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 TEA-21 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, and Metro Transit 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.

Researchers Kevin Krizek, Gavin Poindexter, and Ahmed El-Geneidy
In-Vehicle Driver Assistance for Teenagers

Parents of teenagers often worry when their child starts driving—and not without reason. Teens are among the most risk-prone groups of drivers, experiencing higher crash rates than drivers with a few more years of experience and having the highest traffic fatality rate of any age group. Several researchers with the ITS Institute are working to address this serious public safety issue by developing in-vehicle technology to monitor and correct inexperienced drivers’ unsafe behaviors behind the wheel.

Professor Stephen Simon of the Law School is leading the project, which includes ITS Institute director Max Donath and HumanFIRST Program director Nic Ward as coinvestigators and mechanical engineering graduate student Shawn Brovold, who has designed much of the technology to date.

According to Simon, what can be done among certain groups of high-risk drivers (such as DWI repeat offenders) in terms of controlling or monitoring their driving behavior is limited, but with teenagers, “a parent has absolute control over their car,” he says.

The research team’s Teen Driver Support System (TDSS) is aiming to address the primary causes of most fatal teen-driver crashes: speeding, lack of seat belt use, alcohol impairment, and driver inexperience. The system uses a combination of forcing, feedback, and reporting functions. The forcing function consists of an ignition interlock that will prevent a driver from starting a car if he or she is not buckled up or is not sober. The feedback function provides real-time in-vehicle warnings about illegal or unsafe speeds. The reporting function records vehicle information for later review by parents or licensing agencies.

An example of how the reporting function might operate is that the system would call or send a text message to parents if their teenager continuously exceeds the speed limit past a time threshold. This timing is significant, Simon says, because the quicker an intervention is applied, the more effective it is in stopping the behavior.

To date, the team has developed a prototype system for speed-limit feedback and reporting within Hennepin County. The system links the speed-limiting function to a digital map (derived from a road-classification database maintained by the Minnesota Department of Transportation and a speed limit database from Hennepin County) and a GPS sensor to determine the road on which the vehicle is operating and the road’s speed limit. If the driver’s current speed exceeds the road’s posted limit, an audible warning is used to notify the driver, and details (e.g., time, location, speed) of the infraction are recorded for later review.

The system’s ability to calculate the vehicle’s location means an even more ambitious safety feature might be possible: driver warnings and intervention based on road geometry and weather conditions. Young drivers are involved in a disproportionate number of “run-off-the-road” crashes because they lack the driving experience to recognize hazardous conditions until it is too late to adjust. By “looking ahead” to see if the vehicle is approaching a sharp curve or other potentially hazardous road feature, the system could issue a warning to inexperienced drivers before they get into trouble. In addition, the system could use Mn/DOT’s weather recording devices to get real-time information on current driving conditions, such as icy roads or fog, and adjust the car’s maximum speed limit accordingly.

Brovold points out that most vehicles already have various technologies needed for the TDSS built into them. Vehicle navigation systems could serve as a platform for speed warning systems. Some newer cars even have an event data recorder—a sort of “black box”—that records data leading up to and at the time of a crash (how fast the car was traveling, the seat belt status, etc.). Cars also have an ignition interlock that prevents them from being started if it’s in the “drive” gear. Automakers, who already install seat belt sensors, could
combine these features to make a seat belt ignition interlock. However, these types of safety features have yet to be implemented or offered as factory options.

Next steps in the research are to continue testing the system locally for functionality, test attitudes about the system and how feedback is delivered with teenagers in a driving simulator, conduct multi-vehicle field operations tests, and conduct market analysis. The researchers hope to receive a start-up grant to build, install, and test additional prototypes. From the market analysis, they also hope to gauge the public’s interest in the system as well as learn how to package and market the product.

**Chromatic Perception Effects on Collisions with Snowplows**

Snowplow operators frequently face the hazardous task of clearing slippery, snow-covered roads to make them safe for travel. But in the process of clearing roads, plows can temporarily create even worse conditions for the drivers behind them. Under these low-contrast conditions, drivers often can see that a snowplow is ahead, but cannot tell how far away it is or even that they are approaching it. Some recent experiments also indicate that under low-contrast conditions, people perceive themselves to be traveling significantly slower than they actually are. To compensate, they speed up. Together, these issues constitute some of the most dangerous conditions drivers in Minnesota commonly experience and are why snowplows are so vulnerable to rear-end collisions.

