The mission of the Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program is to apply human factors principles in order to understand driver behavior and support the design and evaluation of usable intelligent transportation systems. As implied by its name, the program’s research strategy is based on a driver-centered approach, considering the “human first” within the transportation system.

The HumanFIRST Program has a core staff of transportation research specialists made up of psychologists and engineers who provide a consistently available base of expertise. This core group is linked to a broad interdisciplinary network of experts in basic and applied sciences throughout the University to provide a flexible and comprehensive research capacity. This network is supported by affiliations with additional University research units, which allows the program to create responsive interdisciplinary teams to investigate a range of complex human factors research issues in transportation safety. The program also has close relationships with the Minnesota Departments of Transportation and Public Safety, private industry, traffic engineering consultants, and other related entities. These connections provide support for implementing research that will influence transportation policy in response to real-world problems both regionally and nationally. In addition, to ensure that research takes into account developments on the world stage, the program’s work is supported by international collaborations with experts in relevant disciplines.

Research in the HumanFIRST Program seeks to propose, design, and evaluate innovative methods to improve transportation safety based on a scientific understanding of driver performance and the psychological processes associated with traffic crashes. This research considers how a driver will accept and use a proposed system while also considering the possibility of its
producing undesirable driver responses and adaptation (e.g., distraction, complacency, fatigue, risk-taking) that could undermine the system goal of improved safety.

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

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

Much of the research of the HumanFIRST Program uses a state-of-the-art driving simulator (supplied by AutoSIM and OKTAL) engineered specifically for human factors research in surface transportation. This Virtual Environment for Surface Transportation Research (VESTR) is a versatile and realistic simulation environment linked to a full-cab SC2 vehicle donated by Saturn using software capable of creating virtual environments that precisely reproduce any geospecific location. In addition, specialized visual-effect software can produce realistic weather and lighting—including light and heat—on the vehicle.

The risk for motor vehicle crashes is extremely high among teen drivers—in fact, vehicle crashes are the leading cause of death for teens. In response, researchers from the University of Minnesota’s HumanFIRST Program (led by research fellow Janet Creaser) and the University of Iowa are examining the use of an event-triggered video system that records and gives limited feedback about driving behaviors that may help motivate safer teen driving.

This study is using teens recruited from an urban high school in the Minneapolis-St. Paul area and complements a similar study conducted by the University of Iowa examining rural teen drivers. In the Twin Cities study, a DriveCam event recorder is mounted behind the rearview mirror in participants’ vehicles. The camera continuously records video and audio data of the driver and the forward scene. The data are not saved, however, unless unsafe driving behaviors such as excessive acceleration, sudden braking, or erratic steering trigger the recorder, which then retains video and audio data 10 seconds before and 10 seconds after the trigger event. Recording these data makes it possible to see what happened immediately before and after incidents.

The research study consists of three stages that together will help determine the system’s efficacy. During the first stage, the cameras record events triggered by driving behaviors without letting the teens know they have triggered and recorded an event, thereby identifying drivers’ normal behavior. In the second phase, when the recorder is triggered, a red light flashes to let drivers know the DriveCam has detected and recorded an event. At the end of each week, parents receive downloaded video recordings and a “driver report card” relative to their teen’s driving performance that details such things as what behavior triggered the recording, the environmental conditions at the time, and whether the driver was wearing a seat belt. Parents are asked to review this information with their teen in the hope that the teens will learn from both their good and bad behaviors. The drivers are evaluated during a third phase, with the camera recording events but once again without providing feedback to teens or videos to parents. The goal is to find out if drivers continue good behavior once the camera and parental feedback components are removed.

The research team’s overall interest is to determine whether systems like the one studied have an effect on safety-related behaviors. The final analysis, set for completion in the fall of 2008, could help generate new means of driver education, decision-support systems, and licensing and training that may result in fewer crashes by teen drivers.
shadow that correspond with season and time of day—as well as vehicle headlights with nighttime glare and water reflections.

