Human-Centered Technology to Enhance Safety and Mobility
INTELLIGENT TRANSPORTATION SYSTEMS INSTITUTE

2001/2002 ANNUAL REPORT


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This has been an extraordinary year for transportation. The tragic events of September 11 have dominated the news and the attention of our government leadership. Yet the number of lives lost pales in comparison to those who die every year on our roads. Every three weeks, we lose the equivalent number of precious lives in vehicular crashes—lives lost often without as much as a sidebar in our newspapers. In 2001, there were 41,730 fatalities on our roads, or 1.5 fatalities per million vehicle miles traveled—about the same number as in the previous year. There hasn’t been a significant decrease in fatalities since about 1992. We need to do better, and I believe that several of our research projects are leading the way.

One example is a new project by Gary Davis who is exploring crash risk and new methodologies to help identify and understand the factors leading up to crashes. This is a difficult problem considering our exposure—with a population of 282 million, we have 220 million registered vehicles that cover 2.7 million million (that’s $2.7 \times 10^{12}$) vehicle miles of travel on this country’s 4 million miles of public roads.

Congestion also continues to be a problem, with much public debate on how to deal with it. Our Metro Transit here in the Twin Cities has been at the forefront of developing a network of bus-only shoulders along major highways allowing buses to bypass congested roads and providing passengers with reduced travel times and an incentive to leave their cars behind. However, steering a nine-foot-wide bus along a ten-foot shoulder ‘lane’ is no mean feat. In previous years, we provided seed funding toward the development of driver-assistive technology that helps a bus driver with lanekeeping along these shoulders—an offshoot of the GPS-based technology that helps snowplow operators see under low-visibility conditions. This effort laid the foundation for a partnership between Metro Transit and the Institute that won competitive funding from the Federal Transit Administration to further explore lane assistive technology and where it might be deployed nationally. A team led by Craig Shankwitz, Nic Ward and Dawn Spanhake organized a workshop for transit professionals from around the country that brought many leaders to the University of Minnesota campus to help define the national problem.

I am also excited to report that we are about to receive two other major contracts. One is from Nissan to explore how one can use various methodologies to ensure that drivers are more aware of other vehicles around them. The effort at Minnesota, led by Nic Ward, is part of a larger multi-university consortium organized by Nissan. The second contract is focused on reducing rural intersection fatalities. This effort, led by Craig Shankwitz in partnership Mn/DOT State Traffic Engineer Gary Thompson, is part of a consortium with California, Virginia and the Federal Highway Administration, exploring ways to reduce intersection-related crashes around the country.

I would especially like to welcome several new faculty and research staff who joined us this past year to further explore solutions to transportation problems. They are “Slim” Alouini, working on wireless communications; Will Durfee, on haptic interfaces in vehicles; Al Yunas, on the effect on drivers of low-luminance contrast conditions associated with snow and fog; Kevin Krizek, on how technology can be used to improve transit planning and ridership; Mike Manser, on human factors and situation awareness; and Chen-Fu Liao, who is developing web-based tools for hands-on learning about traffic signal controllers and traffic management.

We are now entering the second year of our partnership with the Northland Advanced Transportation Systems Research Laboratory (NATSRL) at the University of Minnesota—Duluth. James Riehl, dean of the College of Science and Engineering and director of NATSRL, has pulled together an amazing team of researchers and educators who are addressing technology and its impact on transportation issues in rural environments, smaller urban communities, and northern climates. Several new laboratories are being established. One in particular, the Advanced Sensor Research Laboratory, led by Stan Burns, was developed in partnership with Mn/DOT’s District 1, which provided facilities just off I-35 south of Duluth for testing a variety of traffic, weather and pavement sensors under the rigorous conditions of our northern climate.

As always, we are very appreciative to the Minnesota Department of Transportation for its continued support across the breadth of our activities. The close working relationship between our organizations is a cornerstone of Minnesota’s efforts to develop innovative solutions to our transportation problems.
Mission Statement

The Intelligent Transportation Systems (ITS) Institute is a University Transportation Center (UTC) funded through the Transportation Equity Act for the 21st Century (TEA-21), the federal transportation bill passed in 1998. This funding continues the Institute’s efforts initiated under TEA-21’s predecessor, the Intermodal Surface Transportation Efficiency Act of 1991.

The Institute plans and conducts activities that further the mission of the UTC program of the United States Department of Transportation (USDOT). 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.

The Institute’s activities are guided by its theme of enhancing the safety and mobility of road- and transit-based transportation through a focus on human-centered technology. To that end, the Institute brings together technologists and those who study human behavior to ensure that Institute-developed technologies become tools that optimize human capabilities. This human-centered approach means that new developments in the core ITS technologies of computing, sensing, communications, and control systems will be used to approach safety and mobility problems with a fresh perspective. 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 deployment of core ITS technologies.

Financial Report

Expenditures for Year Three
July 1, 2001 - June 30, 2002

Funding Sources
Total Annual Budget: $4.0 million including matching funds from:
- Minnesota Local Road Research Board
- Minnesota Department of Transportation
- University of Minnesota

Administration 7%
Education 5%
Technology Transfer/Information Services 10%
Research 80%
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). Much of the Institute’s successful leadership in the development and application of intelligent transportation systems and technologies can be attributed to its state and national partnerships, including those with CTS, the Minnesota Department of Transportation (Mn/DOT), private industry, and county and city engineers.

The Institute director leads the operation of the ITS Institute, 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’s responsibilities include working with the director to ensure that the USDOT’s Research and Special Programs Administration (RSPA) requirements are met, approving annual plans and budgets, and meeting 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 disseminate 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 location within the Center allows it to work seamlessly with CTS staff and benefit from its diverse outreach, administration, and communications capabilities.
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ITS Institute Laboratories and Facilities

ITS Laboratory

The University of Minnesota’s ITS Laboratory is a dedicated resource for Intelligent Transportation Systems research, focusing primarily on traffic sensing, modeling, and management.

The lab serves a vital role in providing a safe environment for testing new strategies prior to implementation and in supporting the research, education, and training efforts of transportation faculty, students, and professionals.

Three projects currently under development—Beholder, WaveNET, and the DEN—facilitate research in the lab that will enhance the Institute’s knowledge of traffic behavior.

Responding to limitations of the previous system, Beholder was developed to provide a more flexible and higher-quality video data stream from Mn/DOT highway traffic cameras to the lab, where it is used by traffic researchers. Instead of fixed cameras, Beholder employs freestanding rooftop data collection stations that can be disassembled and moved in the trunk of a car by a pair of researchers.

Currently installed on two high-rise roofs along the “commons” where interstate highways 94 and 35W come together—one of the most accident-ridden freeway sections in the Twin Cities metro area—Beholder allows researchers in the ITS Laboratory to view image data in real time over the Internet using a lightweight Java applet. Signal integrity is sufficient to permit accurate vehicle tracking, and wide-angle video images are archived for use in verifying traffic incidents.

Data are transmitted back to the University campus access point atop Moos Tower over wireless Ethernet using the 802.16 networking standard. The radios operate within the free UNI-II 5.4 GHz band at up to 20 Mb per second using pre-determined Time-Division Multiplexing (TDM) to share airtime between multiple stations.

A deployable “DIVX box” for real-time video compression is currently under development in the lab, taking advantage of miniature form-factor commercial off-the-shelf components and implementing the emerging DIVX CODEC standards used in high-definition broadcast video. When completed, the new system will increase signal compression by a factor of 15.

Transmitting video data in real time places a heavy burden on any network, and wireless networks especially. The WaveNet project explores two techniques to get around the limitations of wireless networking: data compression and Quality of Service (QoS) control.

Phase I of WaveNet evaluated several commercial compression packages that use a type of algorithm known as “wavelet-based” compression. Though not supported by software targeted for Web users, wavelet-based compression offers several advantages, including lower bandwidth requirements, the ability to zoom into an image without loss of quality, and preservation of the video’s original frames, which are “wiped smooth” by conventional compression.
The research team constructed a wireless testing network within the ITS Laboratory, consisting of a pair of local area networks connected by two routers whose bit rates can be regulated. This enabled researchers to introduce various “bottlenecks” into the system to emulate the throughput degradation typical of wireless networks. Phase II of the WaveNet project is currently looking at Quality of Service measures to give important data a guaranteed percentage of available bandwidth at the expense of less-important data streams.

The goal of the Digital Immersive Environment, or DEN, is to allow researchers to virtually “step into” their digital world by incorporating the illusion of 3-D depth. The DEN’s three seven-foot-square projection screens form the back and sides of a large cube-like structure that surrounds the viewer with 3-D graphics. To create the third dimension, a pair of digital projectors display two slightly different images on each side of the cube—one for each of the user’s eyes. These images are polarized in opposite directions, and a pair of specially polarized glasses worn by the user admit only one “channel” of information to each eye.

One of the most important factors in creating a realistic 3-D display is observer motion parallax. The ceiling of the DEN holds a tracking system that monitors the position of the user’s head and relays this information back to a cluster of six computers (one for each projector). The computers use this positional information to draw each eye’s field of vision with the correct perspective.

Instead of a mouse, the user holds a “wand.” The ceiling tracking system translates the wand’s movements in three dimensions into meaningful interactions with the projected environment.

The DEN will have numerous uses for ITS research, including advancing new ideas in surveillance and incident management, traffic visualization, urban planning, and the development of new traveler information systems.

In addition, ITS Laboratory staff are working on development of an ITS interdisciplinary course. These projects include the use of KRONOS (a macroscopic traffic simulation software package) in a lab module for a civil engineering course, and the creation of an Internet-based three-dimensional traffic simulation prototype that interfaces with AIMSUN2 (a microscopic traffic simulation software package).
The Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program’s mission is to apply human factors research to the design and evaluation of usable intelligent transportation systems to improve traffic safety and mobility. 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 is a reconfiguration of the ITS Institute’s original Human Factors Research Laboratory. This new program has a core staff of transportation research specialists made up of cognitive psychologists and software engineers linked to a broader interdisciplinary network of other psychologists, engineers, computer scientists, and public health and safety practitioners. This network is supported by affiliations with additional University research units, which allows the program to create responsive interdisciplinary teams to investigate a broad range of complex human factors research issues. Moreover, HumanFIRST has close relationships with the Minnesota Department of Transportation and the Department of Public Safety, as well as with traffic engineering consultants. These connections provide additional support for implementing research that will influence transportation policy in response to real-world problems both regionally and nationally.

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 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 driver responses and adaptation (e.g., distraction, complacency, fatigue, risk taking) that could undermine the system goal of improved safety.

Current research topics include driver distraction from in-vehicle tasks, cell phones, and alcohol; traffic calming; interventions for crash reduction at rural intersections; bus rapid transit using dedicated narrow shoulders; driver fatigue and methods for its detection; intelligent driver-support systems such as vision-enhancement; collision-avoidance; lane-keeping systems for passenger and specialty-purpose vehicles; and psychological and environmental correlates of aggressive driving.

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 Virtual Environment for Surface Transportation Research (VESTR), provided by AutoSim, is an extremely versatile and realistic simulation environment that can be used for a variety of theory- and application-based research.

Among the features that make VESTR one of the most advanced academic simulators in North America are a 2002 SC2 full-vehicle cab (donated by Saturn) that provides realistic operation of the controls and instrumentation, including force-feedback...
steering and the feel of power-assisted braking; high-fidelity simulation for all sensory channels; a visual scene projected to a high-resolution, five-channel, 210-degree forward field of view, with rear and side mirror views provided by a rear screen and LCD monitors; software (provided by OKTAL) that can generate any type of road environment, including precise reproductions of geospecific locations, and produce a range of realistic weather and lighting effects; and auditory and tactile feedback provided by a three-dimensional surround-sound system, car body vibration, and a three-axis electric motion system.

To support the use of VESTR, the program has access to a variety of closed test tracks and road network field sites for on-road studies with instrumented vehicles.

**Intelligent Vehicles Laboratory**

Research in the Intelligent Vehicles (IV) Laboratory works toward developing innovative human-centered design and driver-assistive technologies that improve the operational safety, mobility, and productivity of road- and transit-based vehicles. These technologies integrate sensors, actuators, computer processors, and specific human interfaces to provide drivers with needed information in difficult driving conditions such as low visibility, severe weather, and congested roadways.

The IV Laboratory uses as experimental testbeds the SAFETRUCK, an International 9400 tractor-trailer; the SAFE- PLOW, an International Model 2540i snowplow; and the recently added TechnoBus, a Metro Transit bus.

Driver-assistive system technologies under investigation include high-accuracy differential global positioning systems (DGPS); high-accuracy geospatial databases; radar and emerging range sensing technologies; collision-avoidance and driver-warning technologies; vehicle navigation, guidance, and control; and conformal, augmented head-up displays (HUDs).

Human interface components, based on human factors principles, work to integrate visual, haptic, and audible stimuli, project images that overlay the actual scene by using HUD technology, and integrate information from multiple sources in order to assist drivers in difficult situations as well as to help accommodate older drivers.

One significant research component of the IV Laboratory is the Intelligent Vehicle Initiative Field Operational Test Program, funded by the USDOT through the Minnesota Department of Transportation. This project is being conducted to increase safety for the drivers of specialty vehicles—snowplows, police cars, ambulances—through the use of vehicle-guidance and collision-avoidance technologies in low-visibility conditions. Engineers at the IV Laboratory, in cooperation with human factors researchers from the Institute’s HumanFIRST Program and engineers from the University of Minnesota Duluth’s Electrical and Computer Engineering Department, are developing and testing a variety of these technologies.

In a series of human factors studies involving driving simulation and field testing, researchers devised a number of lane-departure and collision-avoidance warnings for use with a HUD, which allows drivers to “see” road markings via images.
projected onto a combiner mounted close to the windshield. This system was tested in the driving simulator with 55 specialty vehicle operators. Subsequently, lane-departure warnings based on a combination of visual, tactile, and auditory signals were field-tested at the University’s Rosemount research facility between November 2000 and January 2001.

Follow-up testing to determine driver response to this technology at high speeds was conducted in cooperation with the Minnesota State Patrol and Hutchinson Ambulance in September of 2001. Thirteen troopers and two ambulance drivers used the system under low-visibility conditions, including moonless nights and fog. The system performed as intended, even at speeds approaching 100 mph.

Throughout the summer months of 2001, four snowplows, an ambulance, and a State Patrol car were prepared for the field operational test currently in progress. All of the equipment designed to assist the driver, including the HUD, driver’s seat (which provides the tactile warning), audio warnings, sensors, and computers, was installed in each vehicle. Data acquisition equipment, consisting of four video cameras, a microphone, and an Ethernet connection to the vehicle computers, was installed to record driver-response to the system during operational testing. During normal operation, vehicle and driver data are recorded onto a removable hard drive and are periodically archived onto DVD-RAM for subsequent study and analysis.

As a prerequisite for the operations test, the research team installed six weather stations along a 45-mile stretch of Minnesota Trunk Highway 7 between Hutchinson, Minnesota, and I-494. These stations collect weather and visibility data at five-minute intervals, which is then archived on a central server located at the University of Minnesota. Team members also completed installation of three GPS correction base stations, providing a means to achieve centimeter-level position accuracy of the test vehicles on Highway 7. In addition, a digital geospatial database of the Highway 7 corridor between Hutchinson and I-494 was created and validated.

Results from the project will be used to validate the system, which will ultimately help to reduce the risk of driving snowplows or emergency vehicles in low-visibility situations, to increase public safety through improved emergency response and to provide more efficiently plowed roads.

