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Research Paper

GIS Visualization of electrical network in Kurdistan Region for smart phones

Engineering

KEYWORDS :

Ismael Khorshed Abdulrahman — Assistant Lecturer at: Hawler Polytechnic University, Erbil Technical Engineering College, Department of Information System Engineering, Erbil-Iraq

Salar Kheder Shaikhah — Assistant Lecturer at: Hawler Polytechnic University, Erbil Technical Engineering College, Department of Information System Engineering, Erbil-Iraq.

ABSTRACT

As the computer based models are getting more and more important in the electrical network's development plans, the need for intelligent and adaptive visualization increases. The desire to collect and display GIS data using mobile devices is increasing rapidly. The major reasons want to move to this model is its ease of use, the ability for end-users to collect data, and the ability to easily distribute data to the world and visualize these data on the mobile device.

The aim of this paper is to create the electrical network layers for Kurdistan region using GIS in a way that can be exported to a mobile smart phone to be visualized in offline state with all the details on the map. The GIS layers created for this study is 11kV distribution layer, 33kV and 132kV high voltage layers applied and tested on both Apple iOS and Android devices. While the GIS tool used for this integration is KML toolbox with the benefit of ArcMap functionalities.

1. Introduction

Information associated with electric network has traditionally been presented to the operator as numeric data on single line diagrams and by tabular list displays. This has been supported by a static mimic display in the control center with dynamic data shown by different lights. This relatively simple approach has sufficed the requirements of vertically integrated utilities in the pre-reforms era. With the restructuring of the power-sector, high growth rate and integration of market forces, visualization techniques need to be reviewed and enhanced [1].

GIS allows the spatial locations of the network assets to be shown visually, but relates that to other characteristics of the asset. We mean by network the lines, transformers, switches etc, i.e. all the constituting objects of the electrical supply system. The network database contains the descriptors of these objects, i.e. the important electrical properties, name, other properties (e.g. physical condition, age etc.), and the geographical coordinates describing their location. Besides the pure coordinates, it is common to include public premises data for easier location of the specific network part [2].

Maps provide a power visualization tool to the operator. Geographical maps have been superimposed with the transmission network. It is easier for the operator to locate information on a map and zoom in on an area of interest.

Since electric network are spread geographically, their spatial attributes should be taken into account. GIS provides a rich set of functions to view the electrical network superimposed on various layers and to explore the geospatial relations. In the process of system planning, it is crucial to provide correct information to people involved and help them understand the need for the additional power system facility. The most effective way to explain the new construction plan and its relationship with the environment is to display the plan on a geographic map. Together with the utilization of a database system, geographical representation of electric network will become an essential tool for utility decision makers and the public.

2. Existing situation of Electricity Network

The electricity transmission network in Northern Iraq is operated at 132kV. The main substations usually consist of 132/33kV two winding transformers and 132/33/11kV three winding transformers. There are several 33/11kV substations connected to each 132kV main substation via 33kV network. Medium voltage distribution is at 11kV, which is stepped down to 400V at distribution transformers. Power is then distributed to individual consumers via 400V low voltage distribution networks [3, 4].

The operators use single line diagrams interconnecting various busses to get an overview of the system. Single line diagrams display the most critical parameters and allow the operators to have a macro level view of the system. A single line diagram showing the high_voltage level network in Kurdistan Region separated in three different regions due to three governorates existing in the region is given in Figure 1. Each region is represented by a different color. The black color is referred to Sulaimaniya region, the red one is referred to Erbil region and the blue one represent the region of Duhok. The green color is the part of network that connects the two networks of Kurdistan and the rest region of Iraq. While Figure 2 displays the electrical distribution network (11kV) for Erbil governorate drawn by AutoCAD. The two diagrams have no geographically locations for their component.

