New methods for high-speed rail planning

Robygd, Joakim; Bastani, Mehrdad; Lindgren, Sakarias; Löwenborg, Daniel; Martin, Tina

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ROBYGD, J.[1], BASTANI, M.[2], LINDGREN, S.[3], LÖWENBORG, D.[3] & T. MARTIN[1]
[1]ENGINEERING GEOLOGY, LUND UNIVERSITY, [2]GEOLOGICAL SURVEY OF SWEDEN, [3] ARCHAEOLOGICAL DEPARTMENT, UPPSALA UNIVERSITY

Scope of the research

The project aims to **increase efficiency in the pre-investigation stage of high-speed rail infrastructure** (Fig. 1). The new method relies on archived data as a means for the characterization of underground conditions (Fig. 2). As a case study, a suggested railway corridor in Southern Sweden was chosen (Fig 4b). The initial steps of the methodology are:

- Ground suitability is determined by expert elicitations within an analytical hierarchical process (AHP) framework.
- A machine learning model (XGBoost) is trained on a well database for lithostratigraphic complexity prediction
- A machine learning model (MaxEnt) is trained on an archaeological database for archaeological site prediction.

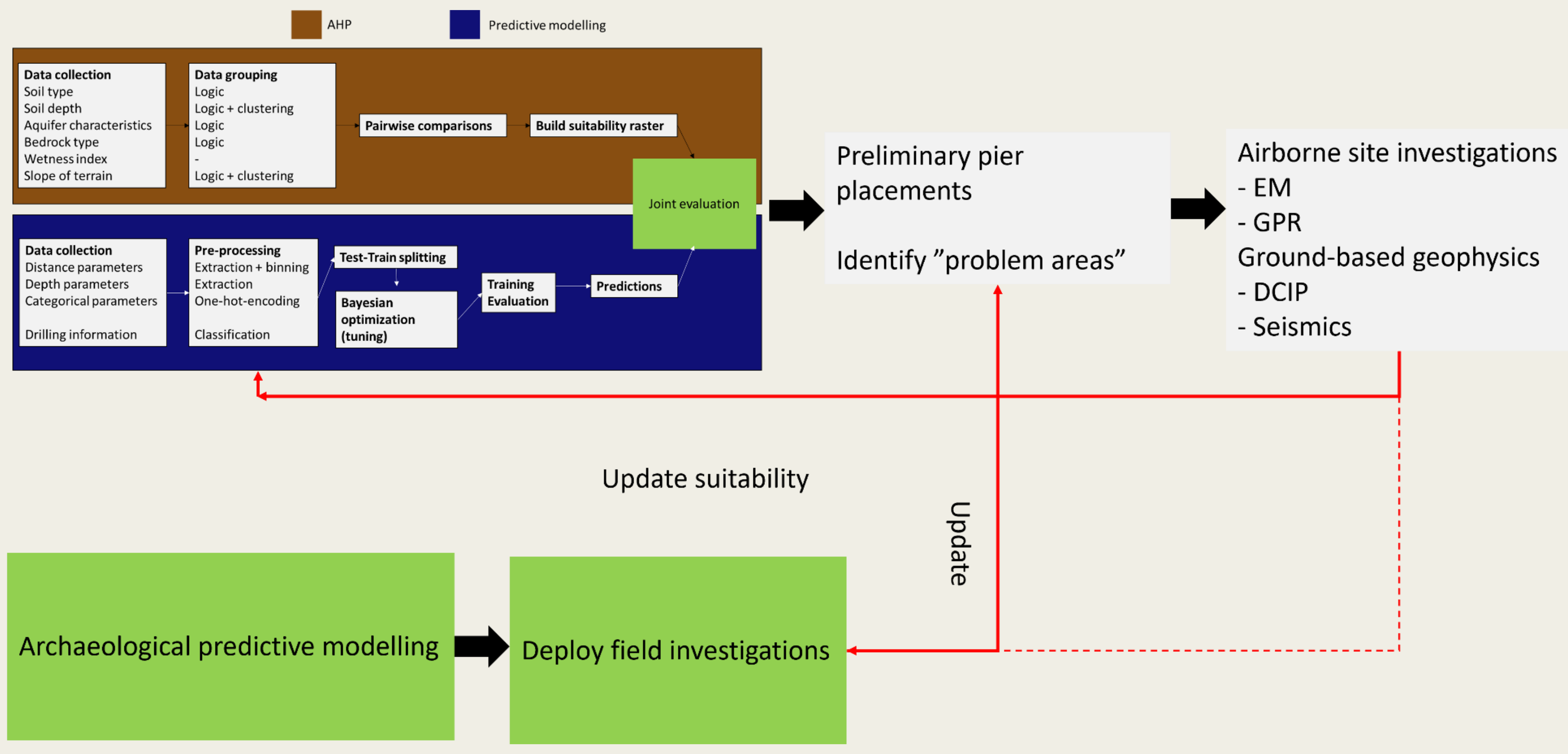

Fig. 2: Graphical illustration of the method workflow.

Fig. 1: Example of piers for the construction of high-speed rails.

The refined data can now provide delineations of the investigated area where more detailed information of ground conditions are needed and where archaeological field efforts are to be deployed. To increase the knowledgebase the following steps are followed:

- Areas requiring additional information are rapidly mapped using airborne EM and GPR methods.
