VISUALIZATION IN MUNICIPAL PLANNING

A Masters Project Presented

by

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1.0 INTRODUCTION

1.1 Introduction

In recent years a variety of groups have been using combinations of GIS (Geographic Information Systems) and Real Time, Virtual Reality modeling for planning applications, as described by Barnes. For these applications, Virtual Reality modeling was used to show existing conditions as well as the effects proposed planning decisions would have on a community. These models allow users, whether they are planners or community residents, to see these effects and make changes to their planning strategies accordingly (Barnes 2002).

The CommunityViz staff describes how the models being used are generated with real time modeling developed for the gaming and simulation industry. Models of this type allow for changes to be updated and displayed almost instantly on the computer screen. This is a major advantage over previous forms of modeling, which took between hours and weeks to create as well as render models before they could be displayed to users.

When used in public planning meetings, participants can make planning policy changes and watch what happens to the model of their community. They can then modify their planning polices based on this feedback. Real time virtual reality modeling has another benefit; unlike previous forms of computer modeling, users can explore these models at will as if they were walking or driving through the planned community (Barnes 2002; CommunityViz-Staff 2003).

The general process of creating GIS based 3D Virtual Reality models has been documented. However, at the time of this writing, this author was
unable to find documentation of the step-by-step, day-to-day, processes of the work. The purpose of this study is to research these techniques and create a model using them to find out what is really involved. Throughout this study, the process is documented to provide a step-by-step reference to anyone wishing to create their own 3D Virtual Reality model.

This project began when David Pesuit of the Accident Analysis Group decided to have a 3D computer model of his building along with the café he proposed to build attached to it integrated with a model of the surrounding buildings. Included in this modeling project was the Armory Street parking lot. A meeting was then arranged with Wayne Feiden, the City Planner for Northampton to discuss the possibility of using this 3D model for city planning and the approval of the Café project. Mr. Feiden was interested in creating a 3D Virtual Reality model of the entire Historic Mill River Corridor running through downtown Northampton. He procured funding for the project and work began in December of 2002.

1.2 Summary of Literature Review

This review of recent literature found that users of real time modeling have written about the planning projects they have undertaking with it. While they are publishing their results as well as the general process, there is very little detailed documentation on the step-by-step process. None that have been found so far have discussed in detail the processes of their work. Therefore, the objective of this project is to research and answer the following questions:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

1.3 Summary of Methods

To answer these questions, GIS, CAD, and 3D modeling software was used to create a virtual reality model. The steps taken are documented in Chapter 3: Methods. This chapter outlines the process of creating a 3D virtual reality model for municipal planning purposes. Included are the steps necessary to answer the questions put forth in the in section 1.2.

1.4 Summary of Application

The steps laid out in Chapter 3 are implemented in Chapter 4. These steps are described in detail for those wishing to follow this process and create a 3D virtual reality model of a community. This process will be accompanied by images of the process as well as the resulting model. The questions put forth at the beginning of this study will be addressed and answered by this process in Chapter 4.

1.5 Summary

In the final chapter, the intended use of these models by the city as well as other possibilities for such models will be discussed. Included in this discussion will be some thoughts on the feasibility of undertaking such an endeavor.
2.0 LITERATURE REVIEW

2.1 Introduction

As described in *Community Character Act: It's One to Watch* by Barnes, more and more regions as well as communities are taking steps to improve their livability by planning for their future. Visioning has increasingly been used as a means of reaching consensus by finding a common ground between different stakeholder groups. Building this consensus requires an innovative, inclusive, and productive public participation process that engages residents and other stakeholders (Barnes 2002).

According to *Visioning and Visualization*, one of the most powerful tools for making informed design and planning decisions is simulating alternatives; ideas, initiatives as well as policies in ways that make them clear to a broad, non-professional audience. This makes communication through visualization the most critical component to any visioning process (SimCenter.org-Staff 2003). A search of recent literature on the topic of using 3 Dimensional (3D) visualization in planning reveals that there has been an increase in the number of communities and organizations that are using a growing number of technologies, with an ever increasing amount of capability.

While the general process has been documented, at the time of this writing, this author was unable to find documentation of the step-by-step, day-to-day, processes of the work. Included in the literature are the uses for Geographic Information Systems (GIS) in planning, not limited to master planning, comprehensive planning, resource management, emergencies,
landuse, utilities, and greenways. Also covered are techniques such as mass modeling for various uses.

3D models have been used to visualize grading plans, view sheds, and other proposed projects, during the design phases, as stated by Faulkner. Modern technology can now produce models of far greater accuracy than ever before (Faulkner 2002). According to Williams, visualization tools also play a key role both in selling design ideas to prospective clients as well as project documentation and design input. The more clearly a designer can help prospective clients conceptualize what their project will look like before the job begins, the more likely it is for the designer to acquire the contract. Since its beginnings, 3D modeling has been showing its value through projects commissioned and is now part of clients’ expectations (Williams 2003).

According to Craighead, Cornell Professor Rodger Trancik has stated “the software takes some of the tedium out of the process, they provide us with another set of extremely effective tools for urban planning and design. You can enter the 3D environment you are creating (Craighead 1997).”

Some of the planning applications that can be modeled include: growth management; corridor, economic, housing, and industrial development; homeland security; landuse, transportation, as well as open space planning. A vast array of planning strategies and tools can also be modeled. According to the staff at CommunityViz as well as the ESLab, 3D visualizations provide more information in more realistic and believable viewing situations. These visualizations are easier understood than flat maps, or even perspective renderings, by the general public as well as planners. Until recently, viewing
movement in 3D modeling was very slow to create and viewers were locked into a preset ‘movie’ style presentation. They could not explore the site at will, often fostering the feeling that something was being hidden from them (CommunityViz-Staff 2003; ESLab-Staff 2002; Hanna 1999).

Animation for games and simulators has grown dramatically in popularity. This technology has also changed the way models are created and presented. As discussed by CommunityViz staff, in these sorts of models if, a viewer chooses to see what is around the next corner they can navigate there and find out. If they what to know what the street is like looking the other direction, they can turn around and see. Since all modeling is done in real time, this sort of demonstration can work well in public forms or meetings with clients, because simple changes can be made on the spot with a few clicks of the mouse. In the case of CommunityViz, even fairly complex changes, such as rezoning an entire neighborhood causing every building to change can be seen in a matter of minutes. Less time in model building equals more time to spend on what really matters, getting the actual design right, including the details (CommunityViz-Staff 2003; MultiGen-Paradigm-Staff MultiGen-Paradigm 3D and GIS Product Information 2002).

A search for recent literature reveals that the use of 3D visualization in planning is increasing, and the general process has been documented. It seems that those using the latest technologies are busy with the application and have not documented the step-by-step, day-to-day, processes of their work. Therefore, the objective of this project is to research and answer the following questions:
1. What are the finer details of building this sort of model?

2. What does this really involve?

3. Is it really as quick and easy to create a real time, base model as it seems?

Since this process uses several forms of computer technology including GIS, CAD, and 3D Modeling, as well as the data used and created by them, a review of this process is in order. To answer these questions, GIS, CAD, and 3D modeling software is used to create a virtual reality model. The steps taken are documented in Chapter 3: Methods, while the process as well as outcome are documented in Chapter 4: Application.

2.2 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) technology, according to Jack Dangermond, enables its users to compile spatial and geographical data within a database, producing a model of the area of interest. According to Hanna, this database can then be used to organize and evaluate site-specific information allowing for the consideration of several alternatives at once, leading to better solutions. Data from several sources can be imported into GIS and used to update the database. Once these evaluations are completed, GIS can output them as maps, tables, and charts, either printed or in digital format which can be used on the web or shared through computer networks, in a quick, easy manner. GIS has the ability to produce 3 Dimensional (3D) views, which are important because they allow planning teams as well as citizens to easily understand spatial relations. GIS allows for the compiling of enormous amounts of data, which can be arranged and used at once by members of the
design team. This allows for running of multiple alternatives to determine which is the best suited for the application (Hanna 1999).

Ervin and Hasbrouck state that digital data, often in the form of Shape or ArcInfo Interchange files, are readily available for GIS from a variety of sources. These include municipal planning departments, departments of public works, state data banks, which are often online, such as MassGIS (http://www.state.ma.us/mgis/massgis.htm), and federal agencies such as the United States Geographical Survey (USGS) (http://www.usgs.gov/) which are often online as well (Ervin and Hasbrouck 2001). As stated by the staff of Richland-GIS, most of the vast amounts of data and decisions made by planning agencies on all levels, deals with a geographic context. Therefore, GIS is the perfect planning tool for organizing this information into one spatially related database. Once the database is setup, any point on a map becomes an index of the available “cultural, economic, environmental, demographic, and political information about that location” (Richland-GIS-Staff 2003).

The virtual reality modeling software used in this project is an add on to ESRI’s ArcView and ArcGIS Geographic Information Systems (GIS) software. The base data used for the creation of these models, is GIS data. This data is either downloaded from the internet or provided by the planners of the community to be modeled. Therefore, GIS is used to arrange the base date, prepare layers for modeling, and creating the terrain for the model. As stated in the Site Builder 3D Tutorial, GIS is also used to view and control the completed models (CommunityViz-Staff 2002).
2.3 Computer Aided Design (CAD) and 3 Dimensional (3D) Modeling

During this project it was necessary to convert data from GIS to a form that could be imported into the 3D Modeling software. Some of the data was supplied as CAD drawing files. It was also necessary to check, modify, and create new data using CAD. Therefore CAD was used during the model creation phase of this project.

As stated by Hanna, Computer Aided Design (CAD) drawings are created and used by municipal departments of public works, landscape architects, architects, and engineers. This technology is used in all phases of the design processes and used to document as built, or existing conditions. These drawings are readily accepted into a Geographic Information System (GIS) databases, and do to the highly accurate nature of cad; this increases the accuracy of the GIS databases as well. GIS data can also be easily imported into CAD. All available data can be overlaid and arranged to best suit the needs of the project planners. The combination of these two technologies allows for highly accurate design work based on existing conditions generated form the GIS database. This shortens the duration of time or intensity of fieldwork, while by passing the need to redo all of the site analysis which someone else has already done and entered into the GIS (Hanna 1999).

