CommunityViz in Transportation Planning and Modeling

CommunityViz software is an ArcGIS[®] extension for planning and analysis.¹ At its core is a powerful, flexible modeling framework that allows users to create tools for all kinds of GIS (geographic information system) modeling applications, quickly and efficiently. What's more, CommunityViz integrates smoothly with external applications, making it an ideal land use planning companion for transportation and travel demand modeling systems.

For general information about CommunityViz, please refer to our library of resources. This paper focuses on transportation planning and modeling. It starts with an explanation of the CommunityViz modeling framework, and then describes a number of common CommunityViz transportation planning and modeling solutions.

CommunityViz Modeling Framework

"Modeling" is the process of creating mathematical representations of real-world systems for the purpose of studying their behavior and improving their design. Regional planners, for example, often use CommunityViz to model future development and estimate its economic, environmental, and social outcomes under alternative planning scenarios. Transportation planning and travel demand models such as TransCAD predict changes in travel patterns and the demands on a transportation system that occur in response to changing regional demographics, land use and development patterns, and transportation infrastructure. Transportation modeling is complex, but decades of modeling research and increasingly powerful computing technology are yielding increasingly accurate and comprehensive results.

While CommunityViz has a number of built-in models for common land use planning and resource management applications, it is not specialized for transportation planning. However, its greatest power lies in its ability to support custom models. Rather than programming complete models into its internal software code, CommunityViz, through the CommunityViz component called *Scenario 360*^{M}, provides an open modeling framework and building blocks—called functions—that let users create the exact models they need, when and as they need them.²

The "open modeling framework" means that users create their own analysis tools. The model formulas and assumptions are completely transparent: anyone can look at them, edit them, or add to them, just as they would with an Excel spreadsheet. To make these changes there are no charges and no data maintenance fees, and consultation from Placeways or other certified CommunityViz consultants is completely optional.

Yet the models can be very sophisticated, and Scenario 360 provides over 80 building block functions to work with. Function categories include numeric, spatial, statistical, database lookup, network, trigonometric, text manipulation, user input, and custom script types. There are also many functions to facilitate moving data across geographic scales (small study polygons vs. large study polygons), such as

¹ CommunityViz is a registered trademark of Placeways LLC. ArcGIS is a registered trademark of Esri.

² Scenario 360 is a trademark of Placeways LLC.

OverlapWeightedAverage and *GetFromClosest*. Two types of processing that Scenario 360 does not provide internal capabilities for are geoprocessing, for which ArcGIS and ArcGIS Model Builder provide ample capability, and looping or iterative computations and simulations, for which external scripts are required.

The figure below illustrates the CommunityViz Scenario 360 modeling environment. Starting at the top left, the User Setup components provide the human interface into Scenario 360 model creation capabilities. Users create projects or models, called analyses, with these parts of the software. Set up includes creating variable input assumptions, various data set up functions, result measurements called indicators, and other components. At the heart of the set up lie "dynamic attributes," which are GIS layer attributes whose values are dynamically controlled and updated by Scenario 360.

Moving downward in the diagram, you see the functions for creating dynamic attribute formulas and indicator formulas. Modelers create Scenario 360 formulas, which look something like Excel formulas and use an easy-to-learn notation. These can be written directly with the Formula Editor, or in a more automated fashion by using a variety of wizards and tools included in the software. Sets of formulas can be saved and reused on other datasets by means of Analysis Templates for the Analysis XML³, which stores the settings that have been created.



Moving downward in the diagram again, the Scenario 360 analysis engine is the proprietary nerve center of the modeling framework. It uses ArcObjects, C#, the ArcGIS platform, and other software to execute formulas and manage the cascade of model updates that occurs each time a change occurs to input data, variable assumptions, scenarios, or map data. Those changes are driven by the intuitive, planner-friendly, "User Analysis" controls shown in the upper right of the diagram.

For all its internal modeling power, CommunityViz architecture also embraces the notion of integration with external models of all kinds. It provides the ability to call custom scripts, import and export tables, exchange database and geodatabase files, exchange analysis structures via XML, share CommunityViz analysis templates, and read external tables (including Excel spreadsheets) dynamically. In addition, because

³ XML is a standard file format designed to allow easy file sharing among applications.

CommunityViz is an ArcGIS extension, it takes advantage of the broad spectrum of interoperability capabilities provided by that platform. This means that users can

- Trade inputs and outputs with other software tools
- Connect to existing spreadsheet-based impact models
- Use data from one, several, or hundreds of external databases
- Call custom scripts
- Make use of almost any data type supported by ArcGIS
- And more

The end result of the Scenario 360 modeling architecture is a powerful, flexible environment for creating modeling tools. It gives CommunityViz users the ability to build new tools for novel problems as they arise. And it also lets them build reliable, reusable models that implement a proven technique and can be used again and again. CommunityViz has been extensively proven in the field during 10 years of projects by thousands of users all over the world. At first, the custom modeling focus of CommunityViz may seem daunting to people who are accustomed to using pre-programmed models. Its huge advantage is an analysis framework that is always made to meet the needs of the project, not the other way around.

