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.

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 TEA-21 legislation, the Federal Highway Administration, and the Federal Transit 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 that contribute funding and in-kind match.

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

In back: Captain Ken Urquhart and Officer Wes Pemble of the Minnesota State Patrol-Commercial Vehicle Section, who served as technical advisors for a sleep-deprivation research project. In front: research associates Kathleen Harder and John Bloomfield and research assistant Ben Chihak

**Research funding sources for all ITS-related research projects**

The total funding for all ITS-related research projects was more than $6.3 million in FY05. Sources for projects receiving funding in FY05 are shown in the chart at right.
Human Performance and Behavior

Fatigue, Sleep Deprivation, and Driving Performance

A century ago when sleep schedules generally followed the sun’s schedule, the average person slept about nine hours a night. Fast-forward to the mid 1970s and this number falls to about seven-and-a-half hours. And today, nearly one-third of Americans get less than six hours of sleep every night. Chronic sleep deprivation can cause a variety of physical and psychological problems, which can be especially dangerous when someone suffering them gets behind the wheel of a vehicle. National Highway Traffic Safety Administration data conservatively estimate that 100,000 police-reported crashes are the direct result of driver fatigue each year, and these crashes cause an estimated 1,550 deaths and 71,000 injuries.

In light of such statistics, researchers from the College of Architecture and Landscape Architecture are investigating the effect of sleep deprivation on the driving performance of commercial motor vehicle (CMV) drivers. Dr. John Bloomfield, the study’s principal investigator, agrees that driver fatigue is an important causal factor in many of the crashes that occur annually on highways in the United States. This is particularly true in the trucking industry, where many operators undertake long-haul drives with limited sleep.

Fatigue, which is a subjective state that can be defined as physical or mental weariness sufficient to impair performance, is clearly related to sleep deprivation. In this study, Bloomfield used an advanced driving simulator to explore the relationship between sleep deprivation and various aspects of driving performance, and also to determine whether or not there are correlations between sleep deprivation, driving performance, and data obtained from fatigue-detection devices. Although many researchers are interested in fatigue, Bloomfield says, very few studies have actually explored the effects of sleep deprivation on driving performance in a controlled setting like that provided by the driving simulator.

With help from the Minnesota Trucking Association, 20 CMV drivers were recruited to participate in the study. Each took part in an experimental session lasting 20 hours. During each experiment, the driver, who was kept awake throughout the session, “drove” in the driving simulator on four occasions. The first drive began at 9 a.m., the second at 3 p.m., the third at 9 p.m., and the fourth at 3 a.m. After participating in the 20-hour session, each driver was taken to the University’s General Clinical Research Center (GCRC), where he or she was able to sleep for at least eight hours.

The simulator vehicle used in the study was a full-sized Saturn coupe; when seated in this vehicle, the driver had a 210-degree forward field-of-view, and rear-view imagery provided via a 10-foot by 7.5-foot screen behind the vehicle and LCD screens installed in place of the side-view mirrors. Each drive—over flat, featureless terrain—was 60 miles long, during which the driver covered 46 miles of divided highway, 12 miles of two-lane bi-directional road, and finally, 2 more miles of divided highway. The driver passed through several intersections on the route and encountered low traffic levels. In addition to collecting driving performance data throughout each drive, Bloomfield, along with co-principal investigator Dr. Kathleen Harder and research assistant Ben Chihak, assessed driver impairment using several test instruments including the EyeCheck™ pupilometer, an instrument that measures pupil dynamics; the psychomotor vigilance test (PVT), a well-validated test of behavioral alertness; and the code substitution test, a measure of cognitive function.
The team is now analyzing the study results. Initial findings reveal that between the first drive and the fourth, drivers showed a significant increase in steering instability. This indicates that drivers’ steering performance was impaired during their last drive between 3 a.m. and 4 a.m. However, there were no other significant differences in driving behaviors, such as average driving speed and stopping behavior, between the first and fourth drives.

