King Fahd University of petroleum and minerals

Civil Engineering Department

Using GIS and GPS in Electricity Network Maintenance: Dowaan Valley Electricity as a Case Study

CRP 514- GIS introduction

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Abstract

The data of features location and features descriptive attributes is the important component of GIS studies. The data which will be used for GIS works is mostly provided from a digitized maps, existing paper maps, and aerial photos or satellites images. Nowadays the data from GPS can be used to make plans and maps of the studied area and the GPS data can be converted into the GIS more easily. GIS and GPS have some useful applications for the rapid preparation of plans and maps of small areas. This paper will try to explain GIS-GPS and give applications during the preparation of Dowaan valley electricity plans.

Key words*: GIS; Spatial data; GPS; signal errors; Electrical distribution network; Dowan Valley Electricity.*

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1. Introduction

According to difficult terrain and difficult weather in summer and winter in Dowaan valley many of specialists, experts and engineers try to monitoring the risk of high-voltage power which has damage effect. They are working to identify and analysis all information. The aim of these studies is to avoid any problems on high-voltage power transmission line by using GIS/GPS application. Generally, this collected information should be linked and integrated to get the goal. Nowadays, there are a lot of efforts in many countries to use this information as interactive maps.

The proper way to reach the goals is the GIS applications.GIS technology has the ability to manage this information and represents it with various maps which allow for users to interact with it completely. Besides, GIS provides us to show all accumulated data which are stored in any format for long time as visible layers linked between location data and attributes.

The purpose of this project is identifying the ways to make early maintenance and decrease the electricity risk of High-Voltage Power Transmission Line in Dowan valley by using GIS/GPS technology. GIS can aid to reduce the risk by finding accurate maps and information about any required location. These maps are the base of many processes which we need to do them for avoiding the risk of High-Voltage Power. GIS applications have the ability to generate all accumulated data and make it active with users' requirements.

This paper will explain the methods that help me to prepare a plan of Dowaan valley electricity by using GIS/GPS application and how we can use this plan to decrease the risk of High-Voltage Power Transmission Line and to do early maintenance. Then it will represent a general view about the GIS technology and its applications. After that, the paper will explain what the types of information are required to create this plan and how we deal with them to identify the risk. Finally the paper will concentrate on the actual case (Dowaan valley electricity) to evaluate it and give the visions to solve the problems of the case.

2. Geographic Information System (GIS):

2.1. History and Development:

In the past, Eskimos of the Canadian Arctic and Bedouin of the Arabian Desert had an almost inborn skill to produce rough but quite accurate sketches on pieces of skin indicating the positions and distances of the localities known to them.

Mapping the map was developing to the 1960 then the designer started to do a lot of searches to put the spatial data on the map by using programs. "Dramatic changes in computer technology have helped fuel the growth of GIS and other information technologies" (Peter, 2009, p. 239). In 1990, the designers put GIS on high-speed client server networks. In 1995, people used GIS from internet, after that the designers put GIS maps in global position system GPS. Now days, by using GIS maps on GPS, you can go anywhere on earth without go missing your position, also you can find information about hotels, hospitals, etc.

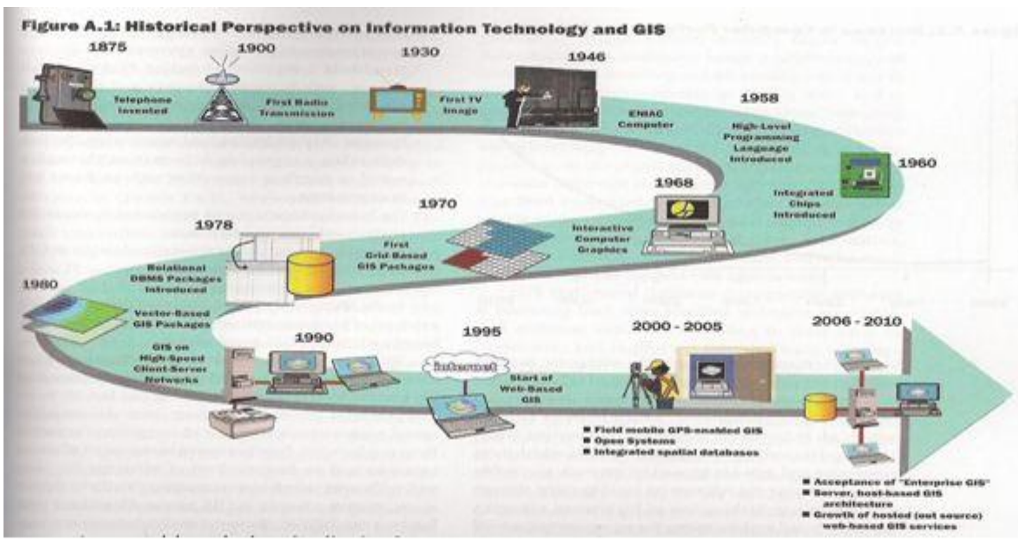


Figure (1): Historical perspective on information technology and GIS. (Peter2009, p. 239)

A geographic information system (GIS) is a set of computerized tools (including both hardware and software) for collecting, storing, retrieving, transforming, and displaying spatial data. GIS is essentially combination of computerized mapping and data base management system. Anything that can appear on a map can be programmed into a computer and then compared to anything on any other map, using longitude-latitude coordinates. Urban planners have used the map to determine the suitable location of a new city to reduce population increasing in big city; also they have used the map to design electrical distribution network, roads, the waste water networks and the service buildings such as hospitals, schools, etc.