Northland Advanced Transportation Systems Research Laboratories

The Northland Advanced Transportation Systems Research Laboratories (NATSRL) is located at the University of Minnesota Duluth. A key mission of NATSRL is to study comprehensive winter transportation systems and the transportation needs of cities in small urban areas. Research covers a wide range of topics, including visual and electronic traffic and road sensors, transportation data management, and inventory management of transportation infrastructure. NATSRL is collaborating with the Minnesota Department
of Transportation District One, other Mn/DOT groups, city and county engineers, and the university research community to address transportation-related needs, especially those that are specific to northern areas and climates.

NATSRL is led by James Riehl, dean of the College of Science and Engineering, with support from Stanley Burns, professor and head, Department of Electrical and Computer Engineering (ECE); Donald Crouch, professor and head, Department of Computer Science; Taek Mu Kwon, professor, ECE; and David Wyrick, associate professor and head, Department of Industrial Engineering (IE).

NATSRL’s laboratories are the Advanced Sensor Research Laboratory and the Transportation Data Research Laboratory.

The Advanced Sensor Research Laboratory has facilities in UMD’s ECE Department and also includes an off-campus field laboratory (along Interstate 35 southbound) where newly developed or existing transportation sensors can be installed and evaluated. This new facility became fully operational in winter 2002, and more equipment is currently being installed to accommodate the increasing experimental effort. The goals of this laboratory include development and testing of advanced sensing technologies for pavement and road conditions (speed, slipperiness, and traffic density); development of new techniques to detect incidents and abnormal traffic conditions; and real-world analysis and real-time measurements of road, weather, and traffic information.

The Transportation Data Research Laboratory is housed in the ECE Department laboratory facilities, and receives project support from the IE Department in the areas of human factors and operations management. This laboratory is working toward development of a statewide traffic data archival and analysis system, development of an automatic inventory management system for transportation infrastructure, and design of efficient management strategies for small urban and large-scale event traffic flow using modern visualization and management tools.

Additionally, NATSRL includes the Roadway Visibility Test Site, located along Interstate 35 near Duluth. This site consists of fixed targets and video cameras used for automatic video-based visibility measurement and detection.

NATSRL research underway includes projects on traffic data automation for Mn/DOT’s traffic monitoring program, an automatic visibility measurement system based on video cameras, and snowplow fleet management.

**Traffic Engineering Laboratory**

The Traffic Engineering Laboratory, housed in Civil Engineering, contains simulation and traffic forecasting programs that researchers and practitioners use for traffic data analysis, demand forecasting, and transportation planning.

**Mn/ROAD High- and Low-Volume Road Test Facility**

The Minnesota Road Research Project—Mn/ROAD—is located in Albertville, Minn., and includes a freeway and a low-volume road pavement test track with 40 Portland cement concrete, asphaltic concrete, and unsurfaced test sections; 4,500 electronic sensors; a weigh-in-motion scale; a weather station; and DGPS correction signals. The ITS Institute uses the facility to test vehicles performing a range of experiments in areas such as collision avoidance, lane-keeping, warning systems, and augmented displays.
Research
The problem of vehicle blindspots is not limited to a driver’s rear view. Forward-looking blindspots can cause a potentially hazardous situation and may contribute to more crashes than previously thought, says Professor Michael Wade of the University’s School of Kinesiology/Human Factors Research Laboratory (HFRL).

Professor Wade and graduate students Curtis Hammond, ChunGon Kim, and Petcharatana Bhuanantanondh have been studying the problem of forward-looking blindspots (FLBs) produced by the support pillar, or A-pillar, found on either side of a vehicle’s front windshield. Because the A-pillar is typically 10 centimeters wide, extending a driver’s line of sight out 150 meters could produce a blindspot large enough to “hide” a semi tractor-trailer approaching an intersection from either the left or right side of the observer’s vehicle.

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 both ISTEA and TEA-21 legislation and the Federal Highway Administration. Other funding partners include the Minnesota Department of Transportation (Mn/DOT), the Minnesota Local Road Research Board, and Metro Transit, in addition to local governments, agencies, and private companies who contribute funding and in-kind match.

Activities undertaken by the Institute support all current 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 underway, while the second briefly describes other Institute projects either recently completed, in progress, or selected to begin this coming year.

**Human Performance and Behavior**

**Eliminating Driver Blindspots at Rural Intersections: Effects of Signage and Vehicle Velocity**

The 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 people to adapt to technology.

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Wade’s research analyzed the relationship between the size of the FLB, the speeds of two vehicles approaching an intersection at right angles, and driver behavior relative to such an accident-likely event. To do so, he used the wrap-around simulator (which includes a Honda Accord modified for data acquisition and simulator interface) at the HFRL to produce a 180-degree forward view of a simulated rural road environment.

Twenty-eight volunteer drivers, 21 to 60 years old, were observed directly and by on-board video cameras while driving in the simulator. Data pertaining to heading, road speeds, gas pressure, brake pressure, and “global” position coordinates were recorded directly by the computer and exported as a text file.

The way in which participants scanned the virtual environment was noted and scored according to one of four levels: 1) eyes fixed, which relies on peripheral vision only; 2) eyes-only scan; 3) eye/head scan, in which the head turns but does not change position; and 4) active scan, in which the head moves left and right, forward and backward, in order to look around the A-pillar. Participants were also scored on whether they actually saw the virtual vehicle and on whether they collided with it.

Results showed that the second level of scanning—eyes only—was used most often (44 percent of the time), but this type of scanning is “inactive,” say the researchers. Participants were more successful in detecting the target vehicle the more “actively” they scanned—especially comparing scanning levels one to two and two to three. Even when participants repeatedly scanned the scene, they failed to see the approaching test vehicle if they didn’t actually move their head. Researchers observed a similar inverse relationship in collision rates relative to scan type—collision rates dropped significantly only when scanning became active.

Wade speculates that the sparse landscape of the virtual environment, typical of many rural roads, may contribute to a state of complacency in the participants—represented by the frequency of “eyes-only” scanning. And therein, he says, lies one of the concerns of rural road intersection design. With no required deviation in heading (such as afforded by a left-turn lane) or reason to scan more actively, and with nothing present to obscure vision for miles, the wide-open rural road intersection may induce a false sense of safety.

To mitigate the hazards posed by FLBs, Wade offers two approaches. First, he says, drivers in training should be made aware of flaws in visual pick-up of information. Making drivers aware of how the human brain can “fill in” missing visual information may lessen their sense of complacency. Second, either vehicles themselves must be re-engineered to provide for better vision or the road must be redesigned to re-orient a vehicle as it approaches an intersection, Wade says.

Although some automobile makers are changing vehicle designs, “there’s no evidence to say it’s an issue that design engineers view as critical,” Wade says. “Active looking is key.” What works against that, however, is that many automakers try to sell the ergonomics of the cockpit of the car—and the idea that the car “wraps itself around you,” he adds. “That tends to minimize motion...[because] all the instruments are there right in front of you. But as you scan left to right and barely move your head, you look right through the pillar.”

For more information:
www.its.umn.edu/research/projects/2001014.html
Intelligent Vehicles Initiative Vision Enhancement System

Last fall, members of the ITS Institute’s Intelligent Vehicles Laboratory and HumanFIRST Program tested their Vision Enhancement System (VES) with those who may one day use it on the job. In a patrol car outfitted with VES technologies, 10 Minnesota State Patrol officers drove a test track at Brainerd (Minn.) International Raceway and offered opinions about the system that is designed to improve safety under conditions of poor visibility, such as at night or in fog or snow. Safe travel in such conditions is vital for troopers and other emergency vehicle operators.

The VES incorporates technologies first developed for use in a prototype snowplow, including Differential Global Positioning System (DGPS) technology, high-accuracy digital road maps, a “virtual” rumble strip, and a head-up display (HUD). The result is a projected virtual view of the roadway with lane boundaries shown on a screen in front of the vehicle’s windshield where the driver can easily view it without looking away from the road. If the driver does stray outside the boundaries, the system issues a warning.

This research is part of the larger three-year Intelligent Vehicle Initiative (IVI) Field Operational Test Program, which is funded by the Federal Highway Administration, the Minnesota Department of Transportation (Mn/DOT), and industry partners. The IVI project is directed by Mn/DOT, with the Institute’s Intelligent Vehicles Laboratory leading the technology development and systems integration.

Researchers wanted to collect preliminary data on the performance of the VES prior to field testing over the winter and examine how the system affects driver speed choice and perception, which may be related to crash risk.

The study was led by Dr. Nicholas Ward, director of the HumanFIRST Program. Participating Intelligent Vehicles staff included program director Dr. Craig Shankwitz and research fellows Alec Gorjestani, who monitored the system throughout the tests, and Bryan Newstrom, who created the geospatial database for the racetrack course.

Tests were run at night, and conditions of reduced visibility were simulated by using headlight covers to reduce light transmission.

Drivers were given several options for how lane boundaries were displayed on the HUD—longer versus shorter previews, solid versus dashed lines. Officers were told to drive the course at a safe and comfortable speed, except for one section where they were instructed to drive to a set speed without looking at the speedometer. Afterwards, officers completed a questionnaire from which the researchers assessed factors such as speed perception, mental workload, and user acceptability.

Most officers reported that they thought the VES would improve safety, particularly on highways and rural roads, but that specialized training would be required to use it and to maintain scanning of the full road scene (thus avoiding “tunnel vision” directed to the HUD).

“All officers reported that they could recognize possible safety benefits for using such a system under very poor visibility conditions,” Ward said. Because of the apparent improved safety, all officers had a positive attitude toward the system, he added. Although the officers noted that the system might require more mental and visual effort to use, they felt it could be used safely with proper training, Ward said.
For preview options, most officers preferred the longer preview on the unfamiliar route because it gave advanced warning of curves ahead, but reached no consensus on a preference for solid versus dashed lines. Based on test results, researchers plan to incorporate some improvements into the system—for example, adding a collision avoidance component. Researchers also learned that any training should emphasize the need for drivers to scan the entire roadway, Ward says.

For more information:
www.its.umn.edu/research/projects/2001046.html

Computing, Sensing, Communications, and Control Systems

Bus Rapid Transit Technologies: Assisting Drivers Operating Buses on Road Shoulders

As congestion worsens on existing highways, the transit industry continues to look for dedicated right-of-way, freeway shoulders, and other express lane options to increase the throughput of their vehicles. As a result, the Twin Cities’ Metro Transit and the Minnesota Department of Transportation are cooperatively operating a bus rapid transit (BRT) system throughout the Twin Cities metro area, using high-occupancy vehicle lanes, entrance ramp bypasses, and most recently, bus-only shoulder operation to give transit riders faster, more efficient service when compared to traditional transit methods.

Applying ITS technologies to BRT issues is a relatively new strategy. A team of researchers associated with the ITS Institute’s Intelligent Vehicles (IV) Laboratory is working to adapt their previously developed driver-assistive technology for bus operations and, consequently, to solve some of the problems associated with bus-only shoulder use.

One such problem is that the shoulders on which transit buses operate are typically no more than 10 feet wide; a transit bus measures 9.5 feet across the rear-view mirrors. These narrow lanes require a driver to maintain a lateral error of less than one-half foot to avoid collisions—a difficult task under the best conditions, and nearly impossible during conditions of bad weather, low visibility, and high traffic congestion. A driver also has to merge into traffic when the bus-only shoulder area ends or a left exit is required.

IV Laboratory team members include IV program director Craig Shankwitz, research fellows Lee Alexander, Alec Gorjestani, and Bryan Newstrom, and graduate research assistants Mike Sergi and Walter Trach Jr. The goal of the team is to equip a Metro Transit bus—dubbed the TechnoBus—with technology that will help a driver operate a wide bus on a narrow shoulder, especially in difficult conditions. Work will focus primarily on lane-keeping and forward collision-avoidance driver-assistive technologies originally developed for snowplows. Collision avoidance for the sides of transit vehicles will also be investigated.

To that end, researchers have met with Metro Transit drivers to...
learn about the difficulties of driving a wide bus on a narrow shoulder. Researchers are building and installing the infrastructure necessary to provide lateral lane keeping. This includes procuring and installing both the method of providing GPS corrections and the GPS receiver to be used as a base station, and creating the geospatial database.

After documenting the mechanical components and cabin layout of the Metro Transit bus, researchers are installing the mechanical, electronic, sensor, actuator, and display systems necessary to provide driver assistance to a bus driver. The technology includes a longitudinal driver-assistive system which incorporates a Head-Up Display (HUD), a DGPS system, an Inertial Measurement Unit (IMU), forward-looking radar, power supplies, computers, steering actuation and amplification, and other peripheral equipment. The HUD will be used to provide vision enhancement when visibility conditions are poor and it is difficult to identify both lane boundaries and obstacles. An active steering wheel will provide haptic feedback, giving additional cues to the driver.

Longitudinal collision avoidance uses forward-looking radar to detect objects in the forward path of a vehicle. Avoiding collisions around the periphery of a vehicle has been a focus of IV Laboratory research, which has led to the development of a “virtual mirror.” The virtual mirror can use a variety of sensors (e.g., radar, laser scanners, etc.) to survey the areas surrounding a bus (or other vehicle) where optical mirrors cannot. Although a virtual mirror has been implemented using existing geospatial database tools, DGPS, and vehicle-to-vehicle communications as a range-sensing device, for practical applications, radar or laser-ranging sensors will have to be used. The team reports that initial results from mounting a prototype laser scanner on the research bus have been very promising.

Additionally, the team hopes to develop long-term relationships with Metro Transit, the Federal Transit Administration, and technology providers to develop and implement strategies to improve transit operations, such as enhancing the ability of a bus driver to merge into and out of traffic.

For more information:
www.its.umn.edu/research/projects/2001046.html

Using GPS and GIS in Developing New Approaches to Assessing Road User Charges

Today, the federal and state motor fuel tax is the primary means of funding state and federal highways. One of the major problems with this approach is that vehicles are becoming more and more fuel-efficient. With hybrid electric vehicles already on the market and the reality of fuel cell-powered vehicles just around the corner, the fuel tax revenue stream will eventually dry up, resulting in less tax money to build and maintain roads. Because of this, more stable funding approaches are being explored. Researchers at the Intelligent Transportation Systems Institute are at the center of evaluating and refining the needed technologies, while collaborators at the University of Iowa are exploring the policy ramifications.

ITS Institute Director Max Donath is the principal investigator of a multidisciplinary research effort involving the Mechanical Engineering and Computer Science departments at the University
of Minnesota. The team is working on technologies that will enable real-time assessment of road user charges based on actual mileage accrual, road type, and road jurisdiction, with other assessment parameters to be added in the future. The key components involve global positioning system (GPS) technology combined with geographic information systems (GIS), based on computerized maps. The team is evaluating the ability of GPS and digital road map databases to meet the requirements of a new road user charge system. Dr. Pi-Ming Cheng, research associate in the Mechanical Engineering department, is evaluating the GPS component; Dr. Shashi Shekhar, professor in the Computer Science department, is evaluating the GIS piece.

To ensure that vehicles are not incorrectly tracked on frontage roads when they are actually moving along the adjacent highway, GPS accuracy must be within one to two meters. To achieve this type of accuracy requires the use of a differential correction signal, which is typically broadcast from a station on the ground.

The researchers are now working to better understand the content and quality requirements of digital road maps and are examining the road map quality metrics that were developed for other applications within ITS. The objective is to refine existing metrics, develop new ones as needed, and define an acceptable accuracy standard for both GPS and digital maps.

