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 diverse research program joins technologists 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 partners such as the USDOT Research and Innovative Technology Administration’s University Transportation Center program, the Federal Highway Administration, the Federal Transit Administration, the National Highway Traffic Safety Administration, the National Park Service, and the National Science Foundation. Local partners include the Minnesota Department of Transportation (MnDOT) and the Minnesota Local Road Research Board. Additional funding and in-kind support are provided by the Metropolitan Council, various Minnesota counties, Metro Transit, Minnesota Valley Transit Authority, City of Duluth, and other local governments, agencies, and private companies.

A selection of research projects under way is highlighted in the pages that follow.

Research funding sources for all ITS-related research projects

New funding for ITS-related projects was approximately $6.2 million in FY12. The sources for these new FY12 research project revenues are shown in the chart, on right.

During this period, 50 faculty and research staff and 65 students were involved in ITS-related research.
A driver-assist system (DAS) developed by the ITS Institute aims to increase driver safety in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. The system combines centimeter-level differential global positioning systems (DGPS), high-accuracy digital mapping systems, vehicle-mounted sensors, a windshield head-up display (HUD), a virtual mirror, and haptic and tactile feedback. Deployed in buses and snowplows, these systems help drivers operate more safely and efficiently in heavy traffic and low-visibility conditions.

Cutting through congestion

The DAS has been in use on 10 Minnesota Valley Transit Authority (MVTA) buses operating in the Cedar Avenue bus rapid transit (BRT) corridor since 2010 and is the first deployed system of its kind. The system monitors a bus’s position on the roadway and provides visual and tactile alerts to quickly deliver critical information to the driver.

A recent evaluation published by the Federal Transit Administration (FTA) found that the DAS is improving bus operations and reducing driver stress for those driving on these

More than 60 percent of bus drivers said the driver-assist system made driving in the shoulder safer and less stressful.
bus-only shoulders. The FTA evaluation measured the performance of the DAS in six areas, including efficiency/productivity, rider satisfaction, and driver satisfaction. It was conducted by researchers at the National Bus Rapid Transit Institute at the University of South Florida.

Overall results indicate that drivers stayed in the shoulder lanes 10 percent longer and drove 3 miles per hour faster while the DAS was active, indicating an increase in driver confidence.

For bus passengers, the DAS was a positive but invisible presence. More than 80 percent of riders rated the ride quality in the shoulder highly, and more than 95 percent were satisfied with travel time reliability. Most people, however, were unaware that the DAS had been installed on the buses.

“The fact that passengers didn’t really notice the system is in fact a good result,” says MVTA transit planning manager Mike Abegg, a leader of the Cedar Avenue project. “The system should function in the background for passengers, with the results only felt in that their trip is faster and more reliable.”

Results from drivers were also positive, with 60 percent of drivers said the DAS made driving in the shoulder safer and less stressful.

The installation of the system was funded by the FTA through the U.S. Department of Transportation’s Urban Partnership Agreement with match from the Twin Cities Metropolitan Council. The ITS Institute’s Intelligent Vehicles Laboratory and HumanFIRST Program collaborated with the MVTA and Schmitty and Sons Transportation on the installation.

“I’m pleased that the evaluation documented a measurable improvement in driver performance,” Abegg says. “The fact that bus operators had a positive reaction overall is also encouraging for the adoption not only of this specific technology, but the wide spectrum of connected-vehicle technologies that are on the near horizon.”

**Working through whiteouts**

Record snowfalls pummeled much of Alaska during the 2011–12 winter—and served as a good test for the DAS installed on Alaska Department of Transportation & Public Facilities vehicles. The technology helps vehicle operators keep an eye on where they are and what else is around them—even when they can’t see the actual road.

In Alaska, the driver-assist technology is currently installed on four snowplows, one blower, and two airport rescue and firefighting vehicles. The system is helping operators clear snow in the Thompson Pass area, a 2,800-foot-high gap in the mountains northeast of Valdez, which receives more than 700 inches of snow annually and routinely experiences whiteout conditions and zero visibility.

