VISUALIZATION DATA STANDARDS FOR PLANNING AND DESIGN

by

Cyrus McCall, P.E.

McCormick Taylor, Inc.

Baltimore, MD

Submitted for the

2006 INTERNATIONAL VISUALIZATION IN TRANSPORTATION
SYMPOSIUM & WORKSHOP

Visualization Accuracy and Data Standards

In 1997 Governing magazine's cover story "The Asphalt Rebellion" stated:

"For decades, traffic engineers have been designing wider, straighter, faster roads. Now, some communities are challenging that approach" *(1).*

The goal of transportation planning and design is to develop solutions that improve communities in terms of mobility, safety, or even to provide an environment suitable for a pleasant afternoon of shopping and dining on Main Street. Because of the many purposes and needs that a road can provide, public stakeholders are often in conflict with each other about a project. These conflicts can be over anything from the overall purpose of the project to impacts to a specific old growth tree or stonewall. They can be expensive, with time and money invested in solutions that do not move forward.

Visualization techniques that place the proposed design in existing site photography have become a critical to support consensus building throughout planning and design. When a before and after photo is presented, a common question is "How accurate is this proposed visualization?" This really depends on the stage in project development and available data. For the purposes of this discussion, consider visualization data standard as the characteristics of the complete set of information that goes into making the final product.

Visualization and Project Stages

In the 1990's transportation agencies began initiatives like "Context Sensitive Solutions" and "Thinking Beyond the Pavement". This movement seeks to avoid conflicts and misunderstandings by adopting a new approach to the overall planning and design process with the following major points:

- More communication throughout the process
- Multi-disciplinary teams where more input is considered
- More flexibility in adapting to local conditions

In another endorsement of this philosophy, the FHWA published *Flexibility in Highway Design*. The planning and design process as described in the first chapter of this document includes 4 major stages where visualization is often used for decision-making: Planning, Project Development, Final Design, and Right of Way. As an essential element of a successful design process they list "Early and continuous public involvement throughout the project" and "The use of visualization techniques to aid the public" *(2).* Additionally, in September 1996, the FHWA and the Federal Transit Administration (FTA) issued Public *Involvement Techniques for Transportation Decision-making,* which also endorses visualization techniques as a critical element "throughout the process" *(3).*

While the recommendation of visualization use is made, there is little reference to specific data standards or techniques. The focus in this paper is photo simulation projects that were purchased by government agencies to facilitate a context sensitive design process. Ultimately, the visualization data standard depends on the amount of information developed during that particular stage. Table 1, shown below, splits these stages into planning and design. It describes the goals as well as what types of design data are typically available.

		Planning Project Development	**Final Design Right of Way**
	Major Objectives	Problem Definition Scoping Select Preferred Alternate	Develop the Design Detail the Design Plans, Specs, and Estimates
PROPOSED	**Paved Edges**	yes	yes
	Bridge Deck Location	yes	yes
	Structure Details	no	yes
	Pavement Markings	no	usually
	Signs	no	usually
	Landscaping Plan	no	usually
	Utility Relocation Plan	no	yes
	Impacted Properties	sometimes	yes
	Vertical Alignment	sometimes	yes
	3D Proposed DTM	sometimes	yes
EXISTING	**Existing Contours**	sometimes	yes
	2D Existing Survey	yes	yes
	3D Existing Survey	no	yes
	3D Existing DTM	sometimes	yes
	Orthophotos	yes	yes
	Aerial Oblique Photos	sometimes	usually
	Ground Photos	usually	yes

Table 1: Typical data available for planning and design. Not a complete list of all possible data sources.

Controlling the cost of the visualization products is always a major concern, especially when designs concepts are apt to change. Part of cost control is to establish a schedule for providing the necessary design data at the right time. For example, in an early planning stage there may be design files that show only the edge of the road, but no cut and fill limits have been established. It might be wise to complete a cut and fill analysis before passing the alignment on to the visualization specialist(s) because evaluation of the cut and fill impacts could reveal that the alignment needs to be shifted. It is also wise to provide data with enough lead-time for plenty of communication and a draft review before the ultimate meeting date.

