Accurate, Reliable, and up to Date Geospatial Data Above and Below Ground is Essential for Planning and Designing Infrastructure for the Development of the Kingdom of Bahrain

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SUMMARY

The development of Standards and Specifications are the basis to improve the locating of underground utilities, utility record keeping and information management. The Kingdom of Bahrain is working to solve one of the greatest challenges of the urban environment in a modern city – knowing where utility assets are located at the planning stage and how to manage the common underground with limited space to not hinder infrastructure and urban development.

A project was undertaken in Bahrain in 2017/18 to identify what had to be done for Bahrain to work towards solving this challenge. The results of the project was an action plan for Bahrain to embark upon of which the foundation was the writing of the Standards and Specifications followed by their implementation, establishment of good Governance and sharing of necessary data between all stakeholders in line with the Standards and Specifications.

The Standards and Specifications have now been completed and are in the process of being put in the Gazetteer ready for implementation. The next phases of establishing the good Governance of the Utility Sector and sharing of the data between all stakeholders is in progress.

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1. INTRODUCTION

Bahrain is an island state in the Arabian Gulf with a surface area of 781km^2 and a population of over 1.6 Million with capital Manama. The Survey and Land Registration Bureau (SLRB) is the government body in charge of land and property registration, cadastral survey, national mapping, and charting of the land and sea of the Kingdom of Bahrain.

The national topographic mapping of Bahrain is mapped at a base scale of 1:000 and is very rich in detail with some 137 surface feature types being collected including all surface utility features. SLRB at present is undertaking several initiatives to improve the currency of this data through As-built surveys as a source for national infrastructure data, modernisation of data capture through UAV's and progressing towards a modern object feature based national mapping environment.

This drive to provide accurate, reliable and current geospatial information is to improve planning, decision making, infrastructure and services, housing and urban development and to help achieve Bahrain's Vision 2030, the Government Programme and support the SDGs. This cannot be complete without the same for underground utility information.

Bahrain's modern and world leading utility and services infrastructure is predominantly underground. This presents a challenge as they are almost all in congested urban areas where the different utility owners contest for space and allocation of corridors for their own utility. The country has some ambitious projects planned which will require careful planning as the utility corridors will be squeezed further by the need to re-route utilities for future projects. This was identified by the Government as critical for the Kingdom of Bahrain's 2030 Economic Vision.

The Ministerial Committee for Infrastructure commissioned the Survey and Land Registration Bureau (SLRB) with the Electricity and Water Authority (EWA), and the Ministry of Works (MoW), to provide the Kingdom of Bahrain with the knowledge and tools of how to apply best practice in the management of underground infrastructure positional information.

SLRB, EWA, and MoW contracted Ordnance Survey International (OSI) to carry out the project 'Optimisation of the positional accuracy of underground utility infrastructure information in the Kingdom of Bahrain'. The project involved all the major stakeholders in Bahrain through workshops and consultations. The project provided a high-level view of the current state of underground utility infrastructure records of Bahrain and proposed an optimal future state for data creation and management processes, and included a gap analysis and corresponding Action plan. It also proposed a Standard for surveying underground utilities and a data capture specification.

This final Standard was developed by SLRB with the support of the other Ministries with the information and conclusions from the project to specifically focus on the needs of the Kingdom of Bahrain.

The output was the production of the 'Bahrain Underground Utility Standard' and 'Bahrain Data Capture and Delivery Specification for the Survey and Mapping of Underground Utilities and Asset'.

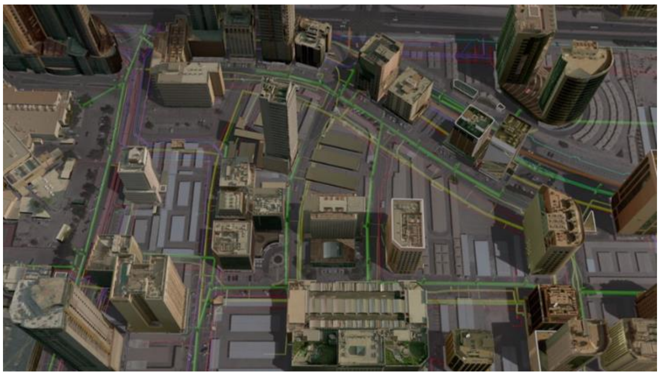
The first part of the Action plan achieved, Bahrain is now looking at the remaining steps to achieve its goal.

