

# Buried Infrastructure as Prerequisites for Development of a Civilisation

## Geolocating the Underworld Maze of

*For eight millennia is mankind using buried infrastructure as prerequisites for development of a civilisation. From ancient clean water and safe disposal of sewage our society has added enormously to this infrastructure, particularly to cater for our modern desire for energy and telecommunications. Therefore the utility companies in the UK have decided to enhance and integrate existing legacy asset information with dynamically acquired accurately geo-referenced data and to get this unseen maze of pipes and cables beneath our feet accurately recorded and mapped.*

By Jo Parker



Utility plan for a highway improvement scheme – or an underground labyrinth?

### Buried Asset Records

In the UK there are currently over 4 million kilometres of buried pipes and cables providing utility services. These are a combination of telecommunications, water, gas, sewerage, electricity and drainage. It is estimated that every year, on average, 1.5 million holes are dug in UK highways and footpaths by utilities in order to install new services, or repair and maintain existing ones. Over the past 25 years, the UK has seen an increase in traffic of 72 per cent, with an increase in cars on the road of 14 million from 10 million in 1972. In addition the amount of freight carried on the roads has increased by 69 per cent since 1980. Latest Government figures forecast that road traffic will increase by about 40 per cent over the next 20 years. Congestion is an everyday part of our lives and has many causes. Busy

roads are very sensitive to small disturbances, such as accidents, weather conditions, traffic volume and road works. Any unnecessary disturbance should be avoided. However, working on apparatus in the street has never been an easy task for utilities. Every time a hole is dug in the road, it impacts on traffic and the local environment, and carries the risk of hitting and damaging other utilities' buried plant and equipment. The highways authorities themselves own extensive cable and pipe networks used for powering streetlights, traffic lights and other highway signs as well as for road drainage.

Records of different utilities' assets have been kept but may be in different formats such as paper, microfiche and digital and may be incompatible between the various companies. Even where a utility uses the latest techniques

to map their new assets, information on legacy services which may have been installed decades earlier by a predecessor organisation may be inaccurate or even non-existent. Pipes in older cities may be over 150 years old. Poor mapping techniques used at the time of installation and the practice of recording the pipe's location relative to a physical feature that may no longer exist means the exact locations of many of today's networks are unknown. As a result the only way to reliably identify the accurate position of any buried service is to excavate a trial hole.

Current surface location and detection techniques are of limited use, being both unreliable and slow to operate. Utilities are faced with the continuing need for high levels of access to an increasingly congested underground environment, with little or no real knowledge of it, and the inevitable costs. As a society, the impact of this work on people and the environment continues to grow, with an increasing recognition of the need to mitigate its effects, evidenced by Landfill Tax, the Aggregate Levy and the Traffic Management Act.

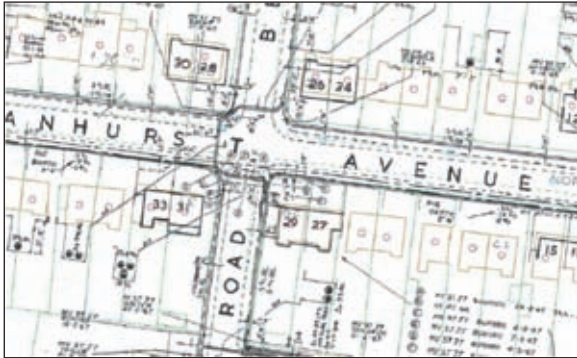
### Economic Disruption

The direct cost of trenching and reinstatement work in UK highways for utilities is in excess of £1.5 billion per year, part of which is attributable to 'dry' holes (plant or equipment not found) and damage to third party assets which is estimated to be as high as £150 million. Large though they are, direct costs are significantly less than the societal costs such as delays to road users, disruption to businesses and environmental damage which may be as high as £5 billion per year.

These costs will continue to rise unless better information and more effective technologies can be made available to those doing the work. Today there is a boom in cable laying. The Government is actively promoting the use of broadband and the fibre optic cables required for this are vast. Today there is over 3 million km of fibre optic laid under the streets of the UK with 60,000 new connections each week. On the other side, many utilities are reaching the end of their design lives. National Grid, for example, has a programme to replace all their iron mains within 30 meters of properties over the next 30 years. Thames Water will replace over 1600 km of iron mains in London over the

ilisation.

# Pipes and Cables



Raster utility data will have to be transformed into digital vector form.

next five years.

Growth in the economy, the introduction of competition into utility services and increasing customer demand for essential services has brought with it a greater number of excavations in the streets in order to supply these services. The increase in the number of utilities licensed to lay mains and cables within our streets brings with it the increased potential for conflict between the utilities and a greater need for readily accessible accurate records. There is also a need to develop better ways to display the information as utility plans become so complicated it is difficult for site operatives to identify what they will actually find below the ground. Interestingly this problem is not limited to the UK. Countries in Europe, USA and increasingly in Asia report that they are suffering from problems with locating and accessing their buried utilities and the disruption that causes particularly in urban areas.

