Participatory Geographic Information Systems and Active Transportation

Collecting Data and Creating Change

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This paper discusses the approach, results, and keys to success in using new mobile geographic information system (GIS) technology in a public involvement context to assess the transportation infrastructure of most relevance to livable and healthy communities. Research on active transportation and the built environment is a fairly recent area of inquiry, accelerated over the past 10 years by an increased interest in the relationship between urban form and public health. As the research has progressed, so has the interest in developing ways to collect data at a fine scale—the streetscape level—and link these data to transportation behavior. This paper discusses the development and implementation of two mobile GIS-based tools that communities can use or adapt for quick, georeferenced, and useful local area analysis; one tool focuses on safe routes to school and the other on more complete local street networks. The public involvement component can help to create a political coalition that becomes active in translating data into political or technical action by appropriate public departments. Both tools were developed specifically to include a general, nontechnical public in the data-gathering and data analysis processes and have been tested in a variety of communities across the country. This paper summarizes both tools and some results from their use in different settings. It also discusses how the tools can be used in research investigating the relationship between the layperson's subjective perception of pedestrian and bicycle environments and objective design variables.

Over the past several years, a series of research efforts have striven to develop assessment tools to measure the walking environment at a very local scale (*1–7*). The goal of these tools was to help identify what makes good walkable environments so that cities can have guidance on how to improve their pedestrian infrastructure in the hope of attracting more pedestrian travel. Although these tools have been used in a variety of ways, a promising application has been their combined use with geographic information systems (GISs) for better spatial location of the walkability data being gathered (*8*). The assessment tools, however, tend to be geared more toward academic research without easy transferability to the public sector.

At the same time as these research-based tools were developed, a series of other walkability assessment tools had been created by advocacy organizations and shared through different on-line resources such as the Pedestrian and Bicycle Information Center, the Center for Neighborhood Technology, and the Active Living Resource Center. These tools are often less technical in nature (such as simple checklists) and are designed to be used by community groups and a general citizenry interested in assessing and improving their local area for pedestrian travel. However, what they gain in simplicity and wider accessibility, they often lose in the more robust potential of a GIS-based spatial analysis.

The past 10 years have also seen the development of a concentration of work known as public participation GIS (PPGIS), which aims to combine the spatial sophistication of GIS with expanded public access to the tools and data linked with GIS technology (*9, 10*). Although in many self-identified PPGIS projects it is rarely clear exactly who the public is and how that public is to participate (*11*), the potential exists to combine the sophistication of GIS with local community knowledge and participation. And for small and medium-sized cities, it may be just this combination of public and community resources that can work together to facilitate local transportation management and planning.

Below is a discussion of two citizen and planning-based GIS tools focusing on nonautomotive transportation planning. The School Environment Assessment Tool (SEAT) can help communities assess strengths and limitations of areas around schools to determine how consistent the neighborhood area is for walking and biking. The Complete Streets Audit Tool (CSAT) helps communities advocating for "complete streets" to perform a comprehensive assessment of the strengths and limitations of the local street network from the perspective of pedestrians, bicyclists, and transit users (*12*). With these tools (and others on accessibility, bikeability, curb ramps, and parking in development but not discussed here), there exists a potential suite of opportunities for small and medium-sized communities to better understand and manage the local transportation system and to engage the citizenry in political coalition building and social change in relation to the transportation priorities of the local area.

PARTICIPATORY APPROACH TO TRANSPORTATION ASSESSMENTS

When GIS, in general, and transportation-planning GIS application, in particular, are considered, they are often viewed as technical tools operated by technical experts with specialized skills. Those experts generally work for a public agency like a public works or city planning department and usually use GIS in an inventory and tracking capacity. Examples of typical GIS functions may include maintaining a land parcel database or maintaining an up-to-date street centerline

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map. In some cases, these data are used for planning or policy purposes, but often GIS is used simply as a spatial database that inventories and maintains records of various pieces of public-sector information. In this conventional use of GIS at the municipal level, especially for smaller or medium-sized cities, the connection between a city's GIS system and community engagement is unlikely. Furthermore, for ordinary citizens who want to engage in transportation planning and policy work, the technical skills needed to take advantage of the spatial and cartographic power of GIS are barriers often too difficult to overcome.

Over the past 2 years, the authors have been working on a suite of coalition-oriented transportation assessment tools (COTAC) designed to give citizens who are interested in active modes of transportation (e.g., walking and biking) access to powerful GIS technology in such a way that they can (*a*) produce rich data with which to work and (*b*) develop a political coalition to bring about local changes in the transportation environment. At the core of these tools is a new type of GIS called mobile GIS that allows users to collect robust GIS data themselves, directly in the community, with handheld computers. And while the technology may be sophisticated, the interface for users can be made to be extremely straightforward. Figure 1 delineates a six-step process that a community interested in assessing its transportation infrastructure would follow with one of the COTAC tools. These steps are described in detail below.