2. BACKGROUND

As the demand on the Kingdom's infrastructure continues to grow due to new developments, and the need to replace and/or maintain existing underground utilities increases, it is essential to have accurate information on the location of Bahrain's vast network of buried assets owned by Government, utilities and other organisations.

Inaccurate, incomplete and/or out-of-date information on the existence and location of utility assets reduces the ability of those involved in new or rehabilitation works to make informed decisions. This lack of reliable information during design and construction activities can result in costly conflicts, delays, utility service disruptions, redesigns, personal injuries and even loss of life.

Accurate and complete recording of utility assets enables asset owners to better plan their own works. Furthermore, sharing this information with others working near their apparatus reduces the risk of third-party damage and its consequential impacts, as well as more importantly ensuring the safety of operators, and the public.



Access to accurate and authoritative mapping of this critical national infrastructure is vital for those involved in undertaking excavations or the planning and implementation of new construction projects.

3. PURPOSE

The aim of the Standard was to set out clear and unambiguous requirements for utility surveys at various stages of development to provide defined high-quality deliverables that can be readily shared within the Utilities community and beyond.

The Standard is for utility owners, Engineers and Surveyors to identify the minimum input requirements and deliverables.

It is to define the accurate location and verification of; known and unknown, public and private, active and abandoned utilities.

The Standard is intended to promote the use and drive the advancement of utility records during the planning, design, construction, and operation of utility infrastructure.

A key driver for the Standard was the requirement for the interchange of data from the client for collative decision making both inside the client's responsibility and for decision making outside the client's responsibility where protection of the client's infrastructure must be respected by other agencies.

4. THE STANDARD

The Standard covered utility surveys required for:

New infrastructure projects – All services in a proposed project area are required to be located and shared, regardless of who requests the work to be done. Typically done through the planning procedure where survey Type D to A (defined below), are required to be carried out to confirm where their existing underground utilities are located within the project area.

Boundary adjustments – Request from Urban Planning to CPO to verify any presence of a utility when land (property) boundaries change. Usually a desktop study only.

Wayleave request – This is usually for the permission to carry out trial holes (Type A survey) for whatever reason, often during the construction period as an asset protection precaution if an asset is thought to be near construction.

Utility owner updating records – Systematic plan to ensure their own records are accurate and up to date. Will involve Type C to Type A surveys.

Emergency works under a GSN – Quick surveys to enable emergency works to be carried out. This should in future still be done at least according to National Standards and Specifications. This will involve Type A surveys only when a utility is redirected not simply repaired.

4.1 Scope

The main body of the Standard was based on the agreed minimum requirement and not the specific requirement of individual entities. It should be used in conjunction with any individual entities' specification requirements where applicable or when instructed to do so. The Standard is meant to be a practical document to guide the owner of the project on how to achieve the required deliverables to a professional level.

The Standard sets out the accuracy to which data is captured for specific purposes, the quality expected of that data and a means by which to assess and indicate the confidence that can be placed in such data.

More specifically it covers:
a) Project Planning and Scoping process;
b) Level of Accuracy, Confidence and Quality;
c) Detection;
d) Verification;
e) Location;
f) Analysis of results;
g) Deliverables.

In the various chapters the Standard explains the role and responsibilities of all organisations that the Standard covers and their involvement in the production and exchange of utility positional data.

The Standard covers the project planning and the scoping process of utility surveys which is aimed at primarily the commissioning organisation, but includes input that should be provided by the Consultant/Surveyor. It provides guidelines on when the four categories of survey, explained below, should be used and the reliability of the results. It further provides an overview of the techniques in survey Type B (Geophysical Survey) to achieve certain accuracy and reliability when commissioning the survey. It also outlines the type of deliverables that should be produced.

It explains the different survey category types in more detail and is primarily the Standards required for the Consultant/Surveyor carrying out the survey to follow. Along with the Specifications, (which refers to the 'Data Capture and Delivery Specification for the Mapping of Underground Utilities') they cover the methodology requirements, terminology and the deliverables in terms of output, attributes and survey accuracy and reliability.

