Multicomponent digital-based seismic landstreamer and boat-towed RMT systems for urban underground infrastructure planning

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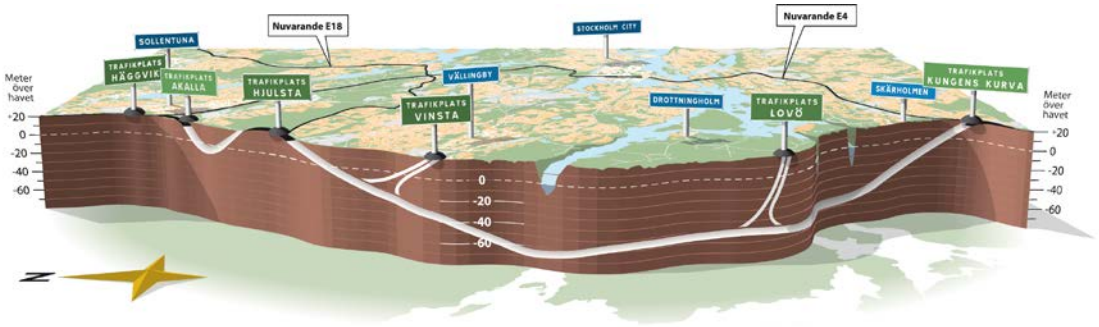
Background

Urban environment:

(i) Highly noisy, (ii) limited access/space as well as time allowed for surveying, (iii) less known geology, and (iv) unknown underground facilities.



Förbifart Stockholm (Trafikverket)

Shallow water covered regions:

(i) Lakes, rivers and brackish water bodies cover 7% of the Swedish land (poorly understood), (ii) there are 97,500 lakes larger than 2 arcs in Sweden, (iii) most freeze over the winters, and (iv) major cities are around these lakes and rivers, hence the infrastructures to be developed.

Can new and improved geophysical methods be used to overcome these challenges?

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Goals

Two unique geophysical systems as well as methods and applications particularly geared towards noisy environments

(a) Multicomponent digital based seismic streamer system:

Varberg multi-lane underground train tunnel planning

(b) Boat-towed radio-magnetotelluric (RMT) system:

Boat-towed RMT system, Äspö

Aims

(a) Seismic landstreamer system:

✓ A 3C seismic recording system to allow the estimation of rock mechanical properties.
✓ MEMS (*micro-electromechanical system*) sensors (digital) allowing tilting to be measured up to 60°, full digital data transmission (no EM noise pick-up).
✓ Lighter (only a single cable) and more capabilities e.g., link to wireless receivers in inaccessible areas, passive, GPS time-stamped (nano-second accuracy).
✓ Much more time- and cost-effective than the conventional system.