Step 1. Base Data Acquisition

The first step in the use of one of the assessment tools is identifying the base map data to use. The SEAT and CSAT community assessment tools focus on four basic types of spatial data:

- Attributes of the street block environment. These tools are designed to collect attribute data along the street one block at a time. If local GIS street data exist, these tools can easily work with those data. Many small and medium-sized cities do not have their own customized street network data, so the freely available topologically integrated geographic encoding and referencing street centerline data becomes a good option, and one that these tools also work with well.
- Attributes of intersections. These tools (in their current form, at least) help evaluate various aspects of intersections and assign those data to a single intersection point. From a base-map perspective, there is generally no preexisting source for intersection points; thus, they must be created via a GIS program by someone with some basic GIS ability.
- Specific barriers or points of interest along the street block. In many areas, a street may be perfectly acceptable for walking except for one or two key issues, such as a small gap in the sidewalk or foliage particularly overgrown in a specific area. These points-of-interest data are designed to be collected by the assessor in the field in an ad hoc manner. Technically, the data are being created from scratch, so no preexisting GIS data set is needed. In this way, the tools support dynamic segmentation for street segments that are not consistent from one intersection to the next.
- Intersection crossings and conflict-ridden turning locations. Similar to the POI data, there may be particular street crossings or pedestrian–car-turning conflicts that warrant specific identification; this component of the module is designed to allow easy representation by users of those conflicts within the GIS data, and because these are observer-generated data, no preexisting GIS data set is needed.

Step 2. Mobile GIS Data-Collection Tool Preparation

The next step of the process is to customize the assessment tools for the local application area. The primary work at this step is to link the general assessment tool to local GIS data and possibly to customize the tool for unique local conditions. This process is not overly complicated but does require technical assistance.

Step 3. Community Coalition Data-Collection Process

After training is completed, participants are prepared to collect the data. As a public involvement process, this step is critically important and should not be treated as simply a data-gathering exercise in which the data will be brought back to a centralized computer and evaluated at some later date. Contrary to most data collection efforts, the process by which the data are collected is as important as the collected data themselves. It is through the data collection process that community capacity and investment are being created or enhanced, and the conversations and insights generated from the data collection process itself may be more valuable in leading to transportation changes than what the finalized set of data contain. That is, ultimately all decisions about transportation systems, land use planning, and city design are inherently and deliberately political, and this process of collecting data on the active transportation infrastructure is designed to enhance the political capital and capacity of an interested coalition of citizens and staff.

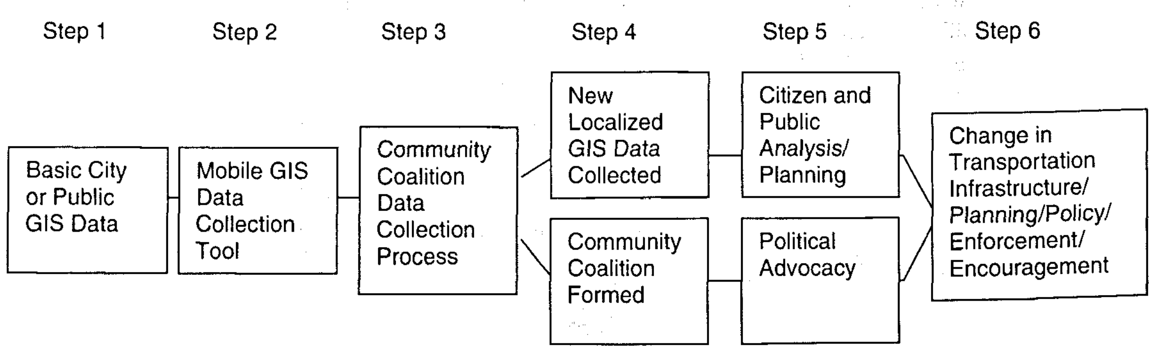

FIGURE 1 Six-step process for transportation assessment tool.

To achieve a balance of data collection, public involvement, and coalition building, the basic 1-day workshop format described in Figure 2 was followed for this study. This workshop format is particularly suited for evaluating an area around a specific school (such as a half-mile radius) or a specific zone targeted for improvements (such as a key downtown area or important sets of corridors).

The 1-day data collection workshop is divided into three main components: (*a*) issue context and tool training; (*b*) data collection; and (*c*) data synthesis and community discussion. Because one of the primary goals of this approach toward transportation system evaluation is to involve a cross-section of the public (which can include city staff, elected officials, teachers, parents, advocates, kids, or a "general" public), it is critically important to orient everyone to the basic context of the evaluation. In relation to the SEAT tool, this orientation involves a summary overview of both pedestrian-friendly neighborhood design, reasons why increasing active transportation to school is a national goal, and an introduction to the national Safe Routes to School (SRTS) program. The introduction to these topics is best accomplished through visual examples of good and bad pedestrian facility design, a visual recounting of the change in obesity levels over time, and showing the different aspects that compose effective SRTS efforts.

