Innovations Deserving
Exploratory Analysis Programs

*Transit IDEA Program*

# COMMUNITY VISUALIZATION OF A LIGHT RAIL TRANSIT ORIENTED DEVELOPMENT

Final Report for Transit IDEA Project 33

Prepared by:
Dr. Ted Grossardt and Dr. Keiron Bailey
University of Kentucky Transportation Center
Lexington, Kentucky

*April 2004*

TRANSPORTATION RESEARCH BOARD
*OF THE NATIONAL ACADEMIES*

# Innovations Deserving Exploratory Analysis (IDEA) Programs Managed by the Transportation Research Board

This Transit IDEA project was funded by the Transit IDEA Program, which fosters development and testing of innovative concepts and methods for advancing transit practice. The Transit IDEA Program is funded by the Federal Transit Administration (FTA) as part of the Transit Cooperative Research Program (TCRP), a cooperative effort of the FTA, the Transportation Research Board (TRB) and the Transit Development Corporation, a nonprofit educational and research organization of the American Public Transportation Association (APTA).

The Transit IDEA Program is one of four IDEA programs managed by TRB. The other IDEA programs are listed below.

- NCHRP Highway IDEA Program, which focuses on advances in the design, construction, safety, and maintenance of highway systems, is part of the National Cooperative Highway Research Program.
- High-Speed Rail IDEA Program, which focuses on innovative methods and technology in support of the Federal Railroad Administration's (FRA) next-generation high-speed rail technology development program.
- Safety IDEA Program, which focuses on innovative approaches for improving railroad safety and intercity bus and truck safety. The Safety IDEA program is funded by the Federal Motor Carrier Safety Administration and the FRA.

Management of the four IDEA programs is coordinated to promote the development and testing of innovative concepts, methods, and technologies.

For information on the IDEA programs, look on the Internet at www.trb.org/idea or contact the IDEA programs office by telephone at (202) 334-3310 or by fax at (202) 334-3471.

IDEA Programs
Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001

# COMMUNITY VISUALIZATION OF A LIGHT RAIL TRANSIT ORIENTED DEVELOPMENT

**Final Report**

**Transit IDEA Project Transit-33**

**Prepared for**

**Transit IDEA Program**

**Transportation Research Board**

**National Research Council**

**Prepared by**

**Dr. Ted Grossardt and Dr. Keiron Bailey**

**Policy and Systems Analysis Team**

**University of Kentucky Transportation Center**

**Lexington, Kentucky**

**April 2004**

**ACKNOWLEDGEMENTS**

The research team would like to thank our partners at the Transit Authority of River City (TARC) for their bold decision to take this new method to the citizens of local neighborhoods and to their partners in this project. We also thank the Urban Design Studio professionals including Professor Michaele Pride-Wells and the architecture students who participated in the UDS during the spring 2002 semester for their contributions and assistance.

Our research project benefited from the guidance of the Program Officer, Mr. Harvey Berlin, of the Transportation Research Board. Both this report and subsequent journal manuscripts have benefited from the incisive and helpful comments of Professor Carl Steinitz of the Department of Landscape Architecture, Graduate School of Design, Harvard University.

This research financed by the Transit IDEA Program of the Transportation Research Board. The Transit IDEA Program is funded by the Federal Transit Administration as part of the Transit Cooperative Research Program.

**TABLE OF CONTENTS**

## EXECUTIVE SUMMARY

### IDEA Concept and Product

This project was aimed at enhancing community involvement in the design of proposed light rail transit-oriented development. A combination of an advanced decision technique and virtual reality computer visualization were tested. This process is designed to enhance public input and cooperation in the planning process, and to provide recommendations for transit agencies, planners, and architects. The process was tested in Louisville, Kentucky, in cooperation with the local transit agency, Transit Authority of River City (TARC).

### Planned Investigation

The research team has devised a novel visual assessment methodology termed Casewise Visual Evaluation (CAVE). The process uses a fuzzy set theory-based modeling system. When there are many design parameters, the CAVE process translates community preference for complete designs into preference for each of the elements in that design. There are many design elements in each scenario, such as building type, open space type, height, density and so on. Once the significant design elements were identified and a highly preferred combination was determined using CAVE, virtual reality visualization was used to display design options and assess community reaction to them.

### Project Results

A Structured Public Involvement protocol was used to gather community input. An iterative series of focus group meetings were organized in partnership with the local metropolitan transit authority, the Transit Authority of River City (TARC). Community feedback on the desired features of the development was gathered and the forthcoming CAVE process was explained.

An electronic scoring system was then used to assess preference for transit oriented developments (TODs) in other cities, using photographs. This allowed for fair, free and anonymous evaluation by the community, using a 1 to 10 point preference scale. The community's response to these existing pictures was then used as input to CAVE. To code the photos in terms of inputs useful to professionals, architectural experts were consulted and a design vocabulary was defined. The architects described the TOD images in useful and familiar terms. Using these as input parameters, with public preference as the output, the modeling process was started and a knowledge base was built. This modeled how community preference responded to varying height; density; typology; and open space type.

The information was used by the design team to determine which combinations of elements were preferred by the residents. In collaboration with architectural experts the output of the knowledge base provided guidance for final design types. These designs have been modeled as scenarios in the virtual reality visualization model.

The CAVE methodology has been demonstrated and provided clear design guidance for experts. Moreover, feedback from community participants has been positive. Comments included an expressed appreciation of the power devolved to the focus group in terms of determining which aspects were preferred. Residents have also commented on the importance of increasing participation at the focus group meetings so that more of their neighbors can participate in the design process. This desire to involve others is a positive indicator.

## CONCEPT AND PRODUCT

This project was aimed at enhancing public involvement in the design of a proposed light-rail transit-oriented development (TOD). It was tested and demonstrated in Louisville, KY. A combination of an advanced decision theoretic technique and virtual reality computer visualization was tested in terms of its capacity to provide recommendations for architects, planners; and its potentials for enhancing public input, interest and cooperation in the planning process.

This project produced a highly effective public involvement design methodology termed Casewise Visual Evaluation (CAVE). CAVE uses a fuzzy set theory-based modeling engine that has demonstrated a capacity for modeling complex non-linear systems accurately and efficiently. This allows professionals to design highly efficient methods for gathering complex preference information from the public, for use in creating TOD designs that meet both public desires and performance needs of the transportation system. The output of the system can be formalized and made transferable to other professionals later in the design process, so that public preferences become part of the 'permanent' design criteria for future steps in a complex infrastructure design process.

