Applications

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Visualization in Urban Planning: They Didn't Build LA in a Day

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Like Rome, Los Angeles wasn't built in a day. And if it had to be done again, thanks to modern planning, zoning, environmental, civic, and political considerations, LA might not get built at all. However, the Urban Simulation Team (UST) at the University of California, Los Angeles (UCLA) and similar groups around the world are using interactive visual simulations (VizSims) and virtual reality (VR) to accelerate the process of designing and obtaining approvals for new buildings and developments. See Figure 1.

As the world gets more crowded, especially in urban areas, more people are concerned about what happens with their neighbors' property. In the US, this concern has prompted a neologism—stakeholder—to identify all the interested parties in an issue. When it comes to a new building or development, stakeholders might include the immediate neighbors, the people downstream from a proposed factory who are concerned about water quality, those who use a park across the street from a proposed high-rise building, the residents and others concerned about a historical area, the taxing authorities, and many others. In the US, where political activism is widespread, stakeholders can stall a proposed project for decades by demanding stringent documentation of the impact on the environment, traffic, air and water quality, light, and more. Both static models and interactive simulations are being used to make the development process and its implications clear to all concerned.

Image courtesy of UST

1 LA wasn't built in a day, and neither was this highly detailed model by the Urban Simulation Team at UCLA. A work in progress, Virtual LA is intended to encompass the entire city.

Having been active in my local government some years back, I can tell you from first-hand experience that the process of reassuring all the stakeholders that their needs are being met is not a pretty sight. In our little town, Mill Valley, California, it once took months to paint a bank. The scaffolding stood starkly in the square, and every few weeks new samples of paint would appear on the front of the historical building. The situation soon became a local joke. But it was no joke to the bank, which spent thousands of dollars trying to demonstrate how the various paint schemes would look. Had there been an interactive VizSim system available, the entire process may have only taken a few hours.

An urban simulation pioneer

Among the pioneers in the field is Bill Jepson of UCLA. He got started in urban simulation in the dark ages of computer graphics—the 1980s. Working with architect Charles Moore, students under Jepson's direction created simulations of Moore's designs. I first learned of his work after the LA riots in the early 1990s, when many buildings were destroyed or damaged. Jepson's team, which had already conceived of a virtual Los Angeles, quickly modeled the riot area and helped the city of LA show the residents what various rebuilding schemes would accomplish. Thanks to the simulation, consensus was reached in an unexpectedly rapid time, and rebuilding started immediately.

Jepsen later founded the UST as an independent operation. The team's primary goal is to create collaborative decision-making tools for use in community environments. As a demonstration of their theories, UST is developing a model of the entire LA basin, an area of several hundred square miles. UST uses aerial photographs, GPS (Global Positioning System) data, street maps, and eye-level photos to create a huge model of LA that is detailed down to graffiti on the walls. Jepsen emphasized the value of 3D models in planning, saying,

> We empower the clients to understand what the architects are doing. The architect wants to control the information flowing to the client. We come

between the architect and the client. Once the client walks through [the planned building], he feels empowered to take a larger role in the design process. Some architects feel this impinges on their artistic imperative. When [their preference] differs from the client's agenda, problems happen. The model shows the problems.

UST's models tend to be very large, and Jepsen anticipates Virtual LA to require terabytes of storage. Most of the bulk of the database is simply due to the number and size of the texture-mapped models. There are tens of thousands of structures, and photos of their facades, included in this open-ended project. In addition, each structure may have a URL attached, and that URL can point to any type of additional information. The sheer mass of data means that the hardware needed to use Virtual LA is still beyond the reach of most architects and planning offices. But as the price/performance ratio in graphics computing improves, Jepsen expects systems like his to become commonplace.

Urban planning is made much easier when simulations are used to present projects (see Figure 2). Walking through a virtual version of a proposed development gives one the sense of actually being in a place, unlike looking at the architects' conventional physical model. "Designs are still done from top view, while they are experienced from eye height," Jepson explained. "We create real-time models and walk-throughs at pedestrian eye height. With physical models, you get a 'helicopter view,' and you can't experience [the design] from ground level. If the design is not pedestrian friendly, it is immediately obvious [in the simulation]."

