Plan for Capacity Building Using 3-D Modeling & Planning Decision Support Systems

Volume 1: Report

For Prince George's County Planning Department

Submitted by: The Environmental Simulation Center (October 18, 2010)

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VOLUME ONE: REPORT

PLAN FOR CAPACITY BUILDING USING 3D MODELING & PLANNING DECISION SUPPORT SYSTEMS

for the
Prince George's County Planning Department
on behalf of
The Maryland-National Capital Park and Planning Commission

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Table of Contents

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1.0 Executive Summary

The Maryland-National Capital Park and Planning Commission (M-NCPPC), recognizing the value of 3D modeling and Planning Decision Support Tools as well as the challenges involved with implementing these tools, issued an RFP for a "**Plan for Capacity Building Using 3D & Modeling Applications**" for the Prince George's County Planning Department. The RFP stipulated that the Plan included an in-depth needs assessment of the Department, an evaluation of available tools, and a survey documenting the use of 3D modeling and PDSS tools by other planning departments across the nation. The Environmental Simulation Center (ESC) – a not-for-profit that specializes in the application of digital tools to the planning process, assisted by Rhodeside Harwell – a multidisciplinary planning firm in the Washington DC region, were selected as the Consultant Team.

The Consultant Team provided a scope of work that responded to the requirements RFP and kicked off the project at the end of September 2009. Although this project started with a focus on matching 3D modeling and Planning Decision Support Systems (PDSS) to the Client's needs and making training recommendations, early research and interviews with other agencies indicated that **the far bigger challenges in tool adoption were institutional in nature**. Indeed, as there are many tools that can be applied to many planning activities, and that set of tools is constantly changing, "building capacity" requires addressing the structure and culture of the organization in terms of how the technology is managed and decisions-made about the allocation of resources. Therefore, our most important recommendations are those that concern building an institutional framework to support capacity-building and decision-making – not only for the tools we recommend, and other technologies, but staffing and the development of applications which would best advance the goals and projects of the Planning Department.

1.1 The Challenges

Skills

Planners now have access to a bewildering number of tools that can enhance almost every aspect of the planning process – from public outreach to complex forecasting models. It is safe to say that there are far more tools available to any planner – in any specialty area – than they can possibly learn, so planners must choose carefully. Naturally, the tools that are easiest to learn and provide the "most bang for the buck" will be the first tools adopted. Spreadsheet and presentation tools, like Microsoft Excel, Word, and PowerPoint, are tools that are relatively easy to learn, and make planners' jobs easier; therefore, they have been adopted to the point where they almost universally used by most planners.

And while working with numbers, writing reports, and making presentations are critical parts of a planner's job, planning also has spatial and design components. Therefore CAD (Computer-Aided Drafting/Design), GIS (Geographic Information Systems), and 3D modeling tools should also be part of a planner's toolbox. In addition, many of these core technologies (GIS. spreadsheets, 3D modeling, and presentation tools) have been combined to create a new class of tools: Planning Decision Support Systems (PDSS). Yet very few planners actually know how to use these tools themselves. This is most likely because these tools are more complex than word processors or spreadsheets, and – especially with GIS -- have their own concepts and vocabularies.

In our survey and interview of the Prince George's County Planning Department staff, we found that – although all the staff interviewed reported using GIS on a daily or weekly basis – their use was mostly confined simple queries and map display via PGAtlas. Less than half of the staff interviewed reported GIS skills at a level where they could effectively define the data and parameters of a Planning Decision Support System. Only 20% of the staff interviewed had the skills necessary to actually set up a PDSS – loading data and building formulas. It's not that PDSSs are excessively complex, but they do require an understanding of the GIS than goes beyond simple map queries and layer manipulation.

For 3D modeling, only one-third of the staff interviewed reported having used software to create 3D visual simulations. Of those, *all* reported using SketchUp and only a few reported using other software. Very few planners said they had the necessary skills, the time to learn those skills, or occasions to use those skills often enough so that they "stick".

Education

We found that few planning schools have required GIS or 3D as part of their core curriculum or even offer it as an elective taught by the department although that is beginning to change. The ESC investigated the curricula of the top 25 planning schools in the United States and only three required a GIS course as part of the core curriculum. This finding was confirmed by a recently published survey of public planning agencies in Wisconsin (hereto after referred to as "the Wisconsin Study") about "The barriers to GIS Use in Planning".[1] (see Appendix B) That study found that only 10% of U.S. planning departments have GIS-related job requirements, and only two departments require courses that focus on advanced GIS capabilities for planning-related applications.

Specialization

Given the complexity of the tools, it is not surprising that most planners and planning departments delegate GIS and 3D modeling to "specialists". Those specialists typically come from a geography or surveying background and the design professions, which makes sense because like CAD and 3D are "primary" technologies for architects, GIS is a "primary" technology for geographers. The problem is most CAD and/or GIS specialists have very little if any training in planning. Conversely, most planners have very little if any training in GIS or CAD.

Communication

There is a divide between GIS Professionals and Planners/Designers – both in terms of how these groups are organized within the agency structure and how they perceive particular tools and planning activities. Our own survey and interviews of other planning agencies – as well as the Wisconsin study – bear out that there are general, chronic communication problems between planners and GIS technicians everywhere. The aforementioned lack of training, coupled with specialization and a lack communication between domains results in planners not understanding the analytical potential for GIS and PDSS's.

Finding the right tools for the job

Many agencies struggle with rapidly changing technology and the challenge that presents to selecting the "right" tool for the job in the first place, as well as managing expectations about its use. Sometimes,

[1] Journal of the American Planning Association by Z. Asligul Gocmen and Stephen J. Ventura

agencies may acquire a tool that ultimately proves too complex to use without significant investments in training. Or they make significant investments in training but the tool quickly becomes obsolete. Agencies may also use tools in ways they were never intended to be used. Unfortunately, there is no one planning tool that does everything well. And while many 3D modeling and Planning Decision Support Tools have similar basic functionality, some tools support certain planning activities much better than others.

Lack of institutionalized skill

Developing a decision-making framework for adopting tools, developing applications, and hiring and/or training current and future staff is critical if an agency is to successfully adapt the existing institutional culture to using the IT tools. Significant capacity building is required at the front end of tool adoption, and agencies need an initial project to learn how to use the tool. It is just not possible to pick up a new tool and change business practices overnight.

When an agency acquires a new tool, particular staff members gravitate to it, but ultimately the use of the tool is never institutionalized due to lack of specialized skills, skill loss as the result of staff turnover, and most importantly – lack of a strategy to build capacity. Lack of institutionalized skills, either because tools were too complex and/or not enough resources were devoted to training, or by the failure of the agency to retain those skills as part of their "institutional knowledge", is a major factor impeding the successful use of these tools by agencies.

1.2 Recommendations for Building Capacity

The major recommendations of this study seek to address some of the most significant questions that emerge from the aforementioned challenges: how does the Prince George's County Planning Department build capacity and institutionalize the use of tools that are constantly changing? And how can the Department keep pace with technology in order to be able to choose the "right" tools and apply them successfully?

1.2.1 Institutionalizing Technology

Institutionalization of technology can be defined as the extent to which technology is integrated into the culture and practice of an agency, rather than being viewed as an add-on program, and the extent to which agency staff take ownership of the technology and its use. In order for 3D Visual Simulation and Planning Decision Support Tools to become institutionalized in the Planning Department, the Planning Department will need to devote the appropriate resources to use and manage the tools effectively in support of their planning activities.

Tools can get institutionalized by agencies in different ways to different extents:

- **Tool use can be assigned to a group of specialists**: An agency designates that specialists or a group of specialists use the tools. In a public agency, this means that official positions and/or entire departments are created specifically around the use of the tool. This is expensive and, with the increasingly rapid pace of technological adoption and change, becoming impractical because

job descriptions and entire departments can become superfluous or obsolete within a relatively short period of time.

- **Tool training can be voluntary/mandatory and application-specific**: Mandates or strong incentives are in place to ensure that all staff, not just technology enthusiasts, receive appropriate training in the use of tools. But, training alone is not enough. The staff need to understand how the tools can be applied to their work see the benefit of using the tools in their day-today work.
- **Tool training *and use* is mandatory and application-specific**: The agency has to have a process in place to make sure all staff are able to use the tool at a certain level of proficiency. (For example, an investment bank may only hire clerical staff who pass an assessment on basic Excel operational Skills, and then provide their own training on Excel applications specific for the financial industry, including the bank's own custom applications.)
- **Tool use is common, and training is primarily peer-to-peer**: A large number of people know how to use the tools and find them helpful. Staff turnover is no problem because the use of the tool is ubiquitous in their industry. Most people already know how to use the tool or a tool like it, and those that don't learn from their co-workers. (CAD for Architects, Spreadsheets for Accountants, Word Processing for just about everyone.)

Ideally, GIS for planners and 3D for urban designers will someday become as ubiquitous as CAD is for architects. This is an ambitious and worthy goal, so in the mean time, the recommendations and strategies to implement them outlined below borrow from all four of the paths to tool institutionalization described above: there is mandatory training for some and voluntary training for others -- but all training is application-specific. There are specialists, but their job is to train staff who, in turn, train their peers.

We strongly recommend that all staff who are interested should have the opportunity to learn the tools to whatever level of expertise they desire. Not everyone needs the same level of training on the tools; but all staff should be at least conversant on the tools, and managers need to understand the tools well enough so that they know when and where the tools might be useful, and what is involved in using the tools so they can manage staff and expectations effectively.

1.2.2 Recommendations to Institutionalize the Tool Selection, Implementation, Application, and Capacity-Building Process

In addition to building a strong institutional framework that supports the cultivation of internal staff capacity to use the tools effectively, these recommendations include steps to institutionalize the tool selection and evaluation process itself. This will provide the Planning Department with an on-going decision-making process to keep pace with technological change so that decision-makers are provided with the information they need to make wise choices about where and how to apply the tools and manage resources accordingly.

1. **Form an Executive Committee for Tools –** The Executive Committee should consist of a small group of management-level decision makers with one representative from each Division in the Planning Department as well as the Parks Planning and Development Division from the Department of Parks and Recreation. Their primary responsibility would be to make recommendations regarding tool selection, implementation, and applications development to the Planning Director or another senior planner appointed by the Planning Director.

The proposed Executive Committee would select which tools to implement based on their potential to improve workflow and planning outcomes, identify all the projects in the Department where applications of the selected tools would beneficial, select the projects that would make appropriate pilots for tool development and implementation, and assign staff to one or more "Ad Hoc" Teams for tool application development under the leadership of the Technical Leads described below. In the future they may also create new types of ad hoc teams related to tools and capacity building like tool post-implementation review, needs assessment, etc.

The Executive Committee would meet at key points in the decision-making process. Once the Ad Hoc Teams are assembled and developing applications, the Executive Committee would probably meet on a regular basis to review their work and track the progress of pilot projects.

2. **Designate or hire Technical Leads** – The Technical Leads are a critical component in the proposed strategy to implement IT tools in the day-to-day planning functions of the Department. They would provide 3D visual simulation and decision support tool expertise and advice to the Executive Committee and the entire Planning Department. They should be either new full-time positions (recommended), or a combination of a new position and existing staff. They would be responsible for researching, demonstrating, and recommending new tools as well as performing any tool-related needs assessments or feasibility studies deemed necessary by the Executive Committee (the role of the ESC in this project). The Technical Leads would also be responsible for implementing, developing curriculum, and providing in-house training on the tools ultimately selected by the Executive Committee and staff. They would also lead the small "ad hoc" teams of 3-5 staff in implementing tools, developing applications of the tools, and evaluating them.

   The Technical Leads would be responsible to the Executive Committee and be able to work on multiple projects in different planning divisions. Two staff are recommended for redundancy, and each one should have strong working knowledge of the all tools selected by the Planning Department (most likely ArcGIS and recommended extensions, CommunityViz, and SketchUp), since many of those tools work together. However, we recommend one or the other or both of the Technical Leads have expertise in and take *primary* responsibility for *one* of each of the following:

   - *3D/Urban Design Technical Lead* – This person is a planner who provides expertise in using SketchUp and AutoCAD/3D Max for planning and urban design applications as well as strong working knowledge of GIS and 3D GIS. Real-time modeling and/or Planning Decision Support Tools experience a plus.

   - *Planning Decision Support Tools 3D/GIS Technical Lead* – This person is a planner who provides expertise in using Planning Decision Support Tools (CommunityViz®) and GIS (ArcGIS) for planning and urban design applications, and has strong working knowledge of SketchUp as well. AutoCAD/3D Max and/or real-time modeling experience a plus.

3. **Implement Tools** that support the Planning Department's needs and are scale-able and adaptable to many different users with many different skill levels:

- Implement **SketchUp** as the primary 3D modeling tool for the Planning Department. It is relatively easy to learn compared with most other 3D modeling programs. It is very quick for simple massing models but can also create photo-real textured models that can be viewed in the application itself, in other real-time environments like Google Earth and ArcGIS Explorer, or in a 3D GIS like ArcGIS ArcScene or CommunityViz® Scenario 3D.

- Implement **CommunityViz®** as the primary Decision Support Tool for the Planning Department. It has "wizards" that walk planners through some of the most common planning applications, such as the use of indicators and performance measures, but can be used for many other kinds of GIS data analysis, from simple tabular summaries to large models with complex formulas with multiple variables, spatial operators, conditional statements, etc.

4. **Train staff on the selected tools before deciding where and how to apply the tools**. – The Executive Committee and all staff that are expected to use the tools or manage other staff who are expected to use the tools should undergo basic training on the tools so as to better understand where and how the tools may be applied.

   As much as possible, the Technical Leads should develop the curriculum and lead staff training **in-house**, so that as many staff that wish to learn the tools have the opportunity to do so. Another reason that Technical Leads should provide staff training is that through the training process, the Leads will begin to identify staff who have an aptitude and/or enthusiasm for the tools and who would be good candidates to start building a pool of staff from which future Ad Hoc Teams (see below) will be created for developing applications of the tools.

   Prior to developing applications of the tools, the Technical Leads would provide in-depth tool training to staff working on the pilot project(s), as well as any other staff who are interested and might be using the tools.

5. **Find appropriate applications and pilot project(s)** – To identify potential applications of the tools within the Planning Department and evaluate them for their suitability as pilot projects for tool implementation and application development, the Executive Committee and Technical Leads would examine all of the Department's current projects and methodologies, what projects and issues they anticipate over the next few years, and what applications and data will be used most frequently. In particular, they should identify the tasks that they do repeatedly, and which would benefit from doing them in a systemic way that builds institutional capacity (e.g. knowledge capture).

6. **Assemble Ad Hoc Teams that will develop applications of the tools** –Based on the selected pilot applications and tools, the Executive Committee and Technical Leads will determine the skills that are required to implement them, the division(s) that would be using the pilot applications, and the division(s) that will likely utilize the application in the future. The Executive Committee with the assistance of the Technical Leads will then assign staff to **Ad Hoc Teams** for tool application development on each pilot project.

   The **Ad Hoc Teams** are small teams of 3 to 5 staff members that are drawn from a pool of qualified staff from existing Planning Divisions including IMD and Parks Planning and Development, and

lead by either the **3D/Urban Design Technical Lead** and/or the **Planning Decision Support Tools 3D/GIS Technical Lead**. There should be a least one team member from the Division where the pilot project is being executed, and at least one team member from Divisions that aren't hosting the pilot project but are interested in or plan on using the tool in the future.

The concept behind the **Ad Hoc Teams** is that, by mixing staff with different skill levels and areas of expertise – whether they are more technical in nature or more planning process oriented – opportunities for peer-to-peer learning and institutional knowledge capture are optimized:

- Less technically skilled staff would learn from the Technical Leads;
- The Technical Leads, working directly with the staff, would gain knowledge and insight that they would not otherwise have had about the how the planning applications are used;
- The staff on the team would gain the knowledge and proficiency that can only be obtained through "learning by doing"; and
- The staff from the Ad Hoc Teams would return to their divisions to demonstrate and train their colleagues with focused tutorials utilizing real applications of the tools that they built

Each Division should designate at least one of their most creative, forward-thinking, technically-capable staff planners in **3D/Urban Design** and one of their most creative, forward-thinking, technically capable planners in **GIS/Planning Decision Support Tools** to be available to serve on Ad Hoc Teams and serve as the Division's "point person" on the tools. However, any staff that have the desire to participate in the development and applications of the tools should be considered. These staff will comprise the "pool" that can be drawn from by the Executive Committee to create the Ad Hoc Teams lead by the Technical Leads to the Executive Committee to implement tools and develop applications of the tools. As these staff get training and experience though implementing and applying the tools, they will become, in effect, the "Technical Leads" to their own Divisions in the future.

The pool of staff available for the Ad Hoc Teams should be comprised of planning and urban design staff who have an affinity or desire to build technical capacity within the Department and their respective Divisions, have demonstrated that they can think creatively and analytically, and have completed in-house training on the tools, and have demonstrated an aptitude for using the tools.

7. **Develop applications of the tools in-house** – Under the supervision of the Team's Technical Lead, the Team staff develops a project plan, builds the application, tests the application and makes corrections if necessary, documents the process, and produces a user manual or knowledge-based memorandum to build "institutional knowledge." They would present their findings to the Executive Committee and/or the entire planning department on a periodic basis.

8. **Monitor and evaluate the effectiveness of the tools** – After the tools are implemented, the Executive Committee and Technical Leads would also devise methods and procedures for monitoring and evaluating the effectiveness of each tool. This would largely be the responsibility of the 3D Visual Simulation Technical Lead and Planning Decision Support Tools 3D/GIS Technical Lead. If the tools are not performing as expected, the Executive Committee could reconvene the Ad Hoc Team or assign a new team to investigate why and make recommendations for changes needed

– either to the process or the tool itself in order to remedy any problems identified or implement improvements.

The aforementioned recommendations are purposely designed to be flexible, scalable, adaptable, and repeatable. Each recommendation builds incrementally on the previous recommendation. There might be only one or two pilot projects and Ad Hoc Teams rather than more. Eventually there might be four or five application development projects going on at once, not only for 3D modeling and Planning Decision Support, but for other new technologies like digital project collaboration, public outreach via social networking, mobile technologies, etc. In all cases the Consultant Team recommends that targets be established to evaluate how well these strategies and their implementation are working.

1.2.3 Additional Recommendations

1. **Provide tools and data "prepackaged" in ways that are useful to planners** – 3D Modeling and Decision Support/GIS capacity can be increased department-wide by the pre-packaging of tools and data in ways that will be both attractive and understandable for planners to use. PGAtlas provides good example of this: by making data and tools easily accessible to planners, this tool has proven to be indispensible for the Planning Staff.

2. **Encourage the Analytical Use of 3D and GIS** – The Wisconsin study found, as well as this study, that planners rarely take advantage of the analytical capabilities of GIS. That study concluded, and we concur, that the issue is less a problem of technical capacity than one of a lack of knowledge about how GIS can be applied to planning situations. We would add that planners rarely take advantage of the analytical use of 3D modeling and visual simulation in planning. The best way for planners to gain 3D modeling and GIS knowledge is to see first-hand how 3D modeling and visual simulation and GIS can be used analytically for planning applications and implementing 3D Modeling and Planning Decision Support Tools would reinforce this.

3. **Revise job descriptions to include more specific GIS and/or 3D modeling and urban design skills as a desired skill** – To assess the current "state of practice" concerning skills requirements for planners (and GIS personnel), and to look for possible models for job descriptions that incorporate skills in 3D modeling, GIS, and PDSSs, the Environmental Simulation Center researched other agencies that are similar to size to the Prince George's County Planning Department and are known to use 3D, GIS, and/or PDSS tools. We found only a few job descriptions for planners that had any reference to GIS, and most of those were only cursory. In fact, Prince George's County Planning Department is one of the few that explicitly mentions GIS, and for that the Department should be commended. None of the agencies we looked at mentioned or required that planners or GIS staff have skills with 3D modeling or PDSS tools.

   In no cases did we find job descriptions for GIS positions that require planning skills or knowledge of planning concepts. In fact, the "divide" between planning professionals and GIS professionals seems to be reinforced by the way planning agencies approach building capacity in those skills: Rather than look for planners with skills in GIS, GIS is identified as an entirely separate activity requiring specialists and most often separate departments. 3D modeling, where it happens at all, tends to similarly get assigned to specialists.

It is clear that the Prince George's County Planning Department has an opportunity to be a thought leader in breaking down this particular barrier to integrating GIS (and 3D) in planning by requiring cross-domain skills for all staff. In fact, as planners become more skilled in GIS, there should be a reduced need for GIS "specialists". And because GIS skills include making cartographic maps for different purposes, including publication, the need for Publications Specialists may also go down. As mentioned in the previous section, 3D/GIS/PDSSs for planners should be thought of in the same way CAD/BIM is thought of for architects: **as a tool not a specialty**.

4. **Work with local planning schools and advocate for the inclusion of 3D and GIS as part of core planning curricula** – The Prince George's County Planning Department could be more proactive in shaping the future job applicant pool to better serve the needs of the Department by sharing its experiences with local planning schools and advocating for 3D and GIS as part of the core curricula required for planners.

5. **Encourage Collaboration through Mutual Education and Support** – Planners and the GIS specialists will need to engage in a mutual education process. A good model of this is the relationship that architects typically have with clients. It is part of the architect's job to educate the client about what is possible and what is not, and the client needs to articulate as clearly and completely as possible how they want their building to perform and look. Planners and GIS specialists need to be versed enough in what they are looking at to assess the data for fitness of purpose. In other words, planners **and GIS specialists need to be better "clients" for each other**.

   In public agencies, which are typically under-staffed and where there are very specific job descriptions and duties, it can be very difficult for planning professionals and GIS professionals to find the time that it takes to learn about each other's work and collaborate on projects. This is time that needs to be planned for and included in the day-to-day operations of the Department. But given limited resources, it needs to be targeted to where it will do the most good and have the greatest positive impact on planning outcomes.

   The Planning Department should explore ways to incentivize learning and communication. The Prince George's County Planning Department already has many talented professionals on staff who are very good at what they do. Those staff, who are really good at a particular task and/or have expertise in a particular domain, could be recognized and – possibly as a "reward" for a job well-done or as part of their job responsibilities – be given time to write white papers or internal knowledgebase articles, or participate on an Ad Hoc Application Development Team. They could also be given time to mentor other staff who are interested in learning more about their area of expertise. The goal should be to educate the "apprentice" to eventually become a "master" themselves. **Resources normally allocated to "outside" training should be allocated for this "internal" training and capacity-building.**

1.3 Conclusion

The biggest challenges that Planning agencies face with building technical capacity are implementation-related: picking a tool that is too complicated or the wrong tool for the job, not enough resources devoted to capacity building at the front end of tool adoption, and the lack of institutionalized skill. The aforementioned recommendations and strategies to implement them, therefore, are strongly oriented towards creating a framework that supports building institutional knowledge just as much as building applications of tools. Although implementing these recommendations may require new investment and/or reallocation of existing resources, we believe that they could ultimately conserve the Department's resources through the more efficient and flexible allocation of staff time and expertise. Furthermore, by building and retaining technical capacity in house, the need to hire outside consultants would be reduced and most importantly these recommendations should enhance the quality of the plans created, the process of creating those plans, and the future livability of Prince George's County.

2.0 Overview

2.1 Background

Planning technology and practice is always evolving, and with the advent of personal computers in the 1980's and the internet in the 1990's, the pace of change has only increased. Planners now have access to a bewildering number of tools that can enhance almost every aspect of the planning process – from public outreach to complex forecasting models. But in order to take advantage of these tools, planners need to invest time into learning them. It is safe to say that there are far more tools available to any planner – in any specialty area – than they can possibly learn, so planners must choose carefully. Naturally, the tools that are easiest to learn and provide the "most bang for the buck" will be the first tools adopted. Spreadsheet and presentation tools, like Microsoft Excel, Word, and PowerPoint, are tools that are relatively easy to learn, and make planners' jobs easier; therefore, they have been adopted to the point where they almost universally used by most planners.

And while working with numbers, writing reports, and making presentations are critical parts of a planner's job, planning also has spatial and design components. Therefore CAD (Computer-Aided Drafting/Design), GIS (Geographic Information Systems, and 3D modeling tools should also be part of a planner's toolbox. In addition, many of these core technologies (GIS, spreadsheets, 3D modeling, and presentation tools) have been combined to create a new class of tools: Planning Decision Support Systems (PDSS). Yet very few planners actually know how to use these tools themselves. This is most likely because these tools are more complex than word processors or spreadsheets, and – especially with GIS -- have their own concepts and vocabularies.

It is not surprising therefore that most planners and planning departments delegate GIS and 3D modeling to "specialists". Those specialists typically come from a geography or surveying background, which makes sense because like CAD and 3D are "primary" technologies for architects, GIS is a "primary" technology for geographers. The problem is, most CAD and/or GIS specialists have very little if any training in planning. Conversely, most planners have very little if any training in GIS or CAD. This study – and others – bear out that there are general, chronic communication problems between planners and GIS technicians everywhere and it is a huge impediment to the use of GIS in planning. Planning Decision Support

Systems actually force the issue: they have great potential to enhance the planning process, but because most require a basic understanding of GIS AND planning, and some require 3D modeling skills as well, very few planning departments find that they have the capacity to use them.

The Maryland-National Capital Park and Planning Commission (M-NCPPC) recognizes the value of 3D modeling and Planning Decision Support Tools as well as the aforementioned challenges involved with implementing these tools and issued an RFP for a "Plan for Capacity Building Using 3D & Modeling Applications" for the Prince George's County Planning Department. In addition to the Plan for Capacity Building, the RFP required that the consultant performed an in-depth needs assessment of the Department, an evaluation of available tools, and a survey documenting the use of 3D modeling and PDSS tools by other planning departments across the nation. In the summer of 2009 the M-NPCPPC retained the Environmental Simulation Center, a not-for-profit that specializes in the application of digital tools to the planning process, to begin work on the plan. The ESC was assisted by Rhodeside Harwell, a multidisciplinary planning firm in the Washington DC region that had worked with the Department on numerous projects and was familiar with the for the Prince George's County Planning Department's structure and work programs.

2.2 Methodology

2.2.1 Task 1: Project Kickoff

The Consultant Team kicked off the project by meeting with representatives from the Information Management Division, the two Community Planning Divisions (North and South), Countywide Planning Division, and Development Review Division. Even though it is not technically part of the Planning Department, representatives from the Parks Department were included as well because they often work closely with planners and can also potentially benefit from the use of 3D modeling and PDSS tools. The purpose of the meeting was not only to introduce the attendees to the consultant team and to outline the work program, but to present an introductory demonstration of the application of 3D modeling and PDSS tools in planning, urban design, and development review processes. The Consultant Team thought that this was important because many planners were not familiar with the state of the art and a brief introduction to the tools and concepts would prepare them for up-coming surveys and interviews.

2.2.2 Task 2: National Survey of Planning Agencies

The purpose of this study was to understand how planning agencies are currently applying available 3D modeling and decision support technology to the planning and project review process. The study consisted of two components: (1) an initial online survey of tools used by planning agencies in the United States and other countries and (2) in-depth interviews with key staff from ten agencies. (see Chapter 3) The information collected from survey responses and agency interviews subsequently informed later phases of this project, including an evaluation of available 3D modeling and Planning Decision Support Tools and final recommendations to The Maryland-National Capital Park and Planning Commission (M-NCPPC) on strategies for building the Commission's capacity with regard to these tools.

2.2.3 Task 3: Tools Evaluation

To assist the Commission with selecting tools that would be most beneficial to their work program, the consultant team researched commercially available and open-source 3D modeling and decision support tools and evaluated twenty for their potential benefits in 10 different planning activities or "use cases". This involved creating a list of all known available tools, developing criteria for narrowing

down the list, defining the planning activities, and evaluating the tools against the planning activities. (see Chapter 4)

2.2.4 Task 4: Needs Assessment

The consultant team approached this task as one of dialogue and mutual learning. This task not only helped the Consulting Team better understand and appreciate the staff's work program, but also gave the Commission staff the opportunity to learn about the capabilities digital 3D modeling and decision support tools and their capacity to enhance their current activities and practices.

The Needs Assessment was broken into three main phases:

- **Interview preparation**, which included background research and a pre-interview survey;
- **Face-to-face interviews**, which occurred over the course of a week; and
- **Post-interview findings and evaluation**, in which the survey and interviews were summarized and important themes highlighted.

