COMITÉ FRANÇAIS DE MÉCANIQUE
DES SOLS ET DE GÉOTECHNIQUE

LA CONGÉLATION _
ARTIFICIAL FREEZING OF SOILS, *IN CIVIL ENGINEERING*

Complex AGF measure near to the Spree Canal in Berlin – directional drilling, freezing and holistic thermal assessment

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Complex Artificial Ground Freezing measure near to the Spree Canal in Berlin – directional drilling, freezing and holistic thermal assessment

Dipl.-Ing. Joachim Meier, Implenia Special Foundations, Technical Competence Center, Mannheim, Germany

Christian Leible, Implenia Special Foundations, Measurement Technique Division, Mannheim, Germany

Tobias Meschenmoser, Implenia Travaux publics - Fondations Spéciales, Echandens, Suisse

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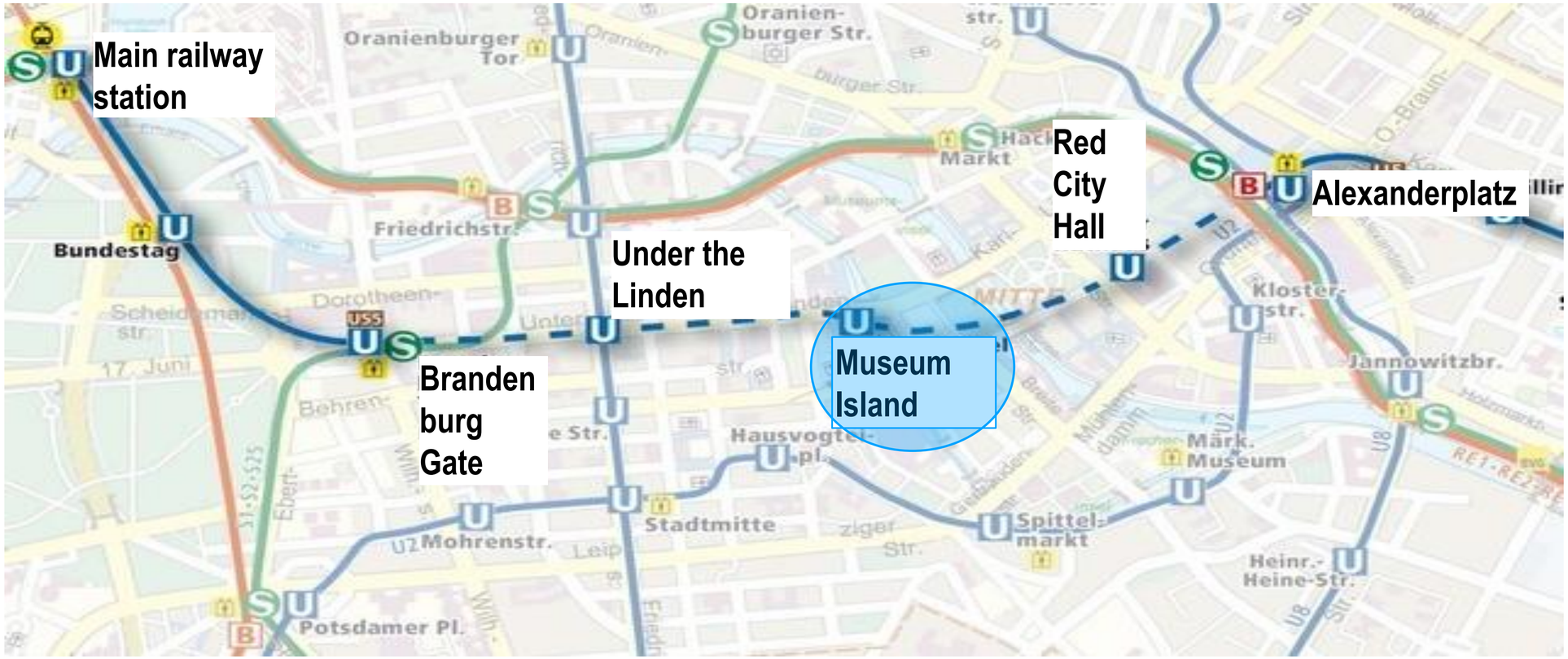
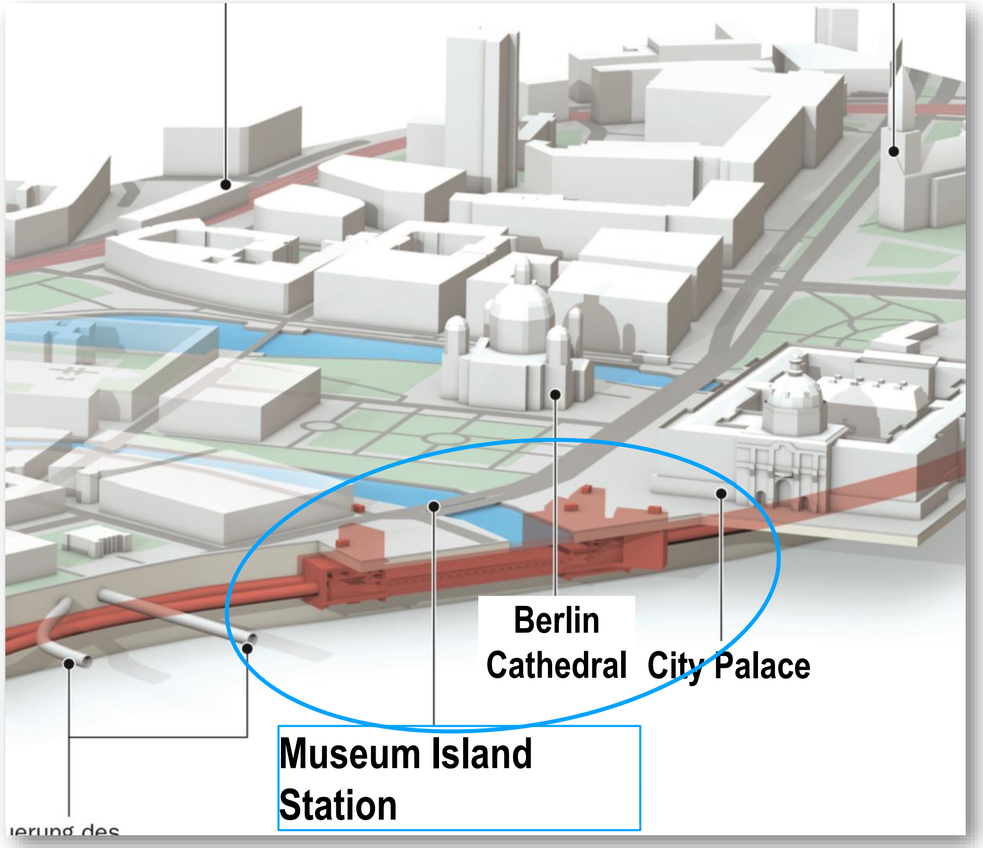
Project overview

