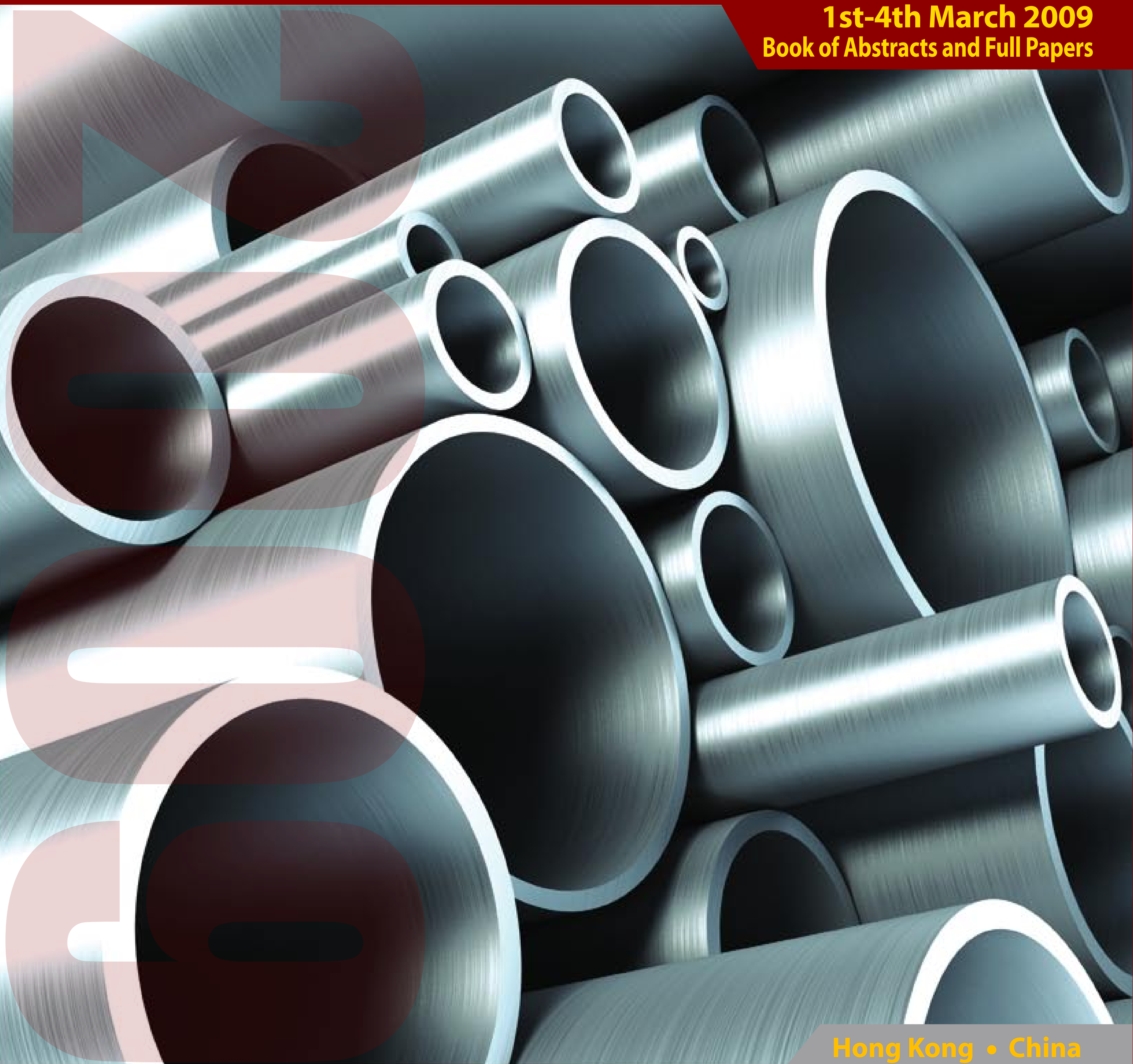
The First International Conference on Utility Management and Safety