## INNOVATION

The CAVE methodology supplies professionals with the capability of querying large groups of disparate participants regarding questions of design, and to capture that information unambiguously and permanently. That information can then be queried repeatedly and in many ways by professionals as needed. It allows for the use of a variety of visualization tools ranging from photographs to physical models to virtual reality computer models, as aptly demonstrated by this project. Thus other cities weighing the possibility of new TOD design could profitably use this methodology to gather public preferences regarding the general characteristics of the design, without compromising the professionals' domain of design, be that architecture, planning, or engineering.

At the same time, public satisfaction with the ultimate designs is more likely, given that their input has been gathered and documented clearly and quickly, and professionals can clearly show how their plans and designs relate to the preferences expressed by the public.

## INVESTIGATION

### Project Background and Description

The Transit Authority of River City (TARC) is in the preliminary engineering phases of developing a light-rail transit system running from downtown Louisville, Kentucky to the city's southern suburbs, a distance of approximately 15 miles. In collaboration with the research team, TARC wished to test an innovative methodology for improving community participation in the design of a light rail transit-oriented development for the Smoketown/Shelby Park area. The Smoketown/Shelby Park neighborhood is a low-income area located to the south of the University of Louisville Medical Center. A suitable site for the station has been identified by TARC and its design partners, but no development has taken place yet. TARC has been conducting extensive outreach in this neighborhood over a span of several years and as a result the community is aware of the nature of the transit project, its purposes and benefits and has participated in the shaping of the route. Given this context the primary purpose of the research was to assist community participants identify preferred design criteria for their local transit oriented area, defined as this particular transit station and a two-block radius around it.

This report sets forth the principles of a novel visual assessment methodology termed Casewise Visual Evaluation (CAVE), describes its application to this problem and summarizes the results obtained during the IDEA funded research program. In brief, CAVE is a visual assessment methodology designed to allow rapid and accurate gauging of preferences for design elements in composite scenarios.

**Timeline of Process**

The community design process was divided into two Stages.

- TABLE 1 Transit -33 Project Stages andTasks

| **Transit -33 Project Stages and Tasks** |
|---|
| Stage I |
| Introductory focus group meeting<br>Analysis of results and design of scoring meetings<br>Focus group meetings (scoring)<br>Analysis using CAVE method<br>Focus group meeting (results and architectural model build)<br>Stage I review |
| Stage II |
| Generation of preferred VR models<br>Focus group meeting (evaluation of VR models)<br>Analysis using CAVE method and generation of final report |

Stage I involved introducing community participants to the methodology and soliciting feedback on desirable criteria. Stock images of specific transit developments were selected and scored by community participants. This information was used as modeling input. The PSA team applied their Casewise Visual Evaluation methodology (CAVE) to build a knowledge base that allows planners and designers to quantify community preferences for specific design elements. Stage II consisted of the building and evaluation of the VR models of preferred design options.

This report describes the objectives, the methods, applications and findings of the Transit-33 project. Project results have been made available to TARC to use in final design and engineering phases: however, the PSA team has no direct involvement in the construction of the transit-oriented development. This is a very large-scale civil infrastructure project with an extended timeline and it is probable that the construction phase is still between three and five years ahead.

**Process Organization – Stage I**

Three sets of meetings were held. Each set of meetings provided information that was used to develop the agenda for the next meeting. Throughout this process, PSA adhered to a set of operating principles regarding the conduct and goals of public involvement. Those operating principles are to design public involvement processes so that:

Participants Provide Meaningful Input
Participants Have Active Participation
Process Shows Respect for Participants' Lives
Process Honors Participants' Ideas
Designers Get Information That Makes Sense To Them
Participants Can Recognize How Information is Being Used

Stage I was designed to introduce the PSA team to the community focus group, to explain the methodology, to dry run the electronic voting system so that further meetings could be held as efficiently as possible and to focus the assessment questions. Additionally, critical issues impacting choice of transit development images were to be solicited, so that the team could select a sensible range of images to show. Next, stock images of transit-oriented developments were selected from a wide range of sources. They came from projects all over the country and internationally, and showed a wide range of potential designs for the transit-oriented Development.

*Stage I*

On January 23 rd 2002 a focus group meeting was held from 5.30-7.30pm at the Mt.Olive Baptist Church in Smoketown, Louisville. The idea was to discuss some issues of neighborhood concern with the potential Smoketown-Shelby Park transit station and to examine some visual images of transit developments. TARC officials mediated the focus group. The following groups attended:

Smoketown residents
Shelby Park resident
Louisville residents from other neighborhoods
TARC officials
Urban Design Studio representatives
Kentucky Transportation Center Representatives

We asked participants about two different issues.

What are the big issues with the proposed transit station, both positive and negative ones?
How much do residents like images of certain transit developments?

These were generated by means of a brainstorming session and input into the electronic polling system. Polling for importance was then conducted using a rating scale of 1 to 10 points. The questions were shown on one computer projector and the images were shown on the other. During the scoring phase of the meeting, real time scoring feedback was then displayed on the first screen while the image being scored was displayed on the second. As the PSA team has discovered in the past, the participants are very interested in seeing their preferences displayed immediately (Illustration 1). Note that all of the issues scored significantly more than average importance because, by definition, these were issues raised by community members at the meeting as important issues. This does indicate the comparative gravity of these important issues, however. Figure 1 is a sample of the transit-oriented development images the participants were asked to consider. Due to differences in perception of photographs versus sketches and renderings, and the PSA team's desire to portray realistic options, only photographs of existing facilities were used in this preliminary evaluation. The team judged sketches and renderings so qualitatively variable that it would be unrealistic to expect participants to judge consistently across the visual types. This principle of presentation consistency was adhered to throughout Stage I.

- FIGURE 1 Sample of Transit-Oriented Development Images Shown to Participants

- ILLUSTRATION 1  Mt. Olive Baptist Church, Louisville, KY. January 23,2002

It became clear that the community group had some preferences regarding suitability for the neighborhood, and that these did not always align with their purely aesthetic preferences. Some commented that an image looked nice, but it wasn't suitable for their neighborhood.  For example, while the transit system itself might be judged appealing in a photo, the high buildings around it might not be considered suitable and therefore it was not regarded as a candidate for development in this locality.  The PSA team therefore decided to streamline the scoring process at future meetings by asking only one scoring question: what is the suitability of the transit development shown in this image for your neighborhood? Verbal comments were also solicited and were appended to each image using the electronic scoring system. These comments were collected at the end of the process. This had the added benefit of allowing the research team to investigate "one-dimensional" or "overlay" variables. These are elementary style or taste preferences that are specific to an area, but which clearly influence design preference strongly.

