Human-centered technology to enhance safety and mobility

ITS INSTITUTE

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We’ve provided Quick Response (QR) codes throughout this annual report. If you have a barcode scanner app installed on your smartphone, scan the QR code to view a corresponding web page with more information on the topic. For instance, scanning this QR code will take you to the ITS Institute’s homepage.

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Cover photos

Front cover (from left to right)

Top row
Ambulance at scene of crash, Minneapolis, 1944. Minnesota Historical Society.

Bottom row
Prototype Teen Driver Support System (TDSS), 2010. ITS staff photo.
CICAS-SSA system field test, near Cannon Falls, Minnesota, 2010. ITS staff photo.
Bus 2.0, a Minnesota Valley Transit Authority (MVTA) bus using a driver-assist system (DAS) developed by ITS Institute, 2011. ITS staff photo.

Nighttime car crash on major highway during rainfall, 2006.

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Human-centered technology to enhance safety and mobility

A report of research, education, and technology transfer activities of the Intelligent Transportation Systems Institute at the University of Minnesota for fiscal year 2010–2011

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In June of this year, proponents of so-called “driverless” automobiles celebrated when the Nevada Assembly passed legislation that would allow autonomous passenger vehicles to operate on the state’s roads. Internet search giant Google has been capturing headlines with its experimental autonomous cars, and the company seems to believe that the concept has commercial potential.

The dream of a car that drives itself while its human passengers relax is nearly as old as America’s love affair with the automobile. In 1939, while planning for the Interstate Highway System was still in its infancy, General Motors’ “Futurama” pavilion at the New York World’s Fair offered visitors a glimpse of a future in which cars guided by directional radio beacons glided along high-speed expressways.

These “magic motorways” were the brainchild of pioneering industrial designer Norman Bel Geddes, who presciently noted that automotive engineers had succeeded in making the automobile far safer and more comfortable than it had been only two decades earlier—but that the driver remained just as susceptible to human error as ever. This led Bel Geddes to conclude that the way to increase safety would be to remove the driver—the “weakest link”—from the driving equation altogether.

This vision of automated road travel captured the public imagination, and the rapid advances in engineering and computing technology in the decades that followed seemed to bring the vision ever closer to reality. Self-driving cars and automated roadways remain staples of futuristic fiction, as in such films as I, Robot and Minority Report, both of which prominently feature cars that drive themselves.

But let’s do a reality check. Consider the highly automated world of flying commercial aircraft. The autopilot still needs the supervision of highly trained pilots. And even then, “things happen.”

Since the ITS Institute was established, we have pursued a different vision of the future—summed up in our focus on human-centered technology. Faced with Bel Geddes’s observation that the capabilities of the driver have not improved along with those of the automobile, we have chosen to focus on improving and assisting the driver rather than taking the driver out of the picture.

Furthermore, many of the human limitations associated with automobile crashes—poor night vision, difficulty judging the speed of oncoming vehicles or the size of a gap between approaching vehicles, inability to see around corners—can be overcome with driver-assist technologies that enhance our sensory and information-processing abilities but keep us “in the loop.” The ITS Institute has already deployed in-vehicle systems that allow snowplow drivers to operate in zero-visibility conditions on Alaskan highways and enable bus drivers to operate comfortably on narrow bus-only highway shoulders in the Twin Cities. Our researchers have also deployed roadside, sensor-driven driver-support systems designed to improve the ability of a stopped driver to make safe decisions about entering rural high-speed through-stop intersections.

And let’s remember that for a fully autonomous vehicle to operate safely, every component of the guidance system—the sensors, data processors, servomotors, and even the network that connects them—must operate with near-perfect reliability. This reliability would need to be maintained throughout its life on every vehicle. Keep in mind that there are 250 million vehicles on U.S. roads today.

The drive to develop fully autonomous passenger vehicles has produced some intriguing results and is certainly a worthwhile endeavor. However, to reap the safety benefits of technology, we believe that trying to remove the driver from the transportation equation rather than enhancing the driver’s abilities is essentially an attempt to reinvent the wheel. The road to the future of transportation starts with an improved understanding of human drivers and a commitment to enhance their ability to reach their destinations safely and efficiently.

I would like to take this opportunity to thank departing ITS Institute board members: Joe Peters of the FHWA’s Office of Operations Research Development, Mary Ellison of the Department of Public Safety, and Mark Hoisser of DARTS. We are grateful for their service and contributions.
The Intelligent Transportation Systems (ITS) Institute is a congressionally designated national University Transportation Center (UTC) funded through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), the federal surface transportation bill passed in 2005. This funding continues the Institute’s efforts initiated under SAFETEA-LU’s predecessors, the Transportation Equity Act for the 21st Century (TEA-21) and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

The ITS Institute plans and conducts activities that further the mission of the U. S. Department of Transportation’s UTC program: to advance U.S. technology and expertise in the many disciplines that make up transportation through education, research, and technology transfer activities at university-based centers of excellence. To help us accomplish this, we direct the work of researchers from multiple disciplines to advance the state of the art in the core ITS technologies of computing, sensing, communications, and control systems to solve today’s challenging transportation problems.

Our focus is on human-centered technology that enhances the safety and mobility of road- and transit-based transportation. To that end, we bring together technologists and those who study human behavior from the University with our partners—the U.S. Department of Transportation, Minnesota Department of Transportation, other government agencies, and private industry—to ensure that Institute-developed technologies become tools that help us understand and optimize human capabilities as they relate to transportation.

Additionally, the Institute addresses issues related to transportation in a northern climate, investigates technologies for improving the safety of travel in rural environments, and considers social and economic policy issues related to the use of core ITS technologies.

**Financial Report**

Expenditures for Year 12: July 1, 2010–June 30, 2011

Total Expenditures: $6.4 million

- Development and Administration 7%
- Education 7%
- Technology Transfer/Information Services 6%
- Research 80%
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 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 funding 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, Hennepin County, St. Louis County, Metro Transit, Minnesota Valley Transit Authority, City of Duluth, and other local governments, agencies, and private companies.

Activities undertaken by the Institute support all ITS-related research projects, regardless of funding source. All current ITS-related projects are listed in the appendix of this annual report, while a selection of research projects under way are highlighted in detail in the pages that follow.

Research fellow Arvind Menon installing components of the Safe Teen Car prototype
Novice teen drivers are overrepresented in vehicle crashes compared to more mature, experienced drivers, and research suggests this is in part because teens are more likely to engage in risk-taking behaviors while driving. In a project sponsored by the National Highway Traffic Safety Administration (NHTSA), the University of Minnesota and Maryland-based Westat Inc., a prominent research organization, are working to create and test a vehicle-based technology solution to reduce teen driver crashes. This team, which includes Institute researchers Mike Manser, Chris Edwards, Janet Creaser, Alec Gorjestani, Arvind Menon, and Craig Shankwitz, has developed a prototype driver support system called Safe Teen Car (STC) that provides feedback to drivers when risky driving behaviors are detected.

STC is a different concept than the Teen Driver Support System (TDSS) on which other Institute researchers are working (see page 6). While the TDSS is designed as an “after-market” device that can be used on any vehicle and has the capability to report unsafe behaviors to parents, the STC project is focused on what can be integrated into future vehicles during manufacturing to make them safer for teens. Specifically, the STC system monitors driving behavior and provides various combinations of auditory and visual feedback and adaptation strategies to the driver as opposed to recording, transmitting, summarizing, and reporting on driver performance.

Researchers recently conducted a four-week preliminary functional road test involving teen drivers and parents in Minnesota and Maryland to evaluate the individual driver feedback subsystems that currently make up the STC system. The subsystems address the most common risk factors associated with teen crashes and are grouped by the type of behavior the STC is trying to affect, including cell phone use, excessive maneuvering, and speeding. Each of these subgroups contains driver identification, passenger detection, seat belt detection, and driving context (external factors) capabilities that address these other known risk factors.

For this study, participants’ vehicles were instrumented with the STC system, and the teen drivers were assigned to one of the three STC subsystems so that researchers could evaluate each subgroup separately and identify effects specific to each.

The study began with a two-week baseline period in which the STC did not provide feedback or adapt vehicle functions. This was followed by a two-week treatment period in which the STC subsystems were activated and participants received feedback and vehicle adaptations based on which group they were in. Those in the excessive maneuver group, for example, received feedback in the form of a visual icon displayed on the driver-vehicle interface (DVI) synchronized with a 10-second tone,

One significant finding involved the speed management subsystem, which showed a reduction in the levels of speeding.

The Safe Teen Car provides the driver with audio feedback, supported by an icon display, when it detects risky behavior.
When it comes to teen driving statistics, perhaps none is more shocking than this: 30 percent of all teen deaths in the United States are caused by motor vehicle crashes—the leading cause of death for teens. Combine inexperience behind the wheel with a propensity to engage in risky behaviors and the results are all too often fatal.

Although graduated driver’s licensing (GDL) programs have been effective at significantly reducing fatal crashes, they do not address all crash causes and are difficult to enforce because they rely heavily on parents to impose restrictions on their teen drivers. So researchers at the University of Minnesota are developing monitoring technologies to address the riskiest behaviors teen drivers engage in, some of which are also covered by GDL programs.

In one project, a multidisciplinary team of researchers developed a prototype Teen Driver Support System (TDSS) that uses a GPS-enabled smartphone mounted on a vehicle’s dashboard to provide the driver with real-time warnings about speeding, excessive maneuvers, and stop sign violations. If an unsafe behavior continues, the device automatically sends a text message to notify parents. The prototype also monitors seat belt use and detects the presence of a cell phone in the car.

Driving behavior data were collected throughout the study and allowed researchers to make comparisons between the stages that would identify the extent to which the STC contributed to changes in driver behavior. One significant finding involved the speed management subsystem, which showed a reduction in the levels of speeding. For example, drivers who drove 10 to 15 mph over the limit prior to STC subsystem activation drove only 5 to 10 mph over the limit once the system was activated.

At the end of the study, each teen driver, accompanied by one parent, participated in unstructured discussions intended to help researchers understand the participants’ specific experiences and impressions of the STC subsystems to which they were exposed. Results from these discussions suggest the STC concept appeals to teens and their parents and that overall, the majority of teens agreed or somewhat agreed that the STC improved their safety.

Observations of driver behavior and system acceptance were used to refine the systems and methods prior to the start of a full system evaluation that began in July. This current study combines subsystems (except cell phone) for a longer time period and is exploring the carryover effects—that is, the extent to which each STC subsystem influences drivers to select safe behaviors even after the system is switched off. Upon completing this study and in relation to other tasks, the team will outline the final specifications for a safe teen vehicle and document the methods, findings, and recommendations of the entire project for NHTSA and other stakeholders.

For more information, see An Evaluation of a Prototype Safe Teen Car at www.its.umn.edu/Research/ProjectDetail.html?id=2010077.
A prototype system uses a GPS-enabled smartphone to provide the driver with real-time warnings about speeding, excessive maneuvers, and stop sign violations.

Infrared sensors count bicyclists, pedestrians on Minneapolis trails to aid planning

In an effort to provide transportation decision makers with more information on nonmotorized transportation facilities, a team of researchers from the Humphrey School of Public Affairs is conducting a study on the use of bicycle and pedestrian trails in Minneapolis. Using infrared counters, the team is collecting data on when and how often these trails are used.

The project, funded by the Institute’s TechPlan program at the Humphrey School of Public Affairs, is led by Greg Lindsey, a professor with the school. Lindsey and his team are using the data they collect to develop more sophisticated models for estimating nonmotorized traffic on Minneapolis streets, sidewalks, and trails. Their models are helping policymakers and planners make better decisions about how, when, and where to invest in nonmotorized infrastructure.

From June through December 2010, the team installed seven infrared devices in Minneapolis: three on the Midtown Greenway, two at Lake Calhoun, two at Lake Nokomis, and one at Wirth Park. When a passing cyclist or pedestrian breaks the infrared beam spanning the trail, the event is registered on an electronic counter. According to Lindsey, this is an unobtrusive way to measure how many people are using a given trail and at what times.
times of the day traffic levels are highest.

The three infrared sensors on the Midtown Greenway are positioned near Minneapolis Department of Public Works bike counters, which are magnetic devices in the trail that register an event when a bike travels over them. Placing both types of counters at the same locations has allowed the research team to test and compare the two measurement technologies.

Each type of counter has limitations, according to Lindsey. Magnetic devices will not register pedestrians because they are not designed to detect the small amount of metal typically on a person, and infrared sensors systematically undercount because they cannot detect if two or more people are traveling side by side. To account for the infrared sensor error, the research team used field observations to develop models that adjust the data.

Data collection is planned to continue indefinitely at all seven locations, Lindsey said. As more data are collected, the researchers hope to gain a clearer understanding of how variables like weather and time of day affect trail use. Additional data will also help researchers examine how the use of trails and bike lanes varies depending on the presence of nearby employment opportunities or the land-use mix in a given area. This information could help decision makers invest in infrastructure where it will be most heavily used.

The data collected by the sensors may also affect trail management in the short term, Lindsey said, citing traffic control changes on the Midtown Greenway as one example. When the trail was developed, there were stop signs on the trail, and vehicles on the streets intersecting the trail had the right-of-way. When traffic counts revealed that nonmotorized traffic on the trail exceeded vehicle traffic on the cross streets, some of the stop signs were reversed. Trail users were given the right-of-way at certain intersections, and vehicles on the cross streets had to stop.

Ultimately, the new models of nonmotorized traffic will provide transportation planners with tools to make more informed choices about investing in new bicycle and pedestrian facilities and reduce the amount of customized work needed for individual projects. “Traffic counts are a basic building block for decision making,” Lindsey said. “They provide evidence to make transportation decisions rationally.”

For more information, see Understanding Use of Nonmotorized Transportation Facilities at www.its.umn.edu/Research/ProjectDetail.html?id=2010058.
Improving emergency medical response for rural crashes

Over the past five years, researchers with the University of Minnesota’s ITS Institute and the Center for Excellence in Rural Safety (CERS) have investigated the role that information technology plays in improving emergency medical response to victims of rural automobile crashes. The goal of this work is to reduce the adverse health impacts of traffic crash trauma, especially those in rural areas, where crashes account for a high percentage of trauma injury and death.

“One key aspect of reducing [these] adverse medical effects...is to decrease the amount of time it takes emergency services to respond, provide care, and take a patient to the right [trauma level] hospital,” explains Tom Horan, a researcher with the ITS Institute and research director of CERS.

Within the first hour after trauma occurs, a patient’s medical fate is usually sealed. Thus, with regard to emergency trauma care, a few minutes can mean the difference between life and death. Working with his colleague Ben Schooley, Horan and his research team assessed the potential value of a web application that would facilitate a more seamless transfer of patient and incident information from emergency medical services (EMS) pre-hospital practitioners to hospital emergency room/trauma center providers as a way to improve patient care during that “golden hour” following a traffic crash. The researchers conducted case studies of EMS systems in San Mateo County, California, and Rochester, Minnesota, to validate the model and study best practices of these rural trauma systems. The case studies included analysis of EMS response data, interviews, and focus group discussions with EMS and emergency room practitioners.