Once the basic issue training is accomplished, the next step is to train participants on the assessment tools themselves and introduce them to mobile GIS technology. The assessment tools discussed here have been designed to be easy to use by nontechnicians and technophobes, and it has been found that people of all backgrounds and technological comfort levels have been able to use these tools with surprising ease. There are three key components to the technological training aspect of the workshop. First, it is important to explain the basics of the hardware of the handheld computer, or personal digital assistant (PDA), which even frequent desktop or laptop computer users may never have used. Second, it is important to guide users through the assessment tool itself, using a mock environment for evaluation. By displaying a photograph of a street segment or intersection, everyone involved can rate the same environment, work out differences in rating standards, engage in discussions about what makes a good walking environment, and become comfortable using the tool. And third, it is important to go through potential problems users may encounter in the field and how to resolve them.

Step 4. Data Collection and Coalition Development

Once the training is completed, the second step of the overall assessment process is to conduct the assessment and collect data. To encourage community building among participants, one recommendation is that participants work in pairs. However, depending on the number of participants and circumstances, it is also possible for assessors to go out individually. Areas are specified for each assessment team, and these can vary depending on the size of the overall study area, number of participants, and particular features of the local community.

The CSAT tool employs a specific and deliberate sequence of subjective and objective questions for each mode of travel. To mimic the natural judgments that people make about the "goodness" of a particular route they choose to take when walking or biking, the data collection process begins by asking a subjective, intuitive question: How does the street feel in relation to comfort and safety from the perspective of a typical user? It is important to capture this impression before asking the assessor to engage in a more rational evaluation based on specific, predefined criteria. After determination of this impression, a detailed but essential set of objective environmental attributes is collected about the street segment or intersection. Again, working through these specific questions serves the dual goal of data collection and education. Finally, the assessor is asked to make a categorical (yes–no) judgment about whether the street accommodates each of the user types. Informed by both their intuitive, gut-feeling perception of the street and a specific well-defined set of objective criteria, this final component offers the opportunity to flag significantly deficient street segments for priority action.

Once each team completes the assessment of its assigned area, the team returns to the workshop location and transfers the GIS assessment data to a central GIS database. When all teams have returned (after 2.5 h in this model), their individual sets of data are quickly synthesized into a master data file and maps are instantaneously created and projected on the wall for participants to see. From this point forward, facilitation of a discussion is key because the intent of these tools is both to collect the data and to catalyze a constituency to do something with that information. With an initial map projected on the wall (the authors like to start with a map that asks assessors to answer the subjective question, "Is this a nice place to walk?"),

- Coffee (10 minutes)
- Introductions of Participants and Instructors (15 minutes)
- Safe Routes To School Overview and Discussion (35 minutes)
- Break (10 minutes)
- Guidance on how to use the SEAT data collection tool (60 minutes)
- Data Collection – workshop attendees will break into small groups and walk one or more routes to collect physical information on the primary walking routes leading to/from school. Box lunches will be distributed, which can be consumed while walking or during a short break during this assessment period (2.5 hours)
- Group will reassemble to discuss their experience and begin to analyze their findings as their data is synthesized and projected as maps (plus have some food) (40 minutes)
- Wrap-up with a reflection of the day's workshop and discussion of next steps (30 minutes)

FIGURE 2 Basic workshop agenda.

the workshop facilitator initiates and leads the discussion with three basic questions:

1. How did the assessment go, and what did you notice?
2. What patterns and issues arise from the maps projected on the wall?
3. What do you want to do to improve the transportation environment?

After a discussion of an initial subjective question on the perceived comfort and safety of the streets and intersections, maps are introduced to show the objective design features of the street network. These objective data capture many of the reasons behind a particular subjective evaluation, deepen and clarify the discussion among participants, and reveal the connections between gut-instinct perceptions and physical environmental qualities. In all the workshops the authors have conducted to date, participants have responded well to this type of facilitated discussion and the kinds of data employed.

With a portable printer on site, each participant can leave the workshop with a representative map from the data they collected. More importantly, however, participants should leave the workshop with some commitment toward next steps. For example, if the assessment was related to SRTS and participants included representatives from the school, city, and neighborhood, then the group may commit to a follow-up meeting to identify key priority areas and develop short-, medium-, and long-term plans to address the problem areas. The data and maps may be used by this group to support a grant application for funds required to do reengineering work on an intersection or to develop an encouragement campaign at the school. Using the shared assessment experience and the coalition of citizens actually collecting the data is a key component in translating the data into tangible action at the local level. As for the data, they can reside within a local city GIS system if one exists, with the technical advisors, or can be translated into a web-accessible map application for easy community access.

Step 5. Community Planning and Advocacy

While agency planners often have the desire to enact positive changes in the built environment and urban form that support active transportation, the political will to implement these changes may be lacking. Many people are unaware of the environmental needs of modes of travel they do not use (e.g., bicycling), and there may even be outright opposition to certain types of change. By participating in a mobile GIS workshop focused on SRTS or complete streets, a broad range of community members can become informed, organized, and in a position to provide strong political support for positive environmental changes. For both topic areas, SRTS and complete streets, a strong and well-established policy context is already in place. In many cases, communities simply require a coordinated effort among a diverse group of advocates to implement these programs and policies in their area.

