

Chapter 5: Analysis and Results

Introduction

The previous chapters completed the ten steps to designing geodatabases as described by Actur and Zeiler (2004). The different approaches, methods and implementation that lead to the final design of the project were explained.

This chapter aims to prove the usefulness of this prototype geodatabase to a building manager responsible for maintaining and keeping up to date information about the electrical network in the study area. The viewing and analysis capabilities of the geodatabase relevant to this study are explained through illustrations and discussions. The prototype model which can serve as a management system is designed in such a way to allow for further expansion in case new buildings are added. This model may also form a basis on which further research can be conducted in the future. The analysis examples in this chapter aim to provide the building manager with ideas to implement this geodatabase in order to solve electrical network problems.

The result of this research project is the prototype PUK geodatabase presented on a CD attached to the thesis. Chapter 5 guides the user through each of the analysis capabilities relevant to this study.

5.1 Building management

This prototype PUK geodatabase should prove to be an effective tool to manage the electrical network of certain buildings. The person using this model should have the basic knowledge to view features and attributes as well as to perform queries to extract information from the PUK geodatabase. This model has the potential to assist a building manager in a variety of ways. Table 5.1 illustrates the basic capabilities that can prove to be useful to a building manager:

Table 5.1: Basic capabilities of the PUK Geodatabase

Geodatabase capabilities	Method
View the geodatabase features in 3D.	Visualization in ArcScene10
Identify the locations of the electrical utilities inside the buildings.	Identify tool
Obtain updated information about the electrical utilities by viewing the attribute tables.	Identify tool and Attribute tables
View general information about the zones, buildings and rooms inside the buildings.	Identify tool and Attribute tables
Use the Unique ID's of the electrical utilities to locate specific features.	Select by Attributes
Determine the location of features within a distance from other features.	Select by Location
Obtain information regarding the contractor personnel who did maintenance on the network.	List of contractors
Keep record of maintenance done on certain features of the electrical network.	Maintenance table
View contact information about owners of specific offices.	Owners Table
View related information between attribute tables.	Related table tool
Determine the shortest route between features	Route model
Find the closest facility when new installments have to be made.	Closest facility tool
Determine which distribution board supplies electricity to which plugs through tracing analysis.	Location-allocation tool
Determine which distribution station feeders and transformers supplies which distribution boards in a building through tracing analysis.	Location-allocation tool

5.2 Visualization of features in ArcScene10

The 3D visualization capabilities of ArcScene10 are a very important aspect of this research project. The electrical utilities forming a connected network between the different floor levels of a building can't be viewed effectively in two dimensions. Therefore ArcScene10 enables the user to view features containing z values in their geometry. The 3D visualization enables the user to view:

- Vertical connections between cables and utilities.
- The different floors of a building from the sub level to the highest level.
- The different building outlines in extruded form through a calculation of the "Number of floors" field as described in Figure 5.1 and 5.2.
- The location of the steps on the different floors inside the buildings.
- Different room outlines on the floor levels.
- The locations of the electrical cables running from the Main Sub Station Feeder to the utility endpoints inside the rooms.
- Main Sub Station Feeders, Distribution Station Feeders and Distribution Station Transformers outside the buildings along with the cable connections between them.
- The connected utility endpoints and distribution boards on the different floor levels.

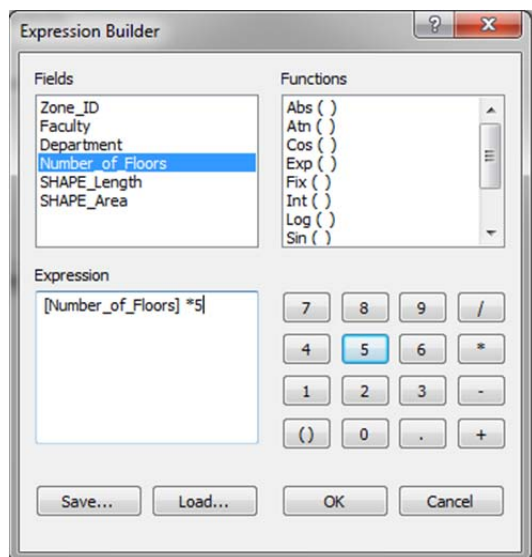


Figure 5.1: Calculating the extrusion for the PUK Buildings feature class.

This calculation performed in the “Expression Builder” window extrudes the floors of the PUK Buildings feature class with an increment of 5 to view the true form of the buildings in the study area as illustrated in Figure 5.2. The transparency is set to 60% to enable the user to view the floors inside the buildings.

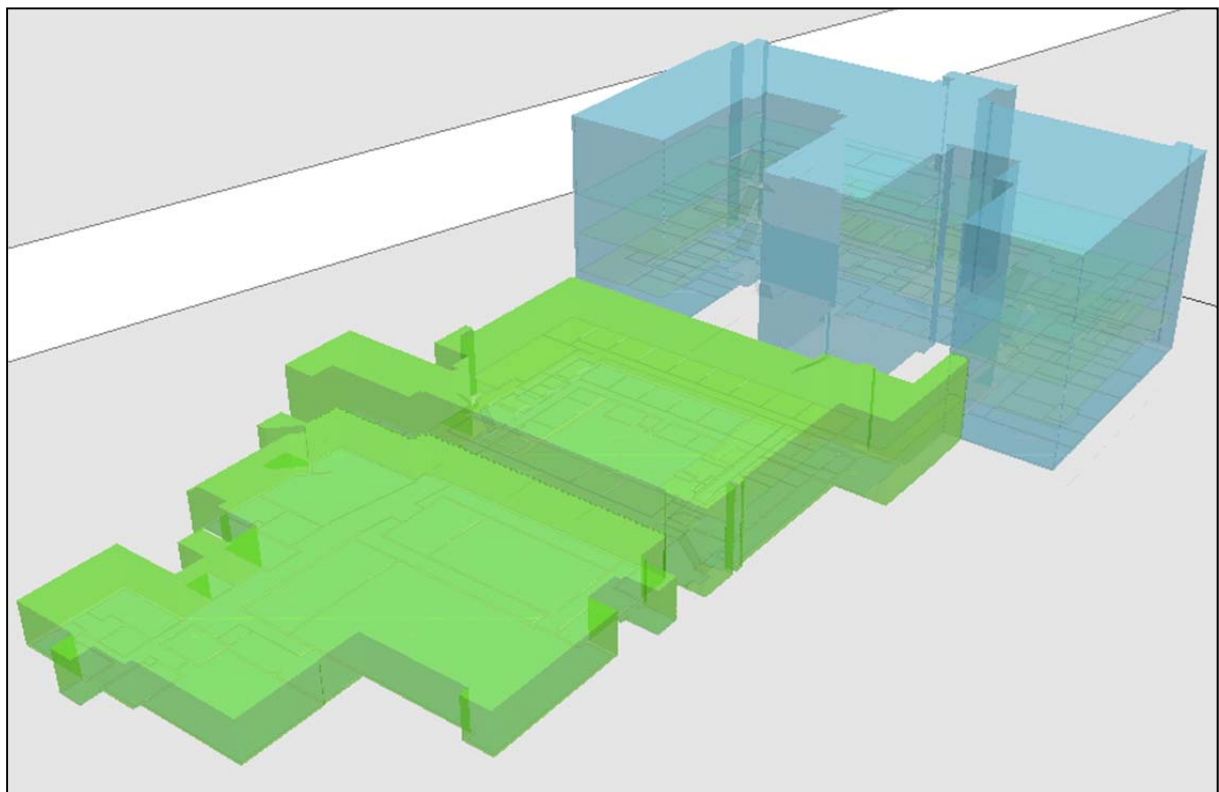


Figure 5.2: Extrusion of the PUK Buildings feature class.

