ITS Institute research is centered on safety-critical technologies and systems for efficiently moving people and goods in the following areas:
- human performance and behavior
- technologies for modeling, managing, and operating transportation systems
- computing, sensing, communications, and control systems
- social and economic policy issues related to ITS technologies

The Institute’s research program joins technologists—for example, engineers and computer scientists—with those who study human behavior to ensure that new technologies adapt to human capabilities, rather than requiring drivers to adapt to technology.

The Institute’s geographic location gives it a unique advantage for developing research applicable to transportation in a northern climate and transportation in rural environments in addition to the metropolitan Twin Cities area. The ITS Institute research program includes research projects funded by various partners, including federal funds from SAFETEA-LU legislation, the Federal Highway Administration, the Federal Transit Administration, and the Department of Homeland Security. Other funding partners include the Minnesota Department of Transportation (Mn/DOT), the Minnesota Local Road Research Board, the Metropolitan Council, Hennepin County, Metro Transit, and the Minnesota Valley Transit Authority in addition to local governments, agencies, and private companies that contribute funding and in-kind match.

Activities undertaken by the Institute support all ITS-related research projects, regardless of funding source; all current ITS-related projects are listed in this annual report. The research section comprises two parts. The first highlights in detail a selection of projects under way, while the second briefly describes other Institute projects either recently completed, in progress, or selected to begin this coming year.

Research funding sources for all ITS-related research projects

The total funding for ITS-related research projects was approximately $9.6 million in FY07. Sources for projects receiving funding in FY07 are shown in the chart to the right.

During this period, 58 faculty and research staff and 69 students were involved in ITS-related research.
Freeway volumes in the Twin Cities metro area grow by about 4 percent each year, according to the Minnesota Department of Transportation (Mn/DOT). This increasing demand coupled with shrinking resources is challenging Mn/DOT—and most state DOTs—to find ways to optimize existing freeway capacity. Changeable message signs (CMSs) are one tool the transportation department uses in conjunction with its Regional Transportation Management Center (RTMC) to do just that.

Changeable message signs are electronic signs posted at various overpasses on the freeway system. During rush hour, traffic incidents, adverse road conditions, and construction, they communicate real-time traffic information to passing motorists. The signs are also used in the AMBER Alert System to display emergency alerts when a child is abducted. Their use, however, has provoked questions about their effectiveness and about their possible safety impacts on traffic. To study these issues, human factors researchers Kathleen Harder and John Bloomfield, with the University of Minnesota’s Center for Human Factors Systems Research and Design in the College of Design, are continuing their work looking at the effects of the signs on driver behavior.

In the first phase of research, Harder and Bloomfield conducted a baseline study on CMSs to learn whether they cause traffic slow-downs or affect traffic flow. In the second phase, taking place throughout 2007 and into early 2008, Harder and Bloomfield will again use a fully interactive, PC-based STISIM driving simulator to conduct experiments in which they will compare the effects of newly worded messages with data from the Phase I research. While Phase I was purely a laboratory study, Phase II bridges the gap between theory and practice. In addition to the simulator experiments, Harder and Bloomfield will work directly with RTMC staff to examine a selected roadway incident in real time and will study characteristics such as when the incident occurred, when it was first noticed by RTMC, when and where RTMC initiated CMS messages related to the incident, when and how the CMS messages were changed to reflect the changing status of the incident, and when the incident was cleared.

To the extent possible, the researchers will compare the driver simulator data with the real-world traffic data collected. Based on analysis of these data along with a review of traffic camera recordings of the actual incident and interviews with RTMC personnel who managed the incident, Harder and Bloomfield will offer recommendations on the best way to use CMS messages when managing such events in the future. Their analysis will consider the location of the CMS message boards, the content and duration of the messages, how the messages relate to the severity of the incident, and the effect of the messages on traffic flow.