In Bahrain, most utilities are located underground. The only definite way a project manager can determine the true position of a utility is to unearth it ('trial-hole') and measure directly to it.

As this is unrealistic to do for every utility in the project area due to time, cost and the possibility of damaging the utility, it is generally accepted that a number of utility searches and surveys will be performed with varying degrees of accuracy (and cost) over the design period of an infrastructure project.

It is also not uncommon for the same utility survey to be performed multiple times when the time span from planning, to design, to construction is spread over a number of years.
The Standard was structured to provide a number of different utility surveys accuracy classes (A, B, C and D). These classes address the different types of utility surveys available during the design process and are presented as a series of options, not a course of compulsory action to carry out all 4 types of survey. These represented the different levels of effort required in obtaining information on the location of utilities, whereby the desktop utility record search requires the least effort and verification the most. Each survey category is independent of each other, but for survey categories A to C, utility records are a necessary prerequisite.

In recognition that different clients at different stages of an asset life cycle will require different levels of detail and confidence in the data provided the Standard incorporated the four (4) survey type approach adopted as an industry norm in many countries and worldwide takes directly from the UK PAS 128 definition of these survey categories with adaptation to the Bahrain context:

Desktop utility record search (survey category Type D) – where underground utilities are identified through the collation and analysis of existing paper/online records. Carried out by the Central Planning Office (CPO) in the pre-planning stage or for asset protection.

Site reconnaissance (survey category Type C) – where existing records are supported and validated by the visual inspection of physical evidence observed during a site visit using SLRB topographic 1:1000 base map as background mapping. Carried out in the planning stage of a project.

Detection (survey category Type B) – where underground utilities are detected and located by geophysical techniques. Carried out for the design stage of a project.

Verification (survey category Type A) – where underground utilities are observed and located at an inspection or manhole chamber or excavated and exposed by a trial pit or slit trench. Carried out during the design stage of a project and during construction.

As-Built Surveys are also mentioned in the Standard as all new utilities should be mapped at the appropriate time as the project progresses and to the correct specifications which should be the same as survey category Type A. The surveys should also follow the As-Built Standards and Specifications. This is important so in future projects the Type D survey will be able to be used instead of extensive Type A and B surveys. As-Built surveys should be carried out during and after construction.

The Standard was aimed at both the commissioning organisation and Consultant/Surveyor to explain the expected workflow and the methodology statement required, which explains how everything will be done before the start of the project. It also explained in more detail how the different types of survey should be executed.

Finally, the quality accreditation and assurance was covered, with an explanation on how this is achieved.

Whilst a client will specify the type of survey required, the Standard provides a quality and confidence level classification that describes the practitioners delivered results in terms of the survey category employed to undertake the work and the quality and confidence level designation achieved based on positional accuracy and the criteria used in the determination of that quality and confidence level.

This Standard defined, in clear simple terms, a hierarchy of detection methods to be used to detect underground utilities for a variety of typical applications in terms of the minimum equipment types to be used, the minimum techniques to be applied and the survey search resolution and relates this to the maximum quality and confidence levels achievable.

In an attempt to improve accuracies and how data is exchanged and integrated, the Standard encouraged the absolute geospatial location of utilities referenced in three dimensions using Bahrain National Grid (Ain Al Abd) and Bahrain National Level Datum (BNLD) 1976.

Survey quality covers not only the positional accuracy (x, y, z) of the located utility but the completeness and correctness of the attribute data assigned to the feature, connectivity, and metadata associated with the point.

The Standard recognises that survey procedures and equipment used must relate to the attainment of the spatial tolerance nominated for each data quality class.

Survey checks should identify the following types of errors:

Systematic errors
Instrument errors or equipment calibration
Errors in information such as control marks, or design information
Human error
Quality Assurance

Quality assurance is the final stage in a quality accreditation process that is defined to confirm; the results of a survey, the delivered data, survey has met the required standards, and that the results are delivered on time and delivered in full.