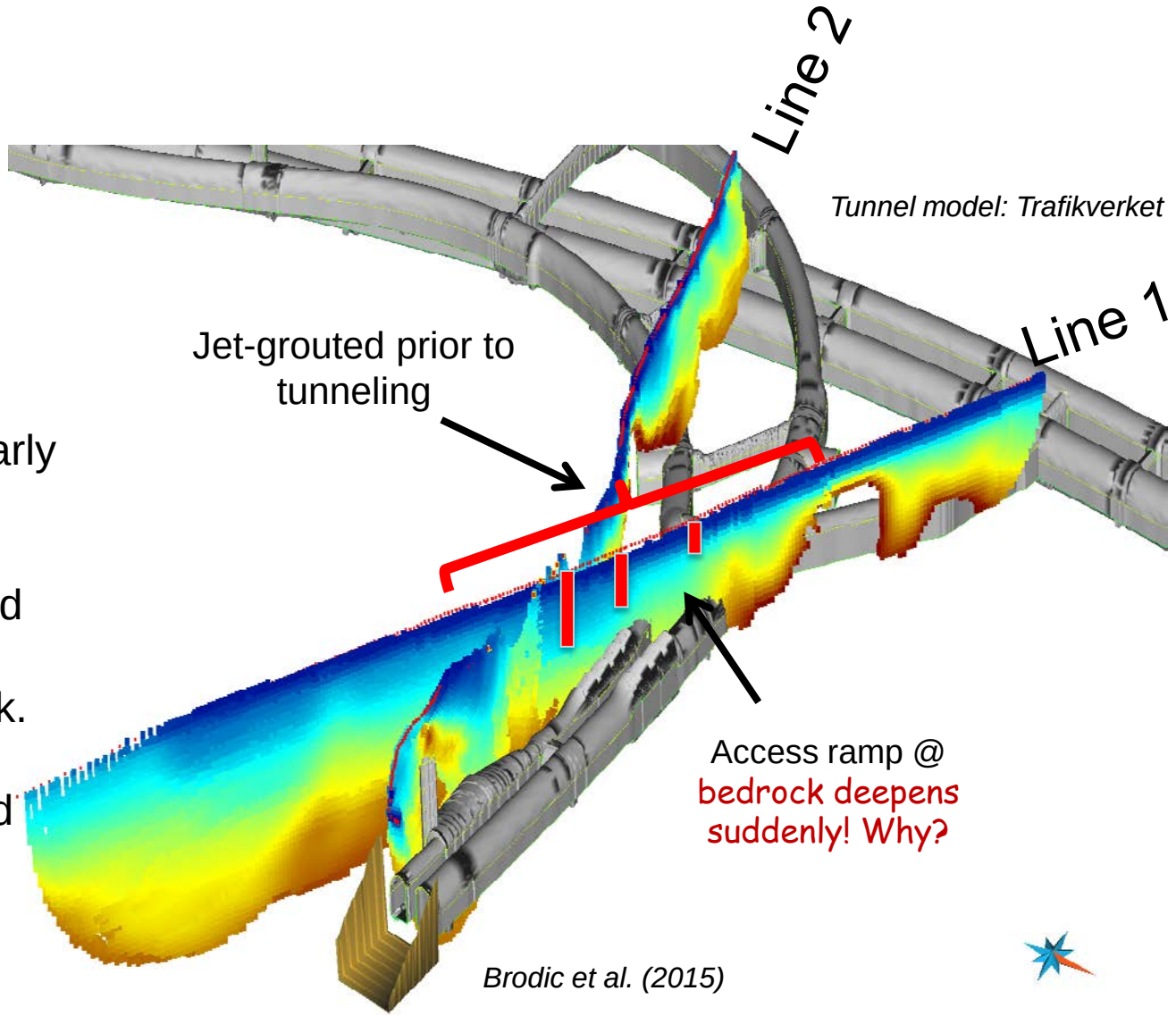
(b) Boat-towed RMT system:

✓ Upgraded to allow faster and more reliable data acquisition with built-in DGPS system for geodetic surveying.
✓ Integrated with controlled-source frequencies (boat-towed) to allow deeper penetrations for fractured bedrock mapping.

Results

Seismic landstreamer survey in conjunction with the Förbifart Stockholm-Vinsta access ramp:

- ✓ Bedrock level was clearly delineated.
- ✓ A sharp drop in the bedrock level is interpreted to be related to a major weakness zone in bedrock.
- ✓ The weakness zone is confirmed and get-grouted prior to the tunneling.



