Department for Transport

Traffic Advisory Leaflet 7/14

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Mapping underground assets

This is one in a series of Traffic Advisory Leaflets providing guidance on methods of working and innovative techniques aimed at reducing traffic congestion due to road works. The series is aimed at utility companies, highway authorities, contractors, equipment suppliers and others involved in road (or street) works. Each leaflet in this series is based on research carried out by TRL Limited on behalf of the Department for Transport and Transport for London.

Introduction

This leaflet provides advice on mapping underground assets to locate and identify buried pipes and cables. Underground asset mapping systems rely on databases that can hold considerable amounts of information tied in to the location of the assets, such as maintenance history, road construction type, etc. This leaflet also covers the use of radio frequency identification markers; an emerging technology where tags are fixed to new assets during installation or to existing assets when exposed by excavation. It should be noted that there are relatively few such tags currently in use but they are expected to quickly grow in number as the technology becomes widely adopted.

Accurate mapping of all assets within a highway should allow for better planning and more efficient repair and replacement of the assets. This, in turn reduces the time works occupy the highway and the attendant congestion. It also reduces the risk of equipment strikes. Comprehensive and reliable data associated with assets can make it possible to carry out targeted excavation as opposed to excavating simply to find out where the assets are, which often results in 'dry digs'.

Section 79 of the NRSWA places a duty on undertakers to record the location and type of their apparatus while Statutory Instrument 2002 No. 3217 The Street Works (Records) (England) Regulations 2002 prescribes, among other things, the level of accuracy required. However, the legislative requirements are relatively basic and it is becoming increasingly common for more detailed methods of mapping underground assets to be used. There is a variety of methods of recording assets available, and costs tend to reflect the level of detail involved. As such, undertakers need to take a view on how much they wish to spend on underground mapping and what they want to map.

Mapping of underground assets can help to:

- minimise the risk of injury to workers and the general public;
- significantly reduce the risk of damage to buried equipment - especially important in the case of assets such as fibre optic cables or underground fuel tanks;
- improve project planning with reduced project downtime and the avoidance of costly rescheduling;

- aid compliance with Health and Safety regulations;
- avoid heavily congested areas when planning new utility routes;
- identify apparatus where infrastructure sharing might be possible;
- make it easier to freely share the information with others who have a legitimate interest (as required by legislation).

Information obtained through mapping can, where specified, also extend to records of buried structures and the available space underground, allowing safer and quicker installation of new services and excavation of existing ones. In addition, some survey methods can be used to make records of the road construction which can assist considerably in the planning stages and help ensure that reinstatement gangs bring the correct equipment with them. Mapping underground assets can be carried out using one or more of a range of technologies. The results can be used to provide:

- 2D plans;
- 3D models of the site and the utilities;
- CAD drawings linked to GIS databases;
- input to Building Information Models (BIM);
- desktop analyses of Statutory Authority plans;
- Statutory Authority plan verification surveys;
- cable/pipe route plant avoidance surveys;
- other specialist surveys.

Techniques used include radio frequency location surveys, ground penetrating radar (or ground probing radar) surveys, acoustic mapping surveys and inertial gyroscopic mapping.

Survey methods

Radio frequency location (RFL) surveys have been the traditional method for locating metallic utilities. There are two modes of RFL - passive and active. Passive location works by detecting the electromagnetic fields inherent in live electricity cables. Active location depends on a transmitting device that applies an electronic signal either directly onto the utility or through the ground by induction.

Figure 1 - Hand held RFL receiver in use

The signal re-radiates some distance either side of the transmitter and it can be detected by a hand held receiver (see Figure 1) which can locate the service in plan and allow its depth to be estimated.

Re-radiated long wave (i.e. very low frequency) signals can be detected in a similar way using the electromagnetic receiver in Radio mode. The same receivers can be used to trace transmitting probes which allow unoccupied non-metallic pipes and ducts to be traced. The transmitting equipment can be inserted into the services using proprietary rod propulsion systems.

Ground-penetrating radar (GPR) is a geophysical sub-surface imaging system that, under the right conditions, can detect and map most underground services irrespective of their composition although it cannot identify the type of service detected. GPR has other limitations such as where there is low velocity contrast (i.e. limited variance in how fast the signals travel in different materials), between the pipe, its contents, and the surrounding material. For example, a plastic pipe full of water buried in saturated clay will be effectively transparent to GPR.

The output from a GPR survey can be processed to provide full 3-D mapping. GPR output can also be used for ‘on site mark out’

Figure 2 - Ground-penetrating radar being towed behind a vehicle

Figure 3 - Inertial gyroscopic device being inserted into pipe

providing quick results without having to wait for post-processing of data. Some GPR systems can work while being towed by a vehicle travelling at low speeds - see Figure 2.

GPR mapping systems using up to eight channels at multiple frequencies over a width of 2m can be used to map carriageways at speeds of 10 km/h. Multiple antennas allow for higher resolution mapping of underground utilities. In some cases, these systems eliminate the need for traffic management and increase survey productivity.

Although not as popular as other types of survey, acoustic mapping surveys can be used on metallic and non-metallic water pipes (or pipes carrying any other liquid) but they rely on the pipe being full. As such, they are only suitable for use on pressurised services. A vibrator is attached to an exposed part of the service under scrutiny and this generates a sound wave that travels along the fluid in the pipe. An operator detects the sound wave with a ground microphone as he walks along the length of the run.

The results from any of these survey techniques can be exported to CAD, BIM or GIS. For reliable results, it is best to survey using more than one technique and cross reference the results. A competent surveying specialist should be able to demonstrate a multi-tooled approach and have an effective quality control procedure for cross referencing the survey information.