“Maintaining the Richardson Highway through Thompson Pass presents a difficult challenge for the Alaska DOT. The driver-assistive system helps us to meet that challenge,” says Ocie Adams, maintenance and operations
specialist in ITS with the Alaska DOT.

Along with Adams, Mark Hanson and Pete Carter of the Thompson Pass Maintenance Station enthusiastically attest to how the system has made for more efficient and less stressful road clearing.

“During a whiteout storm, it’s easy to get confused where you are on the road—not side to side, but what mile marker you’re at,” Hanson says. “Speed can be deceiving, [and] you can’t see any landmarks.” Because the DAS displays virtual landmarks and mile markers, he explains, “It really makes your stress level go down. You can see so much better. You have much better confidence of where you’re at on the road, and you can plow the road straighter. It’s really a nice tool.”

Hanson says that when the DAS was first installed in the vehicles, some operators were uneasy using it. “But now that it’s been in the trucks for a while, and people are realizing how versatile it is …Everybody up here is on board with it.”

“It’s really the issue of new technology and your level of confidence in it,” Adams adds. Since the technology was initially installed, the Institute’s IV Lab team has made some improvements based on feedback from the drivers using it. “The thing that impresses me the most is the [IV Lab] staff’s willingness to listen to us,” says Adams. “They’re one of the best we’ve ever used as far as it being a partnership.”

Besides easing driver stress, Adams notes other benefits: snowplow operators can stay on the highway even when it’s closed to traffic, allowing emergency vehicles to get through and the traveling public to get back on the road quickly once it reopens. The system also gives drivers the ability to clear the shoulder right next to the guardrail (which is often completely buried) without hitting it. Further, the technology can help prevent collisions with other vehicles on the road that may not be visible to the eye but show up on the head-up display.

Carter says the system has improved public service in two ways. “We’re much more efficient. We don’t have to do second passes like before, when we were blind and couldn’t find the road,” he says. And second, there’s less danger that plow drivers will go off the road and end up stuck. “You don’t have to worry about that because you know exactly where you are.”

“We’re much more efficient. We don’t have to do second passes like before, when we were blind and couldn’t find the road.”
—Pete Carter, Thompson Pass (Alaska) Maintenance Station
Crossing a street isn’t risk-free for any pedestrian, but it’s especially challenging for the blind or visually impaired.

Chen-Fu Liao, senior systems engineer in the ITS Institute’s Minnesota Traffic Observatory, led a research team that developed a prototype Mobile Accessible Pedestrian Signal (MAPS) system using a smartphone, GPS, and other technologies to help people with limited or no eyesight cross signalized intersections safely.

For their work (initially funded by the ITS Institute), the researchers interviewed 10 blind and low-vision people to better understand what types of information they use at intersection crossings and to identify what could help them. “Engineers can design great, fancy stuff, but if nobody wants to use it, it’s not useful at all,” Liao says.

Ken Rodgers, president of the American Council of the Blind of Minnesota, was one of the study participants who provided input and helped test the prototype. “I think the whole system and the whole concept is so beautiful,” he says. “It just works well.”

Blind or visually impaired pedestrians face a
number of challenges, such as difficulty locating the edge of the street or crosswalk and interpreting signal and traffic patterns. Current crossing systems, which use audio warnings, have shortcomings for municipalities, including the cost of equipment and maintenance. And because there is no standard location for push-button signals, visually impaired pedestrians must deviate from their preferred travel paths to request a crossing signal, which can make navigating the intersection more difficult.

The MAPS system goes above and beyond existing crosswalk aids. While standing at an intersection, the user can point a smartphone in the direction he or she wants to cross and call up information about the intersection and the signal phase by tapping the unit’s touchscreen once. Tapping twice confirms the desired crossing direction and sends a request for a crossing signal to the traffic signal controller. The user gets feedback from the text-to-speech interface.

Because it’s an app, it’s easy and inexpensive for users. And MAPS puts the assistive technology directly in the hand of the user, avoiding many of the drawbacks associated with conventional infrastructure-based systems while offering greater flexibility and ease of use. [A video explaining MAPS is at www.its.umn.edu/Research/FeaturedStudies/maps/index.html.]