- The results of the aerial screening are used for updating the general model and to provide a basis for an optimized ground-based investigation.
- Follow up ground-based DCIP and seismic refraction investigations.

The updated model is used for pier placements and quantification of site-specific foundation types and reinforcements. Geotechnical drillings and soundings are carried out for model verification.

Results & progress

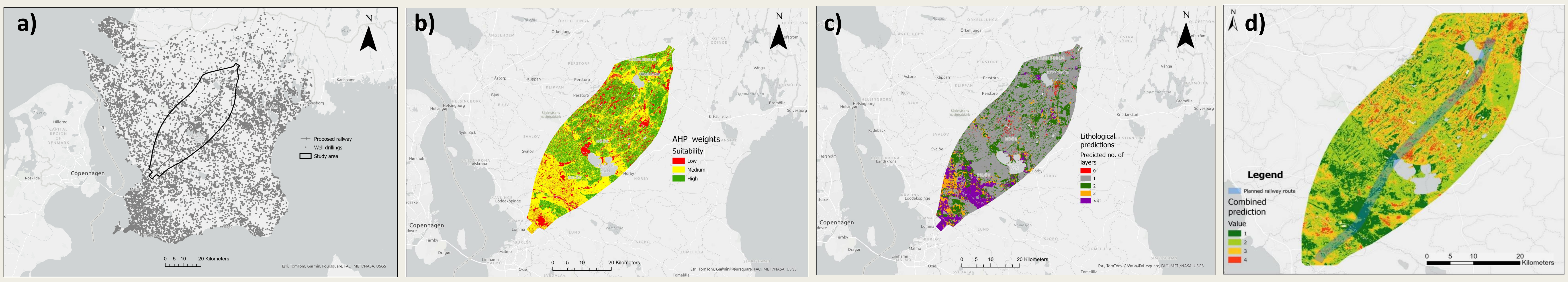

*Fig 3: **a)** The investigation area (black bordered), and the wells used for training the machine learning model in grey points, **b)** Results of the AHP suitability classification after discussions and agreement within the expert group, **c)** Results of the lithostratigraphic complexity predictions, **d)** Results of the archaeological site prediction.*

- All archived and public data is incorporated into a single GIS environment.
- The suitability mapping and predictive modelling for the geotechnical, geological and archaeological data has finished (Fig. 3).
- Drone based measurements with EM instrument (Fig 4a) was conducted by SGU in five areas (Fig. 4b, red spots).
- Signal sources are distant very low frequency (VLF) and LF transmitters in the frequency band 10-350 kHz.
- Measured data are used to estimate the vertical magnetic transfer functions (VMTF) in nine narrow sub-bands and then transformed to the apparent resistivities (Fig. 4d)
- VMTFs will be 2D and 3D modelled to help detailed planning of boreholes and pier locations.
- Maps are used for quick evaluation and detailed ground measurements.
- Ground-based DCIP and seismic measurements were conducted in three of the five aerially surveyed areas so far.