In Faulkner’s writing, he say 3 Dimensional (3D) models have been used by architects as well as engineers to visualize grading plans, view sheds, and proposed projects, during design as well as to present to clients. Any engineering or architectural student knows how to cut cardboard or foam core and arrange it in a pile to represent the ground plane. “Beyond their
questionable physical accuracy, these models are decorated by hand so that the final appearance has everything to do with the skill and patience of the artist and is, at best, an idealized version of reality.” Modern technology using CAD combined with digital satellite data and any variety of modeling systems can produce a model of far greater accuracy to a level, which can be used in court as evidence (Faulkner 2002).

From Pitch Out the T Square, we learn that 3D modeling during the design process allows users to visualize buildings of unprecedented complexity. With this new found power designers have been liberated like “never before from the age-old dominance of the right angle.” Once the designs have been finalized they can then be used by Computer Aided Manufacturing (CAM) equipment to produce designs that previously could not have been built. Known for their “formal inventiveness, expressive power and civic scale” Frank Gehry's “flowing” Guggenheim Museum in Bilbao, Spain, (1997) besides his Experience Music Project in Seattle, Washington, (2000) are examples of what can be done with the power of CAD along with 3D modeling. It is not the shapes it can create, but its ability to analyze millions of variables in a short time, as well as linking design to production, which saves time and money, that are computers greatest contributions to the architectural process (Forgey 2001).

Williams says that visualization tools play a key role both in selling design ideas to prospective clients as well as project documentation and design input. Clients put a lot of money and commitment on the line, so the more clearly a designer can help them conceptualize what their project will look like before the job begins, the more likely it is for the designer to get the job.
Architects have been using CAD and 3D models as design tools for over two decades. Their visualization tools are used not only for creating conceptual presentations to show clients pre-commission, but also to work out design elements as the designers move through a project. Concepts often begin as a 3D visualization, then move to CAD so that plans may be explored, based on what was visualized in 3D. Often the design moves back and forth several times as it takes shape. For architects, 3D modeling and rendering are showing their worth through projects commissioned, so much so, they are now becoming part of a client's expectations (Williams 2003).

According to Craighead, Cornell Professor Rodger Trancik has stated that “the software provide us with another set of extremely effective tools for urban planning and design.” These tools “take some of the tedium out of the process” and “you can enter the 3D environment you are creating” (Craighead 1997). According to Ervin and Hasbrouck, programs such as 3D Studio are very efficient at creating realistic 3D models, which can be output in a variety of formats. These formats allow for viewing as movies or virtual reality. A drawback of these models is that they require an enormous about of rendering which in turn requires an enormous about of time and computer resources to produce (Dickison and Greenwell 2000; Ervin and Hasbrouck 2001).

According to the staff of CommunityViz and MultiGen-Paradigm, recent advances in computer-based modeling called real time modeling, are increasing the speed at which a virtual reality model can be produced, while creating an even more realistic virtual experience within the model. Real time modeling was created for the gaming and simulations industry. Through the use of this
technology a spatially accurate and highly realistic model can now be quickly produced for anyone to take a virtual; self guided tour of the subject area. The user can now control their own experience of the space as if they were moving through the real world. This allows them to explore the model and answer questions about the space, which may not have been considered by the modeler, thus not included in the movie type of view. The viewer can now discover what is around the next corner. They can also turn around and look down the street in the opposite direction or view what is in the side streets. Real time modeling also increases the speed of modeling because the model is all ready in a rendered state. Therefore it does not need to be converted to a movie or virtual reality format, but can be view directly in the simulation, often the same program that created it (CommunityViz-Staff 2003; MultiGen-Paradigm-Staff *MultiGen-Paradigm 3D and GIS Product Information* 2002).

The staff at CommunityViz describes how once existing conditions have been constructed, the model can be used to demonstrate how different decisions and proposed projects would affect the area. Buildings and other elements can be cut, copied, or pasted in the model to immediately see the results. Several scenarios can be quickly created to show the impact proposed projects would have. The viewer can then walk, drive, or fly though the model to see what it would be like to experience the planned space once it was constructed. Effects of vegetation, different seasons, lighting, and amenities can be modeled as well. The model is quickly updated based on policy changes made to the database through the GIS. This combination of technologies allows for planning decisions to be modeled and visualized.
immediately in real-time by the planning team or even members of the community in public meetings. This is very useful in determining the impacts of planning decisions (CommunityViz-Staff 2003). For examples please refer to Figures 18, 19, and 23 through 30. Please also visit the CommunityViz website at: http://www.communityviz.com/ for more examples.

Articles from both the ESLab and CommunityViz, discusses how this software can be used to model planning applications including growth management along with landuse planning. Also, planning strategies such as new street patterns; regulatory processes (e.g. zoning changes); redevelopment strategies (such as adaptive re-use); and proposed projects can be modeled. The software can also model planning tools such as population projections and the resulting development patterns as well as economic impacts. View shed analysis and other visual impacts can also be modeled (CommunityViz-Staff 2003; ESLab-Staff 2002).

2.4 Municipal Planning

As part of the American Society of Landscape Architects (ASLA) Community Assistance Team at the 1997 ASLA Convention in Atlanta, Georgia, Berkshire Design Group, lead by Mark Lindhult, produced a 3 Dimensional (3D) visualization of their plan for redeveloping the area around the Whittier Mill into a park. Using Computer Aided Design (CAD), Berkshire Design created a base model of their proposal, which they then turned into a 3D model. This model was imported into 3D Studio and rendered to produce a realistic model of the proposal. Once the model was done, walk troughs were created using
animated cameras to show what the project would look like from within once constructed (LAF-Ed 1997).

As described by the MultiGen-Paradigm staff and Bitters, combined technologies have been utilized by several different groups and municipalities, for a variety of projects in recent years. The United States Air Force (USAF) uses a Geographic Information System (GIS) combined with Site Builder to create realistic flight simulators for training purposes. This same technology has been used by the Cities of Sunnyvale and Vallejo California to create virtual walk-throughs for planning visualization. Site Builder works in conjunction with GIS to create realistic looking 3D community simulations. GIS is used to arrange all necessary data, including roads, vegetation, terrain, and other geographic features. A 3D terrain model is then created over which these features are placed. Site Builder is used to add 3D models of buildings, vegetation, and other features to the landscape. The result is a realistic, interactive, virtual reality (VR) model which can be used for flythrough demonstrations of the area to be planed (Bitters 2001; MultiGen-Paradigm-Staff MultiGen-Paradigm 3D and GIS Product Information 2002).

According to Kwartler and Bernard, after a model of this sort is completed, CommunityViz can be used to determine how different planning scenarios will affect the community (Kwartler and Bernard 2001). As described by Wendt, with CommunityViz, all elements of the 3D scene are connected to the GIS layers and databases. Therefore when the buildings are changed the 3D scene is changed without needing to re-extract data or reconstruct part of the model, as is the case with other modeling software. This functionality
allows the planner to interact with citizen groups, making changes to the
development map and receiving real time feedback on indicators as well as the
landscape visualization, which can be viewed by the citizens as well. A forecast
of how current planning decisions could shape the community of the future can
be performed with the CommunityViz Policy Simulator function. Population
projections, economic impacts, and visual impacts can all be modeled with this
software. Wendt has assessed that CommunityViz is a good integration of GIS
with attention being paid to the details of planning tools necessary to getting the
bottom line results quickly (Wendt 2002).

Richland County, South Carolina is in the process of building a model of
Columbia. Even though the model has not yet been completed, it is being
implemented in their planning activities. The staff at Richland County GIS plans to
eventually build models of all major municipalities within the county. The
applications for this model include regional promotion for economic
development, homeland security, visualization of proposed structures, view
shed analysis, and city publicity (Richland-GIS-Staff 2003).

According to Barnes, increasing numbers of government officials and
community consortiums are using GIS data, aerial digital photos, and Landsat
infrared images to help demonstrate sprawl so that the public understands its
concept as well as the impact on their future. These spatial tools empower
local communities to control their own future by enabling them to develop smart
growth plans in accordance with local knowledge, culture, and lifestyles.
Residents in Gallatin County, Montana entered an auditorium to watch a video
of their community. The video showed their valley, as it would look 20 years in
the future, with the mountains surrounding their community littered with houses, if policies were not soon adopted to limit sprawl. Next they saw a growth model, which displayed three scenarios: the current policy, a policy developed by environmentalists, and an approach preferred by farmers. After this viewing, the county planning board was able to develop an open-space preservation plan, based on public input derived from these models (Barnes 2002).

2.5 Summary

This review of recent literature found that users of real time modeling have written about the planning projects they have undertaking with it. While they are publishing their results as well as the general process, there is very little detailed documentation on the step-by-step process. None that have been found so far have discussed in detail the processes of their work. Therefore, the objective of this project is to research and answer the following questions:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

To answer these questions, GIS, CAD, and 3D modeling software was used to create a virtual reality model. The steps taken are documented in Chapter 3: Methods, while the process and outcome are documented in Chapter 4: Application.
3.0 METHODS

3.1 Introduction

This chapter discusses the methodology designed for this study of visualization in municipal planning. The previous chapter determined that little has been published relating to the exact methods involved with applying this technology to municipal planning. Therefore this project determines and documents those operations involved in the process of creating a model for use in municipal planning. This chapter lays out the proposed course of action for creating that model in order to answer the following questions put forth in Chapter 2:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

In this chapter, the steps of this process are discussed in general terms. First the software used in this study is discussed. Also included are the methods of acquiring GIS base data and building the base model. Methods of determining which structures to photograph as well as the process of collecting and manipulating those photographs are included. This is followed by a description of the process of constructing the 3D Virtual Reality model and proposal models to demonstrate its use in virtual reality for municipal planning.