Through these efforts, the team found that information collection and handoff from ambulance providers to hospitals is fragmented. “Evidence from literature suggests that more timely patient information could significantly impact patient care,” Schooley notes. The case studies also confirmed that new and emerging mobile-and map-based technologies could be used to address this information-handoff challenge, and the group moved from concept to development of a prototype system called CrashHelp.

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 instant messaging of sorts gives hospitals advance notification of crash severity and related information that can be used to best prepare for a patient’s arrival. EMS agencies responsible for oversight can view aggregate information over time and conduct spatial (map-based) analyses of EMS response trends across the region and state.

According to Schooley, special attention was paid in the design phase to make a user-friendly, electronically secure tool. “We knew we had to make it simple and secure or it wouldn’t be used,” he says. “CrashHelp is as easy to use as a flip phone...it does not require hospitals to install new systems or even to manually download the information sent from EMS personnel.” Additionally, the team has put an important emphasis on system security so that CrashHelp will comply with the Health Insurance Portability and Accountability Act (HIPAA) of 1996 and other electronic healthcare data security requirements.

The research team is now pilot testing CrashHelp with EMS agencies and hospitals in the Boise, Idaho, area and is set to go live with the system by fall 2011. During this three-month pilot study, researchers will evaluate any improvements made in information collected by on-scene EMS personnel, communication between prehospital transport and hospitals, care decision making by hospital personnel (for some incidents), and resource use by hospital personnel. Preliminary results from the pilot will be available in late 2011.

Discussions are currently under way to conduct further testing as part of Minnesota’s Toward Zero Deaths program. For more information on this study, visit www.ruralsafety.umn.edu/.

For more information, see ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phases II thru IV) at www.its.umn.edu/Research/Researcher.html?id=25125.

Benjamin Schooley

“...We knew we had to make [CrashHelp] simple and secure or it wouldn’t be used.”

—Benjamin Schooley

**Cars and roads share data to warn drivers, improve safety**

Today’s drivers tune in to traffic updates on their car radios. But tomorrow’s drivers are likely to rely on a very different kind of radio system to help them avoid congestion. Under the U.S. Department of Transportation’s Connected Vehicles research initiative, researchers are developing a range of applications that transmit data between moving vehicles, and between vehicles and the transportation infrastructure.

Professor M. Imran Hayee of the University of Minnesota Duluth’s Department of Electrical and Computer Engineering, along with his team of students, is developing a system that transmits congestion data to motorists near work zones, where traffic jams are common and collisions with maintenance workers are a safety hazard. The research is affiliated with the Northland Advanced Transportation Systems Research Laboratories (NATSRL), part of the ITS Institute.

The new system is one of many applications now being developed based on the dedicated short-range communications (DSRC) standard, which was allocated specifically for ITS applications by the USDOT in 1999. DSRC is designed for short-range use—typically less than 1,000 meters. It offers high data transmission rates with low latency (i.e., a minimal time delay between input processing and corresponding output) and is largely unaffected by weather disturbances, both of which are critical characteristics for ITS applications with rapidly moving vehicles.

DSRC is intended to support both vehicle-to-vehicle applications, such as cooperative forward-collision warning, and vehicle-to-infrastructure applications, such as communication between the traffic signal and vehicle. In both cases, vehicles and infrastructure...
components become nodes on a wireless network. Each vehicle’s onboard DSRC system constantly updates the topology of its local network as vehicles and infrastructure nodes enter and leave the system’s coverage area.

Hayee designed a system consisting of a portable roadside unit (RSU) that can be installed easily in work zones and onboard units (OBUs) to be installed in vehicles. Both types of units are commercially available. The RSU gathers data on the location and speed of nearby vehicles by engaging their OBUs. With these data, the RSU determines average travel time in the vicinity of the work zone and locates the start of congestion—the point where traffic changes from a free-flowing state to a congested state. This information is then broadcast back to the OBUs. Each OBU calculates the distance to the start of congestion and displays the information to the driver via a separate user interface, enabling the driver to decide whether to take an alternate route and warning him or her of a sudden speed reduction.

Because data from private vehicles are transmitted automatically in an uncontrolled environment, protecting the privacy of users is a key concern. The DSRC communication protocols underlying Hayee’s prototype system include built-in security measures that protect DSRC applications from eavesdropping, falsification of data, and other attacks.

The system can be adapted to any road by changing the input parameters of the RSU; the OBU does not require any data about the road being monitored.

The system architecture supports the use of various user interfaces as needed to avoid driver distraction.

Hayee tested the prototype extensively in a variety of congestion scenarios in both urban and rural areas. The field tests showed that the system can accurately determine travel time and the location of the start of congestion in real time under changing traffic conditions.

One limitation of the current system is that optimal performance requires a clear line of sight between the RSU and OBUs. However, the researchers plan to address this issue in their future development of the system by enabling vehicle-to-vehicle data networking.

For more information, see Development of a Portable Work Zone Traffic Information System with DSRC-Based V2I or V2V Communication and BT Cell Phones at www.its.umn.edu/Research/ProjectDetail.html?id=2010005.

Graduate student Buddhika Maitipe and M. Imran Hayee install the DSRC unit in a car for the system’s field demonstration.

The use of a consumer smartphone as the driver interface is one of the innovative aspects of the prototype system—and one that allows significant cost savings.
The Federal Highway Administration (FHWA) recently selected the Minnesota Department of Transportation (MnDOT) to receive $2 million for a University of Minnesota research project designed to use intelligent transportation systems (ITS) technology to deliver real-time information on parking availability at highway truck stops to truck drivers.

Although only 53 percent of parking spaces at truck stops are occupied on any given night, 90 percent of truck drivers perceive a shortage of parking. Drivers unable to locate empty spaces may become fatigued or stop to rest in unsafe locations, such as on roadway shoulders or ramps.

The University research team includes lead investigator Nikolaos Papanikolopoulos, professor in the Department of Computer Science and Engineering (CSE); Vassilios Morellas, program director with CSE; Max Donath, director of the ITS Institute; Panos Michalopoulos, professor in the Department of Civil Engineering; and Ted Morris, lab manager of the Institute’s Minnesota Traffic Observatory.

Another project partner is the American Transportation Research Institute (ATRI), part of the American Trucking Associations Federation. Dan Murray, ATRI vice president, will be the liaison to the research team. The results of the study are expected to be of interest to the public and private sectors.

The funding is provided through the FHWA’s Truck Parking Facilities Discretionary Grants Program. The program helps improve safety on the nation’s interstates by promoting projects that allow trucks to park safely and securely in areas away from moving traffic, instead of alongside the road itself or on ramps. Drivers unable to locate empty spaces may become fatigued, which is thought to be a contributing factor in a number of crashes.

The new project will implement and deploy findings from ITS Institute-funded research recently completed by Papanikolopoulos and Morellas. In that work, the researchers developed an automated parking space identification system that can compute occupancy at stops. This information could then be used to notify drivers about the availability of parking spots using variable message displays miles ahead of stops.

Using transit data, tools for better planning and scheduling

A common mantra in government now is “do more with less.” For transit agencies specifically, the challenge is to reduce costs while continuing to provide secure, reliable, and convenient services. To address this challenge, more and more transit agencies across the United States are installing automatic data-collection systems (ADCS) on their transit vehicles to monitor vehicle location and gather system performance information to improve their services.

Despite the increasing use of these systems—which collect large volumes of potentially useful transit data—these data are largely underutilized because of limited resources and the tremendous effort required to transform them into usable information. ADCS data are often queried only “as needed” or used only for basic applications such as bus schedule planning. But the detailed data available from ADCS, if more easily processed, could be used for more thorough system evaluation, planning, and decision making.

During a six-month sabbatical at the University of Minnesota, Nigel Wilson, professor of civil and environmental engineering at the Massachusetts Institute of Technology (MIT) and a leading researcher in public transportation policy and technology, provided guidance and expertise on transit data analysis and modeling to researchers at the Institute’s Minnesota Traffic Observatory. He also worked with Twin Cities Metro...
Transit, the primary transit agency in the Minneapolis--St. Paul metropolitan area, on fare policy, fare collection technology, and data analysis.

Through this work funded by the ITS Institute, Wilson and senior systems engineer Chen-Fu Liao with the Minnesota Traffic Observatory developed a methodological data analysis framework able to process an extensive amount of ADCS transit data including vehicle location, passenger count, and electronic fare transaction information. The team recently fine-tuned this framework to produce a route-based trip simulation tool that enables users to apply and analyze various transit scheduling strategies.

For this piece of the project, the researchers obtained one month of automatic vehicle location and automatic passenger counter system data from Metro Transit, specifically for bus route 10 along Central Avenue between downtown Minneapolis and the Northtown Mall in Blaine, a Minneapolis suburb. They then analyzed the time point (TP) time and inter-TP link travel time to describe the relationship between trip travel time and primary independent variables such as number of passengers boarding and alighting. Regression models were calibrated and validated by comparing simulation results with the existing schedule using adjusted travel time derived from data analyses. In addition, three separate months of transit data were used to verify the transit route model.

Other TP time models are based on general parameters such as number of passengers boarding and alighting and bus crowding. However, this new transit route model also considers fare payment type, bus type, stop location, intersection geometry, signal timing, and traffic volume—factors that affect bus travel time. The resulting simulation tool enables transit planners to predict and evaluate the potential impact of different transit strategies such as schedule changes and stop consolidation, prior to deployment.

Metro Transit is currently testing this tool and using it in a study of 11 local bus routes to upgrade current operation to bus rapid transit or equivalent services as another way to improve ridership and service quality.

“This work has already provided important insight into our existing transit service,” says John Levin, director of service development with Metro Transit. “We are excited to continue our partnership with the University to support research that will allow us to provide better, more efficient service.”

In their next phase of study, the researchers hope to investigate the transferability of the TP model to other urban local routes, study the impact of wheelchair lift events, and investigate transit riders’ Origin to Destination patterns as well as travel behavior.

For more information, see System Analysis for Public Transit: Developing Data-Driven Support Tools for Transit Planning and Scheduling at www.its.umn.edu/Research/ProjectDetail.html?id=2010064.

The team produced a route-based trip simulation tool that enables users to apply and analyze various transit control strategies.
Researchers at the Minnesota Traffic Observatory (MTO) are using newly developed traffic monitoring tools to investigate safety and accessibility issues affecting pedestrians and bicyclists at traffic roundabouts.

Once rare in the United States, roundabouts are becoming more common in Minnesota and across the country. Municipalities are increasingly interested in roundabouts in light of recent research showing they provide a variety of benefits over traditional signalized intersections, including reducing the number of automobile crashes and allowing traffic to flow in all directions with virtually no interruptions. The impact of roundabouts on the safety and mobility of pedestrians and bicyclists, however, remains poorly understood. Roundabout safety is a particularly important issue for pedestrians who are elderly or visually impaired.

MTO director John Hourdos, lab manager Ted Morris, civil engineering professor Gary Davis, and a group of nine undergraduate students worked with the Minnesota Department of Transportation (MnDOT), which is funding this research, to identify a pair of roundabouts for study—one in suburban Richfield and another in a residential area of Minneapolis. The two sites differ in terms of road geometry, traffic control features, and traffic characteristics, allowing the researchers to compare and contrast different roundabout situations.

The suburban site is a complex design, typical of recent roundabout designs, with two lanes at each entrance and exit; it is illuminated at night and features traffic control signs and markings, as well as bus stops on two approaches. The Minneapolis roundabout represents an older, less complicated design, with a single traffic lane at each entrance and exit; it is not lighted and does not have many of the traffic control features present at the Richfield site.

Getting accurate data on vehicle-pedestrian interactions at roundabouts was one of the first challenges faced by the researchers. To gather the large number of observations necessary for a thorough analysis, the researchers developed a video-based data gathering system to continually observe the entire roundabout. The heart of the system is a cluster of eight cameras atop a telescoping mast mounted on a trailer that can be positioned at the center of the roundabout. A camera is trained on each of the four marked crosswalks on the roads connected to the roundabout, while the other four cameras (equipped with wide-angle lenses) provide a full 360-degree view.
of roundabout traffic. The camera trailer houses batteries and control software that enable the system to record traffic for up to two weeks without human intervention.

At the suburban site, the video system recorded more than 400 hours of data over nearly a month of operation. An initial analysis of a 12-day period revealed that roughly 25 pedestrian or bicycle crossing events involving an interaction with motor vehicles occurred at each approach to the roundabout each day. These observations have been classified and coded to create a data set suitable for logistic regression analysis.

Drivers’ failure to yield to pedestrians and cyclists is one of the key issues being examined in this research. Although Minnesota law requires drivers to yield to any pedestrian in a crossing, observations at the research sites confirm that drivers often fail to do so, creating a significant safety risk. A preliminary analysis showed that drivers were less likely to yield at roundabout exits, and more likely to yield to pedestrians in the center of the roundabout than to those on the sidewalk. As the project continues, the researchers will examine how other factors—including traffic volume, number of lanes, and general roundabout design—affect yielding behavior.

For more information, see Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings at www.its.umn.edu/Research/ProjectDetail.html?id=2010099.

Preliminary results indicate that drivers are less likely to yield at roundabout exits and more likely to yield to pedestrians in the center of a roundabout than to those on the sidewalk.

To obtain accurate data about vehicle-pedestrian interactions, researchers developed a video-based data-gathering system to continually observe an entire roundabout.
Deployment and Implementation

Bus 2.0 rolls into service in southern metro

On 296 miles of Twin Cities-area roadways, bus drivers are allowed to operate their vehicles on shoulder lanes to avoid rush-hour congestion. Shoulder operation allows buses to provide faster, more reliable service, but maneuvering 9.5-foot-wide buses on 10-foot-wide shoulders is challenging, and heavy traffic and poor weather add to the difficulty.

But now drivers of 10 buses operated by the Minnesota Valley Transit Authority (MVTA) are getting help navigating the shoulder from a driver-assist system (DAS) developed by researchers with the IV Lab and HumanFIRST Program at the ITS Institute. These buses provide express service on the Cedar Avenue bus rapid transit corridor and on Highway 62 between the southern suburbs and downtown Minneapolis.

This Bus 2.0 project is part of a larger effort to improve traffic flow on I-35W. The ITS Institute collaborated with the MVTA and Schmitty and Sons Transit to equip the buses, with funding provided by the U.S. Department of Transportation’s Urban Partnership Agreement and the state of Minnesota through the Twin Cities Metropolitan Council. Installation of DAS technology was completed in March 2010, and use of the buses was progressively increased through January 2011 as drivers were assigned and trained.

The DAS uses highly accurate differential GPS to monitor a bus’s position on the roadway and provide visual and tactile alerts to quickly deliver critical lane (or shoulder) departure warning information to the driver. A head-up display (HUD) mounted just inside the windshield and located in the driver’s line of sight shows the...
location of lane boundaries, helping drivers remain safely on the shoulder even when roads are snow-covered or atmospheric visibility is low. Information about other vehicles or objects on the roadway, detected by laser sensors mounted on the front and sides of the bus, is also displayed on the HUD to help drivers avoid potential collisions.