There does not appear to be a relationship between the impairments that were found in steering control and the data obtained with the EyeCheck pupillometer or other test instruments. This is unfortunate, Bloomfield says. If reliable relationships between driving performance impairment and the fatigue detection devices tested in this study had been found, those devices might have been used by law enforcement officers. The devices, along with the fatigue driving evaluation checklist recently developed by the Minnesota State Patrol, could have been used to test fatigue levels in truck divers in efforts to keep them, and all drivers on U.S. roadways, safer.

Design and Safety Implications for ATIS Use with Cell Phones

Distracted driving—whether the result of cell phones, the car stereo, or any number of other factors—is assumed to be more dangerous driving. Now an Institute study has found that using a cell phone may impair drivers more than alcohol intoxication. The research, led by Nic Ward, director of the Institute’s HumanFIRST Program, assessed the risk of cell phone use while driving compared to commonly accepted in-vehicle tasks, as well as driving while intoxicated.

The study included the work of HumanFIRST research scientist Mick Rakauskas along with Ed Bernat, Meredith Cadwallader, and Professor Chris Patrick of the University of Minnesota’s Department of Psychology.

Because evidence suggests that cell-phone use while driving may be a significant risk factor in traffic crashes, some states have responded by imposing restrictions on the use of hand-held phones. But Ward’s research team, citing research that shows hands-free use is no safer than hand-held, has focused instead on the cognitive aspect of talking on a cell phone while driving. “It’s actually the conversational component of operating a cell phone while driving that is the culprit,” Ward says, “not just the physical manipulation of the phone.”

In particular, the two-part study is probing the risks of using cell phones to access new advanced traveler-information systems (ATIS) recently introduced in many states (e.g., 511 Traveler Information Services). Phase I of the study examined how the performance impairment from cell-phone use compares to other types of impairment risks, such as driving while intoxicated (0.08 blood-alcohol content) and while operating common in-vehicle controls like a radio, fan, or air conditioning. For the first time, research-
ers also examined the combined effects of being distracted and being intoxicated, given that many crashes result from a combination of risk factors. Phase II will examine the design of 511 services in order to make them less distracting for drivers.

Ward explains that use of a cell phone and other typical in-vehicle tasks are considered secondary to the primary tasks of driving and driving safely. Previous studies have shown that the increased mental demand of cell-phone use causes impairment—and an increased crash risk. By Ward’s definition, impairment means exceeding the limit of one’s ability to apply the necessary resources toward a particular task. When that task is driving, impairment may, for example, cause speed inconsistency and slower reaction toward unexpected events. “The brain is dulled because of the secondary task,” Ward says.

In their experiments, the researchers gathered data from test subjects outfitted with a device to measure brain activity and using the Virtual Environment for Surface Transportation Research (VESTR) driving simulator in the HumanFIRST lab. Half the test subjects drank alcohol to near intoxicating levels (just under .08 blood-alcohol content) as measured with a Breathalyzer.

Participants drove normally along a simulated rural route and were exposed to a variety of traffic interactions. Driver impairment was measured in terms of subjective (how difficult they thought driving was), behavioral (how they handled their vehicle), physiological (how their mind and body reacted), environmental awareness (how aware they were of their surroundings), and Breathalyzer measures.

Drivers completing either cell-phone or in-vehicle tasks during a car-following scenario showed worse performance than those driving without a task in terms of time headway, maintaining a consistent speed profile with respect to the lead vehicle, and steering. And, Ward says, “The drunk driver doing nothing but driving was less impaired than a sober driver using a cell phone or playing with the radio.”

Measurements of brain activity showed that drivers who were engaged in secondary tasks were less attentive and mindful of unexpected events. Drivers conversing on the cell phone and completing in-vehicle tasks while sober had lower accuracy during a target-tone task (in which they listened to a sequence of tones and responded to a particular tone via a left-foot pedal) than intoxicated drivers not completing any secondary task. And during an environmental awareness task, both cell phone and in-vehicle secondary tasks led to less accurate identification of road signs.

In measuring driver distraction, Ward draws a distinction between episodic and continuous driving tasks and their effects—when combined with secondary tasks—on a driver’s “workload” and ability to drive safely. Continuous driving tasks, he says, make it easier to see impairments in driving due to secondary tasks. Specifically, hands-free cell-phone conversations demonstrated significant impairment. But in-vehicle tasks consistently showed the most impairment because they combine both cognitive and physical distraction.

