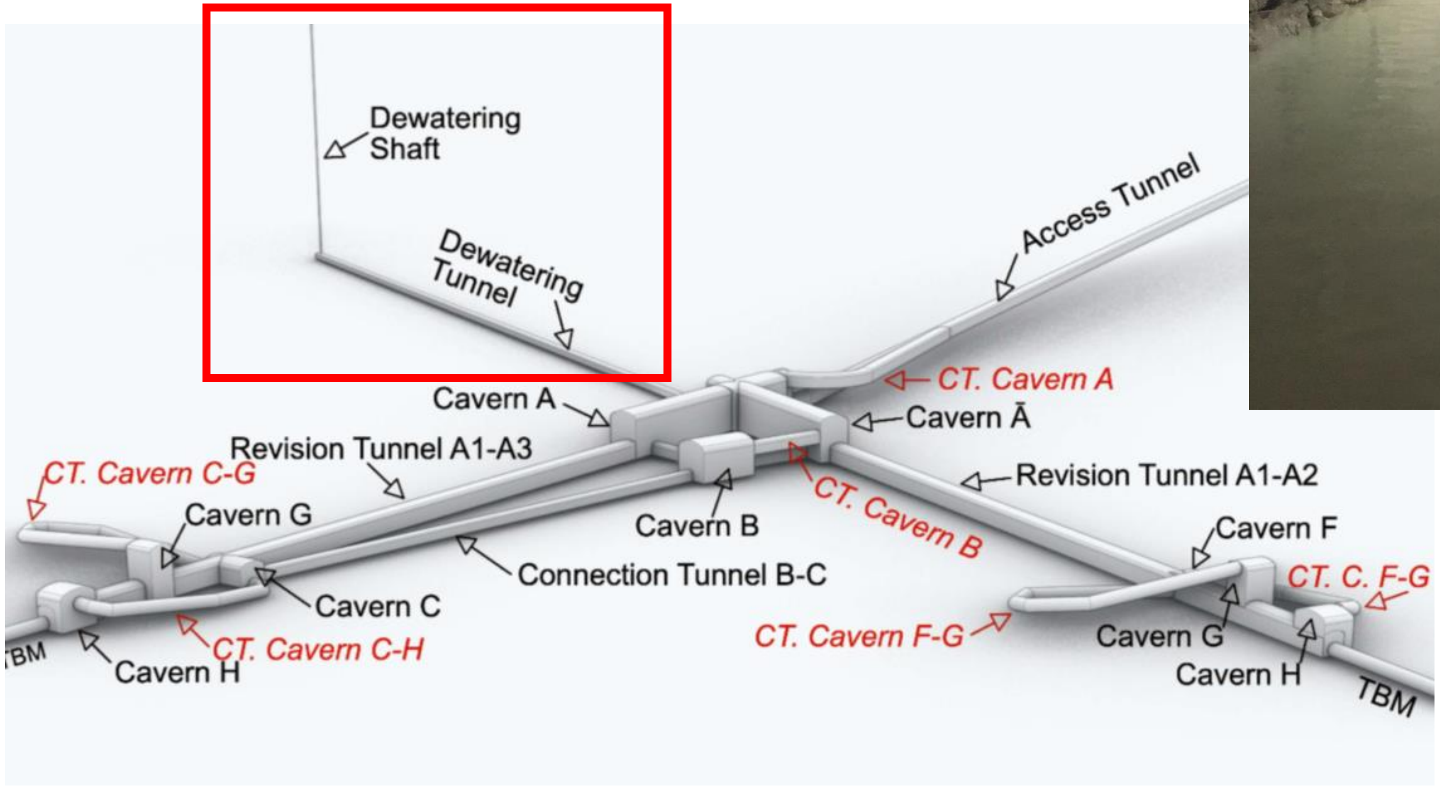
Dewatering



- *Distant to the caverns due to noise*
- *Adapted to tolerable water ingress*

Surface installations

- *Mandatory for Shaft Hoisting and Winding*
- *Protection of the underground facilities from environmental influences*
- *Construction surface space requirement:*
  - *5000 m² Main offices*
  - *2000 m² Small offices*
  - *40000 m² Site facilities*
  - *3000 m² Water treatment*
  - *10000 m² Accommodation*
  - *3000 m² Segmental lining storage*

Courtecy: Implenia AG

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Courtesy: https://www.bbt-se.com

Further considerations

- *Ventilation concept for every stage of construction*
- *Strategy for excavated material (2.6–3.6 Mio. m³), reusability of excavated material for concrete, lining…*
- *Power demand*
- *Environmental aspects related to dust, vibrations and noise, groundwater and water usage and reuse*
- *Minimizing impact using rail-based transport*
- *Noise control related blasting*
- *Water treatment plant*