If the DAS detects the bus beginning to drift from its lane, the white or yellow lane boundary on the HUD will turn red. If the bus touches the lane boundary, the driver’s seat vibrates on either the left or right side, based on whether the bus is departing the lane or shoulder to the left or right, respectively. If both warnings are ignored, the driver feels a “suggestive torque” on the steering wheel; the suggestion indicates to the driver the change in heading needed to maintain proper lane or shoulder position. Drivers remain in control of the buses at all times, but the technology provides these three modes of feedback to help them prevent accidental lane departures.

To familiarize drivers with the new technology, the MVTA built a driving simulator that replicates a DAS-equipped bus cab. Drivers also complete on-the-road training. Feedback from drivers was incorporated throughout the development process; for instance, drivers suggested the “staging” of the feedback levels as the most effective method to display warning information. IV Lab director Craig Shankwitz says the team also made changes after drivers had used the system for a few months.

Michael Abegg, MVTA transit planning manager, says drivers generally like using the system because it’s helpful and they can choose the type of feedback they receive. For example, if a driver prefers the vibrating seat to the head-up display, the visual display can be turned off.

“When the weather is bad, without assistance, a driver is hesitant to use the shoulder. He knows that if he gets stuck, 45 people won’t make it to their destination on time,” Shankwitz adds. He predicts that when people see that the bus can adhere to its schedule in those conditions, they’ll be more willing to ride.

Abegg says the system is working well on a technological level. “It’s doing what it’s supposed to do, and that success shouldn’t be underestimated.” He notes, however, that researchers are having difficulty proving that Bus 2.0 reduces travel time. The problem of congestion is so complicated that it’s difficult to isolate and study a single factor. Changing weather conditions and crashes on the roadway have a major impact on traffic. And actual traffic variability is greater than what models can predict.

As researchers evaluate Bus 2.0, they’ll need to ask, among other questions, whether the buses are running on the right sections of shoulder or if there are other sections that would result in faster travel time. Abegg also points out that the current system includes only a small part of all possible driver assistance. Systems could help vehicles pull up to the exact location of the bus stop so that passengers could board more quickly. Other kinds of assistance could be provided for bus drivers in general lanes.

The IV Lab would like to interest other agencies in the DAS. “We can’t build the roads any wider, but we do have the shoulder,” Shankwitz says. “If we can get DOTs and other transit agencies to look at the shoulder not as just a breakdown lane but as a transit lane, we have an opportunity to deploy more technology in different transit applications.” And this same technology, he adds, could potentially be adapted for passenger cars to help prevent single-vehicle lane-departure crashes, which account for nearly 60 percent of traffic fatalities in the United States.

“If we can get DOTs and other transit agencies to look at the shoulder not as just a breakdown lane but as a transit lane, we have an opportunity to deploy more technology in different transit applications.”

—Craig Shankwitz
Intersections account for more than two million crashes in the United States every year. In rural areas, crashes often lead to more severe consequences than in urban areas because of higher vehicle speeds and longer emergency response times.

Researchers from the ITS Institute’s Intelligent Vehicles Laboratory (IV Lab) and HumanFIRST Program, in cooperation with the Minnesota Department of Transportation (MnDOT), have developed an infrastructure-based driver-assist system designed to help drivers make better decisions and prevent collisions at rural highway intersections.

This Cooperative Intersection Collision Avoidance System–Stop Sign Assist (CICAS–SSA) system uses multiple sensors and advanced computer algorithms to track vehicles moving along a rural divided highway. This information is used to warn drivers stopped on a secondary rural road when gaps in highway traffic are too small to merge or cross safely; an active LED icon-based sign switches to an alert or warning as needed depending on the gaps to the left or right.

System field-testing began in 2010 at the intersection of U.S. Highway 52 and County State Aid Highway (CSAH) 9 near Cannon Falls, Minnesota, and at the intersection of U.S. 53 and Wisconsin Highway 77 south of Spooner, Wisconsin. These intersections were chosen because of their history of serious crashes and fatalities for which unsafe gap acceptance was a key contributing factor.

After the first year of testing, the Minnesota intersection went from six crashes per year to three; the Wisconsin intersection went from three crashes per year and an average of five fatalities every six years to zero crashes last year.

Two more test systems were activated in Minnesota in June 2011: the first on Minnesota Highway 23 at CSAH 7 near Marshall and the second on U.S. Highway 169 at CSAH 11 near Milaca. Between 2006 and 2008, an average of four right-angle crashes per year occurred at each of these intersections.

According to MnDOT District 3 traffic engineer Tom Dumont, during this time period, 21 total crashes occurred at the Milaca intersection, approximately 15 of which were right-angle crashes. This intersection is located at the crest of a vertical curve and beginning of a horizontal curve on a rural stretch of trunk highway where the speeds are 65 miles per hour and sight distance is limited. Previous low-cost safety improvements—adding lighting, advance warning signs, and flashing stop signs, and lowering the grade on 169 northbound—have had limited success in reducing crashes here. And the intersection does not meet the minimal traffic volume levels necessary to justify installing a traffic signal system, Dumont says.

Testing at this and the other selected intersections is planned to run for three years. Researchers are using data collected at these locations to analyze driver responses in relation to the system’s sign modes and to determine whether the CICAS-SSA system improves the gap acceptance of drivers. If drivers learn better behavior, crash rates should drop for all intersections, not just those at which the CICAS-SSA system is deployed.

After the first year of testing, the Minnesota intersection went from six crashes per year to three; the Wisconsin intersection went from three crashes per year to zero.
In 1971, the completion of the George Parks Highway opened up the interior of Alaska, and Denali National Park became a popular tourist destination. Today visitors tour the park in buses that travel along a single road. And as the number of visitors has increased, managing traffic has become increasingly important.

Several years ago, the National Park Service asked researchers at the Institute’s Minnesota Traffic Observatory (MTO) to investigate how changing the annual trip limit would affect both the visitors’ experience and the wildlife they come to see.

The research team, led by Institute director Max Donath, MTO lab manager Ted Morris, and MTO director John Hourdos, created a complex simulation tool that accounted for the unique traffic patterns in the park. Building on this work, the research team next tested several scheduling scenarios that would increase the number of tours during the peak season.

The results revealed that allowing more bus trips might lead to visitor dissatisfaction. For example, the view from a scenic overlook might also include too many buses on the road below. In addition, increased traffic would have a negative impact on the Dall sheep that regularly cross the road during migration and foraging seasons.

As a next step, the research team adapted the simulation tool to test several proposed alternative systems. One system, for example, removed a route and replaced it with another that carried visitors further into the interior of the park.

Park planners eventually focused on two of the alternatives. These were tested against standards, such as: “The availability of vehicle gap headway times at wildlife crossings must be at least 10 minutes on the hour.” MTO researchers also developed additional tools that allow park planners to analyze and visualize violation of standards.

“The simulation tool developed by MTO has been instrumental in helping us understand how different schedules and traffic volumes impact visitor crowding at key locations along the road,” says Melissa Snover, ecologist at Denali Park and Preserve. “The results are being used by management to propose transportation alternatives in the upcoming Vehicle Management Plan/Environmental Impact Statement.”

According to Morris, the next phase will be the development of monitoring tools that use actual GPS and wildlife siting data. Park managers will then be able to evaluate if their transportation system is exceeding set standards while the season progresses. Schedules and other route adjustments can then be made to mitigate overcrowding and other problematic situations.

These tools have broad application for the management of any public space affected by road use. “We want to help protect and preserve not only Denali, but other parks as well—while keeping them accessible to visitors,” Morris says.

A simulation tool developed by ITS Institute researchers is helping managers at Denali National Park plan transportation alternatives. Some stretches of the Denali Park Road are treacherous.
The SMART-Signal system, developed by civil engineering associate professor Henry Liu to improve traffic management on urban arterials, was recently implemented in Pasadena, California—the first installation of the system outside of Minnesota. The Minnesota Department of Transportation (MnDOT) also expects to equip nearly 100 additional Minnesota intersections with the system later this year as part of a large-scale implementation project.

SMART-Signal (Systematic Monitoring of Arterial Road Traffic Signals) simultaneously collects event-based high-resolution traffic data from multiple intersections and generates real-time arterial performance measures, including queue length and travel time. System equipment is installed directly in signal controller cabinets.

Liu began work on the SMART-Signal system in 2006, and it has been installed at 20 intersections on three major arterial corridors in Minnesota. 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, and the National Cooperative Highway Research Program.

The system was installed at six intersections on Orange Grove Boulevard in Pasadena, California, between March and April 2011. It began collecting traffic data in May. Pasadena DOT director Fred Dock became interested in implementing the SMART-Signal system after reading the initial project report, Liu said.

Liu and his team provided system calibration and initial data monitoring, then contracted with California-based technology company Iteris to complete the installation. Beginning in September 2011, Iteris and the City of Pasadena will be responsible for all operations, and the University team will no longer maintain the system at the California sites.

According to Liu, the system is already performing well. Depending on the results at the initial six intersections, the city may be interested in implementing the system in more areas, he said.

Expanded implementation of the SMART-Signal system in Minnesota is also expected later this year. Plans for late 2011 include installing the system at 92 additional intersections on Minnesota arterials, including State Highways 55, 7, and 65. “This will be the first time such a large-scale real-time performance monitoring system has been implemented on urban arterials in the U.S., maybe even the first in the world,” Liu said.

This large-scale implementation will provide the research team with more detailed traffic data on urban arterials than have ever been available, which could lead to even more in-depth research, Liu explained. “The fundamental issues of traffic flow can be reinvestigated,” he said. “These data may allow us to confirm the old traffic model or construct a new one.”
Solar-powered signs aim to improve rural intersection safety

In Minnesota, most intersection-related crashes occur at rural, two-way-stop intersections because drivers stopped on a minor road often cannot see traffic on the major road. Nearby vertical and horizontal curves increase the risk when entering the intersection. At these intersections, right-angle crashes account for the largest percentage of crashes, and most are related to drivers’ inability to recognize a safe gap in the traffic stream.

To improve safety at these rural, two-way-stop intersections, researchers from the University of Minnesota Duluth and St. Louis County, Minnesota, developed the ALERT System (Advanced LED Warning Signs for Rural IntersecTions Powered by Renewable Energy). This low-cost, dynamic warning system provides traffic information to drivers approaching the intersection. The project was funded by the Minnesota Local Road Research Board.

Vehicle detectors placed at each approach send messages to LED blinker signs. The system is wireless and powered by solar panels, which eliminates problems associated with buried wires as well as the need to connect

Researchers developed a low-cost, dynamic warning system that provides information to drivers approaching an intersection. The system is wireless and powered by solar panels.

Institute lab hosts online accessibility tool

People who make transportation and land-use decisions in the Twin Cities region have a new tool: an online “accessibility matrix” that illustrates variations in accessibility—the ability of people to reach the destinations they need or want to visit—to different types of destinations for travelers who drive, bike, walk, or use transit.

The tool is hosted by the ITS Institute’s Minnesota Traffic Observatory (MTO), which is staffed by experts in managing large data sets and creating visual models of complex data.

The matrix displays four types of maps: accessibility (the ability to reach destinations), mobility (the ability of people to move on the network), travel time (how long it will take to get between census blocks with each of the travel modes), and land use (the distribution of activities by census block). Users can select up to four filters, including year, mode, time of day, and destination type (such as retail, restaurants, or recreation). The result, for example, could be maps showing the accessibility of jobs between two distant suburbs by transit or by car.

The tool is an outcome of the Access to Destinations (ATD) Study, an interdisciplinary research effort coordinated by the Center for Transportation Studies, with support from sponsors including the Minnesota Department of Transportation, Hennepin County, the Metropolitan Council, and the McKnight Foundation. ITS researchers on the ATD study team were Gary Davis, John Hourdos, Eil Kwon, Taek Kwon, David Levinson, Panos Michalopoulos, Chen-Fu Liao, and Ted Morris.

This tool is just one of several at the MTO that support effective transportation and land-use planning. Researchers plan to further develop the tool and add new data as they become available. Tutorials are also available to assist users with the new tool. The matrix is available on the MTO website at www.mto.umn.edu/Capabilities/PlanningSupport.
When the alert signs were flashing, westbound traffic on the major road slowed by four miles per hour, drivers on the minor road waited longer before crossing, and roll-throughs were eliminated.

The system was installed at the intersection of West Tischer Road and Eagle Lake Road in Duluth. This intersection has a severe vertical curve on the east approach of the major road that significantly reduces sightlines for drivers stopped on the north and south approaches of the minor road. In addition, westbound drivers on the major road cannot see cross traffic until they are nearly in the intersection.

Westbound drivers see the message “CROSS TRAFFIC WHEN FLASHING.” North and southbound drivers on the minor road see the message “VEHICLE APPROACHING WHEN FLASHING.”

The research team included Taek Kwon, a professor in the Department of Electrical and Computer Engineering; research associate Ryan Weidermann; and St. Louis County traffic engineer Victor Lund.

According to Lund, ALERT was “tremendously successful” at changing driver behavior. When the alert signs were flashing, westbound traffic on the major road was slowed by four miles per hour, drivers on the minor road waited longer before crossing, and roll-throughs were eliminated.

However, when the alert sign was not flashing, drivers on the minor road apparently assumed that there was no cross traffic. As a result, they did not always obey the stop sign, and roll-throughs increased, Lund says. This increases the risk of crashes when the device stops working—as ALERT did on several sunless days last winter.

Gap selection-assistance devices like ALERT are effective, Lund says. But he adds that standardization is needed before these devices can be widely used. This means that state and federal standards must be established for messaging, illumination, and placement of signs. Fail-safe issues—such as malfunctioning solar panels—must also be dealt with.

Ease of maintenance is also an issue. Lund notes that county employees currently need to climb a ladder to service ALERT, but he’s hopeful that one day all components will be enclosed in a ground-level service cabinet, which would eliminate the need for a ladder and allow for easier access.

Craig Shankwitz, director of the Intelligent Vehicles Laboratory, was granted a patent titled “Vehicle Positioning System (VPS) Using Location Codes in Passive Tags.” The patent employs passive electronic tags installed in or on roadways to locate vehicles for a number of ITS applications.

VPS uses codes in the electronic tags to represent locations along the roadway. Electronic tag readers installed in vehicles use the code information to determine a vehicle’s position in relation to the roadway. These on-board readers can then communicate the information with other vehicles or with nearby roadside infrastructure units. Messages may be used for traffic management and control or for issuing alerts about other vehicles, environmental factors, or infrastructure conditions.

The system’s design was motivated by the fact that in certain areas, GPS is unavailable or unreliable, such as environments where tall buildings or expressway overpasses distort or block GPS signals. VPS may also be an alternative to radar-based roadside vehicle sensors, which can experience signal interruptions caused by nearby vehicles or other objects blocking a sensor’s line of sight. According to Shankwitz, because VPS relies on tags installed directly in the roadway, it can provide highly accurate position measurements regardless of what’s around a given vehicle.