5.3 Identify/Information tool

The Identify option in the “Tools” toolbar illustrated in Figure 5.3 can be used to view the attributes of a specific feature. This tool can also be used to view all the relationships between the specific feature selected and other features connected.



Figure 5.3: The identify option on the “Tools” toolbar.

The “Identify tool” opens a window called the “Identify Results” window. This window displays the identified features along with the first non-default field in their attribute tables. The window also shows the location of the selected feature by means of coordinates. After selection the features selected are displayed on the left hand side of the window and the attributes of the features are displayed on the right hand side.

The different relationship classes can be viewed by expanding the selected features on the left hand side of the “Identify results” window. This is done by clicking on the “Plus” sign beneath the specified feature. All the relationship classes will become visible showing the specific feature classes connected. The attributes of these connected features can be viewed by expanding and clicking on the primary and foreign key values used to make the connections. This can be repeated until the last relationship class is viewed as described in Figure 5.4.

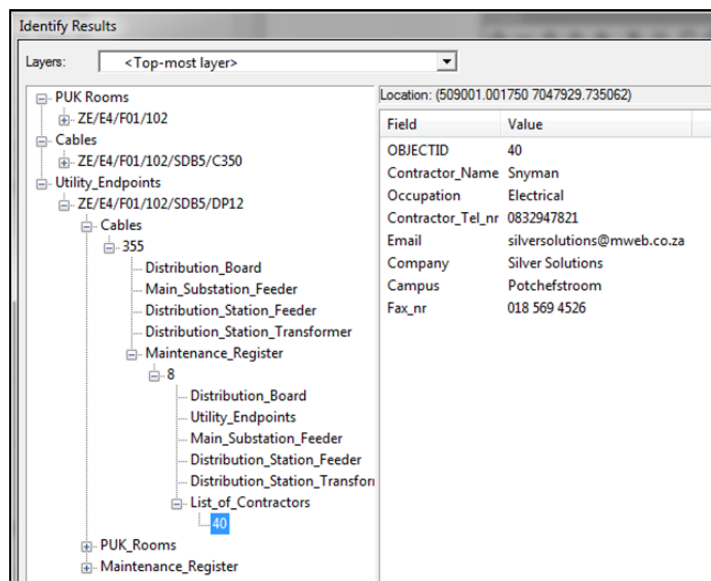


Figure 5.4: Identify results window displaying expanded features.

The “Identify tool” is a very useful tool to view the information and relationships between different features in the PUK geodatabase.

5.4 SQL selections

5.4.1 Select by Attributes

Specific selections can be made by means of the “Select by Attributes” and “Select by Location” options under the “Selection” tab. If the user understands the unique id given to each feature, easy selections can be made to find specific features in the PUK geodatabase. A plug inside a specific room, for example, can be found using the unique id value for that plug as described in Figure 5.5.

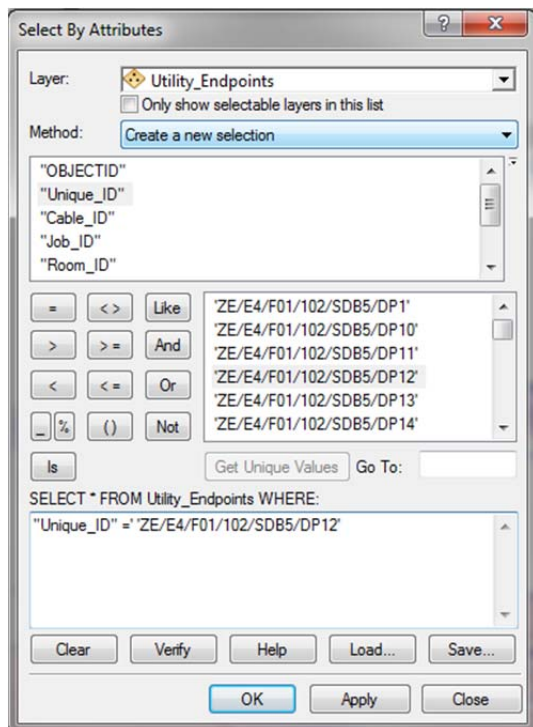


Figure 5.5: Finding a specific plug by means of the “Select by Attributes” option.

A variety of attribute selections can be made using this option for example:

In some cases the phase inside the distribution board that supports all the electrical utilities connected to it may fail. It is useful to the user to run an attribute selection query to determine which electrical features are connected to that specific phase to view the affected areas on the floor level as described in Figure 5.6.

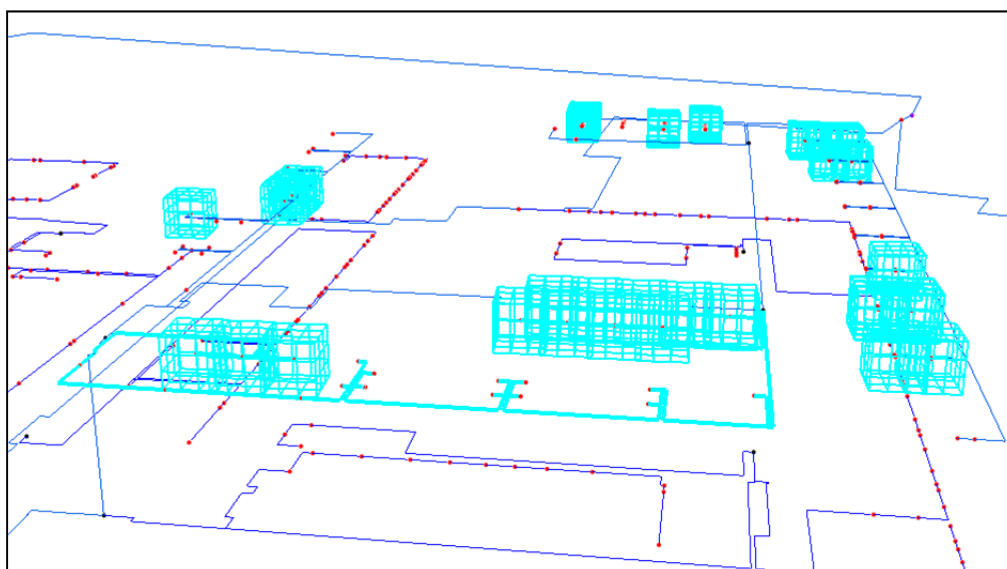


Figure 5.6: Selecting features supported by a specific phase of a selected distribution board.