One example of this was the building material. Many participants stated that they preferred brick. Visual examples that did not feature brick materials were remarked upon during the discussion. Because the CAVE methodology measures the combined preferences for architectural design properties such as building height, density, and open space simultaneously, the building material preference can be incorporated later, no matter the architectural design. By collecting this information now and adding it to the preference knowledge base, however, it is possible to generate a better product since these preferences can be incorporated into the design configuration. Thus, in this example, any good design configuration for this neighborhood (as regards building heights, density, use of open space, etc.) can then be made more preferable to residents by using more brick and less concrete, wood, or steel in the construction.  The participants also commented on issues of visual perception, such as the time of day when the images were captured and the height and angle from which the development was viewed.  Not all of the images were consistent in these regards.

**Definition of the Design Vocabulary: Elements and Classes**

To set the agenda for the next set of focus group meetings, TARC asked that the PSA team meet with the Urban Design Studio (UDS). The UDS is a Louisville-based group headed by Michaele Pride-Wells, a University of Kentucky architecture professor. The reason for integrating an architectural design team into the process was that the PSA team are not qualified architects. As in any public infrastructure design problem, the input of the design professional is critical, and the mapping of public preferences is but one facet of the overall design problem.

The UDS team provided the expertise necessary to identify critical design elements and to classify these elements along linear scales. This step allows each image to be classified in terms of its design properties. It is essential in formatting input for the fuzzy knowledge base and ensuring that the knowledge base can do useful work in real world applications.

In cooperation with the UDS, design variables were identified that are employed by architects when modeling and designing buildings. Each variable has a potential range, encompassing several categories. For example, HEIGHT is considered an important design variable, and in the case of the images surveyed the team decided that HEIGHT was characterized by five classes: Low, Low-Medium, Medium, Medium-High and High. Each of the verbal categories was assigned a numerical equivalent. Low height was designated to be any structure less than 1.5 floors high, for example. Each of the other variables was similarly defined and classified and numerical ranges were specified for each class. This step is important because the knowledge base contains those design variables that can be considered to vary in a reasonably linear fashion from one extreme to another. For variables such as density and height that vary on a ratio scale, the scale arrangement is apparent. For variables such as building typology and parking, the scale arrangement is based on the expertise of the design professionals. Some care is required to ensure that these classifications can be read in such a way that useful output can be produced. Continuous variation from one extreme to another is implied, no matter how few or many classes are used. This is a strength of the approach, because singular ideal types are seldom seen in a design. More frequently, a design is a hybrid, 'in between' two ideal design types (private space will not likely be all balconies (B) or all yard (Y), but somewhere in between, for example). A fuzzy set model, such as CAVE employs, allows this 'indefinite' or fuzzy variable property to be captured and modeled. The complete set of these elements and their classifications was termed *the Design Vocabulary.* These discussions were led by Professor Pride-Wells, however, other UDS team members contributed. Table 2 displays the complete Design Vocabulary.

- TABLE 2 The Design Vocabulary

| Element | Categorical Variation → | | | | |
|---|---|---|---|---|---|
| Height | L | LM | M | MH | H |
| Typology | C | L | B | A | |
| Density | L | M | H | | |
| Open Space | S | P | C | | |
| Private Space | B | Y | | | |
| Parking | O | L | S | | |

Breakdown of Table 2 with named classes

HEIGHT: Low-rise, low-medium, mid-rise, medium-high, high-rise (L, LM, M, MH, H)
TYPOLOGY: Courtyard, linear, block, assembly of parts (C, L, B, A)
DENSITY: Low, medium, high (L, M, H)
OPEN SPACE: Sidewalk, public plaza, central courtyard (S, P, C)

PRIVATE SPACE: Balcony, yard (B, Y)
PARKING: On-street, lot, none (O, L, N)

**Evaluation of images**

The next step of public involvement consisted of two focus group meetings. One meeting was held on Feb 7th and preferences were gathered from a local residents' focus group using the *SharpeDecisions* system. Because the preference gathering process would need to occur at several meetings, we held a second meeting on Feb 13th to test the team's ability to replicate the preference scoring process. This meeting repeated the agenda of the February 7 th meeting. The replication was successful, gaining input from another part of the neighborhood and thus providing a broader preference base. As per design, data from the two meetings was aggregated into one database.

At each meeting two preference votes were solicited. First, a rapid reaction vote was called in which the participants were given no discussion time, and as soon as one vote concluded the next image was shown. This is similar to Nelessen's VPS method. However, the PSA team then showed the participants each image a second time and a facilitated discussion was held. In the interests of holding total meeting time to under two hours these discussions were kept relatively short, nevertheless, as the participants voiced their comments and discussed their feelings about the images, the beginnings of a consensus appeared. The result was a distinct divergence in scoring between votes in round one and two, with images being grouped into a more bimodal distribution in the second round. The images they liked, they liked more the second time around, and the less popular images tended to be liked even less. In almost all cases, image scoring moved further away from the 5-point mean signifying "OK" preference. The matrix shown in Table 3 describes the properties of the TOD images selected for evaluation at both the focus group meetings and displays the mean preference score.

- TABLE 3 Image Properties Matrix

| Image # | Height | Typology | Density | Open Space | Private Space | Parking | Mean Score* |
|---|---|---|---|---|---|---|---|
| 1 | LM | A | H | S,P | B,Y | O | 8.36 |
| 2 | M | B | M | S | B | O | 6.83 |
| 3 | MH | A | M | S | B | O | 2.90 |
| 4 | LM | C | H | P, C | B | N | 3.80 |
| 5 | M | C | H | C | B | N | 5.37 |
| 6 | L | C | L | S,C | Y | N | 4.85 |
| 7 | L | C | M | C | B, Y | L | 5.64 |
| 8 | L | A | M | S | B,Y | N | 4.84 |
| 9 | M | L | M | S | Y | O | 4.94 |
| 10 | M | C | M | S | N | N | 3.00 |
| 11 | LM | A | M | P | N | O | 6.30 |
| 12 | LM | A | H | S | N | O | 3.37 |
| 13 | M | L | M | S,P | B | O | 4.00 |
| 14 | M | L | H | S | B | O | 2.29 |
| 15 | L | B | M | S,P | N | L | 5.49 |

*Mean preference score was computed for residents only. Residents were defined as all respondents answering the Background question "Smoketown/Shelby Park", "Old Louisville" and "Other Louisville." For the first meeting, this totaled 10, and for the second meeting, this totaled 11. Other classes of respondent were ignored.