“Phase I generated a lot of interest from other DOTs who want to improve their use of CMSs,” Harder noted. “We expect our findings from Phase II to further push the field forward in helping Mn/DOT and other DOTs create clear, concise, easily understandable messages that are safer for drivers to read and to respond accordingly, thus reducing traffic slow-downs and improving road safety.”
In July 2000, the Federal Communications Commission (FCC) designated “511” as the national traveler information phone number. Since then, many states, including Minnesota, have implemented information services that enable travelers to dial 511 from any phone to access current weather-related road conditions, construction, congestion, and other travel information 24 hours a day, 7 days a week. While there is little doubt that the 511 program provides a valuable service to travelers, at issue is the fact that more and more travelers are using cell phones while driving to access this information.

Currently, there is considerable debate about the crash risk associated with cell phone use while driving. To study this contentious issue, researchers from the University’s Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program examined how the performance impairment from cell phone use compares to other types of impairment risks, such as driving while intoxicated or while operating common in-vehicle controls like a radio, fan, or air conditioning. They also examined, for the first time, the combined effects of being distracted and being intoxicated, given that many crashes result from a combination of risk factors. Their findings indicated that, generally, both the cell phone and in-vehicle sources of distraction caused more impairment than intoxication at the legal limit.

HumanFIRST Program director Nic Ward and research fellow Michael Rakauskas are now using these findings in a follow-up study to assess the effect of cellular phone access to Minnesota’s 511 (MN511) traveler information service on driving performance and driver mental effort. To begin this follow-up work, Ward and Rakauskas first conducted detailed usage and usability evaluations of MN511, which allowed them to determine the types of information users currently request and what portions of the system’s menu design are most problematic for users when searching for information. This thorough examination allowed the researchers to develop an alternative structure for the 511 menu they call V2. Specifically, the goal of V2 is to integrate the phone menu information with Mn/DOT’s Web-based traveler information (www.511mn.org) while improving the user’s ability to locate relevant traffic and weather information.

The team then conducted experiments in the HumanFIRST Program’s virtual environment for surface transportation research (VESTR) driving simulator, during which participants drove a standard route that involved a car-following task. This methodology is typically used to assess a driver’s performance and attention to the road environment while completing peripheral tasks such as talking on a phone—in this case using a cell phone to access the 511 menus. Participants also were asked to drive through relatively slow traffic as they might do in rush-hour traffic to see how their performance in dense traffic conditions was affected by accessing the phone menus.

Each driver repeated these “drives” three times: two drives were completed while accessing a simulated version of either the current MN511 or V2 menus to answer questions about weather or road conditions. Testing both menu designs allowed Ward and Rakauskas to compare driving performance and information retrieval and determine if the changes implemented in V2 helped decrease mental distraction. During another drive, participants answered simple questions aloud without accessing a phone menu. This served as a baseline in comparison to the drives where 511 menus were accessed.

Through this experiment, the team will learn whether using the 511 system leads to more risky driving behavior compared to not accessing such a system at all. It also will allow them to find out if changing the 511 menu might affect driver performance for the better.

The results of this study will contribute to policy and design recommendations for 511 services accessed while driving. Gaining insight on the interaction between these factors will also contribute to the debate of crash risk associated with cell phone use and suggest policy and design recommendations for the conditions in which 511 may be accessed while driving. As such, this study supports the Minnesota state strategy to provide effective traveler services and promote zero fatality objectives.
Computing, sensing, communications, and control systems

Multi-Camera Monitoring of Human Activities at Critical Transportation Infrastructure Sites

The ability to accurately estimate the number or density of people in a scene has many useful applications in the transportation arena. Urban and regional planners, for example, can use this capability to design corridors based on typical pedestrian traffic patterns in an area. For traffic control, automatic pedestrian and crowd monitoring techniques can be used to increase safety and improve traffic signal timing. But employing the required computer vision techniques to monitor people in these situations is a difficult task.

One issue is that in many group-monitoring applications, most of the cues that aid in detecting and tracking individual people—such as shape, texture, and appearance—simply do not work with crowds, especially when low-resolution surveillance cameras are used. Thus, video monitoring methods that treat a group of people as a single entity instead of processing each person individually generally offer the best results. Although some research has been done on tracking people in crowded scenes in this way, there has been only limited research on the specific problem of counting the number of people in a scene.

