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Application of Ground Penetrating Radar for Underground Utility Detection

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***Abstract:** The accurate location of underground utilities at a construction site can prevent any damage to the utilities during excavation works. The cost of fixing the damage utilities can be very costly and will reduced the expected profit of the construction works. Therefore underground utility detection using Ground Penetrating Radar (GPR) is important in providing accurate information of the utilities at a construction site. In this study TerraSIRch SIR-3000 GPR equipment have been used to detect underground utility, with a 400 MHz ability which can reach up to 3m depth. RADAN 7 software is used to interpret and analyze the GPR data. Based on the results obtained the GPR equipment is capable of detecting underground utilities such as pipe, cable, shaft, etc.. The detected utilities are then shown in the 2-D and 3-D drawing for better visualization and identification.*

***Keywords:** GPR, RADAN 7, utility drawing, underground utility.*

I. INTRODUCTION

Beneath the surface of urban region and big cities all over the world lies a wide complex network of cables and pipelines which provide the vital utility services that reinforce modern civilized life. An extraordinary call for utility services within the urban region leads to bury an accumulative digit of utility pipelines such as; telecommunication lines, fiber optics, water and gas pipelines electrical cables. Today many of underground utilities have reached its ending practical life which makes it necessary to be replaced or repaired. While new utilities are awaiting installation due to urban development and the advancement of human life style such as; advanced communication technologies. Then an accurate data and info of these utilities is needed for engineers, surveyors, utility owners, or contractors, generally as reference for the excavation works [1].

Many have not realized the significance of the underground utility detection which is vital before starting any excavation works. A misfortune could take place if the work is ongoing before the underground utilities are located. Basically, underground utility detection is the procedure of recognizing, isolating and labeling the public and private subsurface utility lines which are hidden beneath the ground surface. These lines comprise of electricity distribution cable, telephones, fiber optics and communication lines, water and waste water conduits and major oil and gas pipeline, mass transit, road tunnels and rail etc. [1],[2].

An electromagnetic technology is used in GPR system to detect lines among subsurface mediums with differing dielectric constants (Table 1). GPR system comprise of antenna that houses the receiver and transmitter with a recorder that reproduce the received signal data in form of a graphic display (Fig. 1) [3].

Table 1: Wave velocities and dielectric constants of subsurface medium [3]

Medium	Velocity (m/ns)	Dielectric Constant
Air	0.3	1
Water	0.033	81
Rocks	0.15–0.087	4–12
Sand dry	0.15–0.12	3–5
Sand wet	0.055	20–30
Clay dry	0.11–0.09	2–6
Clay wet	0.052	15–40
Concrete	0.10–0.087	9–12

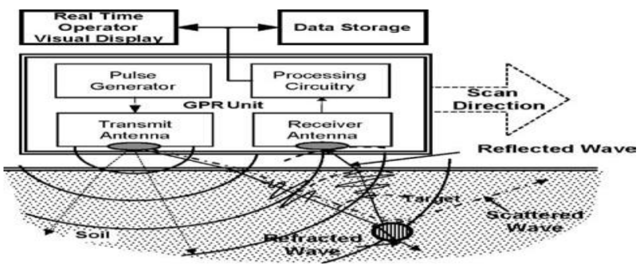

Fig. 1: Diffraction mechanism and schematic of UWB impulse GPR unit [3].

Establishment such as the Department of Survey and Mapping Malaysia is responsible for providing all substructure utility drawing and mapping guidelines to the relevant industries. Regarding to these guidelines, there are four levels of quality for utility data i.e. A, B, C and D, which may be obtained by different methods such as geophysics, trenchless technology, traditional drawing and on-site investigation or survey (Fig. 2). The accurateness and reliability of the utility data decrease from Quality Level A to D [4].

