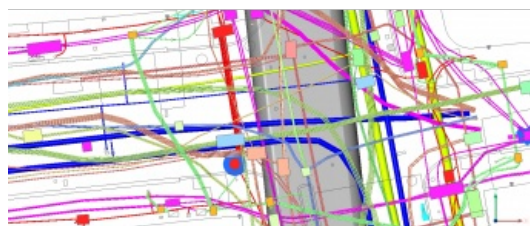


Latest Advances in Ground-probing Radar Technology



In this article, Craig Simmonds presents massive advances in ground-probing radar and discusses the journey of the technology over the past quarter of a century. He particularly highlights the major construction projects where the latest revolutionary high-density array ground-probing radar (HDAGPR) technology has been applied and the extraordinary benefits it has brought to all

involved in these projects.

Ground-probing radar technology has seen staggering advances since the Vietnam War when it was used to locate buried tunnel networks. Although the systems of today are far superior with regards to quality of data and speed of operation, the basic principles have changed little. With today's high-speed processors, the data can at least be read clearly from a screen in real-time or 'post processed' and displayed clearly on a screen, allowing multiple profiles to be assessed at once. The preferred method in 1993 involved printing each GPR profile out on thermal paper, laying them on a table or the floor (side by side), then scaling off visible features and manually plotting their positions in CAD.

As computer processing power grew, it became inevitable that software would emerge which could standardise the process of translating GPR data into CAD information that design engineers and site operatives could easily understand and use. In 1999, after some considerable testing, just such a software platform changed the way in which GPR located targets were imported into topographical survey drawings. Cutting the processing time in half and providing (for the first time) a consistent output across multiple analysts, GPR became a standard tool in the utility surveyor's arsenal.

GPR Data Drawbacks

Combining the GPR data with EML (Electro-Magnetic Locator) derived information added another dimension to the picture that could be created of what lay beneath our feet. The standard utility surveying methodology has been refined through documents such as The Survey Associations 'Essential Guide to Utility Surveys' and the PAS128 specification from the British Standards Institution. However, the basic principles of ground-probing radar deployment changed little until recently. The accepted practice of conducting orthogonal grids of measurements covering the search area, with the interval between measurements varying according to the complexity of the subsurface environment, is an extremely effective one. It does have its drawbacks though.

Given the physical length of many systems, it is very difficult to collect information across a footpath without starting the measurement with the operator in the carriageway. To deploy in the carriageway is time-consuming and requires lane or road closures to protect the GPR engineers. Each measurement needs to be positioned so that it can be interrogated back in the office, usually meaning that the grid needs to be physically marked out first on site. The operator or analyst then has to work out which detected targets in which individual profiles represent the same utility, often having to make assumptions. If this task is being carried out in a complex environment, it can be almost impossible to confidently establish each utility's position.

Revolutionary Technology Tackling the Issues

High-density array ground-probing radar (HDAGPR) represents a step change in application of the technology and addresses these challenges whilst also providing additional benefits. Using multiple radar antennas across a width, with all channels recording data simultaneously, the spacing between these antennas is such that the resulting information can be manipulated to produce plan images at predefined depths. This means that data only has to be recorded in a single direction, removing the need for transversal scans and it can measure along a footpath, achieving full coverage without entering the carriageway. When mounted on a trailer, this system allows comprehensive GPR data to be recorded in live traffic, without any traffic management. This removes the need for marking out grids and greatly enhances the speed of collection.

The most impressive outcome of the HDAGPR technology is the actual images produced; an analyst can see where a utility travels to and from, which inspection covers it travels through and at what depth. This removes the guesswork and has hugely increased the reliability and accuracy of utility surveys. To produce a PAS128:2014 compliant utility survey, the HDAGPR technology can be used in place of the traditional GPR deployment, alongside EML technology. The advantages of this approach are clearly visible in the resulting quality and accuracy of the final survey output. An example of this output can be seen in figure 1. Though not a requirement of PAS128, other pertinent HDAGPR detections such as buried structures, construction changes and voids can also be readily plotted within the

deliverables.

The data provided through using the HDAGPR in conjunction with EML and Inspection cover investigations proved its value during the Aldgate Regeneration Scheme in the City of London.

