# Engineering Survey of Underground Utilities Blok M – Kota in DKI Jakarta

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**Key words:** Measurement, underground utilities, combination GPR and GPS

## SUMMARY

With the rapid development in DKI Jakarta feels that there is a restriction of "Spatial" to accommodate the land use infrastructure to fulfill people needs in DKI Jakarta as a business area and other development infrastructure. DKI Jakarta as a Capital City has been existed since 1527 which has various under ground infrastructures. The limitations of underground information can cause lack of spatial use and the risk of accident caused by underground infrastructure.

The development of electromagnetic technology rapidly in the recent years has conceived a new method in Exploration Geophysical Technology for the necessity of underground infrastructure data processing which is Ground Penetrating Radar (GPR). This GPR method is the way of radiation of electromagnetic pulse into the ground and recorded the reflection by aerial /Antenna on the surface. This method has already been utilized for under ground utilities surveys from Blok M to Kota station for Jakarta area along 16 Km. To determine position (geodetic coordinate ) of measurement line and cross section we use the combination of GPS equipment. The outputs of the survey are GPR image, cross section and 3 D model.

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## 1. INTRODUCTION

As a Capital City, Jakarta has a rule as a Service City which keeps improving its development. For this purpose, it needs accurate information on utility network mapping, either in the ground and underground areas. Such as electricity cable, phone cable, PJU cable – SJU (public street facilities), clean water pipe (PAM), waste water pipe, gas pipe, drainage channel and so on.

The mapping is necessary to avoid a great loss, accident and to facilitate system of network data collection which has been and going to be installed. For the installed network, mapping can be done using geodetic coordinate system or technology of Global Positioning System (GPS).

Related to that matter, in this paper we will explain one of the newest geophysics technologies to research underground utility along the street from Blok M – Station Kota using technology of Ground Penetrating Radar (GPR). By utilizing the feature of radar wave reflection with a high frequency, we can detect and distinguish the various underground utilities network, its depth, the dimension and its distribution.

To meet the Governor Instruction, the GPR Technology can be unified with the Geodetic Coordinate System use GPS (Global Positioning System) equipment so the result of the utilities underground mapping can be used as base map.

The lack of installation mapping and ground utilities are become problems of big cities nationally and also as significant issue. The reason is because each installation or utility is worked by different units, there is overlapping of area and timing, and also there is no coordination among them.

Nowadays and especially for the future, installation mapping or underground utility have became a necessity needs for developing cities. Considering of land use either on the ground and underground is more and more rapidly. Particularly for the future, if we are planning on having of Subway or subway shops.

On of the mission installation research or underground utility is imaging technology development. This research will need modern and variation technology. One of the newest geophysics technologies for research on underground utility, underground geology and environmental problems is GPR, which can be used either in the land and water.

The GPR technology has been successfully worked in underground utility mapping for Blok M – Kota ( Jl. Sisingamangaraja, Jl. Jend Sudirman, Jl. MH. Thamrin, Jl. Medan Merdeka

Barat, Jl. Gadjah Mada). By utilizing the feature of radar wave reflection with a high frequency, we will detect the possibility of underground objects existing such as cable, pipe, buried railway, underground configuration and so on.

## 2. ELECTROMAGNETIC TECHNOLOGY

The rapid development of electromagnetic technology in the last few years has achieved a new method for exploration geophysics science, which is GPR. In this technology, the electromagnetic pulse is transmitted into the ground and recorded by antenna in the surface. The GPR method is intensively used on the land in mapping of underground structure, and searching of archeological objects, pipes, cable, mineral substance, either underground or below sea level.

