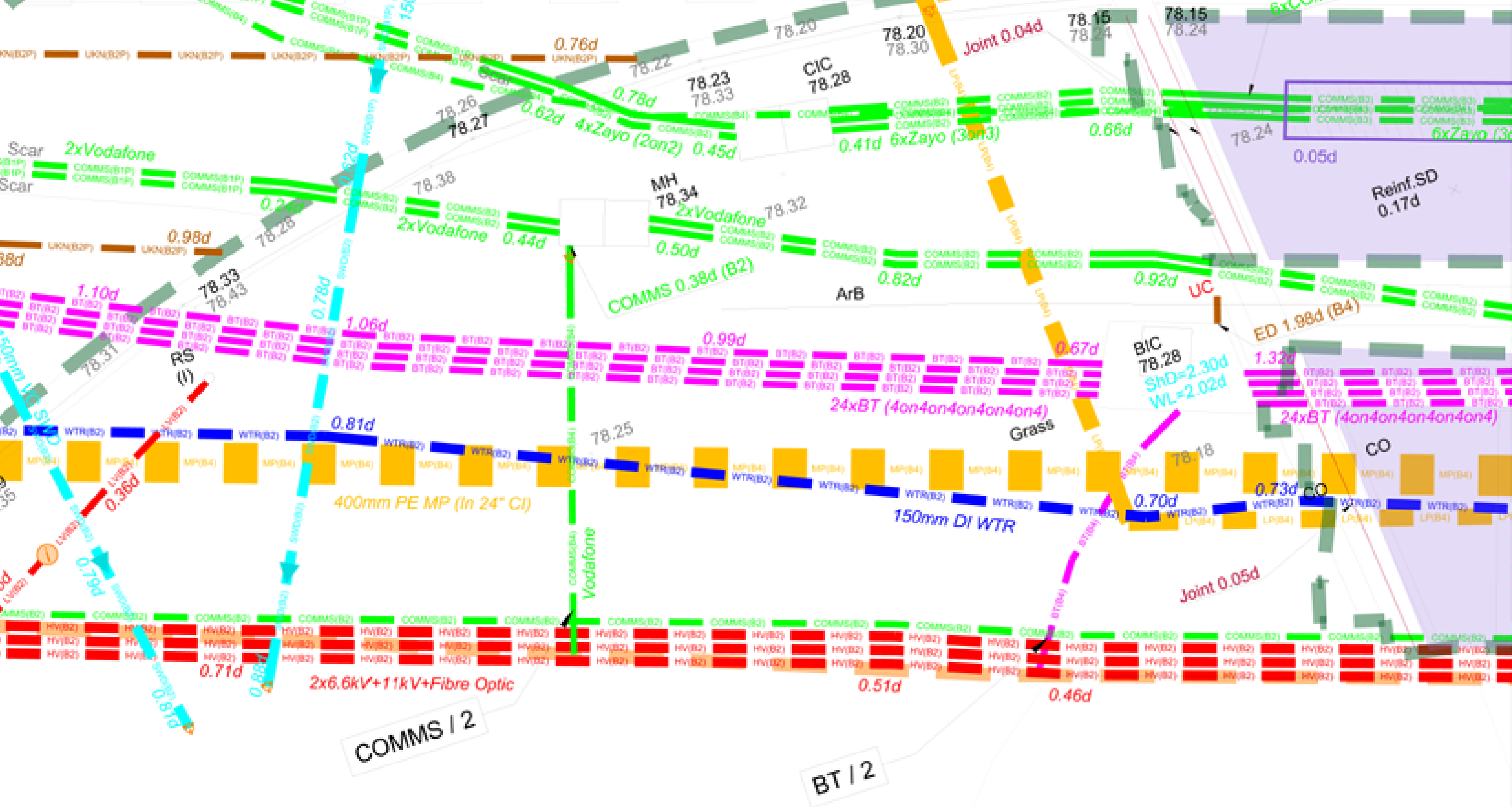

THE SURVEY ASSOCIATION

CLIENT GUIDE TO **BS: EN PAS 128:2022**

SPECIFICATION FOR UNDERGROUND UTILITY DETECTION, VERIFICATION AND LOCATION

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Endorsed by:

RICS chartered ices

The Survey Association's Client Guides are primarily aimed at other professionals such as engineers, architects, planners and clients in general. They are not intended to go 'in depth' into practical issues but to act as a basic guide on a particular topic and in particular, on procedures and regulations which may govern how a particular aspect of the survey is carried out.

Contents

This document has been prepared solely for use as guidance notes and is based on best practice in the industry at the time of issue. Clients should rely on their own professional training and judgment when adopting any of the practices described in the guidance notes. The Survey Association accepts no responsibility or liability whatsoever for any claims against clients or practitioners arising as a result of any practices included in the guidance notes.

Part 1 – The case for PAS128

Introduction

Installing and maintaining the UK's four to five million kilometres of buried assets requires extensive input from utility companies, contractors and highway authorities. With the amount of buried assets dramatically increasing, the number of holes dug has increased. In 2009/2010 Transport for London recorded 370,000 excavations on London's road network. It is generally accepted that this is still a significant underestimate and that there are well over 500,000 holes dug every year. In 2010 London First put the cost to London's economy from disruption due to road works at £752 million per annum, and the annual figure nationally could be as high as £5 billion. With the cost of disruption estimated at £3,160 per roadwork/day, reducing disruption has to be a national strategic priority. All stakeholders now accept that excavations should only be carried out where necessary, and then with minimum disruption and maximum sustainability.

Accurate utility data can provide unrealised benefits. The need for intrusive maintenance practices (road excavations) is reduced with the use of remote robotic techniques, to maintain asset networks in busy highways. Accurate mapping of utility networks can improve asset modelling capabilities and, over time improve utility record modelling information.

In June 2014 BSI published BS: EN PAS 128:2014 Specification for underground utility detection, verification and location. The purpose of this Publicly Available Specification (PAS) is to set out clear and unambiguous provisions to those engaged in the detection, verification and location of active, abandoned, redundant or unknown utilities. The document was reviewed, and an extensive revision was published in 2022, this supersedes the original 2014 specification, which is now withdrawn.

Overview of the PAS128: 2022 revision changes

The 2022 revision was a significant overhaul of the original and introduced a number of changes. These include:

- Guidance on training and the types of qualifications that clients should expect from their chosen survey practitioner
- Updates to the survey methodologies and how utility detection techniques should be applied to specific situations
- An update to when post-processing of ground penetrating radar should be considered mandatory
- An update to how confidence levels should be assigned to detection results
- An expanded list of other technologies that can be used to supplement a PAS128 utility survey
- Updates to reporting and data archiving requirements, introduced to provide an improved audit trail
- A new specification aimed at supporting a process for ensuring safe working ahead of intrusive investigations in specific isolated positions, for example boreholes or trial pits
- Guidance for clients on how to apply the specification and expected accuracies
- Technical guidance on the factors influencing the use of the electromagnetic location techniques and ground penetrating radar, and some of the limitations associated with both methods
- Example decision charts and workflows to aid project planning and management of PAS128 surveys.

The main text of the PAS128 specification is not written from the client's perspective but is meant for use by practitioners (usually a surveyor, geophysicist or subsurface utility engineer). It aims to provide:

- Clarity in the service provided and methods employed
- Consistency in the approach to data capture
- Classification of the results and the confidence that can be associated with them
- Standardisation of the format of deliverables
- Accountability for the work undertaken.

However, with the addition of the changes listed above, the 2022 revision includes a great deal more information aimed at the client to assist with their understanding of the specification, what to expect from a PAS128 survey, and the limitations of the methods used in a PAS128 survey. This Client Guide aims to provide an overview of the PAS128:2022 specification and guidance on how to apply it; it should not be considered a replacement for consulting the BSI PAS128:2022 document, nor can it reproduce the full extent of the information contained within it. The continued publication and updating of TSA's Client Guide on PAS128 to take account of new revisions was agreed with the PAS128 Steering Group during the development process of the specification, and was recognised as a valuable source of Client Guidance.

Using PAS128:2022

A number of different tools and techniques can be used in utility detection, with varying degrees of success. Some are complex, time consuming, costly and may provide diminishing returns for the amount of effort and cost expended. PAS128 specifies utility detection methodologies that increase in complexity (and therefore cost) to provide increasing levels of confidence in the resulting deliverables.

PAS128:2022 clearly specifies four types of utility survey (Type D, Type C, Type B and Type A), providing increasing levels of complexity and accuracy of deliverables, which might be required at various stages of any demolition and/or construction project. With this hierarchical approach to underground utility survey, PAS128 has recognised that projects may require different levels of detail, at different stages of the project or asset lifecycle. Therefore, various methodologies may need to be deployed within certain areas of a whole site, with the associated cost variations that this implies.

Why pay for a full utility detection survey that uses multi-array GPR, Electromagnetic location and pit inspections at project feasibility stage, when a full utility record search compiled into a CAD drawing would suffice?

Conversely, who would press ahead with the design of a major construction scheme based on only the information from existing utility records?

Different detection methodologies and survey types should be considered for specific areas within the entire project site, and at varying stages of the project. It is vital that you, the client, are fully aware of these survey types and the different detection methodologies available in order to maximise confidence in the results whilst achieving the best cost-effectiveness when considering survey time and costs. These utility survey types and methodologies are explained in detail below, and guidance provided on what to ask for from your survey practitioner, and what to expect from your survey deliverables.

Accredited practitioners – the TSA PUMA scheme

In recognition of the specialist skills required in utility mapping, TSA has created a trailblazing PAS128 accreditation scheme for utility surveying companies. Named PUMA (PAS128 Utility Mapping Accreditation), the new accreditation scheme is the culmination of ten years of development work by TSA. The scheme aims to give clients confidence in the level of service and product accuracy, assured by the accreditation. PUMA is run by LRQA, a global leader in assurance, certification and inspection services.

PUMA will provide a benchmark and create a national standard for best practice for underground surveys. Membership of the scheme will give accredited surveyors a competitive edge and will demonstrate their continuous professional improvement. PUMA will give clients of accredited survey companies confidence in the level of service and the quality of data provided, as well as saving them time and potentially costly delays. As well as raising standards, it provides surety that all PUMA accredited survey companies that claim to work to PAS128 actually do so.

LRQA ACCREDITED

PUMA PAS128 ACCREDITATION

All accredited utility detection, verification and location practitioners can demonstrate:

- A minimum ratio of suitably qualified utility detection surveyors on their staff
- A quality management system
- A health and safety policy
- An employment policy
- An environmental management policy
- Suitably trained and qualified staff
- CPD for all their staff
- Compliance with all of the requirements of the PAS128 specification
- Appropriate professional indemnity insurance
- Completed tri-annual Lloyds register accreditation assessments supplemented by annual supervisory visits to ensure continued compliance.

You can consult a list of PUMA accredited survey practitioners on the LRQA website: https://www.lrqa.com/en-gb/utilities/tsa-puma-scheme

Insurance

A utility detection, verification and location practitioner is required to maintain professional indemnity insurance in respect of the organisation's liability to clients. It is also necessary for them to maintain product/public liability insurance as well as employee liability insurance. The amount of the insurance cover and period of liability should be stated by the client and is usually specified in the contractual agreement for each project. Typical values for cover are £5 million for professional indemnity insurance, £10 million for employee insurance and £10 million for public and product liability. Clients should ensure that a practitioner has the required amount of insurance cover commensurate with the project's risk potential.

Added value

This guide shows how a well-chosen utility detection survey practitioner can bring benefits to a project, leading to a successful delivery. It introduces the services that a utility detection survey practitioner may provide and the terms of a utility detection survey practitioner–client agreement. An experienced and professional utility detection survey practitioner will supply much more than just the utility drawings. The client and team will be fully involved in creating a tailored utility detection survey solution for the individual requirements of a project. The chosen practitioner will provide utility information appropriate for the separate phases of the project through design, feasibility, demolition, site clearance and construction.

A successful utility survey will rely on more than just a methodical collection of data using the techniques discussed below. A holistic approach is needed to understand the networks present within the survey area. Awareness and recording of other indicators, such as reinstatement scars, should be part of the survey. This requires experienced, well-trained and suitably qualified staff.

When a client specifies a utility survey it is essential that the end requirement is fully understood and explained to the survey practitioners tendering for the work. It is important that there is no doubt about what is being purchased. PAS128 requires that the client and practitioners engage in a pre-survey meeting, either virtual or face to face, to ensure the survey and the chosen methodology will meet the client's expectations.

A sound working relationship between the client and the utility detection survey practitioner will contribute significantly to the success of a project. Time spent in preliminary discussion about the requirements, timetable, budget, the nature of the work and cost, is time well spent. Professional utility detection survey practitioners can provide a range of services including, but not necessarily limited to, utility record searches, site reconnaissance, utility detection surveys and mapping to BIM standards and utility verification via excavation of trial pits. This adds value to a project by reducing risk and identifying opportunities at all stages. A practitioner who is attentive and reacts to client needs is laying the groundwork for an effective and successful working relationship.

Limitations

There is a perception that all buried pipes, cables and ducts can be detected and mapped, irrespective of their size, duty, depth, location, material type, geology and proximity to other utilities. This is not the case, and the factors listed above can limit the effectiveness of detection techniques in ways that are beyond the practitioners' control. A well designed and executed survey should be able to detect around 80% to 95% of utilities but it may not be possible to achieve a 100% detection rate.

Very deep utilities will likely be beyond the range of both electromagnetic and ground penetrating radar techniques.