For scoring and computation purposes only the second vote was used. This was to allow for the discussion to clarify opinions and to permit the development of some shared meaning regarding design criteria. These second round votes were then aggregated and divided by the total number of residents (n) participating in both meetings to determine mean preference. For this phase, n=21.

For input into the fuzzy logic modeling software, mean preference was classified into categories. Mean preferences ranged from a minimum of 2.29 units for image #4 as presented, to 8.36 unit for image #1 as presented. While there is no *a priori* justification for setting specific ranges, it is better to take advantage of the software's capacity to discriminate between small changes in the input criteria by using the extreme values to set the minimum and maximum preferences. A moderately large number of preference categories was specified as given in Table 4.

- TABLE 4 Mean Preference Categories

| Category | Value (mean preference units) |
|---|---|
| Extremely low | Less than 3.00 |
| Very low | 3.00-3.70 |
| Somewhat low | 3.71-4.60 |
| OK | 4.61-5.39 |
| Somewhat high | 5.40-6.30 |
| High | 6.31-7.00 |
| Extremely high | Greater than 7.00 |

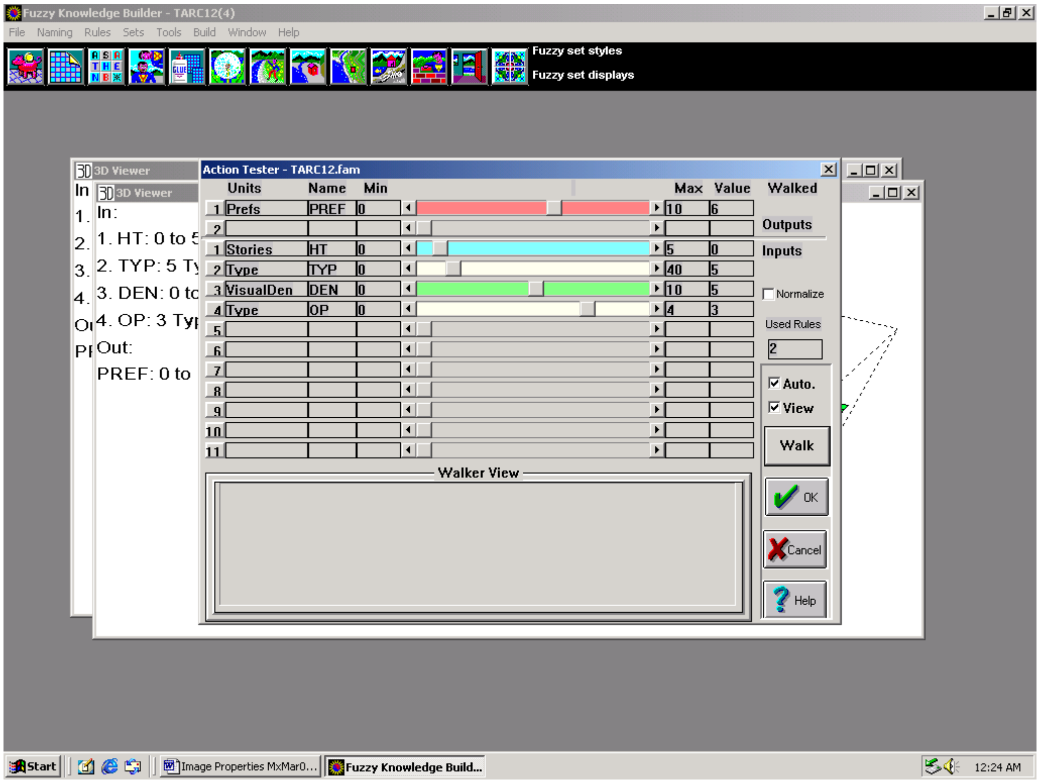
Note: all categories are arbitrary.

**Exploration of the basic model**

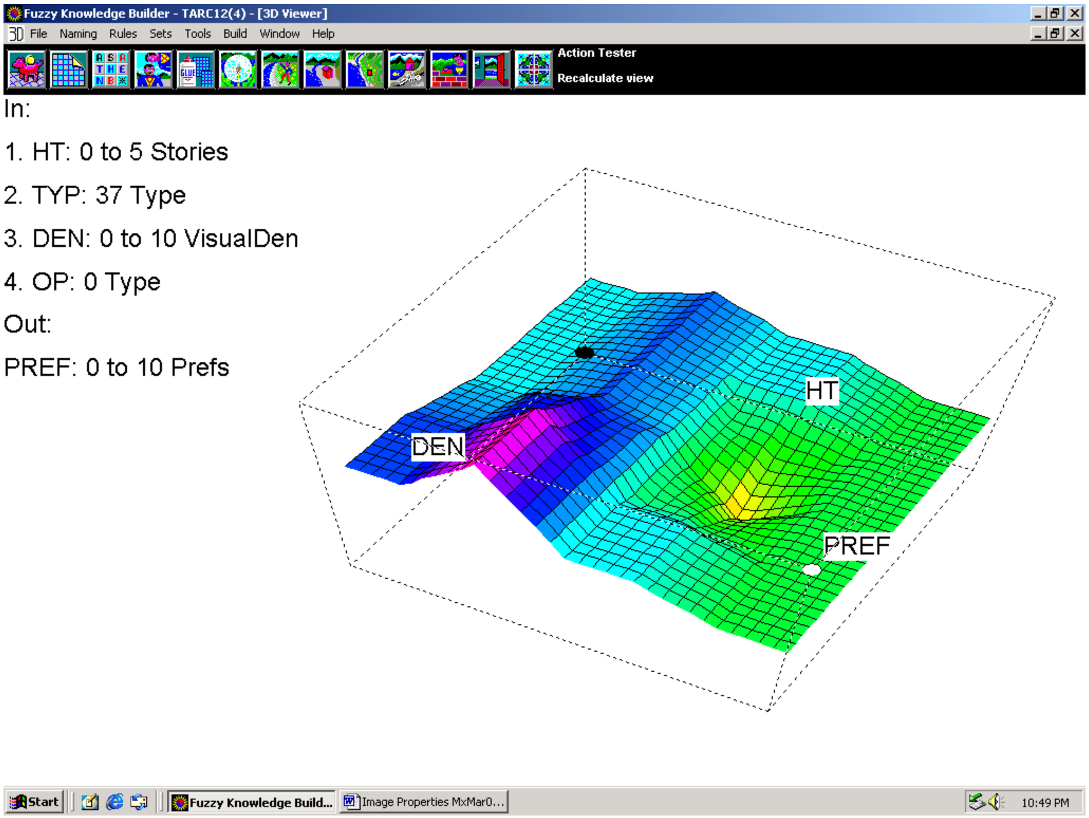
A four variable preference model was built and examined in detail using the FuzzyKnowledgeWalker (Figure 2) and the 3-D surface slice tools (Figures 3 and 4). The four variables used here are height; typology; density and open space. Five and six variable models were tested: however, even with the data-sparse modeling engine, there was inadequate data to generate a reliable surface with five or six variables copresent. Therefore, the UDS team was consulted and the four most important variables, in their estimation, were chosen and used as the input variables to build the fuzzy knowledge base. These four variables were those considered most helpful to designers for the purpose of generating 3-D design models.

