Visualization for Right-of-Way Acquisition

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List of Acronyms

2-D	Two-dimensional
3-D	Three-dimensional
4-D	Four-dimensional
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
CAD	Computer-aided design
Caltrans	California Department of Transportation
DOTs	Departments of Transportation
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
GTC	Genesee Transportation Council
IT	Information Technology
MPOs	Metropolitan planning organizations
Mn/DOT	Minnesota Department of Transportation
MoDOT	Missouri Department of Transportation
NCDOT	North Carolina Department of Transportation
NCHRP	Construction Sciences Research Foundation
NEPA	National Environmental Policy Act
NIST	The National Institute of Standards and Technology
NYSDOT	New York State Department of Transportation
ODOT	Ohio Department of Transportation
PDG	Project Development Guide
ROW	Right-of-way
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SHPO	State Historic Preservation Office
TRS	Transportation Research Services, Inc.
The Uniform Act	The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970
VTrans	Vermont Agency of Transportation
WYDOT	Wyoming Department of Transportation

Executive Summary

The use of visualization technologies and techniques by State Departments of Transportation (DOTs), especially for public involvement purposes, is well-documented. A 2006 Federal Highway Administration (FHWA) scan of transportation agencies, however, showed that visualization use during the right-of-way (ROW) acquisition process of transportation project delivery is not as common, despite the potential benefits. This report identifies some of the reasons, while exploring how select state DOTs have applied, or are applying, visualization to facilitate ROW acquisition. The study synthesizes and presents the findings from a literature review, as well as a series of phone discussions with stakeholders who expressed interest in using visualization technologies to enhance the ROW acquisition process. It is expected that transportation officials will use this information to improve and facilitate their own transportation ROW acquisition processes and outcomes.

Key findings include:

- The ways that ROW practitioners at state DOTs are introduced to visualization varies, leading to (1) a broad range of visualization techniques used, (2) differences in terminology, and (3) varying levels of awareness about visualization opportunities among disciplines.

- ROW practitioners who have incorporated visualization into the ROW acquisition process have experienced a number of benefits that have generally outweighed the costs associated with developing the visualization presentations. Some of the frequently expressed benefits are:
  - Better communication with property owners and other stakeholders about project impacts, thus potentially lowering condemnation rates;
  - Reduced acreage of land to be acquired; and,
  - Potential cost savings through reduced litigation and associated condemnation fees or damages.

- Use of visualization for ROW acquisition has likely not been as widespread as in other stages of transportation project delivery because:
  - Historically, ROW practitioners have had limited awareness of visualization's potential uses in the ROW acquisition process;
  - Visualizations have been perceived as costly to produce or only useful for complex projects;
  - Some state DOTs lack the internal resources (staffing, funding, or hardware/software) to develop and display visualizations; and,
  - There are concerns that visualization presentations might not exactly replicate the look of the actual project, thus potentially damaging public perception.

In addition to these findings, the project team learned about cost saving methods for ROW staff to expand use of visualization during ROW acquisition. The following recommendations, which are among several others reported in Section 4, are intended to help ROW staff overcome barriers to visualization use, and ultimately better identify and capitalize on opportunities.

- Develop an understanding of what "visualization" can mean in the ROW acquisition context and then market the various techniques within ROW offices.

- Spread the cost of visualization development among the various disciplines of transportation project development.

- Make laptop computers and media software available for mobile use in the field, when possible.

- Create a standard method for gathering feedback on, and evaluating the benefits of, using visualization for ROW acquisition to help strengthen the case for its use.

1. INTRODUCTION

This research explores the ways that select State Departments of Transportation (DOTs) have used visualization technologies and applications to facilitate the right-of-way (ROW) acquisition process. Best practice applications of visualization given certain ROW acquisition situations are identified, along with effective strategies for seamlessly incorporating visualization into the ROW acquisition process. Transportation officials will be able to use this information to improve and facilitate their own transportation ROW acquisition processes and outcomes.

1.1 Background

In 2006, FHWA conducted a domestic scan on right-of-way (ROW) acquisition and utility relocation. During the scan, FHWA learned that a few state DOTs were beginning to test the idea that visualization could be a valuable tool to use in the ROW acquisition process. Specifically, Florida DOT (FDOT) showed examples of where it had overlaid aerial photographs with computer-aided design (CAD) drawings, and Minnesota DOT (Mn/DOT) had used three-dimensional (3-D) videos to show property owners the potential impacts of highway improvements to surrounding properties (Cambridge Systematics 2006). Two years later during an international scan of ROW practices, FHWA identified similar applications of visualization at transportation agencies in Australia (FHWA 2008). There, visualization was used to communicate a project's ROW requirements and impacts to property owners and relevant stakeholders to help avoid or mitigate the costs of eminent domain court proceedings.

Based on these examples, as well as a growing belief that there are significant benefits to using visualization techniques in the ROW acquisition process, in 2009 the American Association of State Highway and Transportation Officials (AASHTO) surveyed all state DOTs to elicit basic information about their experiences using visualization to facilitate ROW acquisition.[1] The responses indicated that the use of visualization technologies for ROW acquisition purposes is currently much less prevalent than its use in other areas of highway project delivery.[2] With that said, some of the respondents mentioned they could foresee advantages of expanding visualization's use to the ROW acquisition practice, and most were interested in learning more about what their peers had been doing in this area.

1.2 Purpose and Methodology

This report is intended to identify and disseminate information about the pros and cons of utilizing visualization for ROW acquisition, as well as potentially effective practices for doing so. The research is based on phone discussions[3] with transportation agency stakeholders who indicated previous experience with using visualization for ROW acquisition. Several consultants with experience developing visualizations for transportation agencies were also contacted for their input; they were selected based on information and suggestions gathered from the FHWA and the DOT interviewees. Phone discussions were held from May through June 2010 and included both ROW and visualization professionals from:

- California Department of Transportation (Caltrans)
- FHWA Resource Center
- Florida Department of Transportation (FDOT)
- Minnesota Department of Transportation (Mn/DOT)
- Missouri Department of Transportation (MoDOT)

[1] For these purposes, "ROW" refers to the land a roadway and any related facilities occupy.
[2] See Appendix E for the AASHTO survey and responses received.
[3] A list of stakeholders interviewed is included in Appendix A. The calls followed the discussion guide included in Appendix B. The project team tailored the discussion guide to each participating stakeholder, as appropriate.

- New York State Department of Transportation (NYSDOT)
- North Carolina Department of Transportation (NCDOT)
- Office of the Attorney General of Texas
- Ohio Department of Transportation (ODOT)

Questions focused on the history of visualization use at the agency, the benefits—perceived or real—of doing so, and barriers associated with more fully using visualization for ROW acquisition, among other topics.[4] Where possible, the project team collected quantitative data on the costs and savings associated with using visualization for ROW acquisition. Property owners were not interviewed for this research.

Additional information on the uses of visualization was obtained through a review of literature and documentation collected from interviewees, other state DOTs, and several visualization vendors throughout the research process. The project team then synthesized phone discussion notes and relevant supplemental information collected to formulate the challenges, lessons, and recommendations described below. The report results should inform the development of guidelines for how DOTs and other transportation agencies can incorporate visualization into the ROW acquisition process.

Example Visualizations:

Choosing Visualization for Transportation
http://choosingviz.org/

Eastern Federal Lands Highway Division Design's visualization website
www.efl.fhwa.dot.gov/technology/dv.aspx

Florida DOT Casselberry Interchange Visualization
http://fhwa.ccr.buffalo.edu/case_study_casselberry.html

Mn/DOT Visualization Services
www.dot.state.mn.us/visualization/

NCDOT's Enterprise Visualization website
www.ncdot.org/it/visualization/

NCDOT Example Visualizations
www.youtube.com/view_play_list?p=7EA152FF8EAF0184

NYSDOT's Project Visualizations for the I-87 Exit 6 Bridge Replacement
www.nysdot.gov/regional-offices/region1/projects/i87-exit6/photos

TRB's Visualization in Transportation Committee website www.trbvis.org/MAIN/TRBVIS_HOME.html

[4] See Appendix B for the complete phone discussion guide.

2. WHAT IS ROW ACQUISITION AND VISUALIZATION?

ROW acquisition is a process that involves obtaining necessary property rights for a transportation project when an existing ROW cannot accommodate the planned expansion of an existing facility or the construction of a new facility. In some cases, the process can be controversial, expensive, or time consuming. Visualization can serve as an effective aid to the ROW acquisition process, improving its predictability (e.g., potentially fewer legal disputes) and better informing property owners, while accelerating the overall project delivery process. This, in turn, could enhance the negotiation process, potentially reducing the likelihood of condemnation. This report examines some cost generalities as well as the relative benefits of using visualization in the ROW acquisition process. The following section introduces ROW acquisition (section 2.1), visualization (section 2.2), and how visualization can be a tool throughout the transportation project delivery process (section 2.3).

2.1 ROW Acquisition

When ROW is required for an existing facility, or the construction of a new facility, an agency owning a public road may acquire any necessary property. ROW acquisitions must adhere to the U.S. Constitution's Fifth and Fourteenth Amendments, which prevent private property from being taken for public use without just compensation. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (the Uniform Act), as amended, establishes standard procedures and requirements for any agency using federal funds to acquire ROW, to ensure that property owners experience the protection that the Fifth Amendment provides. These provisions, together with state-specific requirements and statues, guarantee fair and timely compensation for any property acquisition.

The provisions emphasize acquisition through negotiation rather than condemnation, which is the formal application of eminent domain to transfer a property title from its private owner to the government. The ROW acquisition process can be very expensive, time consuming, and potentially controversial—all concerns given the Federal government's commitment to provide due process and just compensation, acquire property without delaying public projects, promote public confidence in Federal and federally-assisted land acquisition programs, and ensure that public dollars are spent appropriately.

ROW acquisition activities typically span several stages of the project delivery process, beginning in planning and extending into environmental review, design, and during and after construction. These activities can be divided into five basic steps, each of which can benefit from the use of visualization: [5]

1. **Planning**. A transportation agency may initially identify the general need to acquire property during the planning stage. Public meetings, notices, and correspondence are ways agencies may communicate this need. Specific property needs will not be identified until after the National Environmental Policy Act (NEPA) process is completed.

2. **Appraisal**. The term "appraisal" means a written statement that a qualified appraiser independently and impartially prepares to set forth an opinion of defined value of an adequately

[5] The entire process and requirements are articulated in 49 CFR 24 Subpart B "Real Property Acquisition," which can be found at www.fhwa.dot.gov/legsregs/directives/fapg/cfr4924b.htm. The FHWA Project Development Guide is also a useful reference for the highway ROW acquisition process and includes information on relevant laws, policies, and best practices for ROW acquisition. It is available at www.fhwa.dot.gov/realestate/pdg.htm.

described property as of a specific date. The appraisal is supported by the presentation and analysis of relevant market information.

Once a transportation agency expresses interest in acquiring property, and before the initiation of negotiations, the agency must establish an amount that it believes is just compensation for the real property. To do so, an appraiser will inspect the property to determine its fair market value, an estimate that must be supported in the appraisal. The Uniform Act requires that property owners or designated representatives be given the opportunity to accompany the appraiser during the property inspection. This allows property owners to identify any features that might affect the appraised value, and assists the appraiser in locating features of the property that are not immediately obvious. Just compensation shall not be less than the approved appraisal of the fair market value of the property, taking into account the value of allowable damages or benefits to any remaining property.

Once ROW practitioners establish and review an estimate of just compensation, the Uniform Act requires that the Agency, as soon as feasible, notify the owner in writing of the Agency's interest in acquiring the real property and the basic protections provided to the owner by law. The appraisal process provides another opportunity for ROW practitioners to be in contact with landowners. Properties are reviewed, offers are made, and negotiations can follow.

3. **Acquisition**. After receiving an offer, a property owner may accept its terms or proceed to the negotiation phase. If negotiations fail to resolve any differences between the agency and the property owner in a timely manner, the acquiring agency may choose to authorize an administrative settlement. If all efforts by the acquiring agency fail to result in a negotiated acquisition, agencies are permitted to rely on their power of eminent domain by filing a condemnation case. Through condemnation proceedings, a jury determines the appropriate level of compensation. Alternatively, if a property owner determines that an acquisition has occurred when the responsible agency did not formally acquire property, the owner may file an inverse condemnation lawsuit in order to receive just compensation for the alleged uncompensated acquisition.

4. **Relocation Process**. If the acquisition of ROW requires that occupants relocate, the Uniform Act outlines benefits and protections for residents, businesses, or personal property that are displaced. These benefits and protections include payments for moving expenses, payments for replacement housing, standards for replacement housing, and the availability of relocation planning and advisory services.

5. **Property Management**. With property acquired and its occupants relocated, the acquiring agency is responsible for managing the property and moving, selling, or demolishing any improvements to the property.

2.2 Visualization

Visualization is any process, technique, or method used to convey complex technical information in a comprehensible, dynamic, visual manner. Generally, information is compiled from photographs, maps, geographic information systems (GIS), computer-aided design (CAD) software, and other resources and then combined with computer graphics to create accurate depictions of what a place might look like after changes are implemented. Visualization tools include:

- Sketches, drawings
- Artist renderings
- Maps
- Physical models

- Simulated photos
- Computer-modeled images
- Videos
- Interactive GIS
- GIS based scenario planning tools
- Photo manipulation
- Computer simulation
- Interactive 3-D modeling

Although these techniques range in level of technological sophistication required (visualizations increasingly involve the use of computer-based tools and display methods), they share a major similarity: each provides a method for graphically presenting the potential impacts of a proposed project on the existing conditions around the project. All of the tools can effectively communicate before and after site conditions, specific project designs and details, or impacts to a project area. [6]

For the purpose of this report, the project team used the terms *visualization*, *visualization technology*, and *visualization technique* synonymously. The team also differentiated between "traditional" and "advanced" methods of visualization, though the term "traditional" should not suggest that advanced skills or expertise are not needed to develop them. For these purposes, "*traditional visualization*" refers to two-dimensional (2-D) images or three-dimensional (3-D) models that can usually be created without highly specialized computer hardware, software, or expertise. In this study, "*advanced visualization*" means any computer-generated visualization that displays information in at least three dimensions. Some advanced visualizations are four-dimensional (4-D), with "time" being the fourth dimension represented. Advanced visualization typically involves the addition of "realism" to the presentation, including the display of people, vehicles, and textures, such as what the pavement or vegetation might look like.

2.3 Potential Uses of Visualization in Transportation Project Delivery

Transportation agencies have used visualizations in a variety of ways, especially in light of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requirement that state DOTs and metropolitan planning organizations (MPOs) employ visualization techniques to facilitate public involvement during the planning phase of project delivery. Recently, state DOTs have cited improved public involvement as one of the primary reasons for developing visualizations (NCHRP 2006 and FHWA 2009). Other common applications of visualization in transportation are for alternatives analysis, environmental review, and design evaluation (Volpe Center 2007 and 2009).