He added,

> What also happens with the process is that we build a highly realistic model of the surroundings. Architects don't do that. Architects want to build something [that looks] different; if it blends in they get no fame. But community wants it to blend in, [because that] makes a better neighborhood environment. If the project is out of context, it is immediately obvious. The good architects take the environment into consideration, anyway, but we give them an additional tool to use.

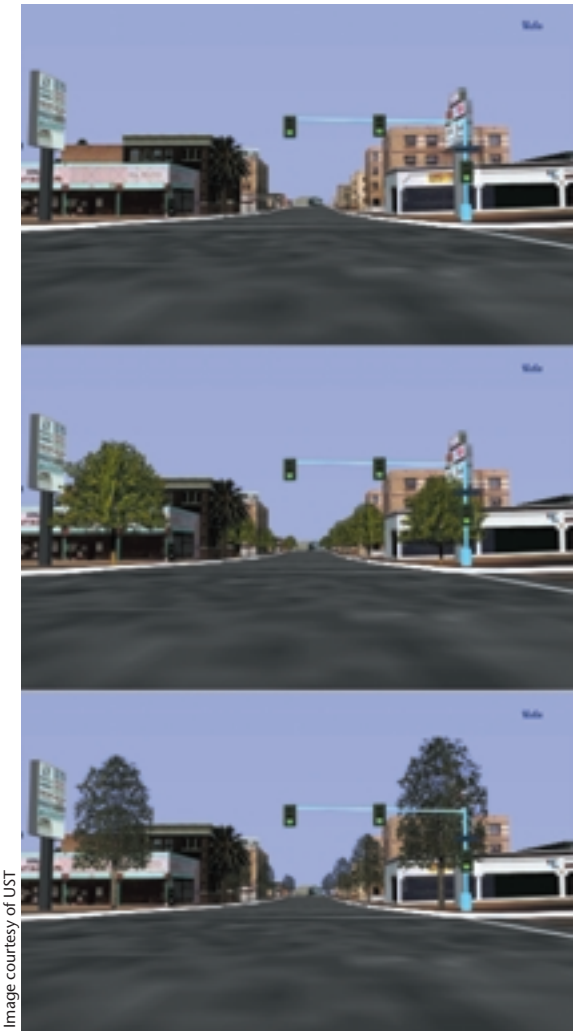


Image courtesy of UST

2 These three images from the Urban Simulation Team show the effect of landscaping at the corner of Pico and Union in Los Angeles. Note how the tree growth changes the feel of the neighborhood.

Now appearing on your home PC

However, virtualization of buildings is useful at scales less intimidating than an urban megalopolis. In Mill Valley, a real estate company is using 360-degree photography to let prospective home buyers see houses with their home PC. Using I-PIX technology supplied by a service provider, Coldwell Banker Real Estate has provided what it calls Virtual Home Tours on its Web site.

Virtual Home Tours works best with the I-Pix plug-in, but also provides a series of still photos for the plug-in-deprived. The system has less versatility than the misnamed Quicktime-VR (no virtual reality there, only 2D photos). However, it definitely provides a better sense of a house than the standard printed description. Now, instead of guessing what "chrmng Med bungalow w/ frpl in up & coming neighborhood" means, home shoppers can easily take a look. See Figure 3.

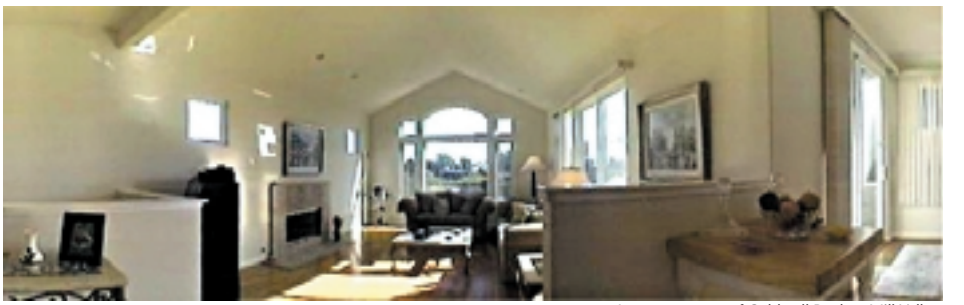
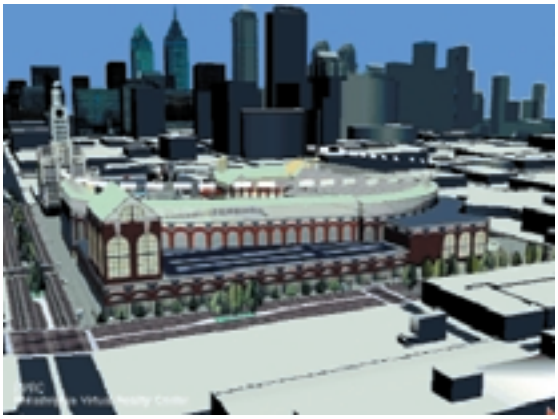