Technology Application at Aldgate Square

The original gyratory at Aldgate reflected 1960s traffic planning. The local topography was dominated by a heavily trafficked four-lane carriageway. The footways had numerous barriers to movement, including wide brick planters, pedestrian subways and guard railings. Pedestrians found it difficult to navigate the area and all user groups felt it to be unsafe. The key aim of the project was to not only dramatically improve the public realm but also to support regeneration in the area. The project included the removal of the ageing pedestrian subway network and one-way traffic system. To do this, the carriageway needed to be rationalised into two-way single lanes with improved space for cyclists and widened footways. Also, a number of new accessible routes were to be created, in addition to much-needed public space, in the form of the Aldgate Square.

During the initial design stages, it became apparent that the location of the project was going to make construction works incredibly complex, mainly due to local stakeholders and traffic flows. To compound issues, it was determined that 11 separate utility companies were affected by the proposals and initial estimates from one company were in the region of £1.5m. This, plus the associated works costs and traffic disruption, were putting the project at financial and political risk. To address some of these issues, a utility survey was commissioned which included the deployment of the HDAGPR systems across the entire project area.

Once the design team had the survey information, they began 'designing out' as many potential issues as they could. As a direct consequence, the final bill for all 11 companies was reduced to £1.2million using the HDAGPR survey data. There were many other benefits realised using this data, over the project period. Some of these included being able to 'slew' some ductwork rather than divert it, knowing in advance where buried structures compromised initial designs, allowing them to be designed out. They also included sharing the information with the utility companies to facilitate accurate time and cost planning, minimising disruption through accurate delivery of essential works in sensitive areas. In the case of the decreased invasive trial hole requirement, for instance, 72 trees were planted using the HDAGPR survey data without any pre-installation investigative excavations. Greatly improved planning which improved efficiency, reduced the need for onsite design changes due to unexpected structures, thus reducing contractor claims and subsequent disputes.

Figure 1 is taken from a utility survey undertaken at the junction of Minories and Crosswall, in the City of London. The grey feature in the centre represents the tube line beneath the roadway. The filled shapes represent the utility chambers present beneath the surface and the line work shows all of the buried pipes and cables present. The red features are 'power' related; the pink are BT, blue is water and yellow is gas. The remaining services are various telecom and signalling ducts.



Underground Survey at the junction of Minories and Crosswall.

Refining the Survey Process to Fully Utilise the Advantages of HDAGPR Technology

Although a very cost-effective way to 'de-risk' infrastructure projects, the EML element of the survey process is extremely manual, costly and time-consuming. It still requires traffic management and for engineers to physically work in the carriageway for extended periods of time. Often, large-scale projects do not have the timescale or budget available to cover an entire scheme. Yet they need the information that they can obtain through having this type of survey undertaken. Through years of research and with a significant amount of experimentation, software development and improvements to the hardware, the HDAGPR systems are now offering an answer to this problem.

A more efficient working methodology for large schemes has been successfully trialled and is being used on many major infrastructure projects across London. This approach sees the HDAGPR technology deployed along the whole route or area of a planned scheme. The resulting data is processed, analysed and transferred into CAD, providing the client with an accurate map of where detected objects, structures and utilities are buried, and at what depth. This information can then be used to base initial designs on, to identify clashes and design them out where at all possible. Areas where further information is needed can then be targeted with EML technology and those strategically important locations quickly brought up to the full PAS128:2014 M4p compliant specification. The result is that the timescale and cost of the overall survey is reduced, whilst the designers and stakeholders get the information that they need.

Figure 2 represents the results generated from an HDAGPR survey that was undertaken in Oxford Street, London. This data was obtained without lifting any inspection covers and without causing any disruption at the site location. On average, obtaining this level of detail requires approximately one-third of the time required to achieve the level of detail shown in the first image above, and will usually cost less than half of that expected to realise a full specification survey. It will show all detected features, objects and utilities, with depths. However, it provides no information on nature, ownership or duct formation.



Results generated from a HDAGPR survey that was undertaken in Oxford Street, London.

Conclusion

From staggering cost and time savings to critical health and safety benefits, the new HDAGPR technology has already played a vital role in the success of high-profile construction projects as well as proving its worth across major UK airports, the busiest UK highways and various construction projects. Following prolonged periods of relatively limited advances in subsurface radar technology, with various pitfalls associated with previous systems, HDAGPR has now completely revolutionised the field of subsurface radar technology and looks set to completely transform the construction industry. These are very exciting times.

