Human Performance and Behavior

Janet Creaser, Department of Mechanical Engineering
Evaluation of Minnesota’s NightCAP
Status: Completed
This project evaluated the Minnesota Department of Public Safety’s Operation NightCAP (Concentrated Alcohol Patrol) program. This overtime enforcement program uses saturation patrols to identify impaired drivers.

The research project consisted of three tasks: a crash data analysis, a driver survey, and an officer survey. The crash analysis indicated that saturation patrols have a marginal statistically significant effect on the decrease in fatal and severe-injury alcohol-related crash rates in Minnesota. The effect of a single saturation is small (about 0.1 percent), indicating that many patrols would be needed to see significant decreases in alcohol-related crash rates.

A survey of 5,000 Minnesota drivers in six counties resulted in 838 complet- ed surveys. Responses showed that approximately 18 percent of Minnesota drivers are aware of the program. Drivers’ beliefs about impaired driving influenced their perception of alcohol-enforcement programs and their choices about whether to drive after drinking.

Fourteen program coordinators and 86 law enforcement officers from the program also responded to a survey and shared their perceptions about the program’s effectiveness. The main conclusions drawn from the surveys were that saturation patrols are not highly visible to the public and the current program advertising is not very effective in communities where it is active. The primary recommendations from the research are to improve patrol visibility and associated advertising.

Project URL: www.its.umn.edu/research/projectdetail/?id=2006032

Motorcycle Riding Impairment at Different BAC Levels
Status: Completed
Alcohol is known to disrupt the effect of neurotransmitters and impair various psychomotor skills. Indeed, alcohol intoxication is a significant risk factor for fatal traffic crashes, especially for riding a motorcycle. At present, there is sparse research on the impairing effects of alcohol on skills involved in motorcycle control. This study was designed to measure the effect of alcohol (up to BAC 0.08%) on a broad set of basic riding skills. These riding skills were assessed on a test track with risk scenarios based on the Motorcycle Safety Foundation’s (MSF) training program. The study used a balanced incomplete block design to remove confounding artifacts (learning effects) by randomizing four BAC levels across three test days. Performance was characterized in terms of riding strategy used to cope with the effects of alcohol as a neurological stressor and the amount of resulting impairment with reference to specified performance standards. The analysis controlled for rider gender and age, riding skill, and drinking history.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2006085

Kathleen Harder, Center for Human Factors Systems Research and Design
Low-Cost Innovative Approaches to Improve Safety at Unsignalized Intersections on Four-Lane Highways
Status: In progress
Intersection crashes represent a significant portion of total crashes nationwide, accounting for an average of 9,000 fatalities and 1.5 million injuries annually. Without resorting to roundabouts or grade separations, there are a number of relatively low-cost approaches—either already in use in other countries or that could be developed—to improve the safety of unsignalized intersections on four-lane divided highways.

In the first stage of this research, the principal investigators (PIs) will use their expertise, along with computer simulation, to develop innovative and viable safety improvements at unsignalized intersections. A select group of traffic engineers will par- ticipate in a roundtable discussion to give input on the recommendations of the PIs, who will incorporate their suggestions. In the second stage, the recommended strategies will be tested at one representative intersection. Mn/DOT will implement the recom- mended interventions and provide data-collection technology. The PIs will conduct the field test, analyze the data collected, and submit a final report. Recommended improvements will likely have a significant impact on reducing the number and severity of crashes at unsignalized intersections on four-lane divided highways, benefit- ing motorists in Minnesota and across the United States.

Project URL: www.its.umn.edu/research/projectdetail/?id=2006049

Psychological and Roadway Correlates of Aggressive Driving (Phase II)
Status: In progress
This research was conducted to better understand the psychological and roadway correlates of aggressive driving. The study had two phases. In Phase I, survey data were used to investigate the relationship between personality, emotional, and behavioral variables and self-reported driving behavior. In Phase II, the findings were validated in a driving simulator experi- ment. The data yielded a number of interesting findings—in particular, there were significant differences in driving behavior between drivers character- ized as “hostile” and those characterized as “low hostiles.”

Our focus on psychological traits, emotional states, and behavioral tendencies is proving to be a valuable way to understand aggressive driving behavior. A future goal is to begin the process for determining mitigative strategies.

Project URL: www.its.umn.edu/research/projectdetail/?id=2002034

Stephen Simon, Law School
Second Generation In-Vehicle Driver Assistance for Teenagers (Year 2)
Status: Newly funded
Motor vehicle crashes are the leading cause of death for teenagers. With this project, systems with the potential to reduce the incidence of teenage-driver crashes was investigated. A first-generation prototype Teen Driver Support System (TDSS) has been designed and developed. This system has demonstrated the technical fea- sibility to develop systems that may reduce staggering teenage crash rates. However, the lack of sufficient parental interfacing severely limits the system’s use as a feedback tool. Before the start date of this project, a second- generation TDSS system (TDSS2) will have been built that ports some or all of the first-generation TDSS technolo- gies into a smart phone. Year 2 will involve developing feedback tools within TDSS2 that provide feedback to the teen driver and that help parents monitor teen driving progress. The research team utilized the prototype TDSS to develop a tool to improve the effectiveness of graduated driving licensure.

Project URL: www.its.umn.edu/Research/Proposal/200806.html

Stephen Simon, Law School, and Max Donath, Department of Mechanical Engineering
In-Vehicle Driver Assistance for Teenagers
Status: Completed
Based on statistics from the Centers for Disease Control and Prevention (2003), motor vehicle deaths are the leading cause of teenage fatalities. A possible approach to mitigate the incidence of teenage driver crashes and fatalities is through the use of in-vehicle technology.

The design and development of a first-generation prototype Teen Driver Support System (TDSS) to explore the feasibility and opportunities of such technology has been completed. The TDSS system includes technology designed to address several primary contributing factors associated with the majority of fatal crashes: speeding, seat belt use, driver inexperience, and alcohol use. This has been implemented using a combination of what the researchers call forcing, feed- back, and/or reporting functions. The research team is developing a form of ignition interlocks to enforce seat belt compliance and sober driving. A feedback function provides real-time tutoring and warnings about illegal or unsafe speeds through auditory warn- ings. A reporting function records ve- hicle information for parents to review and supervise (and enforce) teen driver performance. A speed feedback and reporting component is used for driver compliance with safe travel speeds. The system correlates the location (using GPS) of the vehicle to a digital road map and the road’s corresponding speed limit. A weather-based speed element incorporates current weather information that is used to warn a driv- er if the vehicle’s speed is too high for current weather conditions. Similarly, speed warnings specific to curves are included to warn if speed is excessive for the curve geometry.

With the prototype TDSS, the researchers developed a method of integrating a seat belt interlock that requires the driver’s seat belt to be
engaged before the vehicle will start. Seat belt use is continuously monitored during each trip, and lack of seat belt use is recorded for later review. An additional interlock for alcohol is reserved for teen drivers with preexisting alcohol-related convictions. Since alcohol interlock systems are commercially available, they can be demonstrated as an optional component of the TDSS.

In anticipation of potential future applications, such as the enforcement of certain graduated driver licensing (GDL) requirements, the system includes a biometric fingerprint component, which uses a fingerprint sensor to identify the driver and parent so that the system can log the number of training hours spent behind the wheel.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2004057](http://www.its.umn.edu/research/projectdetail.html?id=2004057)

- **Craig Shankwitz,** Department of Mechanical Engineering

  **Analysis of Highway Design and Geometric Criteria on Pedestrian Crashes**

  **Status:** Newly funded

  Forty percent of fatal highway crashes in Minnesota involve road departure crashes. Road geometry (e.g., curves or tangential sections) and road conditions (e.g., lane width, shoulder width, shoulder pavement type) likely play a role in these crashes. Previous research indicates that two key elements of design—horizontal curvature and shoulders—are primary factors affecting crash frequency and severity. However, the actual effect on crash frequency is not well documented; most of the cited safety strategies are considered experimental or tried (as opposed to proven) so that effectiveness ratios are questionable, and none of the supporting data are from Minnesota.