Researchers now understand why: the visual mechanism that perceives motion is insensitive to color differences, and instead, it depends on brightness, or luminance contrast. Thus, in the absence of luminance contrast, the ability to perceive motion disappears. Albert Yonas, with the University’s Institute of Child Development, and Lee Zimmerman, with the University of Minnesota Duluth’s electrical and computer engineering department, have studied this phenomenon and are working to minimize its contribution to rear-end collisions with snowplows.

According to Yonas, two distinct problems must be tackled. First is the need to get drivers’ attention and let them know a snowplow is ahead. Second is the need to enable drivers to see that they are gaining on it, and how fast they are doing so. Until now, Yonas says, there has not been clear differentiation between these two issues.

Using a simple computer driving simulator to replicate the effects of blowing snow and fog, these researchers monitored test participants who were asked to decide whether a simulated “truck” approached or withdrew as the brightness contrast of the simulator display was varied. This unique experimental setup allowed the team to study snowplow designs and the effects of flashing warning lights on a driver’s detection of approach and impending collision.

Through these efforts, Yonas and Zimmerman observed that lowering the luminance contrast between the simulated image of a vehicle and the background greatly reduces a driver’s ability to perceive approach. Specifically, they found that the low-contrast environment created by snow or fog significantly reduces drivers’ ability to see that they are approaching the snowplow. They also discovered that the flashing lights mounted on snowplows to attract attention interfere with motion perception and make it even harder for drivers to see that they are approaching the snowplow.

From this work, the team has developed a set of recommendations for properly outfitting snowplows with lights that better enable drivers to see that they are approaching the plow.

“There must be a balance in the snowplow lighting and coloring to attract attention, yet not interfere with the ability to tell whether or not a driver is approaching it,” Zimmerman explained. “Our current experiments are getting us closer to finding that balance.”

One suggested design approach is to ensure that rear-facing lights and markings on snowplows create optimal luminance contrast while reducing the offending color contrasts.
This can be accomplished by putting two solid light bars on either side of the rear of the snowplow, as far away from each other as possible, and by making the light as bright as possible. A second possibility involves structuring rear-facing markings to help drivers better tell when they are approaching a snowplow. This involves making sure the flashing lights are placed in such a way that they do not interfere with the ability to see the steady burning lights. For example, steady burning light bars could be positioned on the sides of the snowplow and a flashing light could be placed above the center of the rear of the snowplow.

In the future, these researchers would like to team up with Mn/DOT for real-world testing. The overall findings will likely improve driving safety through the careful choice and placing of color warning markings, as well as through better public education.

**Technologies for Modeling, Managing, and Operating Transportation Systems**

**ROV Surveillance for Transportation Management and Security**

The bird’s-eye view afforded by an aerial platform offers many advantages for gathering data on traffic movements and general surveillance of transportation infrastructure, including a wide field of view and the capability of moving rapidly between different monitoring sites or following a single vehicle as it traverses a network. But the expense and risk associated with keeping a piloted plane in flight for hours at a time—not to mention the highly trained personnel and maintenance required—limit the effectiveness of conventional aircraft as monitoring platforms.

One solution to these limitations is to find an alternative to the pilot—the most sensitive and expensive component in the system. Demoz Gebre-Egziabher of the Department of Aerospace Engineering and Mechanics, along with a team of other researchers, is developing remotely operated aerial vehicles (ROVs) as monitoring platforms specifically targeted at surveillance and inspection of the surface transportation system. Through advances in navigation and guidance systems, sensors, and flight operations techniques, ROVs may play an important role in future transportation data collection and security.

As a remote sensing platform, the usefulness of an unmanned aerial vehicle depends on how well its position can be determined at all times. This is critical not only for the safe operation of the ROV in a complex aerial environment that includes restricted airspace and navigational obstacles such as tall structures, but also for the accurate location of events and conditions observed on the ground.

The navigation and guidance system of the Minnesota team’s ROV is based on high-accuracy Global Positioning System (GPS) receivers. Basic position and velocity can be determined with GPS using the Federal Aviation Administration’s (FAA) Wide-Area Augmentation System (WAAS), which enhances the accuracy of the basic GPS.
Attitude determination for the small craft is a more difficult problem, one which has led Gebre-Egziabher to develop an approach based on three GPS receivers. These receivers track and process the GPS carrier signal (rather than the digital information encoded within the signal) to achieve centimeter-scale range measurement accuracies. Monitoring the relative positions of the three antennas enables the onboard computer to calculate accurate estimates of pitch, roll, and yaw (movement about the lateral, longitudinal, and vertical axes of the vehicle in flight).