The basic foundation of GPR base on electromagnetic theory; Maxwell's equations which mathematically describe electromagnetic physics and constitutive relationships which quantity material properties. In mathematical are expressed as :

$$\overline{\nabla} \times \overline{E} = -\frac{\partial \overline{B}}{\partial t} \qquad (1)$$

$$\overline{\nabla} \times \overline{H} = \overline{J} + \frac{\partial \overline{D}}{\partial t} \qquad (2)$$

$$\overline{\nabla} \bullet \overline{D} = q \qquad (3)$$

$$\overline{\nabla} \bullet \overline{B} = 0 \qquad (4)$$

where :

$\overline{E}$ = electric field strength vector
$\overline{D}$ = electric displacement vector
$\overline{B}$ = magnetic flux density vector
$\overline{H}$ = magnetic field intensity
$\overline{J}$ = electric current density vector
$q$ = electric charge density

In GPR the electric and magnetic properties are importance. There are three quantities are defined. The first, electric conductitvity $\tilde{\sigma}$ is expressed as :

$$\overline{J} = \tilde{\sigma}\overline{E} \qquad (5)$$

which describes how free charges flow to form a current when an electric field is present. The second, dielectric permittivity, $\tilde{\varepsilon}$ is expressed as :

$$\overline{D} = \tilde{\varepsilon}E \qquad (6)$$

which describes how constrained charges are displaced in response to an electric field
The third, magnetic permeability, $\tilde{\mu}$ :

$$\overline{B} = \tilde{\mu}\overline{H} \qquad (7)$$

which describes how intrinsic atomic and moleculer magnetic moments respond to a magnetic field.

A georadar system comprises a signal generator, transmitting and receiving antennae, and a receiver that facilities data processing both while acquiring data in the field and have onboard computer on real time.

The data acquisition on the ground of Blok M - Kota, is conducted by having perpendicular image on the street and park. An antenna will receive the electromagnetic waves while being carried along land surface. The antenna is used at the frequency 500 MHz, and the position of objects underground can be seen on the monitor in a real time through computer which is connected to this equipment. Furthermore, this pulse will spread under the surface and some will be radiated by the changing of di-electricity contrast of soil and rock, meanwhile the media conductivities and the frequency will control the depth of geo radar wave penetration. The receiver antenna on the surface will get the energy radiated by the reflector. ( see figures 1, 2, 3 for the GPR image, GPR equipment).

The transmitter and receiver antenna in this equipment will be placed on the position relatively close and stable or zero-offset. The condition of longitudinal section and the sea surface (configuration of the sea topography), pipe, cable and other objects, and also geology below the sea level can be mapped while it is moving along with the speed of ship that constantly have the same direction with the observed object.

We determine every certain track or interesting objects under the surface area using GPS and geodetic mapping system. In this research, the GPR data can be achieved accurately, compare to other methods.
The purpose of georadar data processing is to improve field data image by causing the interference signal loss and improving signal to noise ratio until we get the good illustration on underground condition visually. The improvement of image quality can further be done by implementing some other techniques such as Automatic Gain Control (AGC), Linier, Exponential, balance trace and some kinds of filters, such as band pass filter, low cut, high cut filter, f-k filter and remove attenuation, which all of those techniques are to reform the weakness of signal and improve the underground image resolution.

## 3. INTERPRETATION

The aim of georadar data processing is to improve After the phase of radargram image data processing has been cleaned up of noise and also to enhance the signal-noise ratio, so subsurface image has a betterquality. we can continue on interpretation of various anomalies which are reflecting the objects on underground.

On radar image at MH Thamrin street, there are clearly various diffraction waves caused by the underground pipe or cables. Using this technology we can distinguish the characteristic, the width and the dimension among the pipe of Telkom, PLN, PAM, PAL, GAS, and other

pipe. Afterwards, the certainty of those pipes unified with the information from related units so that we can illustrate the map which blocks those pipes or cables, either on the sizes and the depth. Furthermore, we can illustrate the installation map or utility into geodetic map until all pipe and cables under the surface can be mapped properly. The interesting one is that there is an image under the surface parallel consistently. It is assumed as a former railway/tram from many years ago.

