# 3-D Modeling in Land Development Planning:

# Community-Centered Scenarios for West Chester Borough

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## INTRODUCTION

Local planning organizations play a crucial role in determining the future of communities across the world. Understanding the way a plan will impact an area and its surroundings is an integral part of the planning process. This is true across all fields of planning: transportation, land use, zoning, and community plans. Geospatial technologies have been widely employed to facilitate the planning process to, among other things, demonstrate the impact of proposed plans on a neighborhood. Commonly, two-dimensional (2-D) maps have served as illustrations for planning, used by local government and private agencies to demonstrate the impacts of the proposed plans. Increasingly, the use of three-dimensional technologies is on the rise in planning agencies across the world.

There are many ways in which 3-D technologies can be utilized in local planning. This research project presents an example of how 3-D geospatial technologies can be utilized in a specific context in West Chester Borough to help inform planning decision-making. Utilizing the latest 3-D technologies, the project demonstrates how it can be used in a local planning context and its usefulness in communicating development alternatives at a neighborhood scale. Specifically, this project had three main objectives: demonstrate how advanced GIS applications can be integrated into West Chester Borough's decision making and management process; create an actual GIS-based 3-D model that can be used for planning, and; demonstrate how the platform can be used for community engagement and participation around development planning. This research is relevant to society today because it can help demonstrate how advanced geospatial technologies can be used to engage the community and present ideas to the public as part of the planning process and ultimately help planners make more informed decisions on planning design elements.

In addition to demonstrating a planning application of 3D technologies, a detailed workflow was produced to serve as a useful resource for others to follow in future 3-D modeling exercises. A fully documented workflow is essential in advanced technology applications to facilitate similar efforts for additional applications and to generally support the development of knowledge in an organization.

## BACKGROUND

A geographic information system (GIS) is an advanced information system designed to store, analyze, manage and present spatial data. GIS is widely used in a planning for a range of analytical and mapping applications. As a visual and spatial tool, GIS can be used to analyze and communicate planning scenarios. GIS allows planners, citizens and public officials to understand how planning decisions will impact their communities. Until recently, GIS was used primarily in the 2-D format. Outputs of this format include flat maps, with spatial statistics pulled from various analyses that can be conducted on the dynamic data used in the computer program. However, with 2-D applications, it is difficult to apply hard, environmental constraints or hypothetical situations to these scenarios, whether they are conceptual or technical. 3-D modeling can overcome some of these obstacles, by creating a comprehensive, to-scale model of an area in question, to better communication the full spatial extent of development concepts, and to integrate data and statistics based on information in real-time.

3-D technologies are particularly effective for communication, allowing the planner to present the words of a plan to the public in a compelling visual way. 2-D maps present spatial information, but they are limited because they are static, and they cannot portray the full spatial extent in all three dimensions. The newest GIS technologies have advanced to incorporate dynamic 3-D modeling, with geographic information tied to the model, coupling spatial data with real-time ideas of what a city or town could look like.

There are many ways in which 3-D models can be used by local governments for planning purposes, but three stand out: first, 3-D models can be used to visually illustrate the spatial characteristics of zoning ordinance requirements; second, 3-D models can visually illustrate proposed development projects, and; third, 3-D models can be effective in promoting community outreach and local engagement in the planning process. In regards to zoning, 3-D models can represent the spatial impact of a zoning ordinance in an area, demonstrating the way development will look visually along with numerical statistics about the implications of the ordinance on the immediate and surrounding environment. When a township or municipality anticipates changing or updating their zoning ordinance, a 3-D model can be a powerful tool to help present conceptualized ideas by physically visualizing them. Another way 3-D modeling can be used in a local government planning context is by presenting how a proposed land development or subdivision will look in a community. A 3-D model can be used to show and display spatial information to gather an overall view of the area, define patterns, and gather spatial statistics, all within the context of the dynamic and physical model of the proposed land development or subdivision.

In the past, architects and developers have used 3-D software to provide plans for buildings, as well as an understanding of what the building or buildings will look like. 3-D is the easiest, most digestible form of media because it transcends many barriers that communities face, such as language and expertise. By understanding how a plan will look, and translating the words of a community plan into a navigable 3-D scenario, plans can be created to be the most compatible that they can be with their surrounding areas. Visually they are compelling and therefore can effectively engage the community and facilitate public input.

In addition to providing effective visuals, 3-D models using spatial information are able to perform authentic, realistic analyses and feasibility studies based on proposed zoning standards or development proposals. Modeling actual environmental processes such as storm water run-off, impervious surface coverage, and sunlight exposure, 3-D models can comprehensively anticipate the physical impacts of a community plan on the area before the plan is adopted or implemented. These processes are also scalable, allowing models to identify the impacts from a range of development types from very large projects such as a 45-unit residential neighborhood subdivision to a one-office building addition to an urban city.