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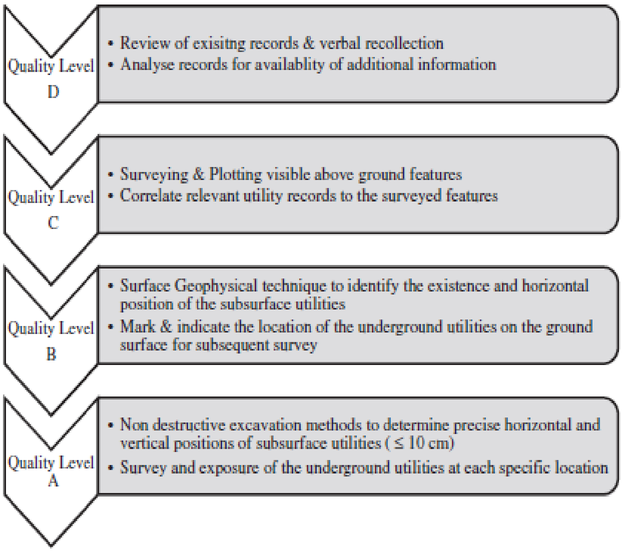

Fig. 2: Quality level of utility data [5]

II. METHODOLOGY

In view to decrease the number of failures in excavations work due to high damaged caused onto subsurface infrastructure, this study emphasis on underground utility detection which aim to spot, label and produce a drawing of detected buried utility by using GPR method. Fig. 3 depicts the process of determining the underground utilities.

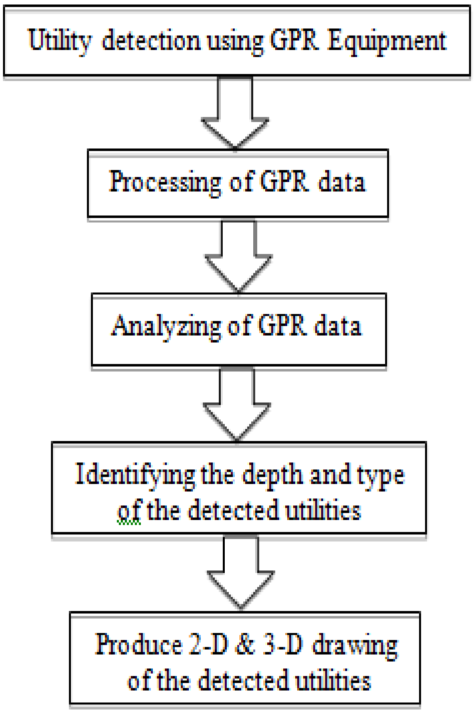

Fig. 3: Process of determining underground utilities

In this study, TerraSIRch SIR-3000 GPR equipment have been used for data acquisition on two sites i.e. site 1 (estimated area of 54 m^2) and site 2 (estimated area of 12 m^2) (Fig. 4 & Fig. 5) at Unipark Suria in Kajang on the west coast of Peninsular Malaysia. The process of measuring the selected area is by marking a 2 m x 2 m grid lines on site (Fig. 6) so that accurate data can be produced of the detected utility.

Fig. 4: Plan view of study area at Unipark Suria [6].

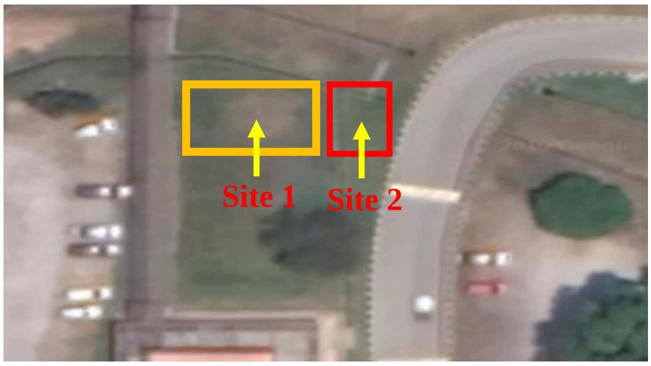

Fig. 5: Close view of site 1 and site 2 at Unipark Suria [6].

