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GEOSPATIAL WORLD FORUM
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HSC
Pipeline Engineering Pte Ltd

DRIVING CHANGES IN SINGAPORE USING GROUND PENETRATING RADAR (GPR) FOR SUBSURFACE DETECTION AND MAPPING

HSC
Pipeline Engineering Pte Ltd

INTRODUCTION

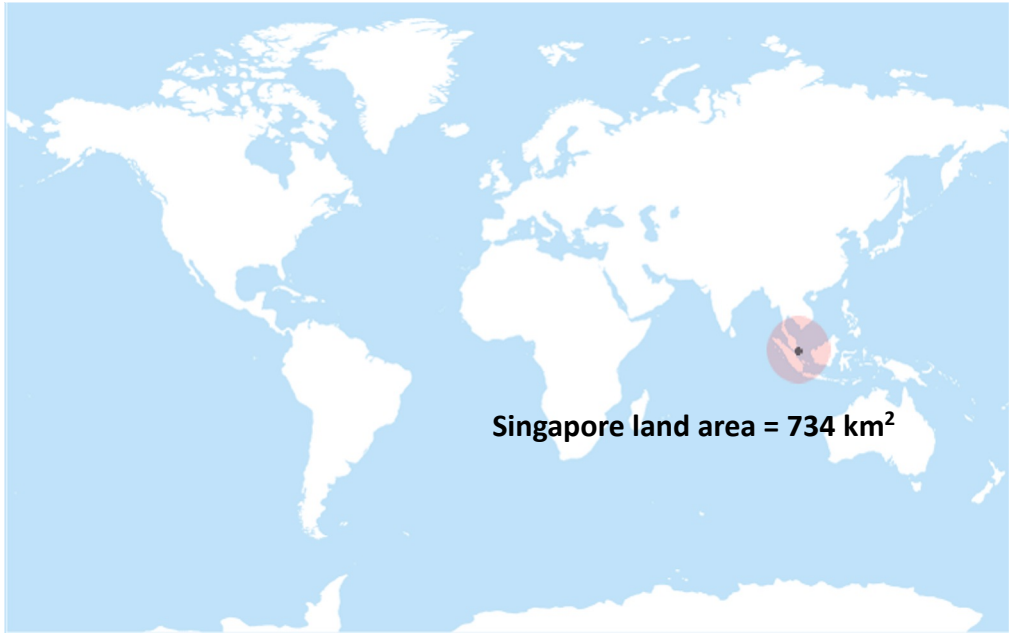
- Incorporated in 1993 as a construction company, focusing on utility pipeline works in Singapore with over 400 employees

- Full Range of Pipeline Installations:
  - High Pressure Transmission Gas Main Pipelines
  - Gas Distribution Pipelines
  - Gas Off-Take Station
  - Water Distribution, Industrial Water, NEWater Pipelines and Pump House
  - Telecommunications Cables
  - Power Cables
  - Chilled Water Reticulation

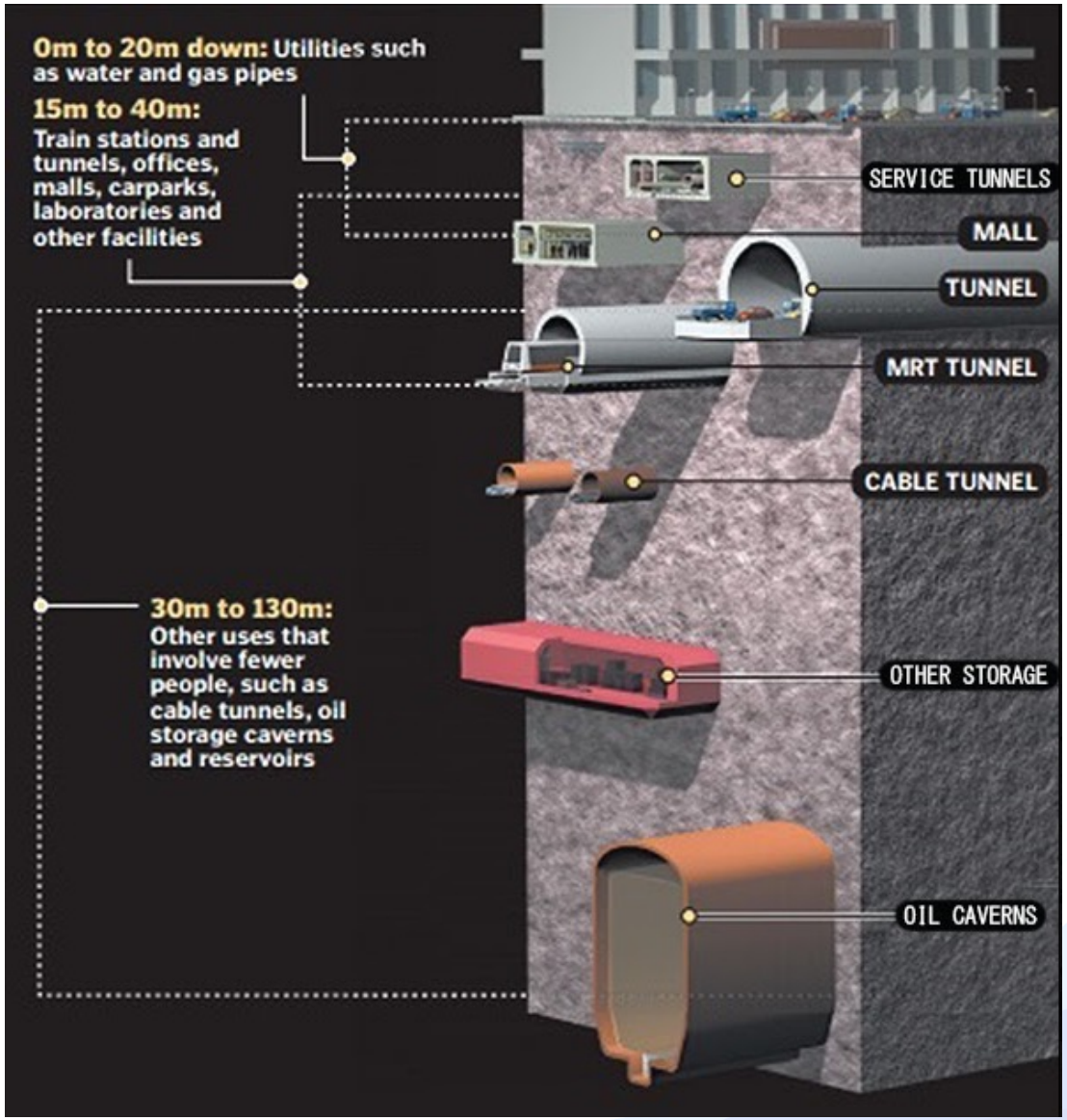
Leader in driving changes with the adaptation of:

- **Subsurface Utility Mapping (SUM)**
- **Ground Penetrating Radar (GPR) / Geolocated 3D Scanning / Building Information Modeling (BIM)**

THE CHALLENGE OF SPACE



- Congested space usage, even in underground
- “Surprises” when digging will cause unnecessary stoppages to project
- Striking existing utilities will cause disruptions to daily life