The geographical information system (GIS) is not limited to a certain science or unique technology, but it has very extended branches of usage in a lot of the daily activities such as the engineers of geological survey have used GIS to do mapping for the layers of the earth. GIS has its usages in governments, general foundations and scientific academies. Recent statistics manifest that about 60% of the users of computer all over the world use GIS, although the users of GIS in Arab countries are not as much as those in Western countries, but it seems that this number is rapidly increasing. More than eight Arab countries depend on GIS in their governmental control, the other countries are about to use this technology. It is a matter of few years to see this technology well established in all Arab countries.

2.2. Types of Spatial Data:

Spatial data is information about location, shape, and relationships among geographic features, usually stored as coordinates (X,Y,Z) and topology (the spatial relationships between connecting or adjacent coverage features such as arcs, polygons) (Al-Khozami, 1992, p.151). GIS is designed to work with spatial data, where numerical data is referenced to a particular location on earth that can be displayed on a map. In GIS the feature attribute table and the map that stores geographic features are dynamically linked to each other with a common field, which locates the geographic feature on the map (Pamuk, 2006, p. 25). GIS works with two types of spatial data:

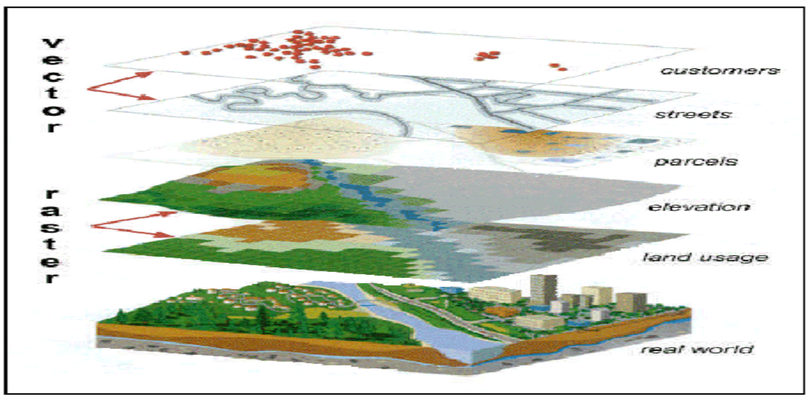


Figure (2): Types of Spatial Data, vector data and raster data. (Pamuk, 2006).

2.2.1. Vector data:

Points, lines, and polygons – altogether are known as vector data, (Easa and Chan, 2000, p.13), as shown in figure (3). The vector data format is suitable when working with discrete variables "For example, population per city is a discrete variable .the basic unit is population. The cities of the world can be represented as points on world map where the attributes of each city (e.g., population) have discrete values (e.g., 8 million)" (Pamuk, 2006, p. 26).

2.2.2. Raster data:

"It is a matrix of identically sized cells (e.g., squares) also known as grids. Each cell stores values for each of the variables associated with that particular raster grid. In GIS there are two types of grids: continuous and discrete"(Pamuk, 2006, p. 26)

3. Global positioning system (GPS):

3.1. Background:

GPS is a satellite-based radio positioning system developed by the U.S. Department of Defense (DOD) for accurate positioning and navigation. Radio signals are used from a constellation of earth-orbiting satellites to determine the 3D position of a receiver. The system consists of 21 satellites and three spare satellites orbiting approximately 20,200 km above the earth's surface in six orbital planes, having a period of 12 hours.

GPS has three main components; the satellite system, the control system, and the users. The control system is operated by the U.S. Air Force for the Joint Program Office (JPO) of the DOD. The system consists of five monitoring stations distributed around the world.

The role of these stations is to monitor the health of the satellites. These tracking stations receive signals from the satellites and transmit the collected data to the master station where new ephemerides are computed and the navigation messages are prepared for uploading to the satellites.

3.2. History and Development:

The GPS system was developed as a worldwide satellite based system by the U.S. Department of Defense (DOD) to simplify and improve military and civilian navigation and positioning.

The system grew Out of the "space race" with the Soviet Union during the 1950s. By the 1960s the Air Force has developed a system in which several satellites with accurate clocks could assist in determining the position of a vehicle moving on land or in the air. In 1973, the Navy and Air Force programs combined and formed the Navigation Technology Program, which eventually became NAVSTAR (Navigation System and Ranging).

More recently the European Union approved funding to develop a GPS system called Galileo, which could be operational by 2008. Development and testing of the system began following the first GPS satellite launch in 1974. These satellites were built by Rockwell Collins and launched by the Air Force. Testing continued into the 1980s when GPS satellites were to be among payloads carried by NASA Space Shuttle flights.