Courtesy: https://www.tecnitude.com/

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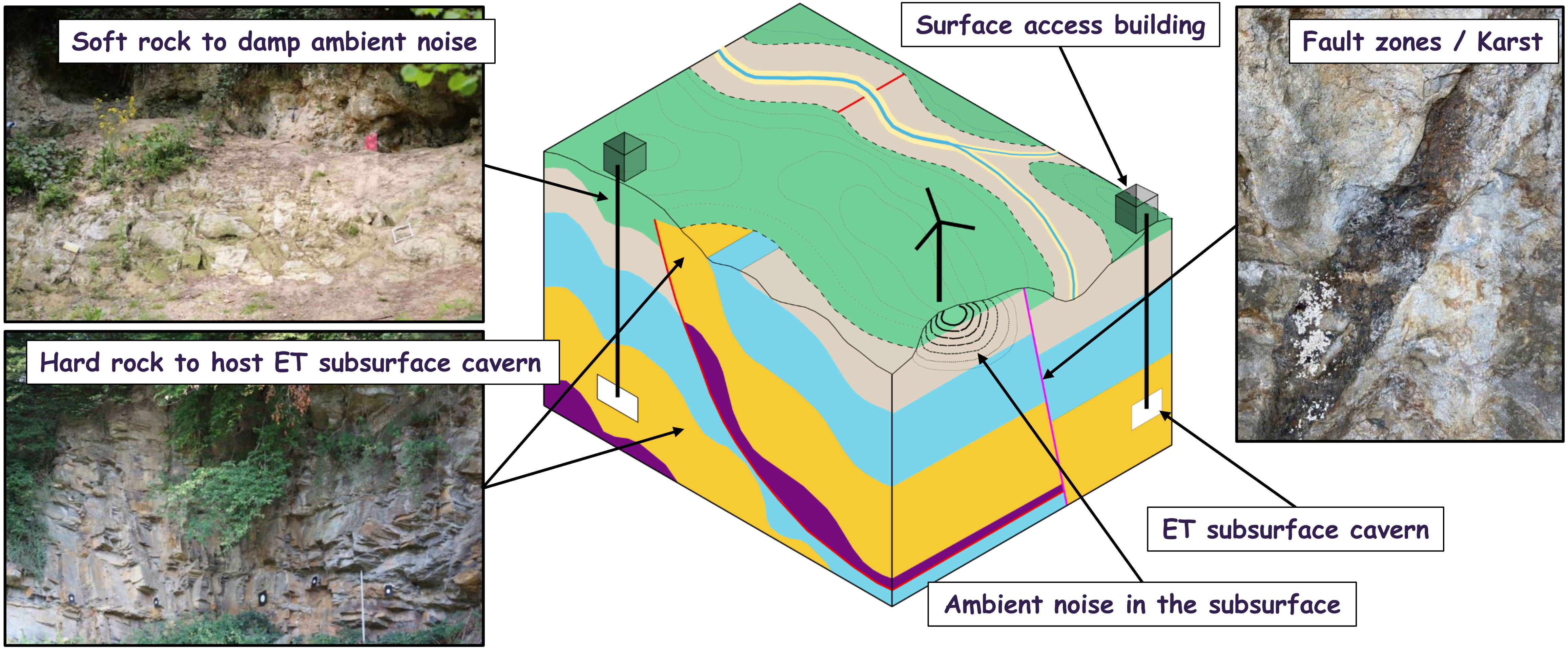
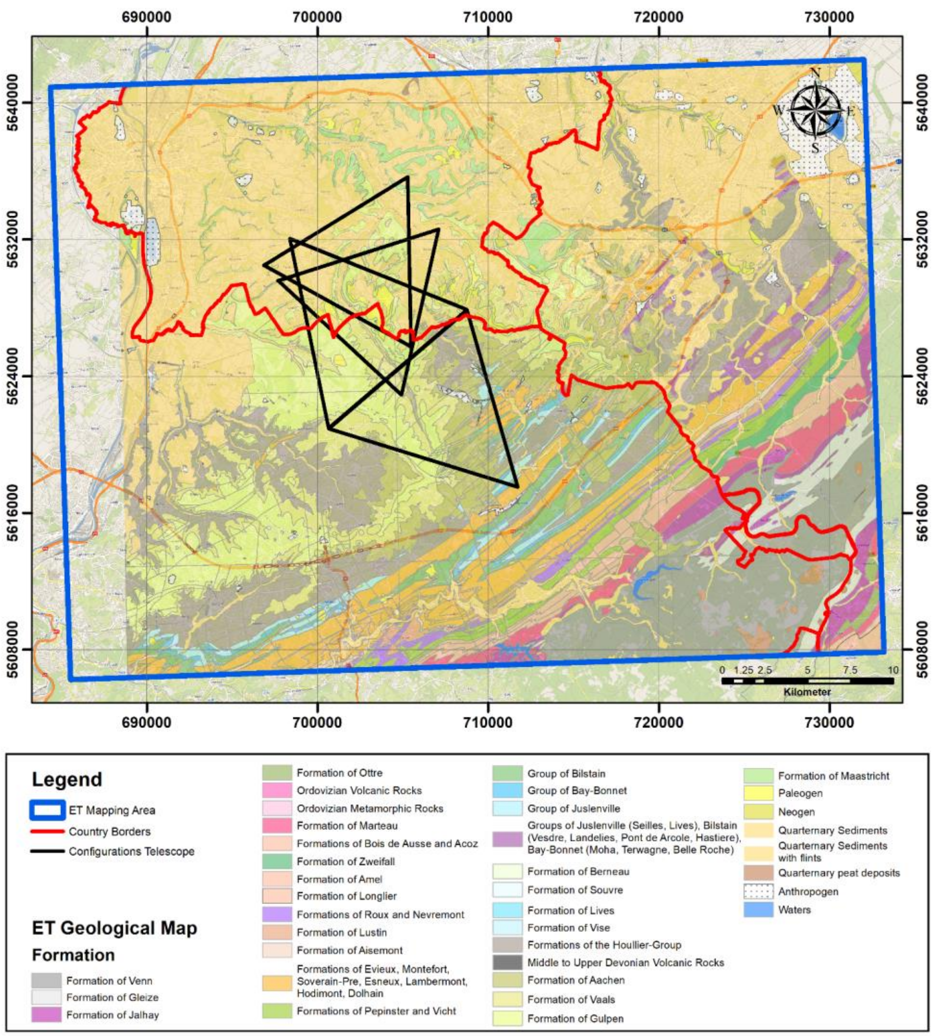
ET Tunnel in “EMR” Region