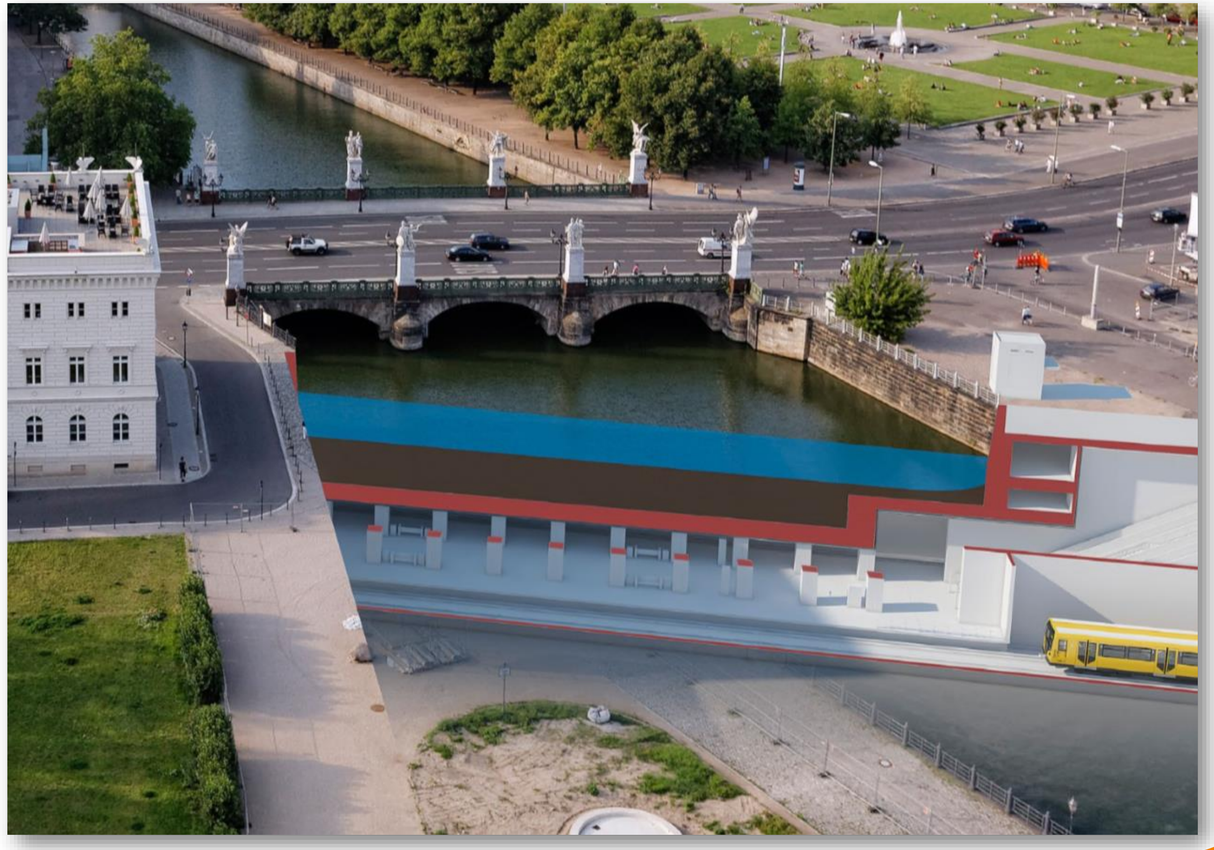
The U5.
For more togetherness.



Project overview

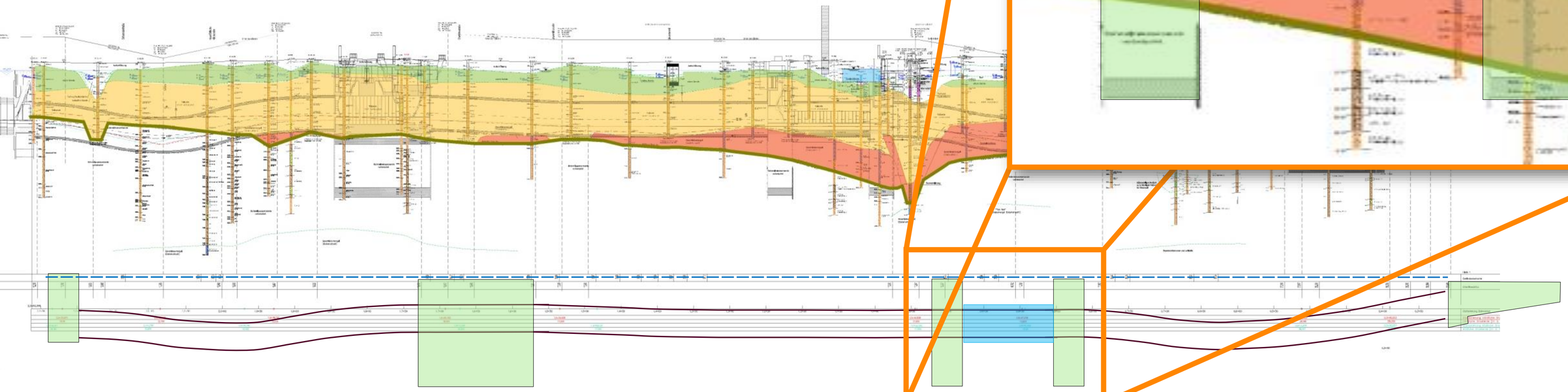
Location in the midst of valuable building fabric