Phase one of this initiative began in September 2000. Actual testing began in spring 2002, when a new Nationwide Differential GPS Service (NDGPS) base station opened in Pine River, Minnesota. Initial tasks involved evaluating the availability of accurate digital maps and methods for acquiring them. To date, the team has developed experimental methods for evaluating the accuracy of digital maps and of GPS technology and is continuing to evaluate road maps of the Twin Cities metropolitan area. The team has also developed a new algorithm for selecting and evaluating problematic areas such as where two or more roads are laterally very close to each other. These are locations where problems in automatically determining which road the traveler is on are likely to occur.

The researchers are currently working on developing performance specifications for GIS databases and GPS and plan to begin evaluating road maps of rural Minnesota in fall 2002. After that, they will begin creating specifications for map-matching software and related hardware. The group hopes to come up with a recommendation for a cost-effective approach for acquiring and maintaining sufficiently accurate GIS road map databases for the road user charge system by the end of phase one, due to wrap up in early 2003. An effort is also underway to initiate a second phase in which to field-test the new system.

For more information:
www.its.umn.edu/research/projects/1999002.html

Technologies for Modeling, Managing, and Operating Transportation Systems

A Case-Control Study of Driving Speed and Crash Risk

"Speed Kills" was a popular traffic-safety slogan initiated in the 1950s and '60s with the hope that lives could be saved if drivers were encouraged to slow down. While "Speed Kills" is still an aphorism to some, controversy exists concerning the relationship among speed limits, vehicle speeds, and the likelihood of being involved in a traffic accident. Some studies have reported a tendency for increased crash risk as
speeds increase; other studies have reported increased crash risk for slower vehicles, while some have even claimed that raising speed limits should reduce crashes. In large part, this disagreement is traced to methodological weaknesses in past research stemming from failure to account for aggregation bias and/or measurement error.

With the unremitting pressure from many drivers today to drive at faster and faster speeds, an understanding of the relationship between speed and crash risk is essential in order to balance the benefits faster speeds provide to individual drivers against the external costs those faster speeds impose on others. Gary Davis, associate professor in the Civil Engineering department at the University of Minnesota, is leading the charge to conduct a methodologically sound investigation on the relationship between crash risk and speed for Minnesota drivers.

Rather than use generalizations as hypotheses to be tested, Davis and his team hope that any plausible generalizations will emerge from a detailed consideration of individual cases. One possible outcome of this project would be findings that would help constrain the national and local debate about speed, speed limits, and traffic crashes.

Researchers are using case-control studies similar to those frequently used in medical research to help identify factors correlated with the occurrence of relatively rare events. A simple example of a case-control study of speeding and crash risk involves first identifying a sample of vehicles involved in crashes (the cases) and a comparable sample of vehicles not involved in crashes (the controls) and then computing the fraction of speeders in each sample. If, for example, a significantly higher fraction of the cases are speeders, that would indicate a positive association between speeding and crash risk.

This research team is using accident reconstruction methods to estimate the speeds of vehicles involved in the sample of fatal crashes used in this study. One major challenge is that there are many uncertainties when reconstructing accidents that affect the precision of speed estimates. Since unacknowledged measurement error can bias the conclusions drawn from case-control studies, accounting for this uncertainty is essential.

Using data from the Road Accident Research Unit (RARU) at Adelaide University in Australia, Institute researchers already have developed and tested their own statistical method for estimating the relative risk of speeding from case-control data when the case speeds are subject to measurement error. The team has also completed a review of methodological issues that arise when attempting to relate speed to accident risk. Once all of the accident reconstruction work is completed, researchers will work on fitting a statistical model relating speed to crash risk. As in other areas of ITS research, this project applies new intellectual tools to transportation problems. Advances in causal modeling and computationally intensive estimation methods—two tools that did not exist in a usable form ten years ago—are here applied to the problem of identifying the role of speed in fatal crashes. The entire project, which began in August 2000, is scheduled for completion in fall 2002.

For more information:  
www.its.umn.edu/research/projects/2001032.html
Traffic Flow Modeling of the Miller Hill Corridor

The Twin Cities area claims the headlines when it comes to traffic congestion in Minnesota, but problems faced by regional population centers can be no less severe. In Duluth, for example, the Miller Hill Corridor of Highway 194 is among the city’s most heavily traveled—and frequently congested—roadways.

Researcher Jiann-Shiou Yang, a professor of electrical and computer engineering at the University of Minnesota Duluth, is focusing on the traffic signals that regulate traffic flow along the route. His goal is to create a complete model of traffic flow through the Miller Hill Corridor, and use this model to determine optimal signal-timing rules.

Installing a Remote Traffic Microwave Sensor (RTMS) system using compact microwave beam generators mounted on sign supports and utility poles allowed researchers to collect data while causing minimal disruption along the corridor. Each RTMS unit is capable of monitoring up to eight lanes of traffic, and can record data on vehicle presence, traffic volume, occupancy, speed, and vehicle classification.

Eight detector units along the route measure traffic moving in both directions, recording data at three-minute intervals throughout the day. Numerous observations over a nine-month period yielded data showing very consistent patterns, with the exception of anomalies like special events, severe weather conditions, and holidays.

In modeling the traffic system, Yang’s goal was the development of a hybrid system—a macroscopic model that incorporates certain advantages of microscopic modeling. The hybrid Yang developed was based on a model originally developed to simulate freeway traffic, which in its original form produced poor results when applied to the Miller Hill data. Yang theorized that by hybridizing this model, he could create a tool to accurately model traffic on a congested, compact route.

Yang conceived the identification of model parameters as a nonlinear constrained optimization problem with a performance index reflecting the difference between the model’s behavior and the observed traffic flow. Because data from different road segments exhibited markedly different characteristics, it was necessary to solve the optimization problem for each segment individually, for both eastbound and westbound traffic lanes.

Optimization of the model parameters resulted in a system that is sufficiently accurate to simulate traffic flow over the entire study area when benchmarked against observed traffic flows. This represents a significant success in the adaptation of a simulator originally created for freeway traffic to the difficult data landscape of a congested urban access highway. Yang plans to further refine his model and begin to apply it to developing better traffic control strategies for one of Duluth’s vital access routes.

For more information:
www.its.umn.edu/research/projects/2001029.html

Jiann-Shiou Yang alongside a stretch of the Miller Hill Corridor.
Social and Economic Policy Issues Related to ITS Technologies

Sustainable Technologies Applied Research: Year 2 Update

Researchers at the Hubert H. Humphrey Institute of Public Affairs’ State and Local Policy Program (SLPP) are investigating transportation technologies that contribute to sustainable communities, by systematically examining the impacts of intelligent transportation systems (ITS) and telecommunications along five dimensions: spatial location, community design, accessibility, network performance, and productivity. The major theme of this work is the relationship between technological networks and places. Through the Sustainable Technologies Applied Research (STAR) project, this theme is being explored in an interdisciplinary fashion with perspectives ranging from urban development to network analysis.

Community Telecommunications Planning and Access

Although only 30 percent of miles driven within the state are on rural roads, 70 percent of fatal crashes occur on them. In addition, 50 percent of rural traffic deaths occur prior to arrival at a hospital. Appropriate medical care during the “golden hour” immediately after injuries are sustained is critical to reducing death and disability. Led by visiting scholar Dr. Thomas Horan, Humphrey Institute researchers are developing a comprehensive framework to understand and enhance the role of wireless systems in assisting transportation and emergency medical service providers. Drawing upon the ITS national systems architecture, which provides a general framework for deploying new ITS products and services, the research team is examining policy, organizational, and technical challenges to the seamless flow of wireless communications for motorists. According to Horan, “with more than 70 percent of motorist emergencies being communicated via mobile phones, the wireless system has become the safety net for ensuring travelers receive needed medical attention. The object of the research is to help ensure that new ITS systems enhance this safety net.”

Over the last year, interviews were conducted with providers from transportation, health care, telecommunications, and public safety. Preliminary findings suggest that while the e-911 mandate (a federal regulation requiring that location information be automatically available from cell phones as they are for landline phones) will create a new platform for ensuring rapid emergency service, a variety of policy and technical steps must be taken to ensure timely service for all motorists, not just those with next generation mobile devices. Possible steps include funding incentives for rural areas, closer coordination among agencies, and communication standards that are realistic for all urban and rural safety providers.

In the next year, the research team will benchmark the state of the Minnesota system with comparable states and conduct an expert roundtable to review and comment upon research findings. These activities will help refine the research team’s recommendations and will help make Minnesota a leader, as it has been in other ITS serv-
Research

The research promises to substantially increase the field knowledge about how ITS and other technologies impact social, economic, and environmental dimensions of communities.

Industry Clusters Analysis

Another facet of the STAR project involves industry cluster analyses on how economic networks drive and benefit from transportation and related networks. Munnich and his team are exploring how geographically clustered businesses in an industry are affected by ITS. In particular, the team is studying the recreational equipment industry in the northwest region of Minnesota.

The ITS applications used by the recreation equipment industry are primarily just-in-time (JIT) inventory and e-commerce. JIT inventory systems have greatly improved efficiency in the firms’ supply chain management. This technology has also enabled the supply chains to be geographically dispersed with many inputs coming from national and international suppliers. With careful planning for inventory availability, it becomes less crucial for suppliers to be locally available.

Recreation equipment firms also use e-commerce as an ITS application. The firms studied have shifted to dealer-direct product delivery rather than relying on distributors. The closer relationship between the recreation equipment firm and its dealers allows consumers to order and customize products through the company website, and then pick up the goods at a nearby dealer. In general, the emergence of e-commerce is facilitating greater decentralization in the distribution system.

Researchers are also evaluating the region’s transportation infrastructure and its response to the changing needs of the recreational equipment industry; they will also study how ITS and other emerging transportation technologies are shaping the supply networks of industry clusters. In the future, the team will comprehensively survey and map the supply networks of a few particular industries in one or two regions of Minnesota. They will then examine how these supply relationships are changing and what role ITS is having in this change.

Additional STAR research is being conducted by other University of Minnesota researchers, including Professor Emeritus Richard Bolan, Humphrey Institute, who is leading the theoretical work and conducting a review of network theory and application; Professor Ken Keller, Humphrey Institute, who is serving as an advisor and reviewer of various research elements; Kevin Krizek, Humphrey Institute, whose research this year focuses on developing a framework for analyzing the effect of information and communication technology (ICT) on personal travel and community design; and David Levinson, Civil Engineering, who is leading the way in creating robust databases to examine the intersection of people and networks.

Throughout the next four years, the entire SLPP research team will extend their research to encompass a range of urban and rural settings, as well as several distinct technological platforms. The research promises to substantially increase the field knowledge about how ITS and other technologies impact social, economic, and environmental dimensions of communities.

For more information:
www.its.umn.edu/research/projects/2001054.html
Abstracts of Research Projects Completed in the Last Year

Human Performance and Behavior

Psychological and Roadway Correlates of Aggressive Driving (Phase I)
Principal Investigator: Kathleen Harder, College of Architecture & Landscape Architecture
Aggressive driving has received much attention in the popular press and from organizations such as AAA, which call it an increasing threat to the safety of future roadway environments.

In the first phase of the project, the team surveyed 300 University of Minnesota students in order to investigate the relationship between personality, emotional, and behavioral factors that contribute to aggressive driving (e.g., acceleration, braking, lane changes, speed, and tailgating) in order to reduce and prevent it.

In the second phase of the research, the team will run a driving simulator experiment at the HumanFIRST driving simulator to validate the self-reported driving behaviors. Subjects will include both high hostiles and low hostiles who will be put into situations of either high emotional manipulation or low emotional manipulation before going into the simulator. When driving, subjects will navigate through several virtual traffic events and environments, including rural and urban settings, congestion, and road construction.

Results of the experiments should give the researchers the ability to link personality traits and styles to types and levels of driving behavior under various traffic events and environments, thereby allowing them to gain some understanding as to what type of person may be “at risk” for aggressive driving.

For more information: www.its.umn.edu/research/projects/2000025.html

Effectiveness of In-lane Rumble Strips
Principal Investigator: Kathleen Harder, College of Architecture and Landscape Architecture

The intent of this study was to investigate the effect, if any, of rumble strips on stopping behavior of attentive drivers at simulated rural controlled intersections. The researchers investigated rumble strip design and deployment issues; with respect to design, they varied the rumble strip type (full-width or wheel-track) and with respect to deployment they varied the number of rumble strips (zero, two, or three). To test the varied aspects of design and deployment, the rumble strips were tested on two different types of controlled intersections (two-way or four-way) and in the presence or absence of traffic.

Results indicate that none of these manipulations seem to affect either the point at which drivers stop or the point at which drivers start to slow down at controlled intersections. The lone effect of rumble strips was observed in braking pattern: in this simulation experiment, drivers brake more and earlier when they are further away from the intersection when rumble strips are installed than if rumble strips are absent. Although drivers started to slow down at the same time and finished their braking at the same time, there was more use of the brake earlier in the slowing down maneuver in the presence of rumble strips. Results also reveal that drivers brake more, earlier when full-cover rumble strips are in place than they do when wheel-track rumble strips are installed. This result seems to indicate that rumble strips are likely to cause drivers to use their brakes more and earlier, and in turn perhaps means safer, more controlled braking behavior at rural controlled intersections. After considering these results, the researchers recommend conducting additional research, perhaps under conditions in which rumble strips are likely to be more effective, such as their use on sleep-deprived drivers and at sight-limited intersections.

For more information: www.its.umn.edu/research/projects/2001019.html

The Effects of Vision Enhancement Systems on Older Drivers’ Ability to Drive Safely at Night and in Inclement Weather
Principal Investigator: Thomas Smith, Department of Kinesiology

Aggressive driving has received much attention in the popular press and from organizations such as AAA, which call it an increasing threat to the safety of future roadway environments. This research is examining the efficacy of vision enhancement systems (VES), which are being developed to help a driver “see” by using sensors in the ultra-violet and infrared spectra and then displaying the information as visible light in a head-up display that is overlaid on the traffic environment. The purpose of VES displays is to assist drivers at night, at dusk, and in inclement weather.

For more information: www.its.umn.edu/research/projects/1999012.html

Computing, Sensing, Communications, and Control Systems

Image Compression for Storage and Transmission of Digitized Images
Principal Investigator: Vladimir Cherkassky, Department of Electrical and Computer Engineering

The Mn/DOT Office of Land Management provides digital mapping products for maintaining Minnesota’s transportation infrastructure and for land management purposes. Researchers also investigated the trade-off between the image quality and image compression for several image compression methods.

Principal Investigator: Vladimir Cherkassky, Department of Electrical and Computer Engineering

Transmission of Digitized Images: Image Compression for Storage and Communications, and Control Systems

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In the first phase of the project, the team surveyed 300 University of Minnesota students in order to investigate the relationship between personality, emotional, and behavioral variables and self-reported driving behavior. Students were targeted because their age range (16-35) demonstrates high levels of anger and hostility and a willingness to engage in riskier behaviors, relative to older adults.

According to the responses, participants who were more distrustful of others, suspicious, and prone to hostility were classified as “high hostiles.” High hostiles reported more driving after drinking than females did. Females reported greater anger caused by other drivers’ rude behavior.

In the second phase of the research, the researchers will run a driving simulator experiment at the HumanFIRST driving simulator to validate the self-reported driving behaviors.

Results of the experiments should give the researchers the ability to link personality traits and styles to types and levels of driving behavior under various traffic events and environments, thereby allowing them to gain some understanding as to what type of person may be “at risk” for aggressive driving.