VPS also provides more specific information than GPS, such as which lane a vehicle is traveling in and the amount of space a vehicle occupies on the roadway. This means that safety messages broadcast using VPS could provide other drivers in the area with more detailed information—for example, which lane a braking vehicle is in, so following drivers could take appropriate action—and decrease the occurrence of false alerts. Because of the ability of VPS to communicate such accurate information to drivers, a large-scale deployment of the technology could substantially reduce vehicle crashes and fatalities.
Five vehicles with driver-assist technology have been deployed in Alaska, where high snowfall rates and blowing snow routinely cause whiteout conditions and zero visibility. Because of its success with the IV Lab, the state of Alaska ordered three new driver-assist systems and two upgrade kits for its systems that operate near Valdez. The kits provide new on-board computation capability not provided by the current computers. In the summer of 2011, IV Lab staff traveled to Alaska to upgrade two vehicles that have been in continuous service since 2003 and to install the driver-assist system in three new snow-removal machines (two plows and one blower).

*Alaska has ordered three new driver-assist systems and two upgrade kits for ones already in use.*
The Institute could not accomplish its goals without sharing its expertise and research results with local, national, and international audiences for use in real-world applications. Technology transfer also communicates to the world who we are—raising the profile of the Institute and its research—and educates students, policymakers, and the general public about ITS issues and solutions.

Our efforts in this area are far-ranging in order to reach a broad and diverse audience of researchers, students, practitioners, policymakers, and others among the public. Over the past year, we have provided tours and demonstrations of our research and facilities, sponsored seminars, sent electronic newsletters and announcements, published printed pieces, and enhanced our website. But perhaps the most direct method of transferring technology has been to educate students who join the workforce.

This section of the annual report highlights some of our technology transfer activities over the past year.

Research showcased through demos, tours, and exhibits

Two ITS Institute projects were featured at University Research Technology Transfer Day, an exhibition of the U.S. Department of Transportation’s Research and Innovative Technology Administration (RITA), on April 6 at the USDOT headquarters in Washington, D.C.

“Traffic Signal Performance Measurement Using High-Resolution Data: The SMART-Signal System,” led by Associate Professor Henry Liu of the Department of Civil Engineering, simultaneously collects event-based

Members of an international research organization visited campus as part of a scan tour of U.S. transportation research facilities.
high-resolution traffic data from multiple intersections and generates real-time arterial performance measures. “Smartphone-Based Novice Teenage Driver Support System (TDSS)” was developed to help inexperienced drivers by providing real-time, in-vehicle feedback. In addition, the TDSS project was selected for a podium presentation, given by researcher Janet Creaser. Co-investigators of this research are ITS Institute director Max Donath, research fellows Creaser and Alec Gorjestani, and HumanFIRST Program director Mike Manser.

“Janet and Henry did a great job answering questions from the many participants who stopped at their tables,” Donath said, adding that the posters generated considerable interest among attendees. The event highlighted research products that have been or are in the process of being deployed into the marketplace or affecting policy.

The ITS Institute was among several University of Minnesota research laboratories that hosted tours from European transportation organizations.

On September 22, members of FEHRL–ECTRI visited campus as part of a scan tour of U.S. transportation research facilities. FEHRL, the Forum of European National Highway Research Laboratories, provides a coordinated structure for the interests of more than 30 national research and technical centers from Europe, together with associated institutes from around the world.

ECTRI, the European Conference of Transport Research Institutes, is an international nonprofit organization whose members are 27 major transport research institutes or universities from 20 European countries. Together, they account for more than 3,800 European scientific and research staff in the field of transport.

Steve Phillips, FEHRL secretary-general, presented the objectives of the tour—the group’s first to the United States—and introduced FEHRL-ECTRI scan team members from France, Great Britain, Spain, Germany, Hungary, Poland, South Africa, and Sweden. Phillips said the aim of the scan was twofold: to identify what’s missing in existing U.S. and European research facilities to meet current and emerging needs, and to recommend opportunities to use existing facilities and collaborate to develop new ones. Minnesota was selected for a site visit because of its research facilities and its extensive experience with international cooperation, he said.

Michael Manser, director of the HumanFIRST Program, provided a tour of the program’s driving simulator, and John Houdos, Minnesota Traffic Observatory (MTO) director, demonstrated the MTO’s lab equipment and technologies.

On September 23, a similar tour was given to representatives from the Swedish Transport Administration. Research fellows Alec Gorjestani and Justin Graving gave a demonstration of a Teen Driver Support System under development in the IV Lab. Mechanical engineering professor Rajesh Rajamani presented an overview of his research related to automated applicator control on snowplows. The group also toured the MTO and HumanFIRST labs and attended an ITS Institute Advanced Transportation Technologies Seminar.

On August 26, a delegation from Russian transportation organizations visited campus for an information exchange and tours focusing on safety innovations. The group heard overviews of various CTS programs and also toured the HumanFIRST lab and the MTO.

The ITS Institute and CTS showcased a variety of transportation-related attractions at the 2010 Minnesota State Fair. Visitors to the University of Minnesota building on August 27 and September 3 chatted with CTS and Institute staff and checked out the latest transportation innovations. Fairgoers of all ages played Gridlock Buster, an interactive traffic-control game designed by the ITS Institute and Web Courseworks (see page 37 for more about the game).
Technology holds promise to prevent drunk driving, speaker says

Addressing the 2011 CTS Winter Luncheon on February 15, highway safety researcher Susan A. Ferguson described how a system to unobtrusively measure a driver’s blood-alcohol content (BAC) is being developed by a government–industry partnership. The Winter Luncheon is sponsored by the ITS Institute.

Ferguson is president of Ferguson International LLC, a consulting firm focused on highway safety issues, and a former senior vice president for research at the Insurance Institute for Highway Safety. ITS Institute director Max Donath welcomed Ferguson and praised what he called her seminal research on crash avoidance and safety technologies.

“There are many people out there drinking and driving...who are involved in fatal crashes who have never been caught,” Ferguson said. According to conservative estimates, even someone who drives drunk 50 times may only be caught once, she explained.

Ferguson described how a consortium of private firms and government agencies came together in early 2008 to explore the potential benefits of in-vehicle alcohol-detection technology as well as the implementation challenges and policy issues associated with introducing such a system. A blue-ribbon panel spent a year identifying promising technologies, then awarded contracts to two companies to develop their approaches to the challenge.

The research enjoys widespread support within the automotive industry, Ferguson said. In addition to the U.S. government, the consortium includes Transport Canada, the Swedish national road administration, and the Japanese government. Ferguson believes that the future of driver alcohol-detection technology is tied to voluntary acceptance by drivers and demand for the systems as a safety feature. Eventually, engagement with the auto insurance industry could lead to incentives for vehicles equipped with these systems.

Institute researchers and their work receive honors

The Minnesota Public Transit Association (MPTA) awarded Intelligent Vehicles (IV) Lab director Craig Shankwitz and Minnesota Valley Transit Authority (MVTA) transit planning manager Mike Abegg its Management Innovation Award for their work on the “Bus 2.0 Driver-Assist System” project. (See page 16 for more about the project.)

The award is given for innovative work in the field of transit or creative new methods of addressing the transit-related concerns of transit users. It was presented at the MPTA annual conference on September 13 in Rochester, Minnesota.
“This [project] is a great example of a successful university–transit agency partnership that is deploying innovative technology to solve a problem,” says Max Donath, director of the ITS Institute.

Shankwitz credits the significant contributions of team members from the IV Lab and the HumanFIRST Program, both units of the Institute, for the success of the project.

The Bus 2.0 project also received a CTS Research Partnership Award at the Center’s annual Meeting and Awards Luncheon in April. The annual award recognizes research projects within the CTS program that have resulted in significant impacts on transportation, and rewards teams of individuals who have drawn on the strengths of their partnerships to achieve those results. Project partners were:

- MVTA: Michael Abegg, Glenn Boden
- Schmitty & Sons Transit: Connie Massengale, Jesse Borchowiec, Mary Blanchard
- University of Minnesota: Max Donath, Michael Manser, Craig Shankwitz, Eddie Arpin, Pi-Ming Cheng, Peter Easterlund, Alec Gorjestani, Justin Graving, Erin Kurshoff, Arvind Menon, Bryan Newstrom

Also at the CTS awards luncheon, David Levinson, an associate professor in the Department of Civil Engineering and the Braun/CTS Chair in Transportation Engineering, was presented with the Richard P. Braun Distinguished Service Award. The award is given to a transportation official who has demonstrated outstanding leadership in research and innovation. Levinson’s current Institute-funded research includes work with the Humphrey School’s TechPlan program, “Consumer Travel Behavior and Retail Geography: A Microscopic Investigation Using GPS Data and Parcel-Level Land Use.”

IV Lab patents research on vehicle positioning system

Craig Shankwitz, director of the Intelligent Vehicles Laboratory, was granted a patent titled “Vehicle Positioning System (VPS) Using Location Codes in Passive Tags.” The patent employs passive electronic tags installed in or on roadways to locate vehicles for a number of ITS applications. (See page 22 for more about the patent.)

Benefits of Institute work highlighted in media coverage

During the past year, local and national media featured Institute research numerous times in print and over the airwaves, in publications that included *USA Today,*
Among the headlines were:

- Researchers aim to make roadsides safer for officers
  KSTP-TV, May 12, 2011
- MnDOT to study mileage-based user fee to replace gas tax
  KSTP-TV, April 18, 2011
- Pay tax by the mile, not gallon?
  Star Tribune, April 20, 2011
- To curb congestion, buses to ride on shoulders
  Chicago Tribune, February 18, 2011
- U tech helps buses battle ice and snow
  Minnesota Daily, February 16, 2011
- Buses using virtual world to navigate
  Star Tribune, January 19, 2011
- Technology aids bus drivers on narrow shoulder lanes

UTC Spotlight, January 2011
- An integrated study of road capacity at Denali National Park
  Park Science, December 6, 2010
- SE Minnesota highway intersection chosen as site for safety study
  Marshall Independent, December 16, 2010
- Smart phones let parents track teen drivers
  WCCO-TV news, September 15, 2010
- Using tech to curb deaths on Minnesota’s roadways
  Minnesota Public Radio, August 10, 2010
- Elbow room on the shoulder: DGPS-based lane-keeping enlists laser scanners for safety and efficiency
  GPS World, July 1, 2010

Institute researchers share expertise at local, national events

ITS Institute researchers discussed their work at the 22nd Annual CTS Transportation Research Conference in St. Paul, Minnesota, May 24 and 25. Presentations included:

- “Development and Evaluation of an Advanced LED Warning System for Rural Intersections,” Taek Kwon, Department of Electrical and Computer Engineering (Duluth)
- “eWorkPlace: Telecommuting Reduces Congestion in the Twin Cities Metropolitan Area,” Adeel Lari, Humphrey School of Public Affairs
- “Impact of Transit Signal Priority on Bus Service Performance,” Chen-Fu Liao, Department of Civil Engineering
- “Vision-Based Bicyclist and Pedestrian Counting Systems,” Guruprasad Somasundaram, Department of Computer Science and Engineering
- “Weekday Peak Hour Mean Flow Estimation Using Two-Day Short-Count Data,” Hui Xiong, Department of Civil Engineering
• “Rural Safety, Health, and Emergency Response,” Tom Horan, Center for Excellence in Rural Safety
• “Mileage-Based User Fee Demonstration and Policy Study,” Lee Munnich, Humphrey School of Public Affairs
• “Traffic Performance Measurements Using Event-Based Detector Data—Recent Developments on the SMART-Signal System,” Henry Liu, Department of Civil Engineering
• “Arterial Travel Time Characterization and Real-Time Traffic Condition Identification Using GPS-Equipped Probe Vehicles,” Yiheng Feng, Department of Civil Engineering

Three University of Minnesota researchers presented their work with ITS technology at the ITS Minnesota 17th Annual Meeting and Information Exchange on March 8 in St. Paul.

Associate Professor Xun Yu (electrical and computer engineering, Duluth) discussed his work with intelligent pavement, which eliminates the need for external sensors by enabling the pavement itself to detect vehicles. Yu creates the pavement by incorporating carbon nanotubes—cylindrical molecules that exhibit changes in electrical resistance in response to mechanical stress—in cement. The resulting pavement has a longer service life and lower maintenance costs than those of traditional vehicle sensors. Yu said the pavement has performed well in preliminary studies.

Center for Excellence in Rural Safety researcher Benjamin Schooley outlined the CrashHelp system, which allows emergency responders to collect information about crash victims on-scene and send it directly to hospital emergency rooms (see related story on page 9).

Minnesota Department of Transportation (MnDOT) commissioner Tom Sorel gave the keynote presentation, which highlighted how ITS technology can improve Minnesota’s transportation system. In-vehicle signing, integrated corridor management, intelligent work zones, and intersection warning systems all have great potential for increasing safety and mobility, Sorel said. In particular, Sorel cited the Cooperative Intersection Collision Avoidance Systems—Stop Sign Assist project currently being conducted by ITS Institute researchers as an example of ITS technology’s potential for improving safety (see related story on page 18).

Linda Preisen, ITS Minnesota chapter president and CTS director of research administration, gave opening remarks and moderated the keynote presentation.

Institute researchers presented their work at the Transportation Research Board 90th Annual Meeting January 23–27 in Washington, D.C. Approximately 4,000 presentations and papers addressed topics of interest to attendees—policymakers, administrators, practitioners, researchers, and representatives of government, industry, and academic institutions.

University of Minnesota faculty and staff presenters included:

- Department of Civil Engineering: Gary Davis, Henry Liu, Panos Michalopoulos
- Department of Computer Science and Engineering: Shashi Shekhar
- Humphrey School of Public Affairs: Xinyu Cao, Frank Douma, Yingling Fan, Adeel Lari, Lee Munnich
- Northland Advanced Transportation Systems Research Laboratories, UMD: Eil Kwon
- Department of Electrical and Computer Engineering, UMD: Imran Hayee, Taek Kwon

ITS researchers also presented at the annual Toward Zero Deaths Conference in October in St. Paul. This conference serves as a forum for sharing information on how to reduce the number of fatalities and injuries on Minnesota roads. Three University of Minnesota researchers gave presentations in concurrent sessions:
Technology Transfer

• Mike Manser, director of the HumanFIRST program, “Age and Driving Behavior: What Can We Do About It?”
• Craig Shankwitz, director of the Intelligent Vehicles Lab, “Rural ITS Safety”
• Lee Munnich, director of the Center for Excellence in Rural Safety, “Political Dimensions of Traffic Safety”

The 2010 annual Summer Institute of the Center for Excellence in Rural Safety, held in Minneapolis, focused on creating a national strategy to improve rural safety. The event featured speakers from across the nation, including ITS Institute researchers. Humphrey School of Public Affairs associate dean Greg Lindsey stressed the need for a collaborative, performance-based approach to rural transportation safety. Tom Horan, who introduced version 3.0 of the online crash-mapping tool SafeRoadMaps, and researcher Benjamin Schooley shared the latest about their ongoing research to improve rural emergency response. And Institute director Max Donath discussed projects under way to support novice teen drivers using special safety technology in vehicles.