The visual environment is generated with high-resolution images (1.97 arcmin per pixel) over a wide field of view (210-degree forward, 50-degree rear, 2 by 20-degree side mirror images). This immersive driving experience is enhanced by realistic motion generated by a three-axis motion base and both high- and low-frequency vibration units, including a surround-sound system. With multiple sound systems, configurable touch panel displays (including head-up displays), haptic feedback through the seat and accelerator pedal, and a head-free eye-tracker that can detect in real time what a driver is looking at, this simulator supports the investigation of a wide range of interface options for ITS development, design, and assessment. These features make VESTR one of the premier driving simulators in North America and Europe.

Additionally, to support the validity of HumanFIRST research, the program has access to a variety of closed test tracks and road network field sites for on-road studies with instrumented vehicles.

**MINNESOTA TRAFFIC OBSERVATORY**

The Minnesota Traffic Observatory (MTO), a joint effort of the ITS Institute and the Department of Civil Engineering, aids researchers’ ability to study the complex dynamics of traffic flow throughout the Twin Cities region. The observatory combines real-time traffic data with state-of-the-art simulation systems, giving researchers and engineers the ability to analyze existing conditions and compare real-world observations with the results of simulated conditions.

Rather than showing one or two locations, the observatory offers a view of large systems where many different parts interact. Video feeds flow into the observatory from an extensive network of traffic cameras. The observatory is connected by fiber-optic lines to the Minnesota Department of Transportation’s traffic operations center, allowing it to capture live feeds from up to 16 of the more than 300 cameras the agency uses to monitor the metropolitan freeway system. In addition, the observatory operates a dedicated system of cameras overlooking the I-94/35W Commons interchange in Minneapolis—turning one of the most accident-prone intersection areas in the state into a real-world laboratory for the study of traffic flows and vehicle crashes.

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

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

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

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

The Digital Environment, or DEN, takes a different approach—putting viewers in the center of the action via three-dimensional immersive graphics. Three sides of the cubical structure are formed by large rear-projection screens presenting polarized images from two slightly different sources; a user wearing specially designed glasses sees a different image with each eye, producing a realistic sense of three-dimensional space. A tracking system mounted in the DEN’s ceiling monitors the position of the user’s head and adjusts each projector to provide an accurate perspective.

Visualizing better planning processes

Project planning by state, county, and city agencies requires a great deal of involvement from various government agencies and the general public to achieve the best project outcomes. Scarce resources among agencies and busy lifestyles among the public at large, however, often create significant barriers to participation. Researchers from the University of Minnesota’s Hubert H. Humphrey Institute of Public Affairs and civil engineering department are working together to find out how technology could be used to minimize these barriers and lead to better stakeholder participation in various planning processes. The research team includes John Hourdos, a civil engineering researcher and director of the Minnesota Traffic Observatory (MTO), Carissa Schively Slotterback, assistant professor in the Humphrey Institute’s Urban and Regional Planning Program, and several graduate students.

Although research is being conducted by others regarding specific technologies, this study provides the next step of determining how to tailor technology to the unique characteristics of different types of planning and participatory efforts. The MTO’s GIS/Map table was influential in getting this project started as team members began to think about how the table might be used to enhance participation efforts. They expanded their thinking to other types of technologies that might be used in participation. The team is now gathering information about typical participation processes in which planners, engineers, and other practitioners are involved—including open house meetings, public hearings, and technical, advisory, or steering committee meetings.

The research team is hoping to understand the typical characteristics of these processes (meeting types) in terms of who participates, when they occur in the planning process, what their purpose is, and what their outcomes are. Once they understand the characteristics, they can better identify ways to tailor various technologies to improve participation efforts. Customizing technology to these unique characteristics would enable planning and transportation professionals to create more realistic pictures of projects throughout the planning and development processes, giving stakeholders more influence over and satisfaction with the completed project.

Through a series of focus group discussions with practitioners that included representatives from the Minnesota Department of Transportation (Mn/DOT) and other state, regional, and local agencies, the research team is examining the agencies’ current participatory processes and their perspectives on applying technology in these settings. Based on the information gathered, the team will identify the strengths and weaknesses of various types of technological enhancements that could be incorporated within these existing processes.