The GPS program suffered a major setback when shuttle launches were suspended following the 1986 Challenger accident. Several years passed until modifications could be made to the Delta II launch vehicle, enabling it to carry GPS satellites. The GPS system became fully operational on 8 December 1993 when the full constellation of 24 satellites, 21 operational and three in reserves, became available.

The Russian Global Navigation Satellite System (GLONASS) consisted, in 1996, of a constellation of 24 satellites in three orbital planes. (White, Rochat, & Mallette. 2006).

The cost to the Air Force (1973 - 2002) to develop the GPS satellites (not including military user equipment or launch costs) is approximately $6.3 billion. It costs about $750 million annually to operate and maintain the constellation, including research and development, as well as procurement for and replacement of satellites. These numbers might seem high until you examine the economic impact of the GPS system on civilians and the economy in general.

Over 1.4 million civilian GPS receivers have been produced each year since 1997. The economic impact of GPS technology is significant, reaching $6.2 billion in 2000, with expectations of surpassing $50 billion by 2010.

3.3. Structure of GPS:

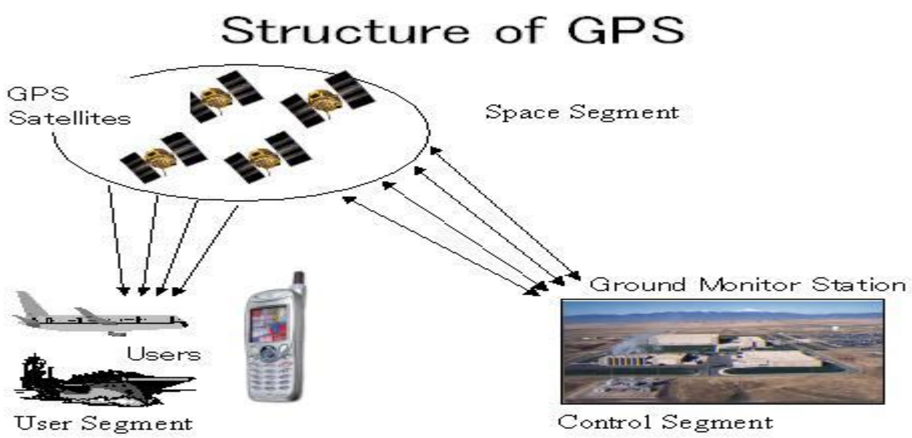


Figure (3): Structure of GPS.

3.3.1. Space segment:

Space segment will consist of 21 GPS satellites with an addition of 3 active spares. These satellites are placed in almost six circular orbits with an inclination of 55 degree. Orbital height of these satellites is about 20,200 km corresponding to about 26,600 km from the semi major axis. Orbital period is exactly 12 hours of sidereal time and this provides repeated satellite configuration every day advanced by four minutes with respect to universal time (Raju, 2003).

3.3.2. Control Segment:

The control segment consists of a worldwide system of tracking and monitoring stations. The 'Master Control Facility' is located at Falcon AFB in Colorado Springs, CO. The monitor stations measure signals from the GPS satellites and relay the information they collect to the Master Control Station. The Master Control Station uses this data to compute precise orbital models for the entire GPS constellation. This information is then formatted into updated navigation messages for each satellite.

3.3.3. User Segment:

The user segment consists of the GPS receivers, processors and antennas utilized for positioning and timing by the community and military. The GPS concept of operation is based on satellite ranging. Users figure their position on the earth by measuring their distance to a group of satellites in space. Each GPS satellite transmits an accurate position and time signal. The user's receiver measures the time delay for the signal to reach the receiver. By knowing the distance to four points in space, the GPS receiver is able to triangulate a three-dimensional position.

3.4. Sources of GPS signal errors:

Factors that can degrade the GPS signal and thus affect accuracy include the following:

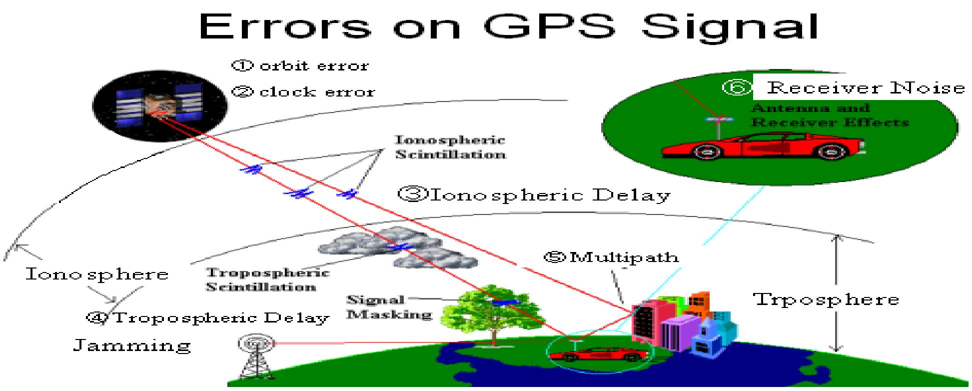


Figure (4): Sources of GPS signal errors (http://www.soi.wide.ad.jp/class/20050026/slides/01/61.html).