INFRASTRUCTURE DEVELOPMENT

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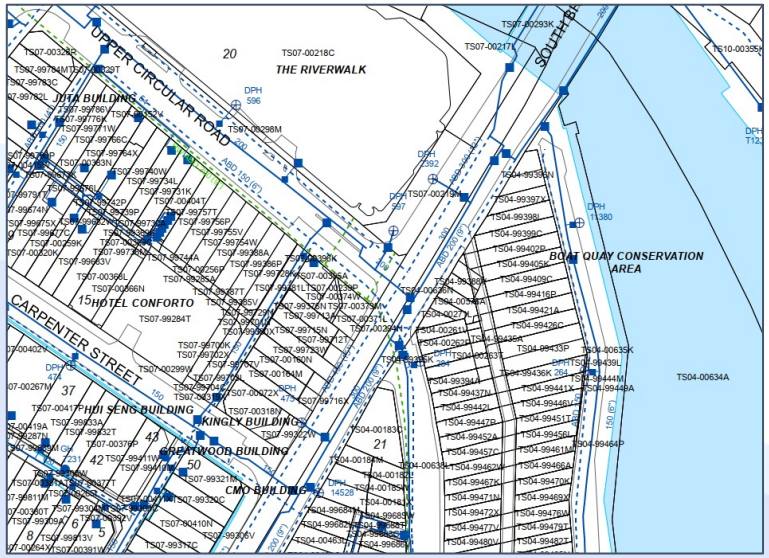
Plenty of digging in Singapore…

PROBLEM STATEMENT

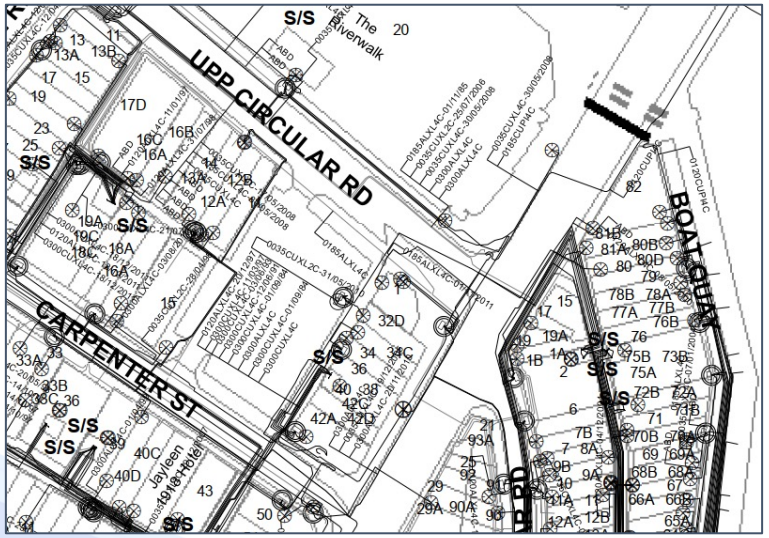
- **Poor accuracy** of subsurface utility as-built and alignment drawings. The common issues are:
  - *Differences in position and depth of the utility found at site as compared to as-built drawings*
  - *Utility found at site not shown in as-built*
  - *Unable to find utility at site shown in as-built*
- Numerous trial hole works required to locate and map subsurface utilities for feasibility study during the design phase
- Inaccurate mapping of utilities may result in the following during civil works:
  - *Design change*
  - *Restart of approval process*
  - *Additional utilities diversion*
  - *Change orders / Variation orders / Extension of time*
  - *Delay in project completion*
  - *Affect stakeholders*
- In the worse case, the civil works need to be **aborted** and possibly leading to **commercial disputes**

AS-BUILT DRAWINGS

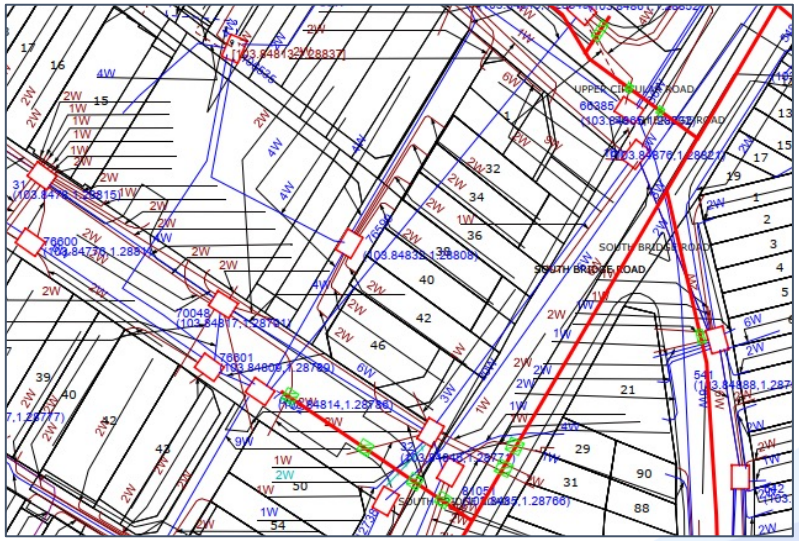
- Individual sheets of drawings from different utility assets owners
- Non Geographic Information System (GIS) and has no geo-referencing in PDFs
- Indicative of utilities in the proposed work zone
- Non-centralised drawings of the existing utilities
- Deviates from site condition



PUB Water Service Plan

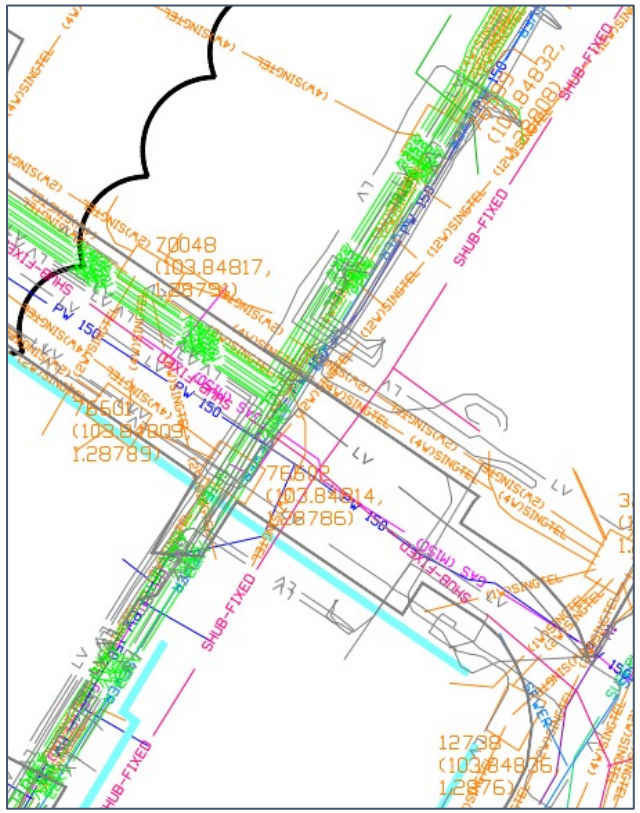


SPPG Electrical LV Cable Plan



Singtel Plan

TRIAL TRENCHES



Massive Resources !

THE COST OF NOT KNOWING

THE STRAITS TIMES SINGAPORE

‘Wild wild wet’: Broken pipe in Orchard Road spews water metres high, PUB investigating

APR 12, 2024

- Accurate information is key
  - Mapping the subsurface is more critical than ever
- Making the map is hard

OUR APPROACH

SUBSURFACE UTILITY MAPPING (SUM)

- In the current practice, massive trial holes contracts are called, executed and trial hole data are collated for feasibility study of the Civil Works. The trial hole contracts are fact-finding, site investigation method to map the subsurface utilities.

- Subsurface Utility Mapping (SUM) can be done using non-destructive Geophysical methods like Electro-Magnetic Locator (EML) and Multi-Channel Ground Penetrating Radar (MCGPR).