It should be noted that the PAS128 specification does not pertain to the detection, verification or location of emergency utility works (as defined by the New Roads and Streetworks Act 1991); above surface infrastructure (such as overhead lines); nor does it cover the detection of underground basements, tunnels (including railway tunnels, road tunnels and underground walkways), plant rooms and non-utility based features. Very deep utilities, e.g. sewers at depth, will likely be beyond the range of both electromagnetic and ground penetrating radar techniques (see below).

Most utility surveys are commissioned to map utility service mains rather than service connections to properties. If service connections to properties are to be included in the scope of a survey, then this should be made clear at the tendering stage. Service connections to individual properties can be difficult to detect – particularly small diameter plastic gas and water pipes, or directly laid fibre optic cables. If these services are to be included in the scope of work then it should be made clear at the tendering stage as it may affect the survey methodology to be employed. Very deep utilities may be beyond the detection range of standard electromagnetic and ground penetrating radar techniques, although if suitable access is available some other detection or location methods may be applicable (e.g. gyroscopic techniques, deep sewer sondes, or other in-pipe systems).

Due to the high cost associated with damage to fibre optic cables, it is worth noting that the detectability of this type of utility requires due consideration. Larger fibre optic cables are likely to have metal sheathing making them detectable with both EML and GPR. Unsheathed cables laid within a duct should be detectable with GPR but not with EML, unless access to the duct is possible with a tracer cable. Small diameter fibre optic cables laid directly into the ground are unlikely to be detectable.

With the exception of the recording of a general condition of inspection chambers during visual inspection, a utility survey is not a condition survey. However, the use of CCTV within gravity drainage systems, or any accessible pipes and ducts, as an addition to the survey, can provide useful information on the structural condition of the pipes. Similarly, trial excavations (Survey Type A), to verify the results of a utility survey can also provide additional information, for example, on the extent of corrosion of metallic pipes, or on specific diameters and materials of utilities detected only with GPR.

Part 2 – How does PAS128 work?

The PAS128 specification takes a hierarchical approach to utility mapping, and sets out the means to approach the identification of utilities via a phased process, which includes desktop utility record searches, geophysical detection, physical and visual verification and the geospatial location of utilities. It can start with a project consultation, which allows the survey practitioner to develop an appropriate methodology for each area of the site or stage of the project. This allows distinct levels of survey to be specified at differing stages, or on different parts of the same site, in line with the requirements and complexity of any individual project.

There are four survey categories identified, which represent the increasing amounts of effort required to obtain a greater level of detail and confidence in the final data provided. The four categories are as follows:

Survey Type D – Desktop Utility Records Search

This involves the collation of existing records from statutory undertakers identified as owning assets in the area. On some sites this can incorporate requests to non-statutory bodies (E.G estate or facility managers) for information on buried services and hazards.

Survey Type C – Site Reconnaissance

A Site Reconnaissance survey will use Type D records supported and constrained by a site visit and visual inspection to identify utility related features, for example: street furniture, trench scars, utility covers or cabinets.

Survey Type B – Detection

The Detection survey is where utilities are detected and located by non-intrusive geophysical methods. The two main methods are electromagnetic location and ground penetrating radar which must always be used if appropriate and possible, however other technologies can also be used to supplement a PAS128 survey, or in certain special cases, to replace one or other of the two main methods. For example, if vegetation across a site means that ground penetrating radar cannot be deployed in some areas, an alternative geophysical method such as magnetometry or electromagnetic conductivity might be used that could provide some additional information on buried features, if existing.

Survey Type A – Verification

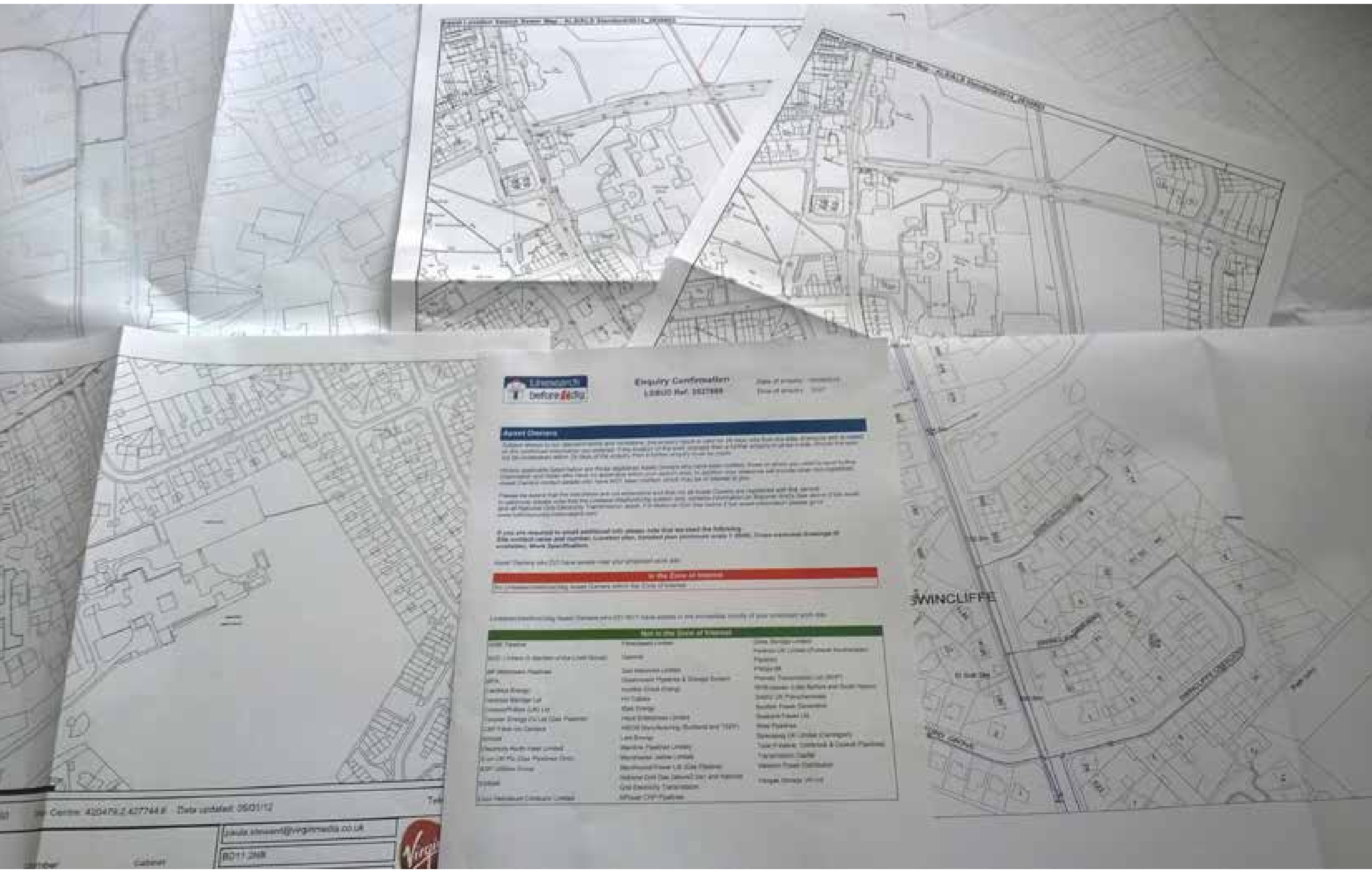
Verification is where utilities are observed at an inspection chamber, or exposed through excavation. Observing utilities within inspection chambers can provide information that is impossible to obtain through a Type B survey, such as the diameter of a pipe or it's material. It can also be used to calibrate and check the results you are obtaining from geophysical detection methods. Similarly, intrusive excavation such as trial holes (either manually dug or through vacuum excavation) can provide verification that a suspected utility exists, even if it cannot be located by geophysical methods, or for ground truthing the results of geophysical surveys.

PAS128 survey types

PAS128 Type D Survey

In the early planning stages of any project, at the Strategic Definition Stage, preliminary utility studies will (or should) be undertaken using a PAS128 desktop utility records search. This identifies existing utility data within the survey area and provides basic information based on what the utility companies believe to be there. There is no locational accuracy associated with any Type D data. It can be out of date and there is limited detail. Data of this type is assigned a Quality Level – D.

The client may decide that the results of the Type D survey should be collated into a combined CAD drawing, to enable a decision on how best to proceed and to develop the overall Strategic Brief. Segments of a utility displayed on a digitised CAD drawing should be annotated as (D) Quality Level D. **Note that a Type D survey is mandatory for all subsequent PAS128 utility survey types.**



A PAS128 Type D survey involves the collation of utility records and plans from all statutory undertakers with assets in the survey area.

Undertaking a thorough search and review of statutory utility record data, prior to any further utility survey works is best practice, mandatory for PAS128 surveys, compliant with HSG47, and regarded as essential for any works in public areas. If a client holds existing/third party utility record data that they believe can be used, the practitioner should be allowed to review this data at the earliest opportunity to confirm that it is up to date and complete. If in doubt, a new search should be commissioned and charged at an additional cost.

The National Joint Utilities Group (NJUG) require their members to respond to requests for utility information within ten working days and most of its members achieve this. However, some are more efficient than others and some statutory undertakers are not members of NJUG. Allowing ten working days is usually sufficient for returns, although some may take longer. Some practitioners claim to provide faster services, but these may vary in completeness, depending on where in the country the site is situated and how many utility companies need to be contacted. It is good practice to allow at least twenty working days for the completion of a full Desktop Records search.

The PAS128:2022 revision contains an important update regarding the validity period for a Desktop Records Search report. It no longer specifies a 90-day period, instead recognising that ALL desktop information should be treated as historical and potentially out-of-date. Instead, it places a responsibility on the practitioner to make every effort to acquire the most up-to-date plans available. Whilst record plans from utility asset owners are the most common focus of a utility records search, it is important to remember that these are often not the only plans available that show utilities that might exist on a site. On large sites under private ownership, especially sites like hospitals, factories, and government or MoD facilities, estate plans, as-built records, private drainage records and site-specific utility plans might be available that can also contribute valuable information. Historical information from sources other than utility asset owners can also be of benefit to any survey and should not be disregarded.

PAS128 Type C Survey

This survey type utilises record information as identified by a PAS128 Type D utility survey, deploys on-site checks to validate the information and assesses if there are any conflicts that need to be resolved. It confirms the existence of any street furniture (lamp posts, telegraph poles, valves and inspection chambers) and correlates the record information to the street furniture and to physical ground features, including road and ground scars.

Documentation of on-site checks may include, but are not limited to, the mark-up and annotation of existing plans, the inclusion of supporting photographic evidence and a written report. Segments of a utility are annotated as (C) Quality Level C.

At this stage, no detection work will be carried out and no inspection chambers or valves will be opened, unless otherwise specified, only their geospatial location surveyed. Accuracy is still undefined and relies purely on the experience and understanding of the reconnaissance surveyor. Depths are not provided unless these are already on the utility record plans. It may provide the client with useful information regarding the requirements of a detection survey.

A site reconnaissance survey can add extra value to the results of a desktop records search and may be all that is required if the aim is to establish where likely conflicts exist with the position of certain utilities in relation to a proposed scheme, or if accurate depth information is not required. This type of survey can be useful at early stages of project planning. but is particularly useful on large projects so that a proper assessment can be made of where utility record data is deficient or where areas of complexity or greater uncertainty exist. These areas may then be targeted using a Type B or Type A survey.

It should be noted that this survey does require a site visit, and on smaller sites it may be more cost effective to directly commission a Type B survey to more accurately locate services, which by its nature will generally incorporate elements of a Type C survey.

Note that a Type D survey is mandatory for a Type C survey.

PAS128 Type B Survey

A detection survey is commissioned when a more accurate depiction is required of underground utilities. This can be for the purposes of project planning, to obtain the information required for design, or importantly, to ensure the safety of project personnel when excavations are planned. Health and safety guidance requires that a search for underground services is undertaken prior to breaking ground. Surveys may also be undertaken when compiling information on sites in advance of land sales, so as to inform prospective purchasers as to the situation with regard to utilities on site. These surveys are becoming essential for designers too. Costly diversions can be designed out and the cost savings from reducing the construction programme can often pay for the survey several times over.

A Type B survey incorporates detailed detection survey using a minimum of two geophysical detection methods. These are usually electromagnetic location (EML – also known as electromagnetic detection or radio-frequency location) and ground penetrating radar (GPR) techniques, combined with visual inspection at chambers and Type D utility records (and possibly Type C data), to assist with detection and identification of utilities.

Geophysical data by itself does not allow identification of the utility detected. This is achieved through a combination of on-site and post-site interpretation from both GPR and EML surveys, combined with any other survey methods deployed (e.g CCTV inspection), together with on-site reconnaissance and correlation with utility records.

Methods used for a PAS128 Type B survey must include electromagnetic location and ground penetrating radar, with recording of results by GNSS or Total Station.

PAS128 prescribes a variety of different survey methodologies (see table 2 below) which can be used as the basis for the utility detection survey. These offer varying spaces between transects in an orthogonal grid pattern and increase in intensity, from the most relaxed search pattern M1 to the most detailed M4. If the methodology is suffixed by a (P) it indicates that post-processing of GPR data should be carried out.

An orthogonal grid refers to a search methodology whereby survey lines are investigated in two directions at right angles to each other. This type of search gives the best chance of all utilities being detected. Some multichannel GPR arrays collect very dense datasets, such that the need for an orthogonal search pattern is reduced, however even with multichannel GPR arrays the use of an orthogonal rid can result in higher detection rates, especially in areas of complex utilities.

