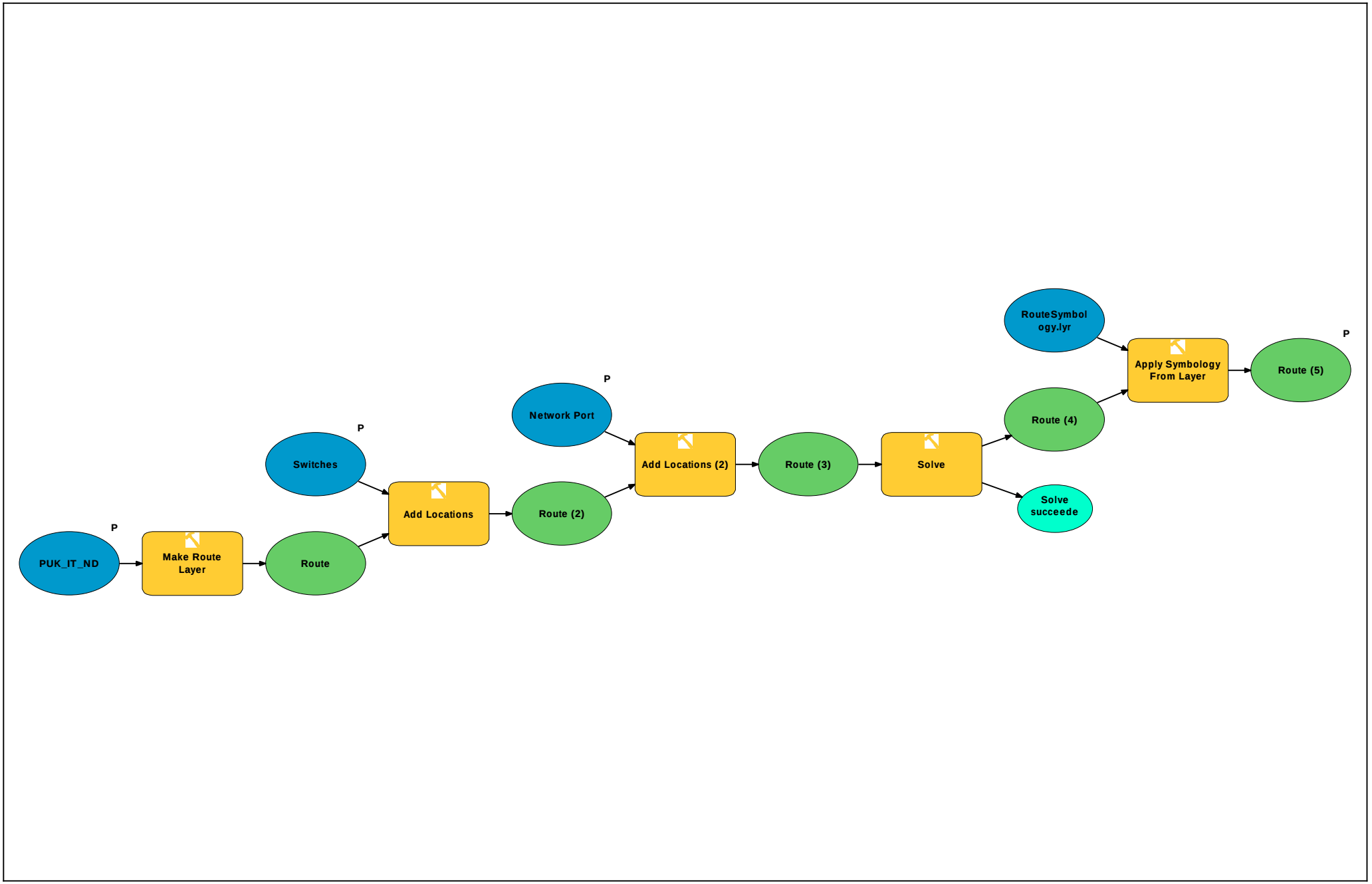
Appendix A : 3D Shortest Route Model



3D Shortest Route Model

Appendix B: Metadata for PUK Geodatabase

Metadata for the PUK Geodatabase

Title	Abstract	Purpose	Data source	Attributes	Coordinate system	Spatial representation	Date created	Created by	Scale
PUK_Zones	The feature class illustrates the different zones of the Potchefstroom campus of the North West University	The PUK_Zones feature class was created by digitizing the zones from a campus infrastructure CAD file.	Potchefstroom Campus Technical Services Department. 2011.	Object_ID, Unique_ID, Number_of_Buildings, Shape, Shape_length, Shape_Area	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Polygon	Apr-11	Carl Bester	1 : 100
PUK_Buildings	The PUK buildings feature class provides a two dimensional sense of where the buildings are located on campus. The feature class participates in the PUK_IT_Topology in order to ensure that network ports and switches are located indoors.	The PUK_Buildings feature class was created by digitizing the polygons from CAD files depicting the layout of buildings E4 and E6.	Potchefstroom Campus Technical Services Department. 2011.	Objec_ID, Shape, Unique_ID, Zone_ID, Name_of_Building, Faculty, Department, Number_of_Floors, Shape_length, Shape_Area	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Polygon	Apr-11	Carl Bester	1 : 100
PUK_Rooms	The PUK_Rooms feature class depicts the rooms of each floor on multiple levels. The feature class also describes the space type of each room. PUK_Rooms is divided into subtypes according to each floor so that potentially all of the campus rooms can be	The rooms were digitized from aligned CAD files.	Potchefstroom Campus Technical Services Department. 2011.	Object_ID, Shape, Unique_ID, Building_ID, Space_Type, Owner_ID, Capacity, Floor, Shape_Length, Shape_Area	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Polygon	May-11	Carl Bester	1 : 100
Switches	The feature class depicts the switches of the campus computer network. The feature class is divided into 3 subtypes. The source switch of the network, the zonal network distributing switches and the local building network swithces. Switches play a major role in the network dataset and acts as one of the	No data were available for the location of the switches. The switches were physically observed and the vertical space between each was speculated.	Field work	Object_ID, Shape, Unique_ID, Model_name, Room_ID, Job_ID, Max_attach, Cable_ID, Type, IP_address, Source_data	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Point	Jul-11	Carl Bester	1 : 100
Network_Port	Network ports serve as the end-point of the computer networks. It depicts the location and attributes of the network ports inside of buildings. Network ports take part in the network dataset which depicts the connectivity between utility infrastructure.	The location of the network ports on the ground floor of building E4 was digitized from a CAD file. The location of network ports on the 1st floor of E4 as well as for the whole E6 building were determined from hard copy building infrastructure layout maps.	Potchefstroom Campus Technical Services Department. 2011. Ingplan Consulting Engineers CC. 1998 - 2000	Object_ID, Shape, Unique_ID, Room_ID, Job_ID, Source_data	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Point	Jul-11	Carl Bester	1 : 100