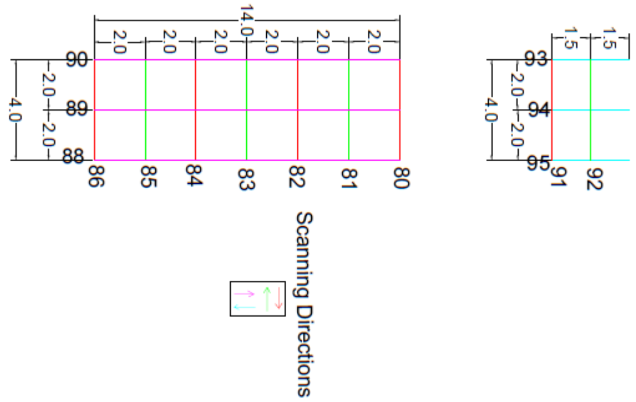

Fig. 6: Grid lines of 2m x 2 m of the study area (site 1 and site 2).

III. RESULTS AND DISCUSSION

The general approach that is used to analyze data is based on the flowing criteria:

a. The good formation of hyperbolic shape of detected utility.
b. The diameter variation of detected utility indicates which type of utility it may be.
c. The sharpness and clarity of produced hyperbolic shape.
d. The softness and clarity of under the produced hyperbolic shape, which prove the electromagnetic wave of GPR been reflected due to solid object detection.
e. Depth standard of underground utility typically buried.
f. Categorizing the processed data into two group high probability and low probability detected utility based on previous criteria.

RADAN 7 GPR data processing software is used to analyze the recorded data.

The GPR data is processed using time zero correction and background removal.

Fig. 7 shows the formation of hyperbola of the detected utility for Site 1, while Fig. 8 depicts the formation of hyperbola of the detected utility for Site 2. Fig. 9 depicts the detected manhole for Site 2.

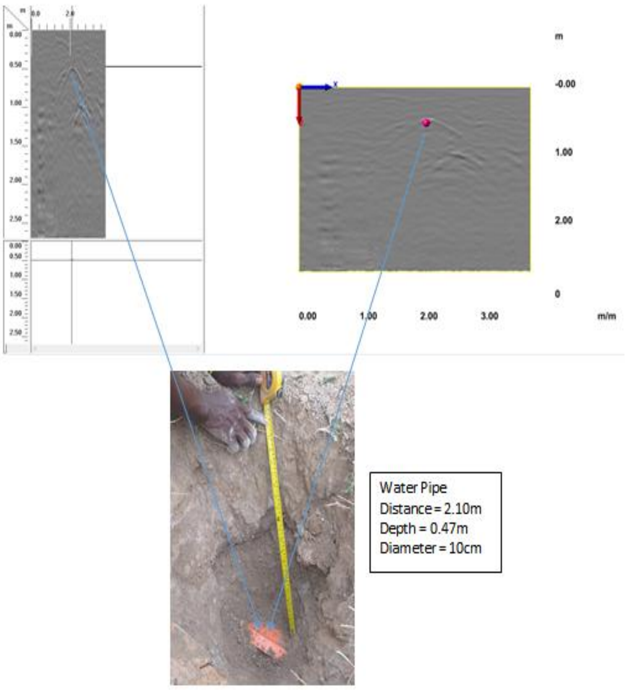

Fig. 7: GPR imaging shows the formation of hyperbola of the detected utility for Site 1