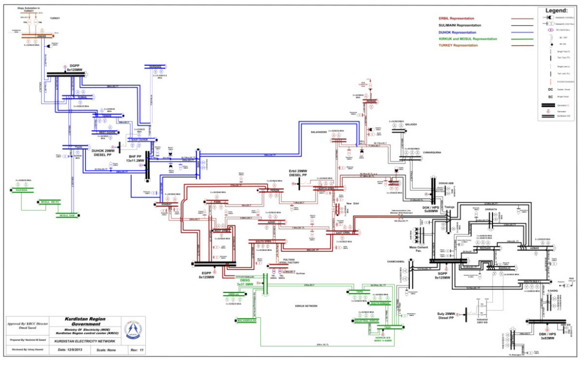

Figure 1 Single line diagram for Kurdistan regional power system

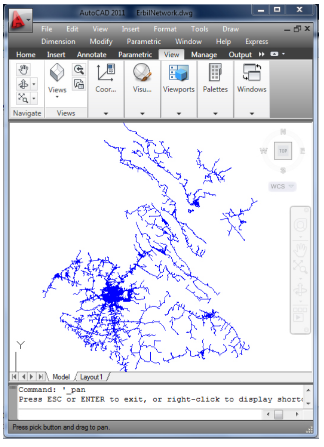

Figure 2 The electrical distribution system for Erbil governorate

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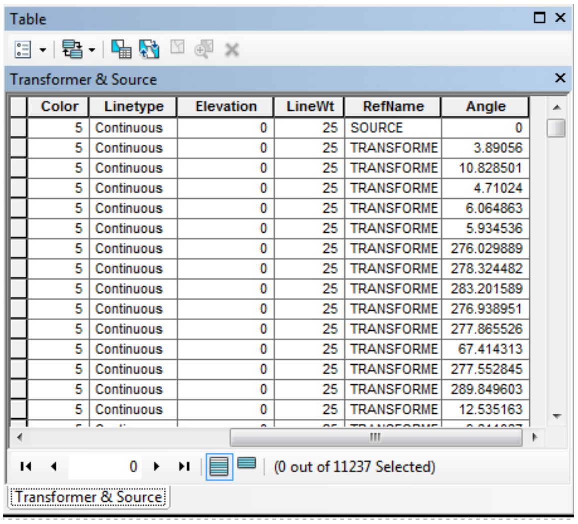

Color	Linetype	Elevation	LineWt	RefName	Angle
5	Continuous	0	25	SOURCE	0
5	Continuous	0	25	TRANSFORME	3.89056
5	Continuous	0	25	TRANSFORME	10.828501
5	Continuous	0	25	TRANSFORME	4.71024
5	Continuous	0	25	TRANSFORME	6.064863
5	Continuous	0	25	TRANSFORME	5.934536
5	Continuous	0	25	TRANSFORME	276.029889
5	Continuous	0	25	TRANSFORME	278.324482
5	Continuous	0	25	TRANSFORME	283.201589
5	Continuous	0	25	TRANSFORME	276.938951
5	Continuous	0	25	TRANSFORME	277.865526
5	Continuous	0	25	TRANSFORME	67.414313
5	Continuous	0	25	TRANSFORME	277.552845
5	Continuous	0	25	TRANSFORME	289.849603
5	Continuous	0	25	TRANSFORME	12.535163

Figure 3 Tabular Information for a part of Erbil electrical network

The tabular format and the single line diagrams present the information in text and numeric format. Tabular displays constitute some of the most important type of displays used by the operators. They are the most frequently referred to displays. A wide variety of information is displayed in tabular format for the operators such as transmission line, generations, voltages, schedule vs. actual values, frequency from different telemetered points, etc. Figure 3 shows tabular information for a part of Erbil distribution network. Detailed tabular displays pertaining to a particular control area are used as and when required by the operators. The texts on the displays use hyperlinks to lead to more detailed displays for the selected item. An advantage of presenting information in the tabular format is quick location of the desired information by the operator.

A crucial attribute of the data model is that it must also describe the relationship between each of the assets i.e. the relationship between transformer and feeder, between feeder and pole, etc. It is this relational design of the data model that give the planner the ability to structure queries that give far more information than a static map of their network could provide, and often far quicker [2].