Metadata for the PUK Geodatabase (continued)

Title	Abstract	Purpose	Data source	Attributes	Coordinate system	Spatial representation	Date created	Created by	Scale
Cables	This feature class depicts the different network cables of the study area in 3D. It makes use of subtypes to depict the different types of cables employed on the Potchefstroom campus. The feature class shows the cables inside of three buildings on multiple floors, and also makes out the bulk of the network dataset.	The location of the cables indoors were derived from hard copy building infrastructure maps, while the outdoor cables were derived from campus infrastructure CAD files.	Potchefstroom Campus Technical Services Department. 2011. Ingplan Consulting Engineers CC. 1998 - 2000	Object_ID, Shape, Unique_ID, Type, Standard_name, IEEE_name, Max_length, Max_attach, Max_speed, Job_ID, NP_ID, SW_ID, Shape_Length	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Line	Aug-11	Carl Bester	1 : 100
Campus_Fishnet	Category 5e, Multi-mode optical fiber, Single-mode optical fiber. The extent of the fishnet is equavalent to approxiametely the extent of the campus. The grid cells are 1m x 1m. The fishnet is utilized when the location of outdoor infrastructure elements are needed.	The campus fishnet was created by utilizing the Create Fishnet tool in Arc Toolbox (Arc Catalog).	The fishnet feature class was automatically created by ArcCatalog.	OID, Shape, Shape_Length	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Vector: Line	Aug-11	Carl Bester	N/A
List_of_Contractors	The List_of_Contractors table lists the contractors who perform regular maintenance tasks on the university campuses, a well as the attributes associated with each contractor, such as contact information, occupation and the company they work for.	The List_of_Contractors table was created in Arc Catalog.	No data was available for the contractors table. The table created for this study was fictional, in order to demonstrate the abilities of GIS in order to achieve the study objectives.	Object_ID, Contractor_Name, Occupation, Contractor_Tel_nr, Email, Company, Campus, Fax_nr	N/A	Table	Jul-11	Carl Bester	N/A
Maintenance_register	The table lists the maintenance tasks that were performed on the IT network of the Potchefstroom campus.	The Maintenance_register table was created in Arc Catalog.	No data was available for the maintenance register. The table created for this study was fictional, in order to demonstrate the abilities of GIS in order to achieve the study objectives.	Object_ID, Contractor_ID, Utility_component, Date_of_job	N/A	Table	Aug-11	Carl Bester	N/A

Metadata for the PUK Geodatabase (continued)