On the other hand, lets say that the visualization requires an element that is not in the CAD file and is not scheduled to be added at all during the planning stage. A common example of this is pavement striping and signs. The visualization specialist can add these based on the project manager's request. This is essentially an added design element, and the visualization specialist is not necessarily expected to come up with a perfect design plan, but simply a visualization product that communicates the design intent. The priority at this time is to explore more alignment options, instead of perfectly detailing a single option.

Keeping the level of visualization commiserate with the stage that a project will properly focus discussion on the decisions at hand. If the same amount of data is visualized at a lower resolution the model doesn't need to be as detailed, and the product can be touched up more easily in PhotoShop. Projects in an early planning stage may opt for low resolution in favor of studying many alternates. Projects in a design stage may use higher resolution. They will have a single design alignment, possibly showing alternate details, such as landscaping, or aesthetic treatments.

Data-driven Visualization Process

Although strictly artist interpretations are still used at meetings in highway development, the majority of visualization products used for decision-making are data-driven. This means that the products have connection to the design information that is developed for the project. Not only does this improve the accuracy of the final product, it allows the visualization to be used as a design tool to detect errors and make refinements. The reviewers can be confident that what they are evaluating is a direct reflection of the design concept.

The University of Maryland investigated the team dynamics and cost of visualization in highway development in terms of the amount of views, alternates, and iterations of change per alternate *(4).* While CAD files are used to create final plans at the end of the process, there is a long lifespan of CAD files used for cost-estimates, displays, and visualization. Project managers seek to provide all possible data that can help drive the visualization process. Whether a project is in a planning, project development, final design, or right of way stage, the simple framework shown below applies (Figure 1).

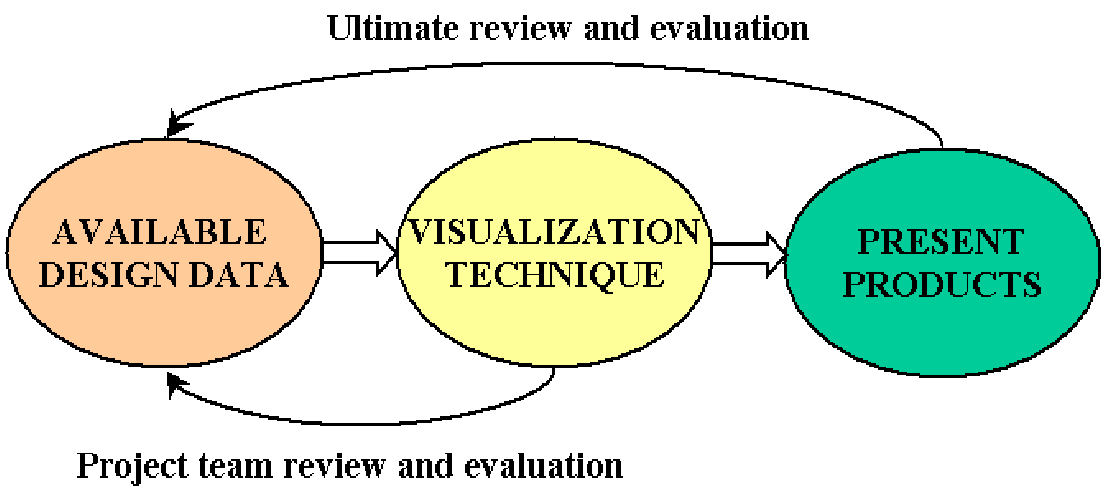


Figure 1: Data-driven visualization.