The density of the search grid used will be dictated by the amount or complexity of the utilities expected to be present. For example, a city centre road junction is likely to require a much closer-spaced survey grid than a rural location. In recognition of the complexity of buried utility environments where a dense survey grid is required, the PAS128:2022 revision mandates postprocessing of GPR data for all surveys at the M3 and M4 levels.

Where post-processing of the GPR data has been instructed, the identification of any detected utilities, the determination of quality levels and other buried obstructions is often deferred until the data is returned to the office. This means that full results will not be marked out on the ground unless a return to site is made specifically for this purpose. If this is going to be required, it should be advised at tender stage so that the practitioner can make allowances for a return visit in their fees.

A Type D survey must be carried out in advance of a Type B survey.

PAS128 Type A Survey

There is no technology currently available that will guarantee the accurate detection of all buried utilities. Buried linear features that are not utilities may also be detected, so often the only way to be certain of correct identification is to expose the features somehow. This can be done at inspection chambers by removing the cover and surveying the positions of all incoming and outgoing utilities. Exposing utilities elsewhere involves excavation. This process can be expensive if not adequately targeted and controlled. A **PAS128 Type A** survey provides detailed, accurate cross-sectional CAD drawings of trial pits and/or trial holes showing the verified position of all exposed utilities. By clamping any metallic utilities in the excavation and using EML and GPR to detect in all directions outside of the excavation, the location of all exposed utilities can attempt to be verified.

Excavation of hand dug trial holes or smaller intrusions made using vacuum excavation are the safest ways to confirm an accurate depth and position on a utility where there is not already access via a manhole or inspection pit. Excavations may take the form of single spot excavations to confirm single utilities or more extensive trench excavations for the verification of multiple utilities. The interval and positioning of trial holes will be project dependent and should be specified by the client based upon conflicts with the project requirements. The survey practitioner may be able to offer valuable advice concerning the practicalities and placement of trial holes based upon the findings of the utility detection survey.

A utility surveyor carrying out a Type A survey.

Any intrusive work should be carried to the requirements of HSG 47 (see Section 15) and should be undertaken with strict regard to the rules and regulations applicable to excavations near or over dangerous utilities, such as electric, gas or fuel. All excavations should be undertaken assuming that utilities are present. Suitable safe systems of work must be employed, and consideration must be given to the installation of shoring equipment, or using stepped and battered excavations to ensure safe access to utilities at depth. Any personnel involved in the excavations and installation of such equipment should be appropriately trained, qualified and certified.

The reinstatement of the trial hole might be an appreciable part of the cost of a survey, particularly if it lies within the carriageway or areas of quality landscaping. The survey practitioner should give proper consideration to the plans for reinstatement prior to undertaking the works, so that reinstatement occurs in a safe and timely fashion. Verification in some locations may not be achievable due to unsuitable ground conditions or construction methods, and this might not always be apparent prior to the survey commencement. If such problems are encountered, PAS128 directs the practitioner to notify the client at the earliest opportunity of any such failures so that the client can decide to reposition the trial holes to ensure the overall aims of the survey are achieved.

Where a verification survey is to involve the opening of manholes and inspection chambers it is the responsibility of the survey practitioner to obtain any permission necessary to lift manhole and inspection pit covers. If, during the course of a survey, it is found that manholes or inspection chambers are obstructed such that they cannot be opened, the survey practitioner must inform the client so that appropriate action to provide access can be taken whilst the survey practitioner is on site, if practicable. It is recommended that the practitioner should not lift broken or damaged covers in the course of a survey and that the client is informed if these are found. The client can then decide, either to take appropriate action to obtain access to these covers, or to exclude them from the scope of the survey.

Note that a Type D survey is mandatory for a Survey Type A, and a Type B survey is recommended.

Survey types and quality/confidence levels

The different survey categories translate to different Quality Levels (QL) (see Table 1 below), with QL-D being assigned to information giving the lowest confidence, and QL-A being assigned to information offering the highest confidence and which has been physically verified. In between, there is a range of quality levels associated with defined horizontal and vertical accuracies.

It is worth noting that it is up to the survey practitioner that has carried out the survey to assign different segments of utilities that have been located with the correct quality level – Quality Level (B1), (B2), (B3) or (B4) dependant on the success or otherwise of the techniques deployed and in accordance with Table 1 of PAS128. Where post-processing has been carried out on GPR data, this is indicated by a [P] suffix so a B1 would become a B1P, and generally indicates an improved level of confidence, within the defined tolerance levels.

For example, a utility that has been located but whose depth cannot be ascertained would be awarded a QL-B3, whereas a utility that has been located with high confidence, possibly by multiple techniques, and has a well-defined position and depth, would be awarded a QL-B1. The specification also distinguishes between methodologies where GPR data is checked in the field and those where data is bought back to the office for interpretation using specialist software, referred to as post-processing. A suffix (P) is assigned to Quality Levels where post processing of GPR data has been used to improve the confidence of the data.

The updated PAS128:2022 version requires that all GPR data is post-processed if the survey methodology is using a 1m, 0.5m or denser grid, so the former M3 and M4 methodology options have now been removed and only M3P and M4P remain as possible options for this level of survey intensity. GPR data collected using a multichannel array should always be post-processed.

Table 1 Quality level of survey outputs (reproduced with the permission of BSI)

Survey type (Establish with client prior to survey)		Quality level (Practitioner to determine post survey)	Post-processing (GDPR data analysis	Location accuracy		Supporting data
				Horizontal [1]	Vertical [2]	
D	Desktop utility records search	QL-D	–	Undefined	Undefined	Copy of utility asset record only
C	Site reconnaissance	QL-C	–	Undefined	Undefined	A segment of utility whose location is demonstrated by visual reference to street furniture, topographical features or evidence of previous street works (reinstatement scar).
B	Detection [3]	QL-B4	No	Undefined	Undefined	A utility segment which is suspected to exist (either on QL-D or QL-C records) but has not been detected and is therefore shown as an assumed route.
		QL-B4P	Yes			
		QL-B3	No	±500mm	Undefined (No reliable depth measurement possible)	Horizontal location only of the utility detected by one of the geophysical techniques used. EML field unable to estimate depth and horizontal accuracies within B2 tolerances with confidence. Features present within the GPR data that indicate the presence of a utility but do not directly correlate to its position (e.g. trench sides or fill detected by GPR without positive identification of utility).
		QL-B3P	Yes			
		QL-B2	No	±250 mm Refer to Annex C for accuracy achievable at what depth.	±40% of detected depth	Horizontal and vertical location of the utility detected by one of the geophysical techniques used.[4] Symmetrical field achieved resulting in peak and null measurements within B2 tolerance and/or present in GPR data where both depth estimates and horizontal location can be confidently established to the required accuracies.
		QL-B2P	Yes			
		QL-B1	No	±150mm Refer to Annex C for accuracy achievable at what depth.	±15% of detected depth	Horizontal and vertical location of the utility detected by one of the geophysical techniques used.[4, 5] Symmetrical field achieved resulting in peak and null measurements within B1 tolerance and/or present in GPR data where both depth estimates and horizontal location can be confidently established to the required accuracies.
		QL-B1P	Yes			
A	Verification	QL-A	–	±50mm	±50mm	Horizontal and vertical location of the top, bottom or centreline of the utility (to be indicated on drawings).

[1] Horizontal location is to the centreline of the utility.
[2] Vertical location is to the top of the utility. Depths determined to the centre of the utility should be indicated as such by exception.
[3] For detection, it is a requirement that a minimum of GPR and EML techniques are used (see 9.2.1.1.2).
[4] Electronic location readings from EML equipment should be obtained by using the signal generator and receiver together. Locations obtained by the EML receiver alone and not confirmed by GPR shall be categorized as a B3.
[5] If only detected by one technique, the practitioner should be prepared to make available to the client clear evidence for the accuracy achieved to be classified as a QL-B1 or QL-B1P.

Note on requesting quality levels

A client can request a Type B survey, but there is no such thing as a Quality Level B1 survey that can guarantee all utilities detected can be found with a defined level of confidence. This is a common misunderstanding amongst commissioning clients, who understandably want to obtain the best possible survey, with all utilities detected to the highest possible level. Due to the limitations of equipment and methodology, and constraints due to site conditions and environment, detection at the highest confidence level is not always possible.

Table 2 Survey Methodologies for Type B surveys (reproduced with the permission of BSI)

Method [1]	Survey grid/search resolution [2]				Quality levels achievable	Typical application (informative)
	EML [3]	GPR		Other techniques [4]		
		General	Post-processing			
M1	Orthogonal search transect at ≤10m intervals and when following a utility trace, search transects at ≤5m intervals	Either: a) boundary survey incorporating a minimum of 5 survey transects around perimeter of site, spaced not more than 3m apart: or b) ≤5m orthogonal grid; or c) multiple antenna array [5]	No	≤5m survey grid	B1, B2, B3, B4	Used where the density of services is typical of an undeveloped area
M1P			Yes		B1P, B2P, B3P	
M2	Orthogonal search transect at ≤5m intervals and when following a utility trace, search transects at ≤2m intervals	Either: a) ≤2m orthogonal; or b) multiple antenna array [5]	No	≤2m survey grid	B1, B2, B3, B4	Used where the density of services is typical of a suburban area or where the utility services cross a boundary of a survey area
M2P			Yes		B1P, B2P, B3P	
M3P	Orthogonal search transect at ≤2m intervals and when following a utility trace, search transects at ≤1m intervals [6]	Either: a) ≤1m orthogonal; or b) multiple antenna array [5]	No Yes	≤1m survey grid	B1P, B2P, B3P, B4	Used where the density of services is typical of a busy urban area or for clearance surveys prior to operations such as borehole/drilling/fencing/tree planting
M4P	Orthogonal search transect at ≤2m intervals and when following a utility trace, search transects at ≤0.5m intervals [6]	Either: a) ≤0.5m orthogonal; or b) multichannel GPR array with swathes collected in both directions, and gaps between swathes limited to ≤0.5m; or c) a dual polarized multichannel array with swathes collected in one direction, but ensuring full area coverage is achieved with no gaps between swathes	Yes	≤0.5m survey grid	B1P, B2P, B3P, B4	Used where the density of services is typical of a congested city area

NOTE 1 In general the effort increases from M1 to M4 and the addition of post-processing. For areas with a greater density of utilities or areas considered high risk by the client, a detection method that has a higher level of effort should be selected.

NOTE 2 "P" indicates post-processing has been included. Post-processing should be used for any method above an M2.

[1] It is a requirement that a minimum of GPR and EML techniques are used (see 9.2.1.1.2).
[2] The tolerance for orthogonal transect centres and survey grids shall be ≤0.1 m.
[3] It is a requirement that passive EML is deployed over the whole survey area and that where an active EML method can be used, it is used (see 9.2.1.2).
[4] The transect centre depends on technique used.
[5] A multiple antenna array radar with antenna separation < 100 mm, deployed in accordance with 9.2.1.3.2.
[6] To achieve a B1 or B1P there might be significant additional effort required to manipulate the electromagnetic field to enable a symmetrical field to establish accurate readings.

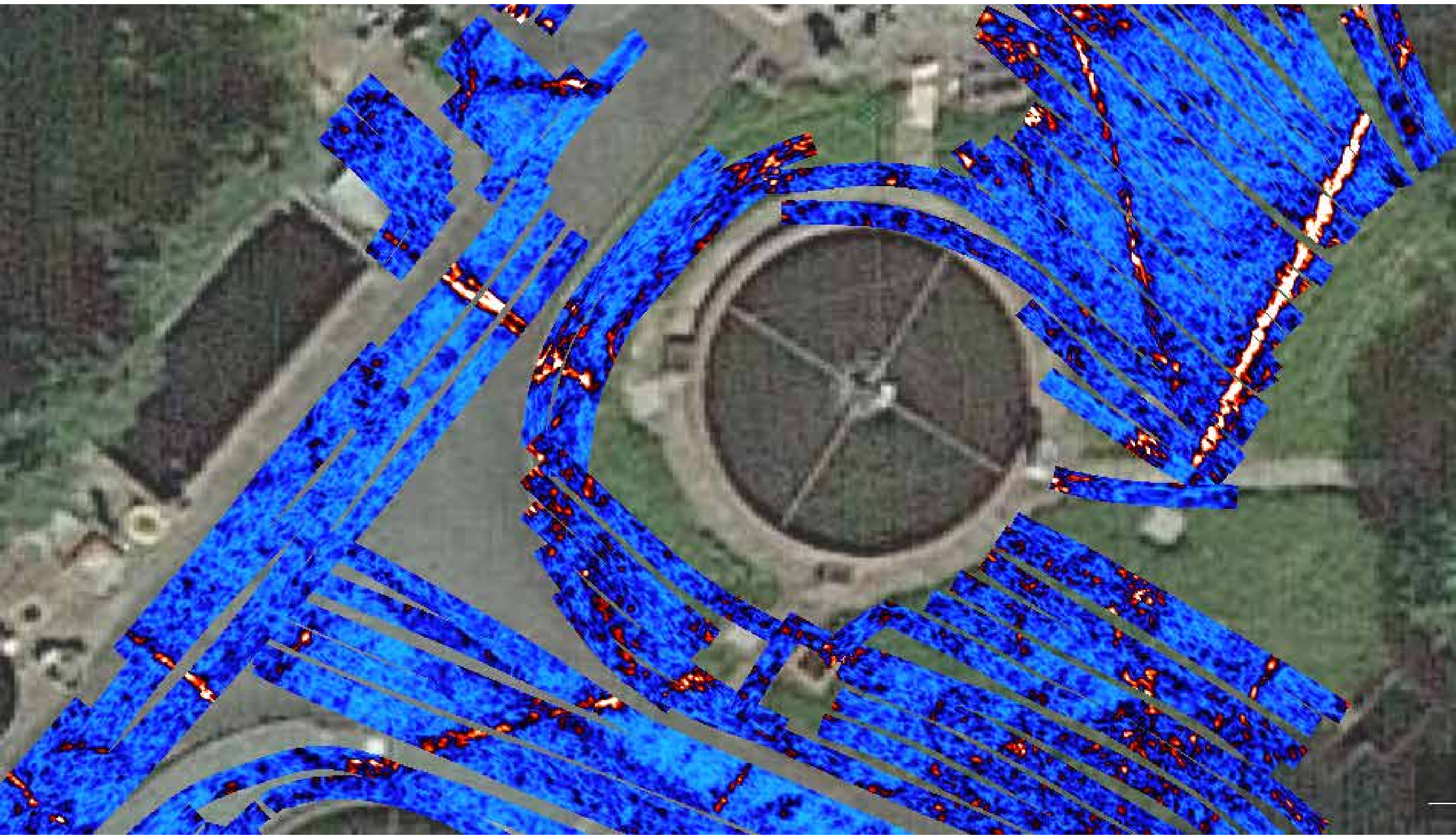
Post-processing survey data and digital audit trails

Post-processing can improve the interpretation of GPR data by resolving weak and intermittent signals or analysing multiple targets to gain a better understanding of complex utility networks, as well as offering better detection rates of other non-utility related hazards, if these are looked for. The client should be aware that there may be significant additional costs and more office time associated with the processing of data, leading to a longer delivery time for final reports and drawings.