## 4. TOPOGRAPHIC MAPPING

This mapping aims to make topographic map along measurement track which will be used as a standard map in this project, until we can determine the correlation between the object position on the ground and the details topographic of the objects on the surface, vertically or horizontally. The output of Topographic Mapping are topographic map and underground utility details, can be on hardcopy as map sheet or digital copy which is put as data of Geographic Information System (GIS). Generally, the scope of work the mapping as follow:

- Measure of the geodetic framework, to get the point reference on the topographic detail measurement (horizontal and vertical framework).
- Measure of the topographic detail, cross section, long section along measurement line
- Measure of the position on georadar lines
- Plotting topographic detail, cross section, long section and underground utility (see figures 4, 5)

## 5. GEORADAR MEASUREMENT

In the framework of spatial planning and developing under the street surface in Jakarta, it needs to know the existing utilities condition along these streets either long section, cross section or vertical (3-D) based on georadar method. These utilities are facilities that either still can be used or the debris of infrastructure in the past that have not been used anymore. These infrastructure include installation from national electric company (PLN), Telkom, PAM (clean water), PAL (disposal water), gas pipe and so on. The output from this detection and measurement are 3-D map content of information about the existence, kinds of material, dimensions and utilities position under the surface.
Scope of Work:

- Introduction surveying
- Having secondary data collecting, prior to the field implementation, from related units concerning of existing infrastructures which are blue print, information, documents and others history data.
- Integrated coordination among the team and related units
- Measuring and detecting use geo radar method
- This is done by making sampling
- Main track which blocks the highway along the track approximately 50 to 200 meters
- For each kilometers of the length of road made a sampling for about 5 tracks.

- Branch tracks for intersection for approximately every kilometer of the highway have 5 intersections which is also made blocking detections with the length for about 10 to 20 meters
- Such sampling made for all roads median where the survey is being done.
- Therefore it is necessary to have sampling for highway and intersection.
- Fix marking on the geo radar fix position using paint or other marks that possible to be done
- Sampling making or test pit for possible location as a hint interpretation of geo radar outcome and compare with the secondary data
- Processing and interpretation to be put on the report representatively
- Integrate the data of geo radar with the developed GIS System

## 6. DEVELOPING UNDERGROUND UTILITIES INFORMATION SYSTEM

To develop the information system which is able to give detail information on the existence of utilities objects such as clean water drainage, waste water drainage, electric cable, phone cable, gas pipe and so on. The given data information are as below:

- Spatial data, is data position of the objects from the visible of 2-D map and vertical profile to show the objects with a certain land depth, until it can be seen the diameter or dimension of the object below the ground.
- Textual data, is descriptive data related to the utilities object on the ground. This data can be a year of installation, until known the age of this object, the material, the capacities and many more.

Based on both kinds of data, we will put them on into information system of underground utility, so it comes up to query of data searching using specific criteria. Sample of query are as follow:

- Searching of utility objects of clean water channel along X street and the age of Y year
- Searching of utility objects of waste water drainage which empty into X street
- Searching the possibility of new installment for utility object under ground along X street, until there will be no crash with other existing objects.

From those various queries, this system will also able to be done on making print report. This report can show either spatial or textual data from query outcome. Particularly for spatial data report, try to be shown by standard presentation of underground utility map.
The process on information system for this underground utility need the following phase:

- Identify the system necessity comprehensively
- Identify and compile the data resulted from Topographic and GeoRadar Survey
- Identify and compile the secondary data from various related units, such as PAM, PLN, Telkom, etc.
- Design the database conceptual, spatial and textual, based on identification output.
- Design database, in this case is management tool of basic data (DBMS) which has been determined for implementation from logical database design
- Design and implement query and report using appropriate system developing tool
- Test the system

The most important thing in this project is the database. There are 4 phase of developing process data. The phases are needs formulation and analysis, Conceptual design, Design implementation, Physic design.
The phase of basic data design and the correlation (input and output) can be illustrated as follow:

- Data collecting done in this phase. The collected data can be on statistic form, graphic/map report which is useful for further compilation process, verification, validation and then put them on developed data.
- Based on the identification and assessment outcome, to determine the relation of inter related data and furthermore make a data hierarchy that has been stated, then arrange and determine the design basic data. The outcome of the database design process is a specification physic from standard database to improve information system of underground utility.

## REFERENCES


Annan, A.P., 2001, Ground Penetrating Radar Workshop Notes, Sensor & Software Inc.