Figure 5.6 illustrates the features affected by the white phase inside sub distribution board 6 on floor 1 of building E4.

Another example can be to select the location of dedicated plugs inside a specific room. The first step will be to find the object id for that specific room. The selection can then be made inside the utility endpoints layer to determine the locations of the dedicated plugs inside the selected room as described in Figure 5.7.

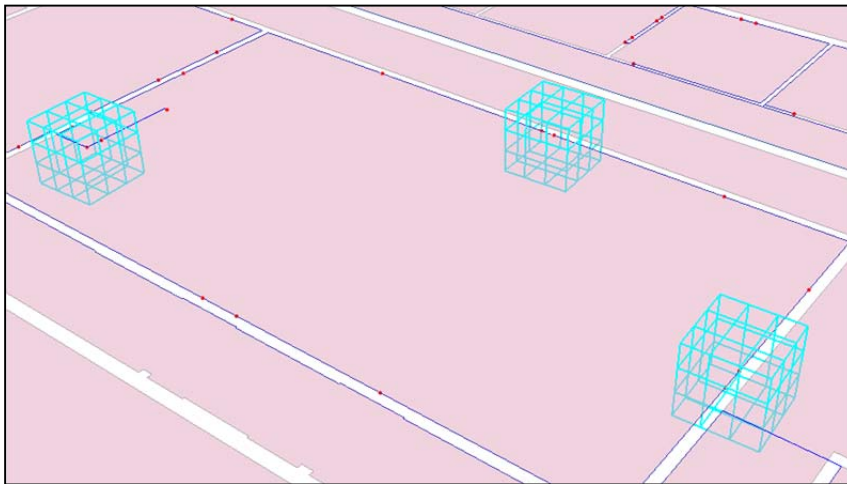


Figure 5.7: Selecting the location of dedicated plugs inside a specific room.

A certain person's office can also be located using the "Select by Attributes" option. A scenario could be that the person experiences a power outage in the specific office and calls the building manager for assistance. The building manager can then use the phone number or the person's owner id to locate the specific office as illustrated in Figure 5.8. A further query can be run to locate the distribution board supplying power to that office. The building manager can determine which distribution board supplies power by viewing the unique id field of the plugs located in the office. A selection can be made to locate the specific distribution board.

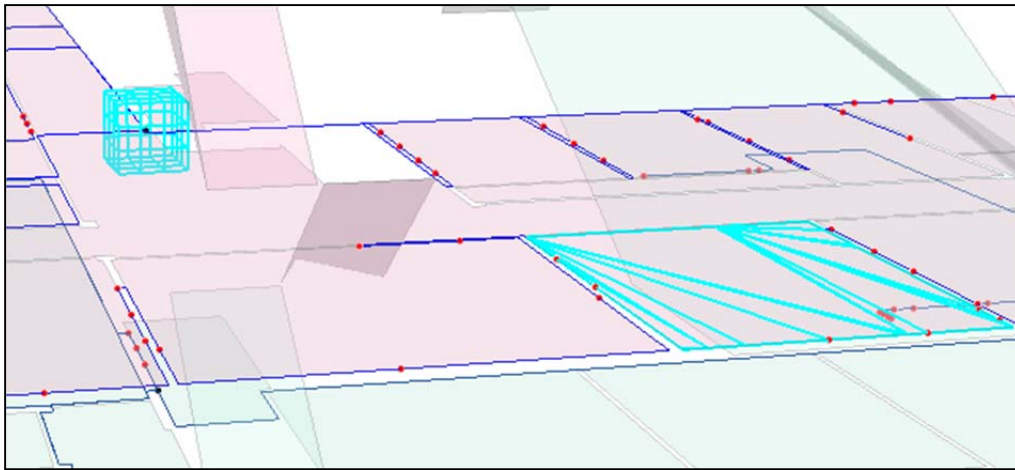


Figure 5.8: Locating the distribution board supplying power to a specific office.

In some cases the building manager has to know the location of a specific electrical cable running from a distribution board to different rooms. There may be scenarios where, for example, the problem doesn't lie within the distribution board. Further searching has to be done to determine if the electrical cable carrying the load experienced a problem along the way. The electrical cables in this prototype model consist of several segments forming a connected network between the electrical point and line features. In order to simulate a single electrical cable running from a distribution board, the different cable segments representing the single cable is given the same "Unique ID" field. Therefore, by selecting that specific unique id the specific cable is highlighted and the location of the cable is known. Figure 5.9 illustrates an example of a single selected cable running from a distribution board through different rooms.

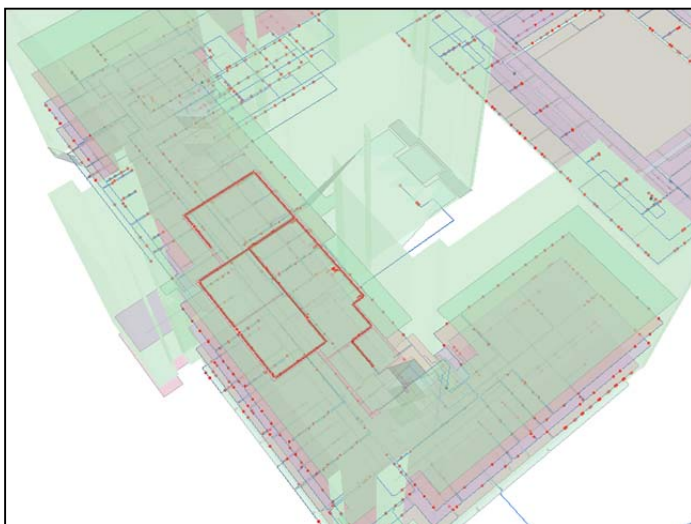


Figure 5.9: Selecting a cable running from a distribution board to several rooms.

5.4.2 Select by Location

The “Select by Location” option under the “Selection” tab can also be used to perform relevant selections inside the PUK geodatabase. A number of options are presented in the drop down list to select features by their location. The following examples illustrate the use of the “Select by Location” option in the database.

A selection can be made to view all the plugs located against the walls inside the different rooms. In this tool, the features are selected from one or more target layers based on their location in relation to the source layer set. An option is then chosen from the drop down list to choose a spatial selection method. In order to view all the plugs against the walls inside the rooms, the option for selecting “target features that touch the boundary of the source layer feature” is chosen. The target layer is set to the “Utility endpoints” layer and the source layer is set to the “PUK Rooms” layer. The result is displayed in Figure 5.10. This could be useful information to determine rooms where there could be a need to install more plugs against the walls. It could also prove to be useful when selecting a room for a future laboratory.