The practitioner should advise the client whether post-processing is needed, based on their understanding of the survey area and the specified requirements. The PAS128:2022 revision mandates post-processing for any survey at an M3 methodology and above but the client can still choose whether to specify post-processing for M1 and M2 levels of survey. The use of post-processing should be reflected in the method statement and in the quality level determined and assigned to the results.

EML does not allow for post-processing and retrospective interpretation of the data and has the disadvantage that usually no digital record is made, so it generally relies on the detected position and depth being marked on the ground surface as the survey progresses. Some EML devices now incorporate GNSS antennas, so that a log of position can be generated during a detection survey. For many of these devices the internal GNSS is not of sufficient accuracy to provide much better than a general position to within a few metres, however some devices are incorporating GNSS antennas that can be used to obtain survey grade centimetre level accuracy, in the right environments.

Example of post-processed GPR data showing linear utilities detected in a park.



When the PAS128 specification was first published, there were many GPR systems that could only be used in site mark-out mode and which could not automatically provide a log of position. GPR technology has advanced such that nearly all equipment will now either have an internal GNSS receiver or can be linked up with external GNNS devices or to a Total Station for positioning purposes. This means the equipment can keep a log of everywhere the system has been used, often achieving centimetre level accuracy for positioning survey transects. This provides a digital audit trail of work carried out in the field.

It is a requirement of a PAS128:2022 survey that all GPR survey transects are georeferenced and the data retained by the survey practitioner for a set period, even if it is not being post-processed. This is so it can be referred to later in case of any issues or disputes, and acts as protection for both Client and Practitioner, and is especially useful in being able to prove the level of survey carried out in any one particular area.

Part 3 – How to specify and manage a PAS128 survey

The PAS128 specification requires a collaborative working partnership between the commissioning client and practitioner. Within this collaborative relationship:

The utility detection survey practitioner undertakes to:

- Use reasonable skill and care in performing the services in conformity with PAS128
- Keep the client informed of progress and on issues affecting time, cost or quality
- Co-operate with any appointed designers and the Principal Designer appointed under the Construction (Design and Management) Regulations 2015
- Obtain and maintain appropriate professional indemnity, product/public and employee insurance cover
- Only make material alteration to the services or the approved methodologies with the client's prior approval
- Provide qualified and experienced staff at all stages of the survey process
- Comply fully with the requirements of the PAS128 specification.

The client undertakes to:

- Advise on the relative priorities of the project and to provide necessary and accurate information
- Appoint other utility or topographical surveying consultants and specialists, as the project requires, under separate agreements
- Comply with the CDM Regulations where applicable
- Take decisions and respond promptly to requests from the practitioner that impact upon full and comprehensive completion of the survey, including approvals of submitted drawings and models sought by the practitioner
- Pay the fees, expenses and disbursements due and value-added tax where applicable.

Developing the brief

The brief will provide the basis for the practitioner to quote for the appropriate type of utility survey and the best methodology for different areas of the project site and give direction to the design, site clearance and construction services. Time spent in explaining the overall project requirements to the tendering practitioners is well worth the effort and may help to achieve deadlines and/ or reduce costs.

In developing the brief clients should consider the following:

- The functions of the finished utility detection survey project.
  - o *Who will use it, and for what?*
  - o *Have you analysed how the anticipated utilities will be affected by/accommodated in the project?*
  - o *What are your core operations and do the anticipated utilities pose any project constraints/conflicts?*
- Your motivations and expectations.
  - o *What do you hope to achieve by undertaking a utility detection survey in the short and long term, for yourself and others? (e.g. project feasibility; project design; site clearance; excavation; transfer of plans to the H&S file for future reference; use of data in a Geographical Information System)*

- Information requirements.
    - o *What information will you require at the end of each project stage and in each differing area of the project site in order to make decisions and proceed with site clearance, excavations, piling and construction?*
    - o *Do you require such information in specific formats, such as spreadsheets, reports, computer aided design (CAD) files, Building Information Modelling (BIM) files?*
- Authority for decision-making.
    - o *Who will sign off decisions about the quality of deliverables, about costs and about day-to-day matters on site?*
- Timetables and budgets.
    - o *When should key survey phases be completed, how much should they cost and how will they be financed?*

The client should establish the survey type(s) required (see above) and where these will be deployed. For example, a client might specify different survey types over different parts of the survey area e.g. the client might require a survey Type D for the whole site, a survey Type B in the proposed area for development or construction, and a survey Type A, only at a specific location, where a potential design element has a possible conflict in a congested area.

Where a Type B survey is requested, the client should either determine, with assistance from the practitioner, which detection methodologies will be deployed for the various sub-divisions of the survey area or ask for the practitioner to suggest a suitable methodology for surveying the site. The choice of survey methodologies that will be deployed will determine the price, and each site is unique.

Whilst some clients may be comfortable with specifying a complex PAS128 survey, others may require the advice of an experienced survey practitioner to properly define the best way to address the needs of a project. It can be useful to ask all practitioners to tender for a blanket survey type and methodology to cover the whole site, and then attend a pre-survey meeting with the successful practitioner to further refine the project brief and project costs. It is worth noting again that price may not be the best arbiter of quality, that quotes using different methodologies may not be directly comparable, and care should be taken to ensure the successful practitioner has a detailed understanding of PAS128 and the ability to provide the guidance that is required.

At a pre-survey meeting, if one is utilised, the project requirements can be discussed and the entire survey area may be broken down into sub-areas, each of which will be scanned using both EML and GPR at transects determined by the PAS128 methodology, as agreed between the client and practitioner.

A written report, as well as the CAD model, is provided as deliverables and a post-survey meeting should also be held to discuss the findings. Additional utility detection survey methods may be agreed at the post-survey meeting to identify and locate any utilities that could not be detected during the survey. This may include advice from the practitioner on where to dig trial holes to verify the survey results.

Requesting a quotation for a PAS128 survey

Whilst clients may expect that the highest level of survey with the highest methodology will give the best and most reliable survey results across the whole site, it is rarely necessary to have the same level of survey applied equally to all areas of a site. Higher survey types and higher Type B survey methodologies will cost significantly more than lower levels, because of the time and effort required to produce the deliverables. It is entirely possible that lower levels of methodology or survey type might be more appropriate and provide deliverables that meet client requirements for their project and longer-term asset information without the high cost and time elements that may be associated with more intensive types of survey.

TSA provide a free download of a PAS128 Quotation template from its website. This covers all survey types (D, C, B & A) and all type B methodologies [M1-M4 with or without post-processing of GPR data (P)] and can be used as a blank pdf template version for manual completion or as an interactive excel spreadsheet which will calculate all quantities based upon client measurement of the survey areas. (http://www.tsa-uk.org.uk/downloads). This template is provided for guidance only and is not a recognised standard. Companies may use their own preferred means of estimating work requirements within the PAS128 specification.

It is important to emphasise that a PAS128 survey supplied by a professional survey consultant is a bespoke service and not a commodity. Each site is unique and will bring its own challenges that will need to be identified and the appropriate survey approach applied. It is also a collaborative process, and the greater the extent of communication and engagement at an early stage between the Client and Practitioner concerning the project's aims, desirable outcomes and any limitations and constraints there may be, the higher the chance of a successful survey.

A multichannel GPR and mobile mapping array.

CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM) relate to the design, construction, use, maintenance, cleaning, repair and demolition of buildings and structures. The regulations seek to eliminate potential hazards, and to ensure that those that cannot be eliminated are minimised by careful design and management.

The regulations impose statutory duties on designers and contractors on all projects. They also impose statutory duties on clients (unless the project relates to their home). If an architect advises that a project is notifiable under the regulations, a CDM Principal Designer and/or Principal Contractor must be appointed.

Non-intrusive site surveys are specifically excluded from the definition of construction work in the regulations [https://www.legislation.gov.uk/uksi/2015/51/regulation/2/made], and therefore the requirements of CDM 2015 do not generally apply to the types of topographic and utility mapping surveys that form a PAS128 compliant survey.

However, PAS128 surveys may often be instructed as part of a larger project, in which case practitioners may be asked for information to help their client fulfil the CDM requirements placed on the project.

On larger projects such as this the client and their appointees will generally be duty holders under the CDM Regulations 2015, which are concerned with health and safety; under the regulations, potential appointees should not accept an appointment unless they can show they are competent to perform their duties.

In the case of PAS128 survey practitioners, checks will often be made by the company instructing the survey on the practitioner's abilities, resources, expertise and qualifications, insurance, as well as financial standing and adequacy of management systems in place. Membership of trade associations that undertake these checks as a condition of membership, as with The Survey Association, can provide an important indicator that the company is competent to perform their role, but they cannot tell the whole story if they do not involve a regulatory aspect.

Accreditation schemes can also act as indicators of competence and show that a practitioner's policies and procedures have been independently audited and deemed satisfactory and compliant. These are especially relevant if they involve regular audits. It is for this reason that The Survey Association has helped introduce an accreditation scheme aimed directly at PAS128 survey companies which includes an annual audit requirement to provide companies with an independent means of demonstrating compliance.

PAS128 Utility Mapping Accreditation [PUMA]

The TSA PUMA accreditation scheme offers a shortcut for commissioning clients to ensure the survey practitioner they choose is competent to undertake the work. PUMA sets a national standard for utility surveys, ensuring that utility mapping practitioners comply fully with PAS128. Developed by The Survey Association (TSA) in partnership with Lloyds Register Quality Assurance (LRQA) and supported by professional institutions like the Chartered Institute for Civil Engineering Surveyors (CICES), PUMA offers a credible, independent audit process, operated by LRQA at arm's length from TSA, but with ongoing monitoring by a governance committee comprising members from across the industry.

Accreditation under the TSA PUMA Scheme provides an assurance of the:

- Execution of a methodology that supports the efficient production of an accurate fully compliant deliverable, which meets clients' expectations
- Implementation of a comprehensive risk management process
- Competence of the participating specialists involved in the risk management process
- Robustness of the systems to identify and mitigate hazards ensuring the safety of operational personnel and the public is protected
- Consistent standards that are achieved and maintained across all participating TSA Members throughout the accreditation validity
- Interaction with the client throughout the project/contract stages and the ongoing dissemination of reliable and accurate information
- Benchmarking of standards, which promotes and raises the professional reputation of participating TSA Members and their staff.

A PUMA Accreditation audit taking place on site.

An essential feature of the accreditation process is the assurance that procedures and practices, against which accreditation has been awarded, are consistently applied and maintained by the TSA Member. This is ensured throughout the approval period by the implementation of a surveillance visit programme.

For companies, PUMA provides a tangible means of demonstrating continuous improvement. Utility contractors and developers reference LRQA accreditation schemes daily when assigning contracts. By adhering to PUMA, TSA utility mapping practitioners can differentiate themselves and prove their commitment to high standards.

For clients, PUMA delivers confidence in the level of service and quality of data provided. By using PUMA-accredited companies that are audited to ensure their outputs and working practices comply with PAS128, clients can be assured that the utility mapping data they receive is accurate and reliable, and PAS128 compliant.

Project leadership and teamwork

The successful delivery of the utility survey project requires continuous leadership and adequate resources of time and money. For complex projects, it may be helpful to establish a small project team of stakeholders to share decision-making and review responsibilities. The group should be led by one person with authority to act as the client's representative and be the point of contact with the practitioner and the survey team.

