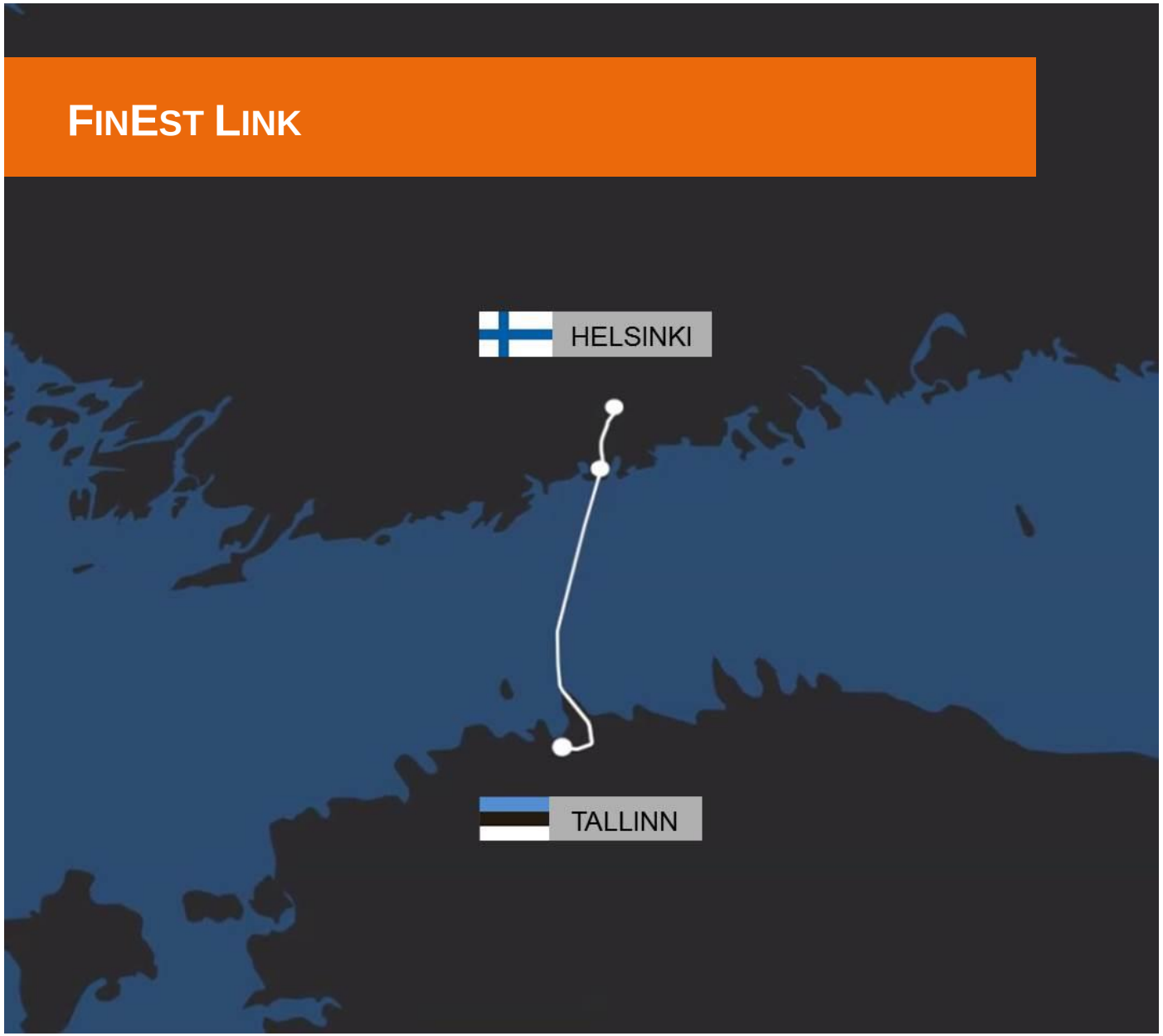

FinEst Link Finland / Estonia

Work package 3 – Technical concept and economic assessments

The Helsinki-Tallinn ferry line as part of the Trans-European Transport Network is one of the busiest marine traffic lines in Europe. A Helsinki-Tallinn transport link crossing under the Gulf of Finland would reduce travel time between the city centres to approx. 30 minutes, add mobility and create competitiveness in this area.

