Human-centered technology to enhance safety and mobility


University of Minnesota
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 2008–2009

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This annual report marks my twelfth year as director of the ITS Institute. In that time, it has been my privilege to work with exceptional researchers from many academic disciplines in the search for innovative solutions to new and old problems. As I reflect on the past decade and look forward to fresh challenges in the coming year, I would like to highlight the importance of real-world collaboration to our success.

Our research is aimed at solving problems in the real world; deployability is a key criterion against which all our efforts are judged. In the current economic climate, it is more important than ever to focus our available resources on the safety and efficiency of our national transportation system to maintain its competitive advantage.

Researchers alone cannot succeed in bringing ITS technology from the research lab to the street. That is why the Institute seeks to develop productive collaborations with transportation agencies, local governments, and private-sector partners.

The SMART-Signal system, developed by civil engineering associate professor Henry Liu in collaboration with the Minnesota Traffic Observatory and local stakeholders, is one example of bringing the benefits of ITS to city streets. This project also exemplifies the Institute’s commitment to working with transportation agencies and other stakeholders to develop deployable solutions to real-world problems.

SMART-Signal addresses the need for more efficient management of arterial streets in urban and suburban areas. Numerous tools and technologies have been developed by ITS researchers to manage traffic flows on urban freeways—the Autoscope™ system, for example, is widely used—but relatively little work has been done to date on arterial traffic.

The name SMART-Signal stands for “Systematic Monitoring of Arterial Road Traffic and Signals”—and as the name implies, the system makes traffic signals...
“smarter” by collecting and archiving real-time data and generating performance measures that include travel time between intersections, queue length, intersection delay, and overall level of service. Dedicated hardware and software installed in the signal control cabinets at intersections carry out monitoring and analysis functions automatically, giving traffic managers an unprecedented level of detailed data on arterial traffic.

This accurate and timely performance data will be the foundation of future SMART-Signal development, as the system is intended to support automatic adjustment of arterial signals in response to changing traffic conditions. By enabling sets of traffic signals to work together in real time, SMART-Signal will make arterial corridors intelligent enough to reduce total congestion and driver delay.

The Minnesota Department of Transportation (Mn/DOT) and Hennepin County, which encompasses the city of Minneapolis, recognized that better arterial traffic management could significantly improve traffic operations. The county worked with Liu to identify an arterial corridor where a prototype of the SMART-Signal could be deployed for real-world testing. Alliant Engineering, headquartered in Minneapolis, joined the project as a private-sector partner with extensive ITS experience.

The Minnesota Traffic Observatory, one of the ITS Institute’s dedicated laboratories, played a key role in the development of SMART-Signal, providing hardware-in-loop simulation capabilities that allowed Liu to experiment and to calibrate the system in a highly realistic virtual traffic environment, including actual signal controller hardware and modeling of street traffic at the level of individual vehicles.

Development of the necessary hardware and software components for SMART-Signal began in 2006, with funding from the Minnesota Local Road Research Board, the ITS Institute, Mn/DOT, and significant in-kind support from Hennepin County. Today, the prototype system has been deployed on an 11-intersection arterial segment in Minneapolis as well as on a signalized suburban highway segment. A third test site, with 14 intersections, is scheduled to be instrumented this year.

The productive relationship between researchers, public agencies, and private industry that made the development of SMART-Signal a success was recognized this year with the Center for Transportation Studies’ Research Partnership Award, which honors collaborative research teams whose work has had a significant impact on transportation.

This project is just one example of the collaborative research and development efforts under way at the ITS Institute; others highlighted in this report include our work with the National Park Service to manage traffic through Alaska’s Denali National Park, the multi-state pooled-fund Intersection Decision Support project to reduce crashes at unsignalized rural highway intersections, and our work with local transit providers to expand bus rapid transit service in the Twin Cities.

In my second decade as director, I look forward to many more opportunities to collaborate with stakeholders on all sides of transportation issues. Together, we can move ITS technologies from the drawing board to the road—and create a legacy of innovation for future users.

In closing, I would like to take this opportunity to thank departing ITS Institute board member Ron Hynes, deputy associate administrator with the Federal Transit Administration. We will miss the valuable contributions he made to the Institute’s mission during his tenure.

Max Donath
Director
ITS Institute
### Financial Report

Expenditures for Year 10: July 1, 2008–June 30, 2009

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<th>Category</th>
<th>Percentage</th>
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<tr>
<td>Administration</td>
<td>6%</td>
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<tr>
<td>Education</td>
<td>5%</td>
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<tr>
<td>Technology Transfer/Information</td>
<td>5%</td>
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<td>Research</td>
<td>84%</td>
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Total Expenditures: $6.5 million

### Mission Statement

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. That mission is 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.
Management Structure

The ITS Institute is located on the Twin Cities campus of the University of Minnesota and is housed within the Center for Transportation Studies (CTS). (A satellite laboratory is located on the 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, private industry, and county and city engineers.

The Institute director leads its operation, implements its strategic plan, and assumes overall responsibility for its success. In this role, he 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:**

Ron Hynes  
Deputy Associate Administrator,  
Federal Transit Administration

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<tr>
<th>ITS Institute Board Members (as of June 30, 2009)</th>
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| Mark Hoisser  
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| Anthony Kane  
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| Sue Lodahl  
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| Joe Peters  
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| Richard Sanders  
County Engineer, Polk County |
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Commissioner, Minnesota Department of Transportation |
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Kathleen Harder

Hubert H. Humphrey
Institute of Public Affairs
John Bryson
Jason Cao
Barbara Crosby
Frank Douma
Thomas Horan
Greg Lindsey
Lee Munnich
Keith Knapp
Carissa Schively Slotterback
Melissa Stone
Elizabeth Wilson

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Institute of Technology
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Demoz Gebre-Egziabher

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Alec Gorjestani
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Caroline Hayes
Michael Manser
Arvind Menon
Bryan Newstrom
Curt Olson
Rajesh Rajamani
Mick Rakauskas
Craig Shankwitz

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 partner-
ship agencies, including Mn/DOT, St. Louis
County, and the City of Duluth.

Faculty and research staff conducting ITS-
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Science and Engineering

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John Evans
Venkatram Mereddy

Civil Engineering
Eil Kwon

Computer Science
Peter Willemsen

Electrical and Computer Engineering
M. Imran Hayee
Taek Kwon
Hua Tang

Mechanical and Industrial Engineering
Robert Feyen
Richard Lindeke
Ryan Rosandich
Xun Yu
The mission of the Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program is to apply human factors principles to understand driver behavior and support the design and evaluation of usable intelligent transportation systems. 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.

The HumanFIRST Program has a core staff of transportation research specialists made up of psychologists and engineers who provide a well-established base of content expertise. This core group is linked to a broad interdisciplinary network of experts in 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 also 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.

Research in the HumanFIRST Program 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. This research considers how a driver will accept and use a proposed system while also considering the possibility of its producing undesirable

Research assistant Danny Drew driving in the HumanFIRST simulator while wearing a psychophysiological data recording cap
Recent research topics include:

- driver distraction from in-vehicle tasks and cell phones
- rural and urban driver attitudes and crash risk
- interventions for crash reduction at rural intersections
- intelligent driver-support systems such as vision-enhancement, collision-avoidance, hazard-awareness, and lane-keeping systems for passenger and specialty-purpose vehicles
- alcohol impairment including motorcycle safety
- intelligent driver-support systems for novice teen drivers

The facility includes equipment for basic research on driver psychological functioning including a vision tester, DOT-certified alcohol Breathalyzer, mobile psychophysiology recording system, mobile eye-tracking system, video editing and behavior analysis suite, and a comprehensive psychometric test battery validated for traffic psychology.

Much of the research of the HumanFIRST Program uses a state-of-the-art driving simulator engineered specifically for human factors research in surface transportation. This versatile simulator consists of a full-cab equipped for advanced research on driver behavior.

Rural expressway intersections pose a significant hazard for Minnesota drivers. At this type of intersection, a small road crosses a larger, multi-lane expressway and the only traffic control device available to drivers is a stop sign. This means drivers at the stop sign must judge gap sizes in fast-moving traffic to ensure the gap they select provides enough time to cross the intersection or enter the traffic flow without causing a crash. This task is difficult for many drivers, particularly when traffic speeds are high.

The ITS Institute developed a dynamic traffic sign that displays information to drivers about gaps in traffic that may make it unsafe for the driver to enter. The HumanFIRST Program then designed and evaluated several dynamic sign displays that could be erected at intersections to aid drivers in making crossing decisions. The goal was to develop a sign that intuitively displayed information about unsafe gaps.

The dynamic sign receives information about approaching traffic from a sensor network located at the intersection that incorporates multiple radar units. The sign depicts a diagram of the intersection, similar to a “divided highway” sign. When an approaching vehicle on the main road is detected within an unsafe gap size, a red box and “do not cross” symbol are displayed for the lanes in which the vehicle is detected. This means it is dangerous for a driver to attempt to enter or cross the intersection because the approaching vehicle is too close and a conflict or crash could occur. When a vehicle is detected by the system but is outside the unsafe gap, a yellow box is displayed on the sign. In this case, the sign warns the driver of approaching traffic, but the decision rests with the driver about whether she or he will use that gap. When no traffic is detected, the sign is blank and it is up to the driver to scan the roadway for approaching traffic and determine if it is safe to enter or cross.

Testing first took place in a driving simulator to assess the effectiveness of the designs and determine the best display to be deployed at the Minnesota test intersection. Further testing at the intersection using an instrumented vehicle supported the results of the simulator study. The results of both studies showed that drivers selected fewer unsafe gaps in traffic when the sign was present. Additionally, no unintended consequences occurred while using the sign.

In the future, a field study will be conducted using Minnesota drivers who live near the test intersection to determine how they behave when using the sign over a longer time period. The hope is that it will improve their ability to avoid unsafe gaps and lead to a reduction in crashes.
The Minnesota Traffic Observatory (MTO), a joint effort of the ITS Institute and the Department of Civil Engineering, supports the ability of researchers to study the complex dynamics of traffic flow throughout the Twin Cities region. 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.

Rather than showing one or two locations, the observatory offers a view of large 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 it to capture live feeds from up to 16 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
Transportation agencies must balance the need for highway construction with public concerns about congestion, delay, and work-zone safety. Full-road closure is one possible way of balancing these conflicting needs. In the Minnesota Traffic Observatory (MTO), researcher John Hourdos, who directs the MTO, and Gary Davis, a professor of civil engineering, evaluated traffic operations and extracted performance measures for partial-closure construction and full-road-closure construction alternatives for a section of Trunk Highway 36 (TH-36) in North St. Paul.

Their study went beyond the usual cost-benefit analysis because it included the cost of the additional time and fuel imposed on road users during the closure. This road use cost (RUC) is usually ignored by planners since, for traditional construction methodologies, the difference between alternatives is small. However, in the case of TH-36, the 20-month difference between a four-month full closure and a 24-month partial closure meant that the RUC was potentially important.

RUC can be calculated in three ways. The first, using algebra and a lot of assumptions, is easy, fast, but often inaccurate, Hourdos says. The second, using travel demand modeling, can also be inaccurate if the models were not specifically calibrated for the relatively small area of the construction project. The third, traffic simulation, can be very accurate but also very time consuming and costly. It also requires data that may not always be available.

“We wanted to see if we could estimate the RUC for the TH-36 project through simulation, and if we could, whether the results would be worth the expense,” says Hourdos. The simulation that he and Davis built aimed at capturing the impact of the TH-36 full closure on the surrounding areas. To achieve this, the model covers approximately one-quarter of the Twin Cities metro area, from I-35W in the west to the Wisconsin border in the east, and from I-94 in the south to I-694 in the north. It is the largest model built to date in Minnesota.

To create the model, the researchers used the AIMSUM traffic microsimulator and entered origin/destination demand data generated by the Metropolitan Council and intersection control information supplied by Mn/DOT and Ramsey County. The model was calibrated with the help of volume and speed data from Mn/DOT’s freeway loop detectors and temporary tube counts collected on the streets of North St. Paul before, during, and after the construction on TH-36. In the end, the model confirmed that a partial closure would have been more expensive than the full-closure method that was used. The researchers’ goal is to create guidelines that will enable transportation professionals to calculate RUC using a method that meets their specific need in a way that is both cost-effective and accurate.
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 on areas of interest.

The Digital Environment, or DEN, takes a different approach—putting viewers in the center of the action via three-dimensional immersive graphics. Three sides of the cubical 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.