(see Chapter 5)

2.2.5 Task 4.5: Recommendations

Originally, the recommendations for tools and implementation strategies were going to be addressed together and comprise one chapter. However, the results from the National Survey and the interviews of the Commission Staff made it clear that building institutional capacity was a major factor in the success of tool adoption and there needed to be a strategy for building institutional capacity that was independent of any specific tools. To emphasize this we divided the chapter into two: recommendations for tools (Chapter 6), and recommendations for building capacity (Chapter 7).

The Tool Recommendations were based on the following factors:

- The current and anticipated planning activities that the Planning Department engages in, and the 3D visual simulation and/or decision support tools that would best support those activities;
- The needs of the Department as articulated by staff on the survey and interviews;
- The current skills and staffing of the Department;
- The characteristics of the Tools as described in Chapter 3, and their "fit" to the Planning Department's needs and staff skills;

- The experiences of similar agencies with specific tools used for specific planning activities.

The Recommendations for Building Capacity were based on the challenges and lessons learned from other agencies as well as the challenges and needs of the Prince George's County Planning Department.

2.2.6 Task 5: Data, Staffing, Software & Hardware Requirements

The final task involved reviewing the data, staffing, software and hardware requirements. The Consultant Team, with the approval of the Project Coordinator, changed the scope of work somewhat so that it would be more responsive to building institutional capacity to adapt all technologies – not just the specific 3D modeling and Planning Decision Support Systems recommended. Because tool implementation would be application-based, the Commission would need to identify applications before and data requirements could be discerned. Therefore, in addition to a method to select applications (see section 7.1), methods for specifying and evaluating data were provided rather than specific data requirements. (see Chapter 8)

2.2.7 Task 6: Final Recommendations

The consultant team produced an Executive Summary that summarized all the previous tasks in terms of how to most effectively build the Commission's IT capacity with a focus on 3D modeling and Planning Decision Support Systems.

Upon completion of the final report, the consultant team presented the Executive Summary and its final recommendations to the Management Team and department staff.

2.3 Overview: Planning Department Organization and General Responsibilities

The Prince George's County **Planning Department** (the Department) and the **Department of Parks and Recreation** (Parks) are overseen by the Executive Committee of The Maryland-National Capital Park and Planning Commission (M-NCPPC). The Planning Department, which is administered by the **Office of the Planning Director**, has five divisions:

- **The Information Management Division (IMD)**, which is responsible for providing information technology support to the Planning Department. The Information Management Division has three sub-sections:
  - **Geographic Information Services**
  - **Data Systems Section**
  - **Network and Technology Services Section**
- **Two Community Planning (North and South) Divisions (CPND & CPSD)**, which divide the Department's work program by the northern and southern geographic areas of the county. Originally, the Division of Community Planning was only meant to serve administrative purposes. Although the two divisions occasionally share staff and resources, over the years they have become more distinct and tend to work independently of each other. Each Community Planning Division's responsibilities include:
  - **Comprehensive Planning** (sub-region plans, area master plans, small area plans, and development plans)
  - **Specialized Planning Studies** (normally conducted at the request of county government and often lead to a master plan or an amendment to the Zoning Ordinance)
  - **Sectional map amendments** (zoning map amendments and text amendments)
  - **Planning services** (planning assistance to municipalities and communities, and intergovernmental coordination)
  - **Development Review** (technical reports to the Development Review Division concerning the conformance of development proposals with approved master plans)
- **The Countywide Planning Division (CWPD)**, which provides planning services for countywide policies and issues. These include:
  - **Environmental Planning** (green infrastructure, woodland conservation and habitat protection, Environmental Impact Assessment)

  - **Transportation Planning** (County Transportation Plan, travel demand forecasting, traffic studies, etc.)
  - **Historic Preservation**
  - **Research**
  - **Special Projects**
- **The Development Review Division (DRD)**, which is responsible for the regulatory process that defines the form and rate of development, reviewing development proposals for their compliance the land use plans and policies established by the county. The Division is divided into six main sections:
  - **Applications (**provides assistance to citizens seeking information on pending development applications and to those filing zoning, subdivision, and urban design applications.)
  - **Planning Information Services** (informs the public about zoning and subdivision regulations, and master plan proposals)
  - **Permit Review** (site grading, construction and building, land use density and occupancy, signs, administrative nonconforming land uses)
  - **Subdivision Review** (preliminary plans, final plans, right-of-way/easement vacations and reservations, premise addressing)
  - **Urban Design Review** (conceptual and detailed site plans, comprehensive and specific site plans, alternative compliance to the Landscape Manual)
  - **Zoning Review** (zoning map amendments, special exemptions, departures and variance from regulation, non-conforming use permits)

Parks Planning and Development (PPD) is a division of the Department of Parks and Recreation, which is separate from the Planning Department. PPD's responsibilities include making recommendations on park, park facilities and trail development as well as the design and construction of landscape and park facilities.

2.4 Tools Overview

For the purposes of this study, we have identified five categories of tools based on their main functionality:

Terms and Definitions

The Planning, GIS, and 3D modeling professions all have their own jargon. To assist the readers of this document who may not be familiar with these terms, a **Glossary** available in **Appendix A**.

- **Real-time 3D Viewers** – Software applications that create virtual 3D environments that are rendered in "real time," or as events occur. This means the user can freely move anywhere in the 3D environment and observe objects from any perspective, rather than from a pre-recorded path or fly-through. Unlike pre-rendered animations that render a scene one frame at a time (say 1 frame per minute) and then sequence the frames together as a movie (30 frames = 1 second of video), the frames are rendered in "real time" (20-30 frames per second).
- **3D Modeling Tools –** Software applications that enable the user to construct 3D geometries of buildings, structures, and other objects. These tools typically allow the user to apply representations of materials and textures to the geometry faces. Most applications are designed to produce pre-rendered stills or animations, although some offer limited real-time capability.
- **3D GIS Tools** – Software applications that generate and display 3D terrain and/or features (buildings, roads, structures, etc.) from GIS layers and display them in a real-time virtual 3D environment. Because these applications are data-driven, they lend themselves to analysis and can be considered a type of Decision Support Tool.
- **Planning Decision Support Tools** – GIS or GIS-based software applications that support the analysis of planning scenarios and the impacts of potential planning decisions. Any GIS would be considered a decision support tool, since by definition a GIS is data-driven and can be quantified and analyzed. These tools are map-based, but some of them can be extended into 3D parametric modelers/viewers (see above)
- **Miscellaneous and "Helper" Tools** – These software applications either do not fall neatly into any of the proceeding four categories, or are tools that are used in conjunction with other 3D modeling and/or Planning Decision Support Tools for file conversion, content creation, etc.

Although the Commission has identified a number of key software tools that it feels will satisfy most of its needs, 3D and modeling technologies are evolving rapidly, so the consultant team conducted a comprehensive survey to identify the current state-of-the-art. To be sure that we identified the most complete and up-to-date information available in this rapidly evolving field, we:

- Researched existing studies/surveys that may already have been done in this area;
- Utilized our contacts in the APA technology division;
- Utilized our commercial vendor contacts;
- Used the results of Task Two to inform this task

The results identified 44 potential software tools that support 3D modeling and Decision Support, plus 8 more "helper" tools that are sometimes used in support of the others. Although this list is not exhaustive, it includes all of the tools found through our research process.

The following table lists the results of the Software Applications Survey. In addition to categorizing each application, we have included columns for the approximate time that the product has been on the market, and for the estimated user base *relative to the other applications within the same category* on the list. This is meant as a rough approximation for product maturity and up-take. The next column gives the number of agencies from our online national survey who reported that they used the tool (see section 3.1.1 below). The next column over gives the number of agencies that we interviewed in detail that reported using the tool.

The tools that we chose to analyze in detail in Chapter 3 are those that have been on the market long enough to evaluate, have a reasonably large user-base and/or were identified by other planning agencies as tools they've had experience with. Those tools are highlighted in **bold.** There is generally enough direct and/or anecdotal information about these Tools to evaluate them for their utility for specific planning activities (see section 4.1).

Tools Survey

Application	Vendor	Years on Market	Estimated User Base	# of Users from Online Survey	# of Users from Interview	Notes:
Real-time 3D Viewers						
ArcGIS Explorer	**ESRI**	**2-5**	**Medium**	**3**	**1**	
Bing Map 3D	**Microsoft**	**2-5**	**Large**	**4**	**2**	**Formerly known as Virtual Earth**
Google Earth	**Google**	**5-10**	**Large**	**14**	**4**	
Simurban World Simulator	**Simmersion**	**5-10**	**Small**	**1**	**1**	**Need Simurban Environment Editor to build content**
TerraExplorer	**Skyline**	**5-10**	**Medium**	**2**	**2**	**Needs TerraBuilder to create content, TerraGate to serve**
Vega Prime	Presagis	10-20	Small	1	1	Create content with Creator (below)
Vizhen	Winston Associates	0-2	Small	1	1	Custom viewer
3D Modeling Tools						
3DS Max	**Autodesk**	**>20**	**Large**	**7**	**4**	**High-end solid modeler**
3DVia	Microsoft	2-5	Small	0	0	Works with Bing to create custom models
ArchiCAD	**Graphisoft**	**>20**	**Medium**	**0**	**0**	**Building Information Modeling (BIM)**
AutoCAD	**Autodesk**	**>20**	**Large**	**11**	**2**	
Blender	Blender Foundation	10-20	Medium	0	0	Open Source, multi-platform
Bonzai 3D	AutoDesSys	0-2	Small	0	0	New, similar to SketchUp
City Engine	Procedural	0-2	Small	0	0	Generates stylized (not place-specific) 3D models of cities
Creator	Presagis	10-20	Small	1	1	Rarely used by planners anymore
form-Z	AutoDesSys	10-20	Medium	1	1	Solid modeler
Google SketchUp	**Google**	**5-10**	**Large**	**21**	**5**	
Microstation	**Bentley**	**>20**	**Medium**	**0**	**0**	
Revit	Autodesk	10-20	Large	0	0	**Building Information Modeling (BIM)**
Rhino	McNeel	10-20	Medium	0	0	
SketchWorlds	SketchWorlds	0-2	Small	0	0	
TrueSpace	Caligari	>20	Small	0	0	Microsoft acquired in 2008. Makes models for Bing
Vectorworks	**Nemetschek**	**>20**	**Medium**	**0**	**0**	

Tools Survey (cont.)

Application	Vendor	Years on Market	Estimated User Base	# of Users from Online Survey	# of Users from Interview	Notes:
3D GIS Tools						
ArcGIS 3D Analyst	**ESRI**	**10-20**	**Large**	**10**	**4**	**Extension to ArcGIS Desktop**
AutoCAD Map 3D	**Autodesk**	**10-20**	**Medium**	**1**	**1**	
CityScape	PixelActive Inc	2-5	Small	0	0	
CommunityViz Scenario 3D	**Placeways**	**0-2**	**Medium**	**5**	**2**	**Replaces SiteBuilder3D (discontinued)**
Geoweb3d	Geoweb3d Inc.	0-2	Small	0	0	Brand new tool
Simurban Environment Editor	**Simmersion**	**5-10**	**Small**	**1**	**1**	**Assembler rather than a modeler. Does not have functions to interact with GIS files**
TerraBuilder	**Skyline**	**5-10**	**Medium**	**0**	**0**	**Creates content for TerraExplorer**
Planning Decision Support Tools						
ArcGIS Desktop	**ESRI**	**>20**	**Large**	**13**	**4**	
ArcGIS Spatial Analyst	**ESRI**	**10-20**	**Medium**	**0**	**0**	**Extension to ArcGIS Desktop**
CityGreen	American Forests	10-20	Small	0	0	Land-cover based environmental analysis
CommunityViz Scenario 360	**Placeways**	**5-10**	**Medium**	**6**	**2**	**Comes with Scenario 3D**
ENVI 3D	ITT Visual Info Solutions	2-5?	Small	0	0	Raster Analysis Tool
Full Circle	???		Small	1	1	Community asset mapping thru mobile phones
INDEX	**Criterion**	**10-20**	**Medium**	**2**	**2**	
IPlace3s	**CA Energy Commission**	**5-10**	**Small**	**1**	**1**	
MetroQuest	**MetroQuest**	**10-20**	**Small**	**1**	**1**	
ModelBuilder	Fregonese Associates		Small	1	1	
NatureServe Vista	NatureServe	2-5?	Small	0	0	
Return on Investment Model	Fregonese Associates		Small	1	1	
Urban Developer	StrateGis	0-5	Small	0	0	Plug-in to SketchUp
UrbanSim	Open source	10-20	Small	0	0	Forecasting Tool

Tools Survey (cont.)

Application	Vendor	Years on Market	Estimated User Base	# of Users from Online Survey	# of Users from Interview	Notes:
Miscellaneous and Helper Tools						
3D Building Exporter	Pictometry	10-20	Small	0	0	Makes models from oblique ortho-photography
Gimp	Gimp.org	10-20	Medium	0	0	Open source raster Image processing tool
Google 3D Warehouse	Google	2-5	Large	0	0	
LIDAR Analyst	Overwatch Geospatial	?	Small	0	0	Creates 3D models from Lidar point clouds
Photoshop	Adobe	>20	Large	1	1	
PolyTrans	Okino	5-10	Medium	0	0	3D and 2D file conversion tool
Second Life	Linden Lab	5-10	Medium	0	0	Social media
TerraGate	Skyline	5-10	Small	0	0	Serves to TerraExplorer

3.0 National Survey of Planning Departments

Introduction

The purpose of this study was to understand how planning agencies are currently applying available 3D modeling and decision support technology to the planning and project review process. The study consisted of two components: (1) an initial online survey of tools used by planning agencies in the United States and other countries and (2) in-depth interviews with key staff from ten agencies. The information collected from survey responses and agency interviews subsequently informed later phases of this project, including an evaluation of available 3D modeling and Planning Decision Support Tools and final recommendations to The Maryland-National Capital Park and Planning Commission (M-NCPPC) on strategies for building the Commission's capacity with regard to these tools. This chapter documents the results and findings of both the online survey and agency interviews.

3.1 Background and Methodology

3.1.1 Online Survey

Using the web-based survey tool SurveyGizmo, the consultant team prepared an online survey (see Appendix C for the complete survey and aggregated survey responses) that asked a series of questions about planning agencies' use of three general categories of tools: **Real-time 3D viewers**, **3D Modeling Tools**, and **Planning Decision Support Tools**. (For definitions of these tool categories, see Section 2.4). The survey first asked respondents to identify the tools currently used by their agency. For all tools identified by an agency, the survey then asked agencies to describe the planning activities for which the identified tools were used— specifically, **Community Visioning & Planning, Developing Plans, Developing Regulations, Development Review, Impact Analysis, Community Outreach**, and **other** planning activities identified by the respondent. Finally, the survey asked respondents to rate the overall utility of a particular tool for each planning activity. The survey also provided opportunities for respondents to share additional information and thoughts if they chose to do so.

The survey was distributed by email to 65 planning agencies in the United States, Canada, Australia and the United Kingdom. These agencies were identified through a variety of means including: internet

Types of 3D Modeling Tools

Earlier in this document, 3D Modeling Tools are divided into two categories: **3D Modeling Tools** and **GIS-based 3D Modelers**. For categorization and description of the tools, this is a useful distinction. At the time of the agency survey, however, we made no distinction – mostly for simplicity's sake.

Planning Activities

After the agency survey, and based on their responses about how they are using the tools, additional planning activities were added (**Urban Design** and **Build-out Analysis**) for tool evaluation purposes. Furthermore, "impact analysis" was divided into three sub-types: **Visual Impact Analysis**, **Shadow Impact Analysis**, and **Quantitative Impact Analysis**.)

research; telephone interviews with experts in planning and information technology; the consultant team's prior knowledge of agencies currently using these tools; and consultations with the client. Recipients of the survey included agencies of various types (i.e., city and county planning departments, metropolitan planning organizations, and transportation planning agencies) representing both planning departments in large and small jurisdictions as well as regional planning agencies.

In total, 26 agencies responded to the survey. The results of this survey are summarized in section 3.2 below.

3.1.2 Agency Interviews

Based on the survey responses and initial research, ten agencies were selected for in-depth interviews. Criteria for selecting agencies for interviews included the following:

- Jurisdiction Size: At least 6 of the 10 agencies selected were to come from jurisdictions with populations of 500,000 or more.
- Range of Available Tools: Collectively, the agencies selected were to represent the range of available 3D modeling and Planning Decision Support Tools.
- Range of Planning Activities: Collectively, the agencies selected were to capture a range of planning activities (i.e., community visioning and planning, plan development, regulation development, development review, impact analysis, community outreach, and other activities).
- Sufficient Experience Using the Tools: The agencies selected would have sufficient experience using the tools (and training staff to use the tools) to be able to share lessons learned from their experience.
- Responded to Survey and/or Willing to Participate in Interview: The agencies selected would have responded to the survey and/or indicated a willingness to participate in an interview.[2]

[2] Seven of the ten agencies selected for interviews responded to the survey. Three additional agencies that did not respond to the online survey were ultimately selected for interviews in order to capture these agencies' unique perspectives and experience with 3D modeling and decision support tools.

- Unique Examples: To the extent possible and appropriate, the selected agencies would include "unique" examples that would provide insight into particular tools or planning activities not employed by other agencies.

Using the above criteria, the following agencies were selected for interviews:

- District of Columbia Office of Planning (DCOP) – Washington, DC
- Gosford City Council – Gosford, Australia
- Metropolitan Area Planning Council (MAPC) – Boston, MA
- The Maryland-National Capital Park and Planning Commission (M-NCPPC) – Montgomery County Planning Department, Montgomery County, MD
- Portland Bureau of Planning – Portland, OR
- Puget Sound Regional Council (PSRC) – Seattle, WA
- San Diego Association of Governments (SANDAG) – San Diego, CA
- Steamboat Springs Planning Department – Steamboat Springs, CO
- Vancouver Community Services Department – Vancouver, BC (Canada)

For each agency interviewed, a member of the consultant team spoke with one or more contacts from the agency and asked a series of questions that addressed:

- Generally, how the agency uses available 3D modeling tools, real-time 3D viewers, and decision support tools to support the planning process;
- The specific tools used by the agency;
- The planning activities for which each tool is used;
- The effectiveness of the tools for particular planning activities;
- Costs, training, staffing and hardware requirements;
- Successes, challenges and lessons learned while using the tools; and
- Any tools that the agency is considering using in the future.

Overall findings from these interviews, as well as profiles of each agency interviewed, are included in the remainder of this document and as Appendix D.

3.2 Agency Survey Results

Of the 65 planning agencies contacted, 26 responded to the online survey. The agencies that responded included 23 in the United States, two in Australia and one in the United Kingdom. Respondents included representatives of 20 planning and economic development departments, 4 MPOs, a public works department, an information technology department, and a transportation planning agency. In general, more agencies reported using 3D modeling tools (24 agencies) than Real-time 3D viewers (18 agencies) or decision support tools (15 agencies).

3D Modeling Tools

Of the 26 respondents, 24 agencies report using 3D modeling tools. The most frequently-used 3D modeling tools include Google SketchUp (20 agencies), AutoCAD (11 agencies) and ArcGIS 3D Analyst (10 agencies). Other tools used by multiple agencies include 3DS Max (6 agencies) and CommunityViz® Site Builder / Scenario 3D (5 agencies). Responding agencies reported using 3D modeling tools for a variety of planning activities. The most frequently-cited planning activity was community visioning and planning, followed by developing regulations, impact analysis, development review and community outreach.

Real-time 3D Viewers

Of the 26 respondents, 18 agencies reported using real-time 3D viewers. By far the most frequently-used tool is Google Earth (14 agencies), although more than one agency also reported using ArcGIS Explorer, Bing, and Skyline Globe as viewers. Responding agencies reported that they use real-time 3D viewers for a variety of planning activities, with responses evenly distributed among developing plans, community visioning and planning, developing regulations, impact analysis, development review and community outreach.

Planning Decision Support Tools

Of the 26 respondents, 15 reported using Planning Decision Support Tools. Tools that respondents reported using include ArcGIS, CommunityViz, INDEX and I-Place^{3}s. The most frequently-cited planning activities for decision support tools were developing plans and community visioning and planning, followed by impact analysis, developing regulations and development review; a smaller number of

agencies reported using decision support tools for community outreach.

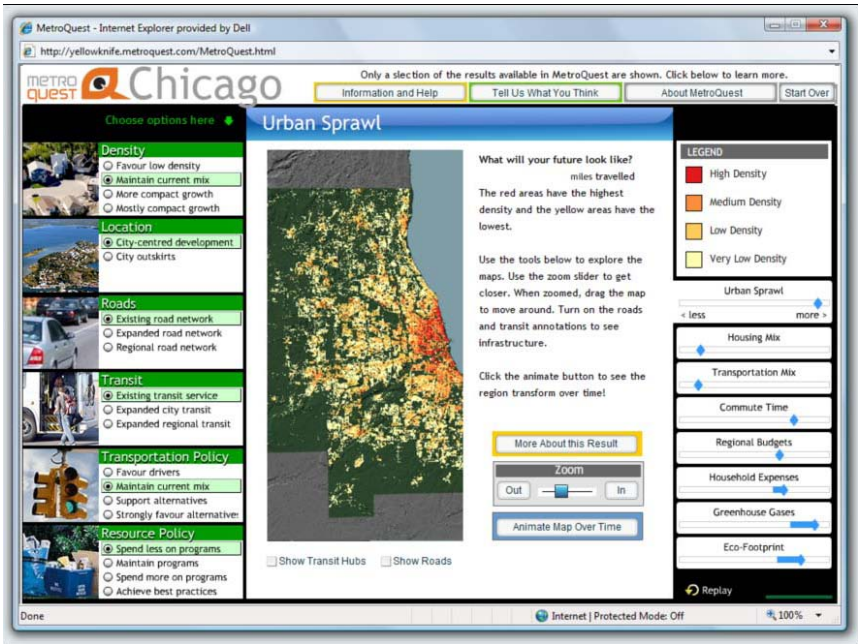
Tool-Specific Comments

In addition, respondents provided anecdotal information about how useful they found the tools for particular planning activities. Given the small sample size for a number of tools and the constraints of the survey format, it is difficult to draw larger conclusions about the utility of each tool from the survey alone. However, the advantages and disadvantages of the tools were addressed in greater detail during agency interviews, as described in sections 3.4 below. The survey results also informed the Tools Evaluation in Chapter 2.

3.3 Profiles of Agencies Interviewed

The following section briefly profiles the ten agencies interviewed as part of this study, describing the primary tools employed by each agency and the planning activities for which the tools are used. A complete summary of each agency interview accompanies this report in Appendix D.

3.3.1 Chicago Metropolitan Agency for Planning (CMAP) – Chicago, IL

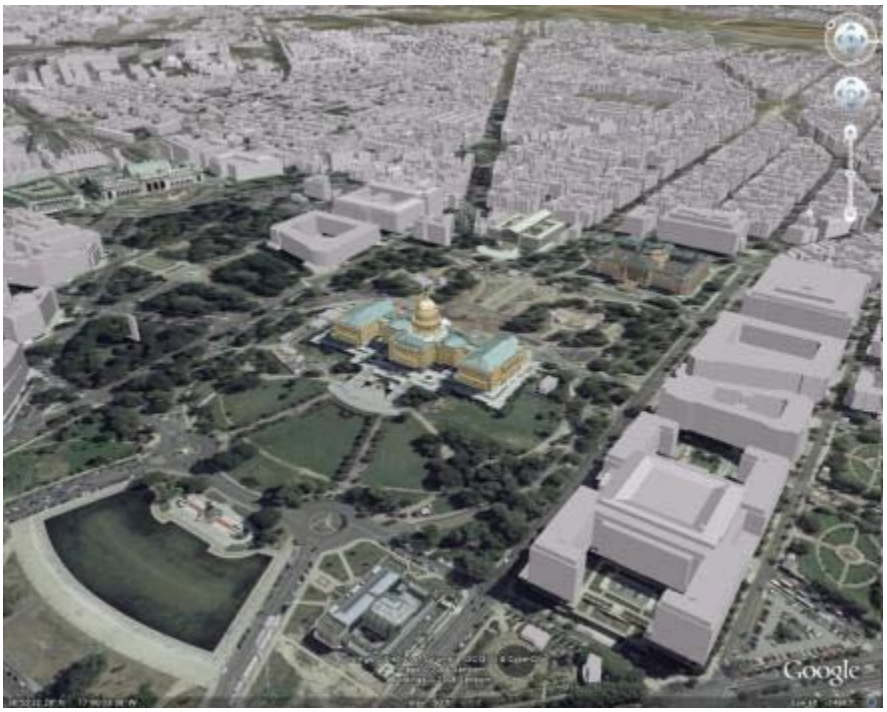


MetroQuest is one of several tools used by CMAP for its community planning and visioning exercises and outreach efforts.

The Chicago Metropolitan Agency for Planning (CMAP) is the regional planning organization for seven counties in the Chicago metropolitan area (population: 9.4 million). CMAP uses a number of decision support tools for a range of planning activities including community planning and visioning, community asset mapping, population projections, and assisting municipal staff with planning decision-making. CMAP planners have used Metroquest as an educational tool to support the largest public-outreach phase of CMAP's GoTo 2040 regional plan, during which CMAP conducted 57 public workshops using MetroQuest and keypad polling tools. In addition, CMAP uses the Return on Investment (ROI) Model, a real estate pro forma tool customized for CMAP by Fregonese Associates, to help municipal planners assess barriers to new development, determine whether land use regulations are feasible from a developer's perspective, and evaluate both proposed development and development incentives offered to developers. CMAP has used INDEX Paint the Region/Future View to conduct population projections for the region using the GIS-based tool to understand the projected long-term growth in terms of population, jobs, building types, etc. Funded by a grant from the MacArthur Foundation, CMAP's Full Circle process uses the agency's own web-based GIS tool for real-time asset mapping by community groups using smart phones. The process has been applied to a variety of projects, ranging from food quality to historic preservation issues.

Finally, CMAP is in the early stages of implementing Model Builder, a GIS-based tool customized for CMAP by Fregonese Associates, as a decision support tool for scenario planning and potential future use as a public participation tool to help the public select development types for future development.

3.3.2 District of Columbia Office of Planning (DCOP) – Washington, DC



The District of Columbia Office of Planning (DCOP) received much of its 3D model from Google's 3D cities initiative in exchange for aerial imagery.

The District of Columbia Office of Planning (DCOP) is the planning department for the District of Columbia (population: 591,833). DCOP staff have used a number of 3D modeling tools, with ArcGIS 3D Analyst and Google SketchUp serving as the staff's primary tools. ArcGIS 3D Analyst is used to conduct line-of-sight studies and terrain modeling, to assess visibility issues, and for some streetscape projects. Google SketchUp is most often used by planning staff to assess proposed development. The tool has also been used as part of the District's zoning rewrite and development review processes by neighborhood planners for 3D visualizations, and for a variety of other projects including shadow studies, streetscape projects, assessing impacts on iconic buildings, and historic preservation. The District also maintains a citywide 3D model, a large piece of which was obtained through Google's 3D Cities initiative in exchange for the use of aerial photography. DCOP also uses ArcGIS and extensions to core ESRI software as its primary decision support tools for all planning activities.

3.3.3 Gosford City Council – Gosford, Australia

The City Council of Gosford, New South Wales, Australia requires developers to submit a 3D digital model of any proposed development in the CBD and nearby beachfront area as part of the development review process. The 3D model must be compatible with the 3D software, Simurban. In addition to having the ability to "drop" new models into the base model, planners can create simple massing models within the virtual environment itself, as pictured here.

The Gosford City Council provides a range of governmental services, including planning, for the City of Gosford (population: 163,469), a coastal city located 80 kilometers north of Sydney, Australia. In 2003, the Council commissioned a consultant and software company, Simurban (now known as Simmersion), to develop a 3D model of its central business district and later expanded the model to include a larger portion of the Central Business District and a beachfront area. The model now includes approximately 1000 buildings and is used by planning staff for reviewing development proposals as well as for studying view and shadow impacts, developing plans and establishing height limits. Today, developers must submit a digital 3D model of proposed development as part of the development review process. While the City can create a basic 3D model of proposed development if applicants cannot do so, most developers choose to hire an outside company to prepare 3D models of proposed development. Because of the model's legal level of accuracy, it has been used successfully by the Council to present its case in court challenges. More recently, Gosford began adopting another tool, Skyline, for use in long-range planning activities focused on larger-scale issues (such as parks, open space, wildlife, and road systems). Simurban will continue to be used for development review.

