Electronic Trial Holes - The way forward?

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SYNOPSIS

Companies working on the installation and rehabilitation of our vital underground utility services are under mounting pressure not to impede the flow of traffic & commerce. Increasing Environmental and Health & Safety considerations place additional constraints on those companies who are still willing to undertake this vital work. Many companies now undertake trial hole programs to achieve a better understanding of the environment in which they are about to start work, but the potential for damage to occur to existing underground services, increases with every excavation and insurance costs continue to rise because damage to third party infrastructure continues to happen.

The cost of these look 'n' see works in time, money & resources, as well as their disruption to the local economy & impact on the environment is no longer a price many are willing to pay.

1. Introduction

With the Highways and Cities of the developed world, grinding to a halt from traffic congestion; the window of opportunity to undertake large scale excavations in highways and footways, gets ever smaller.

AS THINGS USED TO BE

For those companies responsible for the installation, replacement and maintenance of the underground utility infrastructure that feed our modern lifestyle, this is a huge problem.
The potential for damage to existing underground services to occur, increases with every excavation. Yet excavations, where there is no real idea of what services may be present, are opened on a daily basis. The fact that this potential is realised so often year in year out, is no longer a surprise to anyone in the utility industry.

Somehow, despite the existence of these complex and inter-related issues and restrictions; companies across the country, manage to open over 4 million excavations every year, in their attempt to keep the UK's utility infrastructure working. That's more than 1 every 8 seconds, or in the time it's taken for you to read this far, around 20 more excavations will have been opened, somewhere in the UK.

That this number can no longer be sustained and has to come down is universally accepted. The answer to how that can be accomplished has yet to be found. While the debate continues, the excavations continue; the traffic delays continue; the costs to the country and the taxpayers continue and they will only ever continue to rise.

Hidden within this statistic though is what may be the key to the answer.

Over half (around 2.4 million) of the 4 million excavations undertaken each year, are in fact Trial Holes. There is no doubt that we are a long way from consigning the pick & spade to a place in the local museum, but if we can establish a means by which this vital information can be obtained without actually having to dig a hole, then we shall reduce the size of the problem dramatically.

2. Trial Holes – A Necessary Evil

If accurate records were available, that could provide details for the location of the entire network of buried infrastructure under the Highways, there would be little need for Trial Holes to be undertaken. This however, is far from the case.

NO WORK TODAY?

The endless succession of mergers and acquisitions throughout the industry over the last 25 years, has seen many of the old paper based records lost or destroyed and the true identity of the Asset owner become extremely blurred. The number of individual companies who now have the right to undertake excavations in the Highways (Statutory Undertakers) now exceeds more than 200 (1)

3. The size of the problem

Service Type	Assets
Gas	133,000km
Electricity	137,000km
Water & Sewerage	700,000km
Telecommunications	2,300,000km
TOTAL	**3,270,000km**

Due to the ever changing nature of the utilities market in the UK; these figures should only be regarded as approximate and have been compiled from data available on a selection of utility company websites. They are also only a reflection of assets that are currently in use.

With this many assets underground, you have to be extremely lucky not to come across some form of utility, live or otherwise, in the course of a Highway excavation. The problems start when you realise that these figures only refer to those assets for which records are available and that those records cannot be regarded as anything more than advisory for route, rather than provide a definitive location. Under these circumstances, it is understandable that companies wishing to place new infrastructure in to this environment, would look to another means of assessing the true accuracy of the information at their disposal.

The traditional way of meeting this need, is to undertake Hand Dug Trial Holes. These are essentially a spy hole into the unknown; their purpose being to gain additional and confirmatory information over a large area by undertaking a series of small excavations at key points of a project.

4. Traditional Trial Holes

Using whatever existing service drawings are available for the area under investigation, a series of locations will have been identified at which hand dug trial holes are to be undertaken.

In most cases, the actual hole that is dug takes the form of a strip trench between 400mm & 1000mm wide. This is dug across the carriageway, starting at the kerb and extending either to the centreline, or until the particular service or feature, to which future works will relate, is located. A sketch is then drawn of the immediate area showing the dimensions and position of the completed trench. Measurements are taken to show the line & depth of all the services uncovered, with respect to the kerb and the level of the existing road surface. Due to the inaccuracy of the existing records, it is not unusual for a particular service of interest not to be found the first time of looking (normally referred to as a dry hole) and additional works needed to ascertain the correct position.