Transportation experts, scholars, and industry professionals from Minnesota and across the country gathered July 9 in Minneapolis for roundtable discussions of a number of TechPlan projects. TechPlan is a program of the ITS Institute that focuses on planning and policy for ITS. Under TechPlan, researchers with the Humphrey School of Public Affairs investigate how new technology can be used to solve transportation planning and infrastructure challenges.

In the annual forum, called “TechPlan: New Frontiers in Transportation Policy, Technology, and Planning,” researchers received feedback from forum participants about the current findings of their research. Twitter was used to broadcast the talking points in real time during the presentations.

Greg Lindsey gave opening remarks, and Jan Lucke, manager of research administration services for the ITS Institute and CTS, served as moderator. Max Donath, Institute director, gave closing remarks. Humphrey School presenters and their projects were:

- Jason Cao, “Benefit-Cost Analysis of Value Pricing: Case Study for MnPASS”
- Lee Munnich, “Implementing Distance-Based User Fees as a Replacement for the Fuel Tax”
- Melissa Stone and Barbara Crosby, “From Start to Finish: Cross-Sector Collaboration and the Urban Partnership Agreement”
- Tom Horan and Benjamin Schooley, “ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment—Phase II”
- Lindsey, “Understanding Use of Nonmotorized Transportation Facilities”
- Frank Douma, “ITS and Locational Privacy: Suggestions for Peaceful Coexistence”

Visiting researchers bring expertise, build partnerships

During the past year, the Institute continued to work with visiting researchers, allowing for an exchange of information and dissemination of research results to the visitors’ students and colleagues.

The Advanced Transportation Technologies Seminar Series provided an opportunity to host four national researchers (see page 33 for details).

Other visiting researchers include Thomas Horan, an associate professor at Claremont Graduate University and visiting scholar at the Humphrey School of Public Affairs, and Nobuyuki Kuge and Tomohiro Yamamura of Nissan, Jeff Caird of the University of Calgary, and Dick de Waard of the University of Groningen, all working with the Institute’s HumanFIRST Program.
Publications, web highlight Institute work

This year, the Institute updated its web pages for major projects, including rural unsignalized intersections, the teen driver support system, and SMART-Signal. Staff also created a web page compiling all the Institute’s distracted driving research projects.

Among its other electronic communications are the ITS Institute Update, a bimonthly publication sent to about 1,200 individuals. E-mail announcements publicized upcoming events, including Advanced Transportation Technologies Seminars. The seminars as well as luncheon presentations are now regularly broadcast live on the web and recorded for later viewing on the web and through iTunesU.

Nineteen articles about ITS-related research projects ran in the Center for Transportation Studies’ Research E-news electronic newsletter, which is mailed to about 4,000 subscribers and is available at www.cts.umn.edu/Publications/ResearchENews.

In other efforts to explore new channels of communication, staff worked with a production consultant to create a video about ITS careers (see related article, page 32). Staff also created a video highlighting the Institute’s Bus 2.0 project to explain and promote the research’s technology. Both videos are available on the Institute’s website and YouTube channel; more videos are planned for the coming year.

Print publications continued to share the results of Institute research. The Sensor newsletter covered Institute research activities, education, and technology transfer activities; upcoming ITS-related events; and recently published research reports (21 reports were published). The Sensor is available in print and online and reaches about 2,000 subscribers three times each year. It has been one of the primary vehicles for increasing the visibility of the ITS Institute, and its high circulation testifies to a broad interest in ITS research activities among academic and professional readership. The 12th ITS Institute annual report, highlighting work by ITS researchers and students, was mailed to more than 1,400 individuals and is available on the Institute’s website.

Annual report wins third design award

The ITS Institute’s FY10 annual report received its third consecutive American Graphic Design Award from Graphic Design USA, a news magazine for graphic designers and other creative professionals. The competition honors outstanding new work of all kinds—print, packaging, point-of-purchase, Internet, interactive, and motion graphics—and is open to any agency or firm engaged in design.

As a recipient of this award, the Institute received an embossed Certificate of Excellence and was published in the print and web version of Graphic Design USA Awards Annual.

Graphic designer Cadie Wright Adhikary, who designed each winning report, has been with the Institute for seven years. In addition to working on the report, Adhikary designs all the Institute’s communications products—posters for conferences, research fact sheets, displays, the Sensor newsletter, and numerous other materials. So she understands well the role that graphically appealing design can play in communicating complex research concepts.

“Graphic design makes science and research accessible to a wider audience,” she says. “Good design is good communication. A successful design uses visual elements like photography, informational graphics, and typography to communicate a message in a way that resonates with the audience, as well as supporting an audience’s understanding and memory of the message.”

Because science and technology are always developing new ideas, the need for creative design to communicate those ideas to potential end users will grow and evolve as well, Adhikary says. These qualities make her job endlessly interesting and challenging. “I’m always curious to see what technologies in transportation are on the horizon,” she says.
The ITS Institute’s education activities consist of a multidisciplinary program of coursework and experiential learning that supports the Institute’s theme. The educational program includes the disciplines of computer science and engineering, electrical and computer engineering, civil engineering, mechanical engineering, human factors, public policy, and others.

By supporting and sponsoring a variety of educational initiatives for students, the Institute is generating interest in its core ITS science and technologies. These initiatives include developing new curriculum and courses, involving undergraduate and graduate students in research projects, sponsoring students to attend national conferences, giving awards that recognize outstanding students, and offering research assistantships to help attract more students to the study of transportation. This section of the annual report highlights some of our efforts in the area of education.

New video showcases ITS-related careers

The Institute produced a 10-minute video designed to attract potential students to a future in transportation technology. The video, titled *Intelligent Transportation Systems: Your Road to the Future*, provides students with a glimpse of ITS Institute research projects, ITS-related projects and deployments in Minnesota, and a snapshot of Minnesota professionals who use ITS in their jobs.

The video is informative, entertaining, and visually appealing. It includes interviews with ITS professionals and organizations as well as current students planning ITS-related careers. By watching the video, potential students (and their parents) will gain an understanding of the breadth of ITS-related opportunities and gain familiarity with ITS-related careers.

*A student views the ITS Institute careers video.*
The field of transportation technology includes traffic engineering, policy and planning, vehicle and infrastructure design, and human and environmental factors. The video explains why this field is important to both the transportation of our nation and the economy as a whole. It also explains how these careers have longevity in the future of the world economy.

The video is intended primarily for middle and high school students who have an interest in math, science, or engineering. It is the latest Institute effort to attract K-12 students to this field of study. The video is posted on the Institute’s website and YouTube channel and will be used in settings such as career fairs and campus summer camps.

Transportation experts from industry, academia share findings in seminar series

During the 2010 Advanced Transportation Technologies Seminar Series, four visiting researchers presented ITS-related research on topics ranging from evaluating signal coordination to integrating driver privacy. The series also included three presentations from University of Minnesota faculty members on intelligent decision-support systems, analysis methods for data collected in a study of driver behavior, and camera network systems.

In the second presentation of the series, visiting researcher Luca Delgrossi outlined the role of communications in cooperative safety systems that enable vehicles to exchange safety information with other vehicles and roadside infrastructure. Delgrossi is the senior group manager of driver assistance and chassis at U.S. Mercedes-Benz Research and Development.

Communications technology for cooperative safety systems must have the ability to function at high speeds and work in a matter of seconds, Delgrossi said. Other requirements include two-way communication between vehicles and a protocol for short messages using a common data language. According to Delgrossi, the most promising communications technology for use in such systems is 5.9 GHz dedicated short-range communications (DSRC).

A challenge for the deployment of cooperative safety systems is that initial users will likely be paying for an extra feature that won’t come into use until other cars on the road have the same technology. This process could take 10 years or more if the systems are only available in new vehicles, Delgrossi said. To address this challenge, researchers are currently studying how to equip vehicles already on the road. The two most likely approaches are partnering with automotive manufacturers to retrofit existing vehicles with DSRC equipment or using after-market devices (such as smartphones) to accelerate deployment.

Other presentations in the series were:

- “Intelligent Decision-Support Systems Inside the Vehicle: Can They Help Drivers to Make Safer Driving Decisions?” Caroline Hayes, professor, Department of Mechanical Engineering
- “A Causal Model of Traffic Crashes and Conflicts,” Gary Davis, professor, Department of Civil Engineering
- “Avoiding the Matrix: How to Build Privacy into Intelligent Transportation Systems,” Dorothy Glancy, professor of law, Santa Clara Law
- “Camera Networks for Security and Traffic Applications,” Nikolaos Papanikolopoulos, professor, Department of Computer Science and Engineering
- “Automation Mania in the Time of Reason: Considerations for Complex Transportation Problems,” Stephen Popkin, director, Human Factors Research and System Applications Center of Innovation, Volpe Center, Research and Innovative Technology Administration, U.S. Department of Transportation
- “Visualization and Assessment of Arterial Progression Quality Using High-Resolution Signal
Event Data and Probe Vehicle Travel Time Data,” Darcy Bullock, professor, Department of Civil Engineering, Purdue University

This was the tenth year the Institute sponsored the multidisciplinary seminars, during which researchers report on findings from their work and bring new information to the ITS community. The series is offered as a one-credit graduate-level course, or attendees can earn one professional development hour for each seminar. Presentations are recorded and available for viewing on the web.

Institute students awarded travel funds

The ITS Institute gave travel awards to 12 students to support their attendance at national meetings and conferences.

**WTS International Conference in San Francisco, Calif. (May 15–17)**
- Department of Civil Engineering: Xuan Di

**90th Annual Meeting of the Transportation Research Board, Washington, D.C. (January 2011)**
- Department of Civil Engineering: Indrajit Chatterjee, Yiheng Feng, Heng Hu, Arthur Huang, Carlos Madera, Nick Ollrich, Pavithra Parthasarathi, Jie Sun, Hui Xiong
- Humphrey School of Public Affairs: Avital Barnea
- Department of Electrical Engineering and Computer Science, University of Minnesota Duluth: Buddhika Maitipe

One of the graduate students funded to attend TRB was Indrajit Chatterjee, who presented at a poster session on surrogate measures for safety. “The overall feedback from other peers was quite encouraging. I got some additional suggestions to improve and extend my work,” he says of the experience. He adds that it was also helpful to see the wide spectrum of cutting-edge research on traffic safety and operations. “Overall, the whole TRB experience was quite insightful and I hope it will benefit me in my future research efforts,” he says.

Engineering, planning students honored for ITS research

Three graduate students conducting ITS-related research received awards at the Center for Transportation Studies’ annual meeting and awards luncheon, held April 27 on the Twin Cities campus.

Hai Quang Dinh, who completed his master’s degree in electrical and computer engineering at the Duluth campus in February, received a Matthew J. Huber Award (given to students in engineering, science, and technology fields). In his research, Hai worked to develop a tracking-based traffic performance measurement system for roundabouts and intersections. He was advised by Assistant Professor Hua Tang.

David Coyle received a John S. Adams Award (given to students in policy and planning fields). Coyle is a master’s candidate in the Department of Applied Economics. His thesis, “Minnesota Highways: Revenue Source or Revenue Sink,” explores the potential of mileage-based user fees; these fee systems require ITS technologies for operation. Coyle’s advisor is Associate Professor Gerard McCullough.

Saif Jabari, a doctoral candidate in civil engineering, was honored as the ITS Institute Student of the Year Award for 2010. Jabari’s doctoral work concentrates on the development of mathematical models for estimating and predicting traffic conditions along freeways and signalized arterials. Associate Professor Henry Liu, Jabari’s advisor, said Jabari “may be the best student in his cohort” and noted that he contributed greatly to Liu’s research projects.
Career Expo draws record attendance

The ITS Institute teamed with the Center for Transportation Studies, the Minnesota chapter of the Women’s Transportation Seminar, the Minnesota Local Road Research Board, the Minnesota Local Technical Assistance Program, and the Council of Supply Chain Management Professionals to host the 2011 Transportation Career Expo on March 1. The event drew more than 100 students eager to learn about transportation-related careers, receive job-hunting tips, and network with potential employers.

The expo featured a general-session panel discussion with transportation industry experts presenting career alternatives and preparation strategies. Among those serving on the panel was past ITS Institute Student of the Year award recipient Fay Cleaveland, now a transportation planner with the Minnesota Department of Transportation.

An exhibitor fair offered networking and employment-seeking opportunities with representatives from the public and private sectors and professional organizations.

K-12 students try technology at camps, exhibits, and tours

Throughout the past fiscal year, Institute staff participated in several events, camps, and high school visits to introduce pre-college students to transportation and ITS-related fields. Among those efforts:

- The ITS Institute exhibited for the fourth year in a row at TechFest, a one-day event focusing on engineering, held at The Works, a hands-on science and technology museum in Edina, Minn. This year, the Institute’s exhibit featured Scout reconnaissance robots developed by computer science and engineering professor Nikos Papanikolopoulos and graduate students Jesse Purvey and Alex Hambrock in the Center for Distributed Robotics. Scouts are robots roughly the size of a soda can that have multiple mobility modes (e.g., jumping, rolling) and carry a variety of sensors (e.g., camera, microphone). Young visitors enjoyed maneuvering the robots around the exhibit space. In addition, kids and their parents tried their hand at managing traffic by playing Gridlock Buster, the Institute’s traffic control game. Other students staffing the exhibit were Nick Ollrich and Xuan Di with the Interdisciplinary Transportation Student Organization. About 2,000 people attended the event.
- The Institute and the Center for Transportation Studies hosted 25 students from the Leech Lake
Tribal College Summer Transportation Camp, presenting an overview of transportation careers and providing tours of lab facilities at the University of Minnesota.

- In July 2010, Institute staff demonstrated traffic simulation tools as well as Gridlock Buster to about 55 attendees during the CSE Exploring Careers in Engineering and Physical Science Summer Camp, hosted by the University’s College of Science and Engineering. The annual day camp is designed to introduce high school students to careers in science, engineering, and math.

- Institute staff and civil engineering graduate students Xuan Di and Nick Ollrich also assisted in teaching two summer camp courses to fifth and sixth graders at The Works in Edina, Minn., in July and August of 2010.

- In August, the Institute assisted the Center for Distributed Robotics and the Digital Technology Center with a Technology Day Camp, organized by the center’s director, Nikos Papanikolopoulos, and his graduate students. The program gives primarily underprivileged middle school students from the Twin Cities the chance to explore technology and robotics. The 125 participants in the camp, who attend free of charge, toured the MTO and aerospace engineering lab, built robots, and played Gridlock Buster.

- In November, the Institute participated in Mahtomedi Science and Engineering Night, an event for about 100 high school students. The Institute also participated in the Irondale High School STEM Career Fair 2011, during which industry representative Brian Smalkoski talked to students about engineering and planning careers. Another event the Institute took part in was the TwinWest Chamber of Commerce’s STEM Summit in March in Hopkins, Minn., to promote STEM careers to middle school students.