The stages of quality accreditation include;

- The accreditation of organisations
- The accreditation of processes
- The accreditation of individuals
- The audit of organisations
- The quality assurance of output from survey activities

Reconciliation of quality assured results of a survey are used to improve the existing data records. The improved data will then be subject to a new quality assessment and a revised version of the data will be published.

5. THE ACTION PLAN

On the completion of the Standard and Specifications SLRB put forward a proposed Action plan to the Ministerial Committee for Infrastructure.

This was to issue instruction to Contracting Authorities to review, adopt and enforce final standards and specification. (This is now being done through adding the Standard to the Gazetteer).

Directly issue instruction to Contracting Authorities/Ministries to include requirements for full pre-survey of all project sites.

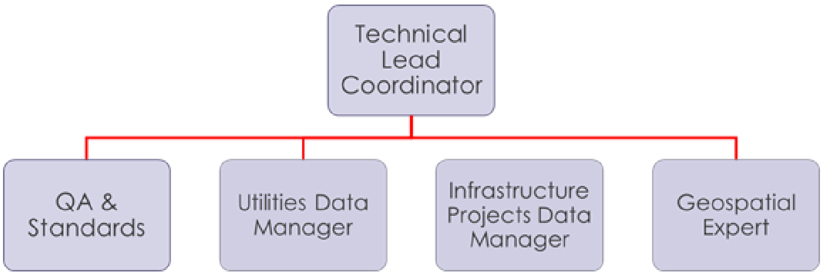
Establish Utilities Data Governance with Overarching principles that:

- Individual operators remain custodians of their own data.
- Only the essential data will be shared between the stakeholders on a need-to-know basis within a project.
- Establish an Executive Board to oversee the improvement of positional accuracy of underground utility data and better coordination of this data between relevant stakeholders.
- Establish a Technical Working Group to agree on practical implementation matters relating to underground asset data.
- Create a Utility Mapping Data Unit in one of the key stakeholder organisations (i.e. Central Planning Office, (CPO) – within the Ministry of Works)

5.1 The Utility Mapping Data Unit

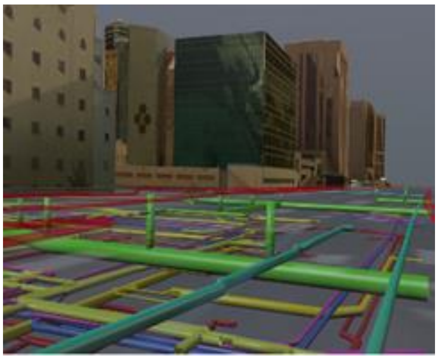
The team as outlined below will eensure stakeholder coordination for data sharing, data quality and standards, be tasked to support one major project initially, with the Head of Unit requiring the authority to access all relevant utility project data to ensure proper coordination of all stakeholders affected by the project and that the project manager has all the information required to make informative and the correct decisions in a timely manner.

The team should be established within an existing Government department ideally the Central Planning Office (CPO) and outsourced to the large infrastructure projects.



6. CONCLUSION

The foundations have been laid with the Standards and Specifications and with the backing of the Ministerial Infrastructure Committee at which most of the major stakeholders are represented Bahrain has a real possibility of achieving the goals set out by the 2030 vision.



SLRB unlike most National Mapping Agencies collect many surface utility features and with ongoing projects to transform the way it captures and stores data, progressing towards a modern object feature based national mapping environment. Based on a database created from the world class OGC compliant data model created for SLRB by OSI. The database will incorporate all the requirements of the stakeholders and so will also provide the platform for incorporating utility data and the sharing of data between all Government and other Stakeholder entities.

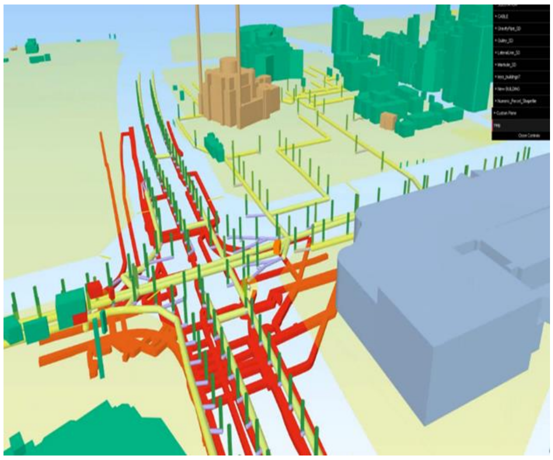
Bahrain has the advantage of size to enable all the required data to be collected, collated, QA/QC and shared between all stakeholders so they can rely on current, intelligent and trusted data to ensure the right people have the right information on which to make good decisions, be it new developments or infrastructure projects. The final goal being to reach utility utopia by creating a digital twin for the nation.