Image courtesy of Coldwell Banker, Mill Valley

3 Using digital still cameras, I-Pix creates panoramic images like this one, which can be seen on the Web while shopping for a home.



Courtesy of Mike Rosen Assoc.

4 The Phillies' new stadium is shown here in situ. 3D models provide the opportunity to examine every aspect of a project while it's still on the drawing board—the most cost-effective time to make changes.

Paul Bragstad, manager of Coldwell Banker's Mill Valley office, told me that once the initial problems were overcome, the system quickly became popular. While the technology has existed for a couple of years, the price was too high at $300 per house. When I-Pix pushed the price down to $99, the agents, who have to absorb the cost, felt the price was right.

"Its something our clients—buyers and sellers—really like," Bragstad told me. "Currently, we average only four homes on our Web site at any particular time, but I expect half of our properties to be marketed like this soon. We like it because it shows that we're staying with the cutting edge of technology." One agent experimented with using 3D models, but found it too expensive and time-consuming. However, Bragstad believes that 3D models are the future of virtual tours.

Meanwhile, in Philadelphia...

At a more technologically intense level, architect Mike Rosen builds complete, 3D models of homes and developments that are used for sales and planning purposes. He first came to national attention when his Great American Virtual Home was shown at the 1996 National Association of Home Builders Convention. Thousands of visitors toured the three-bedroom, furnished house. Corporate sponsors provided CAD files for furniture and appliances, and the model's photorealistic VRML presentation was ahead of its time.

Rosen has continued to build virtual homes, but has also moved on to bigger projects. In 1997 his firm built a Virtual Philadelphia, modeling several blocks of the city center. This model, which runs on a PC, demonstrated to the city's planners that it's practical to model large areas of a city and that the equipment costs had come down enough to be easily affordable.

Last year, Rosen tackled his biggest project. Working with the developers, his firm created a lifelike model of a proposed new stadium for the local baseball team, the Phillies. See Figure 4. Like many new baseball stadia, this one is planned as an inner-city destination, with a site only a few blocks from downtown. While giving a tour of the virtual stadium to then-mayor Ed Rendell, an event occurred that dramatically demonstrated the value of models in city planning.

At one point, as the mayor was "flying" around the inside of the stadium at ground level, he stopped at first base and looked toward the bleachers. He was not pleased. He grabbed his cell phone and called the Phillies' owners, telling them to come to his office immediately. When they arrived, the mayor showed them that the outfield scoreboard obscured City Hall, a dramatic historical building, the heart of downtown, and an object of civic pride. That would not do.

The owners asked Rosen for video of the fly-through to show their board of directors. Based on that presentation, they reoriented the ballpark, moving it about 40 feet, so that views of the revered City Hall would be unobstructed. The fly-through helped everyone realize the importance of the ballpark's downtown location—and the importance of political and social approvals to the success of a project. Said Rosen, "This was the first time that they really got it. They understood the impact of being so close to the city center."

Here she comes, Miss America

Rosen also created a video for the state of New Jersey showing the imminent remodeling of the Atlantic City Convention Center, home of the annual Miss America Pageant. Showing many of the various events planned for the new center, Rosen's video walk-through depicted the space configured for ice hockey, basketball, and, of course, the Miss America Pageant. Governor Christine Todd Whitman showed the video publicly at the pre-remodeling closing ceremony. She used it to graphically demonstrate what the tax money pledged to the $70 million project was buying, and the visualization helped maintain popular support for the project. See Figure 5.