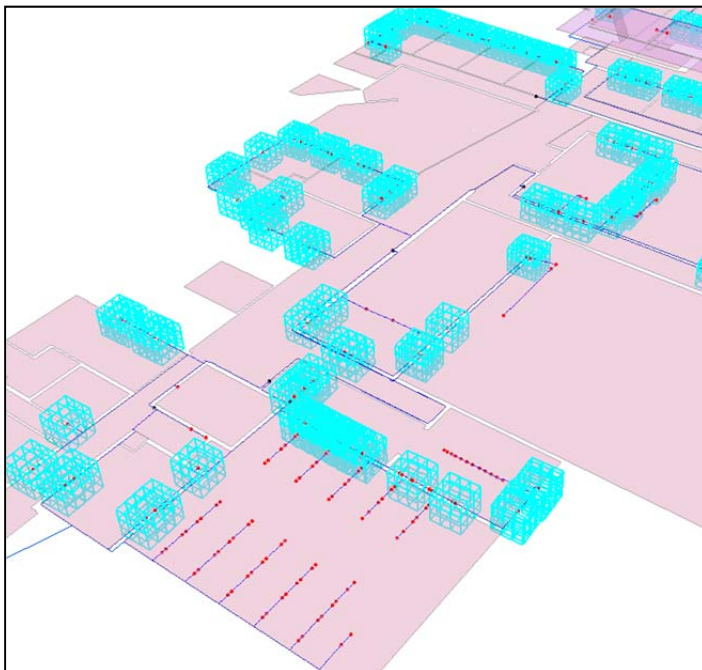


Figure 5.10: Displaying plugs located against the walls inside different rooms.

A second example can be to select the rooms containing distribution boards. It is not always easy to locate distribution boards inside a building in case of power outage. This could be

useful for the building manager if there is a need to locate the rooms. Figure 5.11 illustrates the result of the rooms containing distribution boards.

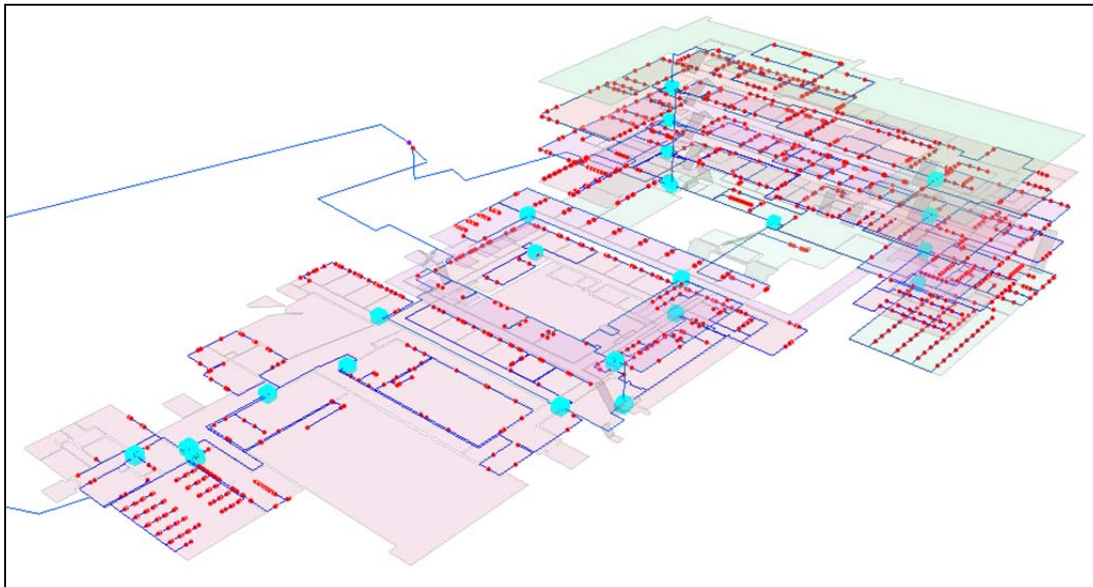


Figure 5.11: Selecting rooms containing distribution boards.

A selection can also be made to determine the location of features that are within a specified distance from other features. This example illustrated in Figure 5.12 shows a selection of all the electrical utility endpoints within a distance of 2 meters from the nearest distribution board.

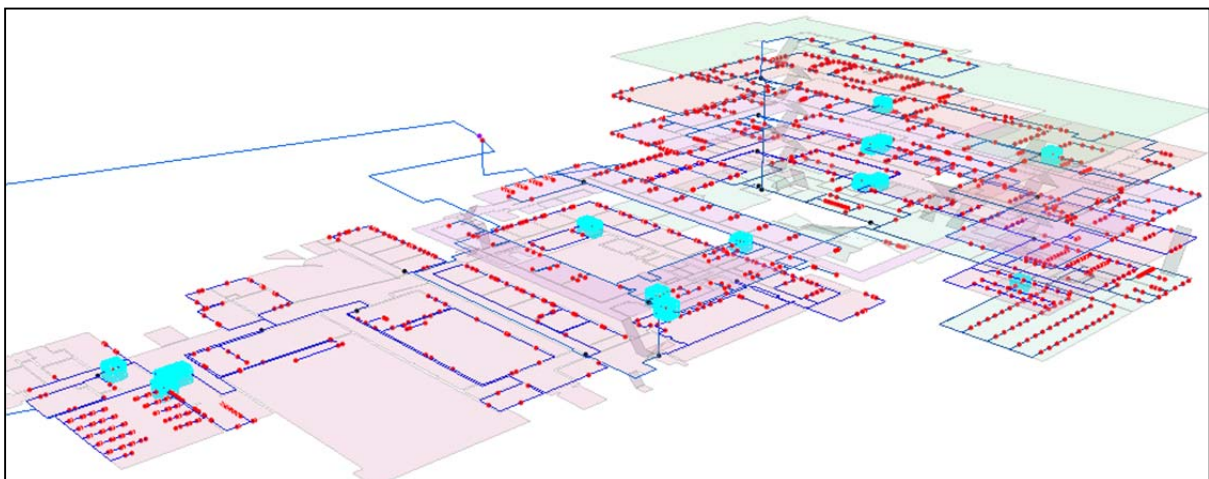
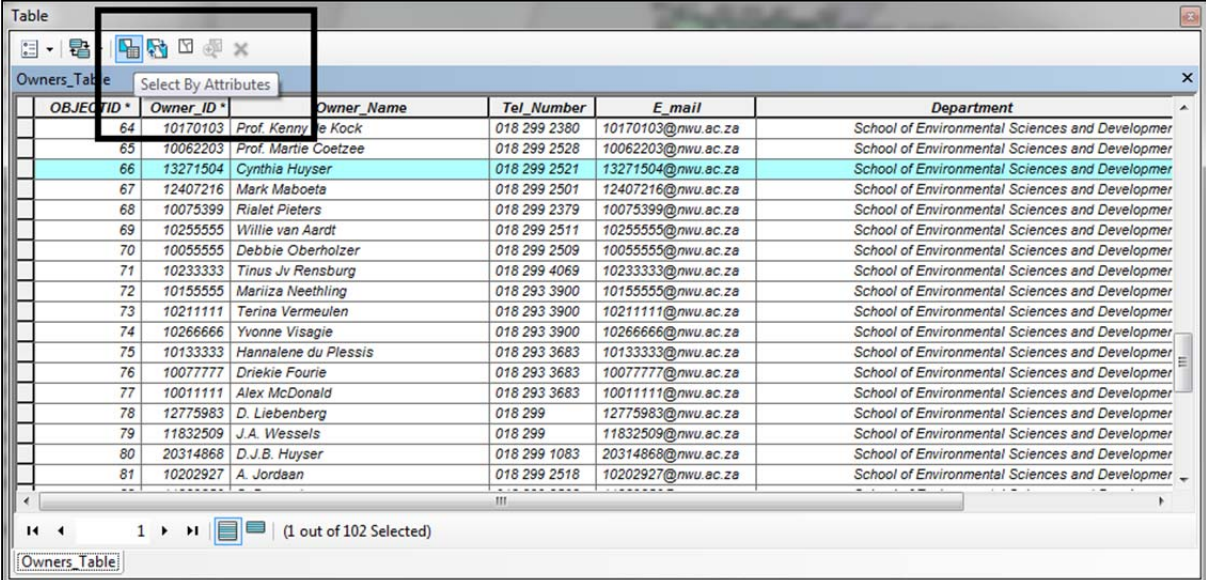