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A wide variety of new driver information systems—such as in-vehicle telephony, laptop top and personal digital assistants, on-road hazard warnings, in-vehicle signs, and digital maps—are among ITS initiatives in the United States, Europe, Japan, and Australia. This research is examining the efficacy of vision enhancement systems (VES), which are being developed to help a driver “see” by using sensors in the ultra-violet and infrared spectra and then displaying the information as visible light in a head-up display that is overlaid on the traffic environment. The purpose of VES displays is to assist drivers at night, at dusk, and in inclement weather.

For more information: www.its.umn.edu/research/projects/1999012.html
pression algorithms using real-life images and made recommendations for selecting the best image compression algorithm for the needs of the Office of Land Management. For more information: www.its.umn.edu/research/projects/2000013.html

Wireless Transmission of Image and Video Data
Principal Investigator: Vladimir Cherkassky, Department of Electrical and Computer Engineering

The growing trend toward wireless transmission of traffic data places stringent constraints on the transmission of image and video data over low-speed wireless channels, such as CDPT (Cellular Data Packet Transmission). This research explored several interconnected technical and system integration issues related to practical implementation of wireless image/video transmission, using a prototype system housed at the Institute’s ITS Laboratory. Specifically, researchers evaluated several commercial products for compression of image/video data and investigated networking issues critical to real-time delivery of compressed video data. This project provided practical recommendations regarding image/video transmission over wireless channels with current technology, in settings representative of the current and future needs of Mn/DOT. For more information: www.its.umn.edu/research/projects/2001026.html

Snowplow Technology Integration for Driver Assistance
Principal Investigator: Max Donath, ITS Institute

The snowplow driver faces difficult environmental problems—icy roads, blowing and drifting snow—and vision problems due to the blowing snow, darkness, etc. In addition to these problems, snowplow drivers experience stress due to the long hours and the tasks required to successfully clear streets and highways. These tasks include avoiding moving and parked cars, bridges, and signs, and determining the application rates of deicing agents. The results from this research are also applicable to drivers of heavy trucks, buses, ambulances, and police vehicles—which, like snowplows, are required to operate in all weather conditions.

The work here set the stage for soliciting additional outside funding from the National IVI in the area of specialty vehicle platforms. The ITS America specialty vehicle committee has identified 16 user services directly related to specialty vehicles (vision enhancement, forward-collision and rear-impact warning and avoidance, obstacle warning and avoidance, driver assistance in task performance, and others) researched in this and future projects. For more information: www.its.umn.edu/research/ivifieldtest.html

Algorithms of Vehicle Classification (Phase II)
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

This research continued the development of algorithms for vehicle classification. This system enables traffic engineers to collect vehicle classification distributions in an automated, safe, and flexible way. Researchers used laser scanners, infrared sensors, and CCD cameras in order to take sequences of images at several state-aid streets and highways. The system was able to analyze these sequences and provide vehicle class counts. For more information: www.its.umn.edu/research/projects/2000026.html

GPS-Based Failure Identification System for Intelligent Vehicles
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project worked to develop and implement a fault diagnostic system for intelligent vehicles that can monitor the health of the sensors and actuators on a vehicle and identify the source of a malfunction as soon as it occurs. Researchers developed and experimentally implemented model-based fault diagnostic systems for both lateral and longitudinal control of the SAFETRUCK, leveraging the SAFETRUCK’s existing instrumentation and software infrastructure. The immediate benefit of this project is the development of a fault diagnostic system that enhances the safety of the SAFETRUCK and also improves its control system performance. The longer-term benefits arise from the fundamental need for fault tolerance in both partially and fully automated vehicles. Vehicles that will use this research include automated vehicles operating at Mn/DOT’s pavement research facility and Mn/DOT snowplows that are being instrumented with collision warning and lane-departure warning systems. For more information: www.its.umn.edu/research/projects/2000009.html

Model-Based Intelligent Vehicle Control Systems
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project developed and implemented an intelligent cruise control (ICC) system on a Volvo truck donated to the University of Minnesota. The ICC system automatically monitors vehicles on the same and adjacent lanes on the highway, detects vehicles that “cut in” from adjacent lanes, switches from speed control to spacing control when necessary, and provides safe and comfortable driving in the presence of moderately dense traffic. The work was done in collaboration with Volvo, which provided detailed engine maps, vehicle parameters, and access to existing sensors and actuators on the truck. The project was cost-shared by using funds from a University of Minnesota Grants-in-Aid research grant and indirectly through engineering person-hours contributed by the Center for Diesel Research and by Volvo.

The immediate benefit of the ICC system is to enable a Mobile Emissions Laboratory on the Volvo truck to safely and accurately follow vehicles on the highway and make reliable exhaust plume measurements. The long-term benefits of the research include the improvement of safety in highway driving, the development of a test-bed for future research related to vehicle automation, the potential use of the vehicle monitoring system for driver assistance in poor visibility, and the reduction of fuel consumption by 25 percent in the case of trucks operating as a fleet through the use of ICC. For more information: www.its.umn.edu/research/projects/1999029.html

High Performance Spatial Visualization of Traffic Data
Principal Investigator: Shashi Shekhar,
Abstracts of Other Selected Research Projects in Progress

Human Performance and Behavior

Fatigue Detection: Can Fatigue Detection Devices Predict the Driving Performance of Sleep-Deprived Drivers?
Principal Investigator: John Bloomfield, College of Architecture and Landscape Architecture

This project aimed to develop high performance spatial tools and techniques to generate critical visualizations of loop-detector traffic data collected at Mn/DOT’s Traffic Management Center and to explore new spatial data structures and algorithms to address the performance bottlenecks in the process of producing novel interactive traffic visualization.

To that end, researchers constructed a web-based video-like visualization software package for observing rapid summarization of major trends. This package can be used to visualize the effects of a sudden increase in load on the traffic network after scheduled events in order to plan traffic management for future similar events. In the underlying database, researchers modeled the traffic data as a data warehouse to facilitate the query engine for online analytical processing used in the visualization software. They also extended their visualization package to support several data mining techniques—e.g., clustering, classification, and outlier detection. In addition, researchers identified the performance bottlenecks in the generation of various visualizations and developed efficient algorithms to address the bottlenecks.

For more information: www.its.umn.edu/research/projects/2001023.html

Psychological and Roadway Correlates of Aggressive Driving (Phase II)
Principal Investigator: Kathleen Harder, College of Architecture and Landscape Architecture

This project addressed the above issues by identifying active bottlenecks and estimating their time-variant capacities. It is critical in managing congestion in freeway networks. The current Mn/DOT metering algorithm, which adopts a zone-based approach, adjusts metering rates of all the ramps in a zone in such a way that the resulting flow level at the downstream zone boundary, i.e., pre-defined bottleneck, can be maintained under its capacity. Therefore, the effectiveness of ramp metering control largely depends on the accuracy of bottleneck capacity values.

Recent studies have found wide variations in the capacity values from different sources. This project addressed the above issues by developing a dynamic procedure to update capacity values for given bottlenecks. Further, as a first step toward developing next generation metering algorithms incorporating ITS technologies, alternative concepts for coordinated ramp metering were formulated. The detailed algorithms that have real-time operational capability will be developed in the subsequent phase.

For more information: www.its.umn.edu/research/projects/2002031.html

Capacity Analysis for Dynamic Bottlenecks and Alternative Concepts for Coordinated Ramp Metering Operations
Principal Investigator: Eil Kwon, ITS Institute

Freeway bottlenecks are, in general, caused by physical geometry changes and/or conflicting flow patterns, such as merging or weaving flows, which reduce the maximum amount of flow that can pass a given location. While capacity of conflict-based bottlenecks depends heavily on the time-variant flow patterns within bottleneck areas, a geometry-based bottleneck, e.g., a lane-drop or a bridge with a narrow shoulder, can also be wiped out by a downstream queue that grows past the bottleneck location.

Identifying active bottlenecks and estimating their time-variant capacities is critical in managing congestion in freeway networks. The current Mn/DOT metering algorithm, which adopts a zone-based approach, adjusts metering rates of all the ramps in a zone in such a way that the resulting flow level at the downstream zone boundary, i.e., pre-defined bottleneck, can be maintained under its capacity. Therefore, the effectiveness of ramp metering control largely depends on the accuracy of bottleneck capacity values.

This project addressed the above issues by developing a dynamic procedure to update capacity values for given bottlenecks. Further, as a first step toward developing next generation metering algorithms incorporating ITS technologies, alternative concepts for coordinated ramp metering were formulated. The detailed algorithms that have real-time operational capability will be developed in the subsequent phase.

For more information: www.its.umn.edu/research/projects/2000032.html

Signal Operations Research Laboratory for Development and Testing of Advanced Control Strategies (Phase I)
Principal Investigator: Eil Kwon, ITS Institute

In the initial phase of this project, a virtual intersection environment consisting of a new microscopic traffic simulator and a 2070 traffic controller was developed to provide a platform for a realistic pseudo-real-time evaluation of intersection control strategies. The implementation of the intersection control strategies into the 2070 controller was performed using the field I/O manager module provided by the City of Los Angeles DOT. The resulting hardware-in-loop simulation system was applied to evaluate different control strategies for an intersection, i.e., pre-timed, actuated, and adaptive methods. Phase II of the project is currently underway, building on the products of this phase.

For more information: www.its.umn.edu/research/projects/1997046.html

For more information: www.its.umn.edu/research/projects/1997046.html
ing incidents of aggressive driving.

For more information:
www.its.umn.edu/research/projects/2002034.html

Reducing Crashes at Controlled Rural Intersections
Principal Investigator: Kathleen Harder, College of Architecture and Landscape Architecture

This proposal is in response to a request by Mn/DOT and the Local Road Research Board for innovative research on ways to improve safety at controlled rural intersections. Right-angle crashes at these intersections are of significant concern. As part of this project, the analysis of crash records databases and site visits to problem intersections have yielded valuable information regarding contributing factors in crashes. The goal for the remainder of this project is to generate innovative ways in which to address and diminish crashes at these intersections. Researchers do not anticipate solving the problem in Phase I, but do expect to make substantive progress toward facilitating creative resolutions to safety-related issues now present at rural intersections.

For more information:
www.its.umn.edu/research/projects/2001008.html

User-Centered Auditory Warning Signals in Snowplows
Principal Investigator: Kathleen Harder, College of Architecture and Landscape Architecture

Architecture
Given the visually demanding environment of snowplow drivers, Mn/DOT’s Office of Advanced Transportation Systems has identified a need for human factors research regarding the type of auditory warning signal that most effectively communicates the intended message. This research is currently investigating the effects of in-vehicle auditory warning signals on driver behavior, with the goal of improving safety for snowplow drivers and other drivers on the roadway. The experiment, which involves testing the auditory warning signals while participants drive through a virtual snowy environment, is nearing completion. Additional testing will be done in the field with snowplow operators.

For more information:
www.its.umn.edu/research/projects/2000038.html

Spatial Orientation and Navigation in Elderly Drivers
Principal Investigator: Herbert Pick, Institute of Child Development

The elderly are an increasing proportion of the total population and are already over-represented in the number of crashes per mile driven. Most of the research on elderly drivers is concerned with control of the vehicle. Because of this emphasis on control, however, research on the main function of driving, i.e., getting from one place to another, has received relatively little attention. A major facet of this topic involves, at a practical level, spatial orientation and navigation. Besides being of interest in its own right, difficulties maintaining orientation and finding one’s way may interact with vehicle control, as a driver becomes distracted or even alarmed by losing his or her way and pays less attention to vehicle control or possibly makes erratic corrections en route.

This research has demonstrated that elderly drivers indeed have more difficulty in organizing spatial information about new neighborhoods through which they have learned a route. This finding has been verified both in an actual and simulated driving situations. Current analyses of the research in the simulated driving situation are examining whether the task of wayfinding is correlated with a deterioration in vehicle control.

For more information:
www.its.umn.edu/research/projects/1999022.html

Older Drivers: Influence of Wayfinding While Driving
Principal Investigator: Herbert Pick, Institute of Child Development

This research is building on previous work done by the principal investigator on driving and navigating, in which it became apparent that older drivers seem to be less oriented in a newly learned environment than younger drivers. The project looks at the consequences of this problem at the level of vehicle control. If driving while wayfinding causes problems for older drivers, it seems reasonable to consider this a so-called dual-task, or mental workload, problem. The participants in simulated driving experiments will be confronted with two tasks: driving and driving while wayfinding. Three measures of mental workload will then be taken and compared as a function of age.

For more information:
www.its.umn.edu/research/projects/2001053.html

Reducing Risk Taking at Passive Railroad Crossings with Active Warnings
Principal Investigator: Thomas Smith, Department of Kinesiology

Mn/DOT’s offices of Advanced Transportation Systems and Freight, Railroads and Waterways believe it is technically feasible to develop an active warning system (AWS) for passive railroad crossings that could be deployed for under $10,000 per crossing and that would not warrant gates and lights. In order to develop and implement this system, Mn/DOT is working with four partners. Two will provide development, proof-of-concept assessment, and implementation of the AWS technology. The TC&W Railroad will provide design specifications for a train and one or more railroad crossings to be used for simulation modeling, and the University of Minnesota Department of Kinesiology’s Human Factors Research Laboratory (HFRL) will conduct human factors analysis of driver behavior and performance with the AWS technology based on both simulated driving research and field study of driver behavior and performance. This will take place at selected test and control TC&W railroad grade crossings with and without AWS technology installed.

Phase I of the project, the HFRL research, comprises usability assessment of alternative AWS designs, simulated driving performance assessment, and development of experimental design and protocol specifications for an extensive field study performance of the system. Phase II will involve proposed large-scale operational testing of system effectiveness. During Phase I, a railroad crossing and a moving train are being modeled for a fixed-base driving simulator. For usability analysis, a selected subject cohort will be asked to provide judgments of utility, acceptability and appeal of different alternative AWS designs, developed in collaboration with 3M and Mn/DOT.

For more information:
www.its.umn.edu/research/projects/2000041.html

Accident Analysis for Low-Volume Roads
Principal Investigator: Michael Wade, Department of Kinesiology

This study will analyze existing accident data...
Abstracts of Research Projects

reported in three categories: fatality, personal injury, or property damage. Data will be analyzed in selected counties in Minnesota for county roads, township roads, and CSAH to determine not only the frequency and location of accidents on the roads but also to record the nature of the signage and other characteristics associated with accidents. Those characteristics include weather, time of year, time of day, and other factors that may be unique to intersections where accidents occur other than by chance. This database and the proposed analysis will provide useful information to engineers to help them better determine the impact of signage and seasonal variation, along with other aspects that affect decisions made relative to intersections at which frequent collisions occur.

For more information:
www.its.umn.edu/research/projects/2002008.html

Deer Avoidance Research: Use of Motion Detector Flashing Light
Principal Investigator: Michael Wade, Department of Kinesiology
This project evaluates the potential impact of a new technology—motion detection information relative to the presence of deer in and around major highways—on driver behavior. Experiments, conducted in a driving simulator, will record driver behavior as a function of the new deer motion detection system. Deer presence will be displayed as a warning light, which will flash in the area adjacent to the detection of the deer. Variables of interest include the location and nature of the illuminated signal and the rate at which the warning light flashes. Data will then be analyzed to determine the impact of the deer avoidance technology on driver behavior.

