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TUM Surrounding Area

3D Modeling with Autodesk Infrastructure Modeler

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Abstract

The approval of infrastructure proposals depends nowadays mostly on stakeholders and investors. The design approach of proposals has always been directed to the project itself, instead of creating a wider image of how the interaction with the future environment is going to be. Autodesk Infrastructure Modeler (AIM) fills this gap in the Architecture, Engineering and Construction (AEC) design industry, by offering a software that allows generating proposals to foretell how project alternatives will perform in the existing surrounding.

The goal to this thesis is to analyze a new conceptual design tool by Autodesk. Autodesk promises a design software created for project engineers as well as GIS and planning professionals to present infrastructure proposals in a rich visual 3D environment. By creating a 3D model of the TUM campus and surrounding area the functionality of Autodesk Infrastructure Modeler will be tested.

The overall impression of AIM is that it is a clear structured design tool. AIM fulfills the promises of Autodesk by allowing the importation of data, creating a robust model and then the styling and the presentation are very easy to understand. Although Autodesk promises a smooth and easy creation and editing of the model, there are a few problems with AIM. These bugs haven't been fixed due to the short amount of time AIM has been in the market. In spite of all the problems, AIM has a lot of potential in the AEC design industry.

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1 Introduction

The protection from weather conditions such as rain, snow, sun, etc. has been necessary for the human being throughout history. The oldest shelter found was built by our ancestor, the Homo Erectus, about 500 000 years ago.¹ Construction and design tasks have notoriously evolved throughout history. Before the Paleolithic Period permanent shelters were not possible, humans were nomads. With the growth of agriculture in the Paleolithic Era the first permanent shelters were built.² The next big step on construction history was at the Mesopotamian Era, where the first form of urbanism was constructed.³

Nowadays urban planning is very important for architects, civil engineers as well as planning and GIS professionals. For many centuries the usage of computer software to help design buildings and cities was unthinkable. Before the usage of electronic medium, building and urban planning design was made by hand, using utensils such as pens, pencils, rules, compasses, etc. Since the beginning of Computer-aided design (CAD) 1980 the usage of draftsmen decreased rapidly and the computer design revolution started growing⁴. Now the computer design software evolution has gone into another Era with Building Information Modeling (BIM). BIM allows the usual 3D modeling and adds more dimensions to the model such as time and cost. BIM covers geographical data such as spatial relationships, geographic information, properties of buildings components (walls, floors, etc.) and much more.⁵ The software company Autodesk offers the Revit line products for BIM building design⁶. With the help of Autodesk Infrastructure Modeler, BIM and other proposals can be presented in their future environment.

1.1 Motivation

The software company Autodesk has been innovating the computational design market since 1982.⁷ This makes each product from the architecture, engineering and construction (AEC) department of Autodesk very appealing for civil engineers. Autodesk Infrastructure Modeler is a new software, which offers a number of design possibilities. It helps delivering new proposals in realistic and rich environment. The goal to this project is to analyze the workability of Autodesk Infrastructure Modeler and to see how customer friendly it is, by modeling the TUM campus and surrounding area.

¹ <http://news.bbc.co.uk/2/hi/science/nature/662794.stm> (Last visit: 15.04.2013)

² <https://www2.bc.edu/~mcdonadh/course/huyuk.html> (Last visit: 15.04.2013)

³ http://books.google.de/books/about/The_Ancient_Mesopotamian_City.html?id=YKlIp9pYMC&redir_esc=y
(Last visit: 15.04.2013)

⁴ http://en.wikipedia.org/wiki/Computer-aided_design (Last visit: 17.04.2013)

⁵ http://en.wikipedia.org/wiki/Building_information_modeling#Definition (Last visit: 17.04.2013)

⁶ http://en.wikipedia.org/wiki/Autodesk#Architecture.2C_engineering_and_construction_.28AEC.29
(Last visit: 17.04.2013)

⁷ <http://en.wikipedia.org/wiki/Autodesk> (Last visit: 17.04.2013)

1.2 Structure

Chapter 2 brings us a little closer to Autodesk Infrastructure Modeler and Autodesk, Inc, the company that develops Autodesk Infrastructure Modeler (AIM). The first version of AIM was AIM 2012 and later on the 2013 and 2013 R2 versions were released. The overview of the AIM 2013 R2's interface and the basic tools will be described and explained.

GIS file format basics, which are described on chapter 3, are very important to better understand how AIM and the geographic object importation work. The definitions and differences of a vector and a raster data are key in this chapter. Each file format and tool besides AIM used for the creation of the model in chapter 5 will be described on this chapter. And finally the definition and difference between the two types of coordinates system, geographic and projected, will be described to later on apply them on chapter 4.

Chapter 4 is the application of chapter 3 and 2, by making a model with Autodesk Infrastructure Modeler of the TUM campus and its surrounding area. AIM offers many possibilities to import data and create a model. This chapter will describe step by step the creation of the TUM surrounding area and which alternatives were available. It will also talk about the enhancement of the model making it more accurate and realistic. And finally the creation of a video presenting the model on AIM will be described.

Due to the short amount of time AIM has been on the market, the software has a lot of bugs. Chapter 5 will describe the problems presented with AIM while importing the data and managing the model.

And finally chapter 6 will be a summary of all pros and cons described throughout the thesis and the analysis of the usage of the AIM software in the working field.

2 AIM - Autodesk Infrastructure Modeler

Autodesk, Inc. is one of the most successful multinational software companies in 3D design. The company was founded 1982 and became famous with the release of the first CAD software of Autodesk, Inc., AutoCAD. The reason why AutoCAD was so successful was because of its affordability for small engineering, design and architecture companies. Autodesk, Inc. took advantage of the technology development in the past years and has now a variety of design softwares that covers the engineering, design and entertainment industry market as well as a consumer market with Pixlr, Sketchbook and Homestyler.⁸ Autodesk has been since 1982 one of the leading design softwares companies in the world and has always brought innovation to its products.

Autodesk Infrastructure Modeler (AIM) is a new product developed by Autodesk that was released 2012 only for Autodesk users and makes its debut with Autodesk Infraworks 2014. Autodesk Infrastructure Modeler is a new conceptual design tool of Autodesk, Inc. It helps project engineers as well as GIS and planning professionals show in a more realistic way infrastructure proposals. The quick creation of an existing surrounding with the evaluation of the future infrastructure helps making infrastructure proposals more appealing via a visually rich design. AIM allows the import of GIS, 2D, CAD, BIM, 3D and raster data to create unrefined city models in 3D, which will give a more realistic view to the local environment. With the real time authoring system, AIM provides a whole new 3D model experience, that is built from 2D and 3D geospatial data, such as terrain data, texture maps, block buildings, etc.⁹

Autodesk Infrastructure Modeler has many options to create proposals. Almost any proposal sketched by an architect, civil engineer or GIS professional can be integrated in Autodesk Infrastructure Modeler. There are simple proposals that can be made such as a new building, a road or a park, but there is much more on AIM. The proposals can get more complicated and precise by modeling whole new city extents, new rivers, new pipeline plans, etc. AIM makes it really easy for any one to import the already existing surroundings, to later on create the proposal.

Being Infrastructure Modeler part of Autodesk it is really easy to exchange parts of proposals or already existing 2D or 3D models between other Autodesk products that are more specialized in infrastructure design such as Autodesk Revit, Civil 3D, etc. An extensive number of companies worldwide use Autodesk products for the design of their projects, which can be easily imported into AIM complementing the presentation of infrastructures to stakeholders. All the other options to import data are also very common for GIS professionals, civil engineers, city planers and architects, making Infrastructure Modeler really easy to use.

AIM has many tools to enhance the proposals or an already existing city extent. Starting with the visual effects available, the model can be viewed on a greyscale, sepia or color. The

⁸ <http://en.wikipedia.org/wiki/Autodesk> (Last visit: 16.03.2013)

⁹ <http://imaginix.com/software-solutions/civil-engineering/autodesk-infrastructure-modeler>
(Last visit: 16.03.2013)

ambient occlusion can be changed and shadows can be implemented and modified depending on the location, time of the day. Each model has a sky that can be changed depending on the time of the day (afternoon, noon, dawn, etc.) and on the weather (cloudy, stormy or clear). Buildings, water areas, roads railways, trees can be added and stylized on AIM. There is also the possibility to stylize imported or created objects on AIM such as roads, buildings, pipelines, railways, etc. Small details such as people walking, cars on the streets, trashcans, trees, etc. can be added to the model. All the tools that AIM has allows the user to create a more accurate resemblance to the real world, that makes the proposal's presentation more pleasant to watch and much more realistic.

The presentation to stakeholders is a very important step for the approval of new proposals, that's why AIM has tools to present the model. AIM allows making snapshots and rendered images with a great pixel resolution. The exportation of the model in an FBX extension gives many possibilities to import the model into another software. The creation of a video helps presenting the model in show motion, making it more appealing for stakeholders and investors.

2.1 Overview of the Users Interface

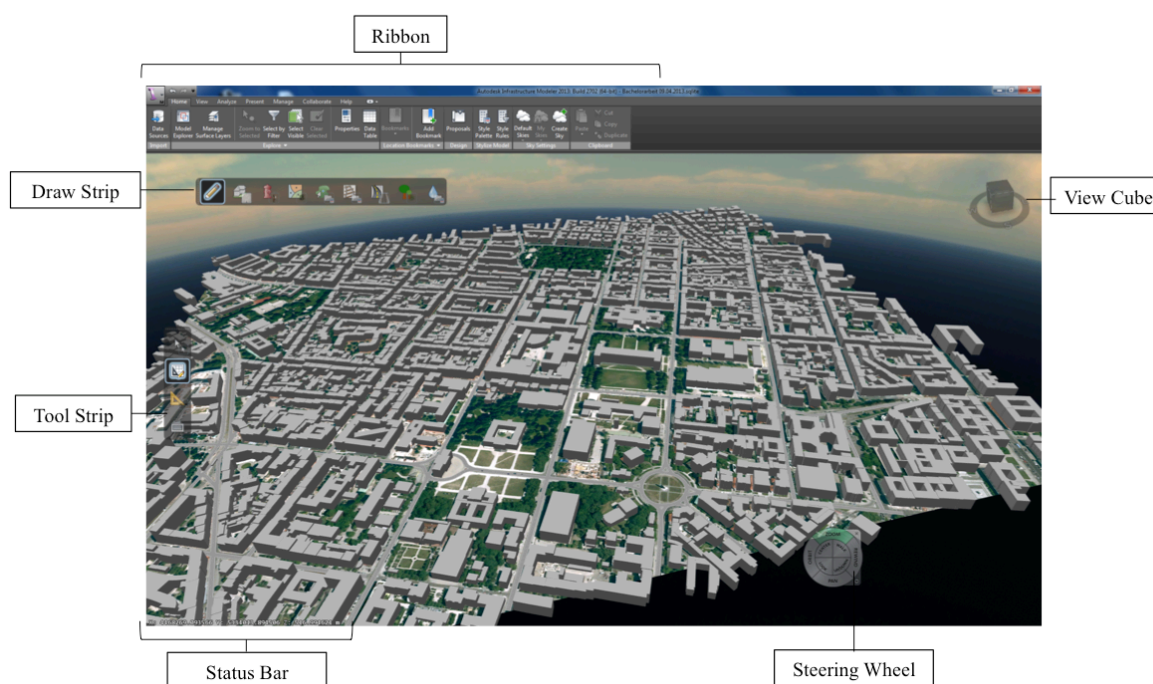


Figure 2.1: Users Interface

The following definitions were taken in a general sense from the Autodesk Infrastructure Modeler 2013 Guide in the Autodesk help website <http://wikihelp.autodesk.com>.