Step 6. Community Change

While community members are conducting the mobile GIS assessment, they directly participate in and embody active transportation ideals (i.e., they are walking to conduct the audit). Through their training on the essential environmental requirements of a pedestrian or a user of a bicycle or transit, they come to recognize the presence or absence of these features in their day-to-day life. Furthermore, in the case of the complete streets audit tool, people who rely primarily on one or another particular mode (e.g., riding the bus but not often commuting by bicycle) gain a new appreciation for other modes of travel. Workshop participants can take on an integral role for ongoing advocacy and community change efforts that seek a more livable and healthy transportation environment.

Two Field-Based Transportation Assessment Tools: CSAT and SEAT

The SEAT and the CSAT tools work on a PDA running ArcPad GIS software, which integrates seamlessly with ArcGIS Desktop, the standard GIS software that municipalities across the United States use. ArcGIS Desktop runs on Windows-based computers that meet minimum RAM requirements (currently 256 MB). The mobile-GIS application ArcPad requires either Windows Mobile or Windows CE for installation on a PDA. The graphic user interface for the tools was designed in ArcPad Application Builder, which also supports scripts written in VBScript, Jscript, and C/C++ to enhance functionality and ease of use.

Users simply load a project that contains streets, intersections, and possibly some reference landmarks like parks or an aerial photograph (although the use of aerial photography has not been found worthwhile). Once the map is loaded, a user taps on the appropriate street segment or intersection and completes the data entry form that automatically appears (Figure 3).

Assessing street blocks and intersections individually and in the field can be time intensive, so both the SEAT and CSAT tools can customize data collection on the basis of street type, because functions and characteristics of the transportation network differ by location. For example, if the conditions along an arterial road are being evaluated, there will be many more attributes to collect than if characteristics along a neighborhood road are being collected. The variations of condition, interaction with vehicles, and mixes of land use are simply greater along arterials, and it would be a waste of time and energy to collect arterial-relevant variables while assessing less-busy environments (Figure 4).

The tools contain both objective and subjective questions, which are all generally closed ended, with occasional opportunities to include unanticipated observations. Many transportation engineers and data-oriented people have difficulty with the subjective questions (e.g., "Is this a comfortable and safe place to walk?") because the answers can deviate on the basis of each assessor's opinion. Experience with these tools shows that such subjective questions are by far the most important, for two reasons. First, at the end of the day, participants and facilitators want to know if a certain place is a good place to walk (if focusing on pedestrian travel), and this subjective question gets right to the point without having to determine the specific attributes of a location. Second, the subjective assessments feed into the subsequent community discussions that take place once the data have been collected. It is this dialogue and discussion about what makes a walkable space, what the norms and standards should be, and how different people may interpret similar conditions differently that lead to a consensus approach to push for changes. So, rather than seeing such subjective questions as an unreliable form of data, the authors believe that it is the most important data with which to begin an analysis and a plan for change. Combining and layering subjective data with objective attribute variables provide a strong foundation

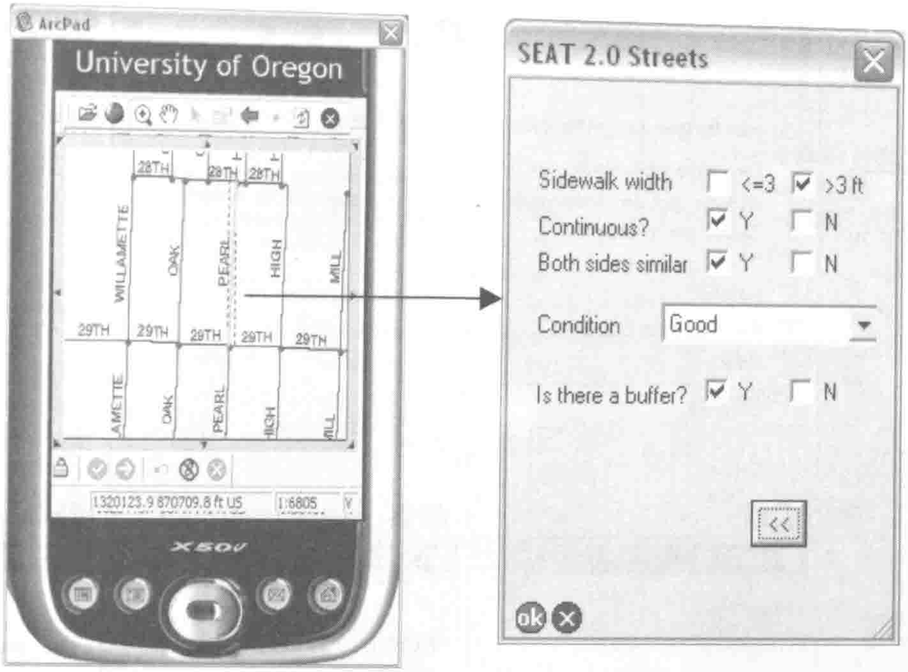

FIGURE 3 GIS data entry on PDA.