第一屆國際管綫管理及安全會議

1st-4th March 2009

Book of Abstracts and Full Papers



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The First International Conference on Utility Management and Safety 2009

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Hong Kong Institute of Utility Specialists

Hong Kong Utility Research Centre

Co-organizers:

Department of Land Surveying and Geo-Informatics, The Hong Kong Polytechnic University

Construction Industry Council
建造業議會

Preface

These proceedings are a compilation of papers accepted for the First International Conference on Utility Management and Safety (ICUMAS), held in Hong Kong in March 2009. The ICUMAS was jointly organized by Hong Kong Institute of Utility Specialists (HKIUS), Hong Kong Utility Research Centre (HKURC) and co-organized by the Department of Land Surveying and Geo-Informatics of The Hong Kong Polytechnic University and Construction Industry Council.

This pioneered conference raised managerial, technical and innovative issues relating to the utility industry and in which continue to be challenges to government officials, utility practitioners, stakeholders and the general public worldwide. The ICUMAS encouraged and facilitated a platform for practitioners and experts from different cities to share their research outcomes, valuable experiences, policies and advanced technological developments. There are 49 papers accepted for the conference in which all accepted papers are presented in the proceedings. The Organizing Committee and the Technical Review Board believe that it will be of great values to researchers, educators and practitioners of the utility industry.

On behalf of the Organizing Committee and the Technical Review Board, we wish you all find the ICUMAS inspiring. We would like to express our greatest gratitude to all the speakers, authors and also those who have assisted to make this conference a success.

Prof. Albert K.H. KWAN
Chairman of Technical Review Board

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The Advancement of Utility Planning and Management in New Developments

John S.V. Chai

Civil Engineering and Development Department, HKSAR

Abstract: To cope with the increase in population and improve the living environment, Hong Kong has developed new towns in the rural areas and undergone major developments in the urban areas. The planning of utility services in these developments over the past decades generally adopted the conventional direct burial approach with larger utility services placed underneath carriageways and smaller utility services put under footways, cycle tracks or amenity strips. With time, advancement of technology in utility planning and management emerges and major new developments are considered as potential areas for implementation of such new technologies. This presentation gives an account of the planning of utility services in existing new town developments and the current land and legal framework for planning, installation and management of utility services. It also gives an overview of the potential application of Common Utility Enclosure and the proposed District Cooling System in Kai Tak Development.

Pipeline Construction and Reconstruction for the 21st Century

Declan Downey

International Society for Trenchless Technology
Jason Consultants Ltd., United Kingdom

Abstract: The challenge for designers and constructors is to build long lasting, functional and efficient utility pipelines with a minimum of disruption to industry, commerce and the general public. Historic experience with traditional materials has not always been satisfactory with serviceability problems encountered in many common materials. With the benefit and clarity of hindsight a number of materials selection decisions may appear ill judged. Notwithstanding some classical examples of extreme longevity society needs water tightness, structural integrity, durability and constructability from modern pipeline materials. The keynote address will attempt to examine the issues and state of the art in materials selection, construction methodology, pipeline performance and condition assessment. It is clear that modern materials and installation methods offer real opportunities for durable construction, enhanced performance and minimal environmental impacts but require improved design, comprehensive testing, informed construction supervision and thorough quality assessment to provide value and sustainability to meet our expectations.

Issues Regarding the Use of Ground Penetrating Radar in Underground Service Detection

FORDE, Michael

University of Edinburgh, Scotland, UK

Abstract: The basic principles behind GPR have been outlined with a focus on the importance of the reflection coefficient in establishing the sensitivity of the system. It was shown that the key to success with conventional GPR is to have a high contrast between the service duct and the background medium. Where plastic service ducts are surrounded by materials of similar dielectric properties, it will be difficult to identify them. Novel antenna designs such as bore head antenna systems have a role to play in service duct detection — but they are still bound by the basic laws of physics.