**Intelligent Vehicles Laboratory**

The Institute’s 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.

Driver-assist systems developed by the IV Lab have been tested on specialty vehicles including snowplows, patrol cars, ambulances, heavy vehicles, and transit vehicles. Ultimately, these systems will also be used on passenger vehicles, providing drivers with warnings and assistance with collision-avoidance and lane-keeping tasks. Numerous vehicles utilizing IV Lab driver-assist technologies have been deployed in both Minnesota and Alaska.

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. 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 developed expertise in wireless communications, embedded computing, visibility measurement and quantification, geospatial databases, virtual environments, image processing, driver-assist technologies, control systems, and sensors.

IV Lab research seeks to increase driver safety in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. Several vehicles serve as experimental testbeds: the SAFETRUCK (an International 9400 tractor-trailer), the SAFEPLLOW (an
International 2540 crew-cab snowplow), a state highway patrol car, and a Minnesota Valley Transit Authority (MVTA) bus. 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 windshield head-up display (HUD), a virtual mirror and other graphical displays; and haptic and tactile feedback.

The IV Lab lane-assistive technology is unique in that it uses DGPS and does not require hardware in the roadway surface. The technology is transferable between various transportation modes and works in all low-visibility situations including snow, fog, smoke, heavy rain, and darkness. In addition, these systems use human-centered technology approach, the driver-assist system of the new BRT vehicles surrounds bus operators with a suite of tools designed to make their jobs easier and safer. The driver interface, the product of collaboration between IV Lab engineers and human factors researchers from the HumanFIRST Program, employs both visual and haptic (touch-based) modes to allow the driver to understand safety-critical information quickly and intuitively.

For the commuters who rely on BRT service to get them to and from work every day, the biggest benefits of the new technologies will be improved schedule adherence and a better overall riding experience. By making it possible for bus operators to use shoulder lanes under a wider range of conditions, buses equipped with the IV Lab’s driver-assist technologies will be able to avoid delays associated with traffic congestion and provide a service with many of the scheduling advantages of light-rail transit systems.

The Intelligent Vehicles Laboratory (IV Lab) is getting ready to put a new spin on public transportation in the Twin Cities. In 2010, a fleet of 10 buses equipped with advanced driver-assist technologies is scheduled to begin offering bus rapid transit (BRT) service on one of the area’s most important commuter routes, the I-35W/Cedar Avenue corridor linking downtown Minneapolis to the southeastern suburbs.

The project is part of Minnesota’s efforts to improve the performance of its transportation system under the U.S. Department of Transportation’s Urban Partnership Agreement (UPA) program. In June 2008, the federal agency selected Minnesota to receive $133.5 million under the program to fund a variety of innovative congestion reduction measures along the corridor. (The University of Minnesota’s portion of this funding is $4.3 million.)

BRT uses transit buses to provide the kind of fast commuter service usually associated with rail transit systems. Because it does not require the construction of rail lines or other specialized facilities, BRT is cost-effective and relatively easy to implement, making it a good option for rapidly improving commuter transit service, says ITS Institute director Max Donath.

The IV Lab has been working with BRT since 2002, when lab director Craig Shankwitz and Donath saw an opportunity to use driver-assist technologies to improve transit service. The result was a successful multiyear collaboration with Metro Transit, the Twin Cities’ primary transit agency.

Keeping track of a bus’s position to within a few centimeters over the entire route is one of the most significant technical challenges of the project. In addition to requiring extremely high accuracy — far beyond the capabilities of the satellite navigation units in new cars — the system must avoid losing track of its position even when the signals from GPS satellites are temporarily interrupted by bridges, buildings, and other obstacles along the route.

To improve the robustness of GPS positioning, IV Lab researchers developed a system that combines laser range sensors (lidar) mounted on the vehicle with radio-frequency identification (RFID) tags located along the road. A lidar sensor monitors the vehicle’s lateral position relative to a curb or barrier, while RFID is used to track longitudinal position along the route. An RFID reader mounted on the bus activates passive RFID tags as the bus passes, causing each tag to transmit its exact linear position along the route. An onboard computer combines the data from the RFID and lidar sensors and updates its internal estimate of the vehicle’s position whenever it determines that the position provided by the GPS system is not up to date.

In keeping with the ITS Institute’s “human-centered technology” approach, the driver-assist system of the new BRT vehicles surrounds bus operators with a suite of tools designed to make their jobs easier and safer. The driver interface, the product of collaboration between IV Lab engineers and human factors researchers from the HumanFIRST Program, employs both visual and haptic (touch-based) modes to allow the driver to understand safety-critical information quickly and intuitively.

For the commuters who rely on BRT service to get them to and from work every day, the biggest benefits of the new technologies will be improved schedule adherence and a better overall riding experience. By making it possible for bus operators to use shoulder lanes under a wider range of conditions, buses equipped with the IV Lab’s driver-assist technologies will be able to avoid delays associated with traffic congestion and provide a service with many of the scheduling advantages of light-rail transit systems.

High-tech buses tackle Twin Cities congestion

The IV Lab is getting ready to put a new spin on public transportation in the Twin Cities. In 2010, a fleet of 10 buses equipped with advanced driver-assist technologies is scheduled to begin offering bus rapid transit (BRT) service on one of the area’s most important commuter routes, the I-35W/Cedar Avenue corridor linking downtown Minneapolis to the southeastern suburbs.

The project is part of Minnesota’s efforts to improve the performance of its transportation system under the U.S. Department of Transportation’s Urban Partnership Agreement (UPA) program. In June 2008, the federal agency selected Minnesota to receive $133.5 million under the program to fund a variety of innovative congestion reduction measures along the corridor. (The University of Minnesota’s portion of this funding is $4.3 million.)

BRT uses transit buses to provide the kind of fast commuter service usually associated with rail transit systems. Because it does not require the construction of rail lines or other specialized facilities, BRT is cost-effective and relatively easy to implement, making it a good option for rapidly improving commuter transit service, says ITS Institute director Max Donath.

The IV Lab has been working with BRT since 2002, when lab director Craig Shankwitz and Donath saw an opportunity to use driver-assist technologies to improve transit service. The result was a successful multiyear collaboration with Metro Transit, the Twin Cities’ primary transit agency.

Keeping track of a bus’s position to within a few centimeters over the entire route is one of the most significant technical challenges of the project. In addition to requiring extremely high accuracy — far beyond the capabilities of the satellite navigation units in new cars — the system must avoid losing track of its position even when the signals from GPS satellites are temporarily interrupted by bridges, buildings, and other obstacles along the route.

To improve the robustness of GPS positioning, IV Lab researchers developed a system that combines laser range sensors (lidar) mounted on the vehicle with radio-frequency identification (RFID) tags located along the road. A lidar sensor monitors the vehicle’s lateral position relative to a curb or barrier, while RFID is used to track longitudinal position along the route. An RFID reader mounted on the bus activates passive RFID tags as the bus passes, causing each tag to transmit its exact linear position along the route. An onboard computer combines the data from the RFID and lidar sensors and updates its internal estimate of the vehicle’s position whenever it determines that the position provided by the GPS system is not up to date.

In keeping with the ITS Institute’s “human-centered technology” approach, the driver-assist system of the new BRT vehicles surrounds bus operators with a suite of tools designed to make their jobs easier and safer. The driver interface, the product of collaboration between IV Lab engineers and human factors researchers from the HumanFIRST Program, employs both visual and haptic (touch-based) modes to allow the driver to understand safety-critical information quickly and intuitively.

For the commuters who rely on BRT service to get them to and from work every day, the biggest benefits of the new technologies will be improved schedule adherence and a better overall riding experience. By making it possible for bus operators to use shoulder lanes under a wider range of conditions, buses equipped with the IV Lab’s driver-assist technologies will be able to avoid delays associated with traffic congestion and provide a service with many of the scheduling advantages of light-rail transit systems.

Artistic concept for the MVTA buses equipped with driver-assist technology
technologies to enhance driving ability and reduce driver error due to distractions, fatigue, and other factors related to difficult driving situations.

Other difficult driving conditions are encountered by drivers on a daily basis. For example, the vast majority of vehicle crashes occurring at rural, unsignalized intersections are the result of drivers incorrectly gauging the size of a gap between oncoming vehicles—not running stop signs. The IV Lab has developed a sophisticated rural intersection data-collection system used to study how drivers waiting at a low-volume minor road enter or cross a high-speed, high-volume expressway. This test intersection is located at the junction of U.S. 52 and Goodhue County Road 9 near Cannon Falls, Minnesota. The data collected at the intersection were used to model driver behavior to determine where the human gap-acceptance decision process fails and leads to a crash, and then used to design effective countermeasures.

Because safety systems can produce improvements only if they are deployed, the IV Lab works with a variety of states to collect data and evaluate system performance. Four vehicles with driver-assist technology have been deployed in Alaska, where high snowfall rates and dry, blowing snow routinely cause whiteout conditions and zero visibility. Because of its success with the IV Lab, the state of Alaska has ordered three new driver-assist systems and two upgrade kits for its systems that operate in Valdez. The kits will provide new computation capability not provided by the current computers.

The Minnesota Mobile Intersection Surveillance System (MMISS) has collected driver behavior at rural expressway through-stop intersections in Wisconsin, Iowa, Michigan, North Carolina, Georgia, Nevada, and California. Data collection in a broad array of states will ensure a nationally deployable intersection safety system designed to save lives among rural drivers. This technology is also being deployed at a rural expressway intersection (U.S. 53 and County 77 in Minong, Wis.) through the USDOT’s Rural Safety Improvement Program (RSIP). This represents yet another out-of-state-deployment of IV Lab technology.

Additional research topics include the design and testing of custom human interfaces, collision-avoidance sensors and algorithms, and wireless communication among vehicles and with the infrastructure. The IV Lab’s partnership with Mn/DOT 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 IV Lab also has relationships with a number of other organizations and government agencies—among them, the USDOT’s Research and Innovative Technology Administration, Federal Highway Administration, and Federal Transit Administration; Twin Cities’ Metro Transit; the Minnesota Valley Transit Authority; Minnesota’s Local Road Research Board; and various counties. These partnerships provide additional support for implementing research that will influence transportation safety in the United States and around the world.

Northland Advanced Transportation Systems Research Laboratories

The Northland Advanced Transportation Systems Research Laboratories (NATSRL), founded in 2000, form an advanced research program located at the University of Minnesota Duluth. Its mission is to develop innovative ITS technologies that can make surface transportation systems in northern areas safe, efficient, reliable, and environmentally sound.

Since its inception, NATSRL has been
According to the National Highway Traffic Safety Administration, drowsy drivers cause about 100,000 crashes every year, resulting in about 1,500 fatalities as well as 71,000 non-fatal injuries and $12.5 billion in damages.

Researchers at the University of Minnesota Duluth are trying to reduce these numbers. Xun Yu, assistant professor of mechanical and industrial engineering, is developing a low-cost sensor to detect drowsiness by measuring the electrical activity of the driver’s heart. He estimates that the final detection system would cost about $100 per vehicle, making it initially attractive to large companies and commercial fleet operators.

Yu, along with graduate student Shan Hu and undergraduate Ryan Bowlds, is using measurement techniques developed for electrocardiograms (ECG), which record electrical waves generated during heart activity. ECGs usually require electrodes to be placed on the head or chest, something that is not practical for drivers. To overcome this difficulty, the research team is examining two methods of measuring electrocardiac activity in the driver’s hands.

The first method involves wrapping each half of the steering wheel with special fabric that conducts electricity. The fabric acts as an electrode, picking up the electrical impulses of the heart as monitored in the hands and transmitting them to an onboard computer for analysis. This method is effective, but only when the driver is bare-handed and keeps both hands on the steering wheel.

The second method consists of installing piezoelectrical film around the inner circle of the steering wheel. The pumping action of blood flowing through the driver’s hands—which is related to the heart beat—causes the film to vibrate, and the vibration creates an electrical signal that can be analyzed by a computer. This method works for drivers who steer with one hand on the wheel, but like the first method, is effective only when hands remain bare.

In the next phase of their work, the researchers will improve the stability of the sensors, which are sensitive to vehicle vibration. They will also conduct large-scale tests to determine whether the sensors can detect drowsiness for most drivers, including those whose heart-rate patterns have slight variations. And they will decide how best to rouse drowsy drivers, Yu says, possibly by using sound or steering wheel vibration.
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 Department of Homeland Security. Other funding partners include the Minnesota Department of Transportation (Mn/DOT), Minnesota Local Road Research Board, Metropolitan Council, Hennepin County, Metro Transit, and the Minnesota Valley Transit Authority in addition to local governments, agencies, and private companies that contribute funding and in-kind match.