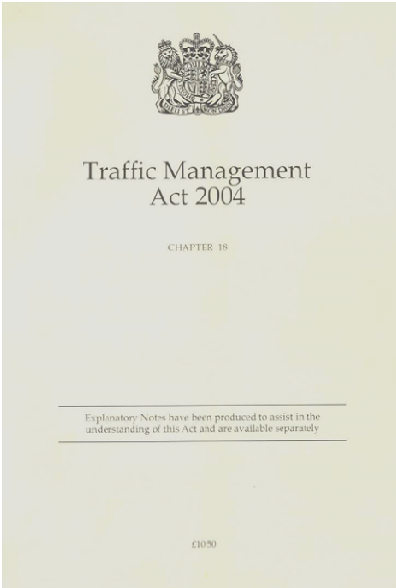
A TYPICAL STRIP TRENCH TRIAL HOLE

Because all of this work takes place in the Highway, some form of Traffic Management will almost always be required; both to protect the safety of the workforce undertaking the work and that of any drivers and pedestrians passing while the works are in progress. This inevitably leads to issues with traffic congestion and concerns from local traders over possible affects to their business. Local residents will also express concern over issues of disturbance to their daily routine.

A report by the Transport Research Laboratory (2) suggested that the cost to the travelling public from the increase in congestion and disruption to traffic, from unnecessary delays caused by street works is an estimated £2 billion a year. Alternative figures released in a consultation document published by the Department for Trade (3) show that the total cost to the country is in excess of £4.3 billion. That represents a loss of over £136 for every second of every day, across the whole year. Reports of damage to any existing services present only normally hits the headlines if someone is killed or seriously injured, but the cost of this type of damage is considerable in itself. Back in 2000, there was in excess of £15 million of third party damage caused to the infrastructure of the UK Water Industry alone. (4)

5. Drivers for Change

In 2004 The Traffic Management Act (TMA) became law in England and Wales, followed shortly after by the Transport (Scotland) Act (TSA) in 2005, the main objectives being to improve the quality & integrity of road surfaces and speed traffic flow. Both of these new Acts interact with and



update parts of the existing New Roads and Streetworks Act, which was originally passed in 1991. Between them, these changes have already had a significant effect on Streetworks operations, but because parts of these Acts were post dated, the biggest changes will come in to effect on or after the 1st April 2008 and will have a much more fundamental affect on the way Streetworks are planned and implemented.

Responsibilities yet to be Implemented

- Minimum notice periods are significantly increased.
- More activities to be registered.
- Increase in the number of Traffic sensitive Streets.
- Operation of a permit scheme (payment of a fee).
- Local Authorities given power to direct timing of works
- Fixed penalty fines for transgressors.
- Blocks on Streets following major works.

If the window of opportunity for companies to undertake Streetworks using traditional methods has all but disappeared, then clearly new ways have to be found and there are many new & improved trenchless technologies around that will no doubt become much more commonplace due to the changes outlined above. Some are relatively straightforward to implement, others require substantial capital investment. This paper is concerned with just one of them & it’s definitely at the straightforward end of the spectrum. Electronic Trial Holes.

6. What is an Electronic Trial Hole

The most obvious difference between Electronic Trial Holes and Traditional hand dug Trial Holes, is that with Electronic Trial Holes, there is no actual need to dig any form of hole at all. The name has purely been coined to facilitate the similarity of purpose, between it and its traditional forebear.

A TYPICAL ELECTRONIC TRIAL HOLE

The second major difference is that; whereas the size of a hand dug trial hole is kept as small as is feasibly possible to reduce the reinstatement costs and of course the potential for damage or injury to personnel, equipment and existing services present. No such restrictions are necessary for Electronic Trial Holes and therefore the only factors that really affect their size are access and time available.

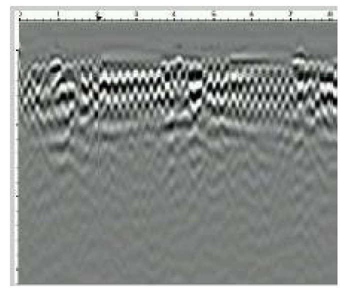
In addition, because no hole is being dug and no permanent access is required to a carriageway for any length of time. It is almost always the case that they can be utilised without any requirement for fixed traffic management. Even when Traffic management is necessary, the difference in time required to complete an Electronic Trial

Hole over a hand dug one, means they can almost always be undertaken outside of traffic sensitive hours and even at night, with virtually no disruption.