Historically, use of visualization in the ROW acquisition practice has been less prevalent or has focused on traditional techniques, such as 2-D graphic images and overlays of roadway engineering and ROW plans on aerial photographs. In cases where advanced visualizations have been used, ROW officials have found that the same hardware and software used to create visualizations for other stages of transportation project delivery (and often the same visualizations) can be used for ROW acquisition purposes—potentially opening the door for visualization cost-sharing agreements among disciplines. Figure 1 summarizes some of the current uses of visualization throughout the transportation project delivery process. As shown, there are also opportunities for visualization use during each stage of the ROW acquisition process, such as in ROW planning, appraisal, acquisition, relocation process, and property management.

[6] For more information see FHWA's Visualization in Planning website at www.fhwa.dot.gov/planning/vip/index.htm. Additionally, the January/February 2010 issue of *Public Roads* (www.fhwa.dot.gov/publications/publicroads/10janfeb/02.cfm) offers more information on 3-D, 4-D, and dynamic (animated or real-time simulation) technological tools for design visualization.

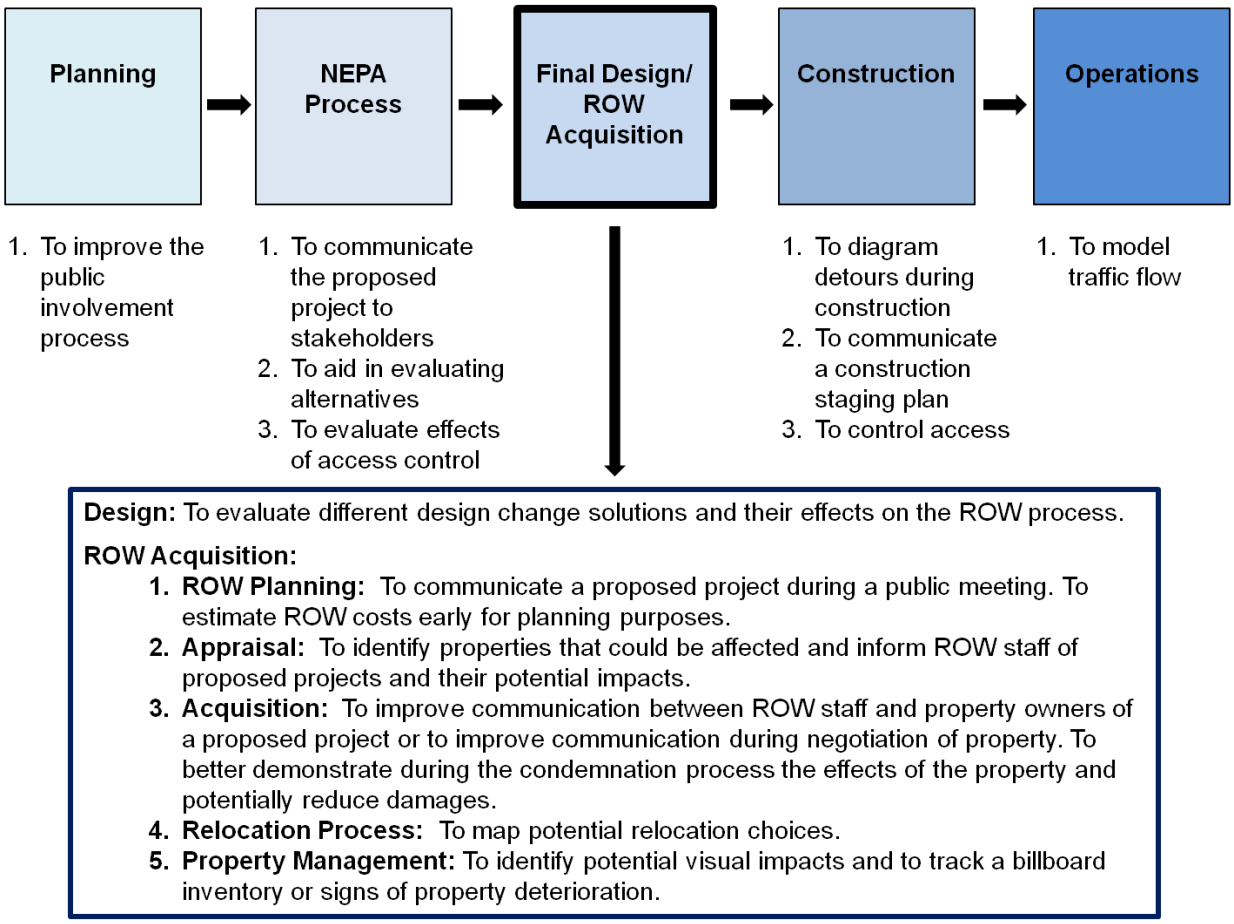

Figure 1. Potential uses for visualization throughout the transportation project delivery process. There are opportunities for any ROW acquiring agency to use visualization throughout project delivery, including the planning, the NEPA process, final design, ROW acquisition, construction, and operations phases. There are often opportunities for transportation agency personnel to use visualizations created for one stage of project delivery for other stages as well. The base data (e.g., ground photography, and aerial images, among others) used to develop a visualization are often useful to practitioners in disciplines other than those for which the visualization was initially developed.

Table 1. Examples of Traditional and Advanced Visualization Techniques

	Visualization Tools	Description	Relative Cost
Traditional visualization ("low-tech" visualization)	2-D graphic image	A graphic representation rendered by hand or with a computer. Two-dimensional graphic images include sketches, drawings, maps, or artist renderings.	Lower cost
	2-D graphic overlay	A transparent graphic representation overlaid onto another graphic image with a computer. Two-dimensional graphic overlays include simulated photos and maps or plans overlaid with aerial photography.	Lower cost
	Physical model	A physical model, typically constructed by hand and that can be physically manipulated, that depicts an existing condition or a proposed change. Physical models are portable, easily manipulated, and a tactile visualization alternative to electronic media.	Moderate to higher cost
Advanced visualization ("high-tech" visualization)	Interactive 3-D (virtual-reality) model	A computer-generated virtual-reality 3-D surface model in which any location and view can be navigated to interactively by the user. The interactive 3-D model can be a simple wireframe or a textured "mesh" surface. Photographic images can be draped on the surface, and above-ground features can be added into the model. Modeling tools are integrated within common CADD programs allowing simple 3-D models to be generated at low to moderate cost. The 3-D models can be imported into Adobe Acrobat 3-D PDF documents and navigated interactively using tools within Adobe Reader. The 3-D models can also be imported into global map viewing programs such as Google Earth.	Low to moderate cost for simple models; higher cost for more complex
	3-D image or video	A rendered graphic image that depicts several angles, or perspective views, of a proposed change. Three-dimensional images or videos include animations, computer-modeled images, interactive GIS, photo manipulations, and computer simulations. Specialized software can add effects and elements of realism, such as lighting, perspective, and shading.	Higher cost
	4D video, or computer animation	A series of closely spaced 3-D graphic images of a surface model following a designated orientation and path and joined to create a moving image. Four-dimensional videos include the passage of time. These tools are used to simulate the dynamics of traffic operations and transportation facilities in actual service from a road user's perspective.	Highest cost

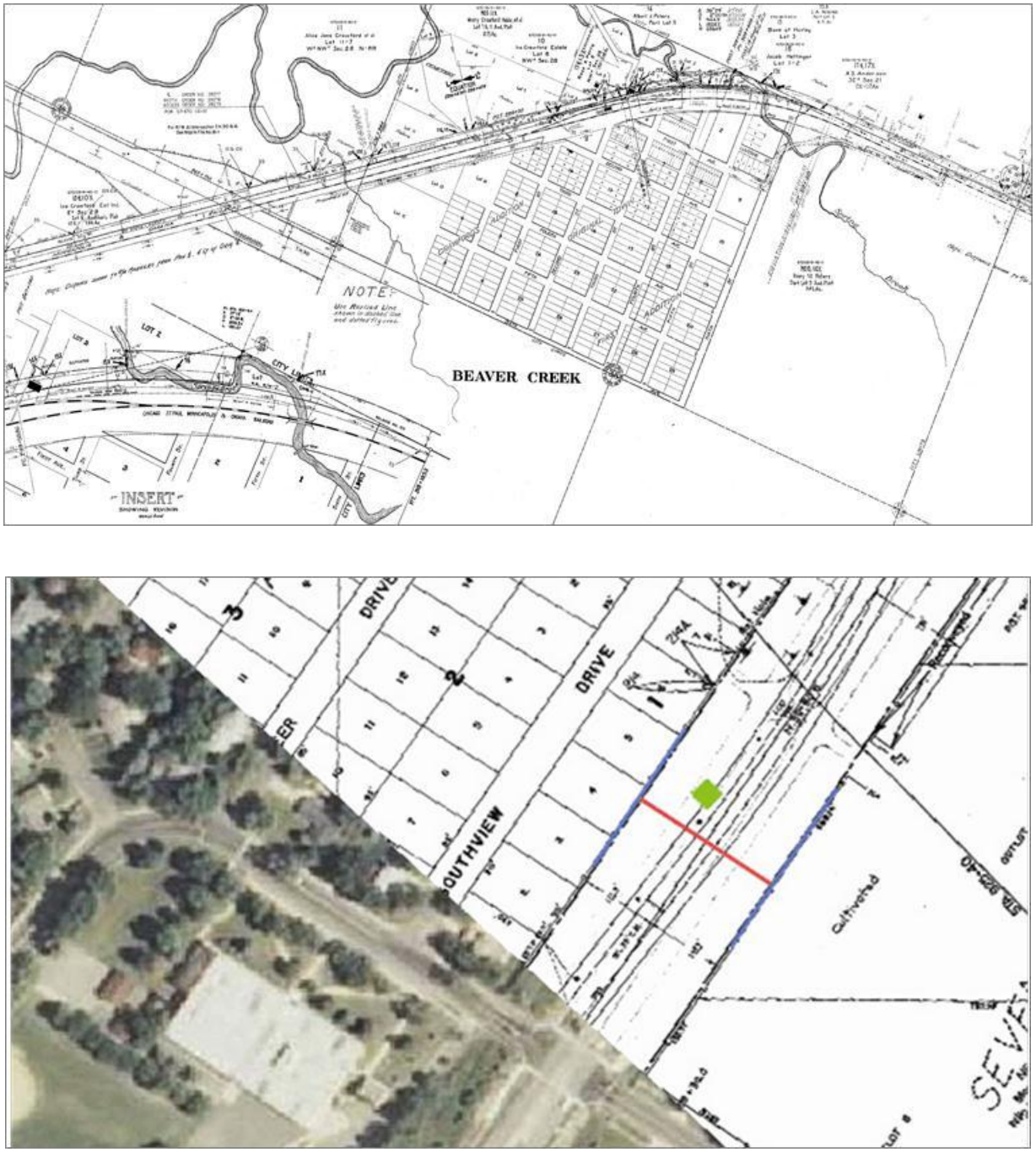

Figure 2. Traditional Visualization: **2-D Graphic and 2-D Overlay**
Black and white ROW plan drawing (top), Source: Mn/DOT. A color aerial photograph with a ROW plan overlaid in a GIS software program. On the ROW plan, one edge of the road pavement has been manually marked in the GIS with a green dot; a transect perpendicular to the road has been manually drawn in the GIS with a red line between the DOT's property lines, which have also been manually drawn in blue (bottom), Source: USDOT Volpe Center.

Figure 3. Advanced Visualization: 2-D Graphic with a 3-D Overlay
Aerial photo and plan drawing with 3-D model components of proposed infrastructure. Source: FDOT.

Figure 4. Advanced Visualization: 3-D Image or Video
Photo simulation of proposed overpass condition on I-87 in New York (top), Source: NYSDOT.
Existing and proposed conditions in a 3-D split-screen, fly-over visualization (bottom), Source: NCDOT.

Figure 5. Advanced Visualization: 4-D Video
Screenshot from a 4-D video for US Highway 12 pilot project in Minnesota. The video includes parcel data, highway and building images, roadway infrastructure, and moving vehicular traffic. Yellow lines represent parcel boundaries; green lines represent existing ROW boundaries; red and blue lines represent future ROW boundaries after acquisition. To see the video, visit www.dot.state.mn.us/visualization/. Source: Mn/DOT.

Table 2. Example Visualization Software Programs*

ArcGIS	Family of programs that is used to compile, manage, analyze, and display geographic information; allows the user to create and store many layers of geographically-related information.[7]
AutoCAD	Used to build 2-D plans and 3-D structures with exact measurements to create 3-D computer-modeled visualizations.
CommunityViz	CommunityViz is GIS software designed to help users visualize, analyze, and communicate about important community planning decisions.
CORSIM	"Corridor Simulation Model" developed by FHWA; micro-simulation program commonly used for modeling vehicle traffic operations.
Google Earth	Google Earth is a virtual globe, map, and geographic information program that displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle, with perspective. Google Earth offers a "street view" perspective for many roads, allowing users to view locations as they would appear in person at the location being viewed.
MicroStation	MicroStation is a CAD software product for 2- and 3-D design and drafting, developed and sold by Bentley Systems.
PARAMICS	Software program used to model the movement and behavior of individual vehicles and transit on local arterial and regional freeway networks.
PDF (Adobe)	File format to view, package, and share 2-D and 3-D design data. A 3-D PDF provides an image view that allows users to rotate, zoom, and pan an object within the PDF file itself (which may be accompanied in the same file by 2-D text or images).
Photoshop (Adobe)	Photo-editing software program used to alter and enhance raster images (photographs, 3-D model stills, illustrations, scans, etc.); used to incorporate stills from 3-D models into photographs.
SketchUp	2-D and 3-D modeling program that lacks the photo-realistic end result of 3-D Studio MAX but allows for experimentation.
SYNCHRO and **SimTraffic**	Software suite, with some animation capabilities, used to analyze transportation models that include traffic movement and behavior on surface roads and freeways.
TransCAD	GIS and transportation modeling in one platform; used for travel demand modeling, mapping, visualization, and analysis. Note: Genesee Transportation Council (GTC) uses TransCAD for its travel demand model.
3-D StudioMAX	Renders stills or animations from AutoCAD and other 3-D models; applies photo-realistic material surfaces to images and animations.
VISSIM	3-D "microsimulation" programs that can be used to model movement and behavior of small surface roads and complex, large-scale transit systems.

**This is not a comprehensive list of visualization software programs, but instead is intended to provide basic information on some of the more common applications. The type and scale of a project will determine the type of visualization used.*

[7] Caltrans provided the project team with material on operations and the use of GIS, See Appendix G.