Title	Abstract	Purpose	Data source	Attributes	Coordinate system	Spatial representation	Date created	Created by	Scale
Owner_table	The Owners_Table lists the owners that are responsible for each room, as well as their attributes such as: the department they work for, e-mail address and the owner's peronnel number.	The Owner_table was created in ArcCatalog.	The information used to create the Owners table was obtained from the building manager of buildings E4 and E6, Mr. L Venter (2011).	Object_ID, Owner_ID, Owner_Name, Tel_Number, E_mail, Department	N/A	Table	Jul-11	Carl Bester	N/A
QuickBird	This raster is a satellite image of the Potchefstroom campus of the North West University. The satelite image was used as a referenced foundation to create the feature classes.The cell size of the raster is approxiametely 0.6m x 0.6m. The datum that the satellite employs is the WGS 1984 datum. The coordinate system it utilizes is the UTM 35S projection.	The QuickBird raster was created beforehand and imported into the PUK Geodatabase.	QuickBird. 2008. Satellite Application Center. CSIR: Pretoria.	N/A	Type: Projected. Datum: WGS 1984. Projection: WGS_1984_UTM_Zone_35S	Remotely sensed imagery	2008	Digital Globe	1m x 1m

Appendix C: Geodatabase schema diagram

Geodatabase schema diagram

This diagram was auto-generated by the Geodatabase Diagrammer application sample and contains graphic elements that you can use to produce a data model diagram. This sample is available from the ArcScripts site on www.esri.com. You can find examples of finished data model diagrams at the data model section of arconline.esri.com.

Geodatabase	Campus IT GDB\PUK Geodatabase.gdb
Date generated	01 September 2011

Table
List_of_Contractors

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
Contractor_Name	String	Yes					50
Occupation	String	Yes					50
Contractor_Tel	String	Yes					50
Area	String	Yes					50
Contractor	String	Yes					50
Campus	String	Yes					50
Pass	String	Yes					50

Relationship class
Contractor_has_Maint

Type Simple
Cardinality One to many
Notification None

Forward label Maintenance_register
Backward label List_of_Contractors

Origin table
Name List_of_Contractors
Primary key OBJECTID
Foreign key CONTRACTOR_ID

Destination table
Name Maintenance_register

Table
Maintenance_register

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
Contractor_ID	Long Integer	Yes			6		
Job_completion	String	Yes					50
Date_of_Job	Date	Yes			0	0	8

Relationship class
Cables_has_Maint

Type Simple
Cardinality One to many
Notification None

Forward label Cables
Backward label Maintenance_register

Origin table
Name Maintenance_register
Primary key
Foreign key OBJECTID
Job_ID

Destination feature class
Name Cables

Relationship class
NP_has_Cables

Type Simple
Cardinality One to many
Notification None

Forward label Cables
Backward label Network_Port

Origin table
Name Network_Port
Primary key Object_ID
Foreign key NP_ID

Destination feature class
Name Cables

Simple feature class
Campus_IT_Manhole

Geometry Point
Contained M values No
Contained Z values No

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	ObjectID						
Shape	Geometry	Yes					
Shape_Length	Double	Yes			0	0	

Simple feature class
Campus_IT_Manhole_Label

Geometry Point
Contained M values No
Contained Z values No

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OID	ObjectID						
Shape	Geometry	Yes					

Simple feature class
PUK_IT_IND_Junctions

Geometry Point
Contained M values No
Contained Z values No

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	ObjectID						
SHAPE	Geometry	Yes					

Simple feature class
Cables

Geometry Polyline
Contained M values No
Contained Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Unique_ID	String	Yes					50
Type	Long Integer	Yes	0		0		
Standard_name	Long Integer	Yes		Standard_names	0		
IEEE_name	Long Integer	Yes		IEEE_name	0		
Max_length	Short Integer	Yes			0		
Max_attach	Short Integer	Yes			0		
Mat_used	Short Integer	Yes			0		
Job_ID	Long Integer	Yes			0		
NP_ID	Long Integer	Yes			0		
SW_ID	Long Integer	Yes			0		
SHAPE_Length	Double	Yes			0	0	
Source_data	String	Yes					100

Subtypes of Cables

Subtype field: Type
Default subtype: 0

List of defined default values and domains for subtypes in this class

Subtype Code	Subtype Description	Field name	Default value	Domain
0	Multimode optical fibre	Standard_name	0	Standard_names
		IEEE_name	0	IEEE_name
1	Singlemode optical fibre	Standard_name	1	Standard_name
		IEEE_name	1	IEEE_name
2	Category 5e UTP	Standard_name	2	Standard_name
		IEEE_name	2	IEEE_name
3	Thick coaxial cable	Standard_name	3	Standard_name
		IEEE_name	3	IEEE_name
4	Thin coaxial cable	Standard_name	4	Standard_name
		IEEE_name	3	IEEE_name