3.4.1. Ionosphere and troposphere delays:

The satellite signal slows as it passes through the atmosphere. The GPS system uses a built-in model that calculates an average amount of delay to partially correct for this type of error.

3.4.2. Signal multipath:

This occurs when the GPS signal is reflected off objects such as tall buildings or large rock surfaces before it reaches the receiver. This increases the travel time of the signal, thereby causing errors.

3.4.3. Receiver clock errors:

A receiver's built-in clock is not as accurate as the atomic clocks onboard the GPS satellites. Therefore, it may have very slight timing errors.

3.4.4. Orbital errors:

Also known as ephemeris errors, these are inaccuracies of the satellite's reported location.

3.4.5. Number of satellites visible:

If there are more satellites in GPS receiver then you can get better accuracy. GPS units typically will not work indoors, underwater or underground.

3.4.6. Satellite geometry/shading:

This refers to the relative position of the satellites at any given time. Poor geometry results when the satellites are located in a line or in a tight grouping. But ideal satellite geometry exits when the satellites are located at wide angles relative to each other.

3.4.7. Intentional degradation of the satellite signal:

Selective Availability (SA) is an intentional degradation of the signal once imposed by the U.S. Department of Defense. SA was intended to prevent 12/29/2010military adversaries from using the highly accurate GPS signals. The government turned off SA.

4. Electrical Distribution Network:

4.1. Background:

In the early days of electricity distribution, direct current (DC) generators were connected to loads at the same voltage. The generation, transmission and loads had to be of the same voltage because there was no way of changing DC voltage levels, other than inefficient motor-generator sets. Low DC voltages were used (on the order of 100 volts) since that was a practical voltage for incandescent lamps, which were the primary electrical load. Low voltage also required less insulation for safe distribution within buildings.

The losses in a cable are proportional to the square of the current, the length of the cable, and the resistivity of the material, and are inversely proportional to cross-sectional area. Early transmission networks used copper, which is one of the best economically feasible conductors for this application. To reduce the current and copper required for a given quantity of power transmitted would require a higher transmission voltage, but no efficient method existed to change the voltage of DC power circuits. To keep losses to an economically practical level the Edison DC system needed thick cables and local generators. Early DC generating plants needed to be within about 1.5 miles (2.4 km) of the farthest customer to avoid excessively large and expensive conductors.

4.2. Distribution network configurations:

Distribution networks are typically of two types, radial or interconnected. A radial network leaves the station and passes through the network area with no normal connection to any other supply. This is typical of long rural lines with isolated load areas. An interconnected network is generally found in more urban areas and will have multiple connections to other points of supply.

These points of connection are normally open but allow various configurations by the operating utility by closing and opening switches. Operation of these switches may be by remote control from a control centre or by a lineman.

Figure (5): Distribution network.

The benefit of the interconnected model is that in the event of a fault or required maintenance a small area of network can be isolated and the remainder kept on supply. Within these networks there may be a mix of overhead line construction utilizing traditional utility poles and wires and, increasingly, underground construction with cables and indoor or cabinet substations. Distribution feeders emanating from a substation are generally controlled by a circuit breaker which will open when a fault is detected. Automatic Circuit Reclosers may be installed to further segregate the feeder thus minimizing the impact of faults.

5. Case Study: Dowaan Valley Electricity:

5.1. Background:

Dowaan valley is a branch of Hadramout valley. Hadramout valley is located in the south of Arabian Peninsula in the eastern region of Yemen. Length of Hadramout valley is more 410Km for the major valley, so it is accounted as one of the longest valleys in the Arabian Peninsula (Had. Gov, 2010).

Most of Dowaan valley towns are located inside the valley, on the banks of the valley or speared in minor channels. Dowaan people preferred to life in the depth of valley because of availability of elements of agriculture such water and soil which are not available on the highland.

Dowaan valley electricity has three branches of high voltage line that covering all towns on the banks of the valley. The length of distribution network is approximately 90.807Km. The owner of Dowaan valley electricity is Abdullah Ahmed Bugshan.