3.3.4 Metropolitan Area Planning Council (MAPC) – Boston, MA

The Metropolitan Area Planning Council (MAPC) of Boston uses SketchUp to create models for use in both CommunityViz® Scenario 3D, Google Earth, and Second Life.

The Metropolitan Area Planning Council (MAPC) is the regional planning agency for the Boston metropolitan area (population: 4.3 million). The agency has employed 3D modeling tools, real-time 3D viewers and decision support tools for master planning and regional visioning processes. Staff from the agency's Data Services division have used Google SketchUp to produce models for master planning processes. Data Services staff have also used CommunityViz® as both a 3D modeling and decision support tool: CommunityViz® – Scenario 3D was used to create 3D simulations and fly-throughs for a master planning process, while CommunityViz® – Scenario360 has served as a scenario planning, public participation and decision-making tool for a regional visioning process and two master plans. Google Earth is increasingly used by agency staff to create fly-through animations for a range of planning activities. As part of the ongoing Participatory Chinatown project, MAPC is collaborating with Emerson College and other institutions to create a "planning video game" using Second Life (a 3D social networking and game environment), for which staff are creating 3D models using Google SketchUp. In addition to applying the tool Second Life, in which participants engage in role playing using avatars, to planning issues, the project also will include a research component assessing the value of 3D visual simulations in the planning process.

3.3.5 The Maryland-National Capital Park and Planning Commission (M-NCPPC), Montgomery County Planning Department – Montgomery County, MD

The Montgomery (MD) County Planning Department uses Google SketchUp for a variety of planning activities, including: master/sector planning; reviewing development proposals; assessing views, shadows and development compatibility; and historic preservation.

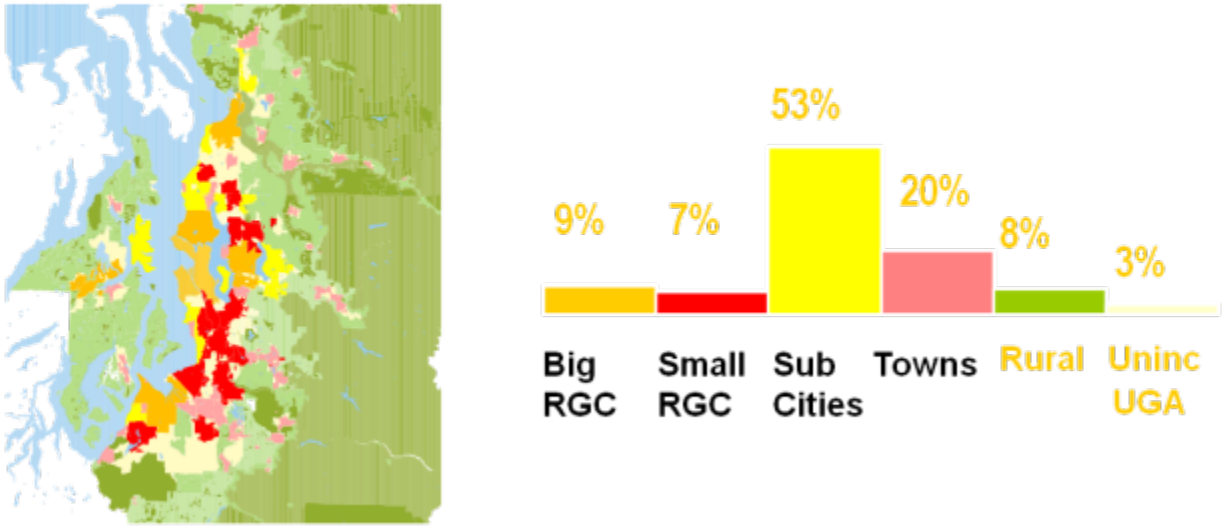
As part of The Maryland-National Capital Park and Planning Commission (M-NCPPC), the Montgomery County Planning Department provides land use planning and development review services for Montgomery County, MD (population: 950,680). The department's community-based planning and urban design staff have used 3D modeling tools—primarily Google SketchUp—for a variety of planning activities, including: master/sector planning; creating 3D visual simulations and fly-through animations; reviewing development proposals; assessing views, shadows and development compatibility; historic preservation; and for a variety of special projects. Other uses of 3D modeling include GIS staff's work on 3D extrusions of GIS data using ArcGIS 3D Analyst and displaying animated 3D models of proposed development projects (created by developers using Google SketchUp) for public comment on the agency's Design Montgomery web site. In addition, staff have used CommunityViz® as an in-house analytical tool at the front end of some long-range planning processes.

3.3.6 Portland Bureau of Planning – Portland, OR

Portland uses 3D modeling primarily for analytical purposes, such as estimating square footage. ArcGIS 3D Analyst is therefore a logical choice of tools.

The Portland Bureau of Planning is the planning department for the City of Portland (population: http://en.wikipedia.org/wiki/City582,130). Bureau staff have built a GIS-based 3D digital model for the entire city, using ArcGIS 3D Analyst and Google SketchUp. The model is used for a variety of citywide planning activities, including 3D visual simulation, reviewing development proposals, studying view impacts, and as an input into an analytical model (for tasks such as estimating square footage). GIS staff use ArcGIS 3D Analyst as the primary tool for creating individual 3D models of buildings, while Google SketchUp is used to finish the models.

3.3.7 Puget Sound Regional Council (PSRC) – Seattle, WA



The Puget Sound Regional Council uses INDEX – Paint the Region as an internal decision support tool to analyze regional growth scenarios as part of the agency's Vision 2040 planning process.

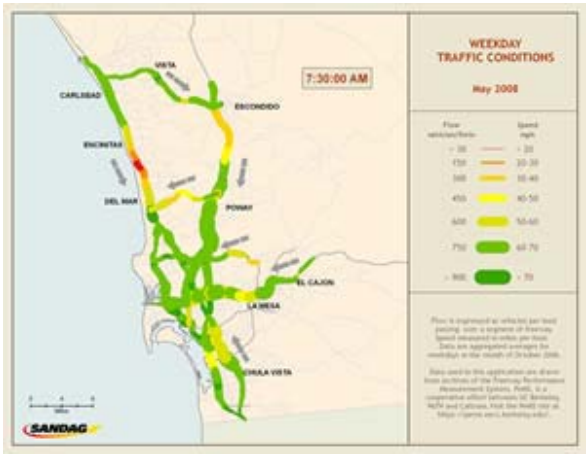
The Puget Sound Regional Council serves as the Metropolitan Planning Organization (MPO) and Regional Transportation Planning Organization (RTPO) for the Seattle metropolitan area (population: 3,582,900). The agency's Growth Management staff used INDEX – Paint the Region as an internal decision support tool to analyze regional growth scenarios as part of the agency's Vision 2040 planning process. In addition, GIS staff have used ArcGIS 3D Analyst to create 3D visual displays (3D "ribbons" and bar graphs) illustrating outputs from the agency's transportation models, INDEX growth scenarios, and population and employment projections.

3.3.8 San Diego Association of Governments (SANDAG) – San Diego, CA

The San Diego Association of Governments (SANDAG) has used I-Place3s as an in-house decision support tool for general plan updates in member jurisdictions. I-Place3s is unique in that it is entirely web-based. The agency found data exchange too cumbersome, however, and is in the process of switching to CommunityViz©, which is desktop based. .

The San Diego Association of Governments (SANDAG) is the regional planning agency for 18 cities and counties in the San Diego metropolitan area (population: 3.1 million). Until 2008, SANDAG used I-Place^{3}s as an in-house decision support tool for General Plan updates in member jurisdictions. The agency recently selected CommunityViz® as a decision support and visual simulation tool. While SANDAG is currently using CommunityViz® for bicycle and pedestrian modeling, the agency plans to use the tool for public participation (as part of the state-mandated Regional Transportation Plan process) later this year and also may use the tool to evaluate transportation alternatives and transit catchment areas. In addition, the agency's GIS and regional modeling staff have also used ArcGIS Explorer and Google Earth for traffic-related simulations.

The agency's regional modeling staff use ArcGIS Explorer and Google Earth to illustrate traffic simulations.



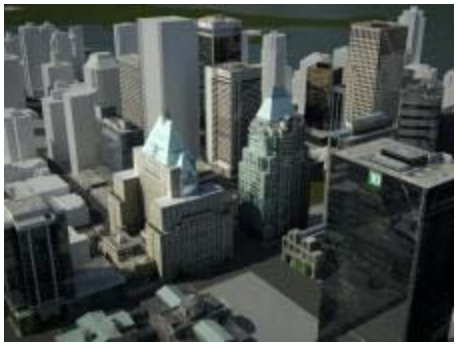
3.3.9 Steamboat Springs Planning Department – Steamboat Springs, CO

The city of Steamboat Springs now requires submittal of 3D digital models of proposed projects as part of its development review process. It uses "Vizhen", a viewer customized to the Planning Department's needs.

The Steamboat Springs Planning Department serves as the planning department for the City of Steamboat Springs (population: 9,815). To enable better tracking and visualization of approved and proposed development in the city, the department commissioned the development of a citywide 3D digital model. The City now requires submittal of 3D digital models of proposed projects as part of its development review process. Most developers choose to hire the City's consultant to create the models, although City planners have the capability of creating a Google SketchUp model for the applicant if needed. In addition to development review, the City occasionally uses the citywide model for other purposes – in public hearings, for developing new development standards and height standards, for assessing protected view corridors, and general planning issues. The model is housed in Vizhen, a hybrid 3D viewer created by Winston Associates that is based on video game software, and includes models created using a combination of 3DS Max and Google SketchUp in combination with photographs and USGS terrain data. The City relies primarily on its consultant to create new 3D models and manage the larger 3D model, but department staff have the capability to run the model at meetings and public events if the consultant is not present.

3.3.10 Vancouver Community Services Department – Vancouver, BC (Canada)

Vancouver has been using 3D modeling to support planning activities for many years and has developed a fairly standardized work-flow for building and maintaining its 3D model.



The Vancouver Community Services Department houses numerous city departments—including planning, development services, cultural services, licenses and inspections, and support services—serving the City of Vancouver (population: 578,000). The City's 3D modeling staff, based in the department's Graphics and Communications section, have developed a citywide 3D model that is used for a variety of planning activities, including: analysis of impacts on view cones (viewsheds) and development of citywide views policies; review of development proposals; shadow studies; character analysis; and skyline studies. Staff (primarily two 3D modeling specialists) do the majority of 3D modeling as well as the updating of existing 3D models. 3D modeling staff use a combination of 3D modeling tools to produce 3D models, including 3DS Max, AutoCAD and Google SketchUp, and maintain two versions of the model, one in 3DS Max and the other AutoCAD Map 3D. In addition, Pictometry is used to create photorealistic "skins" for some buildings.

3.4 Agency Interviews: Overall Findings

The ten agencies interviewed vary in terms of agency type, planning context, the size of the population they represent, and the types of tools they have applied to the planning process. In some cases, the agencies also vary in terms of their experience with particular tools: a tool that one or more agencies found to be useful may have been problematic for another agency. Given the range of agency characteristics and experiences, no single model exists for Prince George's County to emulate. Nevertheless, some overall findings—recurring themes, lessons learned and common issues—emerged during interviews with agency staff that can inform Prince George's County's selection and adoption of 3D modeling and decision support tools.

About ESC Comments:

This section summaries different agencies' perceptions of tools. While these experiences are valuable, occasionally a comment might raise other questions, or be confusing to the general reader and need clarification, or might be based on incomplete facts and might be misleading. Where clarification is needed, the Environmental Simulation Center has *highlighted the text with italics* and added comments of its own in text boxes in the page margin.

The overall findings from the agency interviews are summarized below. While these findings constitute general themes or issues, they also aim to capture the variety of experiences across the ten agencies, where applicable. In some instances, specific examples from one or more of the agencies are included to further illuminate a particular theme. For additional information about individual agencies, please refer to both the Agency Profiles included in Section 3.3 above and the more detailed Agency Interview Summaries that are included as an Appendix D to this document.

In addition to 3D modeling and decision support tools, more than one agency reported using social media and mobile technology tools, such as keypad polling devices and smart phones, to support planning decision-making and data collection. Although these tools are not the focus of this study, some agencies mentioned these tools during interviews. As such, findings pertaining to these tools are included in sections 3.4 and 3.5 of this document.

ESC Comment:

Another reason video game graphics cannot compete with 3D visual simulations is that 3D graphics modeled for video games are highly optimized for the gaming platform; real-time visual simulations, on the other hand, create content "on the fly" and will therefore never look as good as video games. In addition, games are interactive while most 3D visualizations for planning are either static views taken and rendered from a 3D digital model or a pre-pathed rendered animation or a passive viewer.

1. Public Expectations for 3D Visual Simulations

- A number of the agencies noted that the public currently expects 3D imagery to be used for planning activities. For this reason, 3D visual simulations are now "required" to some extent and 3D models are expected to remain current.
- *Young people have grown up with high-end video game graphics and have therefore come to expect high-end 3D graphics; however, 3D visual simulations created for planning activities cannot compete with video game graphics due to the large scale and complexity of planning activities.*

- Planning agencies are currently grappling with developing a core technical capacity with 3D modeling tools that would enable the efficient, high-quality 3D modeling that the public has come to expect. Currently, while planners are increasingly using 3D modeling tools, agencies tend to rely on a few core staff (generally, either designers or GIS staff, depending on the tool being used) with the requisite "production-level" 3D modeling skills. As noted below, a new generation of younger planners are more likely to have 3D modeling and GIS skills when they are hired as a result of prior education and experience.

ESC Comment:
It is important to note that, in some cases, the quality of the model and the graphics depends heavily on the skill of the modeler.

2. Appearance of 3D Graphics

A. Graphics Quality

- Some agencies cited the *poor graphics quality* of many available 3D modeling tools, noting that the *3D graphics look "cartoonish" or "blocky."* Specific tools noted in such complaints include ArcGIS 3D Analyst, Scenario3D (CommunityViz®) and 3DS Max.

ESC Comment:
It is true that perceiving and making sense of a flow of information in a dynamic visual simulation is different than contemplating static information – a picture. In addition, creating compelling 3D digital models that work for both dynamic and static visual simulations, and for what is needed to be communicated, is a function of the skill and visual literacy of the person creating the model as well as their technical capacity. Realism (for example, modeling of 3D features such fire escapes and balconies, textures and/or photos, and streetscape elements) can be added to the 3D massing models, resulting in a believable, eye-level experience, whether static or dynamic).

- *Certain 3D graphics (i.e., those produced by ArcGIS 3D Analyst) may look good while in motion as part of an animation, but prove inadequate when the models are static and can be scrutinized further.* [DCOP]

ESC Comment:
The issue is neither photorealism nor virtual reality, but what needs to be communicated and what is the best way to use visual simulations to help explain complex information. There are many instances in which photorealism may not be appropriate (for example, urban design level 3D massing models to visualize building bulk envelopes or using the massing model to visualize uses in a mixed use building, vacancies, overbuilt/underbuilt analyses, and heights).

- *The public's familiarity with tools such as Google's street view, and with video game technology, have fueled expectations for greater use of photorealism and virtual reality. As a result, it is conceivable that, in the near future, only those tools with graphics that are "virtually real" and photographic in appearance will be accepted by customers.*

- In some cases, agencies have found *2D photomontages* to be more effective than 3D visual simulations. The reasons for this perception may include: the greater photorealism of some 2D photomontages; the ability to share static 2D simulations online more easily than 3D videos; and the time and resources required to produce 3D graphics and animations as opposed to 2D renderings.

ESC Comment:
Photomontages, which are meant to be verifiable, require an underlying, dimensionally correct 3D terrain and massing model of the context to accurately locate the proposed structures with realistic textures in the photograph by matching the perspective and viewpoint in the 3D model to the perspective and location of the viewer relative to the photograph. In this instance, a 50mm lens would be used to take the photograph because it comes closest to simulating the relative distance and displacement of objects in the landscape. A 2D photomontage that is not required to be verifiable is essentially an artistic rendering of a proposed structure in a photograph. Unlike the verifiable photomontage, which has an accurate 3D model "underneath" it, the photomontage is purely visual information.

- *There is a need to learn from the gaming industry.* The industry has a better sense of how the brain interprets moving objects and how to construct 3D graphics using multiple PCs and graphics tools. Demos of game-based and CAD-based tools are showing promise.

ESC Comment:
As noted earlier, comparing video game graphics and 3D visual simulations for planning activities is problematic due to the fact that these graphics are produced for entirely different purposes and platforms.

- Some agencies lament *the lack of a single tool that provides both 3D photorealistic models and GIS-linked analytical capabilities*.

ESC Comment:
This is what ArcGIS 3D Analyst and Scenario 3D are meant to do. The tools exist; the problem is they are not easy to use.

USE CASE EXAMPLES:

- SANDAG hired outside consultants to produce 3D rendered animations (using 3DS Max) and 2D photomontages (using Photoshop) to illustrate general smart growth principles. All visual simulations were posted on the agency's web site as educational tools; the 2D photomontages were also used to illustrate concepts in public meetings.
- M-NCPPC urban design staff originally envisioned CommunityViz® – Scenario 3D as a fast way to generate 3D visual simulations for long-range planning projects; however, because staff were not satisfied with the quality of the graphics (too "cartoony" and "blocky" for presentations to the Planning Board), CommunityViz® is now used primarily as an in-house analytical tool at the front end of master planning projects.

ESC Comment:
The quality of a 3D digital model rests on the capacity and visual literacy of the modeler (it is not merely a technical activity) and the resources available. CommunityViz® does not inherently create "cartoony" or "blocky" models; the modeler does.

B. Selecting the Proper Levels of Detail and Realism

- It is important to ask the questions, "how much detail is required?" and "how much detail is too much?" when selecting 3D modeling tools and a 3D modeling approach. Depending on the particular planning activity, the appropriate level of detail may vary depending on the goal.
- Some agencies [i.e., Portland, M-NCPPC, and Vancouver] produce basic, conceptual models (showing massing and trees, but few architectural details) and have determined that this level of detail is sufficient for their purposes and that greater levels of photorealism are not necessary. The popularity and user-friendliness of SketchUp has likely contributed to this approach, due to the fact that this tool is easily adopted and is particularly well-suited to conceptual models. In some cases [Vancouver], the addition of photorealistic details to 3D models, such as the use of Pictometry "skins" to depict building faces, have been found to obscure the geometry of the original models.

USE CASE EXAMPLES:

- Portland uses its 3D model for a variety of planning activities including visual simulation, reviewing development proposals that are dropped into the model, view impacts (i.e. mountains), and as an input into an analytical model (i.e., estimating square footage). Staff determined that a simple massing model was sufficient for these purposes.
- M-NCPPC uses its Google SketchUp 3D visual simulations for a variety of planning activities, including: master/sector planning; creating 3D visual simulations and fly-through animations; reviewing development proposals; assessing views, shadows and development compatibility; historic preservation (i.e., simulating additions to historic structures); and a variety of special projects (i.e., finding a site for a school; simulations of new buildings on a relocated college campus).
- Vancouver uses its citywide 3D model for a variety of planning applications, including: analysis of impacts on view cones (viewsheds) and development of citywide views policies; review of development proposals; shadow studies; character analysis; and skyline studies.

3. Decreasing Reliance on Proprietary 3D Formats

- In general, agencies are gravitating away from proprietary 3D formats and are instead adopting tools (such as Google SketchUp) that are easier to use, customize and modify without the aid of an outside vendor or consultant.
- Some agencies [DCOP, SANDAG] have been dissatisfied with the 3D rendered animations they have contracted from external consultants or vendors and now consider these animations to be a waste of resources. Common complaints include the time and costs entailed in development of 3D rendered animations using high-end graphics software (such as MultiGen Paradigm and 3DS Max) as well as the inability to modify the animations in-house without the assistance of the contractor. One agency [SANDAG] also noted that the size and length of the video files made it difficult to house the videos on the agency's web site and to show the videos during public meetings.
- At the same time, however, some agencies continue to use proprietary 3D formats and are satisfied with this approach. These agencies [Gosford, Steamboat] note that, while they still rely on outside companies to produce 3D models to some extent, they have become reasonably self-sufficient in terms of day-to-day use of the tools.

USE CASE EXAMPLES

- SANDAG commissioned consultants to produce both 3D rendered animations and 2D photomontages as educational tools to illustrate smart growth principles. The agency found that the 3D rendered animations (produced using 3DS Max) were too large to run efficiently on the agency's web site and during public meetings.
- The DC Office of Planning hired an outside consultant to produce 3D visual simulations, using MultiGen Paradigm, for a neighborhood master planning project but the agency believed that the product was not worth the time and money required to develop the simulation. Staff also found that their inability to modify the final product in-house was problematic.
- Gosford City Council uses Simurban to house its citywide 3D model. While the City is dependent on a local company to produce 3D models, using Simurban is easy to learn and City staff are largely self-sufficient in maintaining the large-scale model in-house and in adding new 3D models as they are produced. Interactions with the software company have been minimal in recent years and limited to technical support for general software issues (i.e., system overloading).
- The City of Steamboat Springs relies on an outside consultant to maintain its citywide 3D model and to produce individual 3D models. The City's reliance on a consultant is due to limited in-house capacity to produce 3D models (one planner can create 3D models using Google SketchUp) and to the fact that the consultant uses its own hybrid 3D viewer to house the model. Staff are able to run the tool if the consultant is not present at the time.

4. Greater Use of Large-Scale 3D Models

- Agencies [Portland, Vancouver, DCOP, Gosford, Steamboat, M-NCPPC] are increasingly creating large-scale 3D models of entire jurisdictions or of particular areas within a jurisdiction, using tools such as Google SketchUp, ArcGIS 3D Analyst, AutoCAD 3D, 3DS Max, and other proprietary 3D formats.
- These models are used for various planning purposes, including development review, 3D visual simulations and fly-through animations, long-range planning, modifying or creating development regulations, impact analysis (views, shadows, historic preservation, etc.), skyline studies, and estimating density and square footage.
- Some jurisdictions [Gosford, Steamboat] use large-scale 3D models to support the development review process and now require developers to submit 3D models of all proposed projects. The 3D models are used by agencies to make decisions regarding proposed development, to track and visualize approved and proposed projects, to present projects to planning boards and elected officials, and, in one case [Gosford], to provide supporting evidence in development-related court challenges. Although developers have to "jump through an additional hoop" and accrue additional expenses for model development, the development community appreciates the value of 3D models and reports that the 3D models not only result in better presentations and discussions but also reduce the amount of time and the number of meetings required as part of the approval process.
- One agency [DCOP] received its citywide 3D model from Google's 3D Cities program in exchange for aerial imagery.

USE CASE EXAMPLES

- Portland's 3D model is a basic massing model and is used for a variety of purposes in citywide planning, including 3D visual simulation, reviewing development proposals that are dropped into the model, view impacts (i.e. mountains), and as an input into an analytical model (i.e., estimating square footage).
- While Vancouver's citywide 3D model was developed as a basic massing model, photorealistic building "skins" have been added to some buildings using Pictometry after the City received these skins for a portion of the city as part of its Pictometry license. Prior to this use of Pictometry, City staff used Pictometry imagery primarily for measurements.
- The DC Office of Planning's 3D model is a basic massing model housed on Google Earth's 3D buildings layer. The agency received the model from Google

in exchange for aerial imagery and it is now housed on Google Earth as part of Google's 3D Cities initiative.

- Gosford's 3D model is housed in Simmersion and is used for development review (applicants must submit a digital 3D model of development proposals), development-related court challenges, view and shadow analysis, development of long-range plans, and establishing height limits for future development. The model has a high level of accuracy (+/- 0.1m verification) and includes photorealistic models.
- The City of Steamboat Springs' citywide 3D model, housed in the proprietary 3D viewer Vizhen (Winston Associates), is used primarily for development review, but is also occasionally used in public hearings, for developing new development standards and height standards, for assessing protected view corridors, and for general planning issues.
- M-NCPPC staff, using Google SketchUp, have created simple massing models of two urbanized planning areas (in Bethesda and Silver Spring) and use the models for development review. New development proposals are added to this model

5. Accuracy of 3D Visual Simulations

- Perspectives on the importance of accuracy vary from agency to agency, and even within individual agencies. Some agencies raised questions about the proper degree of accuracy for 3D visual simulations and the ability of certain tools to ensure sufficient accuracy. Some agency staff, especially planners and designers, are content with 2D or 3D visual simulations that are not verifiable, and in some cases might be produced using insufficient base data and/or without proper georeferencing, but are nevertheless "close enough" to accurate to enable them to communicate an idea or illustrate a vision for development. Other agency staff, especially GIS specialists, place more emphasis on having good data
- One agency [Steamboat], which uses its 3d model for development review, believes that 3D models do not need to be developed at an "engineering level of detail" yet still must be at least "close to accurate." In contrast, a GIS administrator from another agency [DCOP] that correct data is more important than having attractive renderings that are imprecise and potentially misleading [DCOP].
- While Google SketchUp includes the ability to quickly check a 3D model for accuracy, some question the tool's overall accuracy. One detractor [DCOP] notes that Google *SketchUp's poor compatibility with other tools (such as ESRI products) can result in a loss of accuracy* due to incompatible base layer elevations or as a result of efforts to get SketchUp models to

ESC Comment:

It should be noted that the issue with accuracy involves how the software interacts with another software tool; it is not necessarily the tool itself that is not accurate. (See Item 6: Compatibility Between Tools: Google – ESRI Integration)

"fit" into available base layers. Another agency [Vancouver] reports that scaling in SketchUp is inferior to other tools.

- A high degree of accuracy can reap significant benefits for an agency when used as evidence in court challenges. One agency [Gosford] with a highly accurate Simmersion 3D model (+/- 0.1m verification) reports that developers cannot compete with its 3D model and that this relatively expensive tool has "paid for itself" as a result of the agency's ability to win court challenges using the model.
- GIS staff from another agency [M-NCPPC] expressed concern to planning and urban design staff in that agency about the lack of georeferencing in 3D models produced in SketchUp on top of base layers from GIS.

USE CASE EXAMPLES

- The DC Office of Planning comment regarding the accuracy of 3D models refers to the agency's experience creating 3D models with Google SketchUp with base layers created using a different tool. The agency has found that the lack of compatibility between Google and ESRI products causes staff to do "crude things" to get models to fit into the base layer.
- The comment by the City of Steamboat Springs refers to the overall accuracy of the City's citywide 3D model. The opinion of the consultant (and presumably the City itself) is that a model that is "close to accurate" is sufficient for the City's review of development proposal and for the other planning activities for which the model is used (public hearings, developing new development and height standards, assessing protected view corridors, and general planning issues).
- The City of Vancouver uses Google SketchUp and other tools (3DS Max and AutoCAD) to create individual 3D models for its citywide model. The comment about problems with scaling refers generally to one drawback of Google SketchUp as a 3D modeling tool.
- Gosford's large-scale 3D model is used primarily for the development review process. By housing the model in Simurban, the resulting high level of accuracy enables to City to use its model as evidence in development-related court challenges. The City reports that developers' 2D renderings cannot compete with accuracy of Gosford's 3D model.
- M-NCPPC GIS staff have been working with Urban Design staff to establish a coordinate system for 3D models produced by urban designers, using Google SketchUp, for a variety of planning purposes. GIS staff have noted that urban designers prefer to "draw on top of GIS layers" and that many 3D models produced in SketchUp improperly placed on the base layer due to the lack of georeferencing.

6. Compatibility between Tools: Google – ESRI Integration

- Numerous agencies have found the work flow between Google and ESRI products to be unsatisfactory. Google is not keeping

its plug-ins current, and there has been a lack of support from Google for better product integration.

- The poor integration between Google and ESRI products results in poor fits between SketchUp models and GIS-generated base layers, incompatible base elevations and a lack of georeferencing, all of which can compromise the accuracy of 3D models.
- Some agencies [DCOP, M-NCPPC] are exploring ways to better integrate Google and ESRI tools, but have not yet found a satisfactory solution.
- *The missing piece in 3D modeling is finding a way to link 3D models to a range of indicators and GIS attributes.* 3D models ultimately should not be stand-alone tools and simply "pretty and interesting" to look at, but rather should link to larger implications.
- The ESRI platform is mature, and its approach ("single flat screen, do all drawing on a single CPU, we will render for you") is not acceptable any longer.