Relationship class
Switches_has_Maint

Type Simple
Cardinality One to many
Notification None

Forward label Switches
Backward label Maintenance_register

Origin table
Name Maintenance_register
Primary key
Foreign key OBJECTID
Job_ID

Destination feature class
Name Switches

Relationship class
Room_has_NP

Type Simple
Cardinality One to many
Notification None

Forward label Network_Ports
Backward label PUK_Rooms

Origin table
Name PUK_Rooms
Primary key OBJECTID
Foreign key Room_ID

Destination feature class
Name Network_Ports

Relationship class
NP_has_Maint

Type Simple
Cardinality One to many
Notification None

Forward label Network_Ports
Backward label Maintenance_register

Origin table
Name Maintenance_register
Primary key
Foreign key OBJECTID
Job_ID

Destination feature class
Name Network_Ports

Simple feature class
Network_Port

Geometry Point
Contained M values No
Contained Z values No

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Unique_ID	String	Yes					50
Room_ID	Long Integer	Yes			0		
Job_ID	Long Integer	Yes			0		
Source_data	String	Yes					100

Simple feature class
PUK_Rooms

Geometry Polygon
Contained M values No
Contained Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	ObjectID						
SHAPE	Geometry	Yes					
Unique_ID	String	Yes					50
Building_ID	Longinteger	Yes			0		
Space_Type	Longinteger	Yes		Space_Type	0		
Owner_ID	Longinteger	Yes			0		
Capacity	Longinteger	Yes			0		
Floor	Longinteger	Yes	3		0		
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Subtypes of PUK_Rooms

Subtype field: Floor
Default subtype: 0

List of defined default values and domains for subtypes in this class

Subtype Code	Subtype Description	Field name	Default value	Domain
0	Sub Floor_01	Space_Type		Space_Type
1	Sub Floor_02	Space_Type		Space_Type
2	Ground_floor	Space_Type		Space_Type
3	Floor_01	Space_Type		Space_Type
4	Floor_02	Space_Type		Space_Type
5	Floor_03	Space_Type		Space_Type
6	Floor_04	Space_Type		Space_Type
7	Floor_05	Space_Type		Space_Type
8	Floor_06	Space_Type		Space_Type
9	Floor_07	Space_Type		Space_Type
10	Floor_08	Space_Type		Space_Type
11	Floor_09	Space_Type		Space_Type
12	Floor_10	Space_Type		Space_Type

Simple feature class
Switches

Geometry Point
Contained M values No
Contained Z values No

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
SHAPE	Geometry	Yes					
Unique_ID	String	Yes					50
Manuf_name	Long Integer	Yes		Model	0		
Room_ID	Long Integer	Yes			0		
Job_ID	Long Integer	Yes			0		
Max_bandwidth	Short Integer	Yes	24		0		
Cable_ID	Long Integer	Yes			0		
Type	Long Integer	Yes	0		0		
IP_address	String	Yes					50
Source_data	String	Yes					50

Subtypes of Switches

Subtype field: Type
Default subtype: 0

List of defined default values and domains for subtypes in this class

Subtype Code	Subtype Description	Field name	Default value	Domain
0	Source	Model_name		Model
1	Juniper	Manuf_name		Model
2	Cisco	Manuf_name		Model

Relationship class
Room_has_Switches

Type Simple
Cardinality One to many
Notification None

Forward label Switches
Backward label PUK_Rooms

Origin table
Name PUK_Rooms
Primary key OBJECTID
Foreign key Room_ID

Destination feature class
Name Switches

Relationship class
Cable_has_Switches

Type Simple
Cardinality Many to many
Notification None

Forward label Switches
Backward label Cable

Origin table
Name Cables
Primary key Object_ID
Foreign key Cable_ID

Destination feature class
Name Switches
Primary key Object_ID
Foreign key SW_ID

Simple feature class
PUK_Zones

Geometry Polygon
Contained M values No
Contained Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
Shape	Geometry	Yes					
Unique_ID	String	Yes					50
Number_of_buildings	Longinteger	Yes			0		
Shape_Length	Double	Yes			0	0	
Shape_Area	Double	Yes			0	0	

Simple feature class
PUK_Buildings

Geometry Polygon
Contained M values No
Contained Z values Yes

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	ObjectID						
SHAPE	Geometry	Yes					
Unique_ID	String	Yes					50
Zone_ID	Long Integer	Yes			0		
Name_of_Building	String	Yes					50
Faculty	Long Integer	Yes		Faculty	0		
Department	Long Integer	Yes		Department	0		
Number_of_Floors	Long Integer	Yes			0		
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Relationship class
Owner_has_Rooms

Type Simple
Cardinality One to many
Notification None

Forward label PUK_Rooms
Backward label Owner_Table

Origin table
Name Owner_Table
Primary key Owner_ID
Foreign key Owner_ID

Destination feature class
Name PUK_Rooms

Table
Owner Table

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
Owner_ID	Longinteger	Yes			0		
Owner_Name	String	Yes					50
Id_Number	String	Yes					50
E_mail	String	Yes					50
Department	Long Integer	Yes		Department	0		