3. FINDINGS AND CONCLUSIONS

Most interviewed stakeholders agreed that property owners are typically more comfortable with ROW acquisitions in instances where state DOTs are able to portray project details accurately and early during the ROW acquisition process. They also agreed that visualizations, regardless of the form they take, can improve the quality of interactions with property owners by allowing the owners to better anticipate and understand changes to their own and nearby properties. As one stakeholder asserted, the adage "a picture is worth a thousand words" holds true when it concerns the use of visualization. However, while most state DOTs currently use at least some basic form of visualization during public involvement efforts to communicate potential project impacts, few have extended its use to the ROW acquisition process. The following section suggests reasons why.

3.1 State DOTs Using Visualization for ROW Acquisition

ROW acquiring agencies that are pioneering the application of advanced visualization techniques in the ROW acquisition process have typically experienced positive outcomes from using visualization despite not having standard practices in place for doing so. Key findings identified that:

- ROW practitioners have been introduced to visualization in a several ways
- A broad range of visualization techniques have been used
- Anecdotally, the benefits of using visualization for ROW acquisition generally outweighed the costs

3.1.1 State DOT ROW practitioners have been introduced to visualization in several ways

State DOT stakeholders identified a variety of ways in which they had been introduced to visualization, with no one approach being recognized as more effective than another. Ohio DOT (ODOT) learned about the use of advanced 3-D graphic techniques for the ROW process through a consultant that presented an overview of its services to ODOT leadership. Afterwards, the leadership believed that visualization could aid in the ROW acquisition process, and acquisition negotiators began to make use of a consulting firm for some of their larger ROW acquisition projects. North Carolina DOT (NCDOT) began using visualization for ROW acquisition after a reorganization of the agency. In this case, the DOT director was already aware of visualization's use within other state DOTs for public hearing purposes. After learning more about the ROW acquisition process, the director recognized the benefits of using visualization for ROW acquisition and recommended that the agency's negotiators make use of existing visualization resources for their own purposes. Caltrans learned how other DOTs were using visualization techniques at an FHWA peer exchange. Caltrans was already using visualization techniques to analyze environmental impacts, but the peer exchange helped demonstrate best practices for applying visualization techniques to the ROW acquisition process.

Most of the state DOTs with which the project team spoke did not come up with the idea to use visualization for acquisition independently. In each case, an outside entity (e.g., DOT leadership, consultant, or other DOT office) was responsible for identifying, via peer exchanges, visualization demonstrations, and other meetings, possible visualization applications for ROW staff. However, this should not imply that all ROW, survey, and design staffs were unfamiliar with some of the visualization techniques available. Often visualization techniques are used for other stages of project development, such as public participation, and some ROW staff indicated being aware of these techniques. It had simply not been standard practice to use visualization for ROW acquisition.

Figure 6. Map of planned ROW acquisition overlaid on aerial imagery of Chicago O'Hare International Airport
Source: Federal Aviation Administration, Chicago O'Hare International Airport Draft EIS.

3.1.2 A broad range of visualization techniques have been used for ROW acquisition

The type of visualization techniques used for ROW acquisition varies greatly among agencies. Some state DOTs have used comparatively straightforward visualization techniques, such as drawings or 2-D aerial imagery overlaid on ROW plans and maps in Google Earth. These applications typically require less expensive software, less storage capacity, and less technical computing expertise. Other DOTs have developed advanced visualizations to convey complex information in simple ways.

Opinions about traditional versus advanced visualization methods have differed depending on the situation. Missouri DOT (MoDOT) believed that traditional visualizations, such as a 2-D drawing of a parcel, would be sufficient if the property to be acquired could be purchased for a reasonable price. The DOT noted that although "problem properties" might benefit from an advanced visualization, those properties often are not known until the end of the acquisition process. In cases where a property turned out not to be a "problem," advanced visualizations might drive up project cost unnecessarily. Another stakeholder commented that some ROW acquisition tasks can be completed very simply or routinely, and that traditional visualizations offer a way to accomplish the task effectively at effort levels commensurate with the project. Some researchers, however, have suggested that traditional visualizations are not always easily understood by the public.[8] Most stakeholders interviewed for this study agreed that newer, 3-D

[8] Hixon III, Charles . 2006. "Visualization for Project Development: A Synthesis of Highway Practice." NCHRP Synthesis 361.

media hold potential to enhance the effectiveness of project negotiators, especially for large parcels that might require more attention.

Based on their experiences, most state DOTs interviewed, including ODOT, Mn/DOT, and NCDOT, believed that advanced visualization techniques were superior to customary approaches that rely on engineering drawings and ROW plans in educating property owners, sustaining community relations, and avoiding potential lawsuits. According to these DOTs, property owners have sometimes viewed the plans simply as "lines on paper" and not always as the intended conceptual aids. With advanced visualizations, ROW acquisition negotiators have been able to more comprehensively represent and communicate overall "macro" impressions of projects, as well as their potential impacts on specific parcels. One FHWA stakeholder noted "3-D visualizations give the ability to show improvements from different and more natural perspectives." ODOT pointed out that before using 3-D visualization was an option, appraisers and negotiators would take 2-D plans to property owners, lay them on a table, and hope that the changes could be properly communicated. This should not imply that these ROW agents were not thorough in completing their job duties, but that without advanced visualization tools, providing the level of detail required to ensure understanding was not possible. For example, sometimes ROW agents go into the field and stake ROW lines to show horizontal changes to the property. A line of stakes on a property may not always give the owner a feel for elevation differences between the improvement and the property that might be created. In these cases, advanced visualizations could be more informative and detailed than stakes in the ground or points and lines plotted on paper to show a proposed change.

Despite this feedback, the merits of low-tech visualizations, or those that do not involve 3-D computer renderings, for ROW acquisition applications should not be discounted. While some visualization developers might create complex images and multifaceted designs, such elements are not always necessary. In some cases, it may be beneficial to keep the visual concepts at a more basic level. MoDOT commented that it may be difficult to justify creating a sophisticated visualization for a project that only involves a few miles of property. Similarly, FDOT and FHWA suggested that, in the minds of the intended audience, a physical model may be a more tangible representation of a planned project, as it is more difficult to manipulate than a computer-generated model.

Figure 7. Google Earth images that show aerial images, parcel boundaries, and properties in California (top and bottom). Source: Caltrans.

3.1.3 Benefits of using visualization for ROW acquisition generally outweighed the costs

Several stakeholders indicated that benefit-cost analyses for visualization—and particularly those used for ROW acquisition—are rare and difficult to perform. In their experiences, cost effectiveness of visualization for ROW acquisition was generally based on a qualitative assessment rather than benefit-cost data. Most interviewees noted that under their current procedures, they do not have a standard process for feedback from the public and property owners. They acknowledged that having a way to do so would likely improve their ability to quantify the success or utility of visualization in the ROW process, as well as to gain support for its increased use in acquiring ROW.

Nevertheless, there was general agreement among those interviewed that the benefits of visualizations often outweigh the costs, especially when the costs are shared among all the acquiring agency groups that could benefit during the transportation project delivery process. The major benefits documented include:

- Better communication of project impacts to property owners and other stakeholders
- Potential reduction in the amount of land to be acquired
- Potential lawsuit prevention or reduced condemnation damages
- Fewer errors and better project coordination
- Potential to amortize cost across several disciplines

3.1.3.1 *Better communication of project impacts to property owners and other stakeholders*

Impacts to parcels can be subjective, and appraisers and property owners sometimes hold different opinions about the level of damage associated with a given transportation improvement. Such differences in opinion can negatively affect the negotiations process. One goal in the ROW acquisition process, then, is to minimize confusion about project details, potentially circumventing contention.

Visualizations afford this ability by presenting more realistic and precise representations of the project scope and scale. For this reason, they can serve as an aid to help property owners better understand the real impacts to their property. According to Caltrans and ODOT, ROW officials have previously marked up technical engineering plans to explain project impacts, but sometimes found that property owners did not have the expertise to fully comprehend the 2-D plans. For this reason, some interviewees indicated that, whenever possible, they use advanced visualizations when speaking with property owners about ROW acquisition. Equipped with a laptop, a negotiator can visit a property owner, explain project specifics through the visualization, and then answer questions in person and in real-time. Visualizations might even help communicate to a property owner, as a member of the traveling public, a highway project's anticipated safety or travel time improvements.

MoDOT and NCDOT reported that bridge and interchange projects that impact large areas, and often involve numerous engineering drawings or are completed in several phases over a long period of time, can be particularly confusing for property owners. Visualizations enable the state DOT to communicate the context and changes related to these types of projects in ways not possible (e.g., from various angles, approaches, or times of day) with traditional methods. FHWA noted that 2-D plans alone do not sufficiently communicate elevation changes or cross-sections of properties to property owners. With the aid of aerial imagery and visualization, property owners gain a more comprehensive understanding of the anticipated changes. In another example, ODOT has observed that business owners are often most concerned about changes to access, visibility, and parking, property characteristics that are difficult to envision using overhead engineering diagrams. In addition to better depicting these project aspects,

advanced visualizations can also describe project details such as the appearance of sound walls, driveway alignments, and grade changes.

An ancillary benefit of using advanced visualization techniques to communicate more accurately with property owners is improved or sustained community relations. For example, Mn/DOT commented that visualizations have helped gain local business and municipality support for highway projects. While their approval is not always required, their consent early on can help streamline the project delivery process. Interviewees frequently remarked that property owners appreciated when state DOTs provided visualization presentations, even in cases that were not potentially controversial or contentious. NYSDOT commented that visualizations can help alleviate intimidation that property owners might feel, suggesting that using visualizations can help the ROW acquisition process seem less "transactional." NCDOT and Mn/DOT agreed that property owners, having seen a 3-D visualization, seemed to have less "anxiety of the unknown."[9]

3.1.3.2 *Potential reduction in the amount of land to be acquired*

Some DOTs interviewed speculated that using visualization while planning a proposed acquisition(s) could reduce the amount of land to be acquired. With visualization, ROW managers might realize that the proposed transportation project could fit within the existing ROW, potentially alleviating the need to acquire additional property. In particular, 3-D modeling may inform designers and engineers about existing site conditions (such as the property lines, infrastructure, and utilities present), enabling acquisition decisions, for example, on the amount of land to be acquired, to be made with the best information available.

In addition, visualization can help illustrate the location and number of parcels that need to be bought, ultimately helping appraisers justify cost estimates and explain the total budget impact of a given acquisition.

3.1.3.3 *Potential lawsuit prevention, reduced court costs, and reduced damages*

Although transportation agencies rely on experienced appraisers who follow nationally-recognized professional appraisal standards to determine appropriate levels of just compensation, appraisals are inherently subjective valuations.[10] Such subjectivity can make it difficult to predict the impact of condemnation on acquisition costs, including the likelihood of an acquisition proceeding to condemnation, the cost of legal fees, and potential awards a jury might grant.[11] Keeping this in mind, condemnation typically represents a last resort for agencies in ROW acquisition because it usually indicates property owner dissatisfaction and can jeopardize the goals of the acquisition process. Condemnation can also extend project delivery timeframes and overall project costs, resulting in diminished public trust.

NCDOT, NYSDOT, and ODOT believed that the risk of litigation could decrease when property owners better understand the impacts to their property. Although state DOTs proportionally experience few ROW acquisition lawsuits that go to a jury (based on the most recent FHWA data available, the condemnation

[9] Evaluation of Mn/ DOT's "Right of Way Visualization Pilot Project" provided to FHWA via email, July 15, 2010. According to the evaluation, it is best to show to landowners any available visualization during initial field visit. Landowner comments on Mn/DOT's pilot visualization included "We're able to see projects as Mn/DOT does;" [the visualization] "relieved anxiety of the unknown;" and [we are now] "more comfortable" with the project.

[10] Hakimi, Shadi and Kara M. Kockelman. Fall 2005. "Right-of-Way Acquisition and Property Condemnation: A Comparison of U.S. State Laws." Journal of the Transportation Research Forum.

[11] Jury awards are particularly unpredictable in partial acquisitions, where landowners may seek compensation for damages incurred to the remainder of their property (Heiner and Kockelman 2004).

rate in 2010 was 16.5 percent nationally, and ranged between 0.2 percent and 51.3 percent at the state level)[12], the cost and time commitment of those lawsuits can be monumental. This is particularly evident in urban areas where land prices are comparatively high and damages awarded to a property owner could be significant. Some researchers have shown that condemnation awards can add between 25 and 40 percent to basic acquisition costs.[13] Determining which project(s) might result in a lawsuit is difficult, but most interviewed state DOTs agreed that the cost of creating several visualizations would likely be less than the cost of proceeding with one lawsuit.

Nonetheless, some acquisitions will proceed to condemnation despite attempts to negotiate with landowners, and a large claim could have a significant impact on a state DOT's project budget. In court, visualizations can help the jury better understand a proposed project's impacts to the property owner(s) and thus rule accordingly. Several interviewees cited instances in which visualizations were deciding, or mitigating, factors in cases like these. FDOT described how it used a 3-D physical model to effectively convince the jury that prospective changes did not restrict access to a business (a car wash), preventing a potential damage award of over $500,000. According to the interviewee, commercial and industrial property owners are sometimes particularly concerned about access, and visualizations are an effective way to communicate that the impacts of access adjustments are expected to be minimal. Additionally, FDOT believed that this particular court ruling also prevented additional lawsuits from being filed based on the precedent the case set, ultimately saving the agency millions of dollars.

NCDOT described another court case in which the property owner's counsel used a visualization to demonstrate a certain (and inaccurate) noise effect, which ultimately helped secure a decision in favor of the landowner. Although erroneous information was presented, the visualization made an impact on the jury. NCDOT did not have its own visualization to refute the argument. In other instances, visualization has even prevented cases. One interviewee recounted a situation that was settled out of court once the property owner's counsel learned that the state DOT planned to develop a 3-D model for the case.

In Mn/DOT's experience, visualization has not always expedited the direct purchase process or reduced the condemnation rate. This could be attributed, however, to changes in the state's eminent domain policy and not the availability of advanced visualizations. What Mn/DOT did report is that the public has been "impressed" with visualization products and the low cost associated with developing them. Mn/DOT commented that visualization presentations have "given the agency technical legitimacy in what it's doing and has helped build trust."

Finally, since visualizations can help minimize negotiation time, thus maintaining project schedules, inflationary costs related to materials and engineering expenses might also be limited.

3.1.3.4 *Fewer errors and better project coordination*

One DOT noted that 3-D data provides staff with more detailed project information so they can better coordinate projects. According to the DOT, 3-D data reduces the number of errors related to vertical and horizontal layout. In one example cited, there was a twenty-foot gap in the design on a plan that the state had already certified. After viewing the project in a 3-D visualization, the project team was able to notice the error and avoid potential problems during construction.