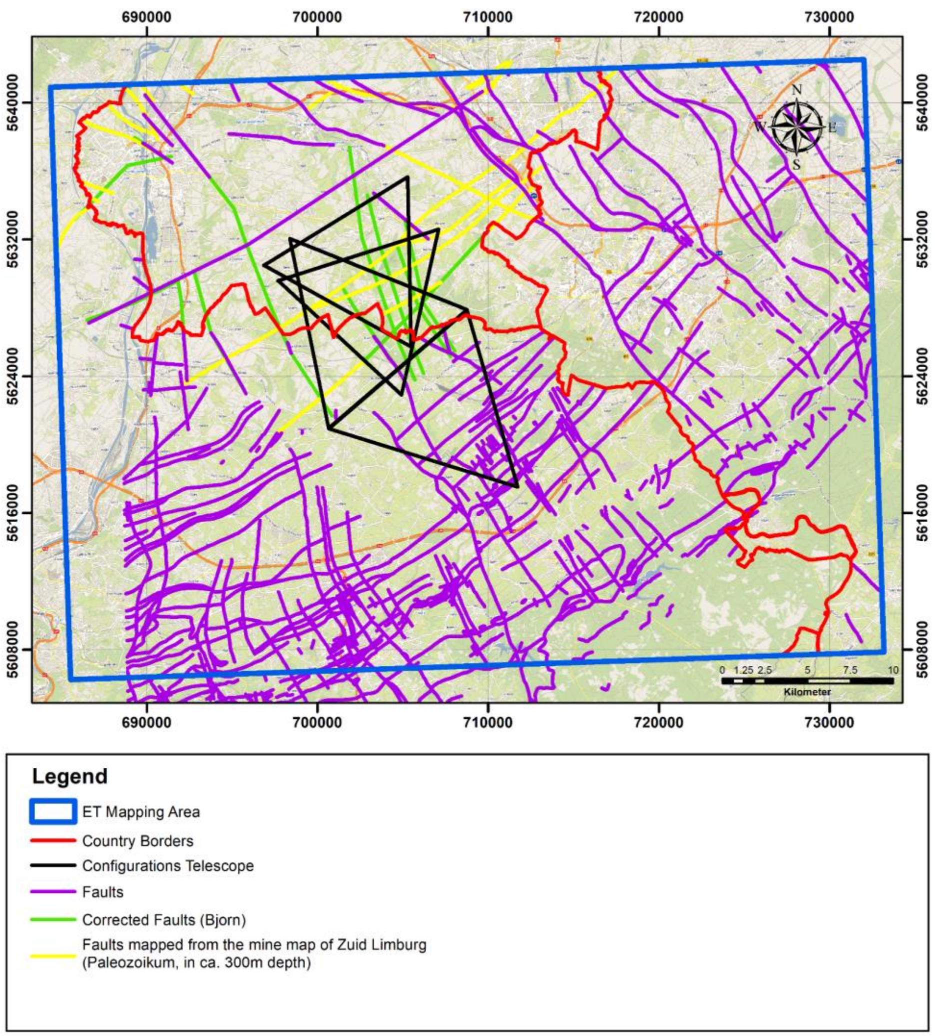
Boundary Conditions



Boundary Conditions



Geological Conditions



Large Fault Structures

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