For greater accuracy and for surveys of deep services, specialist surveying systems such as inertial gyroscopic mapping systems (see Figure 3) can be used.

These systems can locate minute details and defects such as distortion in pipes but they require internal access for the equipment which may be an issue for pressure systems.

Standard for utility mapping

In June 2014, the British Standards Institution launched BS PAS 128:2014 - *Specification for underground utility detection, verification and location* at the Institution of Civil Engineers - see http://www.ice.org.uk/pas. The Standard was sponsored by the Institution of Civil Engineers and a wide range of organisations was represented on the Steering Group.

PAS 128 provides a robust methodology for delivering utility surveys in the UK. It is considered by many to be the minimum standard that practitioners should aspire to and is being increasingly specified by clients. It focuses on four Survey Category Types (levels of accuracy) that can be specified when requiring a PAS 128 compliant survey. The Standard specifies requirements for the detection, verification and location of existing and new underground utilities and applies to active, abandoned, redundant or unknown underground utilities buried up to a depth of 3 metres. It applies in urban or rural areas and covers utilities located in the street or on private sites such as hospitals or airfields.

Research

Mapping the Underworld, is a multi-disciplinary and multi-university research programme, of which the first phase (2008-2013) focused on developing the means to locate, map in 3D and record the position of all buried utility assets without excavation. The aim is to achieve this through the development of a single shared multi-sensor platform including vibro-acoustic, low frequency electromagnetic field, passive magnetic field and ground penetrating radar technologies, combined with the intelligent use of existing utility company records and ground databases. The next phase of the initiative, Assessing the Underworld (2013-2017) is aimed at proving the concept of a single integrated assessment and modelling framework using a multi-sensor approach.

RFID marker Tags

Radio-frequency identification (RFID) tagging is different from the RFL survey techniques described above. RFID tagging allows for the location and identification of services regardless of their electrical conductivity and can provide considerably more information.

RFID marker tags take a variety of forms but in general, they essentially comprise an electronic chip encased in plastic. They have a unique identification code that can be read remotely by equipment specific to the tag manufacturer, and most types can store a small amount of user-recorded data if required. The tags are buried with apparatus allowing it to be identified and located.

RFID tagging provides for effective project planning with data available to review and use as part of the design process, helping to ensure that maintenance teams arrive appropriately equipped and ready to undertake the work correctly on the first visit. The tags dispense with the need for local knowledge - teams from other areas can attend a site for the first time equipped with all the information a local team would possess.

RFID marker tags provide an opportunity for all work sites to be recorded, capturing essential data that should improve future site safety and operational performance. Data can be used for other purposes such as capturing data for CDM requirements. In addition, the information can be examined and analysed at any time - it does not rely on a site visit to obtain it.

Tags can be referenced to a dedicated GIS database that, in addition to the identity, location and characteristics of the apparatus being tagged (e.g. size, material and other features), can hold a considerable amount of other relevant information. The database might include, for example, information on pavement construction and maintenance history, together with details of other services located in the same excavation. It could also include photographs of the excavation prior to reinstatement - see Figure 4.

RFID marker tags are either passive or active. Passive tags require no battery and lie dormant until a corresponding electromagnetic field is generated from a hand-held transmitter at ground level. The chip in the tag sends a response allowing for accurate location and access to the unique RFID code that, in turn, provides failsafe access to data held on the dedicated GIS database. Active tags include a power source that makes them easier to contact but they are only effective as long as the battery lasts.

Tags can be directly secured to an item of plant or they may be offset laterally, typically at the back of a footway, which allows services to be identified and located without the need for traffic management.

Safety systems

RFID tagging can be used in conjunction with advanced plant avoidance systems. One such system downloads the data to a suitably equipped excavator to allow safety distances to be set so that the bucket cannot encroach into a restricted area. The safe working distances can be set for individual utilities or assets if required. Guided using GPS, the machine knows where it is safe to dig and the areas it must avoid.

Figure 4 - Photo of exposed duct and RFID tag being accessed from associated tag data

Recommended further reading

- Avoiding Danger from Underground Services, HSG47 http://www.hse.gov.uk/pubns/books/hsg47.htm
- BS PAS 128:2014 - Specification for underground utility detection, verification and location. http://shop.bsigroup.com/ProductDetail/?pid=000000000030267400
- Specification for Highway Works. http://www.dft.gov.uk/ha/standards/mchw/vol1/
- The Construction (Design and Management) Regulations. http://www.legislation.gov.uk/uksi/2007/320/contents/made
- New Roads and Street Works Act 1991. http://www.legislation.gov.uk/ukpga/1991/22/contents
- The Street Works (Records) (England) Regulations 2002. http://www.legislation.gov.uk/uksi/2002/3217/pdfs/uksi_20023217_en.pdf
- The Construction Plant-hire Association publications. http://www.cpa.uk.net/publications/
- Specification for the Reinstatement of Openings in Highways. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11042/sroh.pdf

Useful contacts

Underground Service Avoidance Group (USAG)
www.utilitystrikeavoidancegroup.org/index.html

Mapping the Underworld
www.mappingtheunderworld.ac.uk

Assessing the Underworld
www.assessingtheunderworld.org

The Survey Association
www.tsa-uk.org.uk/

Energy Networks Association
www.energynetworks.org/news/public-information/dial-before-you-dig.html

Health and Safety Executive
www.hse.gov.uk/contact/

PAS 128 site
www.pas128.co.uk/

Institution of Civil Engineers
www.ice.org.uk/

British Standards
http://bsigroup.com/

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