In their recently completed project, Professor Nikolaos Papanikolopoulos and graduate students Prahlad Kilambi, Evan Ribnick, and Ajay Joshi, all with the computer science and engineering department, tackled the problems of estimating the number of people in a group and being able to update this estimate reliably throughout the video sequence. For this study, they investigated using multiple video cameras for monitoring human activities at critical transportation infrastructure sites—airports and mass transit stops—and specifically examined how to reliably detect specified activities, such as crowd dispersion after a sudden event, and to count people in these crowded areas.

The researchers used two different methods—heuristic-based and shape-based models—to develop and test ways of accurately estimating the number of people in a scene, in real time, without the constraints of detecting individuals. In the heuristic-based method, the number of people in a group is estimated based only on the area it occupies. Although this method provides an extremely simple and efficient solution to the problem of counting people in groups, there are some cases in which it fails, such as when a group is fairly sparse or is dispersed across a long distance. To account for these issues, the researchers also used the more flexible, probabilistic shape-based approach in which the shape of a group’s intersected area is used to estimate the number of people present.

Experiments were performed on three different scenes with eight different camera positions. The videos were shot on the University’s Twin Cities campus and at other crowded scenes, and both the heuristic- and shape-based approaches were tested on these video sequences. The cameras were carefully calibrated to each scene, first to estimate how many individuals fit to a specific number of video pixels and then to expand this estimate to the entire crowd. Using these methods, the team created a monitoring approach capable of counting and tracking people with 80 to 90 percent accuracy and without being significantly affected by occlusions—a typical problem when monitoring crowds or cases in which one group of people splits into two groups, then merges into one again. In addition, favorable results were also shown for counting and tracking groups of various sizes moving unconstrained and in adverse weather conditions.

This is the first system of its kind capable of counting people in both outdoor and indoor environments and as such offers significant improvement over past approaches. Although this approach has important benefits for the transportation field, it can also be used in other applications related to estimating the number of people walking through a crowded area. For example, knowing the size and density of a group outside of a school or at a public event could help authorities identify unsafe situations and regulate traffic appropriately.
In 2007, the Minnesota Department of Transportation and the ITS Institute were selected by the U.S. Department of Transportation to participate in the Cooperative Intersection Collision Avoidance Systems (CICAS) research initiative. ITS Institute director Max Donath and Intelligent Vehicles Laboratory director Craig Shankwitz announced the signing of a cooperative agreement outlining the roles of Mn/DOT, the ITS Institute’s Intelligent Vehicles Laboratory, and the HumanFIRST Program in supporting the innovative and ambitious safety research effort.

CICAS brings together federal agencies, automobile manufacturers, and university transportation centers with the goal of developing new technologies to prevent collisions that kill thousands of Americans and injure more than one million more every year. Donath said that the effort put forth by the ITS Institute will focus on the prevention of crashes at rural highway intersections. This work is a direct outgrowth of the Institute’s Intersection Decision Support (IDS) research, which over the past two years has developed a new approach to preventing collisions at rural unsignalized highway intersections.

In the past two years, IDS research has accomplished several important goals that will contribute to the CICAS effort, including:

- developing an advanced traffic sensor network
- developing an advanced vehicle-trajectory measurement and recording system
- studying driver gap-acceptance behavior on a microscopic level using a driving simulator
- testing new active displays in a driving simulator to determine what information a driver needs to safely maneuver through rural unsignalized intersections

The Institute is currently working with a consortium of other state departments of transportation in a complementary project to better characterize driver gap-acceptance behavior on a national basis.

The USDOT describes CICAS as a “cooperative” system, meaning it integrates data from both vehicle-based and infrastructure-based sensing systems via the newly allocated Dedicated Short-Range Communications portion of the radio spectrum. Warning display systems using this data are to be developed for both in-vehicle and outside-the-vehicle placement.

Minnesota’s CICAS research, expected to last five years, will focus on infrastructure-based solutions and include five main components:

1. A microscopic, in-vehicle measurement of driver gap acceptance at an instrumented intersection.
2. Alert and warning algorithms to be used to appropriately inform drivers in a timely fashion of dangerous conditions.
3. A deployable sensor system used both to compute the dynamic “state” of the intersection and to feed data required for triggering the alert and warning algorithms.
4. A field validation and subsequent field operational test to quantify the performance and safety benefits of such systems.
5. Wireless communications between the vehicle and the roadside equipment.
Research

Technologies for modeling, managing, and operating transportation systems

**Bus Signal Priority Based on GPS and Wireless Communications**

In thousands of cities around the world, the bus is a key part of the public transportation system—and often the only form of public transportation.