Figure 5.12: Utility endpoints within a distance of 2 meters from the nearest distribution board.

5.5 Related Tables

The features modelled in the PUK geodatabase are in relation to each other. These relations are established through the use of relationship classes consisting of primary and foreign key values in the attribute tables of the different features. This method enables the user to view related information of a desired feature if needed.

A scenario example could be that a specific person located inside a building experience an electrical related problem. The person then calls the responsible building manager to solve the problem. The building manager then asks for the person's name. The name is located through the "Select by Attributes" option inside the Owner Table as described in Figure 5.13.



OBJECTID	Owner_ID	Owner_Name	Tel_Number	E_mail	Department
64	10170103	Prof. Kenny Kock	018 299 2380	10170103@nwu.ac.za	School of Environmental Sciences and Development
65	10062203	Prof. Martie Coetzee	018 299 2528	10062203@nwu.ac.za	School of Environmental Sciences and Development
66	13271504	Cynthia Huyser	018 299 2521	13271504@nwu.ac.za	School of Environmental Sciences and Development
67	12407216	Mark Maboeta	018 299 2501	12407216@nwu.ac.za	School of Environmental Sciences and Development
68	10075399	Rialet Pieters	018 299 2379	10075399@nwu.ac.za	School of Environmental Sciences and Development
69	10255555	Willie van Aardt	018 299 2511	10255555@nwu.ac.za	School of Environmental Sciences and Development
70	10055555	Debbie Oberholzer	018 299 2509	10055555@nwu.ac.za	School of Environmental Sciences and Development
71	10233333	Tinus Jv Rensburg	018 299 4069	10233333@nwu.ac.za	School of Environmental Sciences and Development
72	10155555	Mariiza Neethling	018 293 3900	10155555@nwu.ac.za	School of Environmental Sciences and Development
73	10211111	Terina Vermeulen	018 293 3900	10211111@nwu.ac.za	School of Environmental Sciences and Development
74	10266666	Yvonne Visagie	018 293 3900	10266666@nwu.ac.za	School of Environmental Sciences and Development
75	10133333	Hannalene du Plessis	018 293 3683	10133333@nwu.ac.za	School of Environmental Sciences and Development
76	10077777	Driekie Fourie	018 293 3683	10077777@nwu.ac.za	School of Environmental Sciences and Development
77	10011111	Alex McDonald	018 293 3683	10011111@nwu.ac.za	School of Environmental Sciences and Development
78	12775983	D. Liebenberg	018 299	12775983@nwu.ac.za	School of Environmental Sciences and Development
79	11832509	J.A. Wessels	018 299	11832509@nwu.ac.za	School of Environmental Sciences and Development
80	20314868	D.J.B. Huyser	018 299 1083	20314868@nwu.ac.za	School of Environmental Sciences and Development
81	10202927	A. Jordaan	018 299 2518	10202927@nwu.ac.za	School of Environmental Sciences and Development

Figure 5.13: Selecting information through the "Select By Attributes" option in a table.

The selection for the specific person is made inside the Owner Table. The next step is to use the "Related Tables" option to determine which feature is in relation with the selection made. A relationship class is evident between the "Owner Table" and the "PUK Rooms" feature class. The "Related Table" option determines which office belongs to the person. After determining the office of the person, the "Related Table" option can further be used to view the related features of the office established by the participating relationship classes. Figure 5.14 illustrates the selected office along with the related features in connection with the specific office.

Table

Figure 5.14: Displaying the related features of a selected office.

The selections made through the use of the “Related Table” option are displayed on the map. This enables the user to view the selected features determined through the relations in 3D. Figure 5.15 illustrates the “Select By Attributes” and “Related Tables” option used to select features inside the E4 building.