- In May of 2011, high school students from the Osseo (Minn.) school district toured the MTO with lab manager Ted Morris and aerospace engineering lab with Associate Professor Demoz Gebre-Egziabher.
Students find value in simulation program

Students gained valuable perspectives on highway design and urban planning through using the Simulating Transportation for Realistic Education and Training (STREET) program this last academic year. Students in Civil Engineering 3201: Introduction to Transportation Engineering used the program in the lab portion of class to design roadways and understand how different road configurations affect traffic through the Roadway Online Application for Design (ROAD) and Agent-based Demand and Assignment Model (ADAM) STREET modules.

“Both the ROAD and ADAM modules allowed us to have a more hands-on approach to real-life situations than simply solving textbook problems alone,” said Thomas Hall, a junior civil engineering student, adding that STREET gave him experience in creating models for proposed road infrastructure improvements.

Furthermore, students found the software program user-friendly and insightful compared to other programs they used in other classes. “Overall, I enjoyed my time using the program,” Hall said.

The experience with STREET provided students with experiences similar to those they would have as a transportation practitioner. “[STREET] gave me an insight on what projects a transportation engineer may work on, which was helpful in guiding me to make a decision on which emphasis of civil engineering I would like to pursue,” said Christina Caouette, a junior civil engineering student.

Funding for the STREET project comes from the National Science Foundation with matching support from the ITS Institute.

More players try Institute’s traffic game

“Gridlock Buster,” a traffic control game developed by the ITS Institute and Web Courseworks, continues to gain popularity. Gridlock Buster is an online traffic control game based on tools and ideas that actual traffic control engineers use in their everyday work. The goal of Gridlock Buster is to provide a fun way to teach students what is involved in traffic grid management and make transportation interesting and relevant.

Since its original posting online, Gridlock Buster has received more than 3 million game plays and has garnered national interest; for example, in April the game was used during Construction Career Day, an event that drew about 1,000 students in grades 6 through 12, at the University of Rhode Island. Locally, the game continues to be used as a recruiting tool by several area high schools, as a featured activity at related University of Minnesota summer camps and by elementary school children at education events, and as a teaching tool for university undergraduates as part of their coursework. Numerous camps and exhibits that the Institute hosted over the past year also incorporated Gridlock Buster into their activities.
Labs and Facilities

Minnesota Traffic Observatory
www.mto.umn.edu

Staff
John Hourdos, Director
Ted Morris, Lab Manager
Chen-Fu Liao, Educational Systems Engineer

Purpose
The Minnesota Traffic Observatory (MTO), a joint effort of the ITS Institute and the Department of Civil Engineering, supports a wide range of research in safety, monitoring, management, and simulation of traffic systems. The observatory combines real-time traffic data with state-of-the-art simulation systems, giving researchers and engineers the ability to analyze existing conditions and compare real-world observations with the results of simulated conditions.

Research Focus
MTO research focuses on testing and evaluating new transportation management and operational strategies and traveler information technologies. Specific focus areas include traffic data collection, microscopic simulation, traffic model calibration, and incident detection and prevention.

Recent Projects
- A Predictive Study of Use Impacts on the Denali Park Road
- Bus Signal Priority Based on GPS and Wireless Communications
- Enhanced Micro-Simulation Models for Accurate Safety Assessment

MTO lab manager Ted Morris, researcher and professor Gary Davis, and MTO director John Hourdos, pictured with a portable traffic data collection station. Video footage collected for a study on roundabouts is shown in the background.
- Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings
- Identification and Simulation of Common Freeway Accident Mechanisms
- Portable, Nonintrusive Advance Warning Devices for Work Zones With or Without Flag Operators
- Vehicle Probe-Based Real-Time Traffic Monitoring on Urban Roadway Networks

Capabilities
The MTO offers researchers the ability to study large traffic systems where many different parts interact. Video feeds flow into the observatory from an extensive network of traffic cameras. The observatory is connected by fiber-optic lines to the Minnesota Department of Transportation’s Regional Traffic Management Center, allowing the MTO to capture up to 16 live feeds at a time from any of the 400 cameras the agency uses to monitor the metropolitan freeway system. In addition, the observatory operates a dedicated system of cameras overlooking the I-94/I-35W Commons interchange in Minneapolis—turning one of the most crash-prone intersection areas in the state into a real-world laboratory for the study of traffic flows and vehicle crashes. Finally, the MTO has developed expertise in the deployment of portable traffic data stations. The MTO currently has five such stations capable of deploying a 28-foot mast virtually anywhere there is a light pole or traffic light and mounting on it traffic data-collection devices such as cameras or radar.

The availability of a wealth of high-quality video data is ideal for the use of machine-vision systems to monitor and categorize vehicle movements. Computer image-processing algorithms developed by University of Minnesota researchers enable the observatory to track and analyze complex traffic patterns at intersections, on freeway interchanges, and in other areas that are difficult to study using other data sources.

Another key component of the MTO is a virtual traffic control center and simulation lab. Interfacing traffic signal control hardware with realistic traffic network models creates a powerful hardware-in-loop simulation tool for examining system performance under a variety of conditions.

Several traffic simulation packages are used in the MTO, primarily AIMSUN-NG for “microscopic” simulation based on individual vehicles and the KRONOS 9 package, developed at the University of Minnesota, for macroscopic (platoon-based) simulations.

Given the complexity of the traffic issues that the observatory is designed to study, robust visualization tools are critical. In addition to a large projection wall, two innovative pieces of equipment provide researchers with powerful interactive visualization capabilities.

The GIS/MAP table combines the large horizontal working surface of a traditional drafting table with the interactive capabilities of geographic information systems technology. Two ceiling-mounted digital projectors create a seamless image covering the entire conference-table-sized surface, which can be manipulated using a tabletop pointing device to pan and zoom in on specific areas. In contrast to traditional ways of viewing digital maps and models on a desktop monitor, the table allows users to comfortably survey the entirety of a large traffic system and quickly focus in on areas of interest.

The DEN (Digital Immersive ENvironment) is a high-fidelity 3-D interactive immersive display system that allows researchers to observe and explore traffic flow scenarios within any environmental context and from any fixed or moving perspective. Three sides of the cubic structure are formed by large rear-projection screens presenting polarized images from two slightly different sources; a user wearing specially designed glasses sees a different image with each eye, producing a realistic sense of three-dimensional space. A tracking system mounted in the DEN’s ceiling monitors the position of the user’s head and adjusts each projector to provide an accurate perspective.
### Purpose

The Intelligent Vehicles Laboratory (IV Lab) develops and tests innovative, human-centered technologies that improve the operational safety, mobility, and productivity of the transportation network in general, and highway vehicles in particular. These human-centered technologies integrate sensors, actuators, computer processors, and custom human interfaces to provide drivers with needed information under difficult driving conditions such as low visibility, severe weather, and narrow and congested roadways.

Although the IV Lab is focused primarily on vehicles, it also considers the roadway, supporting infrastructure, and electronic wireless communication as part of the transportation network and uses all of these elements in generating solutions to transportation problems.

### Research Focus

The University of Minnesota is recognized as a leader in developing and testing driver-assist systems and is one of a small number of universities nationwide conducting this work. Current research topics include the design and testing of custom human interfaces, technologies to assist and monitor inexperienced teen drivers, collision-avoidance sensors and algorithms, intersection surveillance systems, and wireless communication (vehicle-vehicle and vehicle-infrastructure).

### Recent Projects

- Advanced Bus Rapid Transit: Innovative Technologies for Dedicated Roadways
- Infrared Sensing for Driver-Assist Systems
- Multiuse, High-Accuracy, High-Density Geospatial Databases
- In-Vehicle Driver Assistance for Teenagers

### Staff

- **Craig Shankwitz**, Director
- **Pi-Ming Cheng**, Research Associate
- **Eddie Arpin**, Research Fellow
- **Alec Gorjestani**, Research Fellow
- **Arvind Menon**, Research Fellow
- **Bryan Newstrom**, Research Fellow
- **Erin Kurshoff**, Principal Accounts Specialist

### Partners

- U.S. Department of Transportation
  - Federal Highway Administration
  - Research and Innovation Technology Administration
- Minnesota Department of Transportation
- University of Vermont
- National Park Service
- Next Generation SIMulation (NGSIM) Community
- Other local and regional agencies

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**Intelligent Vehicles Laboratory**

[www.ivlab.umn.edu](http://www.ivlab.umn.edu) | [www.bus2.me.umn.edu](http://www.bus2.me.umn.edu)

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**Outreach and Education**

The MTO is dedicated to supporting transportation education at the University. MTO facilities are used by faculty and students in civil, mechanical, and electrical engineering, computer science, and affiliated disciplines, and MTO staff work with faculty to develop interactive laboratory modules that help students understand advanced topics in traffic management. The MTO also hosts training events for transportation professionals, covering topics such as the effective use of traffic simulations for capacity analysis and planning.
• Motorcycle Riding Impairment at Different BAC Levels
• Guidance Augmentation for Transit Applications
• GPS Augmentation for Robust Lane Assistance
• Analysis of Highway Design and Geometric Effects on Crashes
• Urban Partnership Agreement: Deployment of Driver-Assist Systems for Bus-only Shoulders

Capabilities
IV Lab research focuses on increasing driver safety in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. Several vehicles serve as experimental testbeds for these technologies, including two passenger cars, the SAFEPLow (an International 2540 crew-cab snowplow), a state highway patrol car, and a Minnesota Valley Transit Authority (MVTA) bus used for transit research. Using these vehicles, IV Lab researchers are developing, testing, and integrating advanced technologies, including:
• Centimeter-level differential global positioning systems (DGPS)
• High-accuracy digital-mapping systems
• Range sensors, including radar and laser-based sensors
• A head-up display (HUD), virtual rear-view mirror, and other graphical displays
• Haptic and tactile feedback

The IV Lab’s partnership with MnDOT provides access to roads and other infrastructure, including the Minnesota Road Research Project (MnROAD) test track, which consists of a freeway and a low-volume road pavement test track with 40 different road material test sections, 4,500 electronic sensors, a weigh-in-motion scale, a weather station, and DGPS correction signals.

The core staff of the IV Lab consists of engineering professionals who work closely with an interdisciplinary team of specialists, including cognitive psychologists specializing in human factors from the ITS Institute’s HumanFIRST Program. The staff has expertise in wireless communications, embedded computing, visibility measurement and quantification, geospatial databases, virtual environments, image processing, driver-assist technologies, control systems, and sensors.

Partners
• U.S. Department of Transportation
  • Federal Highway Administration
  • Federal Transit Administration
  • Research and Innovative Technology Administration
• Minnesota Department of Transportation
• Minnesota Local Road Research Board
• Hennepin County
• Minnesota Valley Transit Authority
• Twin Cities Metro Transit
• Alaska Department of Transportation and Public Facilities
• Other local and regional agencies

Technologies developed at the IV Lab help Bus 2.0 drivers navigate narrow shoulders.
HumanFIRST Program
www.humanfirst.umn.edu

Staff
Michael Manser, Director
Ensar Becic, Research Associate
Janet Creaser, Research Fellow
Peter Easterlund, Simulator Manager
Justin Graving, Research Fellow
Chris Edwards, Research Fellow
Robyn Woollands, Research Assistant

Purpose
The Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program applies human factors principles to improve scientific understanding of driver behavior and supports the design and evaluation of usable intelligent transportation systems.

Research Focus
As implied by its name, the program’s research strategy is based on a driver-centered approach, considering the “human first” within the transportation system. Research seeks to propose, design, and evaluate innovative methods to improve transportation safety based on a scientific understanding of driver performance and the psychological processes associated with traffic crashes. It considers how a driver will accept and use a proposed system while also considering the possibility of its producing undesirable driver responses and adaptation (e.g., distraction, complacency, fatigue, risk-taking). Specific research topics include:

- Driver distraction from in-vehicle tasks and cell phones
- Driver-assist systems to reduce teen-driver-related fatal crashes
- Rural and urban driver attitudes and crash risk
- Interventions for crash reduction at rural intersections
- Intelligent driver-support technologies such as vision-enhancement, collision-avoidance, hazard-awareness, and lane-keeping systems for passenger and special-purpose vehicles
- Alcohol impairment, including motorcycle safety

Recent Projects
- Smartphone-Based Novice Teenage Driver Support System
- Vehicle-Based Teen Driver Support Systems
- Fuel Economy Display Design and Assessment
- Technology for Transit: Lane Guidance for Shoulder-running Buses
- CICAS Stop Sign Assist (SSA) System
- Motorcycle Riding Impairment at Different BAC (Blood Alcohol Concentration) Levels

Capabilities
The centerpiece of the facility is a state-of-the-art driving simulator engineered specifically for human factors
research in surface transportation. This versatile simulator consists of a full-cab Saturn SC2 vehicle and software capable of creating virtual environments that precisely reproduce any geospecific location. In addition, specialized visual-effect software can produce realistic weather and lighting—including light and shadow that correspond with season and time of day—as well as vehicle headlights with nighttime glare and water reflections.

The visual environment is generated with high-resolution images (1.97 arcmin per pixel) over a wide field of view (FOV): 210-degree forward field of view, 50-degree rear FOV, and two 20-degree FOV side mirror images. This immersive driving experience is enhanced by realistic motion generated by a three-axis motion base and both high- and low-frequency vibration units, including a surround-sound system. With multiple sound systems, configurable touch panel displays (including head-up displays), haptic feedback through the seat and accelerator pedal, and a head-free eye-tracker that can detect in real time what a driver is looking at, this simulator supports the investigation of a wide range of interface options for ITS development, design, and assessment. These features make it one of the premier driving simulators in North America and Europe.

The HumanFIRST Program also has access to a new bus driving simulator installed at the Minnesota Valley Transit Authority garage, where program staff can test and evaluate bus driver-support systems and bus driver training protocols. Additionally, for real-world testing and validation, the program has access to a variety of test track and operational research settings in which participants can drive the program’s fleet vehicles in a wide range of normal driving situations.

The HumanFIRST facility includes equipment for basic research on driver psychological functioning including a vision tester, DOT-certified breath alcohol analyzer, mobile psychophysiological recording system, mobile eye-tracking system, video editing and behavior analysis suite, and a comprehensive psychometric test battery validated for traffic psychology. A strength of this equipment is that it can be employed in the driving simulator, test track, or on-road research facilities.

The program’s core staff of transportation research specialists, made up of psychologists and engineers, provides a well-established base of content expertise. This core group is linked to a broad interdisciplinary network of experts in advanced, basic, and applied sciences throughout the University to provide a flexible and comprehensive research capacity. This network is supported by affiliations with additional University research units, which allows the program to create interdisciplinary teams to investigate a range of complex human factors research issues in transportation safety.