Some industry efforts are aimed at locking out cell-phone and ATIS functionality during high workload periods, but until those technological developments are implemented, a driver’s discretion is all that limits his or her cell-phone usage. Though he believes legal sanctions against cell phones need enforcement and education, Ward emphasizes that driver education is necessary to understand the risks and to learn when it is safe to engage in secondary tasks.

“Banning cell phones isn’t the solution,” Ward concludes. Rather, it’s determining how to use them appropriately—and safely.

“The drunk driver doing nothing but driving was less impaired than a sober driver using a cell phone or playing with the radio.”
Evaluation and Improvement of the Stratified Ramp Metering Algorithm through Microscopic Simulation

The Minnesota Department of Transportation (Mn/DOT) has a long history of using ramp metering as a traffic management strategy, though in recent years, some members of the public have questioned the effectiveness of the metering system. Results of a legislatively mandated eight-week ramp meter shutdown study in late 2000 showed that ramp metering is beneficial for increasing freeway volumes, decreasing travel times, increasing speeds, and decreasing crashes. Yet motorists surveyed as part of this study, while agreeing that metering improved traffic conditions, felt strongly that ramp meter wait times were excessive.

These findings prompted Mn/DOT engineers to develop a new ramp control algorithm to better balance freeway flow with ramp wait times. Unlike the ZONE metering algorithm Mn/DOT used prior to the shutdown study, the new Stratified Zone Metering (SZM) algorithm does not depend on historical demand data, but rather, bases ramp metering rates on real-time ramp demand and queue size. Although Mn/DOT began deploying this strategy in 2002 at various locations within the Twin Cities ramp metering system, its effectiveness, especially critical quantitative measures of effectiveness (MOEs) such as system delay and system travel time, had not been substantiated.

That’s where researchers from the University of Minnesota’s civil engineering department come in. Professor Panos Michalopoulos, along with research fellow John Hourdakis and research assistants Baichun Feng and Wu-Ping Xin, are continuing efforts from a recent project in which Mn/DOT’s earlier ramp control algorithm was successfully evaluated for two Twin Cities freeways. In this current project, researchers move beyond evaluation to develop a low-cost, innovative method to reliably and quickly evaluate, improve, and optimize the SZM algorithm.

Michalopoulos and his team are focused on two specific objectives: one, identifying how the SZM algorithm compares and contrasts to the ramp metering algorithm used prior to the shutdown study; and two, analyzing the sensitivity of the SZM algorithm to different variables. They integrated a sophisticated control module, which emulates the SZM algorithm, into a state-of-the-art microscopic simulator. They then compared the new stratified metering algorithm with the old algorithm and to a no-ramp-control situation. Through these simulations, detailed statistics have been generated to help the team evaluate critical aspects of the new algorithm’s operation including its effect on queue formation, bottleneck operation, and variations of long and short trip travel times. Using a simulator in this way enables testing and study of a variety of ramp control scenarios and allows time to make improvements before a new ramp control strategy is deployed live. This helps minimize costly and time-consuming field testing and the resultant traffic disruptions.

The results so far suggest that the SZM strategy meets its objective of keeping ramp delays below the predetermined maximum threshold. However, when compared with the ZONE algorithm, the SZM’s
emphasis on limiting ramp wait times shifts ramp delays to the freeway mainline and degrades the quality of the freeway flow. Analysis further shows that the SZM strategy is beneficial when compared to the no-ramp-control alternative in terms of improving freeway performance, but during heavy congestion, the SZM is only marginally better than this alternative.

Researchers also have observed that system delay, system travel time, and fuel consumption and pollutant emissions under the SZM control are unpredictable, and that these MOEs may improve or degrade, compared to the no-control alternative, depending on the freeway geometry and demand patterns. This suggests the need to further analyze the trade-offs between freeway efficiency and reduced ramp delay.