Much of the success of buses is no doubt due to the inherent flexibility and low cost of operating on regular streets rather than on rails or other dedicated facilities. This flexibility, however, comes with a price: a bus carrying 40 passengers is subject to the same congestion as a private automobile with a single occupant.

University researchers Gary Davis, a professor in the Department of Civil Engineering, and Chen-Fu Liao, senior systems engineer for the Institute’s Minnesota Traffic Observatory, are using intelligent transportation systems technologies to make bus transportation faster and more reliable. Combining newly available technologies such as onboard GPS and advanced traffic signal control systems, Davis and Liao’s bus signal priority system will subtly adjust the operation of traffic signals along bus routes so that buses carrying passengers receive fewer red signals—with minimal disruption to other traffic.

Preempting the normal operation of traffic signals in order to help certain vehicles move through intersections has been widely applied in the area of emergency vehicle operations—to give an approaching ambulance an extended green light, for example. This strategy, although suitable for emergency vehicles that travel quickly and without stopping, is problematic in the case of buses. Many bus stops are located immediately before intersections, which causes problems for fixed-interval signal preemption systems because buses may stop to pick up passengers before proceeding through the intersection.

Current systems designed for emergency vehicles do not take this kind of movement into account, causing the green signal phase to expire while the bus is still picking up passengers. In other instances, a bus stop may be located on the far side of an intersection, or the intersection may have no bus stops nearby.

Metro Transit, the transit agency serving the Minneapolis-St. Paul metropolitan area, has recently installed Automatic Vehicle Location (AVL) systems in its fleet of buses in an effort to improve service quality. These systems use GPS receivers to determine the exact position of each bus.

Davis and Liao are working to coordinate the operation of computerized traffic signal controllers with the movements of buses using wireless data transmission. Two protocols currently support this type of communication: the consumer-oriented wireless computer networking protocol such as IEEE 802.11a, b, and g, and the 802.11p Dedicated Short Range Communication (DSRC) protocol designed specifically for use in vehicle-to-vehicle and vehicle-infrastructure communications.

Rather than automatically changing the state of a traffic signal in response to the presence of a bus, Davis and Liao’s experimental system gives individual traffic signal controllers the ability to decide how to respond to an approaching transit vehicle. Because only one bus at a time can receive priority, when determining which request to grant, the signal controller takes into account the time that priority was requested, the amount by which any bus is behind schedule, and the number of passengers on the bus.

An embedded controller feeds this information, along with the speed and location of the bus and predicted levels of traffic delay, into a digital model of bus movements around the intersection. This model includes the location of bus stops relative to the intersection and the predicted “dwell time” of a bus halting at the stop to pick up or let off passengers.
The model enables the signal controller to predict the state of the traffic signal at the time the bus requesting signal priority arrives at the intersection. If there is a sufficient green-signal interval for the bus to pass through the intersection, then the signal controller does not alter signal timing. However, if the bus arrives at a point in the signal phase with insufficient green time to pass through the intersection, the controller determines how to alter the signal timing—either by extending the green-signal interval or truncating the red-signal interval.

To return a preempted signal to its normal timing following a preemption request, the signal is resynchronized with those of neighboring intersections in a single cycle by reducing the length of the green signal phase and ignoring preemption requests during the recovery cycle.

To calibrate and test their system, Davis and Liao turned to the traffic simulation capabilities of the Minnesota Traffic Observatory. With assistance from graduate student HunWen Tao, the priority strategy was applied to a model of a specific transit corridor in Minneapolis using the AIMSUN traffic simulator and historical traffic data.

Analysis of the simulation results showed a consistent decrease in bus travel times during both morning and evening rush hour conditions, despite the heavier volumes present on the corridor in the evening. Delays experienced by non-transit vehicles, on the other hand, were slightly increased by the signal priority strategy.

