Chapter 6: Conclusion and Recommendations

Introduction

The aim of this chapter is to conclude the research and to determine if the research question and the objectives set for this research were met. In order to do so, each chapter that contributed to the final result of this project is evaluated.

The aim of this project is to design and develop a 3D data model to provide a management system for electrical utilities inside buildings. The 3D model should prove to be a useful system providing integrated information between different electrical components forming the network inside the specified buildings in the study area. The model should provide a realistic 3D view of electrical utilities. Possibilities of 3D analysis have to be researched to determine to what extent it can be performed (see section 1.2).

The objectives set for this research project in section 1.2 is:

- To obtain the necessary knowledge through the literature review.
- To collect the relevant data.
- To design and develop a 3D data model.
- To test the 3D analysis and query capabilities of the 3D data model.

6.1 Obtaining the necessary knowledge through the literature review

The literature review provides insight and confirmation that a geographical information system such as ArcGIS10 has the capabilities to obtain the goals set for this project. It is evident that the applications of ArcGIS10 software can be used for the management of utilities in urban environments. Different map projections were compared that lead to the use of a suitable projection to digitize features. Harder (1999) stated that the integration of geography with electrical networks can be beneficial due to the fact that electrical operations take place at specific locations. Therefore a spatially referenced database will allow users to find the locations of electrical utilities and view information about them.

One of the important steps to make this project successful was to find ways to integrate CAD data with ArcGIS10 to view data about electrical utilities and reference the data over a predefined satellite image. The literature showed that it is possible to combine CAD data with ArcGIS10 software and to reference the data according to a coordinate system.

In order to build an effective geodatabase, it is needed to follow a carefully structured design framework. The literature compared different design steps from various authors to find the best suited design framework for this research project (see section 2.4.2). A decision was made to use the ten steps to designing geodatabases as proposed by Actur and Zeiler (2004).

The literature also made it clear that a GIS data model can serve as a storing system containing spatial data. This spatial data is composed of raster and vector features representing the electrical utilities on campus. The user can create, store and manipulate spatial data by means of subtypes, domains, relationship classes, topology rules and analysis capabilities presented by the GIS software. The geodatabase provides an organizational structure ideal for the management of very large datasets in an integrated and continuous environment. Davis and Rich (2010) explained that it is possible to do feature modelling inside buildings through the integration of CAD and GIS (see section 2.7). The network model has the capabilities to serve as an effective tool in planning operations to decrease cost and improve productivity.

This project relied greatly on the abilities of ArcGIS10 to view features in 3D. The literature made it clear that ArcGIS10 has significant improvements in 3D which is more user-friendly. The electrical network running through the two buildings can be modelled by means of vertical connections, z-values in geometry, network datasets and the use of options provided in the “Network Analyst” toolbar.

6.2 Design and develop a 3D data model

The basic structure of the design chapter was formed around the conceptual and logical design phases proposed by Actur and Zeiler (2004). Further investigation identified the exact needs for a GIS to be used by the building managers. An effective design cannot be done without consulting electrical and building managers to obtain ideas in which the data model can manage utilities properly. After obtaining relevant ideas and comparing different database designs, key thematic layers were identified forming the basic framework to build the information system based on the requirements for the network. The case study by Mandloi (2007) provided an important insight that lead to the final design of the PUK geodatabase (see section 2.11). Relevant attribute fields were determined through interviews and discussions with De Beer (2011a) at the technical department of the Potchefstroom campus. These interviews provided sufficient information about which components to model for the electrical network as well as their associated attribute fields that has to be listed to provide descriptive information. The interviews also provided insight to the different functions and operations performed by each electrical feature.

Database integrity is ensured through subtypes and domains. The connections between the various electrical features were established by means of relationship classes. This enables the user to view the attributes of the features in relation with other features by means of the "Identify" tool. When digitizing features from the various base data, human error can cause problems in the functionality between features. Therefore, topology rules are used to identify and correct human errors.

6.3 Collect the relevant data

The methodology and implementation chapter started off by describing the process of collecting the relevant data in which the objective for data collection was achieved (see section 4.1). A list of required data was send to the building manager responsible and the technical department of the Potchefstroom campus. Chapter 4 made it clear that some of the required data was difficult to obtain or not available due to the age of the buildings. A second contributing factor was that many persons were responsible for the management of the electrical utilities inside the buildings over the years. No effort was made to store important information. This determined that there is a need for a centralized storage system to contain the necessary data. The result of this was that most of the data had to be assumed during the digitizing process. This is also a contributing factor in resulting that the PUK geodatabase can only be used as a prototype model because of the lack of sufficient up to date information. The available data retrieved from the building and electrical managers were either outdated or incomplete.