3.2 Computer and Software

The software used is taught by Professor Mark Lindhult, at the Department of Landscape Architecture and Regional Planning for 3D planning.
projects. This software includes AutoCAD Map, ArcGIS, ArcView, Photoshop, and 3D Studio. While being specialized software packages, they are also widely used industry standards, making them readily available through most major software suppliers (Lindhult 2002). The more specialized 3D virtual reality modeling software is acquired through the developers' web sites. This includes CommunityViz, available online at http://www.communityviz.com/ as well as the companion software, Site Builder and Model Builder, both available from http://www.multigen-paradigm.com/. These web sites provided information about the software, including what it does; projects that it has been used for; and manuals or tutorials on how to use it.

3.3 Collection and Arrangement of Base Data

Since the study area for this project lies entirely within the state of Massachusetts, base data was collected from MassGIS, available online at http://www.mass.gov/mgis/. The remaining pertinent base data as well as all other necessary data was provided by the client: The City of Northampton, Office of Planning and Development. All of this data is in a form that can be used in GIS. This data includes orthographic images, roads, streets, building footprints, and elevation contours for the project area. ArcGIS was used to manage all of this data. Once this data was acquired, the data layers were compared to each other to determine accuracy and consistency. The city office of planning and development had determined that the area to be modeled (study area) was that of the historic location of the Mill River through downtown Northampton. This location was provided by the city as one of the GIS data layers. The city also specified that they needed the virtual reality model to
include one row of visible buildings on each side of the Historic Mill River Corridor.

To achieve this, a buffer zone was created along the Mill River Corridor, which was used to clip the buildings layer to that area. This buffer zone was sufficiently large enough to encompass an extra wide section on each side of the Historic Mill River so that all possible buildings within the view shed were included. Those structures remaining in this zone were checked during fieldwork and deleted if determined to be unnecessary.

Also included were the structures that surround the area occupied by the proposed project. This included all buildings surrounding the Armory Street parking lot. The street and topography layers were clipped to this area as well. A topography layer provided by the City of Northampton was used for elevation and ground plane modeling. This topography was converted to a 3D shape file and then a TIN (Triangular Irregular Network) of the ground plane using the 3D Analyst extension in ArcGIS. This data was imported into AutoCAD so that all features could be cross-referenced to the orthographic image and easily adjusted as needed.

Orthographic images from the GIS data set were imported using the import raster image function in AutoCAD. Topography and other GIS data were imported using the import from GIS function of AutoCAD Map. In CAD, the data was cleaned up and checked for precision based on the orthographic photo. The outlines of new structures were traced and structures not showing up on the orthographic image, which was newer than the GIS data, were deleted from the buildings footprint layer. The building footprints layer was imported into
Model Builder for use in creating the 3D building models. This layer along with the rest of the data was then imported back into GIS.

### 3.4 Photography of Study Area

A map of the study area was created from the GIS data, described in section 3.3, using ArcGIS, including the streets, parking lots, railroads, as well as the building that were to be modeled in the Historic Mill River Corridor. The map was used in the field as a basis for a visual survey and assessment of the study area. This intensive, on location fieldwork was the basis for the final determination of which structures needed to be photographed and modeled.

The city needed a model showing what could be seen from the Historic Mill River Corridor. Thus, buildings that were determined to be within the view shed by the GIS were verified. Structures found to be out of view due to topographic relief, dense vegetation, or other obstructions were eliminated. To save time plus consolidate resources, photographing of the necessary structures as well as the general study of the area and context were conducted at the same time as the field survey. This method checked the accuracy of the building data, and contributed to familiarity with the study area necessary when modeling it.

All structures that are to be modeled should be photographed from a point directly perpendicular to the subject’s façade. In this urban setting, some large facades had to be photographed in sections. This was because the close proximity of structures made it impossible to get far enough away to get the entire façade into one image. Because of these conditions, some images had been taken from an angle instead of directly perpendicular due to obstructions.
These situations were dealt with by manipulating the images in Photoshop. All images were edited in some way, even if just to crop to the facade.

Since the end result is in digital format, as well as the necessity of heavy image manipulation, a digital camera was used. The camera used had 3 mega pixels of resolution and a 1-gigabyte Micro Drive for storage. This storage capacity can hold 642 high-resolution pictures, from this camera. This allowed as many pictures as necessary to be taken at a high enough resolution for modeling and site study.

Photography took place during the spring and summer. Once the images had been acquired and downloaded to the computer, they were organized into categories for each section of the project. Since all buildings are along streets or parking lots, each group of images were placed in a folder designated by a street or parking lot name. The image file management program ACDsee was used for sorting images into their categories since it has thumbnails as well as a larger view of the selected image on the same screen. ACDsee also allowed for quick renaming and moving of images between directories. ACDsee is share ware available for download from the ACD Systems web site at http://www.acdsystems.com/.

Since most building facades for the model were based on rectangles, all facade images were clipped exactly to the building façade, leaving a rectangular shape. This was done in Photoshop, which allowed for the stretching, warping, and aligning of image edges. Photoshop also provides the ability to merge images together and crop to a specified area. Every image used in the models went through this process. The images were opened in
Photoshop, then the entire image was selected before cutting and pasting to a new layer. Canvas size was increased to allow sufficient room for stretching the image in both vertical and horizontal directions. Guidelines were used along with the Distort function to align the sides of the building facades so that opposite sides are perpendicular, both horizontally and vertically. Once the image was aligned, the crop tool was used to cut the image exactly to the building facade. Next the image was flattened and resized to a resolution of 150. This resized the image to a suitable size for VR, where it is important to keep image size small. The image was then saved in jpg format, with a name descriptive of the image. This name included the building name and the face depicted (such as 16ArmoryF, F is for front).

For images that required piecing together two or more pictures, first one image was opened and aligned using the above process. The next image was copied and pasted into the first image, where it underwent the same process and was aligned to the previous image. This process was continued for all of the images that were joined into one. Once they were all aligned, the image was flattened and saved using the same naming convention as described above. An approximate 1/3 overlap was used between images that were joined so that the same object, such as a window; present at the edges of each image can be used as a guide while aligning the two images together.

Images of trees, as well as several varieties of generic materials including brick, stone, building siding, concrete, ground cover, and shingles, were also used where standard textures could be applied within the model. These images are supplied with the 3D modeling software by
AutoDesk/Kinetics and MultiGen-Paradigm, for use in models, which are produced using their software. Once all of the pictures had been taken and processed into facades, constructing the 3D building models began.

3.5 Building a 3D Model

All the façade images were moved to a new folder, which became the texture library. Since all images were named by building and façade, model creation began with the building for which the first image in this folder corresponded. Construction of buildings progressed through the folder in alphabetical order. This method provided an easy way to keep track of what structures have been completed and which buildings still needed to be modeled.

The building footprints layer was imported from CAD into Model Builder. Façade images for the first building were added to the first texture palette. The footprint for this building was selected and extruded using the wall tool to create a box. Then the first image was chosen and mapped to the box face representing that side of that building.

Following the processes described in Model Builder 3D Desktop Tutor, the image was traced with the face tool, creating a new face that matches the size and shape for that façade of the building. The old face representing that façade of the building was then deleted before mapping the façade image to the new face. This process was repeated for the rest of the sides of the building. When the sides were completed, the face tool was used to draw the building’s roof. A generic roof texture supplied with the software was added to a texture pallet and then applied to the roof face (MultiGen-Paradigm-Staff Model Builder
This process was repeated for every building that is to be modeled. Each building was then selected, copied and pasted to the center point of the model. The other buildings were deleted and the model was saved with the buildings name. This process was repeated until there was an individual model file for each building.

Once all the buildings were modeled, the GIS project containing the base information was opened again. Following the processed described in Site Builder 3D Tutorial, the TIN (Triangular Irregular Network) representing the ground plane created in section 3.3 and the orthographic image layers were used to create a terrain for use in Site Builder’s 3D viewer. The orthographic image layer was used to create a texture for the terrain (CommunityViz-Staff 2002). As directed by James Thompson, a point layer was created from the building footprints layer creating a point for each building model to be attached to. The buildings models, created in Model Builder were then attached to these points. Once the building models are attached to these points, the 3D Viewer was used to explore the model in 3D Virtual Reality (Thompson 2003).

Once the buildings were completed, a tree layer was created. A new point layer was created for every tree symbol used and named for the type of tree it represented, such as Trees-Pines, Trees-Maple, etc. Points were placed with the draw tool where each tree was desired on each layer. In places where there was a stand of trees, points were only placed along the edge, to provide the effect of there being a large stand of trees. Trees from each of the layers that represent the general forest make up were intermingled along this edge. Since the intent was to create a representation of a stand of trees, it was not
necessary to place the exact type of tree in the exact location that one exists in real life. According to MultiGen-Paradigm, this saves time in creating the layers as well as frame rates when viewing in the 3D Viewer (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor* 2002). Once all the tree layers were completed, the table for each tree layer was opened and a new field named Type was added. The GIS program was closed, so that the tables will be editable in the spreadsheet program.

Microsoft Excel was then used to open each tree table, as described by Thompson. The tree type represented by each layer was entered in the first cell under the Type column heading. This will then be copied down the column for all of the tree records, so that the same value is entered for all trees in this file. The process was repeated for the remaining tree tables before closing Excel. The project was reopened in GIS and the tree layers merged into one new layer named Trees, containing all of the different symbol types. All of the old trees layers were then deleted from the project. The 3D Ledged Editor was used to match 3D tree models from the model library with the name appearing in the Type column (Thompson 2003). After which, the 3D Viewer was used to make sure that the trees appear properly in the model. Once the trees are working, the base model was complete.

### 3.6 Municipal Planning

Once the existing conditions had been modeled, the model was ready for use in planning decisions. Scenarios of proposed planning decisions were modeled and displayed to show what effects they would have on the area. The city had one building already modeled in a different format, which was
converted to use in 3D and inserted into the virtual reality model. Another proposal was provided for modeling by The Accident Analysis Group (AAG). As stated by David Pesuit, the subject is a courtyard café proposed as an addition to the building at 16 Armory Street, owned by AAG. AAG provided three highly detailed 3D models of the proposed courtyard with their building, which were converted and inserted into the virtual reality model. In addition, the adjacent parking lot was redesigned to accommodate the proposal (Pesuit 2003), and added to the virtual reality model. In the future, the city will construct its own proposal models to used in scenario planning with this model as they are required. After viewing the impacts of these scenarios, the city will determine which course of action to take.