Rosen told me that developers often prefer video walk-throughs. Developers need to show what they have been asked to show: the physical impact of a new building on a neighborhood, lighting effects, interior spaces, and so on. However, planners are curious and easily distracted people. Rosen has found that if he gives them total access to the 3D model, they can spend hours in it. Inevitably, some of them become critics, commenting on everything from the carpet pattern to the placement of the phone booths. Rosen's clients prefer to keep the planners on a narrow path that answers their questions without raising new ones.

However, Rosen sees great value in fully interactive 3D models. That value is apparent when the viewer needs to change perspective in real time or wants to address what-if scenarios. Public hearings are always full of unanticipated questions such as "I think you will block the view from this angle" or "Won't that design put the park in the shade?" If these sorts of questions can be evaluated and solutions demonstrated immediately, time and money are saved and consensus reached.

Rosen also mentioned the promotional value of virtual models of unbuilt homes and offices. These models, supplied on CD-ROM, in sales offices, or over the Internet, allow shoppers to see their potential home,

store, or office long before it exists. Decisions are made sooner, providing valuable advance sales. But the immediate cash flow advantage is not the only benefit. Virtual homes are still rare enough that they often generate a lot of free publicity—and the value of that can be enough to offset the cost of developing the models.

Seeing the big picture

While Rosen's work is done primarily for private clients, the government agencies themselves are also looking closely at the advantages of adding 3D to the planning process. In Washington, D.C., the National Capital Planning Commission (NCPC) has the responsibility of overseeing all development in the city and surrounding area. They are actively involved in using and promoting simulation as part of the planning process. VizSim helps the NCPC accomplish its three main objectives:

- *Design review*. Overseeing the construction of anything that affects federal interests, from large scale signage to museums to monuments.
- *Long-range planning*. Looking 20 to 50 years out to help determine how the capital city will look in the future. That includes the study of museums, memorials, and monuments placed on the capital mall. (Generally speaking, a memorial relates to a person, while a monument commemorates an event.)
- *Capital improvements/budgeting*. Helping to plan and account for the money for federal projects.

To accomplish these goals, the NCPC maintains and distributes data including photos, CAD data, specs, and requirements to help project designers and planners.

Michael Sherman is CAD Manager for the NCPC. He is responsible for bridging between traditional pen-and-paper techniques and modern tools. Among his projects, he is working to develop an intelligent, 3D model of the Federal District. To start, he had a consultant develop a 3D model of about a quarter of the city that shows topography, streets, buildings, parking, and more. But it's hard to use in real time on low-cost machines because it's so large. Further development will require large investments of hard-to-get public funds. The politics of funding aside, technical issues also remain. Said Sherman, "One of the most difficult things in my job is generating topography. How do you use a CAD program to generate a slope that might change in three directions?" The tools available now aren't yet good enough for this type of work.

Accuracy and appropriate levels of detail are significant issues. Sherman's office uses photographic data at 0.2m (two-tenths of a meter), 1m, and 2m resolution, derived from aerial photos. This nonclassified data is good, but photos inherently lack index points and the underlying information essential for planning. To add that information is time consuming. Though GPS has made the job a bit easier, registering the satellite data to photos isn't trivial.

Image courtesy of Mike Rosen Associates

5 The remodeled convention center in Atlantic City will host many different types of events in modernized facilities.

Further complicating the situation is the issue of security. The Institute for Defense Analysis (IDA) gave the NCPC a model it had developed to evaluate security options (see Figure 6). But while that model is too sensitive to publish, it's still not accurate enough for planning activities.

Nonetheless, Sherman told me that the NCPC is increasing its use of 3D modeling for individual projects, while they wait for the technology to be good enough and affordable enough to allow them to complete a model of the entire city. So far the NCPC has completed a model of the Capital Mall (the area between the Capital building and the Washington Monument). Sherman provides it to architects or places an architect's model into the mall model. This enables all the stakeholders to better understand how new projects fit into the big picture. Items of interest include the scale of the project, how it affects sight lines, and if people like how it looks in situ. While this step isn't yet a requirement in the planning process, he expects it to be in the future.