The program has close relationships with the Minnesota Departments of Transportation and Public Safety, private industry, traffic engineering consultants, and other related entities. These connections provide support for implementing research that will influence transportation policy in response to real-world problems both regionally and nationally. In addition, to ensure that research takes into account developments on the world stage, the program’s work is supported by international collaborations with experts in relevant disciplines.

**Partners**

- United States Department of Transportation
  - Federal Highway Administration
  - National Highway Traffic Safety Administration
  - Research and Innovative Technology Administration
- Minnesota Department of Transportation
- Minnesota Local Road Research Board
- Minnesota Valley Transit Authority
- Other local and regional agencies
Purpose
The Northland Advanced Transportation Systems Research Laboratories (NATSRL), founded in 2000, is a faculty-based transportation research program at the University of Minnesota Duluth (UMD). The primary mission of NATSRL is to develop innovative technologies that can be directly applicable in making the transportation systems in northern areas safe, efficient, and sustainable.

Research Focus
The current research focus areas in NATSRL include:
- Advanced sensing technologies for detecting and measuring traffic, driver, pedestrian, and pavement condition
- Traffic and driver safety technologies through vehicle and infrastructure integration with wireless communication
- Winter road snow and ice management decision-support strategies
- Advanced traffic operations and management strategies under various traffic and weather conditions

Recent Projects
- Carbon-nanotube-based intelligent concrete pavement for traffic detection
- A non-intrusive sensing system to detect driver drowsiness
- A snow and ice detection system for bridge decks and road surfaces with time domain reflectometry (TDR) technology
- Traffic detection and monitoring based on customized vision-processing hardware
- A realistic snow-rendering graphic simulation model used to visualize and assess the effects of alternative snowplow lighting and coloration designs
- A dedicated short-range communications (DSRC)-based driver information system for work zones
- A hydrogen-gas-based alternative power system for operating ITS devices
- A robotic painter for pavement markings
- An infrared thermal-camera-based deer detection system with automatic tracking
- A decision-support system for proactive deployment of ITS safety strategies
- A road-departure warning system with automatic identification of vehicle location

Capabilities
All research projects supported by NATSRL are performed at individual departments at UMD. The common research facilities, which can be shared by researchers, include a...
driving simulator and an outdoor laboratory where new prototype detection systems for traffic, snow, and ice are utilized for various studies. NATSRL has also been developing cooperative research activities in transportation with foreign research institutes and universities. These include a visiting researcher and graduate student exchange program and joint research projects. Currently one international graduate student is working at NATSRL as a visiting scholar.

**Partners**

NATSRL has formed a partnership with its key stakeholders by developing a Research Advisory Panel (RAP) and Advisory Board structure whose membership includes experts from the following partnership agencies:

- Minnesota Department of Transportation
- St. Louis County, Minnesota
- City of Duluth, Minnesota

The RAP, which meets every semester, plays a major role in managing and guiding NATSRL research activities. Further, it has been working as the ongoing communication channel between NATSRL faculty and local transportation practitioners by addressing the research needs from the field as well as the needs of the researchers in terms of data and testing platforms. The strategic directions and the yearly research programs of NATSRL are discussed and finalized at the annual Advisory Board meeting.
ITS Institute Board and Management Structure

The ITS Institute is located on the Twin Cities campus of the University of Minnesota and is part of the Center for Transportation Studies (CTS), with facilities housed within multiple colleges and departments as well as at the University’s Duluth campus. Much of the Institute’s successful leadership in the development and application of intelligent transportation systems and technologies results from its state and national partnerships, including those with CTS, the Minnesota Department of Transportation, transit agencies, private industry, and county and city engineers.

The Institute director leads its operation, implements its strategic plan, and directs Institute programs, personnel, and funds.

The Institute’s board guides and oversees the implementation of the Institute’s work. The board works with the director to ensure that the USDOT’s Research and Innovative Technology Administration requirements are met, approves annual plans and budgets, and meets at least twice yearly to provide direction to, and approval of, the Institute’s activities.

Institute staff and University researchers, drawing from various areas of expertise, help create and spread knowledge related to intelligent transportation systems through research, education, and technology transfer activities. In addition, the leadership and staff of CTS provide connections and access to an extensive transportation research and education network. The Institute’s affiliation with the Center allows it to work seamlessly with CTS staff and benefit from its diverse outreach, administration, and communications capabilities.

Board member whose term ended during the fiscal year: Joe Peters, Director, Office of Operations Research Development, Federal Highway Administration
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College of Science and Engineering
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Civil Engineering
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John Hourdos
David Levinson
Chen-Fu Liao
Henry Liu
Julian Marshall
Panos Michalopoulos
Ted Morris

Computer Science and Engineering
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Eddie Arpin
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Pi-Ming Cheng
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Peter Easterlund
Chris Edwards
Alec Gorjestani
Justin Graving
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Craig Shankwitz

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John Bryson
Jason Cao
Barbara Crosby
Frank Douma
Yingling Fan
Thomas Horan
Greg Lindsey
Lee Munnich
Ferro Robinson
Melissa Stone
Elizabeth Wilson
Zhirong Zhao

Northland Advanced Transportation Systems Research Laboratories
The NATSRL program director is Eil Kwon.
Support and guidance for NATSRL are provided by its advisory board and research advisory panel, whose members are staff from partnership agencies that include MnDOT, St. Louis County, and the City of Duluth.

Faculty and research staff conducting ITS-related research for NATSRL include the following:

University of Minnesota Duluth, Swenson College of Science and Engineering

Chemistry and Biochemistry
John Evans
Venkatram Meredy

Civil Engineering
Eil Kwon

Computer Science
Peter Willemsen

Electrical and Computer Engineering
M. Imran Hayee
Taek Kwon
Hua Tang
Jiann-Shiou Yang

Mechanical and Industrial Engineering
Seraphin Abou
Hongyi Chen
Ryan Rosandich
Xun Yu
Debao Zhou
Appendix

ITS Institute Research Projects

Projects are listed under their corresponding research category and alphabetically by principal investigator. Project summaries and additional information for each research project listed in this section are online on the ITS Institute’s website at www.its.umn.edu/Research.

Human Performance and Behavior

Gary Davis and John Hourdos,
Department of Civil Engineering
Field Study of Driver Behavior at Flashing Yellow Arrow vs. Green-Ball Permitted Left-Turn Indications
.Status: New

Max Donath, Alec Gorjestani,
Janet Creaser, and Michael Manser,
Department of Mechanical Engineering
Smartphone-Based Novice Teenage Driver Support System
.Status: Complete

Caroline Hayes,
Department of Mechanical Engineering
In-Vehicle Decision Support to Reduce Crashes at Rural Thru-Stop Intersections
.Status: In progress

Caroline Hayes,
Department of Mechanical Engineering
Hand Images in Virtual Spatial Collaboration for Traffic Incident and Disaster Management
.Status: New

Justin Graving and Michael Manser,
Department of Mechanical Engineering
Bus Driver Intersection Task Analysis: Investigation of Bus-Pedestrian Crashes
.Status: New

John Hourdos and Gary Davis,
Department of Civil Engineering
Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings
.Status: In progress

Chen-Fu Liao,
Department of Civil Engineering
Spatial Cognition of the Blind and Visually Impaired while Using a Mobile Accessible Pedestrian System (MAPS) at Intersection Crossings
.Status: New

Michael Manser,
Department of Mechanical Engineering, and Michael Rakauskas,
(formerly of Department of Mechanical Engineering)
Requirements for Effective Fuel Economy Displays for Improving Fuel Economy and Safety
.Status: Complete

Michael Manser, Craig Shankwitz,
Department of Mechanical Engineering
An Evaluation of a Prototype Safe Teen Car
.Status: In progress

Xun Yu,
Department of Mechanical & Industrial Engineering (Duluth)
Real-Time Nonintrusive Detection of Driver Drowsiness
.Status: Complete

Xun Yu, John Hourdos, and Gary Davis
Department of Mechanical & Industrial Engineering (Duluth)
Integrated Approach for Nonintrusive Detection of Driver Drowsiness
.Status: In progress

Computing, Sensing, Communications, and Control Systems

John Evans,
Department of Chemistry and Biochemistry (Duluth)
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Phase II)
.Status: In progress

John Evans,
Department of Chemistry and Biochemistry (Duluth)
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Phase III)
.Status: In progress

John Evans,
Department of Chemistry and Biochemistry (Duluth)
Deployment and Field Testing of Novel Water and Ice Sensor Systems on Bridge Decks
.Status: In progress

John Evans,
Department of Chemistry and Biochemistry (Duluth)
Continued Field Testing and Refinement of Novel Water and Ice Sensor Systems on Bridge Decks
.Status: New

M. Imran Hayee,
Department of Electrical & Computer Engineering (Duluth)
Development of a Portable Work Zone Traffic Information System Based on DSRC and Bluetooth-Enabled Cell Phones
.Status: Complete

M. Imran Hayee,
Department of Electrical & Computer Engineering (Duluth)
.Status: In progress

M. Imran Hayee,
Department of Electrical & Computer Engineering (Duluth)
Development of a Low-Cost Interface between Cell Phones and DSRC-Based Vehicle Unit for Efficient Use of VII Infrastructure
.Status: Complete

John Hourdos,
Department of Civil Engineering
Development of a Low-Cost Interface for Efficient Use of VII Infrastructure
.Status: In progress

Eil Kwon,
Department of Civil Engineering (Duluth)
Advanced Dynamic (LED) Warning Signs for Rural Intersections Powered by Renewable Energy
.Status: Complete

Eil Kwon,
Department of Civil Engineering (Duluth)
Development of Freeway Management and Operational Strategies with IRIS-in-LOOP Simulation
.Status: In progress

Eil Kwon,
Department of Civil Engineering (Duluth)
Estimation of Winter Snow Operation Performance Measures with Traffic Flow Data
.Status: In progress

Taek Kwon,
Department of Civil Engineering (Duluth)
Advanced Dynamic (LED) Warning Signs for Rural Intersections Powered by Renewable Energy
.Status: Complete

Taek Kwon,
Department of Electrical & Computer Engineering (Duluth)
Development of a Weigh-Pad-Based Portable Weigh-in-Motion (WIM) System
.Status: In progress

Taek Kwon,
Department of Electrical & Computer Engineering (Duluth)
New Reporting Capabilities for Continuous Vehicle and WIM Data
.Status: In progress

Nikolaos Papanikolopoulos,
Department of Computer Science and Engineering
Deployment of Practical Methods of

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Appendix: Research Projects

Counting Bicycling and Pedestrian Use of a Transportation Facility
► Status: In progress

Nikolaos Papanikolopoulos and Vassilios Morellas, Department of Computer Science and Engineering Counting Empty Parking Spots at Truck Stops
✔ Status: Complete

Nikolaos Papanikolopoulos and Vassilios Morellas, Department of Computer Science and Engineering Monitoring the Use of HOV and HOT Lanes
► Status: In progress

Rajesh Rajamani, Department of Mechanical Engineering Enhancement and Field Test Evaluation of New Battery-Less Wireless Traffic Sensors
► Status: New

Rajesh Rajamani, Department of Mechanical Engineering Ultra-Reliable Detection of Imminent Collision for Enhanced Passenger Safety
► Status: In progress

Rajesh Rajamani, Lee Alexander, Department of Mechanical Engineering Prediction and Prevention of Tripped Rollers
► Status: In progress

Rajesh Rajamani and Lee Alexander, Department of Mechanical Engineering Limited Deployment of Friction Measurement and Applicator Control System for Winter Road Maintenance
✔ Status: Complete

Ryan Rosandich, Department of Industrial Engineering (Duluth) Improve Safety and Efficiency of Roadway Maintenance by Developing a Robotic Roadway Message Painter
► Status: In progress

Ryan Rosandich, Department of Industrial Engineering (Duluth) Improve the Safety and Efficiency of Roadway Maintenance Phase II: Developing a Vision Guidance System for the Robotic Roadway Message Painter
★ Status: New

Craig Shankwitz, Department of Mechanical Engineering Rural Intersection Collision Avoidance System (RICAS) Design, Integration and Project Management Services
✔ Status: Complete

Craig Shankwitz, Department of Mechanical Engineering In-Situ Testing of State Patrol Vehicle Lighting, Retro-Reflectors, and Paint
► Status: In progress

Craig Shankwitz, Department of Mechanical Engineering Inexpensive 2-D Optical Sensor for DGPS Augmentation
► Status: In progress

Craig Shankwitz and Max Donath, Department of Mechanical Engineering GPS Augmentation for Robust Lane Assistance on Cedar Avenue in Support of the Urban Partnership Agreement
✔ Status: Complete

Shashi Shekhar, Department of Computer Science and Engineering, and Henry Liu, Department of Civil Engineering III-CXT: Spatio-Temporal Graph Database for Transportation Science
✔ Status: Complete

Hua Tang, Department of Electrical and Computer Engineering (Duluth) Development of a New Tracking System Based on CMOS Vision Processor Hardware: Phase II
► Status: In progress

Hua Tang, Department of Electrical and Computer Engineering (Duluth) A Tracking-Based Traffic Performance Measurement System for Roundabouts and Intersections
► Status: In progress

Hua Tang, Department of Electrical and Computer Engineering (Duluth) An Onboard Virtual Rumble-Strip Based Operation for Road Departure Warning
► Status: New

Peter Willemsen, Department of Computer Science (Duluth), Lee Zimmerman, Department of Electrical & Computer Engineering (Duluth), and Albert Yonas, Institute of Child Development Snow Rendering for Interactive Snowplow Simulation – Supporting Safety in Snowplow Design
★ Status: New

Peter Willemsen, Department of Computer Science (Duluth), Lee Zimmerman, Department of Electrical & Computer Engineering (Duluth), and Albert Yonas, Institute of Child Development Snow Rendering for Interactive Snowplow Simulation – Supporting Safety in Snowplow Design (Phase II)
► Status: In progress

Debashis Deb (Duluth), Department of Mechanical Engineering Snow Rendering for Interactive Snowplow Simulation: Improving Driver Ability to Avoid Collisions when Following a Snowplow
► Status: In progress

Debashis Deb, Department of Mechanical Engineering Infrared Thermal Camera-Based Real-Time Identification and Tracking of Large Animals to Prevent Animal-Vehicle Collisions (AVCs) on Roadways
► Status: In progress

Debashis Deb, Department of Mechanical Engineering Thermal Imaging-Based Driver Alert System with Real-Time Mapping of Roadside Deer Locations
★ Status: New

Technologies for Modeling, Managing, and Operating Transportation Systems

Hongyi Chen, Department of Mechanical Engineering Developing an Intelligent Decision Support System for the Proactive Implementation of Traffic Safety Strategies
► Status: In progress

Gary Davis and John Hourdos, Department of Civil Engineering Access to Destinations: Streamlining the Arterial Data Acquisition and the Estimation of Network-Wide Travel Link Times
► Status: In progress

Gary Davis and Henry Liu, Department of Civil Engineering Using Detailed Signal and Detector Data to Investigate Intersection Crash Causation
► Status: In progress