  This research will address these shortcomings. The first objective is to identify the features or characteristics associated with shoulder (type and width) and curve geometry (degree of curve and frequency) that affect road departure crashes. The second objective is to determine, where design changes or countermeasures have been deployed, whether these practices or other countermeasures have quantifiably decreased the frequency and/or severity of these crashes. The third objective is to identify which emerging technologies could be used as an appropriate countermeasure(s) to reduce the frequency and/or severity of these crashes.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2008005](http://www.its.umn.edu/research/projectdetail.html?id=2008005)

- **Nicholas Ward,** Department of Mechanical Engineering

  **Driver Performance During 511 Information Retrieval and Cell Phone Conversation Tasks, Combined Under Varying Levels of Traffic Density**

  **Status:** In progress

  See page 18 for coverage of this project.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2006028](http://www.its.umn.edu/research/projectdetail.html?id=2006028)

- **Thomas Smith,** School of Kinesiology, and **Nikolaos Papanikolopoulos,** Department of Computer Science and Engineering

  **Warning Efficacy of Active and Passive Warnings for Unsignalized Intersection and Mid-Block Pedestrian Cross-Walks**

  **Status:** In progress

  The efficacy of active warnings has received research attention in relation to pedestrian crosswalks, advance warnings at signalized intersections, and railroad crossings. Previous research results have shown that active warnings are clearly more effective than passive warnings at railroad crossings and in advance of signalized intersections. However, results regarding the relative warning efficacy of active versus passive pedestrian crosswalk warnings have been mixed. Given that the cost of active crosswalk warnings is substantially higher than that of passive warnings, further research is needed to ascertain the comparative warning effectiveness of active and passive warnings and to explore low-cost alternative designs. This project includes a literature review of research findings relevant to crosswalk warning systems, a field study of the relative warning efficacy of active versus passive warnings at selected pedestrian crosswalks, and a design analysis of low-cost alternatives for pedestrian crosswalk warnings.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2007028](http://www.its.umn.edu/research/projectdetail.html?id=2007028)

- **Nicholas Ward and Michael Manser,** Department of Mechanical Engineering

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

  **Status:** In progress

  Traffic fatalities are a significant issue for society, especially in rural environments. On a state and national level, two distinct demographic groups emerge with the highest risk of traffic fatalities: teen drivers (under 20 years old) and older drivers (65 or older). To significantly reduce traffic fatalities, it is necessary to implement traffic safety interventions designed to target each of these high-risk groups. This study uses focus groups and structured questionnaires given to various age groups (cohorts) of at-risk drivers. The data obtained will support recommendations for the type and form of intervention likely to be most effective and acceptable within each risk group and community area.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2007067](http://www.its.umn.edu/research/projectdetail.html?id=2007067)

  **The Use of Video Feedback in Urban Teen Driving**

  **Status:** In progress

  Newly licensed teens have an extremely high risk for crashes. According to the Insurance Institute for Highway Safety, in 2003 5,691 teenagers died in motor vehicle crashes. This amounts to more than one-third of deaths from all causes for teenagers. In response, the Universities of Iowa and Minnesota are leading a pilot project to examine the use of new methods to motivate safe teen driving. This method will examine teen driving during the first 6 to 12 months after teens obtain a driver’s license and is based on using an event-triggered video system to record and give feedback about unsafe driving behavior.

  The proposed system has the ability to provide feedback in two distinctly different ways. First, the system has an LED that blinks to tell the teen drivers that an event trigger has been detected and recorded, giving the driver immediate feedback. Data from the onboard diagnostics port such as speed, throttle position, and brake activity may also be recorded and synthesized with the video clips. The video data makes it possible to understand the context of the unsafe event and the task occupying the driver at that time, such as distraction or risky behaviors with passengers. Second, the video recorded during the “unsafe” driving episode is sent to the parent to allow for a second form of feedback: a parent-teen “coaching” session.

  This project will examine the use of event-triggered video feedback to reduce unsafe driving behaviors of newly licensed urban teens. This research differs from other interventional studies because it gives clear, contextual feedback in the form of video and audio of each unsafe driving episode captured. It is hoped that this type of feedback will help teen drivers become aware of the driving behaviors they engage in that may be unsafe, to recognize any patterns of unsafe behaviors, and to improve their driving for the long-term.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2007104](http://www.its.umn.edu/research/projectdetail.html?id=2007104)

- **Nicholas Ward and Michael Rakauskas,** Department of Mechanical Engineering

  **Rural and Urban Safety Cultures**

  **Status:** In progress

  Motor vehicle crashes are a predominant cause of mortality in rural areas. Persons involved in a rural crash are three times more likely to die than persons involved in an urban crash. Since most rural crashes involve rural drivers, it is necessary to consider the pertinent human factors by examining the relationship between the person-aliabilities and attitudes of rural drivers toward safety and the higher rural crash rate and driving style relative to an urban context. This project is attempting to support the development of a human-centered intervention to reduce the loss of life resulting from the high rural crash rate in Minnesota by investigating psychological and social factors that may predispose rural drivers to drive less safely.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2005058](http://www.its.umn.edu/research/projectdetail.html?id=2005058)

- **Xun Yu,** Department of Mechanical and Industrial Engineering (Duluth)

  **Real-time Nonintrusive Detection of Driver Drowsiness**

  **Status:** Newly funded

  Driver drowsiness is a major cause of serious traffic crashes. Continuous monitoring of drowsiness is therefore important for reducing crashes resulting from it. This research aims to develop a real-time, nonintrusive driver drowsiness detection system. Biosensors will be built on the automobile steering wheel to measure a driver’s heart beat. This will enable heart rate variability (HRV), a physiological signal with established links to waking and sleeping stages, to be analyzed to detect driver drowsiness. The novel design of measuring heart rate from biosensors on the steering wheel means the system will cause little annoyance for the driver, while the use of physiological signals ensures the accuracy of the drowsiness detection.

  **Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2008017](http://www.its.umn.edu/research/projectdetail.html?id=2008017)
Max Donath, Craig Shankwitz, and Nic Ward, Department of Mechanical Engineering, and Gary Davis, Department of Civil Engineering

**Status:** Complete

Minnesota joined with California, Virginia, and the FHWA in a pooled-fund consortium (the Infrastructure Consortium) dedicated to improving intersection safety. The Minnesota team’s objective is to develop effective strategies to mitigate high crash rates at rural intersections.

Rural Intersection Decision Support (IDS) focuses on enhancing a driver’s ability to successfully negotiate rural intersections. The system uses sensing and communication technology to identify safe gaps in traffic on a high-speed rural expressway and communicate this information to drivers waiting to enter it from a minor intersecting road. The goal of this system is to improve safety without introducing traffic signals, which on high-speed rural roads often lead to an increase in crashes.

The Rural IDS research program achieved four main research results through an analysis of rural expressway intersections: (a) the development of a technique to identify those with high crash rates, (b) the development of a statistical model that can be used to estimate the benefits of deploying IDS at a specific rural intersection; (c) the design and implementation of a rural intersection surveillance and data-acquisition system capable of quantifying the behavior of drivers; and (d) a task analysis, design study, and simulator-based evaluation of a Driver Interface Interface (DII) concept for communicating relevant information to stopped drivers.

The second item (b) was the result of a project led by Professor Gary Davis. In this project, statistical modeling was applied to crash data from 198 two-way, stop-controlled intersections on Minnesota rural expressways in order to identify intersections that were plausible candidates for future IDS deployment; develop a method for estimating the crash-reduction effect of IDS deployment; develop a method for predicting the crash-reduction potential of IDS deployment; and test the hypothesis that older drivers were over-represented in intersection crashes along U.S. Trunk Highway 52.

These objectives were accomplished using hierarchical model structures similar to those employed in the interactive highway safety design model. Five rural expressway intersections were identified as having crash frequencies that were atypically high, and this group included the intersection of U.S. Trunk Highway 52 and Goodhue County Highway 9, the site chosen for the prototype IDS deployment. It was then determined that a three-year count of crashes after deployment would probably be sufficient to detect any crash reduction effect due to the IDS, although a reliable estimate of the magnitude of this effect would require a longer test period. Assuming that IDS deployment would make the frequency of crashes at treated intersections similar to that of typical intersections, it was estimated that deployment of the IDS at the five high-crash intersections would, over a 15-year period, result in about 308 fewer crashes. Finally, using an induced-exposure approach, 12 intersections were shown an over-representation of older drivers, with 5 of these located on U.S. Trunk Highway 52.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2001048](http://www.its.umn.edu/research/projectdetail.html?id=2001048)

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Max Donath and Craig Shankwitz, Department of Mechanical Engineering

**Status:** In progress

In terms of ITS research, Montana has partnered with California and Virginia in a pooled-fund consortium, the Intersection Decision Support (IDS) project, to improve safety at intersections. The consortium is looking at both near- and long-term solutions that are effective, deployable, affordable, and beneficial to not only the participating states but to the nation as a whole.