First, the project team reviews and evaluates draft visualizations. These sessions may result in pursuing totally new concepts in a planning stage or refined details in a design stage. By using early review sessions, you save extra time spent by the graphic artist on a product that won't be used. The design team may decide to use another photo or make some major design changes. Specific entrances and existing details may come to light in a photo. A healthy debate between reviewers, designers, and project manager can also take place. For example, the decision of whether to remove a particular area of existing landscape often comes up. In this case the best solution may be for the graphic artist to hold off on finalizing this detail, or if budget permits, create the image in both forms for comparison.

Once the project team is satisfied, the final products are prepared for the ultimate review and evaluation. These meetings can be with the general public, key stakeholders, or government officials. The goal is to obtain important feedback for making design improvements. The meetings can also be critical rites of passage. Finally, data for the chosen alternate(s) is collected and organized so it is available for the next stage in the process. A visualization that was produced in a planning stage will be important in kick-off meetings for the next stage.

Photo-matching Process

Photo-matching means creating a camera in the CAD environment that closely matches the camera that took the picture in the real world. It is helpful during this process to have a general idea of the location, target, and focal length (level of zoom) of the real world camera, but the only necessary item is a 3D existing survey. If only 2D mapping is available, a visualization specialist can improvise the third dimension.

A given photo may take half a day for an expert to match. Overlaying the photo with the 3D survey shows how accurate the projection will be. Once a particular photo has been matched, this projection can be reused for additional alternates. Sometimes on difficult matches, the final image of the model is also adjusted with Photoshop as a quick solution. The image below (Figure 2) shows both the 3D survey (upper right) and model (lower left) projected using the same camera. The existing houses and road edges line up nicely, so the proposed model will also be projected into the correct location.