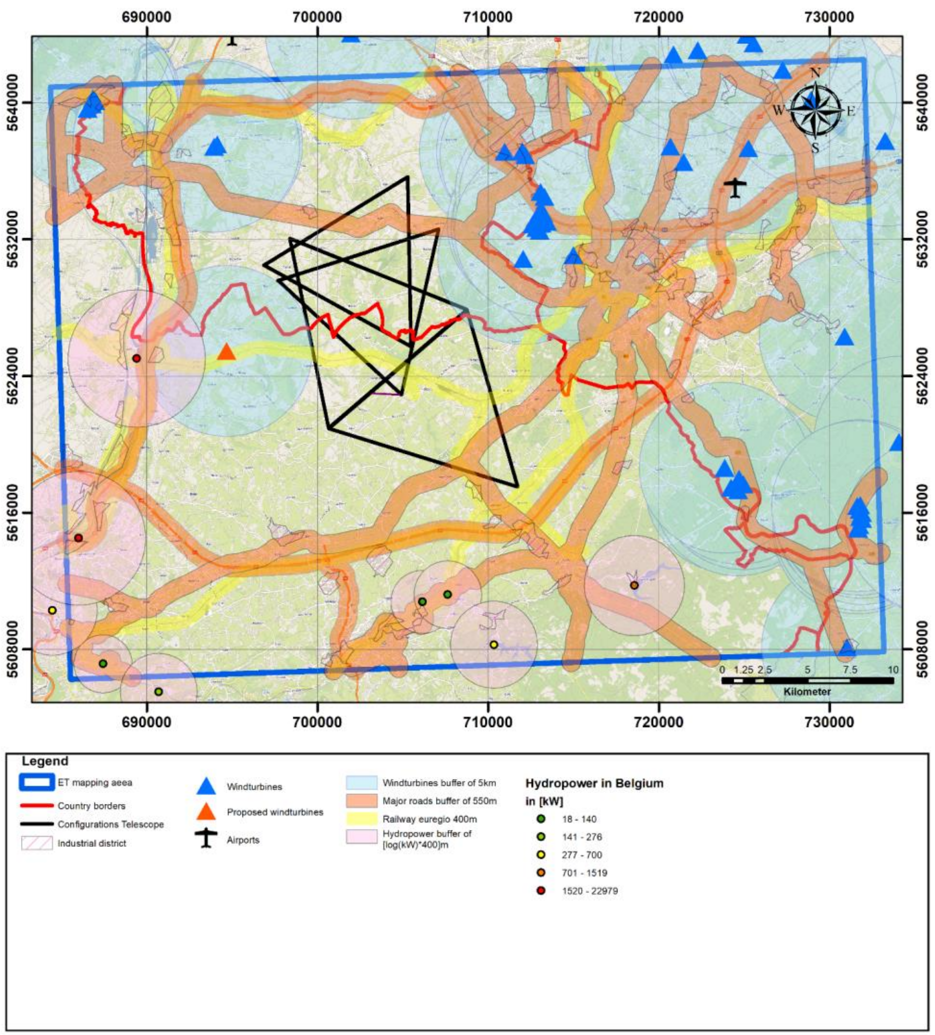
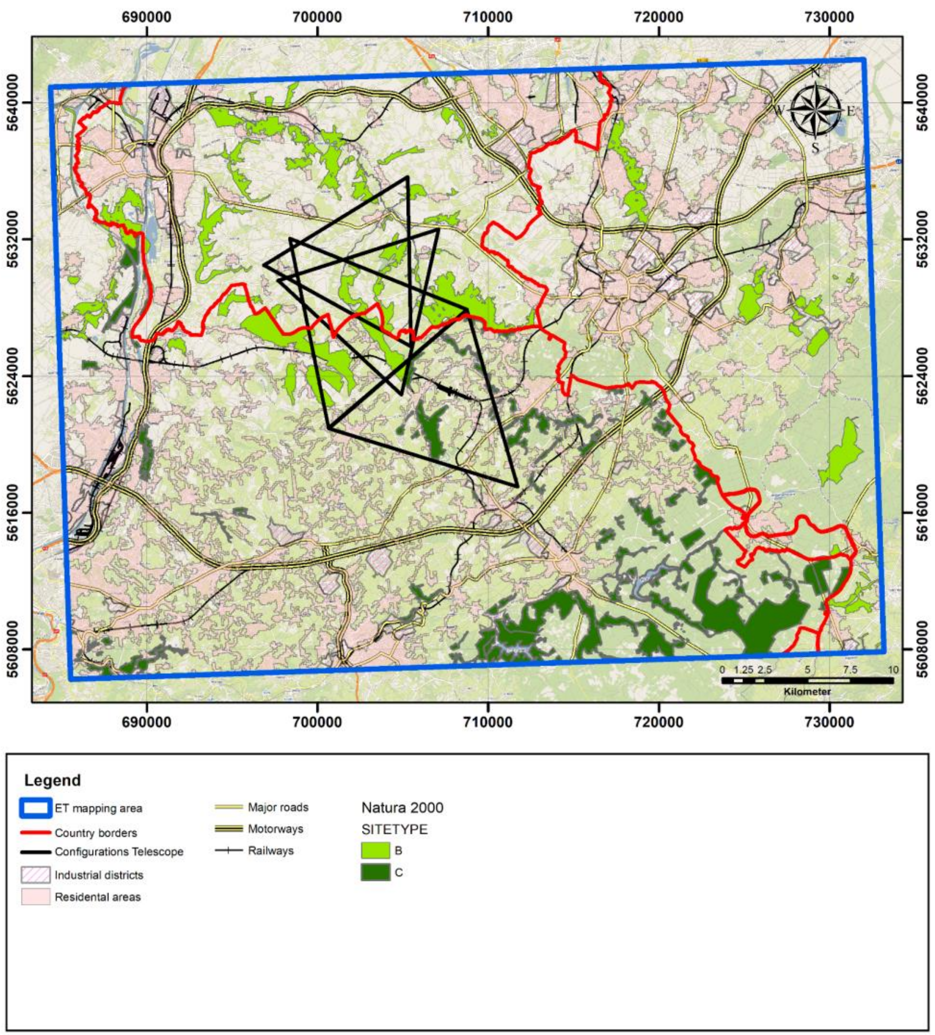
Boundary Conditions

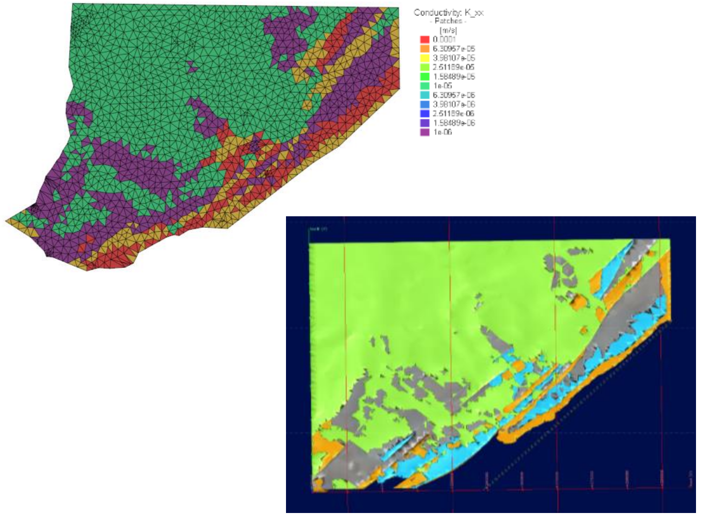


Ambient Noise



Landuse (Natura 2000, Industrial Area etc.)