Relationship class
Zones_has_Buildings

Type Simple
Cardinality One to many
Notification None

Forward label PUK_Buildings
Backward label PUK_Zones

Origin table
Name PUK_Zones
Primary key OBJECTID
Foreign key Zone_ID

Destination feature class
Name PUK_Buildings

Relationship class
Buildings_has_Rooms

Type Simple
Cardinality One to many
Notification None

Forward label PUK_Rooms
Backward label PUK_Buildings

Origin table
Name PUK_Buildings
Primary key OBJECTID
Foreign key Building_ID

Destination feature class
Name PUK_Rooms

Appendix D: PUK Geodatabase domains

PUK Geodatabase Domains

Coded value domain

Model

Description: Switch model
Field type: Long integer
Split policy: Default value
Merge policy: Default value

Code	Description
0	DES 3526
1	DES 3528

Coded value domain

Space_Type

Description: Room description
Field type: Long integer
Split policy: Default value
Merge policy: Default value

Code	Description
0	Office
1	PC Labs
2	Laboratory
3	Seminar/Class room
4	Corridor
5	Steps
6	Kitchen
7	Bathroom
8	Storage
9	Utility room
10	Empty
11	Lobby
12	External area
13	Elevator
14	Library
15	Staff room
16	Exhibition
17	Museum

Coded value domain

Faculty

Description: Educational faculty
Field type: Long integer
Split policy: Default value
Merge policy: Default value

Code	Description
0	Arts
1	Natural Sciences
2	Theology
3	Education Sciences
4	Economic and Management Sciences
5	Law
6	Engineering
7	Health Sciences

Coded value domain

Standard_name

Description: Standard name of
Field type: cables
Split policy: Long integer
Merge policy: Default value

Code	Description
0	1000BASE SX
1	1000BASE LX
2	100BASE T
3	10BASE 5
4	10BASE 2

Coded value domain

Department

Description: Faculty department
Field type: Long integer
Split policy: Default value
Merge policy: Default value

Code	Description
0	School of Languages
1	School of Social and Government studies
2	School of Music
3	Communication studies
4	Philosophy
5	School of Physical and Chemical Sciences
6	School of Environmental Sciences and Development
7	School of Computer, Statisctical and Mathematical Sciences
8	Center for Business Mathematics and Informatics
9	Center for Environmental management
10	Center for Human Metabonomics
11	School for Biblical Studies and Bible Languages
12	School for Ecclesiastical Studies
13	School of Education
14	School of Continuing Teacher Education
15	School of Curriculum-based Studies
16	Potchefstroom Business School
17	School of Accounting Sciences
18	School of Economics
19	School of Business management
20	School of Human Resources Sciences
21	Center for Community Law and Development
22	School of Chemical Engineering
23	School of Electrical, Electronic and Computer Engineering
24	School of Mechanical Engineering
25	Post-graduate School of Nuclear Science and Engineering
26	School of Biokinetics, Recreation and Sport Sciences
27	School of Pharmacy
28	School of Physiology, Nutrition and Consumer Sciences
29	School of Psychological Behavioural Sciences
30	School of Nursing
31	Research focus area: Teaching- Learning Organizations
32	Administration

Coded value domain

IEEE_name

Description: IEEE name of cables
Field type: Long integer
Split policy: Default value
Merge policy: Default value

Code	Description
0	IEEE 802.3z
1	IEEE 802.3u
2	IEEE 802.3
3	IEEE 802.3a

References

ACTUR, D. & ZEILER, M. 2004. Designing geodatabase: Case Studies in GIS data modeling. Redlands: ESRI Press. 3 – 34p.

ANON. 2011. Network topologies. http://www.pctechguide.com/network-topologies. Date of access: 27 May 2011.

.

APDM. 2004. Technical committee paper: Ten reasons. http://www.apdm.net/Files/APDMTopTenReasonsToUseAGeoDB.pdf. Date of access: 12 Oct. 2010.

APPLETON, K. & LOVETT, A. 2003. GIS-based visualization of rural landscapes: defining 'sufficient' realism for environmental decision-making. *Landscape and Urban Planning*, 65(3): 117p. Available: ScienceDirect. Date of access: 18 Nov. 2010.

AQUARIUS.NET. 2011. Analysis and management. http://www.mgaqua.net/AquaDoc/Projections/Projections_Conic.aspx. Date of access: 22 Jun. 2011.

ATHANASIOS, M., IOANNIS, K. & PAOLA, S. 2009. Qualification and Provisioning of xDSL broadband lines using a GIS approach. *World Academy of Science, Engineering and Technology*: 52(2009): 554–557p.

BAARS, M., STOTER, J., VAN OOSTEROM, P. & VERBREE, E. 2004**.** Rule-based or explicit storage of topology structure: a comparison case study. Proceedings of the 7th AGILE Conference on Geographic Information Science. Heraklion, Greece. 29 Apr – 1 May, 2004. http://plone.itc.nl/agile_old/Conference/greece2004/papers/P-06_Baars.pdf. Date of access: 26 Oct. 2010.