ESC Comment:
This is what ArcGIS 3D Analyst and Scenario 3D are meant to do, but in practice this is difficult due to the aforementioned compatibility problems between these GIS-based tools and 3D modeling tools (3DS Max, SketchUp).

ESC Comment:
Unlike many CAD tools, ArcGIS is single-threaded and therefore does not benefit from multi-core processors. Rendering speed, however, has more to with the Graphics Processor than the CPU so it is unclear as to what this comment is critiquing.

7. Speed and Stability of Tools

- Numerous agencies have found that the slow computation speeds of available GIS-based, decision-support tools (such as INDEX and CommunityViz®) have either complicated or prevented the use of these tools for their intended purposes.
- INDEX and CommunityViz, are particularly susceptible to poor computation speeds that may be related to the amount of data to be processed and the size of the area to which the tool is applied (large regions tend to be slower) [PSRC, SANDAG]. Slow computation speeds prevented one regional planning agency [PSRC] from using INDEX in real time during public events (instead, it is used as an in-house analysis tool). Another regional planning agency [SANDAG], which is currently adopting CommunityViz, have found it difficult to the tool run efficiently on agency computers.
- Certain tools (i.e., ArcGIS Explorer for animations and CommunityViz® for 3D visual simulations) are perceived by agencies [Portland, MAPC] as being "buggy" or susceptible to crashing.
- In some cases, planning staff do not have sufficient hardware to run GIS-based tools efficiently.

USE CASE EXAMPLES

- In the case of PSRC, the agency used INDEX to support a visioning process for the Seattle metropolitan area. Due the large size of the area and the highly technical nature of the data inputs, it took a long time to run growth scenarios in INDEX. As a result, the agency decided to use the tool as an in-house analytical tool, rather than during public meetings (as it originally intended).
- SANDAG recently adopted CommunityViz® and hopes to use the tool as part of the public process; however, the agency is currently working with the vendor to get CommunityViz® to run more efficiently on its computers. The agency is currently using the tool for pedestrian and bicycle planning projects (analysis of gaps in the network) and plans to use the tool for the Regional Transportation Plan public process and to evaluate transportation alternatives and transit catchment areas. The agency's CommunityViz® license enables it to share the tool with its 18 member jurisdictions; the agency is currently helping jurisdictions to install the tool.
- The Portland Bureau of Planning uses ArcGIS Explorer (ArcScene) to create animations of 3D models that contain complex GIS information. Although the agency prefers Google Earth as a 3D viewer and has found ArcGIS Explorer to be "buggy," it is forced to use ArcGIS Explorer for tasks that involve complex GIS information.
- MAPC has used CommunityViz® – Scenario3D and CommunityViz – Scenario360 for master planning and visioning projects. One general complaint about the tool is that it is susceptible to crashing when used for 3D visual simulations.

8. Divide between GIS Professionals and Planners/Designers

- Numerous agencies have noted a divide between specialized GIS staff and agency planners and designers, both in terms of how these groups are organized within the agency structure and how they perceive particular tools and planning activities.
- In some cases, planners and designers remain dependent on GIS specialists for everything from production of base layers to more complex data analysis. However, a new generation of younger planners is more likely to arrive with GIS skills, and planners in some agencies do use GIS on a regular basis for at least basic mapping tasks. Some agencies [i.e., MAPC, Portland] are making an effort to hire planners who have skills in both GIS and general planning tasks.
- In some agencies [Gosford, M-NCPPC], there is a "cultural" division between GIS specialists and planners/designers that is related to job responsibilities and divergent focuses and priorities.

- In one agency [Gosford], planning staff are determined to maintain control over the use of its 3D modeling and decision support tool, rather than allowing use of the tools to be managed by GIS staff. The rationale for this decision stems from past experiences in which tools such as CommunityViz® were not well-utilized because they were "stuck" in the GIS division. The perception of planners in this agency is that planners need to take control of the tools to ensure that they get used and that GIS and information technology staff "do not have the same kinds of deadlines" as planners.
- In another agency [M-NCPPC], GIS staff and urban designers tend to focus on different geographic scales and have different objectives and priorities for how tools should be used. While designers in this agency typically focus on a "micro," or neighborhood, level, GIS staff tend to have more of a "macro" focus on larger areas. Moreover, urban designers and planners are most concerned with drawing on top of GIS layers, visualizing design concepts and the end product of a project; GIS staff, on the other hand, are most concerned with the analytical capabilities and accuracy of 3D visual simulations, preferring to generate visualizations "through the data" even if the graphics quality suffers as a result. As one strategy to bridge this divide, GIS staff have been working with urban designers to incorporate georeferencing into 3D SketchUp models so that models are accurately located on top of the base layers.

9. Transitions between Local and Regional Scales

- Numerous agencies, particularly large jurisdictions and MPOs representing large regions, report difficulties transitioning between neighborhood and larger or regional scales, using a variety of tools.
- The challenge of transitioning between local and regional scales occurs for a variety of reasons: *certain 3D* tools *(i.e., ArcGIS 3D Analyst, Google Earth, and detailed 3D models such as Simmersion, CommunityViz®) include too much detail to be used effectively at a regional level*; some decision support tools (i.e., INDEX) run too slowly when processing complex data for a large area; and some tools simply make it difficult to quickly shift between local and regional scales in real time.
- Agencies [PSRC, M-NCPPC, and MAPC] report that decision support tools such as CommunityViz® and INDEX work better at a neighborhood scale than at a regional one.

ESC Comment:

This is more or an issue of data management and choosing the right tool for the job. Military and high-end real-time visual simulation models frequently address the issue of too much 3D detail in large areas by having several levels of detail for each model, and switching automatically to the higher resolution detail when zoomed in, lower resolution when zoomed out. This involves special software and modeling methods that are not practical for planners.

In most cases, a 3D massing model should be used for regional scale, and detailed 3D models should only be used at the neighborhood or street level.

USE CASE EXAMPLES

- MAPC staff, who have used CommunityViz® Scenario360 and Scenario 3D for both regional visioning processes and area master plans, noted that CommunityViz® works better for smaller areas than for larger areas. They also reported difficulties transitioning between a regional scale and a local scale on a map or within a 3D visual simulation.
- PSRC staff found that using INDEX at a large regional scale (for a regional visioning process) and with highly technical and detailed data inputs led to long delays as the tool generating growth scenarios.
- Gosford City Council found that its Simurban 3D model, which is very detailed and can be slow to load, does not work as well when applied to large-scale planning issues such as parks, open space, wildlife, and the road system. It is also not conducive to opening up quickly and looking at the entire city. For these reasons, the City Council is adopting Skyline for "big picture" tasks to which Simurban is not well-suited and for use with a GIS-based 3D model.
- PSRC staff found that ArcGIS 3D Analyst tools, which are designed to be used with CAD inputs, are too detailed to be applied to a regional level. Similarly, Google Earth has not been useful for showing geographic information at a regional scale.
- M-NCPPC staff have had difficulty switching between "macro" and "micro" scales on the fly, using CommunityViz® for master planning projects.

ESC Comment:

Any 3D visual simulation program or decision support tool will have performance limitations. In the case of visual simulations, a computer's graphics card can only render so many polygons at once; and in the case of decision support tools, the computer's CPU can only process so many records at once. In both cases some planning has to be done about the appropriate level of detail for any given scale.

In the case of 3D visual simulations, architectural detail is unimportant at the regional scale.

For decision support tools it is not the size of the area being analyzed that matters – it's the number of records processed. INDEX is parcel-based by default – which does become problematic at large scales. It can, however, be adapted to work with other units of analysis. CommunityViz® comes with no default units of analysis and can be adapted to variety of scales (parcels, blocks, census tracts, etc.) When working at regional scales, data needs to be aggregated into larger units.

10. Adoption of New Tools: Expectations and Realities

- For a variety of reasons, as noted below, numerous agencies report acquiring tools that ultimately were not well-utilized, were not utilized at all, or were used in a different way than previously envisioned.
    - Agencies sometimes acquire a tool when particular staff members gravitate to it, but ultimately never institutionalize use of the tool due to lack of specialized skills or skill loss as the result of staff turnover. One agency [DCOP] acquired Rhino because one staff member had learned to use this tool in school, but use of the tool did not continue after this staff member left the agency.
    - Sometimes an agency uses a tool in ways that are different from the purposes originally intended. One agency [PSRC] found that INDEX took too long to run when loaded with rigorous technical data for a large region, thus forcing the agency to use the tool for in-house analysis rather than the real-time public outreach purposes for which it was intended. When another agency [M-NCPPC] acquired CommunityViz, urban design staff envisioned using

Scenario3D as a way to generate quick 3D visual simulations; as it turned out, urban design staff were *dissatisfied by the quality of the tool's graphics* and stopped using it. Nevertheless, the tool is still used for in-house scenario analysis tool at the front end of master planning projects.

- Agencies may acquire a tool that ultimately proves too complex to use without significant investments in training. One agency [M-NCPPC] purchased multiple copies of 3DS Max because of its high-end graphics capabilities, but the tool has not been used for master planning and 3D visual simulations as intended because staff found it difficult to learn it.
- Some agency staff [Portland, DCOP, M-NCPPC, MAPC] have found that is better to start "cheap and slow" with 3D modeling tools that are relatively inexpensive and easy to use (i.e., Google SketchUp), rather than jumping to more complex, more resource- and training-intensive tools (i.e., 3DS Max). One agency [Portland] takes pride in its ability to capitalize on relatively inexpensive tools (ArcGIS 3D Analyst and Google SketchUp) and the use of basic, conceptual 3D graphics, rather than spending money on more "flashy" tools (i.e., 3DS Max) that require a greater investment in software and training.
- According to one agency [MAPC], developing "innovation pathways" for adopting tools is critical for changing institutional culture. Significant capacity building is required at the front end of tool adoption, and agencies need an initial project to learn how to use the tool. It is not possible to quickly pick up a new tool and change business practices overnight.
- Availability of funding is another consideration affecting decisions on whether to adopt a particular tool. Some agencies report that certain tools have not been adopted due to the cost of adopting the tools (acquiring the tool, training staff and/or hiring staff to use the tool), even though there is an institutional need and desire to adopt the tools.

ESC Comment:

The final graphic quality of any given tool is always a combination of the abilities of both the tool and the person doing the modeling. That said, some tools make it easier to model than others. For instance, the "new" Scenario3D's parametrically generated roads are more crude and blocky than the "old" SiteBuiler3D that used to be bundled with CommunityViz. . But someone with experience can also finesse the software to get better results – but only to a point.

11. Staffing and Management

A. Division between Technical Staff and Planning Staff

- In many agencies, there is a division of responsibilities and skills between planning and urban design staff and technical staff, with planning and urban design staff frequently relying heavily on technical staff for GIS and other technical work. This division is underscored when planning departments acquire certain tools (i.e., INDEX, CommunityViz, Model Builder) that require staff skilled in GIS and/or databases to operate the tools and add data.
- Agencies are now making an effort to hire planners with greater technical capabilities, such as GIS and urban design / 3D modeling skills.
- Agencies have been forced to consider whether planners need ArcGIS on their desktops, or whether providing them with a web-based GIS interface is sufficient. The answer to this question ultimately depends on a range of factors, including budget and licensing considerations, the extent to which planners in a particular agency rely on GIS, and staff skill levels. One agency [DCOP] found that the "what if" data sets used by planners require direct access to all data layers and preclude the use of a web-based tool or remote server in another agency. Another agency [Portland] developed a "stripped-down" ArcGIS engine in-house that is used as a data viewer and is installed on every employee's computer.
- In general, the number of planners with GIS installed on their computers appears to be increasing in numerous agencies.
- In some agencies, planners and urban designers (who often end up with the least powerful and up-to-date computers in an agency) find that their hardware is insufficient for running both GIS-based tools and 3D visual simulation and animation tools that require advanced graphics cards.
- In one agency [Vancouver], specialized 3D modeling staff oversee and update the city's citywide 3D model, create the majority of new 3D models, and finish and finalize all models that are added to the citywide model. In this agency, the dependence on a small number of specialized staff can limit staff's capacity to adequately respond to all 3D modeling requests.

B. New Generation of Planners, New Skill Sets

- Agencies are finding that a "new breed" of younger planners is bringing new technical skills sets to agencies as well as a greater interest in learning and using 3D modeling and decision support tools.
- Younger planners are more likely to bring GIS and urban design / 3D modeling skills acquired in school or through prior work experience; they are more likely to learn tools on their own; and they are more likely to be able to train other staff to use the tools.

12. Training

- Agencies take a variety of approaches to training: some skilled staff arrive with skills from previous jobs and education, and these skills may be factored into hiring decisions; in some cases, formal training is provided; frequently, agencies take a "learn as you go" approach, relying on internal "cross-training" and online training manuals. In addition, many staff are self-taught in certain tools.
- Cross-training and self-teaching is easiest for relatively simple tools such as Google SketchUp and Google Earth that are easier to learn and have effective online training modules.
- Customized software generally requires intensive training and coordination with the vendor. In many cases, agencies report a positive experience with training and eventually acquire the ability operate the tool themselves. At the same time, the process of setting up the tools, providing training and loading data can take a long time. One agency [CMAP] required nine months of tool development and training to launch MetroQuest as an educational tool for a regional visioning process. Another agency that is implementing CommunityViz® [SANDAG] has required *120 hours of the vendor's time and 400 staff hours* to set up the tool and to learn how to use the tool.
- Staff turnover is a significant obstacle to maintaining institutional skills and knowledge and to the continued use of 3D modeling and decision support tools. One agency [MAPC] has found that hiring consultants to train staff is beneficial for transitioning staff to a new tool (in this case, CommunityViz®); however, once a new tool is adopted, it is not necessary to rely on consultants as long as trained and skilled staff remain with the agency and there is a critical mass of projects requiring the tool to maintain staff skills and institutional knowledge.

ESC Comment:
It is not clear what these numbers mean. It appears that primarily staff from the agency's GIS (5 staff total) and Modeling (15 staff total) divisions are implementing the tool, but it's not clear how many staff are actually involved at this point; training lasted 2 days for GIS/Modeling staff and 1 day for planners.

- Staff turnover can also benefit an agency by enabling the hiring of new staff with skill sets that enable greater use of 3D modeling or decision support tools. One agency [Vancouver] cites staff turnover as one of the forces of change that enabled the agency to adopt stronger use of its citywide 3D model.

ESC Comment:
Sketch Planning tools are meant to allow planners to sketch and evaluate alternative scenarios on the fly and are not meant to replace other, more accurate models. That said, INDEX's default formulas are quite solid and CommunityViz® allows the user to build very complex, custom formulas so the analysis is as "rigorous" as the user makes it.

13. Sketch Planning vs. Rigorous Modeling

- Some agencies, particularly MPOs, have found that available *"sketch planning" tools* (such as CommunityViz® and INDEX) *do not substitute for the agencies' more rigorous modeling tools*.
- One agency [SANDAG], which has used both I-Place^{3}s and CommunityViz® as a sketch planning tool, still relies on its four-step model for final analyses that are submitted to the US Environmental Protection Agency. The agency is also focusing on improving its traditional models, linking schematic models to GIS, and displaying model outputs on the web (i.e., as overlays on top of Google maps).
- Another agency [PSRC] discontinued use of INDEX at the conclusion of a regional planning process and is now adopting a customized UrbanSim model. The *agency expects that the rigorous modeling functions of INDEX can be replaced by UrbanSim in the future*.

ESC Comment:
UrbanSim is a forecasting model, whereas INDEX requires users to locate or "sketch," such as creating a future scenario. It appears that the agency may no longer need INDEX because the regional planning stage is done. Indicators previously tracked by INDEX would then be more rigorously addressed by the new UrbanSim.

14. Collaboration with other Agencies and Institutions

- Agencies [PSRC, Portland, MAPC, and Vancouver] are increasingly collaborating with other agencies and institutions, such as universities, to share and acquire data and to jointly pursue new tools.
- One agency [PSRC] participates in a successful regional Light Detection and Ranging (LIDAR) consortium to share and quality-check LIDAR data.
- Another agency [Portland] is working with other government agencies and universities to make 3D modeling more of a collaborative, regional effort.
- Two agencies are currently collaborating with a university or hope to do so in the future. As part of a neighborhood planning process, one of these agencies [MAPC] is working with a local college to test both the effectiveness of 3D visual simulation in general and the effectiveness of Second Life as a simulation and public outreach tool. The other agency [PSRC] is working with other agencies in its region to develop a customized

version of the Arizona State University's 3D simulation tool, Decision Theater, for the region.

- One agency [Vancouver] is participating as a pilot city in Autodesk's Digital Cities Initiative, which will enable the agency to explore and adopt the next generation of tools. Through the Digital Cities Initiative, Autodesk plans to explore ways to integrate CAD, building information modeling (BIM), geospatial, civil engineering, and infrastructure data over a wide geographic area and to combine these types of data with realistic visualization, analysis and simulation tools.

15. Legislative Impetus for Adopting Tools

- An agency's decision to adopt 3D modeling and decision support tools is increasingly influenced by state legislation:
    - In California, the state's climate change legislation requires MPOs to consider land use as part of the transportation planning process and to consider alternative strategies if plans do not meet greenhouse gas targets. In response to this requirement, the updated *California Regional Transportation Plan Guidelines* recommends that MPOs use "fast-turnaround sketch modeling tools for testing scenarios" in public workshops. In response to these requirements and guidelines, one agency [SANDAG] decided to adopt I-Place^{3}s and, subsequently, CommunityViz.
    - The requirements of the State of Washington's statewide growth management legislation influenced one agency's [PSRC] decision to adopt a decision support tool (INDEX) and to purchase a separate server for backing up data.

16. Internet Connectivity / Online Use of Tools

- Reliance on the internet for public meetings (i.e., for the use of Google Earth) can be problematic due to unreliable internet connections at meeting locations.
- Numerous agencies are currently using the web, or would like to use the web, to house 3D modeling and decision support tools for public use.
- Some commonly-used decision support tools, such as CommunityViz® and INDEX, have either limited online functionality or no such functionality. MetroQuest, on the other hand, typically customizes a simpler, online version of the tool

that can be used online. One agency [CMAP], which is using MetroQuest for a regional visioning effort, plans to keep the tool active online once the project is completed.

- On the other hand, web-based decision support tools that *only* work online, such as I-Place[3]s, are constrained by the lack of direct access to data repositories or control over the data [SANDAG].
- One agency [M-NCPPC] is using its web site to house Google SketchUp 3D visual simulations and animations of proposed development projects. The models are created and submitted by developers, and the public has an opportunity to rate and comment on the projects.

ESC Comment:
These are not true animations, but rather snapshots of aSketchUp model that has been rotated in increments. Using Flash to stitch together the snapshots results in the illusion of moving around the SketchUp model, when in fact the model—not the viewer—is moving. Notwithstanding, this technique results in an efficient model which can be shown on a web site.

17. Hardware Obstacles

A. Video Cards

- Some tools require up-to-date and/or gaming-quality video cards. Agencies report having to purchase new hardware to run animations in tools such as Google Earth, Scenario3D, 3DS Max, and Vizhen. In the case of Vizhen, which is based on gaming software, the agency [Steamboat] had to purchase an up-to-date laptop with a gaming-quality video card to run its Vizhen model.
- One agency [MAPC] notes that it is more difficult to replace video cards in laptops than in desktops. For this reason, the agency requires a strategy for upgrading and purchasing computers. The same agency suggests buying high-end computers early on because one cannot assume that the tools will work well on every computer.

B. Computer Speed and Memory

- Although PCs with insufficient speed and memory are becoming less of an issue as more agency PCs are upgraded, this remains a significant issue in some planning departments. Standard-issue PCs remain insufficient for tasks such as 3D modeling and video simulations.
- In particular, some agencies report that planning and urban design staff tend to have older computers and frequently have trouble running ArcGIS and other GIS-based tools.
- Other agencies report that computer speed issues stem from the tools themselves (i.e., INDEX and CommunityViz®) and the time required for data processing, rather than from insufficient hardware.

USE CASE EXAMPLES

- It took PSRC a long time to run INDEX and generate growth scenarios for a regional planning process. The agency attributes the speed of data processing to the size of the region and the data inputs (considerable amounts of data that were unusually technical and detailed for this type of application).
- SANDAG intends to use CommunityViz® as a public participation tool for transportation planning, but staff have found that the tool does not currently run as efficiently as the agency would like. The agency is working with the vendor to address this issue.

C. Data Management and IT Support

- Numerous agencies cite problems with the storage and maintenance of both 3D and GIS data as one of their most significant challenges.
- At least one agency [M-NCPPC] cites a need for IT staff who are specialized in specific applications. Planning and urban design staff in this agency have expressed a desire to hire outside help for certain data (i.e., 3D graphics), but the agency's IT staff has resisted this request (it may be an issue of developing in-house capacity rather than relying on consultants for such tasks).
- Another agency [Gosford] seeks to maintain primary control of its 3D modeling tool, but now relies on IT staff to maintain the model and its data due to the size of both.

18. Topographic Data is Often Problematic

- Numerous agencies cite the challenge of finding sufficient topographic data for use in 3D visual simulations and analysis as well as in 3D rendered animations. Problems include the lack of good topographic data, the large size of topographic data files, and the difficulty learning how to use all available topographic capabilities for certain tools.
- As makeshift solutions, agencies have resorted to drawing in contours by hand [M-NCPPC] and splicing together GIS data and USGS terrain data to create a 3D terrain model [Steamboat].
- One agency [PSRC] would have adopted 3D analysis (using ArcGIS 3D Analyst) to a greater extent if it had had the foresight to create elevation datasets for transportation data in a better way.

19. Social Media / Citizen Data Collection

- Some agencies are adopting new social media and mobile technology—such as keypad polling devices and smart phones—to enhance public participation and data collection.
- Two agencies [MAPC, CMAP] regularly use keypad polling in public meetings for voting and sharing opinions in real time. A third agency expressed a desire to adopt keypad polling.
- One agency [CMAP] uses smart phones as a tool for community asset mapping by groups of volunteers. The agency provides both the smart phones and training on the use of the tool for data collection, and community groups have used smart phones for data collection and real-time mapping of issues ranging from food quality to historic preservation. Data generated by the mapping is then provided to local officials, enabling communities to lobby on their own behalf.

20. Licensing and Interoperability Issues

- Numerous agencies cite software licensing issues as an obstacle to effective use of 3D modeling and decision support tools:
    - Agencies have expressed concern over the licensing of Google products for use by public agencies. Some jurisdictions are cautious about using the free, public version of Google Earth without a license; other agencies continue to use Google Earth even though they are "technically not supposed to" do so. Some agencies also supplement the use of the free version of Google Earth with copies of Google Earth Pro or a Google fusion server.
    - Licensing issues have made it difficult to integrate Google and ESRI data, using a multipatch plug-in [M-NCPPC].
    - For GIS-based decision support tools, such as INDEX, an up-to-date ArcGIS license is required to run the tool. One agency [PSRC] has encountered GIS compatibility issues when first attempting to run INDEX and therefore had to upgrade to a more recent version of ArcGIS.
    - Agencies also cite the challenge of balancing financial considerations with having enough licenses of ESRI tools. One agency [DCOP] notes the inefficiency of providing ArcGIS for a large department of 40+ users. Another agency [SANDAG] is considering switching to

Google Earth or an ArcGIS server due to licensing considerations. Another agency [Portland] developed a "stripped-down" ArcGIS engine in-house that is used as a data viewer and is installed on every employee's computer.

- Some licensing arrangements can benefit agencies. One MPO's [SANDAG] CommunityViz® license includes the ability to share the tool with all of its member jurisdictions free of charge. Another agency [DCOP] received a citywide 3D model from Google in exchange for the use of aerial imagery. With a license to Pictometry, a third agency [Vancouver] received 400-500 building "skins" for downtown buildings to add to its citywide 3D model.

3.5 Agency Interviews: Tool-Specific Findings

In addition to the larger themes that emerged during the agency interview process, the ten agencies interviewed provided specific comments on their experience with particular tools. These tool-specific findings are summarized below.

It is important to note, however, that many of these comments are subjective and do not necessarily reflect inherent flaws or benefits of the tools. Rather, these comments are colored by the experience of a single individual or group of individuals, and an agency's experience with a tool may be influenced by a variety of other factors that can determine the success of a tool for a particular agency: the intended use of the tool; existing staff skills; agency investment in training and maintaining staff; whether the tool was used in-house or by a consultant; available hardware for operating the tool, etc. While these findings are instructive as "lessons learned," they are not an objective and comprehensive assessment of available tools.

For a more detailed and objective survey of available tools, please refer to the accompanying Tools Evaluation in Chapter 2 of this document.

3.5.1 Real-time 3D viewers

3.5.1.1 ArcGIS Explorer

Planning Support Activities

Visual simulations of traffic issues; fly-throughs of 3D building models.

Advantages

- Generally successful overall for transportation-related visual simulations.
- Great at showing how transportation networks work.
- Good for creating videos with complex GIS information.

Disadvantages

- The tool can be "buggy."
- Graphics quality is rudimentary.
- When possible, Google Earth is preferred for creating animations.
- If agencies were not "stuck" using ArcScene for 3D real-time visual simulations with complex GIS information, they might select other tools.

3.5.1.2 Bing

Planning Support Activities

As an alternative to Google Earth for specialized tasks; primarily used with Pictometry data.

Advantages

- Oblique aerial imagery is available in Bing.

Disadvantages

- The tool has less of an open format (in terms of the ability to distribute data) than Google Earth, a similar tool.

3.5.1.3 Google Earth

Planning Support Activities

Corridor-level visual simulations for traffic; fly-through animations and videos; creating a movie that links Google Earth photographs with orthophotos.

Advantages

- The tool is effective for creating movies and real-time visual simulations.
- It is superior to other tools for creating real-time visual simulations.
- It works well with Google SketchUp and is great for georeferencing SketchUp models so that one can be confident that models will end up in the right location when exported.
- Google Earth has more of an open format (with regard to the ability to distribute data as KML files) than Bing, a similar tool.

Disadvantages

- Google Street View does not look good in public meetings due to the graphics quality when projected on a screen.
- Google Earth is difficult to customize.
- The tool is dependent on the internet, which can become a problem if public meetings and workshops are held in locations without reliable internet connections.
- For videos, it requires an up-to-date video card.
- Storage of files on Google's server raises some concerns about intellectual property and sensitive information, especially for controversial projects ("Where do the files go after you are done using them?").
- It is difficult to make groups of images (multiple 3D models) turn off and on.
- Licensing issues are a concern for some public agencies.

ESC Comment:
Models do not necessarily have to be uploaded to Google's server.

3.5.1.4 Pictometry

Planning Support Activities

Measurements; fly-over visualizations; assessments of disaster mitigation and emergency response (state Department of Transportation); creation of building "skins" for 3D models.

Advantages

- The tool is great for measurements and useful for fly-overs.
- Pictometry's new 3D building exporter has potential.
- Pictometry "skins" can give 3D models a photorealistic quality.

Disadvantages

- The tool may not be worth the cost. It is very expensive and requires a lot of upkeep.
- *The geometry of 3D models can be diminished by adding Pictometry "skins."*

ESC Comment:
Adding photo-real textures or "skins" to 3D models will not derogate the underlying geometry. However, photo-real textures/skins may obscure some geometries while viewing. In some cases, for instance height and bulk questions, using textures on models can indeed detract from the issue being examined.

3.5.1.5 Simurban (Simmersion)

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Development review and decision-making regarding proposed development; as evidence in court challenges; view analysis; shadow analysis; long-range planning; establishing height limits for future development.

Advantages

- Excellent graphics quality. ("It's like looking out my window")
- The tool has a high level of accuracy (+/- 0.1m verification) and is very detailed. The high level of accuracy has made it successful in court challenges. Developers cannot compete with it and now often choose not to go to court over development applications because of the model's accuracy.

- The tool's georeferencing capability makes it easy for staff to drop new 3D models into the larger model.
- The tool is effective for reviewing development proposals.
- Minimal training is required for staff to be able to operate the tool for regular tasks, such as adding new models to the large-scale model.
- The tool is mostly self-sustaining after initial model development and training.
- Developers have responded well to the tool because it results in better presentations and discussions and also reduces the amount of time and the number of meetings required as part of the approval process.
- The public has responded well to the use of 3D models to simulate development.
- The tool makes planners' jobs much easier by helping them visualize proposed development with highly accurate model and by facilitating decision-making.
- Council decision-makers have responded well to the tool because it makes decisions easier for them as well.