For more information:
www.its.umn.edu/research/projects/2002023.html

Computing, Sensing, Communications, and Control Systems

Lateral Stability of a Narrow Commuter Vehicle
Principal Investigator: Lee Alexander, Department of Mechanical Engineering
The inevitable increase in metropolitan traffic congestion creates a need for commuter vehicles that take up less space on the road than the standard automobile. Since the majority of the cars on the road during rush hour have only one or two occupants, one approach is to design a narrow vehicle that can carry one passenger in a seat directly behind the driver. The width of this vehicle, about one meter (3.3 feet), would be such that two vehicles would be able to drive side by side down a standard 12-foot (3.7-meter)-wide traffic lane, thereby substantially increasing the number of vehicles per hour that the lane can accommodate. A practical narrow vehicle of this type will have to be stable at all speeds and on all surfaces, be warm on the inside, and be easy to get into and out of. The roll stability of this vehicle when cornering will depend on an active suspension control system that will allow it to react to lateral forces by leaning like a motorcycle even though it has more than two wheels.

This research extends the work of earlier researchers by implementing modern sensors, actuators, and control design methodologies on a three-fourths-scale prototype of this kind of vehicle. Researchers will explore control strategies that will allow such a vehicle to operate on slippery roads without requiring undue skill from the driver. Future work should include the study of human-machine interfaces, the safety envelopes, and collision avoidance. This type of vehicle is a good solution to Minnesota’s traffic congestion for a number of reasons: it requires no infrastructure changes, it will reduce traffic (and parking) problems on existing roads and streets without necessitating new construc-

This skewing of timelines made the joint development of MOEs difficult. Minnesota therefore made a request to the pooled fund, which was approved, to modify the workplan and devote the resources originally scheduled for MOE development to further gangplow development (Task 4).

Task 1 developed a visual-based high-fidelity system able to provide an accurate visual representation of the roadway and surroundings local to the vehicle. In this task, DGPS data, a high-accuracy geographic database, radar information, and a Head-Up Display (HUD) were integrated, resulting in a “see-through” highly accurate HUD-based image displaying road boundaries, relevant geographic features, and obstacles impeding the motion of the snowplow.

Task 2 sought to improve the performance of vehicle-based radar by integrating a geographic database into the signal-processing task. The objective of Task 3 is to determine in real time the dynamic capability of a snowplow under changing weather and road conditions. In Task 4, researchers developed an interface to the snowplow operator through the steering wheel that assists the operator with the collision-avoidance task.

“Gang” snowplowing with the virtual bumper will also be examined. Snowplows operating in formation can be more productive, but without driver-assistive systems, the lead plow often creates a localized snow cloud that reduces visibility for the following snowplow(s). This forces the following snowplow to increase the following distance to the lead plow—and this in turn decreases safety margins. Assisting the following snowplow will reduce the space between plows, and with it the probability that a motorist will try to pass the lead plow, improving safety for all motorists.

For more information:
www.its.umn.edu/research/projects/2000042.html
A New Approach to Assessing Road User Charges
Principal Investigators: Max Donath, ITS Institute, and Pi-Ming Cheng, Department of Mechanical Engineering

Given that new technologies (e.g., fuel cells, hybrid electric systems) are likely to lead to a new generation of vehicles that are more independent of traditional fuels, there is considerable concern that funding of the transportation network will become unstable, as income from motor fuel taxes is reduced. This project is pursuing the development and analysis of a new alternative approach for assessing road user charges based on usage of public roadways.

The system under consideration involves an onboard computer system that would use a differential GPS (DGPS) receiver, a digital map, and map-matching software as the basis for computing charges based on miles traveled, local jurisdiction, and road type. Although the new approach is simple in concept, a number of policy and technological issues need to be resolved. Research partners at the University of Iowa are investigating related policy and privacy issues, while the University of Minnesota team is testing the relevant technologies in order to ensure that such a system can indeed be used as the basis for a road user charging system.

An integrated DGPS/digital map system should have the ability to distinguish different road types and/or jurisdiction for roads in close proximity. Given that distinct road types (e.g., frontage roads and highways) in metropolitan areas can be located as close as one meter (3.3 feet) from each other, researchers are evaluating nationally available navigable digital roadmaps, as well as differential GPS systems, that can achieve lateral dynamic accuracies of one meter. The main goal of the Minnesota project is to develop the system requirements for both the DGPS system and the digital maps that would be part of the onboard computer system. Several commercially available GPS systems and digital maps are being evaluated to see if they meet the criteria.

Testing examined the accuracies of DGPS systems and digital maps compared to a higher accuracy (centimeter-level) DGPS system while the vehicle travels at normal traffic speeds. Preliminary results have shown that certain 12-channel GPS receivers with real-time correction signals from the Nationwide DGPS Service (NDGPS) can indeed achieve a dynamic lateral accuracy on the order of one meter. However, road locations on commercially available digital maps generally exhibit significantly worse accuracy, which will likely limit the charging policies that are used within metropolitan areas. More experiments are underway to determine the systems’ accuracy at higher statistical confidence levels. Many of the experiments to date have been performed in flat urban environments; experiments in hilly rural areas are planned for the coming months.

For more information: www.its.umn.edu/research/projects/1999002.html

United States Department of Transportation Intelligent Vehicle Initiative Specialty Vehicle Field Operational Test
Principal Investigators: Max Donath and Craig Shankwitz, ITS Institute

For snowplow operators and drivers of other specialty vehicles such as police cars and ambulances, winter driving can be difficult and dangerous. These drivers must routinely navigate icy roads in blowing and drifting snow while trying to avoid any number of obstacles. This project is being conducted to increase safety for specialty vehicle drivers through the use of vehicle-guidance and collision avoidance technologies in low-visibility conditions. In time, this technology may become available in standard passenger vehicles.

Engineers at the ITS Institute’s Intelligent Vehicles Laboratory (IV Lab), in cooperation with human factors researchers from the Institute’s HumanFIRST Program and engineers from the University of Minnesota Duluth’s Electrical and Computer Engineering Department, are developing and testing a variety of vehicle-guidance and collision-avoidance technologies.

HumanFIRST researchers have conducted a series of studies involving driving simulation and field testing. They devised a number of lane-departure and collision-avoidance warnings for use with a head-up display (HUD) that allows drivers to “see” road markings via images projected onto a combiner mounted close to the windshield. This system was tested in the driving simulator with 55 specialty vehicle operators. Subsequently, lane-departure warnings were provided with a combination of visual, tactile, and auditory signals and were field-tested using Mn/DOT’s SAFEPLOW. Follow-up testing to determine driver response to this technology at high speeds was conducted in cooperation with the Minnesota State Patrol and Hutchinson Ambulance, during which 13 troopers and two ambulance drivers used the system under low-visibility conditions, including moonless nights and fog. The system performed as intended, even at speeds approaching 100 mph.

Throughout the summer months of 2001, four snowplows, an ambulance, and a State Patrol car were prepared for the field operational test currently in progress. All of the equipment designed to assist the driver, including the HUD, driver’s seat, audio warnings, sensors, and computers, was installed in each vehicle. Data acquisition equipment was installed to record driver response to the system during operational testing. The team also installed six weather stations along a 45-mile stretch of Minnesota Trunk Highway 7 to collect weather and visibility data at five-minute intervals. Team members have also completed installation of three additional GPS correction base stations, providing a means to achieve centimeter-level position accuracy of the test vehicles on Highway 7. In addition, a digital geospatial database of the Highway 7 corridor between Hutchinson and I-494 was created and validated.

Due to the warmest winter on record during 2001–02, there were not enough low-visibility days to evaluate the system.

For more information: www.its.umn.edu/research/ivifieldtest/index.html

An Automatic Visibility Measurement System Based on Video Cameras: Phase II
Principal Investigator: Taek Kwon, Department of Electrical and Computer Engineering, UMD

Accurately measuring and reporting visibility is important for many traffic safety-related applications, but it is a difficult task due to the many variables that exist in the atmosphere. In the past, light-scatter effects have often been used for visibility computation. Although this method works fairly well under foggy conditions, its accuracy tends to drop significantly in snow and rainy conditions. Moreover, under space-variant atmospheric conditions, the distances translated from the light-scatter meters often significantly differ from the visibility human observers perceive.

Video-based approaches provide an important advantage over the light-scatter-based approaches in that the image acquisition and processing steps are similar to the human vision system—i.e., images are obtained through a lens system and the captured images are analyzed using recognizable objects. In this project, the first objective is to study an image normalization algorithm that would allow management of varying degrees of differences in image data caused by differences in video equipment and sam-
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Sensor-based Ramp Monitoring
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

An important component of a real-time traffic control system is the acquisition, processing, and interpretation of available sensory information regarding traffic flow. In this project, researchers are exploring the use of computer-vision techniques in conjunction with a vision sensor in order to collect data about ramps. These data can be used in a variety of applications (e.g., design of ramps). Researchers will use state-of-the-art hardware and imaging methods to design a ramp data-collection system. The experimental verification of their approach will be performed with real images and field data. Their system differs from other commercially available traffic vision systems in that it cannot only detect vehicles but also can track and classify them. The proposed imaging techniques are not limited to ramps, but rather have a general applicability.

Managing Suburban Intersections Through Sensing
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

Vision sensing in suburban intersections can be used for pedestrian and incoming vehicle detection in order to detect situations that may evolve into accidents. In this project, researchers are developing the vision algorithms to gather data (positions, velocities, accelerations, and trajectories of vehicles and pedestrians) in order to monitor safety at intersections. Unlike commercially available systems, the proposed algorithms can handle all this information in real time with acceptable robustness. At this stage, the researchers’ objective is to show the feasibility of this approach based on real data, without changing the federal mandates regarding suburban intersection signaling.

For more information:
www.its.umn.edu/research/projects/2001029.html

Automated Vehicle Control Algorithms and their Influence on Traffic
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

Adaptive cruise control (ACC) systems are currently being developed by many automotive manufacturers around the world. These ACC systems will enhance cruise control by adding the ability to automatically maintain a desired spacing with respect to a preceding car that has been detected in the lane. The first-generation ACC systems are currently available in Japan and Europe and are about to be introduced in the North American market. Existing ACC systems, however, have been primarily designed from the perspective of driver comfort. They suffer from several shortcomings when issues of safety and traffic flow are considered.

This research will investigate a new strategic initiative for the study of automated vehicle control algorithms (such as those used in ACC) and their influence on highway traffic flow. A team of researchers with unique skills in vehicle control, traffic modeling, and traffic flow simulation has been established to lead the project. Researchers will analyze vehicle-following algorithms from the perspective of the individual vehicle—wherein safety, comfort, and time-to-destination resulting from the algorithm are important—and from the perspective of highway utilization, which places more importance on higher traffic flow and stable traffic patterns.

Several standard adaptive cruise control algorithms have been evaluated to describe how individual vehicle benefits are often obtained at the cost of highway traffic flow. Preliminary results on new vehicle-following algorithms indicate that better traffic flow patterns can be promoted without any deterioration in individual vehicle safety and comfort.

This project will concentrate on development of new vehicle-following algorithms and on a rigorous analysis of such algorithms in a unified framework. Theoretical analysis and microsimulation traffic tools will both be used extensively in the analysis.

For more information:
www.its.umn.edu/research/projects/2002004.html

GPS-Based Real-Time Identification of Tire-Road Friction Coefficient
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project is developing a new GPS-based friction identification system for winter-maintenance vehicles. This system will measure road friction coefficient at the tires and make this real-time information available to the maintenance vehicle operator, enabling the operator to adjust the amount and kind of deicing material applied to the roadway.

The proposed friction identification system is based on the idea of combining a knowledge of vehicle dynamics with real-time measurements of the longitudinal and lateral motion of the vehicle in order to calculate the value of the friction coefficient at the tires. As a part of the project, a preliminary wheel-based friction measurement system will be developed, followed by a vehicle-based friction measurement system that requires no external wheels. The preliminary wheel-based system will be used to provide benchmark readings against which the
The research on the vehicle-based measurement system can evaluate the performance of such a system. The proposed vehicle-based friction measurement system has several advantages over commercially available friction meters. It will be more reliable, inexpensive, and provide quicker and more accurate estimates. Work will include development of a preliminary wheel-based friction measurement system that requires no skidding of the wheel; development of a vehicle-based friction measurement system based on measurements of lateral and longitudinal vehicle motion; experimental evaluation on an International snowplow under a wide range of operating conditions and road surfaces; and experimental studies of the sensitivity, reliability, and speed of convergence of the algorithm. Besides winter maintenance, real-time identification of the friction coefficient could also benefit other vehicle systems, including those for ABS, skid-control, collision avoidance, and adaptive cruise control.

Driver-Assistive Systems for Rural Applications: A Path to Deployment
Principal Investigator: Craig Shankwitz, Department of Mechanical Engineering
This project has two components. The first is to develop and implement an automated means to collect geospatial data and process it in order to create a geospatial database suitable for use in driver-assistive systems. The collection of these data will be based on two methods. One method uses machine vision and other sensors to collect data regarding the location of paint stripes present on existing roads. This equipment will be designed to be mounted on county road maintenance vehicles so that counties can update their maps as necessary. The second method involves equipping a paint-stripping machine with DGPS, sensing, and data acquisition equipment, which will allow the precise position of the paint-stripping nozzle(s) to be determined as the vehicle applies paint to the road. Sensors will also be included to determine when the paint is applied. Both of these sensory and data acquisition systems can accurately determine the location of all paint markings on the roadway. Given the collected raw data, the researchers will then convert that data into geospatial information. From that data, smoothing, feature extraction, and formatting software will be developed that will allow for the automated creation of the digital map. Successfully deployed, the cost of creating digital maps will be leveraged against the cost of necessary paint-stripping operations. The cost of map-making, therefore, imposes a small incremental cost to the paint-stripping operation, lessening the burden on state and county budgets.

The second component of this project is to form partnerships with county engineers who are responsible for snow removal in difficult environmental and visibility conditions. Participating counties will work with the University to select a candidate snowplow, determine what technologies to install, and select the area in which the snowplow will work. Once these initial details are addressed, the University will equip the snowplows with the necessary technology and will create a geospatial database for the roads on which the driver-assistive vehicles will operate. Where necessary, the University will work with the county to either locate a DGPS base station and the infrastructure needed to broadcast those corrections or find a provider of DGPS corrections for its vehicle. It is anticipated that the counties will be able to use their driver-assistive systems by December 2002.

For more information:
www.its.umn.edu/research/projects/2002026.html

Advanced BRT: Innovative Technologies for Dedicated Roadways
Principal Investigator: Craig Shankwitz, Department of Mechanical Engineering
This research will develop safe, economical methods to implement fault-tolerant, robust driver-assistive systems that perform vehicle guidance and collision-avoidance tasks for heavy vehicles. At the conclusion of this work, the robustness (and therefore, safety) of the driver-assistive systems under development will be significantly increased. The primary applications for this technology in Minnesota are for buses operating on bus-only shoulders and on dedicated bus ways. The main thrust of this research will use the Institute’s SAFETRUCK as a test bed to develop these robust, redundant vehicle-guidance and collision-avoidance technologies. Once proven on the SAFETRUCK, the technology will be applied to transit buses and exhaustively tested, ideally in a field operational test scenario.