The Users Interface is the group of tools used to interact with the Infrastructure Modeler software. Infrastructure Modeler has descriptions on each available tool making the structure very clear. **¡Error! No se encuentra el origen de la referencia.** shows the entire AIM window with its most basic tools.

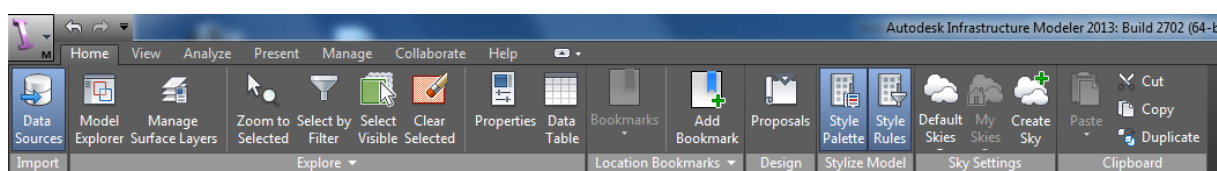


Figure 2.2: Ribbon.

The Infrastructure Modeler users interface is very similar to any other Autodesk design product's interface. Tabs compose the Ribbon: Home, View, Analyze, Present, Manage, Collaborate and Help. The most used tab in Infrastructure Modeler is the home tab in , which allows the importation and managing of the spatial features. On the left side are the most used tools and on the right the less frequently used ones.

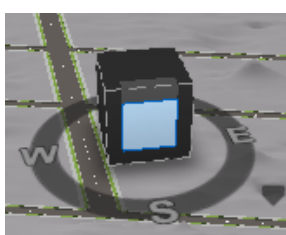


Figure 2.4: View Cube

There are a few options to navigate around the AIM model. The most intuitive one is with the mouse, by orbiting with the left mouse button or pan with the right one. Zoom in or out using the center wheel on the mouse. Another option is using the View Cube in Figure 2.4. To orbit around the model simply drag the cube or tab either side of it to get one perspective.

The third option is using the Steering Wheel in Figure 2.3, which gives the option to zoom, orbit and pan around the model. It also allows rewinding, walking throughout the model, moving up and down and looking around. The Steering Wheel follows the cursor around the model.

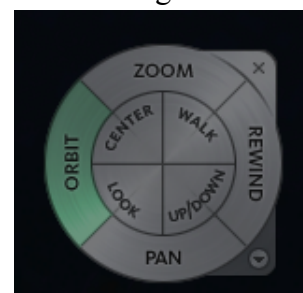


Figure 2.3: Steering Wheel



Figure 2.5: Tool Strip

The Tool Strip in Figure 2.5 contains tools to explore the model and edit or create new features. There is also a tool to measure the length or volume of any feature on the model such as a roads, buildings, etc. The Draw Strip is linked to the Tool Strip. By clicking on the button Create/Edit features the Draw Strip in Figure 2.6 appears. The tools in the Draw Strip can be used to create new features such as buildings, city furniture, coverage areas, points of interest, railways, roads, trees and water areas



Figure 2.6: Draw Strip

The Status Bar in Figure 2.7 shows the X, Y, Z coordinates where the cursor is in the model. On the following figure is a point of the project taken as an example, in Munich. Located in the 3-degree Gauss-Kruger zone 4 and with an elevation of approximately 519 m above the sea level.

X: 4467240.093981 Y: 5334599.722884 Z: 519.459418 m

Figure 2.8: Status Bar

2.1.1 Build a Model

To build a model on Autodesk Infrastructure Modeler there are different tools and options, which the user has to get to know. The following tools for Infrastructure Modeler are key to understand how AIM works and its dynamics. Although the explanation of the different tools used in AIM to build a model are separated in workflows such as styling, making proposals and presenting the model, there are many tools linked to more than one workflow.

Data Sources Panel

The Data Sources Panel allows importing and configuring the features of the model. Each model is made of layers. Each layer is conformed by one or more imported files. In are three layers: buildings, terrain and ground imagery. In more accurate models, if data is available, there can be more layers such as water areas, trees, roads, pipelines, coverages and city furniture. Below the layers in is the Data Source Details Panel, which gives a more detailed description of the feature selected above.

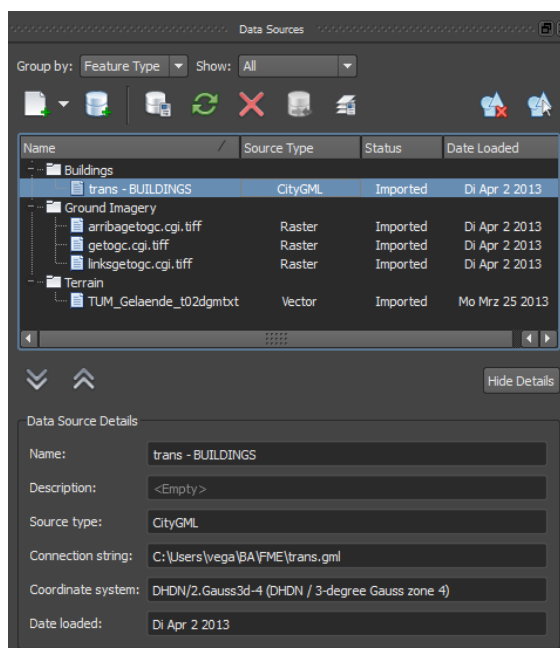


Figure 2.9: Data Sources Panel.

There are two different types of options to import geographical data, using a database or load an independent file. AIM supports the databases Oracle, SWL, WFS and Generic. The most used data source is through an independent file. A database source is far more complicated. In Table 2.1 are listed the independent file formats that can be imported into AIM.

Independent Files	Description and Examples
3D Model	MAX and FBX models
AutoCAD DWG	Only 2D-line work file
Autodesk IMX	Autodesk Civil 3D 2012
CityGML	Only supported by AIM 2013 R2, buildings
LandXML	Terrain models
Raster	DEM file or typical images
SDF	Autodesk GIS file format
SHP	ESRI Shapefile
SQLite	Autodesk Infrastructure Modeler database

Table 2.1: Independent File Attachements recognized by AIM.

Properties Palette

Each object in the model of AIM has its own properties. The Properties Palette shows the features of a selected object such as name, description, manual style, etc. The Properties Palette allows also scaling, rotating translating and styling an object. For example the roof style of a building can be changed in the Properties Palette.

Model Explorer

The Model Explorer allows changing the perspective of each layer, facilitating the work at the time of editing and managing the model. To just work with one layer, Model Explorer offers the possibility to turn off the other layers and make them invisible. This tool allows managing the layers, and having a better perspective of the model. The level of detail (LOD) of the model can be also changed in Model Explorer, where the model shows more or less accuracy.

At the time of editing it can be very frustrating if the wrong object is edited or deleted, so AIM has a locking system to block each layer, making it impossible to change. Model Explorer has an option to highlight different layers, facilitating the view of the entire layer, without being confused with the other ones. Model Explorer works mainly with layers, but there is a possibility to create other groups with features in common by writing expressions. For instance, an expression can describe a subset for the buildings that are higher than 10 meters.

Expression Editor

The Expression Editor allows creating expressions to specify conditions of the model such as calculating values, filtering data, converting data, creating style rules, etc. The interface of the Expression Editor in Figure 2.10 consists of a menu, a toolbar, an expression field and the management tools. The Expression Editor is used in many sections of Infrastructure Modeler. Expressions are very variable depending on what the user wants to condition in the model.

There are many types of expressions such as filtering data, evaluating property value, converting data, creating style rules, calculating values, creating text or numeric expressions, etc. Whenever the user wants to only visualize for example buildings of a certain height or streets of a certain length he can create a filter data expression.

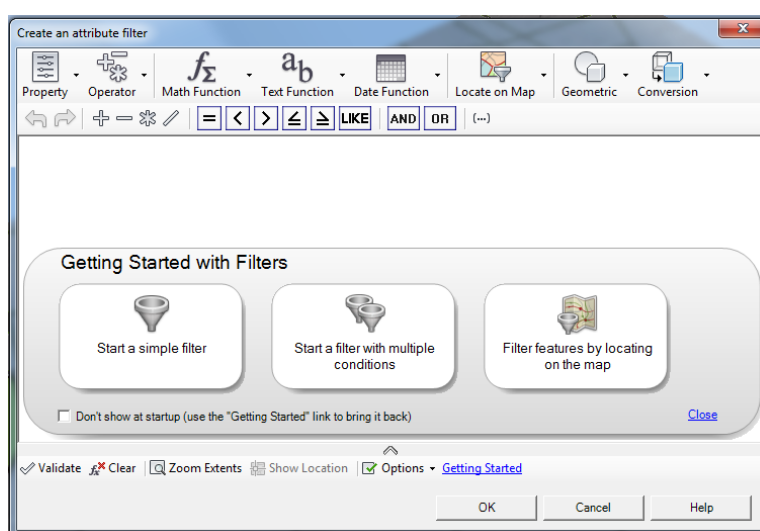


Figure 2.11: Expression Editor.

The data conversion is the process of converting an attribute that the object already has into an attribute that infrastructure modeler recognizes. For instance AIM recognizes the issue date as a date string, but the attribute of the object is only a text string, so with the Expression Editor the user can convert the attribute from a text string to a date string.