When all modeling was completed, the work was presented to The Accident Analysis Group (AAG) as well as the Northampton Office of Planning and Development for review. Based on these meetings, minor revisions were made to the models. Again the project was brought to The Accident Analysis Group (AAG) as well as the Northampton Office of Planning and Development for review. Upon review, this project was deemed completed to the satisfaction of all clients.

3.7 Summary

This chapter discusses the methodology used for this study of the use of Visualization in Municipal Planning. The following Table 1 lists the steps involved in this process. In the following chapter, Application, the details of the process laid out in this methodology for creating a virtual reality model for use in municipal planning are covered.
Step 1: GIS Base Data Collection

Base data including the existing conditions of the modeled area must be collected to use in creation of the model. In this case, base data was downloaded from the MassGIS website, available online at http://www.mass.gov/mgis/. Also the City of Northampton Office of Planning and Development provided data specific to the study area. This data included orthographic images, roads, streets, building footprints, and elevation contours for the project area.
Step 2: Clipping GIS Data

Because the collected base data was highly detailed and covered a large portion of the city, it took a long time to regenerate when moving around on the screen (panning and zooming) with the GIS software. To alleviate this problem, the base data was clipped to the study area.

Step 3: Checking Data

It was necessary to cross-reference all of this data to the orthographic image to verify consistency. Since the orthographic image was newer than the rest of the data, it contained the location of buildings that had been built and also showed where buildings had been destroyed since the building footprints layer had been created.

Step 4: Creating the Topography

To create a 3D model of a community, a 3D model of the ground plan must be created to set the buildings on. This was performed using GIS topographic data downloaded from the internet and provided by The City of Northampton Office of Planning and Development.

Step 5: Photography

The facades of the buildings modeled were created from digital photographs taken of the actual structures in the study area. These photos were also used as references while creating the models.

Step 6: Organizing the Images

Once the images were downloaded to the computer, they were organized into categories for each section of the project.
Step 7: Image Editing

Since most building faces for the model would be based on rectangles, all facade images were made rectangular in nature and clipped exactly to the facade of the building. This was done using Photoshop, which allows for the stretching, warping, and aligning, of images to guides, as well as the ability to merge images together and crop to a specified area. Even very skewed images were corrected in this way.

Step 8: Importing Building Data

In order to create the 3D models, the building footprints layer was imported into the software that would be used to create the building models. These footprints were then used as a base for the 3D model.

Step 9: Setting up the Texture Librarian

In order to use the photos edited in the previous steps for creating the building facades, they were added to the modeling software’s texture library. From the texture library they would be placed on the appropriate 3D faces to create the building facades.

Step 10: Creating a Building Model

To create the building models, all building footprints were extruded to create walls, which the façade images were then placed on to create the facades.

Step 11: Separating the Buildings into Individual Models

After the building models have been completed, they were separated into individual models. This will facilitate future updates to the model as well as scenario planning in which buildings are rearranged.
Step 12: Preparing for Virtual Reality

This step prepares the 3D terrain for use with the orthographic photo used as a ground plane texture. This eliminates the need to create streets, fields, and other ground plane features, since they are already present in the orthographic photo.

Step 13: Creating a Building Points Layer

The building points layer is what the building models are attached to. This controls where the buildings will appear in the virtual reality model.

Step 14: Connecting the Buildings Models to the Points Layer

The software must be told what buildings to attach to which points. This will causes the 3D buildings models to appear in the proper locations in virtual reality.

Step 15: Creating the Trees for Virtual Reality

To have a more realistic virtual reality model, trees must be added to the scene.

Step 16: Navigating the Virtual Reality Scene

This is the step where the model is viewed and explored, in virtual reality.
4.0 APPLICATION

4.1 Introduction

In this chapter the methods laid out in the previous methods chapter are implemented. Throughout this chapter, the parts of this methodology are discussed in depth. This process addresses the questions set forth in Chapter 2:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

This discussion includes the steps taken from the beginning through to the completion of the project. These steps are described in detail so that anyone wishing to undertake a similar project can follow this process. First, the computer software capable of producing a product of this nature is discussed. Methods of acquiring and arranging the GIS base data for building the base model are covered as well. Included are the methods for determining which structures to photograph along with the process of editing and managing those photos. Finally the process of creating the 3D virtual reality model and proposal models for use in municipal planning is described.

In the final chapter, the intended use of these models by the city as well as other possibilities for such models is discussed. Included in this discussion are some thoughts on the feasibility of undertaking such an endeavor along with some points for considerations when deciding to use this technology.
4.2 Computer and Software

Most of the software used in this project is taught by Professor Mark Lindhult, at the Department of Landscape Architecture and Regional Planning for 3D projects. This software includes AutoCAD Map, ArcGIS, ArcView, Photoshop, and 3D Studio. While these programs are highly specialized software, they are also widely used industry standards. Therefore they are readily available through most major software suppliers (Lindhult 2002). For the virtual reality modeling, more specialized software, which is usually only available from the manufacturers web sites, was acquired. SketchUp is produced by At Last Software, and is available from the SketchUp web site at http://www.sketchup.com/. This software, which creates quick 3D mass models, was used to convert an architectural modal to a format that could be imported into Model Builder. This model was provided by an architect (who requested to remain unnamed at this time) who uses SketchUp for conceptualization of projects as well as presentations. CommunityViz was created by the Orton Family Foundation, and can be found online at http://www.communityviz.com/. MultiGen-Paradigm Incorporated produces both Site Builder and its companion Model Builder, which are required with CommunityViz for adding 3D buildings and virtual reality to ESRI’s ArcGIS and ArcView products. Site Builder and Model Builder can be found on the MultiGen-Paradigm web site at http://www.multigen-paradigm.com/. These web sites provide information about the software, including what it does; projects that it has been used for; along with manuals and tutorials on how to use it.
The applications and methods of using this software are discussed throughout the rest of this chapter. What the software was used for, as well as the methods used to perform these tasks are included. However, this is not a manual in how to use GIS, including ArcView and ArcGIS, AutoCAD, Photoshop or 3D Studio. Nor is it intended as a manual for the rest of the software used. It is assumed that the reader has a basic familiarity with this software, or will find the means to become familiar with it, before embarking on the task of creating their own virtual reality model.

4.3 Collection and Arrangement of Base Data

Step 1: GIS Base Data Collection

Base data was collected from MassGIS, available online at http://www.mass.gov/mgis/. The City of Northampton Office of Planning and Development also provided data specific to the study area. This data included orthographic images, roads, streets, building footprints, and elevation contours for the project area. ArcGIS was used to manage all of this data. Data layers were compared to each other to determine accuracy and consistency. After close inspection, it was determined that a recent color orthographic image was the most accurate as well as the most beneficial for this project.

As stated by Wayne Feiden, City Planner for Northampton, his office had determined that the area modeled (study area) was to be that of the historic location of the Mill River through downtown Northampton. This location was provided by the city as one of the GIS data layers (Feiden 2003). It was also necessary to include the area surrounding the Armory Street parking lot since
that is the location of one of the proposals. The study area is displayed on the map in Figure 1 below.

![Figure 1: The Project Area.](image)

The yellow line represents the boundary of the ground plane modeled by the TIN. The pink line represents the project area boundary. The historic location of the Mill River is represented in transparent blue.

**Step 2: Clipping GIS Data**

Because the collected base data was highly detailed and covered a large portion of the city, it took a long time to regenerate when moving around in the view (panning and zooming). To alleviate this problem, the base data was clipped to the study area. Clipping is the process of removing excess information from a data layer by trimming or deleting the unwanted area. This is done to either show only the area of interest or make a piece of data easier to use by removing the unnecessary areas. In Photoshop this is known as cropping. Wayne Feiden specified that The Northampton Office of Planning and Development needed the virtual reality model to include one row of visible
buildings on each side of the Historic Mill River Corridor (Feiden 2003). To achieve this, a buffer zone was created along the Mill River Corridor, which was then used to clip the buildings layer to that area. The buffer zone was made sufficiently large enough to encompass an extra wide section on each side or the Historic Mill River. This was so that all possible buildings within the view shed would be included. Later those buildings that were not necessary would be eliminated during fieldwork based on this data. Street and topography layers were clipped to include this area of downtown Northampton as well. The topography layer provided by the City of Northampton was used for elevation and ground plane modeling.

**Step 3: Checking Data**

It is necessary to cross-reference all data to the orthographic image to verify consistency. Since the orthographic image was newer than the rest of the data, it contained the location of buildings that had been built and destroyed since the building footprints layer had been created. CAD was used so that all features could be easily adjusted if necessary. The orthographic image was imported using the Import Raster Image function in AutoCAD. Topography and other GIS line data were imported using the Import From GIS function of AutoCAD Map. This data was checked for accuracy based on the orthographic photo. Outlines of new structures were traced and structures not showing on the new color orthographic image were deleted from the buildings footprint layer.
Step 4: Creating the Topography

GIS topographic data provided a general ground plane for the surrounding areas as well as the study area. The City of Northampton Office of Planning and Development provided detailed elevation data of specific, important parts of the study area in the form of a CAD drawing. This CAD file was inserted as a block into the CAD file created in Step 3, containing the GIS data and aligned to that data. Since this data was only in 2 Dimensional format, it was converted to 3 Dimensional, by adding elevation parameters to the properties of each line. The area occupied by the new elevation data was clipped out of the old GIS topography. The new topography was then changed to the same layer as the imported GIS topography. This topography layer was imported into GIS. The Map Units for the GIS project were set to Meters, while Distance Units was set to Feet so that the terrain would be created with the correct proportions. Then the topography was converted to a TIN (Triangular Irregular Network) for use as the ground plane model, using the 3D Analyst extension, as is shown in Figure 2 on the following page. The orthographic image was added to the GIS project and used along with the TIN to create a terrain for use in virtual reality in Step 12.
Figure 2: TIN Ground Plane Model.
The TIN was modeled using the yellow outline shown in Figure 1.