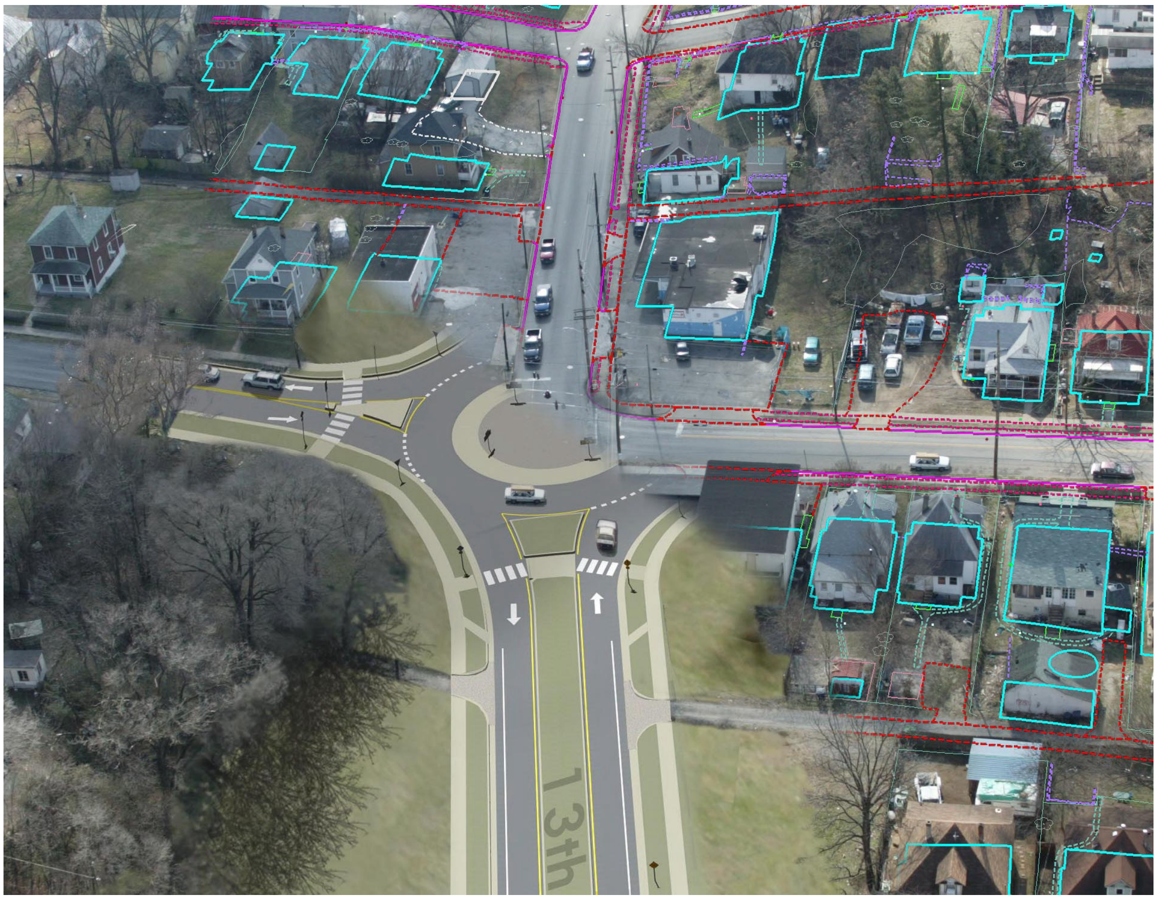


Figure 2: 3D survey is used for accurate projection of proposed highway model.

Project Examples

The following example projects each used a different visualization data standard. What they have in common is that they make the most of available information and a limited budget to accurately convey the design.

- Oblique Aerial Photo Renderings of US 22 / Progress Avenue during early planning for the Susquehanna Township in Pennsylvania
- Orthophoto renderings of the InterCounty Connector (ICC) alternates during project development for the Maryland State Highway Administration (MSHA)
- Ground level photo renderings of Governors Avenue during final design for the Delaware DOT (DELDOT)
- Oblique Aerial Photo Renderings of Hollins Road during final design for the Virginia DOT (VDOT)

US 22 / Progress Avenue- Early Planning, Susquehanna Township

- Proposed Data: Paved Edges (Curbs, Road, Sidewalk, Median), Stripes
- Existing Data: 2D Survey, Contours, Oblique Aerial Photograph
- Elements added by visualization specialists: Signals (based on a rough sketch), Proposed DTM, Cut and Fill Limit, Impacted Properties, Vehicles. The existing contours were used to create an existing ground DTM. This DTM was used to turn the 2D survey and into a 3D survey file for the photo-matching process.
- 3 alternates, 2 photos

Oblique aerial photo

Jughandle solution

Oblique aerial photo

Conventional solution

Initial jughandle solution

Refined jughandle solution

NOTE: Graphics presented in this paper are for presentation purposes only. All designs are subject to change.

InterCounty Connector (ICC)- Project Development, MSHA

- Proposed Data: Paved Edges (Curbs, Road, Sidewalk, Median), Bridge Deck Location, Cut and Fill Limit, GEOPAK GPK file (Vertical Alignments), Cross-sections
- Existing Data: GEOPAK TIN, Orthophoto
- Design elements added by visualization specialists: Stripes, Impacted Properties (identified on the photo)
- Up to 4 alternates per location, 23 view locations