The project team could contribute to such matters as:

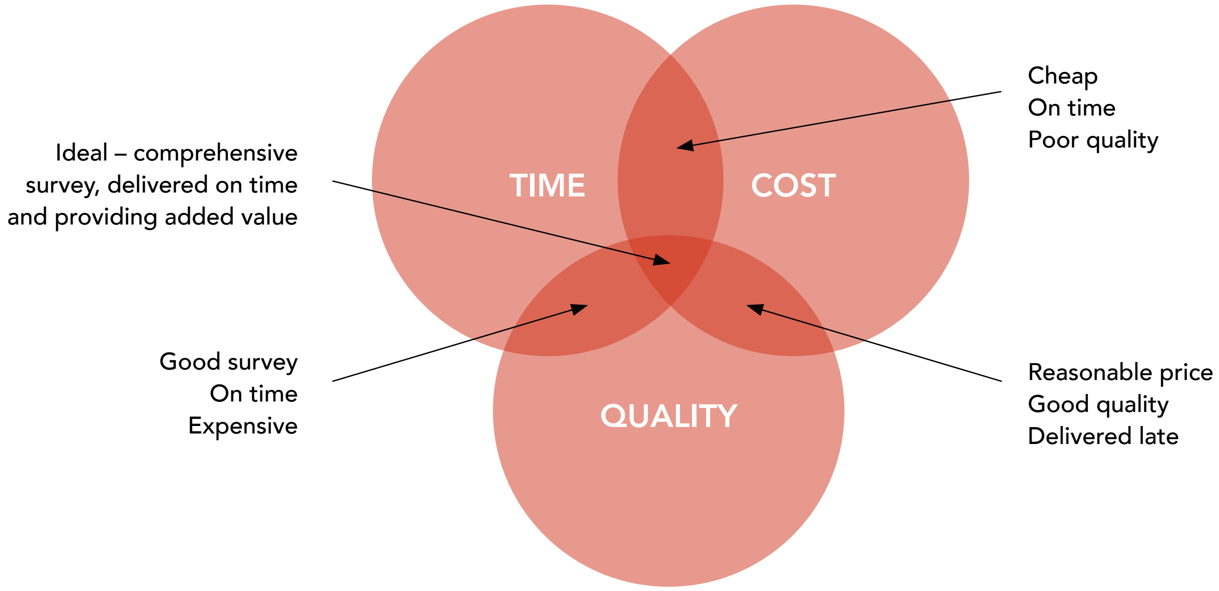
- The management structure for effective performance of the team, including the utility detection practitioner(s) and if required, a Utility Detection Consultant
- Change control procedures for the survey programme and cost matters
- Risk management
- Budgeting and cost control
- Signing off key stages for payment.

To achieve a successful and safe outcome the team should:

- Be encouraged to work together in each successive stage
- Adopt integrated processes and work from the same shared information base, which must be kept up to date
- Have sufficient resources, particularly money and time
- Co-ordinate the utility survey services within contractual obligations and within any other site activities ongoing at time of survey.

Survey project risks

The diagram below illustrates the relationship between three primary forces in a survey project. Time is the available time to deliver the project, cost represents the amount of money or resources available, and quality represents how well the survey project delivers to scope and expectations. The Project Manager's role is to define, communicate and manage all three elements to strive to achieve the ideal enclosed by the intersection of the three elements.



Quality

Quality of deliverables is achieved through the application and successful delivery of the correct survey scope to meet the requirements of the overall project. Scope consists of a list of deliverables, well defined within PAS128, which need to be addressed by the practitioner. PAS128 scope is defined by the survey type and the methodology agreed with the practitioner for each individual differing survey area (e.g. carriageway, footpaths, demolition site).

It is a significant risk that time and cost pressures may affect quality.

A successful project manager will manage both the scope of the survey and any change in scope which impacts time and cost. An experienced practitioner may be able to advise the client on a reduced scope that still meets the quality expectations, helping to keep the project on budget and on time.

As has been referred to above, different areas of the site may benefit from the deployment of different survey types or different survey methodologies. This should be discussed and contractually agreed with the practitioner, prior to appointment.

Time

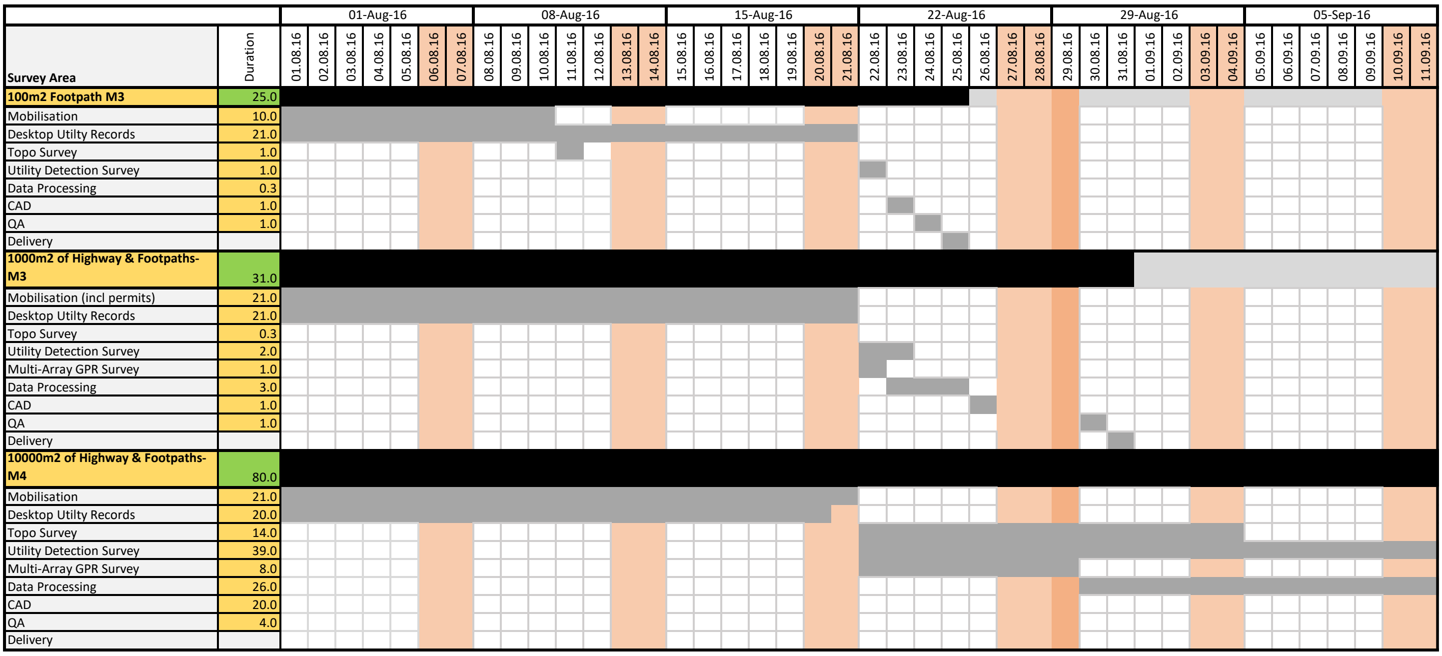
Failure to meet the deadlines in a project can create significant adverse effects. Most often, the main reason for practitioners to fail in terms of time is due to the lack of resources and/or access problems.

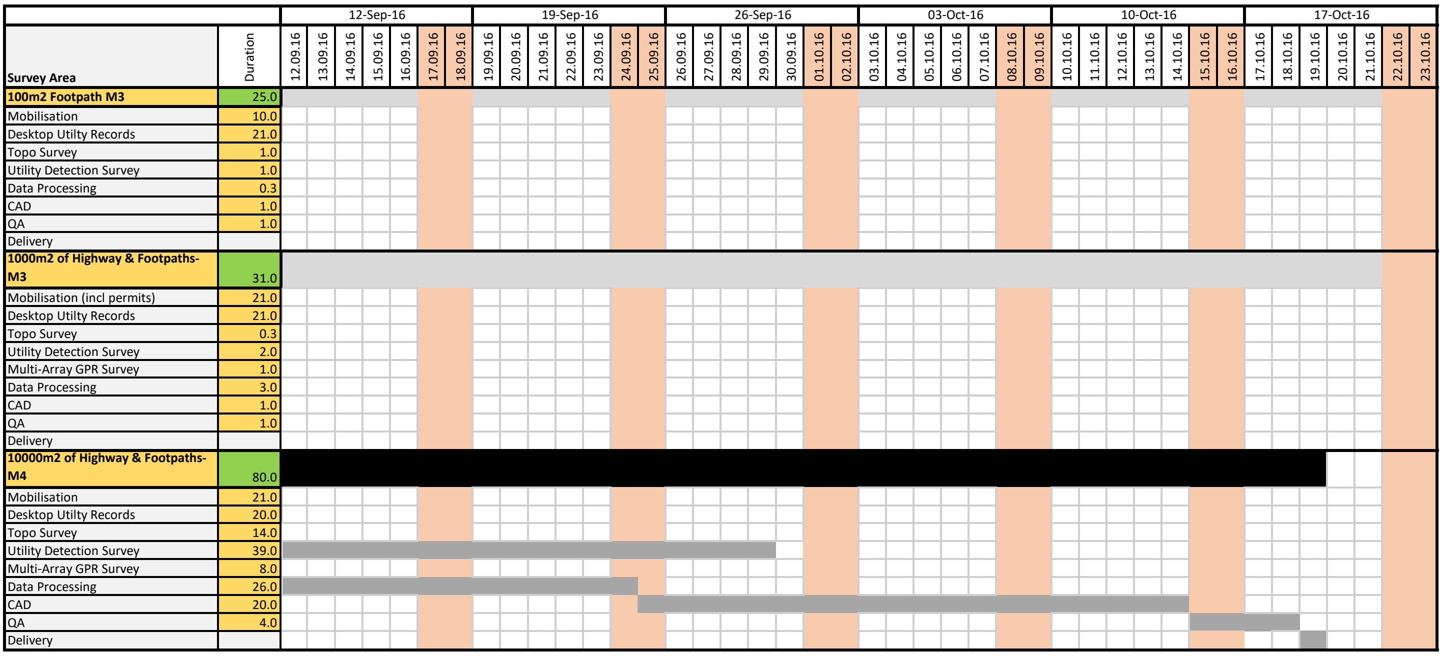
For any PAS128 survey, the practitioner must provide a programme of works submitted in advance of commencement, as well as Risk Assessments and Method Statements (for site survey Type C, B & A only), following the survey commission. It is always possible that unforeseen delays can occur because of weather, access issues, or a site being more complex than anticipated, but the survey practitioner should allow for contingencies and keep the client informed of any such delays at the earliest opportunity.

A successful PAS128 Utility Detection, Verification and Location Survey relies on the provision of the most up-to-date utility records, combined with the reconnaissance, detection and verification expertise of the practitioner. Timeframes for delivery of Type D surveys range from ten to twenty working days whilst a Type C, B or A survey is dependent upon the size of the project and the methodologies employed. Heavy rain, snow and ice will inevitably lead to delays for these surveys. Constant rain will wash away fresh marker paint and snow and ice may render inspection covers invisible or inaccessible.

Survey work in the highway will need the appropriate permits from the local highways department, and if entry into inspection chambers is required, the relevant utility asset owner will need to provide their consent and may need to issue a permit. For those surveys that do involve work on the highway, clients and practitioners should also consider Lane Rental costs and permit lead-in times. These can significantly affect cost and mobilisation times and four to six weeks could be needed for planning processes, sometimes longer for main routes. For large scale works, especially those involving road closures, additional time may be required for the relevant notices to be issued. Type A Verification surveys are also dependent on the type, number, dimensions and locations of excavations and ground surface (tarmac, grass, paving) and soil conditions (sand, clay, made up ground) which can mean associated difficulties for safe excavation and reinstatement.

Allocating more resources to the survey may reduce the time but can also lead to increased costs.





Example Programme of works showing typical durations for 100m2 of Footpath at M3, 1000m2of Highway & Footpaths at M3 & 10000m2 of Highway & Footpaths at M4.

Costs

Budgets will ensure that a survey project is implemented below a certain cost. To meet deadlines, from time to time project managers may ask the practitioner to allocate additional resources, with the obvious penalty of increased survey costs.

If cost is a critical element then discussing the project requirements with the practitioner will allow a survey scope to be designed within the limitations of the budget that correctly addresses the areas of most need. Again, this is where the advice of an experienced practitioner can assist in providing a reduced scope of survey that can meet both budget and quality expectations.

It should be noted that delivering a quality survey invariably involves a base level of cost if the standards outlined in the PAS128 specification are being correctly applied. If during the tender process, a comparison of survey fees indicates that there are significant outliers at a much-reduced cost, further questions should be asked to ensure that the practitioner is fully aware of the scope of survey being asked for and can ensure the requisite standards will be met.

Safety considerations

Surveyors and survey equipment have become the target of organised crime syndicates over the last decade, with thieves targeting survey equipment and often threatening the lives of surveyors in the process. This problem is especially bad in large urban centres, such as Greater London, Manchester, Birmingham and Leeds, but can occur anywhere in the UK. In specific locations, Survey Practitioners may need to charge additional fees to implement security measures in an attempt to ensure the safety of their personnel and equipment.

In some environments, other safety considerations may need to be factored in as well. Work on or near the highway may require traffic management to establish safe working zones. Some companies may be able to provide this in-house, whereas others may need to subcontract to a specialist provider, but either option will incur additional costs.