2.1.2 Style

Autodesk Infrastructure Modeler offers a variety of tools to style a model, making it more accurate and more appealing to the public. There are many options to style each object of the model such as building facade, tree types, road types, etc. The styling can also be personalized by creating expressions.

Style Rules Panel

In the Style Rules Panel the user can create expressions and give styles to the features of the model. This tool helps changing the styles of more than one object with a similarity more quickly. For example, changing the facade of all the buildings in a street.

Style Palette

Depending on the accuracy of the imported data, the model of the city extent will look more or less realistic. The Style Palette helps to improve the realistic 3D view, by allowing the user to style each feature in the model. The Style Palette is conformed by a number of category tabs; each tab contains a catalog for a particular type of style. For example the tab facade has a number of facade styles for buildings and barricades.

2.1.3 Proposals

The purpose of Infrastructure Modeler is to create proposals and present them in a more realistic way, by adding the proposed infrastructure in its 3D future environment. Usually in an infrastructure planning there are more alternative proposals. That's why AIM offers the possibility to create several proposals in one model.

Proposals Manager

With the Proposals Manager the user can create and manage 2D and 3D proposals. AIM allows creating more than one proposal in a model, that's why the structure of the Proposals Manager tool allows the interaction between proposals. The Proposals Manager in Figure 2.12 gives the options to manage the proposals with the original model or choose between 2D and 3D view. The Proposals Manager has a listed overview of the proposals that are categorized in layers. In Figure 2.12 are two proposals in the layer buildings. Proposals can also be roads, city furniture, coverage areas, etc.

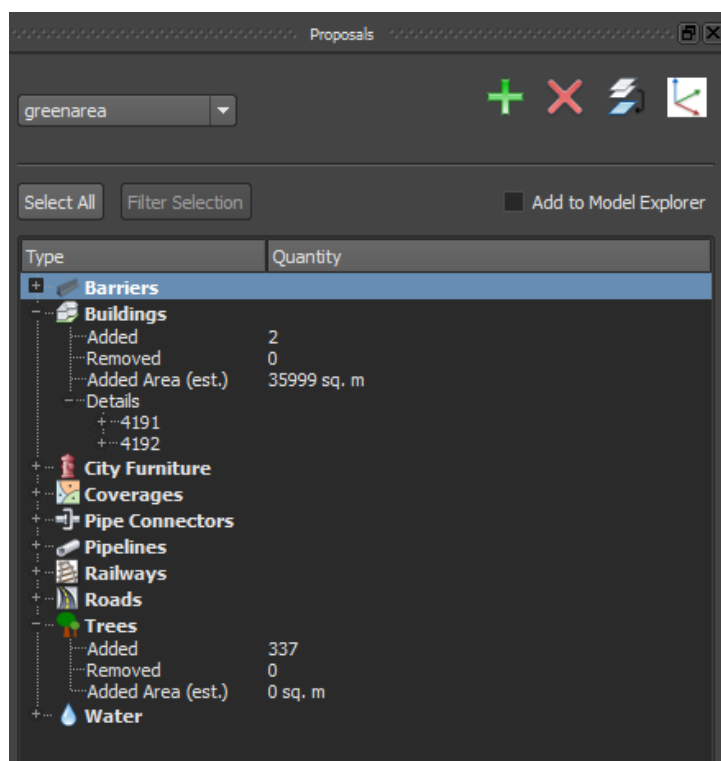


Figure 2.12: Proposals Manager.

2.1.4 Present Designs

Autodesk Infrastructure Modeler offers many possibilities to present the created model by taking snapshots, rendered images, making show motion videos and exporting the model. These tools help making the proposal more appealing for stakeholders and investors. The Presentation tab in the Ribbon mentioned the tools to create storyboards, render images and take snapshots.

Storyboard

AIM allows creating videos with a tool called Storyboard shown in Figure 2.13. A storyboard is a number of images with a certain sequence telling a story. This is exactly what AIM offers, but with the slight difference, that it creates a video. Meaning that although two frames are very different from each other, AIM takes this two frames and moves from one frame to another by moving from one position to the other and creating a video in the process. This is why creating a professional looking video on AIM is very simple. The Storyboard also offers several default animations, which can be used making the video. These animation options could be for instance looking around, zooming, walking through the model, etc.

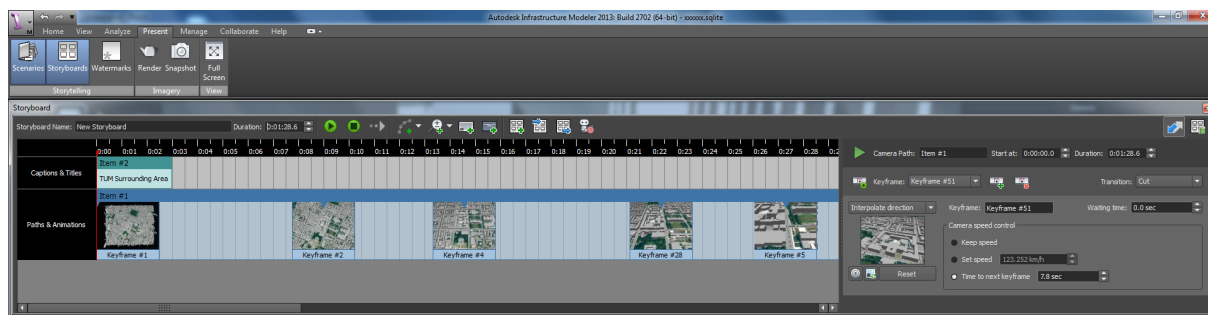


Figure 2.14: Storyboard.

Snapshot

The creation of a snapshot allows the image exportation of a frame on the model. AIM also allows modifying the resolution of the image at the time of the exportation. The Snapshot is an image resembling how a frame looks when working with AIM.

Render

Although both Rendering and Snapshot tools create 2D images, they are very different processes. The render tool processes and analyzes the 3D model frame creating an image with a very realistic 3D view by using visual effects such as shades, texture mapping, shadows, transparency, etc.¹⁰ The objects in the AIM model aren't shown as realistic as in rendered images. When rendering a frame AIM allows the option to give date and time, so that the rendered image has the shadowing and lighting exactly the day, at the time and location desired.

¹⁰ [http://en.wikipedia.org/wiki/Rendering_\(computer_graphics\)](http://en.wikipedia.org/wiki/Rendering_(computer_graphics)) (Last visit: 20.04.2013)

FBX Export

The Autodesk software company owns the FBX file format and is used to provide interoperability between Autodesk products.¹¹ AIM is able to export a part or the entire model in a FBX file, allowing later the importation of the file into other Autodesk products such as 3ds Max, Inventor and Revit products. The FBX exported file is able to describe textures and materials. The exportation could be all into one file or it could also be in more files associating them in feature classes.

IMX Export

AIM also allows the exportation of IMX files. With the Model Explorer layers can be turned off making them disappear. With this tool the IMX export of the model can be modified, only exporting the layers needed. The accuracy of the model depends on the abilities of the software where the IMX file was imported. The IMX file format can be imported in Autodesk Civil 3D.

Exchanging 3D Models with Autodesk 3ds Max

The direct interoperability between AIM 2013 and Autodesk 3ds Max 2013 is possible and simple. AIM has a tool so that a part of the model or a single object can be sent directly into Autodesk 3ds Max 2013. 3ds Max 2013 recognizes the selected part as a single 3D object and allows editing. Afterwards the edited part can be resent to AIM 2013.

2.2 Autodesk 360 Infrastructure Modeler

Presenting the model for a better understanding of the project is key to AIM. Models and specific scenarios can be uploaded in a secure cloud through Autodesk® BIM 360™. The models can be downloaded from the cloud and watched from the iPad® with a free downloaded application called Autodesk Infraworks or through the web with a special plug-in available in the Autodesk website. Autodesk 360 Infrastructure Modeler offers the option to show stakeholders and the public new proposals through the Internet. AIM offers the possibility to publish the model or to limit the viewing of the model for a specific group or person.¹²

¹¹ <http://en.wikipedia.org/wiki/FBX> (Last visit: 19.04.2013)

¹² <http://atlandsend.typepad.com/at-lands-end/2012/10/autodesk-infrastructure-modeler-2013-r2-autodesk-360-infrastructure-modeler-web-mobile-released.html> (Last visit: 19.04.2013)

2.3 System Requirements Autodesk Infrastructure Modeler 2013

For Autodesk to guarantee a workflow without problems on any Autodesk software system requirements have to be met. The Autodesk Infrastructure Modeler 2013 system requirements are online in the Autodesk Wikihelp website¹³. The recommended operating system is Microsoft® Windows® 7 (SP1) 64-bit with a memory of 8 GB RAM, but AIM can also work with the Windows® 7 (SP1) 32-bit with 4 GB RAM (minimum). The CPU should be either Intel Pentium 4 or AMD Athlon with a minimum frequency of 2.x GHz. Although Autodesk suggests a graphics card supporting a resolution of 1024 x 768 or higher with a recommended video memory of 1024 MB, DirectX 10 and 4 x Antialiasing capable, AIM also works with a graphics card with video memory of 512 MB and 2 x Antialiasing. The hard disk should have 10+ GB of memory available for the installation. The recommended pointing device is a MS-Mouse compliant and .NET Framework Version 4.0 should be installed.

¹³http://wikihelp.autodesk.com/Infrastructure_Modeler/enu/2013/Help/0266-Install/0417-Autodesk417/0418-Autodesk418 (Last visit: 15.04.2013)

3 GIS - Geographic Information System

Autodesk Infrastructure Modeler is a software created to present infrastructure proposals in a 3D model with its surroundings. The first step on creating a city extent on AIM is importing data from either a database or independent single files to create layers, which later on are part of the model. This chapter will describe how the file formats, used in this project, are structured. An explanation of the two different coordinate systems (geographic and projected) will be described at the end of the chapter.