The researchers are exploring the possibilities of a novel “click-to-navigate” system that integrates position sensing and an operator interface based on flight simulator display technology. This software uses aerial photographs of the operating area to provide a realistic picture of the terrain below, in pseudo-3D perspective. By feeding the location of the ROV to the flight simulation software, the researchers succeeded in creating an artificial view from the aircraft in real time, which can be presented to the operator side-by-side with the actual camera view. The system can also display the boundaries of prohibited airspace in relation to the ROV. The artificial perspective could be immediately useful as an aid to the operator, providing a clear and unobstructed view of landmarks below. It also shows the potential for displaying augmented information such as map data. Gebre-Egziabher is now investigating the potential to build the simulator approach into a “click-to-navigate” system that would allow an operator on the ground to send the ROV over a designated point on the ground.

While a remotely operated vehicle has advantages over a piloted aircraft, a partially or fully autonomous craft offers even more intriguing possibilities. Designing a degree of autonomy into the ROV’s guidance system would allow the vehicle to move from location to location, or around a patrol route, without requiring an operator on the ground to guide it through each turn.

Being pilotless, however, does not exempt ROVs from the FAA’s strict regulations governing all aircraft operations, including the requirement that aircraft operating in controlled airspace possess the capability to autonomously “sense and avoid” other aircraft. Gebre-Egziabher describes the development of autonomous sense-and-avoid systems as the greatest challenge facing ROV researchers today. Such systems will make it possible for autonomous and semi-autonomous ROV sensor platforms to operate in a wide range of areas. Because highly accurate and dependable navigation is a necessity for future sense-and-avoid capability, much of the Minnesota researchers’ work is directed at developing operational techniques and navigation systems that provide verifiable levels of navigation safety consistent with FAA requirements. For most aviation applications, the threshold navigation integrity during normal operations—i.e., the likelihood that a navigation system will report a position outside the protection levels—is set at one in ten million, or $10^{-7}$.

Due to inherent inaccuracies, a system based purely on GPS cannot guarantee positional integrity at the small scales required for safe navigation. The design of algorithms that combine data from different types of sensors is a challenge in itself. The goal is to take advantage of the strengths of each type of sensor while minimizing its weaknesses. As different sensor types produce data at different rates and with different levels of accuracy, successful “sensor fusion” depends on factoring out a large number of possible sources of error.

The Minnesota researchers’ work has important implications for all types of ROV applications. Unmanned vehicles that can operate autonomously or semi-autonomously could one day replace piloted aircraft in a wide variety of dull, dirty, and dangerous missions—reserving pilots for those tasks where local human decision making is critical for success.
Crash Prevention Based on Automatic Detection of Crash-Prone Traffic Conditions: Phase I

Researchers have long hypothesized that certain traffic conditions create a greater risk for freeway crashes and that if these conditions were detected, certain actions could be taken to lower the crash risk. Although previous research by others has proven the existence of crash-prone conditions, the study methods used were not based on real-time information, and therefore research results did not facilitate development of appropriate crash-prevention countermeasures. Professor Panos Michalopoulos and research fellow John Hourdos, both with the University’s Department of Civil Engineering, set out to develop the real-time algorithms needed to create a driver-warning system designed to help prevent crashes in high-risk areas.

Their first step was to study the reasons for, and mechanics of, crashes by recording them and extracting raw traffic detector measurements. The researchers designed and assembled a set of unique sensors and surveillance equipment, which they deployed along I-94 westbound through downtown Minneapolis—the stretch of road with the highest rate of crash occurrences in Minnesota. With these instruments, the researchers collected individual vehicle speeds, headways, and lengths at 52 points along the freeway. In addition, they simultaneously recorded video 12 hours a day for two years, capturing all of the crashes and near misses occurring during that time.

As they reviewed the data collected, the researchers pinpointed the entire sequence of events leading to each crash and identified three specific elements contributing to nearly all crashes in this area: congestion shock waves that propagate backwards from the merge area of a downstream entrance ramp; the large difference in driving speeds between the right and middle lanes, which makes lane-changes difficult and therefore dangerously distracting for drivers; and last, the fact that in the area where the shock waves begin, vehicles are simply too close to each other to allow drivers time to take evasive actions.