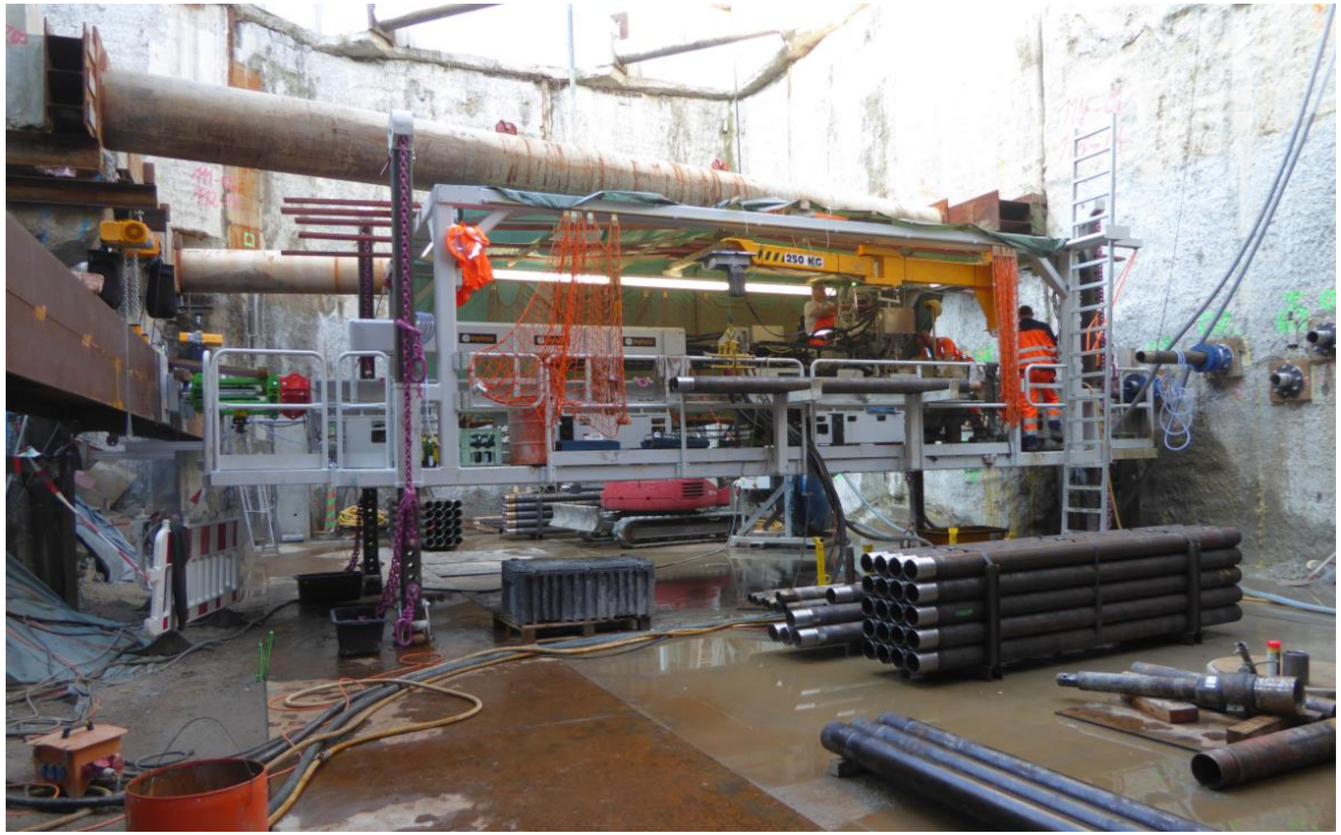
Geology

- Infill
- Sands of the Berlin glacial valley
- Glacial marley till
- Glacially preloaded meltwater sands



Freeze-Pipe Installation

Especially developed rig for accurate horizontal directional drilling over the whole cross-section



