“ORFEUS IN THE UNDERWORLD”

A UK-led European project aims to improve radar technology used when mapping underground utilities to help reduce disruption when building roads or sinking new pipes and cables. As well as enabling existing surface-based radars to penetrate deeper into the ground, scientists hope to create a new radar-based sensor that can be attached to drill heads to give operators real-time information about obstacles in the drill path.

The £4m optimised radar to find every utility in the street (ORFEUS) project, co-ordinated by Newcastle-based OSYS Technology, draws on the resources of eight European organisations. Half of the project was funded by utility company Gaz de France**,** UK Water Industry Research**,** European Gas Research Group**,** German drill manufacturer Tracto-Technik and Italian radar specialist Ingeneria Dei Sistemi. The European Commission supported the partner universities - Brno, Florence and Delft - by providing the rest.

'Ground-probing radar (GPR) is a technology that is used quite frequently to map what is under the ground, particularly buried utilities. It is the only technology we know of that can find non-metallic plant by non-invasive techniques from the surface,' said OSYS managing director Howard Scott.

GPR, an ultra-wide bandwidth technology, transmits electromagnetic energy into the ground at a frequency of between 100MHz and 1GHz and assembles reflected energy from discontinuities to form an image. A normal radar, such as those that find aircraft, would work predominantly at a single frequency of about 10GHz.

'ORFEUS is seeking to develop a frequency-modulated source which will allow greater control of the frequency band and of the performance of the antenna on a frequency-by-frequency basis, which should allow us to improve the penetration of the radar.

'We're aiming to penetrate about four metres under poor ground conditions (the wetter the ground the more strongly it absorbs the energy from the radar). Equivalent present day radar would penetrate up to about three metres,' said Scott.

To achieve the greater penetration, ORFEUS will develop a new stepped frequency source and receiver. In step frequency techniques, the frequency hops from one value to the next, adjusting to the type of soil, and a measurement is taken at each 'step' before it moves on.

'By assembling a whole spectrum of frequencies, one step at a time, the time domain can be reconstructed rather than the frequency domain signal. That allows you to determine what is in the ground as a function of time, and that translates into range, which is depth,' said Scott.

The scientists will also develop algorithms to enhance the signals of the surface-based radar by actively cancelling background noise, or 'clutter' from the materials in the ground.

Scott referred to it as a 'subtraction technique', which is where the systemic clutter signal generated by the radar's interaction with the soil is subtracted from the total signal caused by the ground and the equipment, such as pipes and cables.

Furthermore, according to Scott, there is a big push for companies who install new pipes and cables to do so without digging holes. Instead they use horizontal directional drilling machines that drill holes through the ground and put pipes in after them.

'The problem is, in congested areas you want to avoid other pipes and telecommunications cables, and you don't want to hit a brick or large rock because that would deflect the course of the drill string,' said Scott.

'So we are developing another piece of radar-based equipment that will go on the head of the drill string [the column or 'string' made up of connected drill pipe], which enables it to look forwards and sideways to detect obstacles in the drill path,' he added.

Scott said that no-one currently markets equipment with this capability. He admitted, however, that there are challenges to consider.

'It is very difficult electrically. because the geometry of the drill string is long and thin, it is difficult to design an antenna that looks forward, as the natural tendency of the antenna is to look out sideways,' he said.

'But, of course, the real challenge is the aggressive vibration environment, the shock, and it also gets quite hot as the drill string goes through the ground. So robust electronics have to be built to be able to stand up to that environment.'

To this end, the ORFEUS team is exploring ceramic materials for the antenna that are hard enough to stand up to the abrasive environment, and are also sufficiently transparent for microwave radiation to be transmitted through it.

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See: http://www.theengineer.co.uk/Articles/304934/Orfeus+in+the+underworld.htm