For more information:
www.its.umn.edu/research/projects/2002041.html

Technologies for Modeling, Managing, and Operating Transportation Systems
Gap Acceptance Model/Conflicts and Accidents at Merging and Turn Lanes
Principal Investigator: Gary Davis, Department of Civil Engineering
A recurring problem in intersection and interchange design involves assessing the tradeoffs between the geometric characteristics of ramps, turn lanes, or merge lanes and the potential for accidents during merging. This project is conducting an empirical investigation of merging behavior on selected Minnesota roads with the aim of developing a gap acceptance model that adequately describes driver behavior during merging. The gap acceptance model will then be used to predict the likelihood of “near misses” during merging as a function of 1) geometric characteristics such as design speeds and lengths of merging lanes, and 2) speed and gap distributions of oncoming traffic. Finally, the near-miss model will be coupled with a model of braking, acceleration, and reaction time to predict the number and severity of rear-end collisions in the merge area. This will provide a tool for comparing the differences in expected merging accidents for different merging/turning lane designs.

For more information:
www.its.umn.edu/research/projects/2002022.html

Development of Dynamic Route-Clearance Strategies for Emergency Vehicle Operations (Phase I)
Principal Investigator: Eil Kwon, ITS Institute
This research will develop and evaluate a dynamic route-based, signal preemption strategy that is based on automatic vehicle location and network communication technologies. Unlike existing intersection-by-intersection preemption strategies commonly used in the field, the new strategy will identify an emergency route in real time with given origin/destination information for an emergency.
vehicle and clear the signals on the route to minimize its travel time. The first phase of the research will formulate alternative strategies and conduct preliminary evaluation under the simulated environment. A portion of the University campus network will be modeled in this research using a microscopic network simulation model, which will be calibrated with the emergency vehicle travel time data to be collected in cooperation with the University Police Department. The performance of the new strategy will be compared with that of conventional strategies and its feasibility will be evaluated.

For more information:
www.its.umn.edu/research/projects/2002033.html

Signal Operations Research Laboratory for Development and Testing of Advanced Control Strategies (Phase II)
Principal Investigator: Eil Kwon, ITS Institute
This research will expand the adaptive intersection control strategy developed in the previous phase by including a nearby freeway ramp separately managed by a freeway control system. Alternative concepts for coordinating intersections and ramps, such as one-way or two-way coordination of signals and meters, will be studied and a realistic coordination strategy will be developed. Further, a simulation-based evaluation environment for a corridor, consisting of freeway ramps and intersection, will also be developed with the virtual controllers that emulate the internal process of advanced controllers. The resulting strategy will be the first step toward developing a fully integrated, corridor-wide control system.

For more information:
www.its.umn.edu/research/projects/2000036.html

Dynamic Estimation of Freeway Weaving Capacity for Traffic Management and Operations (Phase 2)
Principal Investigator: Eil Kwon, ITS Institute
Understanding the behavior of weaving flows and estimating the effects of time-variant traffic conditions on the capacity of weaving areas is important for developing effective operational and design strategies for freeway systems that can maximize existing capacity for a given freeway system. The previous phase of this research identified and classified the major weaving areas in the Twin Cities metro freeway network. Further, the traffic behavior and the factors affecting capacity in a type A ramp-weave section, the most common type of weaving areas in the Twin Cities metro freeways (119 out of 226), were analyzed and an online model was developed to estimate the time-variant capacity of type A ramp-weave sections. This research is expanding the previous work by addressing the traffic behavior and capacity issues at multiple weaving areas, where more than two weaving sections are sequentially located. In particular, the flow process at multiple weaving sections, including lane-changing locations and behavioral patterns and the factors affecting flow breakdowns and capacity changes, will be analyzed using field data collected from the selected weaving areas. Finally, the functional relationship between capacity changes and weaving patterns will be identified and modeled.

For more information:
www.its.umn.edu/research/proects/2001022.html

TMC Traffic Data Automation for Mn/DOT’s Traffic Monitoring Program
Principal Investigator: Taek Kwon, Department of Electrical and Computer Engineering, UMD
Mn/DOT has been responsible for collecting, analyzing, and publishing traffic count data from the various roadway systems throughout the state. The traffic reporting system mainly developed by the Traffic Forecasting and Analysis Section (TFAS) of Mn/DOT has been used in several federal programs, in internal Mn/DOT applications, and by many private sectors. This project will continue the TFAS automation efforts by computerized integration of the current manual effort to import, filter, and analyze the TMC portion of traffic data contributed to Mn/DOT’s Traffic Monitoring System. The resulting system will allow users to specify the conditions for acceptance tests required by TFAS for both continuous and short-duration-count volume data. Once the filtering procedures and parameters are set by an operator, the raw data can be automatically processed by the system without human intervention.

For more information:
www.its.umn.edu/research/projects/2001033.html

Improving the Estimation of Travel Demand for Traffic Simulation
Principal Investigator: David Levinson, Department of Civil Engineering
Traffic simulation is only as good as its input data. Unfortunately, it is impossible to inexpensively measure entry-ramp to exit-ramp flows, which would be particularly useful for testing ramp metering control strategies. In the past, research supported by Mn/DOT and CTS has produced a viable method for estimating freeway Origin Destination (O-D) patterns from loop detector data. This research will further develop and apply those methods to estimate O-D demand for use in traffic simulation of freeway sections and corridors. The project’s researchers require zone-to-zone traffic flows from a transportation planning model and the flows entering (and ideally exiting) on freeway ramps. Their objective is to estimate the traffic from each on-ramp to each downstream ramp in short time intervals (e.g., 5 min.). This research will include development and implementation of software to enable the method to be used conveniently with easy-to-collect data, and will then apply the method to selected corridors.

For more information:
www.its.umn.edu/research/projects/2001034.html

Measuring the Equity and Efficiency of Ramp Meters
Principal Investigator: David Levinson, Department of Civil Engineering
The Twin Cities ramp meter system, while successfully increasing the efficiency of freeway traffic flow, has been subject to increased political scrutiny. That scrutiny is due in part to perceptions of inequity in the system. This research has tested alternative control strategies on both efficiency and equity criteria and developed a new strategy designed explicitly to include equity measures. This new strategy has been coded and tested in a simulation framework and compared to existing strategies.

For more information:
www.its.umn.edu/research/projects/2001010.html

Ramp Meter Delays, Freeway Congestion, and Driver Acceptance
Principal Investigators: David Levinson, Department of Civil Engineering, and Kathleen Harder, College of Architecture and Landscape Architecture
Minnesota’s pre-shutdown ramp metering algorithms tried to maximize throughput, implicitly minimizing total delay. If time at the ramp is not weighted the same as time-in-motion by users, this time-minimizing strategy may not maximize utility for travelers. This research will attempt to quantify the weights individuals associate with qualitatively different experiences of travel time: waiting at a ramp meter or freeway-to-free- way ramp meter versus traveling at different freeway speeds requiring varying numbers of acceleration and deceleration shifts. This information will enable researchers to better time ramp meters in a way that responds to individual perceptions.

For more information:
www.its.umn.edu/research/projects/2002018.html
Development of Portable Wireless Measurement and Observation Station
Principal Investigator: Panos Michalopoulos,
Department of Civil Engineering
In spite of progress made in ITS technology over the past decade, road instrumentation for data collection purposes continues to be somewhat inadequate. Furthermore, the majority of data collection devices depend on outdated technologies to take very limited measurements such as volume and occupancy. This was recently experienced in a study for evaluating ramp metering, in which actual ramp demands had to be measured manually. Because of the extent of the roadway system, however, it is impossible to deploy sufficient instrumentation for all planning, traffic, and research needs. For this reason there is a need for an easily deployable, low-cost data collection and surveillance station that can be used for measuring detailed traffic data such as individual speeds, density, and others. The objective of this project is to continue the work of John Hourdakis and Ted Morris in the ITS Laboratory, in which a prototype of such a station was developed, and test it. Such a station could be used for planning and traffic management as well as for research purposes such as simulation, modeling, and control. This “total” station capitalizes on recent advances in machine vision traffic sensors, digital video compression and transmission, and wireless communication networks. In essence, it is the first step toward the development of a highway laboratory for traffic studies and research.

For more information: www.its.umn.edu/research/projects/2002030.html

Employment of the Traffic Management Laboratory (TRAMLAB) for Evaluating Ramp Control Strategies in the Twin Cities
Principal Investigator: Panos Michalopoulos,
Department of Civil Engineering
As freeway traffic congestion spreads, ramp metering is implemented to address the problem. Recently, however, there has been increasing opposition to freeway ramp control because of excessive ramp delays. The objective of this research is to employ a recently developed tool called the Traffic Management Laboratory (TRAMLAB) for assessing the effectiveness of Mn/DOT’s traffic control strategy in three Twin Cities freeway sections totaling approximately 65 miles.

The feasibility of a corridor simulation will be explored and followed by the simulation of the combination of an arterial and a freeway in the Twin Cities. As a result of this testing, TRAMLAB will evolve into an effective tool for developing control strategies that could reduce ramp delays without excessively increasing freeway congestion. Finally, a new traffic management concept for early detection of incident-prone traffic conditions will be developed and integrated for traffic management through ramp metering and variable message signs in order to smooth flow and prevent (to the extent possible) incident occurrence, thereby further reducing delays and improving safety. Although this proposal focuses on evaluating ramp metering and implementing a concept recently developed in a current project, the researchers also address the more general issue of research continuity and suggest a strategic partnership with Mn/DOT.

For more information: www.its.umn.edu/research/projects/1999003.html

Future TMC Operations System Prototype and Testing Facility (Phase II)
Principal Investigator: Panos Michalopoulos,
Department of Civil Engineering
Phase II of this project will work towards developing an innovative and unique “Future TMC operations system prototype and testing facility.” The work has two major objectives. The first is to analyze and understand the Mn/DOT Traffic Management Center’s (TMC’s) current control room operations. This analysis will include the new operator interface developed by the TMC. Based on the results of this analysis, the project will propose and develop alternative concepts for future control room operations, which will be presented to the TMC for feedback and prioritization. Detailed design of the selected concepts will follow, along with the design of a user interface for implementation.

The second objective is to expand the current TRAMLAB system by adding new components such as ramp metering, variable message sign control, and simulation. The expanded TRAMLAB system will serve as a traffic management laboratory able to evaluate operational control policies and objectives, new ramp metering control algorithms, and data/control parameter derivation rules. The new expanded TRAMLAB will serve as a testing facility for the alternative concepts developed here as well as in the future. In short, in this phase, a new facility will be developed for rapid development, testing, and deployment of the next generation TMC that can be incremental and component independent; for example, the simulator, ramp control schemes, etc., will be modules that can easily be replaced and integrated with an easily adaptable user.

For more information: www.its.umn.edu/research/projects/2001047.html

Social and Economic Policy Issues Related to ITS Technologies
Telecommunications and Sustainable Transportation
Principal Investigator: Frank Douma,
Humphrey Institute of Public Affairs
Mn/DOT has taken a leading role in developing ITS technologies aimed at improving the state’s transportation system in both rural and urban areas. Telecommunications technologies, both wireless and wireline, are key components to a number of ITS applications and technology bundles. In particular, Global Positioning Systems (GPS) and telework have the potential to significantly impact transportation operations and travel behavior. This study will attempt to assess these potential impacts by investigating the changes in travel behavior resulting from installation of fiber optic telecommunications into homes in a new residential development, as well as potential opportunities for operations improvements arising from applying wireless telecommunications technologies to an urban, transit-dependent setting and to a rural setting.

The first task examines travel behavior and telework changes that may arise from two residential development innovations: installation of high-speed telecommunications technology directly to homes and New Urbanist guidelines. The second task continues study of the development of services-on-demand public transit (e.g., dial-a-ride, jitney, door-to-door services, taxi, etc.) with particular emphasis on the use of GPS technology as a means of making such services an attractive public transit alternative. The project involves the evaluation of a field test in partnership with the non-profit Dakota Area Resources and Transportation for Seniors (DARTS), an existing provider of such services that is in the process of immediately installing GPS technology on its fleet of passenger vehicles.

The third task examines institutional and technical network requirements to deliver...
Abstracts of Research Projects Newly Funded

Human Performance and Behavior

Driving Performance During Cell Phone Use and Common Secondary Tasks Combined Under Conditions of Driver Impairment
Principal Investigator: Nicholas J. Ward, Department of Mechanical Engineering
There is considerable debate (without sufficient research) about cell phones as a risk factor in traffic crashes and their relative risk compared to other existing secondary tasks drivers may perform in the vehicle. Now that many states intend to introduce traveler information systems that may be accessed with cell phones while driving, there is an even greater need for relevant research to determine the risk of this secondary task.
This project will assess the relative risk of cell phone use on driving impairment and driver mental effort compared to other existing secondary tasks drivers may perform in the vehicle. Now that many states intend to introduce traveler information systems that may be accessed with cell phones while driving, there is an even greater need for relevant research to determine the risk of this secondary task.

Consequences of Chromatic Motion Perception on the Pickup of Information for Impending Collision with Snowplow Trucks
Principal Investigator: Albert Yonas, Institute of Child Development
Low-luminance contrast conditions, such as those created by blowing snow or fog, constitute some of the most hazardous driving conditions that a driver will commonly experience. Some recent experiments indicate that under fog-like conditions, people perceive themselves to be traveling significantly slower than they actually are. To compensate, they speed up. This low-luminance perceived slowing is exactly comparable to the perceived slowing that occurs at equiluminance (no-luminance contrast), where motion information is carried by chromatic contrasts alone.
The researchers will perform a series of experiments to test whether these two phenomena are governed by the same neural mechanism, and will also make controlled color-contrast measurements under actual fog and blowing snow conditions. The combination of physical-measurements and perceptual experiments will allow researchers to determine the impact of low-luminance contrast conditions and color on an individual’s perception of motion and space under actual driving conditions. If such a proven relationship is demonstrated, this research would lead to improvements in driving safety through the informed choice of color warning markings, chromatically controlled lighting, special fog tints, and better public education.
For more information:
www.its.umn.edu/research/projects/2003014.html

Computing, Sensing, Communications, and Control Systems

Bandwidth and Power-Efficient Modulations for Multimedia Transmission over Wireless Links
Principal Investigator: Mohamed-Slim Alouini, Department of Electrical and Computer Engineering
This research is motivated by the demand of spectrally and power efficient transmission systems of multimedia (not only voice but also image and video) traffic over wireless links. Its objective is to design and evaluate the performance of hierarchical constellation systems that have the advantage of offering different degrees of error protection and/or different rates for various bit streams. Research directions include 1) development of multi-component MSK representations of hierarchical QAM constellations for power-efficient transmission of non-constant envelope signals over wireless links; 2) design and performance evaluation of constant envelope hierarchical PSK constellations, and 3) design, analysis, and simulation of adaptive hierarchical modulation systems for simultaneous multimedia transmission in a multi-resolution/bandwidth-efficient fashion of typical ITS image and video data (such as traffic data) over wireless links.
For more information:
www.its.umn.edu/research/projects/2003035.html

Optimal Secondary Controls Using a Configurable Haptic Interface
Principal Investigator: Will Durfee, Department of Mechanical Engineering
Secondary controls are proliferating in automobiles as more and more electronic features are added for communication and navigation. The use of configurable, adaptable control knobs with haptic (touch) and aural feedback properties optimized for the driver and for the task may enable safe operation of a variety of secondary control functions with minimum distraction to the driver. In this project, researchers will develop and test new technology for configurable, manual controls with computer-controlled haptic and aural feedback properties. Controls will be tested in tabletop and driving simulation to determine if optimal control properties can indeed benefit drivers. A future goal is to adapt this technology to drivers with motor, sensory, or cognitive disabilities.
For more information:
www.its.umn.edu/research/projects/2003019.html
Monitoring Driver Activities
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering
This project will develop algorithms for monitoring driver activities. In particular, researchers will use cameras to discover if a driver looks at the road, rearview mirror, left mirror, right mirror, dashboard area (where the speedometer is), and remaining dashboard area. In addition, researchers will study ways to detect specific actions of a driver (e.g., driver approaching for radio controls) and verify the efficacy of the approach.
For more information:
www.its.umn.edu/research/projects/2002029.html

Monitoring Human Activity in Public Spaces (Public Transit, Airports, Planes, Duluth Seaway Port Authority)
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering
Monitoring large public spaces with vision-based sensors is a challenging task with a variety of important applications. For example, computerized camera systems monitoring public spaces like airports, bridges, work zones, or public transportation can be configured to detect all humans and collect information about their activities. Such systems are not limited to detecting people; they can also be extended to detect incidents involving motor vehicles, such as collisions or improper stopping. By detecting certain types of incidents involving people and vehicles, the system can alert its human operators to suspicious or abnormal activity.