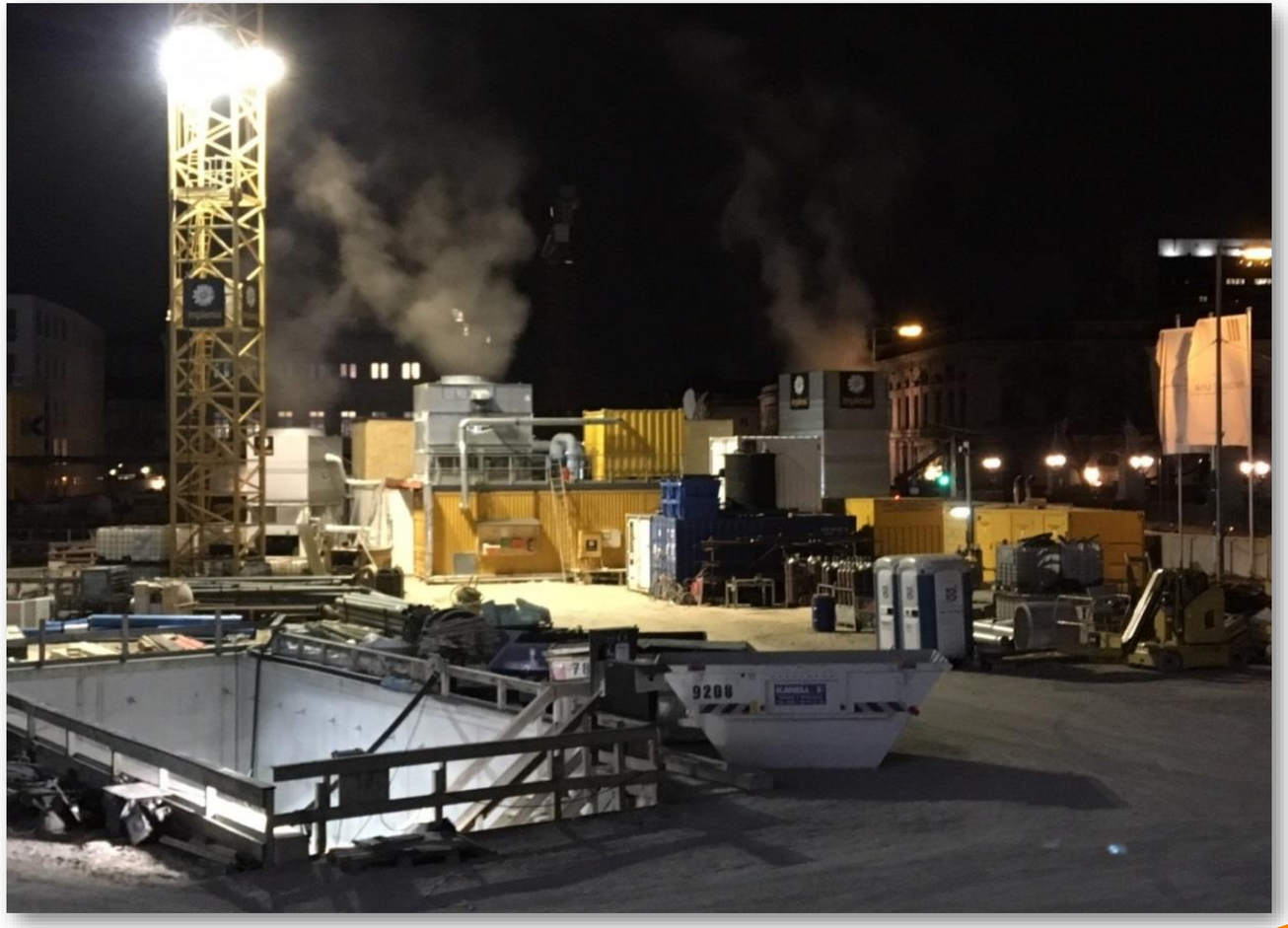
Freeze-Pipe Installation

New inertial steering probe for MWD-drilling with outstanding long-term-accuracy

Freeze-tunneling in Berlin sands

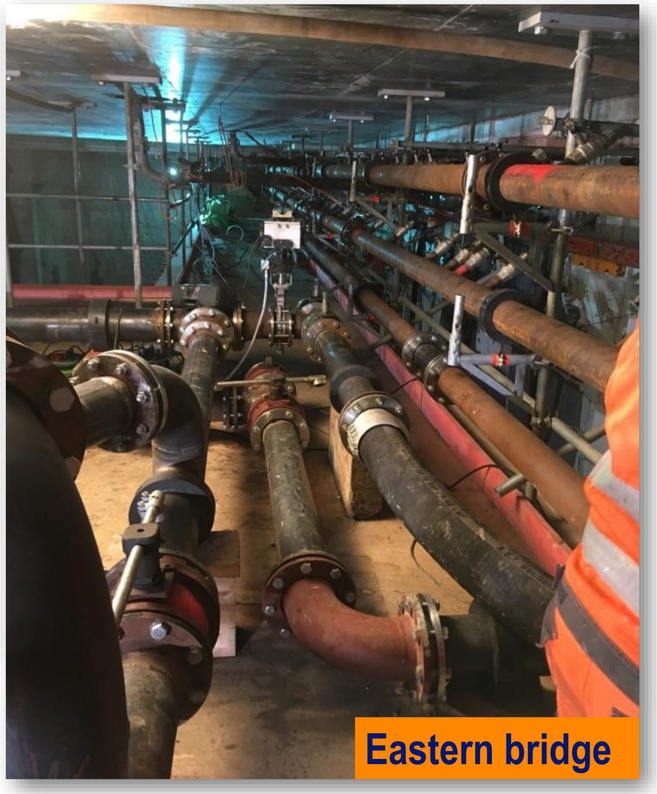
Freeze plant

- 3 coupled chillers
- 1,3 Megawatts freezing capacity
- 81 m³ brine in circulation
- Frozen body dimensions:
  L105m x W26m x H12m
- Duration of freezing: 80 Days



Freeze-tunneling in Berlin sands

Freezing system - Distribution and manifold



Freeze-tunneling in Berlin sands

Main-tunnel drive

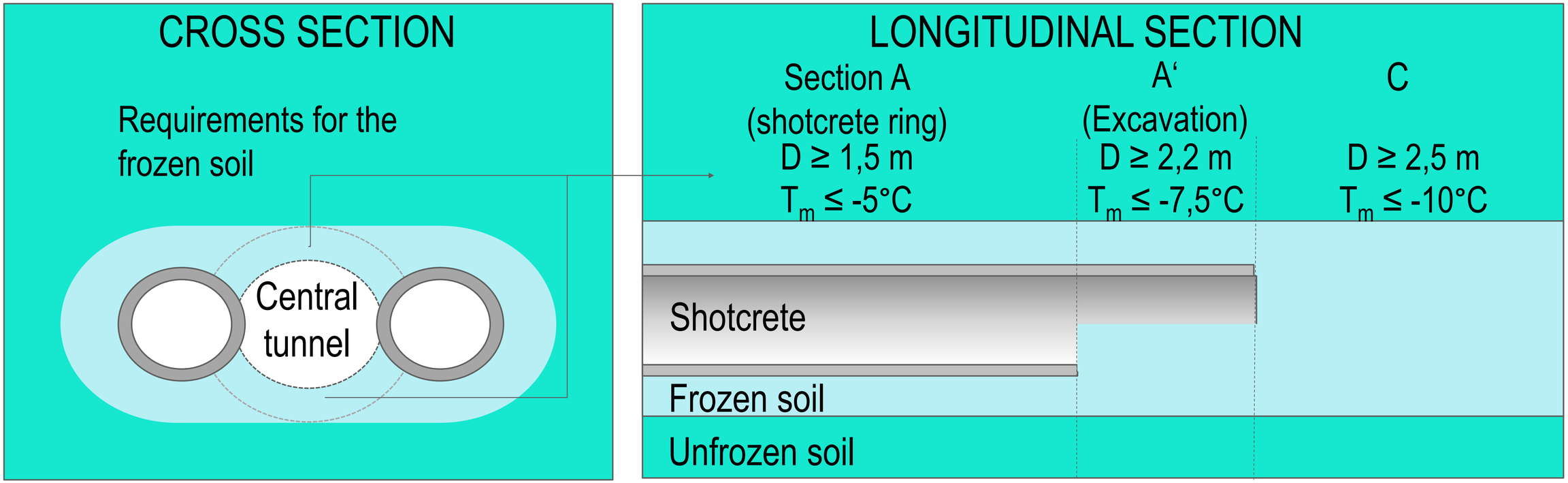
- Excavation using a tunnel excavator with an attached milling machine

- Leading-dome-drive with approx. 6 m trailing sole

Unfrozen core

Freezing Control - Requirements for the frozen soil

Requirements depending on the phase of the tunnel drive and the location in the cross section (ISP ZT GmbH & CDM Smith GmbH)