3.1 GIS Spatial Data

The Geographic Information System (GIS) is an information system that includes hardware (physical parts of the computer), software (programs that run on the computer), and appropriate procedures. GIS is designed to capture, manage, analyze, and display geographical data.^I

What makes GIS distinctive is its vast description of geographic features, not only in a graphical way, but also topological and topographic information that makes the model a more accurate resemblance of the real world.^{III}

GIS data works with the combination of real objects (roads, trees, elevations, etc.) and digital data. There are two divisions of real objects: the discrete objects (for example a tree) and continuous fields (such as elevations). There are two methods how GIS data can be represented, raster data and vector data.¹⁴

The GIS vector data type is based on the point description of spatial objects. The most basic geometric representations are the point, the line, and the polygon. The point and the line are the basic structures, by adding the polygon as a closed polyline. A database gives each of these geometries attributes for better description.¹⁵

On the other hand, the raster data type is based on a matrix. Each element of the matrix has a value. A raster image is composed of pixels, the color values given to each element of the matrix. Additional values for each cell are called discrete values, such as temperature. For a better understanding of both file formats, shows how both visually look like.¹⁶

The decision of using either a vector-oriented or raster-oriented file for a specific description and storage is based on their advantages and disadvantages. The hybrid GIS takes the advantages of both file formats systems and combines them. That way the advantages of vector-oriented and raster-oriented file formats can be unified describing and storing objects. For instance raster files are better suited to describe areal phenomena and continuous data, while vector files best describe line-like shapes and exact delimitable objects.^{III}

¹⁴ <http://en.wikipedia.org/wiki/GIS> (Last visit: 17.03.2013)

¹⁵ http://en.wikipedia.org/wiki/GIS_file_formats#Vector (Last visit: 17.03.2013)

¹⁶ http://en.wikipedia.org/wiki/GIS_file_formats#Raster (Last visit: 17.03.2013)

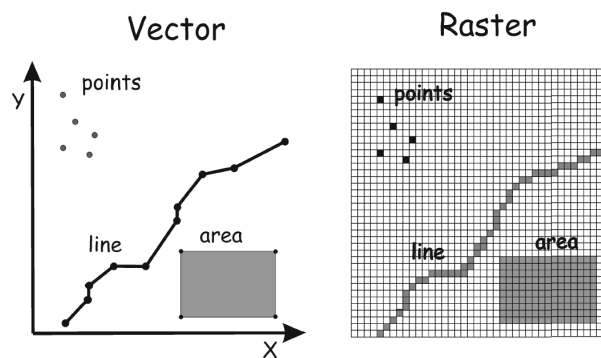


Figure 2-8: Vector and raster data models.

Figure 3.1: Comparison between a vector description of spatial objects and a raster description.¹⁷

3.1.1 CityGML

City Geography Markup Language (CityGML) is utilized in the GIS world as an information model that, through its XML based language, delivers and stores 3D city and landscape representations.¹⁸

XML is a human-readable and machine-readable language created by the World Wide Web Consortium.¹⁹ It was not only created to communicate between applications over the Internet, but also to simplify and standardize data exchange between platforms. Although XML is based on a simple technology, it can be built up into a more complicated system with wider possibilities such as the Geography Markup Language (GML).²⁰

GML is an XML sublanguage developed by the Open Geospatial Consortium (OGC) to model, exchange, and store GIS information.

At the beginning GML 1.0 and GML 2.0 were only able to describe vector objects (geometric feature types: point, line string and polygon), but with the release of GML 3.0 the description of coverage and sensor data were added.²¹

GML gives the possibility to integrate its basic description with GML application schemas. GML application schemas are also written in XML, and are created by a community or an organization to store and retrieve the object types that the community is interested in.²²

CityGML is an application schema for GML3 standardized by the ISO 19100 family framework. CityGML is able to store and model 3D geographical, topological, semantical, and appearance data. As the name implies, CityGML describes not only one isolated building, but also the relation of each spatial object and its properties; modeling entire sites, districts,

¹⁷ <http://www.indiana.edu/~gis/courses/g338/images/chapter2figs/fig2-11.gif> (Last visit: 19.03.2013)

¹⁸ <http://www.citygml.org/index.php?id=1523> (Last visit: 21.03.2013)

¹⁹ http://en.wikipedia.org/wiki/Geography_Markup_Language (Last visit: 24.03.2013)

²⁰ http://es.wikipedia.org/wiki/Extensible_Markup_Language (Last visit: 24.03.2013)

²¹ http://en.wikipedia.org/wiki/Geography_Markup_Language#GML_geometries (Last visit: 24.03.2013)

²² http://en.wikipedia.org/wiki/Geography_Markup_Language#Application_schema (Last visit: 24.03.2013)

cities, regions and even countries. CityGML has 5 levels of detail, describing how accurate the 3D model is.²³

Levels of detail (LOD):^{III}

- LOD 0 has the lowest level of accuracy and describes 2,5D regions or 3D landscapes.
- LOD 1 describes a simple city or region with object blocks. All roofs are flat.
- LOD 2 describes the buildings with actual roof geometry. It is able to give texture to the facade.
- LOD 3 is a very detailed model of the exterior of each building.
- LOD 4 starts with a LOD 3 model and includes the description of the interior of each building (including rooms, furniture, and fixed installations such as stairs)

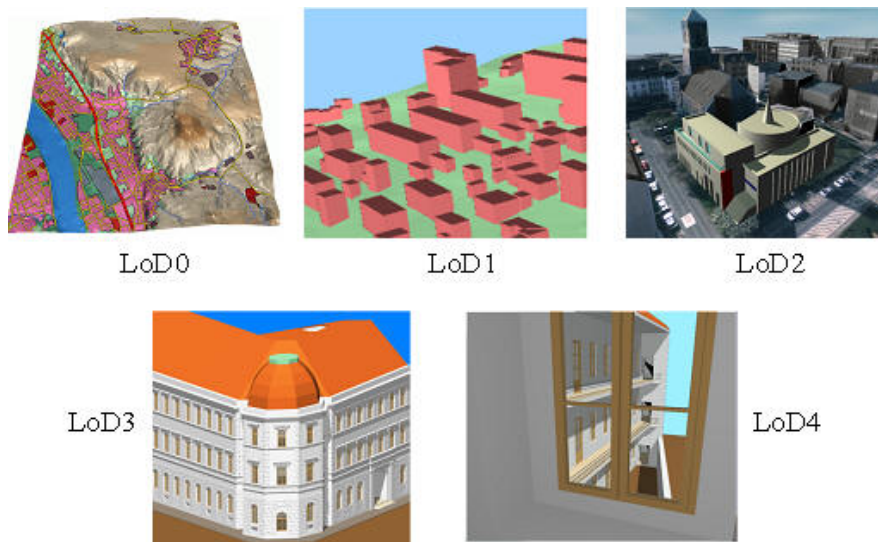


Figure 3.2: The 5 different Levels Of Detail (LOD) in CityGML.²⁴

The development of CityGML started in 2002 with the 3D GIS group Geodata Infrastructure North-Rhine Westphalia in Germany. The first 3D models were only a graphic description of the outside world, limiting the analysis of the spatial objects. Therefore, the purpose of developing CityGML was to revolutionize 3D models by adding to the graphic description, the semantical, and topological aspects. CityGML is now a key component in the transition from 2D models to 3D.²⁵

CityGML helps the new technology BIM (Building Information Modeling) to connect with the urban side, Urban Information Modeling, improving interoperability with the information systems in the tasks to construct, design, and operate infrastructure projects.²⁶

²³ <http://www.citygml.org/index.php?id=1523> (Last visit: 17.03.2013)

²⁴ http://www.directionsmag.com/images/newsletter/2006/06_22/LoD_lg.jpg (Last visit: 17.03.2013)

²⁵ <http://www.citygml.org/index.php?id=1531> (Last visit: 17.03.2013)

²⁶ <http://www.citygml.org/index.php?id=1523> (Last visit: 17.03.2013)

3.1.2 ESRI Shapefile

The following definition was taken in general sense from the ESRI Shapefile Technical Description in the ESRI homepage.

ESRI Shapefile is a nontopological geographic vector data format used to store geographic elements (such as lakes, rivers, etc.) and their attributes (such as name, temperature). ESRI originally created the file format for the software ArcView GIS by ESRI, but because of the importance that ESRI has in the GIS market and the advanced documentation of the Shapefile format, it became a standard file format for the exchange of geographical information.

A Shapefile is conformed by a cluster of files. The three mandatory files are the shape format (.shp) that stores the geographical features of an object, the shape index format (.shx) that stores the positional index of the geometry, and the attribute format (.dbf) which gives each element attributes in a dBase IV format. The optional files are mainly index data to improve the performance of the Shapefile.

3.1.3 FME

The Feature Manipulation Engine (FME) was created by Safe Software, Inc. and was the first tool to translate spatial data between geometric and digital formats. With the spatial ETL (extract, transform, and load) application FME can read data from any format, transform it to meet the customer's needs and then load it. FME was especially created to translate and work with geographic information system (GIS), computer-aided design (CAD) and raster graphics software.²⁷

3.1.4 WFS

The OGC® Web Feature Service Interface Standard (WFS) presents the possibility to request spatial objects in vector data across the web. Although the most common file format to transport the geographic data in WFS is the XML-based GML, there are other alternatives such as the Shapefile.²⁸

There are two types of WFS, the basic WFS and the transactional WFS (WFS-T). With the basic WFS the requester is only able to call and obtain the information, whereas with the WFS-T, they are also able to create, delete, and update the data. The communication with WFS can be produced in two different ways, XML (HTTP POST) and Keyword-Value pairs (HTTP GET).²⁹ The basic WFS has the following static encoding to call the WFS server:^{III}

- **GetCapabilities** shows the available options of the service in an XML document, describing the platform information (available layers, projection system, and type of coordinates). GetCapabilities shows how to use the information to request a GML file with the GetFeature encoding.
- **DescribeFeatureType** describes the structure of a class.
- **GetFeature** asks for the spatial data file, which is normally stored as a GML file.

²⁷ <http://whatis.techtarget.com/definition/Feature-Manipulation-Engine-FME> (Last visit: 20.04.2013)

²⁸ http://en.wikipedia.org/wiki/Web_Feature_Service (Last visit: 20.03.2013)

²⁹ http://en.wikipedia.org/wiki/Web_Feature_Service (Last visit: 20.03.2013)

3.1.5 WMS

A Web Map Service (WMS) offers the possibility to request map images across the web from a GIS database. Normally the map image is in a raster file format such as .PNG, .GIF or JPEG, but can also be a vector image file format. The same company that developed WFS, Open Geospatial Consortium, developed WMS 1999.³⁰ The WMS interface includes the following basic operation encodings:^{III}

- **GetCapabilities** shows the available options of the service in XML language, describing the platform options such as available layers, projection system, and type of coordinates. Adding the encoding DescribeLayer can create additional information about layers. GetCapabilities shows how to use the information to request a map with the GetMap encoding.
- **GetMap** asks for a raster image of a region with the description of available options. WMS is only able to deliver images; it doesn't deliver any attributes or vector data.
- **GetFeatureInfo** asks for information about a spatial data. It doesn't support complex requests.