- With the combination of datasets from these methods, Geo-located Utilities Drawings (GUD) can be produced without conducting trial holes.

- Project owner / Consultant are able to check feasibilities of the proposed civil works, conduct *targeted trial holes* as a *fact-confirmation* exercise instead of a massive quantity of trial holes done as a fact-finding exercise and thus, greatly reducing the overall quantity of trial holes required.

- This will cut down the design, site investigation and construction time significantly.

MULTI-CHANNEL GPR (MCGPR)

- Fast and massive mapping on the roads

StreamUp from IDS GeoRadar

Data	Measure
Footprint width	160 cm
Footprint length	62 cm
200 MHz VV • Number of channels • Spacing between channels • Scan step	 19 8,3 cm (average) ~8 cm
600 MHz HH • number of channels • Spacing between channels • Scan step	 10 16,7 cm (average) ~4 cm
Maximum time-range	180 ns
Max number of samples	512
Maximum radar speed	~150 km/h (w/o stacking)

MULTI-CHANNEL GPR (MCGPR)

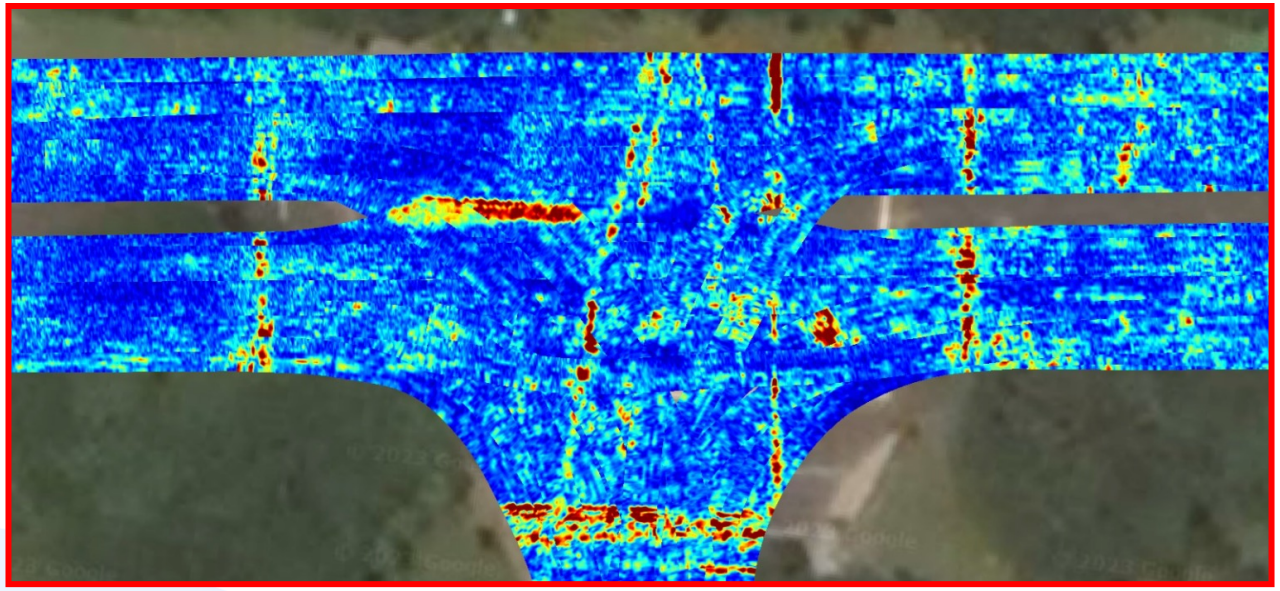
- Fast and massive mapping on walkways

Stream DP from IDS GeoRadar

TECHNICAL SPECIFICATIONS	
Sensor Frequency	200 MHz - 1000 MHz
Weight	42Kg
Stream DP System Size	116X82 cm
Scan Width	82.5cm
Number of channels	30 (19VV-11HH)
VV channels spacing	4.3cm
HH channels spacing	7.5cm
Power Consumption	Acquisition:19W; Stand-by:15W
Max Operating Time	8H (can be extended by hot swap capability)
Environmental	IP65
Max Acquisition Speed	14km/h (8.7 mph)
Positioning	Integrated Encoder and PPS; external GPS and TPS
Certification	EC FCC IC
Recommended Laptop	Panasonic FZ-G2
Temperature range	-20°C – 50°C
Scan Step Resolution	4 cm

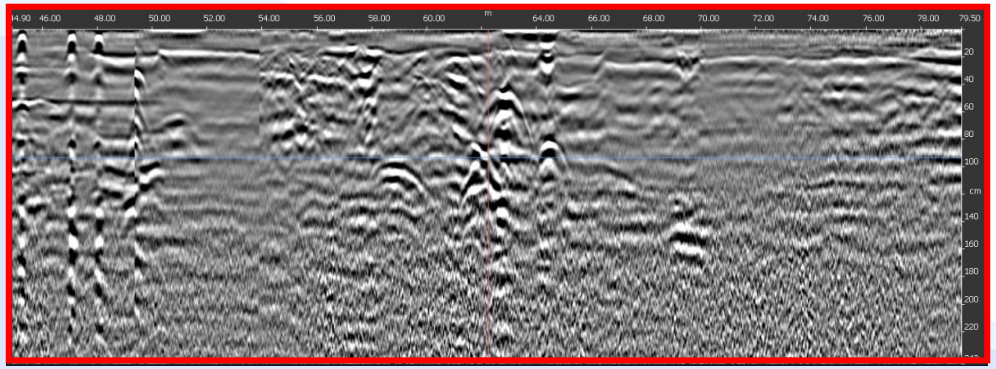
PROCESSING SOFTWARE - IQMAPS

Pioneer Road / Benoi Road Junction



C-scans (Depth slices):

Top-down view of the subsurface, showing the reflections at a constant depth level across the entire survey area. It is a horizontal slice of the subsurface, and it provides information about the distribution of subsurface features at a particular depth. C-scans also use grayscale or color to represent the strength of reflections.