Researchers also verified that the same elements contributing to crashes also cause “near miss” events. They recorded four times the number of near misses as crashes and observed that the difference is a matter of split seconds. With these findings, the team developed an algorithm capable of accurately detecting the presence of crash-prone conditions nearly 70 percent of the time.

In the second phase of this project, currently under way, the researchers will integrate their previously developed detection algorithm into a real-time driver warning system specifically designed for the I-94 westbound commons section. Through a variety of driving simulator experiments, Michalopoulos and Hourdos are working to narrow down the multitude of options for such systems to one or two and will proceed with additional testing from there. One of the systems under consideration includes pavement lights that light up to simulate the shock wave and alert drivers to congestion ahead. The researchers are looking at a number of geometric reconstruction solutions as well as electronic breaking systems capable of vehicle-to-vehicle communications.

Based on the Phase I research results, Mn/DOT is already making changes in the road geometry in the commons area. It will alter the striping at the merge area where the shock waves are generated, a strategy that may significantly reduce crashes in this area. Although it is hard to predict just how many crashes can be avoided, a reduction of even 50 percent would result in millions of dollars in savings from crash costs as well as reduce related congestion, travel time delays, and system productivity losses for drivers throughout the freeway system.
Lateral Stability of a Narrow Commuter Vehicle

The predictions are bleak. By 2010, urban freeway congestion is expected to double in urban areas of every size, resulting in unbearable gridlock and rising costs to motorists in the form of wasted time and fuel consumption. Since most transportation planners agree that we can’t “build our way out of congestion,” other solutions to this growing problem are needed.

A relatively unexplored but promising idea is the use of narrow commuter vehicles that, like motorcycles, can double the capacity of existing freeways since they take up only half a traffic lane. Although smaller, more fuel-efficient vehicles could greatly reduce both congestion and fuel demand, for many people, a motorcycle is not practical or feasible. For the general population to adopt narrow vehicles as a form of personal transportation, the vehicle must be as easy to use and provide the same level of safety as full-size passenger sedans.

A team of University researchers from the mechanical engineering department—including Rajesh Rajamani, Lee Alexander, Patrick Starr, Max Donath, and Samuel Kidane—recently finished redesigning and building a second-generation prototype narrow commuter vehicle. Unlike the team’s first concept model, which was operated and tested via remote control, the improved version is capable of carrying a driver. This model also has a more powerful engine that enables it to travel at highway speeds and several improved safety features, including a driver-protective roll cage.

Perhaps the most significant upgrade to this concept vehicle is the reengineered electronic tilt-control system, which did not work at slower speeds in the first design. The tilt-control system helps the driver balance this three-wheeled, rear-wheel-drive vehicle, which is relatively tall compared to its track width. The benefit of this narrow, tall design is to provide a travel height comparable to that of other vehicles on the highway; however, this design reduces the vehicle’s lateral stability. The electronic tilt-control system helps the driver easily balance the vehicle and keeps the vehicle from tipping or rolling over.

The new steering tilt-control system uses both direct control, which was unavailable in the previous model, and steer-by-wire technology, offering great improvement over the previous version in terms of balancing and overall handling, especially on curves where the vehicle must lean into the curve to ensure tilt stability. The team developed an innovative algorithm that satisfies both the driver handling and tilt stability requirements and incorporated the algorithm into the tilt-control system design. With the steer-by-wire system, the front-wheel steering angle is used to control tilt, while at the same time allowing the driver to use this steering angle for lateral control. The direct tilt-control system incorporates an electric motor in a novel vehicle suspension to achieve directly actuated tilt control. Experimental results show that the control system sufficiently stabilizes the vehicle without all of the limitations of the original design.

The team’s next step is to secure additional funding. With financial support in place, the researchers will work toward further improving the vehicle’s crashworthiness by incorporating front and side air bags and collision-avoidance features. Future work will also involve the study of human-machine interfaces, the addition of drivability and comfort improvements, and improvements to the propulsion system. The results of this study are likely to inform the development of future transportation technologies for reducing congestion on freeways in Minnesota, around the country, and throughout the world.
Decision Support System for Evacuation Route-Schedule Planning: Determining Optimal Contraflow Network Configuration

As Hurricane Rita sped toward Houston and the upper Texas Gulf Coast in late September 2005, hundreds of thousands of people attempting to evacuate the area were stuck in their cars, many running out of gas and sweltering on roadsides in 100-degree heat. This mass, traffic-snarled exodus created colossal 100-mile-long traffic jams, with traffic crawling at just a few miles per hour at best and completely stopping for hours at worst. One method often used to minimize evacuation snafus like this is known as contraflow, or lane reversal. It’s a relatively simple way of increasing the number of lanes available for outbound evacuation traffic.