Dinas Pertanahan dan Pemetaan, 2003, Pengukuran Poligon, Pengukuran Waterpass, Pengukuran Penampang Melintang Pengukuran Detail (situasi) perhitungan Penggambaran, Seminar Utilitas Bawah Tanah, Sari Pan Pasific Hotel, Jakarta.

Project Report, 2000, Pendataan Jaringan Utilitas Bawah Tanah, Programming Bureau Jakarta Provincial Government.

Project Report, 2003, Pengukuran Utilitas Bawah Tanah Thamrin –Kota, Departement of Land and Mapping Jakarta Provincial Government.

Sanny T.A, Handayani G., Sitorus, JEBH, 2003, Application of Ground Penetrating Radar (GPR) for Gold Exploration, Applied of Near Surface Geophysics, Indonesian Association of Geophysicists (HAGI), ISBN.979-95053-3-x

Sanny T.A, 2003, GPR Inspection for subsurface utility, Seminar Utilitas Bawah Tanah, Sari Pan Pasific Hotel Jakarta.

Sanny, T.A., 2004, Subsurface Mapping by using GPR, KOMPAS, Juni 15,2004.


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## Appendix

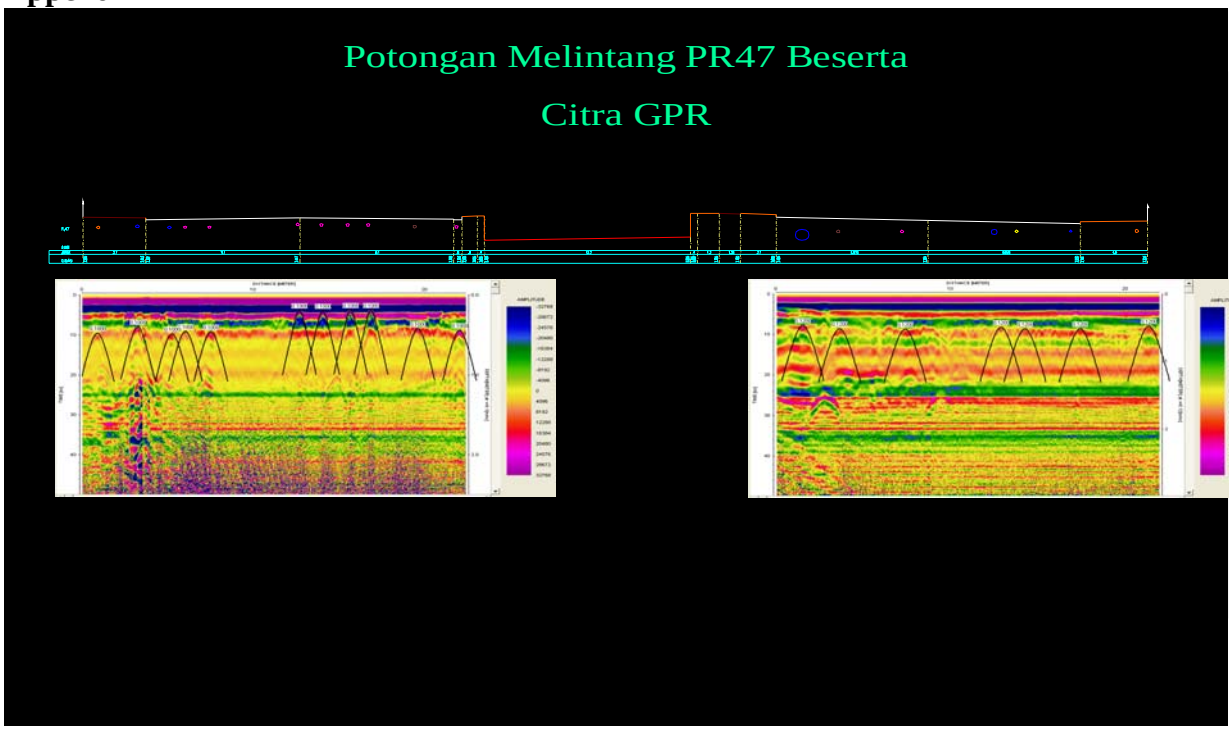



**Figure 1.** GPR Image with using antenna frequency 500 MHz

**Figure 2.** Computer Unit for collecting the data

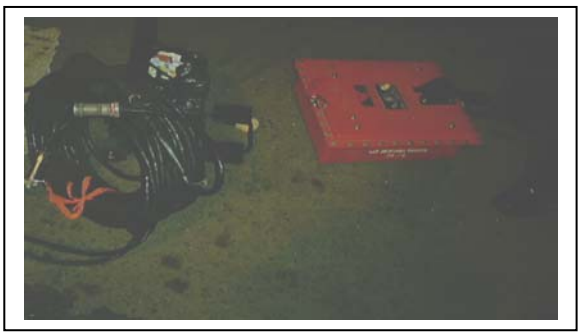


**Figure 3.** Antenna frequency 500 MHz

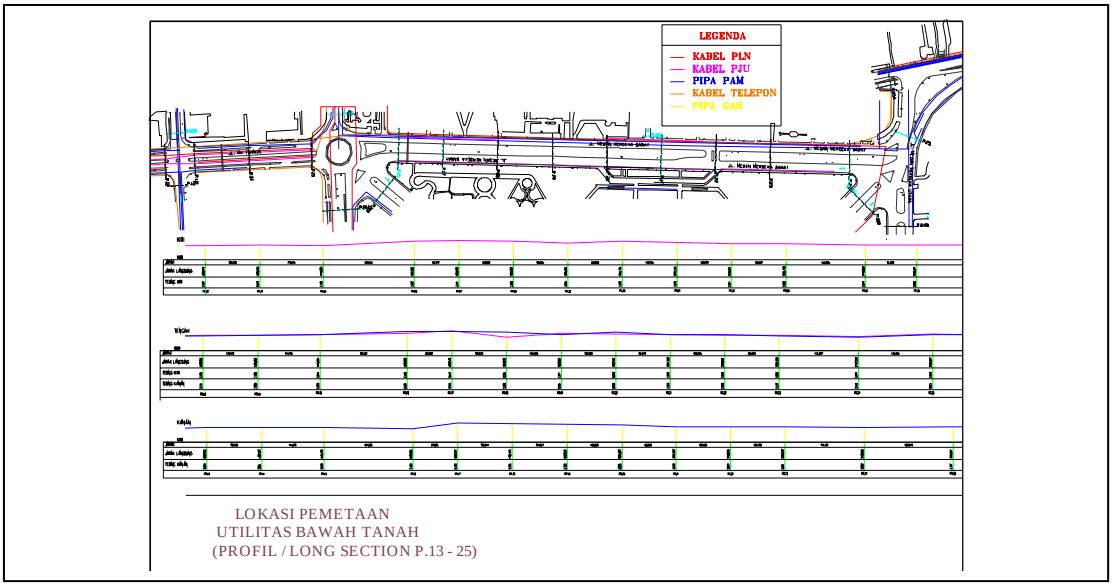
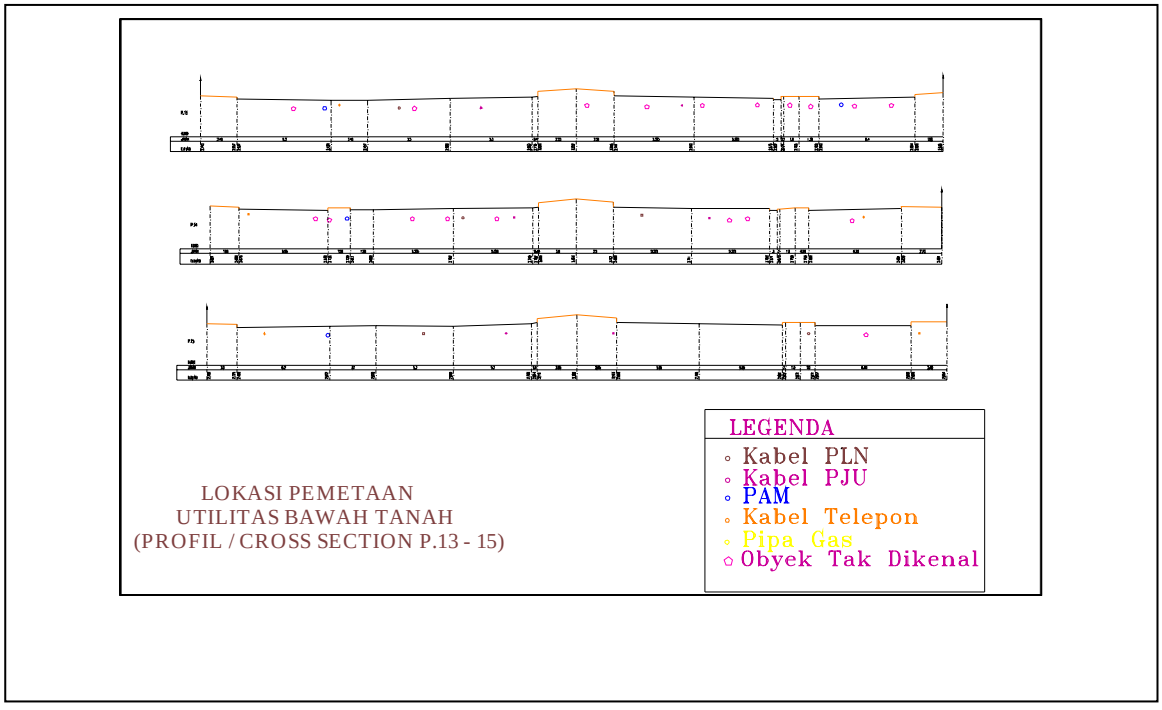