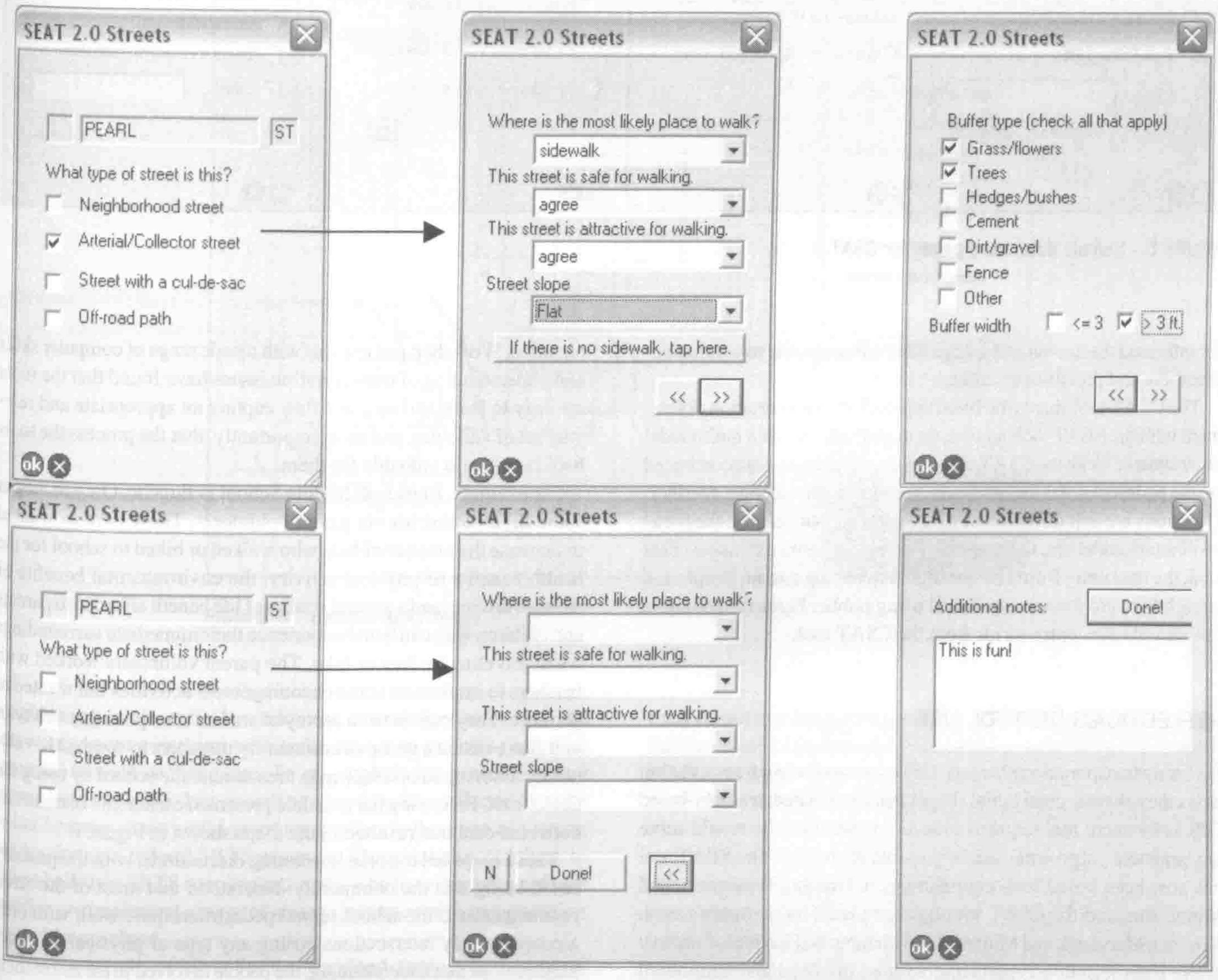

FIGURE 4 Sample SEAT data entry forms by street type.