BARBU, D. & CUMBLIDGE, S. 2002. GIS for a small city government. Proceedings of the ESRI User Conference. San Diego, USA. Jul. 8-12, 2002. http://proceedings.esri.com/library/userconf/proc02/pap0943/p0943.htm. Date of access: 8 Sept. 2010.

BIODIVERSITY GIS. 2004. Data and Meta-data standards, including explanatory text. http://bgis.sanbi.org/metadatastandards.pdf. Date of access: 07 Sept. 2011.

BRATT, S. & BOOTH, B. 2004. ArcGIS 9: Using ArcGIS 3D Analyst. Redlands: ESRI press. 3-8p.

BULIUNG, R. N. & KANAROGLOU, P.S. 2004. On design and implementation of an object-relational spatial database for activity/travel behaviour research. *Journal of Geographical systems*, 6: 237-262p. http://www.geog.utah.edu/~hmiller/muenster/Bibliography/Buliung_object_relational.pdf. Date of access: 07 Jun. 2011.

BUYS, P. 2010. Verbal communication with the author. North West University Department of Information and Communication Technology. Potchefstroom.

CAI, G. 2002. A GIS approach to the spatial assessment of telecommunication infrastructure. *Networks and spatial economics*, 2: 35-63p. Available: ScienceDirect. Date of access: 8 Mar. 2010.

CHILDS, C. 2001. Migrating coverages to geodatabases. http://www.esri.com/news/arcuser/0701/migrating.html. Date of access: 10 Aug. 2011.

COWEN, D.J. 1988. GIS vs. CAD vs. DBMS: What are the differences? *Photogrammetric engineering and remote sensing*, 54(11): 1551-1555p. http://funk.on.br/esantos/doutorado/GEO/igce/DBMS.pdf. Date of access: 11 May 2010.

CRICKARD, P. 17 Oct. 2010. GIS inside the building. Blog: http://paulcrickard.wordpress.com/2010/10/17/gis-inside-the-building/. Date of access: 12 Apr. 2011.

DELMELLE, E. M. 2001. Map projection properties: Considerations for small-scale GIS applications. Buffalo: State University of New York. (Dissertation). 117p.

DEMPSEY, C. 2000. Glossary: Database management system. http://gislounge.com/database-management-system-dbms. Date of access: 26 Oct. 2010.

DEPARTMENT OF TECHNICAL SERVICES. 2011. Verbal communication with the author. Potchefstroom.

ELLUL, C. & HAKLAY, M. 2006. Requirements for topology in 3D GIS. *Transactions in GIS,* 10(2): 157–175p. http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9671.2006.00251.x/pdf. Date of access: 18 Apr. 2011.

ELOFF, T. 2010. Vice-Chancellor's newsletter. http://www.nwu.ac.za/opencms/export/NWU/html/news/lettervc/VC_Newsletter_Vol1_2010/VCNewsletter_15FEB10_a.html. Date of access: 17 March 2010.

ESRI. 1998. ESRI shapefile technical description – An ESRI white paper. http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf. Date of access: 28 Oct. 2010.

ESRI. 2001. CAD and the geodatabase – An ESRI white paper. http://downloads2.esri.com/support/whitepapers/sde_/J8687_CAD-GIS_Geodatabase.pdf. Date of access: 24 Aug. 2010.

ESRI. 2003. ArcGIS: Working with geodatabase topology – An ESRI white paper. http://www.esri.com/library/whitepapers/pdfs/geodatabase-topology.pdf. Date of access: 18 Apr. 2011.

ESRI. 2005. Municipalities and cooperatives: ESRI GIS technology enabling utilities. http://www.esri.com/library/brochures/pdfs/gis-for-municipalities.pdf. Date of access: 4 Nov. 2010.

ESRI. 2007. Transforming CAD datasets. http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Transforming_CAD_datasets. Date of access: 4 Aug. 2010.

ESRI. 2008a. GIS for telecommunications. http://www.esri.com/library/brochures/pdfs/gis-for-telecom.pdf. Date of access: 25 Feb. 2010.

ESRI. 2008b. Types of geodatabases. http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Types_of_geodatabases. Date of access: 28 Oct. 2010.

ESRI. 2010a. What is GIS? http://www.esri.com/what-is-gis/index.html. Date of access: 4 Oct. 2010.

ESRI. 2010b. What are the types of geodatabases? http://resources.esri.com/geodatabase/index.cfm?fa=typegeodatabase. Date of access: 1 Nov. 2010.

ESRI. 2011. ArcGIS resource center: Desktop 10. http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html. Date of access: 10 Jan. 2011.

FEKETE ASSOCIATES INC. 2011. Theory and Equations: Well monitoring calculations. http://www.fekete.com/software/cbm/media/webhelp/c-te-gisterms.htm. Date of access: 22 Jun. 2011.