The available data was obtained and Chapter 4 described the various methods in which the data was utilized to build the end product called the PUK geodatabase. Reasons were presented why some decisions had to be made due to limited resources. Various errors became evident during the digitizing and database design process. The process of handling these errors and making exceptions were documented in Chapter 3 and 4.

6.4 Test the 3D analysis and query capabilities of the 3D data model

The analysis and results chapter proved that the PUK geodatabase has 3D analysis capabilities useful to a building manager. Chapter 5 illustrated that 3D network analysis using a network dataset is possible through tools like:

- Determining the shortest route between features.
- Finding the closest facilities from a feature in the planning process to install new utilities in order to reduce the costs.
- Viewing which electrical features are connected to other features by means of the "Location-Allocation" tool in scenarios where there is a failure on the network.

Chapter 5 also illustrated that relevant query selection could be made to assist the building manager to extract information and view the results in 3D inside ArcScene10 (see section 5.4).

Chapter 5 showed that the aim for this project was met. The literature, design, methods, implementation, analysis and results presented in this thesis provided insight to accomplish the aim set for this research project (see section 1.2). Looking at the objectives that were met, it can be stated that the 3D PUK geodatabase model provided a management system for electrical utilities inside buildings E4 and E6. The analysis and results chapter provided examples to prove that this system is useful to a building manager. The research indicated that electrical features can be viewed in an effective manner in ArcScene10. The examples of the analysis capabilities illustrated the extent in which 3D analysis can be done on the prototype geodatabase. This thesis proved GIS software can be used as an information and storage system with analysis capabilities to assist in the management of electrical utilities on various floors of a building.

6.5 Recommendations

It could be very useful to determine the data availability for the features to be modelled before attempting a project with a similar topic. Valuable time was wasted trying to locate and find relevant data useful for this project. The end result was that most of the data had to be guessed and assumed which resulted in a model that can only be implemented as a prototype.

During the digitizing process, it was clear that vertical lines do not support shape length fields. The field value of a vertical line in an attribute table is a value of zero. This obstacle is the reason why ArcGIS10 cannot yet be used for precision data entry for building planning and designs where CAD software is used in most cases. New technology and future research may enable the measurement of vertical lines resulting in ArcGIS10 begin used for precision data entry to allow this software to be used in building drawings and designs in 3D. This would mean that ArcGIS10 software could be an effective building design and management system.

Tracing analysis in 3D would be a very effective tool to find connected features upstream in the network from a certain point. This would be useful to a building manager to locate a problem on the electrical network in case of emergencies. When conducting further research on this topic, the possibilities of tracing analysis must be explored. New technology may allow tracing analysis in 3D. Topology rules can also be investigated to determine if future technology will allow geodatabase integrity in 3D.

The PUK geodatabase is designed in such a way to allow for further expansion. The model has the ability to add more buildings with their own electrical networks. Further research should aim to expand this project so that the end result may be a connected system of all the buildings and their electrical networks across the entire campus.

Further research can be conducted to link different infrastructures in a single geodatabase. An example can be to link the sewage, storm water, drinking water, information technology and electricity together and allow these datasets to share the same topology rules, network datasets, geometric networks and relationship classes. The result should be an integrated system containing all the different infrastructure datasets across campus.

Should the idea of linking the different infrastructure feature datasets together fail, possibilities can be investigated to determine if future technology can allow several geodatabases to link to each other to integrate the various infrastructures.

The development of Python scripts can be investigated to determine if relevant selections can be implemented into the PUK geodatabase. A Python script using the “SUBSTR” function in a “WHERE” clause can determine and select which distribution boards are connected to which plugs through the use of the “Unique ID” field values. It can be assembled into a toolbox and stored in ArcToolbox to be used in Modelbuilder. The tool can be manipulated to use a “WHERE” clause and the “SUBSTR” function to select the needed features, for example, identifying which distribution board supplies electrical power the which plugs in which rooms. A layer must then be created in Modelbuilder from the selected features to view the result in 3D.