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

Research funding sources for all ITS-related research projects
The total funding for ITS-related projects was approximately $9.5 million in FY09. Sources for projects receiving funding in FY09 are shown in the chart to the right. During this period, 54 faculty and research staff and 48 students were involved in ITS-related research.
Motor vehicle crashes are the leading cause of teenage deaths. In 2008, teen drivers aged 16 to 19 accounted for 12.4 percent of all crashes in Minnesota, even though they represented only 6.8 percent of the driving population. Speeding, seat belt non-compliance, and distractions are the primary reasons for this high fatality rate.

Mandatory driver training programs have not reduced fatalities. Graduated driver’s licensing programs have been somewhat effective, but they are difficult to enforce because they rely heavily on parents to impose restrictions on their teens.

Intelligent speed adaptation, however, has the potential to reduce teen crash rates. This in-vehicle technology, which monitors and in some circumstances enforces speed limits, has been tested primarily in Europe on adult populations. Although some existing commercially available off-the-shelf systems appear to reduce risky driving behavior, few provide real-time feedback to help drivers change their behavior as they drive.

The first Teen Driver Support System (TDSS) prototype, developed by Institute researchers in 2006, gave drivers real-time auditory and visual feedback, but the system was bulky and complicated to install.

More recently a team of researchers created a smaller, more mobile system. A team that included researcher Janet Creaser, graduate student Richard Hoglund, HumanFIRST director Michael Manser, and ITS Institute director Max Donath used a “smart phone” to create a TDSS prototype that provides drivers with real-time auditory and visual feedback. The prototype can also send real-time text messages to parents about infractions and upload data to an online reporting system.

The smart phone is used to provide an in-vehicle display and is placed on the dashboard in such a way that the driver can readily see both the phone’s screen and the road. Four different items are displayed on the screen: vehicle speed, the quality of the GPS signal, the name of the street the vehicle is traveling on, and a traffic sign icon.

The traffic sign icon displays various traffic control signs that correspond to the actual driving environment. For example, if the driver is driving at or below the speed limit, a white speed limit sign is shown. If the driver exceeds the limit, the sign turns red and the speed limit value flashes. Stop signs and yellow diamond curve signs can be displayed as well.

In addition, the phone communicates with the Road/Weather Information Service server so drivers are alerted to low visibility, high wind, snow, rain, hail, or ice by pre-recorded auditory messages stored on the phone. When the weather warrants a reduction in speed, the speed limit sign in the picture box turns blue and shows the recommended speed.

To evaluate this TDSS prototype, the researchers completed a small usability study. The 16 participants were licensed drivers aged 18 and 19. Among them, they had a total of 11 previous moving violations—one for inattentive driving and the rest for speeding. Participants also reported a total of seven previous crashes for which they were considered at fault.

The participants drove an 8.7-mile circuit in Hennepin County both with and without the TDSS. They received visual and audio feedback, and text messages were sent (to one of the researchers) when they failed to alter their behavior. In general, the TDSS encouraged lower speeds in this group of drivers—although this may have been due, at least in part, to the presence of a researcher in the vehicle. The participating teens reported that very
little mental effort was required to interact with the TDSS while driving, but they also reported that the system made driving more stressful. Still needed is a more detailed field study to determine whether the system really changes driver behavior over the long term. “We want to see if drivers simply rely on the warnings provided by the system, or if the feedback really helps them learn to monitor their own behavior,” Creaser says.

During the next phase of the project, researchers will determine what information should be presented to parents in real-time text messages and uploaded into a weekly report. Ideally, the TDSS would help parents mentor their teens in safe driving behavior. If used in this way, the TDSS could be a useful tool for improving compliance with graduated driver’s licensing programs and reducing risky driving behavior.

Generational Perspectives on Teen and Older Drivers on Traffic Safety in Rural and Urban Communities

When planning crash-reduction programs, one size does not fit all, according to a team of researchers investigating how differences in attitude affect crash risk. Michael Manser, director of the ITS Institute’s HumanFIRST Program, and colleague Michael Rakauskas worked with researchers from the Minnesota Center for Survey Research on a study that compared the attitudes of urban and rural Minnesotans of various ages toward driving safety. Former HumanFIRST director Nic Ward, now at Montana State University, also contributed to the study while still in Minnesota.

Expanding on earlier work that investigated broad differences between the attitudes of urban and rural drivers, the researchers’ recent work focused on differences between older and younger drivers’ attitudes toward safety. Specifically, researchers wanted to learn how drivers perceived crash risk, safe driving practices, driving ability, and the importance of personal mobility to their quality of life.

The researchers also wanted to learn how drivers perceived various safety interventions, such as graduated driver’s licensing (GDL) programs and geographically focused campaigns targeted toward specific behaviors such as driving while impaired.

The first phase of the study consisted of a series of 12 focus groups. A total of 116 participants recruited from one rural area and one urban area of Minnesota were divided into three subgroups: teen drivers, senior drivers (age 65 and over), and parents of teen drivers.

During the second phase of the study, researchers evaluated surveys completed by participants before attending the focus groups.
group. The surveys included questions about the participants’ driving behavior, their perceptions of driving risk, and their thoughts about the effectiveness of traffic safety interventions. The questions were formulated in consultation with the Minnesota Department of Public Safety and officials affiliated with the Toward Zero Deaths program of the Minnesota Departments of Public Safety, Transportation, and Health.

Researchers learned that teen and senior drivers in both urban and rural areas rely on driving to preserve their independence and avoid inconveniencing others. In rural areas, driving may also be a necessity due to lack of public transportation or for unique purposes such as hunting or emergency transportation. Although teens and seniors drive for the same basic reasons, researchers found differences in how each group perceived driving risk and behavior:

- Rural residents, regardless of age, reported less frequent use of seat belts.
- Urban drivers reported more frequent driver errors and traffic violations.
- Teens driving in urban environments reported more episodes of aggressive and impaired driving, moving violations, and driver distraction.
- Seniors attributed crashes to slower reaction times, poorer vision, less acute hearing, or other physical problems.

Researchers found that teens and seniors also had different perceptions of safety strategies. Teens were far less receptive to enforcement as a safety intervention. They liked the idea of using “smart” technology to monitor driving behavior but wanted programs to balance cost, robustness, and limitations on driving patterns. Teens were uncertain about whether the state’s GDL program had made them safer drivers and were against limits on the number of passengers and nighttime driving for newly licensed drivers.

Senior drivers were more receptive to transportation and mobility services provided by private, nonprofit community organizations. They also tended to favor mandatory license retesting if it was convenient, fairly administered, and related to driving behavior, not age.

As a result of the study, the research team developed some potential policy recommendations and suggestions for future research. These include:

- Targeted safety campaigns in rural areas to encourage seat belt use.
- Development of a safety policy for teen drivers that addresses driver distraction, especially in urban areas.
- Development of a safety policy for senior drivers that focuses on sensory-motor functioning.
- Identification of ways to tailor the GDL program to better meet the needs of teens and their parents.
- A feasibility study of unique concepts for providing transit services (such as the Independent Transportation Network, which provides transportation to seniors through private, nonprofit organizations), especially in rural areas.

“This research has helped us understand drivers’ attitudes and behavior, as well as their receptivity to various safety interventions,” Manser says. “And that’s an essential part of creating effective traffic safety programs.”
Driver fatigue is believed to be a factor in many heavy truck crashes. The lack of safe, available truck parking on interstate highways may contribute to fatigue. According to a recent survey, most truck drivers prefer truck stops for overnight rests.

It is important and in some occasions absolutely necessary for drivers to have updated information on parking spot availability as they approach nearby truck stops. This will enable them to make timely rest decisions so that they do not exceed the legal limits of continuous driving hours set by the Federal Motor Carrier Safety Administration. Moreover, the availability of timely parking spot vacancy information may deter drivers from parking on the shoulders of highways or ramps, which creates a safety hazard for all motorists. Finally, parking in truck stops ensures the drivers get uninterrupted sleep.

Existing truck stop directories provide helpful information, but drivers could additionally benefit from a system that dynamically informs them of which stops have parking spaces available. Vehicle detection—a core technology component in these systems—presents distinct challenges when operating throughout the day and night. It is imperative that vehicle detection functions reliably under all weather conditions and at all times—especially at night, when demand for parking peaks.

Transportation professionals have introduced or proposed a wide range of technologies to develop parking information systems. After reviewing the most commonly used technologies, Professor Nikolaos Papanikolopoulos, Pushkar Modi, and Vassilios Morellas, all from the Department of Computer Science and Engineering, have determined that machine vision is currently the most practical and reliable technology.

In its simplest form, machine vision uses digital video cameras and image processing software to perform narrowly defined tasks such as counting objects on a conveyor belt or reading serial numbers—or in this case, counting empty spaces at a truck stop. However, this is not always so simple.

The researchers are developing a prototype system that would use video cameras suspended 30 to 60 feet above the parking area on rooftops or poles. Each parking spot would be monitored by more than one camera, which would increase the reliability of the system. The cameras would “see” by noting the percentage of pixels that are occluded, or covered, by a foreground object—in this case, a truck. Each camera would send these data to a computer, which would determine parking availability by using pattern recognition. Since the system does not require a high-quality representation of each truck, it is quite efficient and can compute up to 10 frames per second on a standard laptop computer.

Unlike more rigid systems, the machine vision system could be recalibrated to accommodate a change in environment or traffic conditions.
in parking layout. The system administrator could also improve the accuracy of the system by adding more cameras.

The research team is working on locating a test site that would yield the data needed to create an accurate knowledge base for pattern recognition. An ideal data set would be based on video feeds of one or more truck stops, with coverage of the same areas from more than one angle, in different light and weather conditions. Currently, the team is working with images from Live Maps, Microsoft’s Web mapping service. These maps offer reasonable “bird’s eye views” of truck stops from all four directions.

Truck design also poses a challenge. Detection of certain trucks may not be designated as a compact image region but as a collection of disconnected non-compact components (e.g., as a hollow frame), which makes these vehicles harder to identify and classify. Other trucks have highly reflective surfaces. On a sunny day, this surface could reflect light rays directly into the camera lens, leading to an overload of the optical sensor that would temporarily hamper the functioning of the camera. To prevent this, the researchers plan to rely on a secondary camera overlooking the same parking spot from a different angle. Good-quality optical filters might also solve this problem.

Additionally, the researchers must determine how best to broadcast space availability to truck drivers, since availability is likely to change by the time the driver arrives. “For example,” Papanikolopoulos explains, “if a truck stop has five spaces left, and 30 drivers converge on the truck stop based on a broadcast of that information, 25 of those drivers would end up being unhappy.”

**Cellular Wireless Mesh Sensor Network for Comprehensive Spatial Traffic Movement Detection and Data Fusion**

Engineers analyzing intersection traffic are often forced to rely on manual data collection—workers recording the movements of vehicles through the intersection using handheld data loggers, an approach that is both tedious and error-prone. Research by electrical and computer engineering professor Taek Mu Kwon aims to automate the process with small wireless sensor nodes that are easy to install temporarily on the road surface. Kwon also directs the Transportation Data Research Laboratory (TDRL) on the University of Minnesota Duluth campus and has led several research projects to improve traffic data collection and develop new sensor systems.

Kwon’s sensor nodes are designed to be installed in groups, with each sensor responsible for detecting vehicles in a single lane of traffic. Once in place, the sensor nodes automatically configure themselves as a “mesh” network, moving the raw data to a processing unit that extracts vehicle trajectories. The sensors are particularly suitable for short-term installation because each one is powered by its own battery and mounted on the road surface with an adhesive, but they can also be connected to an external power source for longer-term applications.

A mesh network is defined by multiple links between nodes. In a mesh topology, data can hop from node to node to reach a destination, rather than being transmitted directly to and from a central point. In a full cellular wireless mesh sensor network, components of the sensor network.

Professor Taek Kwon and graduate students Ryan Weidemann and Scott Klar show
The number of links increases rapidly as more nodes are added. Kwon’s sensor network strikes a balance between flexibility and complexity via a partial-mesh topology, in which each sensor is connected to at least two other nodes in order to provide alternative data routes, but not to every other node in the system.

The prototype sensor nodes are similar in size and shape to typical raised pavement markers, and the fiberglass housings are strong enough to protect the sensitive electronics inside when vehicles drive over them. Nodes can be deployed quickly by simply attaching them to the pavement with sprayable adhesive; when data collection is complete, they can be pried off the pavement with a screwdriver and used again.