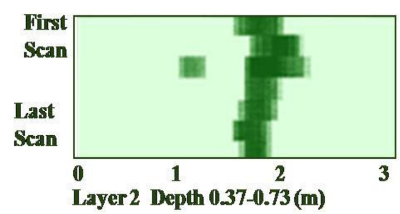
7. The Technology behind Electronic Trial Holes

The concept of Electronic Trial Holes has been around for some time and has been successfully & extensively deployed in specialist situations, but it is only in recent years that the technology and procedures required to undertake them in relation to everyday works, has been advanced enough to make them cost effective and provide results that are reliable and consistent. The success of Electronic Trial Holes relies on the correct implementation of two principle technologies: Electromagnetic Radio Location and Ground Probing Radar. Both these technologies have been around independently for some time and in the UK there are over 100 companies using one or other of these technologies. They both have their own advantages and disadvantages with respect to the location of utilities and it is only by combining the two technologies together with strict procedures in to one single system that the consistent quality of results can be achieved.

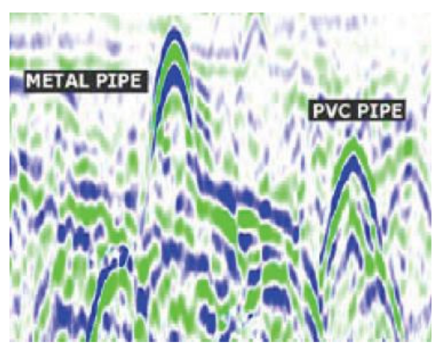
Easy Locator from MALA



PipeHawk MkII from PipeHawk PLC



SIR 3000 from GSSI



Ground Probing Radar

There are several Ground Probing Radar Systems (GPR) now available. Some are designed for geological use by Academics, others designed specifically for the location of utilities and other man made structures by site based technicians. Although differences do exist, principally around the range of frequencies on which they work, there is a great deal of similarity in their basic operation. In basic terms, A GPR system works by transmitting a radio frequency signal into the ground and measuring the variations in the reflected signal received back, the variations being caused by changes in the dielectric properties of the ground between the transmitting & receiving antenna. Those changes are then depicted on screen, for interpretation by the technician operating the system.

All the systems currently available use their own proprietary software for the processing of data collected in this way and relies on a complex set of mathematical calculations, using algorithms formulated from extensive research and results achieved over time and under known conditions. Some also have the means to provide pre-interpretation of the data prior to that undertaken by the technician. Those designed specifically for the location of utilities for example, have the ability to reprocess the collected data and look for significant changes that appear as linear in nature.

GPR Advantages

One of the big advantages with GPR technology of course is its ability to locate Non Conductive Services. When undertaking any work in and around Banks, Financial Institutions and other places were Fibre Optic cables are prevalent, this is particularly advantageous as the high value placed on the data from trade & commerce travelling through these cables, makes it a completely indispensable technology. In one instance 3rd party damage to one Fibre Optic cable alone, is known to have cost over £500,000 to put right.(5)
There are also particular types of Electricity cables for which Radar has a particular advantage over traditional Electromagnetic Radio Locator systems. These are known as Balanced HV systems and they can be a huge problem, because when the cables are laid close together, their respective electromagnetic fields effectively cancel each other out due to 120 degrees of separation making them undetectable by other means

GPR Limitations
The current level of technology does not currently permit the accurate identification of the size, purpose, or material type of any anomalies located and areas with different surface coverings i.e. tarmac, grass, concrete etc must be examined (referred to as a scan) separately.
Areas where the ground is predominantly made of materials such as clay or where the water table is high, will not yield results as conclusive as those areas which are sandy or dry, or any combination between in varying degrees. Those areas where the services are constructed of materials with similar dielectric properties to the surrounding ground may also prove problematic.

Those companies, who operate GPR at the highest standards, will typically scan an area up to 20% or 30% greater than that which their client requires, to mitigate the effects such issues have, on the quality and integrity of the data.