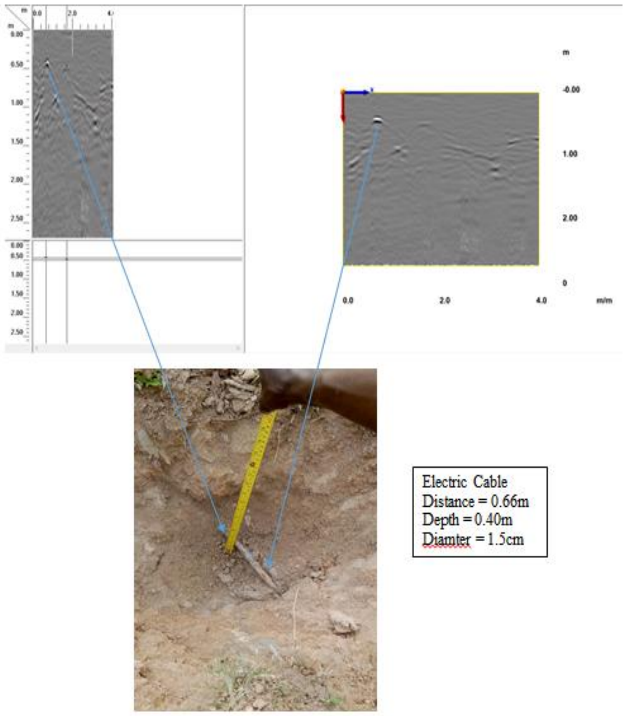

Fig. 8: GPR imaging shows the formation of hyperbola of the detected utility for Site 2

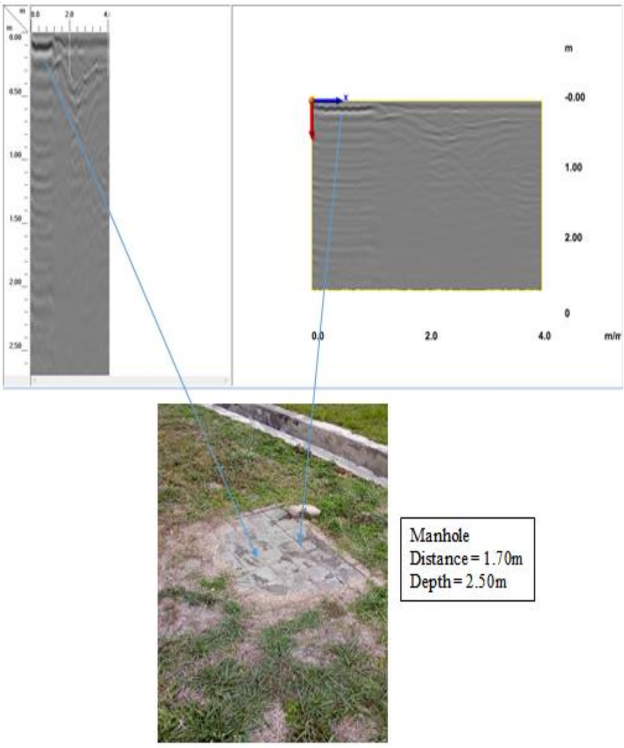

Fig. 9: GPR imaging shows the Manhole for Site 2

As can be noticed from the produced drawing in Fig. 10 for Site 1, there are two separate disconnected water pipe utility, which can be interpreted as no longer in service or discontinued.

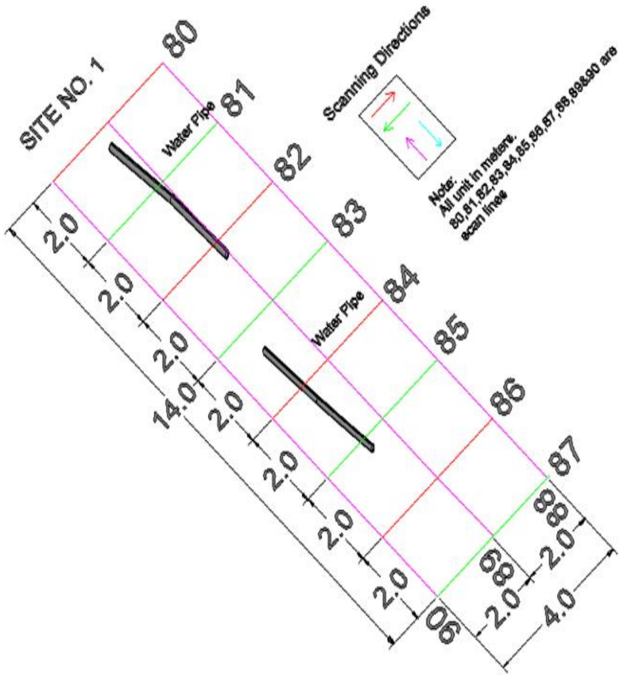

Fig. 10: Shows the detected utility for site 1.