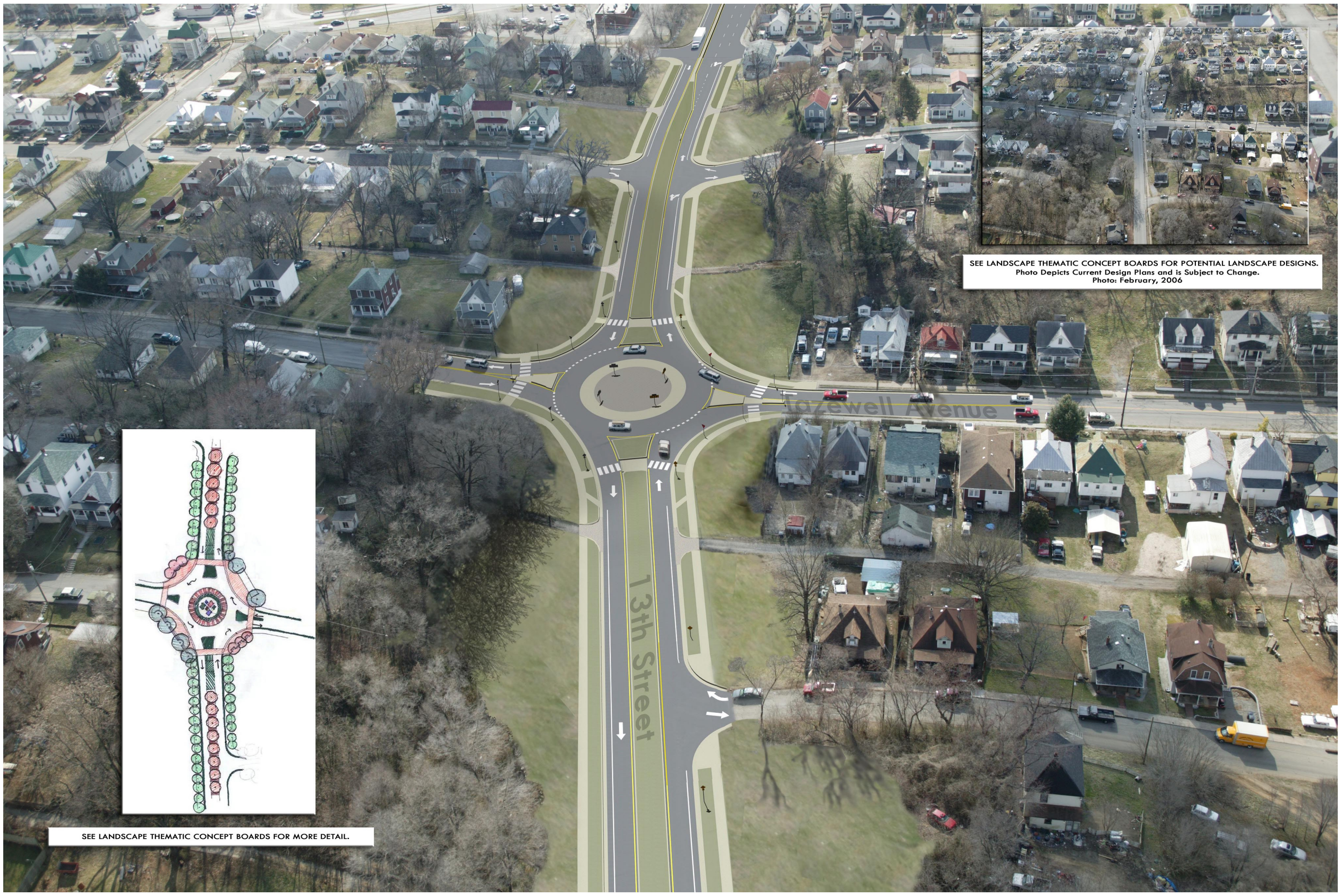
Orthophoto draped onto the existing surface model and 4 alternates that were studied at this location. In total there were over 30 proposed visualizations like these, created for 23 locations, which were included in the ICC FEIS Appendix. While several alternates were visualized that were eliminated from consideration, they still were an important part of the discussion and back up for decisions that were made.

Omitting signs and other details, as well as and limiting the final product resolution kept the visualization cost in control.

NOTE: Graphics presented in this paper are for presentation purposes only. All designs are subject to change.

