Surface and Subsurface Utility Database and Mapping: UiTM Shah Alam

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Abstract. Rapid urbanization needs detail planning to optimize the land use to provide facilities to people. As urban growth, the use of land is shifting from the use available space above ground (surface) to the use of underground (subsurface) spaces. Many have not realized the significance of subsurface utility mapping which is vital as reference before starting any excavation work. Incomplete information about the location of the buried subsurface utilities may cause unwanted incidence to happen and make it difficult for upgrades and maintenance works to be done. In order to provide readily, reliable and up-to-date utility data it is necessary to have a centralized database that combines all utility data. Therefore this study is conducted to propose a utility database to Facility Management of UiTM Shah Alam in storing, maintaining, monitoring, updating and easy to retrieved surface and subsurface utility data that installed inside UiTM Shah Alam area. Data used in this study focuses on Electrical, Telecommunication and Water Supply utility which was obtained from Facility Management of UiTM Shah Alam in form of a digital utility mapping plan separately. As the final product of this study is a database that will have various advantages in future use, SaS Utility Database has been developed based on Underground Utility Mapping Circular prepared by JUPEM and has been applied MS1759 standard attribute for each data to allow data sharing effectiveness in between organizations. Apart from that, to ensure the data stored in the database is at its best, topology analysis has been run by sets 3 types of rules for each utility category to detect any error that may occurs during digitizing or conversion stage. The findings of this study is with the SaS Utility Database, all utility data stored in a database can be secure, manipulate and converted in various formats depending on its purpose in order to create new information or knowledge as well it will enhance the work process in the future in terms of data sharing with other organization.

1. Introduction
A good understanding of what already exists underground is essential for planning, monitoring and maintaining underground spaces since most of underground spaces have been used for the public infrastructure such as utility lines, rail lines and roads. Underground utility mapping refer to the detection, positioning and identification of buried pipe and cable beneath the ground [1]. Basically, utility detection is the procedure of recognizing, isolating and labelling the public and private surface or subsurface utilities. Many have not realized the significance of subsurface utility mapping which is vital as reference before starting any excavation work. Incomplete information about the location of the buried subsurface utilities may cause unwanted incidence to happen and make it difficult for upgrades.
and maintenance works to be done. When underground pipes are damaged, it can lead to major financial losses and may cause loss of life [2]. Incident occur may harm workers and/or residents who stayed nearby as well it may damage the other utility material and may cause environmental pollution. The damage usually happens because the locations of underground utilities are unknown or not well documented, especially in old urban areas or because of differences between design locations and actual in-situ installations [3]. According to [4] studies aim is to model a shared DB containing all information regarding the underground utility lines, including both geo-referenced data and other attributes which are fundamental in the monitoring and maintaining of such networks. This is important where the data of the underground utilities can be shared among different companies and collected in a unique integrated database for the management at the level of at least a single Municipality.

2. Methodology
The development of SaS Utility database consist of five (5) phase; preliminary study, data acquisition, pre-processing and processing, data interpolation and analysis. The preliminary studies phase is a phase that identifies all information needed relating to this study. The crucial part of this phase is to identify the source of data as data is important in any study. Meanwhile, the data acquisition phase is a phase that gathers all the needed data that will use throughout conducting this study. Pre-processing and processing phase is a phase where all the data retrieved are processed to develop the database. Data interpolation relates closely to the analysis phase. The data processed is then interpolated and perform data quality assessment. Figure 1 illustrate methodology structures in developing SaS Utility database.

![Surface and Subsurface Utility Database Methodology](image-url)

**Figure 1.** Surface and Subsurface Utility Database Methodology.
2.1. Preliminary Studies

There are 4 main GIS component consist of software, hardware people and data. This phase focus to identify all related information such as end-user, and selection software and hardware that used throughout conducting this study. This study was conducted within the UiTM Shah Alam as the area was determined as centre study areas which need to provide multiple facilities either to student or staff to fulfil the public demand. For instance, UiTM provide free Wi-Fi that can be accessed by students and staff at UiTM. Therefore, it requires extensive and strong communication lines throughout UiTM Shah Alam. The SaS utility database can be utilized by Facility Management to identify and maintaining telecommunication utilities maximal. An interview session was conducted and few problems have been identified in the context of utility data management and data sharing. Utility data in Facility Management is not up-to-date plan and there is no centralize utility data.

2.2. Data Acquisition

Data is vital for any project and important thing that needs to be identified at the first phase. Wrong data may result to invalid information and may affect the quality of the product. For this study, data was obtained from UiTM Facility Management in digital and printed map formats. Data received from Facility Management has been undergo data sorting and data conversion process. Which it to extract utility data from digital drawing in .dwg formats using AutoCAD software and convert the coordinate from Cassini-Soldner (Old) to MRSO. Apart from that, data from open source also has been used in this study.