**Figure 4.** Subsurface Utilities Mapping and Cross Section



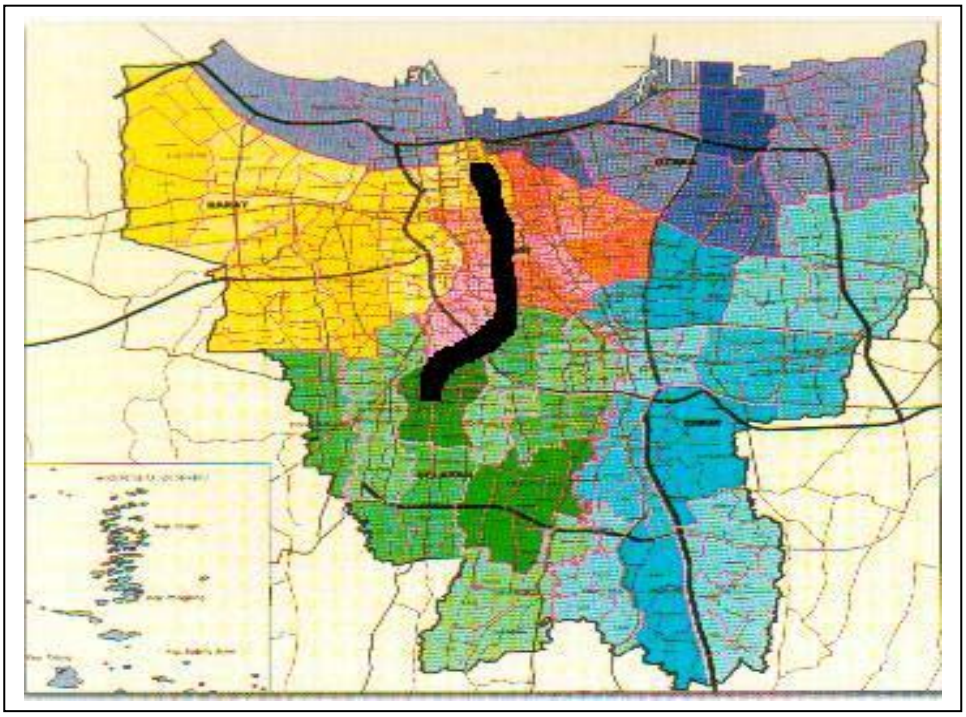


**Figure 6.** Street from Blok M – Station Kota (  )