Finally, 3-D models bridge the gap between local government agencies and the public, allowing the highest level of transparency available. The technology puts the power into the hands of the planning commission and the public, enabling both to easily test scenarios, and thereby to be creative in their decision-making. Different parties in the planning process have opportunities to cross boundaries and try new planning techniques that might have been considered unfavorable in the community. It provides transparency, while also promoting creativity and exploration.

**PROJECT AREA AND PLANNING CONTEXT**

West Chester Borough is a municipality and county seat of Chester County, Pennsylvania. At only 1.8 square miles and 18,461 residents, West Chester is a very dense, urban area (Census Bureau, 2016). Culturally, the borough thrives on its historic roots, while incorporating modern amenities. A diverse population lives here, ranging from older retirees to young professionals to college students attending the university located within the municipality's borders. Historic preservation while providing for growth has been a challenge of planning in the borough, and the local government works hard to maintain West Chester's historic past while planning for a sustainable future. The borough is comprised of eight zoning districts with three overlay districts.

The Borough is presently updating its comprehensive plan. As part of the planning process, four areas were identified as potential locations for substantial change in the future. Called "Future Enhancement Areas," they are locations that are likely to experience substantial development in the future. In all four areas, the current zoning does not support the type of development that is desired. One of these areas was chosen as the site for this project. Called the Gay/Market East corridor by the local community, the area aligns with one zoning district called the Commercial Services District. Located at the eastern edge of the Borough, the Commercial Service District, (one of two areas in the borough zoned this way), is located just outside of the main commercial center of West Chester. The purpose of the Commercial Service District, as stated in the zoning ordinance, was to accommodate highway oriented commercial uses directly outside of the Town Center District. Over time, the corridor grew to accommodate automobile oriented uses such as service stations and fast food restaurants. The Borough hoped to encourage new development in the corridor that would be consistent with the existing historic and pedestrian-oriented character. Ripe for redevelopment the area poses an opportunity to reimagine what it could be, and a good test site for 3-D geospatial applications.

## LITERATURE REVIEW

Studies completed surrounding 3-D technologies and urban planning are currently limited. Much of the literature available focuses on the concept of geodesign, a planning method which combines the creation of a design proposal with impact simulation information using a geographic context (Flaxman, 2009). The field of geodesign, with the incorporation of 3-D technologies, is a new one but is quickly gaining in popularity. Geodesign allows for the sustainability of designs and plans to be evaluated before implementation, which is a valuable tool to planners (Flaxman, 2009). In the past, maps have been used to express ideas and visuals in spatial planning (Eikelboom & Janseen, 2015). As technology has progressed and evolved, geodesign tools have arrived at the forefront of collaborative planning as a tool used to combine stakeholder values with diverse types of spatial information.

In 2015, Eikelboom and Janseen investigated the communicative function of map graphics in planning and the effectiveness of geodesign tools. One of the main focuses of the research project was visualizing multiple stakeholder values at the same time, with a strong emphasis on communication. The study compared four types of geodesign tools to evaluate their effectiveness at visualizing multiple viewpoints and ideas. The study found that the tools used in geodesign practice should be as simple as possible, and that adding advance functionalities made the tools more complicated. Simplicity often lends itself to greater communication, with fewer barriers to cross.

Communication is a key component of geodesign, allowing for multiple users to understand and digest a problem that may be difficult to put into writing or a 2-D format. 3-D models encourage greater communication and understanding, which in turn boosts public participation. Hanzl (2007) argued that new information technologies, specifically geodesign and 3-D modeling, could enable citizens to be more involved in the planning process. In reviewing a range of applications including participatory planning GIS, 3-D models, communication platforms, and computer games, the study found that in most of the new information technology reviewed, the systems focused on how they may be used for visualizing a new development, but fail to recognize how they may be used in public participation. Hanzl (2007) argues that, despite the lack of emphasis, the greatest potential for incorporating 3-D technologies into the public sphere lies in the use of collaborative software for participation of the public to get involved in urban planning.

3-D technologies have been found to allow for higher levels of creativity and experimentation, and take into account the environmental constraints of an area. Investigating the use of 3-D models in developing the Chicago central area plan, Al-Douri (2009) found that using the technology resulted in increasing the design detail and design content of a plan, as planners were able to communicate different elements. The study also found that 3-D models improved the quality of the decision-making process by increasing users' cognitive and communication abilities by providing a platform for efficiently coordinating across multiple groups involved in the planning process.

Plans require a high level of functioning analytical and statistical work. One way in which geodesign works to enrich tradition planning and design is by utilizing the power of modern computing, communications, and collaboration technologies by combining them (Ervin, 2011). This collaboration requires the integration of various types of data, software, and multiple systems. Geodesign is multi-disciplinary across a range of domain areas, making it a versatile tool in planning. Utilizing the new support given by modern computing and communications technology is an important aspect of this new level of geodesign.

A recent study done by Kim, Kang, and Han (2014) proposed a framework that automatically generates a textured, high-resolution 3-D city model, which can be used for ground-level applications. They argue that existing large-scale 3-D city modeling methods do not provide rich visual information at the ground level, failing to provide for more diverse areas which require higher levels of detail (Kim, Kang, & Han, 2014). To complete the framework and model, a mobile mapping system was used to automatically gather high-resolution images and GIS data, and was then integrated with 2-D imagery and base models using MMS data. They focused on very high detail modeling, which can be utilized most at the ground view.