While any deployment of transit signal priority in the Twin Cities area is still some time off, Davis and Liao say they hope to work with Metro Transit to explore ways of implementing their work to improve transit service in the Twin Cities. The next phase of their research will focus on developing a prototype system to further validate signal priority using wireless communication.

Development of Real-Time Arterial Performance Monitoring System Using Traffic Data Available from Existing Signal Systems

While signalized arterial corridors such as Minnesota and U.S. trunk highways facilitate the bulk of the Twin Cities metro area’s transportation needs, the signaled intersections along these arterials often fail to operate as a well-integrated system. Poor traffic signal timing contributes to traffic delay, and the subsequent frustration can lead to motorists running red lights or engaging in other forms of unsafe driving behavior.

Despite the growing need to improve signalized intersection management, addressing problems in this area is not easy. Although collecting and analyzing freeway traffic data is fairly straightforward, these tasks become much more complex when they involve signalized arterials. Signal lights are operated by a signal control box, frequently in conjunction with a vehicle detection system, located at the intersection. Usually low-resolution information from the controller, such as 15-minute intervals of traffic volume data, is collected and archived, but signal phase data—that is, how long the green, yellow, and red lights last—are lost. With this control dimension missing from the equation, the true dynamics at play at a signalized intersection are not captured, making it difficult for traffic engineers to properly describe traffic conditions and identify problems in these areas.

Further complicating matters is the fact that controllers do not record and store any data for later study; to evaluate signal system performance, technicians must manually collect information using inefficient, time-consuming, and expensive methods.

With support from the Minnesota Local Road Research Board, the ITS Institute, and Hennepin County’s transportation department, assistant professor Henry Liu and graduate student Wenteng Ma, both with the University’s civil engineering department, have developed a framework to automatically collect and record traffic data from signal controller cabinets and calculate the corresponding performance measures for an arterial road with a group of signal-
ized intersections. This Systematic Monitoring of Arterial Road Traffic and Signals (SMART-Signals), the first system of its kind in the United States, acts much like an airplane “black box” to record every event that happens at an intersection 24 hours a day, 7 days a week. Unlike standard low-resolution data-collection efforts for which traffic volume is counted only every 5 to 15 minutes, SMART-Signals data are considered “high resolution” in that every signal-light phase change is recorded, as is every time the vehicle detector is actuated. This system essentially reconstructs the entire history of an intersection or group of intersections, enabling traffic managers to study such performance elements as intersection delay, queue length, progression efficiency, and arterial travel time.

Since fully launching this project in October 2006, Liu and his team have installed and implemented SMART-Signals devices at 11 contiguous intersections on France Avenue in Hennepin County. These researchers are now retrieving and analyzing the traffic surveillance data collected and working on procedures and methodologies to calculate the appropriate performance measures. Liu and Ma will use these performance measures in future research to identify problems, such as outdated signal phase timing, that occur within a signalized intersection or corridor, and will then fine-tune the signal timing parameters to respond to the identified problems.

Intelligent transportation systems such as SMART-Signals are critical in helping transportation departments cost-effectively manage and optimize existing transportation resources and deliver better services to road travelers. Specifically, the results from this research will help county and state DOTs create and maintain an efficient system along signalized arterial corridors that reduces travel times and delays—and may even help mitigate vehicle emissions and fuel consumption.

Graduate student Wenteng Ma and assistant professor Henry Liu
Research

Social and economic policy issues related to ITS technologies

STAR: Networks and Productivity
Search, Information, Learning, and Knowledge in Travel Decision Making

For the past six years, an interdisciplinary team of researchers from the Humphrey Institute’s State and Local Policy Program (SLPP) and the ITS Institute have been working together to conduct a set of studies, collectively called the Sustainable Technologies Applied Research (STAR) initiative, on how transportation systems can be planned in an increasingly complex social, political, economic, and technological environment. In the final project of this initiative, David Levinson, an associate professor of civil engineering, advised graduate student Lei Zhang (now an assistant professor of transportation engineering at Oregon State University) as Zhang addressed some of the shortcomings of existing travel demand and travel behavior models.