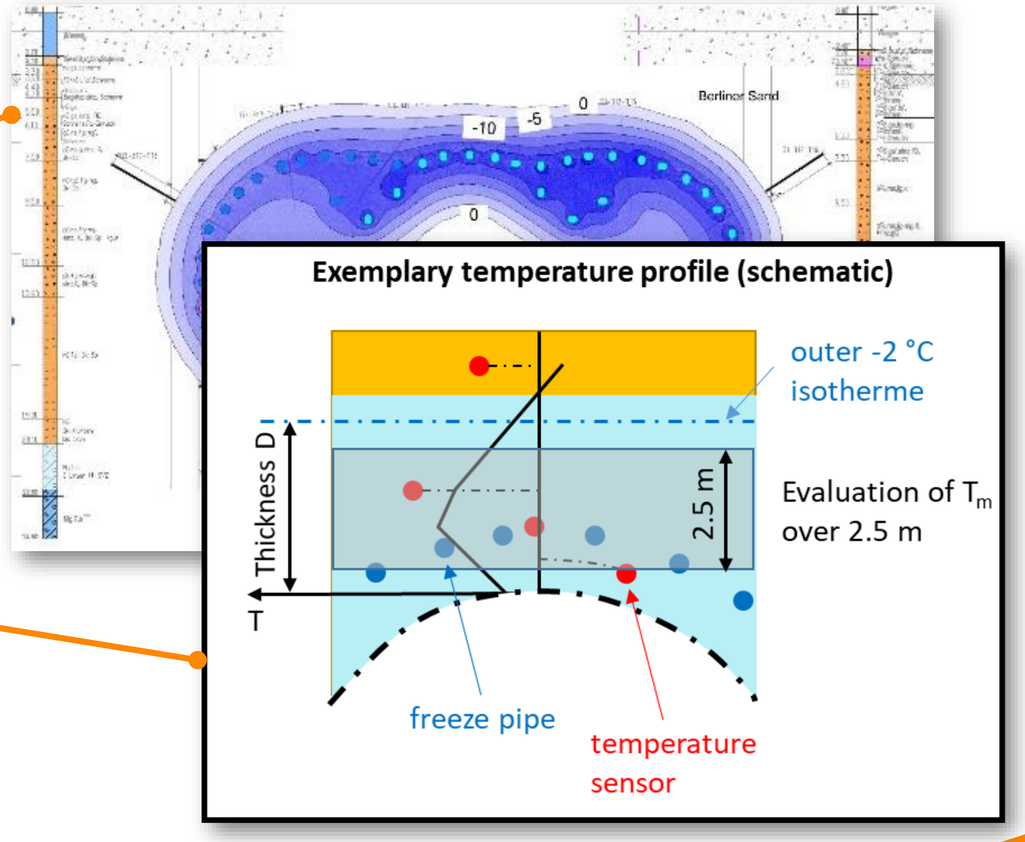


Freezing Control – Evaluation Methods

Daily quantitative evaluation of the frozen soil (mean temperature and thickness)

- Cooling-Down Phase:
  Measurements + numerical simulations

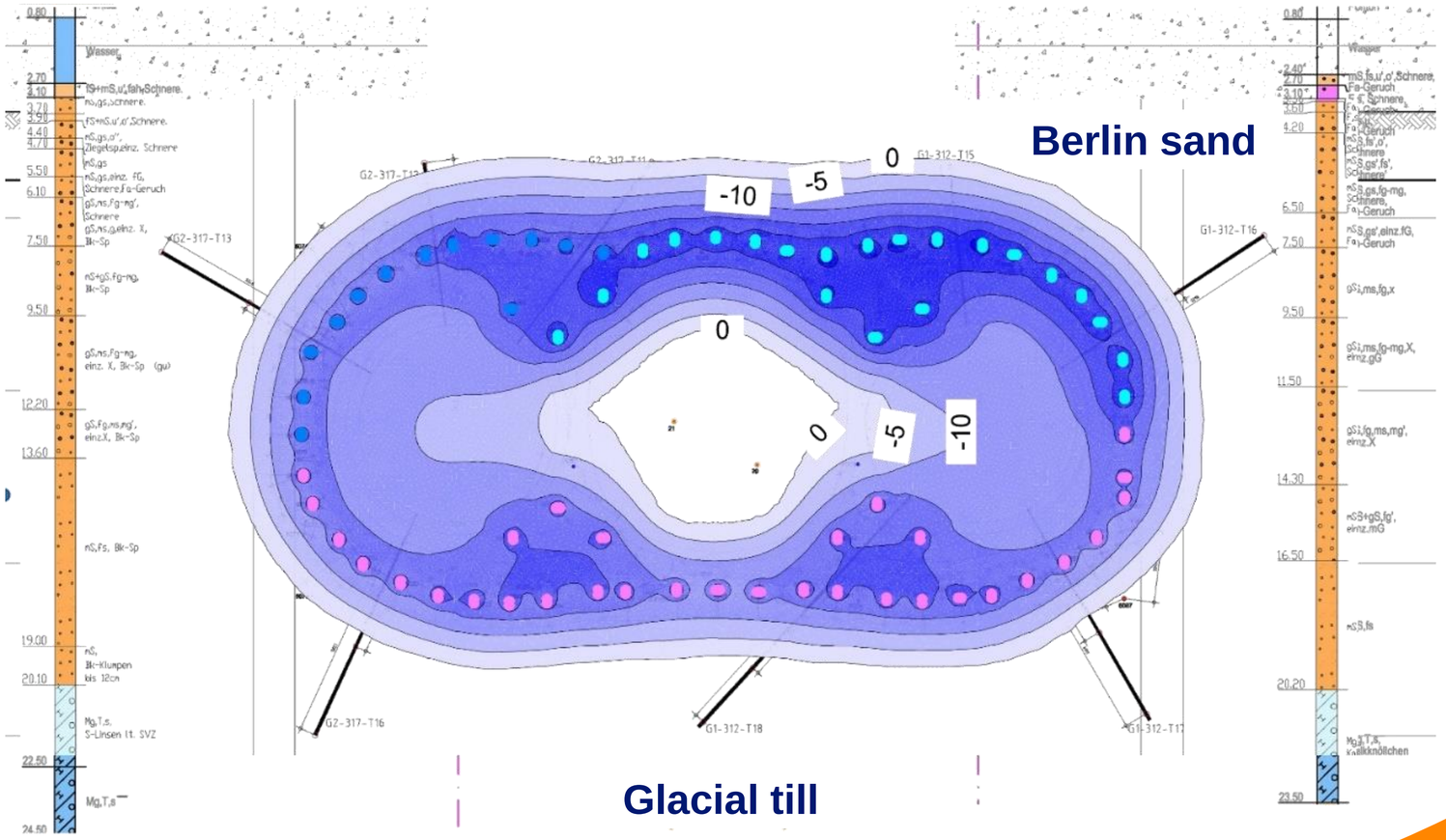
- Maintenance Phase:
  Direct evaluation based on measurements