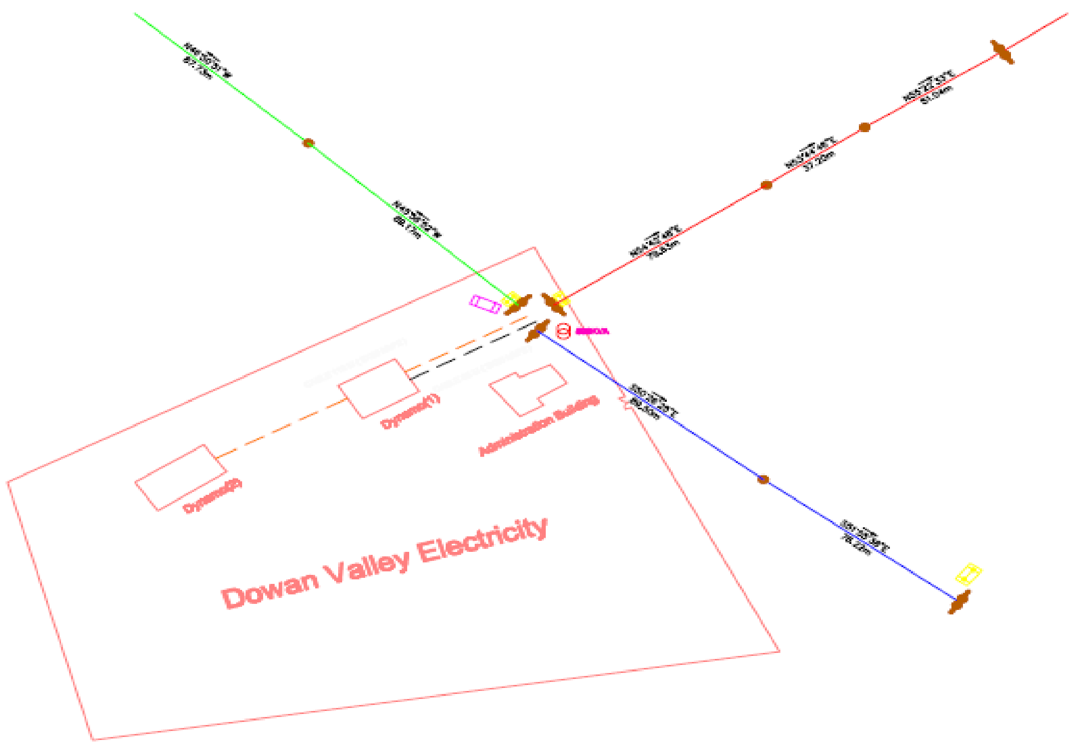


Figure (6): Dowaan Valley Electricity.

5.2. The Steps of Project

Step (1): Collection data:

The Global Positioning System (GPS) has become an essential tool for GIS users. It is very easy to use, portable and can locate the feature within millimeters to 10 meters. In this project, I used low cost, Magellan 315 type handheld GPS for collecting GPS data (Figure 2).
There is a wide variety of free and low cost software packages on the market, allows data communications between GPS receivers and your computer, including full data editing and storage options. My GPS is one of them and it is used in this study. More than 1000 points were collected at the Dowaan area. The points were collected while walking. But in this project, I used more than 100 points. The coordinates(x, y, and z) of the points were recorded in the GPS and the attributes of the high voltage line were obtained at the same time.

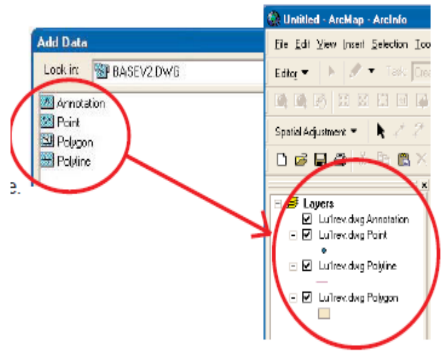
Figure (7): Handheld type GPS is used for this study (www.gpsnavigator4u.com/.../Magellan-Gps-315/).

Step (2): The preparation of plan:

The preparation of Dowaan Valley electricity plan was achieved by using programs such as Excel and Land development. First of all, I took the coordination data from GPS software and entered it to Excel. After that I cleaned the data and took x, y data. By using the importing command for points in land development, I entered the collected point from Excel. Finally, I connected all points by using ployline command; also I put all attributes of the high voltage line in this plan Fig (6).

Step (3): Converting dwgCad Files to GIS Shapefiles:

Depending on project needs, it may or may not be desirable to transfer the entire CAD drawing to GIS. By selecting only the elements on these layers and copying them to a new drawing, all unnecessary drawing elements will be left behind. Also, by using the *ERASE* command, delete all unwanted drawing elements - titleblocks, borders, legends, etc. Only the pertinent drawing elements to be transferred to the GIS database should remain. Then we can export cad data as shapefiles**.** When the blue CAD file is added to ArcMap, the file will be divided into data sets, based on the four types of GIS data: point, line, polygon, and annotation. Shapefiles can be created from the point, line, and polygon data sets.



Step (4): Entering the Maintenance Data:

For achieving this aim, I should use access relationship between tables. This aim was a challenge for me. In this project, I used one to many relationships between points table and Transformers table as shown in the fig (8).