Ultimately Bahrain wants to be a Smart Nation utilising AI with new generations of sensors and control circuits have the potential to transform the way infrastructure is delivered, managed and optimised. Underground networks will be critical for delivery of this across Bahrain, meaning the potential for rapid changes to existing infrastructure and more complex underground ecosystem.

In addition, new infrastructure will be required to support photovoltaic generation, as well as recharging electric vehicles.

A tight integration between an upgraded utility infrastructure, and the data and the navigation infrastructure necessary to guide autonomous and connected vehicles may be an important future driver.

Bahrain sees utility infrastructure as a foundation for a future sustainable smart nation and infrastructure developments, as an important factor to achieve its goal as a globally recognised economy.



Disclaimer

The views expressed in this paper are solely those of the author/s and do not necessarily reflect those of the Survey and Land Registration Bureau, its affiliates, and the Kingdom of Bahrain

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REFERENCES

Ordnance Survey International, 2018, Action Plan - Optimisation of the positional accuracy of underground utility infrastructure in the Kingdom of Bahrain

PAS 128: 2014 Specification for the underground utility detection, verification and location

PAS 256: 2017 Buried assets – Capturing, recording, maintaining and sharing of location information and data – Code of Practice

Survey Land and Registration Bureau, 2020, Bahrain Standard for the Mapping of Underground Utilities v1.0

Survey Land and Registration Bureau, 2020, Data Capture and Delivery Specification for the Mapping of Underground Utilities v1 DRAFT

TSA Essential Guide to Pas128-2014 Issue 6 March 2018 The Survey Association (TSA)

BIOGRAPHICAL NOTES

Mr Jon DAVIES MRICS

Jon qualified with an MSc in Land Surveying at UCL before spending 7 years throughout Africa and the Middle East as a Land Surveyor and Party Chief in the oil exploration field becoming a Member of the Royal Institute of Surveyors in 1991. After a year in the UK specialising in GPS surveys he spent 10 years in Zimbabwe initially as a Lecturer in Land Surveying and then he set up his own company specialising in RTK GPS. His company consulted for the Surveyor General to write the specifications and standards for cadastral surveys by GPS in Zimbabwe. Returning to the UK in 2001 Jon spent 12 years working for various survey companies in managerial positions working on Railway and the Crossrail projects in the UK. He moved to his present job in The Kingdom of Bahrain in 2014 as Chief of Survey Operations and Product Development and then in 2016 as Advisor/Consultant to the Topographic Survey Directorate (TSD) of the Survey and Land registration Bureau, (SLRB).

Dr Mathew WARNEST

Dr Mathew Warnest is the Advisor for Survey Affairs in the Office of the Head of the Survey and Land Registration Bureau. Mathew has broad experience over 15 years in the public and private sectors in land administration and spatial information management throughout South East Asia, Africa and the Middle East. He specialises in national level programming and policy development, translating national development objectives into practical implementation. He holds specialist skills in land administration, geospatial information management, land information systems and urban and rural development. Mathew has previously contributed to the National Green Growth and Low Carbon Strategy for Rwanda with the Smith School for Enterprise and Environment, University of Oxford, and has undertaken various consultancy assignments with UNFAO, The World Bank, IFC and the private sector. He holds a PhD in Engineering (University of Melbourne), BGeom (Surveying), BSc (Environmental studies).

Mr. Isa Ali ABDULLA

Isa qualified in the United Kingdom at the University of East London whilst working at The Survey Land and Registration Bureau as a Surveyor. He quickly rose through the ranks to position of Chief of Cadastral Data in 2012. In 2017 he was promoted to Director of the Topographic Survey Directorate which is his present post.

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