Freezing Control – Cooling Phase

Numerical simulation of the ground freezing in four measurement cross sections

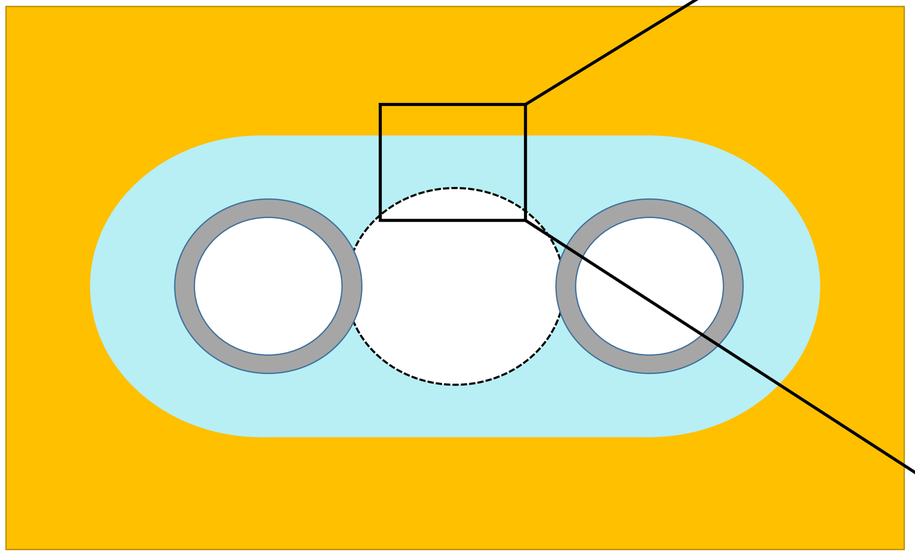
- Comparison and validation with measurements
- Verification of the state of the frozen soil before tunnel drive

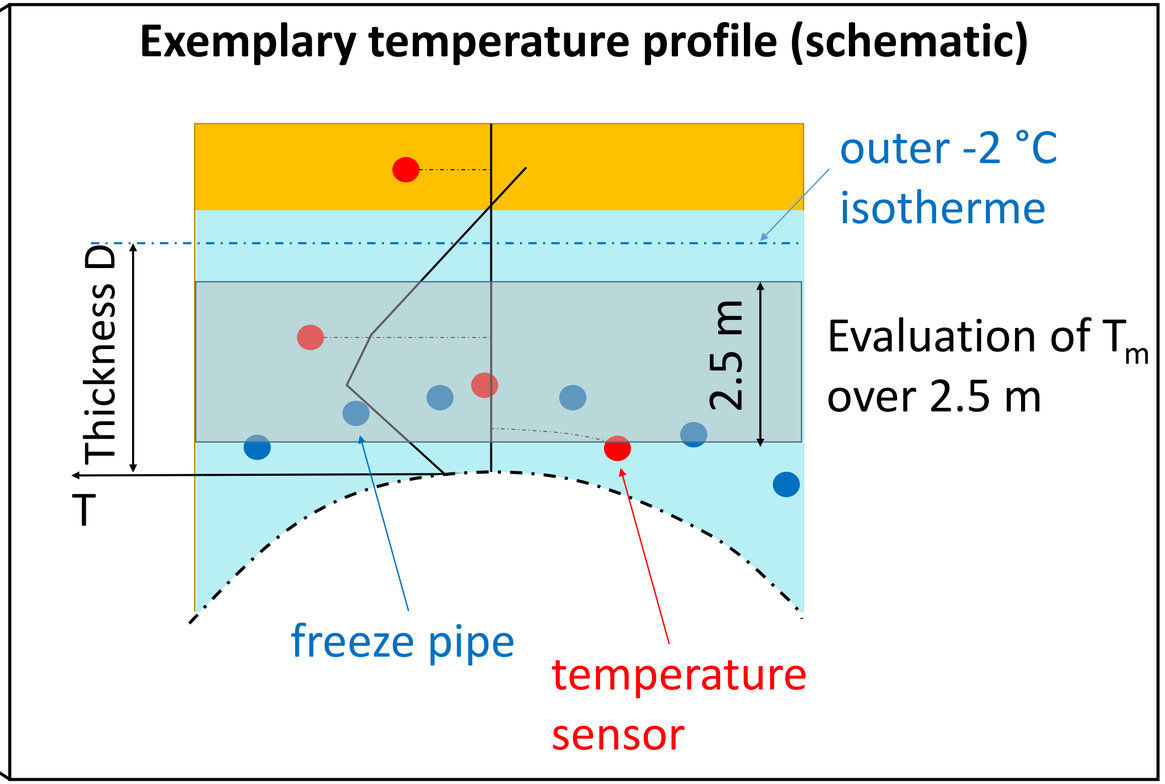


Freezing Control – Maintenance Phase

Evaluation of the temperature profile for relevant cross sections

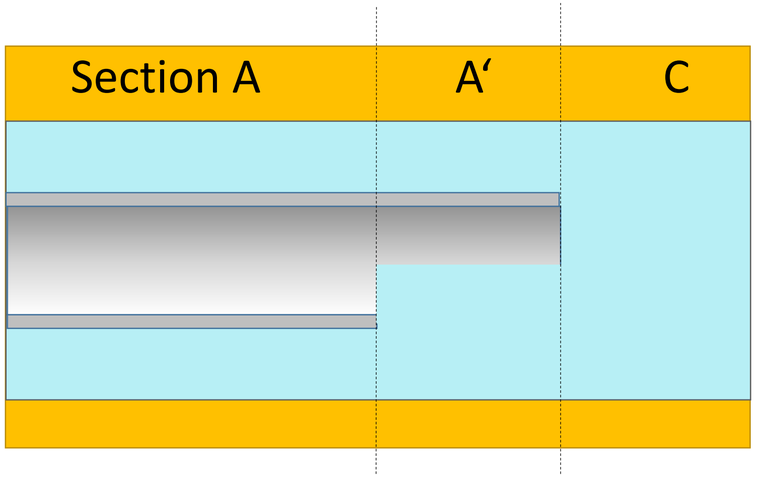
- Automated and fast data evaluation
- Objective basis for the freeze mode