Plenty of obstacles must be overcome before 3D models become part of the daily planning process. When the process works smoothly, it's because many architects have converged on Autodesk's AutoCAD, Discreet's 3D Studio, and Bentley's MicroStation for the CAD and modeling. Though these file formats are easily exchanged, the data interchange issue is still a big one. Issues include the size and quality of files received from various sources, where to store these often-huge files, how to maintain the security of the data while providing access to the public and officials who need it, and how to protect the intellectual property rights of the design-

Image courtesy of NCPC

6 The Institute for Defense Analysis, which created this model of the capital city showing the Capital Mall, placed its logo on the Washington Monument.

Image courtesy of NCPC

7 **This is how the approved design of the World War II Memorial will look in place on the Capital Mall. The model was created in 3D Studio.**

ers. Sherman doesn't see any show-stopping problems here, but recognizes that they must all be addressed to general satisfaction.

These issues haven't stopped Sherman from using 3D models in the planning process. The recently approved World War II Memorial, which will be built on the mall, is a good example. The memorial's design was chosen in an international competition, and the winning entry was submitted to the NCPC as a 3D model. The commission used this model as part of the evaluation process. They found great value in being able to see the memorial in place on the mall, from any angle (see Figure 7). Experiencing it this way enabled them to decide that the proposed scale was too large and that the placement blocked important views. The revision process went quickly (by Washington standards), and construction of the new, approved design will start soon.

Typically, Sherman doesn't present the actual 3D

Systems for Planning

Ben Delaney

Models made up of terabytes of polygonal, textural, and structural data need substantial computing systems to provide access in anywhere near real time. That's why most major urban planning applications run on big iron—specifically SGI's InfiniteReality graphics on Onyx2 computers. While every developer with whom I spoke stressed the desire, indeed the requirement, for less expensive and more portable systems, nearly all of them use SGI hardware for their biggest presentations.

The only problems anyone mentioned with the SGI machines are size and cost—size, because many presentations must be made in city council chambers and similar settings. Lugging an Onyx2 to a meeting is far from trivial. That's why most of the people developing and using urban planning simulations are moving quickly to Windows-based solutions and actually presenting some of their work on high-powered laptops running Windows NT. Most also use videotaped fly-throughs of their databases as presentation tools.

In addition to computers to display the models and scenarios, urban planning simulation developers use some space-age technology. GPS data is combined with satellite and aerial photographs to ensure that buildings, streets, and utilities are indeed where expected and depicted. Also, technology developed by NASA to create 3D elevations from 2D photos is commonly used to provide accurate contour modeling. This is an important issue, since real-world sites are seldom the perfect planes that most CAD programs assume as a starting point.

While no commercial software products yet provide the full range of urban simulation capabilities, MultiGen/Paradigm comes closest to supplying a one-stop solution with Creator/CreatorPro software, popular for modeling and database creation. The company's TerrainPro and RoadPro are leaders in creating accurate models.

Many other software tools are also popular, and most developers have a toolbox that includes a variety of special-purpose options. Discreet's 3D Studio is often used in combination with Adobe's Photoshop to create 3D models and associated textures. For CAD, Autodesk's AutoCAD and Bentley's MicroStation are preferred. Most of the groups seriously involved in urban simulation have developed or modified software to meet their needs. For example, ESC modified ESRI's ArcView so that it connects to various databases they find useful.

The data included in an urban simulation can be as simple as a map or as complex as a modern city (well, almost). The Ascutney, Vermont system includes data related to demographic information, such as neighborhood income, population density, average number of vehicles per household, and the number of children; physical information, including the locations of buildings, utilities, and roads; and detailed topological and geographical information. However, this isn't enough data, and the methods of correlating it are still too crude. The objective, as ESC founder Michael Kwartler said, is to "make a complex situation understandable without dumbing it down."

model to the commission, but, like Rosen and Jepson, shows them screenshots and animations. He feels that the technology is still too cumbersome and too glitchy to use in a very important presentation to a group of nontechnical people. Secondly, Sherman explained, "From a time standpoint, it's a little dangerous to provide a 3D model. They might get too enthralled. You want to stay focused, but stay as accurate as possible."