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[12] The range of this statistic has been shown to vary based on certain acquisition practices, such as the amount of time given to landowners to consider compensation offers and the use of "quick take" procedures, as well as demographic variables, such as the degree of urbanization, education levels, and political party affiliation (Hakimi and Kockelman 2006). A "quick take" occurs when an agency acquires property prior to settling on a compensation amount in order to facilitate tight project timeframes. FHWA Annual ROW Statistics are available at www.fhwa.dot.gov/realestate/rowstats/index.cfm.

[13] Heiner, Jared D. and Kara M. Kockelman. January 2004. "The Costs of Right of Way Acquisition: Methods and Models for Estimation." Presented at the 83rd Annual Meeting of the Transportation Research Board, Washington, D.C.

3.1.3.5 *Potential to amortize cost across several disciplines*

Since many disciplines in the project delivery process will likely benefit from visualizations, the cost for developing the visualizations could potentially be amortized across the disciplines. If consideration of visualization techniques were fully integrated into a planning process that is inclusive of all project delivery disciplines (including realty and ROW practitioners), those involved in the discussions could articulate their respective visualization needs and determine how the entire agency could share the costs rather than charging them to one specific office or project.

3.2 Why Using Visualization for ROW Acquisition is Not More Widespread

Evidence from the interviews suggests that there are four principal reasons why the use of visualization is not as prevalent in the ROW acquisition process as it is in other stages of highway project delivery:

- Visualization uses are unconventional in the ROW acquisition process
- A perception that visualizations are costly to produce or only useful for complex projects
- Lack of internal resources to develop and display visualizations
- A concern that visualizations might not look exactly like the actual project

3.2.1 Visualization uses are unconventional in ROW acquisition

At a fundamental level, there may be a discrepancy among ROW professionals as to what constitutes "visualization." One stakeholder indicated that "3-D imaging" was sometimes used synonymously with "visualization," while others noted that visualization in the ROW context means "anything that can help the property owners understand what the changes to his/her property will be."

Advanced visualization techniques in transportation settings have sometimes been viewed as public involvement tools, and less so as tools to aid ROW acquisition. This is likely attributable to limited or inconsistent intra-agency communication as well as a perception that ROW offices within state DOTs follow older data management methods and can sometimes be reluctant to try new techniques. The latter reason suggests that visualization staff should better market their capabilities. One DOT commented that although the staff members developing visualizations sit in an office nearby the ROW office, to date the two groups had not communicated about creating visualization for ROW acquisition. Typically, one of this DOT's discipline area employees will complete and submit a visualization request that clearly specifies what he/she wants the visualization to communicate. However, it was reported that the DOT' ROW practitioners had probably only had limited exposure to visualization, and thus it is unlikely that they were aware of all available visualization options (and their potential benefits). This DOT's visualization staff recognized this as a possible area for future outreach that would require management support to initiate trial projects.

One district or region within a state DOT may use visualizations or new visualization techniques, while other districts or regions are either unaware of them or are not ready to change existing negotiation methods already perceived as effective. Some state DOT interviewees indicated that visualization techniques for ROW acquisition had not been widely adopted due to satisfaction or familiarity with existing practices, and unfamiliarity with visualization technologies. For instance, FDOT commented that "the lion's share of our parcels can be clearly displayed through construction plans, an overhead view of what's coming. That will suffice for negotiation." MoDOT questioned the need to spend additional funds to create visualizations when the agency historically has been able to acquire properties for reasonable costs without them. Despite acknowledging that visualization could be helpful in contentious acquisitions,

MoDOT has remained reluctant to utilize visualizations for ROW acquisition, citing a fear that extra data collection necessary to develop visualizations would strain project development timelines. Ultimately, managers would need to weigh the pros and cons of this rationale based on project requirements.

Figure 8. Halff Associates Inc. images show roadway configurations, driveways, buildings, and vehicle access. Source: Halff Associates Inc.

3.2.2 Perception that visualizations are costly to produce or only useful for complex projects

Some DOTs indicated that very few projects (in one case, less than five percent) use visualization, and then only when there is a "high-profile" need. Visualizations were more likely to be created on projects where the cost of developing them represented a minor percentage of the larger cost. On smaller, low-

budget projects, however, it was expected that the production of sophisticated, 3-D visualizations would be cost prohibitive given increasing pressure to "do more with less." One interviewee said that a "six-figure dollar amount" for visualization would immediately be considered cost-prohibitive. In fact, several DOTs, including Caltrans, Mn/DOT, and MoDOT, cited labor, data-gathering, and training costs as the main deterrent to using visualization for ROW acquisition.

According to FDOT and MoDOT, visualizations, unlike ROW plans, do not necessarily need to be generated to complete the acquisition process and, thus, doing so might be viewed as an unnecessary expense—particularly during economically stressed times. FDOT indicated that the economic downturn had shifted the nature of their projects, and therefore, their acquisitions. Recent budget strains had forced them to focus on small improvement projects rather than new construction, requiring mainly simple partial acquisitions with little threat of condemnation. Several interviewees indicated that they had only considered using visualization in contentious acquisitions, particularly when they proceed to condemnation or when a landowner files an inverse condemnation suit and juries are asked to imagine complicated issues based on the plaintiff's contradictory descriptions. In these instances, the use of visualization "limited to specific parcels with unique issues that are hard to visualize" was recognized as a potential deciding factor in multi-million dollar settlements. Except in the specific instances cited above, these organizations could not justify the cost of developing visualizations for single properties, or those with a low risk of litigation.

This apprehension may be unfounded, especially when visualization development costs are balanced against considerations such as overall project and ROW cost; the likelihood that the property owner(s) are resistant to ownership transfer; the likelihood of condemnation proceedings and large damages; and the number of acquisitions being performed (per parcel visualization cost might be minimized with several acquisitions). None of the interviewees had collected quantifiable data on the effectiveness of their visualizations for ROW acquisition relative to the costs of producing them. In one example, none of the projects for which visualization had been used in the ROW acquisition process had been constructed, rendering measurement of ultimate success impossible. Another state DOT questioned the feasibility of conducting an accurate cost-benefit analysis, citing the individuality of acquisitions and an inability to control variables other than the use of visualization.

Mn/DOT, provided information on a pilot it conducted in 2007 to help landowners better understand highway construction improvements and corresponding property acquisition impacts. By assembling aerial photography, electronic highway design files, property lines, rendering, and animation, Mn/DOT created a 3-D video model of the "After Condition" for a proposed urban highway reconstruction. According to Mn/DOT's pilot project evaluation, although property owners believed the visualization cost seemed "reasonable" when broken down on a parcel-by-parcel basis, "[i]nformal, formal, and statistical product evaluations were attempted, but it was found very difficult to measure results of utilizing this tool for right of way acquisition purposes."

In general, however, the development costs of visualization tools for ROW acquisition depend on several factors, not limited to:

- The complexity of the project and parcel(s)
- The requirements of the project manager
- Equipment and staff time needed to take site photos; gather aerial imagery; and ROW, construction and cross-section plans
- Staff time needed to develop the visualization

Costs increase as visualizations become more elaborate and realistic, and begin to include elements like vegetation, people, or vehicles. For example, 2-D plan drawings, where the CAD drawings are already completed for design, that are overlaid on photos without animations typically cost between a few hundred dollars to a few thousand dollars including staff time. Three-dimensional PDFs[14] generally require 1 to 2 days labor and cost $1,000 to $2,000 to create. Animations that one DOT produced in-house were described as being more expensive than 3-D PDFs, with costs ranging from $3,000 to approximately $25,000. The high-end of that estimate was based on the in-house development costs of a 3-D fly-over, split-screen animation covering a project that was roughly 5 miles in length. It required approximately 600 labor hours at a rate of $40/hour. In another case, Mn/DOT spent $35,000, or $406 per parcel, in direct labor cost to develop a visualization of proposed acquisitions along a 1.5-mile section of urban roadway. Though no evidence was found to confirm the assertion, NCDOT reported that some consultants have charged upwards of $75,000 per minute of animation. Instead, one consultant indicated that animation costs vary from $3,000 to $100,000 depending on the level of detail desired, whether images are available, the amount of coordination time needed with the DOT, and whether photo-realism is needed. Another consultant mentioned that an animation of one parcel, 1–10 minutes in duration, is typically about $15,000–$75,000, including time required to serve as a non-testifying expert.[15] In most cases, however, visualization tools for ROW acquisition cost those interviewed approximately $10,000 to $15,000 per visualization.

Table 3. Approximate relative costs and development time frames for traditional and advanced visualizations. Two-dimensional graphic overlays are the least costly and time-consuming visualization to develop. Computer animations, which typically require the most time to develop, are the most expensive, ranging from $3,000 to $100,000 or more. *Source: The costs and development time lines are based on information provided during telephone conversations between the project team and both DOT and consultant stakeholders.*

	Visualization Tool	Approximate Cost	Approximate Development Time
Traditional visualization ("low-tech" visualization)	2-D graphic overlay	$200 to $2,000 per overlay	1 hour to 2 days
	Physical model	~ $3,000 per parcel	1 week to 4 months
Advanced visualization ("high-tech" visualization)	3-D image or 3-D PDF	$1,000 to $2,000 per 3-D image	1 to 2 days
	3-D or 4-D video, or computer animation	$3,000 to $35,000 per video when developed in-house; $3,000 to $100,000 per video when contracted	1 week to 4 months for lower cost animations. Visualizations in the $75,000 cost range might take 8-9 months to develop.

Some interviewees also cited the expense of purchasing the requisite software and hardware as additional cost barriers. Caltrans indicated that the computers of ROW practitioners are often "woefully inadequate" for visualizations and that presenting visualizations to property owners could require the purchase of laptops. According to Caltrans, "[e]ven when an enthusiastic ROW person who wants to try something innovative is identified, his/her computer is underpowered." This trend, however, may be changing. NCDOT said that over the last decade some of its ROW offices have equipped agents with laptops for

[14] See ftp://ftp2.bentley.com/dist/collateral/Web/Civildemo.pdf for an example of a 3-D PDF.
[15] This consultant noted that visualizations for public meetings that might involve 50-300 parcels or more could cost well above $75,000.

property owner meetings, and are even considering functionality that would enable agents to print property owner compensation checks in the field.

FDOT cited a secondary cost beyond the need to purchase additional hardware and software. When one of its physical models was admitted in court, an expert witness was required to testify that it was accurate. Although FDOT acknowledged that its ROW office likely had the capabilities to create or explain visualizations, it was not permitted to present the model already developed in court unless it was accompanied and supported by the testimony of an engineer, which is required under state law. This sort of uncertainty about potential extra secondary costs could dissuade agencies from using visualization for ROW acquisition, and encourage status quo practices.

3.3.3 Lack of internal resources to develop and display visualizations

All of the DOTs interviewed had some in-house visualization development expertise, ranging in size from two staff people in NYSDOT's headquarters to several groups spread across a number of districts in Ohio. Most, however, indicated having had limited experience developing visualizations for ROW acquisition purposes. They also noted that workloads were becoming increasingly strained and that staff sizes were not growing in a commensurate way. NCDOT pointed to the design and art skills necessary to produce high-quality visualizations, stating that when it had the opportunity to expand its visualization team, it had sometimes been difficult to attract potential staff with this requisite background.

Additionally, according to one consultant stakeholder, visualization software can be very data-intensive and most state DOT ROW staffs do not have the computer hardware, even if they had the time, to manage these data in-house. Likewise, most DOTs interviewed had no standard practices for using visualization.

3.3.4 A concern that visualizations might not look exactly like the actual project

Some state DOTs expressed a concern that visualizations might differ from the end project leading to property owner dissatisfaction between the expected and actual results. One stakeholder cited an example where the final project differed in appearance from an animation because seedlings, as opposed to the mature trees displayed in the visualization, had been planted at the project site. Based on this experience, a DOT might hesitate to employ visualization early in the project development process due to a fear that it could create an unrealistic expectation among property owners that the projects, when built (often years in the future), would exactly match the visualized representation. Additionally, it is possible that a DOT periodically revise its ROW needs as the acquisition process proceeds, potentially making the agency feel compelled to adjust and readjust visualizations created for the acquisition.

Additionally, one DOT exhibited hesitation in considering the use of computer-generated visualizations in condemnation proceedings, suggesting that "a technological presentation…brings up more questions in court." This assertion was based on the notion that computer-based visualizations are inherently pliable and, therefore, open to manipulation.

Figure 9. Two-dimensional aerial visualization of existing (top) and proposed overpass conditions (bottom). Source: FDOT.

4. RECOMMENDATIONS

The use of visualization has not been as widespread in the ROW acquisition process as in other stages of transportation project delivery because there has been a lack of awareness among ROW practitioners of visualization's potential ROW acquisition applications. Visualizations have also been perceived as too costly to produce unless the project was confronted with complex property issues. Some ROW practitioners expressed concern that visualization presentations might not exactly replicate the look of the actual project, thus potentially damaging public opinions about a particular project.

However, there was general agreement among stakeholders and in the literature that the use of visualization for ROW acquisition purposes will continue to grow. This is especially true as the demand for information that is accurate and easily communicated (e.g., via maps and visual displays) increases, and funding and timelines are scrutinized more rigorously. According to those interviewed, visualizations can offer a cost-effective way to enhance the ROW acquisition process. Communication with property owners and other stakeholders about project impacts can be improved, potentially lowering condemnation rates and associated fees or damages. The amount of land to be acquired can also be reduced in some cases. Project coordination among transportation disciplines is encouraged, potentially reducing the likelihood of design or construction errors further along in the project delivery process.

Determining which visualization techniques are most suitable for ROW acquisition is less clear. Current literature and the stakeholders interviewed for this report indicate that there may not be one universally preferred technique.

The technical level of a visualization that would best serve a ROW official in the acquisition process is highly dependent on the issues and concerns of the acquisition. For purposes of negotiation with property owners, simple visualizations, including ROW maps overlaid with aerial photography that are geometrically corrected or sketches created with CAD software, are likely sufficient. This does not suggest that more sophisticated techniques be overlooked, but the simplicity and scope of some negotiations may not warrant the investment of time and resources that complex visual aids can require. Traditional visualizations might also be better suited for situations that demand extra flexibility, as making changes to advanced visualizations, such as 3-D simulations or video flyovers, can be costly and complicated. An advanced computer-generated video exhibit that guides viewers through multiple scenarios might confuse, rather than clarify, a project when presented to a jury due to the potential number of issues displayed in the video.

In instances where the scrutiny of court proceedings are a concern, software that can provide for high degrees of accuracy and easily incorporate new changes or present new views are likely better than photo-editing software. Similarly, advanced visualizations also offer useful means to demonstrate less complex scenarios, such as on-site traffic maneuvers, grading changes, partitioning of remaining parcels, or simple renderings of the completed facility, to many people over longer periods of time (e.g., looping video at a public meeting or presentation to a home-owners association).