A study done by Ki (2011) puts emphasis on the development of a ubiquitous city (u-city) using a web-GIS system. In the past, u-city development focused primarily on building the physical infrastructure of a city into a 3-D model. Ki (2011) suggests the addition of real-life modules to the physical infrastructure would be effective for local governments involved in urban planning, citizen participation, and city marketing. The author demonstrates how the system can become a tool to encourage public participation through public information sharing, sustainability analysis, urban physical planning, environmental planning, citizen participation, and city marketing.

## PROJECT DEVELOPMENT

The project itself had three main objectives: demonstrate how advanced GIS applications can be integrated into West Chester Borough's decision making and management process; create an actual GIS-based 3D model that can be used for planning, and; demonstrate how the platform can be used for community engagement and participation around development planning. This section describes the basic project development steps.

**Project Development Tasks**

Three major tasks were involved in developing the 3D model for use in a planning application:

1. Create Geodatabase of West Chester Borough Spatial Data (2-D Model and databases)
2. Develop a 3-D simulation model for development planning
3. Design a framework/methodology for interactive planning review

**Data Collection and Analysis Procedures**

This study was conducted at the parcel level in West Chester Borough, Chester County, Pennsylvania. Data was collected using Chester County's Open Data Portal, and includes: parcel lines, building footprints with height information, road centerlines, township boundaries, and zoning districts. Along with these shapefiles, rule files were brought in from CityEngine's base project files and edited using the computer software CityEngine.

*Software*

Two of ESRI's software packages were used to complete this project and explore the 3-D workflow. ArcMap is a geospatial-processing program used to view, edit, create, and analyze geospatial data. This program is one of the most commonly used, and does not incorporate 3-D technologies yet. However, ArcMap was used to process and edit the data preliminarily that will be used in the 3-D program, CityEngine. Some of the functions used in ArcMap include preparing aerial imagery and a Digital Elevation Model, edits to the attribute table in various data sources to make them legible and functional in CityEngine, creating a File Geodatabase, and clipping the data to the specific study area. ArcMap's visual tools are also helpful in creating basic 2-D maps by symbolizing the data for meetings with the borough to identify the study area.

CityEngine was the primary software used in this project. Defined as 3-D modeling software for urban environments, it can be used to transform 2-D GIS data into Smart 3-D city models. One of the major components of this modeling system that sets it apart from software packages such as Sketch-Up and AutoCAD is that it uses a procedural modeling core to build flexible scenarios. Procedural modeling is driven by rules that can be customized to use personal textures and 3-D assets, but also allow for the use of predefined rules that enable instant creation (ESRI, 2016).

As discussed, the Commercial Services (CS) District on the eastern side of the borough was selected as the project area to model with CityEngine. For the purposes of this project, only principal uses identified in the current zoning ordinance were modeled. Conditional and other uses can be added in at a later date, but for the purposes of simplicity and explicitly, only principal uses were used to create the model. The permitted principal uses of the CS District are: retail stores and shops, wholesale stores and distributorships, restaurants and fast-food restaurants, personal service shops, offices, automotive sales and service facilities, car wash facilities, clubs or lodges, motels, public service facilities, municipal uses, and commercial parking lots. The CS District requires off-street parking to accommodate these uses.

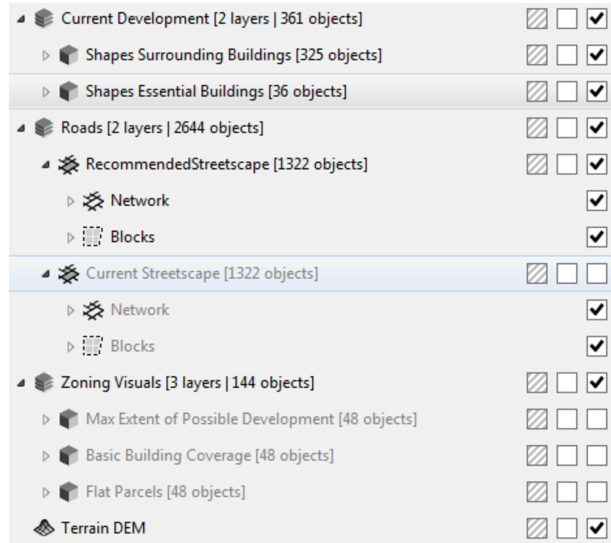
In addition to uses defined in the zoning ordinance, physical environmental constraints such as height regulations and setbacks were also taken into account. The maximum height of buildings and other structures in the CS District is 35 feet. Other area and bulk regulations include:

- Minimum lot area per use: 7,500 square feet.
- Minimum lot width at the building line: 100 feet.
- Minimum lot width at the street line: 75 feet.
- Front yards: 15 feet minimum; 20 feet maximum.
- Minimum rear yard: 35 feet, except that, where the CS District adjoins a residential district, the minimum rear yard shall be 45 feet.
- Minimum side yard: 20 feet.
- Minimum setbacks for parking and loading facilities:
    - Front yard: 15 feet.
    - Rear yard: 15 feet, except that, where the CS District adjoins a residential district, the minimum setback shall be 25 feet.
- Maximum building coverage: 60%.
- Maximum impervious coverage: 85%.
- Minimum green area: 15%.

