KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI

NUKLEAR MALAYSIA

'Teknologi Nuklear Pemacu Wawasan Negara'
'Nuclear Technology Propels The Nation Vision'

UNDERGROUND UTILITY INSPECTION USING GROUND PENETRATING RADAR (GPR)

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OUTLINE

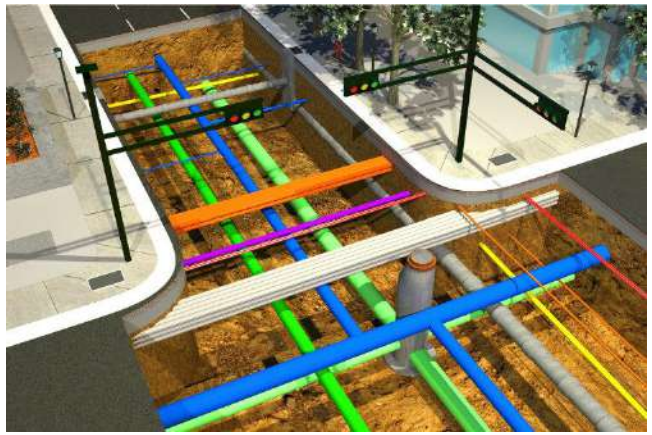
- INTRODUCTION
- GROUND PENETRATING RADAR
- APPLICATION
- UNDERGROUND UTILITY INSPECTION
- CONCLUSION

UNDERGROUND UTILITY INSPECTION

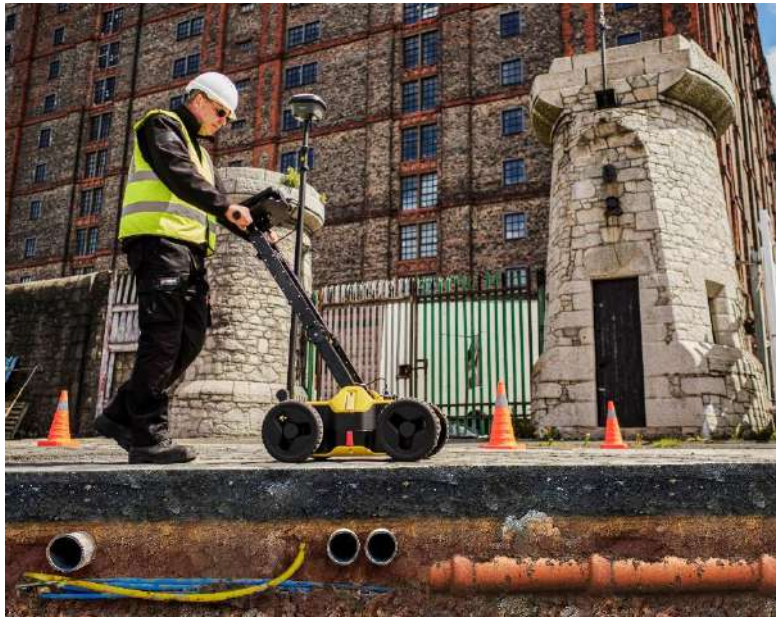
- process of locating, mapping and managing underground utilities and infrastructure

- It involves using various techniques and technologies to identify the location, type, and condition of subsurface utilities, such as water pipelines, gas lines, electric cables, telecommunications networks, and sewage systems

INTRODUCTION



WHY WE NEED TO INSPECT UNDERGROUND UTILITY



SAFETY

potential hazards such as gas leaks, live electrical wires, and unstable ground conditions

PREVENTING DAMAGE

helps locate and map existing underground utilities before any construction or excavation work

COST SAVING

prevent costly delays and unexpected expenses

INTRODUCTION

ELECTROMAGNETIC LOCATORS (EML)

GROUND PENETRATING RADAR (GPR)