2.3. Pre Processing and Database Developing

The concept of SaS Utility database is a database that easy to maintain, improve data consistency and cost-effective in terms of disk storage space. Surface and Subsurface Utility Database development has undergo Database Development Cycle (DDC) as shown in Figure 2. Basically, there are 4 stage in developing the database. It start with database requirement analysis, database design, implementation and testing. Figure 3 shows the database design that been created based on Chen Notation Entity-Relationship Diagram that shows the relationship in between Entity.

![Figure 2. Database Development Cycle (DDC).](image-url)
3. Results and discussions

According to standard guideline for Underground Utility Mapping BIL.1/2006 provided by JUPEM under subtopic 7.1-Database Design, it mentions the utility database should consist information such as;

a) Digital Cadastral data  
b) Large Scale Topography Data  
c) High Resolution Satellite Images  
d) Underground Utility

Therefore the development of SaS Utility Database is based on the criteria mention in the Guideline. The main data used in developing this database is received from Facility Management in forms of softcopy drawing map and using Open Street Map (OSM) open source data to extract building data. All of these data are then processed and be adapted according to the Facility Management needs.

Since the data used in this study fall in D level which obtained from existing data, therefore these data have gone thru a Topology Analysis process to identify the possible error that occurs during the digitizing stage. It is necessary to identify the error and fixed it to ensure the quality of the data is in good condition.

3.1. Surface and Subsurface Utility Database

Figure 4 shows the type of spatial data stored in the Surface and Subsurface Utility Geodatabase which consists of Electrical Utilities, Water Supply Utilities, and Telecommunication Utilities information. The presentation of the data is more explicit when presented in vector data formats in form of point, line and polygon. JUPEM’s Underground Utility Mapping Guideline Bil.1/2006 under subtopic 7.4-Data Exchange Standard, it mentions to use the Malaysian Standard Geographic Information/Geomatics Feature and Attribute Code (MS1759) shall be utilized in developing and maintaining utility data. Thus, the code for each data feature is following the MS1759 standard attribute formats. Therefore, all the utility spatial data is given different code as listed in the Table 1.
Figure 4. Type of Utility Data stored in Geodatabase.

Table 1. Utility Data Feature Code using MS1759 Standard Attribute.

| Category       | Features                  | Code | Shape     | NAM (Name)                   |
|----------------|---------------------------|------|-----------|------------------------------|
| Electric       | Electricity Manhole       | UA0090| Point     | Feature Code                |
|                | Electric Station          |      | Polygon   | Station, Subtype (Station Subtype) |
|                | Substation & Switching Station |     |           | NAM (Name)                  |
|                | Electrical Station        | UA0060| Point     | ARM (Area Measured (ha))    |
|                | Feeder Pillar             |      |           | Feature Code                |
|                | Power Line                | UA0010| Line      | NAM (Name)                  |
|                | Street Light              | UA0020| Point     | NUM (Num)                   |
| Telecom        | Telecommunication Mandate| UB0020| Point     | Feature Code                |
|                | Telecom Cable             | UB0250| Line      | NAM (Name)                  |
| Water Supply   | Pipeline                  | UC0110| Point     | Pipeline, Subtype (Pipe Line Subtype) |
|                | Water reticulation        |      |           | Feature Code                |
|                | Fire Hydrant              | UC0130| Point     | NAM (Name)                  |
|                | Water Valve               | UC0120| Line      | Feature Code                |

The structure of the geodatabase consist of file geodatabase, feature dataset, feature class and feature subtype as shown in the Figure 5. All of these data has been converted and projected onto same projection as stated in JUPEM’s Underground Utility Mapping Guideline Bil.1/2006 under subtopic 7.3-Projections and Coordinate Systems mention all underground utility maps in Malaysia should be based on the Rectified Skew Orthomorphic (RSO) coordinates which referenced to the Geocentric Datum of Malaysia 2000 (GDM2000) horizontal datum. However, only certain feature have feature subtype depending it characteristic. For example, Water Reticulation Pipeline have several different type of pipe used to supply water to consumer.
Figure 5. Surface and Subsurface Utility Data Structure.

Figure 6 shows the interface of the Surface and Subsurface Utility Database by using ArcMap Software. The processed data are presented in one layout. The data also organized based on its category. Figure 7 shows the attribute table interface that developed based on MS1759 standard attribute. The advantage of designed the standard attribute table format, it provides multiple choice of information relates to the feature characteristic. Thus, users are able to choose the information based on the feature type.