Fig. 11 & 12 show the successive number of GPR profiles through perpendicular-to-pipe scanning method and along-to-pipe scanning method for Site 1.

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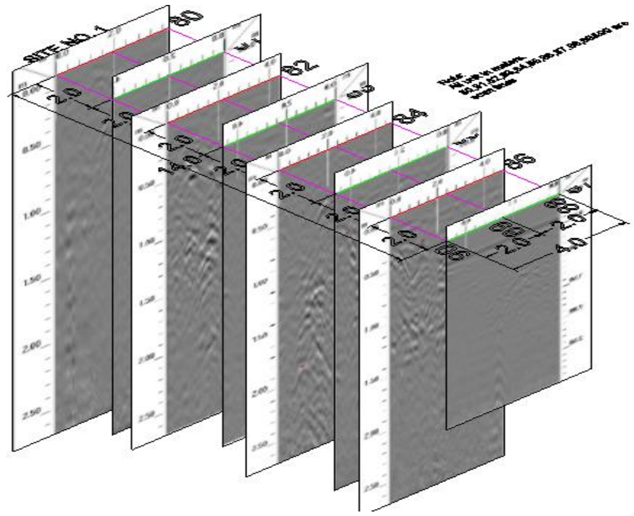

Fig. 11: Shows a successive number of GPR profiles through perpendicular-to-pipe scanning method for site 1.

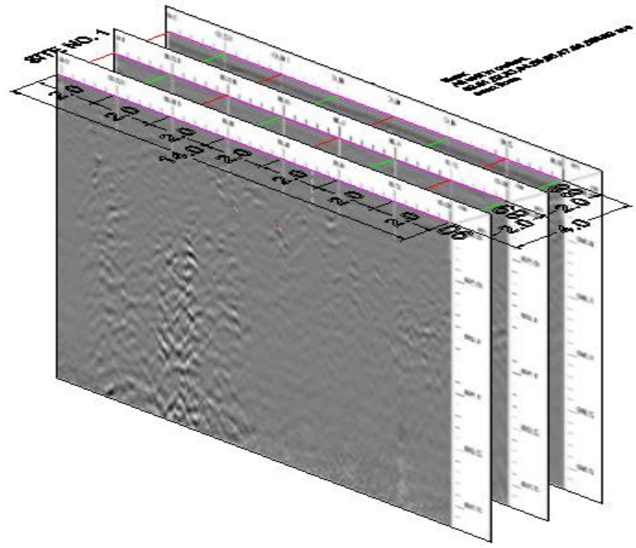

Fig. 12: Shows a successive number of GPR profiles through along-to-pipe scanning method for site 1.

As can be noticed from the produced drawing in Fig. 13 for Site 2, there is water pipe utility, manhole, and electricity cable detected. This shows a combination of utilities, which is a good example of depth variety, which each utility is placed in different depth to avoid utility clashing.

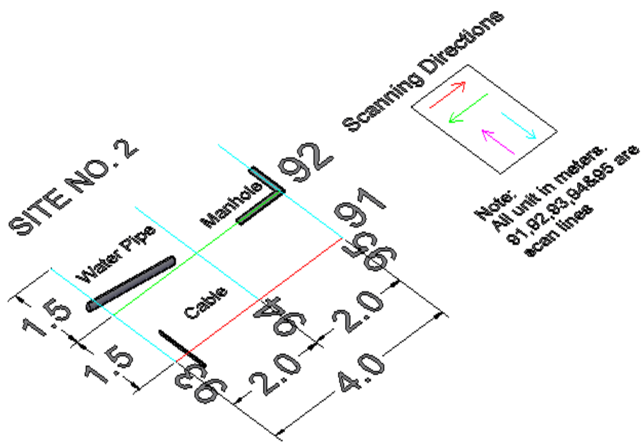

Fig. 13: Shows the detected utility for site 2.