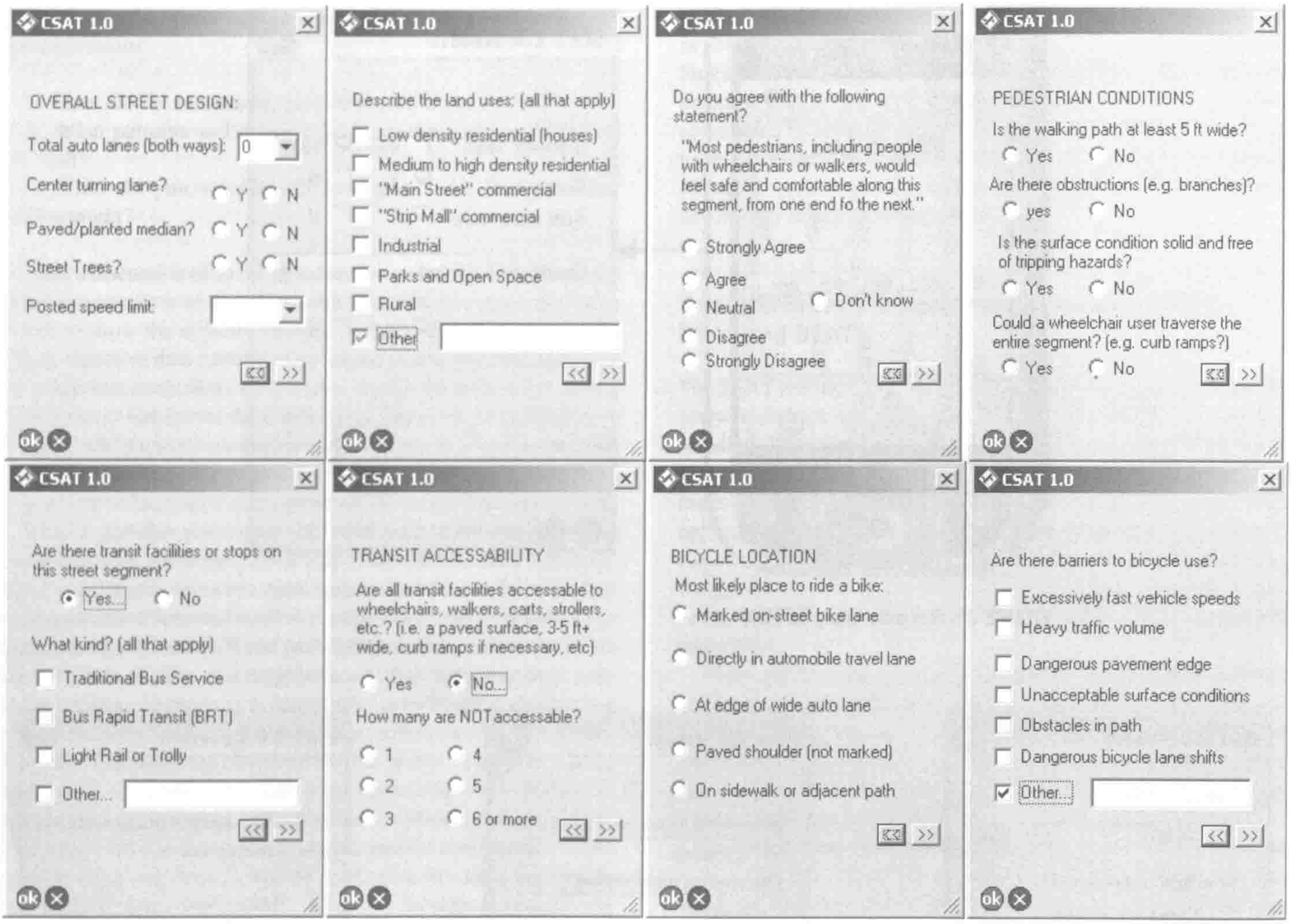

FIGURE 5 Sample data entry pages for CSAT.

for informed discussion and analysis that are accessible to community members and practitioners alike.

The CSAT tool shares the basic approach to transportation assessment with the SEAT tool but focuses more explicitly on a multimodal environment. With the CSAT tool, separate evaluations are conducted on the pedestrian, biking, and transit environments along a corridor. Questions are still differentiated by road type, but because the focus is on multimodalism, the range of questions is more extensive. That said, the data entry form and question sequencing remain simple and straightforward for a nontechnical using public. Figure 5 displays a few sample data entry forms from the CSAT tool.

REFLECTIONS ON TOOL USE

For many transportation planners, GIS users, and active transportation advocates, there is great initial skepticism about whether a field-based GIS assessment tool targeted toward a general public would serve any practical purpose or even be possible to employ. The SEAT tool has now been tested with communities in Oregon, Wisconsin, and Minnesota, and the CSAT tool has been used by communities in Virginia, Maryland, and Minnesota. With input and advice by national active transportation experts and with an involved and committed public, these tools have in fact been extremely useful and well regarded. Workshop participants with a wide range of computer skills and understanding of transportation issues have found that the tools are easy to learn and use, that they capture an appropriate and relevant set of variables, and most importantly, that the process the tools help facilitate is valuable for them.

For example, Roosevelt Middle School in Eugene, Oregon, began some SRTS activities via parent volunteers. These parents wanted to increase the number of kids who walked or biked to school for the health benefits of physical activity, the environmental benefits of reduced driving, and a general quality of life benefit afforded to parents and children who can better experience their immediate surroundings when traveling by foot or bike. The parent volunteers worked with teachers to implement some encouragement activities but wanted to do more. They conducted a survey of student transportation behavior and also enlisted a group of community members to conduct a walkability assessment of a half-mile area around the school by using the SEAT tool. Following the schedule presented earlier, the community collected data that resulted in the maps shown in Figure 6.