Scope

- More than 100km long high-speed railway tunnel connection between Helsinki (Finland) and Tallinn (Estonia) under the Gulf of Finland
- Integrated to local and national transport network in both countries
- Stations below Helsinki city centre and the Helsinki-Vantaa airport
- Transport concept comprising passenger train shuttles, car and truck shuttles and conventional freight trains
- Planning of location and functionality of train terminals in Estonia and Finland
- Economic assessments

Challenges

- Subsea tunnel with a total length of more than 100km
- Logistics / Provision of intermediate accesses
- Under-passing of a city centre and an airport
- Changing geological and hydrogeological conditions
- Complex project organisation

Amberg Services

- Project management and work package lead
- Tunnel construction design
- Tunnel safety concept
- Material logistics
- Economic assessments
- Risk management

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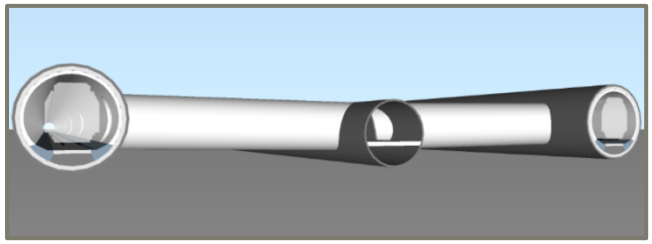
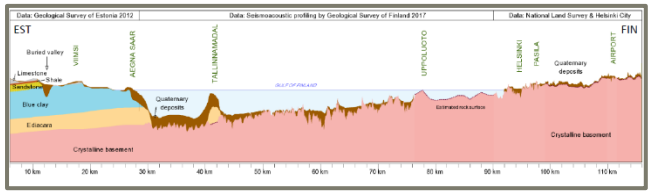
- Vision of the FinEst link project



- Tunnel layout for FinEst link



- Geological longitudinal profile

AMBERG FACTS

Contracted value JV

- JV TheLink with Sweco Environmental and WSP Finland under lead of Amberg Engineering AG: Total € 300'000

Contracted value Amberg

- Total € 111'000

Project phases & duration

- Feasibility study 2016 – 2018

Project details

Tunnel

- Tunnel layout consisting of two single-track tunnels and one service tunnel
- Cross passages at intervals of approx. 330 m
- External tunnel diameter of 10 m (running tubes) and 8 m (service tunnel)
- Design based on a clearance profile for European standard 1435 mm railway-gauge (according to TSI UIC GC standard)
- Excavation by means of TBM
- Single-shell segmental lining
- Sealed with gaskets to ensure the water tightness of the lining even for water pressure exceeding 20 bar

Rescue stations

- 4 rescue stations at maximum intervals of 20 km
- Equipped with smoke-extraction system and/or a fixed firefighting system (FFFS)

Stations

- Underground connection to Helsinki Central railway station, Pasila station and Helsinki-Vantaa airport
- Additional cargo train bypasses to allow overtaking as well as for safety reasons

CLIENT FACTS

Overall cost

- Total costs approx. € 13 - 20 bn
- Feasibility study: € 1'3000'000

Overview project

- Co-operation project of six partners: Finnish Transport Agency, Estonian Ministry of Economic Affairs and Communications, Helsinki-Uusimaa Region, Harju County Government, City of Helsinki, City of Tallinn
- Project is divided into the following five work packages:
  - WP1 – Management
  - WP2 – Comparative Impact Analysis
  - WP3 – Technical concept and econ. Assessments
  - WP4 – Benchmarking, policy frameworks and stakeholder dialogue
  - WP 5 – Communication
- The core content of the feasibility study is produced by WP2-4, who work in collaboration and feed information to each other's processes

Geology

- Mainly crystalline bedrock of gneisses and granitoids
- Overlapped by layers of Blue clay and Ediacaran sandstone on Estonian side
- Ediacaran sandstone is a hydraulically conductive aquifer and important groundwater reservoir for Tallinn and surroundings

Contact Person

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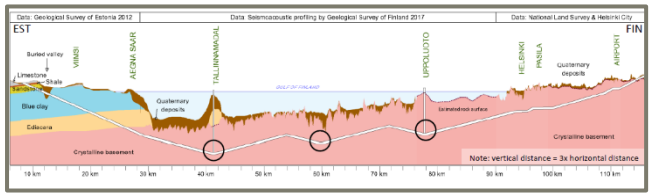
CHALLENGES

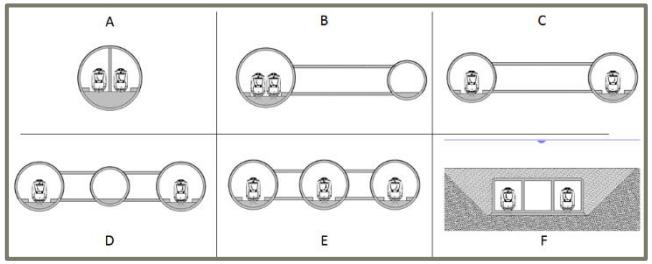


Vertical tunnel alignment and lowest points

Vertical tunnel alignment

- The vertical alignment is a crucial design element both for construction and operation.
- Design requirements for tunnel's subsea section:
  1. Tunnel should be situated predominantly in crystalline bedrock
  2. Rock cover should not fall below 40m at any point of the tunnel
  3. Longitudinal gradient: min. 5‰, max. 10‰
- Since any incoming water needs to be transported from the tunnel level up to the surface, the lowest points are situated at the intermediate access locations.
- An alignment with a continuous roof pitch between the two lows at the intermediate access points is not favourable since this would lead to very deep access shafts but also to a very steep and long ramp up to the tunnel portals. Therefore, an additional low in the subsea section is taken into account.
- At the deepest point, the tunnel runs approx. 215m below sea-level