Hollins Road- Final Design, VDOT

- Proposed Data: Paved Edges (Curbs, Road, Sidewalk, Median), Bridge Deck Location, Stripes, Cut and Fill Limit, InRoads DTM, Structure Details
- Existing Data: InRoads DTM, Oblique Aerial Photograph
- Design elements added by visualization specialists: Stripes, signs, Impacted Properties (identified on the photo)
- 1 alternate, 4 photos



The high resolution (4064 by 2704 pixels) allowed these images to be printed on very large 40 by 30 inch boards for public information meetings. VDOT chose to not include landscaping in the photo-simulation and instead provide a potential landscaping plan with a rough artist concept feeling. This is a wise decision in many cases to avoid a public perception that the DOT was committed to providing landscaping, when in fact this would be most likely funded by the city, and no specific were yet decided.

Governors Avenue- Final Design, DELDOT

- Proposed Data: Paved Edges (Curbs, Road, Sidewalk, Median), Bridge Deck Location, Stripes, Cut and Fill Limit, InRoads DTM, Structure Details, Overhead lights
- Existing Data: InRoads DTM, Ground Photo (using camera mounted on a 10' pole for best viewing angle)
- Design elements added by visualization specialists: Standard overhead light detail
- 1 alternate, 2 photos

This project had a high level of detail available in the plans that was represented in the visualization. By using a 10' pole attached to the camera, an excellent view angle was achieved. These were used in various meetings, including those with the impacted property owners.

Conclusions

This paper used specific examples to illustrate data standards. By providing a consistent set of visualization data standards, the visualization specialist and design team can more easily streamline the visualization process. However, a complete categorization of specific meeting milestones and the required available data may be impossible since all projects are handled somewhat uniquely, depending on political and economic factors.

There are no cut and dry rules for visualization data standards. A data-driven approach simply means incorporating the best available data into the product. The rule of thumb is to develop as much information as possible before passing the data on for visualization. This ensures that the visualization is accurate and provides a better look into what the current design data represents. As design data is added, as more review and feedback arrives, the project can be visualized again for the next round of communication. During a planning stage more alternates are considered and less detail is shown. Since more alternates are considered, the time spent to visualize each alternate is limited. One way to do this is to use lower resolution images, and another way is to limit the amount of design elements shown that are added by the visualization specialist. In a final design stage one alternate is explored in more detail.

What about a project where absolutely no data exists except the existing photo? Perhaps there is a simple project with minimal improvements and all that is available is a rough sketch. 3D models can still be employed for visualization purposes, but these must be simple and hastily developed in order to keep cost in control. This may be a time for a visualization that uses only image compositing techniques. However, if data is used to drive the visualization process a more detailed and valuable product can be created, so some effort to collect and develop CAD information is always recommended.

Software Used

The following visualization techniques in this paper were applied using the software as listed here.

- Road modeling: InRoads or GEOPAK
- 3D Modeling and Rendering: MicroStation, 3D Studio Max
- Orthophoto Drape: Descartes
- Image compositing and touch-up: Adobe PhotoShop

Acknowledgements

I would like to thank the entire management of McCormick Taylor, Inc. (MT) for their support of my work in visualization, especially Dana Knight, Andy Smith, Wayne Trautman, and James Wiggans. Also, thanks to all of our visualization clients, including MDSHA, VDOT, DELDOT, Susquehanna Township in Pennsylvania and others. Finally, I want to acknowledge the talented graphic artists at MT who worked with me to produce the graphics shown, including Adam Dall, Bart Gibson, John Herndon, and Jason Ritchey.

References

1. Ehrenhalt, Alan. *The Asphalt Rebellion, Part I: Communities Fight Back.* Governing Magazine, October 1997.

2. Federal Highway Administration (FHWA). *Flexibility in Highway Design*, Washington DC, 1997.

3. Howard/Stein-Hudson Associates, Inc. and Parsons Brinckerhoff Quade and Douglas. *Public Involvement Techniques for Transportation Decision-making*. Publication No. FHWA-PD-96-031. Federal Highway Administration and Federal Transit Administration, Washington DC, 1996.

4. Sircar, Jayanta K., and McCall, Cyrus G. *Cost Effective Computer Visualization for Highway Development.* Technical Report No. CTSM-99-MDSHA-IT-3. University of Maryland, 1999.