WHAT EQUIPMENT IS USED

VACUUM EXCAVATORS

SONAR AND CCTV INSPECTION SYSTEMS

GLOBAL POSITIONING SYSTEM (GPS) RECEIVERS

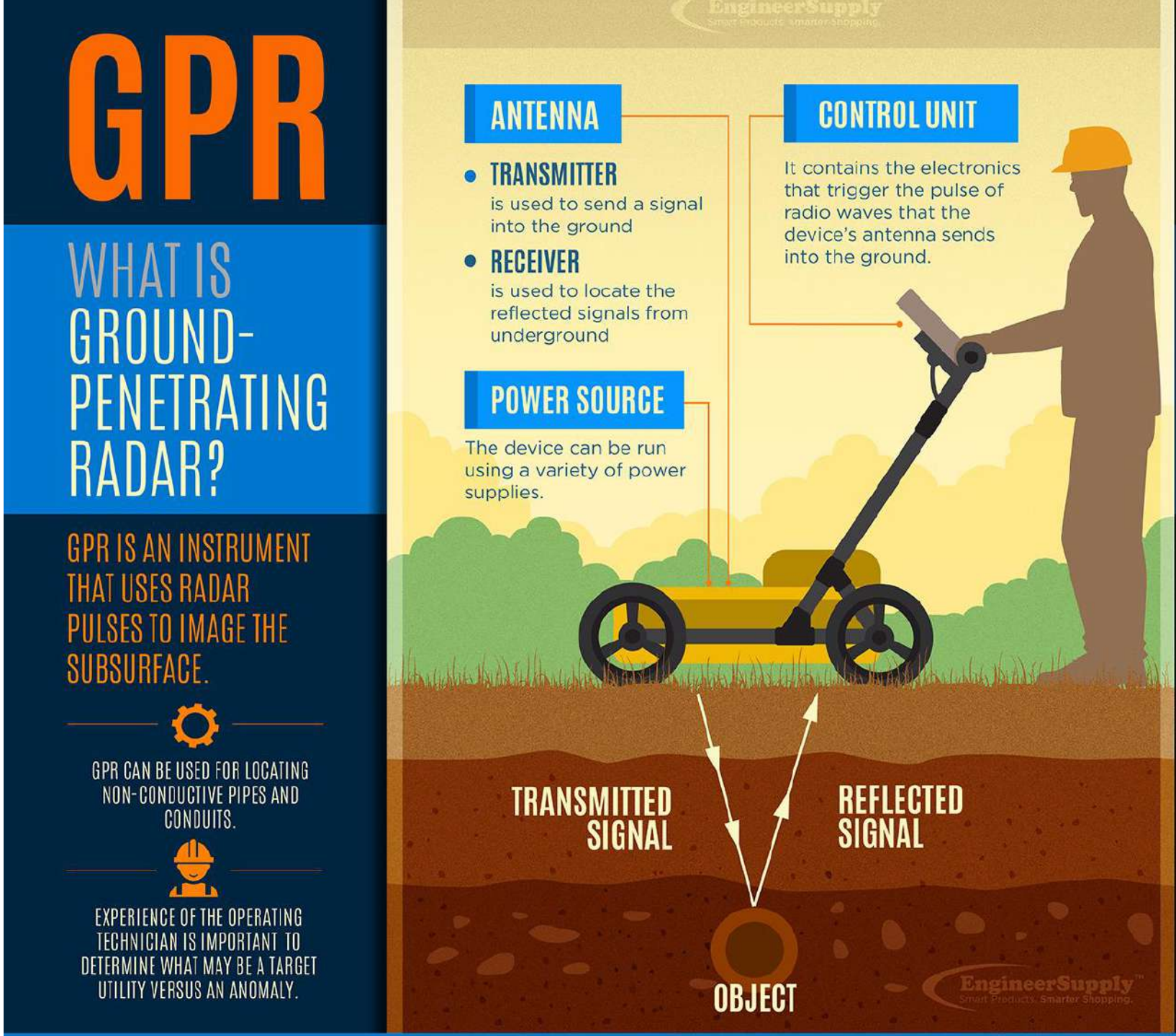
SURVEYING EQUIPMENT

➢Non Destructive Testing (NDT) : Evaluate structure without causing damage

WHAT is GPR ?

- Ground Penetrating Radar (GPR) is a geophysical imaging technique that uses electromagnetic waves to visualize and detect objects and structures beneath the ground's surface.
- It's a non-destructive method that provides insights into the subsurface without the need for excavation.

OVERVIEW FOR GPR



WHERE use GPR?

- ARCHAEOLOGY
- CIVIL ENGINEERING AND CONSTRUCTION
- GEOLOGY AND ENVIRONMENTAL STUDIES
- UTILITY LOCATING
- FORENSICS
- ROAD AND PAVEMENT INSPECTION
- MINING AND QUARRYING
- GLACIOLOGY
- ENVIROMENTAL MONITORING
- CONCRETE INSPECTION

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Type of frequency in GPR

- HIGH- 0.5 GHz - 3 GHz
- MEDIUM- 100MHz - 500MHz
- LOW- 25MHz - 100MHz
- ULTRALOW- LESS THAN 25MHz
- MULTI

EXAMPLE

Target Size

All things being equal, antenna choice determines how deeply you are able to penetrate and the minimum size of the targets that you are able to see. Lower frequency antennas see deep, but the minimum target size that they can see is larger. Rather than focus on what each antenna can see, the table below lists the appropriate antenna by application and depth range.

Frequency	Sample Applications	Typical Max Depth Feet (meters)	Typical Range (ns)
2.6 GHz	Structural Concrete, Roadways, Bridge Decks	1 (0.3)	10
1.6 GHz	Structural Concrete, Roadways, Bridge Decks	1.5 (0.5)	10-15
900 MHz	Concrete, Shallow Soils, Archaeology	3 (1)	10-20
400 MHz	Shallow Geology, Utility, Environmental, Archaeology	9 (3)	20-100
200 MHz	Geology, Environmental	25 (8)	70-300
100 MHz	Geology, Environmental	60 (20)	300-500

Antennas by Application

ADVANTAGES OF GPR

- NDT
- VERSATILITY
- REAL-TIME DATA
- DEPTH PENETRATION
- RESOLUTION
- RAPID DATA COLLECTION
- MINIMAL SITE DISRUPTION
- MAPPING SUBSURFACES FEATURES

SCANNING AREA FOR UNDERGROUND UTILITY INSPECTION

*** Focus target: mild steel pipe**

Evaluation and verification facilities (EVF)

EQUIPMENT

Ground penetrating radar (GPR)