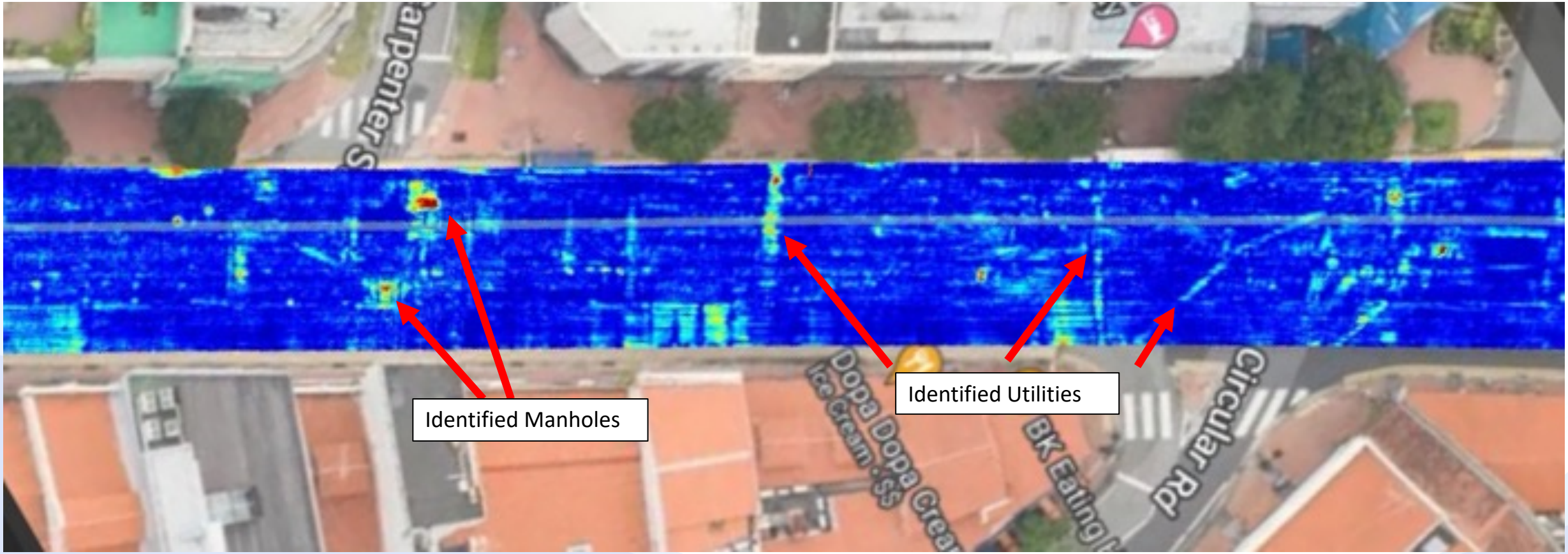


B-scans (Time-slice images):

Cross-sectional view of the subsurface at a specific depth. In a B-scan, the vertical axis represents the time (or depth) of the reflection, and the horizontal axis represents the distance along the survey line. The amplitude of the reflections is usually displayed using grayscale or color to indicate the strength of the reflections at different points in the subsurface.