3. Overview of Geographic Information Systems (GIS)

Environmental Systems Research Institute (ESRI), the world leader in Geographic Information Systems' technology, defines a GIS as "an arrangement of computer hardware, software, and geographic data that people interact with to integrate, analyze, and visualize data; identify relationships, patterns, and trends; and find solutions to problems. The system is designed to capture, store, update, manipulate, analyze, and display the geographic information. A GIS is typically used to represent maps as data layers that can be studied and used to perform analyses." [5].

Broadly speaking Geographic Information Systems (GIS) are tools for the management of geographical information; for spatial analysis and the visualization of this information. For an electricity network this means having a system which allows the geospatial relationships of critical assets such as transformers, lines, and cables to be presented to planners and operational staff alike GIS allows them to view, understand, query, interpret, and visualize this data in many ways that reveal relationships, patterns, and trends in the form of maps, reports and charts [2].

Geographical Information System has come as the boon to solve many problems in the electric power system where demographical and geographical spread are the root cause of problem. It is one of the most effective visualization techniques that used for mapping and analyzing data. For an electricity network this means having a system which allows the geo-spatial relationships of critical assets such as transformers, lines, and cables to be presented to planners and operational staff alike. GIS allows them to view, understand, query, interpret, and visualize this data in many ways that reveal relationships, patterns, and trends in the form of maps, reports and charts. Also, GIS provides seamless environment for applications like load flow, transient stability, short circuit analysis and load forecasting.

Figure 4 displays all 11kV feeders in Erbil governorate geographically including transformers, poles, switches and capacitor banks. While Figure 5 illustrates the high voltage 132kV and 33kV network for Kurdistan region. All the tower locations are collected and placed geographically with all the substations.
The red color refers to 33kV towers while the blue color represents 132kV towers. The attribute data are appended and the figure shows two dropped data on the tower position; the tower height and the location height on the sea level. Many other data are appended and can be displayed on the map.

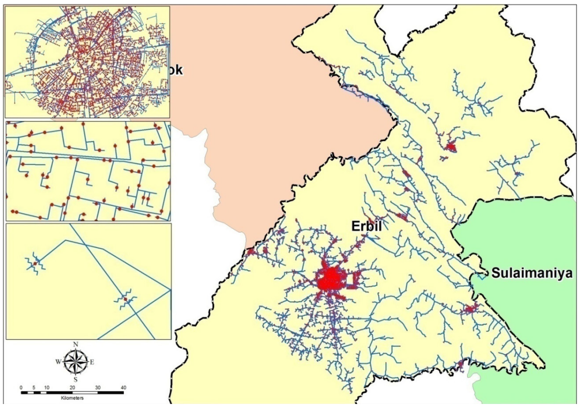

Figure 4 displays all 11kV feeders in Erbil governorate geographically

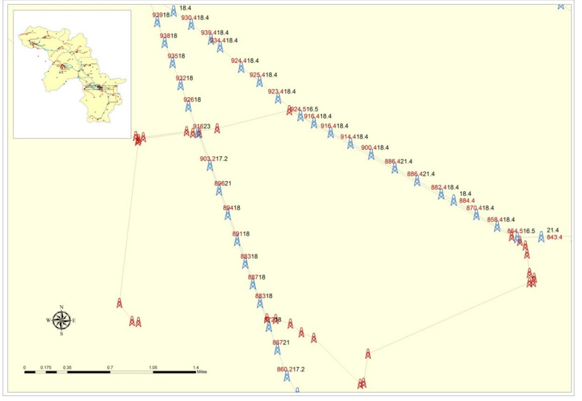

Figure 5 illustrates the high voltage 132kV and 33kV network for Kurdistan region

4. GIS Modeling of Kurdistan Electric Network

At its simplest, the data model is the structure of an asset database. This may include electrical characteristics such as rating and voltage, but may also include physical properties such as dimensions, age, manufacturer, and importantly, geographical location .