4.4 Photography of Study Area

Step 5: Photography

The facades of the buildings modeled were created from digital photographs taken of the actual structures in the study area. These photos were also used as references while creating the models. A map of the study area, Figure 1, was created from the GIS data, described above in section 4.3. This map included the streets, parking lots, railroads, and buildings that were modeled in the Historic Mill River Corridor. The map was used in the field for a visual survey and assessment of the study area. This intensive, on location fieldwork was the basis for the final determination of which structures needed to be photographed and modeled.

As stated by Feiden, the city needed a model showing what could be seen from the Historic Mill River Corridor (Feiden 2003). During this fieldwork, buildings that had been determined as being within the view shed were verified. Some were found to be unnecessary because they were out of view due to topographic relief, dense vegetation, or other obstructions. The footprints of these structures were then deleted from the buildings footprint layer. To
eliminate excess site visits, saving time and consolidate resources, all necessary photographing was conducted at the same time as this field survey. This method also contributed to an intimate familiarity with the study area.

A digital camera was used to take these pictures, since the end result is in digital format, and every image would require manipulation in Photoshop. The camera used has 3 mega pixels of resolution and a 1-gigabyte image storage capacity, which can hold 642 high-resolution pictures. This allowed for the taking of as many pictures as necessary at a high enough resolution for modeling and site study.

Northampton is typically a busy urban setting. Therefore there is a large amount of traffic, pedestrians, as well as large service vehicles parked in streets and alleys obstructing façade photography. To avoid these conditions, photography commenced just after dawn and continued until about 7 A.M., when the streets began to get busy. Although this was a narrow window of opportunity, two hours is plenty of time to shoot enough digital pictures to keep one person busy editing for the rest of the day.

Structures in the study area to be modeled were photographed from a point directly perpendicular to the subject’s façade as often as possible, as shown in Figure 3 on the following page. This method provides an image that requires the least adjustment with Photoshop to create a usable façade image. Some large facades were photographed in sections. This was because the close proximity of structures made it impossible to get far enough away to fit the entire façade into one image. When this was the case, the images were taken so that they overlapped by 1/3 or preferably 1/2 of each image as in Figure 4 on
the next page. This was so that there would be enough objects on the façade in each image to align the next image to. It also helped to minimize photographic distortion from the extreme outside edges of the pictures. Some images could only be taken from an angle to avoid obstructions, resulting in a skewed image due to perspective. Photoshop was used to correct these skewed images. All images required at least minor editing, even if just to crop to the facade.

![Figure 3: Building Photography Camera Positioning.](image)

*The position illustrated on the left is to be avoided if possible while the one on the right will achieve the best results.*
Figure 4: Overlapping Facade Images.

Certain objects such as trees and newspaper boxes were not avoided since they add character and realism to the facades. To avoid snow banks and inclement conditions, photos were taken during the spring and summer. Pictures were also taken on overcast days to avoid sharp contrast in the images between sunlight and shadows. Ultimately, pictures of the study area were taken on 27 different days.

Step 6: Organizing the Images

The images were downloaded to the computer, and organized into categories for each section of the project. Since all the buildings modeled were along streets or bordered parking lots, they were arranged into folders by these designations. A folder was placed inside the category folder for original images,
and another within it for images already edited. The image file management program ACDsee was used for sorting images since it has thumbnails as well as a large view of the selected image on the same screen. ACDsee also allows for quick renaming and moving of images between directories. This software can be downloaded from ACD Systems at http://www.acdsystems.com/.

**Step 7: Image Editing**

Since most building faces for the model would be based on rectangles, all facade images were made rectangular in nature and clipped exactly to the facade of the building. This was done in Photoshop, which allows for the stretching, warping, and aligning, of edges to guides, as well as the ability to merge images together and crop to a specified area. Even vary skewed images were corrected in this way.

**Step 7a: Preparing the Image for Editing**

Every image used in the models went through this process, which is as follows: First the image was opened in Photoshop, and the entire image selected. Next it was cut and pasted creating a new layer that can be edited. Then Canvas Size was increased a few inches in both vertical and horizontal directions to allow sufficient room for stretching the image.

**Step 7b: Aligning the Image**

A guideline was created and snapped (automatically align to the edge) to the right side of the layer created above. Another guideline was snapped to the left side of this layer. Two more guidelines were aligned with two elements that were to be made horizontal near the top and bottom of the image. This was
usually the bottom of the first floor windows and the top of the upper floor windows or roof edge as in Figure 5 below.

Figure 5: Image Guideline Process - Changing Image Distortion.

The Distort function was used to align the horizontal elements with their respective guidelines. This was done by sliding the grips that appeared at the corners of the layer up or down along the vertical guidelines. After the image had been aligned vertically, it was aligned horizontally. The guidelines along the top and bottom objects were dragged up and down until they snapped to their respective edges of the image. Next, the guidelines along the vertical edges were dragged in so that they lined up with an element that was supposed to be vertical on the left and right sides of the image. This was usually the left and right ends of the façade walls, as in Figure 5 above. The distort function was repeated to align these vertical elements. This time the corner grips were slide along the top and bottom guidelines until the ends of the walls lined up with the vertical guidelines, as in Figure 5.

For wall facades that required piecing together two or more pictures, first one image was opened and aligned using the above process. The next image
was opened and pasted into the first on its own layer. This image was then aligned horizontally and vertically using the same methods described above for the previous image. Once it was perfectly square, it was scaled and aligned to the first image in the file that it had been pasted on top of. An approximately 1/3 overlap was used between the two images. This was so that the same object, such as a window, was present at the left edge of one image and the right edge of the other image to use as a guide while aligning the two images together.

Sometimes different images imported into the file did not match due to color, brightness, or contrast. These differences were corrected for each layer by using the Color Balance and Brightness / Contrast functions until the images matched.

For facades made up of more than two images, this process was continued until the whole facade was completed. Once all parts of the image were aligned, the guidelines were removed.

**Step 7c: Cropping and Flattening**

The image was cropped exactly to the façade without leaving any part of the image outside of the façade. When a particular wall was not rectangular in shape, such as a gabled roof end, the image was cropped to the absolute outer most ends of the wall. Both these situations are illustrated in Figure 6 on the next page. Once the image was cropped, it was flattened into one layer.
Step 7d: Resizing

Image Size was chosen and resample image was checked at the bottom of the Image Size dialog box. The resolution was set to 150 to provide some playroom, as in Figure 7 on the following page. An image height range was set based on the buildings height. If it was a 1-story structure this number was set to 200, a 2-story structure would be set to 300, and so on, adding 100 for each floor. If the structure was taller than 5 floors, only 75 would be used per floor in this range. As discussed by Lindhult, this is so that the image is small enough so that it did not slow down the virtual reality viewer. However, the image must still be large enough so that it still looks realistic without any ‘jaggies’ (Lindhult 1998).
As described in the *Model Builder 3D Desktop Tutor*, a model will consist of thousands of images, with hundreds being viewed at the same time. Each one must be regenerated for every little move in virtual reality. Even a simple model consisting of relatively few faces can move very slowly and awkwardly if the images are too large. These images need to be small enough to allow a system
of reasonable power, to move realistically through the model, with little or no
jerks or jumps in the action. However they should be of a high enough
resolution and quality to appear realistic, allowing for easy recognition of the
structures by the viewers, with few jagged or distorted edges (MultiGen-
Paradigm-Staff Model Builder 3D Desktop Tutor 2002).

**Step 7e: Saving the Image**

The image was saved as jpg format into the directory containing the
finished texture images for the project. A descriptive name containing the
buildings name and the side of the building (such as 16ArmoryF, F is for front)
was used for each image. A quality of 10 was used for all jpgs. Important note:
choosing a value less than 10 may result in loss of image quality for relatively
little hard drive space saved, less then 8 may not even be recognizable in the
virtual reality model, with no gain in speed. Saving the image with a quality
higher than 10 will dramatically increase the file size with no increase in quality.
This process was then repeated for the remaining images until all were
completed.

In total, 1,697 pictures were taken of the project area, which required
2.72 Gigabytes of hard drive space, before editing. Some images were only
used for reference while building the model, but most were used as facades.
Facades were captured in one image, as much as possible, but as discussed
above, many were pieced together using multiple images. The resulting
material library contains 1,021 images created from the pictures taken on site.
Some were used multiple times, such as a plain shingle pattern that could be
applied to several roofs. Images of trees and shrubs used in the model were
also copied to the texture library along with several varieties of generic materials, such as the shingles mentioned above. These included asphalt, brick, stone, building siding, concrete, ground cover, and shingles, which were used where standard textures could be applied within the model. These images were supplied with the 3D modeling software by AutoDesk/Kinetics and MultiGen-Paradigm, for use in models produced using their software. Besides the images, the material library also contains an attribute file for each image used in the model. This brings the total number of files in the Material library to 2,385. The total size of this library only required 127 megabytes (0.127 gigabytes) of hard drive space for the edited facades and other texture images as well as their attribute files.

4.5 Building a 3D Model

Step 8: Importing Building Data

Once the images had been processed, building the 3D model could begin. To create the 3D models, the revised building footprints created in Step 3, were then imported as a CAD drawing directly into Model Builder by choosing the import function and selecting the file to import. These footprints were then used as a base for the 3D model.

Step 9: Setting up the Texture Librarian

To use the photos edited in the previous steps for creating the building facades, they were added to the modeling software's texture library. Facade images for the first building were added to a pallet of the texture library in Model Builder. The Texture Librarian in Model Builder was then arranged in a single row across the bottom of the screen. This was so that a whole texture pallet
was visible at one time, but out of the way during modeling, as in Figure 8 below. This eliminated the need to minimize and maximize different windows, flip flopping between them all of the time. It also allowed for all images of the building facades to be seen and used as a visual reference while the facades were being created. This saves steps as well as time.

Figure 8: Building Footprint and Texture Library.

Throughout the modeling process, images for simple buildings, which consisted of only a few facades, were placed on a pallet with a few other simple buildings. More complex buildings required their own pallet in the texture library. This allowed for easy selection of the images during the modeling process, without having to scroll through the pallets searching for the
appropriate image. Generic materials were placed on their own pallets as well, with one pallet for roof materials, another for wall materials, etcetera, which also allowed for easy location of the appropriate texture.