ALIGNMENT AND WIDTH

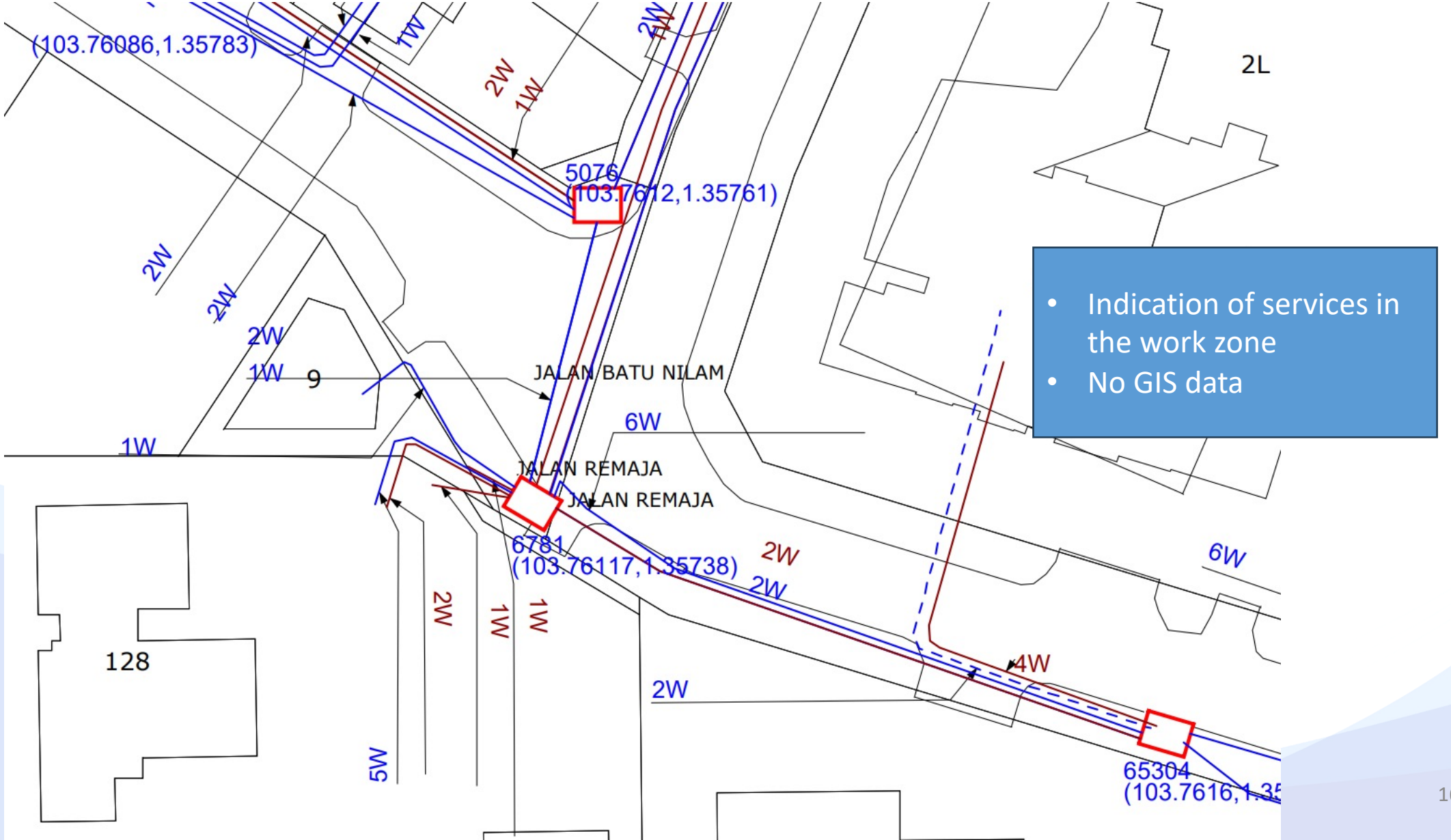
Heat Map - Tracking by depth



DRIVING CHANGES – UTILITIES DETECTION WITH MCGPR

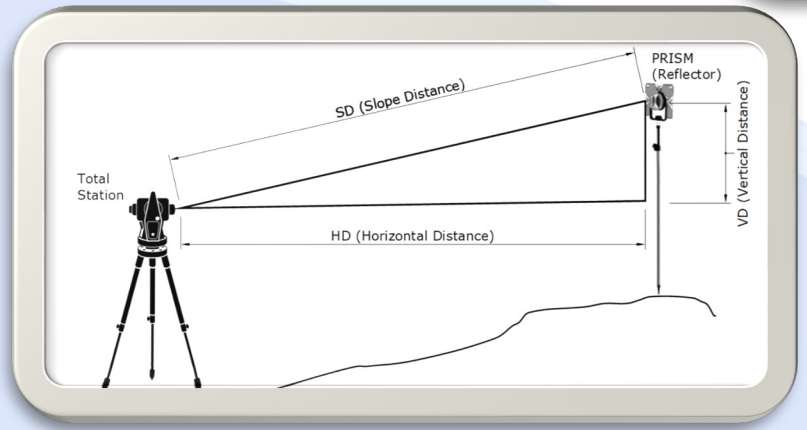
Case Study - Singapore, Jalan Remaja

TELECOM PLAN

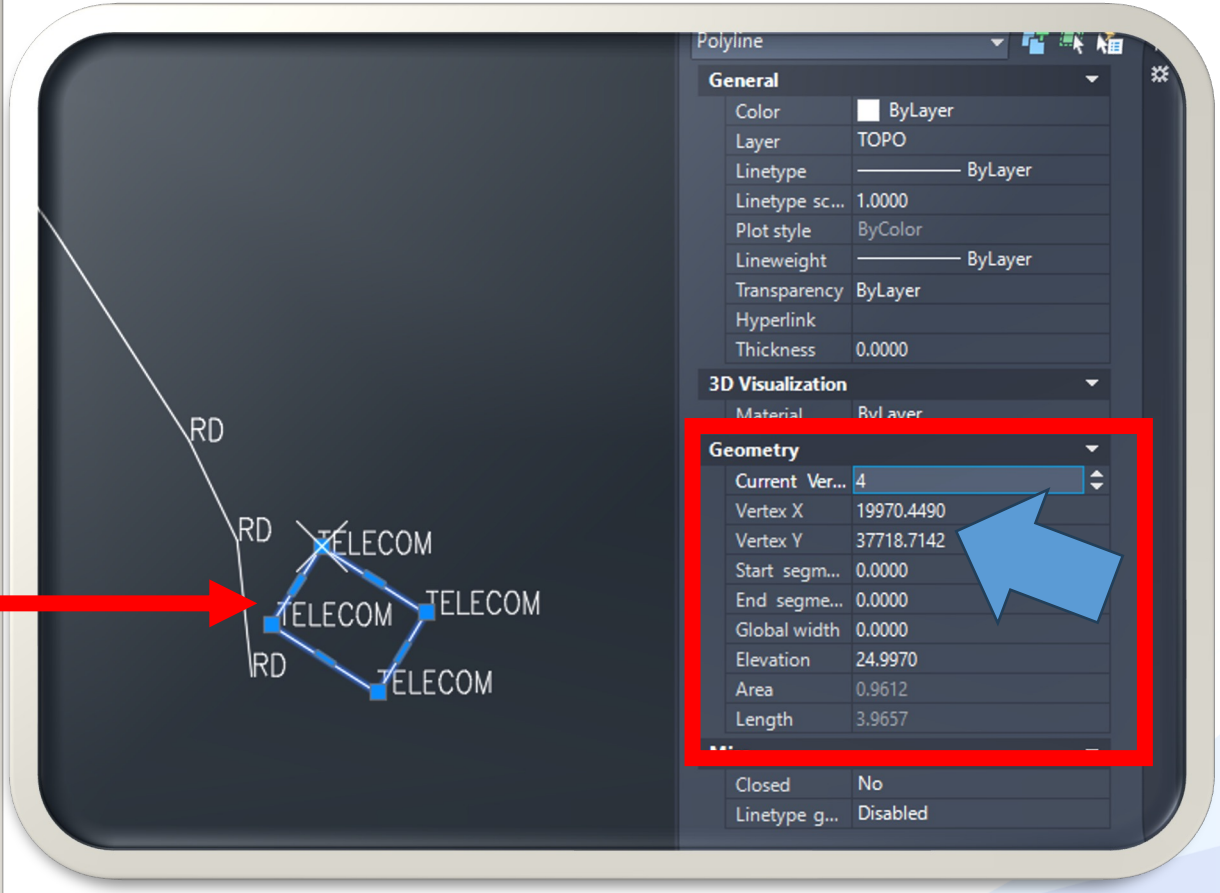