## Mapping the Underworld

The UK's EPSRC - Engineering and Physical Sciences Research Council announced in 2004 that it would establish a programme as an initial attempt to tackle these issues. It organised an 'Ideas Factory', whereby invited academics, industrialists and EPSRC got together in the autumn of 2004 to review the problems and agree priority research topics. Out of this a £1 million research programme was identified with four projects funded:

- Buried asset location, identification and condition assessment – a multi-sensor approach
- Enhanced Methods of Detection of Buried Assets
- Mapping and Positioning
- Knowledge and Data Integration.

In addition, a network was funded which has been used to establish a web site for the programme and organise regular seminars to disseminate the findings from the programme and collect industry views to inform future research directions. Further details of the programme can be found on the web site.

The first project investigated the feasibility of several novel approaches alongside enhanced

existing approaches to be combined into a single multi-modal unit which would locate, identify and condition assess buried assets. These techniques include developing ground probing radar, acoustic and electro-magnetic techniques as well as considering the interaction of the utility with the surrounding soil to develop tools which can both operate from the surface and through in pipe systems.

The second project is developing low cost detectable labels which can be affixed to pipes, cables and ducts and which can be remotely interrogated from a surface based unit to give information on the location and nature of the asset.

The final two projects have laid the foundation for a further project funded by the DTI - Department of Trade & Industry, 'Visualising Integrated Information on Buried Assets to Reduce Streetworks' (VISTA).

## VISTA

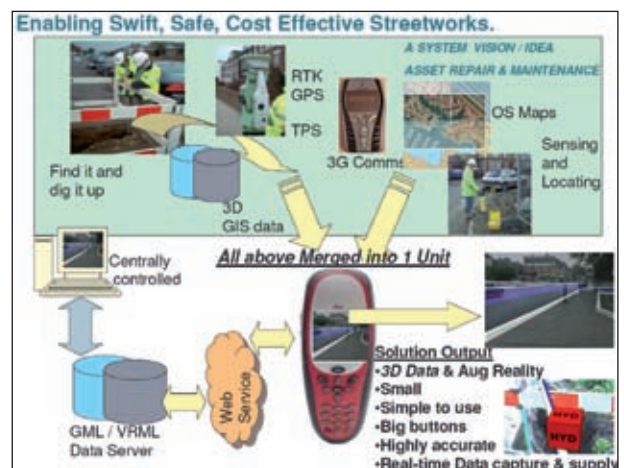
This project, lead by UKWIR - UK Water Industry Research brings together the University of Nottingham and the University of Leeds as well as 19 other organisations including various utility companies, highways organisations, professional organisations, utility contractors, consultants and survey companies. The research for this project focuses on the enhancement and integration of existing legacy asset information together with dynamically acquired accurately geo-referenced data in the street. Novel techniques will be devel-

oped to display the information to digging teams and network designers. The work will include field trials to confirm issues and trial solutions.

## Mapping and Positioning

The research carried out by the University of Nottingham through their IESSG - Institute of Engineering Surveying and Space Geodesy will develop a prototype positioning system which can deliver 3D absolute co-ordinates to centimetre accuracy, using local transmitters such as Localites, Inertial Navigation Systems (INS), Leica's Smartstation, commercially available GNSS technology and GNSS simulators developed by the IESSG.

The accuracy, availability and reliability of satellite based positioning are very dependent on the number of tracked satellites and their spatial geometry. One of the limiting factors in using GPS is the requirement of having direct line of sight with the satellites themselves and the GPS receiver. Ideally, the GPS receiver should see at least 5 satellites to allow On-The-Fly ambiguity resolution to take place. Most of the utility mapping required will be in built up areas where line of sight to a sufficient number of satellites is not always possible. In addition the presence of trees as well as buildings can cause masking issues as well as introducing multipath errors, i.e. interference caused by the signal reflecting from a number of surfaces. This part of the project will research various means of improving the position availability, integrity and precision through a GPS based system augmented with other systems such as Galileo, GLONASS, INS and Localites.



The VISTA vision.

## Data Integration

The University of Leeds is investigating the various data issues related to buried asset records and is currently developing a schema which can be used to allow organisations to access varied digital records via the web. In order to allow other media to be easily included, additional research is investigating how raster data can be converted in to vector. Finally the Leeds team is considering how accuracy can be displayed to allow the users of asset information to be aware of the confidence the owning organisation has in the data.

## The Future

Traffic Management Regulations are likely to require all utilities to improve the information they currently hold about their buried assets. This has been supported by the results of a review of the current process carried out recently by the NUAG - National Underground Asset Group a group of stakeholders from utility companies, local authorities, contractors, Government Departments and industry organisations which was established in 2005. Its role is to fully represent all industries view to support the Department for Transport's decision making associated with the Traffic Management Act. Acting under the Departments governance the group is currently developing and implementing standards on recording, storing and sharing underground asset data across Great Britain. The research described above will facilitate this and allow the UK to significantly improve managing of buried assets as well as help ensure that any excavation carried out is minimised.

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VISTA team members surveying buried utility assets.