The Montana effort is focused on rural intersection safety. Crashes at rural intersections, although less frequent than those at urban or suburban intersections, are often more costly than their counterparts because of the high vehicle speeds associated with them. The National Safety Council estimates that 32 percent of all rural crashes occur at intersections, and approximately one in every four fatal crashes occurs at or near an intersection.

To create a system that can be deployed nationwide, the extent of the national problem must be understood, and a nationally applicable solution to that problem must be designed, developed, tested, and evaluated. The University of Minnesota and the Minnesota Department of Transportation have initiated a state pooled-fund study to gain a national basis for deployment of its IDS Project. The plan consists of three facets. The first is a review of state intersection crashes for each participating state. The crash data will be used to understand rural intersection crashes on a national basis and to identify candidate intersection(s) for subsequent instrumentation and study. The second facet is participation in the process to design and refine candidate intersection Driver Infrastructure Interfaces (DII). Representatives from the pooled-fund states will participate in driver interface workshops and give input on the effectiveness of the design and its feasibility from the deployment, operations, and maintenance viewpoints. The third facet is development of a portable intersection surveillance system that can be used to instrument candidate intersections as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. Collection and analysis of such data will indicate whether regional differences exist regarding how drivers accept gaps at rural intersections and whether these differences are likely to affect the operation of the IDS system. Moreover, states choosing to instrument intersections will be well positioned to participate in the second phase of the IDS program, a field operational test designed to evaluate the performance of these systems.

The portable system has been developed and tested at the Minnesota test intersection at U.S. 52 and County 9 near Cannon Falls, Minn. The system was run for one month; a few problems were identified (e.g., sun glare, occasional wireless problems) but have been corrected. The next step is to acquire data in each of the partner states by February 2008.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2004039](http://www.its.umn.edu/research/projectdetail.html?id=2004039)

Max Donath, Department of Mechanical Engineering, and Ted Morris, Department of Civil Engineering

**Status:** In progress

The primary objective of this project is to develop management tools to predict and access interactions between traffic volume, wildlife behavior, visitor experience, and park computing, sensing, communications, and control systems.
research to help improve its operations and planning process. This research is using the archived ITS data to introduce and explore various research methodologies that can help Metro Transit improve service reliability, schedule adherence, and on-time performance. Visualizations of the data will be part of the research.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2007005](http://www.its.umn.edu/research/projectdetail.html?id=2007005)

**John Evans,** Department of Chemistry (Duluth)
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy

**Status:** Newly funded

This research seeks to develop low-cost sensing systems for monitoring ice and water on bridge deck surfaces. These sensing systems are based on the measurement of impedance of the sensor in contact with or in close proximity to ice, water, or aqueous solutions of deicing chemicals. The researchers will further explore alternative technologies. Impedance analysis at lower frequencies will determine the presence of solutions of deicing electrolyte (a type of “conductivity measurement”), while high-frequency dielectric relaxation using time-domain reflectometry will probe the physical state of precipitation and deicing chemicals on the deck or road surface. In both approaches, the methodologies will use significantly lower-cost electrodes in the respective impedance analysis schemes.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2008020](http://www.its.umn.edu/research/projectdetail.html?id=2008020)

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

**Status:** In progress

The Mn/DOT Office of Transportation Data & Analysis (TDA) manages 29 vehicle classification (VC) sites and 6 weigh-in-motion (WIM) sites installed on various roadways in Minnesota, and the numbers are expected to grow significantly within a few years. Consequently, the amount of data is expected to grow substantially, requiring an efficient data warehousing and management system.

This research will develop a VC/WIM data warehouse at the UMD Transportation Data Research Laboratory (TDRL) and provide the data reporting needs of TDA through online automation. For the data warehouse design, the characteristics of VC and WIM data will be carefully analyzed, and then the two types will be integrated as a single data resource from which a statistical summary can be queried directly from both types of data.

Since the TDRL currently archives statewide R/WIS data and Minneapolis-St. Paul freeway traffic data, the addition of WIM and VC data is expected to increase the amount and diversity of information by allowing researchers and engineers to cross-reference various types of transportation data.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2007036](http://www.its.umn.edu/research/projectdetail.html?id=2007036)

**Development of Portable Eight-Channel WIM Analysis System Based on Analog WIM Signals**

**Status:** In progress

Weigh-in-motion (WIM) data have long served as a key component for traffic data. Over the past few years, Mn/DOT has begun moving from the traditional expensive bending plates and load-cell-based systems to low-cost quartz Lineas technologies. In using quartz Lineas technology, one of the challenges has been determining how trustworthy the sensor readings are, since the only available outputs from the present systems are the converted weight and axle data.

This research aims to significantly improve WIM data quality by developing an eight-channel WIM analysis system that could simultaneously probe and analyze eight channels of analog signal and provide signal diagnostic data.

During the preliminary study on WIM funded by NTSRL over the past year, the researcher found that adding WIM measurement to the probe is not significantly difficult. The new system should be developed to operate in two operational modes: a probe mode and a data-collection mode. In the probe mode, it will simultaneously probe eight WIM channels, analyze the raw analog signals of each channel, and report the analysis results. In the data collection mode, the system should compute real-time weight translation and record the data so that it can operate as a stand-alone WIM data-collection system of up to eight channels (four lanes). The base system will be developed and field tested using off-the-shelf components so that Mn/DOT can easily reproduce in-house WIM data collection systems at a low cost.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2006022](http://www.its.umn.edu/research/projectdetail.html?id=2006022)

**Cellular Wireless Mesh Sensor Network for Comprehensive Spatial Traffic Movement Detection and Data Fusion (Phase II)**

**Status:** Newly funded

Humprey to build on its previous work using signalized, high-speed rural intersections that contain blind areas (where the view of approaching or crossing vehicles is blocked) are at a high risk for crashes. Static advanced warning signs or flashers in such intersections have been ineffective. This research proposes to develop and evaluate a new, dynamic LED (light-emitting diode) warning system to actively detect vehicles near the intersection and notify approaching vehicles that are crossing it.

The project will be conducted over two years, with the first year spent on developing system and control logic, and the second year on implementing and evaluating the advanced warning system.

There are two challenging aspects of rural implementation: the installation should not involve extensive construction, and the operation should not require connections to the power grid. Two ITS technologies developed by the current UMD research team solve the
two rural implementation challenges. The first is the solar/wind integrated renewable power station, which eliminates the need for connection to the electric grid. The second enabling technology is low-cost wireless magnetometers for detecting vehicle movements, which eliminates the wiring requirements in the intersection.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2008003

Freeway Network Traffic Detection and Monitoring Incidents
Status: In progress
Freeway management requires advanced data-collection methods. In particular, special emphasis is given to data such as vehicle trajectories, gaps, lane changes, and accelerations in weaving sections, freeway bridges, tunnels, and freeway segments around airports, rail, and bus stations. The process of collecting traffic data and recognizing patterns or events of interest is complex, since it often involves crowded scenes. The researchers suggest using cameras in the visible range in order to collect data and classify certain events as meriting further examination by a human operator. Examples include a car stopped on a bridge or a car driving erratically.