Through efforts of this project, these researchers have developed a reliable and efficient methodology for evaluating and improving the SZM algorithm that will greatly assist Mn/DOT in designing, deploying, and operating ramp metering strategies. In future work, researchers will explore additional improvements to the SZM algorithm that factor in ramp queues and other traffic pattern measurements such as the formation of shockwaves. The goal is to “tweak” the SZM algorithm so that it is effective in not only dissipating ramp queues faster while keeping maximum ramp delays well below the desired threshold, but also in smoothing the mainline traffic flow and decreasing the freeway mainline delays.

Identification and Simulation of a Common Freeway Accident Mechanism: Collective Responsibility in Freeway Rear-End Collisions

It’s rush hour and freeway traffic is heavy. The first car in a cluster of seven slows down and a wave of red brake lights spreads as each successive vehicle in the group slows down to avoid hitting the car ahead. But some drivers react faster than others. A few seconds after the first car slows down, the last car in the group collides with the car ahead of it. It’s a scene that happens every day in high-traffic conditions. Usually, it’s the person who hits the car ahead who receives the blame. Yet studies dating back to the 1950s have suggested that within clusters, or “platoons,” of cars traveling in high traffic, a driver further ahead in the group may actually cause the collision and that such crashes result from the actions of the entire group. Ultimately, if the platoon is long enough, the collision may be inevitable.

Says Gary Davis, associate professor in the Department of Civil Engineering, “I like to think of it as a common bank account. The people with a longer reaction time make a bigger withdrawal from a finite account.” If that account of stopping time is depleted before the last driver in the cluster starts to stop, a collision results.

To further assess this theory, Davis and graduate student Tait Swenson analyzed video recordings of crashes on Interstate 94 in Minneapolis. Their study is part of a larger investigation, “Identification of Accident-Prone Conditions,” funded by the ITS Institute and conducted by Professor Panos Michalopoulos and research fellow John Hourdakis, both of the Department of Civil Engineering. The goal of this research is to provide low-cost, innovative solutions for identifying causes of crashes in crash-prone freeway locations and to develop a crash avoidance and prevention system.

In a method of study that Davis says is unlike anywhere else in the world, video cameras were installed on high-rise buildings adjacent to I-94. The cameras were connected to a computer that recorded the weekday traffic activity from morning through evening rush hours. Davis and Swenson analyzed three crashes that occurred in locations where it was possible to measure vehicle trajectory information from the video. A computer program allowed them to record the sequence of coordinates representing each vehicle’s trajectory to understand the sequence of events in the crashes. They also analyzed various theoretical examples of what might have happened if each driver’s reaction time or following distance had been different.

The result of the study indicated that of 19 drivers, 10 probably had reaction times that were longer than their following distance.
research

The result of the study indicated that of 19 drivers, 10 probably had reaction times that were longer than their following distance. In all three collisions, had the colliding driver maintained a following headway of two seconds, the collision would probably have been prevented. Perhaps more pertinent, they found that for each of the crashes, it was possible to identify actions by earlier drivers in the cluster that contributed to the occurrence of the collision, even though these drivers did not actually collide. Says Davis, “Short headways translate into higher traffic flows, so one can argue that short headways help make use of limited freeway capacity.” He suggests that short of having fewer cars on the road or a tremendous improvement in drivers’ competency, deploying collision-avoidance technology in vehicles (or potentially in the road itself) could help reduce traffic delays without, for example, adding more lanes to the freeway.

It’s a situation that Davis compares to air traffic control used in busy airports. “You need some sort of central controller,” he says. “There’s a limit to what you can do with people.”

Intersection Decision Support: Improving Safety on Rural Highways

Rural highways are a vital part of our transportation network, but their pastoral setting can hold a hidden danger. Intersection crashes account for more than 30 percent of all vehicle crashes in rural areas; from 1998 through 2000, 62 percent of Minnesota’s intersection-related crash fatalities occurred in rural areas. Far from the city lights, ITS Institute researchers are developing new ways to prevent crashes at vulnerable rural highway intersections, in Minnesota and across the country.