Design standards were also noted for use in creating the CityEngine model. Buffer planting strips with a minimum of eight feet in width must be installed along any abutting side or rear lot line. Other design elements include making the streets more pedestrian and bike friendly by implementing complete street and streetscape improvements.

As part of this project, a comprehensive 3-D workflow was developed. Three-dimensional technologies are innately complex and made more challenging to master due to the ever-changing nature of technology. In order to best employ the technology, either individually or within an organization, it is necessary to develop detailed workflow guides. The full workflow is included as an appendix to this paper.

## Completed Model

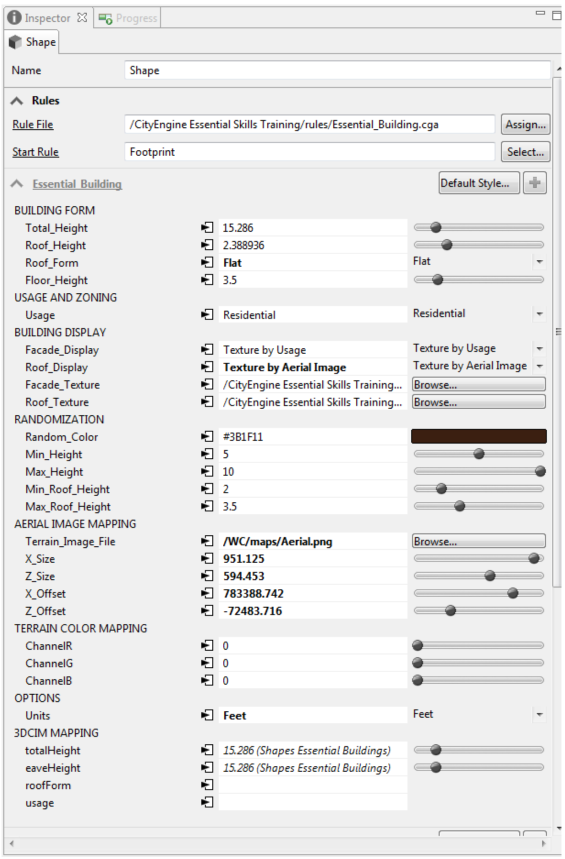


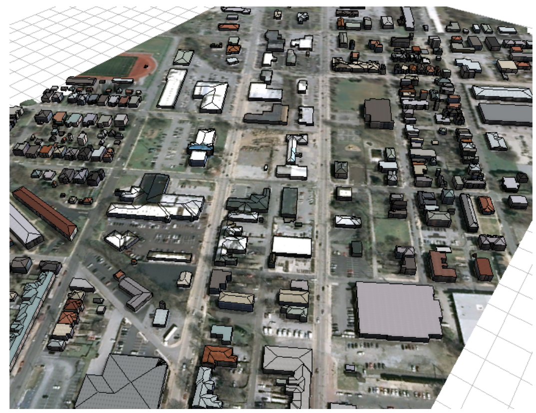

The final model of the Commercial Service District in West Chester Borough is made of thirty-six buildings located within the CS District, which are surrounded by 325 less-detailed buildings for context. The road layer is comprised of 1,322 line segments. The model is overlaid onto an aerial image, which makes up the terrain within the model. There are a total of eight layers in the final model output. The layer "Essential Buildings" and "Surrounding Buildings" are building footprints modeling the current infrastructure. The layer “Max Extent of Development” is created from a parcel layer, and represents the maximum build out of parcels based on zoning restrictions. “Basic Building Coverage” is similar to the Max Extent of Development, but provides a more simplistic view and will provide reports. There are two street layers. The first is a Recommended Streetscape, with a high level of detail including recommendations for street improvements to be more pedestrian and bicycle friendly.

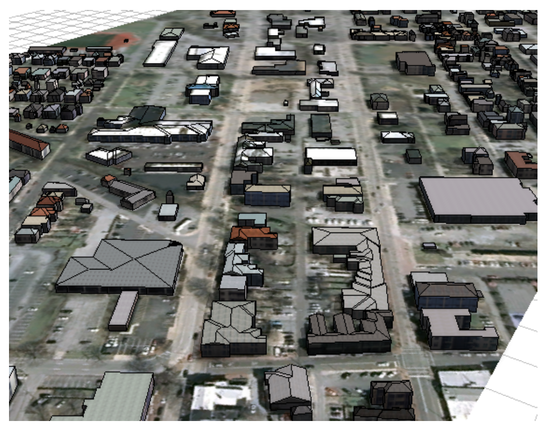
*Existing Infrastructure/Buildings*

Two layers comprise this part of the model: essential buildings and surrounding buildings. Both layers were created using the building footprints layer imported into CityEngine in the File Geodatabase. Included in the building footprints layer was the height of each building. The difference between the two layers is detail: essential buildings have more personalized and exact detail to represent the existing buildings. The surrounding buildings layer is used to provide context outside of the CS District, and do not have as much detail.