- Indication of services in the work zone
- No GIS data

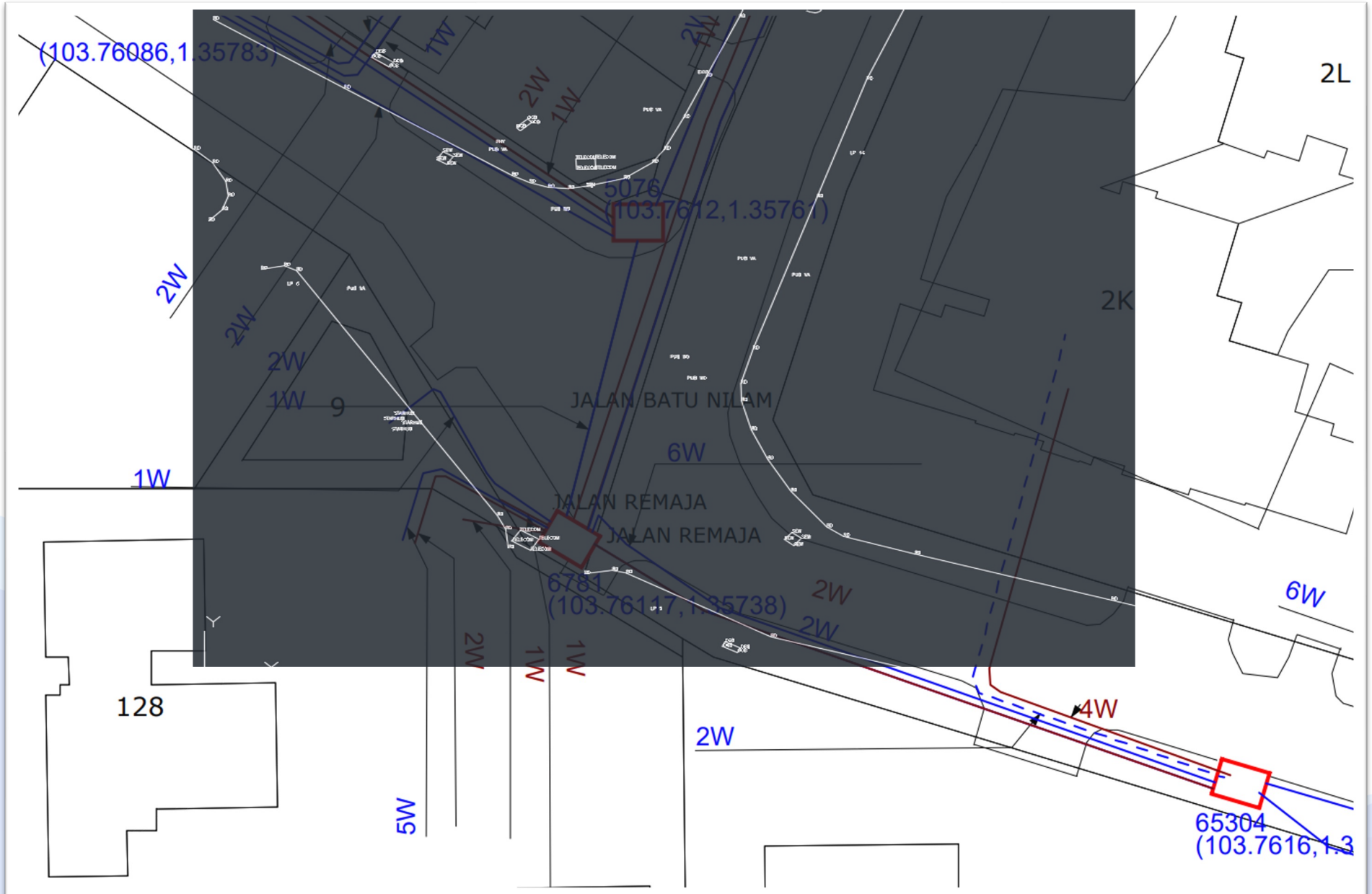
TOPOGRAPHICAL SURVEY



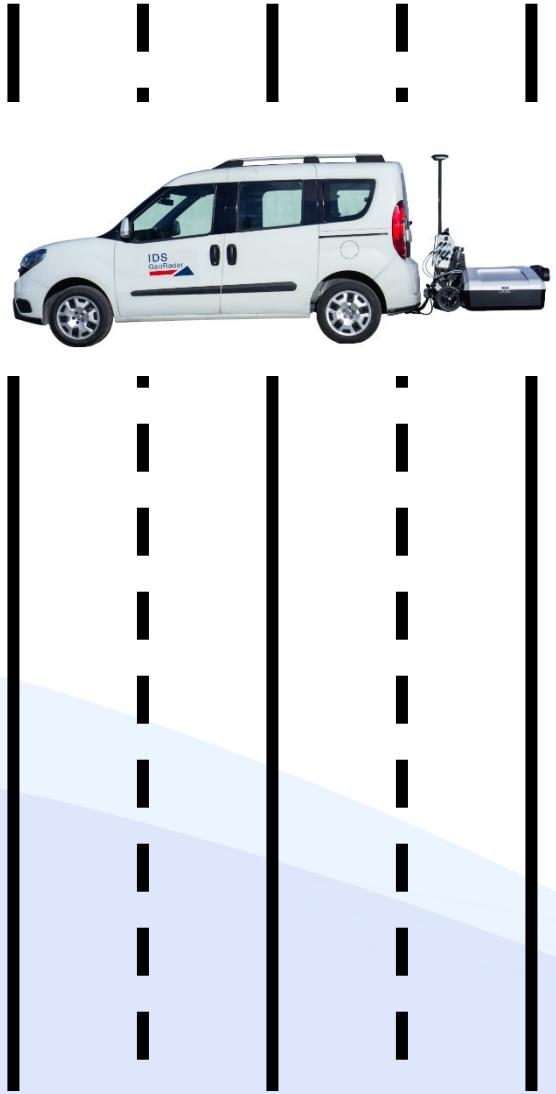
TOPOGRAPHICAL SURVEY RESULTS

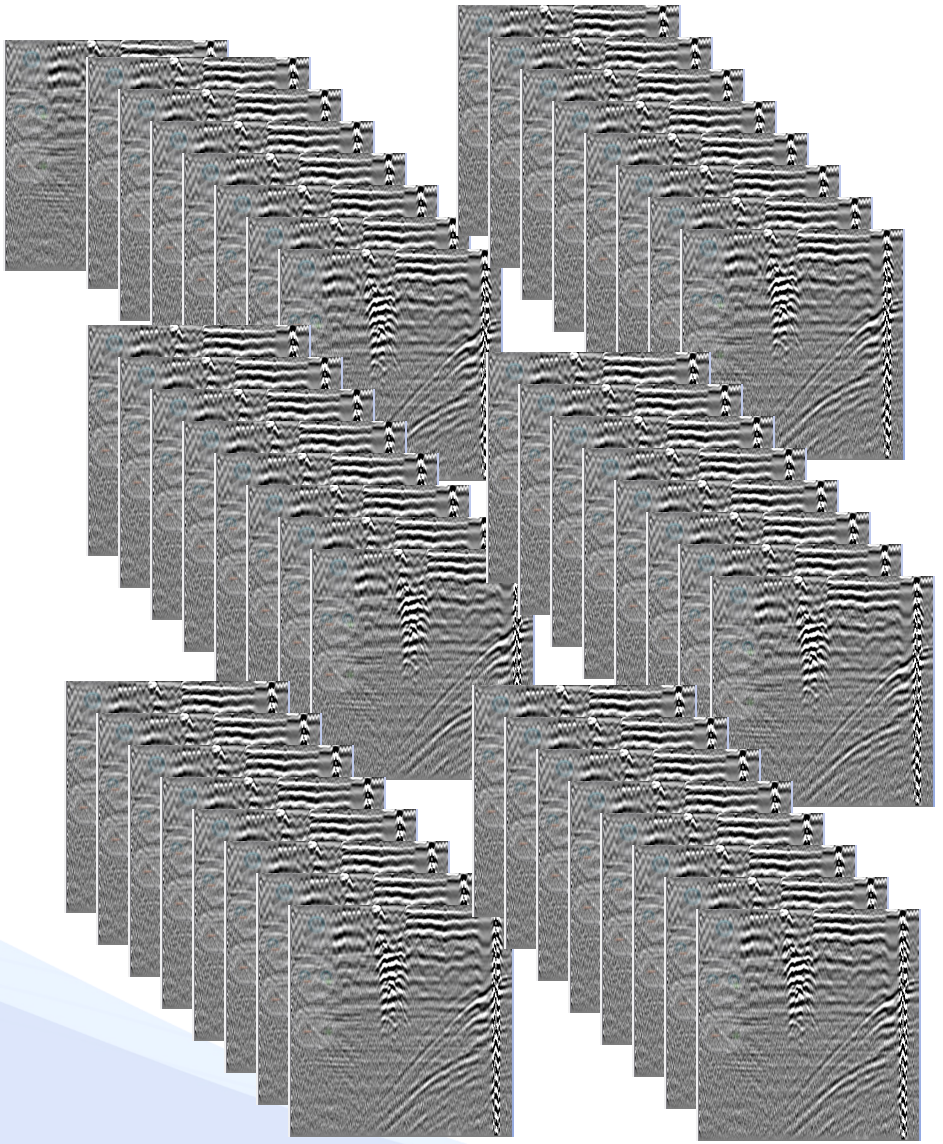