One avenue being explored is that of developing ways to distribute project information other than at public meetings. For example, this might be a Web site with interactive features that allows individuals to study the pros and cons of different project scenarios, offer comments, and take part in the planning process entirely online.

The final analysis from this work will produce important feedback about ways to integrate technology into planning and participatory processes and further insight about the importance of tailoring technology to various settings. As a follow-up to this study, the team hopes to develop a Web site on which technology-related information would be posted and organized to help practitioners make decisions about the technology options available for their particular situation.
The Institute’s Intelligent Vehicles (IV) Laboratory develops and tests innovative, human-centered technologies that improve the operational safety, mobility, and productivity of the transportation network in general, and highway vehicles in particular. These human-centered technologies integrate sensors, actuators, computer processors, and custom human interfaces to provide drivers with needed information under difficult driving conditions such as low visibility, severe weather, and narrow and congested roadways.

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

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

The University of Minnesota is recognized as a leader in developing and testing driver-assistive systems and is one of a small number of universities nationwide conducting this work. The IV Laboratory’s core staff consists of engineering professionals who work closely with an interdisciplinary team of specialists, including cognitive psychologists specializing in human factors from the ITS Institute’s HumanFIRST Program. The staff has developed expertise in wireless communications, embedded computing, visibility measurement and quantification, geospatial databases, virtual environments, image processing, driver-assistive technologies, control systems, and sensors.

IV Laboratory research seeks to increase driver safety

The Intelligent Vehicles Laboratory continued to work on improving rural intersection safety in fiscal year 2007 as a member of the federally supported Cooperative Intersection Collision Avoidance System–Stop Sign Assist (CICAS–SSA) research coalition.

The IV Lab’s efforts to develop collision-prevention technologies for rural deployment began with the Intersection Decision Support (IDS) research program. In that effort, the lab developed a system of sensors and computer processing algorithms that tracks vehicles approaching an intersection on a high-speed rural highway, processes the data to measure gaps in traffic, and displays a warning to drivers waiting on a minor road if the gap in highway traffic is too small to permit safe crossing or entry onto the highway.

Following the testing of a prototype IDS data-gathering system at a rural intersection in southern Minnesota, as well as the successful deployment of a portable data-gathering system in several partner states, the IV Lab (led by Craig Shankwitz) and the HumanFIRST Program (led by Michael Manser) were selected by the Federal Highway Administration (FHWA) to participate in CICAS. Minnesota’s research, with major funding and support from the FHWA and Mn/DOT, focuses on developing infrastructure-based systems for rural deployment.

Over the past year, IV Lab staff worked to refine the alert and warning-timing algorithms using models of driver gap acceptance behavior. This research is linked to the development of effective infrastructure-mounted animated graphic displays, currently under way in collaboration with human factors researchers from the HumanFIRST Program.

Other work during the past year focused on the sensor suite required to perform vehicle tracking. To reduce the cost and complexity of the system under development, the researchers explored alternative sensor types and reduced sensor sets for both the minor road and major highway system components. Alternative sensors included standard inductive loop vehicle detectors and a type of small “microloop” detector.
in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. Several vehicles serve as experimental testbeds: the SAFETRUCK (an International 9400 tractor-trailer), the SAFEPLow (an International 2540 crew-cab snowplow), a state highway patrol car, and a Minnesota Valley Transit Authority (MVTA) bus. Using these vehicles, IV Laboratory researchers are developing, testing, and integrating advanced technologies including centimeter-level differential global positioning systems (DGPS); high-accuracy digital-mapping systems; range sensors, including radar and laser-based sensors; a windshield head-up display (HUD), a virtual mirror, and other graphical displays; and haptic and tactile feedback.

The IV Laboratory’s lane-assist technology is unique in that it uses DGPS and does not require hardware in the roadway surface. The technology is transferable between various transportation modes and works in all low-visibility situations, including snow, fog, smoke, heavy rain, and darkness. In addition, these systems use human-centered technologies to enhance driving ability and reduce driver error due to distractions, fatigue, and other factors related to difficult driving situations.