Surveys that need to access deep sewers, service ducts, basements, tunnels or similar spaces will require personnel trained to enter and work in confined spaces safely, and the additional requirements this brings will inevitably result in additional costs. This kind of work needs to be carried out with due care and attention, and additional safety personnel may be required beyond the survey team, as well as specialist access and safety equipment. Programmes may also need to take account of particular working windows which are safer than others, or may be weather dependent.

Surveys in the natural environment can also introduce risks and hazards, such as working near water or around livestock, or poisonous vegetation and invasive species. A high-level risk assessment should be carried out by the Practitioner at the quotation stage, so that the control measures required to mitigate these risks can be highlighted and included in the fee proposal. Even then, some risks and hazards may only become known following a site visit, and therefore dynamic risk assessments should be employed to ensure that work can stop if required to do so and the plan of work altered to allow for any additional mitigations required. This may also result in additional costs being incurred. The more information that the Client can provide to the practitioner at the planning stage, the more likely a fully costed proposal can be drawn up that does not have any additional and unexpected costs arising at later stages in the project.

Expenses

In addition to the project fee, expenses may also be chargeable for the cost of copies of drawings and other documents, travel and accommodation. Disbursements, such as the fees that must accompany applications for utility records from asset owners, may also be chargeable. Clients should ensure that these are disclosed ahead of appointment or are noted as included within the fees.

Payment

Clients should bear in mind that Utility Survey Practitioners are usually small to medium enterprises and that their cash flow is an extremely important factor.

For contracts where the survey work is likely to take longer than two to three weeks to complete on site, consideration should be given to phasing the survey so allowing each phase to be invoiced upon completion.

Fees will normally be invoiced in monthly instalments, based on the progress of the survey, for payment within thirty days.

Part 4 – What to expect from a PAS128 survey

Depending on the type of PAS128 survey commissioned, the deliverables produced at the end of a successful project can take a variety of formats. Suitability can be ascertained by engaging in discussion with the survey practitioner from the beginning of the process so that the required outputs are known and understood before the survey work starts.

A pre-start meeting

It is always a good idea to hold a pre-survey meeting, either in person, via telephone, or web conference, so the client can discuss and agree with the practitioner:

- Why they want the utility detection survey
- Areas of specific interest
- Areas with special difficulties
- Which methodologies and survey types are required for which areas of the project site
- Anticipated timescales.

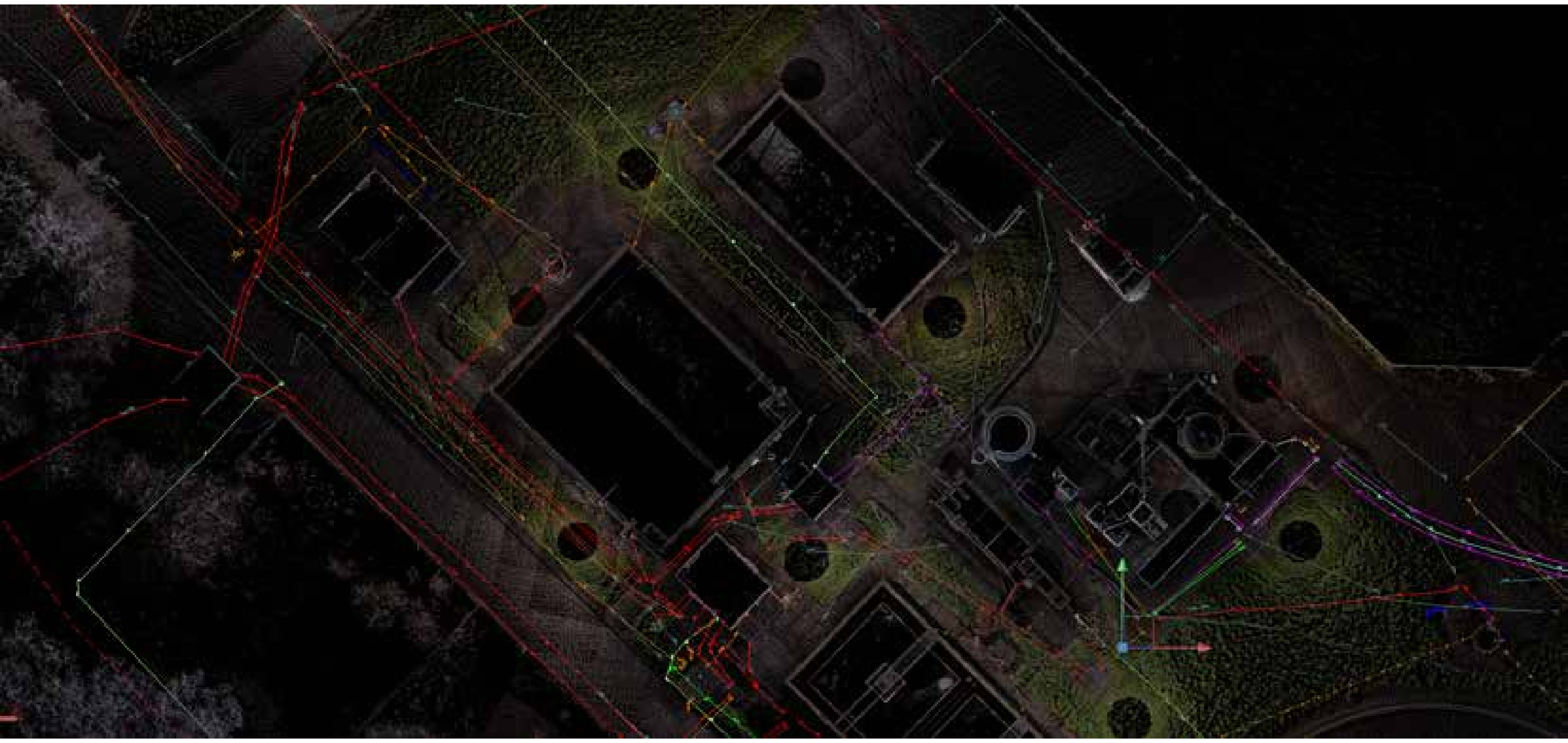
The practitioner can discuss and agree with the client:

- What they are technically and practically able to provide
- What they're not able to provide for technical, logistical or physical reasons (e.g traffic/parking constraints)
- Where they may have some difficulty (due to terrain, physical access issues)
- Which methodologies might be considered appropriate for which areas of the site
- How long the work will take.

Survey data and drawings

Survey data can be presented in a variety of outputs, such as CAD, GIS or BIM file formats, and/or written report and/or any other project-specific deliverable. The client should determine the format and media for file transfer.

For Type B surveys in particular, the survey data output as a drawing is one of the key deliverables. In the planimetric data the quality level achieved is usually applied to each five-metre segment of utility surveyed in accordance with Table 1 above. This is usually provided in CAD format, although requests for GIS outputs or BIM compliant models are becoming more common.



Utility survey data combined with a laser scanning pointcloud.

For any data output, it should be noted that:

- Survey Type D results can only be classified as Quality Level D in the deliverables
- Survey Type C can have utility segments that are classified as Quality Level C or Quality Level D in the deliverables
- Survey Type B can have utility segments that are classified as Quality Level B1, Quality Level B1P, Quality Level B2, Quality Level B2P, Quality Level B3, Quality Level B3P or Quality Level B4 in the deliverables. Record information or suspected utilities that cannot be found using geophysical methods should be denoted as B4. All information within the designated survey area where survey has been attempted should be awarded some form of B quality level, and QL-D and QL-C designations should not be retained once a Type B survey has been carried out. Information designated QL-A can form part of a Type B survey (for example at inspection chambers)
- Survey Type A can have utility segments that are classified as Quality Level A in the deliverables if utility(ies) are exposed, inspected and measured. Other Quality Levels can also be applied if detection is deployed from the exposed utilities radiating outwards, or if a wider area is subjected to a desktop search or reconnaissance survey.

The original PAS128 specification recommended that line styles used for 2D models or paper plots and CAD layers should be compliant with The Survey Association's Utility Survey Linetype Scheme & CAD Template, – see Appendix A in this document. In recognition of the increasing use of 3D CAD, BIM and GIS outputs, this recommendation is no longer included in the PAS128:2022 specification, however the TSA scheme has been widely adopted and the CAD template remains available to download from the TSA website and is free to use.

In addition to the planimetric information, PAS128 requires specific metadata and attribute data to be recorded and presented as part of the drawing or within the survey report. Some metadata recorded to evidence work carried out might not be presented in drawing or report format, but should be retained for audit purposes (see below).

The specification requires that all recorded and processed site data, including georeferenced GPR survey transects and EML findings, site notes, metadata and intermediate stage processing files be retained for a minimum period of six years, (12 years for contracts under seal) and be made available to the client on request.

This requirement provides a valuable digital audit trail for any survey and also allows site information to be interrogated at a later date if any issues or disputes arise or if the data becomes useful for any purpose other than its original intention. GPR data for example, can provide information on a range of ground conditions in addition to the detection of utilities, and this might become useful to project planning at various stages along the project lifecycle.

The survey report

A written report detailing the results of the survey and any issues encountered, together with an outline of the techniques and methodologies deployed is a required output for any PAS128 survey. The different levels of survey have differing requirements.

Survey Type D

The practitioner normally presents the results of a Type D desktop utility records search in report format. A report should include, as a minimum:

1) Company details of practitioner

2) Client details

3) Plan showing the boundary of the survey area

4) List of utility owners contacted

5) List of utility owners who have responded, and actions taken to contact non-responders

6) Any information received from respondents, e.g. plans, letters, asset guidance notes

7) Date of issue of any maps/plans/letters and their period of validity, if stated

8) Note detailing how the information was obtained and the limitations of such information. This should include a warning that neither a site visit nor geophysical detection techniques were used in the compilation of such information.

Practitioners may offer additional options, the most common of these being a compiled plan in digital format, often using CAD, GIS or BIM software. Any useful information contained in the statutory records should be reproduced in a compilation plan, subject to the asset owners terms and conditions of what can be reproduced. All utility information should be designated as Quality Level D.

Where this is an option, attention should be paid to the type of base mapping used for the final output, and the consequent accuracies associated with such mapping. OS base mapping, often used for record information, is surveyed at scales of 1:1250 for urban areas and 1:2500 for rural areas. Topographic information can also be used, which would be of higher accuracy and smaller scale. However, scaling issues may arise when attempting to fit asset plan information.

Survey Type C

The required deliverables of a Type C survey have been formalised in the PAS128:2022 revised document and now are to be presented in a report format to include the following information:

1) Site location
2) Time and date of any site visits
3) Weather Conditions
4) Identity and Competence of the Surveyor(s)
5) Plan showing the survey extents
6) Survey methods deployed on site (plus relevant calibration certificates)
7) A photographic record of the site with plan showing photo locations
8) Notes on site limitations
9) Register of available statutory records and other information sources
10) A digital plan showing utility asset information relocated according to the findings of the survey.

If the utility asset plan information does not match with any site features observed during the site visit, and cannot be repositioned, the quality level designated should remain as QL-D as per Table 1.

A Type B utility mapping survey being undertaken.

Survey Type B

A written report for a Type B survey is more detailed and should contain:

1) A description of the survey project requirements and defined survey area

2) A list of the detection methodologies used during the survey

3) Ground and Weather conditions at the time of the survey and any issues that might affect the survey

4) Information on GPR calibration methods and locations

5) Variations in depth penetration achieved in various parts of the site using GPR

6) What GPR post-processing software has been used

7) Survey outcomes including:

a) Planimetric information

b) Metadata

i) The date the information was obtained or where information is taken from records, the date shown on the record drawing

ii) Utility type

iii) Quality level of the utility segment in accordance with Table 1 (QL-A, QL-B1, QL-B1P, QL-B2, QL-B2P, QL-B3, QL-B3P, QL-B4)

iv) Detection method in accordance with Table 2 (M1, M1P, M2, M2P, , M3P or M4P)

8) Description of the success of each detection methodology and a plan showing any areas where these detection methodologies were not successful

9) A list of any utilities that were expected to be present that were not detectable using these detection methodologies

10) A list of other buried features and obstructions detected during the execution of the survey

11) Plans showing all areas of conflict between record information, site information and detected utilities

12) Photographs where specified, or useful

13) Recommendations for any further survey work, especially if required to fulfil client requirements.

Survey Type A

PAS128 requires comprehensive detail to be recorded during a Type A verification survey, but the presentation format is not strictly specified beyond comprising some form of data sheet. The information could therefore come in a variety of formats, and the preferred requirements should be discussed in detail with the survey practitioner prior to commencement.

The minimum information that should be presented is as follows:

1) Utility type

2) Utility depth

3) Location of the excavation/inspection chamber relative to local detail that can be georeferenced

4) Geospatial location of the utility

5) Dated digital photographs showing location, open excavation and exposed utilities

6) A description and location plan of the excavation or inspection chamber.

Examples of data presentation might be:

- Section drawings showing the depth of burial and positioning of the trench
- GIS or BIM database with plan positions of utilities and all associated metadata
- Report detailing all work undertaken with relevant measurements and photographs.

Positional location of survey data

For Type B surveys, with only a few minor exceptions, the location of detected services will be positioned digitally by using a Total Station or GPS/GNSS. The use of tape measure and scaling to a paper plan is discouraged except for small inaccessible areas. The position of utilities exposed during a Type A verification survey should also be located using total stations, GNSS or other similarly accurate measures.

Type D data is taken from records and does not have a defined positional accuracy, whilst Type C data is usually relatively positioned or marked up by hand onto plans (even if digitised later), therefore no accuracy requirements are defined under PAS128.