This section presents some conclusions derived from visual inspection of the preference surfaces and use of the knowledge walker tool. The following figures show examples of various two-dimensional slices through this four-dimensional public preference knowledge base.

- FIGURE 2 Fuzzy Knowledge Walker used to analyze preference response



- FIGURE 3  Example slice through community preference knowledge base




*Variations with Height*

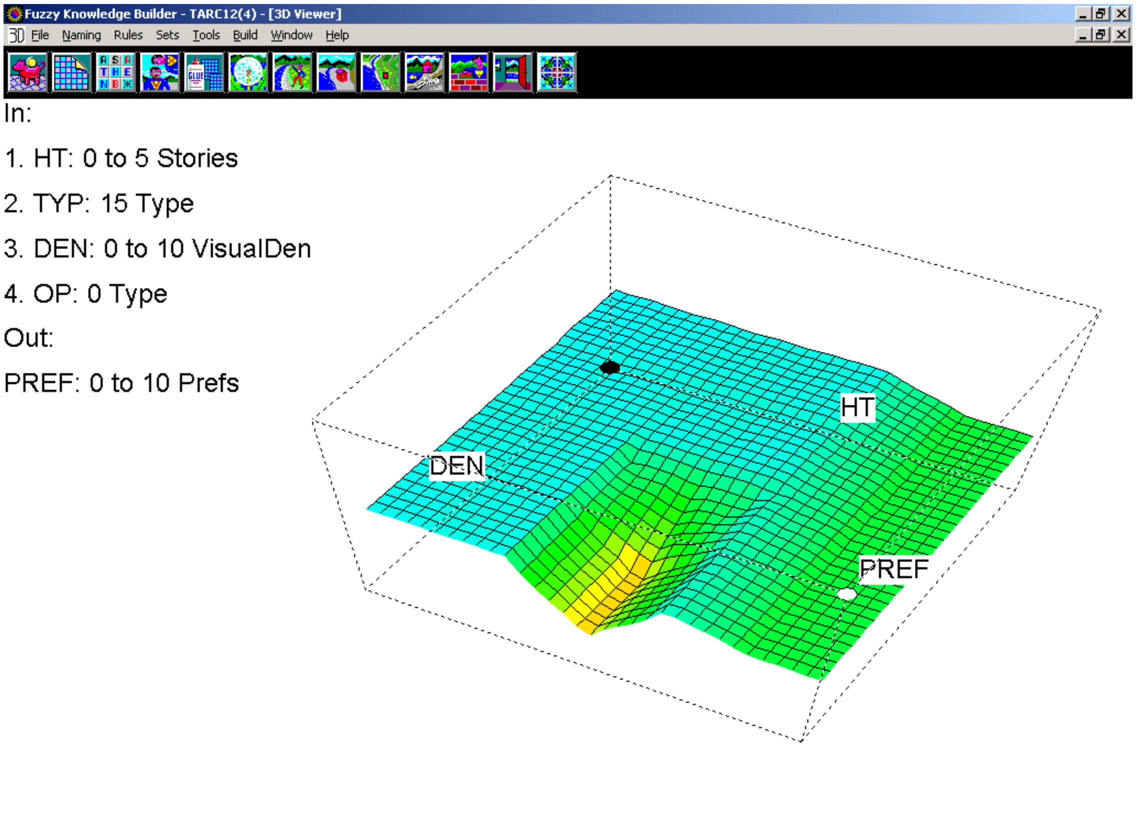
At low heights, typology is the dominant criterion controlling preference. However, very low heights are rarely preferred. A height between *low* and *medium* often shows highest preference. As height rises past medium, typology becomes relatively less significant and preference falls globally. This only applies while the open space and the typology criteria are held constant. At maximum height, changing any of the other three variables from minimum to maximum only alters preference somewhere between 3 and 5 units.

*Variations with Typology*

With the courtyard typology, generally, low density is preferred. With height and density both low or with height low and density high, changing the open space makes no difference. However, if height is low and density is medium, preference reacts strongly to the kind of open space provided. Preference doubles from three to six units open space transitions from sidewalk through plaza to courtyard.

With linear typology and low density, low heights are preferred. Preference falls slowly away from 5 to 3 units as height rises. With height set low, changing either the density or the open space makes no difference at all to preference: it remains at 5 units regardless. With low buildings, therefore, this typology is relatively insensitive to open space and density arrangements. However, preference is "OK." There may be better arrangements, but this arrangement can accommodate different space characteristics without outraging the public. But if height is set at medium, with Plaza-type open space, a very different picture emerges. Preference responds negatively to increasing density. At medium density, a preference "sinkhole" is encountered. Figure 3 shows this sinkhole. However, with increasing density, preference recovers. This should be a "no-go" design zone.

- FIGURE 4  Example slice through community preference knowledge base




Changing the type of open space changes the preference function significantly.  With input conditions the same as Figure 3, except for changing the type of open space to open courtyard, a flat preference function appears.