To create these buildings, the "Essential Building.cga" rule was applied. This rule provides many different functionalities and customizations. In addition to customizing each building with the appropriate rule file/options, the aerial imagery used in the terrain was then used as a texture file to overlay on top of the building footprint to give them a higher level of detail.

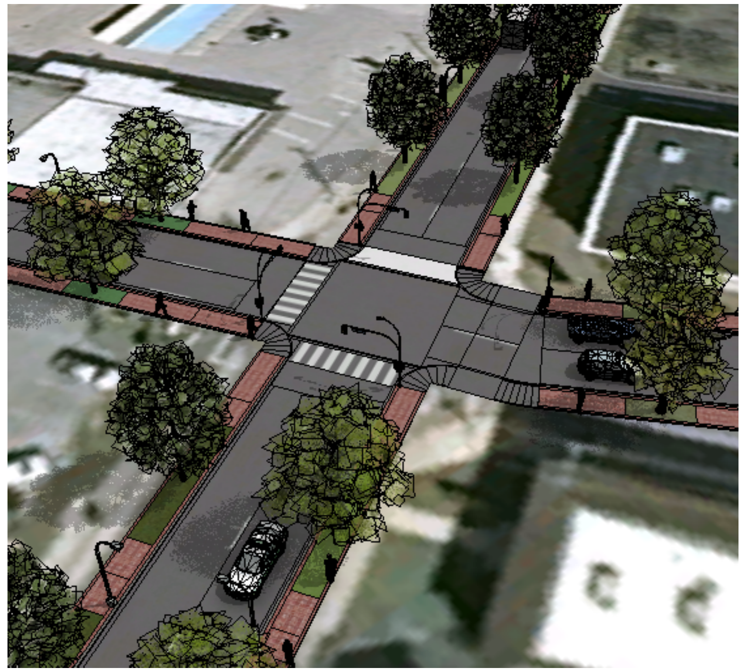




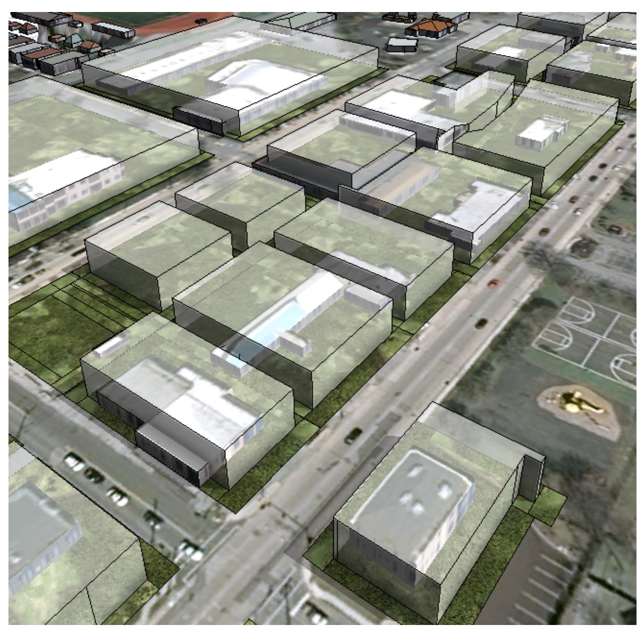
*Complete Streets*

The rule layer used to create and customize the streets layer was the “Complete Streets.cga” rule. This comprehensive rule allows complete customization, including road width, sidewalk material, and extra features such as car models and street trees. The road layer was created to be the ideal “streetscape” for the CS District, including trees and sidewalk improvements recommended in the Borough’s Comprehensive Plan. It gives a really good look at how the landscape can be improved with a few simple changes.