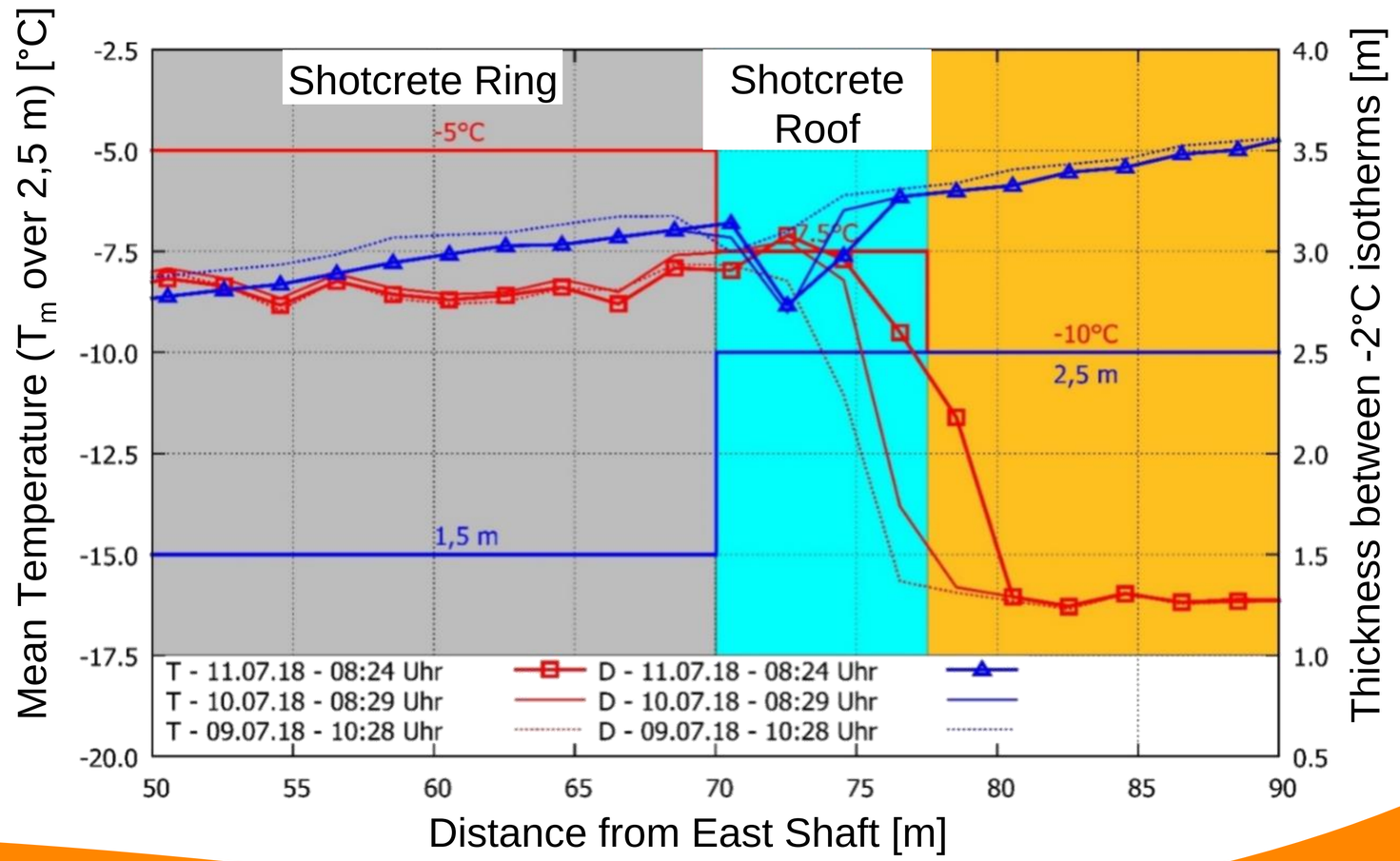




Freezing Control – Maintenance Phase

Exemplary evaluation of thickness and temperature of the frozen mass (main-tunnel drive)