At the center of the research effort is an unremarkable-looking through-stop intersection in southern Minnesota’s Goodhue County, where a divided highway carrying high-speed traffic intersects a two-lane collector road. Led by Intelligent Vehicles Laboratory director Craig Shankwitz, researchers have installed a web of unobtrusive sensors around this intersection, including multiple radar units, laser-based (lidar) vehicle detectors, and visible-light and infrared video cameras mounted on a portable camera mast overhead. Despite the sophistication of the equipment, most highway drivers pass through without even knowing it’s there.

That unobtrusiveness is a key design goal of the Intersection Decision Support (IDS) project, which aims to produce a system that tracks highway vehicles and uses that data to give drivers stopped on a secondary road better information about approaching traffic, without disrupting highway traffic flow.

“Our system focuses on reducing driver error, which is the most common cause of crashes, rather than on restricting vehicle movements.”

Computing, Sensing, Communications, and Control Systems
and to broaden the range of intersection data available for analysis.

After reviewing crash statistics and road geometries of hundreds of intersections, the researchers selected the Goodhue County site to equip with an array of data-gathering sensors. At the study site, the intersection geometry is complicated due to a substantial grade difference between the two halves of the divided expressway. Both the expressway and the rural road are frequently used by large commercial vehicles.

The core of the IDS system is a central processing unit that integrates speed and location data from the system’s array of sensors to create a digital snapshot of traffic—including vehicle position, rate, range, and time-to-intersection—10 times every second, both on the main highway and on the collector road. Using predictive algorithms, the processing unit projects vehicle trajectories continuously in real time, and tracks gaps between vehicles on the highway.

The vehicle tracking system has been gathering data around the clock for several months. These data are stored in a spatial database, allowing the research team to search for specific vehicle configurations and turning behaviors. Of particular interest are “near miss” scenarios, in which two or more vehicles cross the intersection within a short time gap; by querying vehicle detector data, it is possible to pull up stored video footage of any such incidents for further human analysis of driver behavior.

The HumanFIRST Program’s VESTR immersive driving simulator also plays a central role in IDS research. Inside VESTR, a realistic model of the research intersection has been programmed, complete with virtual vehicles controlled by data from the real-world intersection. This enables detailed observation of driver response to various intersection conditions in a way that would be impossible on the road. A variety of types of driver interface can also be tested under completely controlled conditions, including critical issues such as information complexity and the varying response patterns of different driver groups, such as older drivers.

Members of the IDS project team have been working with representatives of participating state transportation agencies on the design of the portable data-gathering system. This system will be transported by truck and set up by members of the IDS research team at selected intersections in each state in order to explore possible regional differences in driver intersection behavior.

HumanFIRST researchers have completed initial evaluation of a variety of different interface designs and are currently developing candidate designs for review by participating state agencies. The final design must satisfy a variety of constraints, including effectiveness, maintenance requirements, and compliance with uniform standards for traffic control devices.
Optimal Secondary Controls Using a Configurable Haptic Interface

Can a single knob make a vehicle safer? Professor William Durfee of the Department of Mechanical Engineering thinks the answer is yes. Durfee is conducting research on a new type of control interface that aims to reduce driver distraction by consolidating many non-critical control functions in one multi-purpose knob that behaves differently depending on how it is being used.

Driver distraction due to a complex control interface is becoming more problematic as car manufacturers add new electronic features for in-vehicle communication and navigation. One potential way to reduce the driver’s cognitive load is to consolidate secondary controls into a single multi-function device while leaving controls for critical systems on the dashboard.

Durfee’s work aims to advance the multi-functional control concept by designing a knob that exhibits different “personalities” depending on the function it is performing. For example, the knob might offer clicking detents when being used to change radio frequencies, but turn smoothly when adjusting temperature. A computerized servomotor system within the dashboard would emulate friction, resistance, and other sensations experienced when using a conventional knob.

In order to determine optimal haptic characteristics for different control functions, Durfee and his collaborators have constructed a unique experimental apparatus. It consists of an unassuming knob connected to a computer-controlled servomotor that emulates a variety of haptic feedback in real time, while a second computer provides auditory feedback, such as the “scratch” of friction or clicks as the knob turns. To create a more realistic testing environment, a video monitor in front of test subjects shows the knob as it would appear when installed in a control panel.