The next several sections provide examples of how this approach is proving itself in transportation planning and modeling applications.

4D Demand Reduction Models

Transportation and land use planners seeking to reduce travel demand and the production of greenhouse gas (GHG) emissions from transportation are aware that choices regarding the physical form of development can reduce travel demand. The so called 4 Ds are design, density, diversity and destinations, all measurements of characteristics land use and transportation system patterns. Empirical studies are showing that changes in these factors produce reductions in travel demand, although data is still scarce and

the models are still maturing. Newer models are adding additional factors to make 5D, 6D, 7D, and so on, but we use the term 4D to refer generically to all models of this type.

Measuring the 4 (or more) Ds for a given planning scenario is a straightforward exercise in CommunityViz using its built in GIS analysis functions. 4D models then provide simple algebraic formulas including empirically determined (or estimated) reduction coefficients. The final result is a number that is the estimated percent reduction in vehicle miles traveled (VMT) for the study area compared to other areas in the region. The figure on the right is a sample chart showing this kind of analysis in CommunityViz.



For 4D analysis at this level, CommunityViz provides two great advantages. One is that the input data and layers are not fixed. There is no need to provide, say, a particular kind of "place type" or a particular pre-

processed layer with a particular field specifying one of the Ds. The CommunityViz analyst can look at the available data, decide on a logical way of calculating each D given that data, and write the necessary formulas on the spot, usually in a few minutes' time. The other advantage is that the coefficients are very easy to adjust. They can be fine-tuned for regional variations, for example (Portland, Oregon coefficients are different from Atlanta, Georgia coefficients), or adjusted during the course of a discussion to prove or disprove the model's sensitivity to controversial assumptions.

More sophisticated 4D and 4D-like models are being created as stand-alone, usually in-house applications by major regional planning agencies and leading transportation planning firms. Planners and modelers who have access to those tools use CommunityViz primarily for its extraordinary ability to provide input data in a suitable form, as described in the "Mismatch Fixer" section below.

Sketching

Creating good plans that meet a particular set of objectives is an iterative process. The process starts with visions or concepts, progresses through preliminary sketches and revisions, moves on to scenario planning and assessment, and eventually results in an approved and committed plan. The problem with iteration, from a transportation modeler's point of view, is that each cycle requires at least one run of the model. If it takes days or weeks to run a model (as is often true for regional transportation forecasts), then each new sketch or revision turns into a rushed, costly, time consuming project. The modeler's preference is usually



for plenty of time to run a few, carefully chosen scenarios with enough care and deliberation to produce reliable, precise results.

CommunityViz can help. Among its interactionmany friendly features are tools that allow untrained users to sketch ideas or proposals and receive quick, approximate

feedback about their results. An emerging term for this kind of process is *geodesign*. The calculations take place in CommunityViz, not the transportation model, using simplified formulas that run in near-real time. Planners or even modelers can try many experiments and variations, narrowing down the options before deciding on the specifics of a few, particular scenarios to run through the "real" transportation model. The process saves considerable time and resources, and it is more satisfying for planners and modelers alike.

Just one example is shown on the previous page. This "transit sketch tool" shows a map of the San Diego region in a screenshot from CommunityViz Scenario 360. The tool allows planners to drop proposed new

transit stops (from the palette in the lower right) onto the map and find out how many people they will serve. Other symbols on the map give planners Scenario 360-provided information about where the greatest needs are, and the Scenario 360 charts give real-time feedback on the results of any proposal. This tool was created over the course of a few days by a Placeways consultant using the CommunityViz open modeling framework. A virtually infinite variety of other sketching applications is possible: smart growth areas, bike lanes, land use plans, regional retail developments, and many more. Two limitations are that CommunityViz cannot do actual 4-step transportation modeling, and real-time network analysis is usually too slow for easy sketching. However, experienced practitioners can sometimes "design around" even these limitations using strategically chosen pre-calculations.

Climate Change and Greenhouse Gas Models

Planners often need to estimate the climate change effects of alternative scenarios. For transportation, the primary considerations are the greenhouse gas (GHG) emissions that result from the combustion of vehicle fuel and, to a lesser extent, generating electricity for electric cars and rail. Planners have four categories of approaches available:

- Capital improvements in the transportation system
- Planning policies that improve 4D-like characteristics (see the section in this paper on 4D)
- Travel demand management programs such as HOV/HOT lanes, parking restrictions, and other fees and incentives
- Alternative transportation technologies, such as hybrid electric cars and alternative fuels

As with other applications, CommunityViz allows modelers to approach the problem at various levels of detail, ranging from simple internal multipliers to interaction with sophisticated external calculators.

Most simply, modelers can start from a single estimate for vehicle miles traveled (VMT) in the study area during a given year and multiply by estimates for the amount of carbon dioxide equivalent of various GHGs generated by the average vehicle in the fleet per mile traveled. From that point, there are many ways to increase the precision of the estimates or, at least as important, model how the amounts would change in response to alternative GHG reduction strategies. For example, CommunityViz can

- Apply 4D-based travel demand reduction estimates to the starting value for VMT
- Adjust VMT based on external models or expert opinion giving the effect of travel demand programs
- Adjust GHG ratios on the basis of external models or expert opinion giving the effect of alternative transportation technologies.