HYDROGEOLOGY



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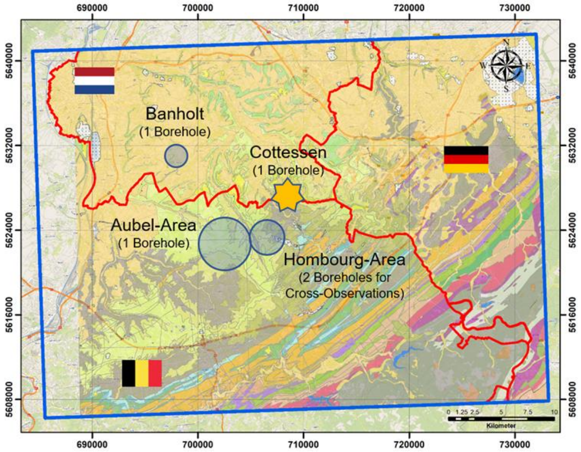
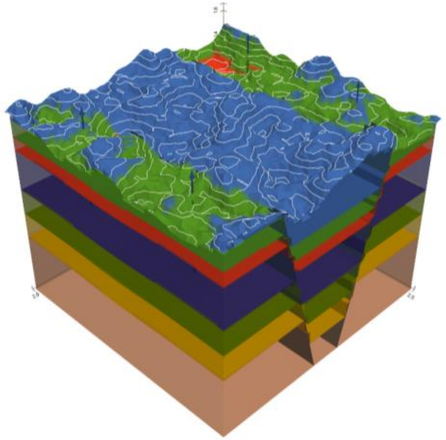
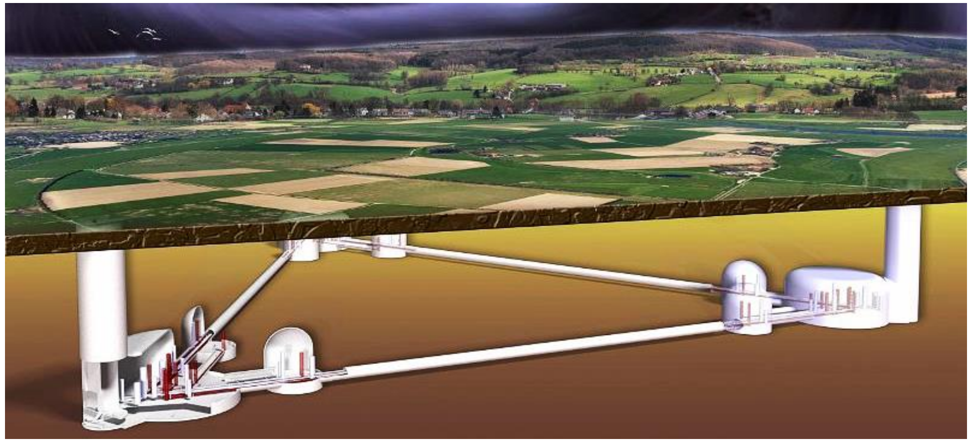
IN-SITU & LAB TESTING



GEOLOGICAL & STRUCTURAL MODELLING



ET TUNNEL DESIGN



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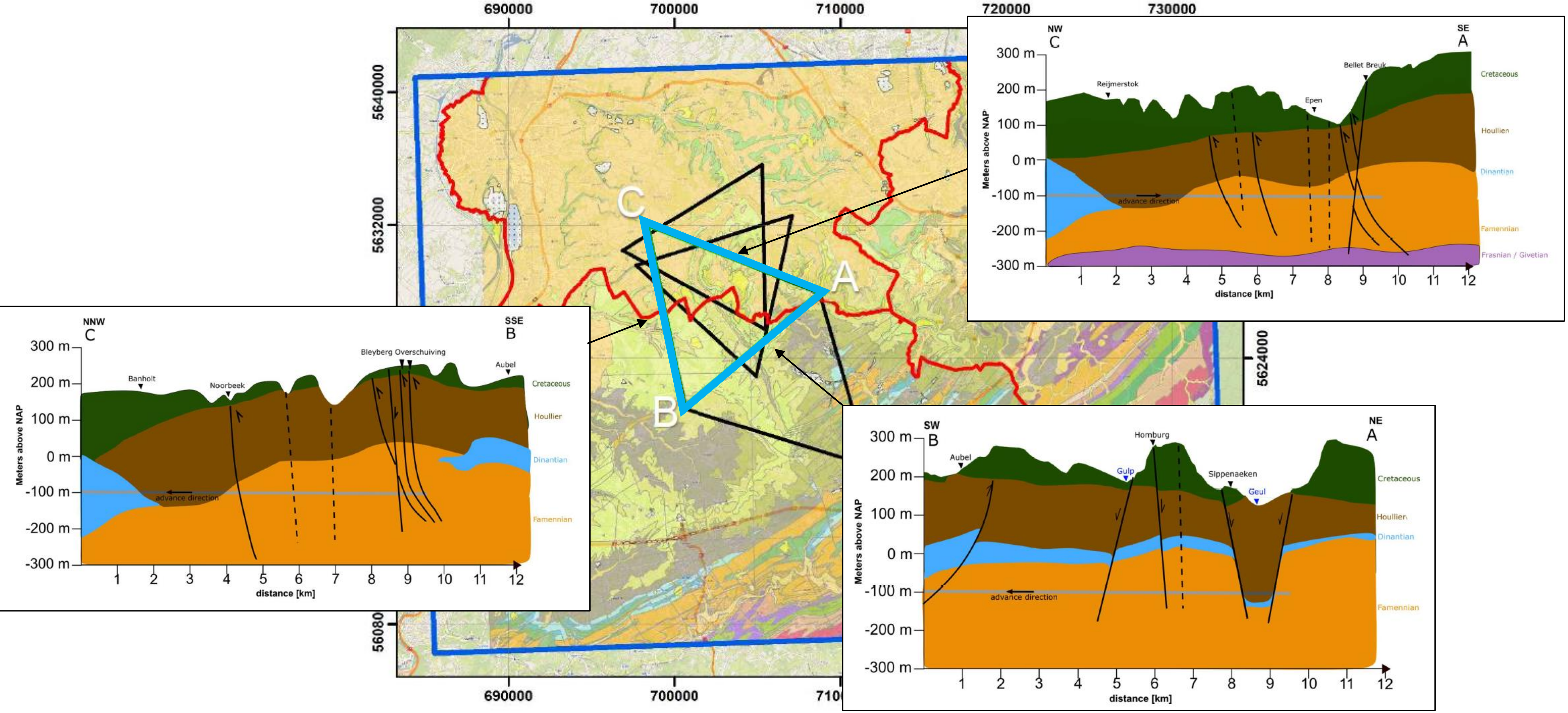
Ground Behaviour Prediction for ET Tunnel