In operation, each sensor node in an intersection registers the magnetic disturbance caused by a vehicle passing directly over it and transmits the exact time of that event through the mesh network to a data logger positioned nearby. The nodes’ communication protocol ensures that their internal clocks are synchronized, so the timing of every vehicle detection event is recorded accurately.

The tracking algorithm used by the mesh sensor system is a type of multiple target tracking (MTT) algorithm. Originally developed for military applications such as radar tracking of multiple aircraft, MTT algorithms are now used in commercial data collection systems due to the availability of powerful and inexpensive hardware and software technology. The MTT system partitions incoming data into sets of observations—tracks—produced by the same source. Based on these tracks, an MTT system can determine the number of current objects being tracked, compute their velocities, and predict likely future trajectories.

To monitor an intersection, a single sensor is responsible for each lane of traffic. Taking into account the geometry of the intersection, each node is designated either an “entrance” or an “exit” node. The tracking algorithm then matches events recorded by entrance nodes to events recorded by exit nodes, producing a set of node-to-node trajectories representing the movements of individual vehicles.

Testing of the sensors and tracking algorithm in both a traffic simulator and a real intersection installation have shown that the system can be a useful tool for engineers to count vehicle turning movements, according to Kwon. Future refinements of the tracking algorithm and the physical sensor design have the potential to make the system even more accurate and useful.
Every year, hundreds of thousands of visitors flock to Denali National Park for a spectacular glimpse into Alaska’s wilderness. They pile onto buses and travel the park’s single road, hoping to see wildlife and gaze at the 20,320-foot summit of Mount McKinley. But to do this, they have to find a spot on one of the 10,512 vehicle trips allowed into the park on the restricted Denali Park Road each year.

About four decades ago, not many visitors made the trip to Denali National Park. The only way to reach it was by train or by a bumpy, remote road. But when a major highway was built to the park, everything changed. In the past three decades, the number of visitors coming to Denali has grown nearly 200 percent—creating increased pressure to reevaluate the vehicle trip limit.

The National Park Service wanted to investigate how a change in the annual trip limit would affect the park’s wildlife and park visitors’ experience. To answer these complicated questions, they turned to researchers at the Institute’s Minnesota Traffic Observatory (MTO).

“The question that arose was, should this annual trip limit be different?” says MTO lab manager Ted Morris. “We needed to figure out if we could protect the park’s natural surroundings, park wildlife, and the visitor experience all at the same time by adding trips, or if we could change the system to make it better.”

The MTO researchers partnered with a multidisciplinary team to analyze three critical factors. The first was tracking wildlife movement and sightings. Buses were equipped with special devices so drivers could easily log the reason for a stop—including the type of wildlife they were stopping to view. Grizzlies and Dall sheep were also given tracking collars, allowing researchers to document their movements.

The second factor was visitor experience. Visitors were asked detailed questions about how their experience was affected—for better or worse—by crowding at rest areas and at wildlife sightings on the roadway. Researchers then analyzed those results.

The final task was to design a traffic simulation that combined the factors of wildlife movement, visitor experience, and the park road’s traffic patterns. MTO researchers created a complex traffic model that accounted for the unique traffic patterns in the park including traffic flow, bunching, and traffic density. Their model even accounts for some rather unusual research findings, such as the fact that buses stop an average of three to six minutes longer for a bear than for any other type of wildlife.

The result of this study was a traffic simulation tool that will allow park managers to make informed decisions about vehicle trip limits in Denali National Park. For example, they can use the simulation to evaluate trade-offs between visitor experience and visitor capacity. They can also test various alternatives to see how those choices would affect the park’s wildlife.

In the future, researchers hope the findings of this study can help protect and preserve not only Denali, but other parks as well—while keeping them accessible to visitors. The traffic simulation from the Denali Park study can be used as a framework for a tool to help any park facing crowding and capacity issues assess the potential impacts of visit limits.

Morris says their research may shape how the park is used for decades to come. “It is so important that wilderness areas are preserved,” he says. “In Alaska, 13 percent of the entire economy is tied to Denali Park, and also, Denali is one of the few true wilderness areas left for future generations to experience.”
The collapse of the Interstate 35W bridge over the Mississippi River on August 1, 2007, resulted in a tragic loss of life and a major disruption of the Twin Cities’ transportation system. As University of Minnesota structural engineers began to investigate the causes of the collapse, another group of researchers recognized a unique opportunity to study how metropolitan travel patterns respond to the sudden loss of a major transportation link.

In the weeks immediately following the collapse, civil engineering (CE) associate professor David Levinson, CE assistant professor Henry Liu, and human factors researcher Kathleen Harder received funding from the National Science Foundation (NSF) Small Grants for Exploratory Research program to gather traffic data, perform a preliminary analysis, and identify further research needs. They received subsequent funding from the NSF to study the traffic equilibration behavior after network disruption.

The NSF-supported effort also helped the researchers win funding for additional research. With support from the Minnesota Department of Transportation, their project, “Traffic Flow and Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River,” led by Levinson, aims to understand the effect of the bridge closure on observed travel behavior, shifts in traffic flows, and resulting effects on alternate routes.

The researchers are developing models of local travel behavior before and after the reconstruction of the bridge using data from surveys of travelers affected by the collapse as well as route-choice data gathered with GPS vehicle-tracking units. These models will enable the researchers to predict the distribution of traffic flows and impacts on alternate routes. The observations and models will also be used to estimate road user costs associated with the bridge collapse.

Another current project, “BRIDGE: Behavioral Response to the I-35W Disruption—Gauging Equilibration,” funded by the NSF and led by Liu, is studying how an extensive traffic system responds to a sudden, major network disruption. Equilibration refers to the process of establishing equilibrium—a stable condition that is assumed to characterize normal operation in many complicated transportation systems. Following a serious disruption, the researchers theorize, the Twin Cities surface transportation system is likely to settle into a new state of equilibrium as thousands of users adapt their behavior to the new demands of getting from place to place. On the other hand, the possibility that the system will remain chaotic for a long time cannot be ruled out without gathering detailed data.

“The problem of traffic flow evolution after a major network disruption has not been well-studied in transportation science,” said Liu. “We hope to fill in the gap.”
The federal Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy of Users (SAFETEA-LU) enacted in 2005 mandates that each state develop a Strategic Highway Safety Plan to reduce the number of roadway fatalities and crashes resulting in serious injury. Plans must be collaborative, comprehensive, and based on accurate and timely safety data.

Yet transportation planners have difficulty identifying and using new data sources beyond traditional crash data systems. They also find it challenging to identify strategies for sharing a wide range of data across multiple agencies. As a result, there has been little focus on studying how emergency medical services (EMS) and trauma systems could provide safety-related data for both real-time benefits and retrospective analysis that could improve planning and performance.

Tom Horan, executive director of Claremont Graduate University’s School of Information Systems and Technology and a visiting researcher at the Humphrey Institute of Public Affairs, has examined how information systems (IT) and intelligent transportation systems (ITS) are used to respond to vehicle crash emergencies and for evidence-based safety planning as required by SAFETEA-LU.

Horan, along with his colleague Benjamin Schooley, took a holistic approach. They studied the emergency response process from beginning to end—from crash notification to patient care and recovery. They began by reviewing previous research on the use of IT and ITS to integrate data about emergency response and treatment. They looked at automatic crash notification systems, next-generation 911 systems, the National Emergency Medical Services Informations System (NEMSIS), EMS and trauma communication systems, electronic medical records, and the Crash Outcome Data Evaluation System (CODES). The review confirmed that these systems operate in silos. Linking them is a technological challenge that requires organizational and policy-level attention.

As a second step, the researchers analyzed several Strategic Highway Safety Plans. They found that state-level efforts focus either on crash notification, identification, and location or on improved data and systems collaboration between EMS and trauma agencies. Conversations with leaders in state and federal departments of transportation also revealed that many plans did not have new tactics for addressing emergency response practice and improvement.

The researchers next carried out two in-depth case studies—one at the state level and one on the local level. In the state-level analysis, the researchers conducted a series of focus group discussions and follow-on interviews with decision makers in Minnesota to learn how crash, EMS, and trauma information is integrated and used.

Participants described organizational and policy challenges to information sharing. All agreed, however, that an integrated, secure system would improve patient care, reduce crashes, and decrease fatalities and disabilities, along with the associated costs to the state.

The local case study focused on the Mayo Clinic trauma information system in Rochester, Minnesota. Researchers conducted three focus group sessions at Saint Marys Hospital, one of two hospitals associated with Mayo. Participants included personnel from
emergency communications, medical transport, corporate communications, and IT. Also participating were emergency medicine physicians and a trauma surgeon. The sessions revealed a range of technological, organizational, and governance challenges to information sharing.

Finally, Horan and Schooley developed the concept and normative architecture for an Integrated Crash Trauma Information Network. This network of emergency responders, health care professionals, and IT/ITS systems would collect and share real-time data. These data could be used immediately to care for trauma victims and would also be valuable for retrospective analysis.

Within the next year, Horan plans to validate the Minnesota case studies by conducting comparative case studies in another state. Findings from this cross-case comparison will be used to create an initial prototype of the network. The researchers will then present the prototype to focus groups of stakeholders in Minnesota and elsewhere to demonstrate its potential value and get feedback.

“We want to spotlight the emergency response process, especially in rural states like Minnesota where accidents often occur miles from the nearest hospital,” Horan says. “Better coordination across the entire system has the potential to save many lives and improve traffic safety in general.”

Technology and Collaboration in Effective Transportation Policy

A collaboration of disparate organizations formed to respond to a proposal by the USDOT is the focus of an analysis by researchers from the Public and Nonprofit Leadership Center at the Hubert H. Humphrey Institute of Public Affairs. The study was sponsored by the ITS Institute through the Humphrey Institute’s TechPlan program.

In 2006, federal funding became available for the USDOT’s Urban Partnership Agreement (UPA). The goal of the program is to reduce urban traffic congestion. When the request for proposals was officially announced, the Minnesota Department of Transportation (Mn/DOT) applied for a grant in collaboration with the Metropolitan Council (Met Council), which operates the bus transit system for the Twin Cities region.

Proposal development was overseen by an inter-agency steering committee. Despite disagreements, the steering committee and outside advocates eventually came to consensus. Their proposal focused on a series of projects aimed at reducing congestion on Interstate 35W, on Highway 77/Cedar Avenue, and in downtown Minneapolis through a combination of transit, road pricing, technology, and telecommuting. In August 2007, the USDOT awarded the Twin Cities metro area $133.3 million. A local match of $50.2 million was secured in the 2008 legislative session.

In addition to the USDOT’s Federal Highway Administration, Mn/DOT, and the Met Council, other key stakeholder partners in this complex collaboration were

- Metro Transit
- the City of Minneapolis
- the Minnesota Valley Transit Authority
- the University of Minnesota’s Center for Transportation Studies, the Hubert H. Humphrey Institute of Public Affairs, and the ITS Institute
- Anoka, Dakota, Hennepin, and Ramsey Counties
- transportation management organizations

Additional stakeholders in this effort included the Minnesota governor’s office, the state legislature, the I-35W Solutions Alliance, the Citizens League, and Transit for Livable Communities.

Humphrey Institute researchers John Bryson, Barbara Crosby, Melissa Stone, and J. Clare Mortensen interviewed 26 people closely involved with the UPA. Their analysis of
the collaboration included the external forces affecting it; the internal processes, structures, and competencies that allowed it to operate; and its accountability mechanisms.

Their study confirms previous research on collaboration but also highlights new findings:

- **The role of technology as solution, motivator, and facilitator.** Dynamic pricing and other elements of the UPA are pragmatic solutions to the problem of congestion. The success of previous dynamic pricing helped skeptics to accept tolling, and technology attracted people interested in cutting-edge work. Communications technology, such as e-mail and broadband connections to both workplace and home, allowed people to work together on a complex proposal with tight timelines.

- **The importance of linkages connecting high-level federal policymaking to local, operational details.** The UPA existed primarily within a complex intergovernmental system. Both horizontal and vertical relationships were critical.

- **Emphasis on multiple roles played by sponsors, champions, neutral conveners, process designers, and technical experts.** All needed to play their parts well for the collaboration to succeed. Especially important to the process were designed and managed forums that promoted and stabilized horizontal relationships.

- **The importance of specific competencies.** These include leadership skills, the ability to frame issues persuasively, coalition-building, grant writing, technical expertise, and an understanding of the transportation field.