Linear typology.  With linear typology, and low height, increasing the density slightly increases preference from 4 units to 5.  Changing open space makes no difference under these conditions.  At medium height, there is only a limited response to both open space and density.  If height is high, preference remains very low at 3 units and shows no response to either open space or density.

With an assembly typology, under some circumstances there is great variation in response to the other variables (see Figure 4).  Changing density from medium to high, and changing open space type from plaza to courtyard drops preference rapidly from as high as 8 units down to 3 units.  This typology exhibits the most complex preference response function, suggesting that the design team must analyze and test such combinations with care.  The response function for this typology can be contrasted with the much less complex courtyard typology response function.

It should be noted that the figures presented in this report are only a very small sample of the possible graphical outputs that could be generated.  Every time a "hidden" variable is changed, the surface must be recomputed and redisplayed.  Additionally, visual inspection takes some time and is best performed with coalition partners present so that the implications of design strategies are clearly and immediately understood.  Keeping the professional partners involved at all times ensures that everyone can clearly understand the import of the knowledge base.

Another problem worthy of note is that the principles of the logical functions of the preference modeling engine are rather challenging to explain to the participants and for coalition partners.  This is particularly true for people who do not have technical education and professional experience.  The team discovered in several public forums that inspection of the visual output surfaces is the most effective means of conveying how the method works and what it can do. Excessive abstract discussion about its properties can cause confusion and act as a barrier to adoption. No skepticism was evident from those who had been "walked through" the performance of the software and had seen how design alternatives could be evaluated using the public preference knowledge base. This was clear not only from the comments of the neighborhood participants and transit partners, but also from attendees at forums such as the Community Design Symposium and the Transportation Research Board's Annual Meeting where the team presented the methodology.

**Discussion**

The preference function may have been influenced by differences in perceived visual quality between pictures (Hughes 1998). Nevertheless, useful qualitative data analysis can be performed even in this restricted case. Preference inconsistencies can be isolated and targeted for further investigation. Further integration of the preference function into a decision support system for planners and designers can be achieved by complementing this information with engineering costings for design alternatives. Steep gradients in the plot represent sensitive tradeoff zones and signal design combination changes that should be carefully assessed. The software allows users to extract marginal cost vs preference functions so that trade-offs can be better understood. An analysis of these gradients thus enables an optimal design strategy to be defined in terms of changes in the two variables under consideration.[1]

First, the knowledge base was used by the design team to build some preliminary wood form models of potential developments showing gross characteristics such as massing, height and density. These were shown to participants at a following focus group meeting and feedback was gathered. Distilled feedback from CAVE was also presented in verbal form (as above) and public comment was solicited. A written report that described the process and the scoring from earlier Stages was made available to all participants. A final set of three different virtual reality visualizations was generated based on this interrogation of the community preference knowledge base. The architectural experts used both the overlay variables obtained from the public involvement process and the community preference knowledge base to design these visualization options.

[1] In this project no designs were funded for build. This was explained to the participants at the first focus group meeting. Since no costings were made available, this capacity of the methodology remains theoretical.

- FIGURE 5 Preferred composite TOD as shown to community using VR visualization


The final community meeting was held at Meyzeek Middle School at Smoketown/Shelby Park on November 15th between 5.30 and 7.30pm. 15 respondents attended. The three final VR vizualizations were displayed and, as previously, scored using the *SharpeDecisions®* electronic system.

The response to these visual models was striking. The team had been concerned about the overall qualitative ‘feel’ of the models and whether participants would be distracted by the differences between ‘real’ photographs and simulated landscapes such as the one we had prepared. Instead, respondents ignored such differences and immediately went to the design issues they were interested in. In short, the ‘reality’ question was never a question, and the VR scenarios served as a launching pad for participants to begin suggesting minor qualitative changes such as building surface treatments, types of commercial establishments ( eg. art store vs. video store), and landscape treatments (grass vs. trees vs. shrubs) etc. The architectural team added suggestions as well that were specific to the building designs they had originated. As rendered, the architects detected differences between their intent and the final products, even though the buildings all met the technical requirements for shape, height, housing density, and arrangement. In this vein, it highlighted the extent to which it is actually very unlikely that public input into such a complex problem constitutes a significant restriction on the designers’ remit. Our experience was quite the contrary: the primary challenge was in gathering and typifying public input so as to pragmatically limit the number of possible designs to a manageable number, both for professionals and the public. The overall design problem is sufficiently large to allow much latitude both to the preferences of the public and the responsibilities and creativity of the professional.

The final three scenarios were viewed, reviewed, and scored by the public, and, even though the attendees included those from the original meeting and first time attendees, the relative rank of the three scenarios was consistent with the original public input. That is, for example, the scenario that included the least-preferred combinations of design properties was the lowest-scored, and so on. This result confirms the team’s approach and may suggest research into a labor-saving strategy: it may be that the use of the CAVE methodology accurately captures public preferences for a design problem, so that professionals can then proceed with confidence in their design phase without needing to use expensive VR modeling to confirm their design. This is a significant possibility, since it may go a great distance toward making the process of public involvement more attainable, and does not require nearly so many resources as the more complicated visualization processes.

**Observations on the final community meeting**

Some of the participants had attended several of the previous meetings. They were familiar with the protocols and the history of the VR scenarios being shown. However, the first-time attendees made several comments. One male in his 40s observed that he saw how the method gave him real input. He asked why this process wasn't more generally used in planning and design, and why more people weren't attending to give input on the future of their community ("Where are all my neighbors?"). Although this indicated again that the SPI approach was achieving its goals of devolving design authority, and being seen by participants to do so, it raised the issues of participation and representation.

Another issue was the relatively long time gap between public meetings for the project. Since limited public engagement was conducted regarding the design problem between April and November of 2002, at the final meeting the process was not as fresh in people's minds as it might have been. This overall period (February to November) was somewhat lengthy because of the necessary modeling feedback step added by the research team in April. After that step, it was correctly anticipated that considerable time would be required to build VR models that responded to the preferences gauged in the initial meeting round. A number of technical challenges at the VR modeling stage were encountered with regard to importing necessary image and 3D model formats to create the desired building characteristics. These kind of delays are inevitable when using relatively new software and stretching the design envelope.[2]

The Transit-IDEA Program Officer conferred with the Board and the team presented three sample VR scenarios at a Transit-IDEA Committee meeting in Washington, DC, in December 2002. Several improvements to the VR were suggested by the committee and subsequently implemented by the research team. These included; a more realistic turning motion for the light rail transit vehicle; a more lifelike appearance for the vehicle's frontage and windshield. The team was able to produce a more realistic transit vehicle by working further with the VR software. With these improvements, the Transit-33 project was concluded.