Fig. 14 & 15 show the successive number of GPR profiles through perpendicular-to-pipe scanning method and along-to-pipe scanning method for Site 2.

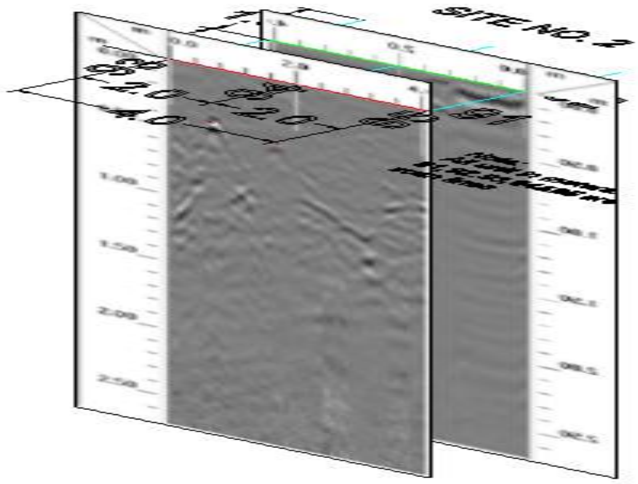

Fig. 14: Shows a successive number of GPR profiles through perpendicular-to-pipe scanning method for site 2.

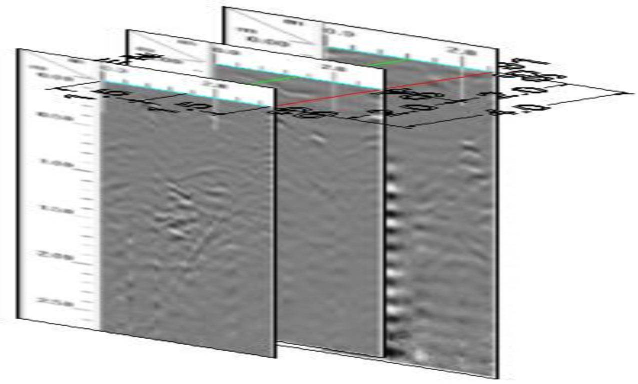

Fig. 15: Shows a successive number of GPR profiles through along-to-pipe scanning method for site 2.

IV. CONCLUSION

It can be concluded that TerraSIRch SIR-3000 GPR equipment with a 400 MHz shielded antenna is capable of detecting underground utilities. The technique used is efficient and nondestructive for locating underground utilities in construction sites. It is advisable to perform underground utility detection before carrying-out any excavation works in order to avoid damage to the utilities which can be costly to be fixed. A damaged water pipe and electric cable can caused the community around the area to be without water and electricity for a period of time.

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REFERENCES

1. L. Desai, G. Jjadhav, V. Shinde and S. Patil, "Underground Utility Survey", *Imperial Journal of Interdisciplinary Research (IJIR)*, vol. 2, Issue 6, 2016.
2. M. Metwaly, "Measurement", *Elsevier*, 60, 2015, pp. 139–145
3. J. Lester and L.E. Bernold, "Automation in Construction", *Elsevier*, 2007, pp. 546–555
4. W. Wai-Lok Lai, X. Derobert and P. Annan, NDT and E International, *Elsevier*, vol. 96, 2018, pp. 58–78
5. S.W. Jaw, and M. Hashim, "Tunnelling and Underground Space Technology", *Elsevier*, 2013, pp. 35, 20–29
6. Google map. (2020, 7 January). Available: *www.googlemap.com*

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