**Step 10: Creating a Building Model**

**Step 10a: Extruding the Footprint**

The first building to be modeled was chosen, as described in *Model Builder 3D Desktop Tutor*, then its footprint in the model was located (Figure 8, page 48), selected, and extruded using the Wall Tool in Model Builder. This creates the whole building as a box, with all the walls drawn at once to an even height (*MultiGen-Paradigm-Staff Model Builder 3D Desktop Tutor 2002*), as in Figure 9 on the next page. These walls are actually only a guiding surface. They were extruded to a height much higher than they would actually be modeled, to make selecting these faces easier while perform the following steps.
Step 10b: Mapping the First Façade Image

Since the first picture sets the height for the entire building, each building was begun on a façade that’s picture was known to have required as little manipulation as possible. This was so that its’ height to width ratio was known to be accurately proportional, resulting in an accurately sized building. The first wall is usually either the front or a gabled end, which provides the best reference for creating the rest of the building. As described in Model Builder 3D Desktop Tutor, this image was selected in the Texture Librarian. The wall was selected, followed by the texture-mapping tool. The two bottom corners of the wall were selected with the middle mouse button, which snaps the corner of the
image to the corner of the wall. The command was completed by clicking on the OK button, (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor 2002*) as in Figure 10 below.

![Figure 10: Mapping a Facade Image to a Building Face.](image)

**Step 10c: Creating a New Face for the Façade**

The create face tool was selected, then the middle mouse button was used to snap to face corners and edges. Since the image mapped to the wall face during the previous step was not rectangular, the left mouse button was used to click on corners of the image that did not correspond to points on existing faces. (The point of the gabled roof, as in Figure 11 on the next page.) A double click of the middle mouse button or single click on OK,
completed the face, as described in *Model Builder 3D Desktop Tutor* (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor 2002*).

![Figure 11: Drawing an Irregular Face Over an Existing Face.](image)

Then the original extruded wall face was selected and deleted from behind the new face that had just been drawn. The top of the box created when the footprint was extruded, was also deleted at this time. Using the same method described in Step 10b above, the image was mapped to the new face, completing the facade. The results can be seen in Figure 12 on the following page.

For a new rectangular face, as on the left in Figure 12 (next page), the create face tool was selected. Using the middle mouse button, the new face was snapped to the lower left corner of the existing face, then to the upper left corner of the adjacent gabled wall face completed above. As above, a double click of the middle mouse button completed the face, as in Figure 12.
Figure 12: Drawing a Rectangular Face from the Facade Image.

The original extruded wall face was selected and deleted from behind the new face that had just been drawn. Then the facade image was selected in the Texture Librarian and mapped to the new, properly sized wall face. Again, as for the previous face described above, this was done by selecting the map texture button and middle clicking the lower left followed by the lower right corners of the facade, then the ok button, as in Step 10b. The results can be seen in Figure 13 on the following page.

**Step 10d: Continue the Walls**

This process was then repeated for the remaining sides of the building. For each new wall drawn, the previously created wall was used as the height reference. If the façade image did not line up with the top of the previously created wall, it was aligned by dragging up or down along the right side of the facade with the middle mouse button. While doing so, the snap function, actuated by the middle mouse button, kept the image vertically aligned, until it
meets the top of the previously created wall. OK was then chosen to complete the command as in Figure 12 on the previous page. The completed walls can be seen in Figure 13 below.

Figure 13: Creating a Roof.
On the left, the face is being drawn; on the right is the completed face for the gable roof.

**Step 10e: Creating the Roof**

Once all sides of the building were completed, the roof was created. The face tool was used to create the roof by clicking on the top corners of the walls, as described in *Model Builder 3D Desktop Tutor*, with the middle mouse button to snap to them, and double clicking the last corner. If the roof was gabled, the sides were created one at a time. Since this was intended as a virtual representation, over hangs were not created along the edges of the roofs to save time and system resources, (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor 2002*) as in Figure 13 above.
If the building had two or more converging gable roofs, a gabbled end was copied to the other side for use as a guide and then deleted once the roof was completed. Roof sections going beyond the intended intersection were cut off by first clicking on the align grid to face tool, then on the roof face they were to intersect, as described in *Model Builder 3D Desktop Tutor*. This placed the grid plane, which will be used as a slicing plane along this surface. Next, the faces to be trimmed were selected, followed by choosing the Slice tool, which then separated the faces along the slicing plane, as in Figure 14 below. The ends of the faces which had been separated by the slice command along with the gabbled end used for a guide were deleted (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor 2002*).

Figure 14: Changing the Slicing Plane to Create an Intersecting Gable Roof. *On the left the face representing the plane to be used is selected. In the center, the grid can be seen aligned to the new face. On the right the excess has been cut of from the intersecting roof faces to complete the adjoining sections.*
**Step 10f: Texturing the Roof**

![Image of a 3D model with a house and a texture editor window]

Figure 15: Adjusting the Roof Texture Scale.

Textures were added to the roof by choosing the appropriate texture from the roof texture pallet, which was created by adding the images of roof textures, supplied with the program, to a separate pallet in the texture library. Next, the roof face was chosen, followed by the Map to Surface tool. As described in *Model Builder 3D Desktop Tutor*, with this tool, the scale (size) of the texture was set by dragging the slider until the roof texture appeared at an appropriate size (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor* 2002), as in Figure 15 above. This was then repeated for all the roof sections of the building. Steps 9 through 10f were then repeated for all the remaining building footprints, until all the buildings were completed.
An interesting problem:

Three weeks into this process, the file was opened to find that all of the façade images had been replaced by a black X on a white background. The façade images also no longer appeared in the texture library. There was no mention of this abnormality in the manuals for the software. A call to Gary Smith at tech support revealed that occasionally Model Builder “will lose” the texture library, even though they had not been moved. This also occurs anytime that the location of any part of the images or models are moved on the computer or from one computer to another. The solution is to open the texture library in Model Builder, then choose List Textures from the Info menu, as in Figure 16, on the next page. From here the images were re-linked to the library by re-specifying their location. If the images are in different folders, only small groups of images can be re-linked at a time. To save time, the solution is to place all images, which were used in the model library into the same folder. This way, whenever the links are lost, only that one folder needs to be selected during the re-link process (Smith 2003).
Step 11: Separating the Buildings into Individual Models

With the buildings completed, it was time to separate them into individual models. This will facilitate future updates to the model as well as scenario planning where buildings are rearranged. To do so, one building was selected, copied from its original position, using its center point as a reference point, as described in Model Builder 3D Desktop Tutor. Its center point was then pasted to the center of the grid (0,0). The rest of the buildings were deleted from the model and it was saved as the name of the building. Next an icon was created for it, which will be used in the Model Librarian later, by choosing Snapshot from
the View menu. This process was repeated for every structure. (MultiGen-Paradigm-Staff *Model Builder 3D Desktop Tutor* 2002).

**Step 12: Preparing for Virtual Reality**

This step prepares the 3D terrain for use with the orthographic photo used as a ground plane texture. Once all the buildings were separated into their own model files, it was time to return to the GIS project set up in Step 4. Set 3D View Directory was chosen from the SiteBuilder3D menu to set the directory path to where the project data is stored. This added a folder labeled 3ddata to this location, which is where Site Builder places all the information for the 3D scene it creates. As prescribed in *Site Builder 3D Tutorial*, a terrain was created from the TIN (Triangular Irregular Network). The orthographic image was used to create a texture for the terrain. This eliminates the need to create streets, fields, and other ground plane features since they are already present in the orthographic photo. The terrain was now ready for virtual reality (CommunityViz-Staff 2002).

**Step 13: Creating a Building Points Layer**

As instructed by James Thompson of the Northampton Office of Planning and Development, a points layer was then created to attach the building models to. The buildings footprint layer created in Step 3 was imported into GIS. Xtools was used to create a new points (centroids) layer from the buildings footprint layer. This new layer was named Structures and added to the project. The table of the Structures layer was opened and edited to add a new column, named Buildingid. The record for the first point was selected, which highlighted it in the view on top of the orthographic image. This makes it easy to identify
which building the point represents. The name of the corresponding building model created with Model Builder in Step 11 was then entered into the point’s record under the Buildingid column. This process was then repeated for all the remaining points in the table (Thompson 2003).

**Step 14: Connecting the Buildings Models to the Points Layer**

To connect the building models to the points layer, the 3D Legend Editor was used, as described by James Thompson. Point was clicked, which opened the Place Parameters box. On the Place Parameters box, Single Value was chosen for all three options in the left column before clicking on the arrow next to the Model (flight file) box, in the right side column. This opened the Model Selector box, where Value Field was chosen from the Legend Type pull down before clicking on the Model Librarian. The Model Selector was moved so that it occupied the far left side of the screen while the Model Librarian was moved so it was directly to the right of the Model Selector (Thompson 2003). (See Figure 17 on the following page.)

On the left window of the Model Librarian, all files were removed from under the Catalog heading except Vegetation, which was renamed Trees. A new folder was created called MRC-Structures (MRC stands for Mill River Corridor). This new folder was opened and New Items was chosen from the Insert menu. When the Select File window opened, all of the building models were selected and added to the MRC-Structures folder in the Model Librarian. All of their icons, created with the snapshot command, appeared in the right window.
Figure 17: Arrangement of Place Parameters and Model Selector.

On the Model Selector, BUILDINGID was chosen from the Values Field pull down, causing the building names entered into that column in Step 13 to show up in the Flight File column of the Model Selector. As instructed by Thompson, all the building models where then dragged from the right column of the Model Librarian to the model box under the Values Field pull down, next to the corresponding names. Please refer to Figure 17 above.

This linked all of the building models to their respective points so that they will be displayed in the 3D Viewer. OK was clicked on the Model Selector
and the Model Librarian was closed. Save was chosen on the Place Parameters box to save the new 3D legend, followed by Build to generate the 3D models locations for use in the 3D Viewer. Once this generation process was completed the Place Parameters box closed automatically (Thompson 2003). Launch 3D Viewer was chosen from the Site Builder menu. When it opened after several minutes, all the buildings appeared in the proper locations. Since the building models were all created in one model based on their building footprints before being divided into individual models, rotation of the building models was not an issue. In total, 113 buildings were modeled as existing structures.