- **The role of rules and routines as drivers of collaboration.** On the one hand, the UPA request for proposal process drove innovation and new collaboration. On the other, the use of normal planning, decision-making, and accountability mechanisms allowed the partners to meet tight timelines.

- **The importance of organizational ambidexterity.** Partners had to manage tensions such as stability versus change, hierarchy versus lateral relations, and the existing power structure versus power sharing. To do this, they used both a strategy of spatial separation—keeping some things stable while changing others—and a strategy of temporal separation—relying primarily on lateral relations during the planning phase while operating more with formal hierarchies during implementation.

Bryson and his colleagues focused on the period from late 2006, when stakeholders began collaborating on the proposal, through June 2008 or the first phase of implementation. The researchers plan to continue studying this cross-sector collaboration through the completion of the final project in October 2010. The team also plans to look at UPA collaborations in other metropolitan areas.

“A multi-agency collaboration like [the] UPA is a complex assemblage of human and non-human elements. It is not an easy answer to hard problems, but rather a hard answer to hard problems,” Bryson says. “We hope that our findings will be useful to departments of transportation as they design and implement other large cross-sector collaborations.”
Project summaries and additional information for each research project listed in this section are online on the ITS Institute’s Web site at www.its.umn.edu/Research.

Human Performance and Behavior

Janet Creaser and Michael Manser, Department of Mechanical Engineering
Development and Evaluation of a Second Generation In-Vehicle Driver Assistance for Teenagers to Facilitate a Reduction in Crash Rates
Status: Completed

Janet Creaser and Michael Manser, Department of Mechanical Engineering
Usability Evaluation of the Teen Driver Support System
Status: Newly funded

Max Donath, Janet Creaser, Michael Manser, and Craig Shankwitz, Department of Mechanical Engineering
Smartphone-Based Novice Teenage Driver Support System
Status: In progress

Kathleen Harder, College of Design
Psychological and Roadway Correlates of Aggressive Driving (Phase II)
Status: Completed

Kathleen Harder and John Bloomfield, College of Design
The Effectiveness and Safety of Traffic- and Non-Traffic-Related Messages Presented on Changeable Message Signs (Phase II)
Status: Completed

Kathleen Harder and John Bloomfield, College of Design
Comparison of Dual-Phase Static Signage
Status: In progress

Computing, Sensing, Communications, and Control Systems

Max Donath and Craig Shankwitz, Department of Mechanical Engineering
Toward a Multi-State Consensus on Rural Intersection Decision Support
Status: Completed

Max Donath, Craig Shankwitz, and Mike Manser, Department of Mechanical Engineering
CICAS Stop Sign Assist (SSA) System
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 (Year 1)
Status: Completed

John Evans, Department of Chemistry and Biochemistry (Duluth)
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Year 2)
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 (Year 3)
Status: In progress

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

Taek Kwon, Department of Computer and Electrical Engineering (Duluth)
Cellular Wireless Mesh Sensor Network for Comprehensive Spatial Traffic Movement Detection and Data Fusion (Phase II)
Status: Completed

Taek Kwon, Department of Computer and Electrical Engineering (Duluth)
Advanced Dynamic LED Warning Signs for Rural Intersections Powered by Renewable Energy
Status: In progress

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

Taek Kwon, Department of Computer and Electrical Engineering (Duluth)
Development of Data Warehouse and Applications for Continuous Vehicle Class and Weigh-in-Motion (WIM) Data
Status: In progress

Taek Kwon, Department of Computer and Electrical Engineering (Duluth)
Migration of Automatic Traffic Recorder (ATR) and Short-Duration Traffic Data Warehouse at UMD Data Center to Mn/DOT Office of Transportation Data and Analysis (TDA)
Status: In progress

Venkatram Mereddy, Department of Chemistry and Biochemistry (Duluth)
Development of Novel Hydrogen Storage Materials for Road-Traffic-Related Applications (Phase I)
Status: In progress

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

Nikolaos Papanikolopoulos and Vassilios Morellas, Department of Computer Science and Engineering
Deployment of Practical Methods for Counting Bicycling and Pedestrian Use of a Transportation Facility
Status: Newly funded

Nikolaos Papanikolopoulos, Department of Computer Science and Engineering
Data Mining of Traffic Video Sequences
Status: In progress
Rajesh Rajamani, Department of Mechanical Engineering  
Automatic Safety Alert System for Work Zones with Flag Operators  
Status: Completed

Rajesh Rajamani, Department of Mechanical Engineering  
New Battery-less Wireless Traffic Sensors as a Replacement for Loop Detectors  
Status: Completed

Rajesh Rajamani and Lee Alexander, Department of Mechanical Engineering  
Automated Vehicle Location, Friction Measurement, and Applicator Control for Winter Road Maintenance  
Status: In progress

Rajesh Rajamani and John Hourdos, Department of Civil Engineering  
Enhancements and Field Test Evaluation of New Battery-Less Wireless Traffic Sensors  
Status: In progress

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

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

Craig Shankwitz, Department of Mechanical Engineering  
Guidance Augmentation Using Vehicle Positioning System (VPS) for Transit Applications (Year 2)  
Status: Completed

Craig Shankwitz, Department of Mechanical Engineering  
2-D Optical Sensor for DGPS Augmentation  
Status: Newly funded

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

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

Peter Willemsen, Department of Computer Science, Al Yonas, Institute of Child Development, and Lee Zimmerman  
Snow Rendering for Interactive Snowplow Simulation: Supporting Safety in Snowplow Design (Phase I)  
Status: In progress

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

Gary Davis, Department of Civil Engineering  
Bus Signal Priority Based on GPS and Wireless Communications (Phase II: Signal Priority System Development)  
Status: Completed

Gary Davis and Al Yonas, Institute of Child Development, and Lee Zimmerman  
Snow Rendering for Interactive Snowplow Simulation: Supporting Safety in Snowplow Design (Phase I)  
Status: In progress

Gary Davis and John Hourdos, Department of Civil Engineering  
Access to Destinations: Arterial Data Acquisition and Network-wide Travel Time Estimation (Phase II)  
Status: In progress

Gary Davis and John Hourdos, Department of Civil Engineering  
Using Detailed Signal and Detector Data to Investigate Intersection Crash Causation  
Status: Newly funded

Robert Feyen, Department of Mechanical and Industrial Engineering (Duluth)  
Assessing Coordination Between Agencies Involved in Traffic Incident Management  
Status: Completed

Techologies for Modeling, Managing, and Operating Transportation Systems

Gary Davis and Chen-Fu Liao, Department of Civil Engineering  
Bus Signal Priority Based on GPS and Wireless Communications (Phase II: Signal Priority System Development)  
Status: Completed

Gary Davis and Chen-Fu Liao, Department of Civil Engineering  
Cross-Median Crashes: Identifications and Countermeasures  
Status: Completed

Gary Davis and John Hourdos, Department of Civil Engineering  
Access to Destinations: Arterial Data Acquisition and Network-wide Travel Time Estimation (Phase II)  
Status: In progress

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

Robert Feyen, Department of Mechanical and Industrial Engineering (Duluth)  
Assessing Coordination Between Agencies Involved in Traffic Incident Management  
Status: Completed

Demoz Gebre-Egziabher, Department of Aerospace Engineering and Mechanics, and Ted Morris, Department of Civil Engineering  
Remotely Operated Vehicle Surveillance for Transportation Management and Security  
Status: Completed

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

Nikolas Geroliminis and Panos Michalopoulos, Department of Civil Engineering  
Development of the Next-Generation Stratified Ramp Metering Algorithm Based on Freeway Density  
Status: In progress

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

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

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Project summaries and additional information for each research project listed in this section are online on the ITS Institute’s Web site at www.its.umn.edu/Research.

John Hourdos and Gary Davis, Department of Civil Engineering
Vehicle-Probe-Based Real-Time Traffic Monitoring on Arterials
Status: Newly funded

John Hourdos and Gary Davis, Department of Civil Engineering
TH-36 Full Closure Construction: Evaluation
Status: In progress

John Hourdos and Gary Davis, Department of Civil Engineering
Monitoring on Arterials
Status: In progress

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: In progress

Chen-Fu Liao, Department of Civil Engineering, and Mick Rakauskas, Department of Mechanical Engineering
Accessible Traffic Signals for Blind and Visually Impaired Pedestrians
Status: Newly funded

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

Chen-Fu Liao, Department of Civil Engineering
Using Archived Truck GPS Data for Freight Performance Analysis on Interstate I-94/I-90 from the Twin Cities to Chicago
Status: In progress

Henry Liu, Department of Civil Engineering
Evaluation of Cell Phone Traffic Data
Status: Completed

Henry Liu, Department of Civil Engineering
Responding to the Unexpected: Development of a Dynamic Data-Driven Traffic Operation Model for Effective Evacuation
Status: In progress

Henry Liu, Department of Civil Engineering
Estimating and Measuring Arterial Travel Time and Delay
Status: Newly funded

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 Panos Michalopoulos, Department of Civil Engineering
Development of a Real-Time Arterial Performance Monitoring System Using Traffic Data Available from Existing Signal Systems
Status: Completed

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

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: In progress

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

Henry Liu, Department of Civil Engineering
Development of a Platoon-Priority Control Strategy and Smart Advance Warning Flashers for Isolated Intersections with High-Speed Approaches
Status: Completed

Henry Liu, Department of Civil Engineering
Low-Cost Portable Video-Based Queue Detection for Work Zone Safety
Status: In progress

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

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

Panos Michalopoulos, Department of Civil Engineering
Development of Real-Time Traffic-Adaptive Accident Reduction Measures for the I-94/35W Commons Section
Status: Completed

Panos Michalopoulos, Department of Civil Engineering
Enhanced Micro-Simulation Models for Accurate Safety Assessment of Traffic Management ITS Solutions
Status: Completed

Panos Michalopoulos, Department of Civil Engineering
Transportable Low-Cost Traffic Data Collection and Wireless Surveillance Device for Rapid Deployment for Intersections and Arterials
Status: In progress

Panos Michalopoulos and Ted Morris, Department of Civil Engineering
Development of Real-Time Traffic-Adaptive Accident Reduction Measures for the I-94/35W Commons Section
Status: Completed

Panos Michalopoulos, Department of Civil Engineering
Enhanced Micro-Simulation Models for Accurate Safety Assessment of Traffic Management ITS Solutions
Status: Completed

Panos Michalopoulos and Ted Morris, Department of Civil Engineering
Transportable Low-Cost Traffic Data Collection and Wireless Surveillance Device for Rapid Deployment for Intersections and Arterials
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Development of Algorithms for Travel-Time-Based Traffic Signal Timing (Phase I)
Status: In progress

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Chen-Fu Liao, Gary Davis, and Panos Michalopoulos, Department of Civil Engineering
Development of Algorithms for Travel-Time-Based Traffic Signal Timing (Phase I)
Status: In progress

Chen-Fu Liao, Gary Davis, 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: In progress

Social and Economic Policy Issues Related to ITS

John Bryson, Melissa Stone, and Barbara Crosby, Humphrey Institute of Public Affairs
Technology and Collaboration in Effective Transportation Policy
Status: Completed

John Bryson, Melissa Stone, and Barbara Crosby, Humphrey Institute of Public Affairs
The Urban Partnership Agreement: A Comparative Study of Technology and Collaboration in Transportation Policy Implementation
Status: In progress

Jason Cao and Lee Munnich, Humphrey Institute of Public Affairs
Benefit-Cost Analysis of Value Pricing: Case Study for MnPass
Status: Newly funded

Jason Cao and Frank Douma, Humphrey Institute of Public Affairs
Substitution Between E-shopping and Travel: Evidence from the Twin Cities
Status: In progress
Frank Douma, Humphrey Institute of Public Affairs
Improving Car Sharing Transit Service with ITS
Status: Completed

Frank Douma, Humphrey Institute of Public Affairs
ITS and Privacy: Developing New Rules for Virtual Roads
Status: In progress

Frank Douma, Humphrey Institute of Public Affairs
ITS and Locational Privacy: Suggestions for Peaceful Coexistence
Status: Newly funded

Thomas Horan, Humphrey Institute of Public Affairs
ITS and Safety Planning: ITS and EMS System Data Integration for Safety and Crisis Information and Decision-Making Systems
Status: Completed

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

Elizabeth Wilson, Humphrey Institute of Public Affairs, and Julian Marshall, Department of Civil Engineering
Decision Tools for Assessing Transportation Impacts of School Policy and School Choice
Status: In progress