Several states and federal agencies use humans to observe these events and collect data. This project is working toward developing an automated system to collect this information and notify human operators about interesting data or events in the vicinity of the freeway network.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2005070

Counting Empty Parking Spots at Truck Stops
Status: Newly funded
With this project, the researchers plan to develop an automated truck stop management system that computes occupancy rates at stops and informs drivers of the availability of parking spots using variable message displays located about 30 or 40 miles before the stop. The proposed system will detect, classify, and localize vehicles on the truck stop’s grounds by using a set of video cameras, from which video frames will be analyzed in real time. Since the system will know exactly which spots are occupied, variable message displays onsite will be able to direct drivers to free spots. In some cases it would be possible for two or more smaller vehicles to share a single parking spot, so the system will also determine partial spot occupancy. The system will operate in two basic modes—a day mode and a night mode—that would typically require different methods for vehicle detection. For vehicle dimensions to be accurately estimated, the managed sites will be calibrated so that the correspondence between the camera views and actual site dimensions is available.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2006033

Nikolaos Papaniolopoulos and Osama Masoud, Department of Computer Science and Engineering
Automated Winter Road Maintenance Using Road Surface Condition Measurements
Status: In progress
This project aims to develop an automated road sander control system for a snowplow using the friction coefficient of the road surface and pavement temperature as key measurements for feedback. The project consists of two major technical activities, both of which have been completed. The first was the development of an improved tire-road friction measurement system on the SAFEPLow. The performance of the friction measurement system in terms of accuracy and reliability is being evaluated using experimental tests on different types of road surfaces with the snowplow.

Learning consists of extracting the relevant grammar for each class of events from the data. To accomplish the learning goal, the system makes use of a small number of trajectories corresponding to each class as provided by a user to obtain a preliminary model of the grammar. Using this model, the system iteratively refines the grammar from new trajectory data obtained directly from the scene. Given that the system requires only a very small number of labeled trajectories and can iteratively learn from the observed data, the system is easily portable to new scenes with little system initialization from the user.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2005037

New Battery-less Wireless Traffic Sensors as a Replacement for Loop Detectors
Status: In progress
This project is developing new battery-less wireless sensors to measure traffic volume, vehicle speed, vehicle length, and number of axles on each vehicle. Each sensor will comprise of two components: a piezoelectric element embedded in the road and a data processing unit located on the road shoulder. Compared to existing loop detectors, these sensors have several advantages: cost ($50–$100 each, compared to more than $700 in hardware for a typical loop detector); ease of installation (drilling a small hole in the road surface, with no wiring required to connect with the data processing unit on the shoulder); gathering new types of data (reliable measures of vehicle speed, length, and number of axles, as well as an estimate of vehicle weight); and significantly smaller roadside data-processing units.

This project aims to develop both a basic sensor (capable of measuring traffic volume, speed, and number of axles on each vehicle, emphasizing minimal size and ease of installation) and a full sensor that can also measure vehicle weight. Research activities include experimental tests to evaluate
Among the potential benefits of the system are that it will ensure the safety of the flag operators and the crew inside the work zone, and it will be inexpensive and portable. (The audio speaker system will cost less than $200, and the complete system including the radar-based automated intrusion warning system will cost less than $2,000. The audio speaker system could be used manually by itself if the flag operator to provide warnings to both the intruding vehicle and the work crew). The system will lead to fewer panic-stops and rear-end collisions and smoother transitions as traffic flows through the work zone, and the flag person will have better control of the traffic and will feel empowered with regard to safety.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2008004](http://www.its.umn.edu/research/projectdetail.html?id=2008004)

**Status:** Completed

A driver-assistive system that uses high accuracy, differentially corrected GPS (DGPS), high-accuracy geospatial databases, radar, computers, and driver interfaces (both a head-up display, or HUD, and a tactile seat), has been developed to help drivers maintain lane position and avoid collisions during periods of low visibility. These systems have been tested and deployed both in Minnesota and in Alaska.

Collision avoidance information is provided to a driver through the HUD. Objects located within the HUD field of view determined to be a threat to a driver are indicated as square boxes. White boxes represent an advisory, and if the detected object is fewer than 50 feet or three seconds from a collision, the box turns red (a warning).

**Research**

**SDRC and HDRC technology failed to meet expectations, but infrared imagery was successfully integrated with the standard HUD.**

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2004056](http://www.its.umn.edu/research/projectdetail.html?id=2004056)

**Status:** In progress

High-accuracy (2-8 cm) DGPS and high-accuracy (5-20 cm) geospatial databases are the primary components of the IV Lab driver-assistive systems. In addition to vehicle-based systems, the IV Lab geospatial database has found utility in other applications. For instance, the database has recently been used for the Intersection Decision Support (IDS) project, where radar sensors are used to determine the state of an intersection as a first step in warning drivers when it is unsafe to enter an unsignaled intersection. The geospatial database is used in this application to improve the ability of the radar system to determine whether a target represents a legitimate threat at the intersection. The IV Lab geospatial database was designed and optimized for vehicle applications and provides real-time access to extremely accurate, dense geospatial data. Because of this optimization, its functionality in other applications is somewhat limited.

As new applications arise, a more “global” approach to the design of the existing geospatial database is required. This research is pursuing a redesign of the geospatial database and database manager and the development of a new front end to serve a wide application base.

**Project URL:** [www.its.umn.edu/research/projectdetail.html?id=2005047](http://www.its.umn.edu/research/projectdetail.html?id=2005047)

**Guidance Augmentation Using VPS for Transit Applications (Phases I and II)**

**Status:** In progress

High-accuracy, dual-frequency, carrier-phase differential Global Positioning System (DGPS) units can provide kinematic positioning estimates with accuracies of a few meters.
centimeters under favorable conditions. High-accuracy DGPS serves as the basis of the various driver-assistive systems developed by the Intelligent Vehicles Lab.

Under FTA sponsorship, a DGPS-based lane-assist system was pilot tested by 16 trained Metro Transit bus drivers in mixed traffic on bus-only shoulders in 2002. Results of the pilot testing showed that the lane-assist system improved lane-keeping capability by approximately 75 percent compared to shoulder operation without assistance. However, driver stress did increase somewhat, indicating that more than a four-hour training session is needed to familiarize a driver with the system.

The DGPS system described above was tested on a suburban corridor. Urban areas offer significant obstacles to implementing this system, including restricted views of satellites, multipath reflection of satellite signals, and cellular network holes that interfere with DGPS connection. This project addressed these issues with urban DGPS by fusing the position information provided by a vehicle positioning system (VPS) with data from scanning laser sensors. In a previous ITS Institute project, VPS was developed to provide lane-level positioning. This provides the information needed to determine the lane of travel of a bus, as well as the length of the path traveled from a known reference. Also developed (albeit to a lesser degree) was a technique that uses laser scanners to identify the presence and location of curbs with respect to a moving vehicle. The goal of this project is to demonstrate an integrated urban lane-assist system for dedicated bus lanes, integrating information from VPS, laser scanners, and a map representation describing the optimal distance from bus to curb as a function of distance traveled along the lane.

Project URL: www.its.umn.edu/research/proposed/200805.html

Craig Shankwitz and Max Donath, Department of Mechanical Engineering
GPS Augmentation for Robust Lane Assistance
Status: In progress
The Minnesota Valley Transit Authority operates express bus service linking the southern suburbs with downtown Minneapolis. This express bus service uses bus-only shoulders to maintain bus route schedules during periods of high congestion. During periods of poor weather and low visibility, MVTA drivers are often unable to use the shoulders. To improve passenger service, MVTA hopes to operationally test lane-assist technology on the Cedar Avenue Corridor.

The Intelligent Vehicles Lab at the University of Minnesota has developed a number of differential GPS-based lane-assist systems for snowplows, state patrol cars, a meteorological data collection system, and MVTA has identified this as the technology it wants to deploy on Cedar Avenue.