**Step 15: Creating the Trees for Virtual Reality**

To have a more realistic virtual reality model, trees were added to the scene. A new points layer was created in GIS for every type of tree symbol that was used. To make arranging layers easier, these layers were named based on the type of tree they represent, such as Trees-Pines. On the first tree layer, points were placed where each tree of that type was desired. This was repeated for all of the tree layers using a different color for each.

In places where there was a stand of trees or a forest, trees were only placed along the edge, to give the effect of there being a large stand of trees. The internal part of the stand cannot be seen from the virtual reality (VR) scene, unless the viewer is passing through or flying over the stand. Trees from each of the layers that represent the general forest make up were intermingled along this edge, as in Figure 18 on the next page.
Since the intent was to create a representation of a stand of trees, it was not necessary to place the exact type of tree in the exact location that it is in real life. This saves time in creating the layers, as well as frame rates when viewing in the 3D Viewer. According to MultiGen-Paradigm, due to the extreme number of faces, an entire forest, or even a few large stands of trees would noticeably slow down the movement of the VR simulation. This can reach a point where the motion becomes jerky or even pauses, and therefore is no longer a virtual simulation (MultiGen-Paradigm-Staff Model Builder 3D Desktop Tutor 2002).
Once all the tree layers were completed, the table for each tree layer was opened and a Type field was added with a String field Type, and a Width value of 30. The tree type represented by this layer was entered in the first cell under the Type column heading. This was then copied down the column for all of the tree records, so that the same value was entered for all trees in this file. The file was saved, and the process repeated for the remaining tree layers. After this was completed, all the tree layers were merged into one new layer named Trees. This new layer was added to the project and the old tree layers deleted.

The 3D tree models provided with Site Builder were connected to the Trees points layer in the same way that the buildings had been connected to the Structures layer in Step 14. This time (Tree) Type, was chosen from the Values Field pull down, causing the labels for the tree types to show up in the column on the right. The trees corresponding to these names were then chosen from the Trees folder in the Model Librarian. After all of the selections were made, Build was chosen, followed by Save.

**Step 16: Navigating the Virtual Reality Scene**

Now that the model was completed, it could be explored with the 3D Viewer. Once the 3D Viewer is open, mode of travel can be selected from the Motion menu. Walk, drive, and fly all provide excellent ways to explore the model. These modes of travel allow for viewing the model in 3D Virtual Reality, moving around the model by simply holding and dragging the left mouse button, with the motion following the mouse arrow. Moving in reverse was simply done by holding the right mouse button. The middle mouse button stops all motion.
If the movement became too slow or fast, it was remedied by adjusting the Speed control on the Motion menu. It is also helpful to raise and lower the viewer’s eye point above the terrain by selecting Height Above Terrain. The View window was resized and arranged next to the 3D Viewer. When this is done, a view cone in the view on the left, depicts the direction of the view seen in the 3D Viewer, on the right as in Figure 19 above.

Sometimes the 3D Viewer opened with a yellow and blue pattern on the terrain instead of the orthographic image. According to Christensen at CommunityViz tech support, this is caused by maxing out the computers video memory with a highly detailed scene. The solution is to first turn off all layers by...
clicking on them under the Themes menu (a check mark means the layer is on) of the 3D Viewer (the terrain cannot be turned off). Then chose Frame Rate from the Display menu, which will open the Limit the Frame Rate box. Next, drag the slider all the way to the left, to the lowest possible setting (1). In a few seconds, the image mapped to the terrain will appear. Once the image had appeared, the frame rate can be dragged to left to the desired setting. Then the desired layers can be turned on in the Themes menu, before exploring the model (Christensen 2003).

4.6 Municipal Planning

Once the existing conditions had been modeled, the model was ready for use in planning decisions. Scenarios of the proposed planning decisions can be modeled and displayed to show what effects they will have on the area. After viewing the impacts of these scenarios, the city can determine which course of action to take.

Wayne Feiden of the Northampton Office of Planning and Development decided to have a model built for one of the city’s proposals to try in a modeling scenario. This model was a new building proposed by the city and still in the preliminary design phase. A basic mass model, which included the general shape, size and location of the proposed structure was provided to be converted for use in virtual reality (Feiden 2003).

The proposed structure was in a completely new location; therefore there was no building footprint to create a point from to connect the model to in GIS. The provided model contained several adjacent buildings to which the proposed structure’s relationship was crucial. Therefore the point from the closest
building was copied to a new layer and used as the attachment point for the proposed building model.

The provided proposal model was in the form of a SketchUp model. SketchUp was downloaded from the SketchUp web site at http://www.sketchup.com/. SketchUp was then installed and used to explore the model before exporting it in a form that Model Builder could import. It was then imported into Model Builder, where it was simplified by deleting interior features and rearranged to have fewer faces for use in 3D. The file was saved along with a snapshot for its’ icon in the Model Librarian. This model representing the proposed structure was attached to its point layer in GIS in the same way the existing buildings had been in Step 14. Since the model of the proposed structure has no applied textures, it stands out well as a proposed structure among the rest of the buildings in the area. This proposal can easily be turned on and off to show before as well as after views in the 3D Viewer simply by clicking on its’ layer in the Themes menu.

Due to the uncertain nature of the project and that the preliminary state of the design, the architect involved with this proposal wished to remain unidentified and that no images be provided of the model at the time of this writing.

Another proposal was made by David Pesuit of The Accident Analysis Group (AAG) involving the addition of a coffee shop with a courtyard café to their building. AAG provided four highly detailed 3D models of the proposed courtyard and building at 16 Armory Street. To accommodate the proposed courtyard, the adjacent parking lot was redesigned and modeled. The same
method of copying a point from the Structures layer to use as the base point for the proposal model was used. Since this proposal had five components, five points layers were created using this method (Pesuit 2003).

Plans of the existing parking lot were not available from the city, so measurements and parking counts were taken on site. A recent orthographic photo depicting the parking lot was printed out and used as a base map. This map, along with a pencil, and tape measure were taken to the site for use in measuring the lot’s dimensions. This was commenced at dawn to avoid traffic during the procedure. The end of the tape was hocked on the edge of the curb to hold the tape while it was pulled out to measure the parking stalls, travel lanes, islands, etcetera. As measurements were taken for each section, they were written onto the printed orthographic image of the lot in the corresponding locations. The number of parking stalls were counted in each row and also recorded into the corresponding locations on the map. In this way it was easy for one person to measure this small lot.

The orthographic image and the existing conditions model were imported into AutoCAD and aligned to each other. Geometry for the parking lot was traced from the orthographic image, and the measurements taken on site were used to create a base map of the existing lot. Proposed changes to the lot were laid out using the existing lot and the specifications provided by Harris and Dines in Time Saver Standards for Landscape Architecture as guides (Harris and Dines 1998).

The topography layer used to create the TIN (Triangular Irregular Network) for the 3D project was clipped to the area surrounding the parking lot.
Since the proposal called for a sunken courtyard, a new TIN was created. To make sure that all objects line up in the correct locations, the topography and building footprint layers were imported into AutoCAD with the proposed parking lot and courtyard. An outline was drawn around the area of the proposed sunken courtyard. This outline was then used in GIS to create a sunken space in a new TIN for the courtyard.

This new TIN was then used to create a new terrain for the project and the orthographic photo was used as a texture for this new terrain. Next, the new TIN was imported into Model Builder and used to create a base for the proposed parking lot. The orthographic photo was edited in Photoshop to show the proposed layout of the parking lot and saved as a new texture. Trees from the Model Builder vegetation library were inserted in the planting strips around the lot based on the specifications of the new plan in Figure 21 on page 73.

Since there was now an excavation in the base TIN for the entire 3D Scene, a mask was created to cover the hole when the Accident Analysis Proposals were not being displayed. A new rectangular face with the Face Tool over the opening in the proposed parking lot TIN and covered with the appropriate section of the orthographic image. This was then saved as a new model for use in virtual reality.

Since the models provided by the Accident Analysis Group were in 3D Studio format, each was opened in 3D Studio and a screen capture was taken of the façade in each proposal. This was then cropped in Photoshop to the facade before saving. All excess features were removed and the file saved with a new name. The proposals were imported into Model Builder and aligned to
the building belonging to the Accident Analysis Group. Then they were saved as new models, which were added to the Model Library. Next they were attached to the appropriate points using the 3D Legend Editor, with the same process used for the building models in Step 14. The 3D Viewer was now launched and the scene was navigated to the Armory Street Parking Lot where the new models were turned on and off to test them.

The Accident Analysis Group (AAG) did not have GIS to view the VR models with so these models were converted to 3D Studio format. Site Builder and Model Builder do not export any formats that could be used in 3D Studio, so these models were recreated in AutoCAD and 3D Studio. The plan for the proposed parking lot changes was printed out from the AutoCAD drawing and the proposed models were placed on a CD ROM, which was brought to The Accident Analysis Group for review. At the meeting, it was agreed that a walkway would be added across the parking lot would be added. Also before and after views as well as plans would be created. Plus the facades of the surrounding buildings would be added to the 3D Studio models.