Electromagnetic Radio Location (ERL)

Although many people are familiar with basic Cable Avoidance Technology; this equipment, although similar in concept, is much more powerful and is designed to allow the operator to locate individual services, not avoid them. There is some variation across the different manufacturers as to the choice of frequencies (KHz) used and the standard & specialist application accessories available, but there are always two principle pieces of equipment; A Transmitter, often referred to as a Genny (short for Signal Generator) and a Receiver.
There are also two principal means by which this equipment is deployed; these are referred to as Passive and Active Signal locates.

Passive Signals

A Passive signal is one which causes an electromagnetic field to be generated, around a conductive service, that is not instigated by the Location Operative, but happens as a result of either natural electrical forces within the earth using it as the easiest path, or by a coupling effect taking place with adjacent or nearby electrical services. This electromagnetic field can, when strong enough, be detected by the receiver, revealing the line of the conductive service around which the signal is centred.

Active Signals

An active signal is one which is deliberately generated by the Location Operative using the transmitter and is therefore of a known frequency, which can easily be identified by the receiver. Two methods of use are possible:-

Method 1 is to connect either directly to a service via a known surface feature such as a valve, lamp post etc, or by the use of an inductive clamp placed around a cable which is exposed or accessed via an inspection cover.

Method 2 is to broadcast a signal from the surface, which will induce a current into any conductive service within range causing an electromagnetic field to form around it.

The signal in both cases will be of a frequency chosen specifically by the operative for its tracing potential, relevant to the service being traced.

RD 4000 System from Radiodetection

ST510 Transmitter & SR20 Receiver from Ridgid

ERL Advantages

The biggest advantage of ERL systems is that you are able to identify the service (in the majority of cases) because it is being traced from a known point, such as a valve, or cable pit.

They are also light and easily carried, which can be a distinct advantage when working on sites with poor access, or uneven ground.

ERL Limitations

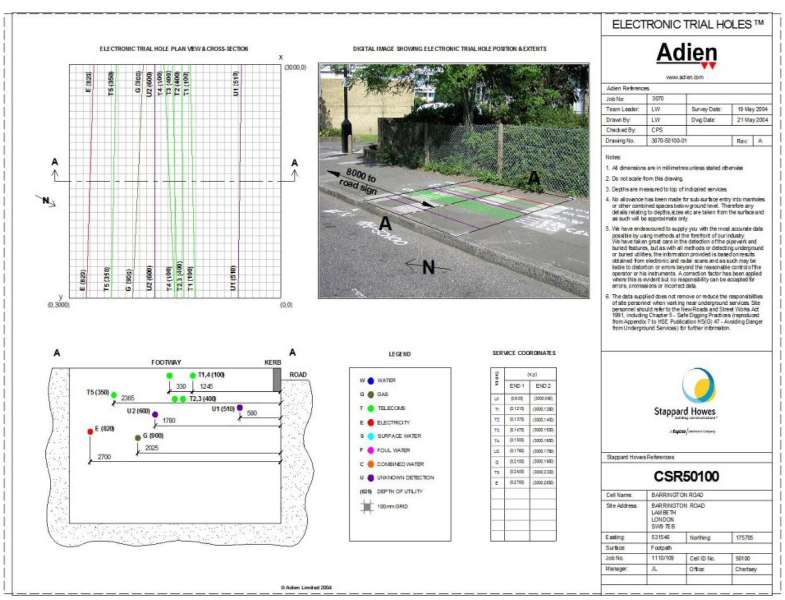
The main limitation of this technology is that it has no capacity for locating non conductive services such as HDPE Pipes and Fibre Optic cables. This means a large majority of Gas & Water services installed since the mid 1970’s cannot be located using this technology. It is also a big problem where old conductive pipes such as cast iron, have been refurbished or repaired with modern HDPE fittings. This causes continuity to be lost in the electrical path resulting in gaps in the service network. The exception to this is where it is possible to insert a conductive trace wire or sonde (mini transmitter on a flexible rod) into the service. This is often the approach taken when tracing the route of a sewer system for example.