**Public reaction to the participatory design process using CAVE**

After Stage I of the project, neighborhood panelists were invited to participate in an expert review panel (Grossardt and Bailey 2002).

- TABLE 5 Neighborhood Panelist Comments on the project

1. Need a glossary of terms to allow residents to more quickly understand and join the discussion.
2. The presence of professionals at the meetings sometimes had an intimidating effect on local participants. Local participants weren't sure whether professionals' scoring results were being included with theirs.
3. Every effort should be made to increase attendance and exposure of the overall project.
4. In the spirit of honoring people's time, future projects of this sort might consider paying a nominal amount to participants for their time at meetings.
5. Recognition of the value of the process for efficient use of participant's time.
6. Observation that they had never seen this level of public involvement before in a similar project.

[2] With the experience gained in this project, such modeling time delays have been reduced by over 50%, at least for the types of buildings that were modeled in this project.

Points 1, 2 and 3 highlight the necessity to explain all aspects of the process and render it as transparently as possible to all participants regardless of their backgrounds. Point 4, the desirability of paying participants, was debated by the design team before starting the project and it was decided to attempt to gather respondents without paying them. This decision was reached in the interests of equity: because other participants, in this same area on previous occasions and in other metropolitan areas, were not being paid for their time, it was felt that these participants would be unfairly privileged compared with those participating in different processes in other areas of the city. Another viewpoint was that it was not reasonable to pay participants in this public involvement process because it would establish a burden of expectation for all future projects.

However, points 5 and 6 are especially important in the context of improving public involvement. It appears that this methodology has considerable potential, when applied in the right context to do more than aid design choices: used suitably, it might improve confidence in public outreach generally.

It appears strange to the research team that much of the literature on participatory planning and dialogic community involvement fails to stress the necessity to manage the time and/or access demands of public involvement processes. We propose that this should be recognized as a principle of public involvement. This is not to say that public involvement time should be rationed to be as short as possible; rather that it should be kept as short as necessary. It is easy for researchers and/or professionals who work full-time on these projects to propose that community dialog can be enhanced by increasing the number of meetings, and/or the time budget for each meeting. However, none of the citizens' comments point to this conclusion. On the contrary, point 5 shows that "efficient use of participants' time" should be taken into account explicitly. It behoves professionals to show participants that they have given the matter some thought, and that by keeping their demands to a minimum while obtaining appreciable results. We believe that the success of this method in part accounts for point 3, a desire to "increase attendance" at meetings and to "increase the exposure" of the project. This suggests that the participants recognize that the CAVE process is in some meaningful way capturing their opinions and that they want more of their neighbors to be involved in defining this aspect of their community's future.

There are many possible approaches to meaningful public involvement in planning/design problems such as this. The process described here has maximum utility when it is difficult, expensive or otherwise challenging to arrange highly intensive public involvement activities that demand a large time input from the participants. This information has been generated from a very efficient and low-impact participation protocol. The low demands of the protocol, its rapid and simple assessment criteria using electronic voting, and its highly mobile form, permitted a number of local forums to be held in convenient locations with small numbers of participants. It also allowed for a rapid response to changing circumstances. Such flexibility greatly enhances the perceived utility of visual analytic method.

Assuring adequate participation in low-income communities is always a problematic issue (Webb and Rhodes 2002). Even during these first stages, the research team discovered that without the involvement of a proactive and community-engaged transit authority, TARC in this case, such a project would founder. Community participants are suspicious of "experts" coming from the outside and presenting ideas. The existence of the community group allowed TARC to request their cooperation in this process, and this familiarity ensured adequate community participation even over a short time span such as this.

This project showed that, when integrated into a planning support system, the CAVE method was able to generate useful design preference guidance from limited input information. Specific design recommendations have been generated using the design vocabulary in conjunction with CAVE method. The involvement of architectural experts in the form of the UDS team significantly strengthened the utility of the knowledge-base modeling approach. The input variables and thus the model outputs were couched in terms familiar to designers. Therefore it was possible to draw on the community preference knowledge base as a design guide with immediate effect.

But this project was designed to examine possibilities that extend beyond generating design recommendations for the site at hand. Conceptually it was intended to have the advantage that the participants see professionals responding to them, and over a period of time bringing ideas to them that they can see they helped to shape. We contrast this mode with the more traditional mode of bringing experts and their models to public forums and then asking for feedback on a small set of predetermined options, or as public involvement professionals sometimes wryly encapsulate it: DAD, or "decide, announce and defend" (Campbell-Jackson 2002:3). In this case, the public knows that it is responding to professional input rather than the reverse. As Docherty et al. (2001:2225) note: "Citizen participation may be fostered as much by the creation of opportunity structures that build confidence in the efficacy of participation as by the intrinsic levels of civic culture." Based on the citizens' panel feedback, and the comments and feedback offered at each of the neighborhood meetings, the signs are encouraging.

However we also recognize that this process could be improved. As deployed here the CAVE method links community preferences with a professional understanding of building characteristics. A more direct connection to community understanding could be generated by connecting community preferences for images with what the community sees in the images. To accomplish this, group dialogic methods can be used to elicit and define a citizen design vocabulary, using brainstorming followed by affinity grouping (Grossardt et al. 2001). The research team is now exploring these options in similar complex public infrastructure decision questions.

**Lessons Learned for Transit Agencies**

In summary then, a few basic points stand out for transit agencies:

- Use technologies strategically to make public participation faster and easier: more can participate.
- Use technologies wisely to make complicated concepts and issues more understandable: better public participation and input will result.
- Integrate technologies thoroughly into existing public outreach processes: technology is an enhancement of, not a substitute for, a larger public participation process.

**IMPLEMENTATION**

The research team has disseminated the process and sought feedback from other design and community involvement professionals at several professional conferences. These include:

- Community Design Symposium, Harvard University Graduate School of Design. March 2002.
- Annual Meeting of the Southeastern Division of the Association of American Geographers, Richmond, VA. November 2002.
- 82nd Annual Meeting of the Transportation Research Board, Washington DC. January 2003.
- Cover story and general interest article in the May-June 2002 issue of *Passenger Transport.*
- Story in Transportation Research News (TR News). October 20, 2002.
- Proceedings of the American Public Transit Association Conference. Milwaukee WI. May 2003.