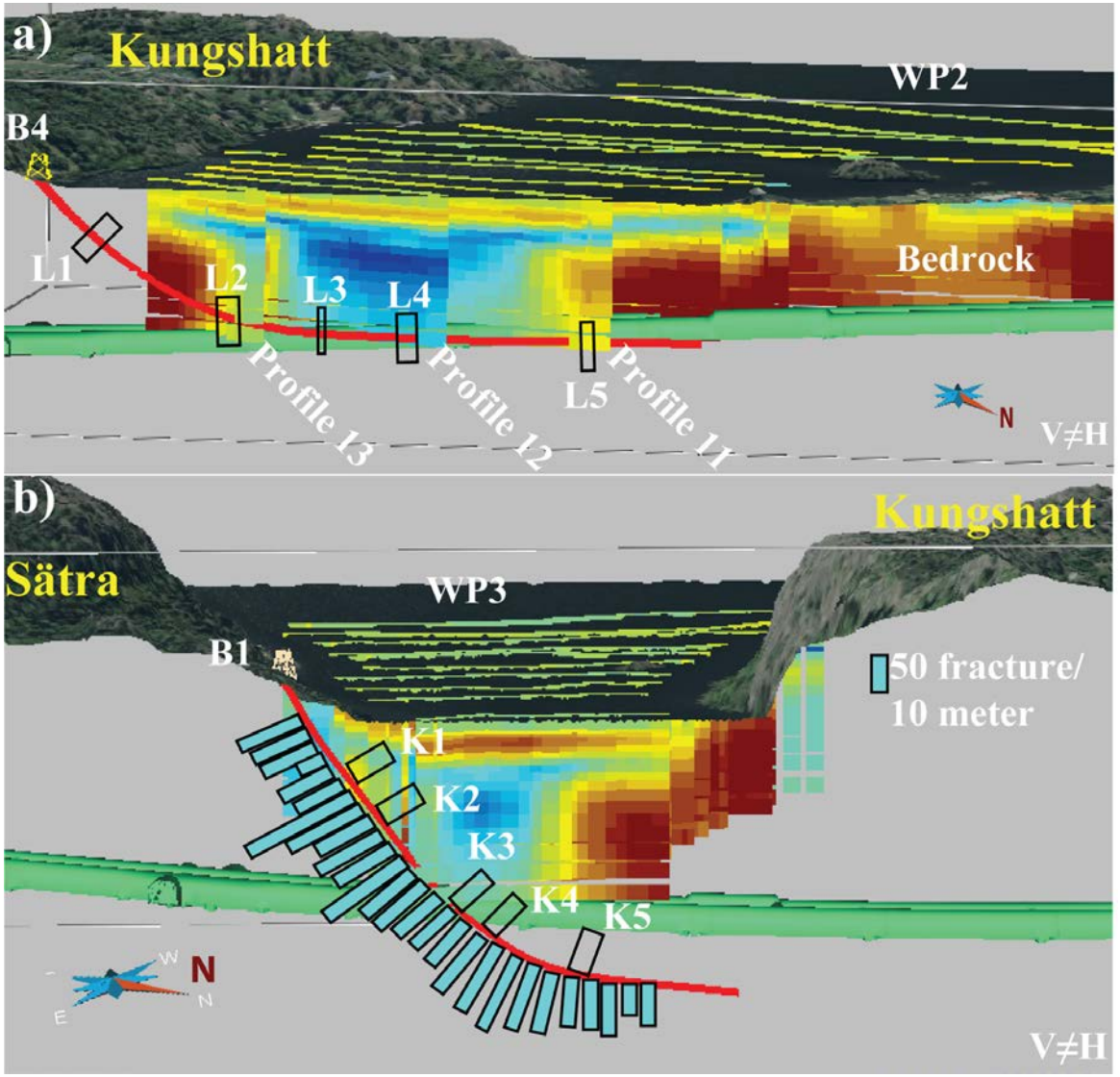
Tunnel model: Trafikverket

Brodic et al. (2015)

Results

Boat-towed RMT survey in conjunction with the Förbifart Stockholm:

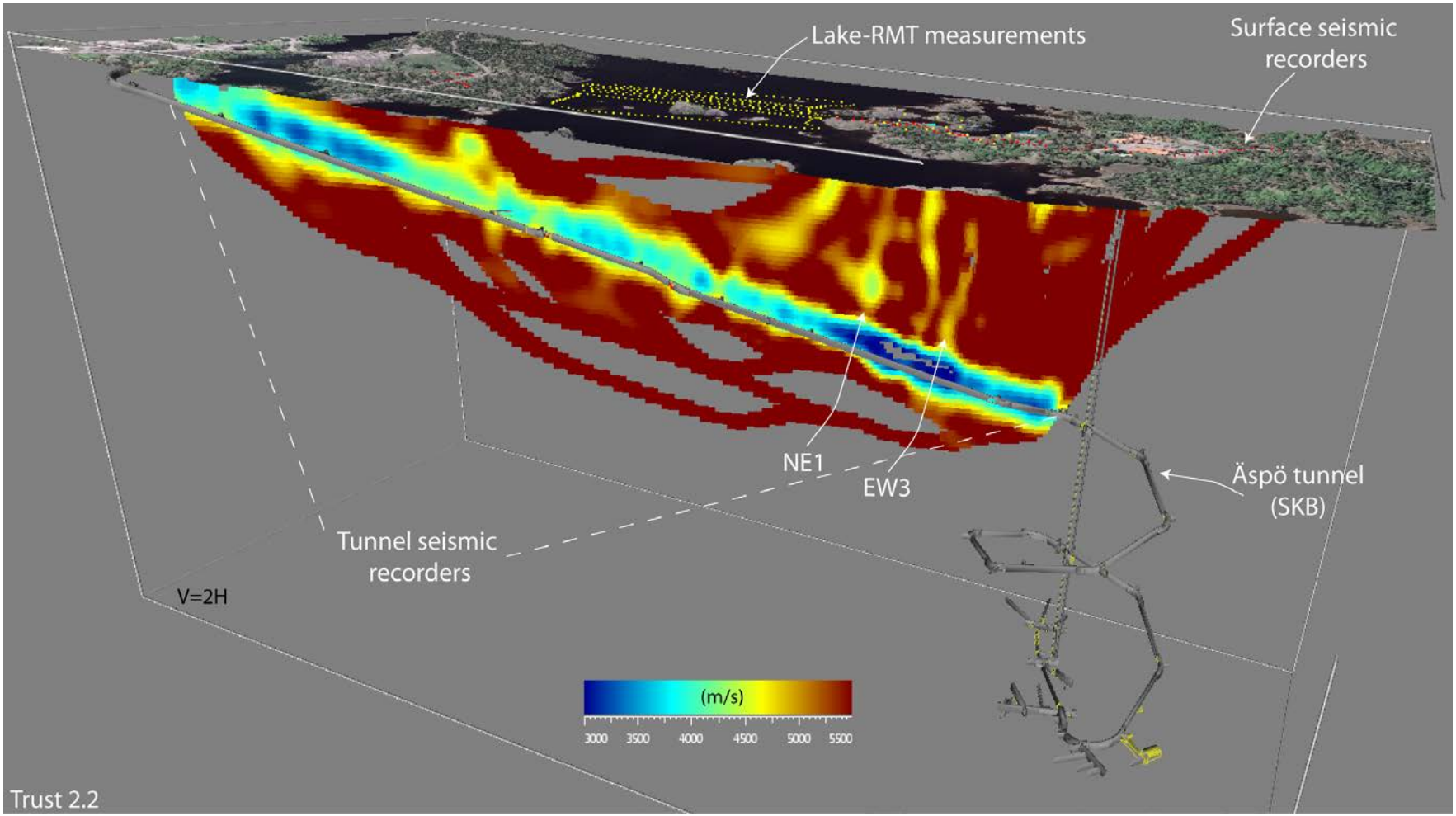
- ✓ Water column is resolved as a resistive (fresh to brackish-water) layer.
- ✓ Sediments above bedrock are resolved close to the shores as conductive layers.
- ✓ Bedrock is resolve close to the shores as another resistive body.
- ✓ In the middle of the water passages the conductivity zone is large due to both a larger sediment thickness and likely highly fractured bedrock.



Mehta et al. (2016)

Results

Surface-tunnel-surface seismic survey for fracture delineation and characterization, Äspö



Brodic et al. (2017)

User values and innovation aspects

Sweden (11 sites):
Laisvall (October 2014): Mineral exploration
Stockholm (Nov. 2013): Förbifart Stockholm
Kristianstad (April 2014): Contaminated site
Varberg (May 2014): Planning of a double-track train tunnel
Bollnäs (October 2014): Post-glacial fault imaging
Äspö (April 2015): Tunnel-surface seismics for fracture mapping/characterization
Ludvika (Oct. 2015): Mineral exploration
Möra (Oct. 2015): Geological mapping
Malmberget (Nov. 2015): Structural mapping/exploration
Varberg double-track train tunnel (June 2017): Contaminated site
Åre, ICDP Drilling preparation (August, 2017): High-resolution imaging
Norway:
Oslo (June 2015): Planning of E18-Oslo tunnel
Finland (2 sites):
Turku (July 2014): Esker structures and water management
Siilinjärvi (July 2014): Mineral exploration/mine planning
Denmark:
Copenhagen PhD school/course (May 2016): Stevns chalk group imaging