These maps led to some interesting discussions, with the primary result being that the community understood that most of the environment around the school served pedestrians quite well, with only a couple of key intersections posing any type of physical or safety barrier. With that understanding, the people involved in the assessment decided that the best course of action was not to ask the city for major

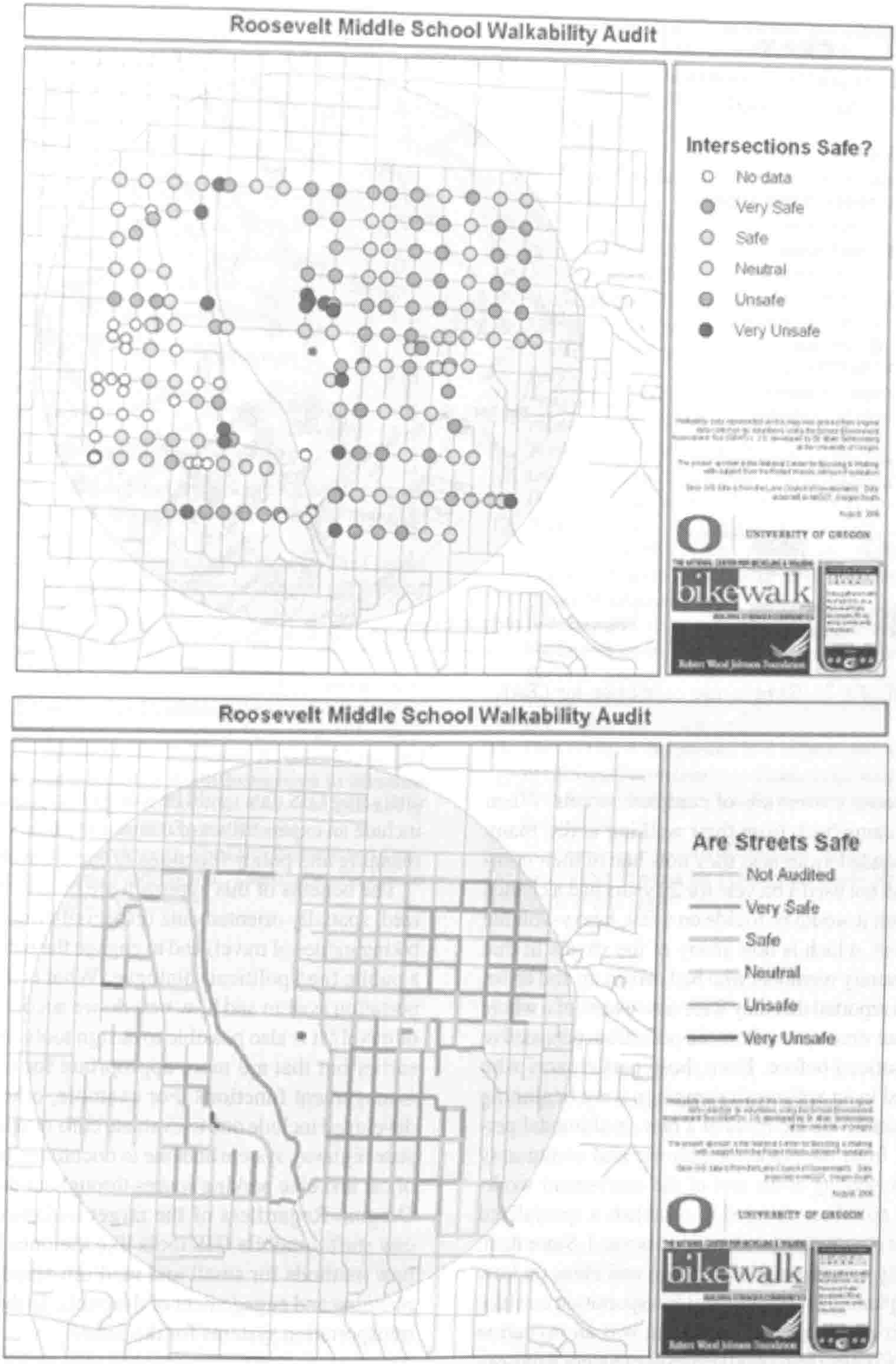

FIGURE 6 Sample SEAT maps.

engineering solutions but to work on an extended informational and encouragement campaign within the school to get kids (and their parents) to walk or bike more. To accomplish this goal, the school group used these GIS data, as well as other data they collected, to write what became a successful grant application to the State of Oregon under the new federal SRTS program. The grant allowed them to hire a half-time SRTS coordinator on site, who has since been actively working to implement a range of ideas to increase active transportation to and from school.

The community of Silver Spring, Maryland, carried out a complete streets audit with the CSAT tool in June 2008, and although it is too early to see any long-term successes, the assessment process itself fulfilled many of the hoped-for community organizing and education functions (Figure 7, sample map). The community members who gathered for a complete streets workshop there were primarily concerned with the pedestrian environment. Few of them rode bicycles, and some of them were even part of an organized effort among home owners to oppose a proposed transit project in the area. During preparations for the workshop, the organizers even thought of "turning off" the bicycle and transit modules of the tool so as to focus on the expressed interests of the participants. It was decided, nevertheless, to include all modes in the audit, and the workshop