Sherman's next goal is to add zoning, environmental, and traffic intelligence to his models. He wants to create not just Virtual Washington, but Smart Virtual Washington—a model city that will calculate the impact on infrastructure, traffic, and other factors when a model is dropped into it. Technical immaturity makes that impossible now, but he expects fairly quick progress. Combined with improved presentation modalities, this is the direction of simulation in city planning, said Sherman: "The future is combining all the technologies. More and more the data will all converge into one system."

Building the smart virtual city

Some of Mike Sherman's hopes are being realized in New York City. There, at the Environmental Simulation Center (ESC), director Michael Kwartler has assembled a team with an ambitious objective: making virtual cities smart.

"What we're doing," he told me, "is adding intelligence to the models." He continued,

> We're trying to mesh words, numbers and images as a way of representing reality. The [real] 3D world is intelligent. It's the world of experience. We make the words and numbers and images [of planners and designers] all accountable to each other. GIS (geographic information systems—typically 2D data) people see 3D as a frill. Most planners think the maps are just fine. If the maps are so fine, why is the country so ugly? The new urbanist presents three-dimensional images. They give you an idea of what [a project] is going to look like.

Working with architects and planners, Kwartler came to the realization that words and numbers don't tell the whole story. He would build 3D models according to the specifications and the architects' words and numbers, and the models turned out poorly. So he started bending, then breaking, the rules to make the models more aesthetically pleasing than the descriptions would have suggested. Architects loved it because he made them look good.

He's been working on the idea of understanding the complexity of cities and the buildings in them for years. Ten years ago, he founded ESC to provide a home for his work. He was influenced early on by Christopher Alexander's book, *Notes on the Synthesis of Form* (Harvard University Press, 1970), which provided Kwartler with insight into what makes cities good. "The best places are not rational. Think about it. New York, San Francisco, Venice; they are all a little strange, intriguing."

Another important early influence was the popular "game," Sim City. It demonstrates the complexity and unpredictability of urban planning and city growth. In fact, Kwartler tried to get Sim City's creator, Will Wright, to work with him, but "Wright found it too real; he preferred to do games."

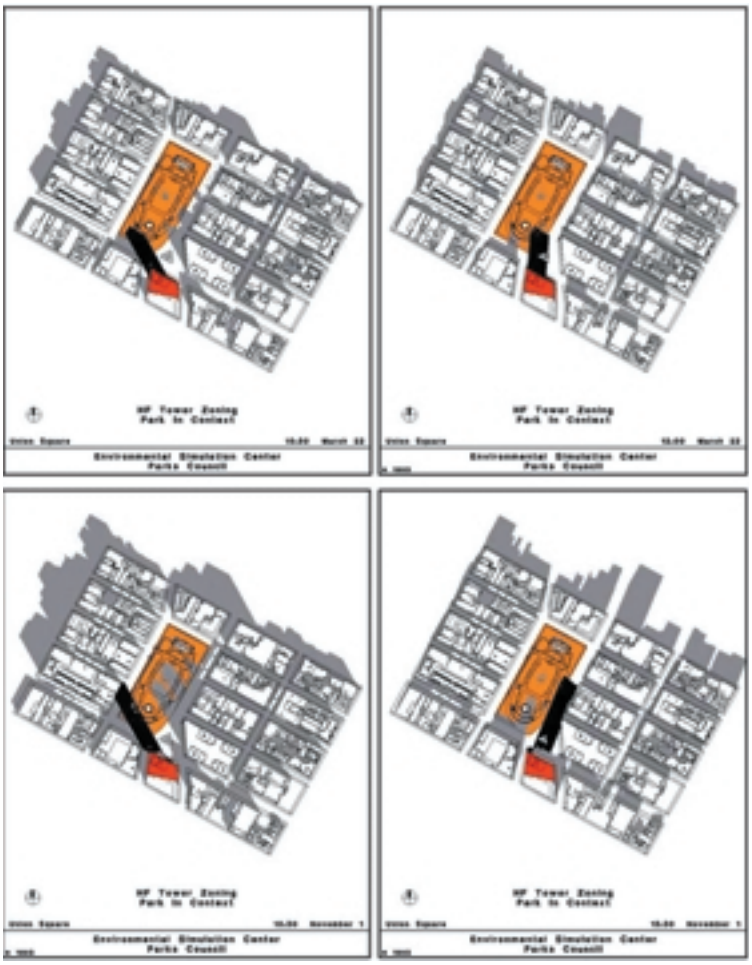


Image courtesy of ESC

8 These images show how the shadow of a proposed new building at Union Square in New York would shade the square at various times and seasons.