Gary Davis, John Hourdos, and Chen-Fu Liao, Department of Civil Engineering Estimating the Crash Reduction and Vehicle Dynamic Effects of Flashing LED Stop Signs
► Status: In progress

Max Donath, Craig Shankwitz, and Michael Manser, Department of Mechanical Engineering CICAS Stop Sign Assist (SSA) System
✔ Status: Complete

Max Donath, Department of Mechanical Engineering Aggregating VMT within Predefined Geographic Zones Using a Cellular Network
► Status: In progress

Max Donath, Department of Mechanical Engineering Analysis of the Impact of Road Use for Alternate Transportation in Denali Park
► Status: In progress

Demoz Gebre-Egziabher and Greg Nelson, Department of Aerospace Engineering & Mechanics Analysis of Uninhabited Aerial Vehicles ITS Concept of Operations
★ Status: Complete

Demoz Gebre-Egziabher, Department of Aerospace Engineering & Mechanics,
and Craig Shankwitz, Department of Mechanical Engineering
Development of an Accurate and Low Cost GPS-Based Heading Determination System
➤ Status: In progress

Demoz Gebre-Egziabher, Department of Aerospace Engineering & Mechanics, and Craig Shankwitz, Department of Mechanical Engineering
Using Velocity Constraints to Enhance Carrier Phase GPS Robustness
➤ Status: In progress

John Hourdos and Panos Michalopoulos, Department of Civil Engineering
Development of Next Generation Simulation Models for Twin Cities: Freeway Metro-Wide Simulation Model (Phase I)
➤ Status: In progress

John Hourdos, Nikolaos Geroliminis, and Gary Davis, Department of Civil Engineering
Vehicle Probe-Based Real-Time Traffic Monitoring on Arterials
➤ Status: In progress

John Hourdos, Department of Civil Engineering, and Seraphim Chally Abou, Department of Mechanical & Industrial Engineering (Duluth)
Effectiveness of Urban Partnership Agreement (UPA) Measures in the I-35W Corridor
➤ Status: In progress

John Hourdos and Gary Davis, Department of Civil Engineering
Expanding and Streamlining the RTMC Freeway Network Performance Reporting Methodologies and Tools
➤ Status: In progress

John Hourdos and Zuduo Zheng, Department of Civil Engineering
Evaluating Twin Cities Transitways’ Performance and their Interaction with Traffic on Neighboring Major Roads
★ Status: New

David Levinson, and Henry Liu, Department of Civil Engineering, and Kathleen Harder, College of Design
Traffic Flow and Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River
✔ Status: Complete

Chen-Fu Liao and Gary Davis, Department of Civil Engineering
Bus Signal Priority Based on GPS and Wireless Communications (Phase III)—Bus to Roadside Infrastructure Communication Framework for Intelligent Transportation
➤ Status: In progress

Chen-Fu Liao, Department of Civil Engineering, and Michael Rakauskas, formerly Department of Mechanical Engineering
Accessible Traffic Signals for Blind and Visually Impaired Pedestrians
✔ Status: Complete

Chen-Fu Liao and Henry Liu, Department of Civil Engineering
Advanced System Analysis for Public Transit (ASAPT) Using Data-Driven Transit Performance Measures for Transit Network Analysis
➤ Status: In progress

Chen-Fu Liao and Gary Davis, Department of Civil Engineering
Automate Traffic Data Quality Verification and System Malfunction Identification for ATR and WIM Systems
➤ Status: In progress

Henry Liu, Department of Civil Engineering
BECS Collaborative Research: Modeling the Dynamics of Traffic User Equilibria Using Differential Variational Inequalities
➤ Status: In progress

Henry Liu and Panos Michalopoulos, Department of Civil Engineering
Development of Algorithms for Travel-Time-Based Traffic Signal Timing, Phase I
✔ Status: Complete

Henry Liu and Panos Michalopoulos, Department of Civil Engineering
Development of the Next Generation Metro-Wide Simulation Models for the Twin Cities’ Metropolitan Area: Mesoscopic Modeling
✔ Status: Complete

Henry Liu and Chen-Fu Liao, Department of Civil Engineering
SMART-Signal: Systematic Monitoring of Arterial Road Traffic and Signals, Phase II
➤ Status: In progress

Henry Liu and David Levinson, Department of Civil Engineering, and Kathleen Harder, College of Design
BRIDGE: Behavioral Response to the I-35W Disruption: Gauging Equilibrium
✔ Status: Complete

Henry Liu, Department of Civil Engineering
Research Implementation of the SMART-Signal System on TH13
➤ Status: In progress

Henry Liu, Department of Civil Engineering
Further Development of the SMART-Signal System with the City of Eden Prairie
➤ Status: In progress

Henry Liu, Department of Civil Engineering
Estimating and Measuring Arterial Travel Time and Delay
➤ Status: In progress

Henry Liu, Department of Civil Engineering
Intelligent Pavement for Traffic Flow Detection (Phase I)
➤ Status: In progress

Henry Liu, Department of Civil Engineering
Intelligent Pavement for Traffic Flow Detection (Phase II)
➤ Status: In progress

Henry Liu, Department of Civil Engineering
A Prototype System for Chemical Hydrogen Generation and Storage for Operating ITS
★ Status: New

Panos Michalopoulos and Nikolaos Geroliminis, Department of Civil Engineering
Development of the Next Generation System with the City of Eden Prairie
➤ Status: New

Panos Michalopoulos, Department of Civil Engineering
Low Cost Portable Video-Based Queue Detection for Work Zone Safety
✔ Status: Complete

Xun Yu, Department of Mechanical & Industrial Engineering (Duluth)
Intelligent Pavement for Traffic Flow Detection (Phase I)
➤ Status: In progress

Xun Yu, Department of Mechanical & Industrial Engineering (Duluth)
Intelligent Pavement for Traffic Flow Detection (Phase II)
➤ Status: In progress

Panos Michalopoulos and Nikolaos Geroliminis, Department of Civil Engineering
Development of Algorithms for Travel-Time-Based Traffic Signal Timing, Phase I
✔ Status: Complete

Venkatram Mereddy, Department of Chemistry and Biochemistry (Duluth)
Development of Hydrogen-Based Power Systems for ITS Applications
➤ Status: In progress

Venkatram Mereddy, Department of Chemistry and Biochemistry (Duluth), and A.R. Hasan, Department of Chemical Engineering & Material Science
A Prototype System for Chemical Hydrogen Generation and Storage for Operating ITS
★ Status: New

Chen-Fu Liao, Department of Civil Engineering
SMART-Signal: Systematic Monitoring of Arterial Road Traffic and Signals, Phase II
➤ Status: In progress

Henry Liu, Department of Civil Engineering
BECS Collaborative Research: Modeling the Dynamics of Traffic User Equilibria Using Differential Variational Inequalities
➤ Status: In progress

Venkatram Mereddy, Department of Chemistry and Biochemistry (Duluth)
Development of Hydrogen-Based Power Systems for ITS Applications
➤ Status: In progress

John Bryson, Barbara Crosby, and Melissa Stone, Humphrey School of Public Affairs
Urban Partnership Agreement: A Comparative Study of Technology and Collaboration in Transportation Policy Implementation
✔ Status: Complete

John Bryson, Barbara Crosby, and Melissa Stone, Humphrey School of Public Affairs
From Start to Finish: Cross-Sector Collaboration and the Urban Partnership Agreement
➤ Status: In progress

Jason Cao and Frank Douma, Humphrey School of Public Affairs
Substitution between E-shopping and Travel: Evidence from the Twin Cities
✔ Status: Complete

Jason Cao and Lee Munnich, Humphrey School of Public Affairs
Benefit-Cost Analysis of Value Pricing: Case Study for MnPASS
➤ Status: In progress

Frank Douma, Humphrey School of Public Affairs
ITS and Locational Privacy: Suggestions for Peaceful Coexistence
➤ Status: In progress
Appendix: Research Projects

Frank Douma, Humphrey School of Public Affairs
ITS Data Needs: How Much Do We Really Need to Know?
▷ Status: In progress

Yingling Fan and Frank Douma, Humphrey School of Public Affairs, and Chen-Fu Liao and Julian Marshall, Department of Civil Engineering
Smartphone-Based Travel Experience Sampling and Behavior Intervention among Young Adults (UbiActive Phase I)
▷ Status: In progress

Thomas Horan and Benjamin Schooley, Humphrey School of Public Affairs
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phase II)
▷ Status: In progress

Thomas Horan and Benjamin Schooley, Humphrey School of Public Affairs
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phase III)
▷ Status: In progress

Thomas Horan and Benjamin Schooley, Humphrey School of Public Affairs
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phase IV)
▷ Status: In progress

David Levinson, Department of Civil Engineering
Computing Auto Accessibility to Other Destinations
▷ Status: In progress

David Levinson, Department of Civil Engineering
Consumer Travel Behavior and Retail Geography: A Microscopic Investigation Using GPS Data and Parcel-Level Land Use
▷ Status: In progress

Greg Lindsey, Humphrey School of Public Affairs
Understanding the Use of Nonmotorized Transportation Facilities through Application of Infrared and Radio-Frequency Technologies
▷ Status: In progress

Lee Munnich, Ferrol Robinson, and Zhirong Zhao, Humphrey School of Public Affairs
Implementing Distance-Based User Fees as a Replacement for the Gas Tax
▷ Status: In progress

Carissa Schively Slotterback, Humphrey School of Public Affairs, and John Hourdos, Department of Civil Engineering
Technology in Planning and Participatory Processes: Identifying New Synergies through Real World Application
✔ Status: Complete

Elizabeth Wilson, Humphrey School of Public Affairs, Kevin Krizek, University of Colorado (formerly Humphrey School of Public Affairs), and Julian Marshall, Department of Civil Engineering
School Travel and the Implications for Advances in Transportation Related Technology
✔ Status: Complete
Selected Publication of Work by ITS Institute Researchers


Chatterjee, I., and Davis, G. “Using High-Resolution Detector and Signal Data to Support Crash Identification and Reconstruction.” *Transportation Research Record* (in press).


Proceedings of the American Control Conference.


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Selected Presentations by ITS Institute Researchers


Cao, X. (2011, May and March). “Benefit-Cost Analysis of Value Pricing: Case Study for MnPASS.” Minnesota Department of Transportation Metro District Managers Meeting, Roseville, Minnesota; and Metro Transit Quarterly Meetings, Minneapolis, Minnesota.


Selections of Presentations and Publications by ITS Institute Researchers.
Appendix: Selected Publications and Presentations


www.its.umn.edu
Published Research Reports on ITS Institute Research

Reports are available in PDF format at www.its.umn.edu/Publications/ResearchReports.

Advanced LED Warning Signs for Rural Intersections Powered by Renewable Energy
Taek Mu Kwon and Ryan Weidemann
MnDOT 2011-04

Usability Evaluation of a Smart Phone-based Teen Driver Support System (TDSS)
Janet Creaser, Alec Gorjestani, Michael Manser, and Max Donath
MnDOT 2011-13

Gary A. Davis, Yorgos J. Stephanedes, and Jeong-Gyu Kang
CTS 95-05

Real Time Prediction of Freeway Occupancy for Congestion Control
Vladimir Cherkassky and Sangkug Yi
CTS 97-12

School Choice and Children’s School Commuting
Elizabeth Wilson, Julian Marshall, Kevin Kriek, and Ryan Wilson
CTS 09-01

Technology in Planning and Participatory Processes: Identifying New Synergies through Real World Application
Carissa Schively Slotterback and John Hurdos
CTS 09-09

Henry X. Liu and Xuan Di
CTS 10-10

The Interactions between E-Shopping and Store Shopping: A Case Study of the Twin Cities

Xinyu (Jason) Cao, Frank Douma, Faye Cleaveland, and Zhiyi Xu
CTS 10-12

Development of a Low-Cost Interface between Cell Phone and DSRC-Based Vehicle Unit for Efficient Use of IntelliDriveSM Infrastructure
Beau Roodell and M. Imran Hayee
CTS 10-14

Development and Field Demonstration of DSRC-Based V2I Traffic Information System for the Work Zone
Buddhika Maitipe and M. Imran Hayee
CTS 10-15

Real-Time Nonintrusive Detection of Driver Drowsiness – Phase II
Xun Xu
CTS 10-16

Low-Cost Portable Video-Based Queue Detection for Work-Zone Safety
Ted Morris, Jory A. Schwach, Panos G. Michalopoulos
CTS 11-02

Development of the Next Generation Metropolitan Simulation Models for the Twin Cities’ Metropolitan Area: Mesoscopic Modeling
Henry X. Liu, Adam Danczyk, and Xiaozheng He
CTS 11-03

Snow Rendering for Interactive Snowplow Simulation—Supporting Safety in Snowplow Design
Peter Willemsen
CTS 11-04

Development of the Next Generation Stratified Ramp Metering Algorithm Based on Freeway Density
Nikolas Geroliminis, Anupam Srivastava, and Panos Michalopoulos
CTS 11-05

Analysis of Unmanned Aerial Vehicles Concept of Operations in ITS Applications
Demoz Gebre-Egziabher and Zhiqiang Xing
CTS 11-06

The Urban Partnership Agreement: A Comparative Study of Technology and Collaboration in Transportation Policy Implementation
John M. Bryson, Barbara C. Crosby, Melissa M. Stone, Emily Saunoi-Sandgren, and Anders S. Imboden
CTS 11-07

Counting Empty Parking Spots at Truck Stops Using Computer Vision
Pushkar Modi, Vassilios Morellas, and Nikolaos P. Papanikolopoulos
CTS 11-08

Dual Frequency, Carrier Phase Differential GPS Augmentation
Eddie Apin, Bryan Newstrom, and Craig Shankwitz
CTS 11-09

Development of Mobile Accessible Pedestrian Signals (MAPS) for Blind Pedestrians at Signalized Intersections
Chen-Fu Liao, Michael Rakauskas, and Avanish Rayankula
CTS 11-11

Determination of the Alert and Warning Timing for the Cooperative Intersection Collision Avoidance System – Stop Sign Assist Using Macroscopic and Microscopic Data: CICAS-SSA Report #1
Alec Gorjestani, Arvind Menon, Pi-Ming Cheng, Craig Shankwitz, and Max Donath
FHWA-CICAS

The Design of a Minimal Sensor Configuration for a Cooperative Intersection Collision Avoidance System – Stop Sign Assist: CICAS-SSA Report #2

Download or order research reports online
Cover photos

Back cover (from left to right)

Top row
Nicollet Avenue from Sixth, Minneapolis, 1923. Minnesota Historical Society.


Traffic signal, Sixth and Nicollet, Minneapolis. Photographer: Charles J. Hibbard (1924), Minnesota Historical Society.

View west from the roof of the main post office of traffic and streetcars on the Third Avenue Bridge over the Mississippi River, November 1, 1951. Photographer: Minneapolis Star Tribune, Minnesota Historical Society.

Bottom row
Nicollet Avenue from Sixth, Minneapolis, 2011. Photographer: Ujwal Adhikary.


Multiple-lane highway traffic jam, 2009.
Human-centered technology to enhance safety and mobility