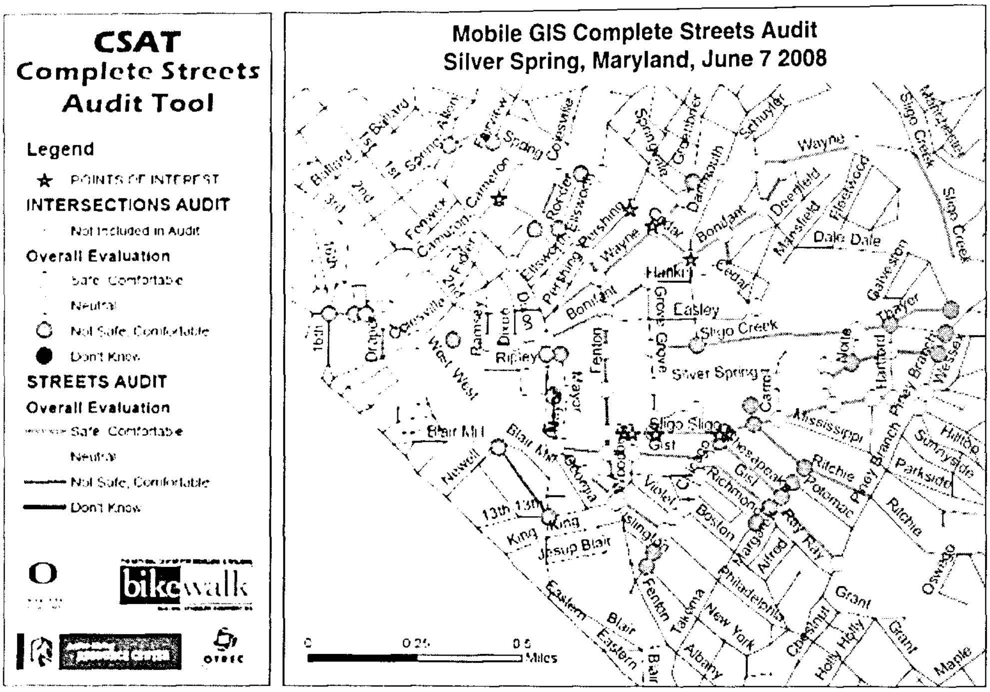

FIGURE 7 Sample map conclusion for CSAT.

began with a comprehensive overview of complete streets. When community members came back from their walking audit, many commented on the expanded awareness they now had of their community. People who had not used a bicycle for 20 years had a chance to reflect on how difficult it would be to ride on a fast, heavy-volume road without a bike lane, which is how many of the streets in that community are. Community members who had driven up and down the same road for years reported that they were now aware of a whole range of features of those streets, seen from the pedestrian perspective that they had never noticed before. Even those participants who were actively involved in an antitransit campaign were beginning to reevaluate their positions on the basis of a new, multimodal perspective that resulted from the mapping exercise and community discussions. Before dispersing at the end of the assessment workshop, the community members decided to establish a specialized listserv about complete streets and the area they assessed. Since then, they have been actively exchanging information and ideas on how to move forward with planning this important transportation corridor in Silver Spring. Their most recent achievement was an invitation from the Montgomery County (Maryland) Pedestrian Safety Advisory Committee to deliver a presentation on July 15, 2008, on the results of the June 2008 complete streets workshop, their experience with the mobile-GIS tools, and the mode-specific map set that was produced with the community-gathered data.

Many small and medium-sized communities lack sufficient GIS skill and infrastructure to engage in large-scale GIS-based data collection, analysis, and planning. And those cities large enough to have a relatively robust GIS infrastructure may not think that GIS and citizen participation connect in any way. Regional planning for active transportation is still important and in some ways cannot be replaced by extremely localized environmental assessments: "So while regional plans and formal advocacy organizations are very positive and necessary elements, multimodalism and 'complete streets' must be required constraints, not optional, in CSS (context sensitive solutions)" (*13*). But engaging citizens in gathering and analyzing GIS data could be a useful way to extend GIS reach and to include an expanded set of community members in the transportation planning and policy functions of local government.

The benefits of this approach are both to collect extremely localized, spatially oriented data (especially important to pedestrian and biking modes of travel) and to engage the public in what is essentially a public (and political) dialogue: What is the purpose of our transportation system and how best do we accommodate multiple modes of travel? It is also possible to design tools similar to those described earlier but that are more appropriate for city staff and their asset management functions. For example, other tools currently being developed include one to evaluate curb ramps throughout the Oregon state highway system and one to document the location and attributes of car and bike parking spaces throughout the urban core of Eugene, Oregon. Regardless of the target audience—a general public or city staff—mobile GIS tools like the ones discussed here provide new methods for small and medium-sized cities to use for better planning and engagement of the public in the creation of sustainable transportation systems for the future.

OPPORTUNITIES FOR ADDITIONAL RESEARCH

As noted earlier in this paper, the inclusion of subjective and objective measures is a unique feature of these tools. In addition to helping facilitate public involvement in community transportation issues, the data collected provide an intriguing opportunity for research. First, the data sets collected lend themselves to statistical analysis that investigates the relationship between the layperson's subjective perception of the walking and biking environments and objective design features of streets. Second, it is possible to compare the subjective and objective data gathered through these tools with a variety of travel behavior information. In particular, travel behavior research that focuses on PDAs and Global Positioning System monitors (*14, 15*) would integrate very well with the GIS model and could provide significant insight into the correlation between attributes of the built environment, people's perceptions of that environment, and travel behavior.

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