3.2 Coordinate System

A coordinate system is a system to locate points and objects in a geometric space³¹. The Cartesian coordinate system is the most common coordinate system. Two or three orthogonal axes equally scaled define the Cartesian coordinate system, depending if it is a 2 dimensional or a 3 dimensional system. Describing the location with the distance between the axes and the point or object.³²

For GIS professionals it's necessary to describe and compare the location of spatial objects in the earth with a predefined coordinate system. Infrastructure Modeler is based on the most used GIS coordinate systems types, the geographic coordinate system and the projected coordinate system. To recognize in which coordinate system type each file is described it is important knowing the basics of both coordinate system types.

The following definitions were taken in general sense from the <http://help.arcgis.com/> website.

3.2.1 Geographic Coordinate System

A geographic coordinate system is a coordinate system to locate every spatial object on the earth. It describes the earth as a 3 dimensional spherical surface. The location of a point is determined by an angle of measure, a prime meridian and a datum. Figure 3.3 shows that the geographic coordinate system establishes the point of origin in the center of the earth and describes a point on the earth's surface by measuring angles, called latitude and longitude (unit of measurement: degrees). On the surface of the earth horizontal lines that have the same latitude are called parallels, and the vertical lines that have the same longitude are called meridians.

³⁰ http://en.wikipedia.org/wiki/Web_Map_Service (Last visit: 27.03.2013)

³¹ <http://de.wikipedia.org/wiki/Koordinatensystem> (Last visit: 10.04.2013)

³² http://es.wikipedia.org/wiki/Sistema_de_coordenadas (Last visit: 10.04.2013)

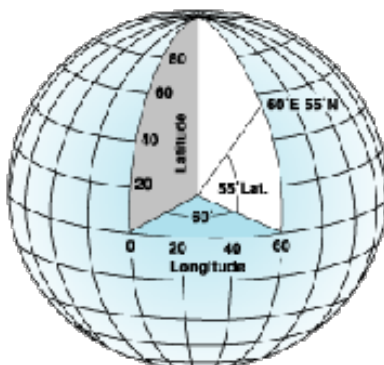


Figure 3.3: The earth is represented as a sphere and shows the center of the earth as point of origin. Latitude and longitude are describing a point on the surface.³⁴

The 0° parallel cuts the earth's surface on half horizontally and is called the equator, dividing the north and the south hemisphere. The north hemisphere is ranged from 0° to +90° and the south from 0° to -90°. The 0° prime meridian cuts also the earth's surface in half but vertically and is called the Greenwich meridian. The meridians west from the Greenwich meridian are ranged from 0° to -180° and east are ranged from 0° to +180°. With this coordinates the earth is divided in 4 geographical quadrants, above the equator being the north hemisphere and beneath the south hemisphere and to the left and right of the Greenwich meridian being the west and east hemisphere. The combination of parallels and meridians on the earth as Figure 3.4 on the right shows create a gridded network called a graticular network.

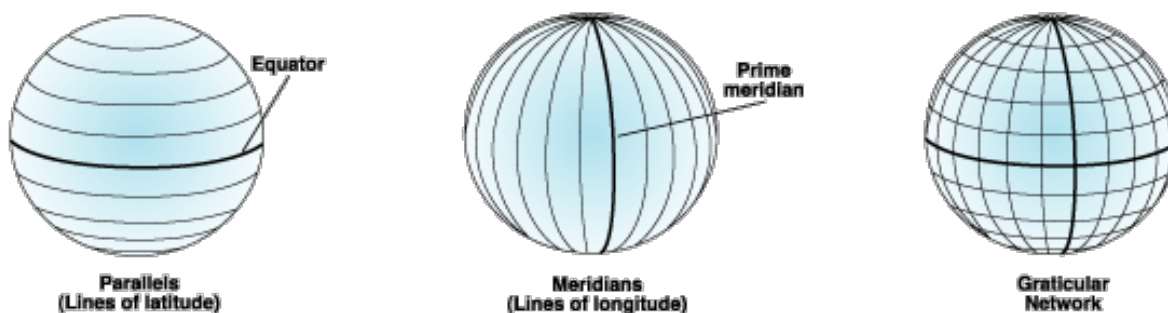


Figure 3.4: Division of the earth in parallels and meridians and the combination of both composing a Graticular Network.³⁵

The definition of a coordinate system is a system that has equally scaled axes. Although the geographic coordinate system can give the exact location of a point on the earth's surface, the distance on the earth's surface of a latitude degree and a longitude degree are not uniform. The only parallel where the latitude degree distance and the longitude degree distance are approximately the same is along the equator. This is because the circumference of the equator

³⁴ <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#na/003r00000006000000/>
(Last visit: 10.04.2013)

³⁵ <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#na/003r00000006000000/>
(Last visit: 10.04.2013)

and a meridian is approximately the same. All meridians above and beneath the equator have smaller circumferences, which leads into bigger distances for a latitude degree. That's why the parallels get gradually smaller by getting closer to the poles.

3.2.2 Projected Coordinate System

The difference between the geographic and the projected coordinate system is that the projected coordinate system describes the earth in a plane surface instead of 3 dimensional. The projected coordinate system is a Cartesian coordinate system. The geographic coordinate system is the base of the projected coordinate system, but with its 2 dimensional projection all the problems of the discontinuous angles, lengths and areas that the geographic system has disappear.

The projected coordinate system is conformed by two axes, the x-coordinate and the y-coordinate, on a grid. Each position is described by a horizontal value and a vertical value. Normally the point of origin is the center of the grid, dividing the grid into 4 quadrants. The lines that divide the quadrants are called the x-axis, the horizontal line, and the y-axis, the vertical line. Being negative numbers from the y-axis to the left and values beneath the x-axis, the positive from the y-axis to the right and values above the x-axis.

To describe the earth in a flat map the simplest way is to project it onto geographic figures that can be flattened without stretching the surface such as cones, cylinders and planes. The conic projection in Figure 3.5 is an example of how a cone is flattened.³⁷

There are many projection types worldwide such as the Transverse Mercator projection, which is a cylindrical projection used worldwide, including the UTM (Universal Transverse Mercator) and the Gauss Kruger projection.

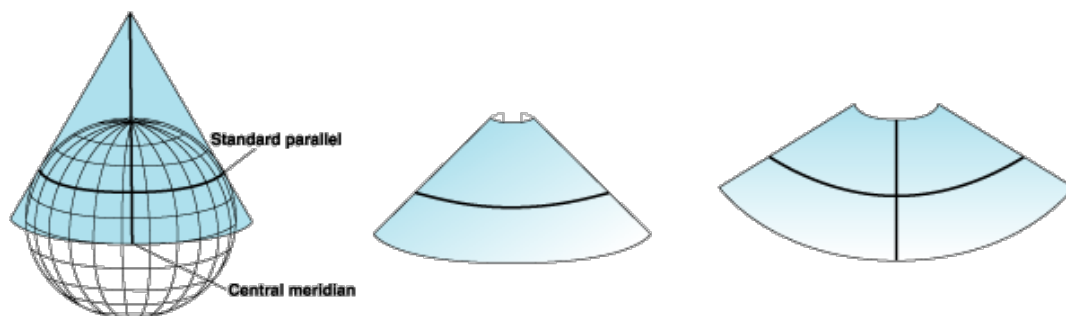


Figure 3.5 Cone is placed over the globe and than flattened into plane.³⁸

The coordinate system in Infrastructure Modeler is very important at the time of importing and configuring the model. Each file imported in Infrastructure Modeler is categorized in layers. Each layer has a number of files, that summing all together composes the model. If the position of each file doesn't concord, the model doesn't concord either.

³⁷ http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Projection_types/003r000000r000000/

³⁸ http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Projection_types/003r000000r000000/

4 3D Modeling with AIM - TUM Surrounding Area

The goal with this chapter is to better analyze how the AIM software works by creating a model of the TUM campus and Surrounding Area. The first part of the chapter is an explanation of the GIS data gotten from the chair of Computational Modeling and Simulation. Then the process of importing and configuring the GIS objects will be described in each layer. And finally the model will be styled and presented as a video.

The TUM main campus is located in the Maxvorstadt district between the center and the Schwabing district of Munich. King Maximilian I. founded Maxvorstadt between 1805-1810. Maxvorstadt has besides the Technical University many cultural points of interest. Important museums such as the Neue Pinakothek, Alte Pinakothek, Pinakothek der Moderne, Brandhorst and Glyptothek (Königsplatz) are located in the Technical University surroundings.³⁹ The model created in Infrastructure Modeler will describe all the locations mentioned above and all the buildings located in the Gauss-Kruger coordinates between (4467080, 5334000) and (4468000, 5335440).

4.1 Importing the GIS Data

4.1.1 Preparation

The first step starting the project was to collect the files needed to build the city section. The chair of Computational Modeling and Simulation provided the GIS files needed to achieve the modeling. The surface information came in two different file formats, an ESRI Shape file and in a text file, which gave the option to choose between one of them. The so-called “Klötzenmodell”, the block shaped model, were described in a CityGML file.

Despite getting all the independent file attachments, WMS and WFS addresses from the Bavarian State Office for Surveying website <http://geoportal.bayern.de/geoportalbayern/> were also available. WMS offered the possibility to request orthophotos across the web from a GIS database and WFS offered the possibility to request the CityGML “Klötzenmodell”.

The software Autodesk Infrastructure Modeler was easy to access, because of the available student license from the students Autodesk website <http://students.autodesk.com>. The chair of Computational Modeling and Simulation also offered an available computer with the already installed software in their offices.

The roads were downloaded later on from the <http://www.geofabrik.de/> website, which offered available GIS information data around the world.

4.1.2 Terrain

The first layer created in an AIM model is usually the terrain, which describes the shape of the earth’s crust in a particular city extent.⁴⁰ The city Munich has a very flat terrain, that’s to

³⁹ <http://www.muenchenwiki.de/wiki/Maxvorstadt> (16.04.2013)

⁴⁰ http://es.wikipedia.org/wiki/Relieve_terrestre (06.04.2013)

say it doesn't have any big differences of relief such as mountains or lakes. That's why Figure 4.1 doesn't have a big color difference. Although there aren't big height differences each small elevation difference is visible. The level of detail in Figure 4.1 is high, that's why each area-usage (roads, building areas, etc.) is recognizable. Importing terrain data into AIM makes the model a more accurate resemblance of the real city extent.