PLANT MAPS VS TOPO SURVEY

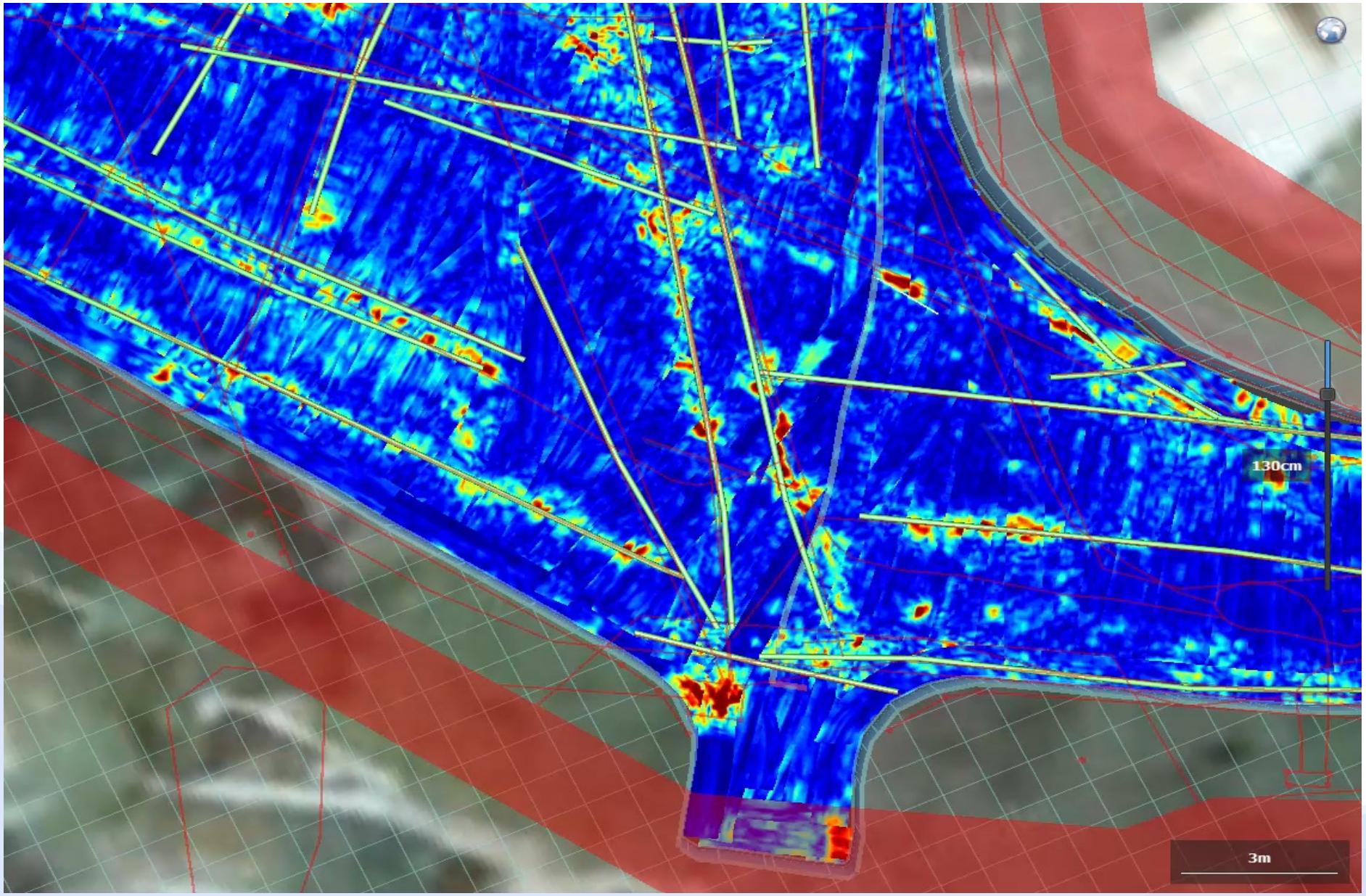


MCGPR

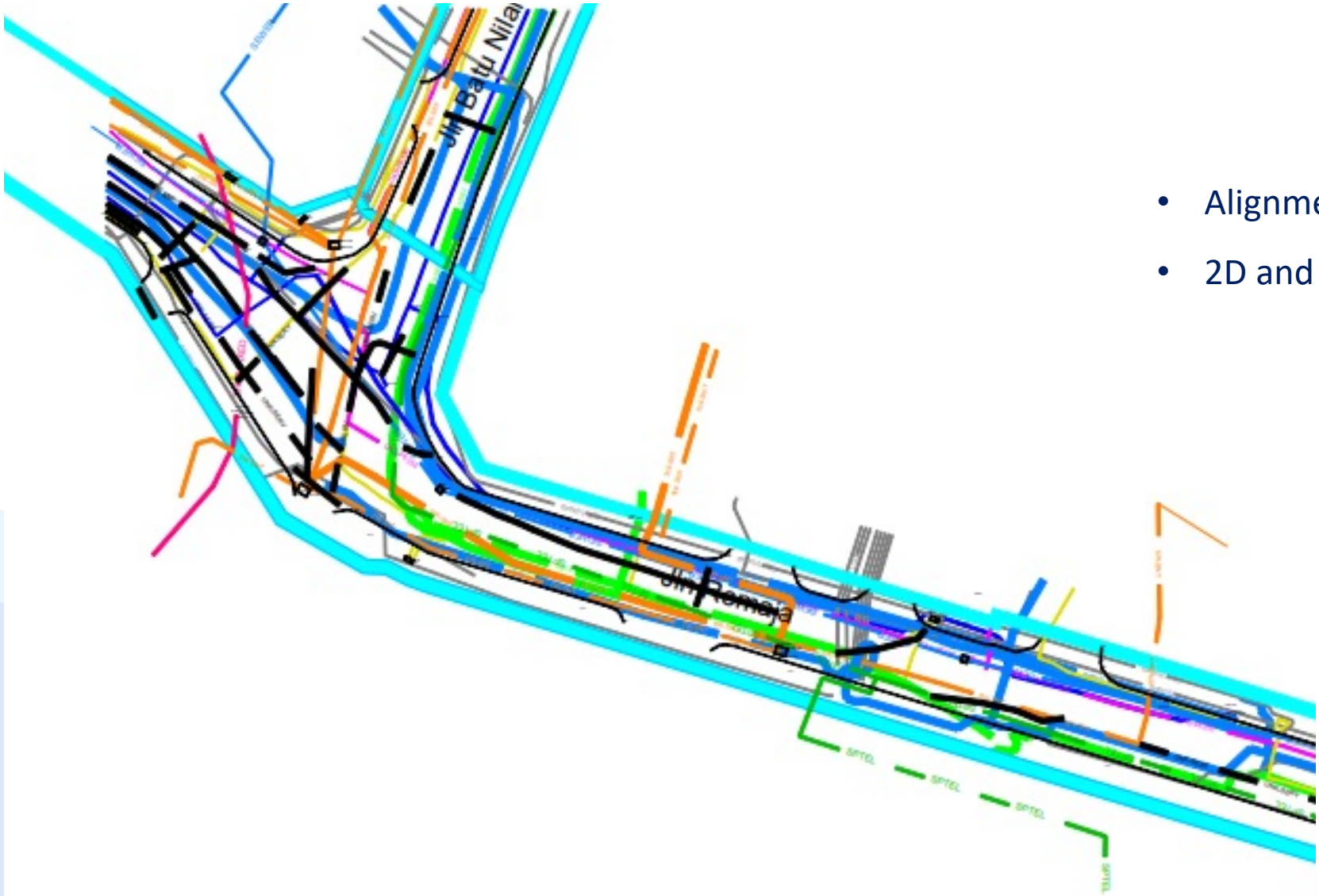




MCGPR (RESULTS)



GEO-LOCATED UTILITY DRAWING



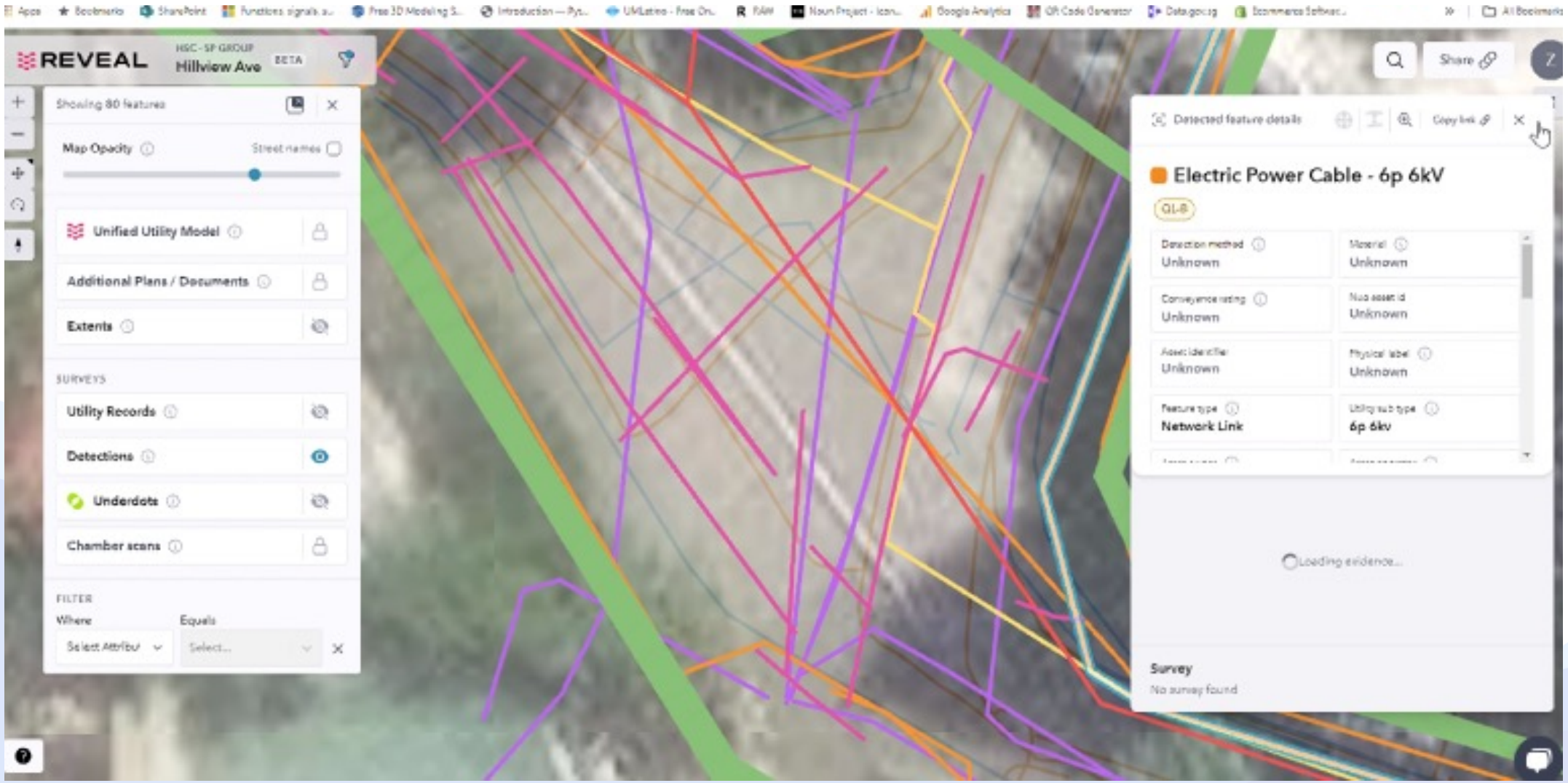
- Alignment and width of utilities
- 2D and 3D GIS Data