Cons

- The tool is proprietary, and an agency must rely on outside parties to develop the model.
- The tool is expensive.
- The latest version of the software is problematic because it has made the tool unnecessarily complicated. Some of the latest features (i.e., showing the glare of the sun reflecting off a building and additional sound effects) are not necessary. In addition, changes in the under interface have made the measurement tools more difficult to use.
- Simurban is less effective than other tools, such as Skyline or Google, for loading quickly and looking at the entire city.

3.5.1.6 Skyline (Terra Explorer)

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

In-house analysis of large areas; regional planning; analysis of parks, open space and wildlife issues; analysis of transportation issues.

Advantages

- Can be linked to GIS data.
- The tool can be loaded and opened quickly relative to other, more detailed tools.
- It is useful for looking at "big picture" issues and at a larger area.
- It is cost-effective for large-scale planning.

Disadvantages

- A learning curve is involved in adopting the tool.
- The graphics are poor and do not compare to the more detailed 3D modeling tools (i.e., Simurban).

3.5.1.7 Vizhen (Winston Associates)

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Development review; general planning activities.

Planning Support Activities

As a viewer for citywide 3D model; 3D visual simulation and 3D rendered animations

Advantages

- Easy to learn how to navigate in the tool.
- Planning staff are able to operate the tool (i.e., navigate the 3D model) on their own, without the use of a consultant.
- The expansive terrain modeling in Vizhen goes beyond what is possible in SketchUp alone.

Disadvantages

- The tool will not run on some computers, due to insufficient video cards and/or processor speeds. A gaming-quality video card is required.
- Dependence on consultant to develop models.

3.5.2 3D Modeling Tools

3.5.2.1 3DS Max

Planning Support Activities

3D visual simulations and animations; development of 3D models; finishing 3D models created using other tools; housing large-scale 3D models.

Advantages

- Good graphics, animation and rendering capabilities; serves as a good tool for finishing 3D models and viewing the models.

Disadvantages

- Models can be difficult to maintain in 3DS Max because the tool does not have the capacity to use large origin point numbers. It rounds off these numbers and consequently distorts the model. For this reason, models need to be converted back to an AutoCAD file with a GIS extension and must be housed in a separate version of the model.
- The tool is relatively expensive compared to other 3D modeling tools.
- The tool has a steep learning curve, is "too technical," and takes time to learn how to use.
- There is no support for attributes.
- Consultant-generated rendered 3D animations can be a waste of money. They require a lot of time and resources, with lots of back and forth with the consultant, but yield comparatively few benefits.
- The 3D video simulations *take too long to load and view* to show at public meetings.
- *The 3D videos look too "cartoonish."*

ESC Comment:
The videos are large but could easily be reduced in length and/or file size converting them to another format with any number of video editing tools. Any large file will take a while to download of the internet, but once they are saved locally, the files open almost instantly on a reasonably new computer.

ESC Comment:
3DS Max is an extremely capable and sophisticated tool and can create very life-like renderings; however, maximizing these capabilities depends on the user having a high level of skill.

ESC Comment:
Very often, public agencies may enter into agreements with visualization consultants, in which the ownership of the underlying 3D model used to create the rendered animation may reside with the consultant and not with the agency.

- *Agency staff are not able to modify consultant-generated visualizations*.

3.5.2.2 AutoCAD

Planning Support Activities

Site/project measurements; building individual 3D models for inclusion in larger citywide model.

Advantages and Disadvantages

None specified.

3.5.2.3 Google SketchUp

Planning Activities

Visioning; master planning at the county, region, municipal, district/neighborhood level and for streetscapes; urban design analyses and presentations; design and assessment of development regulations; historic preservation reviews; development review; site analysis and selection; and civic engagement.

Planning Support Activities

3D modeling; 3D animations in real time and/or pre-rendered/pre-pathed animations; perceptual density analyses; shadow studies; and "finishing" models created in other software (i.e., ArcGIS 3D Analyst)

Advantages

- Users are generally happy with SketchUp because it is quick, fun, and easy to learn and use.
- SketchUp is available at no cost for the basic version, which meets the needs of most agencies.
- It is easy to pick up the basics of the tool.
- Tasks can be completed in a reasonably short period of time.

- Designers especially like the tool.
- SketchUp is a great tool by itself, even if it is used only to create a conceptual model, because it helps people wrap their minds around a development or planning concept. The tool lends itself to being conceptual.
- The tool has a user-friendly interface.
- Google's online training videos are very helpful. Google Warehouse is great in terms of providing ways to dress up 3D models.
- SketchUp looks better and is more distributable than 3D Analyst.
- Many planners are eager to use SketchUp.
- Use of SketchUp brings a "whiz bang factor" to planning activities.

Disadvantages

- SketchUp models are *not always accurate*. It is easy to lose track of perspective, and there can be a difference between how a building looks in the model and how it looks in reality. This assessment of the tool reflects the experience that SketchUp also does not scale as well as other 3D modeling tools.

ESC Comment:
The level of visual and dimensional accuracy, in fact, depends on the skill of the modeler; SketchUp can be a very accurate tool if used properly.

- The tool lacks "out-of-the-box" analytical capability, and this deficiency is compounded by poor compatibility with ESRI products.

- Even though SketchUp is relatively easy to use compared to other modeling tools, *there is still a learning curve* involved as well as time involved getting up to speed.

ESC Comment:
Of course there is a learning curve, which is modest. The tutorials are clear and easy to understand and building models is straightforward after one feels comfortable with the methodology, which is also quite intuitive.

- Finding proper base information can be challenging, and sometimes *base elevations can be inaccurate* due to compatibility issues with other tools, such as ESRI products.

ESC Comment:
If this comment is about Google Earth, its terrain is generalized so that it can display large areas. The size of the project area and the type of project is another consideration which should determine the accuracy needed. For large-area projects, USGS information may be sufficient; at a site level, one could use an electronic site survey.

ESC Comment:
This assessment should be contingent on the purpose, activity, and resources. SketchUp, as it is called, is a sketch tool which allows the user to quickly create objects and visualize them in real time. It cannot compare with a highly rendered, pre-pathed animation done in 3DS Max. SketchUp serves a different purpose.

- The tool has *poor rendering and animation capabilities relative to other tools*, such as 3DS Max.

- Management, maintenance and storage of 3D files can be challenging.
- Google Warehouse does not include sufficient imagery that reflects local conditions (trees, buildings, etc.).
- Integration with CommunityViz® is problematic; *exported images are assigned individual generic file names*.

ESC Comment:
The vendor indicates that this issue will be corrected soon.

Other Findings

- SketchUp users often tend to be self-taught.
- "What starts in SketchUp often stays in SketchUp" due to issues with exporting data.
- While a growing number of agency staff are using SketchUp, the number of staff who are truly proficient in the tool and capable of production-quality work is still comparatively small.

3.5.2.4 MultiGen / Paradigm

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

3D visual simulations.

Advantages

None specified.

Disadvantages

- 3D visual simulations produced with the tool are not maintainable.
- It was expensive to hire an outside consultant to produce the 3D visual simulations with the tool, and visualizations were not well understood by the intended audience. [Consultant Comment: We assume that the 3D visual simulation was a real-time, rather than pre-pathed, rendered animation. However, the fact that the simulations were not well understood may have more to do with poor communication of the intended information than with an inherent characteristic of the tool.]

3.5.2.5 Rhino

Planning Activities

Sophisticated drawing tool for curved surfaces.

ESC Comment:
Only one agency's views are reflected in the following comments.

Advantages

- The tool produces beautiful drawings.

Disadvantages

- The tool has a steep learning curve.

3.5.3 3D GIS Tools

3.5.3.1 ArcGIS 3D Analyst

Planning Activities

Views and visibility analysis; terrain modeling; streetscapes; rendered 3D animations; 3D extrusions of building data; 3D visualization of data related to transportation, economic development, population and demographics, and growth management.

Advantages

- The tool provides analytical capabilities, and its analytical tools are very sophisticated.
- 3D Analyst is effective for representing proposed population and employment distribution generated by INDEX outputs.
- 3D representations (i.e., population and employment) have been well-received by the public when included in a PowerPoint.
- The tool improves day-to-day efficiency and business practices by clarifying certain issues for the public and decision makers.

Disadvantages

- Poor integration with Google tools.
- Poor graphics quality. *Although not a lot of detail is needed when objects are in motion, people look at these graphics critically when the scene stops moving*. In this respect, 3D Analyst falls short.
- The tool is not as good as SketchUp and other 3D tools for creating "finished" models.
- Spatial joins building data indicating the number of stories are problematic for multi-building properties.
- Management, maintenance and storage of 3D files can be challenging due to the size of the data files.
- Many of the *3D Analyst tools are too detailed to be used at a regional level*.

ESC Comment:
3D Analyst was probably not intended for the pedestrian-level viewing needed for urban design, but rather for larger scale landscape that is more appropriate to GIS applications.

ESC Comment:
It is unclear as to what is being referred to here. The tools themselves? Or detailed 3D models imported by the tools? Again, the appropriate level of detail for 3D models needs to be determined by the scale of the area being examined.

3.5.3.2 AutoCAD Map 3D

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Maintaining large-scale 3D models.

Advantages

- Better than other tools (i.e., 3DS Max) for maintaining large-scale 3D models due to its georeferencing capabilities and ability to handle large origin point numbers without distorting model.

Disadvantages

None specified.

3.5.3.3 CommunityViz® - Scenario3D

Uses

Long-range planning and 3D visual simulations; scenario analysis.

Advantages

- The tool combines analytical and 3D modeling capabilities.
- The tool has good navigation capabilities.

Disadvantages

- Poor graphics quality. Graphics were reported to be too "blocky" and "cartoony" in appearance. The tool's proprietary 3D component is unconvincing and inadequate for design staff, and these capabilities were ultimately not leveraged. 3D outputs are not convincing enough for presentations in front of the Planning Board. *It is not possible to "design buildings through the data."* It is hard to get buildings to "look good."
- The tool is not intuitive in terms of rotation values and point specifications.
- The tool can be "buggy" and sometimes crashes.
- It is hard to export from certain versions of SketchUp; *file names get altered to generic names*.
- The tool's fly-though capabilities are inferior to those of Google Eart**h**

ESC Comment:
Designing buildings is not the intended purpose of the tool. It is, however, supposed facilitate the creation of a 3D scene by parametrically creating some elements of the scene, such as vegetation and roads.

Also, see prior consultant comments on constructing models that "look good."

ESC Comment:
The vendor indicates that this issue is being resolved.

3.5.4 Planning Decision Support Tools

3.5.4.1 CommunityViz® - Scenario 360

Planning Activities

Master planning; in-house scenario analysis; public participation; bicycle and pedestrian modeling; evaluation of transportation alternatives and transit catchment areas; evaluation of zoning changes.

Advantages

- The tool offers good 3D visual simulation capabilities.

- The use of slider bars, bar graphs and formulas is intuitive.
- The tool has a good overall interface and aesthetic.
- It is easy to teach and show others how to use the tool.
- It can handle many indicators (including all of the 25 different indicators required by one particular agency in its RFP for sketch planning tools).
- Overall, it is a great extension to GIS.
- CommunityViz® can do a lot of great analysis on a range of indicators and planning issues (i.e., environmental, economic, transportation modeling).
- The tool's price point is good relative to the power of the tool.
- The tool's real value is linking visual and analytical outputs.
- Fosters (and requires) collaboration among key agency staff and specialists.

Disadvantages

ESC Comment:
The tool does create some web-ready outputs, but most of the functionality of the tool is limited to the desktop.

- The tool is not web-based.

- Still working with vendor to get the tool to run efficiently on computers and in public meetings.

- Tasks take too long to complete.

ESC Comment:
This response may suggest that effective use of the tool requires an agency to think about doing business in a more integrated way.

- It has been *a challenge to evolve longstanding business practices* and to coordinate the staff time and participation necessary to use the tool. This requires enlisting all of the different players to help build the model and make it fit with existing business processes.
- It is difficult to customize outputs in the agency's preferred manner.
- The tool's presentation functions lack the capability to customize the graphs and charts (PowerPoint is used instead). Data must be taken out of CommunityViz® to display in the agency's preferred manner.
- If there were more time and money, it would be possible to get the more out of the tool, but it takes time to master.
- CommunityViz® requires a consultant to train staff.
- The tool works better for a small area than for a region.
- Overall, *there is a lot to think about while using the tool*.

ESC Comment:
Yes, and that is exactly the idea of the tool. If used as intended, CommunityViz® is designed to handle complex issues without "dumbing them down."

3.5.4.2 INDEX

Planning Activities

Regional growth management plan; population growth projections.

Advantages

- Overall, INDEX was beneficial. It is most useful for creating future land use inputs.
- The tool is viable for getting a point across to the public and to decision makers.
- It is offers good public relations capabilities in terms of achieving "buy-in" from constituents when the tool is used in a technically rigorous way.
- The tool could be very powerful and useful if applied to a neighborhood-level or subarea planning process.
- The tool was "not that hard" to learn.
- No problems were experienced with technical support or troubleshooting from the consultant.

Disadvantages

- The tool requires staff who have GIS training.
- *Although the tool could be used at community meetings, it would be resource-intensive to do so and would require breaking participants into small groups with one GIS-trained facilitator for each group.*
- Works better for smaller areas than for larger areas.
- The tool is slow to process data; technical data and data for large regions are especially slow to process, which makes the tool unsuitable for real-time analysis.
- The tool was not useful for public participation when applying the tool to a large region, due the amount of data and the time required to process it.
- The tool requires an up-to-date ArcGIS license to run.

ESC Comment:
This could be said of any GIS-based Decision Support Tool – except, perhaps MetroQuest, which is more of a presentation tool than an actual GIS tool.

3.5.4.3 I-Place^{3}s

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

In-house scenario analysis tool for General Plan updates.

Advantages

- As a tool, it was successful for long-range planning to some extent.

Disadvantages

- The tool is very expensive, and it is hard to justify the cost: $60,000 per year for hosting and support (in contrast, CommunityViz® will cost less for 5 years than I-Place^{3}s does for one year). An additional $15,000 was spent on needs that went beyond the original contract.
- The agency was dependent on the vendor. Only 2 staff knew how to use the tool, but they were only "conversant" in the tool.
- It takes a long time to get up to speed with the tool.
- Web-based format was a constraint because there was no direct access to data repositories or control over the data.
- The agency did not have a good relationship with the vendor; the vendor was slow to respond when approached with questions.
- There was a lack of expertise in-house to leverage all of the tool's capabilities (even though this is possible, as illustrated by the Sacramento Area Council of Government's use of Place^{3}s).
- The tool is a very customized product, which means that there are not a lot of coordinated updates to the tool.

Other Findings

- The agency interviewed had used the tool as an in-house tool, but noted that tool has been used elsewhere (i.e., Sacramento metropolitan area) as a public outreach tool.

3.5.4.4 MetroQuest

Planning Activities

- Public visioning efforts; as an educational tool for community outreach.

Advantages

- The benefit of MetroQuest is that planners already know the set of questions and assumptions and can keep control of the conversation (i.e., no wild requests from stakeholders).
- The tool allows the public to pick their own priorities and policy "levers" and to compare multiple scenarios at the same, in real time rather than after-the-fact.
- The response from the public was "very positive."
- MetroQuest worked well as an educational and interactive tool and was "worth the money."
- The agency would like to continue using the tool.

Disadvantages

- MetroQuest is a time-, people- and resource-intensive tool.
- Developing a customized version of the tool can be time-intensive, especially for large regions.
- It is expensive to implement (as much as $350,000 for a large region).
- About 1% of the public, the most "analytical" of participants, questioned the inner workings of the tool and wanted to see the data inputs and parameters; for this reason, these individuals were a little dissatisfied with MetroQuest.
- Developing the language of the questions requires time and thought, and this process would have benefited from focus-group testing (i.e., some rural stakeholders perceived an urban bias in the questions).
- The tool's "real-time" simulation is somewhat "pre-programmed."
- Requires the assistance of the vendor to set up the tool. Data inputs must be sent to the vendor.
- The tool is better suited for the visioning stage of the planning process than for later, more detailed stages of planning.

3.5.4.5 Model Builder (Fregonese Associates)

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Scenario planning; public participation; 3D visual simulation.

Advantages and Disadvantages

As the tool is still in its early stages of implementation, no specific advantages or disadvantages have been identified at this point.

3.5.4.6 Return on Investment Model (Fregonese Associates)

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Helping municipalities assess barriers to new development; assessing impact of local land use regulations to development; assessing incentives offered to developers when negotiating development approvals; revising land use codes; developing RFPs and RFQs for development projects.

Advantages

- Staff who are primarily generalists have been excited to be able to plug regulations and proposed developments into the pro forma.

Disadvantages

None specified.

3.5.5 Social Media / Mobile Technology Tools

3.5.5.1 Keypad Polling

Planning Activities

Real-time polling during public outreach events.

Advantages

- Using keypad polling devices is a simple but effective approach to obtain input in meetings.

ESC Comment:
This assumes that the participants were given the time to review the issues and information and then come to a considered decision.

Disadvantages

None specified.

3.5.5.2 Second Life (Hybrid 3D Modeler and Viewer)

Planning Activities

Public outreach and role playing.

ESC Comment:
Only one agency's views are reflected in the following comments.

Advantages

- Second Life can be a very powerful public outreach tool, especially for engaging the next generation (which has grown up with 3D video games).
- The tool forces stakeholders to play and consider multiple roles.
- Since participants adopt avatars, it is a good tool for engaging people who are more introverted and may not want to speak up in a meeting.
- The tool opens up the time continuum, which gives participants time to process information at their own speed.
- Operates in a closed environment.

Disadvantages

- Second Life has only recently been applied to planning.
- It requires a lot of work to use the tool.
- Currently, the tool is not cost effective.

- The tool's virtual interactivity does not replace human interactivity.

3.5.5.3 Smart Phones

ESC Comment:
Only one agency's views are reflected in the following comments.

Planning Activities

Community asset mapping; data collection.

Advantages

- The data generated has subsequently been used to get new grants for future work.
- Communities are able to lobby on their own behalf, while municipalities are very excited to collect new data.

Disadvantages

- It is important to ensure that community groups have the capacity to collect data and a sufficient number of people to do data collection.

3.6 Agency Interviews: Future Directions

In addition to comments about the tools they have used to date, agency contacts also noted other tools they are considering adopting as well as insights on potential future trends and developments in the industry. These comments are summarized below.

3.6.1 Potential Tools of the Future

When asked whether they were considering adopting other 3D modeling or decision support tools in the future, agency contacts mentioned a number of new or "next generation" tools and technologies as well as their rationale for considering these. Tools mentioned included the following:

- Acrobat 3D (Version 9 of Acrobat Extended): One agency [M-NCPPC] staff member noted that this tool has potential as a 3D viewer. It is possible to export 3D models from 3DS Max and AutoCAD and to embed the 3D models in a PDF file. The potential benefits of this tool are that 3D models can be viewed

and manipulated in a free reader and in a file format that everyone can view on their own computers.

- ArcGIS 9.4: Staff from more than one agency noted that the latest version of ArcGIS will have improved functionality with 3D importing and exporting.
- ENVI 3D image processing system: One agency [PSRC] reports that the ENVI 3D rendering engine is better than 3D Analyst for draping images over 3D wire frames. The agency will continue comparing this tool with 3D Analyst and, based on trials of ENVI 3D, will determine whether to formally adopt the tool.
- FME Server: One agency [Vancouver] purchased a new license for this tool, which enables the online delivery of spatial data.
- LandXplorer: One agency [Vancouver] is exploring the potential to house its large-scale 3D model in the new Autodesk tool LandXplorer, which merges photorealistic 3D modeling capabilities with analytical tools based on GIS, CAD, and other building and engineering data.
- LIDAR Analyst and Future Analyst/Extraction: These tools show potential as future 3D tools. GIS staff from one agency [M-NCPPC] would like to see whether the process of 3D extrusions could be automated by creating polygons from different color thumbprints for roofs and subsequently extruding 3D images from these polygons.
- Pictometry 3D Building Exporter / 3D Digital Cameras: One agency [MAPC] noted that the new 3D building exporter to be released by Pictometry has great potential; however, the agency suggests that a better, alternative approach may be to invest in the new Nikon digital camera that takes 3D photographs.
- Second Life: One agency [MAPC] that is currently experimenting with the tool notes that there could be a more significant role for Second Life in the planning process, especially if it is possible to merge such tools with Google tools.

3.6.2 Emerging Trends and Industry Developments

Agency contacts also identified the following emerging trends and industry developments:

- Potential integration of some components of CommunityViz® and MetroQuest, pending an agreement between these two companies.

- The Sacramento Area Council of Governments is exploring the possibility of making the I-Place[3]s decision support tool an open source, rather than proprietary, tool.
- One agency [MAPC] is participating in a project that includes research on the benefits of 3D visual simulation tools. The study involves two groups of stakeholders participating in a planning process: a control group of stakeholders that are not shown 3D imagery and a second group that is shown 3D imagery. The goal is to assess the extent to which 3D tools are meaningful for the planning process and decision-making.
- Online web mapping and open layers are redefining the continuum of mapping services.
- The future of these 3D modeling and decision support tools will entail the merging of data, visualization and social media tools.

4.0 Tools Evaluation

Introduction

The consultant team researched commercially available and open-source 3D and modeling software tools and evaluated each for their potential benefits for various planning activities or *use cases*. This involved creating a list of available tools (see the **Tools Survey**, section 2.4) as well as identifying a range of planning activities that the tools would be measured against (**Planning Activity Use Cases**, section 4.1.2 below).

A detailed analysis of each tool was performed that identified the benefits, challenges, and staff and training considerations of each tool. The tools are organized by their functional categories: Real-time 3D Viewers, 3D Modeling Tools, 3D GIS Tools, and Planning Decision Support Tools. For each category of tools, a comparative evaluation of the tools is made based on how well they support each of the ten identified Planning Activity Use Cases. A summary matrix of our findings is provided below (section 4.2).

4.1 Planning Activity Use Cases

The term "use case" is commonly used in software development and refers to how an end-user would interact with a piece of software to achieve a particular task or activity. The utility of software is measured against how well it supports those use cases. Use cases tend to focus on operating software as an end-user would conduct their day-to-day activities. Use cases can be quite broad (i.e. write a letter in Word), or quite disaggregated and specific (i.e. open a new document, select a template to use, set margins, choose a font, etc.) If we were designing software, more specifics would be best. But we were not designing the software, we were evaluating of how well existing 3D modeling and Planning Decision Support Systems software serves planner's needs in general. With this in mind, we tried to keep the list of use cases relativity small but as distinctly different types of planning activities.

4.1.1 How the Use Cases Were Developed

Prior to the Planning Agency Survey and Interviews in Task Two, the Consultant Team identified an initial list of typical planning activities and asked the agencies to identify which tools they used with each

planning activity. The choices of planning activities included on the survey were:

- Community Outreach
- Community Visioning and Planning
- Developing Plans
- Developing Regulations
- Development Review,
- Impact Analysis,
- Community outreach
- Other (fill in)

The results of the survey seemed to confirm that theses basic planning activities we picked were valid in that there were very few "fill-ins" and that most of the fill-ins that were added tended to be more specific activities that could fall under one of the more of the general activities listed. (i.e. "Comprehensive Plan Update" falls under the more general activity "Developing Plans".)

The Consultant Team also interviewed the Prince George's County Planning Department and learned about the various planning activities the Department engaged in. Again, most of them fell under the more general activities list, but a few were mentioned enough (specifically "Urban Design" and "Build-out Analysis") to warrant adding to the list. It also became apparent that at least one of the "original" uses cases – impact analysis – was just too broad and would need to be broken out into several more specific use cases: visual impact analysis, shadow impact analysis, and quantitative impact analysis.

4.1.2 Final Planning Activity Use Cases

The final set of use cases and their definitions are listed below and are used to evaluate the software applications:

Community Outreach
For purposes of this study, this refers to tools that support the ***production*** of materials that educate the public about visions, plans, projects, and regulatory and policy issues and therefore does not evaluate public collaboration and/social networking types of outreach tools. The materials can be in a variety of formats with the emphasis on exporting to the web.

Community Visioning and Planning
Visioning within the context of planning is the process of identifying, developing and documenting community vision and values, typically

leading towards the principles, objectives, and implementation strategies that are the underpinnings of a Master or Area Plan. Typically, these are tightly run workshops or charettes facilitated by either planning staff or consultants designed to reach consensus within a certain time constraint. In addition to any software actually used at public events, the study considers tools that are typically used prior to the visioning activities to provide supporting maps, studies, alternative design scenarios, etc. which are used to inform the participants' decision-making process

Developing Plans
"Plans" refer to all the various types of plans that planners create. These can be comprehensive plans, master plans, section plans, area plans, Plans normally define the goals and objectives that determine how land will be used, and are the basis for regulations such as zoning or design guidelines.

Developing Regulations
A regulation is a form of secondary legislation issued by a government agency under the authority of primary legislation. Regulations are used to make the detailed arrangements which give effect to the intent and purpose of primary legislation. In the case of planning, zoning, historic preservation, environmental quality, etc. are examples of the laws that regulate the use of land to effect the intent and purpose of the Master Plan (the Primary Legislation).

Urban Design (added)
Urban design concerns the arrangement, appearance and functionality of towns and cities, and in particular the shaping and uses of urban public space. Urban Designers typically work at the neighborhood, district, and streetscape level, and consequently need tools that work at a greater precision and level of detail than tools land use planners use.

Development Review
Development review is a regulatory process that includes both reviews by staff and public reviews by a planning commission. Development Review involves checking development applications against the zoning, master plans, environmental regulations, transportation plans, design guidelines, etc. established by the community.

Visual Impact Analysis (expanded from "Impact Analysis")
A visual impact analysis can be quantitative (how much can be seen/not seen) or qualitative (does a design "fit in" with its context). Visual impacts can be assessed with viewshed analyses, photomontages, 3D models, artist renderings, etc.

Shadow Impact Analysis (expanded from "Impact Analysis")
The change in the amount of direct sunlight and shadow a piece of land or structure receives as the result of a proposed action. For the purposes of this study, Shadow Impact Analysis may include daylight analysis - which is the amount of direct AND indirect sunlight that a piece of land or structure receives as the result of a proposed action.

Quantitative Impact Analysis (expanded from "Impact Analysis")
The quantitative assessment of the magnitude of loss or gain to be realized should a specific event or scenario occurs. In planning, some typical quantitative impacts are: traffic impacts (traffic counts, LOS), environmental impacts (storm water runoff, air quality), social impacts (demographics, housing affordability), fiscal impacts (tax revenue, capital improvement costs), etc.

Build-out Analysis (added)
A build-out analysis is an estimate of the amount and location of potential development for an area (or "holding capacity" based on current zoning and other applicable land-use regulations). Evaluation of potential development impacts begins with a build-out analysis. Typically, the analysis is broken into two parts: hypothetical build-out and practical build-out under current zoning. The former simply multiplies out the allowable building densities in a zoning code by the area of the land. The latter (practical build-out), removes land from the analysis that, while zoned for development, is not likely to be developed due to limited access to infrastructure, impractical lot configurations, and natural constraints (like bad soils, steep slopes, wetlands).

4.2 Summary Matrix: Tools Evaluated by Planning Activities

Key
● Excellent Support
O Good Support
○ Some Support

	1. Community Outreach	2. Visioning & Planning	3. Developing Plans	4. Developing Regulations	5. Urban Design	6. Development Review	7. Visual Impact Analysis	8. Shadow Impact Analysis	9. Quantitative Impact Analysis	10. Build-out Analysis
Real-time 3D Viewers										
ArcGIS Explorer	●	●	–	–	○	–	–	–	–	–
Bing/Pictometry	O	O	–	–	○	–	–	–	–	–
Google Earth	O	●	–	–	○	–	–	–	–	–
Simurban World Simulator	○	O	O	O	●	O	●	O	–	–
TerraExplorer (Skyline)	●	O	○	○	O	O	●	O	–	–
3D Modeling Tools										
3DS Max	○	○	–	O	●	●	●	●	–	–
ArchiCAD	○	○	O	○	●	●	O	O	O	–
AutoCAD	○	○	O	○	●	●	O	O	–	–
Google SketchUp	O	●	○	●	●	●	O	O	–	○
Microstation	○	○	O	○	●	●	O	O	O	–
Vector-works	○	○	O	○	●	●	O	O	O	
3D GIS Tools										
ArcGIS 3D Analyst	○	O	O	○	O	○	O	–	○	–
AutoCAD Map 3D	○	○	O	○	●	●	O	O	○	–
CommunityViz® - Scenario 3D	○	O	O	○	O	○	○	–	O	○
Planning Decision Support Tools										
ArcGIS (Desktop)	O	O	●	O	○	○	–	–	●	O
ArcGIS Spatial Analyst	○	O	●	O	○		O	–	●	O
CommunityViz® - Scenario 360	O	●	●	O	○	○	○	–	●	●
INDEX	O	●	●	O	○	○	–	–	●	–
IPlace3s	○	●	●	O	○	○	–	–	●	–
MetroQuest	●	●	O	–	–	–	–	–	○	–

4.3 Real-time 3D Viewers

Real-time 3D viewers are software applications that create virtual 3D environments that are rendered in "real time" as compared to pre-rendered/pre-pathed animations which are essentially movies. This means the user can freely move anywhere in the 3D environment and observe objects from any perspective and location, rather than from a pre-recorded path or fly-through.