David Levinson, Department of Civil Engineering
The Role of Social Networks and Information and Communications Technology on Destination Choice
Status: Complete

Greg Lindsey, Humphrey Institute of Public Affairs
Understanding Use of Nonmotorized Transportation Facilities
Status: Newly funded

Lee Munnich and Ferrol Robinson, Humphrey Institute of Public Affairs
Implementing Distance-Based User Fees as a Replacement for the Gas Tax
Status: Newly funded

Carissa Schively Slotterback, Humphrey Institute of Public Affairs, and John Hourdos, Department of Civil Engineering
Technology in Planning and Participatory Processes: Identifying New Synergies Through Real-World Application
Status: In progress

Elizabeth Wilson, Humphrey Institute of Public Affairs, Kevin Krizek, University of Colorado (formerly, Humphrey Institute of Public Affairs), and Julian Marshall, Department of Civil Engineering
School Travel and the Implications for Advances in Transportation Technology
Status: In progress
Selected publication of work by ITS Institute researchers in FY09


ITS Institute research reports published in FY09

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

Chen-Fu Liao, Priya Iyer, and Gary A. Davis
CTS 08-18

Automatic Detection of Accident Prone Traffic Conditions Phase I
John Hourtos, Vishnu Garg, and Panos Michalopoulos
CTS 08-12

Automatic Detection of RWIS Sensor Malfunctions (Phase I)
Carolyn Crouch, Donald Crouch, Richard Maclin, and Aditya Polumetla
CTS 09-10

Automatic Detection of RWIS Sensor Malfunctions (Phase II)
Carolyn Crouch, Donald Crouch, Richard Maclin, and Aditya Polumetla
CTS 09-11

Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy Phase I
John F. Evans
CTS 09-12

Development of a New Tracking System Based on CMOS Vision Processor Hardware: Phase I
Hua Tang
CTS 09-04

Development of Real-Time Traffic Adaptive Crash Reduction Measures for the Westbound I-94/35W Commons Section
John Hourtos, Wuping Xin, and Panos Michalopoulos
CTS 08-28

Chen-Fu Liao

Directional Sound for Long Distance Auditory Warnings from a Highway Construction Work Zone
Grisdasa Phanomchoeng, Rajesh Rajamani, and John Hourtos
CTS 08-20

The Effectiveness and Safety of Traffic and Non-Traffic Related Messages Presented on Changeable Message Signs—Phase II
Kathleen A. Harder and John R. Bloomfield
Mn/DOT 2008-27

Enhanced Micro-Simulation Models for Accurate Safety Assessment of Traffic Management ITS Solutions
Wuping Xin, John Hourtos, and Panos Michalopoulos
CTS 08-17

Fleet Asset Life Cycle Costing with Intelligent Vehicles
David A. Wyrick and Santiago Erquicia
CTS 08-13

Impending Box Impact Warning System for Prevention of Snowplow-Bridge Impacts: A Final Report of Investigations
Richard R. Lindeke, Hilal Katmale, and Ravi Verma
CTS 09-08

Improving Carsharing and Transit Service with ITS
Frank Douma, Ryan Gaug, Thomas Horan, and Benjamin Schooley
Mn/DOT 2008-43

Industry Clusters and ITS
Lee W. Munnich Jr. and James Leinhoff
CTS 08-15d

In-Situ Vehicle Classification Using an ILD and a Magnetoresistive Sensor Array
Stanley G. Burns
CTS 09-06

ITS and Emergency Medical Services Response
Benjamin Schooley and Thomas A. Horan
CTS 08-15c

ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment
Benjamin Schooley, Thomas Horan, Nathan Botts, and Aisha Noamani
CTS 09-02

Multiuse, High-Accuracy, High-Density Geospatial Database
Bryan Newstrom and Curtis Olson
CTS 09-05

Krishna Vijayaraghavan and Rajesh Rajamani
CTS 08-16

Overview of Rural Intersection Crashes at Candidate Intersections for the Intersection Decision Support (IDS) System
Howard Preston, Richard Storm, Max Donath, and Craig Shankwitz
Mn/DOT 2008-52

Overview of New Hampshire’s Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)
Howard Preston, Richard Storm, Max Donath, and Craig Shankwitz
Mn/DOT 2008-30

Portable Cellular Wireless Mesh Sensor Network for Vehicle Tracking in an Intersection
Taek Mu Kwon and Ryan Weidemann
CTS 08-29

Portable Traffic Data Processor
Nikolaos Papanikolopoulos and Harini Veeraraghavan
CTS 08-14

Privacy Issues of ITS
Adam Kokotovich and Lee W. Munnich Jr.
CTS 08-15e

Real-time Nonintrusive Detection of Driver Drowsiness
Xun Yu
CTS 09-15

Review of California’s Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)
Howard Preston, Richard Storm, Max Donath, and Craig Shankwitz
Mn/DOT 2008-31

Review of Nevada’s Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)
Howard Preston, Richard Storm, Max Donath, and Craig Shankwitz
Mn/DOT 2008-32

Review of New Hampshire’s Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)
Howard Preston, Richard Storm, Max Donath, and Craig Shankwitz
Mn/DOT 2008-30

Technology Enabling Near-Term Nationwide Implementation of Distance Based Road User Fees
Max Donath, Alec Gorrjesta, Craig Shankwitz, Richard Hoglund, Eddie Arpin, PiMing Cheng, Arvind Menon, and Bryan Newstrom
CTS 09-20

Transportation Data Research Laboratory: Data Acquisition and Archiving of Large Scaled Transportation Data, Analysis Tool Developments, and On-Line Data Support
Taek Mu Kwon
CTS 09-07

TDRL Projects: Solar/Wind Hybrid Renewable Light Pole, Gravel-Road Traffic Counter, DLL-Based Traffic Software Development Kit
Taek Mu Kwon, Ryan Weidemann, and Dan Cinnamon
CTS 08-21

Safety: EMS System
Aisha Noamani

User Fees
Nathan Botts, and
Thomas Horan,
Benjamin Schooley,
and Treatment
Emergency Response
Data Integration to
Safety: EMS System
Aisha Noamani

WPV/UAV Surveillance
for Transportation
Management and
Security
Demoz Gebre-Egziabher
CTS 08-27

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Selected presentations given by ITS Institute researchers in FY09

Gary Davis


Technologies Seminar Series, University of Minnesota, Minneapolis.


Liu, H. (2008, December). Modeling day-to-day traffic equilibration process under network disruption. Hong Kong University of Science and Technology, Hong Kong, China.


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.

Seminar series brings transportation experts from industry, academia to Minnesota

Hybrid electric generators, systems for high-speed intersection safety, and innovations in transit fare collection were several topics featured during the Fall 2008 Advanced Transportation Technologies Seminar Series. Minnesota faculty and visiting researchers presented their recent ITS-related work on a variety of transportation topics.

Among the presenters was visiting professor Nigel Wilson, who gave an overview of technological and policy issues related to transit fare collection. Wilson, professor of civil and environmental
engineering at the Massachusetts Institute of Technology, is the director of major research and education collaborations between MIT and transit agencies in Chicago and London.

Wilson highlighted several emerging technologies that are likely to become more widespread in the coming years. New “contactless” fare cards that can be read when they are briefly held in front of a fare card reader are poised to replace current card-reader technologies, a change that will speed up boarding.

Implementing new technologies can also raise important policy issues, Wilson noted. Among the most significant are those related to equity. For example, payment systems that require riders to purchase a large-capacity prepaid fare card can effectively exclude low-income transit users who cannot afford the initial cost.

Wilson also discussed a variety of business models applicable to transit agencies.

Other presentations in the series were:

- “Evaluation of Platoon-Priority and Advanced Warning Flasher System at High-Speed Signalized Intersections,” Henry Liu, assistant professor, Department of Civil Engineering
- “Summary of Research Activities at the Center for Sustainable Mobility,” Hesham Rakha, professor, Department of Civil Engineering, and director, Center for Sustainable Mobility, Virginia Polytechnic Institute and State University
- “Solar and Wind Hybrid Electric Generators for Rural ITS Applications,” Taek Kwon, professor, Department of Electrical and Computer Engineering, University of Minnesota Duluth
- “Intelligent Transportation Systems and Safety: Innovative Uses of Information Systems to Improve Timeliness and Quality of Emergency Response,” Tom Horan, executive director, Claremont Information and Technology Institute
- “A Predictive Study of Use Impacts on the Denali Park Road,” Ted Morris, laboratory manager, Minnesota Traffic Observatory
- “A Perspective on ITS Research at the USDOT,” Shelley Row, director, ITS Joint Program Office, U.S. Department of Transportation

This was the eighth year that 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, which is a required course in the University's Graduate Certificate Program in Transportation Studies, is offered as a one-credit graduate-level course, or attendees can earn one professional development hour for each seminar. Presentations are available for viewing on the Web and are recorded onto DVD for loan by request.

An additional Institute-sponsored seminar was held in the spring of 2009, “Trunk Highway 36 Full Road Closure: Lessons for the Future,” given by John Hourdos, director of the Minnesota Traffic Observatory.

**Arpin is Student of the Year**

Eddie Arpin, a recent graduate from the University of Minnesota with a master's degree in mechanical engineering, was honored as the ITS Institute’s 2008 Outstanding Student of the Year at the Transportation Research Board (TRB) 88th Annual Meeting in January 2009.

Arpin started his graduate studies at the University of Minnesota in January of 2006, emphasizing robotics, controls, and automation. He began working for the University of Minnesota's Intelligent Vehicles Laboratory (IV Lab) in September of 2006. While with the IV Lab, he was part of a three-person team that competed in the Intelligent Ground Vehicle Competition, which took second place in the Autonomous Vehicle challenge. At the same time, he began his thesis research on developing a vehicle positioning system to work in urban environments.
ITS Institute director Max Donath said Arpin was selected as Student of the Year for many reasons: he graduated with a 3.83 GPA in his graduate studies, he recently finished his thesis, “A High Accuracy Vehicle Positioning and Guidance System Fusing RFID and LiDAR,” and he is currently employed as a research fellow at the IV Lab, working on a driver-assist system for transit bus drivers. “It is truly remarkable what Eddie has been able to accomplish these past two years since he started working in his thesis research,” noted Donath. Each year, the U.S. Department of Transportation (USDOT) honors an outstanding student from each UTC at a special ceremony held during the TRB Annual Meeting. Each student receives $1,000 and the cost of attendance for, and travel to, the annual meeting from his or her center, plus a certificate from the USDOT.

Engineering students honored with Huber award

Two ITS students received this year’s Matthew J. Huber Award, which is presented annually to University of Minnesota graduate students demonstrating an outstanding contribution in research, writing, and educational activities in the field of transportation. Shan Hu is a master’s candidate in engineering management (mechanical engineering) at the University of Minnesota Duluth. Her work focuses on nonintrusive detection of driver drowsiness through a sensing system that monitors the heart rate of vehicle drivers (see related article on page 15). This project was one of three North American finalists in the 3rd Collegiate Student Safety Technology Design Competition. Her advisor is Xun Yu, assistant professor of mechanical and industrial engineering.

Evan Ribnick is a doctoral candidate in electrical engineering at the Twin Cities campus. His research, centered around computer vision and image processing, has focused extensively on transportation-related applications, including a specific project sponsored by the Department of Homeland Security to develop an automatic surveillance system to protect busy transportation hubs. His advisor, professor Nikolaos Papanikolopoulos, said Ribnick is a “dream student” who has been published in some of the best academic journals. Ribnick said that as a researcher, he wants to develop technology that’s useful and applicable in the real world. “This award indicates that we’re headed in the right direction,” he said.

Duluth research earns spot in international student competition

A team led by Xun Yu, assistant professor of mechanical and industrial engineering at the University of Minnesota Duluth, was selected as one of three teams representing the North American region to participate in the 3rd...
Collegiate Student Safety Technology Design Competition at the 21st International Technical Conference on the Enhanced Safety of Vehicles, held in Stuttgart, Germany, June 15–18. Senior Ryan Dowld and graduate student Shan Hu made up one of two teams selected from the United States; the other group was from Canada. With support from the Northland Advanced Transportation Systems Research Laboratories (NATSRL), Yu has been working to develop a Driver Drowsiness Detection System (see related article on page 15).

