Visualization
Empowering Innovation

Visualization Issues for Transportation Agencies

Approaches and Challenges

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The transportation design community is using visualization tools for a variety of purposes—from public involvement to traffic analysis to planning and design. Visualization technologies are making an impact on the planning, design, and maintenance of our roadway systems.

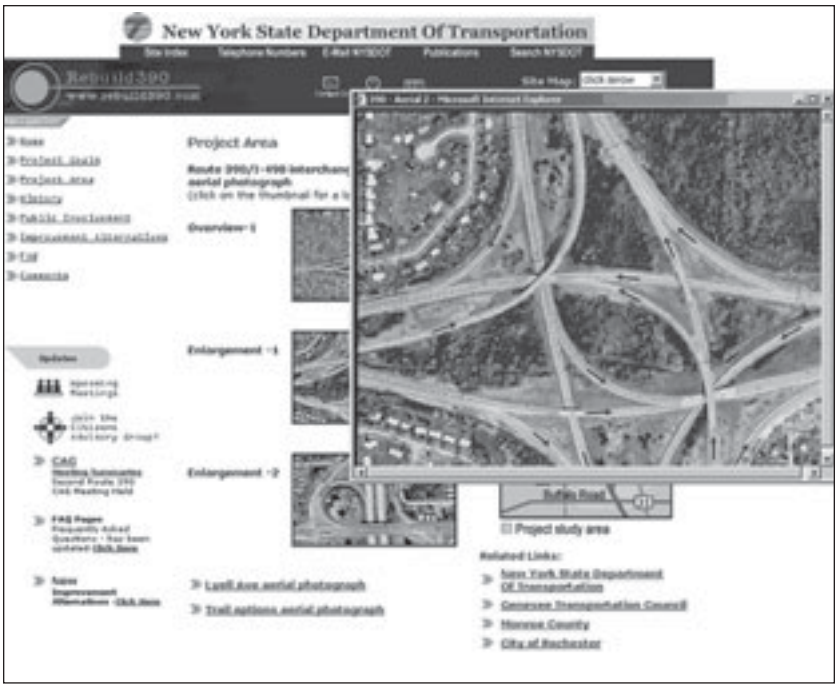
Nevertheless, project managers and department heads in state agencies often ask what visualization is and how it is used. Visualization is difficult for most people to understand because it encompasses many definitions and uses.

Essentially, visualization is the use of graphics to explain any planning or design issue. It can be a simple rendering by hand, a physical model, or a three-dimensional (3-D) computer-generated animation. The visual tool box encompasses many tools, and the choices are predicated on a project's budget and production schedule.

Agency Initiatives

Transportation agencies are using visualization technologies in three primary categories:

Visualization of a proposed gateway traffic circle.



Public outreach websites, like this by New York State DOT, allow access to up-to-date project information and offer ways to post comments; the sites are updated with such information as project milestones, analyses of traffic impacts, alternative solutions, meeting reports, and schedules.

- Public involvement and stakeholder approval,
- Context-sensitive design, and
- 3-D computer-aided design and drafting (CADD).

Public involvement is the primary use. The general public has become aware of visualization techniques through the media and entertainment industries and expects to see these same types of sophisticated applications when reviewing proposed projects. Many departments of transportation (DOTs) have found that visual tools are a necessity for large projects, not only to convey the goal clearly but also to advance an image of the DOT as sufficiently innovative and sophisticated to develop and manage such a project.

Visual tools are gaining widespread use in the planning process for context-sensitive design. Many DOTs are attempting to involve key stakeholders and the public earlier in the planning process, to ensure that projects are more readily accepted and approved. Visual tools such as photo editing can play an important role. Design charettes—small group meetings to collaborate in problem solving—are common ways to review design ideas with the public and often rely on visualization.

Because the public has become better informed and more sophisticated, the days of an agency unilaterally designing, announcing, and defending a project are past. Context-sensitive design and visualization are helping to bridge the communication gap between transportation agencies and the public.

Some agencies are beginning to plan and design projects in 3-D, allowing planners, designers, and engineers to improve their understanding of the design issues and impacts. With 3-D CADD applications, for example, engineers have made 3-D digital terrain models for machine-controlled cut-and-fill operations. The visual application has improved construction accuracy and saved significantly on construction costs.