An electromagnetic (EM) energy signals that penetrates through subsurface

GPR GSSI with 400MHz antenna shielded

SIR 4000 for GPR acquisition system

Extract data by using RADAN 7 Software

SIR 4000 display

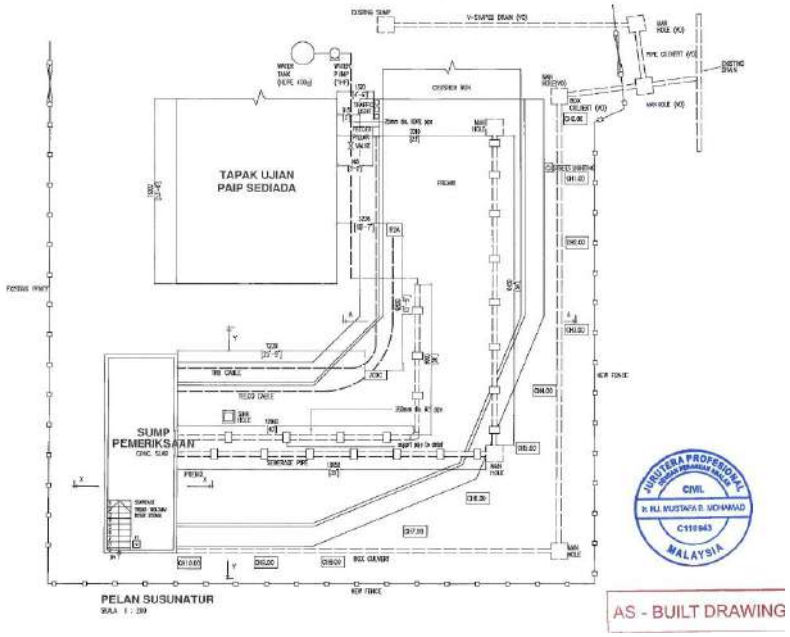
- **GPR also known as georadar is a non-destructive and non-invasive geophysical technique for rapidly imaging the shallow subsurface structure and producing high resolution 2-D graphical sections in real time.**

400 MHz antenna is used since the objective is to focus on the deeper depth as low frequency will travel in long distance and able to create deeper images on radargram which will be recorded on SIR4000 storage system.

METHODOLOGY

The experiment was done by:

- Comparing 3D view data of the GPR with as-built drawing
- Comparing the reference depth of MS pipe with the GPR depth



METHODOLOGY

MS PIPE SCAN

1ST PHASE

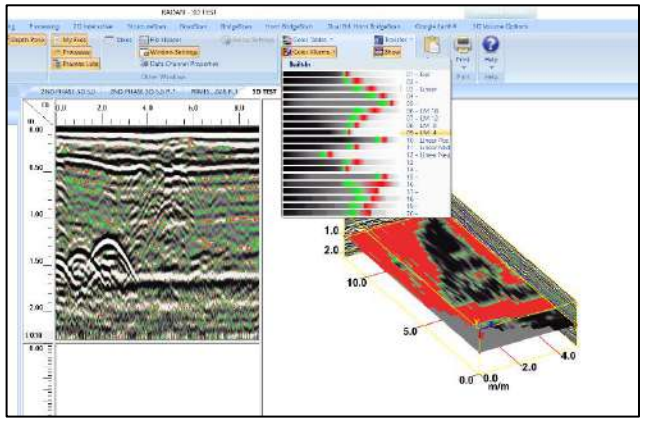
2ND PHASE

STUDY THE ACTUAL DEPTH OF MS PIPE FOR REFERENCE (1.15M)

COLLECT DATA PER ROW AND COLUMN (X/Y) USING GPR 400MHz

TRANSFER DATA TO RADAN 7 FOR ANALYSIS & 3D FILE ASSEMBLY

THE VALIDATION OF THE DATA



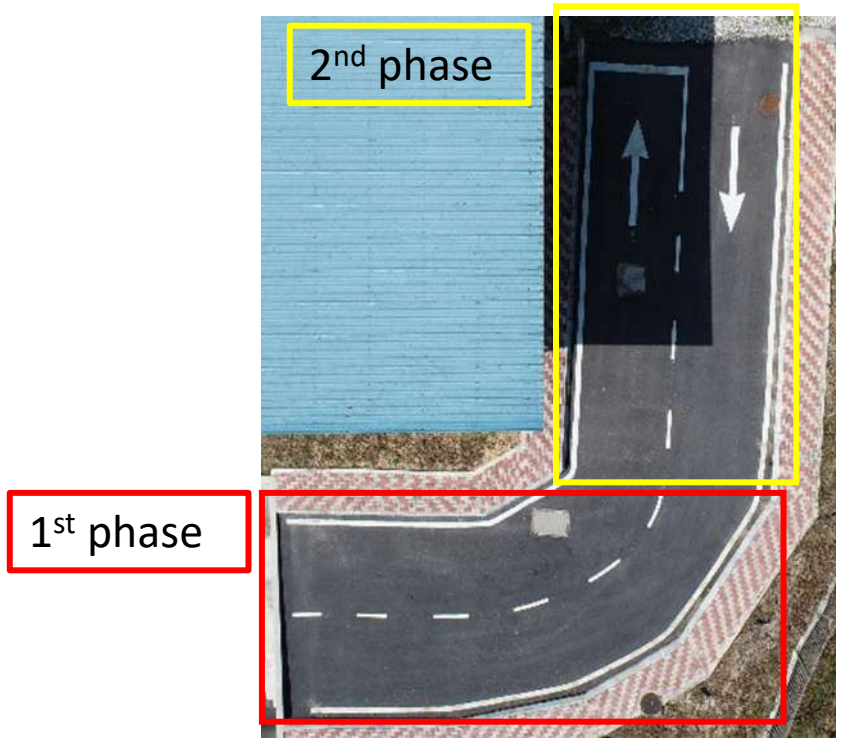
MS is the mild steel pipe located 1.15m below the ground of EVF in the Malaysia Nuclear Agency