Transportation planners use travel demand models to understand actual travel patterns and forecast future demand conditions. These models are based on travel behavior theories that describe individuals’ travel decision-making processes. But traditional travel behavior theories tend to assume that drivers have “perfect” information that allows them to make rational choices about the best routes and modes available for a given trip. The reality is that drivers do not have perfect information. For example, they generally do not know real-time traffic congestion levels of various roadways and may not know every possible route available, so their travel choices are less likely to be optimal as assumed by existing travel models.

By studying how people actually make travel decisions, Zhang, constructed a general theoretical framework, called the SILK theory for its emphasis on the role of search, information, learning, and knowledge in travel decision making, that describes an individual’s actual decision-making process. He then looked at whether using these more realistic—or positive—behavior assumptions in a travel demand model could lead to different policy recommendations and could affect investment and other planning decisions.

Next, using the SILK behavior theory, Zhang developed a quantitative route choice model—or behavioral user equilibrium (BUE) model—for estimating travel demand on different facilities. Rather than assuming that drivers have perfect information, the BUE model is based on the more realistic behavior assumptions from the SILK framework. In this case, Zhang derived a set of if-then rules using empirical data from route search/choice field experiments in the Twin Cities to describe individuals’ travel decision-making process.

In a typical transportation analysis study area, millions of individuals behave simultaneously and interact with each other. To model these interactions, Zhang applied an agent-based simulation technique that aggregates the individual behaviors, enabling him to track the decision-making process of each individual in the study—something that traditional travel demand models cannot do. By tracking these individual behaviors, he could easily see how a particular policy or project affected individuals with different characteristics (income, age, gender, location, etc.) and how using different behavior assumptions could lead to very different, and sometimes opposite, policy recommendations.

Through the agent-based simulation, he also found that transportation policy analysis that relies on the “old” or normative travel demand and travel behavior models tends to overestimate the benefits of transportation policies and
projects and underestimate associated costs. By using the travel demand and travel behavior models developed in this research, which rely on more realistic behavior assumptions and more accurate estimates of demand responses, DOTs and other agencies can improve their transportation decision-making process and better allocate increasingly scarce resources.

For this study, Zhang compared the new positive approach to the existing normative approach, using only the route choice dimension, to analyze its effect on two different transportation analysis scenarios: aggregate network flow estimation and the traffic diversion effects of ramp metering. However, there are other choice dimensions—e.g., destination, transportation mode, and time of day to travel—that individuals use to make travel decisions. Future work could involve modeling these other dimensions using the SILK theory and then using this new approach to analyze important transportation policies.

Developing ITS to Serve Diverse Populations

Minnesota remains one of the fastest-growing states in the Northeast and Midwest according to recent population estimates by the U.S. Census Bureau. With this growth comes an increasingly diverse population with increasingly diverse transportation needs. This requires new data and analysis to better predict future travel behavior and identify suitable intelligent transportation systems (ITS) technologies to meet these emerging travel needs, as well as plan transportation systems based on new demographic patterns.

In 2003, the State and Local Policy Program (SLPP) at the University of Minnesota’s Hubert H. Humphrey Institute of Public Affairs began a series of research projects exploring how ITS could be used to deliver transportation services to Minnesota’s changing demographics. The latest of these focused specifically on how ITS could be used to support transportation initiatives for people who do not drive an automobile either because they cannot drive or cannot afford a vehicle.

Researchers first conducted a series of analyses to identify the ITS applications that appeared most promising to improve mobility and access for Minnesota’s diverse population. The team determined these applications to be community-based transit (CBT), car sharing, value pricing, and Web-based advanced traveler information systems (ATIS). Various studies were then carried out to address each of these applications individually.

Community-Based Transportation

Humphrey Institute researchers Frank Douma, Gary Barnes, Heather Dolphin, and Sarah Watters studied the community-based transportation (CBT) aspect. Past research in this arena indicated that CBT services could be improved in terms of both operational and administrative

Frank Douma and SLPP research assistants Britta Stein, Tyler Patterson, and Steve Petersen are working to determine the cost and time benefits of using a car-sharing service or MnPASS for potential trips.
efficiency. In this study, the team examined whether ITS and related innovations could help achieve these goals. Specifically, this team sought to better understand the existing inefficiencies so that technologies could be identified or developed to address these specific needs.