The AutoCAD drawing, which was the base documentation for the parking lot section of the project, was edited to reflect these changes. Space was made for the center walkway through the parking lot, which caused some shifting of the parking spaces, requiring a slight shifting of the islands as well. Three layouts were also added to the cad drawing which enabled the print out of the plans, before, after, and a combination of the two together for easy comparison, as in Figures 20, 21 & 22 on pages 72 - 74.
The original parking lot consisted of a set of streets that border it on two sides and pass through it on the other two sides. Inside the parking lot was another loop for cars to circulate around the lot, amounting to a road with parking stalls surrounded by another road. Using Harris and Dines as a reference, these two outer roads function as little more than connections between and through parking lots. All lot traffic still flows along them, entering at congested points. The two outer roads were easily incorporated into the present lot by creating two more curb cuts on both ends, opening up the lot. The inner parking lot loop was eliminated, allowing the parking lot islands to be extended to the ends along with their parking stalls. As shown in Figure 21, this results in four long, parallel rows of parking as opposed to the six, short and perpendicular rows. Traffic congestion within the lot is reduced by the longer, straight runs, and reduced number of turns. As seen in the accompanying plans (Figures 20, 21, & 22, on pages 72 - 74), the original parking lot has 67 public parking spaces. The proposed changes to the parking lot, as approved by Pesuit, not only makes room for the proposed courtyard café, but also improves the traffic circulation through the lot (Harris and Dines 1998; Pesuit 2003). These proposed changes add 21 public parking spaces bringing the total to 88, as in Figures 21 & 22 on pages 73 & 74. Figure 20 shows 9 parking spaces along the 16 Armory Street building, which are removed to make room for the proposed courtyard café in Figures 21 & 22. As indicated in Figure 20, these are private spaces belonging to the Accident Analysis Group (AAG) who proposed this project, and are not available for public parking. AAG has decided to sacrifice these private parking spaces, to make room for the
proposed courtyard and increase public parking. This increase in public parking by 21 spaces will more than make up for the loss of 9 private spaces (Pesuit 2003).

Figure 20: Armory Street Parking Lot - Existing Conditions Plan.
Figure 21: Armory Street Parking Lot - Proposed Plan.
The virtual reality model and 3D Studio models were updated accordingly. Facades of the surrounding buildings were added to the 3D Studio models. Next, the AutoCAD drawings and 3D Studio models were copied to a
CD Rom for delivery to The Accident Analysis Group. Thus concluding the project, with all clients satisfied. Please refer to the virtual reality model of the existing conditions in Figures 23, on the following page, as well as proposals A, B, and C, in Figures 24, 25, & 26 respectively on the following pages. Figure 26, Proposal C, is the preferred plan.
Figure 23: Existing Conditions at 16 Armory Street. 
Top: view from on top of the parking garage. Center: view from curb on corner near coffee shop (extreme center left in both top and bottom images). Bottom: from within parking lot near east side (just outside on the right of both top and center images).
Figure 24: Court Yard Proposal A at 16 Armory Street.
Top: view from on top of the parking garage. Center: view from curb on corner near coffee shop (extreme center left in both top and bottom images). Bottom: from within parking lot near east side (just outside on the right of both top and center images).
Figure 25: Court Yard Proposal B at 16 Armory Street.  
*Top:* view from on top of the parking garage. *Center:* view from curb on corner near coffee shop (extreme center left in both top and bottom images). *Bottom:* from within parking lot near east side (just outside on the right of both top and center images).
Figure 26: Court Yard Proposal C, at 16 Armory Street.

The preferred design. Top: view from on top of the parking garage. Center: view from curb on corner near coffee shop (extreme center left in both top and bottom images). Bottom: from within parking lot near east side (just outside on the right of both top and center images).
4.7 Summary

In this chapter the methods laid out in the previous chapter were implemented. Throughout this chapter, the parts of this methodology were discussed in depth to address and answer the questions set forth in chapter 2, restated below:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

To answer questions 1 and 2, this discussion includes the steps taken from the beginning to the end of the project in great detail so that anyone wishing to undertake a similar project can follow this process. These steps are summarized in Table 1.

Section 4.3 covers the collection and arrangement of GIS base data, involving Steps 1 – 4. Photography including Steps 5 - 7 is discussed in Section 4.4. The Steps involved in model creation are (8 – 16) are covered in Section 4.5.

After completing the model of the city in its existing conditions, models of proposed structures were created for use in scenario modeling. As described in Section 4.6, the city had proposed a structure, which was converted to a virtual reality model. Another proposal by the Accident Analysis Group was constructed and also inserted into the Virtual Reality model (Figures 23 – 26). These models can be turned on and off within the 3D Viewer to show the
present conditions and how the proposed development would affect the area in virtual reality.

In continuing to answer question 2 and 3, this project required the knowledge and use of several technical computer programs. Included in this list are AutoCAD, ArcGIS, Photoshop, CommunityViz, Site Builder, and Model Builder. Even with several years of computer experience with some of these programs along with their manuals, it was still necessary to contact James Thompson at the Northampton Office of Planning and Development, who had been trained on the virtual reality software. At other times it was necessary to contact the manufactures technical support. The scale of the project along with the trial and error process made this project far more involved as well as time consuming than had been foreseen. A project of this nature would be better accomplished with a small group of people than by one individual. Even so, to create a model of this size or even a whole community, would take several weeks at the very least.

In the final chapter, the intended use of these models by the city as well as other possibilities for such models will also be discussed. Included in this discussion will be some thoughts on the feasibility of undertaking such an endeavor along with some points for considerations when deciding to use this technology.
5.0 CONCLUSION

5.1 Introduction

The emerging technology of real time modeling has been combined with GIS and applied as a planning tool to help understand the visual effects planning decisions will have on a community. A review of recent literature determined that there was no published documentation of the step-by-step process involved in creating models of this nature for use in planning. Therefore, the purpose of this study was to determine in detail, the steps involved in the process of building a 3D virtual reality model for municipal planning. Through this process, this study also ascertained the ease of which a model of this type can be constructed.

5.2 Literature Review

Chapter 2 is a brief review of the literature dealing with computer based 3D modeling. This literature covers the topics of GIS (Geographic Information Systems), CAD (Computer Aided Design), as well as 3D modeling, including real time, virtual reality modeling. In recent years this last form of modeling has been combined with GIS for use in planning applications. While users of real time modeling have written about the planning projects they have undertaking with it, there is very little detailed documentation on the step-by-step process. Therefore, the objective of this project is to research and answer the following questions:

1. What are the finer details of building this sort of model?
2. What does this really involve?
3. Is it really as quick and easy to create a real time, base model as it seems?

5.3 Methods

The related combined technologies are used to create a model of this type in order to answer these questions. This includes GIS, CAD, and 3D modeling software used to create a virtual reality model. The steps taken are documented in Chapter 3: Methods, while the process and outcome are documented in Chapter 4: Application. Please refer to Table 1, for a list of the steps involved in this process.

5.4 Application

In the Application chapter, the methods laid out in the previous chapter were implemented. The parts of this methodology are discussed in depth to address and answer the questions set forth in Chapter 2, restated above in Section 5.2. This provides a basis for anyone wishing to follow the process and create a virtual reality model for their community.

Section 4.3 discusses steps 1 – 4 of the process, which cover the collection, and arrangement of GIS base data. Steps 5 - 7 are discussed in Section 4.4 covering the photography and editing of those images. Steps 8 – 16, which are the actual creation of the model are covered in Section 4.5. After the model was completed, models of two proposals for this area were created for use in scenario modeling, as described in Section 4.6.

This project required the knowledge and use of several technical computer programs. These included AutoCAD, ArcGIS, Photoshop, CommunityViz, Site Builder, and Model Builder. The large scale of this project
made the process far more involved and time consuming than had been originally foreseen. A project of this nature would be better accomplished with a small group of people than by one individual. Even so, to create a model of this size or even a whole community, would take several weeks at the very least.

According to Wayne Feiden, City Planner for Northampton, the city plans to build an entire virtual reality model of the city over the next several years. This model will be comprised of sections built at different times as needed and when funding is available. The city’s objective is to eventually use these models in support of planning decisions and display them for community feedback in public meetings (Feiden 2003). The model produced of the Mill River Corridor is now in preparation for its first assignment. More building models were created and added to the model so that it can be used in planning charrettes for the City of Northampton during the summer of 2005 (Figure 27 and 28 on the following page). There is also a possibility of expanding this model to connect it to another model of a nearby street. By expanding the model’s coverage it will become more useful to the city. There are also discussions of adding more sections to the model. The planned charrettes will involve the Office of Planning and Development; affected landowners; and concerned citizens. This set of charrettes will determine buildings for demolition and replacement as well as an attempt to save one structure that is currently slated for redevelopment (Feiden and Thompson 2005).
Figure 27: New Buildings for the West Street Addition in Model Builder.

Figure 28: Views Along West Street.
5.5 Summary

Over the past few years, 3D virtual reality modeling has been used in conjunction with GIS for planning purposes. This project documents the step-by-step process involved in creating these models. With this documentation, anyone with an understanding of the technologies can follow these steps to create a community model. This model could be used for planning purposes, but could also be built for historical inquiry, simulations, virtual tours, or just for fun.

While this process was time consuming, constituting a major undertaking for one person, this was due to the size and scope of the project. The area modeled was over a mile long and consisted of nearly 100 hundred structures. There was also a lot of trial and error discovery involved in determining this process. Even with the time spent, when compared with the recreation of one section of the model using 3D Studio with AutoCAD in Section 4.6, 3D virtual reality modeling is faster and easier.

While less precise and detailed, this method of modeling is more useful for planning purposes. Images pasted on faces make creating irregular shaped structures quick and easy. No rendering is involved with real time modeling, which means that everything in the model is seen as it will be in the virtual reality model. No longer does a camera path have to be created and edited. This also means hours of rendering time are spared. Since it is interactive with GIS, changes in the GIS data change the model. This includes changes to planning scenarios. Users are not locked into a pre-determined movie style view of the model. They can explore the model at will, as if they were walking...
or driving through their neighborhood to see how proposed changes would affect the community.

The steps of this process have been documented to eliminate the trial and error process, allowing anyone to follow the process. Therefore, while the modeling process still takes time, real time virtual reality modeling is faster and more beneficial to planning activities than older forms of modeling.

Figure 29: West Street Overview.

Please refer to Figure 29 above for an overview of the West Street area of the model. The image on the left is looking in a southwesterly direction, while the image on the right is facing northeast toward downtown. On the following page, Figure 30 depicts more images from within the model. Please also refer to the enclosed CD for an animated movie walk through / flyover of the model in avi format.
Figure 30: Selected Model Images.
Top: Bridge over the bike path. Top Middle: Part of downtown section. Lower Middle: West Street facing downtown (northeast). Bottom: Downtown street leading to the Armory Street parking lot.
REFERENCE LIST:


Thomson-ISI-Reasearchsoft-Staff. Endnote 7.0.0 (Bld98). Thomson ISI Reasearchsoft, Stamford, Conn., USA.


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