Cedar Avenue between Apple Valley, Minn., and 78th Street (Minneapolis Trunk Highway 62) passes under a number of bridge decks. These bridge decks block GPS signals, rendering the lane-assist system inactive while under the bridge deck and for a period of 7 to 10 seconds after emerging from under it. This research is working to develop and test a DGPS-augmentation system designed to provide seamless vehicle positioning while passing through bridge decks. This project will facilitate a potential FTA-sponsored operational test and field demonstration of lane-assist technology on buses. This work does not address the problem where GPS signals are unavailable across larger geographical areas, such as those found in urban canyons or central business districts (i.e., downtowns). The proposed solution is not based on inertial measurements. In a narrow shoulder application, a bus that is 9.75 feet wide across the mirrors may operate in a 10-foot-wide lane. Moreover, after passing under a bridge, a GPS outage may last 5 to 10 seconds. To maintain lane position in this situation, an inertial system would have to allow only 6 inches of lateral error in a 10-second time span. With the technology available today, this requirement far exceeds the capability of an inertial solution.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2007093

Shashi Shekar, Department of Computer Science
Decision Support System for Evacuation Route-Schedule Planning
Status: In progress
Contraflow is a potential remedy for congestion during an evacuation resulting from a national security incident or natural disaster such as a hurricane. Given a transportation network having some travel arcs and designated nodes, the researchers have aimed to find a contraflow network configuration—i.e., an ideal direction for each edge—to minimize evacuation time. This problem is computationally challenging because of the very large search space. This work presents possibly the first macroscopic approaches for the solution of contraflow network reconfiguration incorporating road capacity constraints, multiple sources, congestion factors, and scalability. The researchers formally define the contraflow problem based on graph theory and provide design decisions to classify their approaches. An integer programming formulation is designed to produce optimal contraflow configuration, a greedy approach is applied to produce high-quality solutions, and a minimum cut is used to create a heuristic to deal with the infinite number of evacuees. Finally, the researchers evaluate proposed approaches both analytically and experimentally using a real-world data set; experimental results show that their contraflow approaches can reduce evacuation time by 40 percent or more.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004006

Hua Tang, Department of Electrical and Computer Engineering (Duluth)
Development of a New Tracking System Based on CMOS Vision Processor Hardware (Phase I)
Status: Newly funded
Vehicle tracking processes on roads are computationally very intensive. In the past, the different algorithms employed in vehicle tracking have been implemented using various software-based approaches. While software approaches have an advantage of flexibility in implementation and future modifications, the long computational time of these approaches often prevents real-time vehicle tracking from high-resolution spatial or temporal data. This gives rise to a need for direct implementation of tracking algorithms in hardware.

The goal of this project is to build a tracking system with a new algorithm based on vehicle motion detection, which is implemented in hardware whenever possible so that the computation time for tracking is minimized. The proposed overall tracking system consists of two parts. One is a hardware processor for vehicle motion detection. The other part is the software for tracking vehicles. The main computational time-saving for the tracking process comes from the hardware aspect, since the core of the new tracking algorithm—motion detection—is run on dedicated hardware for that particular purpose. The performance of real-time vehicle tracking can be greatly improved with such a hardware-based tracking system.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2008016

Pete Willemsen, Department of Computer Science (Duluth)
Snow Rendering for Interactive Snowplow Simulation: Supporting Safety in Snowplow Design
Status: Newly funded
During a snowfall, following a snowplow can be extremely dangerous. This danger comes from the human visual system’s inability to accurately perceive the speed and motion of the snowplow, often resulting in rear-end collisions. For this project, the researchers’ goal is to use their understanding of how the human visual system processes optical motion, under the conditions created by snow blizzard, to create a simulation framework that could be used to test emergency lighting configurations that reduce rear-end collisions with snowplows. Reaction times for detecting the motion of the snowplow will be measured empirically for a variety of color set-ups on a simulated snowplow that slows down while driving on a virtual road with curves and hills. The simulated driving environment will utilize a head-mounted, virtual reality display to render an improved snow cloud model behind the snowplow. This driving simulator environment will serve as the basis for testing the effects of color and lighting alternatives on reaction times. The results of this work will move the researchers closer to determining optimal color and lighting configurations on real snowplows.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2008014
Technologies for Modeling, Managing, and Operating Transportation Systems

Gary Davis, Department of Civil Engineering
Access to Destinations: Estimation of Arterial Travel Times Status: Completed
The primary objective of this project was to identify and evaluate parametric models for making default estimates of travel times on arterial links. A review of the literature revealed several candidate models, including the Bureau of Public Roads (BPR) function, Spiess’s conical volume-delay function, the Singapore model, the Skabardonis-Dowlng model, and the Highway Capacity Manual’s model. A license plate method was applied to a sample of 50 arterial links located in the Twin Cities seven-county metropolitan area to obtain measurements of average travel time. Also obtained were the lengths of each link, measurements of traffic volume, and signal timing information. Default values for model parameters were obtained from the Twin Cities planning model’s database. Using network default parameters, we found that the BPR and conical volume-delay models produced mean average percent errors (MAPE) of about 25 percent, while the Singapore and Skabardonis-Dowlng models, using maximal site-specific information, produced MAPE values of about 6.5 percent. As site-specific information was replaced by default information, the performance of the latter two models deteriorated; however, even under conditions of minimal information the models produced MAPE values of around 20 percent. A cross-validation study of the Skabardonis-Dowlng model showed essentially similar performance when predicting travel times on links not used to estimate default parameter values.

Project URL: www.its.umn.edu/research/projectdetail/?id=2006016

Safety Effect of Left-Turn Phasing Schemes at High-Speed Intersections Status: Completed
This research estimated crash modification factors (CMFs) associated with different left-turn phasing schemes at intersections where the major approach speed limit exceeds 40 mph. For installation of signals at what were previously thru/stop-controlled intersections, rear-end crashes increased while right-angle crashes decreased. Installation of the signal had no effect on major or minor approach left-turn crashes as long as the protected-only left-turn phasing was used on the major approaches. At one intersection where a signal was originally installed with permitted/protected phasing on the major approaches, the researchers found evidence for an increase in major approach left-turn crashes, which vanished when the major approach left-turn treatment was changed to protected-only. For several other phasing changes it was not possible to construct an after-treatment data set of sufficient size to permit reliable estimation of an effect.

This project also described a simple simulation model for left-turn, cross-path crashes, where a probabilistic gap acceptance model for the turning driver is combined with a standard braking model for the opposing driver. The model characterizes left-turn crashes as the result of the turning driver accepting a minimal gap and taking a longer time to complete his/her turn, while the opposing driver takes a longer time to react before braking. Reconstruction of an actual fatal crash, however, was more consistent with the opposing driver reacting normally, but with the turning driver selecting an atypically short gap. Characterizing the rate at which such selection errors occur would then be necessary to accurately predict left-turn crash frequencies.

Project URL: www.its.umn.edu/research/projectdetail/?id=2002043

Cross-Median Crashes—Identiﬁcations and Countermeasures Status: In progress
A cross-median crash occurs when a vehicle leaves its traveled way, completely crosses the median dividing the highway’s directional lanes, and collides with a vehicle traveling in the opposite direction. AASHTO’s Roadside Design Guide recognizes two countermeasures for preventing cross-median crashes: medians wide enough to provide adequate “clear zones” where a driver can stop or regain control of the vehicle before crossing into the opposing traffic stream, and installation of median barriers when medians are less than 10 meters wide and annual daily traffic is greater than 20,000 vehicles per day.

As with any safety countermeasure, installation should begin with those locations showing the greatest expected benefits. This project will first review the state of the art in median-crossing crash protection through a literature review and a survey of current practices. This will be followed by statistical insufficient measures of median-crossing crashes in Minnesota, with the goal of identifying those locations where countermeasure installation is most likely to pay off. Finally, this project will investigate and develop cost-effective tools for predicting the crash-reduction benefits of median barrier treatments on particular highway sections.

Project URL: www.its.umn.edu/research/projectdetail/?id=2005057

Gary Davis and Chen-Fu Liao, Department of Civil Engineering
Bus Signal Priority Based on GPS and Wireless Communications (Phase I: Simulation Study) Status: Completed
The final product of this project will be a database of arterial link travel times on the Twin Cities network for the years 1995 of the median-crossing

Project URL: www.its.umn.edu/research/projectdetail/?id=2007060

Gary Davis and Henry Liu, Department of Civil Engineering
Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II) Status: In progress
This research is a continuation of a previously funded project on arterial travel-time estimation. In Phase I, a suite of link-performance functions based on demand flow, traffic control, and geometric characteristics was developed and evaluated; the goal was to produce plausible default estimates of travel times when given predicted flows. The expectation was that these estimates could be updated where and when field measurements are available.