GPR is an excellent tool as part of a data fusion exercise, but high precision location systems are essential — such as using robotics.

Keywords: Ground Penetrating Radar, GPR, Accuracy, Dielectric Constant

1. INTRODUCTION

The rapid changes in society are placing greater demands on service providers, asset owners and City Authorities in terms of services to both offices and home dwellings. Examples include renewal of water supplies, gas, sewerage and provision of new fibre optic telephone and data link services.

2. BACKGROUND TO GROUND PENETRATING RADAR (GPR)

Ground Penetrating Radar, was originally developed as a geophysical technique — penetrating the ground, and referred to as GPR [1]. Other applications quickly followed including superstructures [2]. Of recent interest is the area of buried underground services [3].

There are three basic types of antenna used in GPR — horn antennas, bow tie antennas and borehole antennas. Figure 1 shows a monostatic bow tie antenna. Figure 2 shows examples of a greyscale radargram and a GPR wiggle plot.

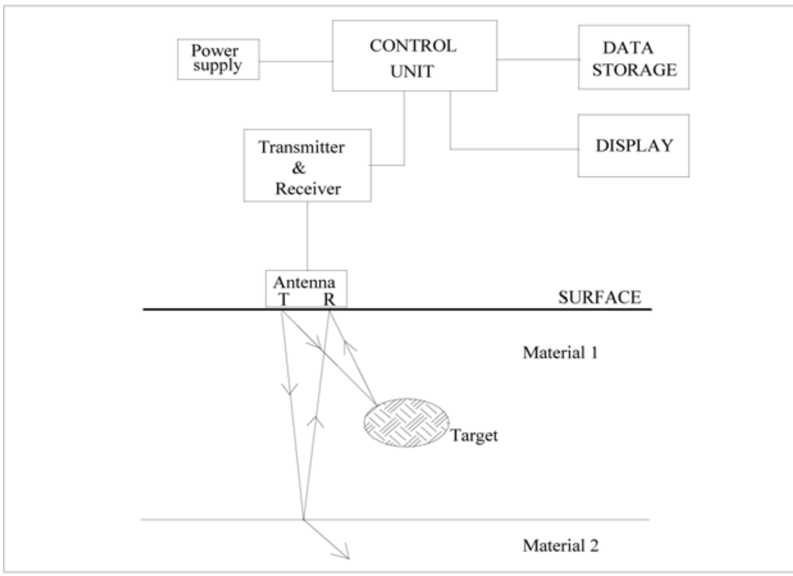

Figure 1 Basic principles and components of a radar system with a monostatic antenna

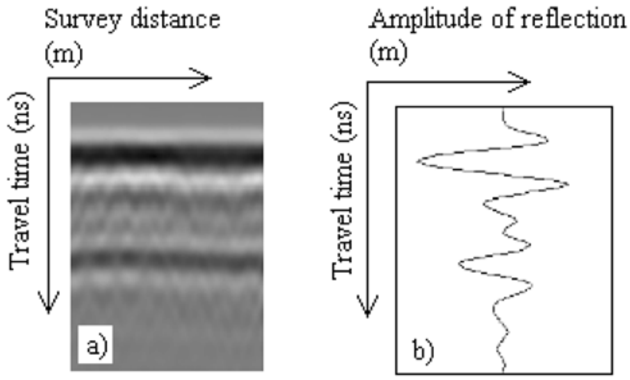

Fig. 2. (a) Example of a greyscale radargram and (b) of a GPR wiggle plot

The basic principles of GPR analysis are as given by Annan [4], Figure 3:

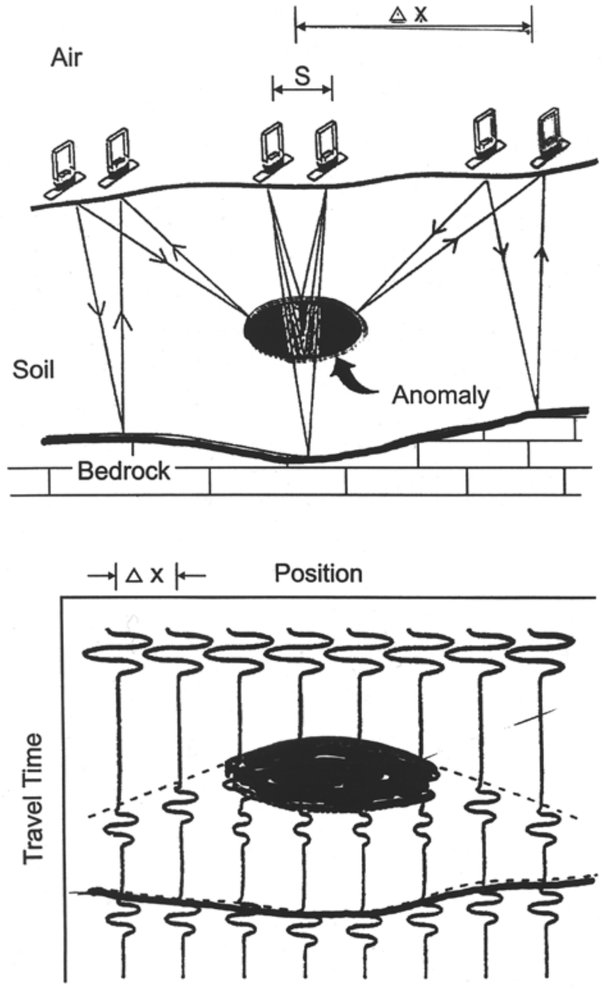

Figure 3 — basic principles of GPR [4]

In addition specialist companies have developed different types of antenna for specific purposes — such as the borehead GPR [3] — Figures 4 & 5.

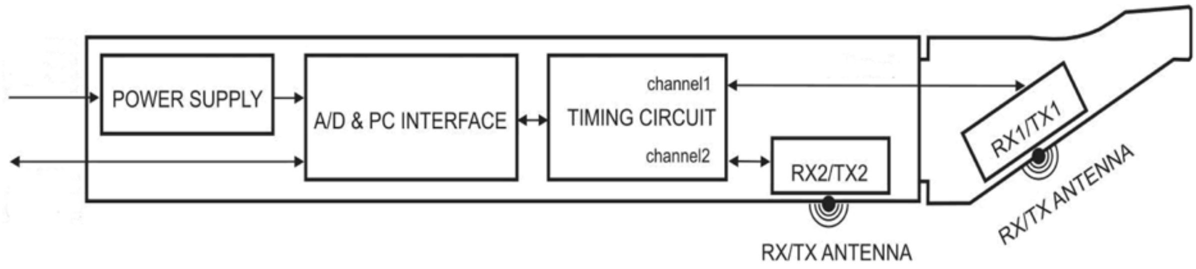

Figure 4. Schematic diagram of the bore-head GPR [3]

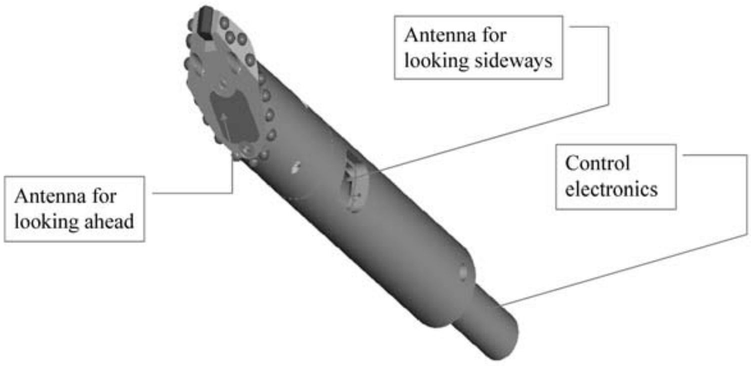

Figure 5. Bore-head GPR [3]

3. GPR THEORY RELEVANT TO UNDERGROUND SERVICE DETECTION

The default convention in most publications and practice has been that the centre frequency in air of the antenna represents the centre frequency of the radar signal in the target medium.