From a set of surveys, the team determined that of the approximately 3,000 organizations in Minnesota providing and arranging transportation, most are unaware of each other. Nonetheless, these organizations showed some interest in collaboration but felt that several barriers, including insurance restrictions and legal constraints, got in the way of doing so. Other barriers result from the many rules attached to the variety of funding sources for these programs. Overall, the survey results suggested that coordination would be a large undertaking, given the multiple types of trips served by these organizations.

**Car Sharing**

Douma, along with graduate student James Andrew, examined car sharing services, which employ ITS technologies to efficiently and cost-effectively handle car reservations, access, and billing. They studied a number of perspectives to assess whether and where car sharing might succeed in the Twin Cities and how the conventional car sharing business model might be modified to bring the benefits of car sharing to low-income users.

The researchers interviewed car sharing organizations throughout the United States and conducted focus groups in Seattle and Chicago of members and non-members in car sharing neighborhoods. They used these findings to model ideal car sharing neighborhoods in the Twin Cities, assessed the factors that could lead to the success or failure of such a model in different neighborhoods, and analyzed which of the neighborhoods in the Twin Cities would be most likely for such a model to succeed. They found that higher-density mixed-income neighborhoods in the Twin Cities (e.g., Uptown, Loring Park, the University of Minnesota) have the greatest potential for car sharing.

More research is needed to define the nature and travel behaviors of car sharing users in the Twin Cities. Andrew and Douma are now working with HOURCAR and Zipcar, two firms that offer car sharing services locally, to conduct a follow-up study to investigate the impact car sharing options have on travel behavior in the college marketplace.

**Value Pricing**

Researchers Johanna Zmud and Chris Simek, with the consulting firm NuStats, and Steven Peterson, with SLPP, analyzed preferences and travel behavior for individuals in the Interstate 394 (I-394) travel shed before and after the 2005 conversion of the high-occupancy vehicle (HOV) lane to a high-occupancy toll (HOT) lane, a change enabled in part through ITS technologies that allow for at-speed toll collection. Their primary objective was to assess attitudes and awareness of the MnPASS toll lane system and any resulting changes in travel behavior after the conversion.

Findings from three waves of attitudinal panel surveys show support for the HOV conversion across all income levels and genders. Most significant, both users and non-users of the HOT lane perceived that congestion went down after the lane was converted. In addition, users said they experienced high levels of satisfaction with
the all-electronic toll operations. Other technology-related aspects of MnPASS—such as ease of opening a transponder account, use of a credit card to replenish the account, ease of installing the transponder, clarity of prices on overhead signs, and toll amounts that vary with traffic levels—also received high satisfaction levels.

Mn/DOT continues to support ongoing research investigating changes that could further enhance and benefit the transit aspects of the MnPASS system and continues to invest in and research ways of making MnPASS even more user friendly.

**ATIS evaluations**

In their study of an ATIS (advanced traveler information system) evaluation model, Thomas Horan, with the Claremont Graduate University and the U of M's State and Local Policy Program at the Humphrey Institute, and Tarun Abhichandani, also with Claremont, examined the experience of individuals who used metropolitan transit authority Web sites to plan transit trips. They conducted user surveys and focus groups in Minneapolis and Los Angeles to gather reactions to Web sites for Minneapolis/St. Paul Metro Transit and Los Angeles County Metropolitan Transportation Authority, based on trip-planning scenarios presented to participants.

The study showed that in terms of general usability, the two Web sites studied provided a good way to plan transit trips. However, respondents in both the cities indicated the need for improved customization features such as the ability to store trips for future planning, more location information, and standard interactive Internet-ready maps.

Although the Web sites considered in this study represent only one type of many Web-based interactive services, they do characterize citizens’ experience using a government-led ATIS. As such, the evaluation model in this study could be used by government agencies to assess other systems such as those for public library, water works, and tax payment services. Metro Transit, for instance, found the results of this study valuable and is undertaking further study with SLPP researchers.