ENGINEERING APPROACH

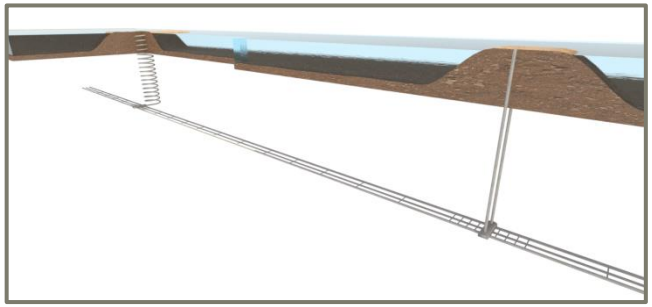


Different tunnel schemes (Cross section layouts)

Determination of transversal tunnel scheme

- Several transversal tunnel schemes were evaluated in a generic way in order to find the best-suited tunnel system for FinEst link.
- A matrix was developed to assess the different tunnel options by using seven criteria categories including "Tunnel concept and construction", "Maintenance and operation" and "Tunnel safety management" with several sub-criteria each.
- For decision-making, a utility value analysis based on a "scoring model" was used. The scale of grades ranging from one meaning not suitable to five meaning excellent was selected for the assessment of the individual criteria.
- The total score determined for each tunnel scheme was composed of the section scores multiplied with their weighting factors.
- In order to make sure that the decision was made in a robust and resilient manner, a sensitivity check was made by variation of weighting scores.
- It was concluded that tunnel scheme D is the most suitable and best-possible solution for FinEst link

TECHNICAL SOLUTIONS



Tunnel system and intermediate access points

Artificial islands and intermediate accesses

- For subsea tunnels, possibilities for providing intermediate accesses are not evident but technically demanding.
- Artificial islands that serve as launching basis for construction of intermediate accesses offer several advantages, like for instance the protection of the access whether shaft or tunnel as well as available space for material storage, installations, etc.
- For FinEst link, it is planned to build two artificial islands at Uppoluoto and Tallinnamadal with a total size of approx. 400 x 300m each.
- Two different kinds of access types will be constructed due to geological reasons.
  - On Tallinnamadal island, 2 vertical shafts will be sunk to a depth of approx. 215m below sea-level
  - On Uppoluoto island, an approx. 1'500m long inclined access tunnel will be constructed. As the dimensions of the artificial island are limited it is planned to build the tunnel helix-shaped.
- During operations, the intermediate accesses will be used for ventilation purpose.

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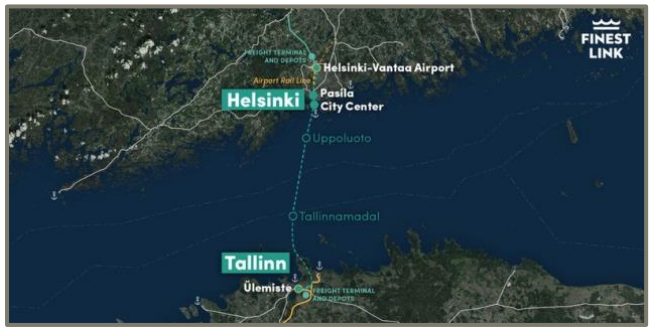
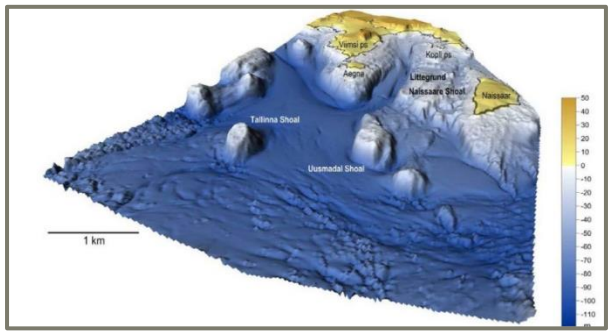
Challenges - Project