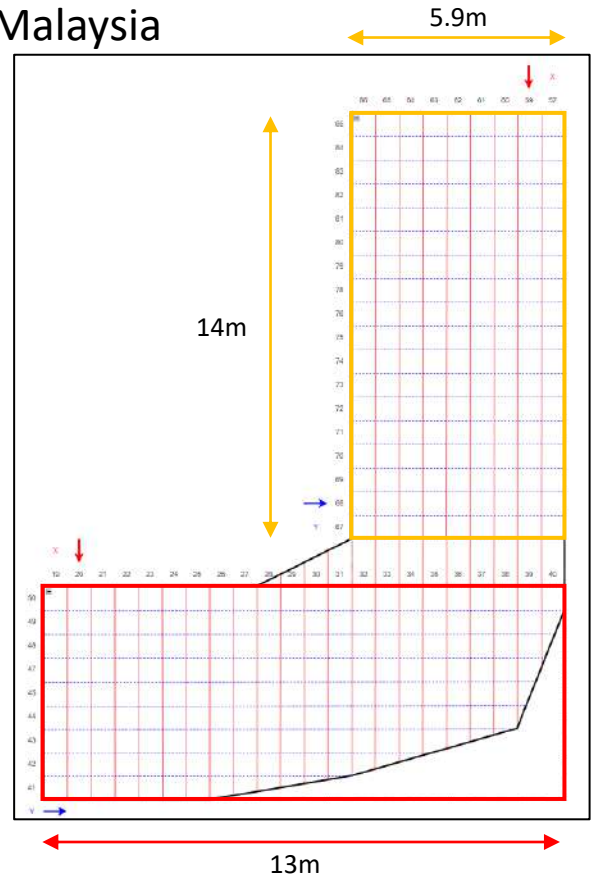
EVF = Evaluation Verification Facility

Nuklear Malaysia

SCANNING LOCATION

- Blok 60, Evaluation Verification Facility (EVF) Agensi Nuklear Malaysia





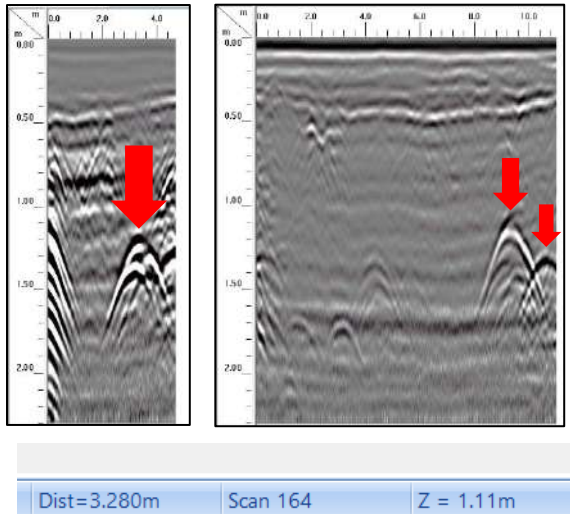
2nd phase
X-axis (vertical)
Y-axis (horizontal)

1st phase
X-axis (vertical)
Y-axis (horizontal)

- 22 profiles for the X-axis and 9 profiles for the Y-axis (1st phase)
- 9 profiles for the X-axis and 18 profiles for Y-axis (2nd phase)
- Collect profiles used to assemble into 3D files to assist data analysis in RADAN 7 software.

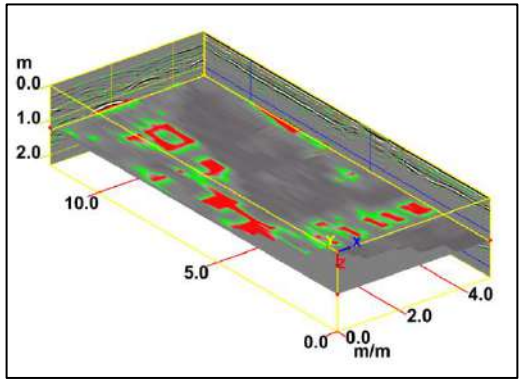
DATA COLLECTION

Interpret data from GPR radargram



Assemble File into 3D file

The collected profile assemble into 3D file to get better view



Adjust range and gain to control the output display

Adjust data in RADAN 7 using the range gain command. Select smart mode and how many channels to be divided on radargram

Applied same setting to obtain the desired outcome

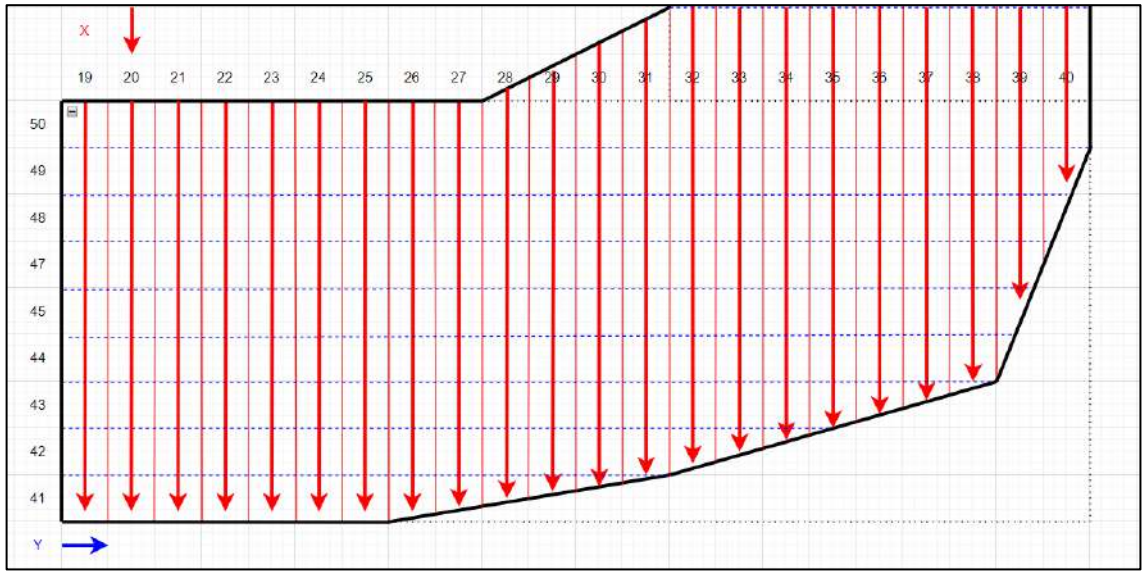
Use the same setting method as before for 3D file so that we can get the output detection based on desired depth that we need