NCHRP Synthesis 361: Visualization for Project Development[16] reports that the current state of visualization within the transportation community is one of eagerness to use the technology but of minimal organization for its implementation. According to the study, transportation agencies nationwide were looking for guidelines and best practices for its use. To begin to address this gap, as well as the

[16] NCHRP Synthesis 361: Visualization for Project Development is available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_361.pdf.

barriers identified in this research, the project team proposes the following recommendations for using visualization techniques in ROW acquisition.

Barrier addressed: Lack of awareness of visualization's potential uses in the ROW acquisition process

- **ROW offices within state DOTs should reach out to visualization staff to learn about visualization techniques available.**
  It is important to instill an understanding of the range of visualization tools available for ROW acquisition. Potential visualization users, especially novices, may not know what to ask for or how to write a task order for visualization services.

  In state DOTs where visualizations are developed in-house, ROW practitioners should consider approaching visualization staff (and vice versa) to discuss potential visualization needs and capabilities. DOT leadership can help initiate these conversations, if necessary. In situations where visualization development is outsourced, real estate staff should request that consultants or agency ROW project managers present the agency with various visualization possibilities that could be specifically tailored to the ROW acquisition process. In both cases, the first topic of discussion should be to define the term "visualization." There are a variety of different visualization techniques, and not all involve sophisticated computer modeling or require digital graphics expertise. It is important for visualization staff to adapt the visualization technique to the need. Overlaying an ortho-rectified, or geo-referenced photo would likely facilitate the ROW acquisition process and not necessarily be expensive. "Home use" modeling software packages, such as Google SketchUp, are often free resources for those wanting to explore computer visualizations without learning specialized engineering tools. At a minimum, ROW staff should engage in early consultation with aerial photo and mapping personnel to understand how the most appropriate technologies might be utilized and best mapping products obtained. Without comprehension of the spectrum of options—from hand drawings to technologically-sophisticated computer renderings—this might not be feasible. See Appendix C for an example visualization request form that NYSDOT developed, which includes a synopsis of visualizations offered internally, as well as a listing of other relevant outreach and educational resources on visualization topics.

- **Use visualizations to supplement, not replace, existing practices or tools**.
  As visualizations are integrated into the ROW acquisition process, it is important to use them to complement existing practices, such as a property walk-through. Before visualizations were used, negotiators would often take property owners to the actual site of where the proposed property change was to occur so that the property owners could mentally visualize the impacts to their properties and ROW practitioners could more easily stake the owners' land. To the extent possible, a site visit with property owners should accompany visualizations, regardless of the technique used. Project managers should continue to offer owners the opportunity to do a walk-through of properties being acquired. Negotiators should allow owners to compare plans and visualizations of the parcels in question with the actual property. In these cases, more simple visualizations, such as aerial images and ROW plans, might be more effective since computer simulations cannot replace physically being at a property. Visualizations would continue to be beneficial for more complex landscape alterations, grading changes, or the addition of structures such as walls.

Barrier addressed: Perception that visualizations are costly to produce or only useful for complex projects

- **Identify opportunities to spread the cost of visualization development**.
  During the initial stages of project development, each functional discipline on the project team should consider whether a visualization presentation would enhance its role, for example, through improved

communication with affected landowners and other stakeholders at public meetings or through enhanced ability to assess environmental impacts. Additionally, some visualization techniques, such as interactive 3-D modeling, can be a by-product of the design or other project development process (e.g., 3-D surface models are frequently developed for automated machine guidance during construction) and do not always need to be rendered with a high degree of realism to convey basic project concepts or certain effects such as the geospatial proximity of the project to the ROW or adjacent property. By having multiple disciplines involved in communication early on, the costs of developing the visualization(s) could likely be spread among all the groups poised to benefit from the presentation. More low cost visualization techniques could be applied to more projects.

Another pragmatic approach is to show existing ROW lines faintly in all visualizations created for project development purposes. This minor addition can enhance the usability of a presentation and demonstrate the added value of visualization.

- **State DOTs that are already utilizing, or plan to use, visualizations for ROW acquisition should develop a standard process for evaluating the visualizations, preferably before the visualization is produced and used.**
  State DOTs would benefit from a consistent method to record the benefits of visualization for ROW acquisition, as well as from documentation of the actual costs expended for visualization. Though the interviewed DOTs using visualization for ROW acquisition purposes recognize the value of establishing standard evaluation procedures and measures, none have been effectively implemented and shared. While one interviewed state DOT did indicate that it surveys property owners at the end of a negotiator's visit, the survey does not specifically solicit feedback on visualizations that may have been presented, nor are survey results between acquisitions completed with and without visualizations compared.

  Potential criteria for evaluating visualization for ROW acquisition include:
  - Time to complete acquisition compared to historical trends
  - Acquisition cost relative to visualization development cost or historical acquisition costs, when corrected to current dollars
  - Condemnation rate trends
  - Settlement rate trends
  - Initial property owner reaction to visualization(s) presented
  - Level of comprehension of proposed acquisition and improvements based on post-appraisal or negotiation property owner feedback
  - Satisfaction with the acquisition process based on post-acquisition property owner feedback (e.g., via confidential questionnaire)
  - Effect of visualization on property owner's attitude toward the acquisition process or DOT
  - The number of other uses (e.g., in the project development process) for the visualization

Barrier addressed: Lack of internal resources to develop and display visualizations

- **Make laptop computers and media software available for mobile use**.
  In order for appraisers and negotiators to make best use of visualizations during ROW acquisition, they need to present the visualizations to property owners in the field. Some interviewees indicated that equipping staff in the field with laptops had been a challenge due to budget constraints. Given visualization's potential benefits in the ROW acquisition process, DOTs should modernize appraisers' and negotiators' field equipment and maintain up-to-date visualization software to the extent practicable. ROW officials in the field could find additional uses for laptops beyond showing visualizations, such as changing and printing documents on-demand, thus saving a trip to the office

and potentially days in the process. These additional uses further justify the financial investment in laptops.

Barrier addressed: Concern that visualizations might not look exactly like the actual project

- **Keep the complexities of the parcels in mind**.
  Conveying a partial or complete project rendering in the ROW acquisition phase of project development can be challenging given that actual project completion is likely years away, during which substantial changes may occur. State DOTs interviewed, as well as existing literature, emphasize the importance of creating visualizations that are realistic rather than idealistic. Given the range of possibilities that visualization tools present, it is tempting to create a vision of what a finished project could look like, rather than what it will actually look like, as discussed earlier in the example where seedlings were planted onsite rather than the mature trees depicted in the visualization. Sharing visualizations that depict unfinished projects can foster public involvement by conveying that the projects are still in development, and that public feedback is welcome. In contrast, sharing a "finished" project plan may alienate stakeholders who believe that the project was finalized without their input.

Other Recommendations

- **Use visualization tools to improve the ROW acquisition process and, by extension, accelerate the overall project delivery process**.
  FHWA's "Every Day Counts" initiative is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of roadways, and protecting the environment. The ROW process, which includes the ROW acquisition process, is a major part of project delivery, and significant time savings can be achieved. Visualization is an innovative tool that land acquiring agencies should consider in their efforts to expedite ROW acquisition.

Going forward, FHWA should:

- **Conduct a test study on the degree to which visualization can expedite ROW acquisition**.
  To quantify advantages of advanced visualization techniques over traditional approaches, the FHWA should support a project to test the effectiveness of visualization in expediting ROW acquisition. Although this experiment would not have a "control" case, it would allow for a comparison of visualization techniques on presumably similar properties related to one transportation improvement. The project should track the dollar and labor hour costs of producing the visualizations, and should compare traditional versus advanced visualization techniques in terms of time to develop, time to settle the acquisitions, settlement and condemnation rates, and any effect on damage payment that may be necessary.

- **Establish a working group to collaborate and share state of the art techniques and information on visualization for all aspects of the ROW process.**
  A working group could collect and disseminate best practices and lessons learned to maintain accurate cost data and share visualization techniques. The group, which could be organized as an AASHTO ROW committee focus group, could organize webinars, conferences, or sessions at semi-annual meetings to update visualization and ROW experts, as well as individuals who may need visualization assistance. The working group might also provide DOTs with up-to-date information on software and hardware capabilities and requirements or work with software companies to develop software packages appropriate for ROW offices.

- **Conduct research on the use of visualization tools in other core ROW process areas, such as appraisal, relocation, property management or asset management, and outdoor advertising control.** This research primarily focused on the acquisition aspects of the ROW process. Although other core ROW process areas were mentioned, an in-depth evaluation and analysis of the benefits and costs of visualization in the other areas was not conducted. Future research on these topics could yield useful information for practitioners seeking lessons learned in applying visualization for ROW purposes other than ROW acquisition.

- **Create guidelines and contract templates for visualization agreements**. In coordination with visualization firms, traffic engineers and appraisers often develop the terms in ROW visualization contracts in the parlance of their respective fields, potentially predisposing a visualization product toward one particular use, and away from a more holistic application. The project team also found that the contracting language used often varies depending on a project's scope. For example, sometimes language will be added to include preparation for and testifying at a court hearing. Going into a visualization project, some companies require the following:
    - Auto-turn data
    - High-resolution ground photography
    - 3-D topography
    - Road geometry and schematics
    - Striping plans
    - Planimetrics
    - Aerial data
    - Grading plan
    - Any state specific design standards
    - Traffic counts

  Other companies ask for more basic information, such as whether the DOT wants an advanced visualization versus a basic visualization, or whether additional details (e.g., people, buildings, and vehicles) will be included.

  FHWA should work with a select group of ROW offices within DOTs to produce guidelines and sample language for contracts between state DOTs and visualization consulting firms, should a visualization contract be necessary. Appendix F offers sample specifications, parameters, and deliverables that could be included in a scope of work for visualization services.

Sources Consulted and Literature Review

Hannon, Jeffrey John and Tulio Sulbaran. NCHRP Synthesis 385: Information Technology for Efficient Project Delivery. University of Southern Mississippi. October 2008. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_385.pdf. Prepared for TRB.

The National Institute of Standards and Technology (NIST), the U.S. Department of Commerce, the General Services Administration, the Construction Industry Institute consortium, the International Alliance for Interoperability, and the Construction Sciences Research Foundation (NCHRP) commissioned this synthesis report to study interoperability issues specifically related to state DOTs. The scope aimed to identify sharing of information throughout all phases of the project delivery process, including procedural, institutional, human, and technical constraints and mechanisms.

American Association of State Highway and Transportation Officials Task Force on Environmental Design. July 2003. *Visualization in Transportation: A Guide for Transportation Agencies*. http://cms.transportation.org/sites/design/docs/VisualizationGuideJuly2003.pdf

The AASHTO Task Force on Environmental Design presents the different types and uses of visualization in transportation and associated benefits and constraints. The purpose of visualization in transportation is to sufficiently convey to the public the full extent of proposed improvements without the need for specialized technical knowledge. Since visualizations are often created during the early stages of a project when final details are not certain, it should be clear that they only represent preliminary designs, which may ultimately change before the project is completed. In certain cases, where the appearance of a project may change between the time of its completion and a future date (for instance, based on the growth of vegetation planted during construction), these anticipated changes should be communicated to the public or documented in additional visualizations. Visualizations have the potential to accelerate the process of reaching a consensus on the design of a project with stakeholders, the public, and communities directly affected by the construction and ultimate operation of a project. However, AASHTO warns potential users of visualization technology for transportation projects against misrepresenting the ultimate intent of a project by augmenting images with features that will not be included in the actual improvement. Adding features purely for visual appeal can introduce bias, and may ultimately necessitate the inclusion of any superfluous visualized features into the end design.

Cambridge Systematics, Inc. December, 2006. "U.S. Domestic Scan Program: Best Practices in Right-of-Way Acquisition and Utility Relocation, Final Scan-Tour Report." http://onlinepubs.trb.org/onlinepubs/trbnet/acl/FR1_NCHRP2068_Right-of-Way_all-in-one.pdf

In July 2006, the NCHRP initiated a scanning tour of three state DOTs to highlight successful practices in right-of-way acquisition and utility relocation. In Florida, the scanning team noted that FDOT employs aerial photographs with the existing and proposed alignments superimposed during the ROW acquisition process to communicate to landowners the projected impact to their property. The use of these maps, which cost about $10,000 per mile, have been particularly useful in highly developed urban areas, where businesses use the ROW for parking and other commercial-based activities. Minnesota DOT employs a more sophisticated form of visualization in its ROW acquisition process, presenting landowners with a 3-D video depicting the proposed improvement and the adjacent property. At an estimated cost of less than $500 per parcel, this

practice is intended to help landowners understand the impact of a project on their property while they consider the fairness of an acquisition offer.

Campbell, John *et al*. June 2009. "Streamlining and Integrating Right-of-Way and Utility Processes With Planning, Environmental, and Design Processes in Australia and Canada." Federal Highway Administration. http://international.fhwa.dot.gov/pubs/pl09011/execsum.cfm

In September 2008, a group of state DOT and FHWA staff sponsored by FHWA, AASHTO, and the NCHRP conducted a scan of innovative ROW practices in Australia and Canada. The scanning team found that certain Australian states are beginning to employ visualization technology in the ROW acquisition process, posting three-dimensional animations of proposed projects online. Although the tools to create the animations were expensive, the higher level of public engagement the tools allowed sufficiently offset the tools' costs. As a result, the scanning team recommended that DOTs in the United States begin to research and promote a similar use of the technology.

Charles L. Hixon III. 2006. "Visualization for Project Development: A Synthesis of Highway Practice." NCHRP Synthesis 361. Prepared for TRB. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_361.pdf

The authors of this NCHRP publication define visualization as "the visual representation of proposed project alternatives and improvements and their associated impacts on the existing surroundings." They suggest that traditional 2-D technical documentation like design plans often exacerbate confusion among members of the public while newer CAD-based three-dimensional media hold potential for allowing the public to understand the proposed impacts of a project. They also find that visualization can aid transportation professionals during the design process by allowing them to view potential points of interference between project elements or comprehend complex construction sequences. The authors present case studies of the Utah, California, Minnesota, New York, and Florida DOTs and the FHWA to highlight common challenges in employing visualization in transportation. These include a lack of standards and guidelines, insufficient cost/benefit data to justify the use of visualization, limited knowledge on the potential of visualization, a shortage of qualified visualization technicians within agencies, and limited opportunities for training.

FHWA. 2007. Virtual Highways—A Vision of the Future. *Public Roads* article. www.fhwa.dot.gov/publications/publicroads/07may/05.cfm

This article appearing the May/June 2007 issue of *Public Roads* describes how FHWA demonstrated new visualization technologies for a roadway design process in Montana to improve project delivery time.

