

## ACE Deliverable 2.3D6

*ACE-VCE Common Research Plans for using GPR test facilities.  
for the Second Year.*

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### Abstract

The organisations represented in WP2.3-3 are all involved in research and/or development in the field of antennas for through-surface radar, with applications from civil engineering to medical imaging. Through 2004 the organisations have been working together to specify and commission a common research facility, thereby enabling – for the first time - valid comparisons between candidate antenna designs. The research activities within the WP2.3-3 group for the year 2005 are presented herein.

### Keyword List:

Research plan, wideband, surface-penetrating, ground-penetrating.

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## 1.0 GPR Facility Commissioning

Possible measurement set-ups were considered. Dry sand offers the best repeatability but is not representative of most common GPR scenarios. Liquid media could be proposed that would give good repeatability and excellent homogeneity; however such materials would need to be developed and would pose serious practical problems. Damp soil is the most representative medium; however there are issues regarding repeatability between measurements and homogeneity (largely with respect to moisture content).

The group visited DTU's GPR antenna test facility in April 2004. This is a 1m deep timber box, with a width of 3m and a length of 4m, containing fine soil. One buried cable led to a buried, single-polarised, loop antenna probe at the centre of the box. The antenna under test can be scanned in a plane over the surface of the soil. At the time of this visit one scan took 24 hours.

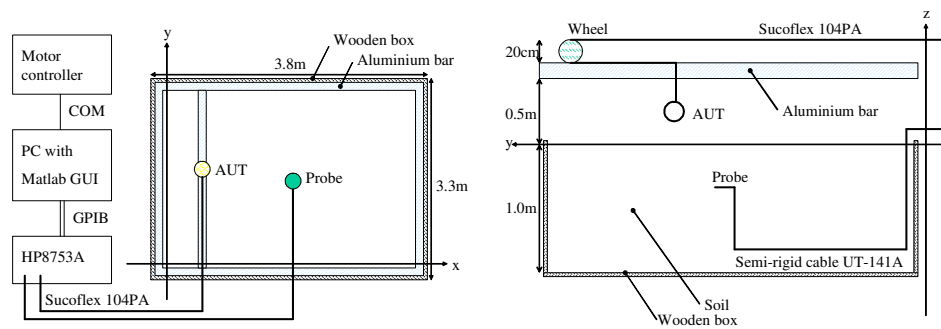


Figure 1: DTU test facility schematic (plan & side views)

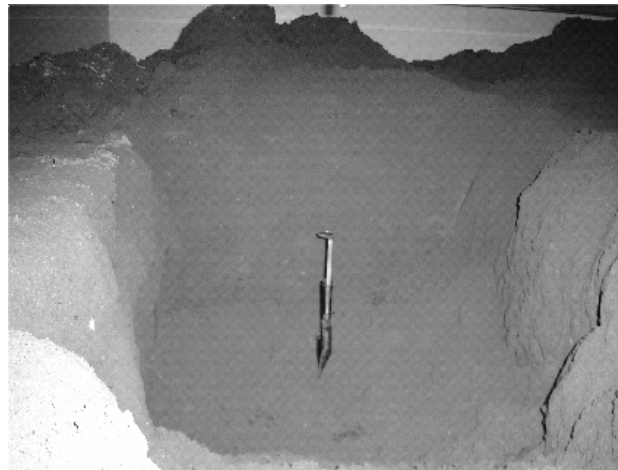


Figure 2: Probe antenna and soil box at DTU

It was agreed that the DTU facility appeared to be suitable for the proposed measurements. Various technical problems were considered:

- The scan time of 24 hours seemed excessive. This was resolved by replacing the s-parameter test set with a directional coupler and direct sampling of the receive port. This resulted in a considerable reduction in scan-time to just 3 hours.

- A watering system and soil-levelling devices have been introduced.
- Moisture content of the soil must be monitored. This could partly be derived from the probe's input impedance; however this does not yield information about possible variations in moisture content over the box. A permittivity-sensing meter was then introduced, which takes measurements at a number of depths without being moved. The results from this indicate large variations in permittivity with depth (presumably due to gravity causing water to drain from the surface) and also smaller variations over time.
- The frequency range of the VNA (up to 3GHz) would be adequate, however the frequency range of the loop antenna (buried probe) was limited to 1.05GHz to 1.8GHz. A rotation of the antenna resolved this problem.

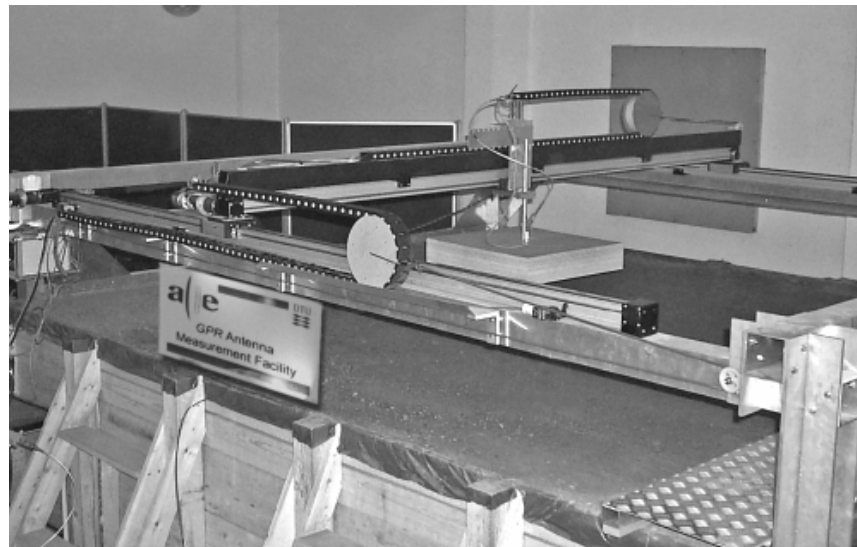


Figure 3: Revised ACE GPR facility

It has been agreed that all available antennas will be measured between 13th & 17th December (there would be no watering during this period). DTU staff will be assisted by a PhD student from Univ Nice, and other staff from ACE would visit as appropriate.

## 2.0 Initial Measurements

The initial measurement campaign for GPR antennas will be complete by early 2005. Comparisons between measured antennas will be made in terms of input responses and radiated fields. A jointly-authored research paper will be presented by the team at a special session of IEEE-APS & URSI in July 2005 in Washington DC.

Measurements will be repeated with wet soil to determine the influence of the ground conditions on the antenna performance – this is a well-known problem with GPR antennas.

Later measurements are expected to include antennas from TU Delft, which has recently joined the activities of this workpackage. Other organisations have already expressed a desire to be involved.

### **3.0 Antenna Synthesis**

An investigation of ground sensitivity of the different designs to see if there are intrinsically ground-insensitive designs.

It is expected that new designs will be synthesized based on the insight obtained from the measurement programme, including, but not limited to, scaled versions of existing designs that might be useful in other applications.

More detailed research plans will be formulated in the light of the forthcoming measurements.