The prototype has been field-tested at intersections in Minneapolis and Golden Valley, Minnesota. Work continues to refine the accuracy, resolution, and usability of the system. In addition, the researchers have recently begun a new project funded by the Minnesota Department of Transportation. This project aims to enhance the system to help the visually impaired travel safely around work zones.

Liao also received a 2012 Access Achievement Award from the University of Minnesota’s Disability Services, which recognizes individual outstanding achievement in support of access to the University.

“I think the whole system and the whole concept is so beautiful. It just works well.”

—Ken Rodgers, American Council of the Blind of Minnesota
One of the primary obstacles to improving the performance of signalized arterials has been the difficulty of gathering accurate and reliable data to assess arterial traffic conditions. The need to manually collect the data and then calculate performance metrics for individual intersections or arterials has made assessing performance a time-consuming and expensive process for transportation agencies.

Institute researchers in the Department of Civil Engineering and Minnesota Traffic Observatory (MTO) have developed a new system that automatically collects data and assesses performance in real time. It then creates performance measures, including information on the times and locations of congestion on a given roadway. Because it can also refine the traffic signal parameters intelligently using archived data, the system has been dubbed “SMART Signal,” for Systematic Monitoring of Arterial Road Traffic Signals.

Civil engineering associate professor Henry Liu led the research team that developed SMART Signal, which has been deployed at more than 30 intersections in Minnesota and six intersections in Pasadena, California.

Chen-Fu Liao, a senior systems engineer at The system has benefits for the traveling public: less congestion, less delay, and improved travel times throughout the corridor.

Using SMART Signal for smart congestion relief
the MTO, also contributed to the project.

The Institute researchers worked with Minnesota Department of Transportation (MnDOT) operations staff for about five years, says Steven Misgen, metro traffic engineer with MnDOT. “I think it’s a good relationship between the U of M theoretical researchers and the real-world traffic operations personnel. We’ve [provided] input into the device so that we get exactly what we want.”

The SMART Signal system is intended to be installed at a series of intersections along an arterial road. A dedicated microprocessor module is installed in the signal control cabinet at each intersection, interfacing directly with the cabinet electronics without interfering with signal operations. SMART Signal collects two types of event data: signal-phase change events and vehicle-detector actuation events. Event data are then packaged and transmitted in real time to the server located at the MTO.

“The device is very important to us because it takes all the data that we have in the traffic signal cabinet and turns it into usable information—performance measures—for traffic engineers to use to assess how their signals are doing.”

Misgen says the system also has benefits for the traveling public: less congestion, less delay, and improved travel times throughout the corridor. “As a result, they will have a better quality of life, [and] less time sitting in congested intersections.”

In 2011, the University of Minnesota’s Office of Technology Commercialization signed a licensing agreement with startup company SMART Signal Technologies Inc. to commercialize the system.

Funding and in-kind support for the SMART Signal system have been provided by MnDOT, the ITS Institute, the Minnesota Local Road Research Board, Hennepin County, the City of Pasadena, and the National Cooperative Highway Research Program.

A video from the ITS Institute highlighting the SMART Signal system is available on the Institute website (www.its.umn.edu/Research/FeaturedStudies/smartsignals/index.html).
Improving survival odds for crash victims

“CrashHelp holds the potential to significantly improve the notification of and the communication between prehospital care providers and emergency departments.”
— Scott Tucker, Canyon County Paramedics

Only one-third of traffic crash victims die immediately; another one-third take 10 to 90 minutes to die. During that so-called “golden hour,” there is the highest likelihood that prompt medical intervention will prevent death.

In an ongoing effort to facilitate communication and improve patient care following traffic crashes, researchers with the University of Minnesota’s ITS Institute and Center for Excellence in Rural Safety (CERS) have been conducting pilot studies of the prototype CrashHelp system.