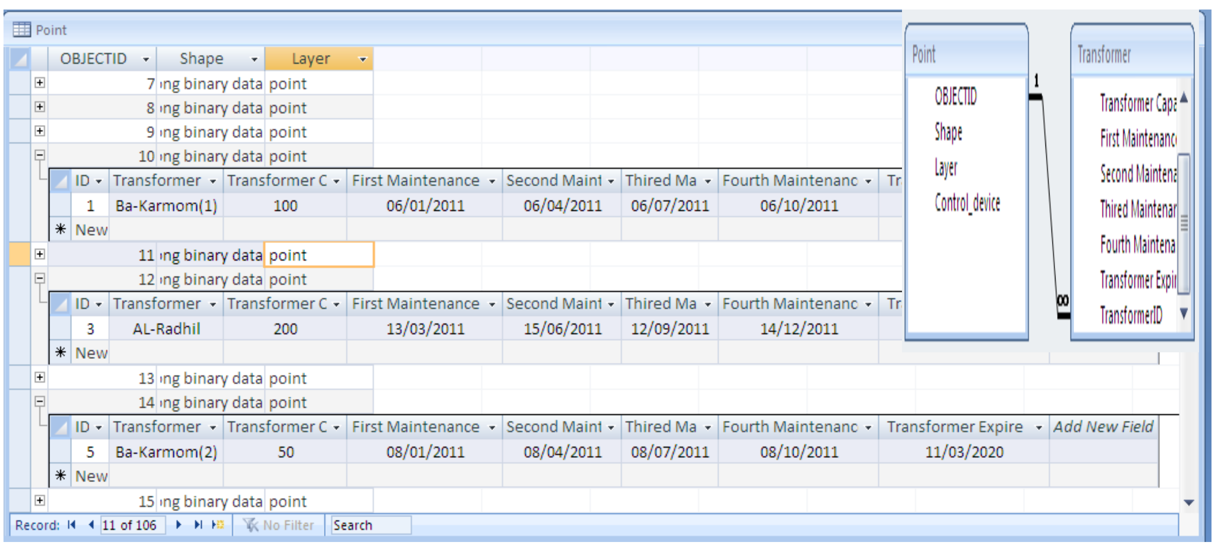
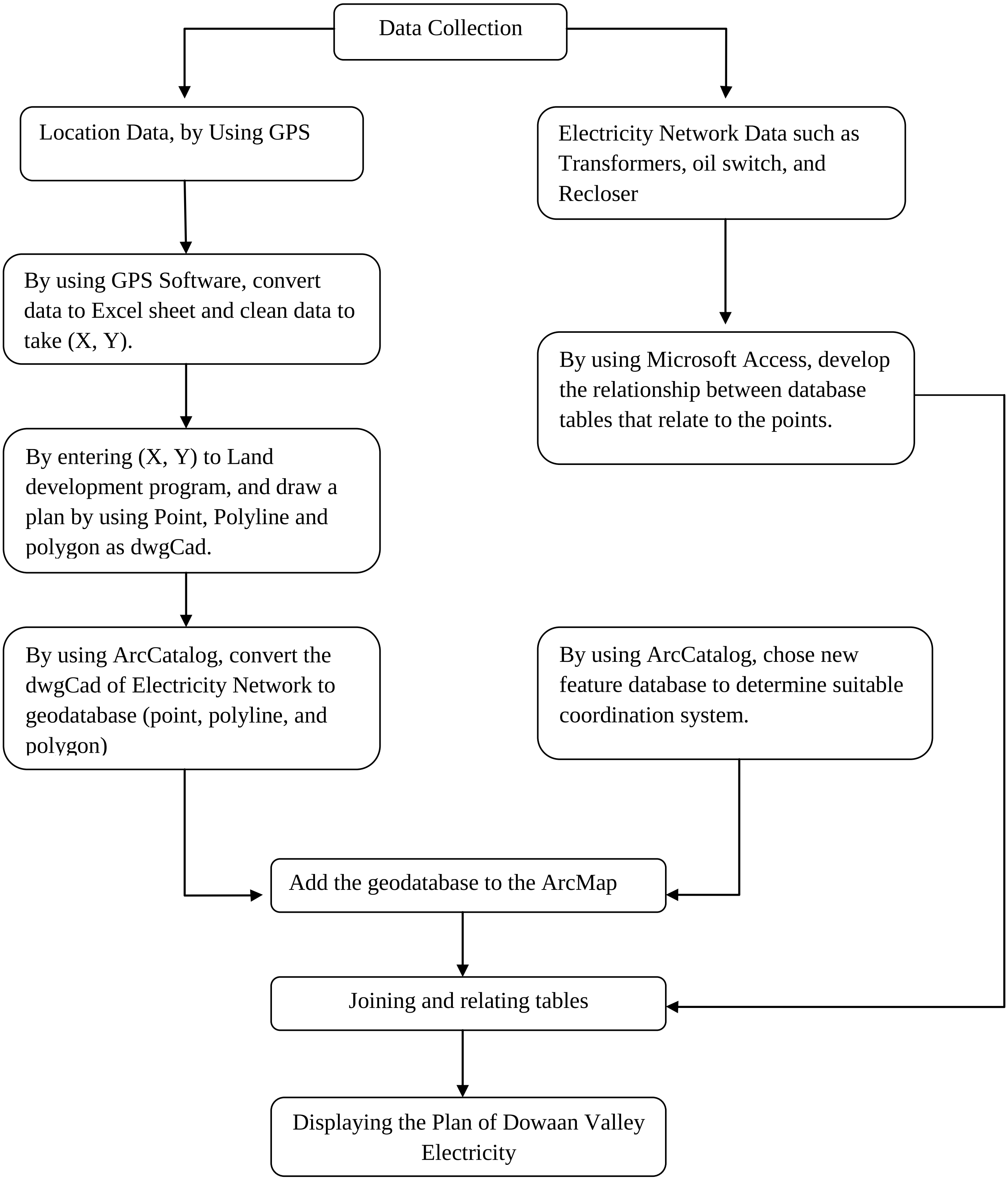


Figure (8): Entering the Maintenance Data

Figurer (9): Diagram Shows the Technical Steps and Application Necessary to Create Dowaan valley electricity.