1st phase

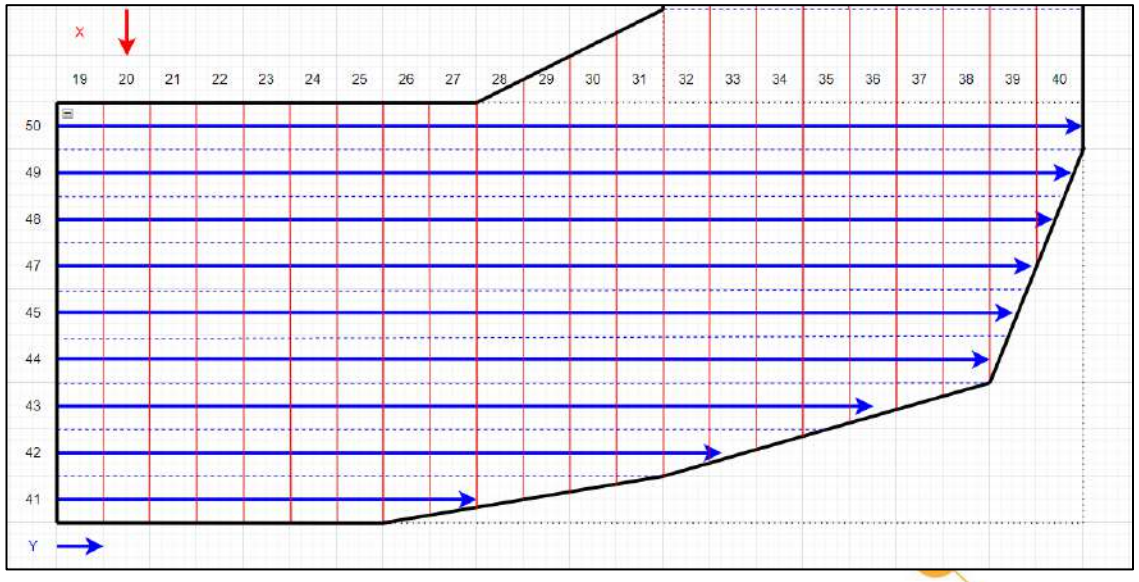
- The GPR will be rolled on each line profile

Experimental Setup

a) Vertical scan for X-axis



b) Horizontal scan for Y-axis



- (19-40) for X-axis lines profile
- (41-50) null 46 for Y-axis lines profile

These 3D files were obtained from the combination of radargrams in the X and Y directions. Every radargram has the detail of the image below the surface. From that, using radargram can observe the potential area that has the underground utility that has been desired for inspection. Below are several examples of the radargram:

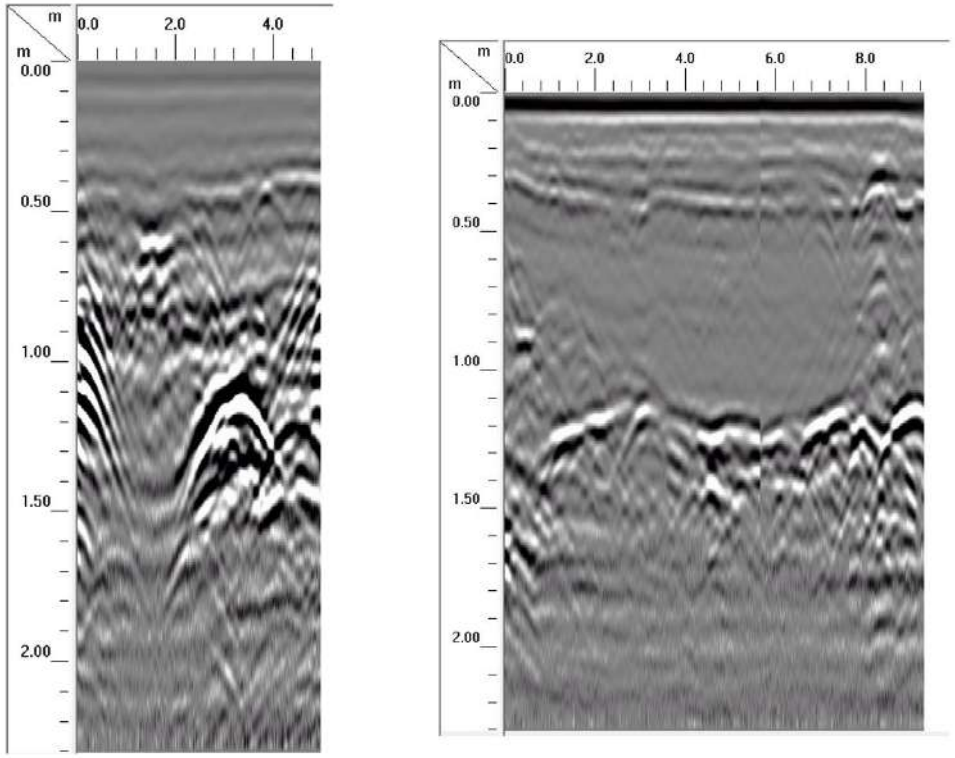


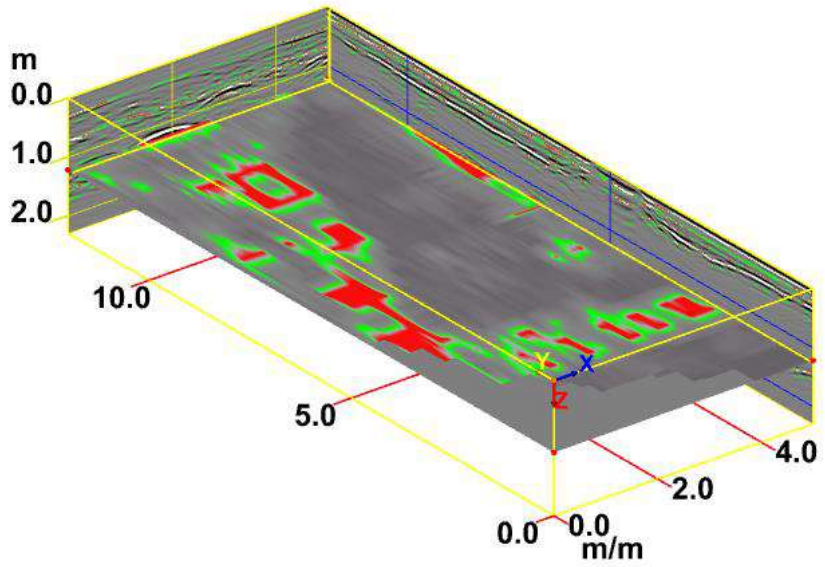
Figure 10

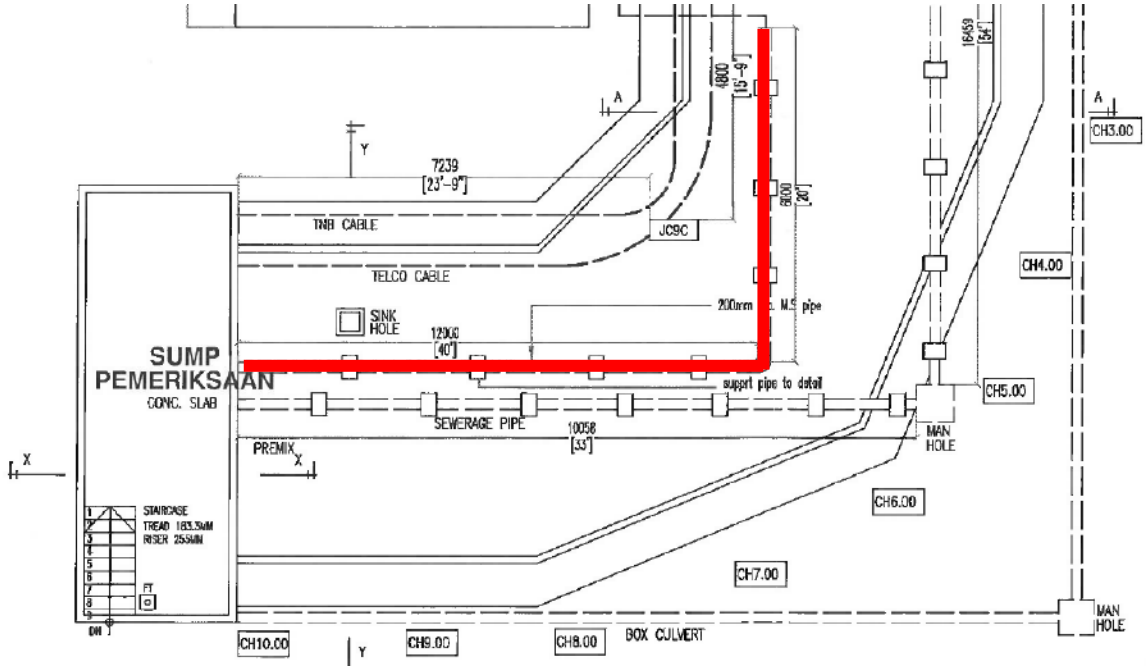
Figure 13: (a) Radargram for X direction 1st phase (b) radargram for Y direction 1st phase

Results and Findings

3D view 1st phase

depth detection 1.09m below the ground
for profile number 19 (x-axis) with distance 10 m





- The red-marked are the area that indicates the MS pipe based on the as-built drawing from the contractor.
- The MS pipe pattern in L-shape same as the drawing.