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

Because safety systems can produce improvements only if they are deployed, the IV Lab works with a variety of states to collect data and evaluate system performance. For instance, three vehicles (and a fourth planned) with driver-assist technology have been deployed in Alaska, where high snowfall rates and dry, blowing snow routinely cause whiteout conditions and zero visibility. By March 2008, the Minnesota Mobile Intersection Surveillance System (MMISS) will have collected driver behavior at rural expressway through-stop intersections in Wisconsin, Iowa, Michigan, North Carolina, Georgia, New Hampshire, Nevada, and California. Data collection throughout the United States will ensure a nationally deployable intersection safety system designed to save lives among rural drivers.

Additional research topics include the design and
At first glance, a snowplow might seem hard to miss. But winter weather conditions can interfere with human visual perception in ways that make it difficult to judge the position and speed of even a big, bright orange plow, resulting in dangerous collisions. To help prevent these errors, researchers at the University of Minnesota Duluth are developing new tools to study the effects of winter conditions on human vision.

One of the main sources of difficulty for drivers in conditions of blowing snow, according to assistant professor of computer science Peter Willemsen, is a condition known as equiluminance in which the apparent brightness of an object is nearly the same as that of the surrounding scene. Equiluminance can be produced by particulates, such as snow, suspended in the air; it is particularly problematic at dawn and dusk, when low light levels make accurate distance perception even more difficult.

To learn more about the visibility problem, Willemsen and his research team are moving from the real world to a virtual environment where visibility conditions can be fully controlled. But doing simulator research has its own problems—such as how to mimic the visibility-reducing effects of snow. So the researchers are developing new computer graphics techniques that will produce more realistic snow effects.

In the first phase of their study, the researchers developed a snow rendering system that uses a model of millions of individual particles to compute how light is scattered and absorbed as it passes through a snow cloud. The team is currently working on integrating this snow rendering capability into a driving simulation system in order to carry out a series of experiments with different lighting configurations mounted on the plow. They hope to find a better way to light up snowplows to make it easier for other drivers to determine a plow’s speed and distance.

When the simulation system is complete, the researchers say, it may find a place in training programs for snowplow drivers, who work regularly in conditions of low visibility. Beyond helping drivers avoid collisions with snowplows, this research has the potential to improve scientists’ understanding of human visual perception in low-light or equiluminant conditions.

Virtual snow for safer winter driving

Pete Willemsen (front center) with students Michele Olsen, Daniel Schobert, and Siddharth Deokar
The Northland Advanced Transportation Systems Research Laboratories (NATSRL), founded in 2000, is an advanced research program located at the University of Minnesota Duluth. Its mission is to develop innovative ITS technologies that can make surface transportation systems in northern areas safe, efficient, reliable, and environmentally sound.

Since its inception, NATSRL has been strongly supported by its key stakeholders, including the Minnesota Department of Transportation, St. Louis County, and the City of Duluth.

Current research focus areas in NATSRL include advanced traffic/pavement sensor technologies; vehicle/driver safety technologies; transportation data archival and analysis methods; renewable power for ITS operations in rural areas; and traffic safety and operational strategies for rural and urban areas.

Specific NATSRL research projects currently ongoing in these focus areas include a wireless detection network to measure spatial traffic data; a video-based vehicle tracking system with a customized processor for efficient real-time traffic detection; an early detection and warning system for driver drowsiness; a realistic snow-rendering simulation system to assess the effects of alternative snowplow truck color and lighting options on the perception of following drivers; a carbon nanotube-based integrated pavement sensor for traffic detection; an advance warning system to prevent snowplow box collisions; and development of a freeway travel time database and Mn/DOT weigh-in-motion data archive design.

In addition, NATSRL partners with Mn/DOT District 1 each year to provide a research workshop, where ongoing research efforts are presented to local practitioners.

Research is investigating how to make snowplows more visible in blowing snow.