Raster - Global Mapper

Global Mapper, a GIS data processing application, was used to convert the given coordinates (x,y,z) into a raster file (*.dem) that was used as the terrain. The following picture shows the terrain layer made with Global Mapper.

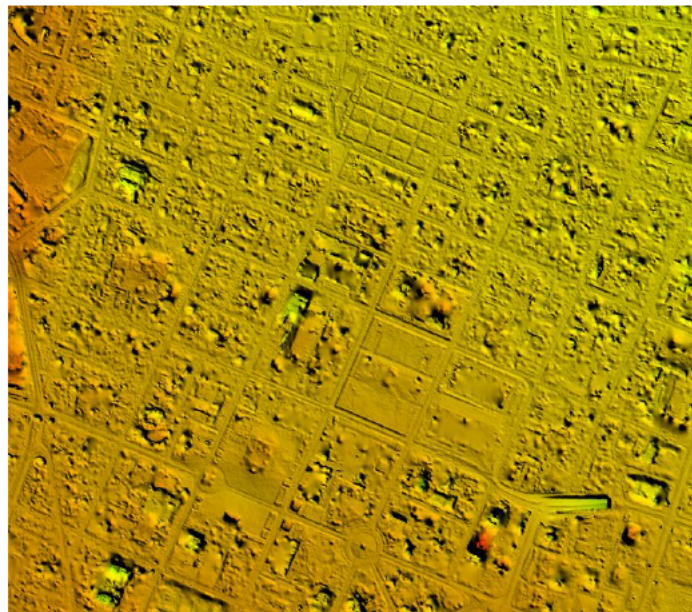


Figure 4.1: Raster image created from the ASCII encoding in Global Mapper. The difference of the color shows the elevation of each point. Being red the highest point, and, in this case, green the lowest.

Vector - ESRI Shape

Another option to import the terrain into Infrastructure Modeler was using the ESRI Shape file. The Shapefile is a geospatial data vector format that contains the mandatory files *.shp, *.shx, *.dbf and in the case of this project also the optional files *.idx and *.prj. At the time of importing the data only the *.shp file extension is imported. The *.shp file extension calls all the other file extensions to create the vector model.

In spite of being the raster file my first option, it was by far the most complicated choice. The vector file was very simple to import without any conversion and the terrain in AIM was exactly the same as the raster file.

4.1.3 Ground Imagery

AIM allows the importation of areal images, which are draped on top of the terrain showing where streets, buildings, green areas, etc. are located. Figure 4.2 is one of the 2 images used to drape on top of the terrain of the TUM surrounding area.

AIM accepts the importation of many raster file formats, but not all of them are recognized as ground imagery. That's because not all file formats contain the world location of the image. For instance, the GIS database of the Bavarian State Office for Surveying can deliver the orthophoto in a *.png format, which stores the image without the location. Although AIM accepts the importation of the *.pgn data, at the time of the configuration an error pops up. Table 4.1 shows the file formats that AIM accepts as ground imagery.

	Picture File Extension	World File Extension
Erdas Imagine	*.img	*.jgw
JPEG	*.jpg/*.jpeg	*.jgw
MrSID	*.sid	*.sdw
Tiff	*.tif/*.tiff	*.tfw

Table 4.1: Ground Imagery file formats recognized by AIM. The Picture File Extension is the actual image file extension and the World File Extension stores the location of the image.⁴²

The available and usable image file extension was *.tiff. The image was called from the GIS database of the Bavarian State Office for Surveying website through a Web Map Service. The usage of 4 images instead of one was because the GIS database could only deliver square images and the city extent was rectangular. Figure 4.2 covers 1500 x 1500 m² of the city extent and has a ground pixel size of 20 cm. The image is located in the 3-degree Gauss-Kruger zone 4 also called EPSG=31468. The lower corner of the square has the (X, Y)-coordinates (4467002, 5333902) and the upper corner (4468502, 5335402), being the unit of measurement in meters.

The first step to figure out how to write the encoding to call the database through the Web Map Service is to ask for the XML file, which contains all the available options of the service. The XML document shows the version of the WMS, 1.1.1 in this case; the available layers, which are the available images such as shooting date, orthophotos in color or orthophotos in greyscale; the minimum and maximum coordinates of the bounding box, which had to be described in Gauss Kruger coordinates or geographic coordinates; the available image format; the minimum and maximum image size (width and height) in pixel; and the style as the default style. With all the information mentioned above the GIS database was called to get color areal images, which were then imported in the AIM as independent files.

⁴²<http://www.retrievecontent.com//Frame.spr?libId=283&bookId=1577&username=aimcustomerpublic&hash=b64d99b36bea13b56cbdd0f1d37a6a7fd578f9&mobile=false>



Figure 4.2: TUM surrounding area. City extent: 3-degree Gauss-Krüger zone 4, Coordinates: 4467002, 5333902, 4468502, 5335402⁴³

4.1.4 Buildings

The buildings of the city extent were described in a CityGML file. The building blocks had a LOD 1, which meant that the buildings had no texture description and the roofs were all flat. The location of the buildings was in Gauss-Krüger coordinates.

CityGML

After the release of Autodesk Infrastructure Modeler 2013 came the AIM 2013 R2 version. With the release of AIM 2013 R2 new features came along and also the possibility to import CityGML files. AIM reads the CityGML coordinates in y,x,z sequence, which locates the model in an entire off position. That's why the coordinates were inverted by FME in a x,y,z sequence. The CityGML file format is able to carry information about the file and single objects. That's why AIM recognized the data as building layer with a location of 3-degree Gauss-Krüger zone 4. Figure 4.3 shows how the city extent after the importation of CityGML looked. Because the CityGML file format is able to carry attributes, AIM recognizes it as a building layer with a location of 3-degree Gauss-Krüger zone 4.

⁴³http://www.geodaten.bayern.de/ogc/ogc_dop20.cgi?REQUEST=GetMap&VERSION=1.1.1&LAYERS=adv_dop20c&SRS=EPSG:31468&BBOX=4467002,5333902,4468502,5335402&FORMAT=image/tiff&WIDTH=2000&HEIGHT=2000&STYLE=

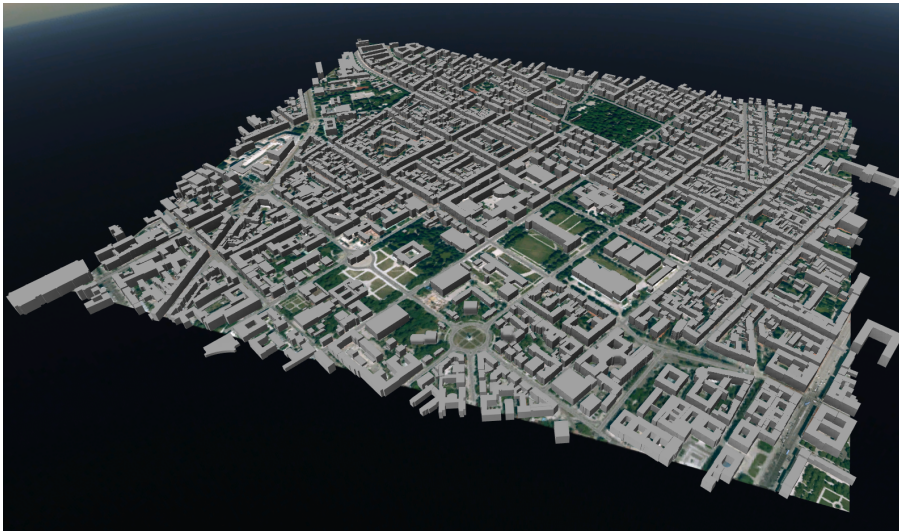


Figure 4.3 CityGML model in AIM 2013 R2 with ground imagery and terrain.

4.1.5 Roads

Many GIS websites offered to download geographical data, mainly USA data. Although there were many options to download GIS data from the United States, Germany had very limited free data available. The GIS website <http://www.geofabrik.de/> provided GIS data around the world, including Germany. The website had gave several options to download data from Upper Bavaria (Oberbayern) where Munich is located. The download data best suited for the project was a .zip file, which contained ESRI Shapefiles describing a number of city type objects. The most significant needed data at that time was the roads description and location, which the .zip file contained.

ESRI Shapefile

The data downloaded had the obligatory ESRI Shape extensions *.shp, *.shx, *.dbf and the optional *.cpg, *.idx, *.prj. The file extension *.prj described what kind of coordinate system was used to describe the roads. It was a geographic coordinate system that had to be converted in projected Gauss-Kruger coordinates. The conversion was made once again with the FME Quick Translator.

Although the description of all the roads was found as an ESRI Shape download file on the Internet, this option wasn't the one chosen for the model. The road system data gotten from the GIS website was very accurate and contained also sidewalks and footpaths, information that could make the model look more accurate. The problem was that these extra features didn't help the model; they did exactly the opposite making it look sloppier. With the help of ground imagery the roads were sketched directly on AIM as it is described in section 4.2.

4.2 Styling the model

Importing all the GIS data wasn't enough to create a 3D realistic model. The model had to be stylized. The ground imagery imported gave the model a very realistic view, but the problem was that all the trees and other objects beside the buildings were flat.

Roads

The styling started with the sketching of all the roads highlighted in Figure 4.4 the city extent with the help of the ground imagery. AIM was very helpful sketching the roads, because it recognized, where two roads were crossing each other. There are many options to style a road such as a simple road, a road with sidewalks and lamps, a boulevard, etc.



Figure 4.4: Created roads in AIM 2013 R2 highlighted in red.

Coverages

After creating the roads two options were available to sketch the sidewalks, creating already existing default sidewalks from the AIM style palette or sketching coverages with a sidewalk texture. Because the default sidewalks were too narrow, the second option was the best option to create a more realistic looking model. AIM offers different ways to create an object, so that the user has more liberties on creating the project. Coverage area was used in the project to cover grass extensions.

City Furniture

Small details such as cars, bus stops, traffic lights, people, etc. make the model more accurate and realistic. AIM offers an extent number of city objects, which help enhancing the city. There are many types of cars and people, so that the user can chose the most appropriate piece. Figure 4.5 shows how the enhancement in the intersection between Theresienstraße and Arcisstraße next to the TUM looks like.



Figure 4.5: Intersection Theresienstraße – Arcisstraße. Rendered Image.