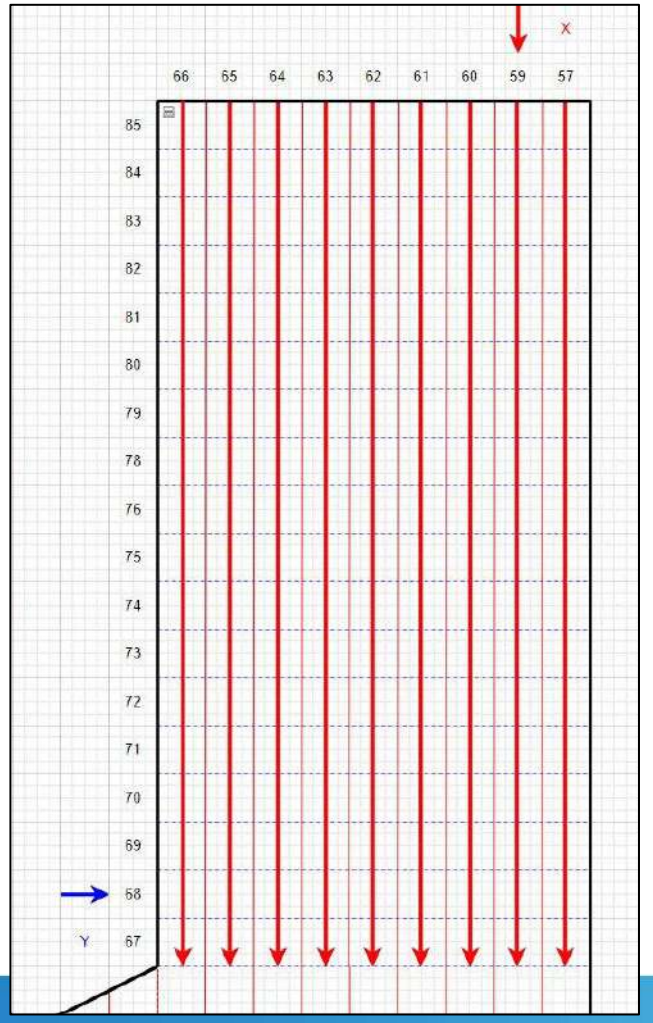
2nd phase

Experimental Setup

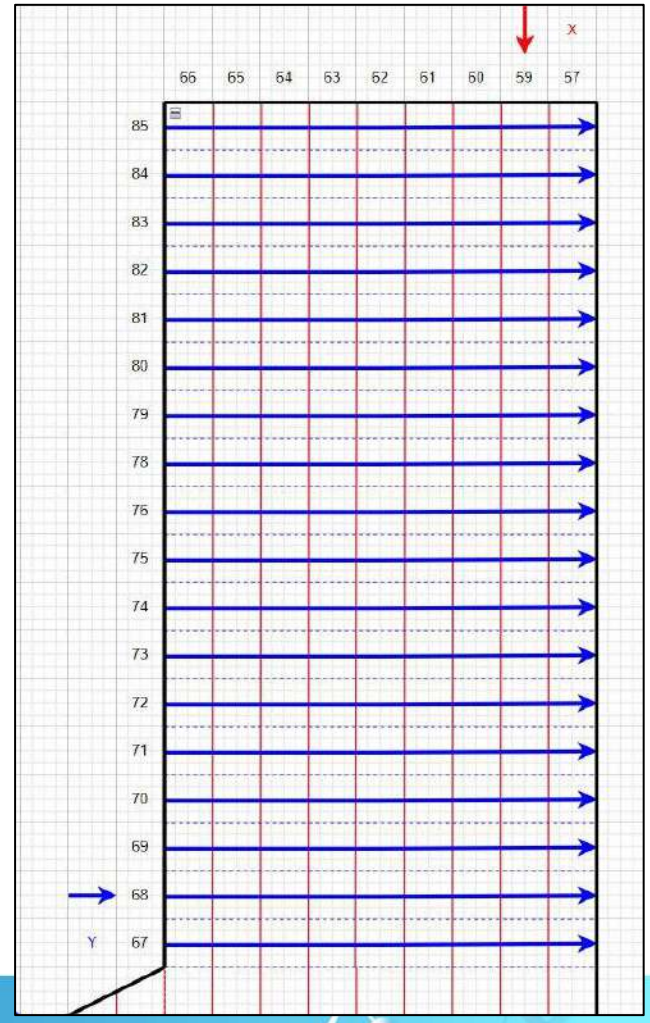
- The GPR will be rolled on each line profile

➢ (57-66) null 58 for X-axis lines profile
➢ (67-85) null 77 for Y-axis lines profile

a) Vertical scan for X-axis



b) Horizontal scan for Y-axis



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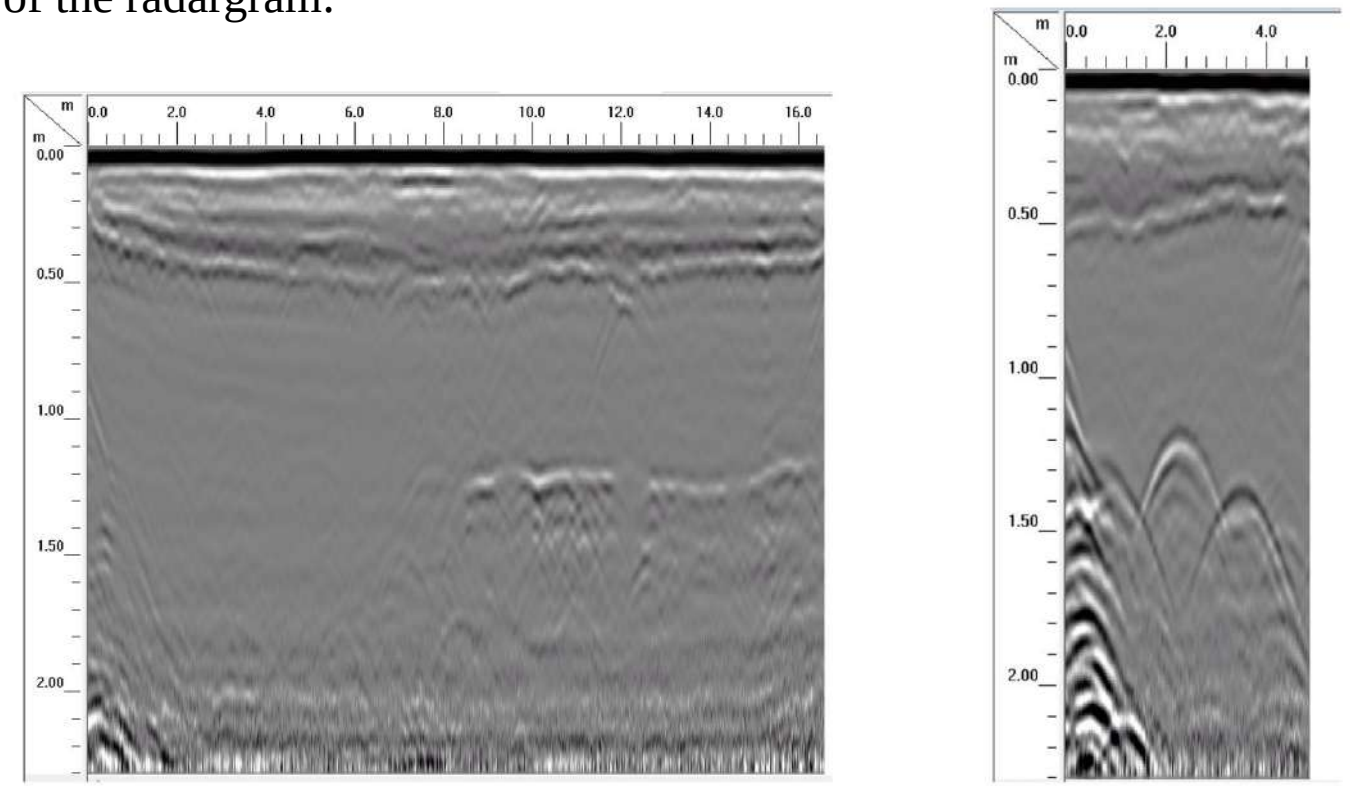
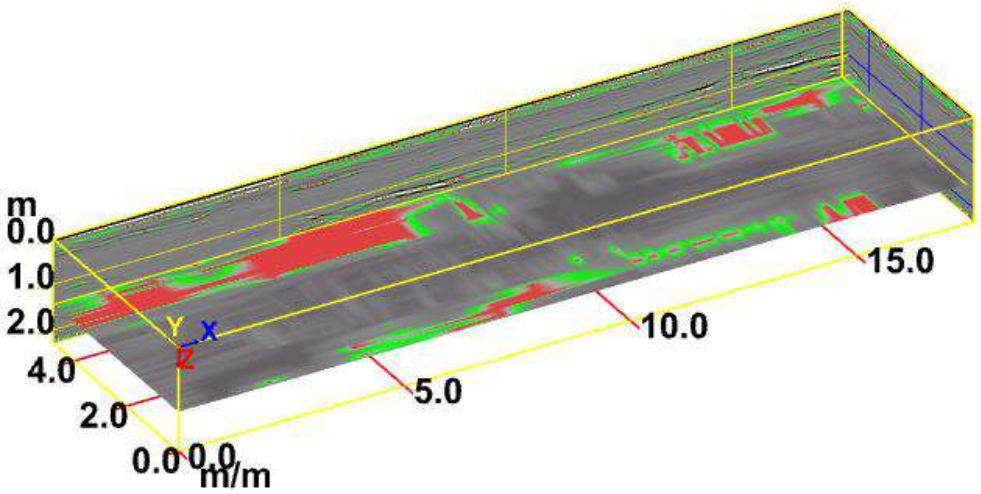