Choosing Tools

What kinds of visual tools are transportation agencies applying? Most agencies rely on key department personnel or consultants for advice and recommendations. Decisions typically are made case by case and often are determined by the project size, budget, and schedule.

A range of tools is available. Traditional tools, such as physical models and 2-D renderings, are still prevalent. More advanced applications—such as photo editing to show before-and-after images, and web-based or multimedia graphics—have become commonplace. Once considered extras, these applications are now integral to the planning and design process.

Larger projects with robust budgets tend to rely on higher-end applications, such as 3-D animation and virtual reality. These applications are more expensive and take time to produce, but the results offer high-quality imagery that can render the proposed designs realistically.

Planners can use visualization to resolve construction sequencing issues and present cost-efficient approaches.

Implementing Visualization

Despite increased use, visualization remains misunderstood. No standards or guidelines are available to assist agency project managers, who must make fundamental decisions each time a visual need arises. These decision makers often have limited knowledge or understanding of the technology, leading to ineffective use or misapprehension of the benefits.

The primary hindrance to the development of standards and guidelines is that visualization is not yet considered part of the planning and design process. Visuals often are not addressed until the end of the planning process, when public involvement issues arise. As a result, the visuals become extra expenses that usually have no set budget. To be more effective, the technology must become part of the planning and design processes.

Quantifying Value

A valid cost–benefit analysis is needed for visualization technology. Project managers require some kind of a reference to determine how much an application will cost or how long it will take to create. In addition, quantifiable data are needed to back up the perceived values of visualization.

For example, what were the positive effects of the technology on the quality of the design? Did the technology save on productivity, enhance the production schedule, or speed the approval process? Most project managers want to know the return-on-investment. Empirical data to support the effects of visualization technologies are lacking. Project managers value the uses of visualization but have difficulty explaining what that value is.

Another issue is the lack of understanding of the technology among decision makers. Most project managers and decision makers are unfamiliar with the processes of visualization, making it difficult for them to determine schedules and budgets. Often they rely on outside consultants for advice and decisions. The combination of an insufficient understanding and minimal references for guidance has kept project managers from embracing the technology.

Establishing Units

Most transportation agencies do not have units responsible for visualization but instead rely on key personnel to produce visualization content. For the most part, these assignments have no formal job descriptions or defined career path. Without formal job descriptions and distinct business units, training personnel to advance their skills in visualization is difficult.

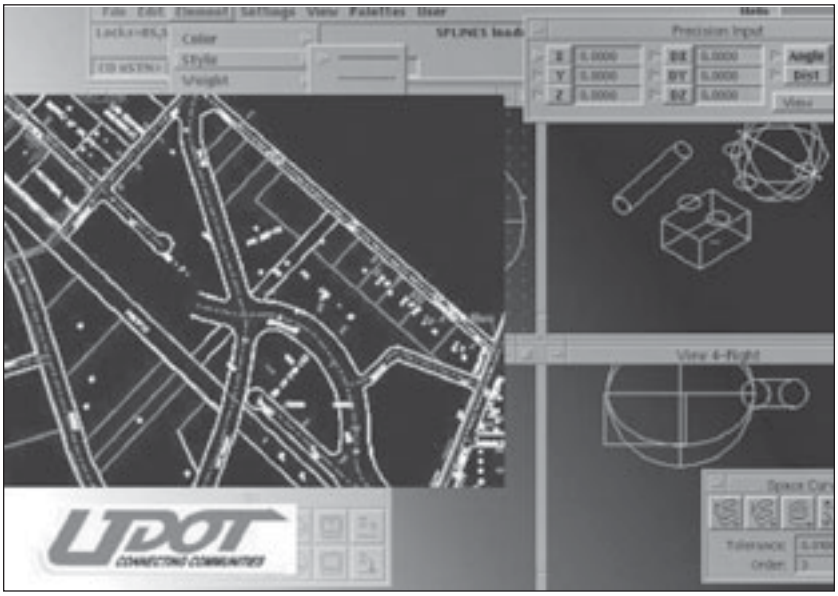
Often the staff who are familiar with visualization are assigned to other business units, such as landscape architecture. This makes it difficult for transportation agencies to track, hire, or start up visualization units.