FHWA. 2010. Visualization's Next Frontier. *Public Roads* article. www.fhwa.dot.gov/publications/publicroads/10janfeb/02.cfm

This article appearing the January/February 2010 issue of *Public Roads* describes how visualization can be used as a tool in the engineering and design phases of project development. It includes descriptions of many 3-D, 4-D, and dynamic (animated or real-time simulation) technological tools for design visualization.

FHWA. 2008. Right of Way and Utilities International Scanning Tour—Australia and Canada: Summary Report. www.fhwa.dot.gov/realestate/scans/rowutilint08.htm

In September 2008, an International Scanning Study Team visited Australia and Canada to learn about innovative practices on ROW and utility processes that might be applicable for implementation in the United States. This report documents the findings of the scan.

FHWA. 2005. "Acquiring Real Property for Federal and Federal-aid Programs and Projects." Publication no. FHWA-HEP-05-030. www.fhwa.dot.gov/realestate/realprop/index.html

This brochure explains the rights of owners of real property to be acquired for a federally-funded programs or projects.

Federal Lands Highway Division. *Design Visualization Guide*. www.efl.fhwa.dot.gov/manuals/dv/manual/chapter1/1_0.aspx

FHWA's Federal Lands Highway Division defines design visualization as a "simulated representation of a design concept and its contextual impacts or improvements." Federal Lands Highway Division acknowledges that design visualization is not commonly used by transportation agencies for small- or medium-scale projects due to the perception that the techniques are expensive and require a highly-specialized skill set. Their Design Visualization Guide presents visualization techniques ranging from basic to advanced that utilize computer-aided design and drafting software. They also present innovative tools for communicating designs to a general audience, including 2.5-D animations that combine an aerial photograph with a 3-D model in a single video sequence, 3-D applications, and real-time interactive models, which allow stakeholders to navigate through an animation interactively. Finally, the guide depicts seven case studies in which design visualization techniques were used to communicate the effects of a proposed improvement on a Federal Lands Highway project alignment.

Garrick, Norman W. *et al*. July 2005. *Effective Visualization Techniques for the Public Presentation of Transportation Projects*. Prepared for The New England Transportation Consortium. www.netc.uconn.edu/pdf/netcr48_00-6.pdf

Garrick, Miniutti, Westa, Luo, and Bishop identify the components of successful visualization techniques in the public involvement process of transportation projects, highlight the state of the practice in New England, and provide an overview of the techniques available to transportation professionals. The need for effective presentation methods has evolved concurrently with the availability of computer-based visualization techniques and technologies but transportation agencies need to be careful in order to ensure that visualizations are constructed accurately. In addition to involving the public more easily in the transportation planning process, visualization can be used to evaluate alternatives and identify problems early in the planning and design processes. Through their survey of visualization techniques, the authors found that, although available visualization techniques range from artist renderings to 3-D animations and simulations, New England DOTs generally use static image composites as their primary form of visualization. Furthermore, when the survey was conducted, visualization had not been fully integrated into the transportation design process at most of the DOTs that responded.

Genesee Transportation Council. *An Introduction to Visualization.* www.gtcmpo.org/Resources/Topics/Visualization.htm

The Genesee Transportation Council provides an overview of the use of visualization in transportation, including reasons for its use, available techniques, and recommendations for using visualization appropriately. Since the public may not possess the same level of understanding of

engineering concepts as transportation professionals, visualization can help translate and convey the intent of proposed transportation projects. Projects of all scales can impact surrounding communities, so it is important that some form of visualization is available to the public for all projects. However, given the predictive nature of visualization, transportation professionals should qualify any visual depiction of a potential project and its source data in order to avoid misrepresentation.

Gentry, Ann H. November/December 2000. "3-D Animations: Power Tools for the ROW Professional." *Right of Way Magazine*. Pgs. 12-17.

Ann H. Gentry, of Precision Simulations Inc. presents various uses for visualization technology in the ROW industry. She focuses, in particular, on its use in litigation, where a three-dimensional animation or simulation can convey to a jury what maps and engineering plans cannot. A three-dimensional model allows the jury to fully understand the nature of a condemnation case and understand visually the impacts to a property that a proposed project will have or has already made. In the latter case, visualization techniques can allow an attorney to depict to the jury the appearance of a property before the improvement in question was constructed.

Hakimi, Shadi and Kara M. Kockelman. Fall 2005. "Right-of-Way Acquisition and Property Condemnation: A Comparison of U.S. State Laws." *Journal of the Transportation Research Forum.* Pgs. 45-58.
www.ce.utexas.edu/prof/kockelman/public_html/TRB05ROWCondemnations.pdf

Hakimi and Kockelman investigate the correlation between state ROW acquisition practices, demographic characteristics, and condemnation rates. They suggest that condemnation introduces uncertainty into estimates of cost and timeframes for ROW acquisition and, while fairly constant across years, condemnation rates represent a sufficient indication of success for ROW statutes. Their analysis found that states that allowed the acquisition of property prior to an agreement of compensation or acquisition of uneconomic remnants left over as a result of a partial acquisition experienced generally higher condemnation rates, while states that engaged in early, open, flexible, and explicit acquisition practices experienced lower condemnation rates. Their investigation of state condemnation rates also indicated that certain demographic variables like urbanization, high educational attainment, and certain political affiliations correlated with higher condemnation rates.

Hancock, Kathleen. February 2011. "NCHRP 8-55A: Developing a Logical Model for a Geo-Spatial Right-of-Way Land Management System." Prepared for the Transportation Research Board.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-55A_FR.pdf

The objectives of this project were to (1) develop an enterprise-level logical model for a prototypical geo-spatial enabled, ROW land management system for state departments of transportation, (2) demonstrate a crosswalk between the logical model and DOT enterprise systems now in use to determine the gap between the state-of-the-art system and existing systems, and (3) deliver a presentation-ready executive summary in print and electronic formats that demonstrates the usefulness and validity of the logical model.

Hart, James M. June 29, 2009. "Integrating Modern Surveying and Mapping Technology into the Right of Way Acquisition Process." Presentation to 55th Annual IRWA International Conference, Indianapolis, IN.
https://www.irwaonline.org/EWEB/upload/2009Conference/Monday/Integrating%20Modern%20Surveying%20and%20Mapping%20Technology%20into%20the%20Acquisition%20Process.ppt

James M. Hart of Towill Surveying, Mapping, and GIS Services presented to the 55th Annual Right of Way Association International Conference the benefits of modern mapping and surveying technology, including GPS, aerial photography, and Google Earth, in the ROW acquisition process. Hart expressed the effectiveness of aerial photography and Google Earth as tools for interacting with landowners, particularly highlighting the power of the latter when displayed on a GPS-enabled and wirelessly-connected laptop.

Heiner, Jared D. and Kara M. Kockelman. January 2004. "The Costs of Right of Way Acquisition: Methods and Models for Estimation." Presented at the 83rd Annual Meeting of the Transportation Research Board, Washington, D.C. www.ce.utexas.edu/prof/kockelman/public_html/TRB04ROW.pdf

Estimating Right of Way acquisition costs can be a difficult task, and one that has many variables that are difficult to predict. Agencies typically have little time or information to estimate ROW acquisition costs, which represent a significant portion of a project's cost. Heiner and Kockelman introduce models to help agencies estimate the cost of acquiring parcels. Their analysis indicates that in full property acquisitions, the value of improvements is typically more important than the value of the underlying land, while in partial acquisition, the size and shape of the remainder as well as characteristics like parking and access are significant in determining damages.

Linné, Mark R. and Michelle M. Thompson. 2010. Visual Valuation: Implementing Valuation Modeling and Geographic Information Solutions. Appraisal Institute. Chicago, IL.

The three sections of this book target readers at different levels of sophistication. Early chapters instruct the technological neophyte trying to get up to speed on the issues. Later chapters address the power user who is comfortable with practical applications of the technology. The final chapters explore the academic arena, where experts apply the most sophisticated modeling techniques in original research work.

Morgan State University, Institute for Transportation. July 2004. "Geographic Information System Implementation of State Department of Transportation Right-of-Way Programs." Prepared for the Office of Real Estate Services, FHWA, www.fhwa.dot.gov/realestate/rowsurvjuly04.htm

As part of its report for the FHWA Office of Real Estate Services, the Institute for Transportation at Morgan State University surveyed the use of GIS by eight state DOT ROW programs. The Maryland DOT utilizes ESRI ArcView GIS in the ROW acquisition process to display tax assessment data visually. Certain districts of the NYSDOT also use GIS to digitize the geographic features of properties being considered for acquisition. The Minnesota and New Mexico DOTs also indicated that they used GIS for ROW acquisition.

Transportation Research Board. NCHRP Report 695: Guide for Implementing a Geospatially Enabled Enterprise-wide Information Management System for Transportation Agency Real Estate Offices. 2011. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_695.pdf

This report presents a guide for implementing a geospatially enabled enterprise-wide information management system for ROW offices and includes a logical model to assist with this implementation. The report will be of immediate interest to staff in state highway agencies responsible for the acquisition, management, and disposition of real estate for ROW.

Transportation Research Board. NCHRP Synthesis 229: Applications of 3-D and 4-D Visualization Technology in Transportation. 1996.

This NCHRP publication describes the application of computer graphics to transportation practice. The publication is intended for transportation planners, facilities design and construction personnel, and traffic engineers. The report of describes the use of 3-D and 4-D as well as the requirements of hardware and software, costs, production time, and issues of complexity.

Transportation Research Board. NCHRP Synthesis 372: Emerging Technologies for Construction Delivery. 2007.

Chapter 5 describes the use of 3-D modeling and visualization for Automated Machine Guidance purposes.

Transportation Research Board. January-February 2007. "It's About Decisions: Advancing Transportation Project Development with Visualization Technologies." *TR News*. http://onlinepubs.trb.org/onlinepubs/trnews/trnews248.pdf

This article provides an editorial perspective describing a leading intent of visualization technologies.

Transportation Research Board. September-October 2007. Visualization in Transportation: Empowering Innovation." *TR News.* http://onlinepubs.trb.org/onlinepubs/trnews/trnews252.pdf

TR News presents an issue that focuses specifically on the use of visualization technology in transportation, featuring articles by several transportation professionals. Michael A. Manore, Chair of the TRB Visualization Committee, generally defines visualization as "any progressive visual means of representing static or temporal spatial and geometric information." Alan E. Pisarski, a member of the Urban Transportation Data and Information Systems Committee, illustrates the growing need for visualization in transportation, suggesting that visualization allows the public to envision complex information, and facilitates their buy-in for investing in large, expensive, and necessary transportation projects. Doug Walker, president of the visualization software and consulting firm Placeways, LLC., echoes Pisarski's message, highlighting the importance of community concerns in the project development process and the need for visualization as a common language through which experts, stakeholders, and the community can communicate. Finally, Charles L. Hixon III, the consultant for NCHRP Synthesis 361: Visualization for Project Development, notes several considerations for transportation agencies interested in employing visualization technology. He recommends that visualization be fully integrated into the planning process so that the costs are amortized. He also suggests that transportation agencies should house visualization staff in a specialized unit to provide the greatest opportunity for training, and to spread the cost of visualization over the entire agency rather than only to specific projects.

USDOT. 2002. Acquiring Real Property for Federal and Federal-Aid Programs and Projects. FHWA Publication No. FHWA-PD-95-005.

Volpe Center. July 2009. Applications of 3-D Visualization: Peer Exchange Summary Report. Prepared for FHWA's Office of Interstate and Border Planning. www.gis.fhwa.dot.gov/documents/PeerEx_report_3-D.pdf

On July 8–9, 2009, The FHWA's Office of Interstate and Border Planning sponsored a peer exchange to promote the use of three dimensional visualization technologies within transportation agencies. The peer exchange included presentations from the North Carolina, New York State, Minnesota, and California DOTs as well as the Baltimore Metropolitan Council and the Volusia County Metropolitan Planning Organization. The presenting agencies noted common challenges, including a difficulty determining the effectiveness of visualization tools and gaining support from upper management, difficulty organizing visualization staff within the organization, and difficulty ensuring that visualizations are used in the most appropriate and effective manner. Certain participants also emphasized the importance of developing true-to-life visualizations rather than idealized versions of a project. The key themes highlighted during the peer exchange were that visualization techniques allow transportation agencies to converse with a wide range of stakeholders, but agencies need a way to evaluate the effectiveness of visualization, develop a channel for hiring and retaining qualified visualization designers, and facilitate training and information sharing between transportation visualization specialists and practitioners from the overall industry.

Volpe Center. November 2007. Visualization Case Studies: A Summary of Three Transportation Applications of Visualization. Prepared for FHWA's Office of Interstate and Border Planning and Office of Project Development and Environmental Review. www.gis.fhwa.dot.gov/documents/visual_toc.htm

In 2007, the USDOT Volpe National Transportation Systems Center, in coordination with the FHWA developed three case studies on the use of visualization techniques by the Arizona, Ohio, and Wyoming DOTs (ADOT, ODOT, and WYDOT, respectively). As part of an improvement project for its Interstate 10 corridor, ADOT proposed replacing an existing interchange with a design that accommodates both express and local lanes. In order to communicate the complicated proposed design to the public, ADOT created a video simulation that it showed during three public meetings. Following the display of its visualization, ADOT noted that it was effective in engaging the public and increasing support for the project. ODOT employed visualization to quantify the impact of a proposed rail grade separation following a finding of adverse effect by the Ohio State Historic Preservation Office (SHPO). As part of a Visual Impact Assessment Report, ODOT created a drive-through simulation of its proposed project that enabled the Ohio SHPO to better understand the projected impacts of the project. Finally, WYDOT required the use of visualization in proposing alternatives for managing landslides along an existing alignment. It chose to enlist a consultant to create a series of photo-simulations and animations that would show the anticipated impacts of each alternative on the surrounding environment. The creation of these visualizations aided the U.S. Forest Service and the Wyoming Fish and Game Department in quantifying the impact of each alternative during the environmental review process.

Volpe Center. March 2009. "Visualization in Transportation: Five Case Studies." Prepared for FWHA's Office of Project Development and Environmental Review.

As a follow-up to its 2007 summary of three case studies in the use of visualization in transportation agencies, the USDOT Volpe Center, in coordination with the FHWA, developed five additional case studies to document the use of visualization techniques by state departments of transportation. The case studies focused on the Washington state DOT, the Idaho Transportation Department, the Vermont Agency of Transportation (VTrans), the NCDOT, and the Massachusetts Highway Department, all of which had used visualization for public and stakeholder involvement during the transportation planning process. VTrans, in particular, had used video simulations in evaluating alternatives for redesigning an especially contentious

intersection. In addition to allowing the public to understand the operations of each proposed alternative, the visualization illustrated to the public the need for VTrans to acquire property to build each option, and even showed VTrans where they could afford to reduce the acquisition of surrounding parcels.