Trees

Munich is a city with a lot of vegetation. It has countless amount of parks and recreational areas. Around the Alte Pinakothek next to the TUM campus shown in Figure 4.5 to the right are such recreational parks mentioned before. These two areas are full of trees, which were sketched with the AIM editor, making a richer 3D visual model. The TUM campus is enhanced with 3D trees, which were found with the help of the ground imagery. AIM allowed creating entire tree areas, so that it would be much faster sketching entire forests. The trees on the AIM software didn't look as realistic as in a rendered image such as Figure 4.5. The reason why the trees looked different on AIM was because the size of each realistic tree would have made the software a lot slower.

4.3 Presenting the model

The options offered by AIM to present a project were creating a storyboard, taking snapshots and rendering images from the model. All these options were created to better present the model. Tools creating real day shadows and skies improved the realistic visual effects.

Storyboard

The Storyboard created for the project shows the features of the model. It zooms in showing all the details such as city furniture, trees and roads and then the camera flights around the TUM campus. How to use the Storyboard tool is very clear and intuitive for the user. AIM allows creating frames showing the path of the camera. The path's speed from one frame to another can be also fixed. The Storyboard is a great tool to present a project showing all its great features.

Render

The time of rendering a frame depends on how accurate the user wants the image to be. AIM loads more and more details as time goes by, and the user is allowed to cancel this process whenever he gets to his desired image. Figure 4.6 shows the difference between a snapshot and a rendered image on AIM.

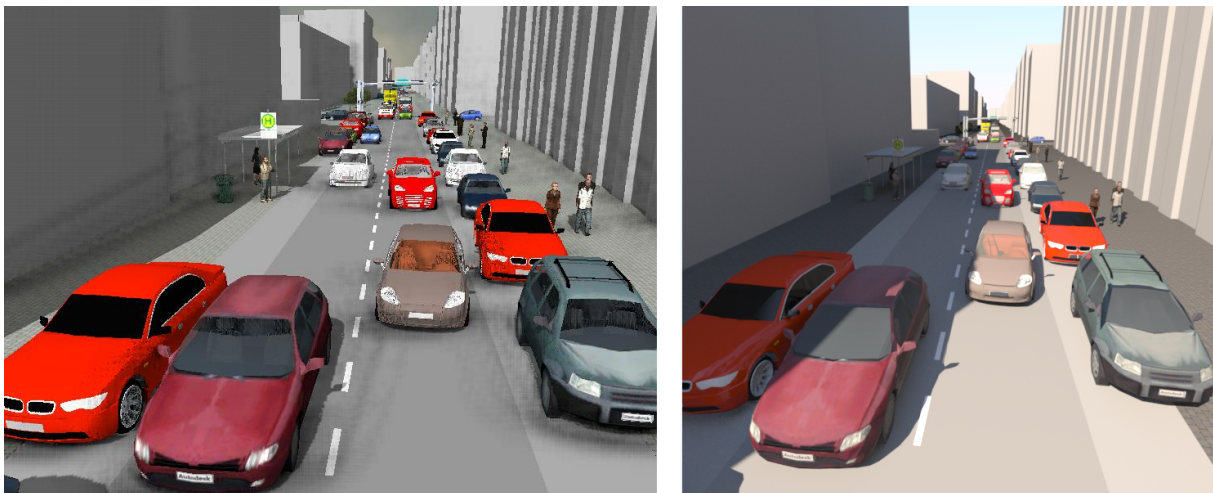


Figure 4.6: Gabelsbergerstraße. Left: Snapshot. Right: Rendered image.

5 Problems presented in AIM while creating the model

This chapter will describe what problems appeared throughout the process of modeling the TUM Surroundings. Starting with the general problems about the AIM software. Then moving on with the issues when importing the data.

AIM is an Autodesk product that was released 2012. Usually new products have a lot of problems. AIM runs very slow, which decreases the performance when creating a model. Fast movements make the software slower and sometimes even to shut down. Autodesk published a list of problems known that are available online. The main problem that Autodesk mentioned in its website and was present on the creation of the project was the issue of the inverted coordinate system at the time of importing the CityGML.

Most problems presented on AIM were because of the limited available information and tutorials across the Internet at the beginning of the project. The publication of more extensive information on how to use AIM was released after a few months of starting the project. A basic knowledge about the geographical data that could be imported into AIM was necessary to understand how to create the basic model. This information was later released on a website. The editing and managing of the model were very easy to understand, because of the users interface. At the beginning of the project there wasn't enough information about how to present and create the model, which made very difficult to learn this task. After a few months this information was also released. AIM 2012 and 2013 don't recognize CityGML, a very common vector file format for buildings. This is also a problem that was later on fixed by Autodesk with the release of AIM 2013 R2, that wasn't available for the public, but for Autodesk Members.

5.1 Importation of the data

The main problem was to figure out how to use the given GIS information to import in the model. As the time passed more and more information was added to the Internet. A new AIM tutorial from Autodesk was created. On the webpage a number of videos were uploaded with the steps on how to find geographic data across the web to later on import the files creating a model on AIM. As mentioned on 2.1.1, data can be imported in 2 different ways, through a database or using an independent file attachment.

5.1.1 Database

The importation of the database through the Internet was a great idea at the beginning. Each change made by the Bavarian State Office for Surveying in their database would have also been changed in the AIM model and improved it.

WFS

The first thought on importing the buildings was through WFS. WFS is a service, which delivers GML data by calling a GIS database. This service was offered by the Bavarian State Office for Surveying that also offered the WMS for the ground imagery. The Bavarian State Office for Surveying provided a username and password needed to call the GIS database. AIM gave an option to import data from a database by giving the address to call the data,

username and password. The problem was that the login given to call the data was restricted for that data information making it impossible to get the buildings file with the WFS. The second problem was that the AIM 2012, which was the current AIM version at that time, didn't recognize CityGML. So this option was no longer available for the importation of data.

5.1.2 Independent Files

The data format of the buildings was CityGML, but Autodesk Infrastructure Modeler 2012 and 2013 didn't allow the importation of that file format. That's why the conversion of the buildings file format, from CityGML into one that AIM was able to read, was essential at the beginning.

3D Model

The first conversion made from the CityGML file was in a 3D Model format. AIM was able to process the data, but the model was up side down, the x and y coordinates were exchanged and the z-axis was pointing down instead of up. This caused that the buildings didn't match with the surface's location. After importing only the buildings data into AIM, the 3D model could be configured to get the z-axis pointing up instead of down. This configuration didn't help very much, because the model was still mirrored, but with the help of FEM the x and y coordinates could be exchanged. AIM allows the 3D importation, but this kind of importation is not made for more than one building. Meaning that the buildings data was recognized by AIM as a single object, instead of hundreds of single blocks, which made it impossible to style and manage.

ESRI Shapefile

Learning how an ESRI Shapefile looked like and how to import the data into AIM was necessary. The main problem when importing the data into AIM was to understand in what coordinate system the file was and how to configure it in AIM. The building blocks model was converted then through the FME Quick Translator into an ESRI Shapefile. The problem presented in the 3D Model conversion of the coordinates persisted, but the AIM recognition of each building as a single object was there. FME Quick Translator gave the possibility to exchange the x and y coordinates, but again not the z-coordinate, so the buildings were still up side down.

6 Summary and Conclusion

This chapter will summarize all pros and cons about AIM found with this project and then an overall conclusion about the software and its usability in the working area.

This thesis described a new Autodesk product that was released 2012. The workability and usability of the new Autodesk Infrastructure Modeler, now called Autodesk Infraworks, was analyzed by creating a model of the TUM campus and its surrounding area.

The AIM itself was found a very intuitive software to work with. Once the right importation was done the model was really easy to manage and edit. The structure of the users interface was very clear structured, making it really simple to operate.

One of the problems was the basic knowledge about the imported files. Although working with AIM itself was very clear, the importation was a little more complicated. Basic knowledge about the files before the importation in AIM was necessary to understand the process of configuration. AIM didn't always recognize the data imported in the model, so that the user had to know how to configure the importation. The AIM software has also a lot of bugs; some of them have to be considered at the time of importing data.

Usually new products in the market have a lot of problems; this is also the case of AIM. Because of the size of each data the importation took very long. The main problem with the AIM software was styling the model. The time of the styling took a very long time and needed a lot of patience. The software often crashed down after a simple editing. The recording of a video took also a lot of time.

The options given by AIM to present the model to stakeholders were very intuitive. With very simple steps AIM allowed creating a very appealing and professional looking video showing the model.

The AIM software is overall a very appealing product of Autodesk, but needs a lot of improvement. It is a very well structured and designed product that has a lot of potential to present new proposals. AIM is a product that would complement other Autodesk products with a more directed view on BIM infrastructure design. Although AIM 2013 R2 is not ready for the working field, with a lot of bug fixing and adding more tools to edit and manage the model it would be a great software for architects, civil engineers as well as GIS and planning professionals.

Annex A.

Known Issues AIM 2013 R2

Autodesk published the following list of issues presented on AIM 2013 R2:

The following content offers information pertaining to known issues.

- You cannot use the rendering feature in a 32-bit installation. It is available for 64-bit installations only.
- Rendering a model that uses large raster data files can cause memory issues. To avoid this, set the model extents to the target area, then render.
- You can use the web browser add-in with the Chrome and Firefox browsers, as well as the 32-bit version of Internet Explorer 9 (but not the 64-bit version).

If you use Internet Explorer 9, click Settings ► Internet Options ► Programs and click Manage Add-ons. Show all add-ons. Make sure the Autodesk 360 Infrastructure Modeler For Web add-on is enabled.

- If you run Autodesk Infrastructure Modeler 2013 on a computer where Adobe® 3D Capture® Element or the Adobe® Acrobat® 9 Pro Extended 64-bit add-on is installed, filenames in dialog boxes and title bars will not display. For example, in the Open dialog box, you will see file icons, but no filenames.