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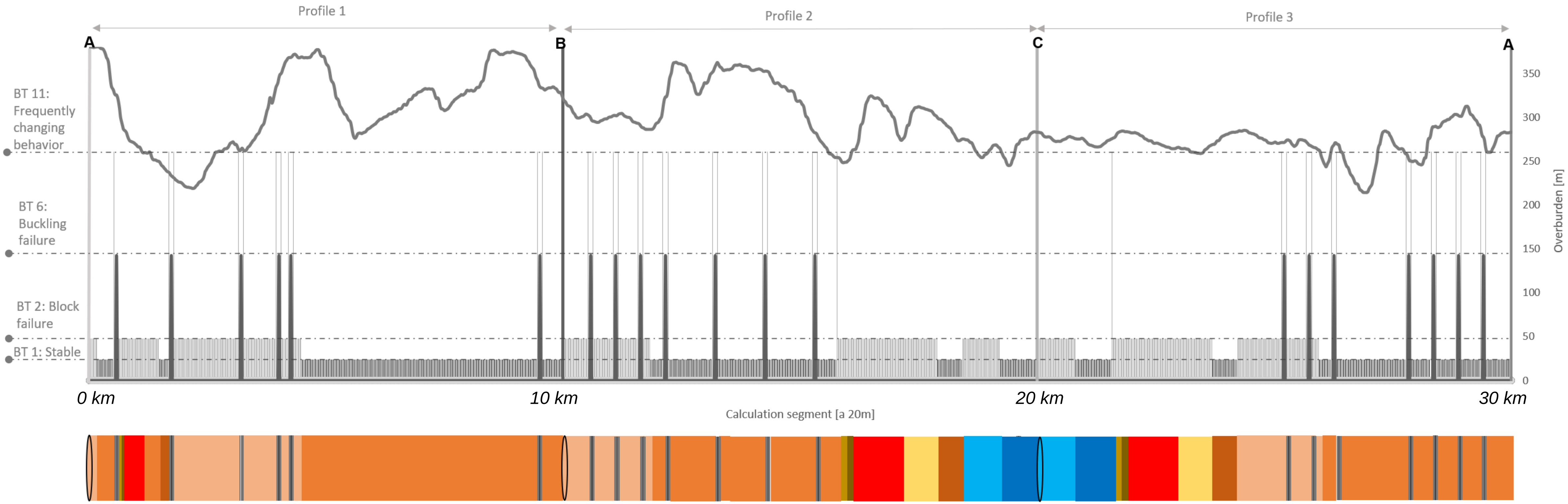
Ground Behaviour Prediction for ET Tunnel Construction



Legend- Tunnel:

Fam_1	Westphal_1	Namur_3
Fam_2	Westphal_2	Dinant_1
Fault_fair	Namur_1	Dinant_2
Fault_center	Namur_2	