With CrashHelp, emergency responders use a mobile smartphone on-scene to collect multimedia data about crash victims—including digital pictures, audio recordings, and videos—as well as other basic patient and incident information. These data are sent directly into the emergency/trauma department to a web-based interface practitioners can view on demand. This information gives hospitals advance notification of crash severity and related information that can be used to best prepare for a patient’s arrival.

Access to emergency medical services (EMS) is a long-standing rural safety problem in the United States; since EMS service is based
on population density, rural areas are often underserved, resulting in higher fatality rates per rural mile traveled.

To help ready CrashHelp for deployment in rural regions throughout the country, researchers conducted one pilot study in Idaho and have launched a second in central Minnesota. Institute researcher and CERS research director Tom Horan and his colleague Ben Schooley, now an assistant professor at the University of South Carolina, have been leading the studies.

The Idaho pilot was conducted from July through October 2011 in the Boise area and included participants from six hospitals and two ambulance providers. Overall results were positive, with a total of 801 incident transmits completed during the study period—including more than 400 images and nearly 450 audio recordings.

The study included follow-up focus groups with personnel from participating hospitals and ambulance providers, state EMS agencies, and the Idaho Department of Transportation. Results indicate that CrashHelp allowed for the efficient collection of usable information. Seeing hospitals use that information spurred medics to use the system more, and hospital personnel said it particularly helped them prepare for the arrival of patients coming from farther away.

“CrashHelp holds the potential to significantly improve the notification of and the communication between prehospital care providers and emergency departments,” says Scott Tucker, deputy director of Canyon County Paramedics in Idaho. Tucker also says information collected and transmitted using CrashHelp “could significantly impact patient care decisions made in the emergency department.”

The second pilot study, currently under way in Crosby, Minnesota, is being conducted in partnership with the Central Minnesota Regional Trauma Advisory Committee (CENTRAC) and funded by the Minnesota Departments of Transportation and Health as part of the Minnesota Toward Zero Deaths program.

In preparation for the Minnesota study, the CrashHelp system was adapted to meet the specific needs of rural EMS and emergency practitioners. The enhanced system has been implemented at the Cuyuna Regional Medical Center (CRMC) and its ambulance service provider in Crosby.

Following the initial trial period at CRMC, the research team will evaluate the feasibility of expanding the system throughout the CENTRAC region, which includes 14 counties in central Minnesota. The Minnesota pilot also will include an evaluation of CrashHelp’s effects on EMS communications, EMS decision making, and medical outcomes that could result from using the system in a regional setting.
Once rare in the United States, roundabouts are becoming more common in Minnesota and across the country. Although research has shown that roundabouts can successfully ease congestion and reduce serious crashes, there are concerns about roundabout accessibility and safety for pedestrians and bicyclists.

In a study funded by the Minnesota Department of Transportation, researchers from the Institute’s Minnesota Traffic Observatory (MTO) examined the experience of pedestrians and bicyclists at two roundabouts in the Twin Cities. Led by MTO director John Hourdos, the team used video surveillance equipment to collect data on driver and pedestrian behavior at each site.

The researchers deployed the video equipment at a two-lane roundabout in suburban Richfield and a one-lane roundabout in a residential area of Minneapolis. Between the two locations, the team captured video of more than 6,900 pedestrian crossings and 7,500 bicycle crossings.

Among the thousands of crossing events captured by the study, there were only three cases that could marginally be termed close calls. However, study findings do highlight the existence of friction between pedestrians and drivers at roundabout crossings.

“The [research] offers information worth considering for those looking to construct roundabouts with pedestrian/bicycle movements.” —Kristin Asher, Richfield city engineer
One concern is that many drivers fail to yield to pedestrians and bicyclists, even though Minnesota law requires them to do so. In fact, findings show that drivers at the Richfield roundabout yield only about 45 percent of the time. The yielding rate in Minneapolis was higher, averaging about 83 percent.