Some data needs georeferencing of its objects before they used by the model. The Georeferencing toolbar is used to georeference raster and CAD data. Georeferencing is the process of spatially adjusting a raster and CAD drawing without actually changing the original source data. In ArcGIS for Desktop this is performed by registering arbitrary points in the CAD drawing to known geographic coordinates. Once you have georeferenced a CAD dataset, subsequent ArcMap sessions transform the dataset in memory on the fly while the source data remains unchanged on disk [6].

In the preparation of network maps, a digital map for Kurdistan Region is used by ArcGIS 10.1 software as the base map. Coordinates of various network locations such as stations, substation, transformer, pole and tower locations are verified through GPS readings and the existing map.

The following coordinate system is used in all the mapping works;

Projection: Universal Transverse Mercator (UTM)

Grid : WGS84

Zone : UTM Zone 38, Northern Hemisphere (WGS84)

4.1 Network Modeling Procedure

The first step to build the GIS system is constructing the single line diagram using ArcMap tools with the extension of shapefile. ESRI defines a shapefile as "a vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

Once the shapefiles were produced, each feature had a record containing locational information and its unique name. These shapefiles were used to build the final geodatabase. Figure 5 illustrates the procedure of building single line diagram in GIS.

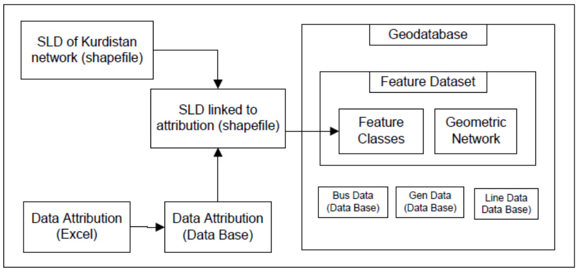

Figure 6 Procedure of building the single line diagram of Kurdistan network by GIS

The second step in building the GIS model is incorporating tabular attribution from the result spreadsheets to allow operability in the GIS software. Since this attribution already is existed in tabular format within Excel, it is therefore exported from .xls to dBASE format then easily "joined" to the respective shapefile's database according to the unique identifier. Once the dBASE files are imported into the GIS, they are joined based on unique identifiers.

4.2 Building the geodatabase

The real features of a GIS come from the data model and geodataset that hold the key data about the network. It is the design of this model, and the collection of the geodataset, that form the bulk of this phase of implementation [2].

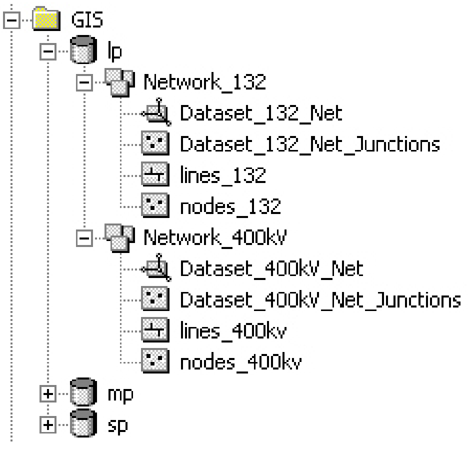

Figure 7 The structure of the geodatabase

Geodatabase is a virtual "container" for various types of information relevant to a GIS. It provides an organizational structure for a variety of data sources and provides a level of intelligence to help in managing this information. In addition to assisting data management, a geodatabase also extends GIS functionality [7].

In this research, The shapefiles that represented the network nodes and lines are exported to individual feature classes using ESRI tools. After that, they were loaded into the geodatabase. Once the basic layers resided in the geodatabase, feature datasets were created. The feature dataset is another level of organizational structure that allows the added functionality of network building and strictly enforces the precision of grouped, spatial datasets. This procedure of building a geodatabase is applied on all networks that included in this paper, high voltage 132kV network and 11kV distribution network. Figure 7 displays the exact structure of the geodatabase utilized in this paper.

5. ArcGIS-Google Earth Integration

ArcGIS desktop applications and the geodatabase can be used to define, manage, and create KML content. KML (Keyhole Markup Language) is an XML-based language for defining the display of three-dimensional spatial data in the program Google Earth. Most KML elements can be opened to display information about themselves, particularly their name and description [8].