An illustration of these approaches appears in the figure below, which is taken from a project in Cape Cod, Massachusetts sponsored by a coalition of federal agencies.



The precision and sophistication of this approach depends greatly on the input value for VMT. Ideally, that single value takes into account a complete transportation model and incorporates factors such as fleet composition, mode shares, passengers per vehicle, vehicle speeds for peak and non-peak hours, weather conditions, and more. Factors like this can only come out of a specialized transportation modeling tool, so the complete modeling process would involve several cycles of data exchange from the transportation model, to CommunityViz, back to the transportation model, back to CommunityViz, and so forth.

Improving Land Use/Transportation Data Exchange: "Mismatch Fixes"

No matter how sophisticated a transportation model or climate change impact model is, it must rely on outside sources—usually regional and local planning agencies—for input data on future demographics, development, and land use. Almost universally, transportation planners find that the first available data is incompatible with their needs. In particular, they find two mismatches:

- Scale. Regional land use planning is performed at different scales from transportation modeling. For example, future land use maps are often built using zoning districts, artificial planning grids, or parcels rather than transportation's preferred TAZs.
- **Designations.** Regional land use designations, such as "high density residential" or "mixed use commercial" do not match the travel-specialized designations used in travel demand and 4-step transportation models, such as "medical office."

Fortunately, CommunityViz is well suited to overcoming the mismatch challenge. Modelers who use CommunityViz can

- Quickly and easily convert their plans from any scale into any other scale, such as from parcels to TAZs.
- Quickly and easily translate between designations, such as specifying how many square feet of retail space are implied by a regional land use type called "Mixed Use."

1	OBJECTID	ZOINING_TY	ZONING_DES	LU Land Use Name	LU LBCS Function	1
	1	A	Agriculture/Conservation District	LU Rural	1100	1
	2	ALUR	Alternative Land Use Regulation District	LU Rural	1100	Τ
	3	RS1	Single-Family Residential District	LU Res Low Density	1100	Т
	4	A	Agriculture/Conservation District	LU Rural	1100	Τ
	5	A	Agriculture/Conservation District	LU Rural	1100	Τ
	6	A	Agriculture/Conservation District	LU Rural	1100	Т
	7	u	Light Industrial District	LU Rural	1100	Τ
	8	A	Agriculture/Conservation District	LU Rural	1100	Т

• Create custom designations for land use planners to use that are directly related to those that transportation modelers will use, potentially saving steps and reducing confusion in certain settings where this kind of process makes sense

The first two bullets are accomplished using the Scenario 360 open modeling framework described earlier in this paper. The third bullet is supported by Scenario 360 Sketch Tools and Land Use Designer, which are specifically designed for creating custom designations that can be used for land use sketching.

Novel Applications

No software tool or model can anticipate every need. But by providing an open modeling framework, a large set of building block functions, and a core set of useful tools, CommunityViz is well positioned to help transportation planners work with new and novel ideas.

As an example, a transportation planning team studying climate change recently suggested the idea of placing solar arrays in highway rights of way to generate energy and achieve some GHG offsetting effects. At the time, at least, this was a novel idea and no one had created any kind of model of its costs and benefits. But using CommunityViz, an analyst could quickly create such a model. Here is a likely sequence of steps:



1. A CommunityViz suitability analysis to calculate which roadway segments could best support solar panels based on considerations like available space, tree cover, aspect, or congestion (these are just examples). CommunityViz has built-in algorithms for this kind of geographic suitability analysis.

2. Potential capacity for solar panels based on summing the length of suitable rights of way. This is trivial for CommunityViz formulas.

3. Penetration rate assumptions. CommunityViz has built-in, elegant controls for creating user-adjustable assumptions that are used by the models.

- 4. Cost estimation based on cost per solar panel and, perhaps, adjustments for location, ease of access, or other factors. CommunityViz can use both numeric and geospatial data for calculations like this.
- 5. Energy generation based on per-panel coefficients, perhaps adjusted for transmission losses over distance that will depend on the location of each panel.
- 6. GHG reductions resulting from the source substitution of solar in place of average sources.

The resulting analysis tool would be open and transparent, so it could be inspected for accuracy, edited, and shared freely with other agencies interested in modeling the same approach in different locations.

Conclusion

CommunityViz is a powerful ally for anyone doing analytical modeling in ArcGIS, and transportation planners and modelers will find a particularly strong match to their needs. As this paper described, the Scenario 360 open modeling framework provides a powerful, flexible platform for creating the tools you need, when and how you need them. These, combined with the rich set of built-in analysis and interaction features of CommunityViz, provide an ideal framework for transportation planners and modelers to perform 4D analysis, sketching, climate change modeling, data exchange between planning tools, and other novel applications.

Much more information on CommunityViz is available online at *placeways.com/communityviz*, or call Placeways toll-free (in the U.S. and Canada) at 1.866.953.1400 to ask for help, ideas, and suggestions.