**Online game lets students explore the world of traffic management**

A new traffic control game developed by the ITS Institute and Web Courseworks lets high school students try their hand at working in the engineering and transportation field. The game is based on work by Chen-Fu Liao, the ITS Institute’s senior systems engineer, and his earlier “STREET” traffic control game. The goal of “Gridlock Buster” is to provide a fun way to engage students in the traffic engineering field, teach what is involved in traffic grid management, and make transportation interesting and relevant.

Gridlock Buster incorporates tools and ideas that traffic control engineers use in their everyday work. Players must pass a series of levels while acquiring specific skills to control the traffic and minimize delays. For example, a player might need to manage a high volume of traffic passing through an intersection, where long lines form if vehicles don’t get enough green-light time. The more drivers are delayed, the more the game’s “frustration meter” rises. Sound effects and animation simulate cars honking and drivers’ fists shaking to illustrate the realistic results of backed-up traffic queues.

**Exhibits, camps engage pre-college participants with hands-on learning**

Over the last fiscal year, the Institute has staffed exhibits and participated in numerous classes and camps to introduce K–12 students to transportation and ITS-related fields of study.

On May 15, Institute director Max Donath provided a group of multicultural students from Patrick Henry High School in Minneapolis with a University-level class experience—an introduction to robotics.

In March, the ITS Institute participated in Irondale High School’s first Science, Technology, Engineering, and Math (STEM) Career Fair. Around 200 students and parents met with representatives from local companies, government agencies, and universities promoting STEM careers. Shawn Haag, program coordinator for CTS and the Institute, and Randy Newman, traffic engineer for the City of Eden Prairie (Minn.), staffed the exhibit.

The Institute was also an exhibitor at the National American Indian Science and Engineering Fair in St. Paul in March and provided a $2,000 travel grant to help several Native American students and their families attend.
The annual event, sponsored by the American Indian Science and Engineering Society, offers students in grades 5–12 the opportunity to compete for scholarships and prizes and encourages them to prepare for careers in science and technology-related fields.

For the second year in a row, the Institute participated in TechFest, a one-day event focusing on engineering. The event, which drew about 1,200 people, was held in February at “The Works” museum in Edina, Minn. The Institute’s exhibit focused on remote aerial vehicle research by Demoz Gebre-Egziabher of the aerospace engineering department. The Institute is providing funding for Gebre-Egziabher to develop autonomous or semi-autonomous aerial vehicles that can monitor traffic movements, detect disruptions, and perform a wide variety of other surveillance and monitoring tasks under both normal and emergency conditions. Children and their parents were intrigued by the prototype vehicle on display and talked with Institute staff about its capabilities.

The ITS Institute teamed up with CTS, the Minnesota Local Road Research Board, the Minnesota Local Technical Assistance Program, WTS Minnesota, and the Council of Supply Chain Management Professionals to put on the 14th annual Transportation Career Expo, held February 5 in Minneapolis. This year’s event featured a new, shorter format with a single general-session panel discussion. Speakers from the public and private sectors shared advice with the 82 students on transportation-related careers and offered tips and advice. Also new this year, each of the 20 exhibitors introduced themselves to the full group and said a few words about their organizations.

Over the winter, students at Patrick Henry High School got an extra lesson in the science of traffic management when program coordinator Shawn Haag visited the school to teach a curriculum unit on traffic engineering. Approximately 25 students from the 11th and 12th grades worked through curriculum developed by the ITS Institute as part of its outreach efforts to high school students. The curriculum unit is designed to teach students about fundamental traffic management issues with an intelligent transportation systems perspective.

“It was a very diverse group of students, and they all really dove into the curriculum,” says Haag, who coordinates outreach efforts to pre-college students, including school visits and student tours of transportation research facilities on the University of Minnesota campus.

About 75 students participating in the Fond du Lac Community College Summer Transportation Camp spent a day in July 2008 learning about traffic and transportation at the University of Minnesota. Each summer, the University hosts the group as part of an effort to educate young people about transportation.

The campers began their day with a lesson in traffic engineering as they tried out the STREET traffic signal control game (the predecessor of Gridlock Buster), followed by tours of Institute labs. CTS program coordinator Shawn Haag said the youth, who were between the ages of 11 and 18, seemed interested and excited about their day at the University. “The students really enjoyed learning about transportation technologies being researched at the U of M and they were energized throughout the entire time,” he said.

Also that summer, the Institute provided assistance and funding for a Technology Camp for middle school students organized by computer science professor Nikolaos Papanikolopoulos and his graduate students. (The camp was sponsored by the National Science Foundation’s Center for Distributed Robotics.) Kids from across the Twin Cities region came to the Minneapolis campus to engage in hands-on learning activities related to ITS applications, robotics, and other technology topics during the series of day camps.

The Institute partnered with CTS and the Institute of Technology Center for Educational Programs (ITCEP) to host the transportation portion of Exploring Careers in
Engineering and Physical Science, a day camp for high school students. Participants were given traffic engineering lessons centered on the STREET traffic control game. “It’s pretty cool,” said 15-year-old Taysha Martineau. “I’ve always wanted to see how [traffic control] really works.”

“We have a wide variety of kids who all understand transportation on a different level,” said camp chaperone Cameron Lindner. “Some of them have been here for a couple years so it’s cool for them to see the progress that the ‘U’ makes.” The campers also visited the ITS Institute’s Minnesota Traffic Observatory, where lab manager Ted Morris showed them the tools used to track traffic in the metro area.

According to CTS outreach and education services manager Stephanie Malinoff, the camp is a good way to help kids learn about the world of transportation. “The curriculum offers students a chance to get excited about engineering at an early age,” she said. “The simulation provides a real-world example of traffic engineering at work.” The long-term goal of the camp is to integrate curriculum into high school classrooms as part of an ongoing course and to increase the number of students enrolling in transportation engineering and ITS courses.

The Institute also hosted a tour and demo of current research technologies to students in the St. Cloud Summer Transportation Academy and students from Blaine High School Center for Engineering, Math and Science.

Institute director Max Donath, center, gave Patrick Henry High School students an introduction to robotics.
Technology Transfer

The Institute could not accomplish its goals without the transfer of its expertise and research results to 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 serves to educate 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 general public. Over the past year, we have provided tours and demonstrations of our research and facilities, sponsored seminars, published printed pieces, and updated our Web site. But perhaps the most direct method of transferring technology has been to send graduating students out into the workforce.

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

Speed adaptation is low-cost, high-benefit technology to save lives, speakers says

Intelligent speed adaptation (ISA) technology can act “like a medicine that gets people to stop speeding,” said Oliver Carsten at the CTS Winter Luncheon on February 11.

The luncheon was sponsored by the ITS Institute. Institute director Max Donath introduced Carsten, who is a professor in the Institute for Transport Studies at the University of Leeds in the United Kingdom (UK).

“ISA is speed management with 21st century technology,” Carsten explained. Its components include a GPS-based satellite navigation system, a digital road
map with speed limits, and a human-machine interface that displays the speed limit on the dashboard (or on a cell phone). ISA can also take control of the vehicle through a link to the drive train.

The European Union has identified rule violation—including speeding—as the major factor in injury and fatal crashes, Carsten said. Studies using actual crash data have shown that injury crashes go up with the proportionate change in speed squared; serious injury crashes with speed cubed; and fatal crashes with speed to the fourth power. “Small changes in mean speed will give you very dramatic changes in accidents,” he said.

ISA initially faced resistance in the UK, and opponents warned of a “nanny state” or a “spy in the sky,” he said, but popular opinion is now favorable. To advance ISA here, he urged the transportation community to make its case and educate the public, particularly through the press.

‘Smart Signal’ research receives award

A system to monitor the performance of urban arterials and improve traffic flow received this year’s CTS Research Partnership Award. The system—known as SMART-Signal (short for “Systematic Monitoring of Arterial Road Traffic Signals”)—is a real-time arterial performance monitoring system that uses traffic data from existing signal systems. The project was a joint effort of the University, Hennepin County, Mn/DOT, and the private sector. The research was funded by the ITS Institute, the Minnesota Local Road Research Board, and Mn/DOT with significant in-kind support from Hennepin County.

Henry Liu, an assistant professor in the Department of Civil Engineering, accepted the award on behalf of the project partners. Although traffic engineers have tools to measure real-time freeway performance, he said, similar approaches for urban arterials do not exist but are urgently needed. The development of SMART-Signal fills this gap. “We can do much better to manage traffic...if we have the right tools.”

The University is currently in the patent application process to protect the intellectual property, Liu said. He also noted that his team has received a grant from the National Cooperative Highway Research Program to extend its work on SMART-Signal, and that the system is used as an education module in a civil engineering course at the University.

IV Lab technology in Alaska featured on Discovery Channel

Minnesota winters are known for heavy snowfall and gusty winds, so it’s no surprise that researchers at the IV Lab have created technology to aid snowplow operators as they work to clear the roads in less-than-ideal conditions. The driver-assist system, which combines lidar and radar sensors with head-up display technology and onboard geospatial databases, helps snowplow operators keep an eye on where they are and what else is around—even when they can’t see the actual road.

The driver-assist technology has been installed on two snowplows and two airport rescue and firefighting vehicles operating in Alaska, where high snowfall rates and dry, blowing snow routinely create whiteout conditions and zero visibility. Because of the success to date, the state of Alaska has ordered three new driver-assist systems and two upgrade kits for current systems.

Alaska DOT employee Dwight Dietrich has been operating snowplows and blowers since 1998 and says the GPS system has helped him tremendously. The system is especially helpful when visibility is poor, as it provides him with a sense of direction as he plows through intense
storms. “It’s like running on autopilot; it makes the job a lot less stressful…I wonder what we did before we had this technology,” he says.

In April, the Discovery Channel highlighted some of the equipment on a television show called “Alaska: Most Extreme.” During a segment about heavy snowfalls along Alaska’s central coast, the camera shows Dietrich using the GPS vision-enhancement technology as he plows the road during a dangerous storm. The system allows him to work quickly and efficiently to clear the road in time for morning traffic.

Researchers’ work in media spotlight

Dramatic reductions in pollution could be achieved simply by retiming traffic lights, said several local experts in a story aired by Minnesota Public Radio in June. Many signals in the metro area haven’t been retimed for years because of a lack of staff and money, the story stated. John Hourdos, Minnesota Traffic Observatory (MTO) director, said another problem is that most Twin Cities road signals are controlled by the cities and counties that install them, and they are not coordinating with each other. Hourdos predicted that in 20 years, vehicles will talk with one another via computer as they approach an intersection, modifying their speeds so they don’t have to stop.

KUWS Radio (Wisconsin) aired a story in May about the installation of traffic safety equipment near Minong, Wisconsin, that was developed by ITS Institute researchers. IV Lab director Craig Shankwitz said the idea is to make rural highway intersections safer without having to use traffic signals that back up traffic.

Lee Munnich, director of the State and Local Policy Program at the Humphrey Institute, told WCCO-TV News in March that about one-third of the people driving in the high-occupancy vehicle lane on Interstate 35W are violating the rules of use. Munnich’s research tracks how well HOV lanes work.

Another Institute researcher, Elizabeth Wilson, weighed in on an old concept receiving renewed interest—that of children walking to school. The article on organized “walking school buses” meant to abate car emissions, childhood obesity, and local traffic jams appeared in the New York Times in March.

In September, KARE-11 TV News featured assistant civil engineering professor Henry Liu commenting on Mn/DOT’s addition, and possible removal, of an extra lane on the I-94 detour route following the collapse of the I-35W bridge. Liu said his research would help Mn/DOT make a decision about the lane.

In a WCCO–TV news story that aired in August 2008, IV Lab director Craig Shankwitz was asked, “Can Tire Pressure Solve [the] Oil Crisis?” Shankwitz pointed to tire inflation as one of three factors that influence fuel economy (the other two are engine efficiency and speed) and explained the physics behind tire pressure.

In the summer of 2008, the Institute and the Center for Transportation Studies worked with University News Services and associate professor of civil engineering David Levinson to create an “Expert Alert” video related to traffic patterns following the I-35W bridge collapse. (Levinson is one of three researchers who received a grant from the National Science Foundation to study the issue.) The resulting video generated stories airing on KARE-11 TV News, “Twin Cities Live,” and Minnesota Public Radio and appearing in print in the St. Paul Pioneer Press. Levinson discussed findings from the study—in particular, how most drivers were able to adapt to detours within two months after the collapse, showing
that the transportation system is robust.