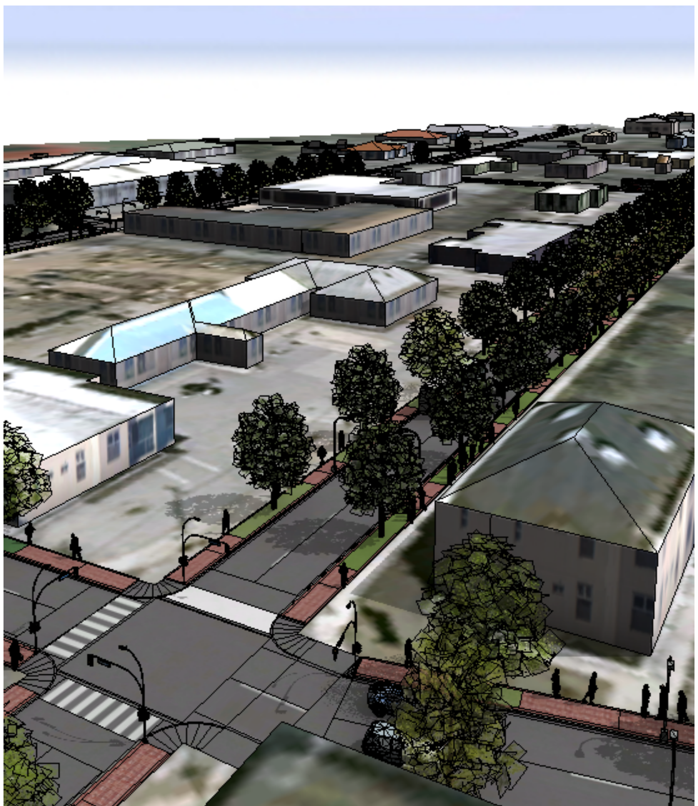
*Zoning*

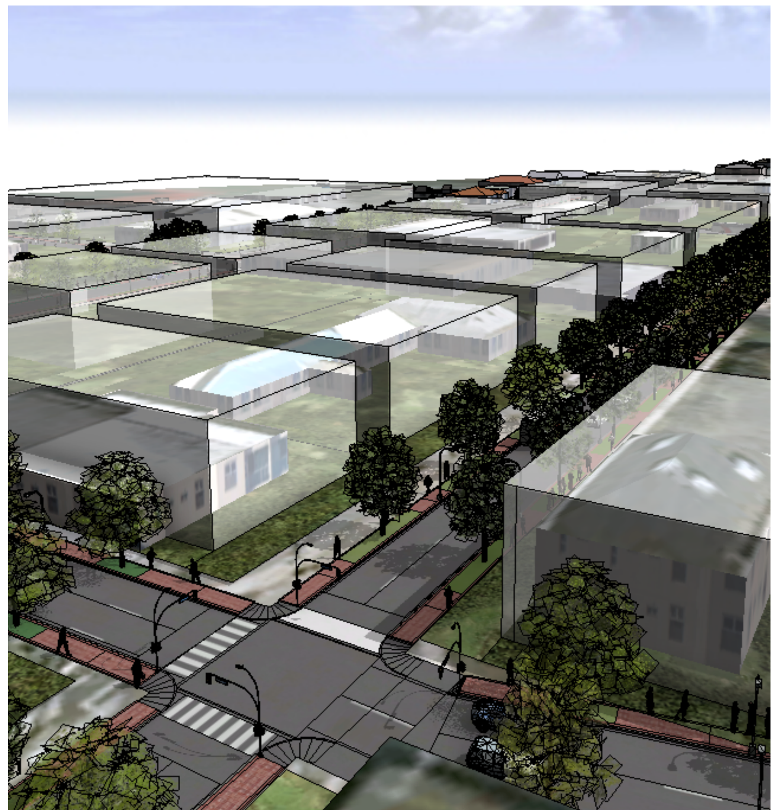
Another feature added into the model was a layer representing the current zoning of the CS District. The zoning layer was created using the parcel layer of the CS District. The “Max Extent of Possible Development” layer uses the Parcel.cga rule, which was created to show the “envelope” of zoning extents within parcels. It was edited to include the current max and min extents of setbacks and height limitations.

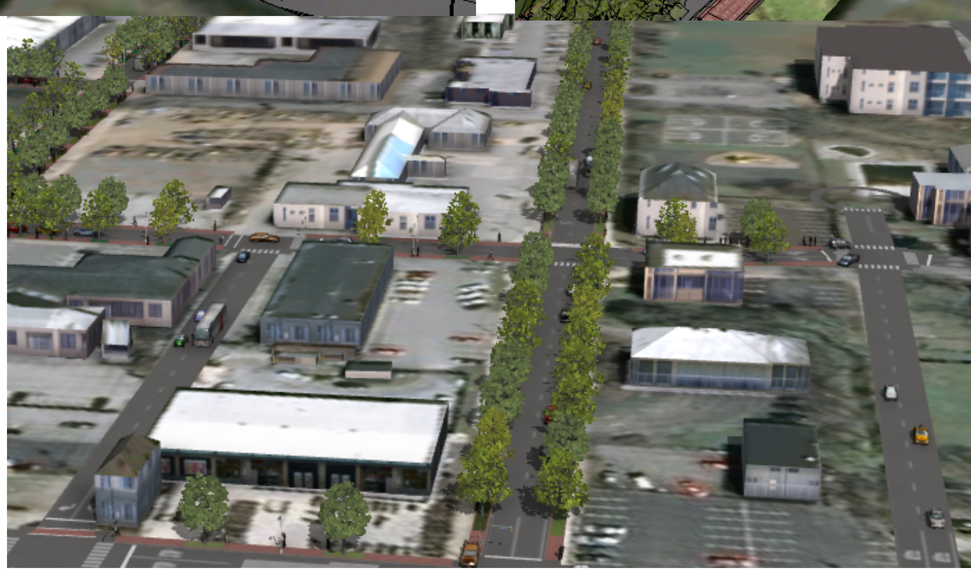


*Final Export*

The final model in the CityEngine interface can be seen below. In addition to having the model available using the software, the model was also exported to a CityEngine WebScene, where it can be viewed by stakeholders as well as commented on by the general public. This allows for greater collaboration and transparency.