FRENCH, S. & JIA, X. 2007. Georgia high-speed telecommunications atlas: An ArcIMS implementation. Proceedings of the ESRI International User Conference. San Diego, USA. Jul. 9-13, 2001. http://proceedings.esri.com/library/userconf/proc01/professional/papers/pap259/p259.htm. Date of use: 12 March 2010.

GLOS, P. 2008. Building and Technology Passport for Masaryk University. Proceedings of the ESRI International User Conference. San Diego, USA. Aug. 4-8, 2008. http://proceedings.esri.com/library/userconf/proc08/papers/papers/pap_1432.pdf. Date of access: 9 Nov. 2010.

HALFAWY, M.R., PYZOHA, D. & EL-HOSSEINY, T. 2002. An integrated framework for GIS-based civil infrastructure management systems. Proceedings of the annual Conference of the Canadian society for civil engineering 2002. Montreal, Canada. Jun. 5-8, 2002. http://pedago.cegepoutaouais.qc.ca/media/0260309/0378334/SCGC-BON/Documents/GE012-Halfawy%20et%20al.pdf. Date of access: 5 Mar. 2010.

HARDER, C. 1999. Enterprise GIS for energy companies. Redlands: ESRI press. 103-107p.

HIJAZI, I., EHLERS, M. & ZLATANOVA, S. 2010. BIM for Geo-Analysis: Setup of 3D information system with open source software and open specifications. Proceedings of the 5th International 3D GeoInfo Conference. Berlin, Germany. Nov. 3-4, 2010.

IEEE. 2011. IEEE 802.3 Ethernet working group. www.ieee802/3/. Date of access: 21 Jun. 2011.

KENNEDY, M. & KOPP, S. 2000. Understanding map projections. Redlands: ESRI press. 2-21p.

KING, K. 2008. Preparing AutoCAD drawings for GIS: A step-by-step process for implementation. Proceedings of Southern California CAD summit 2008. San Diego, USA. Sept 25, 2008. http://www.uscad.com/assets/edocs/Preparing_AutoCAD_Drawings_for_GIS.pdf. Date of access: 11 Aug. 2010.

KNIPPERS, R. 2009. Geometric aspects of mapping. http://kartoweb.itc.nl/geometrics/Reference%20surfaces/refsurf.html. Date of access: 8 Apr. 2011.

KUMAR, S.R.N., SUDHARSON, S., RAMACHANDRAN, R. & GUPTA, R. 2004. Optimization of cable path in a WAN using GIS. Proceedings of the Map India Conference 2004. New-Delhi, India. Jan. 28 – 31, 2004. http://www.gisdevelopment.net/application/utility/power/pdf/mi04021.pdf. Date of access: 12 Apr. 2010.

LEE, J. & KWAN, M.-P. 2005. A combinatorial data model for representing topological relations among 3D geographical features in micro-spatial environments. *International journal of geographic information science,* 19(10): 1039-1056p. http://pdfserve.informaworld.com/623716_751319468_727754398.pdf. Date of access: 18 Apr. 2011.

LEWIS, M.P. & OGRA, A. 2010. An approach of geographic information system (GIS) for good urban governance. Proceedings of the 18th International Conference on Geoinformatics 2010. Beijing, China. Jun. 18-20, 2010. Available: IEEE Xplore. Date of Access: 4 Nov. 2010.

MANDLOI, D. 2007. A GIS data model for enhanced navigation in urban environments. Buffalo: State University of New York. (Dissertation). 73p.

MARTIN. R. 2008. The benefits of AutoCAD Map 3D to AutoCAD users. http://images.autodesk.com/adsk/files/the_benefits_of_autocad_map_3d_to_autocad_users.pdf. Date of access: 18 Oct. 2011.

MATTIX, M. 2005. How to: Transform CAD data in Arc Map to line up with other data. http://resources.arcgis.com/content/kbase?fa=articleShow&d=29039. Date of access: 16 Aug. 2010.

MATTIX, M. 2006. Converting CAD data: Creating a stand-alone feature class with the correct spatial reference. *ArcUser,* 2: 48 – 51. Available: ESRI. Date of access: 4 Aug. 2010

MEEHAN, B. 2007. Empowering electric and gas utilities with GIS. Redlands: ESRI Press. 9p.

MMS. 2011. The Co-ordinate delusion. http://www.mmsdesign.co.za/files/tutorials/images_and_lo_co-ordinates.pdf. Date of access: 22 Jun. 2011.

MORGAN, M.F. 2004. CAD-GIS interoperability issues for facilities management: enabling inter-disciplinary workflows. Columbia, USA: University of South Carolina. (Dissertation – M.Sc.).

MURPHY, S. 2004. Integrating CAD into an Enterprise GIS. Proceedings of the Survey and GIS Summit. San Diego, USA. Aug. 8, 2004. http://proceedings.esri.com/library/userconf/survey04/docs/SteveMurphyPAP.pdf. Date of access: 11 May 2010.