It is observed that when an antenna is brought into contact with a surface, the transmitted/received signal frequency changes — the received signal centre frequency is usually lower by around 30% than that specified by the manufacturers for transmission in air [5]. This may be due to the fact that the target actually becomes part of the antenna. See Table 1 below for some examples.

Material	ε_r	**Centre Frequency in air (MHz)**	**Centre Frequency in material (MHz)**	**Velocity (v) (mm/ns)**	**Wavelength λ (mm)**	**Resolution λ/2 (mm)**	Z_{min} **λ/3 (mm)**
Sand	6	1,500	1,050	123	117	59	39
Damp Concrete	10	1,500	1,050	95	91	45	30
Partially saturated clay [6]	25	1,500	1,050	60	57	29	19
Sand	6	900	630	123	195	98	65
Damp Concrete	10	900	630	95	151	76	50
Partially saturated clay [6]	25	900	630	60	95	48	32
Sand	6	500	350	123	351	176	117
Damp Concrete	10	500	350	95	271	136	90
Partially saturated clay [6]	25	500	350	60	171	86	57
Sand	6	100	70	123	1757	879	586
Damp Concrete	10	100	70	95	1357	679	452
Partially saturated clay [6]	25	100	70	60	857	429	286
Where ε_r = dielectric constant (real)							

Table 1: Resolution of GPR

The Velocities in Table 1 were calculated using the simplified equation (assuming a low value of conductivity):

Signal velocity (v)

$$v = \frac{c}{\sqrt{\varepsilon_r}} \tag{1}$$

where: v = signal velocity
c = velocity of light (0.3 m/ns)
ε_r = dielectric constant

From [7]

The resolution was taken as wavelength/2 = λ/2

The first detectable target was taken as wavelength/3 = λ/3

The ability to detect a target at all depends upon the Reflection Coefficient defined below in equation (2):

Reflection Coefficient (*R*)

$$R = \frac{\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}}{\sqrt{\varepsilon_{r1}} + \sqrt{\varepsilon_{r2}}} \quad (2)$$

where: ε_{r1} = dielectric constant of first material,
ε_{r2} = dielectric constant of second material.

Table 2 below gives some typical values of dielectric constant:

Material	**Dielectric Constant ε_r**
Air	1
Plastic	3-5
Dry sand	6
Damp Concrete	10
Partially saturated clay	25
Water	80
Metal	“81”

Table 2: Some typical values of dielectric constant:

From the above, the larger the value of the Reflection coefficient (R) — the easier it will be to detect the target.

4. PRACTICAL COMMENTS ON USING GPR TO DETECT UTILITIES

Clearly the best result will be obtained when using GPR to detect metallic utilities in dry sand, where the sand would have a dielectric constant of around 6 and the metal pipe would give a total reflection — Figure 6 below is from Boston USA (courtesy of GSSI)