The testing knob itself is mounted on a specially colored background, which a third computer digitally replaces with a virtual dashboard.

Durfee explains that the function of knobs can be broadly categorized into two types of tasks. The first is to select among a collection of pre-determined settings—for example, the climate control knob in a car. “You can choose to have the air come out on your feet, or the windshield to prevent frost, or all around you for comfort. This would be a selection task where you choose among a set of choices,” he says.

The other task is to set a property. With the blower setting in a car, the operator spins the blower knob to get the desired temperature—there are no predetermined settings. Often knobs used for selection have detents while knobs used for setting do not.

Durfee and graduate student Reann Dargus are now embarking on a series of experiments to determine what type of knob works best for each of these tasks, and whether the properties of that “best” knob should be different from person to person.

This becomes particularly important for those operating heavy equipment or who must master complex panels on machines, or for use in buses or airplane cockpits as well as cars, Durfee says. Having knobs with haptic properties that are cued to the task and are optimal for the task may reduce operator error and make the interface easier to operate.

Durfee hopes to use the results from the enclosure simulations to incorporate a servomotor-controlled knob into the dashboard of a STISIM virtual driving simulator, enabling researchers to test the advantages of different feedback characteristics in a driving environment.
Sustainable Technologies Applied Research Initiative: Networks and Productivity
Since 2001, a team of researchers from the Hubert H. Humphrey Institute of Public Affairs’ State and Local Policy Program (SLPP) and the ITS Institute has been working together to conduct a set of federally sponsored studies, collectively called the Sustainable Technologies Applied Research (STAR) initiative, on how transportation systems can be planned in an increasingly complex social, political, economic, and technological environment. As part of this interdisciplinary team, David Levinson, associate professor in the Department of Civil Engineering, is researching the dynamics of the Twin Cities metropolitan-area freeway network.

Transportation networks such as this are inherently complex systems because of their structural connectivity, dynamic behavior, and nonlinear and heterogeneous interactions between elements. It is this complexity that drives the need for ongoing study of these systems. Levinson’s goal in this case is to develop a better understanding of transportation network dynamics over time—that is, how these networks grow and decline. Gaining deeper knowledge in this area is particularly important considering that today’s decisions regarding transportation network expansion and contraction significantly alter the choices available to future decision makers.

In previous related research, Levinson, who brings a strong economic component to his analyses of transportation issues, developed a regression and a simulation model, which enabled him to partially examine the impacts of network expansion decisions in one point in time on future choices. He later used network dynamics modeling to bring together relevant transportation models to simulate network growth and further study network properties and dynamics. Now, he is working to expand this network growth model using agent-based modeling techniques, which, more so than trip- and activity-based modeling, provide a powerful, flexible travel forecasting framework that facilitates the prediction of important macroscopic travel patterns from microscopic “agent” behaviors, and thereby facilitates study on individual travel behaviors.

Levinson’s work on this agent-based travel demand model builds on the capability of the pilot model developed in year-four STAR efforts. In the pilot model, travel demands emerge from the interactions of three types of agents: intersections (nodes), arcs (road links), and land use (travelers or trips). But there are other agents in the transportation system, and they have significant impacts on travel demand. It is necessary, for instance, to define agents that represent transit links and railways so that these modes can be studied and more realistic traffic assignment algorithms can be approximated. In his current work, Levinson is using estimated model parameters based on Twin Cities network and land use data to incorporate the emergence of these new agents so that those impacts can be modeled and more fully analyzed.

Because network models play an increasingly important role in urban planning and transportation/land use policy evaluation, Levinson also is working to develop a policy analysis tool that combines the network growth model with policy models that reflect how well a given network satisfies selected performance measures (e.g., congestion levels, accessibility, and system cost). By comparing the predicted networks created using different investment strategies against their performance, the networks with the best performance (or preferred networks) and thus the preferred investment strategies that created them can be selected.