The research team will develop a system capable of classifying the activities of human individuals or groups in public spaces, and notify system operators when certain specified activities are detected. The robustness of this system will be tested by deployment in an actual public space. In particular, the researchers plan to work with Metro Transit to apply this technology to bus stops, to detect suspicious activity such as prolonged loitering or lurking, with the objective of increasing passenger safety on public transit.
For more information:
www.its.umn.edu/research/projects/2003022.html

Infrared Sensors for Driver-Assistive Systems for Specialty Vehicles, Including Snowplows
Principal Investigator: Craig Shankwitz, Department of Mechanical Engineering
The University of Minnesota driver-assistive system has been proven in tests with snowplows on Highway 101 between Elk River and Rogers, with snowplows in field tests at the Rosemount Research Station, and on patrol cars during high-speed tests at Brainerd International Raceway. The system has worked well, allowing drivers to drive normally under low- (including zero-) visibility conditions.

Through the course of these previous projects, a number of limitations of vehicle radar have been identified. What is likely to be missed by radar optimized for vehicle applications will be more likely to be detected with infrared (IR) sensors. This is especially important when dealing with animal-vehicle collisions, which cause $1.2 billion in property damage and an average of 120 fatalities annually.

Previous work has also shown that snowplow operators and patrol officers place a high priority on the ability to “see” objects detected by vehicle sensors. At the present time, the driver-assistive system relies on Eaton Vorad EVT-300 forward-looking radar sensors for forward collision avoidance. These sensors work very well but exhibit two shortcomings. The first is that the EVT-300 sensors are not specified to detect soft tissue and are insensitive to temperature gradients. This is critical when scanning the roadway ahead for animals and humans. IR sensors offer the ability to sense whether a deer is on the side of the road or whether a driver is trapped in a stalled vehicle. The second shortcoming of the EVT-300 is that it will provide information pertaining to where the obstacle is (range, range rate, and azimuth angles), but not information regarding what the obstacle is.

Clearly, IR sensors and radar sensors complement each other. Radar can provide information regarding where an obstacle is, but it cannot provide information regarding what that obstacle is. IR sensors can show what is detected, but cannot precisely locate the position of that obstacle. Successful integration will yield a system capable of answering both questions of what and where.

This research will investigate the applicability of IR sensors for use as a stand-alone system for general snowplow operations and as an integrated sensor for the University’s driver-assistive system. Based on deployment timelines and budgets, IR systems may be deployed prior to the deployment of comprehensive driver-assistive systems. It is important to ensure that these IR systems work well alone and that they can be integrated into driver-assistive systems as they are deployed in the future.
For more information:
www.its.umn.edu/research/projects/2003020.html

Technologies for Modeling, Managing, and Operating Transportation Systems
Identification and Simulation of Common Freeway Accident Mechanisms
Principal Investigator: Gary Davis, Department of Civil Engineering
Mn/DOT has requested guidance in classifying urban freeway accidents and recommending accident prevention treatments. The main principle underlying this proposal is that identifying effective strategies for reducing traffic accidents is more likely if the mechanisms by which accidents occur are understood. This project will advance this understanding by first collecting a sample of accident occurrences at one or more freeway sites and then modeling the mechanism underlying the accidents. These models will be used to identify causal factors, i.e., changes in conditions sufficient to prevent the accidents. Although presented as a standalone project, it is anticipated that this project will cooperate closely with research proposed by principal investigators Panos Michalopoulos and John Hourdakis in “Accident Prevention Based on Automatic Detection of Accident Prone Traffic Conditions.”
For more information:
www.its.umn.edu/research/projects/2003033A.html

Accident Prevention Based on Automatic Detection of Accident Prone Traffic Conditions
Principal Investigator: Panos Michalopoulos, Department of Civil Engineering
This research is in response to a Mn/DOT problem statement requesting low-cost innovative solutions for identifying causes of crashes in high-accident freeway locations and for developing an accident avoidance/prevention system. This will be accomplished by simultaneously video-recording accidents and extracting raw traffic detector measurements that can be used for understanding accident dynamics as well as the causes of accidents. New traffic measure-
ments such as traffic pressure, quality of flow, and others that can be derived from the raw data will be defined, extracted, and analyzed in order to determine whether they are related to accidents and to identify accident-prone condition patterns. Based on this, researchers will develop a proactive system for warning drivers and TMC operators in order to calm traffic flow and effectively prevent accidents. Most important, the system envisioned will be based on raw detector data (i.e., speed, occupancy, volume, time headway) that can be extracted from conventional sensors such as loops. Consequently, the resulting system should be low-cost and able to be implemented in both urban and rural settings. The proposed research capitalizes on earlier projects related to establishing feasibility, incrementing a high-accident area with newly developed wireless detection and surveillance stations, and a recently completed traffic management laboratory facility.

For more information:
www.its.umn.edu/research/projects/2003051.html

Social and Economic Policy Issues Related to ITS Technologies

Sustainable Technologies Applied Research Initiative

Year 3 activities

Principal Investigator: Lee Munnich, Humphrey Institute of Public Affairs

As the STAR project enters its third year, the research team is building on the achievements of year two and focusing on four major project components intended to develop a deeper understanding of the relationships between transportation, business, and technology.

The first project area deals with information technology and implications for multinational manufacturing location decisions. A series of case studies of “old economy” firms is expected to be completed by November 2002, when they will be presented at a national conference. The researchers are also analyzing the location patterns of information workers, basing their approach on a similar study undertaken in Japan; this research is concerned with, in addition to the distribution of workers among urban areas, their spatial distribution within discrete urban areas. In addition, further study of the phenomenon of industry clustering will build on the knowledge developed in previous years. Finally, the impacts of ITS and telecommunications technology on household travel behavior is also a subject of investigation, including a synthesis of existing studies and the development of a novel household survey.

In the second project area, researchers are investigating telecommunications planning and access as they relate to transportation usage. Building on the knowledge of emergency response gained in year two, this research effort will delve into the capability of the wireless infrastructure to provide a range of transportation information services, e.g., the statewide 511 and e-911 initiatives.

The third project area examines the importance of transportation and information networks to industry clusters previously identified in rural areas, including an assessment of the capability of ITS applications to deliver a competitive advantage to the clusters which make up an important part of the Minnesota economy. The supply networks that service these industry clusters are changing, and this research examines the role of ITS in that evolution. The State and Local Policy Program at the Humphrey Institute will also develop a web site to incorporate ITS implications for industry clustering.

Finally, the fourth project area is concerned with transportation network dynamics, i.e., the ways in which current network expansion or contraction decisions alter the choices of future decision-makers, and the means by which expectations of the future alter current decisions, will be analyzed. A long-term database of at least 25 years of data will be constructed in order to track the results of investments over an extended period. While this research component focuses on urban highway networks, it is anticipated that future extension to urban transit networks and intercity passenger and freight networks will be feasible.

For more information:
www.its.umn.edu/research/projects/2003012.html
**Selected Papers and Reports**


Bayesian identification of high-risk intersections for older drivers via Gibbs sampling. *Transportation Research Record* 1746: 84–89.


Shashi Shekhar, professor of computer science and engineering, presents a seminar on “A Unified Approach to Spatial Outliers with Application to Traffic Data.”
The Institute’s activities in education encompass a multidisciplinary program of coursework and experiential learning that reinforces 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 sponsoring and supporting varied educational initiatives for students, the Institute is raising awareness of, and generating more 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, presenting 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.

**Transportation seminars highlight diverse ITS research**

During the 2001–2002 academic year, the Institute continued its multidisciplinary seminar series at the University. These Advanced Transportation Technologies Seminars included a diverse set of presentations by local and national researchers addressing different areas of ITS research, such as traffic management and modeling, human factors, sensing, and intelligent vehicles as they relate to road- and transit-based transportation.

From the seminars, students learned about ITS technologies in areas outside their current field of study, researchers learned about other research projects in progress, and practitioners learned about the technologies of the future.

New this year, the seminar series was offered for credit and was made a required course in the new Graduate Certificate Program in Transportation Studies at the University of Minnesota.

The past year’s presentations were:

- “Orientation and Navigation in Elderly Drivers” by Herb Pick and Selma de Ridder, College of Education and Human Development
- “The Effect of Intelligent Cruise Control Vehicles in Mixed Traffic on the Environment and Traffic Flow Characteristics” by Petros Ioannou, Department of Electrical Engineering Systems, University of Southern California
- “Simpson’s Paradox, Measurement Error, and Ecological Fallacies in the Speed Versus Safety Debate” by Gary Davis, Civil Engineering
- “Effects of Advance Warning Flashers at Signalized Intersections on Simulated Driving Performance” by Tom Smith, Kinesiology
- “Networks and Places: New Hierarchies in Access and Activities” by Lee Munnich, Tom Horan, and Ken Keller, Humphrey Institute, and David Levinson, Civil Engineering
- “The Use of Range Sensors in ITS Applications” by Alec Gorjestani, Mechanical Engineering
- “Can Advances in Vehicle Technologies Provide Solutions to Highway Congestion?” by Rajesh Rajamani, Mechanical Engineering
- “A Unified Approach to Spatial Outliers with Application to Traffic Data Analysis” by Shashi Shekhar, Computer Science and Engineering
- “Advanced Traffic Signal Control and Prioritization” by Thomas Urbanik II, University of Tennessee–Knoxville, Civil and Environmental Engineering
- “Vehicle-Based Student Competitions at the U of M: History and Educational Impact” by Patrick Starr, Mechanical Engineering
- “Comparing Dualmode Transportation Systems with Other Proposed and Existing Systems” by Francis D. Reynolds, Dualmode Transportation Inventor and private consultant
- “ITS Laboratory: Building for the Future” by Ted Morris, Center for Transportation Studies
- “Traffic Flow Study of the Miller Hill Corridor” by Jiann-Shiou Yang, Electrical and Computer Engineering, University of Minnesota Duluth
- “Behavior Variability is More Than Just Noise: The Meaning of Behavioral Entropy” by Erwin R. Boer, Erwin R. Boer Consulting
Students hear advice at Career Expo

In March, the Institute partnered with the Center for Transportation Studies, the Women’s Transportation Seminar, the Minnesota Local Road Research Board, and the Minnesota T2/LTAP Program to hold the seventh annual Transportation Career Expo in Minneapolis.

The 75 student attendees represented not just the University of Minnesota Twin Cities and Duluth campuses but also Metropolitan State, North Dakota State, St. Cloud State, St. Paul Technical College, the Technical University of Holland, and the Massachusetts Institute of Technology. The expo was “simply the best networking forum I have ever attended,” said John Luis, a visiting student from MIT.

The event offered a general session on career preparation and four concurrent sessions on specific areas of transportation: engineering/technical careers, transportation planning and policy careers; transportation logistics careers; and Intelligent Transportation Systems. The ITS session was moderated by Dawn Spanhake, the Institute’s manager of research development and contract coordination.

Institute offers summer education events for high school students

During the five-week Summer Explorations in Science, Engineering and Mathematics program, held in July 2001 on the University of Minnesota campus, the ITS Institute sponsored a week of activities focused on transportation technology issues. Ten students toured laboratories at the Minnesota Department of Transportation and the Center for Transportation Studies to learn about traffic management and modeling, ramp metering algorithms, and other research projects that receive funding from the UTC program. Students also participated in demonstrations of the HFRL driving simulator, visited the Anoka County Airport, received instruction in surveying techniques, and toured a consulting firm to learn about project development.

In August, the ITS Institute again partnered with the Fond du Lac Tribal and Community College to host the National Summer Transportation Institute (sponsored by the Federal Highway Administration). Fourteen students from five Duluth-area high schools traveled to the Twin Cities to learn about ITS-related research and technologies. The program emphasizes outreach to students from Minnesota’s Native American communities, and this year’s group included eight Native American students.

By exposing high school students to advanced transportation research projects funded by the UTC program, these events help encourage students to choose transportation- and technology-related educational fields when they enter college.

Students prepare for Intelligent Ground Vehicle Competition

The Institute continued its support for undergraduate engineering students gaining practical experience by competing in vehicle-based student competitions like the Intelligent Ground Vehicle Competition. This annual event calls
for students to design and construct a vehicle capable of navigating a set course using its own autonomous guidance and control systems. The students gain invaluable experience tackling real-world issues of project management and design while carrying out a rigorously theory-based multidisciplinary project.

This year’s team focused on refining and upgrading the platform previously developed by the 2001 team, including the integration of a differential Global Positioning System (DGPS) receiver into the existing control system. Team captain Dave Champion said the team had learned a lot from studying the experiences of the previous year’s team, including the importance of scheduling a comprehensive testing program. Failing to do so last year resulted in the vehicle not faring as well as expected, Champion said.

Student of the Year awarded to Ben Chihak

Benjamin Chihak, a graduate research assistant in the ITS Institute’s HumanFIRST Program, received the Institute’s 2001 Outstanding Student of the Year Award.

Chihak’s contributions to the HumanFIRST Program include the analysis of data to explore various passing lane configurations and the design and implementation of a custom audio system for a new VESTR driving simulator.

Previously, Chihak was a research assistant with the Human Factors Research Laboratory, where he worked on the Intelligent Vehicle Initiative Field Operational Test Program. In other projects, he conducted a technical review of technologies to combat right-angle crashes at rural intersections, collected and analyzed data for investigating the effectiveness of rumble strips, and developed an educational tool to assist lay people in their understanding of human factors.

“Receiving this award demonstrates to me that human performance continues to be recognized on an institutional level as a key component of the ITS universe,” Chihak says.

Ben Chihak (second from left) receives the award from Mary Peters, Jennifer Dorn, and Ellen Engleman.

Institute students receive CTS awards at April ceremony

This year’s Matthew J. Huber Award for Excellence in Transportation Research and Education went to Mazen O. Hasna, a doctoral student in the Department of Electrical Engineering advised by Assistant Professor Mohamed-Slim Alouini, and Praveena Pidaparthi, a graduate student in urban and regional planning at the Humphrey Institute advised by Assistant Professor Kevin Krizek. Hasna said he has always believed in peaceful applications of technology, of which ITS is an example. Pidaparthi noted she val-
ued her experience working at the Center for Transportation Studies (CTS) and the Humphrey Institute.

The award is named in honor of the late Professor Matthew J. Huber, in recognition of his contributions to the teaching and study of transportation at the University of Minnesota.

The awards were presented by Robert Johns, CTS director, at the center’s annual meeting and awards ceremony held in April in Minneapolis.

**Institute sponsorships help students attend national conferences**

The Institute grants travel awards to students so they can attend various conferences to report on their research to a larger audience. Students also interact with conference participants by helping to staff Institute exhibit areas. This past year, the Institute sponsored 18 students to attend national meetings of the Transportation Research Board (TRB) in January and ITS America in April.