Marked up utilities that have been detected during a Type B utility survey. Confidence levels can be ascribed once GPR data has been analysed and interpreted.

The debrief

PAS128 advocates a post-survey meeting which may be a face to face meeting or may be via conference call or multimedia on-line meeting facilities. Whichever option is chosen it is important to discuss the written report, the survey deliverables and any conflicts that may have been realised following analysis of the survey results. This will allow all involved in the project to fully understand the achievements and limitations of the survey that has been carried out. If a post-survey meeting is offered by the practitioner but not taken up by the client, this should be recorded so that the survey practitioner can demonstrate compliance with the specification. On the Client side, if the practitioner refuses a post-survey meeting, this is a demonstrable non-conformance with the specification.

In addition to the role as the provider of utility information for the project, the practitioner can be invited to address the client's project team to answer specific utility related questions and to provide detailed information relating to further survey work. This could include advice on the positioning of trial pits to verify the location of detected utilities, where these might be suspect or in conflict with the project design.

A meeting of this kind can often lead to information being highlighted that might otherwise have been missed due to surveyors and engineers having different viewpoints or attitudes to information, or understanding of drawings. Continued dialogue within the project team will ultimately benefit the project as a whole, and can lead to a reduction in risks and overall project costs.

Part 5: Technical factors affecting geophysical methods used in PAS128 surveys

PAS128 surveys aim to map buried utilities accurately using two key detection technologies: Electromagnetic Location (EML) and Ground Penetrating Radar (GPR). Each of these technologies has specific capabilities and limitations that impact the effectiveness of the surveys.

Electromagnetic Location (EML) systems

EML systems are a mandatory component in PAS128 Type B (Detection) surveys. These systems use electromagnetic fields to detect metallic utilities. EML technology typically operates in two modes: active and passive. Both modes help to identify utilities, with active methods relying on direct signal transmissions and passive methods detecting existing signals.

Key capabilities and limitations

- Detection Scope: EML systems can detect metallic utilities or those that can hold an electromagnetic charge. However, as newer utilities increasingly use non-metallic materials like MDPE (for pipework) and glass fibres (for fibre optics), these utilities become non-detectable with EML.
- Interference and Reliability: Dense utility networks, nearby metallic structures, high-voltage substations, and reinforced concrete can cause interference and lead to inaccurate detection. Signal distortions can occur, causing errors in the positioning of utilities. Operator competency is critical in mitigating these challenges.
- Estimation of Depth and Position: EML systems estimate depth based on the symmetry of electromagnetic fields. However, the proximity of multiple utilities or cables can distort these fields, leading to unreliable depth measurements. Surveyors must regularly calibrate the system on-site to correct these inaccuracies.

- Detection of DC Cables: Low-voltage DC cables are often not detectable using passive methods. Active methods must be used, often requiring manipulation of earthing circuits. This adds complexity and may require additional permissions and access to installations.
- Passive Radio Mode: EML's passive radio mode detects re-radiated signals from buried conductors. However, atmospheric variability and non-utility conductors, such as buried fencing or tram tracks, can mislead survey results.

A utility surveyor using an electromagnetic locator.

Operator competency and system selection

Sophisticated EML systems allow the use of a wide range of frequencies and multiple methods of signal application. Competent operators must understand how to select appropriate frequencies and adjust their approach in response to interference and signal distortion. Modern systems may support GNSS compatibility for precise positioning and have capabilities to identify signal distortions.

Ground Penetrating Radar (GPR) systems

GPR is the other mandatory technology used in PAS128-compliant surveys. GPR employs electromagnetic waves to detect changes in subsurface electrical properties. It can identify non-metallic utilities, making it a valuable complement to EML systems.

A vehicle mounted GPR System.

Deployment methods

GPR surveys can be conducted using two main methods:

- On-site Analysis and Markout: This involves real-time analysis where operators identify anomalies and mark out detected utilities. This method relies heavily on operator skill and real-time software aids. The georeferenced data should still be saved in case of later need and for audit purposes.
- Off-site Analysis with Post-Processing: Data is collected systematically and analyzed later in an office environment. This approach allows for advanced data analysis, offering a more detailed understanding of complex subsurface conditions.

Depth and penetration capabilities

The effectiveness of GPR is dependent on multiple factors:

- Penetration Depth: GPR systems measure the time delay (Two-Way Travel Time) of reflected signals, which must be converted to depth estimates. The depth of penetration depends on the system's frequency, ground conductivity, and moisture content. Higher frequencies provide better resolution but shallower penetration, while lower frequencies penetrate deeper but offer less detail.
- Contrast in Physical Properties: GPR relies on differences in electrical properties between utilities and the surrounding ground. High contrasts in relative dielectric permittivity (RDP) are essential for detecting utilities like plastic pipes. Saturated or dense soils can reduce GPR penetration and signal reflection.
- Lateral Resolution and Survey Design: To detect utilities effectively, GPR surveys must be systematically scanned at appropriate grid intervals. For large areas, multi-channel GPR arrays provide comprehensive coverage but may require supplementary scanning around obstructions.

GPR Systems can be used in most situations, and are relatively unaffected by electromagnetic fields, which are sometimes problematic for electromagnetic locators.

Limitations of GPR

- Ground Coupling and Surface Conditions: The quality of ground coupling significantly affects GPR performance. Rough or uneven surfaces can lead to energy loss and reduced depth penetration. Vegetation or obstructions should be cleared to enhance survey quality.
- Interference and Signal Clutter: GPR systems are susceptible to ambient electromagnetic noise and reflections from above-ground features. Careful interpretation and the application of filtering techniques are necessary to avoid false positives.
- Metal Interference: GPR cannot penetrate metallic objects, so utilities buried beneath reinforced concrete or metal layers may not be detectable. When possible, operators should opt for higher-frequency systems that can look through reinforcement layers.
- Interpretation Challenges: Identifying utilities based on GPR responses requires expertise. GPR responses often need to be correlated with other data sources, such as EML results or historical utility records. Proper data processing by experienced practitioners is essential to enhance the accuracy of interpretations.

Comparison and complementarity of EML and GPR systems

The combination of EML and GPR provides a robust detection capability for PAS128-compliant surveys. Each technology has specific strengths and limitations that complement the other:

- EML excels in detecting metallic utilities but struggles with non-metallic ones and may be affected by signal interference.
- GPR can detect non-metallic utilities and provide additional context by identifying subsurface features like trenches or protective capping layers. However, it is sensitive to soil conditions, penetration depth, and interpretation challenges.

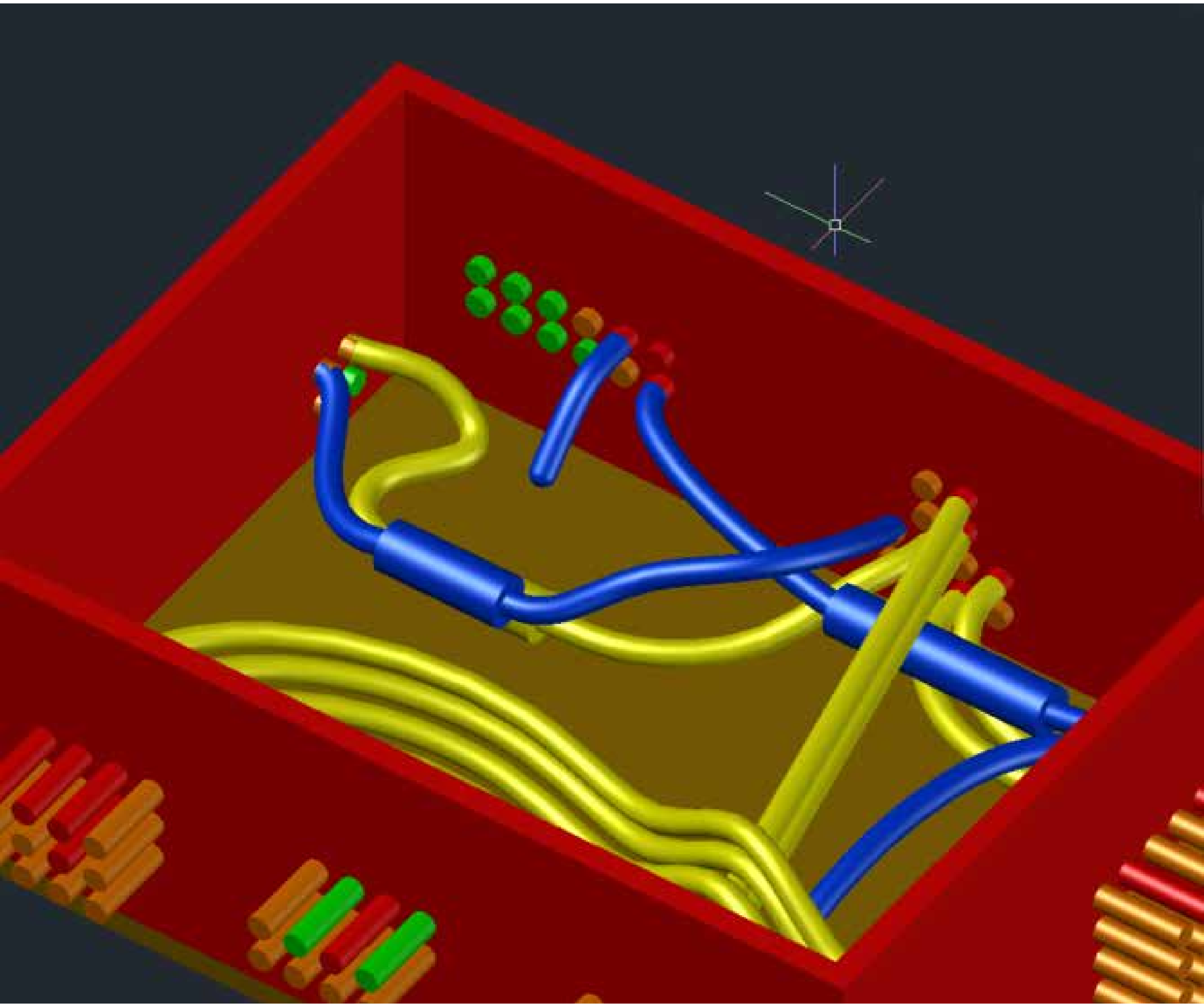
Environmental and operational constraints

Both EML and GPR are subject to environmental conditions and ground properties. Weather, soil saturation, and surface characteristics play a significant role in the effectiveness of both technologies. Preparing the site by clearing vegetation and removing obstructions can improve detection quality. Additionally, ongoing monitoring of changing conditions and performing frequent recalibrations are necessary to maintain accuracy.

Data processing and interpretation

Post-processing and careful interpretation of collected data are crucial steps in utility mapping. EML and GPR data require the application of filters, corrections, and in-depth analysis by skilled practitioners. Site-specific factors must be taken into account to ensure reliable outcomes. Modern multi-channel GPR systems enable rapid data capture, but interpretation remains dependent on practitioner expertise.

PAS128 surveys rely heavily on the appropriate use of EML and GPR systems. While both technologies offer valuable tools for non-intrusive investigations, their limitations require careful consideration during survey planning and execution. Achieving successful surveys involves balancing technology capabilities, operator skill, and environmental factors to ensure the accurate detection and mapping of underground utilities.



Once the survey results have been obtained, they can be presented in a variety of ways – this shows an inspection pit with services modelled in 3D.

Other detection techniques

There are a number of other techniques which can be used to detect buried utilities. These vary in cost and effectiveness and may only be applicable in limited special circumstances. It is useful to be aware of the existence of other techniques and some are listed below:

a. *Closed Circuit Television*

The use of CCTV is a well-established technique used to assess both the structural and service conditions of gravity drainage systems and ducts. Used in conjunction with a utility survey it can provide useful additional information on diameter, line, pipe defects and construction material that geophysical techniques alone would not provide.

The provision of a simple camera on a push rod system as a supplement to utility mapping can help determine the reason for Sonding surveys (see 2.1 above) being prematurely terminated, as it identifies pipe blockages or collapse. This will help in planned maintenance of the system rather than just reporting an ‘end of trace’ (EOT) on the drawing.

b. Gyroscopic based pipe location logging

For pipes and ducts that cannot be detected using EML or GPR because they are too deep or other ground conditions prevent these techniques being successful. Clear access is required with precise coordinates of the start and end points. The instrument uses gyroscopes to accurately calculate its position as it passes along the pipe.

c. Magnetics

Total field magnetometers and gradiometer systems can be used to locate metallic pipes and cables or utilities which have an electromagnetic field present. Sensitive magnetic instruments may also be able to detect the magnetic components of fired clay pipes, as might be used in field drainage, or detect disturbances in ground conditions that result from utility trenches.

d. Ground conductivity

Changes in ground conductivity can indicate the presence of utility features or trenches for utilities, as well as other sub-surface features. These instruments are generally portable and hand-held. They do not require ground contact so can provide an alternative to ground penetrating radar where ground conditions are not suitable.

e. Earth resistance

This technique measures the ease with which current can flow through the ground. It is popular in archaeological surveys due to its ability to locate features such as ditches and walls, but the method can also be used to detect modern features such as utility trenches, underground culverts and buried chambers.

f. Metal detectors

Their main application within utility detection surveys is to locate buried manhole covers, but they can also be used to detect pipes or cables in some specific situations.

g. Infrared (thermal imaging)

Changes in heat radiated from the ground can indicate the route of utility apparatus by detecting trench features, or even heat radiated from pipes used to transport fluids. This technique can also be used to indicate faults along electrical cables.

h. Seismics/acoustic

Traditionally, this is used for geological applications. Traditional seismic applications ccould be used to detect large underground features such as culverts or tunnels, but other methods also exist that introduce a regular noise into a pipe (usually water or liquid gas) at a connection point (e.g a valve) which then allows the pipe to be traced from the surface using a stethoscope or similar instrument. An alternative acoustic method is using sound to trace open drains, but whilst this method can be useful for proving connectivity, it does not provide any information on the subsurface route of the pipe or sewer.

i. Optical (laser)

More often used by total stations for measuring distance, there are some optical pipe-based systems that can scan pipes or tunnels and identify deformation and defects. As they become smaller and more portable traditional laser scanners are being used more often for surveying underground pipes and sewers.

j. Microgravity

This technique measures small fluctuations in the earth's gravitational field that indicate changes in the density of the earth's subsurface. It can be used to locate voids such as those found in underground sewers, culverts or tunnels. The technique is extremely sensitive to vibration and therefore it must be used during quiet periods as environmental contamination arising from site traffic, nearby roads and piling operations can lead to bad data. The data also requires complex mathematical modelling to simulate the effects of the nearby environment and requires highly accurate digital terrain models of the surrounding site/landscape, therefore this technique is usually expensive and time consuming to deploy.

k. Drain tracing dye

Introducing dye into the flow of fluid in a pipe allows the flow route and pipe connectivity to be traced downstream of the point where it is introduced. This must be planned meticulously to ensure that the lengths of pipe required are not contaminated by dye introduced into other upstream pipes.