4.3.1 Tools Overview

Quick Facts
A text box with general information about each tool is included in the margins next to the tool's evaluation. It has general information about the tool including name, vendor, initial costs, maintenance costs, platform, and prerequisite software.

Cost are all indicated as relative. In general, the symbols roughly indicate cost per seat:

$	-	$1 - $500
$$	-	$500 - 1500
$$$	-	$1500 - $3000
$$$$	-	$3000 - $5000
$$$$$	-	> $5000

Five real-time 3D viewers are evaluated here. All of them, except Simurban, are "globe" viewers that permit the user to look at the entire globe, or zoom down to a particular street. All of the globe viewers have different levels-of-detail/resolution for both the geometry of the terrain, and the imagery draped over it. As you zoom closer and closer in, higher resolution data is switched on and the lower resolution is switched off. This is done to optimize the performance of the real-time fly-through. Frequently the highest level of terrain detail for the globe viewers is not fine-grained enough to accurately represent the terrain at eye-level – particularly in very hilly areas. In these situations it is generally preferable to generate a fine-grained terrain model.

All of the globe viewers need to be connected to the web in order to be able to work properly. This is particularly true of Bing, which is entirely browser-based. The other globe viewers all have stand-alone viewers that work independently from the web browser. This permits the user to load data that has been saved to a local computer, or cached in the local computer even if the computer is not connected to the internet. Simurban is the only real-time 3D viewer of those discussed that does NOT connect to the internet.

Simurban and Skyline are different from the other viewers in that they both consist of a viewer application, and a content generation application. Although the content generation components have a lot in common with some of the 3D GIS tools, Simurban and Skyline are discussed here along with the viewers because, in both cases, it is rare when the end-user generates the content themselves. Most of the time the vendor or a consultant does that. Simurban does, however, allow users to position buildings interactively, as well as create massing models.

4.3.1.1 ArcGIS Explorer (ESRI)

Tool:	**ArcGIS Explorer**
Vendor:	**ESRI**
Type:	**3D Real-time Viewer**
Initial Cost:	free
Maintenance:	none
Platform:	PC or Mac
Prerequisite software:	ArcServer, Browser

Description

ArcGIS Explorer is a globe viewer that is ESRI's response to Google Earth. It provides a stand-alone virtual 3D viewing platform on desktop computers to view GIS features (in both 2D and 3D), KMZ files and many other media file formats. It also acts as a desktop viewer for ArcServer hosted datasets and performs light spatial analyses. Basic layers such as high resolution aerial images are provided through ESRI's server.

What is KMZ?

KMZ is Google Earth's native file format. It has become a very popular format for storing geo-referenced 3D models.

Outputs

Real-time 3D Visual Simulations; Web-based Real-time 3D Visual Simulations; Snapshots

Benefits for Planners

- Easy to use
- Can deal with large context
- Import custom 3D files from SketchUp
- Ability to display 3D models and other layers via the internet
- Comparison of different scenarios by turning scenarios and/or their subcomponents of layers on and off.
- Can add place markers with annotations and links to websites

Challenges for Planners

- Low resolution terrain models do not necessarily represent the actual topographic characteristics of a place.
- No in-place 3D modeling. User has to edit a building's geometry or change its GIS attributes to rotate or move it. Can't move or rotate the model in the viewer.
- Requires high speed internet connection; cannot be used without internet connection.

Staff and Training Considerations

Because of the widespread popularity of computer gaming and Google Earth, most all users will have had some experience "flying" through or tilting and panning a 3D virtual scene. The end user does not have to have a great deal of technical skill to use ArcGIS Explorer, and most (but not all) planners already have these skills.

However, ArcGIS Explorer needs other ESRI software to create layers and content, and therefore requires someone with solid GIS experience it implement it. This can be a planner; however this is more of a technical task and therefore this is the type of task probably best done by GIS staff with input from planners.

A planning agency may also want to customize this viewer for a Community Outreach Effort and/or their own internal use. This requires staff or a consultant with skills in GIS and web technologies to implement.

4.3.1.2 Bing Maps 3D (Microsoft)

Description

Tool:	**Bing Maps 3D**
Vendor:	**Microsoft**
Type:	**3D Real-time Viewer**
Initial Cost:	free
Maintenance:	none
Platform:	PC and Mac
Prerequisite software:	Browser

Bing Maps is a browser-based online mapping tool that includes 2D maps, high resolution aerial images, bird's eye (oblique) view images, street level images and a 3D viewing environment (when an optional plug-in is installed). Bing Map 3D provides detailed and textured 3D models for major cities. In addtion, birdseye oblique views are provided through Pictometry's service – although the image is not as current or as high a resgolution as it is for paying subscribers to Pictomerty. Bing is also creating more and more street-level views by stitching together eye-level photographs created by users and others using their "Photosynth" technology.

Custom datasets can be hosted on a web server and displayed on the maps through an API (Application Programming Interface). Custom 3D models can be uploaded to the mapping service through specialized 3D modeling tools such as 3DVIA and TrueSpace. 3DVIA's free version provides very limitted modeling features campare with other free tools like SketchUp. TrueSpace is much more advanced 3D modeling tool that is similar to 3D Max and Blender, which have steep learning curves.

Outputs

Real-time 3D Visual Simulations; Web-based Real-time 3D Visual Simulations; Snapshots

Benefits for Planners

- Easy to use.
- Can deal with large context.
- Import custom 3D files from 3DVia or TrueSpace
- Comparison of different scenarios by turning scenarios and/or their subcomponents of layers on and off.
- Can add place markers with annotations and links to websites
- Can become familiar with a place before actually visiting the place: high resolution aerial images, 3D models, integration of Bird's-eye and Street-level Views, etc.

Challenges for Planners

- Low resolution terrain models that do not necessarily represent actual topographic characteristics of a place.
- No in-place 3D modeling – although well integrated with 3DVia. User has to open up the model in its own window to edit. Can't move or rotate the model in the viewer.
- Requires a 3D modeling tool called 3DVia to create custom 3D models, and users cannot locally save their 3D models or export the models to file formats that can be used in other 3D modeling tools.
- Requires high speed internet connection; cannot be used without internet connection.

Staff and Training Considerations

The most all users will have had some experience this or Google Earth and will already know how to navigate a 3D virtual scene. The end user does not have to have a great deal of technical skill to use this tool, and most (but not all) planners already have these skills.

Importing a custom 3D model requires 3DVIA, or Caligary's TrueSpace (both are available for free).

A planning agency may also want to customize this viewer for a Community Outreach Effort and/or their own internal use. This requires staff or a consultant with skills in GIS and web technologies to implement.

4.3.1.3 Google Earth/Google Earth Pro (Google)

Tool:	**Google Earth**
Vendor:	**Google**
Type:	**3D Real-time Viewer**
Initial Cost:	free/$ (pro)
Maintenance:	$/year (pro)
Platform:	PC & Mac
Prerequisite software:	None

Description

Google Earth is a virtual globe, map and geographic information program that was originally called EarthViewer 3D, and was created by Keyhole, Inc, a company acquired by Google in 2004. It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and a GIS 3D globe. It is available under two different licenses: Google Earth, a free version with limited functionality and Google Earth Pro ($400 per year), which is intended for commercial use and adds features like movie making, a GIS data importer, and advanced printing modules.

Google Earth has become the most widely used globe viewer in the world.

Outputs

Real-time 3D Visual Simulations; Web-based Real-time 3D Visual Simulations; Snapshots,

Benefits for Planners

- Easy to use.
- Can deal with large context.
- Import custom 3D files directly from SketchUp.
- Ability to distribute 3D models and other layers via the internet.
- It has the largest user community among applications in this category. The user groups provides good support.

- Comparison of different scenarios by turning scenarios and/or their subcomponents of layers on and off.
- Can add place markers with annotations and links to websites.
- Can become familiar with a place before actually visiting the place: high resolution aerial images, 3D models, integration of Google Street View, etc.

Challenges for Planners

- Low resolution terrain models that do not necessarily represent actual topographic characteristics of a place.
- No in-place 3D modeling – although well integrated with SketchUp. User has to open up the model in its own window to edit. Can't move or rotate the model in the viewer.
- Requires high speed internet connection; cannot be used without internet connection.

Staff and Training Considerations

Because of its widespread popularity, most people have had some experience with Google Earth. The end user does not have to have a great deal of technical skill to use this tool, and most (but not all) planners already have these skills. Doing "virtual site visits" is something that many planners already do.

However, getting 3D content into Google Earth requires someone with some technical ability in 3D modeling. Google Earth, when used in conjunction with SketchUp, is relatively easy to use but does require some technical ability which in itself is probably the easiest 3D modeling tool to learn. (SketchUp is discussed separately under "**3D Modeling Tools**").

A planning agency may also want to customize Google Earth for a Community Outreach Effort and/or their own internal use. This requires staff or a consultant with skills in GIS and web technologies to implement.

4.3.1.4 Simurban World Simulator & Environment Editor (Simmersion)

Tool:	**World Simulator**
Vendor:	**Simurban**
Type:	**3D Real-time Viewer**
Initial Cost:	$$
Maintenance:	N.A.
Platform:	PC only
Prerequisite software:	Windows XP

Description

Simurban is a is a software suite for creating and deploying realtime simulation on a desktop or notebook computer. It consists of the Simurban World Simulator – which a the real-time 3D viewer, and the Simurban Enviroment Editor – which is an athoring tool that genrates content for the viewer from GIS data (primarily MapInfo) and 3D models. The World Simulator allows the user to navigate through 3D real-time environment, model simple geometries and simulate shadows on the fly.

The viewer utilizes modern gaming technologies and provides superior graphic quality than many other popular real-time viewer used in the planning field. This is partially because, in spite of the name, it is geared to smaller scale scenes than, say, Google Earth or ArcGIS Explorer, which truly are "world" viewers. Simurban only loads the local data for the scene on the local machine. It is not web-based and does not integrate with on-line content like ArcGIS Explorer, Bing, or Google Earth.

Outputs

Real-time 3D Visual Simulations; Recorded Animations; Snapshots

Benefits for Planners

- Good control over accuracy and level of detail.
- Works well at the neighborhood, district, or small city scale.
- Not web-based. Don't need a connection to run the model.
- Imports 3DS or VRML files.
- Interactive shadow analysis and simple massing tools are useful for planners to evaluate proposals and quickly develop their own alternatives.
- Ability to interactively move/rotate models in the 3D scene.

Challenges for Planners

- Not as good as other viewers in looking at regional issues.

3DS is 3DS Max's native file format, and is a very popular format for importing and exporting to and from other formats.

VRML stands for Virtual Reality Markup Language. It is meant to be the open standard for 3D models on the web, but due to limitations in performance and functionality, it has not been widely adopted. Nevertheless, it is still used as an import and export format.

- Not web-based. Can only run on a local computer and frequently involves large file transfers. Can't integrate other web-based data.
- Proprietary file format. Once models are imported they can be manipulated, but not exported with changes.

Staff and Training Considerations

Navigating in a 3D viewer, like Simurban, is something planners are becoming comfortable with. Simurban, however, is more than just a viewer. Simurban allows planners to modify the 3D scene by adding or removing buildings and move and rotate them within the virtual environment. It also allows planners to build massing models in the virtual environment. Simurban, therefore, requires some investment in training, albeit minimal. Most users can get up to speed in a few hours and become comfortable with it in a day. Also, it is not necessary to know GIS to use this tool.

But like all the viewers, some consideration needs to be given as to how the 3D data gets created and loaded into the viewer in the first place. For Simurban, the vendor typically does this – which involves an additional fee. Using the Simurban Environment Editor, planners and/or GIS staff can create the models themselves. Simurban uses base GIS data and maps and has some parametric modeling functions to generate site features like roads, sidewalks, trees, etc. (Once the data is loaded, however, there is not a real-time connection back to the GIS data so it can't really be called a 3D GIS.) Using the Simurban Environment Editor would require someone with both GIS and 3D modeling skills.

4.3.1.5 Skyline TerraExplorer & TerraBuilder (Skyline)

Description

Tool:	**Skyline TerraExplorer**
Vendor:	**Skyline**
Type:	**3D Real-time Viewer**
Initial Cost:	viewer free
	TerraBuilder - $$$$
Maintenance:	N.A.
Platform:	PC only
Prerequisite software:	TerraBuilder
	TerraGate Server for Hosting

Skyline is a 3D scene assembly and 3D viewer suite consisting of TerraExplorer (the 3D Viewer) and TerraBuilder (for scene assembly and content creation).

TerraExplorer is a desktop 3D viewer similar to Google Earth. There are three versions of TerraExplorer: free Viewer, Plus, and Pro. Viewer is literally just for viewing 3D contents, turn on and off pre-installed layers, and retrieve information linked to 3D and 2D objects.

With TerraExplorer Plus, users can run tools and extensions developed by others that utilize the comprehensive TerraExplorer Pro API. TerraExplorer Pro adds editing, analyzing and control tools to TerraExplorer Viewer and Plus so that users can create new information layers to be shared across a network, as well as export movies and create internet and CD distribution kits.

TerraBuilder is required to create and assemble contents for TerraExplorer. It enables the creation of large 3D terrain databases, combining any number of aerial photos, satellite images, geographic terrain information and, digital elevation models and vector data.

Outputs

3D Models; Real-time 3D Visual Simulations; Record Animations; Snapshots

Planning Activity Use Cases

Benefits for Planners

- Good control over accuracy and level of detail.
- Can load your own terrain model.
- Shadow analysis can be performed in real time
- Public and council members can see what a proposed development will look like in place and appreciate freedom of movement.
- Able to customize the viewer controls. (i.e. only show certain layers; allow certain navigation methods, etc.)

Challenges for Planners

- Proprietary file format. Once models are imported the can be manipulated, but not exported with changes.
- Requires high speed internet connection; cannot be used without internet connection.

Staff and Training Considerations

Skyline is very similar to Simurban, in that the end user or client rarely produces the 3D content. The degree of interactivity with the 3D

viewer, however, varies depending on how customized the product is. For the most part, if users are comfortable with using other globe viewers like Google Earth and/or Bing, they'll be comfortable with Skyline. In some respects, Skyline might be easier for users to use because all the extraneous features and layers that come with Google Earth and Bing (Wikipedia, Picassa, etc.) aren't there so there are fewer layers to manage.

Skyline's pricing structure is very complicated so it is very difficult to know exactly what versions are needed and the amount of end-user skill required to run the software; but suffice it to say, if you want to create your own content it will require a technically savvy planner and/or GIS staff person. The viewer itself can be customized as well through the developer API, but this requires someone with programming knowledge.

4.3.2 Comparative Evaluation

Key
● Excellent Support
⊙ Good Support
○ Some Support

	1. Community Outreach	2. Visioning & Planning	3. Developing Plans	4. Developing Regulations	5. Urban Design	6. Development Review	7. Visual Impact Analysis	8. Shadow Impact Analysis	9. Quantitative Impact Analysis	10. Build-out Analysis
Real-time 3D Viewers										
ArcGIS Explorer	●	●	–	–	○	–	–	–	–	–
Bing/Pictometry	⊙	⊙	–	–	○	–	–	–	–	–
Google Earth	⊙	●	–	–	○	–	–	–	–	–
Simurban World Simulator	○	⊙	⊙	⊙	●	⊙	●	⊙	–	–
TerraExplorer (Skyline)	●	⊙	○	○	⊙	⊙	●	⊙	–	–

Real-time 3D viewers ("Viewers" for short), which were once fairly rare and used primarily for military flight simulation, are now fairly ubiquitous thanks to improvements of desktop computer hardware and software. The popularity of computer games has also made the general public much more comfortable with exploring virtual 3D environments. For that reason, real-time 3D viewers are generally good for activities that engage the public, like **Community Outreach** and the **Visioning and Planning** process.

For **Community Outreach**, ArcGIS Explorer and Skyline TerraExplorer stand out because their user interfaces can be customized more readily than others, and unneeded functions, data, and controls can be eliminated so that the user only get what they need. It is possible to use APIs for Google Earth and Bing web plug-ins to create custom web applications, but requires someone who can write code. Nevertheless, both tools are widely used and it is possible to show and annotate alternative scenarios. Google Earth and Bing (by themselves, not customized through the APIs) have lots of extraneous information by default and limited functionality. Of this group, Simurban is the only one that is not web-based or that pulls in data from the web. The application and data reside only on the host

machine. It does, however, export stills and movies that can be used for Community Outreach activities.

Being able to explore existing conditions and alternative scenarios is a real-time 3D environment is very useful for planners for the **Visioning & Planning** processes. ArcGIS Explorer stands out because it is easier than others to integrate existing GIS data. Google Earth also stands out because its native format, KML, has become so common. KML is a close variant to GML (Geographic Markup Language) which is an open standard. Most GIS and 3D modeling tools now either import and/or export to KML.

For **Developing Plans** and **Developing Regulations** Simurban is useful because planners can draw, measure, and move simple massing models within the virtual environment and test sightlines, shadows, heights, etc. Skyline also has some abilities to manipulate and measure features, although these are customized per installation and it is not clear just how extensive these functions are. Also, Skyline is more geared towards being a public outreach tool than an in-house design and analysis tool, which Simurban is. For these same reasons Simurban is a better tool for **Urban Design** than Skyline. Although other 3D viewers can be used for Urban Design, both Skyline and Simurban allow planners to use more detailed terrain and 3D models and are more precise in general.

Precision, scale, control over context models, and the ease of switching between alternative proposals are what make Simurban and Skyline good for **Development Review**, **Visual Impact Analysis**, and **Shadow Impact Analysis**. Both tools excel at visual impact analysis; however, Shadow Analysis is only visual, and cannot be quantified easily.

None of the 3D real-time viewers perform any kind of Quantitative Impact or Build-out Analysis as part of their core functionality.

4.4 3D Modeling Tools

3D modeling tools are software applications that enable the user to construct 3D geometries of buildings, structures, and other objects. These tools typically allow the user to apply representations of materials and textures to the geometry faces. Most applications are designed to produce pre-rendered stills or animations, although some offer limited real-time capability.

4.4.1 Tools Overview

Six 3D modeling tools are evaluated here. There are three basic types of 3D modeling tools: "traditional" vector-based CAD tools, like **AutoCAD** and **Vectorworks**; 3D solid modeling tools, like **3DS Max** and Google **SketchUp**; and Building Information Modeling (BIM) tools like **ArchiCAD** and **Microstation**. (Note: All of these tools have been adding BIM functionality in later releases, but these are their basic types at their core.)

Building Information Modeling is the process of generating and managing building data during its life cycle. The process produces the Building Information Model (also abbreviated BIM), which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components. With "traditional" CAD tools and 3D solid modelers like 3DS Max, AutoCAD, and SketchUp, designers draw shapes and volumes that represent real-world objects. CAD stores properties about the shapes (e.g. line thickness, color, fill, etc.) rather than properties about the objects the shape represents (e.g. door, wall, etc.) With BIM, designers create virtual real-world objects that are "smart" (i.e. they have properties about the real-world object and interact with other objects in the virtual world just like they would in the real world).

ESC Comment about CityGML:
The ESC has experimented with CityGML in 2009 and found that, although it enables the rendering of only the appropriate level of detail improving graphics performance, parsing the data – which includes information down to the doorknobs and window frames – and extracting only the information needed takes a long time. So models took a long time to load and were sluggish when transitioning between levels of detail. This may improve with time and better hardware and software; but at the time of this writing it doesn't seem like CityGML is "ready for prime time".

BIM is often referred to as *parametric* modeling. Parametric modeling for these tools normally means using the computer to design objects by modeling their components with real-world behaviors and attributes. This is a slightly different definition than the one we use later in this chapter when discussing parametric modeling abilities of 3D GIS tools. In that case, parametric modeling means using a description (attributes) of a 3D object to automatically model the object *itself*.

The biggest issue surrounding BIM for planning applications is the issue of scale and levels of detail. BIM is primarily designed for individual buildings – although engineers have been using it for years to manage building complexes and campuses. Planning works more at the neighborhood, city, and regional scales. BIM provides almost too

much information at those scales. CityGML (City Geographic Markup Language) is an open standards format that has multiple "levels of detail" and is meant to bridge the gap between BIM and GML, the open stands for a format that is now widely supported by many GIS vendors. CityGML is relatively new and has not been widely adopted and tested yet. Utilizing CityGML at a neighborhood or city level is challenging because every building needs to be modeled to the same standards so that the software can recognize and classify components of the model correctly.

4.4.1.1 3DS Max (Autodesk)

Tool:	**3DS Max**
Vendor:	**Autodesk**
Type:	**3D Modeling Tool**
Initial Cost:	$$$$
Maintenance:	$$$
Platform:	PC & Mac (virtual PC)
Prerequisite software:	None

Description

3DS Max is a high-end, comprehensive 3D modeling animation, and rendering solution that is frequently used for architecture, product design, design visualization specialists, and the film industry. Its sole purpose is to produce 3D renderings and pre-pathed animations. The software uses sophisticated lighting simulation (also called "ray-tracing") and atmospheric (haze, wind) engines that are considered superior to most if not all other 3D modeling applications. It also comes with "Camera Match" function that can be used to produce "verifiable photo simulations".

Outputs

3D Renderings; Sections; Elevations; Shadow Renderings; Daylight Analysis; 3D Animations; 3D Models

Benefits for Planners

- Renders photo-real 3D renderings and pre-pathed animations that could be used for public presentations.
- Simulate shadow impacts from proposed developments.
- Its lighting analysis engine, (sun, sky, artificial) was "validated by the National Research Council Canada (NRC), Canada's leading organization for scientific research and development, and the same organization that has conducted validation studies on Radiance for lighting simulation."
- It comes with a daylight simulation system that complies with the standards set by the Illumination Engineering Society. The sun/sky illumination intensity of the scene will be set

automatically by 3DS Max based on geographic location, time and date.

Challenges for Planners

- High learning curve, especially if you have no prior training in any other kind of 3D modeling and/or CAD software.
- To get good results, you need someone who is proficient in the software.
- Complex, professional user interface. Hard to find functions you need.
- Photo-real rendering is an art that requires intensive and continuous use of the tool.
- Requires a thorough knowledge of computer graphics (raster, vector, material, etc) to create images.
- It provides more functions than planners need.
- Shadow analysis and photomontages require extensive manual labor in Photoshop or similar tool (e.g. Gimp).
- Expensive relative to other 3D modeling tools
- Currently, there is no support for attributes that could feed into a larger scenario analysis.

Staff and Training Considerations

Successful use of 3DS Max requires extensive experience with it or other similar 3D modeling and graphics applications. This is difficult to sustain in-house, unless there is sufficient volume of work that can support a staff member nearly full-time. Typically, architects and/or planners who already have 3DS Max skills will also be proficient in AutoCAD (or similar, e.g. ArchiCAD, Microstation) and Photoshop (or similar, e.g. Gimp). Conversely, it is easier for someone with AutoCAD skills and Photoshop skills to learn 3DS Max.

The degree of realism that can be achieved with 3DS Max is really more of an art than a purely technical function. In particular, creating convincing lighting, atmospheric effects, and smooth motion paths are complex and subtle operations that require “an eye” for detail. Training cannot substitute for experience. To build capacity to use 3DS Max in house would require a long-term commitment of resources either to train staff, or hire new staff that already have 3DS Max skills. This would need to be coordinated with longer strategic goals with regards to the allocation of monetary and human resources.

4.4.1.2 ArchiCAD (Graphisoft)

Tool:	**ArchiCAD**
Vendor:	**Graphisoft**
Type:	**3D Modeling Tool**
Initial Cost:	$$$$
Maintenance:	N.A.
Platform:	PC & Mac
Prerequisite software:	None

Description

ArchiCAD is popular architectural BIM (Building Information Modeling) CAD software for Apple Macintosh and Windows. ArchiCAD's most distinguishing feature is that it was the first true BIM software tool on the market and has always been a BIM tool. 3D models are created as "virtual buildings" in 3D rather than as 2D drawings projected into 3D. The 2D drawings – sections, elevations, plans, site plans, and construction documents – are created from the 3D model. In addition, all objects can have attributes associated with them, including attributes that manage cost and material estimates, construction scheduling, building maintenance.

Outputs

3D Renderings; Sections; Elevations; Daylight Analysis; 3D Models; Site Plans; Tables; Reports

Benefits for Planners

- A popular CAD tool used by architects and engineers.
- Drawings and 3D models created by the tool can be converted to file formats that can be used in most other popular CAD software such as AutoCAD, 3DS Max, SketchUp, etc.
- Provides sophisticated and collaborative BIM functions for advanced users which have the potential -- in theory -- to populate GIS fields, although we have not been able to find any examples of this.
- ArchiCAD was the first BIM software to export to the neutral and open IFC (Industry Foundation Classes) file format. (Other BIM providers, such as Autodesk Revit and Bentley Microstation have followed suit.) In the future, this may make communication with open GIS standards (GML, CityGML) possible. As open standards become more widely demanded by governments and adopted by private industry and consultants, this is more likely to become a reality. At the moment, however, integrating BIM with GIS data is in its infancy and only practical for tightly controlled environments, like campuses.

Challenges for Planners

- Complex user interface may be intimidating for new users.
- Because of its interface oriented toward designing real-world objects, users may feel less inclined to work conceptually, even though it is possible.
- It emphasizes BIM and inter-professional collaboration features that do not seem to be useful to planning activities, at this point in time.
- Expensive relative to other 3D modeling tools.
- The level of detail ArchiCAD can accommodate is more than most planners need.
- High learning curve, especially if you have no prior training in any other kind of 3D modeling and/or CAD software
- To get good results, you need someone who is proficient in the software

Staff and Training Considerations

ArchiCAD's greatest strength is its greatest weakness when applied to planning situations: it is a design tool built for architects, engineers, etc. who are designing and building structures and not for planners. As a tool it is geared towards creating very detailed, hyper-realistic models rather than the conceptual massing models planners typically use and are easy to create quickly. It can be used both ways, but creating hyper-realistic models can be a labor intensive process that is difficult to sustain in-house unless there is sufficient volume of work that can support a staff member nearly full-time.

It should be noted that, because Prince George's Parks, Planning and Development Department does design and build buildings, it does have the volume to support in-house architects that use ArchiCAD. But those architects currently do not do any modeling for The County's urban design or planning efforts. The fact that the department is in a separate building from the planning department only reinforces that divide.

Although BIM, in theory, should translate well into GIS – the persistent problem with BIM (including ArchiCAD) is the mismatch of scales and levels of detail from the building level to the neighborhood level. In short, BIM is a bit of "overkill" for planners. Using ArchiCAD at a neighborhood level would be an unorthodox use of the tool that would require a level of commitment that allows for a great deal of trial and error.

4.4.1.3 AutoCAD (Autodesk)

Tool:	**AutoCAD**
Vendor:	**Autodesk**
Type:	**3D Modeling Tool**
Initial Cost:	$$$$
Maintenance:	$$$
Platform:	PC only
Prerequisite software:	None

Description

AutoCAD is the most commonly used 2D drafting and 3D modeling tool used by architects, engineers, and landscape architects. Its native file format is DWG which is a proprietary file format for Autodesk. The file format is the most commonly used in architecture and engineering industries and literally all major CAD and BIM applications support this format. Originally developed as a 2D CAD drafting program for the PC, it has evolved to include solid 3D modeling and 3D tools. The release of AutoCAD 2007 improved 3D modeling functionality even more, adding better editing, navigation, and rendering capabilities – although not as sophisticated as 3DS Max. Later releases of AutoCAD have been adding BIM functionality and support for open standards.