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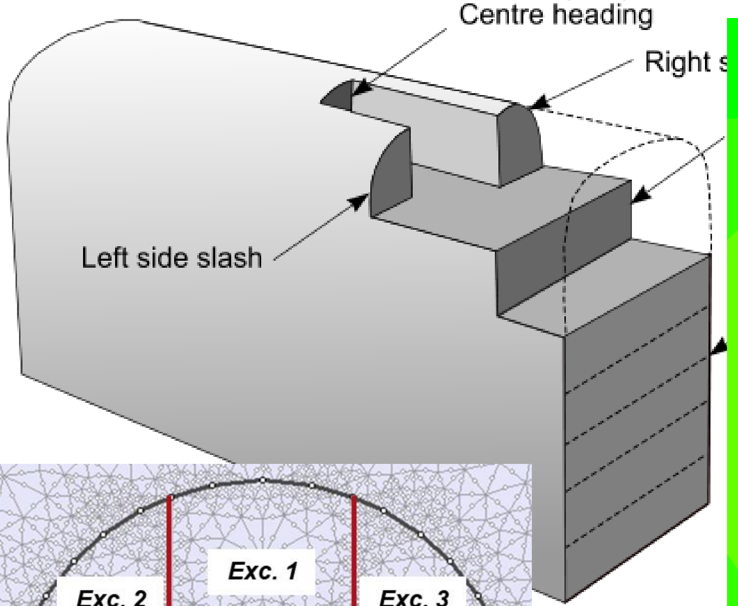
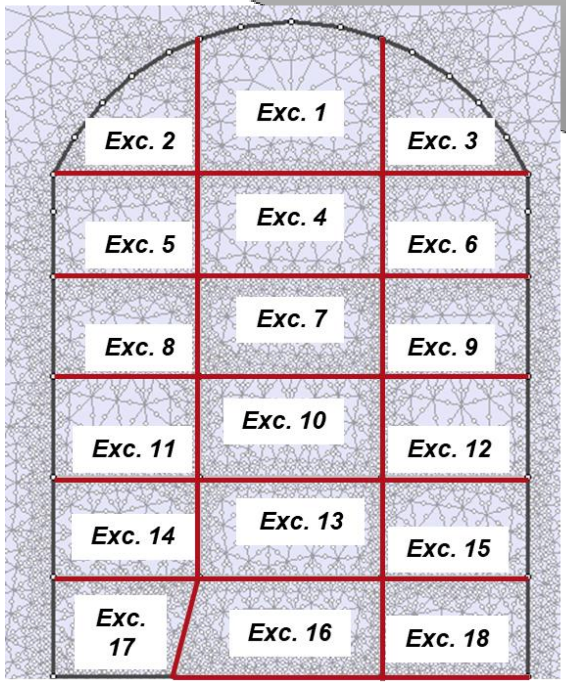
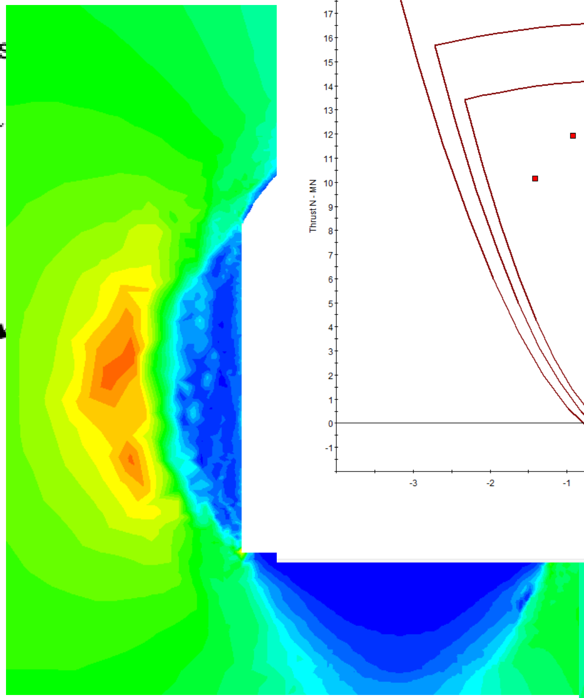
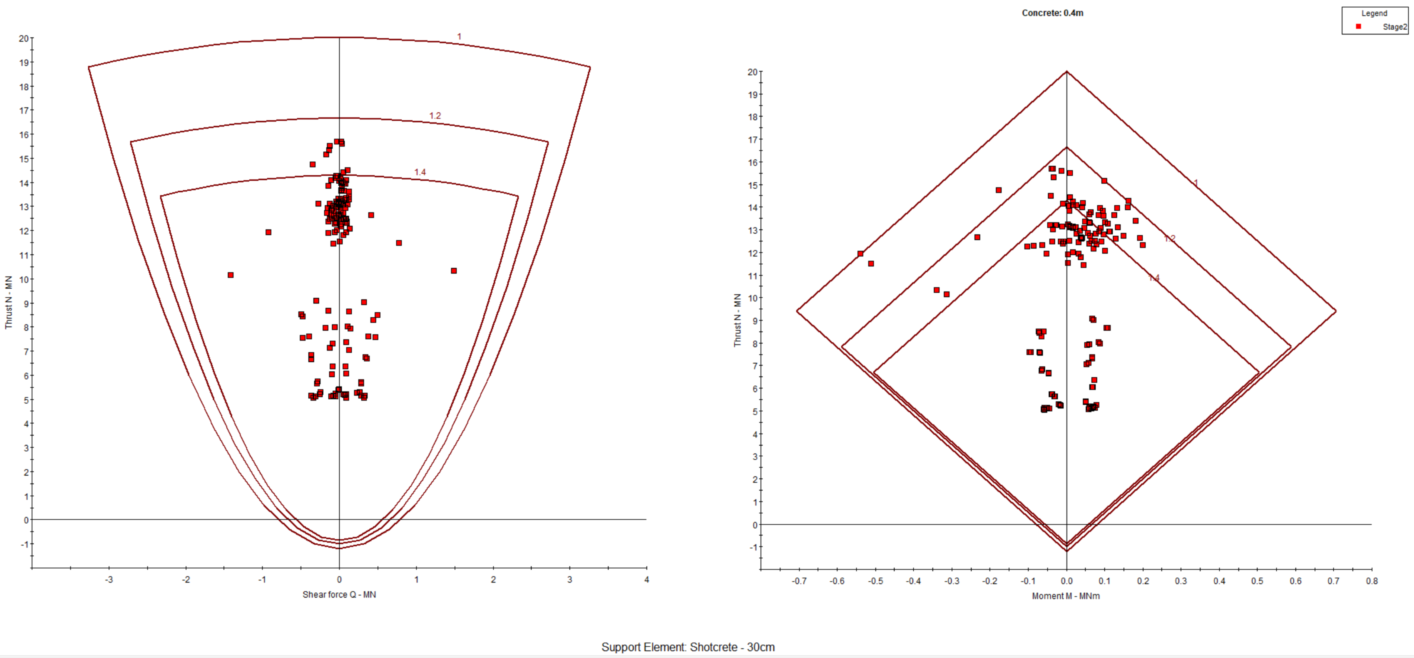
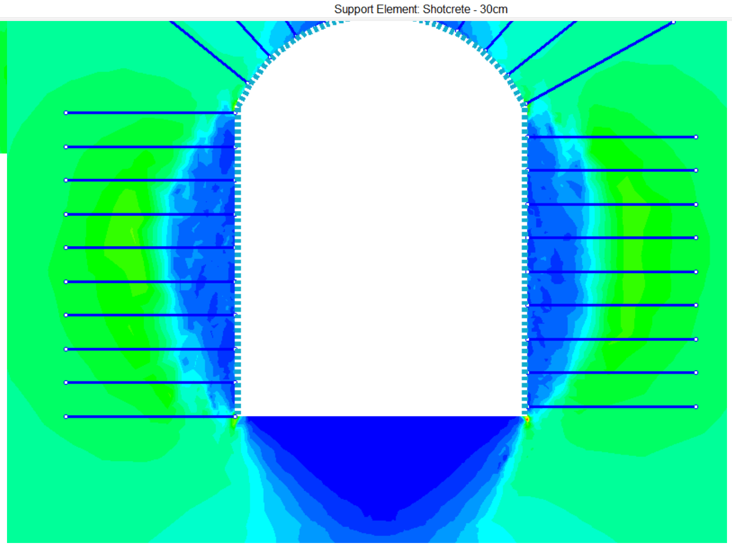
Cavern Support Desi



