Abstracts

HUMAN PERFORMANCE AND BEHAVIOR

Janet Creaser, Department of Mechanical Engineering
Evaluation of Minnesota’s NightCAP
Status: Newly funded
Discussions with Minneapolis’ Office of Traffic Safety indicate a strong need for a rigorous analysis of Minnesota’s saturation patrol enforcement strategy to reduce alcohol-related crashes. With 32,100 driving-while-intoxicated (DWI) citations and alcohol-related crashes costing $350 million in Minnesota last year alone, reducing the number of impaired drivers is a key focus for Minnesota’s Comprehensive Highway Safety Plan.

Minnesota conducts saturation patrols under a program called Operation NightCAP (Nighttime Concentrated Alcohol Patrol) as an alternative to sobriety checkpoints, which cannot be conducted legally in Minnesota. These saturations are coordinated by staff in each of the Minnesota State Patrol districts and include participation by county and local law enforcement agencies. Drivers who demonstrate unsafe behaviors (e.g., speeding, running traffic signals) are stopped, giving officers the chance to determine whether alcohol may be a factor in the observed behavior.

Although anecdotal evidence suggests that more DWI offenders are caught through the use of saturations, the actual effectiveness of the campaign in reducing alcohol-related crashes and deterring individuals from driving while intoxicated is unknown. Support for alternative enforcement programs like Operation NightCAP is hindered by a lack of understanding of its influence on the rates of DWIs and alcohol-related crashes. Since its inception, no formal, rigorous analysis of the effectiveness of Operation NightCAP has been conducted. Moreover, little research has been conducted on saturation patrols in general as an enforcement tool against drunk driving. The objective of this project is to describe the overall impact of saturations on DWI offenses and alcohol-related crashes in Minnesota, as well as identify the operational factors affecting the program’s usefulness.

Project URL: www.its.umn.edu/research/database.html

Kathleen Harder, College of Architecture and Landscape Architecture
Investigating the Effects of Rumble Strips on the Stopping Performance of Sleep-Deprived Drivers
Status: Completed (in FY05)
For this project, the researchers designed three studies to investigate the influence of in-lane (transverse) rumble strips on the braking patterns of drivers when the rumble strips are used to warn drivers of an upcoming traffic control device. Prior to these studies, no empirical work existed that could provide accurate confirmation of the effects of rumble strips on braking patterns. The researchers used a simulator to study braking patterns among sleep-deprived drivers who encounter rumble strips upon approaching a stop sign. The 20 subjects were commercial drivers between the ages of 25 and 60 with at least three years’ driving experience. Each participant drove the 60-mile test route four times. Driving performance was measured using a battery of tests, including an EyeCheck device, an acuity test, a contrast-sensitivity test, a psycho-motor-vigilance test, and a code-substitution test.

Results show little difference in mean approach speeds to controlled intersections with or without rumble strips. However, the presence of rumble strips caused drivers to brake to a greater extent earlier in the approach. Although sleep deprivation affected the steering patterns of drivers, it did not seem to affect their braking patterns.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003001

Psychological and Roadway Correlates of Aggressive Driving (Phase II)

Status: In progress
A greater understanding of the factors that contribute to aggressive driving will allow for the development of programs and policies to prevent and reduce it. This study was conducted to better understand the psychological and roadway correlates of aggressive driving. The study had two phases. In phase one, survey data were used to investigate the relationship between personality, emotional and behavioral variables, and self-reported driving behavior. In phase two, the findings were validated in a driving simulator experiment. The data yielded a number of interesting findings; in particular, there were significant differences in driving behavior between drivers characterized as “high hostiles” and those characterized as “low hostiles.” The researchers’ focus on psychological traits, emotional states, and behavioral tendencies is proving to be a valuable way to understand aggressive driving behavior; their goal is to begin the process to determine strategies for mitigating it.