NAUGLE, M.G. 1994. The illustrated network book: a graphic guide to understanding computer networks. New York: Van Nostrand Reinhold.

NIU, X., GOA, H., GU, Y. & YOU, L. 2010. GIS based network management study and its application. Proceedings of the 5th International Conference on Computer Science and Education. Hefei, China. Aug. 24-27, 2010. Available: IEEE Xplore. Date of access: 13 Oct. 2011.

NPS NORTHEAST REGION GIS. 2005. CAD to GIS: A step-by-step guide to converting .dwg CAD files to GIS shapefiles. http://mms.nps.gov/gis/applications/documents/cadgis_rev1d.pdf Date of access: 11 Aug. 2010.

NWU. 2011. The NWU. http://www.nwu.ac.za/nwu/glance.html. Date of access: 09 Aug. 2011.

PACURARI, D.I. 2002. The use of Oracle Spatial and ArcSDE for geodatabase access. Morgantown: West-Virginia University. (Dissertation – M.Sc.).

PEACHAVANISH, R., KARIMI, H.A., AKINCI, B. & BOUKAMP, F. 2006. An ontological engineering approach for integrating CAD and GIS in support of infrastructure management. *Advanced Engineering Informatics:* 20(2006): 71-88p. Available: ScienceDirect. Date of Access: 9 March 2010.

PETERSEN, D. & TABER, T. 2007. Managing a fiber optic network with GIS. Proceedings of Electric and Gas User Group Conference 2007. Nashville, USA. Oct. 8-11, 2007. http://proceedings.esri.com/library/userconf/egug2007/papers/tuesday/am/d_managing-fiber.pdf. Date of access: 9 Nov. 2010.

PU, S. & ZLATANOVA, S. 2006. Integration of GIS and CAD at DBMS level. Proceedings of Urban data management society conference 2006. Aalborg, Denmark.15-17 May, 2006. http://www.gdmc.nl/publications/2006/Integration_of_GIS_and_CAD_at_DBMS_level.pdf. Date of access: 11 May 2010

QUICKBIRD. 2008. Satellite Application Center. CSIR: Pretoria. Date of capture: 02 Nov. 2008

RATH, R. 2007. CAD for beginners. http://ezinearticles.com/?CAD-for-Beginners&id=703084. Date of Access: 13 Oct. 2010

RESURGENT SOFTWARE. 2011. UTM coordinates. http://www.resurgentsoftware.com/GeoMag/utm_coordinates.htm. Date of access: 22 Jun. 2011.

SERUMAGA-ZAKE, J.M. 2006. Experimental models for network mesh topologies with designs that enhance survivability. Potchefstroom: North-West University. (Dissertation – M.Sc.)

TANENBAUM, A.S. 2003. Computer networks. 4th ed. Upper Saddle River, New Jersey: Pearson Education, Inc.

TIEDE, D. & BLASCHKE, T. 2005. A two-way workflow for integrating CAD, 3D visualization and spatial analysis in a GIS environment. Proceedings of the 6th conference for Information Technologies in Landscape Architecture. Dessau, Germany 26-28 May, 2005. http://www.masterla.de/conf/pdf/conf2005/23tiede_c.pdf. Date of access: 11 May 2010.

TURKSTRA, J., AMEMIYA, N. & MURGIA, J. 2003. Local spatial data infrastructure, Trujillo – Peru. *Habitat International*, 27(2003): 669 - 682p. Available: ScienceDirect. Date of access: 28 Apr. 2010.

VAN MAREN, G. (GvanMaren@esri.com) 14 Feb. 2011. 3D geometric network. E-mail to: Bester, C.B. (20232144@nwu.ac.za).

VENTER, L. 2011. Verbal communication with the author. Potchefstroom.

WONNACOTT, R. 1999. The Implementation of the Hartebeeshoek94 co-ordinate system in South Africa. Proceedings of the FIG Working Week assembly 1999. Sun City, South Africa. 30 May – 4 Jun, 1999. www.fig.net/commision5/reports/wonnacott.pdf. Date of access: 14 Feb. 2012.

ZEILER, M. 1999. Modeling our world: The ESRI guide to geodatabase design. Redlands: ESRI press. 5-194 p.

ZHANG, L. 2005. Implications of Geodesy, Spatial Reference Systems, and Map Projections in Processing, Conversion, Integration, and Management of GIS Data. http://www.saudigis.org/FCKFiles/File/SaudiGISArchive/1stGIS/Papers/10.pdf. Date of access: 8 Mar. 2010.

ZLATANOVA, S., TIJSSEN, T.P.M, VAN OOSTEROM, P.J.M. & QUAK, C.W. 2003. Research on usability of Oracle Spatial within the RWS organization. http://www.gdmc.nl/publications/reports/GISt21.pdf. Date of access: 29 Oct. 2010.