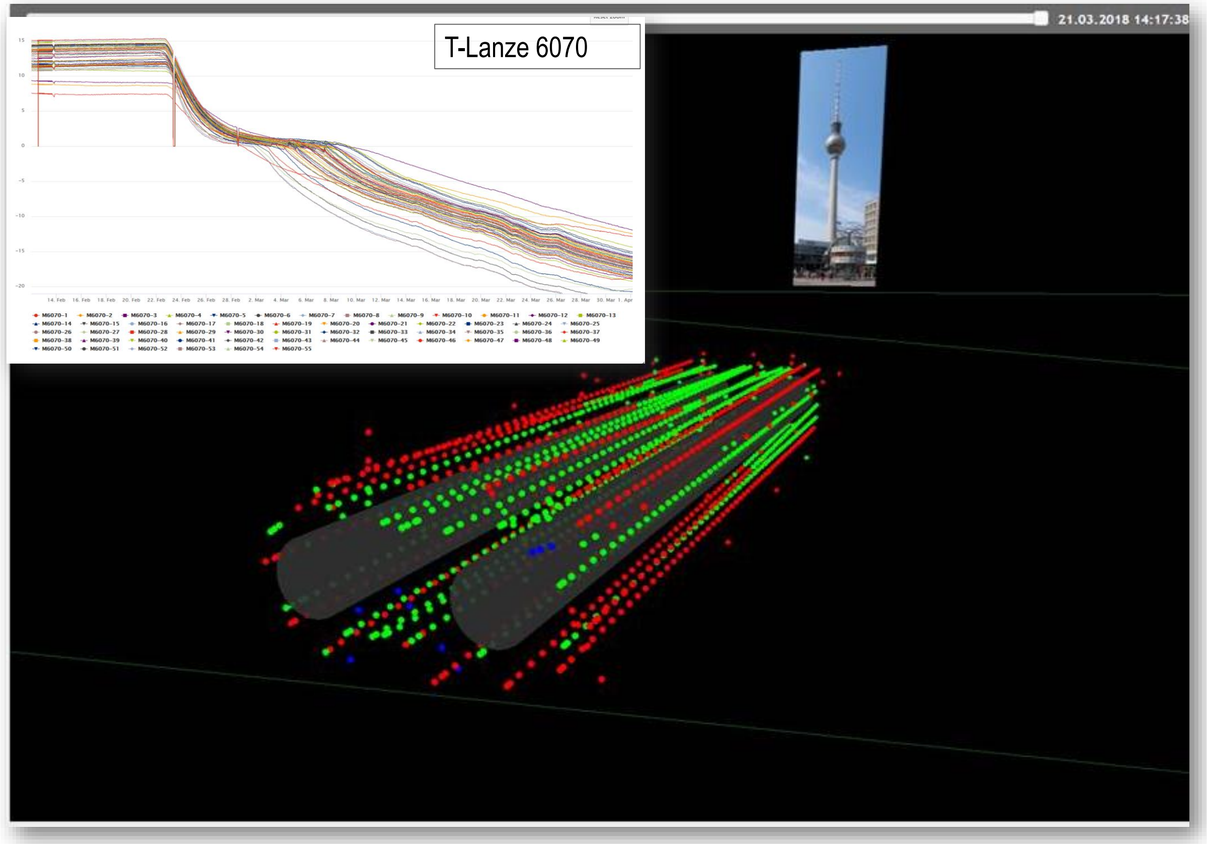




Monitoring of the frozen body

3D- Visualization with fully mobile Web-UI

- High sampling rate, display in near realtime
- Meshed bus system
- 1911 pieces of fully digital temperature sensors
- 81 fully digital pressure sensors



Freezing Control – Thawing Phase (Active)

Heating system with district heating

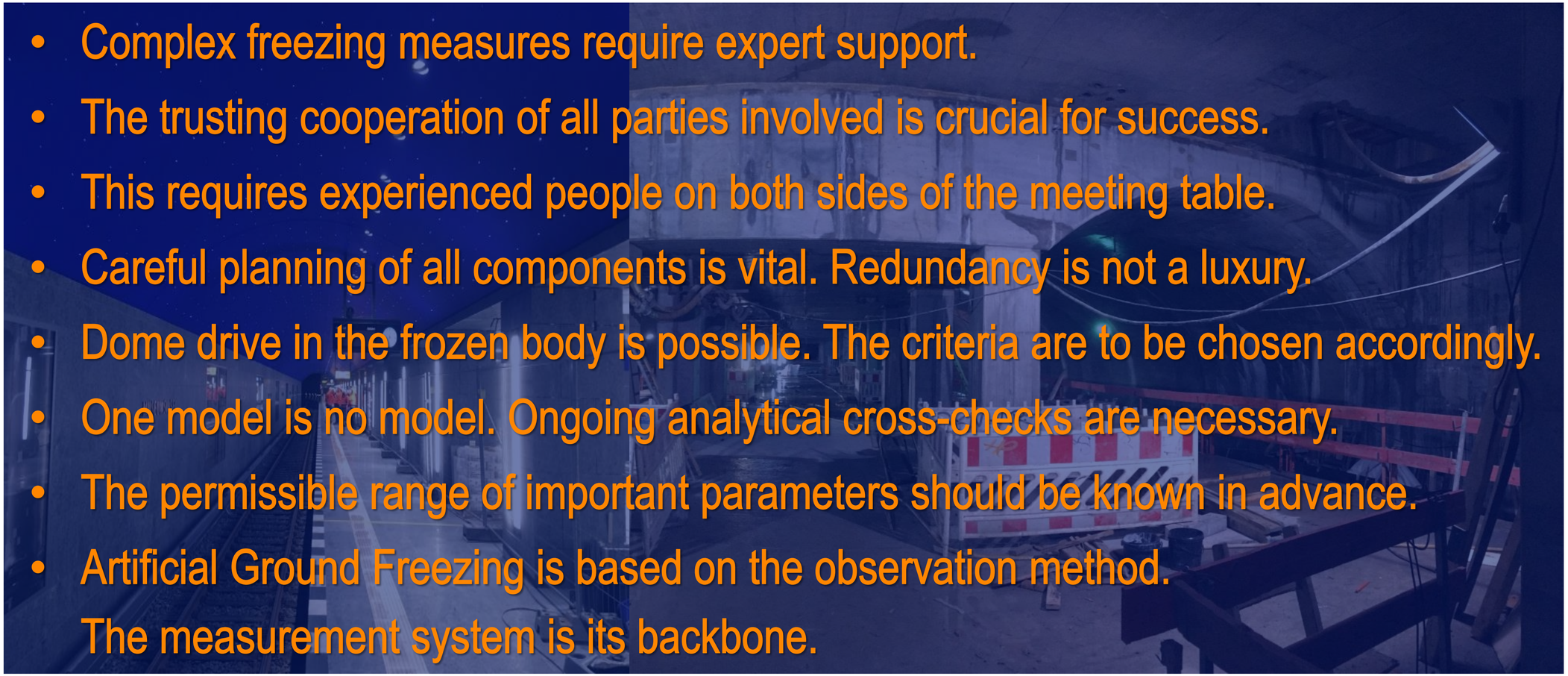
Goals

- Early impact of water pressure on the inner shell → leak test
- Faster thawing of the frozen body within the cohesive soil →Faster lifting resets

Execution

- Duration: 87 days, of which 33 days with heated brine, then with hot water at 35 - 40°C
- Feeding of 17 freezing pipes below the tunnels
- Energy input approx. 290 MWh

Conclusions



- Complex freezing measures require expert support.
- The trusting cooperation of all parties involved is crucial for success.
- This requires experienced people on both sides of the meeting table.
- Careful planning of all components is vital. Redundancy is not a luxury.
- Dome drive in the frozen body is possible. The criteria are to be chosen accordingly.
- One model is no model. Ongoing analytical cross-checks are necessary.
- The permissible range of important parameters should be known in advance.
- Artificial Ground Freezing is based on the observation method.
  The measurement system is its backbone.

Thank you

for your kind attention

Thank You

Any further questions ?

D'autres questions?

joachim.meier@implenia.com