Although considered a potential remedy to reduce evacuation time and congestion during emergencies, contraflow as it exists today relies on configuration algorithms that address only a single-source/multiple-destination situation. These approaches cannot handle a multiple-source problem and so are not effective in cases when the number of evacuees is finite, road capacities are constrained, or specific destination nodes are prescribed. Researchers Shashi Shekhar and Sangho Kim from the University’s computer science and engineering department are exploring alternative algorithms that address the limitations of current approaches.

Using graph theory, the team has developed a set of new algorithms and software tools that can help disaster planners determine the optimal network configuration given both the physical transportation network and traffic demand for a particular evacuation scenario.

In the initial stage of this project, Shekhar and Kim evaluated algorithm alternatives analytically and experimentally using real-world data sets based on evacuation scenarios for the Monticello nuclear power plant and the Twin Cities metro area. In experiments using the Monticello scenario, the team found that evacuation times could be reduced more than 40 percent by selectively reversing just 10 percent of the entire road segment, which mainly included major highways I-94 and MN-Hwy 10 from St. Cloud to Maple Grove, and some roads around the evacuation shelter at the Osseo high school.

The team then developed a computerized evacuation route system for the Twin Cities metro area to generate large-scale evacuation scenarios for user-specified locations. This system enables evacuation planners to explore multimodal evacuation options, such as pedestrian versus vehicle-based evacuation processes, and observe the differences among contraflow configurations affected by the options.

In addition, the researchers studied the effects of overload degree—that is, the ratio of the number of evacuees to bottleneck capacity of a transportation network without contraflow. They discovered that overload is a key determinant of overall evacuation time and need for contraflow. In situations when there are only a small number of people needing to evacuate, contraflow offers little or no benefit. The real benefits of lane reversal appear once the transportation network reaches overload and it becomes computationally possible to identify an optimal contraflow reconfiguration.

Shekhar and Kim are now working to refine the algorithms to allow for incoming emergency vehicles and to account for resource or infrastructure limitations to implementing contraflow. Ultimately, these efforts will provide improved tools to help evacuation planners come up with the most effective disaster evacuation routes and schedules. This will greatly minimize evacuation times and presumably avoid the Hurricane Rita-type chaos when quickly moving a large number of citizens out of harm’s way.
Social and Economic Policy Issues Related to ITS Technologies

Understanding the Potential Market of Metro Transit’s Ridership and Services
In 2000, Metro Transit, the local transit provider for the Twin Cities region, served more than 73,000 unlinked passenger trips. In 2003, this number fell to slightly more than 67,000. This indicates a decline in demand for public transit service in the Twin Cities during this period—a decline not found in other major transit agencies around the country.

Then, in 2005, the opening of the Hiawatha Light Rail line led to a 30 percent increase in transit ridership relative to the previous year. Still, Metro Transit faces other challenges that relate to serving a diverse population made up of people of all ages and backgrounds with varying riding habits, needs, and preferences.

University researchers Kevin Krizek from the Hubert H. Humphrey Institute of Public Affairs and Ahmed El-Geneidy, who holds a joint appointment with the Humphrey Institute and the Department of Civil Engineering, recently wrapped up their analysis of results from two surveys conducted in the Twin Cities metropolitan region over the past few years: one of existing riders and the other of non-riders. Their objective was to better understand the attitudes and preferences of current and potential riders and recommend transit technologies that could help increase the ridership of the Metro Transit system.

Conventional travel analysis typically focuses on only two types of transit users: captive and choice riders. Captive riders are usually those who lack an alternative to transit and so use it as their main mode of travel to reach their destination. Choice riders are those who typically choose to use transit or a different mode (driving or walking) to reach their destination. Krizek and El-Geneidy also considered the regularity of commuting habits, enabling them to classify transit riders into four categories: captive with regular commuting habits, captive with irregular commuting habits, choice with regular commuting habits, and choice with irregular commuting habits. Similarly, they classified non-transit riders into four categories: captives with regular commuting habits, captives with irregular commuting habits, potential riders with regular commuting habits, and potential riders with irregular commuting habits.

Using statistical factor analysis followed by a cluster analysis, these researchers examined the relative importance of different factors to different survey populations, especially those who choose to ride the bus even though they have access to private automobiles, and potential riders who may be interested in using public transportation but feel that it does not meet their needs. Through this analysis, they identified a number of factors affecting the decision to use public transportation, including safety, reliability, driver attitude, amenities, and wait time for service.