The team has already published preliminary results of the research in the *Transportation Research Record*. A manuscript is under consideration at *Environment and Planning B: Planning and Design* and the team is working on a manuscript for the *Journal of the American Planning Association*. They have also prepared a User's Guide in the form of a CD-ROM for use by interested transit authorities in deciding whether and how to use the CAVE methodology.

The Casewise Visual Evaluation (CAVE) methodology developed by Dr. Keiron Bailey for this project was awarded the John Fraser Hart Award for the Outstanding Paper at the Annual Meeting of the Southeastern Division of the Association of American Geographers.

As a result of the success of its application and its perceived utility, in combination with these associated scholarly activities, the IDEA-sponsored project research has acquired a high profile.

## CONCLUSIONS

This IDEA project achieved the following.

1. A novel and efficient visual evaluation methodology developed by the research team, the Casewise Visual Evaluation, was used effectively in a real TOD context. In collaboration with the architectural team's input, the methodology achieved its design goals of generating a community knowledge base with limited focus group input. It also demonstrated the capacity to be interrogated in such a way that specific preferred design combinations could be identified easily and quickly by design partners.

2. A coalition of academics and transit professionals worked effectively together to develop and implement a Structured Public Involvement protocol in a low-income minority urban neighborhood. Based on the CAVE method, in conjunction with Virtual Reality visualization, community involvement in the TOD design process was enhanced.

3. Perhaps most importantly, the project struck many community participants as a real advance over current engagement approaches. Their verbal comments and Citizen's Panel feedback demonstrated that, once they had participated in one or more meetings, the attendees felt that they were being taken seriously. They also felt that their preferences - not those of the architects and designers - were used to shape possible TOD designs.

4. While TARC is not yet ready to engage in the final design process for the light rail system, it is impossible to state unambiguously how the designs arrived at will be incorporated into that design. However, it is possible to make the information regarding neighborhood preferences part of the design conversation, since it has now been unambiguously quantified and recorded in terms that can be used by design professionals when the final design process is undertaken. TARC was fully engaged in this process throughout, and can expect their community participants to continue to expect responsiveness to the preferences that have been documented. By its formal nature, such an information base raises the legitimacy and profile of public involvement in the design process.

The project also raised several questions. The first concerns a perennial problem for professionals, that is securing adequate representation and participation. While in this case the demographic characteristics of the focus group participants matched the community profile well, and the team believes that the opinions are representative, more participation is always better. Comments received during the focus group meeting indicate that participants found value in the process: however, despite the outreach efforts by TARC, it is hard to convince residents of the value of these processes up front. It appeared to the team that, once at the meeting, the participants appreciated the considerable differences between this form of Structured Public Involvement and the more usual forms of public engagement in which real decision making power is reserved for elites. Effective SPI is the best promotion for further activities of this type, and in this sense the project's success in building community trust in the public involvement process can be viewed as a long-term asset. It means that, subject to some recognizable design elements appearing in the final build, people in these neighborhoods are more likely to be enthusiastic about participating in the future.

A second problem concerns the adoption of distributed participation when design coalition members have different goals. Over the longer term, in order to translate the preliminary designs into real developments, working with private sector professionals is necessary. These other stakeholder factions include commercial developers, real estate professionals and private sector financiers.

A process of building trust in the methods used here, and overcoming entrenched approaches towards what constitutes the "appropriate" voice of the community, will be required if this method, or something similar, is to be widely adopted and used. In terms of immediate improvement to the current process, it is clear that the universe of possible design alternatives could be discussed with members of development coalitions at the same time as community input is being solicited. This level of process integration requires a further increment in the level of systemic cooperation. Given the complexity of typical urban TOD decision environments, and the number and variety of stakeholder factions, this long-range goal is a much broader undertaking than the IDEA T-33 research project.

Unfortunately it is hard to involve commercial organizations without financial incentives, and, given real-world research budget constraints, this creates something of a gulf between private sector developers and researchers.

Nevertheless, with the increasing desire and imperative for public involvement across all sectors of infrastructure planning and design, and particularly with respect to TOD, better means of soliciting and incorporating community values must be developed and implemented.

**INVESTIGATOR PROFILE**

Dr. Theodore H. Grossardt
Community Transportation Innovation Academy Program Manager
University of  Kentucky Transportation Center
176 Raymond Building
University of Kentucky  40506-0281
Email: thgros00@uky.edu
Phone: 859-257-4513 x 291

**REFERENCES**


1) Transportation Tomorrow, 2002, Greater Louisville's look at light rail, available at http://www.t-2.org, accessed 24 August 2002.

2) Transit Authority of River City, 2001, Light Rail, available at http://www.ridetarc.org/light-rail/default.htm, accessed 24 August 2002.

3) Hughes, R, 1998, "Guidelines for use of visualization" (Division of Highways, North Carolina Department of Transportation, Raleigh, NC).

4) Grossardt T. and Bailey K. Transit-IDEA T-33 Expert Panel Review Meeting Interim Report, Transportation Research Board, National Research Council, Washington DC, 2002.

5) Webb C, Rhodes D, 2002, Outreach to Low-Income and Minority Communities for a Large Urban Interchange Project, presentation given at the 82nd Annual Meeting of the Transportation Research Board, Washington, DC.

6) Campbell-Jackson M, 2002, Public Involvement, Transportation Research News May-June 2002, 3.

7) Docherty I, Goodlad R, Paddison, R, 2001, Civic culture, community and citizen participation in contrasting neighborhoods, Urban Studies 38:12, 2225-2250.

8) Bailey K, Brumm J and Grossardt T. Towards Structured Public Involvement in Highway Design: A Comparative Study of Visualization Methods and Preference Modeling using CAVE (Casewise Visual Evaluation). *Journal of Geographic Information and Decision Analysis* Vol. 6, No.1, 2001, pp.1-15.

*9)* Grossardt T, Bailey K, and Brumm J. AMIS: GIS-Based Corridor Planning Methodology. In *Transportation Research Record* 1768, TRB, National Research Council, Washington, DC, 2001, pp. 224-232.

10) Bailey K, Grossardt, T and Brumm, J. Integrating Visualization into Structured Public Involvement: A Case Study of Highway Improvement in Central Kentucky. In *Transportation Research Record*, TRB, National Research Council, Washington, DC, forthcoming.