6. Conclusion

The geographical information system (GIS) is not limited to a certain science or unique technology, but it has very extended branches of usage in a lot of the daily activities.

GIS technology has the ability to manage the information and represents it with various maps which allow for users to interact with it completely. GIS provides us to show all accumulated data which are stored in any format for long time as visible layers linked between location data and attributes.

GPS has three main components; the satellite system, the control system, and the users. Over 1.4 million civilian GPS receivers have been produced each year since 1997. The economic impact of GPS technology is significant, reaching $6.2 billion in 2000, with expectations of surpassing $50 billion by 2010.

Distribution networks are typically of two types, radial or interconnected. A radial network leaves the station and passes through the network area with no normal connection to any other supply and interconnected network is generally found in more urban areas and will have multiple connections to other points of supply.

In the future, I am going to put GIS map in Dowaan valley electricity because I would like to help people to avoid the dangers of electricity.

ACKNOWLEDGEMENT

I would like to thank Dr. Baqer M. Al-Ramadan (ARE Department), Dr. Talat. Bader (CE department), Eng. Omer. AL- Habeshy (project manager of Dowaan Electricity) for help and facilitates that made this term project possible.

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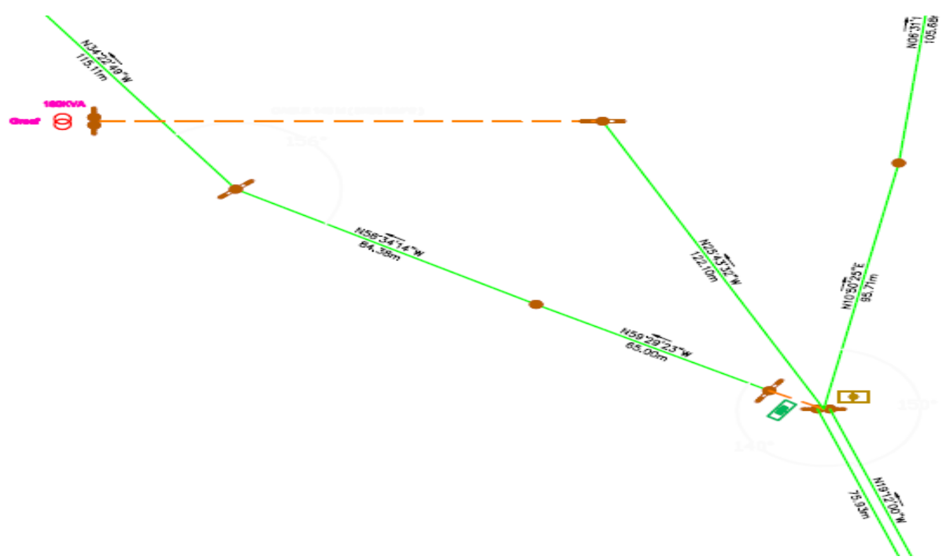
http:// www.gpsnavigator4u.com/.../Magellan-Gps-315/