To resolve this issue, remove Adobe 3D Capture Element and the Adobe Acrobat 9 Pro Extended 64-bit add-on. If you installed Acrobat X, the problem applications may not be listed as independent installed programs. If this is the case, look for the following registry entries:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Adobe\Adobe Acrobat\9.0\Installer]
```

```
"AppInit_DLLs"="acaptuser64.dll"
```

- Coordinate system settings for new models are now available on an Advanced Settings tab on the New Model dialog box. In most cases, you should not change the coordinate system for a new model.
- Some CityGML data sources may display incorrectly when you import them. This is usually due to georeferencing issues. You can try changing the coordinate system for the data source. If this does not resolve the problem, try changing the coordinate system in the original file.
- CityGML does not support UTF-8 filenames. As a result, you cannot open CityGML files with filenames containing, for example, Chinese, Japanese, or German characters.
- You cannot publish scenarios whose names contain Unicode characters, for example, Chinese, Japanese, or Russian characters.

-
- In the Storyboard window, keyframes that are less than 2.1 seconds long and also contain no events cannot be selected directly. Use the Tab key or the Details view to select such keyframes.
 - If you uninstall Autodesk Infrastructure Modeler 2013 on a computer running Windows 7, you may see an error message indicating that the shortcut icon cannot be removed. This issue is related to the InstallShield® application. The uninstall process will complete, but you must remove the shortcut manually.
 - When you publish a model with no raster imagery to AIM 360, the progress bar may indicate that it will take many hours to publish. In reality, the publish will complete in minutes.
 - When an Admin invites someone to a group, the Admin receives a copy of the invitation. If the Admin clicks the Bluestreak link in his or her copy and accepts the Bluestreak invitation, the invited user cannot accept the Bluestreak invitation.

To fix this issue, do the following:

- Delete and re-add the user to the group or account or
 - Log in to Bluestreak and invite the user to the group.
- If the network connection is lost during a publish operation, the model size may display as 0 bytes. If you delete the model using the Online Models dialog box, you may see a database error indicating that the model is locked. To fix this issue, wait 3 minutes after the lost network connection issue before you try to delete the model and publish again.

Annex B.

Rendered Images

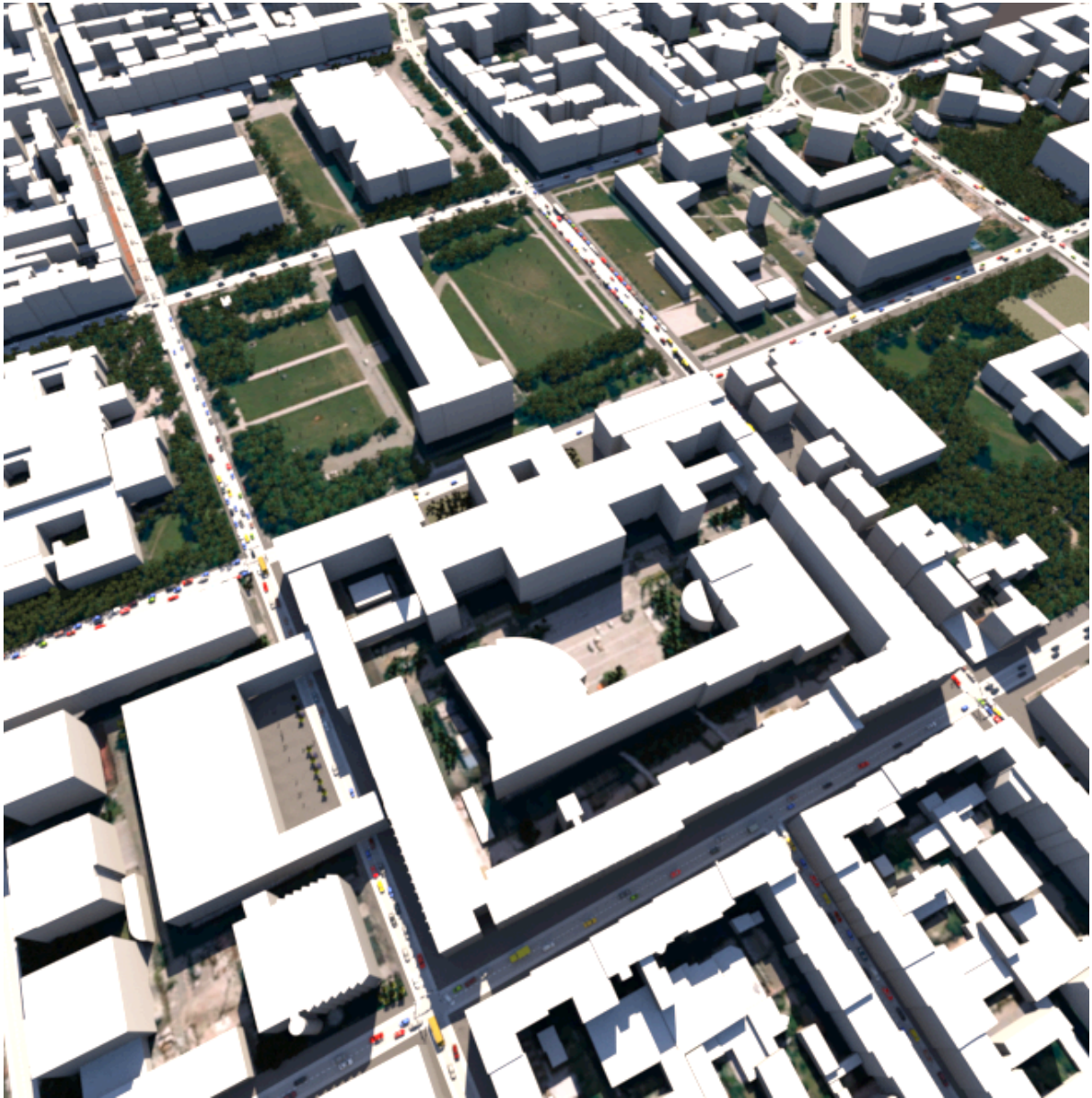


Figure B.1.: TUM campus and surrounding area rendered image.

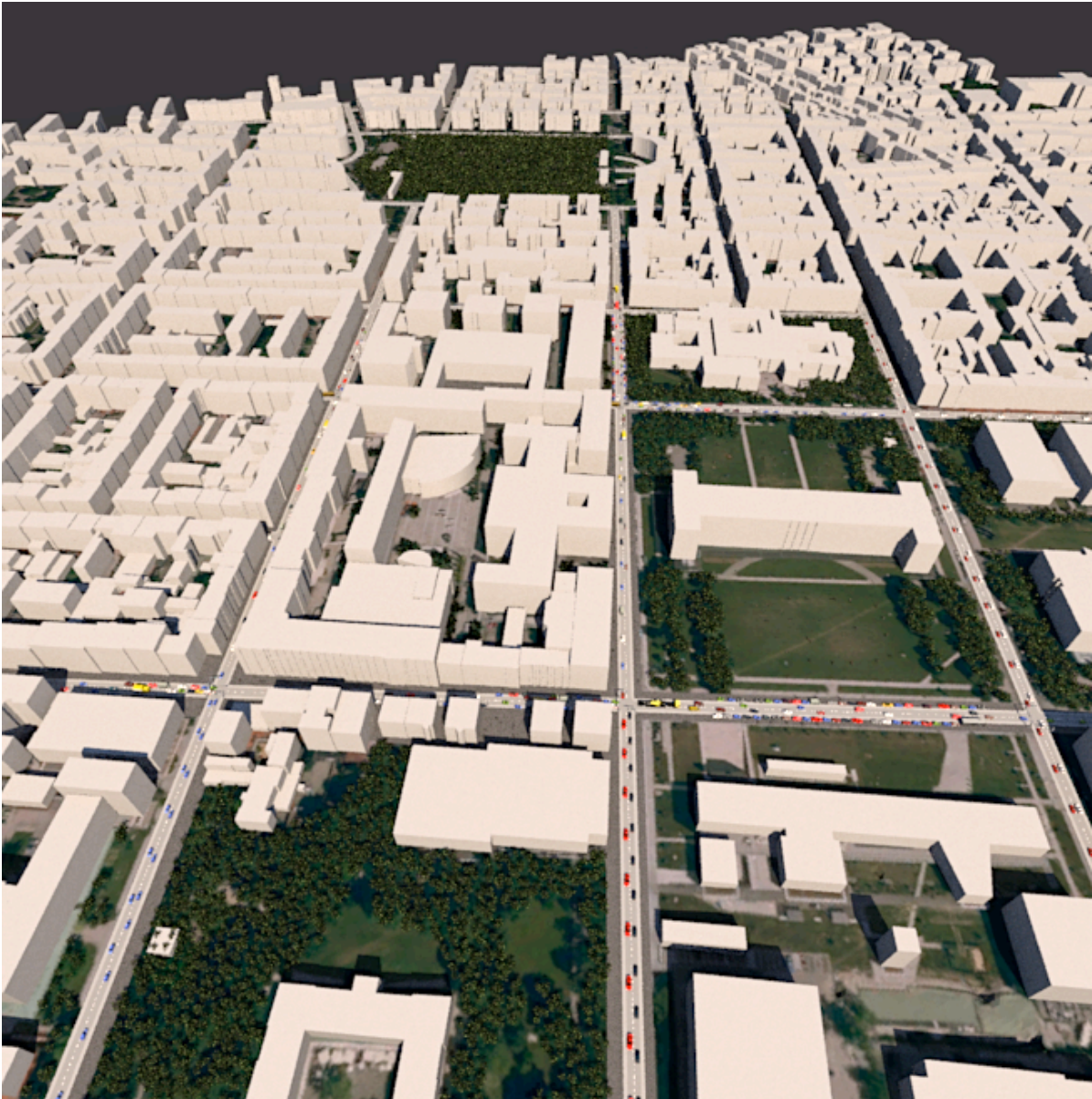


Figure B.2: TUM campus and surrounding area rendered image.



Figure B.3: Theresienstraße rendered image, bus stop Pinakotheken.

Annex C.

Compact Disc

- Written project in a Word document and in a PDF file
- TUM Surrounding Area model in SQLite
- TUM Surrounding Area model in a FBX File
- Video showing the model and a scenic flight of the TUM Campus
- ESRI Shapefile downloaded with roads location

Bibliography

- I. Heywood, I. (2006). An introduction to geographical information systems. Third Edition.
- II. Workboys, M.(2004). GIS: A Computing Perspective. Second Edition.
- III. Bill, R. (2010). Grundlagen der Geo-Informationssysteme. 5. Auflage.

Eidesstaatliche Erklärung

Hiermit erkläre ich, dass ich die vorliegende Bachelor-Thesis selbstständig angefertigt habe. Es wurden nur die in der Arbeit ausdrücklich benannten Quellen und Hilfsmittel benutzt. Wörtlich oder sinngemäß übernommenes Gedankengut habe ich als solches kenntlich gemacht.

Ich versichere außerdem, dass die vorliegende Arbeit noch nicht einem anderen Prüfungsverfahren zugrunde gelegen hat.

München, 29. April 2013

Vorname Nachname

Name