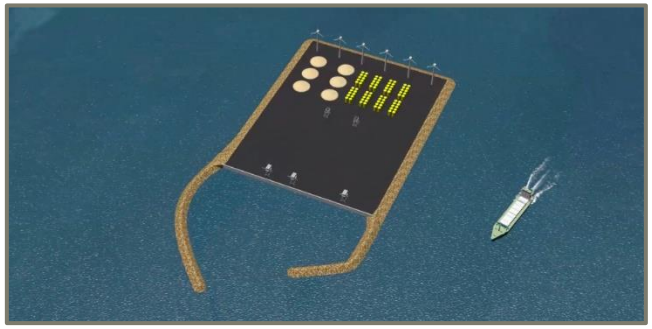
- Project location

- Different railway gauges in the project

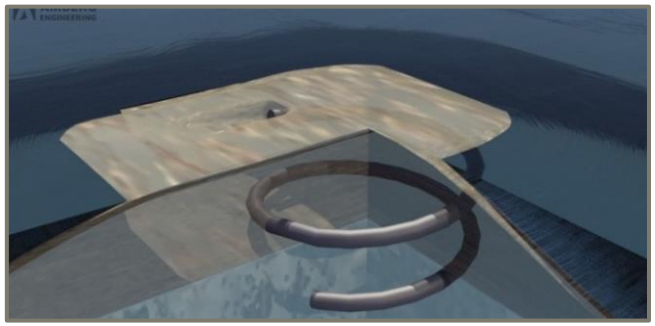


- 3D surface of the Estonian coast

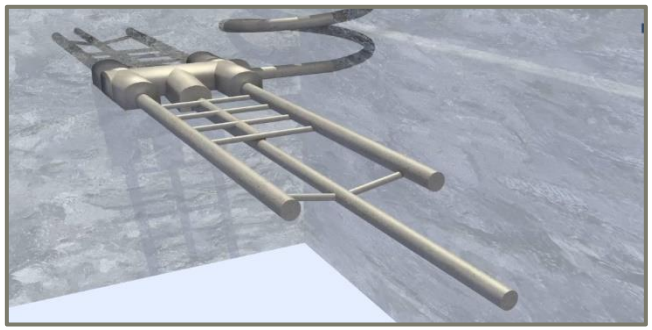
Engineering Approach – Intermediate Accesses



- Artificial island with harbour facilities

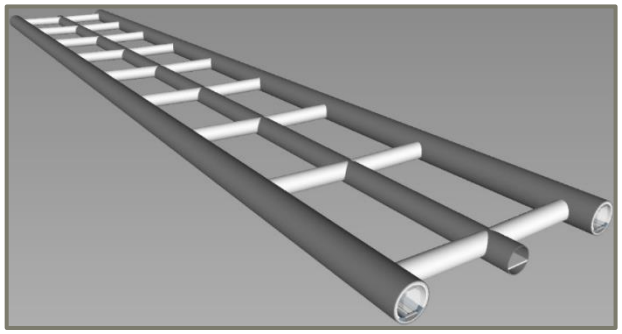


- Helix-shaped access tunnel

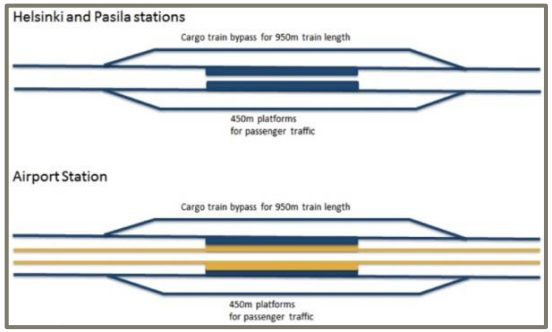


- Construction process

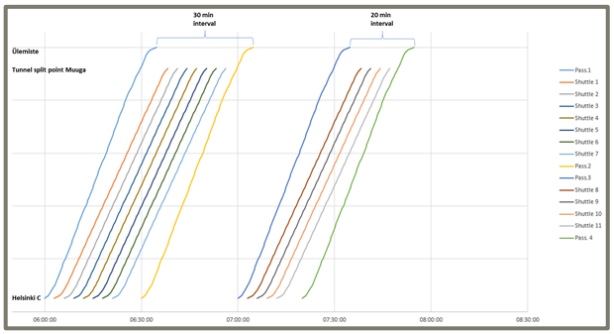
Technical Solutions



- Layout of rescue stations



- Cargo train bypasses at underground stations



- Graphical presentation of train time table

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AMBERG KEY PEOPLE INVOLVED

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Project Manager / Work package leader

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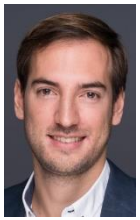

Klaus Wachter
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Dpt. Project manager / Dpt. Work package leader,
Task leader “Tunnel concept & construction”, “Tunnel safety management” and “Additional functions of the tunnel”

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