Google Maps, Google Mobile Maps, and Google Earth use keyhole mark-up language (KML) to store spatial coordinate and feature attribute information. KMZ is a zipped (compressed) form of KML, allowing storage of information from several KML files in a single archive. To move map data to or from ArcGIS to Google Maps/Earth, ESRI shapefiles/feature classes must be translated to KML or vice-versa [9].

The ArcGIS KML layer treats the KML document as read-only information.

For this paper, KML files that were created in shapefiles are used with the ArcMap KML tools in toolbox. The ArcMap Toolbox made KML file does a nice job of formatting the attribute table as seen here.

Figures 8 and Figure 9 display the medium voltage network for Erbil governorate that exported from ArcGIS to Google Earth as KML layers. This involves all data associated with these layers as shown in the figure. While Figures 10 and 11 show the high voltage network (132kV and 33kV levels) for Kurdistan region including all the exact locations of the towers. Figure 11 shows how the detailed attribute data can be displayed just clicking on any point on the network to show the relevant data of that point.

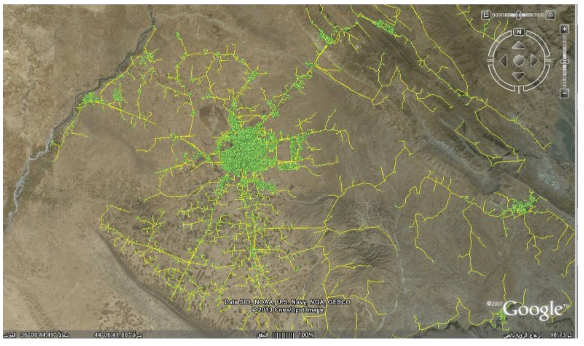

Figure 8 GIS layer for the medium voltage network for Erbil

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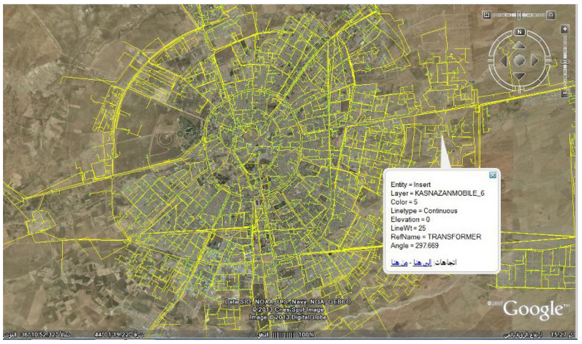


Figure 9 GIS layer for the medium voltage network for Erbil (Zoomed)