Geophysical methods can be used to supplement a PAS128 survey, this is an example of an electromagnetic conductivity meter being used to survey a large open area.

The Survey Association

Formed in 1979 as The UK Land and Hydrographic Association, TSA is now established as the representative organisation for UK private surveying firms.

The Association's vision statements are:

- TSA will help you build a better business
- Clients with a survey requirement will prefer to use a TSA member
- Every young person should know about land surveying as a career.

Using a TSA member

By using a TSA member you can be assured that your project will get off to the best possible start. Whatever the size of project, you can be certain that TSA member companies are expert in the provision and management of spatially related data on which to base your concept, design and construction. Professional attention from a TSA surveyor will reduce risk, repetition, possibly save you money and will ensure that your project receives the best possible attention.

TSA disclaimer

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Appendix A

CAD drawing conventions and layer names

When preparing CAD drawings, it is best practice to adhere to a codified layering system. It is also important to ensure adherence to the data interoperability requirements dictated by Building Information Modelling working practices.

The current British Standard for CAD layering within the UK is BS1192:2007. It is this standard, together with the guidance presented on the BIM UK website (www.bimuk.co.uk), which has been used to devise the layering conventions contained within the TSA CAD template, available to download from the TSA website. It is recognized that the layers contained within the CAD template cannot be guaranteed to cover all eventualities, and therefore outline guidance is given below on the naming conventions used in case new layer names need to be devised and added to the basic template. See the BIM UK website for more detailed guidance.

BS1192:2007 allows for the following fields to be included within any Layer Name:

Field 1	Field 2	Field 3	Field 4
Role/Discipline	Classification/Element	Presentation codes	Alias

The "Role" field is a single character code which indicates the role held by the creator of the data produced, and under BS1192:2007 the "role" field also denotes the Author or the Owner of the information. There is currently no designation for a utility mapping surveyor, though there is a code for GIS Engineers and Land Surveyors [G] which is the closest designation, and should be used as a prefix for all layers generated.

BS1192:2007 encourages the use of Uniclass codes for the classification element of the layer name. The uniclass coding system is under constant review and made available on the websites www.cpic.org.uk/uniclass/ and https://toolkit.thenbs.com. Generalised uniclass codes are included in the table below, however it is possible to be very specific if required, and the online resources can be used to search for specific codes.

The standard codes for presentation as outlined in BS1192:2007 are as follows:

D	Dimensions
H	Hatching and Shading
M	Model related elements
P	Plot/paper related elements
T	Text

For more complex models, two character codes can be used but the above are the basic set.

The Alias field is for description of the layer. This description is not prescribed but should be kept as short as is functional so that layer names are kept to a reasonable length. The main reason for this is that some BIM software is limited to the amount of characters that can be used. Whilst the uniclass codes are a descriptive element, they are not easily recognizable to most users therefore a more accessible description should be used. This description should include the name of the asset owner, the type of utility and should also contain the quality level of the line segment. The layer name for a gas supply pipeline owned by National Grid, detected to quality level B1, would therefore be:

G- Ss_55_20-M-NatGridGas_B1

Requests have been received from some end users of utility drawings for line types to be used that identify the asset owner, particularly for telecommunications providers. A range of these have been included in TSA's template. This is not an exhaustive list and there may be a need to update the template as new providers appear or if current providers have been missed out. Recommendations for additions to the template should be directed to the TSA technical committee.

Colour codes for 'on site' mark up and drawing line codes

Despite carrying out extensive enquiries no published guidance appears to be available advising on the colours and line-styles to be used in both marking up the detected lines of utilities onsite, nor for the depiction of such utilities in drawings. The National Joint Utilities Group (NJUG) Publication, Volume 1 Issue 8, 'Guidelines on the positioning and colour coding of underground utilities' apparatus', published 29th October 2013, provides information on the colours used for buried ducts, pipes, cables and marker/ warning tapes. These NJUG guidelines have been used as a basis for the schedule below and the standardized CAD template produced for use with PAS128 by the TSA. As most suppliers only stock seven different colours of spray paint and wax crayon (namely black, green, orange, red, blue, white and yellow) it is practical to limit the on-site mark up to seven colours.

Notes

1. Yellow printed out on drawings is low contrast against a white background. If photocopied in black and white yellow is likely not to reproduce and may not appear on the copy.

2. Black is not an ideal spray paint colour to use on blacktop and blue can disappear at night under sodium lighting.

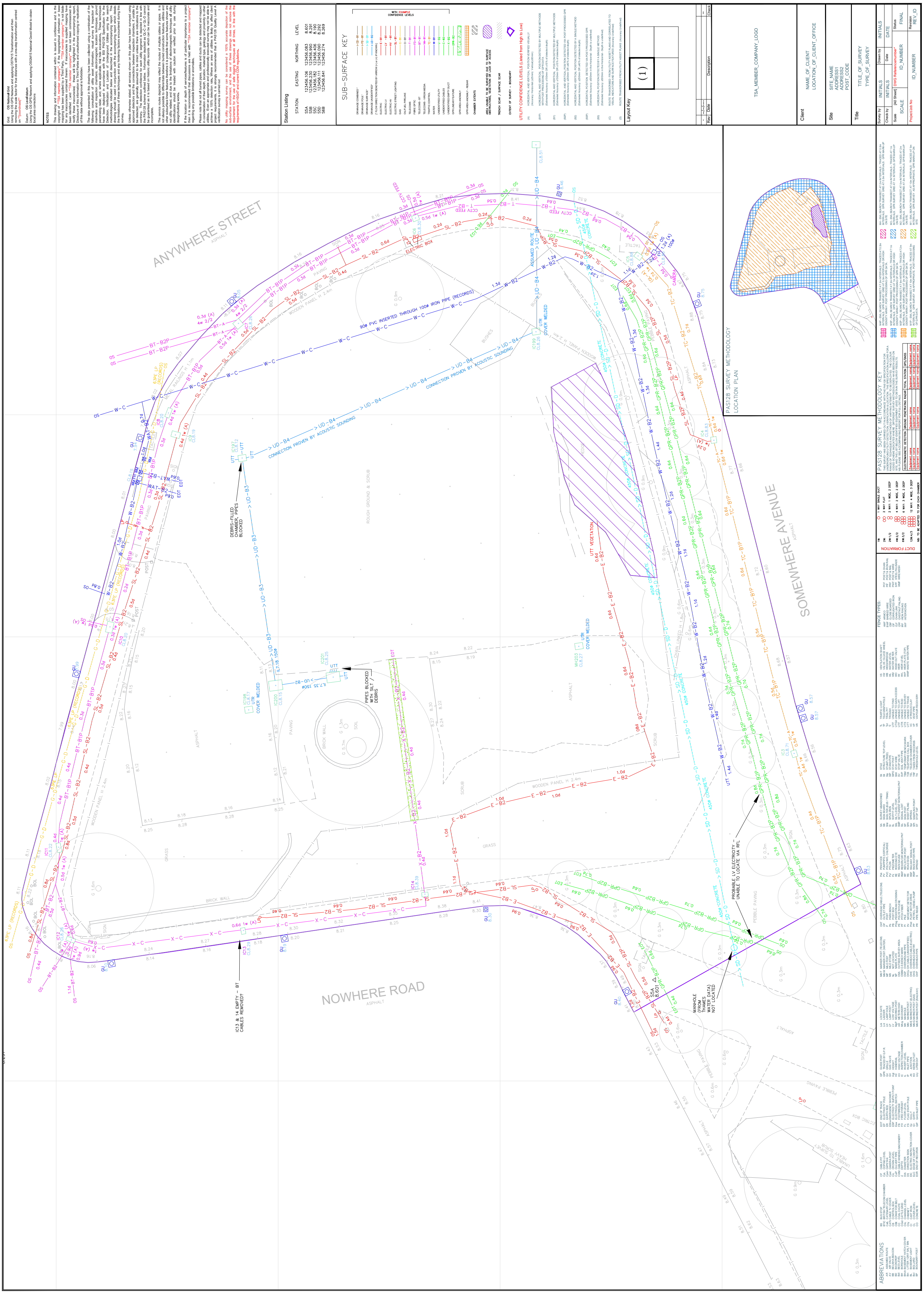
3. It is recommended that green is used for marking out unidentified GPR anomalies and for unknown utilities on drawings.

4. When drafting up the results of a survey in CAD it is recommended the base mapping is greyed out to increase contrast with the utility lines and so improve clarity.

5. The –XX– signifier in the line type relates to the quality level of the line segment. A gas pipeline detected to quality level B1 would be denoted by a –G–B1– line type whilst if the information is from records it would have a –G–D– line type. The layer name should also contain information pertaining to quality level.

6. Telecommunications providers may also be assigned a line type that indicates ownership. For example, British Telecom would be denoted by a –BT–XX– line type, whilst Virgin Media would be –VM–XX–. If this scheme is used the colour would identify the lines as telecoms, together with the key indicating the abbreviations used for the different owners.

Utility	Buried Duct	Buried Pipe	Buried Cable	Marker systems	On Site Mark-up	CAD Drawing Line Colour	CAD Colour code	2D linetype (XX denotes Quality Level)	3D linetype	UNICLASS Code
Gas	Yellow	Yellow, yellow with brown stripe or black with yellow stripe	N/A	Black legend on PE pipes	Yellow	Yellow (see Note 1)	40	–G–XX–	Continuous line	Ss_55_20
Water	Blue or grey	Blue or Blue with brown stripe (removable)	N/A	Blue	Blue	Blue	5	–W–XX–	Continuous line	Ss_55_70
Non potable Water	N/A	Black with green stripes	N/A	N/A	Blue	Blue (with note)	5	–W–XX–	Continuous line	Ss_55_70
Water – fire fighting	N/A	Black with red stripes	N/A	N/A	Blue	Blue (with note)	5	–W–XX–	Continuous line	Ss_55_70
Water – for special purposes such as contaminated land)	N/A	Blue with brown stripes (non-removable)	N/A	Blue or blue/ black	Blue	Blue (with note)	5	–W–XX–	Continuous line	Ss_55_70
Oil/fuel pipelines	N/A	Black	N/A	Various	Black (see Note 2)	Black (with note)	250	–O–XX– –F–XX–	Continuous line	Ss_55_50
Foul & Combined Drainage	Black	Not specified	N/A	N/A	Blue	Red-Brown	36	–FD–XX– –CD–XX–	Continuous line	Ss_50_30_08_30 Ss_50_30_08_15
Surface Water Drainage	Black	Not specified	N/A	N/A	Blue	Light Blue (Cyan)	4	–SD–XX–	Continuous line	Ss_50_30_08_85
Electricity (HV) & (LV)	Black or red – with tile	N/A	Red or black	Yellow with black and red legend	Red	Red	1	–E–XX– –LV–XX– –HV–XX–	Continuous line	Ss_70_30 Ss_70_30_45 Ss_70_30_35
Telecommunications (inc Highways Authority & Motorways)	Grey, white, green, black or purple	N/A	Light grey or black	Various	White	Magenta	6	–T–XX– –FO–XX– or as Identified [6]	Continuous line	Ss_75_10_21
Street Lighting (Includes Motorways)	Purple (Scotland) Orange (Rest UK)	N/A	Purple Black or Orange	Yellow with black legend	Red	Red	1	–SL–XX–	Continuous line	Ss_70_80_25_70
Traffic Control	Orange	N/A	Orange	Yellow with black legend	Orange	Orange	30	–TC–XX–	Continuous line	Ss_70_30_45_45
Street Furniture cabling	Black or Orange	N/A	Black	Yellow with black legend	Orange	Orange	30	–SF–XX–	Continuous line	Ss_70_30_45_45



Example of the results of a utility survey using the TSA CAD template.

Document revision history

Issue 1	December 2017	Original document
Issue 2	March 2018	Text revisions
Issue 3	May 2025	Text revisions and updated images to reflect changes made in the PAS128:2022 specification