Without a tracking mechanism, visualization decisions and budgets often are incorporated into other project budgets or are categorized as CADD applications. These challenges are daunting and have led most transportation agencies to refer visualization-related projects to consultants instead of developing a specific in-house group for visualization.

Screen shot of a virtual reality simulation of a proposed reversible lane corridor in Florida.

Positive Trends

Although the challenges are many, the prospects for the use of visualization technologies within transportation agencies are positive. Within the past 10 years, software and hardware costs have decreased



The Utah DOT visual technologies web page documents the use of visualization in design projects.

Rendering of a towboat in a replacement lock proposed near Nashville, Tennessee.

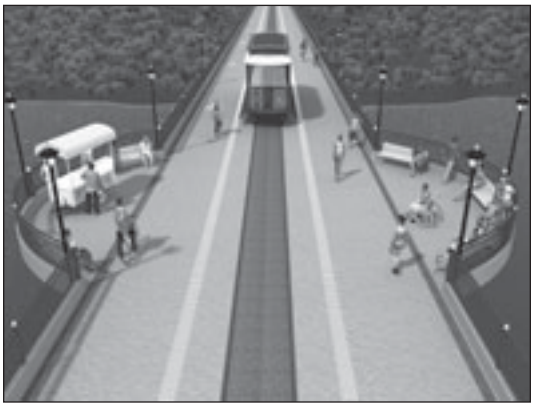
dramatically, and analysts say this trend will continue.

Formerly an expensive and exclusive undertaking, visualization now can be accomplished by a wider range of personnel. The trend is analogous to the evolution of computerized word processing from expensive systems operated by typing specialists to a commonplace and inexpensive application usable by most personnel.

Enhancements continue in CADD applications, with integrated 3-D tools and visualization capabilities, as tool sets become easier to use and much more powerful. Transportation agencies already have made substantial investments in CADD hardware and software, facilitating the integration of visual tools. Many agencies are beginning to develop projects using 3-D design techniques. With the design already in 3-D, visualization output, such as photosimulation, becomes easier and more cost-effective.

Transportation agencies also are using visual tools for analysis. Several traffic microsimulation programs, for example, link 3-D models to traffic data, so that traffic engineers are able to analyze potential traffic scenarios in 3-D.

Geographic information systems applications are also becoming more prevalent in the analysis and design process. A major initiative with the technology is the output of data into visuals such as aerial maps and overlays. These applications and others support the trend to the increased use of visualization tools in planning and design.



Proposed rehabilitation of a rail bridge over the Hudson River.

Into the Mainstream

Visualization technologies have become more of a mainstream application for transportation agencies in the planning and design process. Today, most visualization applications require a specialist, but as CADD applications continue to mature, engineers, designers, and technicians will be able to produce visuals themselves. The visuals will become part of the design process, adding value to the application and to the project.

In 2006, the Federal Highway Administration (FHWA) drafted interim guidance for implementing provisions in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) on planning, environment, and air quality:

> As part of transportation plan and TIP [transportation improvement plan] development, MPOs [metropolitan planning organizations] shall employ visualization techniques. States shall also employ visualization techniques in the development of the Long-Range Statewide Transportation Plan. States and MPOs must employ visualization techniques prior to adoption of statewide and metropolitan transportation plans and metropolitan TIPs addressing SAFETEA-LU provisions.

This guidance makes visualization applications part of the future for the planning and design process.[1]

The challenge for most agencies is how to implement the technology effectively into their processes. The Transportation Research Board, the American Association of State Highway and Transportation Officials, and other organizations will need to help guide and inform transportation agencies on how best to implement the technology. Agencies will need to determine what investment to make in implementing visualization technologies—not only the hardware and software applications, but the training.

Visualization technologies have evolved from a niche service to become part of the planning and design process in most transportation agencies, and the uses will expand. Computer graphics are being used in information kiosks in stores, Hollywood movies, and video games. Transportation agencies need to understand and implement this powerful tool.

[1] A detailed version of the SAFETEA-LU guidance is available at www.fhwa.dot.gov/hep/igslpja.htm.