## DISCUSSION AND CONCLUSION

The results of the completed model were basic but comprehensive. The model effectively visualizes what current exists, along with the possibility of what could be developed. It also created a tool for many major discussion points for township officials and the public, providing a starting point for future redevelopment and imagining the possibilities of the CS District. The surrounding area and current infrastructure provides context to the CS District and what could and couldn't fit within the borough. Together, the three main layers of buildings, streets, and zoning work to show the potential of the current zoning ordinance, and serve as a jumping off point to develop and work with new ideas.

Some limitations to the project involve the development of the zoning rules. Editing and creating rules requires a strong background in programming, while learning an entirely new language. It is difficult to produce new rules from scratch. New rules were experimented with in the model, but ultimately weren't used due to limitations with the robustness of the rule. Rules that were already created could be edited, but required a deep understanding of the rule and the language surrounding the rule. Building up a library of rules would be beneficial to any agency looking to implement 3-D technology. In the end, rules were edited to suit the purpose of the model and project, but it was often a convoluted process to get there.

While they are by nature very complex, 3-D technologies are on the rise in planning commissions and agencies across the world. As the costs of utilizing the technologies are reduced and they become more user-friendly, it is expected that they will become an integral part of the planning process. This research project demonstrates the potential application of 3-D modeling to a current planning exercise in West Chester Borough, and suggests the advantages of the technologies in the local planning process. 3-D technologies can be useful in demonstrating the impacts of zoning ordinances and visualizing development proposals. As a communication tool, they can be effective in engaging the local community in the development planning process. Other uses that are likely to become more prominent in the future include modeling build out scenarios, and modeling land use plans. Local governments need to pay attention to the evolution of these technologies and their potential applications. Incorporating the technology into the planning process can be effective in better communicating the impacts of proposed developments and regulations and thereby better engaging the community in discussions about proposals.

## BIBLIOGRAPHY

*Al-Douri, F.A. (2009). The impact of 3-D modeling function usage on the design content of urban design plans in US cities. Environment and Planning B: Planning and Design 37 (75-98). doi: 10.1068/b35055*

*Eikelboom, T. & Janseen, R. 2015. Comparison of geodesign tools to communicate stakeholder values. Group Decis Negot. 24:1065-1087. DOI: 10.1007/s10726-015-9429-7.*

*Environmental Research Institute, 2016. ESRI CityEngine. http://www.esri.com/software/cityengine*

*Ervin, S. 2011. A system for geodesign. http://www.kolleg.loel.hs-anhalt.de/landschaftsinformatik/fileadmin/user_upload/_temp_/2012/Proceedings/Buhmann_2012_19_Ervin_Keynote_2011.pdf*

*Hanzl, M. 2007. Information technology as a tool for public participation in urban planning: a review of experiments and potentials. Design Studies. 28: 289-307. DOI: 10.1016/j.destud.2007.02.003*

*Ki, J. (2011). Developing a geospatial web-GIS system for landscape and urban planning. International Journal of Digital Earth. 6:6(580-588). http://dx.doi.org/10.1080/17538947.2011.631223*

*Kim, H., Kang, Y., Han, S. (2014). Automatic 3-D city modeling using a digital map and panoramic images from a mobile mapping system. Mathematical Problems in Engineering. Volume 2014. http://dx.doi.org/10.1155/2014/383270*

*Koninger, A. & Bartel, S. (1997). 3D-GIS for urban purposes. GeoInformatica, 2:1 (79-103).*

*U.S. Census Bureau. (2010). Population data. Retrieved from http://www.census.gov/topics/population.html*

**APPENDIX**

## 3-D Workflow

*Setting Up Workspace*

The first thing to do after opening the program is set up the workspace. It is important to note that CityEngine works in meters, and all measurements provided are given in meters. These measurements can be converted into feet by multiplying 0.3048. Understanding how the program works and integrates 2-D from ArcMap is crucial to the development of a successful 3-D model. When CityEngine is installed, it creates a default workspace on the computer's hard drive. When creating a new workspace, the default area on the computer's hard drive can be used, or it can be worked in a new area by switching to a new workspace. After the workspace is defined, a new project is created (File—New--CityEngine Project). Projects are created within the workspace as a new folder, comprised of eight subfolders: Assets, Data, Images, Maps, Models, Rules, Scenes, Scripts. This is where all of the information pertaining to the 3-D model will be created and stored, and all of the data will be stored in the data subfolder. It is within the 2-D subfolder that the 2-D data will be imported.

*2-D Data Preparation*

After the workspace is established, 2-D data in the form of shapefiles or TIFF files gathered from various sources needs to be prepared for use in the 3-D format using the ArcMap program. Desired outcomes of this process are the incorporation of a Property Polygon Feature Class (building footprints and/or parcel boundaries), a Digital Elevation Model (DEM), an Orthophoto, and a Street Line Feature Class into a File Geodatabase.