In Phase II, field measurement data such as traffic volumes, speeds, and traffic control plans will be acquired and a relational database integrating appropriate geographic information systems (GIS) capabilities will be constructed. The primary objectives of Phase II are to compute default estimates of arterial travel times on all Twin Cities arterial links by applying the methods developed in Phase I, to update these default estimates using the collected traffic data, and to incorporate these data into the database. Considering the correlation among network links, the travel time update with the link performance functions is non-trivial and the methodology needs to be designed carefully. The final product of this project will be a database of arterial link travel times on the Twin Cities network for the years 1995-1999.

Project URL: www.its.umn.edu/research/projectdetail/?id=2007060

Robert G. Feyen, Department of Mechanical and Industrial Engineering (Duluth)
Assessing Coordination Between Agencies Involved in Traffic Incident Management Status: Newly funded
One of the key roles of the Minnesota Department of Transporta-

Project URL: www.its.umn.edu/research/projectdetail/?id=2005038

Bus Signal Priority Based on GPS and Wireless Communications (Phase II: Signal Priority System Development) Status: In progress
Providing signal priority for buses has been proposed as an inexpensive way to improve transit efficiency and productivity while reducing operation costs. Bus signal priority has been implemented in several U.S. cities to improve adherence to schedules, reduce transit operation costs, and improve customer ride quality. Current signal priority strategies implemented in various U.S. cities mostly use sensors to detect buses at a fixed or preset distance away from an intersection. Traditional presence-detection systems, ideally designed for emergency vehicles, usually send signal priority request after a preprogrammed time offset as soon as transit vehicles are detected without the consideration of bus readiness.

This study’s goal is to take advantage of the already equipped GPS/WAL system on Minneapolis buses and develop an adaptive signal priority strategy that would consider bus schedule adherence, number of passengers, location, and speed. Buses can communicate with intersection signal controllers using wireless technology to request signal priority. Communication with the roadside unit (e.g., traffic controller) for signal priority may be established using the readily available 802.11x WLAN network or the DSRC (Dedicated Short Range Communication) 802.11p protocol currently under development for wireless access to and from the vehicular environment. This research will develop a prototype model using existing GPS and wireless technologies to provide signal priority for buses.

Project URL: www.its.umn.edu/research/projectdetail/?id=2007089

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Research

Security Using Remotely Operated Aerial Vehicles
Status: In progress

Recently, the idea of using remotely operated aerial vehicles (ROVs) for traffic management and infrastructure security has received significant attention. The economic and social motivations for using ROVs in this application are very compelling. For this vision to become a reality, however, methods for inexpensively building and safely operating these ROVs must be developed. Safety is paramount, since these ROVs are expected to operate over populated areas and potentially share the same national airspace with passenger-carrying aircraft.

This work will aim to develop and demonstrate a systematic methodology for evaluating whether the operational concept of using multiple ROVs to monitor vehicles and other traffic management parameters meets safety requirements established by regulation. The methodology involves identifying hazards associated with the operation and quantifying the likelihood of their occurrence. For hazards for which the likelihood of occurrence is judged to be too great, risk mitigation strategies will be developed. This methodology will be useful for establishing certification standards by federal and state agencies responsible for the safe operation of ROVs and for designers of ROVs, since they could be used to map operational requirements into hardware specifications. Operational procedure designers could also use them to determine the required operator qualifications.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2008018

Demoz Gebre-Egziabher, Department of Aerospace Engineering and Mechanics
Methodology for Evaluating the Concept of Operation for Traffic Management and Infrastructure

Demoz Gebre-Egziabher, Department of Aerospace Engineering and Mechanics, and Ted Morris, Department of Civil Engineering RPV/UAV Surveillance for Transportation Management and Security
Status: In progress

This work is aimed at developing the capabilities to investigate the technical and operational issues of using Remotely Piloted Vehicles (RPVs) or Uninhabited Aerial Vehicles (UAVs) for traffic monitoring. The outcome of this work will be a prototype flying platform, sensors, algorithms, and operational procedures that enable autonomous monitoring of highways and relaying of information in real time to remotely located decision makers.

To this end, a low-cost RPV instrumented with an inexpensive georeferencing sensor suite and a camera system has been built and flight-tested. The georeferencing sensor suite consists of a GPS receiver for generating estimates of position and velocity and an on-board high-speed moving platform for attitude determination. A dual camera system is used to capture video images. The georeferencing data and video images are transmitted via a data link to a ground station and used for real-time monitoring and pilot-in-the-loop control of the RPV. In addition to the video images, a synthetic image of the RPV’s area of operation is generated by fusing information from a digital terrain and cultural database with the GPS position solution. This synthetic image is displayed on the ground station computer and is used for enhanced situational awareness, which ensures that RPV operations occur outside controlled airspace at all times.

Soon, a GPS-based attitude determination system will be added to the RPV, which will enhance the georeferencing accuracy. In addition, the ground station will incorporate georeferencing and video data archiving capabilities. This will allow users to monitor vehicle cohorts to determine traffic parameters useful for traffic management. Operation of the systems and procedures developed will be validated in a final capstone demonstration. The demonstration will show how the navigation state vector of a ground vehicle can be estimated using remotely sensed data from an RPV.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2005040

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

Transportation professionals are sensitive to public dissatisfaction with work zone congestion, delay, and safety and are continually exploring new approaches to improve traffic operations in and around work zones. Transportation agencies are also challenged to balance the increasing need for work zone increases with public safety concerns expressed by the public and government agencies. Full road closure is one method that transportation agencies are considering as a potential way to balance these conflicting needs. It is a relatively new strategy of road closure that has never before been employed in Minnesota.

The purpose of this study is to analyze the effects and measure the benefits of utilizing full closure construction. This study has the unique advantage of using an actual ongoing project as a test case. Metro District has selected the full closure of Highway 36 to construct a project in North St. Paul. A comprehensive analysis of such a construction strategy includes the evaluation of all traffic operation alternatives in the greater project area, the cost/benefit comparison with other construction alternatives, market research to identify the public’s acceptance of the project during and after completion, and an identification of lessons learned.

The final product of a comprehensive study will be a guide for other projects considering full road closure as a construction alternative. This project covers the first part of the aforementioned comprehensive study, which is the evaluation of traffic operations and extraction of performance measures from the four basic traffic operation alternatives: no-build, build, non-full closure construction, and full closure construction. This research will provide valuable data for the cost/benefit analysis as well as effective traffic management on future full road-closure projects.

Project URL: www.cts.umn.edu/Research/ProjectActive.html?id=2007077

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

This research is in response to a request from Mn/DOT for the development of an intelligent control system for isolated intersections with high-speed approaches, including a platoon-priority control strategy and smart advance warning flashers (SAWF). A significant number of Mn/DOT signalized intersections operate under isolated control. At many of these intersections, it is not uncommon for an approaching platoon of vehicles to face a red signal because of a single vehicle on one of the conflicting approaches.
Responding to the Unexpected: Development of a Dynamic Data-Driven Traffic Operation Model for Effective Evacuation

Status: In progress

Recent natural and man-made disasters around the world have stressed the need for effective evacuation traffic management to maximize use of the transportation system. This research is responding to the need for innovative evacuation operation strategies and for evaluation of current evacuation planning models with advanced traffic modeling techniques. The goal is to advance the state of the art in evacuation modeling from the planning stage to real-time, dynamic operation by developing a suite of conceptual, analytical, and simulation tools for evacuation traffic management. To squeeze additional capacity out of current traffic networks and fully utilize available network capacity within the evacuation time window, this research is examining the idea of adaptive adjustment traffic operation strategies by comparing the difference between system-optimal states and real-world observations. The system-optimal states will be generated using a reference model in a rolling horizon scenario, and researchers will develop a feedback control mechanism using the difference from real-world observations. The model will be tested and evaluated using microscopic traffic simulation software with the network data set from the Minneapolis-St. Paul road network.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2007045

Development of Algorithms for Travel-Time-Based Traffic Signal Timing (Phase I)

Status: Newly funded

This research is in response to a Mn/DOT request for algorithms for travel-time-based traffic signal timing. With nationwide demonstrations of vehicle infrastructure integration (VII), and cell phones used as traffic probes, travel times may someday be a parameter available on roadways in real time. The USDOT envisions that one future use of real-time travel times may be to select timing plans for traffic signals. However, the theory on how to relate current real-time travel times to desired traffic signal timing does not exist. This project will study this relationship and develop algorithms that use real-time travel-time data for traffic signal control purposes. With available travel time, intersection delays can be estimated, and it is possible to use movement delay for green time split and offset. In addition, the researchers also plan to investigate travel-time data requirements for such applications. Data requirements include the spatial and temporal resolutions, time latency, and data accuracy. With different data requirements, it is likely different algorithms should be developed to relate travel time with traffic signal timing.