MCGPR

Productivity, Cost, Time, Safety, Sustainability

DIGITAL TWIN

RevealTwin Platform



AUGMENTED REALITY

AR APPLICATIONS

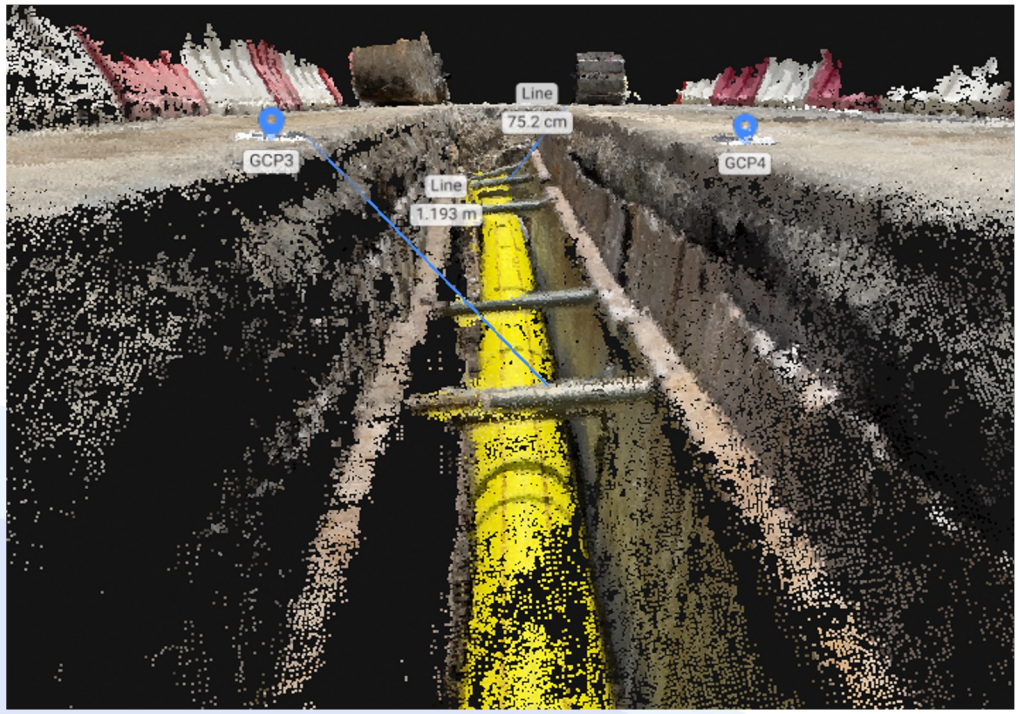
- We can use AR to project the utilities on site, which is much more intuitive to any personnel, from project officers, planners, safety and to project managers.

- If we are able to mount this view to the excavators, we will then be able to minimise utility damages during excavation, as the excavator operators will exercise greater caution near the utilities that they see from the AR.

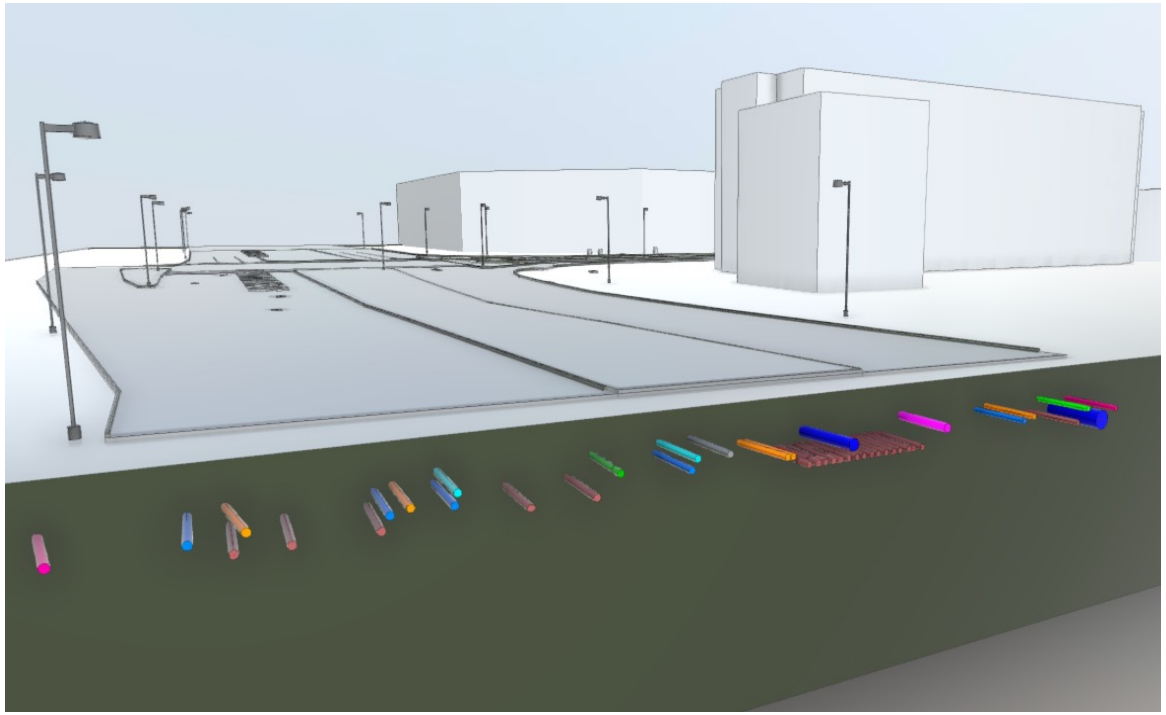
- For utility owners, having an AR view of their assets will be extremely helpful as their officers on site are now able to visualise the impact of the works on their assets.

The potential of AR is significant and the initial crucial step involves conducting precise Subsurface Utility Mapping. This involves embracing MCGPR technology and acquiring the relevant technology know-how.

GEO-LOCATED POINT CLOUDS AND BIM



Geo-located point cloud



BIM Underground Utilities

THE END