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

Low-Cost Innovative Approaches to Improve Safety at Unsignalized Intersections on Four-Lane Highways
Status: Newly funded
There is national interest in using low-cost innovative treatments to improve safety on highways in the United States. Intersection crashes represent a significant portion of total crashes nationwide; they account 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 that are 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 an iterative design process, the researchers aim to develop innovative and viable safety improvements and use computer simulation to help select viable safety treatments. It is likely that, if implemented, the recommended improvements would have a significant impact on reducing the number and severity of crashes at unsignalized intersections on four-lane divided highways.

The study was conducted using a simulated driving environment consisting of various HRI scenarios and 25 subjects. Major results show that the presence or absence of a train, fog, or signage significantly affects dependent variables for all measurement intervals; the incidents of vehicles beating a train or hitting a train are higher with passive advance warning signs, relative to active warning signs; with a train present and clear visibility, for all measurement intervals, active advance warning signs are associated with lower mean vehicle speeds, compared to mean speeds observed with passive advance warning signs; active advance and crossing warning signs were perceived by respondents as more usable and

Tom Smith, School of Kinesiology
Reducing Risk-Taking at Passive Railroad Crossings with Active Warnings
Status: Completed (in FY05)
This simulated driving study evaluated driver interaction with a low-cost active warning system being considered by Mn/DOT for potential installation at passive highway-rail intersections (HRIs). The objective of the study was to ascertain if, relative to HRIs with passive signage, drivers interact more cautiously with HRIs equipped with active warning system technology.

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more perspicuous than passive advance and crossing warning signs; and finally, flashing words (e.g., a variable message sign) are perceived by respondents as more perspicuous than flashing lights on an active advance HRI warning sign. Project URL: www.its.umn.edu/research/projectdetail.pl?id=2000041

Active Advance Warnings at Highway-Rail Intersections Status: Newly funded

Although active advance warnings (AAWs) are not currently permitted at highway-rail intersections (HRIs), a recently completed Mn/DOT-sponsored simulated study by the principal investigator documents the potential safety benefits of installing AAWs at HRIs. Unlike AAWs at roadways signalized intersections, there are no dilemma zones associated with AAWs at HRIs, because at-crossing active warnings at HRIs do not have a (yellow) caution mode. Further, the AAW configurations evaluated in the previous study were limited. Nevertheless, if installation of low-cost active warning technology at currently passive HRIs proves feasible, including AAWs at HRIs is likely to receive serious consideration.

To further understanding among Mn/DOT and the surface transportation community regarding the impact of HRI AAWs on driver behavior, this research will conduct a simulated driving study to examine driver interaction with different types and configurations of HRI AAWs under both clear and limited-visibility driving conditions. The rationale is that, relative to AAWs at signalized intersections, understanding driver effects of HRI AAWs is more limited, and careful documentation of which type of HRI AAW system design might best promote safe driver behavior at HRIs has not yet been collected. Project URL: www.its.umn.edu/research/database.html

Deer Avoidance Research: Use of Motion Detector Flashing Light Status: Completed (in FY05)

This study explored three signage techniques in an attempt to reduce the incidence of vehicle/deer collisions on highways in Minnesota. A simulated environment was created along a stretch of U.S. Highway 23 near Marshall, Minnesota, with participants chosen from the University of Minnesota and the surrounding community. The simulation consisted of a standard warning sign as well as a prototype of the experimental signage. The prototype consisted of a beacon light attached to the top of the warning sign designed to flash when deer were present. During the simulation, participants were exposed to the standard signage as well as the new signage with and without the beacon flashing. The main objective was to determine whether the prototype signs would modify driver behavior such that drivers decreased their speed. The study found that the prototype signage was effective in decreasing the speed of the participants when the beacon light was flashing. These results were consistent across the variations of age and gender. The results for the prototype signage with the beacon light turned off were essentially no different from the standard signage.