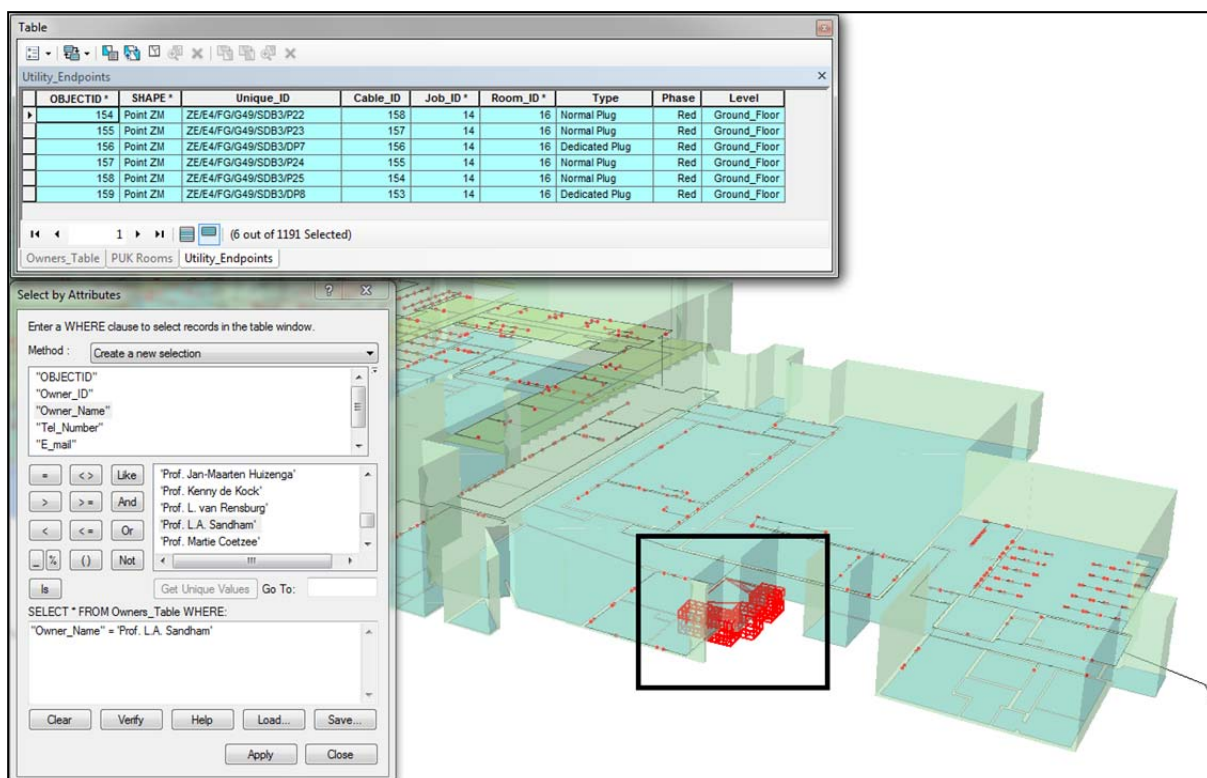


Figure 5.15: Viewing features selected through the “Related Tables” option.

5.6 Shortest route analysis

The use of a network dataset in the PUK geodatabase enables the user to perform network analysis on the electrical network of the specified buildings in the study area. A model is created using “Modelbuilder” and saved in a toolbox inside the PUK geodatabase. Shortest route analysis is performed by opening the toolbox and clicking on the saved model. A window will appear showing the five participating feature classes as illustrated in Figure 5.16. The “Add” feature button is used to select features to determine the shortest route between them. Shortest route analysis can be meaningful when new development and planning has to take place in determining the best paths to install new electrical cables between features.

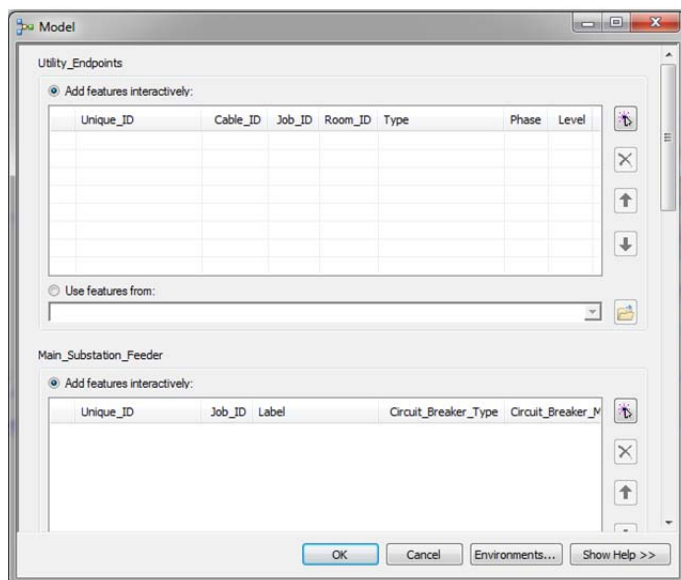


Figure 5.16: Participating feature classes in the route model.

Two or more features can be added to the window to enable the user to perform shortest route analysis. Care must be taken to make sure that the correct features are selected in ArcScene10. Otherwise the model won't work properly and incorrect results may appear. Figure 5.17 illustrates an example of the shortest route from one electrical utility to another located in different buildings. Appendix D illustrates the model diagram for the shortest route analysis between features.

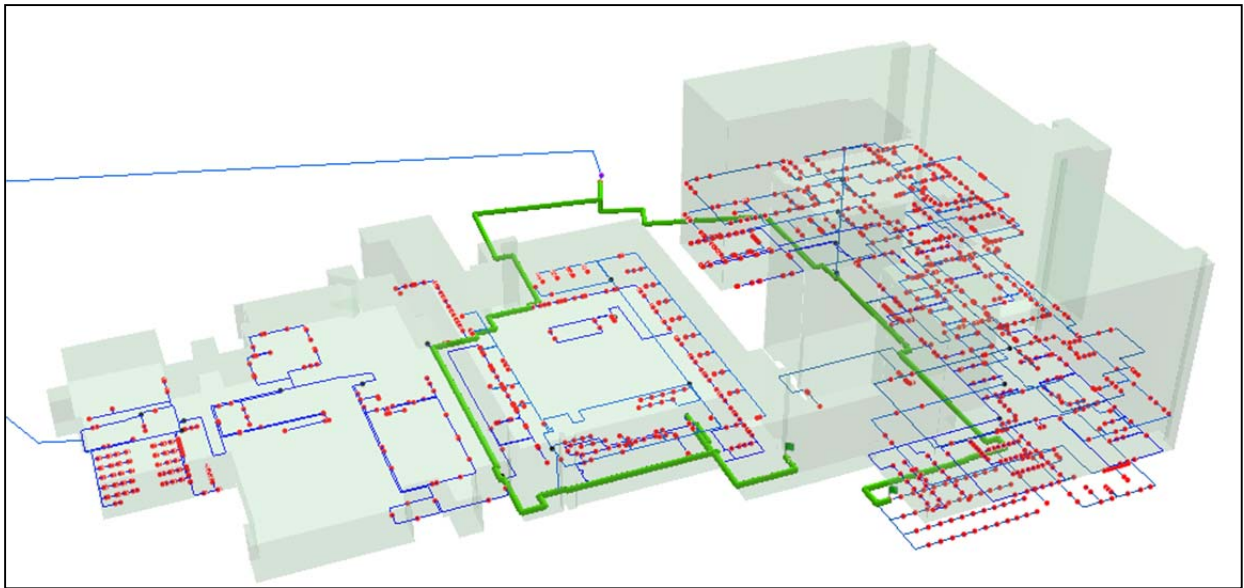


Figure 5.17: Shortest path between two selected features.

5.7 Finding the closest facility

The “New Closest Facility” option in the “Network Analyst” toolbar enables the user to find the closest facility from a selected feature in a network. This analysis is done in ArcMap10 due to the fact that the “Network Analyst” toolbar can’t be used in ArcScene10. This analysis is useful when there is a need to determine, for example, the closest distribution board for a specific plug inside a room. It can also be useful when installing new plugs or electrical cables. This analysis determines the closest facility through the network of cables and electrical utilities. Figure 5.18 illustrates the option for selecting a new closest facility.

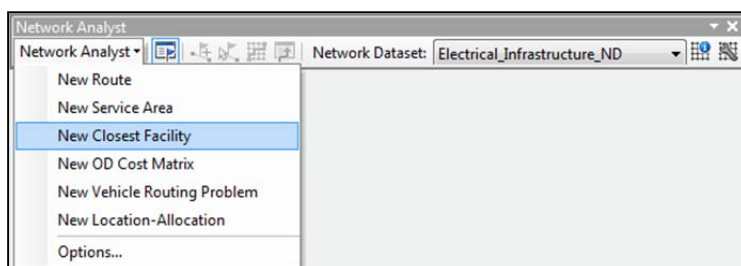


Figure 5.18: Selecting a new closest facility.