Krizek and El-Geneidy then developed a list of technological advancements Metro Transit could use to address several of these attitudes and preferences. For example, installing cameras inside buses increases security; automating stop announcements could help riders with disabilities or people unfamiliar with the route; encouraging the use of swipe cards could decrease travel time by reducing the delay during passenger boarding. Other technologies, such as automatic vehicle locator (AVL) systems, are gaining popularity as ways of improving transportation service by providing information—via electronic displays in stations or by cellular
phone—about schedules and wait times and by helping drivers stay on schedule.

Using technology to decrease transit wait and travel times appears to provide the best opportunities for increasing ridership, especially when expanding routes is not an option, Krizek and El-Geneidy concluded. So, although Metro Transit previously used an AVL system chiefly for monitoring drivers’ on-time performance, it is currently testing the system to inform riders about arrival and departure times at selected bus stops in the region. In addition, Metro Transit is now armed with a better understanding of the attitudes and preferences of the eight types of commuters classified in this research and can use this knowledge to improve its efforts to retain current riders and attract new ones.

**Sustainable Technologies Applied Research Initiative: Privacy and ITS**

Since 2001, researchers from the Hubert H. Humphrey Institute of Public Affairs’ State and Local Policy Program (SLPP) and the ITS Institute have been working together to conduct a set of federally sponsored 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. As part of this interdisciplinary team, SLPP director Lee Munnich and graduate student Adam Kokotovich are beginning research on ways to identify and address privacy issues related to the use of intelligent transportation systems.

ITS technologies are experiencing widespread growth, from OnStar technology to automatic toll collection. The growth in technology, however, is leading to more concerns about privacy, says Munnich. As a result, a primary policy challenge related to the use of ITS technology will be ensuring the privacy of the users.

In addition to a broad examination of transportation privacy issues, Munnich and Kokotovich are focusing on specific ITS technologies that are generating privacy concerns: electronic toll collection and Global Positioning Systems used in value or congestion pricing (charging drivers fees for road use that vary according to time of day or traffic conditions) and mileage-based fees.

The researchers want to determine what the privacy concerns are, and how they can be mitigated by incorporating this information into the framework of ITS systems. To date, little research has been done on privacy as it relates to transportation, the researchers say. “The need is there not just because people are concerned about [privacy] but because, for the implementation of these intelligent transportation systems, public acceptance is key,” Kokotovich says.

The public may be more likely to accept these technologies if the processes for collecting and using data are transparent, and if people understand the processes, Munnich says. “It’s not only about how you are collecting information, but also what people’s perception is of what you’re doing,” he says.

In addition to its use for transportation financing options, emerging ITS technologies are being developed to improve
safety. In-vehicle systems can track a particular car on the roadway and individual driving behaviors inside the car. Such a system might give a warning or reminder to the car’s driver to encourage safer driving. This information that is generated, however, could be used in ways that would invade privacy, Munnich says. For example, if you were driving in your car and received a message advertising a nearby business, you might perceive that as a benefit, or you might consider it an intrusion, Munnich says.

Transportation planners need to anticipate these issues before they arise, he adds. “If you move too quickly with the technology and the public isn’t ready for it, you may have to backtrack.”

People have different perceptions and acceptance levels of privacy, and the definition is constantly changing, Kokotovich says. Whereas few people might object to technology that prevents a repeat DWI offender from starting a car without passing a Breathalyzer test, “monitoring traffic on a freeway and having it personally identifiable to the vehicle and who’s driving the vehicle—everyone is going to object to that,” he says. “There’s a need to find the middle ground as far as what’s acceptable technology-wise.”

When ITS is used to improve safety or convenience for a driver, such as with OnStar, that may be an acceptable trade-off, Munnich adds. “It may be that the overall benefits to the individual and to society outweigh the privacy concerns. There may be significant benefits but it may not be possible to guarantee that privacy won’t be negatively affected.”

So far, the researchers have met with a nationally recognized expert on privacy, Professor Colin Bennett from the University of Victoria, who also spoke on the issue of privacy at the Center for Transportation Studies’ annual Transportation Research Conference. Kokotovich is now working on a paper to frame the issue of privacy related to transportation and suggest some specific issues to examine in-depth. The researchers’ ultimate goal is to provide relevant, useful information for planners and policymakers to incorporate into future transportation systems.