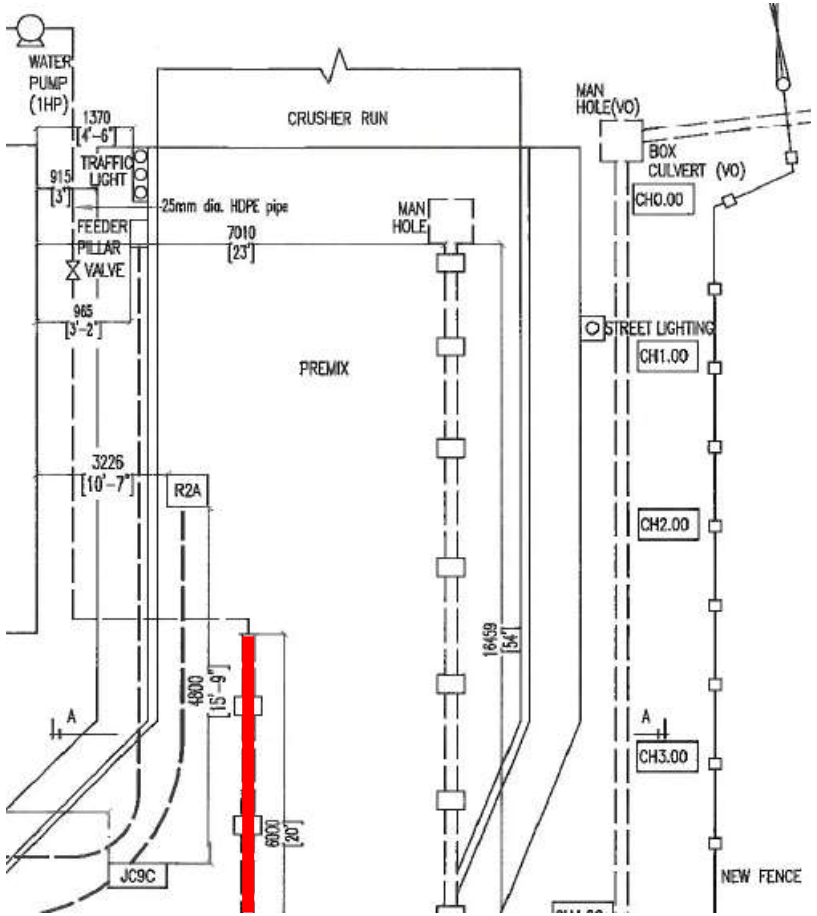
Figure 13: (a) Radargram for X direction 2nd phase (b) radargram for Y direction 2nd phase

Results and Findings

3D view 2nd phase

depth detection 1.16m below the ground for profile number 68 (Y-axis) with distance 8 m





- The red-marked are the area that indicates the MS pipe based on the as-built drawing from the contractor.

Discussion

The data was obtained from radargram by using SIR4000 and then was processed by Radan 7 software. 31 radargram was obtained for phase 1 and 27 radargram was obtained for phase 2. From the radargram, the average depth was obtained for mild steel pipe. The average depth from the radargram is 1.10m with a tolerance of ±0.07m. Compared with the reference depth of 1.15m, we get the accuracy using GPR is 1.10/1.15 x 100% = 95.65%. For comparison, the 3D file from Radan 7 software shows the pattern of mild steel pipe below the ground.

Conclusion

1. GPR can be used to inspect the underground utility
2. Overall, GPR is an excellent device to obtain the data in 3D view
3. The accuracy and reliability of the GPR method can be compared with the EML method for better reference

THANK YOU

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