The “New Closest Facility” option is selected in the “Network Analyst” toolbar. A list of options appears in the network analyst window. The user right-clicks on the facilities layer and load the locations to be used as the closest facilities as illustrated in Figure 5.19 and Figure 5.20.

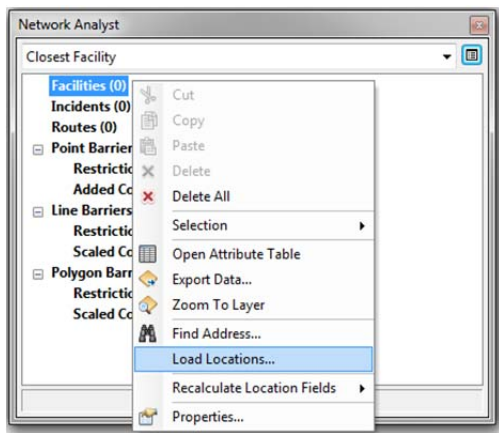


Figure 5.19: Locations loaded in the facilities layer.

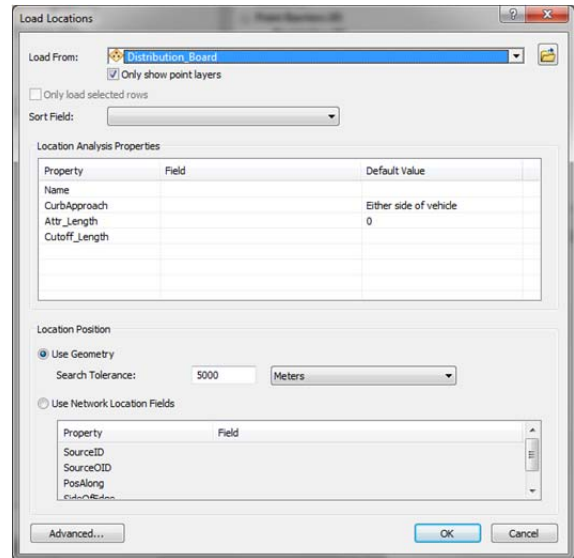


Figure 5.20: Loading distribution boards.

In order to perform the closest facility analysis, the specific feature has to be selected by means of the “Selection” tool and a layer has to be created from this selection. After creating the layer, locations can be loaded by right-clicking on the incidents layer in the “Network Analyst” window. After loading the selected layer, the “Solve” button on the “Network Analyst” toolbar can be used to locate the closest facility from the selected feature as described in Figure 5.21.

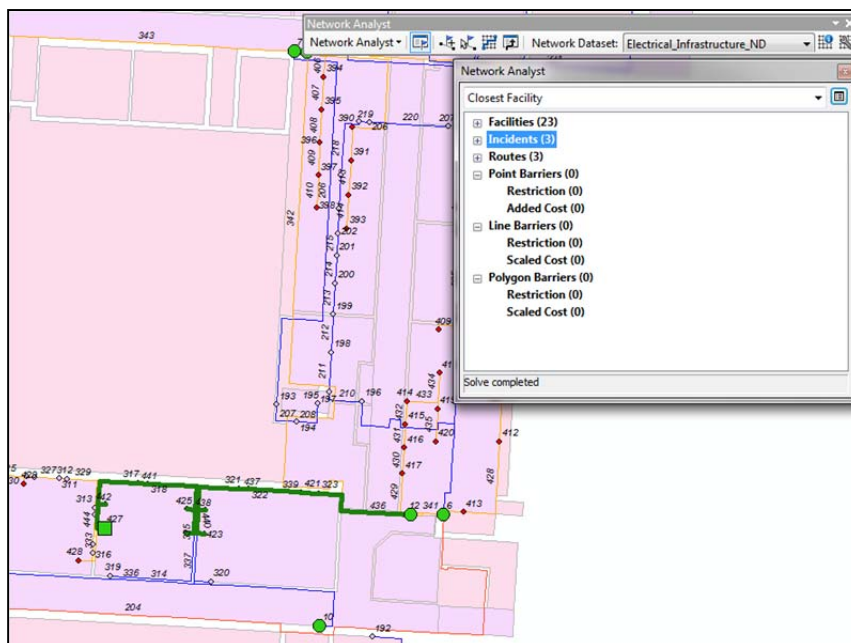


Figure 5.21: Displaying the closest distribution board for the selected plug in 2D.

In order to view the closest facility analysis in 3D, the layer is simply added to the table of contents in ArcScene10. The result is illustrated in Figure 5.22

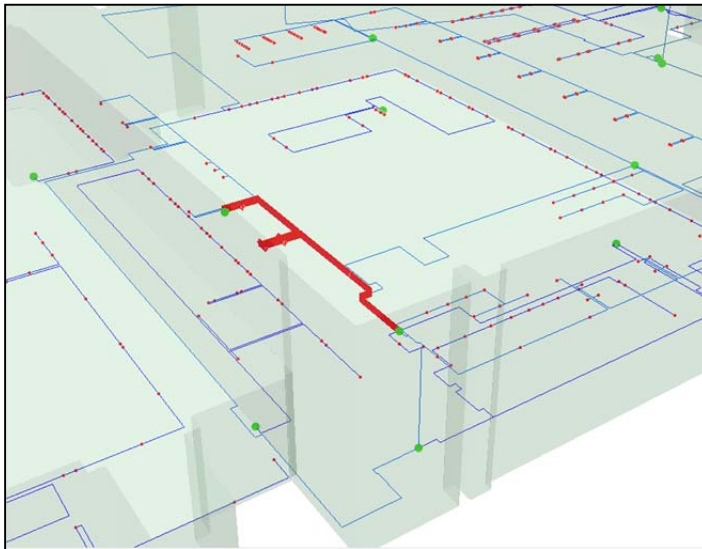


Figure 5.22: Viewing the closest distribution board for the selected plug in ArcScene10.

5.8 Location-Allocation

The “Location-Allocation” option in the “Network Analyst” toolbar enables the user to view the network connections from a specific utility. The building manager may want to find out which electrical utilities, for example, are connected to a certain distribution board. In order to do this, the “Location-Allocation” option is chosen from the list in the “Network Analyst” toolbar as illustrated in Figure 5.23.

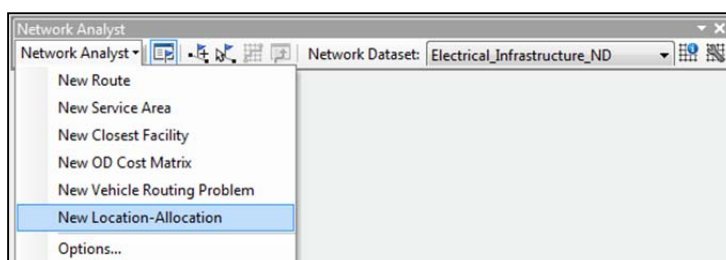


Figure 5.23: Selecting “New Location-Allocation” from the “Network Analyst” toolbar.