Waltersheid, David. October 23-26, 2006. "Use of Visualization Technology for ROW Acquisition and Eminent Domain." Presentation to 5th International Visualization in Transportation Symposium and Workshop. Denver, CO. www.teachamerica.com/VIZ/08_Waltersheid/index.htm

David Waltersheid from the FHWA Office of Real Estate Services presented several examples of the use of visualization technology for the right-of-way acquisition process to the TRB 5th International Visualization in Transportation Symposium and Workshop. Examples included projects from Texas and Florida in which the acquiring agency used three-dimensional computer visualizations to communicate to landowners the projected impact of a project to their property. In one instance, a three-dimensional animation was used to communicate to a jury the anticipated effects of a project on a commercial property, which reduced the land owner's claim of just compensation from $2 million to an award of about $200,000.

APPENDICES

Appendix A. Stakeholder Contacts
Appendix B. Phone Discussion Guide
Appendix C. Additional Resources
Appendix D. Example Property Owner Feedback Survey
Appendix E. AASHTO Survey on Visualization for ROW Acquisition
Appendix F. Example Specifications and Deliverables for a Visualization Scope of Work
Appendix G. Caltrans GIS Marketing Documents

Appendix A. Stakeholder Contacts

Bentley Systems, Inc.	Jackie Cissell 828-505-2050 Jackie.Cissell@bentley.com
Caltrans	Don Grebe 916-654-4456 Don.Grebe@dot.ca.gov
FHWA Resource Center	Mark Taylor 720-963-3235 Mark.Taylor@dot.gov
Florida DOT	John Garner 850-414-4545 John.Garner@dot.state.fl.us
Halff Associates, Inc.	Jeff Christiansen 214-346-6365 jchristiansen@Halff.com Mark Janicki mjanicki@Halff.com
Missouri DOT	George Kopp 573-751-7886 George.Kopp@modot.mo.gov
New York State DOT	Marci Sammons 518-458-2442 msammons@dot.state.ny.us Bob Dudley rdudley@dot.state.ny.us
North Carolina DOT	Tom Childrey 919-571-4191 tchildrey@ncdot.gov David Hinnant 919-212-3126 dbhinnant@ncdot.gov
Office of the Attorney General of Texas	Cavitt Wendlant 512-936-1151 Cavitt.Wendlant@oag.state.tx.us
Ohio DOT	Wayne Pace 614-995-3541 Wayne.Pace@dot.state.oh.us

Transportation Research Services, Inc. Brad Rodenberg
719-494-8067
Brad.Rodenberg@trscorp.us

Appendix B. Phone Discussion Guide

1. **Please tell us your title and describe your main project responsibilities.**

2. **In what capacities have you used visualization tools and techniques other than for ROW acquisition?**
   - Who are the primary users and audiences?

3. **How did you first learn/think about using visualization for ROW acquisition? How were you introduced to the concept?**

4. **Did you do/review any research on other agencies' use of visualization for ROW acquisition?**

5. **Can you describe some specific situations/circumstances that called for using visualization for ROW acquisition purposes? What ROW acquisition need does/can visualization fill?**

6. **Before you used visualization for ROW acquisition, how did you carry out the uses or communicate the relevant information/concepts to stakeholders? What, if anything, did visualization replace?**

7. **Do you develop the visualizations in-house or do you hire consultants? If consultants, who?**

8. **Can you estimate the development costs for a typical visualization application for ROW acquisition purposes?**
   - When you consider the costs of visualization for ROW acquisition, do you view it as a cost associated primarily with the ROW process, or have you analyzed how the cost is spread over the entire project development spectrum?
   - What was the cost of developing/purchasing the visualization application relative to the total project development cost, or overall project delivery costs?
     - E.g., can you comment on the cost of developing a visualization tool compared to the potential increase in project costs due to construction delays?
   - Do you include staff training or maintenance costs in your calculation of the total cost of developing/purchasing the visualization application?

9. **What lessons learned/best practices can you share about <u>pricing/costing/investing</u> in visualization applications/tools/services based on your experience?**

10. **Have you evaluated the benefits (actual cost-benefits or other) of using visualization?**
    - Have you compared and contrasted different visualization methods/techniques for relative effectiveness? How have you done so?

11. **As a user, what have been the <u>challenges</u> of using visualization for ROW acquisition?**
    - If you could do it all over again, would you have invested in the same tools for the same purposes? If no, what would you change?

12. **Have you received feedback from <u>stakeholders</u> about the relative benefits/advantages or disadvantages of using visualization for ROW acquisition?**
    - How did you collect their feedback? What did they say?

13. **Do you have any ideas regarding what makes ROW acquisition so different such that visualization uses have not seeped over into the field yet as much as in other areas?**

14. **Do you believe there is value in posting visualizations to social networking websites?**

15. **What advice would you give to other states that are thinking of undertaking a similar project?**

Appendix C. Additional Resources

NYSDOT Visualization Request Form

Instructions:
Fill out the information below and e-mail or fax your request to:
The Visualization Section may be reached by calling 518-845-2442.

General Information:
Project Name:

Contact Name: PIN #:

Phone Number: Date Needed:

Regional Data Manager:

Visualization Objective:
What are your visual communication needs? Who is your audience?

Project Phase:

- ☐ Planning (IPP or EPP)
- ☐ Prelim Design (Phase I-IV)
- ☐ Final Design (Phase V-VI)

Project Type:

- ☐ Intersection/Roundabout
- ☐ Highway
- ☐ Bridge Structure
- ☐ Planning
- ☐ Visual Impact
- ☐ Other (explain)

Visualization Type:

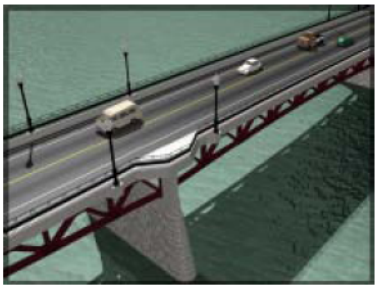
- ☐ 2D Quick Photosim
- ☐ 3D Photosim
- ☐ 3D Rendering
- ☐ 3D Animation
- ☐ 3D/4D Content

Deliverable Form:

- ☐ Image File(s)
- ☐ Video File(s) – playback method: Web☐ PC☐ TV☐
- ☐ Interactive Multimedia

Visualization Products

2D Quick Sim
Used for quick, illustrative purposes, this product does not claim to be highly accurate, but it can convey a design intention quickly without relying on accurate 3D geometry. This product relies predominately on image editing and hand-rendered perspectives.
Time requirement: 2-4 days each



3D Rendering
3D renderings are images generated entirely from three dimensional geometry (models). Usually, the geometry will have patterns (images) attributed to them to make them appear more photorealistic. Once a model is render ready, subsequent images are easily created from other locations.
Time requirement: 1-2 weeks each

3D Photosim
Excellent for depicting multiple design alternatives, this product requires a high resolution photo, from a known location, as the foundation. Once a 3D model has been created and patterned with photorealistic materials, a virtual camera is then positioned from the same coordinate location and a rendering of the geometry is made. Support photos may be required if substantial portions of the photo are being removed (i.e., foliage, buildings, etc.). Combining the photograph and the rendering makes it nearly complete. Some image editing is usually required to complete the final montage.
Time requirement: 1-2 weeks each

3D Animation
Once a 3D model has been created and patterned, a virtual camera can travel through a modeled environment, down a defined path, to capture what is seen, or a still virtual camera can record the animated motion of discrete objects. Thirty images per second are recorded, saved, and compiled to a video file. Changing the defined path or camera location requires a regeneration of animation frames.
Time requirement: 2-6 weeks

3D/4D Model Content
To populate a 3D computer graphics model, virtual content is used to represent real world objects. Examples could be buildings or other structures, lighting, signage, automobiles, or 3D terrain. Content can be created to populate Microstation and VISSIM 3D environments. Comprehensive 3D environments require considerably more time than simple discrete 3D objects.
Time requirement: 1-3 week

Appendix D. Example Property Owner Feedback Survey

***INSTRUCTIONS**: The cover letter below could be used as a guide to introduce a survey intended to collect feedback on the experience of showing property owners a visualization presentation.*

[State] Department of Transportation
[Date]

Dear Property Owner:

You are receiving this letter because you were contacted at your home or business by a representative from the *[Right of Way]* office from *[State]* DOT. This meeting was regarding the agency's need to acquire private property for the upcoming *[project]*.

[State] DOT would like to ensure that property owners have a clear understanding about the purchase of private property for Right-of-Way. *[State]* DOT is testing current methods of presentation tools to make it easier for a property owner to comprehend a proposed change. *[State]* DOT would like to continue to improve on our site visits and discussions with property owners.

Please respond to the enclosed survey so that *[State]* DOT can better serve the public *(The survey could be made available online)*.

Please call if you have any questions.

Thank you,

[Name]

[State DOT contact name and contact number]

INSTRUCTIONS: *The survey below could be used as a guide for developing your own feedback-collection survey.*

State DOT Right of Way Representative Site Visit Survey

Please answer the following questions about the ROW staff visit to your home or business.

1. Please indicate if you had a DOT right of way representative visit you in the past year. If yes, during which month?

2. Please state if the DOT representative visited you about your home or business.
    a. Home
    b. Business
    c. Other, please state here

3. Please state if this is the first visit by a DOT representative?
    a. Yes
       If yes, how many visits have you received from a ROW representative?
    b. No

4. How well did you understand the impact to your land that will result from the DOT's planned right of way purchase after the visit?

Not at all		Neutral		Completely
1	2	3	4	5

5. How did the representative communicate the project and the planned take to you? Circle all that apply.
    a. Aerial photos
    b. Plan drawings
    c. Site walk through
    d. 3-D physical model
    e. 3-D images on paper
    f. 3-D images on a computer
    g. Video played on a computer
    h. Other, please explain below
    i. Not sure

6. Did you feel that this method(s) was informative?

Not at all		Neutral		Completely
1	2	3	4	5

7. How positive did you feel toward the DOT representative after the visit?

Not positive		Neutral		Positive
1	2	3	4	5

8. What could the DOT representative do differently to improve future visits?

9. Please provide additional input about the visit to your home or business.

Thank you for your input on this survey. Your answers will inform *[State]* DOT of their current practices and inform our staff on how to improve on future site visits.

***NOTE**: The example survey above was adapted from a Mn/DOT survey that was offered to property owners after Mn/DOT made initial visits to the owners' places of residence or business. The Mn/DOT survey was distributed as part of a pilot project to assess the effectiveness of using visualization for ROW acquisition.*

Right of Way Initial Visit Survey

Please answer about the **initial visit at your place of residence or business**, as best you can recall.

1. In which month were you visited by a Mn/DOT Real Estate Representative?

   _____ (please write in month)

2. For the following, please circle a number from 1-5, with 1 meaning "not at all" and 5 meaning "completely." A 3 means "I am neutral," and write in "Don't know" if that applies.

	Not At All		Neutral		Completely
a. How well did you understand the impact to your land that will result from Mn/DOT's planned Right of Way purchase, after the visit? ....……	……1…….	…2…	….3…...	…4…	……5
b. How clear (not confusing) were Mn/DOT's maps and layouts? ………..	……1…….	…2…	….3…...	…4…	……5
c. How positive did you feel toward Mn/DOT, after the visit, in light of the need to purchase some of your property? ……	……1…….	…2…	….3…...	…4…	……5

3. Did Mn/DOT's Real Estate Representative show you a video representation of what the project will ultimately look like?

   (circle): YES - NO - DON'T REMEMBER

4. Please provide any input you may have about this first visit to your home or business by the Mn/DOT Real Estate Representative.

We very much appreciate your time and willingness to give us input.
We know this may be a difficult transition, but your answers will help Mn/DOT understand the clarity of materials as presented to property owners.

Please return this survey in the envelope provided.

Appendix E. AASHTO Survey on Visualization for ROW Acqusition

2008 International Scan Identified visualization

Requested by: **State of Texas**
Survey Deadline: **February 28, 2010**

The 2008 International Scan identified visualization as having potential to improve the ROW acquisition process and build relationships with property owners.

1. May we contact you in regard to your experience with Design Visualization as a suitable tool for ROW acquisition? Please provide contact information for a good resource to contact. Name, agency, phone number:[17]
2. Briefly describe how Design Visualization can be a cost effective tool to facilitate ROW acquisition?
3. Are procedures or methods available that can help determine best practices for the specific application of acquiring ROW, or for other Realty related purposes?

Thank you for your time and assistance.

ARKANSAS

The Department uses simulation models to analyze how well the traffic will flow, not anything that relates to ROW Acquisition.

GEORGIA

We are not use Design Visualization; however it looks like a tool to look into.

MICHIGAN

We are beginning to use visualization for some major projects but it is not yet the norm.

MINNESOTA

We have tried this on a very limited basis, and cannot meaningfully contribute on this.

MISSOURI

1) Design Visualization is fairly expensive and would only be cost effective on projects where the property values are very high or in areas where there are several contentious property owners. For an average project, we have not found Design Visualization to be cost effective.

2) We consider the use of Design Visualization on a project-by-project basis.

NEW YORK

1) Design Visualization can be a cost effective tool to facilitate ROW acquisition by providing better service to the public and save negotiations time. The benefits would include less time in using traditional methods, maps, cross sections and specially prepared exhibits, to negotiate damages; reduce the confusion of how to anticipate changes to their properties; result in higher quality appraisal products through more accurate analysis of impacts, thereby reducing the need for settlement justifications later

[17] Names and contact information have been removed from the states' responses.

on in the process once the project is completed and the impacts fully understood, and, ultimately saving on negotiations breaking down and cases ending up in the Court of Claims.

2) Are procedures or methods available that can help determine best practices for the specific application of acquiring ROW, or for other Realty related purposes? No – none as a standard at NYSDOT, but I strongly condone implementing this method.

OHIO

1) The cost effectiveness for ROW acquisition can reduce the appropriation rates because property owners would have a better understanding of the impact to their property. Reduce the unknown for property owners by providing a post construction visual of their property. To aid the Appraiser in the evaluation of impact for the damage to the residue, as well as assist the Review Appraiser to determine the recommended FMVE. Improve public relations at public information meetings to show what the project will look like at post construction. Have a better understanding of the actual construction plans to see the elevation changes to a parcel.

2) Yes, ODOT uses Personal Service Contracts as a method to hire consultants that are able to perform the visualization task.

A best practice to determine the need for this application is based on the complexity of the project or parcel and anticipating if the parcel would be appropriated. It is not recommended to use on every parcel because of the time commitment and the cost per parcel for preparation.

PUERTO RICO

Currently we only use aerial photos with cadastral layers, and some time with row plan sheets with Arc map (GIS). I will love to have more information about this kind of technology because we are trying to bring it to this area but so far with no luck.

SOUTH DAKOTA

South Dakota does not use visualization for ROW activities.