Figure 6. Surface and Subsurface Utility Database Interface.

Figure 7. Structure of the Attribute Table.
From the data stored in the database, surface and subsurface utility data can be easily updated and a map can be generated as shown in Figure 8. This map shows the location of the utility data buried either on the surface or subsurface which will assist Facility Management in making any decision for future development.

![Surface and Subsurface Utility Map in UiTM Shah Alam.](image)

3.2. Advantages of having Utility Database

The advantage of SaS Utility database is it allows data sharing with other organizations either private or government sectors easier. That is because the development of the database is according to standard attribute format that used in Malaysia namely Malaysian Standard Geographic Information/Geomatics Feature and Attribute Codes (MS1959) which have been used as a reference in the industry. Apart from that, the database formats have also been integrated with JUPEM standard formats which are the main reference to all works of Geomatics or Surveying in Malaysia. Utility data stored in the geodatabase is in shapefile format which considered as most portable format in GIS nowadays. Thus, data can be shared with any GIS platform. Utility data is supported and compatible with any GIS software formats such as ERDAS Imagine and MapInfo software. In addition, the data also can be import into GIS Mobile Applications such as SW Maps or IGIS apps that available in Play Store and Apps Store respectively. Thus, utilities data can be used as handheld data which is flexible to be used either in the office or on-sites as a reference to related works. Figure 9 shows example of utility data interface in iGIS mobile apps.

![SaS Utility Data Uploaded in iGIS Mobile Apps.](image)
4. Conclusions
Many issues need to be identified before makes any decision. It requires a complete, reliable and up-to-date data to make a good decision. However, not all utility data installed are mapped especially underground utility. Utility data in UiTM Shah Alam also does not spare from these issues. To achieve the goal of developing prototypes of Surface and Surface Utility Databases, it has gone through many processes and it is not an easy task. Where data is the most important component that needs to be identified before beginning any database development. Nowadays, data can be obtained from various sources in various formats types. With the help of the latest computer technology software that available in the market, data can be manipulated using specific tools equipped in the software and converted into various formats depending on its purpose in order to create new information or knowledge. Thus, a standard database development needs to be implemented and applied by any organization either government or private sector to allow effectiveness in data sharing. Malaysian Government itself has an effort to provide a standard attribute data schema namely Malaysian Standard Geographic Information/Geomatics Feature and Attribute Code (MS1959). Thus, the SaS Utility Database have applied MS1759 standard attribute data in the database to enhance data sharing. The development of the SaS Utility Database is based on Guideline prepared by JUPEM. In the guideline already mentioned the required data, attribute information and projection that must be include in the utility database. Therefore, with the implementation of Surface and Subsurface Utility Database in UiTM Shah Alam (SA), it will enhance the work process in terms of storing, maintaining, monitoring, updating and easy to retrieved SaS Utility data that installed inside UiTM SA area for future use.

References
[1] Jamil, Hasan, Zoher, Nomanbhy, and Mohd Yunus Mohd Yusoff 2012 “Underground Utility Mapping and Its Challenges In Malaysia” Mining and Underground Engineering Surveying II
[2] Li, Jingxia, Tian Guo, Henry Leung, Hang Xu, Li Liu, Bingjie Wang, and Yang Liu 2019 “Locating Underground Pipe Using Wideband Chaotic Ground Penetrating Radar.” MDPI
[3] Ghozzi, Rim, Samer Lahourar, Kamel Besbes, and Chokri Souani 2018 “Mapping of Sewer Lines Using GPR: A Case Study in Tunisia” MDPI
[4] Cazzanigaa, Noemi Emanuela , Daniela Carriona, Federica Migliaccioa, and Riccardo Barzaglia 2013 “A Shared Database of Underground Utility Lines for 3D Mapping And GIS Applications” 29th Urban Data Management Symposium
[5] Jabatan Ukur dan Pemetaan Malaysia 2006: Garis Panduan Mengenai Pemetaan Utiliti Bawah Tanah, Pekeliling KPUP Bil. 1/2006. Kuala Lumpur Malaysia.
[6] Jabatan Ukur dan Pemetaan Malaysia 2016: Garis Panduan Penerimaan Data Digital Dan Pelan Utiliti Dari Jurukur Tanah Bertauliah (JTB) Oleh Jabatan Ukur Dan Pemetaan Malaysia (JUPEM), Pekeliling KPUP Bil. 2/2016. Kuala Lumpur Malaysia.
[7] Malaysian Standard Geographic Information/Geomatics Feature and Attribute Code (MS1959)

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