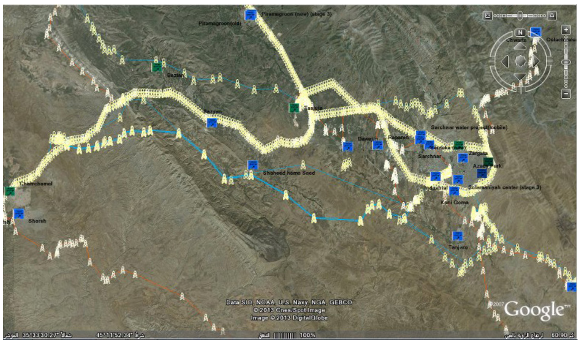


Figure 10 GIS layer for the high voltage network for Kurdistan region

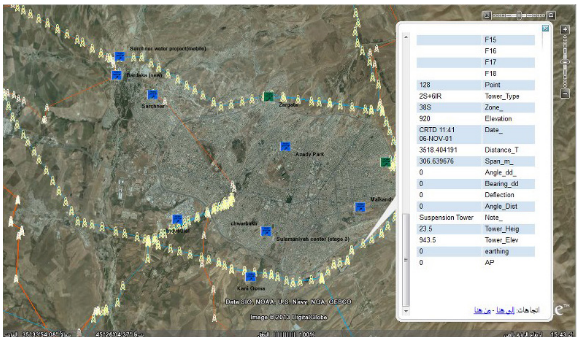


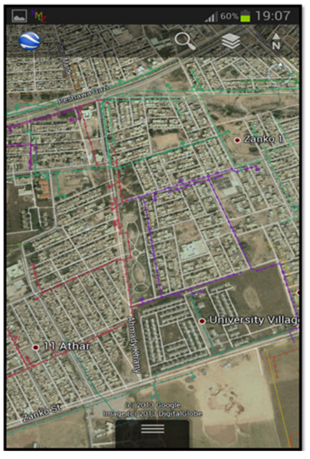
Figure 11 GIS layer for the high voltage network for Kurdistan region (Zoomed)

6. Mobile GIS Solutions

Attribute data is stored by feature, and changed fields flagged. This solution will serve both online and offline needs. The mobile GIS app is also cross platform, meaning it will run across multiple devices; Apple iOS, Android and Blackberry. ESRI are gearing up to add offline viewing and editing capabilities within ArcGIS, just for mobile apps. An issue we often get questions about relates to offline GIS and mapping. How do we take our mobile device into an area which lacks WI-FI connectivity and still be able to access base maps and our layers? How does a true GIS mobile app allow non WI-FI connected users to visualize layers in ArcGIS? base maps tiles loaded onto a mobile device for offline use are no problem. How do we store this in offline mode? The obvious choice is a shapefile. So this spatial layer entity can be stored on the device and loaded when required [10].

The growing proliferation of mobile devices and the displaying of GIS data on the web have been changing the GIS industry. The desire of organizations to collect GIS data using mobile devices and to display that data on the web is increasing rapidly. The major reasons organizations want to move to this model is its ease of use, the ability for end-users to collect data, and the ability to easily distribute data to the world [11].

Using KML Files Detailed Instructions Several of the data collection and display solutions discussed in this paper use KML files in some capacity. The iOS Mobile App for Google Earth can also display created KML files by first loading the KML into "My Maps" through Google Maps then opening "My Maps" within the iOS Earth App. At this time the Android App for Google Earth cannot display custom KML files. Google Maps While it is used less frequently, KML files can also be displayed as a layer in Google Maps. There are two main ways to display a KML file within a Google Map. The first is to import the KML into "My Places" in Google Maps after signing into a Google account. Once Imported the KML can be turned on and off as a layer in Google Maps anytime the user are logged in. The second way is to post the KML to a website then create a Google Maps URL that points to this file. The format of the URL is http://maps.google.com/?q=[URL to KML]. If a website is not available the KML file can be stored in Google Fusion Tables. Once stored in a Fusion Table the Fusion Tables mapping interface can be used or the direct access URL to a KML version of the stored table supplied by Google Fusion Tables can be used to build a Google Maps URL using the format above. Google Maps has full integration with the mobile device built-in GPS allowing full turn by turn directions to be given as the device moves in live time. Any features added in a custom KML file can also take advantage of this routing. It allows the user to view satellite imagery and street views [11]. Figures 12 and 13 are representing the work out of this paper. The first one is tested on Android mobile device (Samsung Galaxy III). While the Figures from 14 to 17 are screen-captured from Apple iOS device (iPhone 5) for distribution system.



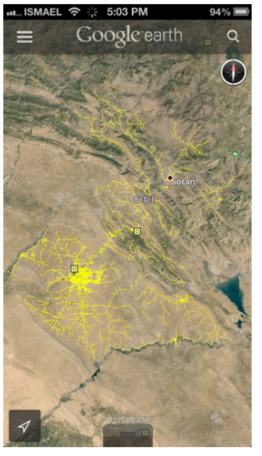


Figure 13 GIS layer by Android device (Galaxy S3)
Figure 12 GIS layer by Apple device (iPhone 5)

Figure 15 **Figure 14**

Figure 16 **Figure 17**

The figures 18 and 19 are referred to high voltage 132kV and 33kV system in Kurdistan. The window is zoomed to show more details on the network to visualize the ring area of Sulaimaniya region. The data are entered to ArcGIS for every tower and substation's location with their details then the GIS modeling for the smart phone is built. The yellow color for the towers and blue line refer to 132kV network while the white color for the tower and red line are regarding the 33kV layer.