Outputs

3D Renderings; Plans, Elevations; Sections, Site and Subdivision Plans, Engineering Plans and Sections; 3D Models

Benefits for Planners

- AutoCAD is one of the most popular CAD software used by architects, landscape architects and engineers.
- Its native file format, DWG, is probably the most commonly used 3D/2D file format in the industries; and it can be used directly in ArcGIS with saved coordinate transformations for geo-referencing and conversion into shapefiles.
- More suitable than solid modeling tools (like 3DS Max) for laying out planimetric features like property lines, curbs, sidewalks, etc.
- AutoCAD can render nearly photo-real renderings.

Challenges to Planners

- Comes with somewhat complex user interface although Autodesk claims that AutoCAD 2010 is more intuitive than previous versions.

- Because of its interface oriented toward designing real-world objects, users may feel less inclined to work conceptually, even though it is possible.
- Steep learning curve, especially if you have no prior training in any other kind of 3D modeling and/or CAD software
- To get good results, you need someone who is proficient in the software

Staff and Training Considerations

AutoCAD is a complex tool that can be used in variety of ways for a variety of purposes. Therefore, the level of staffing and training may vary. In general, most planners will not need to know AutoCAD, but it might be useful to have some staff that know how to view, manipulate, clean-up, or prepare AutoCAD files for export to another, easier-to-use format. AutoCAD is also useful for its planimetric drawing capabilities, which are generally considered superior to GIS tools. Given the fact that AutoCAD dxf is a file format that GIS can read, it might be useful to have some in house-capabilities to actually draw in AutoCAD as well. AutoCAD can also create simple massing models, which is also very useful to be able to do in-house.

AutoCAD has a steep learning curve, so cost of building capacity in house would include either a significant investment in training existing staff, or hiring new staff that already have the skills. These costs would have to be weighed against the benefits of having this capacity in house with regards to a larger strategic monetary and human resource plan.

4.4.1.4 Google SketchUp/SketchUp Pro

Tool:	**SketchUp**
Vendor:	**Google**
Type:	**3D Modeling Tool**
Initial Cost:	free - $
Maintenance:	$
Platform:	PC & Mac
Prerequisite software:	None

Description

SketchUp is a 3D modeling program designed primarily for designers and general hobbyists. Its intuitive interface is designed to be easier to use than other 3D CAD programs; yet it is still quite a powerful and extensible tool with an increasing number of design professionals using it. As it becomes more powerful, more professionals are using it. It also includes features to facilitate the placement of models in Google Earth. A feature of SketchUp is the 3D Warehouse that lets SketchUp users search for models made by others as well as contribute models to the 3D Warehouse.

The free version of SketchUp has most 3D modeling features planners might need. However it is limited to saving and exporting files to either .skp, .dae, or .kmz formats, which, for the most part, limits the use of the models to SketchUp and Google Earth. The "Pro" version adds on additional export options such as .3ds, .dwg, .dxf, .wrl, among others. It also adds layout functions for professional printing and plotting; and "Dynamic Components". Dynamic Components enable the user to create models with custom behaviors and attributes (in other words, some BIM functionality.)

Because of its popularity, there are growing number of plug-ins that enhance its functionality. Many of those plug-ins are available for free. The tool has very active user groups and plug-ins are actively developed by commercial entities and do-it-yourself hobbyists.

Outputs

Sections; Elevations; 3D Animations; 3D Models; Site Plans; Real-time 3D Visual Simulations

Benefits for Planners

- Its easy-to-use graphical user interface allows users to use the tool more intuitively than most other 3D modeling tools such as AutoCAD or Vectorworks. SketchUp covers almost all 3D modeling needs planners may possibly require for their planning and urban design projects.
- SketchUp is designed to work extensively with other graphic applications including most other common CAD software, ArcGIS and Photoshop, etc.
- SketchUp models do not use external references to other 3D models or texture files. All geometry and texture files, regardless of source, are saved with the single file. This makes for easier file management, but very large file sizes can become problematic (see "Challenges" below).
- Ruby Scripts, many of which are available for free via the internet, provide many added features that do not come with the original packages.
- Because the tool gained popularity very quickly, a lot of other tools are developed so that they work with SketchUp.
- Good collection of video tutorials is available on line.
- The Free version has all modeling functions that the Pro version offers, but does not import and export the most common 3D files typically used by designers. Pro version can

import and export to popular formats, and is still inexpensive compared to other CAD software

Challenges to Planners

- Simple and intuitive graphical user interface, which may still be a challenge for planners who have difficulty visualizing objects in three dimensions and/or who have no formal design training.
- File sizes tend to become very large and large SketchUp files tend to be unstable.
- Because SketchUp was designed to create small 3D environments, large and complex geometries such as a city scale 3D model with detailed terrain may require optimization.
- While SketchUp supports ESRI Multi-patch feature, it requires specific combination of SKP and ArcGIS versions in order to export out back to ArcGIS after importing in footprints to SketchUp to use as a base for modeling. ArcGIS to SKP works with any versions, but SKP to ArcGIS requires ArcGIS 9.2 installed.

Staff and Training Considerations

Google SketchUp has become very popular because it is relatively easy to use, creates good quality 3D models and renderings, and is inexpensive. A shallow learning curve coupled with a low price translates into a low-risk investment with a potentially high rate of return. It should be noted, however, that manual 3D modeling can be labor and time intensive; and in order to produce realistic looking buildings, they need to be drawn at correct scales and dimensions. For Urban Designers and/or Physical Planners who would be expected to have a design background and an understanding of building and site design standards, SketchUp is well suited to quickly drawing conceptual designs and alternative development scenarios for Community Outreach and Visioning and Planning workshops and charettes.

Physical Planning and Urban Design does overlap a number of other planning activities (e.g. Regulatory Design, Development Review, Community Outreach) so staffing and training considerations will mostly be determined by when and how often 3D modeling would likely produce a better planning outcome. Not every planning activity requires visual simulation - particularly those that are at a regional

scale. But many regional policies may have local impacts on how development might occur and which could be visualized in 3D.

Given that SketchUp is well suited to a number of planning activities and its shallow learning curve, it is likely that some capacity already exists in house. The extent to which that in-house capacity expanded through training or hiring will depend on the number of planning activities The County thinks will benefit from using this tool and the costs of building the capacity. This will be part of a larger strategic plan.

4.4.1.5 Microstation (Bentley)

Tool:	**Microstation**
Vendor:	**Bentley**
Type:	**3D Modeling Tool**
Initial Cost:	$$$$
Maintenance:	N.A.
Platform:	PC only
Prerequisite software:	None

Description

MicroStation is one of the most popular BIM CAD software used worldwide. The tool provides all BIM functions such as parametric building modeling, streamlined construction document production, construction scheduling management, etc. The tool comes with a superior built-in 3D rendering engine compared to many other popular BIM applications including Autodesk Revit, and ArchiCAD. The tool utilizes geographic coordinate systems and is designed to work with GIS and GPS data.

Outputs

3D Renderings; Sections; Elevations; 3D Animations; 3D Models; Site Plans; Maps; Daylight Analysis; Shadow Renderings

Benefits for Planners

- Parametric modeling of objects (e.g. buildings, structures, etc.) permits them to have attributes and be "smart" (e.g. "A" can connect to "B", but not to "C").
- Photo-real renderings and animations
- It recognizes geographic coordinate systems and read files from GIS and GPS software.
- MicroStation's BIM software, which can export to the neutral and open IFC (Industry Foundation Classes) file format, can be used with other Bentley tools to create CityGML, which is an open-standard format specifically geared for urban planning. At the moment, integrating BIM with GIS data is in its infancy

and only practical for tightly controlled environments, like campuses. In the future, as open BIM/GIS standards become more widely demanded by governments and adopted by software vendors and consultants, this may become more of a practical reality.

Challenges for Planners

- 3D models modeled with its parametric modeling features may not be suitable for a real-time environment if the model has too much geometric detail. The challenge is to use the parametric modeling to create or extract "light" models.
- Comes with too many features/functions that may not be of utility to most planners.
- Relatively expensive compared to other 3D modeling tools.

Staff and Training Considerations

Similar to ArchiCAD, Microstation is a BIM system that is geared towards the design, construction, and maintenance of buildings. While it's very effective for architects, it is "overkill" for planners and would be difficult for non-architects to learn. As already mentioned, 3D modeling is generally a labor intensive process depending on the level of detail and realism and difficult to sustain in-house, unless there is sufficient volume of work that can support a staff member nearly full-time.

Bentley's commitment and progress towards data interoperability through open standards is worth following, as well as similar efforts by Autodesk (Digital Cities) and ArchiCAD. However, utilizing these features across the domains of building construction and maintenance and urban planning would require staff with highly specialized skills as well as significant institutional buy-in towards requiring open standards for digital plans submittals and GIS.

Tool:	**Vectorworks**
Vendor:	**Nemetschek**
Type:	**3D Modeling Tool**
Initial Cost:	$$$
Maintenance:	N.A.
Platform:	PC & Mac
Prerequisite software:	None

4.4.1.6 Vectorworks (Nemetschek)

Description

Vectorworks, like other CAD software described here, comes in different versions for different industries. The "Architect" version is probably the version that would be of most interest to planners. It provides CAD, BIM and advanced rendering (both still images and

animations) functions for a very affordable price compared to most other CAD tools such as AutoCAD or Microstation. It also provides a number of site planning and sustainable design analytical functions that planners may well find useful. Unlike most other popular CAD tools, Vectorworks has a powerful rendering engine that renders in both 2D and 3D, which makes it possible to create colorful and attractive 2D maps and site plans without utilizing other tools such as Photoshop and Illustrator. The tool also comes with components and a detailed plant database that will be useful for creating landscapes and streetscapes.

Outputs

3D Renderings; Sections; Elevations; Shadow Renderings; Daylight Analysis3D Animations; 3D Models; Site Plans; Maps, Reports

Benefits for Planners

- Relatively inexpensive compared to other CAD tools of similar capabilities.
- Conducts a number of site analyses out-of-the-box (slope, water runoff, cut and fill).
- Parameter modeling (BIM)
- Embedded sustainable design features (solar radiation and illumination, thermo-mass and insulation calculations, air flow simulation, carbon footprint / energy consumption calculations, shading calculation)
- Renders interior and exterior shadows in animations
- Potentially interesting tool for municipalities that seek to implement sustainable design ordinance
- Video tutorials

Challenges for Planners

- Although some trained professional claims that Vectorworks provides much more intuitive and efficient modeling environment compared to other comparable CAD software (e.g. AutoCAD, ArchiCAD, MicroStation), it will still be very hard to use for planners with no design background.
- 3D models modeled with its parametric modeling features may not be suitable for a real-time environment if the model has too much geometric detail. The challenge is to use the parametric modeling to create or extract “light” models.

- Comes with too many features/functions that may not benefit planners

Staff and Training Considerations

Vectorworks is a complex tool that can be used in variety of ways for a variety of purposes. Similar to ArchiCAD and Microstation, Vectorworks is a BIM system that is geared towards the design, construction, and maintenance of buildings. While it's very effective for architects, it is more than planners and non-architects would need.

Vectorworks has a fairly steep learning curve, so cost of building capacity in house would include either a significant investment in training existing staff, or hiring new staff that already have the skills. These costs would have to be weighed against the benefits of potential applications to planning activities and a larger strategic plan.

4.4.2 Comparative Evaluation

Key
● Excellent Support
O Good Support
○ Some Support

	1. Community Outreach	2. Visioning & Planning	3. Developing Plans	4. Developing Regulations	5. Urban Design	6. Development Review	7. Visual Impact Analysis	8. Shadow Impact Analysis	9. Quantitative Impact Analysis	10. Build-out Analysis
3D Modeling Tools										
3DS Max	○	○	–	O	●	●	●	●	–	–
ArchiCAD	○	○	O	○	●	●	O	O	O	–
AutoCAD	○	○	O	○	●	●	O	O	–	–
Google SketchUp	O	●	○	●	●	●	O	O	–	○
Microstation	○	○	O	○	●	●	O	O	O	–
Vector-works	○	○	O	○	●	●	O	O	O	

All of the 3D modeling tools listed can create 3D models at the level of detail and accuracy needed for **Urban Design** and **Development Review**. Although the rendering quality varies from the high-end tool (3DS Max, used in the game and entertainment industries) to the low-end tool (SketchUp), rendering quality across the board has improved considerably over the last few years so that even the low-cost tools produces results that are more than satisfactory for most planning activities.

All of the tools support **Visual Impact Analysis** and **Shadow Impact Analysis** as well, but 3DS Max gets the edge on the former because of its sophisticated and precise camera match function, and the edge on the latter because of its ability to isolate shadows as a separate layer that can then be precisely measured and quantified.

All of the tools also can produce renderings and/or movies that are suitable for **Community Outreach**, but SketchUp gets the edge this time because of its integration with Google Earth. SketchUp also gets a big edge over other 3D modeling tools for **Visioning and Planning** because, as the name implies, you can "sketch" simple massing models

very quickly and explore alternative designs – even in a workshop setting. SketchUp is particularly useful to test ideas and scenarios when **Developing Regulations**.

When **Developing Plans**, it is useful to have tools like AutoCAD, Vector-works, Microstation or ArchiCAD that were developed for the architecture, landscape architecture and civil engineering professions and are well suited for drawing site plans, parcel plans, subdivision plans, etc. Google SketchUp is not designed for drawing coordinate geometry, but it is still possible to produce site plans and subdivision plans.

ArchiCAD, Vector-works, and Microstation are actually BIM (Building Information Modeling) tools. This makes it possible to perform **Quantitative Impact Analysis** with these tools, and most of them have sustainability measures built into them or available as plug-ins. SketchUp is more like traditional CAD, but you can assign attributes to components; and AutoCAD has added BIM functionality to its latest release.

CAD vs. BIM

With "traditional" CAD tools like 3DS Max, AutoCAD, and SketchUp, designers draw shapes and volumes that represent real-world objects. CAD stores properties about the shapes (e.g. line thickness, color, fill, etc.) rather than properties about the objects the shape represents (e.g. door, wall, etc.) With BIM, designers create virtual real-world objects that are "smart" (i.e. they have properties about the real-world object and interact with other objects in the virtual world just like they would in the real world).

4.5 3D GIS Tools

3D GIS Tools are software applications that generate and display 3D terrain and/or features (buildings, roads, structures, etc.) from GIS layers and display them in a real-time virtual 3D environment. Because these applications are data-driven, they lend themselves to analysis and can be considered a type of Decision Support tool.

The process of automatically generating 3D features from data about those features (attributes) is also referred to as "parametric" modeling – whereby 3D geometry is generated through data and a rule-based system or "parameters". Because these applications are data-driven, they lend themselves to analysis and can be considered a type of Decision Support tool.

4.5.1 Tools Overview

We evaluate three tools in-depth here: **ArcGIS 3D Analyst**, **AutoCAD Map 3D**, and **CommunityViz® Scenario 3D**. 3D Analyst and Scenario 3D more similar to each other than AutoCAD Map 3D; they both have ability to *parametrically* create 3D models of surface features like roads, fences, wall, and building extrusions from GIS features, whereas AutoCAD Map 3D only has tools for creating terrains and draping imagery or 2D features over the terrain.

Simurban and Skyline, both evaluated in the 3D Real-time Viewers section, also have components that generate terrain models and parametrically build 3D feature models from GIS data called Simurban Environment Editor and Terrabuilder, respectively. In both cases, however, they are not typically tools that planners use directly; rather, a specialist, a consultant, or the vendor themselves uses the tools to construct the base model. We therefore evaluate them with Real-time 3D Viewers.

Other GIS-based parametric 3D Modelers that are available but not evaluated here are those typically geared towards creating scenery for flight simulations for the defense industry. While these tools are quite good, they are extremely expensive and require a specialized skill set beyond what should be required for planners.

About Parametric Modeling and 3D GIS

One of the big 3D modeling challenges for planners has always been the sheer size and number of features that are required to be modeled in order to create a convincing visual simulation at a neighborhood, corridor, or city scale. Another challenge has always been how to visualize data (like building uses by floor) in 3D. Parametric 3D modeling "automates" some of the more tedious tasks associated with 3D terrain generation and placement of those features on the terrain. It also can create the features themselves, such as building massing models, walls, roads, fences, etc., by using attribute data that describes the third dimension through an attribute, such as "height" or "number of stories". Another way to think about these tools is that they allow you to create a 3D legend and apply it to 2D GIS features.

So how do 3D legends work? A good example would be a building footprint layer. In the legend editor for any regular 2D GIS system, you would be able to assign a color to the footprint based on the building's primary use, and that would show up in the legend. But with the legend editor in a "3D" GIS, there are addition options to assign "Z" values to the features based on attributes. This can include information on extruding the object in the third dimension as well as determining what the base height should be. So in the case of a building footprint, the base height is most often taken off the terrain directly below the footprint, and the polygon representing the footprint is extruded to a height. So like assigning a color based on an attribute in a legend, you are assigning a height to an attribute and the 2D polygon is extruded to that height in the 3D Viewer.

2D features that don't have thickness or width (lines and points) can also be turned into 3D objects by assigning thickness or width as well as height. So lines can become walls with width (X,Y) and height(Z), fences with height (Z) but very little thickness (X,Y), or roads that are wide (X,Y) but not thick (Z). Walls, fences, and roads all must be "draped" onto the terrain and deform their geometries to follow.

4.5.1.1 ArcGIS 3D Analyst (ESRI)

Tool:	**ArcGIS 3D Analyst**
Vendor:	**ESRI**
Type:	**3D GIS Tool**
Initial Cost:	$$$
Maintenance:	Varies with license
Platform:	PC only
Prerequisite software:	ArcGIS

Description

ArcGIS 3D Analyst extension comes with a suite of 3D analysis and visualization tools. ArcScene and ArcGlobe, visualization components of the extension, can generate large scale 3D scenes with relatively limited effort and directly out of popular GIS features such as building footprints, Digital Elevation Models, and orthophoto aerial images. Therefore, it would be the most accessible 3D visualization tool for planners with ArcGIS experience/knowledge. The extension also performs surface analysis functions: contour lines, slope, hillshade, cut and fill, viewshed, etc. that will be helpful for site planning and development reviews[3].

Outputs

3D Renderings; 3D Animations; 3D Models; Real-time 3D Visual Simulations; Snapshots; Maps

Benefits for Planners

- Quickly generates a large scale 3D scene directly out of popular GIS layers.
- Parametrically generate 3D features using the layer properties interface. Create walls, fences, streets, or any other linear feature from lines; extrusions or surface conforming polygons from polygons; or substitute 3D symbols/models for point features.
- Familiar ArcGIS interface and quite easy to use for planners with basic ArcGIS skills.
- Real-time virtual flythrough of project area and development scenarios.
- Can import detailed or simple 3D models created in popular modeling tools such as SketchUp, AutoCAD, etc.

Challenges for Planners

- It is difficult creating realistic 3D scenes using GIS data.

[3] These same surface analysis features are available Spatial Analyst; however Spatial Analyst does not include the 3D viewers (ArcGlobe and ArcScene). 3D Analyst, however, does not contain the raster overlay and analysis functions of Spatial analyst.

- When substituting 3D models for points, the tool is not intuitive in terms of rotation values.

Staff and Training Considerations

It will be helpful if GIS trained staff could perform, for example, view shed, aspect, and cut/fill analyses and also could create 3D scenes with ArcScene using GIS layers they already have. For intermediate GIS professionals, learning this extension will not be difficult; probably takes a two-day intensive training to master the basics of this tool.

4.5.1.2 AutoCAD Map 3D

Tool:	**AutoCAD Map 3D**
Vendor:	**AutoCAD**
Type:	**3D GIS**
Initial Cost:	$$$$
Maintenance:	varies w/ license
Platform:	PC only
Prerequisite software:	None

Description

AutoCAD Map 3D is a light GIS tool developed on top of AutoCAD which is the most popular CAD software among architects and engineers. The tool enables AutoCAD to recognize geospatial references, attach attributes and perform simple spatial queries. It comes with all 2D and 3D modeling capabilities of AutoCAD and provides a more efficient and accurate map layer authoring environment compared to ArcGIS. AutoCAD Map 3D is a lighter version of AutoCAD Civil 3D which has more advanced terrain editing/modeling and analysis features.

Outputs

3D Renderings; Sections; Elevations; 3D Terrain Models; Site Plans; Real-time 3D Visual Simulations

Benefits for Planners

- Bridges a gap between CAD and GIS applications.
- Far more efficient and precise 2D drawing features than that of ArcGIS.
- AutoCAD can handle larger number of geometries than SketchUp so it is a good platform to manage large 3D models such as 3D buildings for an entire city, etc.

Challenges for Planners

- Does not parametrically generate 3D features from GIS layers.

- Need to be familiar with AutoCAD as well special functions and operations that AutoCAD Map 3D provides.

Staff and Training Considerations

AutoCAD Map 3D is a complex tool that can be used in variety of ways for a variety of purposes. It has all the functionality of AutoCAD, all of the staffing and training considerations for AutoCAD would apply here as well. The additional GIS features are quite specific and geared mostly to traditional GIS functions like cartography, spatial relationships, and surface analysis. The benefits of having AutoCAD Map 3D capacity would need to be weighed against the cost of learning these functions, taking into consideration the fact that most of the GIS functions AutoCAD Map 3D provides already exist in house with ESRI products.

AutoCAD has a steep learning curve, so cost of building capacity in house would include either a significant investment in training existing staff, or hiring new staff that already have the skills.

4.5.1.3 CommunityViz® – Scenario 3D (Placeways)

Tool:	**Scenario 3D**
Vendor:	**Placeways**
Type:	**3D GIS**
Initial Cost:	$$
Maintenance:	$$
Platform:	PC only
Prerequisite software:	ArcGIS

Description

Scenario 3D is an extension to the ArcGIS Desktop and a component of CommunityViz. It is used to create interactive, real-time 3D visual simulations from GIS data. As a component of CommunityViz, Scenario 3D can be used to explore alternative scenarios created in Scenario 360 and display related charts, indicators, and assumptions.

Scenario 3D is a new product, and replaces SiteBuilder3D which was a Multigen-Paradigm product originally bundled with CommunityViz. Multigen-Paradigm (now known as "Presagis") provides high-end simulation tools primarily for the defense industry, but hasn't supported SiteBuilder3D for at least 5 years. The result is that SiteBuilder3D doesn't work on many current 3D graphic cards. Multigen's expertise in terrain and surface feature generation tools was evident in SiteBuilder3D, and unfortunately Scenario 3D is not as proficient at creating detailed terrain and surface-conforming features like roads. In time, we hope, this should improve.

Scenario 3D does add new features that SiteBuilder3D didn't have. As mentioned, it is integrated with Scenario 360 so it can easily switch

between scenarios. It has an ArcMap-style layer list for better control over layers. It also allows you to select feature/buildings in 3D, have them simultaneous selected on the 2D map, display attributes, or hyperlink to a web page.

Scenario 3D must be purchased as part of CommunityViz. This, however, is not a problem since CommunityViz® costs considerably less than any other 3D GIS tools. .

Outputs

Real-time 3D Visual Simulations; Snapshots, Shareable 3D Scenes, Movies

Benefits for Planners

- Creates terrains from TIN, DEM (grid), or features (contours, points).
- Parametrically generate 3D features. Create walls, fences, streets, or any other linear feature from lines; extrusions or surface conforming polygons from polygons; or substitute 3D models for point or polygon features.
- Uses KMZ (Google Earth, Google 3D Warehouse) models.
- Combines analytical and real-time 3D visual simulation capabilities.
- Good navigation capabilities and options.
- Inexpensive
- Creates real-time 3D visual simulations that can be packaged with a free viewer so they can be shared.

What are TINs and DEMs?

TIN stands for Triangular Irregular Network. A TIN is created by triangular geometries between known elevation points.

DEM stands for Digital Elevation Model. A DEM can be thought of as a grid where each cell has an elevation value.

In general, TINs are more efficient than DEMs because only known elevation points are used to create geometry rather than a grid of elevation points covering an entire area, including flat areas with no variation.

Challenges for Planners

- Terrain-conforming 3D features, like roads, curbs, sidewalks, or any polygons have trouble rendering correctly if only slightly above the terrain model (otherwise known as "Z-fighting")
- When substituting 3D models for points, the tool is not intuitive in terms of rotation values.
- Tends to be "buggy" and crashes
- It is difficult creating realistic 3D scenes using GIS data because it is typically too coarse and/or there may not be enough attribute information.

What is Z-fighting?

"Z-fighting" refers to a phenomenon in real-time simulation when two geometric planes are very close together and the rendering engine has difficulty determining which one to draw on top of the other. The end result is that the two surfaces are "fighting" to be drawn first and the viewer sees each surface flickering on and off.

- Sometimes difficult to use models crated from later versions of SketchUp; file names get altered to generic names, causing textures to end up on the wrong buildings.

ESC Comment
The vendor indicates that they are aware of this issue and are working to resolve this.

Staff and Training Considerations

Scenario 3D is potentially very useful to planning staff, but requires a high level of GIS literacy and proficiency with ArcGIS; so any of the staff and training considerations that are mentioned for ArcGIS (section 4.6.1.1 below would apply here as well).

To create 3D models to be used within scenario 3D would require someone with 3D modeling skills in 3DS Max or SketchUp capabilities. The person using Scenario 3D should also understand Scenario 360 (also part of CommunityViz®) because there are many ways you can use Scenario 360 formulas to generate attributes that assist in parametric modeling. And creating "convincing" 3D visual simulations requires that the person doing the modeling understands urban design and site planning standards so that features are scaled and configured in ways that are appropriate and people recognize. So basically this means that in order to use Scenario effectively, staff would need to be proficient in GIS, 3D Modeling, Urban Design, and CommunityViz® as a package.

CommunityViz® and 3D modeling literacy would probably be considered a bonus for new planning staff, not a requirement. However, basic GIS skills should be a prerequisite for all new planning staff. More advanced skills, including Urban Design skills, would be highly desirable and probably would make learning Scenario 3D that much easier.

4.5.2 Comparative Evaluation

Key
● Excellent Support
O Good Support
○ Some Support

	1. Community Outreach	2. Visioning & Planning	3. Developing Plans	4. Developing Regulations	5. Urban Design	6. Development Review	7. Visual Impact Analysis	8. Shadow Impact Analysis	9. Quantitative Impact Analysis	10. Build-out Analysis
3D GIS Tools										
ArcGIS 3D Analyst	○	O	O	○	O	○	O	–	○	–
AutoCAD Map 3D	○	○	O	○	●	●	O	O	○	–
CommunityViz® - Scenario 3D	○	O	O	○	O	○	○	–	O	○

All three of these 3D GIS tools provide only marginal support for **Community Outreach** in that they can produce snapshots and movies, but little else in terms of web-ready content. ArcGIS 3D Analyst can export to VRML but the ESC has had little success in exporting scenes with any complexity, and it is not clear how well AutoCAD Map works in this regard.

All three tools also support assist in creating 3D visualizations of alternative scenario plans for **Visioning & Planning**, **Developing Plans**, and **Urban Design**. AutoCAD Map 3D gets an edge over the others for **Urban Design**, **Development Review**, and **Shadow Impact Analysis** due to the fact that it shares AutoCAD's precision and rendering abilities. It gets marked down for Visioning and Planning, however, because its lack of parametric modeling features which come in handy for quick visualizations.

For **Visual Impact Analysis**, AutoCAD Map 3D also is good because of its precision and rendering capabilities, and 3D Analyst is good because it has viewshed analysis. Scenario 3D creates visuals, but they are difficult to create with any accuracy.

However Scenario 3D excels at **Quantitative Impact Analysis** due to is tight integration with Scenario 360 (CommunityViz®). The other tools, because they are also GIS-based, allow the user to quantify impacts, but in a less user-friendly way.

Scenario 3D can take the outputs of a Scenario 360 “Visual” **Build-out Analysis** and parametrically generate a 3D visualization, however the results are not very realistic looking.

4.6 Planning Decision Support Tools

Planning Decision Support Tools are GIS or GIS-based software applications that support the analysis of planning scenarios and the impacts of potential planning decisions. Any GIS would be considered a decision support tool, since by definition a GIS is data-driven and can be quantified and analyzed. These tools are map-based, but some of them can be extended into 3D parametric modelers/viewers.