8. The Electronic Trial Hole Process (ETH)

Now we have an understanding of the technology to be used. We need to look at developing good processes and procedures to ensure the advantages of both technologies are utilised to the full, whilst doing everything possible to mitigate their limitations.

i. Agree the Type of Results Required

If Electronic Trial Holes are being undertaken as a direct replacement for traditional hand dug trial holes, then it may be acceptable to have results drawn up by hand on site, with an accompanying sketch of the ETH location. One approach is to have a pre printed form to ensure none of the essential information is missed. These can then simply be filed for retrieval at a later date, or returned to a drawing department for digitising. The best option though is to provide the means to draw then up electronically on site as they are completed.



TYPICAL ELECTRONIC TRIAL HOLE RESULTS

This requires either a mobile CAD office or a laptop with a suitable drawing package, preferably GIS enabled. This will reduce your potential for creating draughting errors during copying and make the information more widely available in a shorter time.

It is also important to consider the reasons why the Electronic Trial Holes have been commissioned. If the reason is for example; confirmation of the Water records, it may not be necessary to locate all services in the ETH area. It would however be extremely important to ensure that this was noted on the completed records to ensure that it could not be assumed that no other services were present because they were not shown.

ii. **Agree Accuracy Requirements**

The highest standard of accuracy for Electronic Trial Holes is normally regarded as being +/- 100mm in line and +/- 10% of depth quoted for each service. This is essentially accuracy down to the width of a spade. This may not however be appropriate in all occasions. Pre-planning works may only require accuracy to +/- 500mm for example to reduce the cost whilst surveying a large number of prospective routes. The priority route could then be resurveyed to a higher accuracy at a later date.
At this point you should also agree a standard marking policy. This will need to cover everything from colours of marks, to whether you are working in mm or cm.

iii. **Gather All Information Available**

Just like with traditional trial holes, every investigation should start with the full facts available. There is no point in making it hard for yourself. Obtain copies of all statutory records and old street maps where applicable, making sure they exceed the area of the ETH by at least 20-30 metres in each direction. It's amazing how many times the records are incomplete, only in the area you're working. If there are 3 gas mains shown at either end of the street, it's a fair bet that there should be three in the middle as well. This will also help in identifying where potential connection points can be found for the ERL part of the survey.

iv. **Use Multi Technology Approach**

There is no other way of making this work than with a Multi Technology approach. That means having a good quality ERL kit and a good quality GPR system that is equipped for Utility location work.

HARD WORK BY HAND HERE?

The ERL kit should be used in a logical sequence through all the services, whether they are believed to be present or not. This means an agreed order which is consistent across each ETH location.

ie. Water; Gas; Telecommunications; Electricity; Traffic Control; Other

The GPR system should be deployed across the entire area of the ETH completing an orthogonal grid in both planes. It is also suggested that you have an agreed start and end point ie. Working clockwise, starting from the kerb.

v. **Confirm Accuracy of Results**

Once all the location work is apparently finished and the results drawn up on site, ensure both the physical results and the recorded results are confirmed as being the same and that the findings have been x-checked against the available records. Not to see if they are exactly the same, that's very unlikely. You are looking for the number of services and the direction of runs, you may have found more than the records show, but it's quite rare to find less.

If your results may have critical consequences for your proposed works, use an additional technology such as vacuum excavation to run a % confirmation check on key points.

vi. **Use Results to Update Records**

Once you are satisfied that your results have met your required standard of accuracy, make sure they are transferred to your permanent records. This will soon become a mandatory requirement under the TMA / NRSWA improvements.

9. Conclusion

The detection and location of buried services is often treated as some form of mystical black art, because it deals with the unknown, but there is no secret about how to do it successfully. It requires a combination of science, hard work, good observation and strict adherence to tried and tested practices and procedures. It is not however infallible. It is never possible to establish in advance, the precise number of services present at any given location, or exactly where they are, both in relation to each other and to the surrounding topography. If it were, there would be no requirement to complete an Electronic Trial Hole survey at all. It is therefore always impossible for the technicians undertaking a survey to know with 100% certainty that every service has been detected, identified and located correctly. It is however as accurate as the current system, with minimum detriment to traffic flow and without any of the associated risks.

10. References

1. ‘ Keep Traffic Moving’ (DfT Consultation on TMA 2004 – October 2006)

2. 'Mitigating the Disruption caused by Utility Street Works' (TRL report 516)

3. Halcrow report for DfT – 2004

4. Sonden L (2002). Information supplied by NJUG to UK Water Industry Research Ltd.

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