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WARAN – A Mobile Wireless Array Analysis System For In-Field Ambient Vibration Dispersion Curve Estimation

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Introduction

Ambient vibration array analysis is considered an alternative low cost tool for near surface shear wave velocity profiling. Shear wave velocity models are derived by inverting surface wave dispersion curves which are estimated from the array recordings by frequency wavenumber or spatial autocorrelation techniques.

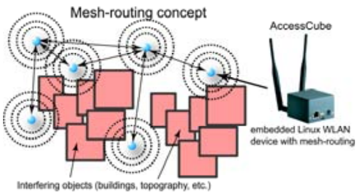
For the inversion of reliable shear wave velocity profiles, phase velocities need to be accurately measured within the broadest possible wavelength range. Given the economical and logistical constraints for array experiments (especially in urban areas), the number of sensors that can be used is restricted. The resulting coarse spatial sampling of the wave field does therefore not permit to cover a broad wavelength range using a single array deployment. An iterative measurement strategy with repeated deployment of arrays with varying apertures are required. Well defined dispersion curves over large frequency bands can then by obtained from combining partially observed branches during each individual measurement.

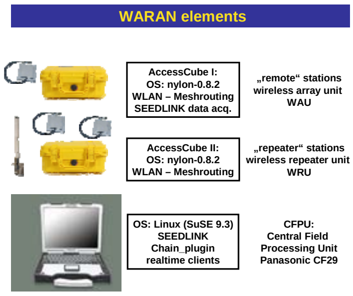
Following this idea of an iterative array deployment, it would be desirable to obtain reliable information about the observable wavelength range during the course of the field measurements. Then, a direct control of the appropriateness of array geometries in subsequent deployments can be achieved. Without this information it seems difficult to optimize array setups in advance for a particular site of interest.

In order to implement such a measurement strategy in practice we have developed a wireless mobile array system enabling the operator to process the recorded data in realtime with different array analysis techniques. This on-the-fly acquired information can be immediately re-used for improved array design, enhanced dispersion curve estimation over large wavelength ranges and iterative improvement of the velocity model inversion procedure.

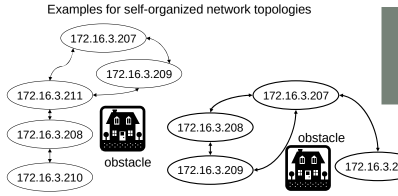
WARAN components

In order to accomplish the real time in-field data acquisition and transmission to a central field computing facility (laptop), we attached specialized embedded linux devices with wireless connectivity to AD-converters. The key element of this custom system is the use of open source wireless LAN networking protocols, called mesh protocols. The mesh protocol enables the devices to automatically organize themselves within short time (typically less than a minute) as a multipoint-to-multipoint wireless LAN. Compared to traditional point-to-point to multipoint-to-point data transmission strategies, this type of network enables a relatively free deployment of our seismic stations even in urban environments with least logistical efforts.





Examples for self-organized network topologies

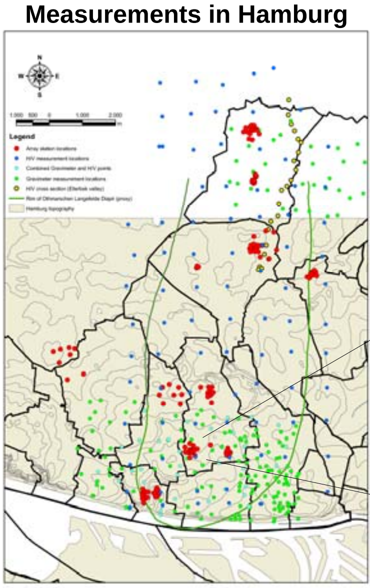


As data acquisition software we use the seedlink client/server software developed at the GFZ Potsdam for the global GEOFON virtual broadband seismic network (seiscomp package, Hanka et al., 2000). The real time data analysis tools (frequency wavenumber array analysis and H/V single station computation) have been implemented as seedlink clients accessing the real time data feeds at the central field computing facility (standard laptop).

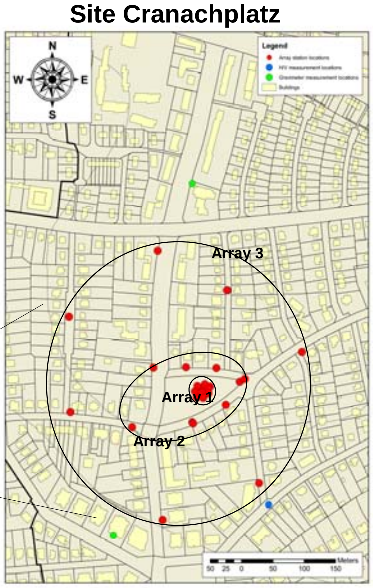
First Field Experience – Project HADU

Within the project HADU (Hamburg – a dynamic underground), financed by the German Federal Ministry of Education and Research, we aim to determine the depth of the top of the Othmarschen-Langenfelde salt diapir situated beneath the city area of Hamburg, Germany. As this gelogical structure is relatively well-known from interpretation of seismic reflection profiles (Linke, 1993), the project allows to explore the capabilities of ambient vibration array analysis techniques for structural mapping purposes in urban environments.

Measurements in Hamburg



Site Cranachplatz



In the first half of 2006 we have peformed array measurements with the newly developed system at 9 sites in the city area of Hamburg (see leftmost map for an overview of site locations). We have selected sites both in simple deployment environments (park surroundings, see photos below) as well as in densely populated living areas with lots of obstacles (compare map to the left). Data acquisition and transmission was successfully achieved in all cases. The multipoint-to-multipoint wireless network concept allows flexible station positioning in practice.

Small aperture wireless array deployment in park

Remote control of data acquistion and realtime in-field processing by operator

On-the fly array geometry determination by differential GPS-Rover equipment

References

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Linke, G. (1993). Seismische Erkundung der Salzstruktur Othmarschen-Quickborn (Hamburg) in Verbindung mit geplanten Forschungsbohrungen. Niedersächsiches Landesamt für Bodenforschung, geowissenschaftliche Gemeinschaftsaufgaben, Tätigkeitsbericht 1991/92, pp. 67-68.

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