4.6.1 Tools Overview

We evaluated six tools: **ArcGIS desktop**, **ArcGIS Spatial Analyst**, **CommunityViz® Scenario 360**, **INDEX**, **I-Place3s**, and **Metroquest**. Of all the tool categories, the tools in this one are the most varied. This is because the concept of "Decision Support" can be interpreted quite broadly, as opposed to the other categories which are quite specific. As a result this group includes a variety software tools that are commonly used by planners to analyze and evaluate alternatives.

Process Models
Process models are processes of the same nature that are classified together into a model. A process model describes a sequence of functions that can be replicated with different inputs.

Any GIS could be viewed as a decision support tool, particularly ones that let you build *process models*, such as ArcGIS's ModelBuilder. ArcGIS is also included in this group because it serves as the base software for many of the other tools, yet can perform many types of analyses on its own. Two ArcGIS extensions that are particularly useful to planners are ESRI's 3D Analyst (covered in the previous section) and Spatial Analyst, which provides raster-based functions such as cut-and-fill, suitability analysis, habitat fragmentation analysis, and view-shed analysis.

Sketch Planning Tools
Sketch planning tools enable planners to "sketch" different land uses on a map to generate alternative scenarios for testing evaluation. Sketch planning tools are GIS based and typically perform impact analysis for various indicators...

CommunityViz® Scenario 360, INDEX, and I-Place3S are decision support tools designed for planners specifically. All three are scenario *sketch-planning* tools, whereas MetroQuest is mainly a presentation/education platform. MetroQuest is included, however, because it does perform alternative scenario analysis – albeit the interface most users are referring to when talking about MetroQuest is a web interface that presents the *results* of alternative scenario analyses that were previously run. Nevertheless, it provides enough options and variables to test out many possible scenarios and is excellent for public outreach and education.

4.6.1.1 ArcGIS (ESRI)

Tool:	**ArcGIS**
Vendor:	**ESRI**
Type:	**Decision Support**
Initial Cost:	$$$
Maintenance:	$$
Platform:	PC only
Prerequisite software:	None

Description

ArcGIS is a suite of Geographic Information System (GIS) software products produced by ESRI. The suite consists of number of desktop applications including ArcReader, which allows the user to view and query maps created with other ArcGIS products; ArcMap, which allows the user to view spatial data, create layered maps, and perform spatial analysis; and ArcCatalog, a geodatabase administration application that provides a unified view of all data and metadata files, databases, ArcGIS documents, and remote GIS web services. ArcToolbox is a collection of geoprocessing scripts included with ArcGIS that can be run from either ArcMap or ArcCatalog, and includes "*ModelBuilder*", a drag and drop graphical interface that allows the user to string together numerous geoprocessing scripts and data inputs to automate geoprocessing workflows. (See sidebar)

3D Modeling vs. Data Modeling
The terms "modeling" or "model building", as used in the fields of GIS and Urban Planning are really shorthand for the terms "3D modeling" or "data modeling". The two are quite different and should not be confused. ArcGIS ModelBuilder is a geographic data modeling tool; whereas ModelBuilder 3D is a companion product to older versions of CommunityViz's SiteBuilder3D that is used to build 3D models of buildings and other objects.

ArcGIS comes in three versions, each with a different level of functionality. The first level is ArcView, which allows the user to view spatial data, create layered maps, and perform basic spatial analysis. ArcEditor, the next level up in functionality, includes more advanced tools for manipulation of shapefiles and geodatabases. ArcInfo, which is considered the "fully loaded" product, adds on more capabilities for data manipulation, editing, and analysis. For the purposes of most planners, ArcView is sufficient. However is some cases – such as when new, accurate data needs to be created, or when more complex analysis needs to be performed with multiple layers of inputs, ArcEditor or ArcInfo are advantageous.

Adding to the complexity of ArcGIS's licensing and functionality model are the availability of ArcGIS "Extensions" that add on specific functionality to the core ArcGIS product. The two most useful for planners are Spatial Analyst and 3D Analyst, which will be discussed separately. There are also 3rd party extensions, such as INDEX and CommunityViz, which also will be discussed separately.

Outputs

Maps, Analytical Maps, Tables, Charts, Data Layers (Shapefiles or Geodatabases), Reports

Benefits for Planners

- An essential tool for creating and managing any geospatial information critical for planners.
- Creates base maps for a range of planning activities
- Also serves as a base application for other tools that are useful for planners, such as INDEX, CommunityViz, 3D Analyst, etc.

Challenges for Planners

- GIS is a science/discipline in itself that has its own language, concepts, and terminology. Many planners are not trained in GIS and therefore have difficulty understanding and using GIS effectively.
- A complicated interface with many functions can be intimidating for many planners. Frequently, GIS staff create "macros" for common planning activities, such as generating hearing notification radii.
- Consumes and creates large sets of data that are difficult to keep track of and manage.

Staff and Training Considerations

Most in-house planning staff should be able to produce simple thematic maps and have a basic understanding of GIS concepts. In addition to dedicated GIS staff, it s often desirable to have at least a few planners who are GIS-savvy who are readily available to "non-techy" planners in each division. Project managers (Planning Coordinators) do not necessarily need to be able to run GIS but need to understand the concepts well enough to be able to know when and what type of GIS analysis might be useful for their projects.

Many agencies provide GIS trainings to planners; but frequently, staff do not use the tool at all and forget how to use it short time after the trainings. In many cases, this appears to be a case of planners viewing ArcGIS solely for making maps, rather than as an analytical tool. If GIS is used more often for activities such as site suitability analysis, habitat fragmentation analysis, build-out analysis, etc., the likelihood of retention will increase as well as the likelihood of discovering other ways GIS can support planning activities will increase. To that end, and to best utilize limited time and resources available, trainings might be more effective if well-targeted towards specific planning activities

rather than providing "one shot" and "generic" trainings – although a generic training as an introduction to GIS concepts would help planners understand GIS structure and capabilities. Trainings should be designed specifically to deal with local planning issues so that trainees can use new knowledge and skills from day one of the training. It may also make sense to identify planning activities that would most benefit from GIS analysis and incorporate it into a more "standardized" workflow.

Since GIS is becoming a more critical tool for planners, and is not being taught in planning schools, basic GIS skills should be a prerequisite for all new planning staff. More advanced skills would be highly desirable, and probably recommended if there is a lack of planners with advanced GIS skills in the existing staff.

4.6.1.2 ArcGIS Spatial Analyst

Description

ArcGIS Spatial Analyst is an extension to ArcGIS Desktop that provides powerful tools for comprehensive, raster-based spatial modeling and analysis. Using ArcGIS Spatial Analyst, you can derive new information from your existing data, analyze spatial relationships, build spatial models, and perform complex raster operations. ModelBuilder, a graphical process-flow modeling framework, allows others to understand the spatial analysis process applied, examine what-if scenarios, and compare results.

ArcGIS Spatial Analyst tools are good for suitability analysis, performing land-use analysis, find routes of least environmental/cost impacts, habitat fragmentation analysis, as well as surface analysis functions like slope, contours, hill shade, viewshed, and cut and fill.

Benefits for Planners

- An essential tool for processing and analyzing raster-based data.
- Raster overlays are better for suitability analysis than vector overlays, especially when weighting various factors.
- Surface analysis functions are quite useful for site planning and development review.

Challenges for Planners

- GIS is a science/discipline in itself that has its own language, concepts, and terminology. Many planners are not trained in GIS and therefore have difficulty understanding and using GIS effectively.
- Raster analysis has its own set of concepts and terminology that planners are typically not versed in.
- A complicated interface with many functions can be intimidating for many planners.
- Consumes and creates large sets of data that are difficult to keep track of and manage.

Staff and Training Considerations

Most of the staff and training considerations for ArcGIS apply here as well. The analysis functions in Spatial Analysis are just additional GIS functions that would be helpful to planners. Therefore the users of Spatial Analyst should probably have intermediate skills with ArcGIS. Although raster analysis is frequently delegated to specialized GIS staff, it make sense to have at least a few planners in every division who can use the software and understand at what points in the planning process the software can be of value.

4.6.1.3 CommunityViz® – Scenario 360 (Placeways)

Description

Tool:	**Scenario 360**
Vendor:	**Placeways**
Type:	**Decision Support**
Initial Cost:	$$
Maintenance:	$$
Platform:	PC only
Prerequisite software:	ArcGIS

CommunityViz® planning software is an extension for ArcGIS Desktop. Planners, urban designers, resource managers, local and regional governments, and many others use CommunityViz® to help them make decisions about development, land use, transportation, conservation and more. A GIS-based decision-support tool, CommunityViz® "shows" you the implications of different plans and choices. It supports scenario planning, sketch planning, 3-D visualization, suitability analysis, impact assessment, growth modeling and other popular planning techniques. Its many layers of functionality make it useful for a wide range of skill levels and applications.

CommunityViz® consists of two ArcGIS® extensions: Scenario 360 and Scenario 3D. Scenario 360 adds interactive analysis tools and a decision-making framework to the ArcGIS platform. Scenario 360 helps planners view, analyze and understand land-use alternatives and impacts. Scenario 3D provides tools to create 3D scenes using the

underlying GIS data, and is discussed in the next section of this document.

Scenario 360 differs from other scenario and sketch planning tools such as INDEX or IPlace3s in that it provides a framework to create formulas, variables, indicators, charts, and reports to perform planning analyses rather coming pre-populated with the formulas, variables, indicators, charts, and report templates themselves. This makes Scenario 360 much more flexible in terms of what it can do, but potentially more difficult to get up and running. To address the latter concern, a "Common Impacts Wizard" has been added to Scenario 360 that automatically creates formulas, variables set at common default values, indicators, charts, and reports that evaluate typical land use impacts such as population, dwelling units, jobs, auto emissions, commercial and residential energy and water use, etc. Additional wizards have been added to guide the user through setting up analyses for other common tasks such as build-out analysis, suitability analysis, and report generation. The Land Use Designer component lets you customize attributes for different mixes of land uses and "paint" them onto the map like INDEX and I-PLACE3S.

Disclaimer:
The consultant has been closely involved in the development of CommunityViz, and therefore has a deeper understanding of the strengths and weakness of this tool compared to similar tools like INDEX and IPlace3s. However, the consultant has had hands-on experience with all these tools and will present the most factual and unbiased representation as possible for each tool. The consultant also does not make any financial gain from the sale of this, or any other tool reviewed in this report.

Scenario 360 can be integrated with other specialized analysis models for particular disciplines like traffic or conservation by using tables, databases, .xml, or Excel spreadsheets. As the external data is updated, Scenario 360 can update the linked analysis automatically.

Scenario 360 must be purchased as part of CommunityViz. This, however, is not a problem since CommunityViz® costs considerably less than any other 3D GIS tools. It is $350 for a "self-service" stand-alone license which provides access to on-line technical support only. A full service stand-alone license which includes telephone and email support and adds additional decision support tools (including Allocator, Analysis Publisher, LandFrag Wizard, and Optimizer) costs $850. Network licenses start are $850 for three, and drop in cost/unit as quantity goes up.

Benefits for Planners

- The tool is specifically designed to support planning and urban design activities and has wizards to help set up analyses.
- The "Formula Wizard" enables users to write formulas using plain English.

- Its many layers of functionality make it useful for a wide range of skill levels and applications.
- Strong analytical capabilities.
- Flexible and scale-able: can be used to perform very simple analyses and data processing as well as very complex custom analyses.
- Open and accessible framework allows the user to see and have control over all formulas, variable assumptions, charts, etc.
- Can save a template of an analysis and apply it to different (but similarly structured) data.
- Can be linked to outside models (e.g. transportation, fiscal impact, etc.)
- User interface (slider bars, charts, wizards, and formula builders) is easy to understand.
- Any data layers that are manipulated by the software are first imported as copies into a geodatabase. Original data remains intact.
- Low acquisition cost.

Challenges for Planners

- The tool can be challenging to learn and use and master.
- Must be very familiar and proficient with GIS (specifically in order to be comfortable using CommunityViz®.
- Processing time can be too slow to run at public meetings, particularly for large areas with many features.
- Very limited customization for charts and graphs as well as HTML reports.
- Difficult to manage windows for multiple charts, views, tables etc.
- Tends to be buggy and may crash.

Outputs

Maps, Analytical Maps, Tables, Charts, Reports, HTML Reports.

Staff and Training Considerations

CommunityViz® is potentially very useful to planning and urban design staff, but requires a high level of GIS literacy and proficiency with ArcGIS; so any of the staff and training considerations that are mentioned for ArcGIS would apply here as well. In addition to the basic GIS training needed, this includes issues about lack of retention by the user if not used fairly regularly early on, as well as the benefit of training targeted to the specific needs of the planning agency and incorporating the use of the tool into a more "standardized' workflow for certain tasks.

An additional consideration regarding the skills of staff is that, in order for the tool to be use effectively and appropriately, the user not only has to have a good understanding of the GIS data but also the planning issues and process. Because the tool is more of a framework than a template, and like using Excel, the user has to supply the formulas and assumptions and those are derived from a clear understanding of the planning issues and process. Therefore, a staff person only trained in GIS, or a staff person only trained in planning, will not get the full benefit of the tool as a staff person trained in both disciplines.

Like other specialized tools, not all staff need to have the same level of proficiency. Managers don't need to be able to set up analyses, but should be conversant enough about the software to understand its capabilities and what it can and cannot do. Scenario 360 also has many different modules that may be a great use to some people, and little or no use to others. There is no need for everyone to learn every function within the program. But there are certain core elements, like formulas, variable assumptions, and indicators, than should be understood.

CommunityViz® literacy should probably be considered a bonus for new planning staff, not a requirement. However, basic GIS skills should be a prerequisite for all new planning staff. A higher skill level (intermediate or advanced) would be very desirable, and probably would make learning Scenario 360 that much easier.

Tool:	**INDEX**
Vendor:	**Criterion Planners**
Type:	**Decision Support**
Initial Cost:	$$$
Maintenance:	N.A.
Platform:	PC only
Prerequisite software:	ArcGIS

4.6.1.4 INDEX (Criterion Planners)

Description

INDEX is an extension to ArcGIS that is specifically designed to support the process of community planning and development. The software can be used to benchmark measurements of existing conditions to identify problems and opportunities that merit attention in plans. INDEX can then be used to design alternative planning scenarios, analyze and score their performance, and compare and rank alternatives based on goal achievement. Once plans are adopted, INDEX supports implementation by evaluating the consistency of development proposals against plan goals. Over time, achievements can be periodically measured with progress reports.

At the heart of INDEX are indicators that stakeholders select to measure conditions and gauge change. INDEX PlanBuilder comes with a comprehensive set of 90 indicators that address land-use, urban design, transportation and the environment. Custom versions of INDEX have indicators specially designed for local issues. There is also a custom version called "Paint-the-town" which lets users explore alternative land-use scenarios by "painting" land uses on a map.

INDEX has very specific data needs depending on what indicators are selected to track. It is a rather complicated system to set up, but the documentation is quite extensive and clear. Most often, INDEX is installed by the vendor: Criterion Planners. It is usable by anyone familiar with ESRI products and GIS modeling generally.

Outputs

Maps, Analytical Maps, Tables, Charts, Reports, HTML Reports.

Benefits for Planners

- The tool is specifically designed to support planning and community development.
- Strong, performance-based analytical capabilities using well established indicator formulas and assumptions.
- Although complex, setup is relatively straightforward with clear documentation.
- Can be delivered nearly as a turn-key solution.

- Well supported by a team of planners.
- User interface is clear and easy to understand.

Challenges for Planners

- The tool can be challenging to learn and use and master.
- Often base data must be preprocessed so that it is in a format compatible with the requirements of the software.
- Processing time can be too slow to run at public meetings, particularly for large areas with many features.
- It is land-use based and requires information on number of housing units. Most often, this information is available through tax assessor data linked to a parcels layer. There can be very many parcels over a large area and that can take a long time to process.
- Customization is very difficult, and most often requires the vendor.
- Although formulas are well documented, it can appear to be rather "black box".

Staff and Training Considerations

INDEX is a very useful tool for planning staff for Community Visioning and Planning and Developing Plans, and is relatively easy to use once it is set up and running. However, even when it is set up and running, planning staff would need to understand the core functions of ArcGIS and feel comfortable manipulating and editing layers (intermediate GIS skills).

The biggest question about INDEX is whether to attempt to implement it in-house or have Criterion Planners do it and train planning staff on how to use the software. Although there is significantly more cost involved, having the vendor install it provides more certainty of success and therefore more agencies tend to take that route. However, that would limit the County's ability to implement it in other areas.

The ease of installing and/or maintaining the model in-house would depend how large an area and/or how many areas are being studied. As mentioned, INDEX (and any Decision Support tool) begins to slow down when there are a large number of records. So if the intent is to

use the model at public workshops, the number of records would need to be minimized. This would probably mean aggregating parcel/tax assessor data up to some larger units of analysis, and that is something that requires someone with advanced ArcGIS expertise who is very familiar with the base GIS data as well as INDEX. One or more staff would need to be designated as stewards of the INDEX model.

Like other specialized tools, not all staff need to have the same level of proficiency. Managers don't need to be able to set up the system, but should be conversant enough about the software to understand its capabilities and what it can and cannot do.

Finding new staff who have had direct experience with INDEX us highly unlikely; and most likely any new hire would need to learn it in order to use and/or maintain it. Basic GIS skills, which should be a prerequisite for all new planning staff, would be necessary to run it. More advanced skills would be necessary to feed and maintain it.

4.6.1.5 I-PLACE3S

Description

Tool:	**I-PLACE3S**
Vendor:	**CA Energy Commission**
Type:	**Decision Support**
Initial Cost:	$$$$$
Maintenance:	$$$$$
Platform:	Any
Prerequisite software:	Browser

I-PLACE3S is a web-based software-as-service that facilitates use of the PLACE3S planning method, which is a form of scenario sketch planning.

I-PLACE3S is designed to support Smart Growth planning in regions, cities, and communities, and is meant to be easily accessible to planners, policymakers, citizens, and students. It supports an "interactive, participatory analytical process to evaluate land use planning scenarios and their impact on a community and region".

The I-PLACE3S model uses a real-time GIS service to analyze and display the results of different land use scenarios in map format. I-PLACE3S can be used to create multiple future scenarios and present the information in a series of digital maps and data tables. The data generated in I-PLACE3S can be exported and turned into tables, charts, and maps to help to illustrate difference among scenarios.

PLACE3S evolved from being a hand calculator based tool which compared and ranked relative performance (e.g. Scenario A performed better scenario B) to desktop software, developed through collaborative efforts among the California, Oregon, and Washington State Energy Departments. In 2002, the California Energy

Commission commissioned EcoInteractive (a software development company) to convert the desktop version of PLACE3s to an internet version of the PLACE3s land use model. The internet version is referred to as I-PLACE3S. The desktop version is no longer updated and is not offered or recommended for use. Access to the full I-PLACE3S program and all of the related services can be acquired by contacting the California Energy Commission

Outputs

Maps, Analytical Maps, Tables, HTML Reports.

Benefits for Planners

- The tool is specifically designed to support alternative scenario planning.
- In theory, I-PLACE3S can harness the power of an off-site server or the computing power of "the cloud" and run faster than desktop decision support tools. (not verified) This would better support real-time scenario analysis at public workshops.
- Strong analytical capabilities include built-in modules for Return On Investment and travel models.
- Can account for redevelopment and infill development, although the process for designating redevelopment potential is mostly manual.

Challenges for Planners

- The tool can be challenging to learn and use and master.
- Very techy and abstract interface and very "black box".
- Not many options for changing graphics, which are poor.
- Not really a "sketch" tool. Can only change "Place Types" – which are simply the attributes of a feature. Changing geometry involves uploading shapefiles.
- Web-based format provides no direct access to data repositories or control over data.

- Still requires ArcGIS to create base layer shapefiles to upload. Creates a problem coordinating changes in base data with the data on the server.
- Closed system. Does not allow for other models to be linked to it.
- No way to link real-time output with a 3D model.
- Expensive.

Staff and Training Considerations

In theory, once IPLACE3S is installed, a planner could run it with very little GIS experience. The problem with the theory, however, is that updating "Place Types" manually or by querying within the software is very cumbersome, and the user would probably want to use shapefiles anyway to update place types. And like INDEX, PLACE3S requires lots of GIS work to create the base layers in a format acceptable to the program. Therefore it would probably be necessary to have someone highly skilled in GIS setting up and maintaining the model. The only exception might be for planners who, either in a workshop or as part of their own exploratory process, only want to click on parcels and change "Place Types".

An additional consideration regarding the skills of staff is that, in order for the tool to be use effectively and appropriately, the user not only has to have a good understanding of the GIS data but also the planning issues and process. IPLACE3S is very "black box" and if someone was running it in a workshop setting it would be advisable that they were very studied in the underlying models and assumptions so as to be able to field questions. IPLACE3S is highly specialized and difficult to learn, so it would take a significant investment in resources to build staff capacity.

Most likely, planners will be unhappy with the graphic outputs (or lack thereof) so additional resources would most likely have to be devoted to taking the exported data and creating tables, charts, and maps that would be suitable for workshops or publications.

4.6.1.6 MetroQuest

Description

Tool:	**MetroQuest**
Vendor:	**MetroQuest**
Type:	**Decision Support**
Initial Cost:	$$$$$
Maintenance:	N/A
Platform:	Bowser/Flash
Prerequisite software:	Flash

MetroQuest is quite different from the other decision support software packages that are described in the section. It is, first and foremost, a community outreach and education tool. However, it does explore alternative development scenarios and their impacts so in that respect, it can be viewed as decision support. It is worth mentioning in this section because although it cannot stand as a true Planning Decision Support System on its own, it could be used to make up for the main weakness in the other tools: their outputs may be far too "wonky" for public consumption.

The three main applications for MetroQuest are Regional Growth Planning, Greenhouse Gas Reduction and Transit-Oriented Development. A municipality sends base layer and population/job forecast information to MetroQuest, as well as layers to determinate where development can occur, where it can't occur, where it is likely, and where it is not likely. MetroQuest staff then works with the municipality to generate some basic development scenarios organized around some basic policy choices (i.e. For development mix, do we want low density, current trend, more compact growth, or mostly compact growth? For transit, do we want to maintain existing system, moderately expand, or significantly expand? Etc.) MetroQuest staff then runs the model, and pre-generates all the possible combinations of choices then packages them into an interactive Flash interface. Complex planning concepts are translated into user-friendly images and diagrams. One of MetroQuest's most power features is that it shows the connections between issues such as fiscal health, sustainability, air quality, etc. and the consequences, some often not intended, of choices. The MetroQuest interface allows stakeholders to select from the predetermined set of policy options, and see the consequences of their choices in "real-time". The reality is that that there is no real-time data processing; rather, the interface simply calls up the appropriate maps and charts based on the user's set of selections.

The MetroQuest cannot be bought as a tool. It is really a service and MetroQuest is the consultant. Each application of MetroQuest is customized for each location, although there are elements that seem to be quite common across all applications. The vendor is reported

working on a version of the software that will allow planners to "Get under the hood" more and run the model themselves.

Outputs

Interactive Flash Application which includes urban footprint maps, tables, charts, and illustrative pictures and diagrams.

Benefits for Planners

- Excellent public outreach and education tool.
- Allows stakeholders to quickly explore multiple sets of policy options and see the results nearly instantaneously.
- Limited set of questions and assumptions helps planners keep control over the debate during public meetings.
- Excellent graphics.
- No GIS skills necessary to explore

Challenges for Planners

- Data, questions, assumptions, and outcomes are all "pre-cooked" and results emerge from a "black box".
- Requires a great deal of preparation of base layers and development/suitability analysis.
- Fairly expensive for a "one shot" output.
- Must use vendor to update and host.

Staff and Training Considerations

As mentioned, MetroQuest is really a consultant service rather than a tool that requires staff training. The end product is something that anyone can use.

However, as with any consultant project, planning and staff would need to work closely with the consultant. Planning/GIS staff would need to provide base transportation and land use layers, socio-economic data, population and employment forecasts, etc. Planning staff would also need to vet the results, and provide localized imagery and narratives. So if MetroQuest was used, there would need to be a significant investment in staff time as well, although this would probably only be for the duration of the project (3-6 months).

4.6.2 Comparative Evaluation

Key
● Excellent Support
ⓞ Good Support
○ Some Support

	1. Community Outreach	2. Visioning & Planning	3. Developing Plans	4. Developing Regulations	5. Urban Design	6. Development Review	7. Visual Impact Analysis	8. Shadow Impact Analysis	9. Quantitative Impact Analysis	10. Build-out Analysis
Planning Decision Support Tools										
ArcGIS (Desktop)	ⓞ	ⓞ	●	ⓞ	○	○	–	–	●	ⓞ
ArcGIS Spatial Analyst	○	ⓞ	●	ⓞ	○		ⓞ	–	●	ⓞ
CommunityViz® - Scenario 360	ⓞ	●	●	ⓞ	○	○	○	–	●	●
INDEX	ⓞ	●	●	ⓞ	○	○	–	–	●	–
IPlace3s	○	●	●	ⓞ	○	○	–	–	●	–
MetroQuest	●	●	ⓞ	–	–	–	–	–	○	–

The term "decision support" can mean many things. For the purposes of this report, we are defining it as "supporting the analysis of planning scenarios and the impacts of potential planning decisions." GIS is clearly the "base line" tool for analysis of planning data, therefore ArcGIS (or any other GIS application) would be the most generic tool that could be used effectively for decision support.

For **Community Outreach**, MetroQuest is by far the best tool for educating the public and stakeholders about the tradeoffs and consequences of different planning policies. The user interface is clear and easy to use and does not require any understanding of GIS. The response is instantaneous – although this is because the user has limited choices and the results are "pre-cooked". CommunityViz® has a "Webshot Wizard" function that produces something similar: you select up to six variable assumptions, and up to six pre-determined values for each variable. This produces up to 36 possible scenarios, and CommunityViz® outputs maps and charts for each scenario and outputs them in an interactive HTML/JavaScript format. The graphics and layout, however, leave a lot to be desired. The remainder of the tools, except for I-PLACE3S, all produce graphic outputs that are suitable to support Community Outreach efforts. I-PLACE3S, being a

web-based tool, produces no graphic outputs at all, except for maps that are displayed in the browser window.

For facilitated **Visioning and Planning** processes, Scenario 360, INDEX, and MetroQuest are all good tools. MetroQuest is particularly good in a live setting – because it is fast and is almost bullet-proof. The fact that it limits choices is not necessarily a draw-back and, in fact, a plus according to many. INDEX and CommunityViz® can and are used for Visioning and Planning workshops, but they are more "wonky", prone to crashes, and can be slow because, unlike MetroQuest, they are actually processing data. This means that choices aren't limited, which is a good thing to some and not a good thing to others. Certainly when preparing scenarios for the Visioning and Planning process, INDEX and Scenario 360 are superior to MetroQuest.

I-PLACE3S can be used to "paint" alternative land-use scenarios in a Visioning or Planning workshop. The graphics, however, are poor and it requires an internet connection in order to run. ArcGIS and Spatial Analyst are useful for preparing materials and graphics for Visioning and Planning.

ArcGIS, Spatial Analyst, Scenario 360, and INDEX all support the sketching, internal analysis, and graphic requirements of **Developing Plans** and, secondarily, **Developing Regulations**. The exceptions are I-PLACE3S and MetroQuest, neither of which have any ability to sketch, but do provide analysis capabilities. I-PLACE3S gets an edge over MetroQuest, however, because it allows you to edit your own data and run the model yourself whereas MetroQuest does not.

For **Urban Design** and **Development Review**, ArcGIS, Spatial Analyst, Scenario 360, and INDEX are all of only limited utility – albeit for different reasons. ArcGIS, Scenario 360, and INDEX can all support the analysis of Urban Design measures and compliance and impacts for Development Review, but this is not typically how they are used. Spatial Analyst's surface analysis tools, like viewshed, slope, and cut and fill all can be used for peripherally these activities as well.

For Visual Impact Analysis, Spatial Analyst's viewshed function can be useful but mostly only for terrain. It is difficult to integrate building models into the analysis. Scenario 360 is useful for visual impact analysis only when it is paired with Scenario 3D. None of the tools support Shadow Impact Analysis.

All of the tools are data-driven and therefore support **Quantitative Impact Analysis** quite well.

Finally, for **Build-out Analysis**, Scenario 360 stands out because it has a tool specifically for that purpose, and the software is flexible enough that you can build your own Build-out Analysis model if you wish. ArcGIS and Spatial Analyst provide critical spatial analysis and suitability analysis functions in support of Build-out Analysis. INDEX does not help so much in performing a Build-out Analysis, but can be used to test the impacts.