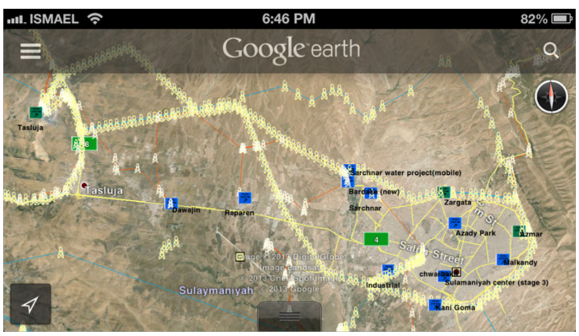


Figure 18

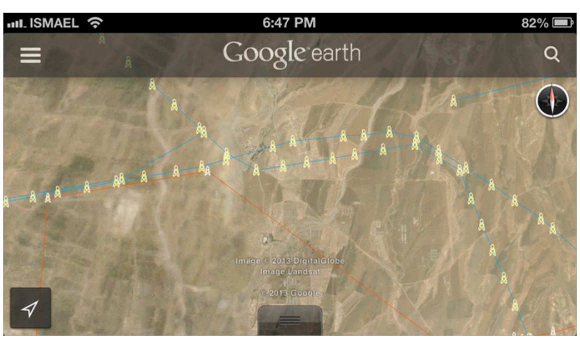
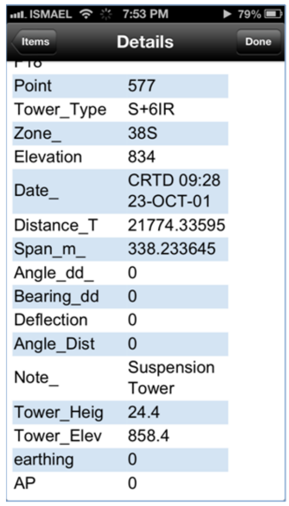


Figure 19

Figure 20 and 21 show the attribute details of a part of the electrical network of Kurdistan region. It can be easily getting these details by one clicking on any part of the layer on the mobile screen area.



Point	577
Tower_Type	S+6IR
Zone_	38S
Elevation	834
Date_	CRTD 09:28 23-OCT-01
Distance_T	21774.33595
Span_m_	338.233645
Angle_dd_	0
Bearing_dd	0
Deflection	0
Angle_Dist	0
Note_	Suspension Tower
Tower_Heig	24.4
Tower_Elev	858.4
earthing	0
AP	0

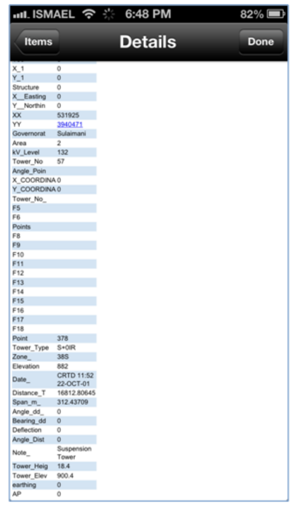


Figure 21 **Figure 20**

7. Conclusion

The Mobile GIS solution serves both online and offline needs. It can be run across multiple devices; Apple iOS and Android. It is easier for the operator to locate information on a map and zoom in on an area of interest. GIS is a good tool used for visualizing the attribute data of the electrical networks on a digital map in multi layers for Kurdistan region. The single line diagram of electrical network can be mapped with different layers according to their different voltage levels with deferent voltage levels (11kV, 33kV and 132kV). Exporting these GIS layers with the integration of Google Earth and Google Map by creating KML layers is a vital way to access these data by portable mobile or tablet devices. Shapefile is the obvious choice to create the KML files in ArcGIS to allow non WI-FI connected users to visualize layers on the map.

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