Appendix F. Example Specifications and Deliverables for a Visualization Scope of Work

The list below includes example considerations that should be made when determining and negotiating what visualization services are sought. It should be noted that not all of the example specifications and deliverables listed below apply to all visualizations.

Potential Specifications and Considerations

- **Purpose of Visualization.** Identify the purpose of the requested visualization. For example, is the purpose to convey what the future experience could be like or to identify particular facilities and precisely where they will be located?

- **Scale and Accuracy**. Scale is the size of features in a visualization relative to those features' actual size. Similarly, accuracy is the degree of closeness of measurements of features to their true values. These concepts hold whether the visualization is traditional or advanced. Include specifications on the scale and minimum accuracy of the presentation requested in statements of work for visualization services.

- **Duration**. Include durations for the visualizations required. If different visualizations will be created (e.g., one to post on the Internet and one to use on laptops in the field), durations for each should be specified.

- **Perspective**. Include indication of the number of view angles that are expected. For advanced visualization, the scope might also indicate whether more advanced functionalities, such as being able to observe relevant details in a 360º environment, are required.

- **Should users be able to modify the viewpoint of the visualization?** In an animation, the viewpoint or path is chosen ahead of time. Once the animation has been developed its viewpoint cannot be modified without completely recreating the animation. Real-time simulations do not have this limitation; however, they can be more costly.

- **Aspect Ratio**. The aspect ratio of an image is the ratio of the width of the image to its height. Include information on the desired or required aspect ratio.

- **Will additional nearby features be included?** Include specification of whether the visualization will incorporate features such as people/pedestrians, moving water, lighting, and textures, colors, materials, or finishes consistent with the plans, concepts, and designs provided. Articulate whether, and to what degree, areas adjacent to the project site(s) will be modeled and displayed. This is especially important in advanced visualizations, as some viewers may expect those types of models to reflect reality to a greater degree than with traditional visualizations. Viewers may also expect each element depicted in a visualization to be rendered with extreme realism, regardless of its relevance to the focus of the visualization (e.g., power lines along a roadway). Therefore, it may be necessary to omit certain features that do not need to be portrayed in the interest of reducing the amount of measurement and rendering necessary, and eliminating potential points of distraction.

- **Will existing and proposed features both be displayed?** Describe the degree to which features or visual cues, such as interchanges, buildings, landscaping, and related structures will balance realism (the existing

built environment) with future project phases. A visualization might be developed to show only existing conditions, only future conditions, or both, as in a 3-D flyover where a transition to future conditions might be seamlessly simulated.

- **Interactivity**. In the case of advanced visualizations, describe whether the visualization will include "hot spots" where the user is able to zoom and pan at a specific location. The scope might also describe whether users should be able to accelerate or decelerate the visualization.

- **Data Already Available**. Include a list of the data already on hand. A project manager could inventory and report whether the following data, for example, are available to the entity developing the visualization: auto-turn data; high-resolution ground photography; 3-D topography; road geometry and schematics; striping plans; planometrics; aerial data; grading plan; any state specific design standards; traffic counts; current site plan; digital terrain map; CAD files of the existing and proposed structures; information on landscaping.

- **Environment Required**. Include a discussion of whether specialized computer hardware or software programs will be required to view the visualization. It might also include the environment or medium (i.e., computer, hardcopy, or physical model) that the visualization is ultimately to be displayed in. For visualizations to be displayed in a computer environment, describe whether the project manager is requesting the visualization be navigable in a web-based environment, a laptop environment, both, or some other environment. A deliverable could be information on minimum hardware and software requirements. Another specification could be to require the visualization developer to provide installation packages for a variety of computing environments (e.g., Windows XP, Mac OS X, Linux, etc.). Alternatively, web-based dissemination where the visualization runs through a web browser would eliminate the need to download and install the visualization.

- **Technical Support Required**. Include a description of whether ongoing technical support will be required once the visualization has been produced and approved. Example technical support activities include running or demonstrating the visualization on a computer or troubleshooting problems with playback. Consider including language that allows for the preparation for and testifying in court hearings as an expert witness to attest to the accuracy of a visualization and the methods used to create it. An organized training program that transfers knowledge about using the visualization to practitioners in the field would also be helpful. A multifaceted education, outreach, and training program can be an important component to effectively using visualization for ROW acquisition.

- **Revisions Required**. Include indication of how many draft versions of the visualization are necessary. Some common points of review are at 50 percent and 90 percent completion. Indicate whether the visualization should be editable to accommodate for the following at a future date: changes to the structures as future phases are constructed or modifications occur at the visualized site; the ability for a production house to incorporate background music, narratives, and other media throughout the visualization. A deliverable could be an intermediate, draft visualization(s), including an agreement on the number of revisions to be provided.

- **Ability to Accommodate "Add-ons."** Include a description of whether the visualization should be developed with the ability to be integrated with other components or services in the future. For example, the scope might describe whether the visualization could be made viewable in a real-time Google Earth or whether project timeline animations could be added. A project timeline animation might identify project phases or funding expended as the user travels in the virtual tour.

- **Method of Visualization Delivery**. For advanced visualizations, include requirements for how the visualization will be delivered. Some example formats are physical model, hardcopy print out, visualization

in a zip file, visualization on a CD-ROM or DVD, or visualization on a website. Request that documentation of the visualization development methodology be delivered.

Appendix G. Caltrans GIS Marketing Documents

The following could be used as a model for a marketing document for visualization services.

Implementing an Information Management System in Right-of-Way Offices An Overview for Executives

Increasing responsiveness and maximizing resources are important factors in how transportation agencies improve their business in today's data-driven, performance-based environment. The ability to deliver projects on time and within budget is one measure of a transportation agency's performance. The effective delivery of real property by the right-of-way office is fundamental to achieving this agency objective. A well designed and implemented information management system can substantially improve this capability. Adding geospatial capabilities (GIS) to the system to replace reliance on hardcopy maps and tabular information and to give additional management and analysis functions can significantly increase its usefulness.

Understanding the critical factors necessary to successfully implement an information management system can ensure the best value for the necessary outlay in resources and can substantially improve the realization of the system's full potential. Obtaining strategic buy-in from agency executive-level decision makers to pursue implementation will provide the necessary foundation for system.

Implementing a System

The process to implement an information management system is well documented and follows standard procedures:

- Formalize support
- Assess requirements
- Assess capabilities
- Define the system
- Develop an implementation plan
- Implement the system
- Maintain the system

Implementation is typically considered complete at the point when the system being implemented has transitioned to "business as usual" for its users.

Implementation Responsibilities

- ***Project champion:*** This person is typically known and trusted by agency management and is responsible for marketing and promoting the system both inside and outside the agency.

  Without an identified champion, history has shown that projects flounder at the first major challenge.
- ***Steering group:*** The steering group is responsible for ensuring that there is active and appropriate input and feedback to the system during the implementation process.

  Transportation agencies consist of multiple departments and offices responsible for different aspects of doing business. Without representation from each group that will be impacted by the system, the system will face numerous challenges including: a) meeting agency information technology (IT) requirements, b) obtaining buy-in from stakeholders, and c) coordinating data sharing between data owners and users, as well as performing the tasks necessary to support right-of-way activities.
- ***Project manager:*** The project manager is responsible for the day-to-day management of the process.

This person must have the necessary skills, authority and resources to coordinate sometimes conflicting input from the groups and individuals involved in the process. The project manager must also have the organizational skills to ensure that the process stays on track and within design boundaries and sufficient technical understanding of the right-of-way process and individual functions to reasonably evaluate input during the development process.

- ***Development team:*** The development team consists of the people who will actually be developing the system.

  They can be wholly from within the agency or wholly contracted from outside or a combination of both. The importance, at the proposal stage, is that the skills necessary to the project be clearly identified and articulated.

Implementation Factors

- ***Assessing requirements***: Any proposal for a new information system should include a clearly stated understanding of the scope and goals of that system. As these requirements are refined, consideration should include the business areas to be included (often referred to as the *enterprise*), the functions that should be performed, the data needed to support these functions, other systems that should interact with the proposed system, security issues, and any legal and regulatory requirements.

- ***Assessing capabilities***: An understanding of the capabilities in the right-of-way office and across the agency is critical to successfully implementing a system. Considerations include available or required hardware and software, existing applications including database management systems and GIS, datasets along with who is responsible for them, and agency policies and procedures related to IT including application development, data and data standards, and hardware and software acquisition. Knowing who will be responsible for maintaining the system and any corresponding data and output is also necessary. Availability of funding for development and continued maintenance is critical to the project's success.

- ***Defining the system***: This is the core of the system and will be the basis for the tool that manages the information associated with right-of-way offices. The technical considerations will be included in the detailed implementation plan. An important aspect of this definition is knowing the starting point for system development. Three common starting points include:
  - The system is being developed from scratch with no existing information management system or GIS.
  - The system is expanding on an existing information management system to include GIS.
  - The system is being developed to take advantage of existing GIS capabilities.

  Knowing this information will ensure that appropriate coordination is considered in the design.

Additional Considerations

The current evolution and expansion of technology is extremely rapid and most transportation agency policies and procedures are not designed to operate at the same rate of change. Innovative and flexible approaches to supporting improved information management tools could save money and time both in their implementation and use.

From concept to operation, a comprehensive information management system can take 12 to 24 months or longer, and, during that time, technology will become more powerful, faster, and more flexible at the same time that the general public will become more technologically sophisticated with fingertip access to information through smart phones and other similar devices. A flexible design can readily take advantage of this changing technology without requiring major modifications. However, waiting for the next

advancement before initiating the process can, and often does, result in never starting.

Many transportation agencies are in the process of either designing or building an agency-wide infrastructure for sharing data and/or integrating computer systems. Although, the desire to fold individual systems into this larger initiative is compelling, the reality may be more problematic given the scale, complexity, and cost of the larger effort. With current technologies, consideration should be given to supporting individual systems if they provide the necessary connections to and support for integrating with the larger initiative.

For More Information

This document is part of the National Cooperative Highway Research Project 8-55A "Developing a Logical Model for a Geo-Spatial Right-of-Way Land Management System". The project was managed by Ed Harrigan EHARRIGA@nas.edu and was performed under Kathleen Hancock hancockk@vt.edu at Virginia Tech and was completed in 12/10. A detailed implementation guide was developed as part of this project and will be available through TRB.

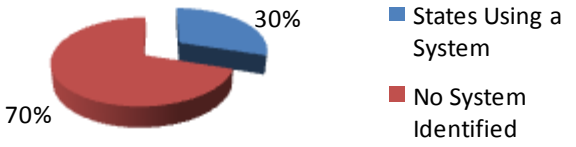
Results of the first phase, 8-55 "Integrating Geo-Spatial Technologies into the ROW Data-Management Process", including the documented savings reported here, are available at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_310.pdf and www.trb.org/news/blurb_detail.asp?id=7308

Improving Resource Management and Operations in Right of Way Offices with Right-of-Way Information Management Systems

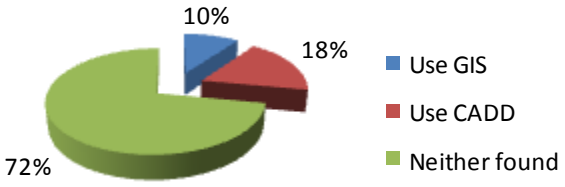
A well designed and implemented information management system can substantially improve management of resources – **personnel**, **money**, **information**, and **time** – which is critically important to successfully meeting state performance goals and budgets. Adding geospatial capabilities (GIS) to the system to replace hardcopy maps and tabular information and to give additional management and analysis functions can significantly increase its usefulness.

In the Right-of-Way office, this is particularly important because of the resources required to deliver real property for transportation improvements and manage state-owned land.

State Use of ROW Information Management Systems



State ROW Office Use of GIS/CADD



BENEFITS

- **Improved on-time delivery of project real property**
- **Expedited project award**
- **Reduced staffing and/or improved staff efficiency**
- **Improved scheduling**
- **Improved access to information both internally and by the public**
- **Improved customer service and public relations**
- **Improved documentation and reporting uniformity**
- **Reduced time to perform tasks**
- **Reduced redundancy, primarily in data entry**
- **Increased management flexibility**
- **Improved oversight capabilities**
- **Improved integration, use, and sharing of information**

DOCUMENTED SAVINGS

- ***A return on investment of more than 21%***

Pennsylvania invested $829,000 on a ROW information system that ***reduced annual operating*** costs by nearly $680,000 while providing ***greater convenience*** to users. Because the system integrates with their financial system, the time to process payments ***reduced from several days to several minutes.***

- ***Staffing reductions and improved on-time performance***

  In Virginia, the ROW information system provides over 500 staff and contractors all information on ROW projects, providing ***exceptional customer service***. Information is entered only once, ***eliminating duplication of effort***. ***Clear project tracking*** provides staff with a comprehensive understanding of the status of each project including resource allocation.

  In Maryland, ***research staff has been reduced by half*** because parcel and other geospatial information are available through the intranet. ***In-person courthouse research and travel time have been eliminated***.

  New Mexico uses GIS to generate summaries on excess property for sale to the public, ***reducing the time required*** to provide this information from several hours to several minutes. The information includes a map with an aerial photograph image background resulting in dramatically **reduced questions from the public**.

  Using GIS, the San Antonio district of Texas provides its staff with electronic access to project drawings, thus **eliminating the manual locating and reviewing of large drawing sets**. Drawings are accessed by simply clicking on a desired section of road.

- ***One-person project oversight and management of real estate activities***

  In Illinois, a multi-million dollar airport project is managed by a single person who has desktop **access to near real-time information** about the project.

RISKS OF NOT IMPLEMENTING A SYSTEM

A primary purpose of this type of information management system is to facilitate standard business operations and support information and decision making by providing easy access to both internal and external information relevant to meeting the goals and operational needs of the transportation agency and the real estate office.

Without such a system, decision makers are limited in their ability to monitor performance and identify opportunities quickly and make strategic adjustments to resource allocation as needed. The real estate office will be limited in its ability to respond to the rapidly increasing reliance on digital information exchange to perform its functions.

Expectations in the current technological environment are for faster, more accurate information with fingertip access to on-line maps. Without a geospatially enabled system, these expectations cannot be met for staff or the public.

FOR MORE INFORMATION

This document is part of the National Cooperative Highway Research Project 8-55A “Developing a Logical Model for a Geo-Spatial Right-of-Way Land Management System”. The project is managed by Ed Harrigan EHARRIGA@nas.edu and is being performed under Kathleen Hancock hancockk@vt.edu at Virginia Tech and is scheduled to be completed in 2/10 *[sic; The research is now complete]*.

Results of the first phase, 8-55 "Integrating Geo-Spatial Technologies into the ROW Data-Management Process", including the documented savings reported here, are available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_310.pdf and www.trb.org/news/blurb_detail.asp?id=7308