Mike Wade, School of Kinesiology

Accident Analysis for Low-Volume Roads Status: Completed (in FY05)

For this project, three sets of analysis were carried out on the database. First was a descriptive analysis of the data to determine the general frequency rates of accidents. A second identified dangerous roadways. Counting the number of crashes on specific roadways and dividing this number by the average daily travel (ADT) on a roadway generated crash rates for those roadways, including county state aid highways (CSAHs), county highways, and township roads. Roadways with the highest percent were considered significantly dangerous. In the third analysis, crash rates were generated for specific locations. This method identified 14 dangerous locations: 9 on CSAHs, 3 on county highways, and 2 on township roads. There were only 235 cases where no improper driving was implicated. The remaining 1,554 cases suggested that driver error was the major cause. The factor most likely to be involved in an accident on a highway with an ADT of less than 400 is an animal. Road design factors such as number of lanes and the speed limit seem to be the factors related to these accidents. Project URL: www.its.umn.edu/research/projectdetail.pl?id=2002008

Driving Performance During 511 Information Retrieval and Cell Phone Conversation Tasks Status: Newly funded

Currently, Minnesota has a 511 service that users may
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In these studies, data were collected from each participant to establish the minimum velocity threshold for discriminating approach from withdrawal. The computer display presented a square similar in retinal size to that of a vehicle ahead on a highway. The display translates in a random direction, and at the same time it either expands (specifying approach) or contracts (specifying withdrawal). An adaptive program regulates the velocity to find the value at which participants were correct on 75 percent of the trials. Using these methods, the researchers found that as contrast between the simulated vehicle and background is reduced, much higher velocities are necessary for approach to be detected. In addition, a low-contrast display that flashes on and off, rather than being presented continuously, reduces sensitivity to information for a potential collision.

Physical measurements of luminance and color-contrast under real fog and blowing snow conditions were made. Researchers measured the way that snow filters the frequencies of light reflected from a snowplow and its surroundings in order to begin evaluating the effects of the paint colors selected on the availability of luminance-contrast and color-contrast information. Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003037

Improving the Ability of Drivers to Avoid Collision with Snowplows in Fog and Snow Status: In progress

The researchers have created a laboratory test bed for investigating the effects of blowing snow, fog (luminance contrast), flashing warning lights, and color on the ability of drivers to perceive that they are approaching or withdrawing from a simulated vehicle. Findings indicate that lowering the luminance contrast between the image of a vehicle and the background has a powerful negative effect on the ability to perceive approach. In a low-contrast situation, drivers required twice as much retinal motion as normal to begin to sense approach. Flashing lights, such as those mounted on snowplows to attract attention, also interfere with motion perception. The researchers have continued work to characterize the chromatic contrast effect of blowing snow and fog on the color space by making systematic physical measurements on a selected number of carefully chosen color surfaces. In addition, they have begun to use their computer-controlled laboratory simulation, and well-understood psychophysical methods, to investigate the impact of vehicle color and lighting enhancements. For example, they are investigating the effects of the number, location, color and flashing of warning lights on the ability to perceive that a driver is approaching a vehicle. Results at this time suggest that flashing displays may impair the ability of drivers to perceive that they are approaching a snowplow that is ahead.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2005

Mohamed-Slim Alouini, Department of Electrical and Computer Engineering

Bandwidth and Power-Efficient Modulations for Multimedia Transmission over Wireless Links Status: In progress

This project is motivated by the demand of spectrally and power-efficient transmission systems of multimedia traffic data (not only voice but also image and video) over wireless links. The main objective is to design and evaluate the performance of hierarchical constellation systems that offer different degrees of error protection and/or different rates for various bit streams. The main research achievements include the development and performance analysis of a variable rate non-coherent M-FSK modulation scheme for power-limited systems, the derivation of the exact-bit error rate expressions for a variety of hierarchical PSK and QAM constellations, and the investigation of the effect of fading as well as timing and phase-synchronization errors. This project is also pursuing several applications of hierarchical constellations, in particular, for simultaneous voice and data transmission over fading channels; for multi-resolution data transmission; and for multi-user opportunistic scheduling. Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003017