The research team identified several factors that influence drivers’ yielding behavior. Study results indicate the following trends:

- Drivers are more likely to yield to pedestrians or bicyclists beginning their crossing in the center island.
- Vehicles exiting the roundabout are less likely to yield than those entering it.
- Drivers are more likely to yield to larger groups.
- Vehicles entering the roundabout at the immediate upstream entrance are more likely to yield than those coming from other entrances.
- Drivers are less likely to yield if they encounter another vehicle merging into the roundabout immediately before the exit where the pedestrian is trying to cross.
- Yielding probability decreases with more vehicles present in the roundabout.

The team also examined the delays experienced by pedestrians waiting to cross at roundabouts, and results indicate that their wait times are actually shorter than at signalized intersections. For example, a signalized intersection with daily traffic comparable to the Richfield roundabout has an average pedestrian delay of 30 seconds. The average delay at Richfield was nine seconds. At Minneapolis, the wait was even shorter—less than two seconds. However, the researchers suggest that the non-yielding behavior of drivers at roundabouts may intensify the experience of delay, making it seem longer than it actually is.

In addition, drivers’ failure to yield creates a significant safety risk, particularly for pedestrians who are visually impaired. Although the researchers did not observe any visually impaired pedestrians in this study, the observed yielding rates demonstrate that such pedestrians cannot assume drivers see them or are willing to stop.

Kristin Asher, city engineer for Richfield and a member of the project’s technical advisory panel, says the research helped answer questions about roundabout safety. “It was reassuring to find out that there were no safety-compromising situations observed in all the...thousands of pedestrians and bicyclists observed using the crossings,” she says. And results also showed that delays are much improved when compared to signalized intersections, which is “information worth considering for those looking to construct roundabouts with pedestrian/bicycle movements,” she adds.

There are about 2,000 roundabouts in the U.S., compared to 20,000 in France, 15,000 in Australia, and 10,000 in the U.K.
Exploring public support for automated speed enforcement

Automated speed enforcement (ASE) has proven to be an effective strategy for reducing speeding and improving road safety. Its use in the United States, however, has been limited in part because of a perception by policymakers that it is unpopular and controversial. As part of a recent study, U of M researchers asked Minnesotans what they think of ASE. They found strong support—particularly for ASE in work zones and school zones and if revenues from fines are dedicated for road safety programs.

ASE uses radar and cameras to identify a speeding vehicle and capture images of the license plates, and, in some systems, the driver. Citations are then mailed to the vehicle’s registered owner or, alternatively, the identified driver. ASE has been deployed in 14 states and in many countries, especially in Europe.

Minnesotans are “overwhelmingly supportive” of using ASE in construction zones where workers are endangered and on roads near schools.
are endangered (83 percent net support), on roads near schools (82 percent net support), on roads where many have died (77 percent net support), and on Minnesota roads where many people violate speed limits (69 percent net support). The level of support for using ASE on all roads falls just below the majority threshold, at 48 percent net support.

In addition, about seven in ten Minnesotans indicated they would be more likely to support ASE if the money raised from speeding tickets were used for local road safety improvements or if tickets were issued only to those driving at extreme speeds, Douma said.

The researchers also examined the legal and related political obstacles for deploying ASE in Minnesota, including a state supreme court ruling that invalidated a Minneapolis red-light photo enforcement ordinance. The court’s ruling was narrow, Douma explains, and did not bar automated enforcement generally or the concept of owner liability.

Moving forward, Douma said deploying ASE in Minnesota would require authorizing legislation, particularly to clarify liability issues and the role of local authorities. The researchers recommend that if legislation were drafted, it would authorize pilot testing of ASE in school zones and MnDOT work zones. Though authorizing only pilot projects, the legislation should include the full set of ASE program design elements used in other jurisdictions to further increase the public’s acceptance of ASE as well as to reduce the risk of legal challenges.

At the 2012 Toward Zero Deaths conference, during which Douma and others discussed the issue, State Senator Kathy Sheran said the research findings and recommendations provide the groundwork for shaping potential legislation. “We’re beginning to work on the design of legislation in order to do what we need to do [to authorize a pilot],” she said. “We’re exploring, and we’re learning from other states.”

The study was funded by the Institute and the Minnesota Department of Transportation.