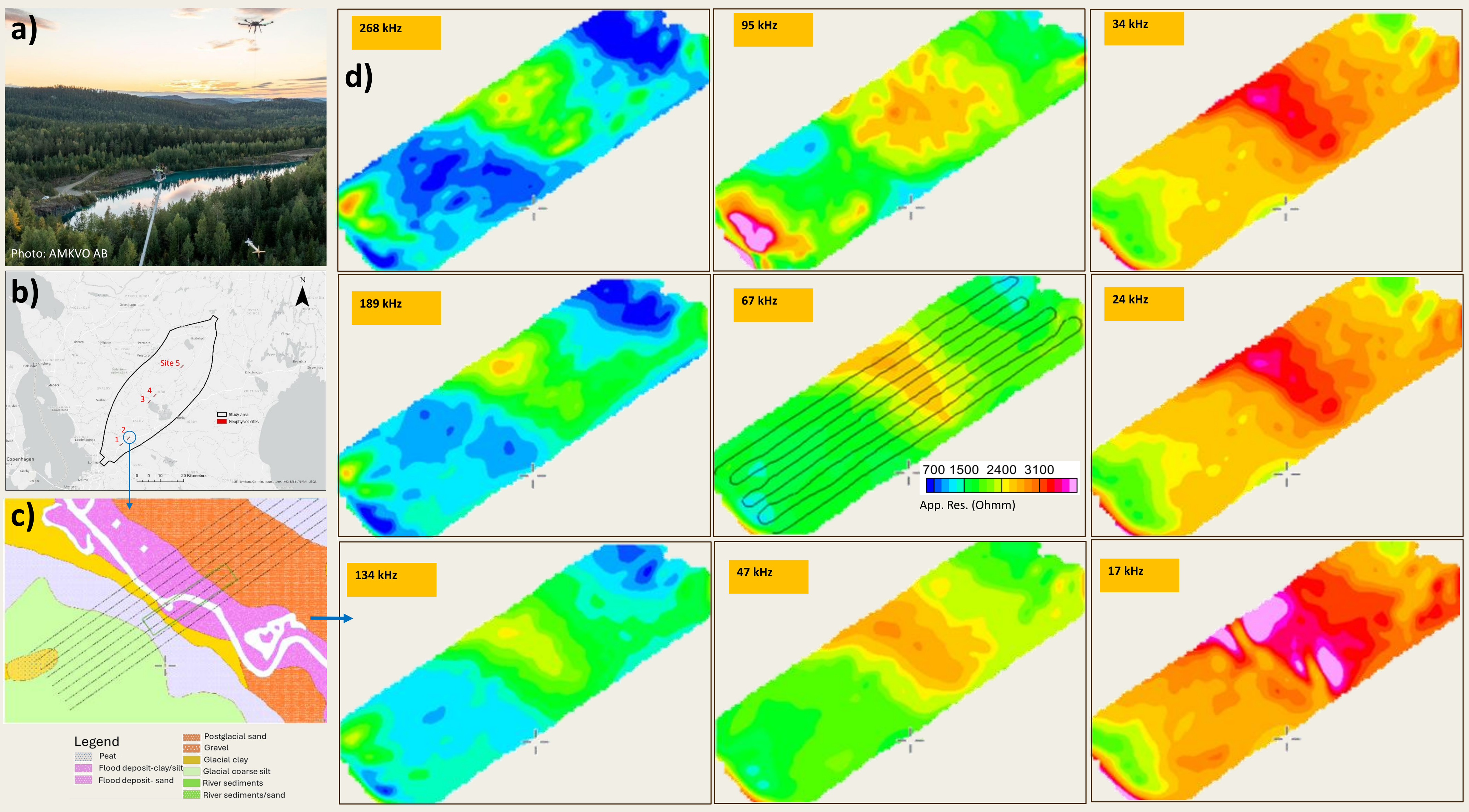

*Fig. 4: **a)** Photo of SGU's drone EM system; **b)** Overview map of the five test sites within the corridor; **c)** SGU Quaternary map of study area 2; **d)** Calculated apparent resistivities from the vertical magnetic transfer functions at different frequencies.*

Outlook

- Drone GPR measurements are planned for the spring as well as additional geophysical ground investigations (site 1 & 2)
- Detailed comparisons of the information gained from airborne versus ground-based data will be conducted.
- Update the overall ground classification according to the new data and adjust pier placements and reinforcements.

Contact

Name: Joakim Robygd, Tina Martin
E-mail: joakim.robygd@tg.lth.se, tina.martin@tg.lth.se
Poster for DGG annual meeting 2024