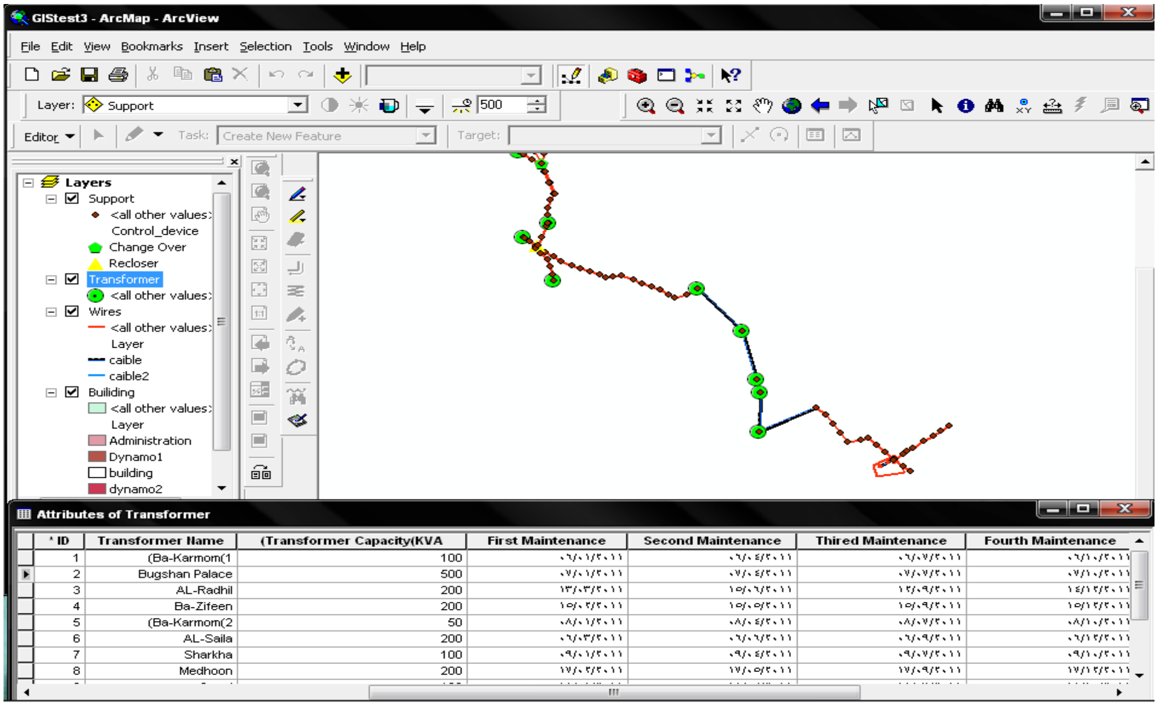
Appendix

1. This Figure shows that there is a long distance between countries. As result, there is no control for maintenance.

2. The high voltage line branches of Dowan valley electricity are displayed by dwgCad.

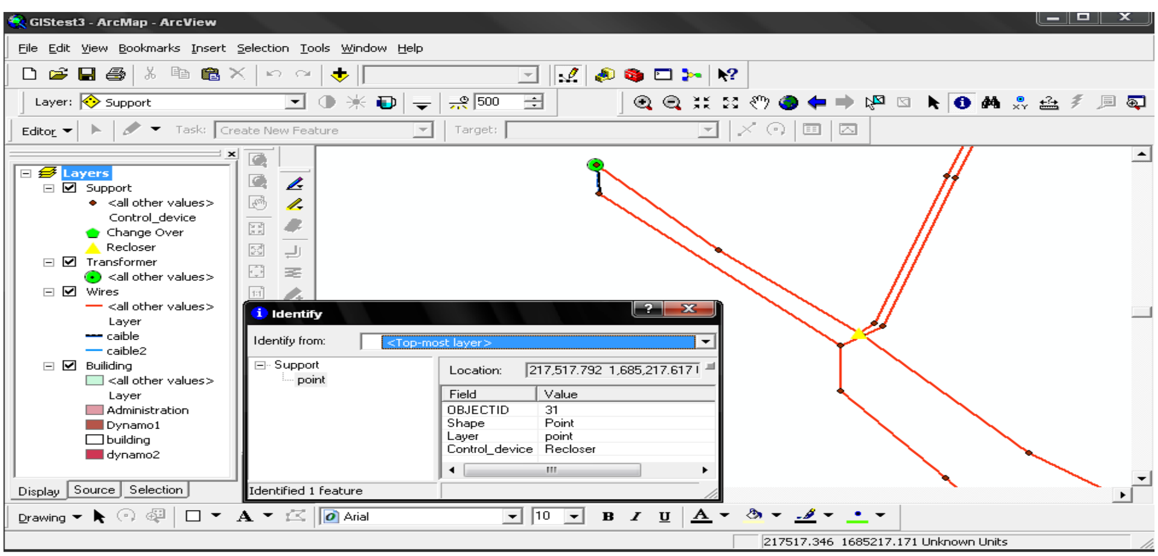


2. The attribute table is divided to different fields such as transformer name, transformer capacity, and first maintenance. etc.



ID	Transformer Name	(Transformer Capacity(KVA	First Maintenance	Second Maintenance	Thired Maintenance	Fourth Maintenance
1	(Ba-Karmom(1	100	٠٦/٠١/٢٠١١	٠٦/٠٤/٢٠١١	٠٦/٠٧/٢٠١١	٠٦/١٠/٢٠١١
2	Bugshan Palace	500	٠٧/٠١/٢٠١١	٠٧/٠٤/٢٠١١	٠٧/٠٧/٢٠١١	٠٧/١٠/٢٠١١
3	AL-Radhil	200	١٣/٠٣/٢٠١١	١٥/٠٦/٢٠١١	١٢/٠٩/٢٠١١	١٤/١٢/٢٠١١
4	Ba-Zifeen	200	١٥/٠٢/٢٠١١	١٥/٠٥/٢٠١١	١٥/٠٩/٢٠١١	١٥/١٢/٢٠١١
5	(Ba-Karmom(2	50	٠٨/٠١/٢٠١١	٠٨/٠٤/٢٠١١	٠٨/٠٧/٢٠١١	٠٨/١٠/٢٠١١
6	AL-Saila	200	٠٦/٠٣/٢٠١١	٠٦/٠٦/٢٠١١	٠٦/٠٩/٢٠١١	٠٦/١٢/٢٠١١
7	Sharkha	100	٠٩/٠١/٢٠١١	٠٩/٠٤/٢٠١١	٠٩/٠٧/٢٠١١	٠٩/١٠/٢٠١١
8	Medhoon	200	١٧/٠٢/٢٠١١	١٧/٠٥/٢٠١١	١٧/٠٩/٢٠١١	١٧/١٢/٢٠١١

3. This figure shows that how we can use Arcmap to find control advices such as Recloser in Dowaan valley electricity.



4. This figure shows that how we can use Arcmap to determine the information about cables in Dowaan valley electricity.