To some observers, decisions to expand transportation networks have been made, by and large, myopically in time and space and have generally ignored non-immediate and non-local effects. While this insular decision-making process tends to improve the relative speeds and capacities of links already in use in a network, the full ramification of network expansion—including future limitations leading to possible worsening conditions on the network—on future infrastructure decisions seldom has been considered.

Social and Economic Policy Issues Related to ITS Technologies
Student Norah Montes de Oca, David Levinson, and student Mike Corbett
Through ongoing refinements to network modeling techniques, Levinson hopes to provide transportation planners, managers, and other decision makers with the tools they need to better forecast future networks in much the same way similar models are used to forecast population and travel demand.

**Sustainable Technologies Applied Research Initiative: Modeling of Wireless Rural Emergency Medical Systems Performance**

Although the widespread use of cellular phones is a relatively recent phenomenon, these wireless devices have clearly become an integral part of a new digital lifestyle. And while wireless services afford people on the go the convenience of keeping in touch with family, friends, and work, they also have proven to be an invaluable safety tool for travelers, particularly those driving on rural roads. Over the last decade, use of mobile communications for emergency services has grown exponentially, and the increased demand created by these calls continues to put more and more pressure on the 911 system.

The spread of high-speed and wireless telecommunication throughout rural areas is creating far-reaching social impacts that have prompted University of Minnesota researchers to study ways of enhancing technology’s contribution to the development of small communities and the transportation networks that serve them. Specifically, Thomas Horan, research fellow at the Hubert H. Humphrey Institute of Public Affairs, is leading a multiphase examination of wireless networks and their use for emergency management systems. As part of the Humphrey Institute’s State and Local Policy Program (SLPP) and the ITS Institute’s Sustainable Technologies Applied Research (STAR) initiative, this study aims to improve the understanding of emergency response and management systems (ERS/EMS) aspects of intelligent transportation systems, giving special attention to measuring and communicating about the performance of these systems.

The research is being conducted in three phases. The first involved developing a draft architecture for investigating rural ERS/EMS based on field visits and an in-depth case study in Minnesota. This framework allowed researchers to identify related technology, institutional, and policy issues and make recommendations for improvements. The second phase, currently underway, involves building on Phase I findings to outline performance metrics and the potential role of technology in monitoring and improving ERS/EMS performance. For example, one use of ITS can be to provide real-time data of system performance, such as ambulance response times. A second case study of the Baxter/Brainerd, Minnesota, area—which included interviews with Minnesota Department of Transportation (Mn/DOT) experts, State Patrol members, and Public Service Answering Points (PSAP) representatives—was conducted to test this Web system.

During this year-long study of the Baxter/Brainerd area, Horan gathered information necessary to gauge the demand for emergency response and the need for technology. Through the process, he discovered that all days are not equal when it comes to fatalities. In this study region, five events control the majority of fatalities—the fishing season opener, an auto race, and the Memorial Day, Labor Day, and Fourth of July holidays. As a result, there can be big spikes in crashes and in response times.
Horan used business-process software populated with data collected from the Brainerd case study to simulate rural EMS systems under both normal and crisis conditions in order to model and assess system performance. The simulation revealed the extent to which rural response systems quickly can become overloaded during peak or crises periods. This simulation was completed by case study interviews that enabled contextual analysis and revealed the need for a more dynamic and comprehensive management information system as well as a forum for sharing EMS performance information across the full range of organizations involved in EMS. The interviews also identified various policy constraints to enhancing EMS systems, such as a lack of funding for new technologies. And, while local EMS providers may have an intuitive understanding of how the entire system performs, evidence shows that there is a lack of systematic data to support, confirm, or refute perceptions about overall performance.

Horan asserts that using technology to respond to emergencies in rural areas should be a top transportation and public health priority. However, experts agree that although the technology exists to support a fully operable, state-of-the-art, end-to-end E-911 emergency management system, the reality of making these networks work efficiently and effectively is complicated. Phase 3 of this STAR task will explore deployment issues for the EMS framework both in Minnesota and nationally. The drive behind all these efforts is to ensure that the speed, accuracy, and efficiency of dealing with 911 calls improve despite the fact that the volume of calls, especially those over wireless systems, continues to increase.