Students funded to attend the TRB Annual Meeting were Ravi-Praveen Ambadipudi, Ben Chihak, Shantanu Das, Sujay Davuluri, Rhamachandra Karamalaputi, Jiji Kottommannil, Satyanarayana Muthuswamy, Prasoon Sinha, Adarsh Shekhar, Bahnu Yerra, and Lei Zhang.

Students attending ITS America were Kwasi Dadie-Amoah, Wenling Chen, Fadel Digham, Emily Kuhn, Yao Wu, Haifeng Xiao, and Xi-Zou.

**Institute staff work to increase learning opportunities**

In its efforts to reach high school students and their teachers, the Institute’s K-12 Coordinator, Mark Tollefson, developed a strategic plan that outlines more than a dozen potential activities for the Institute to initiate over the next several years, time and funding permitting. As phase one of this plan, Tollefson has developed and tested a research web module on the topic of ramp metering aimed at high school math and science students. The research module was used by several classrooms in late spring, and students reported that it was a “fun way to learn about ramp metering.” Tollefson is currently working on a “web quest” geared toward middle school students on the topic of Global Positioning Systems (GPS) and mapping.

By reaching students early with engaging, hands-on activities, the Institute hopes to spark an interest that may potentially lead students to a career in transportation. Many of the products developed under this effort will also be used by parents and others in the general public, thereby increasing the knowledge base concerning transportation issues and ITS solutions.

In January, the Institute also added a new full-time staff member, Chen-Fu Liao, to lead and implement two ITS outreach/education program initiatives for distance learning and a multidisciplinary ITS engineering course. Liao, a graduate of the University of Minnesota and previously a senior product development engineer, will also provide technical assistance for real-time vehicle simulator development and other transportation, sensing, and communications projects.
Clockwise from top left: Bus Rapid Transit workshop attendees; high school students tour the ITS Laboratory; orientation session for ITS researchers; students and grads at the Transportation Career Expo. Center: ITS Institute executive committee member Edward L. Thomas addresses a BRT workshop session.
An Institute-sponsored workshop on lane-assist technology for bus rapid transit (BRT) was attended by representatives of local, state and federal agencies as well as universities around the country.
Technology Transfer

The Institute could not accomplish its goals without technology transfer, which moves research results from the Institute to local, national, and international audiences to be used 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.

The Institute’s efforts in this area are broad, 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 created and staffed informational exhibits, sponsored seminars, published printed pieces, and maintained and improved our website. But perhaps the most direct method has been to send graduating students out into the workforce.

This section of the Annual Report highlights some of the our technology transfer activities over the past year.

BRT workshop features TechnoBus debut

Researchers introduced a lime-green Metro Transit demonstration bus outfitted with advanced navigational technology, dubbed the “TechnoBus,” at a workshop hosted by the ITS Institute in May.

The workshop helped identify the requirements for using lane-assist technology with bus rapid transit and offered a live demonstration of a prototype lane-assist system installed on the TechnoBus during an extended ride to the workshop at the University’s Minneapolis campus. Representatives from transit agencies and universities across the country, state transportation departments, and the federal government, as well as manufacturers and consultants, attended the event.

Jennifer Dorn, Administrator of the Federal Transit Administration (FTA), toured the bus in conjunction with her visit to the American Public Transportation Association’s bus and paratransit conference, also held in Minneapolis. The project team from Metro Transit and the University took the opportunity to demonstrate the lane-assist technology to Dorn as she sat for a few moments in the driver’s seat of the TechnoBus. Earlier, Dorn had noted how the innovations further expand transit options and demonstrate the adaptability of technology from other industries.

A number of high-tech tools can be used to help navigate narrow lanes. The goal of the workshop was to establish the needs from various regions of the country and help determine which technology will best suit those needs. A facilitated workshop discussion sought to identify the top challenges faced by transit agencies, the general requirements of those agencies needed to design and implement lane-assist technology, and ways to evaluate success and reliability.

Metro Transit project manager Aaron Issacs, presenting an overview of the lane-assist project during the ride, pointed out that buses rigged with lane-assist technology can take maximum advantage of narrow freeway shoulders and other dedicated lanes. Ultimately, the technology promises to increase bus safety while improving efficiency, which could mean higher speeds and quicker boarding.

At the workshop, Edward L. Thomas, Dorn’s former Associate Administrator of research and technology, addressed participants. “It’s all about integrating systems,” he said, outlining his plan to utilize the expertise of the private sector, university researchers, and transit agencies in developing standards to guide the industry. Thomas also stressed the practical side of research efforts, looking to build reality checks into project plans. FTA engineer Brian Cronin added that the lane-assist project is a good example of the kind of ideas needed as the FTA solicits systems requirements for larger bus rapid transit projects. This project and the workshop are funded by the Intelligent Transportation Systems Joint Program Office at the

FTA Administrator Jennifer Dorn discusses the TechnoBus with Aaron Issacs and Steve McLaird of Mn/DOT, and ITS Institute director Dr. Max Donath (left).
FHWA. Metro Transit, managing the project, furnished the bus, while the ITS Institute has provided the technical expertise and analysis to implement it. The project will also involve human-factors testing, led by Nic Ward and the University’s HumanFIRST Program, to measure driver adaptability to the technological innovations and to compare the stress levels of drivers using the system to those without it.

**Institute holds research showcase**

As a part of the 13th Annual CTS Transportation Research Conference, held in May 2002, the Institute held its first ITS Institute Research Showcase. Faculty, researchers, and students from all technology areas within the Institute discussed research findings, implementation, and impacts of recently completed ITS-related research during this half-day event.

The research, categorized according to the ITS Institute’s core technology areas, allowed for topic-specific tracks on technologies for modeling, managing, and operating transportation systems; human performance and behavior; and computing, sensing, communications, and control systems.

The Research Showcase was open to CTS conference attendees who wanted to learn more about ITS technologies. Attendees had the opportunity to provide input and feedback on the implementation of research results.

The showcase also served as the ITS Institute’s research program review. Review committee members, which included representatives from federal, state, and local governments, academia, and the private sector, met with the Institute director following the showcase and provided suggestions for improving both individual projects and the Institute research program as a whole. Overall, the comments were favorable for the Institute’s program and its peer review process.

**Institute researchers lead TRB workshop on rural fatalities**

ITS Institute director Max Donath and HumanFIRST Program director Nicholas Ward organized and led a workshop on rural driving fatalities at the Transportation Research Board 81st Annual Meeting in Washington, D.C.

“Fatalities Arising from Driving in Rural America: What Can Be Done?” consisted of a series of presentations and directed discussions. The workshop brought together representatives from the Minnesota Department of Transportation, the Federal Highway Administration, the University of Minnesota, Montana State University, Virginia Tech, and engineering consulting firms in order to examine fatal crash statistics, identify the role of human factors (including sociological factors), review engineering and technology interventions, discuss strategic barriers, and identify future needs. Presenters also discussed policy issues, engineering and technology case studies for rural crash interventions, and funding programs.

Vehicle crashes in rural environments are a significant problem, said Donath. Although more crashes occur in urban environments, rural fatalities outnumber urban fatalities two to one—a trend that is consistent from year to year and when considering vehicle
In the workshop’s opening discussion, Ward emphasized that since the human factor is the most common factor in both rural and urban fatal crashes, possible solutions must be designed to account for that. Some intervention strategies include the use of ITS to monitor impairment, warn of potential collisions, manage integrated systems, offer lane departure support, and help enforce compliance. There is a need, however, to balance technology with traditional intervention methods of education, enforcement, and engineering, he added.

In another session, Donath addressed lane departures—a leading cause of fatalities in rural crashes—and the potential of lane-departure warning systems. According to Donath, integrating high accuracy differential GPS with a new type of digital map would produce enough information to provide suitable warnings to drivers in order to mitigate the effects of driver distraction, fatigue, and alcohol-induced impairment.

**IVI test vehicles hit the road**

A kickoff event in November 2001 marked the next phase for the Intelligent Vehicle Initiative (IVI) Field Operational Test, as six specialty vehicles equipped with driver-assistive technologies went into service on Highway 7 between Hutchinson, Minn., and Minneapolis.

The event showed project partners and the media the technologies installed in a Minnesota State Patrol squad car, a Hutchinson Area ambulance, a McCleod County snowplow, and three Mn/DOT snowplows. The technologies, which include Differential Global Positioning Systems (DGPS), high-accuracy digital road maps, a “virtual” rumble strip, and a head-up display (HUD) will allow vehicle drivers to “see” the road, via images projected onto a windshield display, in conditions of blowing snow, fog, or darkness.

Among those in attendance were representatives from the University’s Intelligent Vehicles (IV) Lab, Mn/DOT, the State Patrol, and local government.

Christine Maziar, vice president of research and dean of the University’s Graduate School, commented on the successful, mutually beneficial relationship between Mn/DOT and the University, especially CTS and the ITS Institute. This demonstrates that the University can go beyond conventional research, outreach, and extension to implement systems that will directly help Minnesota citizens and communities, she said.

Major Mike Asleson of the Minnesota State Patrol/Department of Public Safety added that this research “is about safety, about serving people better, and about reducing injuries.”

Also providing answers to the press were the ITS Institute’s IV program director Craig Shankwitz, project technical liaison, and Mn/DOT’s John Scharffbillig, field project manager.

The three-year IVI project is funded by the Federal Highway Administration, Mn/DOT, and industry partners. Mn/DOT is directing the project, while the University’s Intelligent Vehicles Lab is providing the technology and systems integration.

**Visitors view Institute labs, research**

Over the past year, the Institute has provided many tours and demonstrations of its laboratories and research projects. Visitors have included local, national, and international government officials, legislators, and the general public,
Among others. These efforts allow visitors to see and experience the work underway at the Institute, thereby increasing support behind its activities and increasing its visibility.

Among the visitors were four congressional staffers in August, who were provided with an overview of transportation-related activities at the University. The day’s agenda included the following Institute topics and presenters:

- Technological advancements and research, Dawn Spanhake, manager of research development and contract coordination, ITS Institute/CTS
- Human Factors Research Lab tour, Selma de Ridder, research associate, HFRL
- ITS Laboratory tour and demonstrations, Ted Morris, ITS Institute/CTS, and John Hourdakis, research fellow, Civil Engineering
- ITS Intelligent Vehicles Lab and SAFEPLow, Craig Shankwitz, program director, Intelligent Vehicles Lab
- Transportation policy research, Lee Munnich, director and senior fellow, SLPP

Other visitors included attendees of the Women’s Transportation Seminar national conference, held in Minneapolis in May 2002. Tours were given of the HumanFIRST Program lab and the Intelligent Vehicle Lab’s TechnoBus, and presentations were made by ITS experts.

Institute participates in new forum on transportation policy, technology

The ITS Institute joined with the Center for Transportation Studies in helping to plan and participate in the first James L. Oberstar Forum on Transportation Policy and Technology in April on the Twin Cities campus. The forum is named after Minnesota Congressman James L. Oberstar, a longtime leader in creating national transportation policy and establishing research and education programs in transportation technology. The forum brought together national policymakers and experts to address issues that relate to all modes of transportation. Keynote speaker was U.S. Secretary of Transportation Norman Mineta.

Institute director Max Donath participated in a panel discussion titled “Setting the Stage: Long-term Impacts of 9-11 on Transportation,” in which he offered the technological perspective on the aftermath of September 11.

Future forum events will be administered and hosted by CTS in partnership with its affiliated University colleges and campuses, including the Northland Advanced Transportation Systems Research Laboratories at the University of Minnesota Duluth.
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**ITS Lab site of training for Mn/DOT, FHWA staff**

In April, the ITS Laboratory facilities were the site of AIMSUN traffic simulation software training, taught by Institute research fellow John Hourdakis. During this three-day course, Hourdakis trained staff from the FHWA and Mn/DOT on traffic modeling and simulation tools developed by a research team led by Hourdakis and Professor Panos Michalopoulos (Civil Engineering). According to Hourdakis, the unique modeling interface of AIMSUN should make it easier for field practitioners, such as those in attendance, to effortlessly evaluate traffic management strategies and road geometry improvements.

The three-day course introduced participants to AIMSUN and other specialized tools that interface Mn/DOT’s loop detector information with urban network models representative of the Twin Cities metropolitan area. Hourdakis also presented methods of calibrating the simulation models and introduced new result presentation applications that the researchers have developed.

**Institute exhibits provide hands-on learning and public outreach**

The ITS Institute once again exhibited at the Minnesota State Fair as part of the University’s Institute of Technology exhibit in the “Wonders of Technology” building. This year’s exhibit featured a completely autonomous robotic vehicle built by University of Minnesota mechanical engineering students. The students had built the vehicle for and competed in the Ninth Annual Intelligent Ground Vehicle Competition in Rochester, Mich., in June with funding from the Institute.

At the State Fair, the vehicle and a display area documenting its design and construction were seen by hundreds of fairgoers, and it served as a hands-on educational tool and a concrete example of transportation technology and engineering research at the University. Members of the design team and ITS Institute personnel were on hand to explain the vehicle’s operation and how it addresses technical challenges in intelligent vehicle design.

In addition, the Institute joined the Minnesota Guidestar exhibit at this year’s ITS America conference held in Long Beach, Calif., in April. The Institute sent staff members and students to manage the booth and answer ITS-related questions. Visitors to the booth also received Institute folders, information sheets, and other publications.

**Institute communications expand in depth, reach**

Development, updates, and expansion of the Institute’s web site (www.its.umn.edu) continued over the last year. More project information was transitioned from the Institute’s research project database to the web site, and the web site was partially reorganized to make it easier to find information on research projects, including giving users the ability to browse project information by different criteria. Information on the Advanced Technology Seminar Series was also augmented to include slides or other presentation materials used by the presen-
ters and synopses of the presentations.

Other information that site visitors can access includes the Institute’s strategic plan, descriptions of Institute facilities and laboratories, contact information, ITS-related University courses, a listing of upcoming events, the Institute’s quarterly newsletter, the Institute’s annual reports (as PDF files available for download), and links to related sites of interest.

In addition, new web pages were created for the Institute’s bus rapid transit research to provide more comprehensive coverage on the progress of this new project (see www.its.umn.edu/research/brt/index.html). As part of this effort, Institute staff developed an e-mail distribution list to communicate research progress to interested parties who subscribe to the service.

Increasing the amount of information available on the Internet has made it easier for researchers and the public to learn about research activities at the Institute.

Other communications this past year continued to further the Institute’s mission by raising awareness among academic and professional communities and by disseminating the results of Institute research. Publications included the Institute’s quarterly Sensor newsletter, a source of detailed information on specific research projects; a semiannual and annual report; research reports; fact sheets describing Institute laboratories and research projects; and posters publicizing the Institute’s advanced transportation technologies seminars.

**Visiting Institute researchers help promote exchange of ideas**

The ITS Institute continues to work with visiting researchers and to foster information exchange among its own researchers.

Over the past year, Chang Sik Choi of the municipal government of Seoul, Korea, has been housed in the ITS Institute and is working with Dr. Eil Kwon, the Institute’s advanced traffic systems program director. Dr. Choi is researching urban transporta-

Dr. Kwon is on temporary assignment at the Mn/DOT Office of Traffic Engineering, where he continues his research on urban traffic dynamics. Kwon is also developing an electronic document clearinghouse for transportation researchers, which will contain a large number of relevant publications and other documents and be available over the Internet.

Finally, 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 initiative. Horan’s research is focusing on the challenges to integrated ITS and telecommunications planning in a rural context.