John Hourdos, director of the MTO, was also interviewed by FOX 9 News for a story on the perils of highway merging broadcast in May. Hourdos explained the traffic dynamics affecting one area that has become notorious for merge-related crashes: the I-94/35W Commons area near downtown Minneapolis. Research by Hourdos, civil engineering professor Panos Michalopoulos, and MTO lab manager Ted Morris led Mn/DOT to change the lane markings in one part of the Commons to discourage problematic merging behavior; preliminary results indicate that the change has reduced the number of crashes and near misses.

The HumanFIRST Program’s immersive driving simulator was featured in a FOX 9 segment examining the dangers of sleepy drivers. In “In-Depth: Sleep Deprived Bus Drivers,” a report prompted by the recent crash of a bus driven by a sleep-deprived driver, newscaster Trish Van Pilsum participated in a sleep-deprivation protocol similar to that used by HumanFIRST researchers to study the affects of fatigue, and then got behind the wheel of the simulator for a virtual drive.

Researchers receive honors, awards

Professor Panos Michalopoulos received the 2007 IEEE Outstanding Intelligent Transportation Systems (ITS) Application Award for his development of Autoscope™, a video detection sensor. He was presented the award at the 2008 IEEE ITS Conference held in China in October 2008.

Michalopoulos has been a professor of traffic and transportation engineering at the University of Minnesota since 1977. His research led to the development of Autoscope, the first and most widely used machine-vision-based vehicle detection and surveillance system, with more than 20,000 installations worldwide since 1993. To commercialize the technology, Michalopoulos founded Image Sensing Systems, Inc., for which he served as chairman, chief scientific adviser, and board member. The video imaging system is patented by the University of Minnesota.

IEEE, formerly the Institute for Electrical and Electronic Engineers, is a nonprofit organization and a leading professional association for the advancement of technology.

ITS Institute director Max Donath received the 2009 ITS Minnesota Public Sector Recognition Award at ITS Minnesota’s annual meeting on March 10. Donath is also a professor of mechanical engineering at the University of Minnesota. He was recognized for his “outstanding contributions” to intelligent transportation systems in Minnesota, according to ITS Minnesota president Ray Starr, who presented Donath with the award.

Visitors view Institute research through tours, demos

As part of the ITS Institute’s Fall 2008 Advanced Transportation Technologies seminar series, Shelley Rowe, director of the U.S. Department of Transportation’s ITS Joint Program Office, shared her views on the state of ITS and the directions for the future. Rowe also toured the Minnesota Traffic Observatory (MTO).

In December, Paul Brubaker, former administrator of the USDOT’s Research and Innovative Technology Administration (RITA), toured Institute facilities; met with Max Donath, program directors, and other Institute staff; and watched demonstrations of current research. Among those projects were the IV Lab’s driver-assist system on buses, the HumanFIRST Program’s Cooperative Intersection Collision-Avoidance System.
dynamic sign and Teen Driver Support System (TDSS), and the MTO’s SMART-Signal system.

Scott Belcher, president and CEO of ITS America, visited the ITS Institute in June 2009 and toured the HumanFIRST program facilities, MTO, and IV Lab. Belcher also met with lab directors and took part in demonstrations of the TDSS and the HumanFIRST driving simulator.

Institute researchers share thoughts on transportation at national, local events

TZD Conference
The Institute was well-represented at the annual Toward Zero Deaths (TZD) conference October 7–8 in Rochester, Minnesota. The conference serves as a forum for sharing information on how to reduce the number of fatalities and injuries on Minnesota roads.

In a general session, Tom Horan, with the Humphrey Institute of Public Affairs, spoke about his work focusing on technological developments that affect rural safety and the issues surrounding their deployment (see page 25 for related article). In a concurrent session on intersection collision prevention, Institute director Max Donath discussed research efforts to develop infrastructure-based technologies capable of reducing driver error at unsignalized rural highway intersections. Mike Manser, director of the HumanFIRST Program, talked about a study that is using video feedback as a coaching tool for beginning drivers. And another researcher with the HumanFIRST Program, Janet Creaser, shared results from a study on the effects of alcohol on motorcycle riding skills during a concurrent session on motorcycle safety.

TRB
Institute researchers were among those who presented their work at the Transportation Research Board (TRB) 88th Annual Meeting, held in January in Washington, D.C. Presentation topics covered traffic monitoring and signal control techniques, privacy law and ITS technologies, safety research, congestion pricing, and traffic simulation. University of Minnesota faculty, staff, and student presenters included:

- Kathleen Harder: Center for Human Factors Systems Research and Design
- Gary A. Davis, Nikolas Geroliminis, David Levinson, Chen-Fu Liao, and Henry Liu: Civil Engineering
- Frank Douma, Keith Knapp, Lee Munnich, and Carissa Schively Slotterback: Humphrey Institute of Public Affairs
- Michael Rakauskas: HumanFIRST Program
- Max Donath: ITS Institute
- Xun Yu: Mechanical and Industrial Engineering, University of Minnesota Duluth (UMD)
- John Hourdos: Minnesota Traffic Observatory
- Eil Kwon: Northland Advanced Transportation Systems Research Laboratories

Research Day
On March 12, the Northland Advanced Transportation Systems Research Laboratories (NATSRL) held its annual Research Workshop on Intelligent Transportation Systems at Mn/DOT District 1 headquarters in Duluth. NATSRL director Eil Kwon gave opening remarks.

The event featured presentations by faculty and students on a diverse set of current research projects under way on the Duluth campus, including:

- “Real-Time Nonintrusive Detection of Driver Drowsiness,” Shan Hu, Ye Gu, and Xun Yu, Mechanical and Industrial Engineering
- “Intelligent Pavement Sensor for Traffic Detection,” Baoguo Han and Xun Yu, Mechanical and Industrial Engineering
- “Development of Novel Hydrogen Storage Materials
**CERS Summer Institute**

Presenters explored the connections between rural transportation safety and community health at the annual Summer Institute of the Center for Excellence in Rural Safety (CERS), held last July in Santa Rosa, California. The two-day gathering of leading state and national transportation officials, researchers, policymakers, and professionals is aimed at sharing information, setting research priorities, and developing strategies for improving rural transportation safety. Speakers included Institute researchers Tom Horan, who discussed his research into rural emergency response times and the quality of health care outcomes, and Mike Manser, director of the HumanFIRST Program, who moderated a panel discussion about the role communication tools play in advancing rural traffic safety issues.

**CTS Research Conference**

ITS Institute research projects presented at the CTS 20th Annual Research Conference in St. Paul, Minn., included

- “Development of the Next Generation Stratified Ramp Metering Algorithm for Minnesota Freeways Based on Density,” Nikolas Geroliminis, Civil Engineering
- “Smart Signal Theory,” Henry Liu, Civil Engineering
- “Bus Rapid Transit Technologies for Cedar Avenue and I-35W,” Craig Shankwitz, Mechanical Engineering
- “Counting Empty Parking Spots at Truck Stops,” Pushkar Modi, Computer Science and Engineering
- “Substitution Between E-shopping and Travel: Evidence from the Twin Cities,” Frank Douma, Humphrey Institute of Public Affairs
- “Snow Rendering for Simulation,” Peter Willemsen, Computer Science (Duluth)
- “Impending Box Impact,” Richard Lindeke, Mechanical and Industrial Engineering (Duluth)
- “Wireless Mesh Sensor Network for Vehicle Tracking in an Intersection,” Taek Kwon, Electrical and Computer Engineering (Duluth)
- “Portable, Low Cost Intersection Traffic Measurement and Surveillance Station,” Ted Morris, Civil Engineering
Publications, new Web services highlight Institute work

Over the last year, the Intelligent Vehicles Laboratory launched a new Web site to provide information about research capabilities and projects. The IV Lab focuses on developing and testing innovative, human-centered technologies that improve the operational safety, mobility, and productivity of vehicles.

Two new featured study pages for the SMART-Signals and Rural Unsignalized Intersections research projects were developed to highlight advances in these high-impact research areas. The Education section of the ITS Institute Web site was enhanced and expanded to display the wide variety of educational activities conducted at the Institute, from participating in a variety of K-12 student camps to the development of a traffic simulation game called Gridlock Buster.

Another new feature visitors will notice on the ITS Institute Web site is a “Meet a Researcher” sidebar appearing on many research-related pages. Showing photos and brief descriptions of the work done by the many Institute researchers is a new way of highlighting the diversity of ITS research at the University of Minnesota.

Work is under way to create a blog for managing news on the Web site (expected to go live in fall 2009). The blog will give the Institute flexibility in communicating more frequent updates and news to its audience and to drive more users to the site. A companion project and ongoing effort is search engine optimization, which will improve the ability of search engines to find information from the Institute in response to search terms related to its work.

In addition to ongoing work on the Institute’s Web sites, electronic communications continue to play an important role in quickly disseminating information. Electronic mail announcements were used to publicize upcoming events, including Advanced Transportation Technologies Seminars, conferences, luncheon presentations, and other ITS-related events. The seminars and luncheon presentations are now regularly broadcast live on the Web as well as recorded for later viewing.

Eleven ITS-related research projects were featured in the Center for Transportation Studies’ Research E-news electronic newsletter, which is mailed to about 4,000 subscribers and is available on the Web at www.cts.umn.edu/Publications/ResearchENews. These articles also provide links to more information about each project.

Institute print publications continued to raise awareness of ITS work in academic and professional communities and share the results of research. The Sensor newsletter covered Institute research activities, education, and technology transfer activities; upcoming ITS-related events; and recently published research reports. The Sensor is available in print and online and reaches about 2,100 subscribers four 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 tenth ITS Institute annual report (fiscal year 2007–08), highlighting work by the Institute’s researchers and students, received an American Graphic Design Award from Graphic Design USA in the annual report category. This is the second consecutive award for the Institute’s annual report and graphic designer Cadie Wright Adhikary. The report was mailed to more than 1,400 individuals and is available as a PDF file downloadable from the Institute’s Web site.

Visiting researchers bring expertise, build partnerships

During the past year, the Institute continued to work with visiting researchers and instructors, 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 two national researchers. During the spring series, visiting professor Nigel Wilson presented an overview of technological and policy issues related to transit fare collection. Wilson is a professor of civil and environmental engineering at the Massachusetts Institute of Technology and the director of major research and education collaborations between MIT and transit agencies in Chicago and London. In the fall, Hesham Rakha, a professor in the Department of Civil Engineering and director of the Center for Sustainable Mobility, Virginia Tech, described a study that estimates the safety benefits of deploying a forward-collision warning system across the national fleet of heavy vehicles.

Thomas Horan, an associate professor at Claremont Graduate University and visiting scholar at the Humphrey Institute of Public Affairs, is part of the Sustainable Technologies Applied Research (STAR) Initiative and the new TechPlan research program. Horan is investigating wireless EMS and telecommunication network planning and access in a rural context.

Yorgos Stephanedes, a visiting professor from the University of Patras, Greece, worked with civil engineering professor Gary Davis and MTO director John Hourdos during spring semester. Stephanedes used the MTO’s facilities to collect information on freeway crashes and analyze the potential of using neural networks for the detection of crash-prone conditions.

Other visiting researchers, all working with the Institute’s HumanFIRST Program, include Nobuyuki Kuge and Tomohiro Yamamura of Nissan, Jeff Caird of the University of Calgary, and Dick de Waard of the University of Groningen.

Assistant professor Jason Cao discussed findings from his research on the effects of e-shopping on travel during the TechPlan annual forum.

TechPlan research sparks discussion, insights at forum

TechPlan projects were featured at an annual forum held June 18 at the University’s Hubert H. Humphrey Institute of Public Affairs. “TechPlan: New Frontiers in Transportation Policy, Technology and Planning” allowed researchers to present their current findings, followed by a discussion with transportation experts, thought leaders, and policymakers about the research and its possible implications.

TechPlan is a federally funded research program partnering the ITS Institute with the Humphrey Institute to investigate how new technology can be used to solve transportation planning and infrastructure challenges.

One project featured at the forum is investigating the effects of e-shopping on travel. In discussion before
the presentation, forum participants talked about the impacts they believed e-shopping might have—including a reduction in trips and sales tax revenue. Some were surprised to learn that researchers found e-shopping actually results in more local shopping trips, and that e-shopping and retail shopping actually have a complementary relationship.

“The shopping process is really complicated. It is not just simple substitution,” said assistant professor Jason Cao, who is leading the project. “You go to a number of places to research and investigate, you may look for information online, you may go to look at a product in the store, and then buy it at home.”

Other featured TechPlan projects were those on improving emergency response in rural areas through data system integration, a tool for assessing the impacts of school choice policies on school transportation, and a comparison of the Urban Partnership Agreement programs in Minnesota, New York City, and Miami.