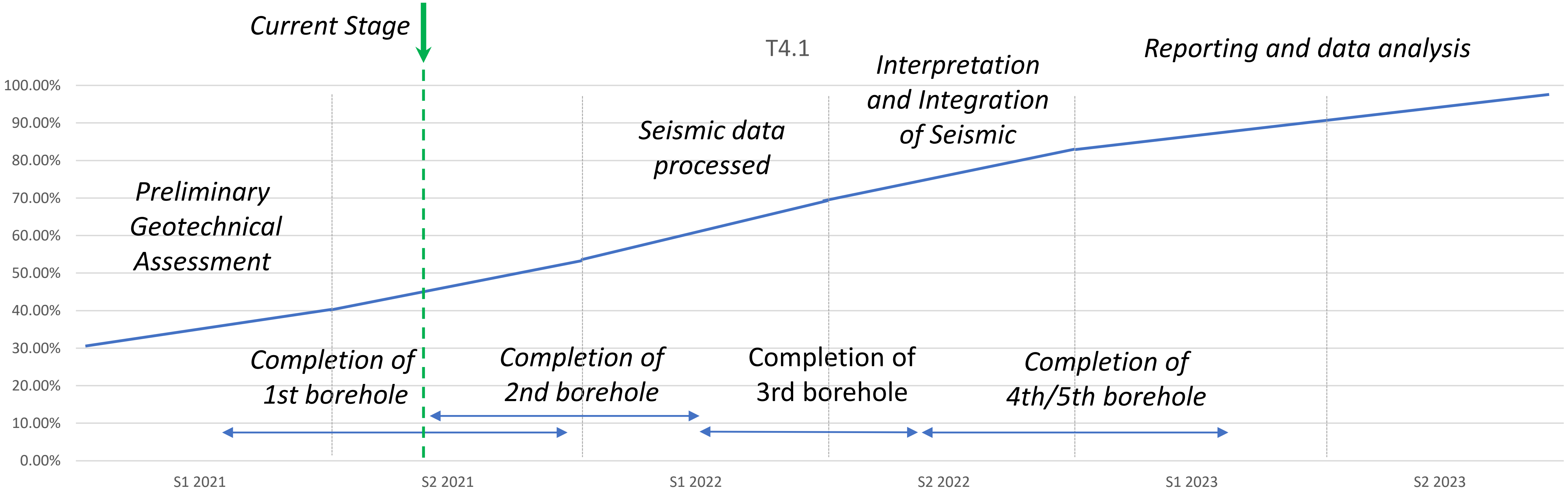




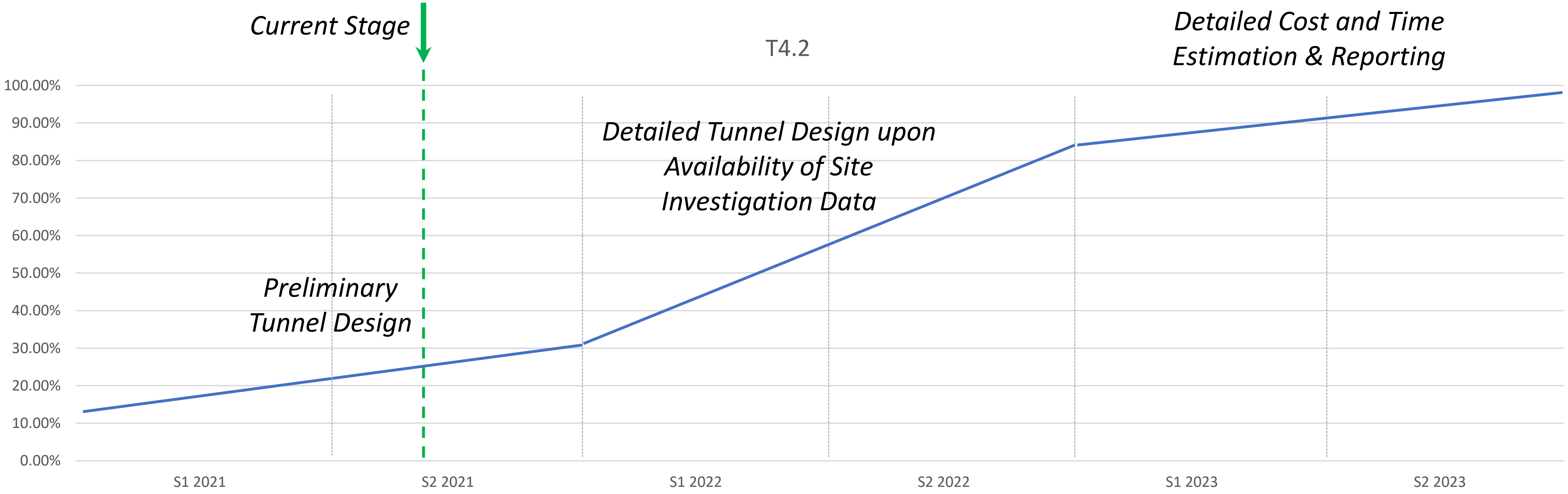




Forecast – Site Investigation



Forecast – Final Optimization & Tunnel Design



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