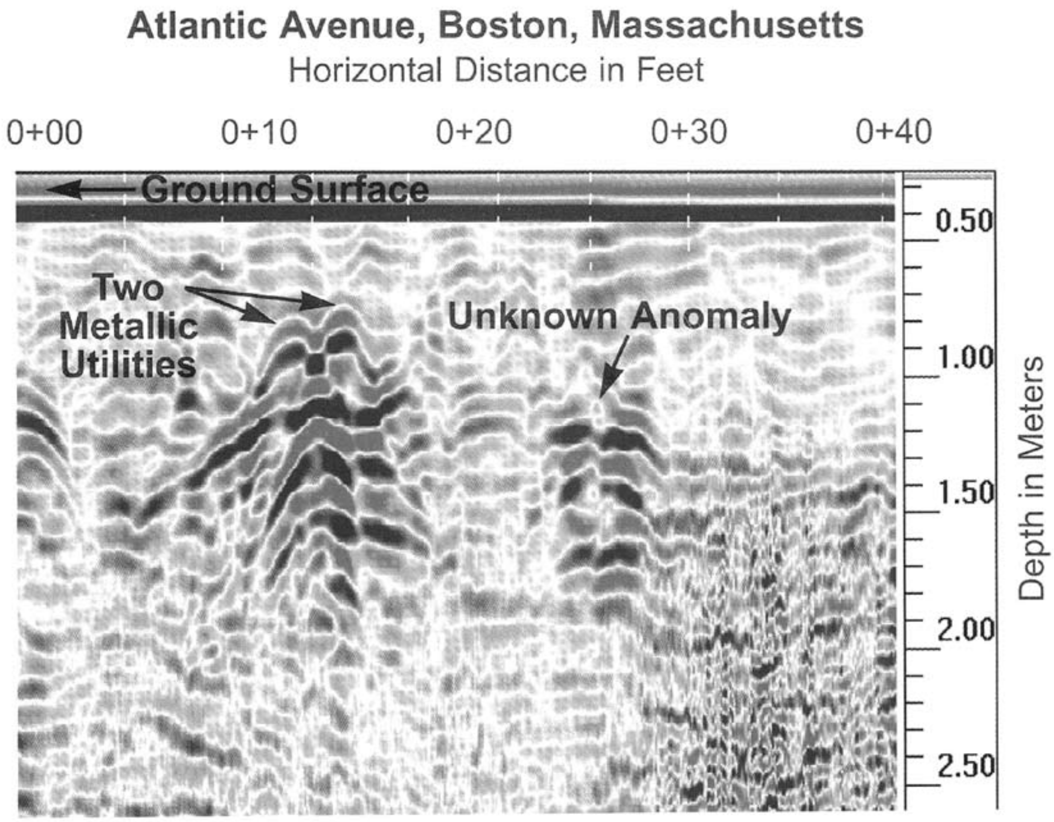

Figure 6: Utility detection in Boston, USA

A similarly successful image was achieved using the Bore-head GPR system [3] when the drill head was 30cm away from a metal pipe — as published at GPR-2008 — Figure 7:

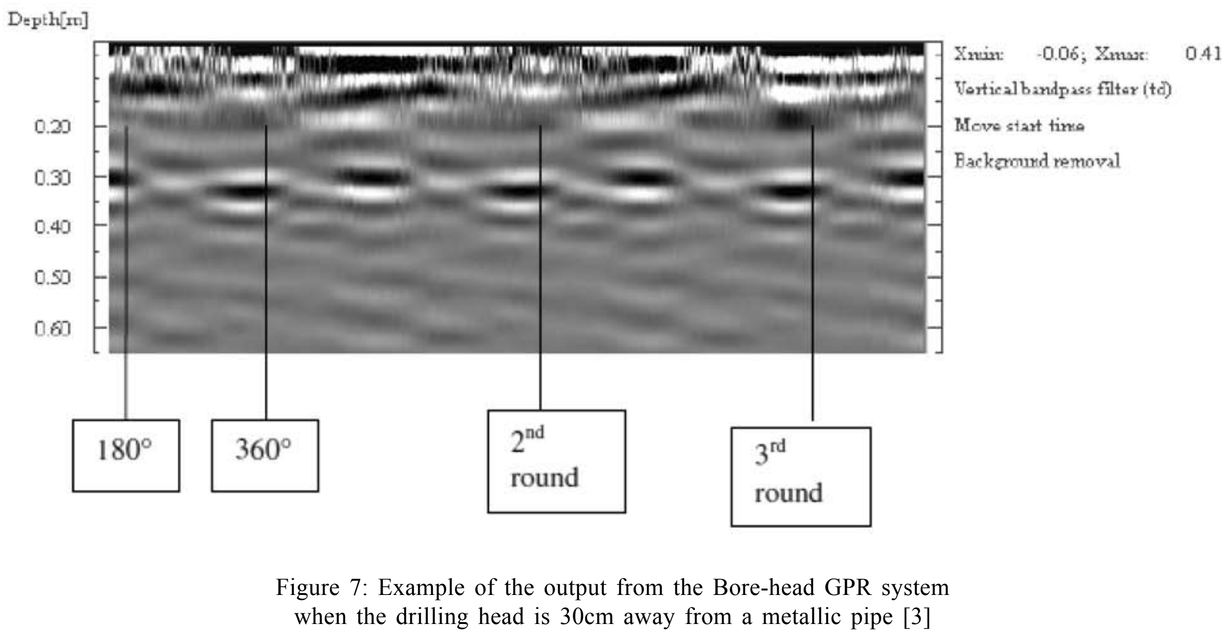

Figure 7: Example of the output from the Bore-head GPR system when the drilling head is 30cm away from a metallic pipe [3]

Mancorda et al illustrate a seriously complex layout of multi-material services in Figure 8:

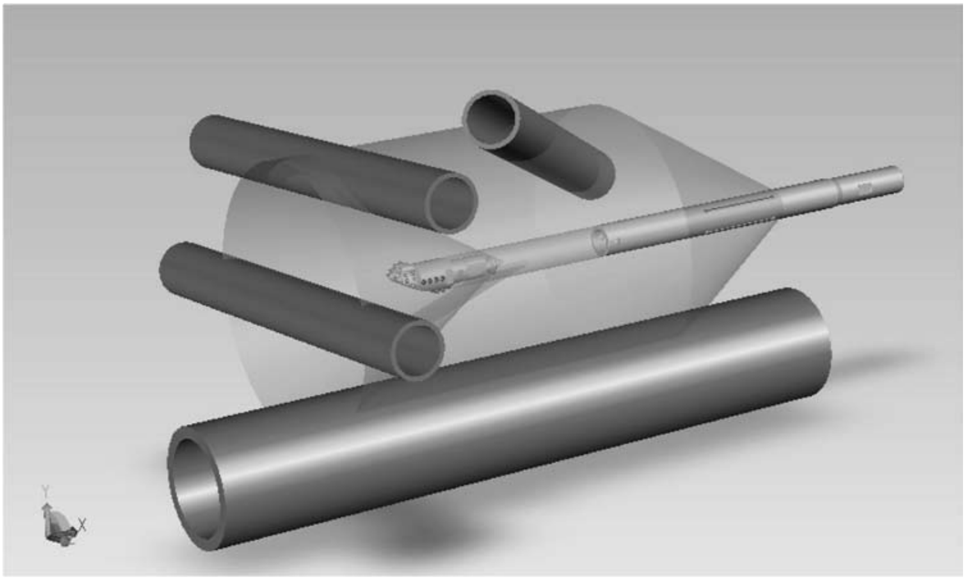

Figure 8: complex layout of multi-material services [3]

From equation 2 and Table 2 — it will be appreciated that the detection of buried services will be easiest when the services are metallic.

Other important issues to take into consideration are:

- Impulse radar is particularly effective through non-conductive materials, or insulators.
- The greatest depth penetration using impulse radar can be achieved using low frequency antennae through dry granular materials.
- Impulse radar will not penetrate through conductors such as metals.
- The total reflection of the radar signal from conductors makes it an ideal tool for identifying buried metallic utilities in insulators such as dry sand.
- Impulse radar is reflected at water interfaces with a phase change and is therefore effective for identifying leakage from utilities in otherwise dry soils such as sand.
- Impulse radar is highly attenuated when penetrating through clays and salt water.
- At low frequencies the electromagnetic wave attenuation is significantly less than at higher frequencies — reinforcing the desirability of using low frequency radar systems, subject to resolution constraints.
- At frequencies below 500 MHz, the radar signal is very frequency dependent, thus any calculations relating to velocity should be undertaken using the generalised expression for velocity rather than the simplified one. This means that accurate depth estimation using GPR may prove difficult [8].
- With an increasing value of site di-electric constant and large targets, the avoidance of clutter indicates the need to use lower frequency antenna.