Project URL: www.its.umn.edu/Research/Proposed/200802.html

Henry Liu and Panos Michalopoulos, Department of Civil Engineering

Development of a Real-Time Arterial Performance Monitoring System Using Traffic Data Available from Existing Signal Systems

Status: In progress

See page 22 for coverage of this project.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2007035

Panos Michalopoulos, Department of Civil Engineering

Access to Destinations: Twin Cities Metro-Wide Traffic Micro-Simulation: Feasibility Investigation

Status: In progress

As traffic demand increases, the economic importance of effective traffic management is increasingly evident. Well-designed and well-managed roadway systems reduce the cost of transporting goods, cut energy consumption, and save countless person-hours of driving time. To reduce congestion, many countries have been investing heavily in road construction as well as improving their traffic control systems. However, since traffic management improvements are costly, alternatives must be carefully evaluated for their impact on the entire system. Traditional methods of design and evaluation have relied on empirically supported guidelines such as the Highway Capacity Manual. These methodologies have worked well for isolated systems such as freeway interchanges that are sufficiently distant from each other, but their use has encouraged the common practice of evaluating traffic management systems in isolation rather than as parts of a system. Several metropolitan areas—including Toronto, London, Barcelona, Tokyo, and Paris—have realized this problem and have invested in the creation of metro-wide simulation systems. These larger regions, such as the German state of Hessen, have also taken this path. In the United States, preliminary investigations of metro-wide simulation models have begun in Milwaukee, Wisconsin, the San Francisco Bay area, and Orange County in California. Such undertakings are not simple. Microscopic simulation requires a lot of information even for a small-scale application. The objective of this first phase is to have the creation of a Twin Cities metro-wide microscopic simulation model is to evaluate the feasibility of such a program, taking into account local needs and capabilities.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2006051

Development of Real-Time Traffic Adaptive Accident Reduction Measures for the I-94/35W Commons Section

Status: In progress

According to Mn/DOT statistics, the westbound section of Interstate 94 at the I-94/35W commons south of downtown Minneapolis, Minnesota, has the highest crash rate in the Twin Cities. In an ongoing project related to crash prevention and the detection of crash-prone conditions, this site was heavily instrumented and observed, and detailed traffic measurements were analyzed. Data showed that these incidents occur under certain traffic conditions that can be detected prior to a crash.

This project is capitalizing on the results of the ongoing research by utilizing the available techniques for the early detection of crash-prone conditions to develop a traffic calming/driver warning system for reducing crashes. The system will be specifically tuned for maximum effectiveness on the I-94 section. The goals of this first phase are to develop microsimulation models based on available technologies and site characteristics; implement the designs in an appropriate visualization environment; and perform a preliminary evaluation and prioritization of the crash-prevention solutions. The more promising solutions will later undergo thorough human factors analysis (e.g., driving simulator studies). Work will commence on the development of new and improved microscopic simulation models. These models should overcome the current model deficiency—the inability to emulate unsafe driving behavior—and will be capable of evaluating traffic safety solutions based on intelligent transportation systems approaches.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2005056

Employment of Traffic Management Laboratory for the Evaluation and Improvement of Stratified Metering Algorithm (Phase III)
**Status:** In progress

Evaluation results from a previous phase of this research demonstrated that the stratified zone metering (SZM) strategy was generally beneficial. However, freeway performance degraded by reducing ramp delays. Therefore, it is desirable to improve the effectiveness of the current SZM control.

There were two objectives for this project. One was to improve the control logic of the current SZM strategy. This was accomplished through an estimation algorithm for the refined minimum release rate. The simulation results indicate that the improved SZM strategy is very effective for postponing and decreasing freeway congestion while resulting in smoother freeway traffic flow compared to the current strategy. The second objective was to improve the current queue-size estimation. Depending on the counting error of queue and passage detectors, freeway ramps are classified into three different categories, and different methods are applied, respectively, for improved queue-size estimation. The surveillance video data were recorded, and results indicate that the proposed methods can greatly improve the accuracy of queue-size estimation compared to the current methodology. In addition, the proposed method was evaluated by microsimulation, results of which indicate the performance of the freeway mainline was significantly improved, and the total system performance is better than with the original SZM control.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2006074

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**Enhanced Micro-Simulation Models for Accurate Safety Assessment of Traffic Management ITS Solutions**

**Status:** In progress

In recent years, much research has been conducted in the development, implementation, and evaluation of various innovative ITS technologies aiming to improve traffic operations and driving safety. As part of the process, microsimulation has become an increasingly indispensable tool for assisting in system design and evaluation. As such work has proceeded, it has become clear that existing microsimulation models are deficient when evaluating sophisticated safety-related ITS techniques because they target only normal driving behavior under typical traffic flow conditions. Vehicle collisions are artificially excluded from simulation. To date, realistic car-following models pertinent to the true nature of driver behaviors that take into account subjective judgments, misperceptions, and randomness in driver’s reactions are lacking.

The goal of this research is to expand, or create new if necessary, car-following models capable of replicating real-life car-following behaviors with all its risks and imperfections. The research will focus on the detailed car-following data collected in Germany, Japan, and the Twin Cities to assist with model development, calibration, and validation. Concepts such as less-than-adequate perception—response times, stochastic selection of desired space headways, and driver inattention and misperception will be introduced to the improved (or new) car-following model. Research outcomes will help add a knowledge of real-life car-following behavior while improving microsimulation modeling to help assess freeway safety concepts at the high-definition microscopic level.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2006043

**Transportable, Low-Cost Traffic Data Collection and Wireless Surveillance Device for Rapid Deployment for Intersections and Arterials**

**Status:** Newly funded

In spite of recent advances in technology, most traffic engineering studies at intersections and arterial streets are still performed manually. This is especially true for measuring turning volumes at intersections. This is a task that needs to be performed at regular intervals for retiming traffic signals in order to minimize delays, stop excess energy consumption, and pollution levels as well as to improve coordination and reduce congestion levels. Not only are manual measurements subject to errors but also, because of time, logistics, and cost considerations, they are usually performed only when absolutely necessary (e.g., as a result of reconstruction, excessive public complaints, congestion, unusually high accident rates, or other emergencies).

This project aims to develop and test a rapidly deployable turnkey, low-cost, non-intrusive, stand-alone video-data-collection and surveillance system. Such a system will automatically measure traffic volumes, turning movements, speeds, and other characteristics to improve and study traffic operations at intersections and urban streets. The device will have additional features needed for visual verification such as video recording and wireless video for remote surveillance.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2008011

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**Panos Michalopoulos and John Hourdos, Department of Civil Engineering**

**Accident Prevention Based on Automatic Detection of Accident-Prone Traffic Conditions (Phase I)**

**Status:** Completed

The goal of this research was to provide low-cost innovative solutions for identifying the causes of crashes in crash-prone freeway locations and to develop a crash avoidance and prevention system. This was accomplished by simultaneously video-recording crashes and extracting raw traffic detector measurements utilized in understanding crash dynamics as well as the causes of crashes.

New traffic measurements such as traffic pressure, quality of flow, and others that can be derived from the raw data were defined, extracted, and analyzed to determine whether they were related to crashes and to identify crash-prone condition patterns. Based on this, a proactive algorithm for warning drivers and TMC operators was developed. This algorithm can be the cornerstone of a system aimed at calming traffic flow and effectively preventing crashes. The developed algorithm successfully established a relationship between fast evolving real-time traffic conditions and the likelihood of a crash. Testing was performed in real time during 10 days not previously used in the model development, under varying weather and traffic conditions. The crash likelihood model and the detection algorithm succeeded in detecting 71 percent of the crashes accompanied by a 5.4 false-detection rate. Most important, the algorithm is based on raw detector data (e.g., speed, occupancy, volume, time headway) that can be extracted from conventional sensors such as loops. In this manner the resulting system can be low-cost and implementable in both urban and rural settings.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2003031

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**Panos Michalopoulos and Henry Liu, Department of Civil Engineering**

**Employment of Traffic Management Laboratory for the Evaluation and Improvement of Stratified Metering Algorithm (Phase IV)**

**Status:** In progress

This project continues the work of the currently ongoing project related to improving and evaluating the effectiveness of Mn/DOT’s stratified zone metering (SZM) strategy. From field operations and offline evaluation, the improved SZM strategy was found to be effective in meeting the maximum ramp delay objective, at the expense of freeway and system performance, as expected. However, the strategy can be further improved in several ways. This research aims to address the most promising improvements by developing an efficient and streamlined optimization methodology to identify the best control parameter set for the strategy based on site and demand characteristics. These parameters are currently estimated by trial and error and are constant for the entire freeway system.