This analysis is also done in ArcMap10 due to the fact that there is not a “Network Analyst” toolbar in ArcScene10. The next step is to load facilities in the “Network Analyst” window. In this example to view the connections to a certain distribution board the

“Distribution_board” feature class layer is loaded in the “Facilities” layer. A layer must be created from selected features to view their connection to the distribution board supplying electricity. After creating the layer from the selection, the layer is loaded in the “Demand Points” layer in the “Network Analyst” window. The “Solve” button is used to view the results.

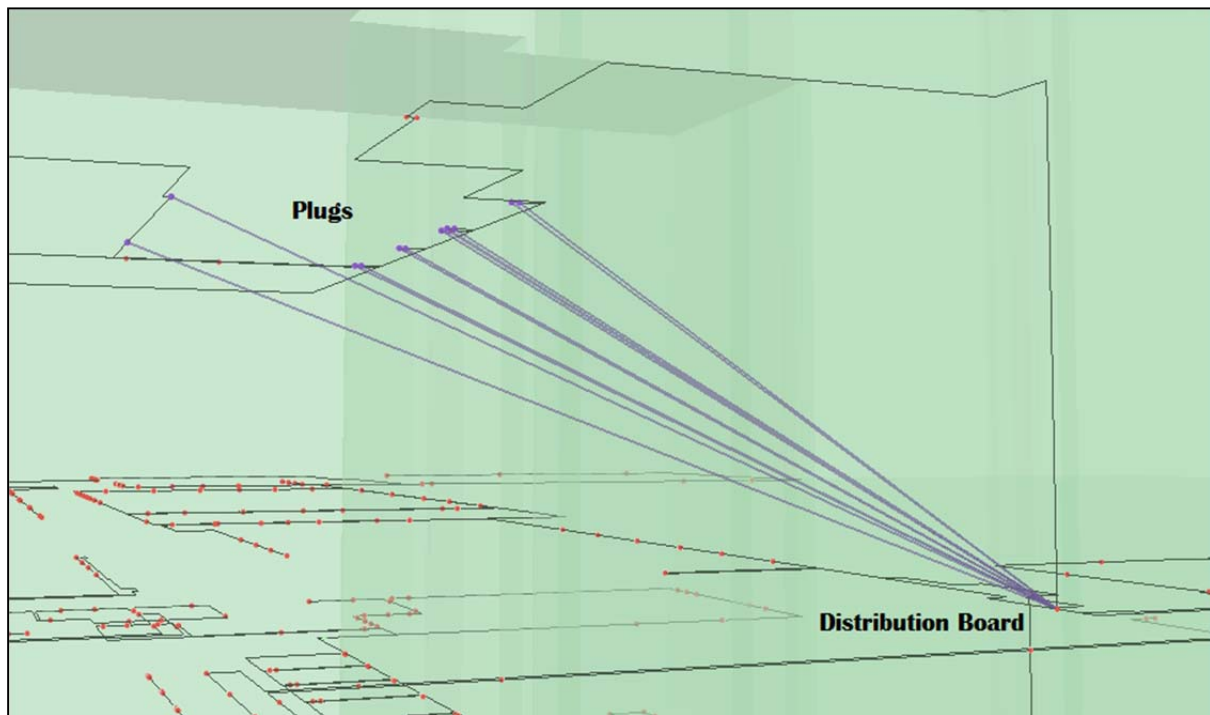


Figure 5.24: Viewing which distribution board supplies electricity to selected plugs.

The “Location-Allocation” layer is pasted in the table of contents in ArcScene10 to view the results as illustrated in Figure 5.24. This example shows a direct connection between the distribution board supplying electricity to plugs in a selected room. Each plug is connected directly to the distribution board supplying electricity. The building manager can determine which distribution board to check in case of a power outage in a specific room.

The “Location-Allocation” option is used to locate features connected to each other without following a path along the network. It connects related features directly to each other. The “New Closest Facility” option locates the closest facility in relation to the selected features following a path along the network.

5.9 Evaluating the PUK Geodatabase

Each basic capability of the PUK Geodatabase is evaluated to determine if it was a success or failure. The limitations of the capabilities are also identified. Table 5.2 describes the evaluation of the data model.

Table 5.2: Evaluation of the PUK Geodatabase

Geodatabase capabilities	Method	Status	Limitations
View the geodatabase features in 3D.	Visualization in ArcScene10	Success	Labels and Annotation of features in 3D don't display effectively.
Identify the locations of the electrical utilities inside the buildings.	Identify tool	Success	No
Obtain updated information about the electrical utilities by viewing the attribute tables.	Identify tool and Attribute tables	Success	No
View general information about the zones, buildings and rooms inside the buildings.	Identify tool and Attribute tables	Success	No
Use the Unique ID's of the electrical utilities to locate specific features.	Select by Attributes	Success	The selections can only be made through the use of a "WHERE" clause.
Determine the location of features within a distance from other features.	Select by Location	Success	No
Obtain information regarding the contractor personnel who did maintenance on the network.	List of contractors	Success	The list provided is a fictional list because of unavailable data.
Keep record of maintenance done on certain features of the electrical network.	Maintenance table	Success	The table provided is a fictional table due to unavailable data.
View contact information about owners of specific offices.	Owners Table	Success	No
View related information between attribute tables.	Related table tool	Success	No
Determine the shortest route between features	Route model	Success	No
Find the closest facility when new installments have to be made.	Closest facility tool	Success	A direct connection cannot be made at once by one mouse click. A layer from the selected features has to be created first to perform the analysis.
Determine which distribution board supplies electricity to which plugs through tracing analysis.	Location-allocation tool	Success	A direct connection cannot be made at once by one mouse click. A layer from the selected features has to be created first to perform the analysis.

Determine which distribution station feeders and transformers supplies which distribution boards in a building through tracing analysis.	Location-allocation tool	Success	A direct connection cannot be made at once by one mouse click. A layer from the selected features has to be created first to perform the analysis.
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5.10 Conclusion

Chapter 5 explained how the prototype PUK geodatabase can be useful to the building manager maintaining the electrical network of the specified buildings in the study area. The examples provided illustrate the possible functionalities of the database. 3D visualization of features plays a key role for this database to be effective. The different analysis capabilities tested in this chapter proved that this prototype PUK geodatabase representing the electrical network from the main substation feeder to the endpoint utilities can truly be used as tool for building management.

Features can be viewed in 3D along with their attributes and relationship connections using the identify tool. Different attribute and location selections can be made to view specific requests. A route model could also be implemented to find the shortest path between features along the network. This model can also be used in the planning process for future developments like finding the closest distribution board to connect a new cable. Different connections between features can also be viewed by means of the “Location-Allocation” tool in cases where electrical network problems have to be solved.

The following chapter concludes this research project and determines if the objectives set for this study were met. Recommendations are also provided for future studies on this particular topic.