5. DATA FUSION OPPORTUNITIES

Research into the detection of voids in plastic tendon ducts in post-tensioned concrete bridges using multiple NDT methods such as GPR and impact-echo have shown the benefit of data fusion in creating tomographic images. However the key to success depends on observing the above detailed notes plus very high precision in data co-location. This may require the use of robotic systems to ensure complete repeatability.

6. CONCLUSIONS

The key to success with conventional GPR using a close coupled bi-static bow tie antenna is to have a high contrast between the service duct and the background medium. Where plastic service ducts are surrounded by materials of similar dielectric properties, it will be difficult to identify them. Novel antenna designs such as bore head antenna systems have a role to play in service duct detection — but they are still bound by the basic laws of physics.

GPR is an excellent tool as part of a data fusion exercise, but high precision location systems are essential — such as using robotics.

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Implementation of a Territory-Wide Programme of Rehabilitation and Replacement of Water Mains in Hong Kong

Lee Tak MA

Water Supplies Department, HKSARG

Abstract: Hong Kong's water supply and distribution networks, mostly underground, are continuously expanding and now comprise some 7,800km of water mains. Effective management of the networks is essential for reliable supply and conducive to water resources sustainability. To this end, the Hong Kong Water Supplies Department has drawn up an underground asset management plan and embarked on a major replacement and rehabilitation programme for those aging water mains since 2000. For the last eight years, the multi-stage programme has been progressing well and experiences are gained. This presentation gives an overview of the implementation of the water mains replacement and rehabilitation programme, including the methodology adopted and the challenges encountered, and provides an update on the programme status.

Getting Maximum Safety From Limited Resources

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Abstract: With proper selection of safety related measures, the title of this speech is achievable. During the recent years the speaker has conducted two large-scale research studies. Both are based on close interactions with dozens of construction safety experts and construction practitioners. The first study identified the most effective four (out of 27) distinct measures and techniques for construction safety management, which, according to a selected group of construction-safety experts, are capable of eliminating about 80% of severe work-accidents at construction sites. The research method combined Pareto Analysis with a Delphi Study approach. The four selected measures are the following: 1) A comprehensive safety-risk analysis at the onset of the project; 2) Synergetic and integrated management, assurance, and control of Safety with Quality, for economical utilization of the joint resources involved; 3) Systematic and comprehensive safety-related guidance and instructions to all subcontractors and their workers upon commencement of their work on site; and, 4) Prompt investigation and Root Cause Analysis of safety events (potential accidents, as well as accidents), and immediate implementation of corrective and preventive measures throughout the project, the organization, and the construction industry as a whole. Directing adequate resources to these four measures, may yield approximately 80% of results, for merely 40% of resources. About one half of these 40% resources are yet to be saved with the aid of the second study.

While the former study dealt with the “What”, the “Why” and the “How”, the latter study aimed at the “When”, the “Where”, and the “Who”. It is based on the realization that the risk levels at a construction site for every crew, and in fact, for every individual worker, is time-dependent and location-dependent (4D). Thus, different workers (“Who”), at different times (“When”), at different locations (“Where”), are threatened by different hazards. Consequently, a sophisticated, yet simple to apply, model was developed, using the “Lean Construction” approach. It ensures that the limited resources devoted for safety-related activities, are well-spent and are in-tune with the dynamic changes (in time and space) of the risk levels for every particular crew or worker. This model is superimposed on the project schedule, and yields substantial added safety for merely marginal added resources.

In conclusion, doing the right thing (i.e. focusing on the most effective safety measures) at the right time at the right place (i.e. utilizing these measures in a most efficient manner), enables the achievement of roughly 80% results with 20% resources. The speech will present and exemplify in more detail the prescription for realizing this promise.

Keywords: construction, safety management, lean construction, risk analysis, root cause analysis.