In addition, this research aims to produce a more reliable ramp demand-prediction technique and an improved location-dependent bottleneck capacity estimation methodology based on real-time traffic conditions. All the enhancements and improvements to the SZM strategy will be computationally feasible, and their effectiveness will be assessed by comparing it with the current prototype version through microscopic simulation. This will avoid costly, uncertain, and time-consuming field-testing as well as disruption of traffic flow.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2006074
Social and Economic Policy Issues Related to ITS Technologies

Frank Douma, Hubert H. Humphrey Institute of Public Affairs
Developing ITS to Serve Diverse Populations
Status: Completed
See page 25 for coverage of this project.
Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004047

Improving Car Sharing and Transit Service with ITS
Status: In progress
In partnership with the Minnesota Department of Transportation and the University of Minnesota’s Center for Transportation Studies, the State and Local Policy Program at the University of Minnesota’s Humphrey Institute of Public Affairs has performed a wide range of previous research regarding development of transportation policies enabled by intelligent transportation systems (ITS). Most recently, that research examined how ITS can serve Minnesota’s increasing diverse population and the increasingly diverse types of population it takes. Findings from that research showed that car sharing and advanced traveler information services (ATIS) were two ITS applications that could offer significant benefits. This research project focuses on developing policies to allow potential users to maximize the benefits of these services.
Project URL: www.its.umn.edu/research/projectdetail.htm?id=2006013

Thomas Horan, Hubert H. Humphrey Institute of Public Affairs and Claremont Graduate University
Status: Newly funded
SAFETEA-LL legislation mandates the creation of Strategic Highway Safety Plans (SHSPs) that are collaborative, comprehensive, and based on accurate and timely safety data. Transportation planners are challenged to identify and use a range of new data sources beyond traditional crash data systems; they must also identify strategies for sharing a wide range of data across multiple agencies to support evidence-based safety planning and emergency response. Likewise, while ITS has long promised safety benefits, the extent to which it is capable of providing safety-related data for assessment and planning purposes has not been emphasized.
This research project will examine the linkages between ITS systems and the SHSP, focusing on the role of ITS and emergency medical services (EMS) to provide timely and visually oriented safety data for system performance improvement and informed decision making. It will also consider how these systems might be adapted to the context of emergency/crisis planning.
Methods that will be employed in this project include analysis of existing data from safety reports (SHSP), ITS, EMS, and health information systems.

TechPlan: Transportation Planning and Policy Applications of ITS-Related Technologies
TechPlan: Transportation Planning and Policy Applications of ITS-Related Technologies is a research, education, and outreach program that addresses the ITS Institute’s high-priority transportation application area of societal issues related to ITS technologies. It is housed at the Hubert H. Humphrey Institute of Public Affairs’ State and Local Policy Program and funded by the ITS Institute at the Center for Transportation Studies. The overall objective of TechPlan is to investigate and propose policies that will take advantage of the increased presence of intelligent transportation systems (ITS) and ITS-related information and communication technologies (ICT) in the planning of transportation and related infrastructure. The work will include analysis of skills and challenges related to planning and managing regional and local transportation and infrastructure systems from a technological perspective, including identifying opportunities for training for both professionals and those seeking graduate degrees in the field.

David Levinson, Department of Civil Engineering
TechPlan—The Role of Social Networks and ICT on Destination Choice
Status: Newly funded
This research proposes to investigate the impact of traditional social networks and information and communication technologies (ICT) on travelers’ destination choices. The extent to which social networks and ICT affect where destinations are located is an area that is gaining more attention. This research will focus on two areas of interest. The first is the role that social networks and communication technologies play in establishing individuals in long-term arrangements such as finding their work. The second is the role that social networks play in daily-to-daily activities. The project plans to choose to engage in outside of their work. By using a survey about how people identified their current job, the physical locations of their social activity destinations, and the social networks and communication technologies they adopt to mediate both these long- and short-term decisions, this study aims to advance the researchers’ understanding of the role of social networks in everyday travel decisions. In two phases this project hopes to develop models that incorporate important elements of social networks and ICT for different trip purposes.
Project URL: www.its.umn.edu/research/projectdetail.htm?id=2008008

Kevin Krizek, Hubert H. Humphrey Institute of Public Affairs (formerly)
Understanding the Potential Market of Metro Transit Ridership and Services
Status: Completed
Ridership is a key element in the transit industry. Conventional travel analysis focuses on two types of transit users: captive and choice riders. Captive riders are typically those who lack an alternative to transit; they therefore use it as their primary mode of transportation to reach their destination. Choice riders are those who have realistic alternatives (e.g., driving) but choose to use transit for various trips. Service reliability and availability affects the ridership of both populations. However, it is assumed that substantial increases in ridership are usually derived only from choice riders. Populations not using transit may be further considered as two distinct populations: auto captives and potential riders. Auto captives are mainly auto users who don’t have transit as a potential mode of transportation or would not even realistically consider using transit. Potential riders are currently not using transit for certain reasons and/or concerns, but may consider using transit based on certain criteria.
This research analyzed results from two surveys conducted in the Twin Cities metropolitan region: one of existing riders and the other of non-riders. The aim was to understand the characteristics of both captive and choice riders, with an eye toward the factors that can increase ridership of the latter population. This research classified riders and non-riders differently from previous research. In addition to the captivity of modes, the
classification considers regularity of commuting. Accordingly, transit riders are classified as one of four categories: captive riders with regular commuting habits, captive riders with irregular commuting habits, choice riders with regular commuting habits, and choice riders with irregular commuting habits. Similarly, there are four types of non-riders: auto captives with regular commuting habits, auto captives with irregular commuting habits, potential riders with regular commuting habits, and potential riders with irregular commuting habits. Using the survey data to uncover such populations, this research then commented on how using advanced forms of technology could increase the ridership from various populations.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004060

Elizabeth Wilson and Kevin Krizek, Hubert H. Humphrey Institute of Public Affairs, and Julian Marshall, Department of Civil Engineering TechPlan—School Travel and the Implications for Advances in Transportation-Related Technology

Status: Newly funded

This project will evaluate how children’s school travel has been affected by new information and transportation technologies and by changes to education and transportation policy. How can ITS technology be effectively employed to address school travel, and how does its impact vary by age of student and travel distance? How can children’s travel to school be most accurately simulated—accounting for issues of school choice—to address congestion and safe routes to school? This project will begin to address such questions.

A basic understanding of how children travel to school and which factors influence parents’ decisions for school travel mode is critical for the deployment of innovative information and transportation technologies but has not yet been established. This research will establish accurate baseline information to evaluate how new forms of information, emerging transportation technologies, and other possible changes to education or transportation policy could affect children’s school travel. First, information will be collected on where children go to school and how they get there. Parents in three local school districts will be surveyed to learn: (1) the geography of where children live and attend school, (2) parent concerns about school travel and how technology may alleviate them, (3) travel modes used for school travel, (4) factors influencing travel and school choice, and (5) relevant socio-demographic information.

In collaboration with the Association of Metropolitan School Districts and local school districts, surveys will be distributed to parents. Distances traveled by each transportation mode will be mapped using Geographic Information Systems (GIS). Then the project will evaluate parents’ travel choices and the district’s use of buses, and compare travel behavior among districts with differing school-choice policy. This study will inform future investigations of emerging technological developments by providing essential information about which technologies might provide the most realistic utility for school transportation.

Project URL: www.its.umn.edu/research/projectdetail.html?id=2008009