Realizing that people need help to understand the complexity of interactions in a city, Kwartler began developing software to simulate as many factors as possible. This has been applied in his home, New York City, where he wrote a zoning regulation with 26 variables—what he calls performance-based zoning. The application of this regulation to a project can only be done with computers. It has been very successful, providing a much more realistic prediction of how a development will affect traffic, infrastructure, and the attitude of the people in the neighborhood (see Figure 8).

Based on his success with neighborhood planning, the ESC has started a much more ambitious project: modeling an entire town. With funding from the Orten Family Foundation, ESC has started work on a virtual version of Ascutney, Vermont, a town of around 1,000 people.

Virtual Ascutney is a pilot project started in 1997. ESC began with 3D GIS data, then connected that to an interactive 3D model of about 100 buildings. The model includes roads, the river, and a bit of surrounding area.

Image courtesy of ESC

9 TownBuilder 3D is a fully interactive, real-time, 3D environment used in conjunction with the Scenario Constructor module. The 3D environment is synchronized with the Scenario Constructor module and Arcview, allowing the user to freely navigate and change conditions in the 3D and 2D environments, while evaluating their implication in real time. The view also displays a hypothetical new town center scheme for the demonstration town of Ascutney, Vermont.

To be useful to planners and citizens, Virtual Ascutney is getting more detail, more variables, and more accessibility. There is a need to incorporate policies, such as zoning, in the simulation. The simulation should answer questions such as what would happen if a policy of development rights transfer, used in preserving open space, was instituted? (Development rights transfer policies allow owners of land protected from development, such as farmlands and parks, to assign a value to the lost development and sell that development right to the owner of another property.) Planners want the model to demonstrate how such issues will affect infrastructure, open space, traffic, and housing preferences. The implications are nonlinear and nonhierarchical.

In part, policy simulation is based on the behaviors of individuals, modeled as software agents, using complex adaptive systems theory. Unlike most policy models, which are deterministic and econometric, ESC's agents have cultural beliefs, demographic backgrounds, and strong preferences about where they want to live and what kinds of neighbors are appropriate.

The Orten Family Foundation intends to develop a functioning application, a sort of serious Sim City based on ESC's work, for small communities to use in planning. However, many challenges remain. Among the questions ESC expects to answer soon are

- How does one provide appropriate levels of detail to various users? Some stakeholders require photorealism, while others are satisfied with blocks that represent the location and mass of buildings.
- What is the best way to integrate data from census information, city records, and other sources?
- What is the best way to incorporate and display the environmental impacts of decisions?
- How does one validate the model and simulation?

Virtual Ascutney is already being used for growth management, planning sustainable development, and determining growth boundaries. See Figure 9 on the next page. The software doesn't provide absolute answers, but it does help to better understand the situation. You can build a bridge and see people move to the other side. Adding a proposed mall to Virtual Ascutney recently demonstrated this. The virtual residents apparently liked the new mall. They started moving near the site even before the (virtual) construction started.

Try before you buy

The growing acceptance of simulation in planning has extended even to highways. In southern California, the California Department of Transportation (CalTrans) highway management agency recently made a deal with MultiGen/Paradigm to model a section of I-710. The model will show the effect of various development and retrofit options. The database will span a 2.5-mile section of the freeway and help transportation planners understand the impact of the work before it begins. The simulation is also expected to promote consensus building by offering realistic and high-impact presentations of the improvements.

Simulation is quickly becoming an essential tool for planners at the town, city, and regional levels. As computers become more powerful, we can expect planet-wide simulations to extend our understanding of the impact of development on large areas of the globe. Just as today's weather forecasting systems have increased their scope and accuracy with improved data and computational resources, so will every town be able to assess the impact of proposed development long before a single shovel of earth is moved.

As Bill Jepson asked, "If a picture is worth 1,000 words, what's a 3D model worth?" When it comes to planning the future of a town, or the entire planet, a 3D model may be priceless. ■

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