In ArcMap, import all shapefiles and aerial imagery into the data frame. Because CityEngine usually defaults to the State Plane Coordinate System, make sure all data in ArcMap is set to the local State Plane System. Define the scene's extent by drawing a rectangle from the "Drawing Toolbar". In the "Drawing Toolbar" dropdown menu select "Convert Graphics to Features", and use this new polygon as the Study Area boundary and clipping extent for all feature classes to be exported as. Save all vector files as part of the File Geodatabase specific to the project. DEM rasters and Aerial Imagery will be saved outside of the geodatabase and should be imported into the CityEngine project folder of "Maps". DEMs and aerial imagery should be saved in the TIFF files format.

*3-D Data Import*

Once the 2-D data has been prepared and imported into a File Geodatabase, CityEngine can be opened again. Once CityEngine is open, create a new "Scene" by going to File, New, CityEngine Scene. The first step in importing data is to bring in the terrain. This is done by dragging and dropping the DEM and Aerial image into the "maps" folder. Once they are there, they can be dragged and dropped in the scene/data view. A new menu will appear, and the Heightmap File will be defined as the prepared DEM while the texture file is the Aerial image. This provides a basemap to work with to create 3-D city models. Once the terrain is imported, the geodatabase created can also be imported by right clicking on the data folder and clicking "import geodatabase". The data layers will appear in the "Scene" menu in the bottom left corner of the viewfinder. After the data layers are imported into the CityEngine scene, they are no longer independent data files from GIS. All data alteration done in CityEngine will not impact the original data source, and any alterations done outside of CityEngine will not affect the data inside the project folder. It can be noted that all line data imported into CityEngine becomes a “graph network” and all polygon data become a “shape layer”.

Once the data is imported into the CityEngine scene, it is most likely project to sea level, with the terrain hovering above it. In order to fix this, right click on the graph network layer and select objects. This will select all of the lines data within the graph network. Navigate to the top menu Graph, and click “Align Graph to Terrain”. In the pop-up, select “Project All” for Align Function and the terrain layer for height map. The process to get all of the shape layers aligned to the terrain is similar: right click on the shape later and select all objects. Right click on the same layer and select the “Align Shapes to Terrain” function, using the same input for project all and height map.

*Creating Roads*

Once the line network of roads was imported, roads may be automatically generated in the scene. These roads are created using a series of grey rectangles of varying sizes. The large inner rectangles close to the central part of the line represent traffic lanes, and small outer rectangles represent sidewalks. To clean this up, find a rule file most appropriate to generate roads in an area, such as the Complete Streets rule available online through ArcGIS. Once the rule is downloaded to the rule folder, select all of the streets in the graph network and drag and drop the rule file onto the selected features. To eliminate cul-de-sacs at road ends re-select the entire network and under “Intersection Parameters”, change the “type” to “Junction” or “Crossing” using the rule file. Once a rule file is brought in, there will be dozens of attributes will appear under the “Rules” section, allowing for countless modifications. Basic options such as lane and sidewalk width will always appear under the “Shape Parameters” section at the very top of the layer attribute.

Creating Buildings

The shape layers that are in the scene will originally be represented by a flat, grey polygon on the surface of the terrain. In order to extrude these layers into a building format, a rule file must be applied. This can be done by using rule files available in the example tutorials, or written. Rule files applied to polygons may be specifically written for different types of polygons, such as a building footprint or parcel. Similarly to adding a rule file to a graph network, the polygon or polygons that will have the rule file be applied should be selected then the rule file can be dragged and dropped on top of the selected features. After finding a rule file most appropriate to generate buildings in the scene, drag the rule onto the selected shapes. Most rule files will ask which "start rule" to select, the options usually being "Parcel"/"Lot" or "Footprint", which specifies which type of polygon is being used. A Parcel/Lot rule will usually generate a building in a portion of the area and surrounds the remaining area with open space. A footprint start rule will usually generate a building that will fill the entire shape extent. Downloaded rules usually give dozens of customization options to model the buildings in the scene.

*Exporting to WebScene*

A critical step in the CityEngine process is to share the 3-D model with stakeholders in a plan or development. One way to do this is by exporting the scene created in the CityEngine interface to the Web, where it can be worked into a user-friendly application for distribution amongst stakeholders. There are several strategies that can be used to streamline the user experience in exporting the CityEngine scene. The final scene in CityEngine should have a few clickable layers as possible, which can be done by merging layers together. Since the layers exist only in the scene file, it would be ideal to create a backup scene with all layers in the final editable state that are available to import if something goes wrong. Static model layers and shapes layers cannot be merged into one. Static models can be selected and converted into shapes, but texture will be lost on these models. Roads can be in the same layer as buildings, but the graph network should be selected first then converted to a static shape. Errors are frequent with this process, and it is crucial to maintain backups of all scenes.