Vladimir Cherkassky, Department of Electrical and Computer Engineering

Quality of Service Implementation for Transmission of Video Data (Phase II)

Mohamed-Slim Alouini, Department of Electrical and Computer Engineering

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Vladimir Cherkassky, Department of Electrical and Computer Engineering

Quality of Service Implementation for Transmission of Video Data (Phase II)
and the severity of crashes. The consortium is looking at both near-term and far-term solutions that are effective, deployable, affordable, and beneficial not only to the participating states, but to the nation as a whole.

The focus of the Minnesota effort is rural intersection safety. Crashes at rural intersections, although less frequent than those at urban or suburban intersections, are oftentimes more catastrophic 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. Moreover, approximately one in every four fatal crashes occurs at or near an intersection. Because of the high speeds (and the associated high levels of kinetic energy), the ratio of intersection crash fatalities to intersection crash frequency is higher for rural intersections than for urban or suburban intersections.

To create a system that can be deployed nationwide, the extent of the national problem must be understood (and quantified where possible), and a 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.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004039

Ravi Janardan, Department of Computer Science and Engineering

Real-Time Collision Warning and Avoidance at Intersections

Status: Completed (in FY05)

Monitoring traffic intersections in real time as well as predicting possible collisions is an important first step toward building an early collision-warning system. In this project, the researchers present the computer vision methods used in a system addressing this problem and describe the practical adaptations necessary to achieve real-time performance. In their results, they present a novel method for three-dimensional vehicle size estimation and describe a method for target localization in real-world coordinates, which allows for sequential incorporation of measurements from multiple cameras into a single target’s state vector. Additionally, they developed a fast implementation of a false-positive reduction method for the foreground pixel masks and a low-overhead collision-prediction algorithm using the time-as-axis paradigm. The proposed system was able to perform in real time on videos of quarter-VGA resolution. The errors in target position and dimension estimates in a test video sequence are quantified.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2002025

Taek Mu Kwon, Department of Electrical and Computer Engineering (Duluth)

An Automatic Visibility Measurement System Based on Video Cameras (Phase II)

Status: Completed (in FY05)

Poor-visibility conditions often lead to large-scale chain crashes that might have been prevented had motorists been warned to reduce speed and remain cautious before moving into the poor-visibility zone. The objective of this research was to advance visibility measurement technologies that compute visibility by processing images captured with video cameras.

There are two fundamental difficulties in measuring visibility. The first is that visibility is a complex multivariable function of many parameters such as objects available, light sources, light scatter, light absorption, etc., so that measurements of one or two parameters (as in most of today’s visibility meters) cannot accurately estimate the true human-perceived visibility. On the other hand, any attempt to measure every possible atmospheric parameter to derive human-perceived visibility is simply too complex and costly. The second source of difficulty is attributed to the attempt to express the spatially variant nature of atmospheric visibility using a single representative value, distance. It works only if the atmosphere is uniform, which rarely happens.

A solution developed by the researchers is to measure visibility using visual properties of video images (perceived information) instead of indirectly measuring physical properties of atmosphere and converting them to visibility. The spatial variance problem in visibility was solved by introducing a new concept of relative measurement of visual information referred to as the relative visibility (RV). The researchers also studied the limitation of charge-coupled device cameras in visibility measurement applications and show how to overcome them through spatially arranged multiple targets. In addition, they explored various apparatuses of near infrared (NIR) light source and cameras for measuring night visibility.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2000024
TMC Traffic Data Automation for Mn/DOT's Traffic Monitoring Program

Status: Completed (in FY05)

The Minnesota Department of Transportation (Mn/DOT) has been responsible for collecting, analyzing, and publishing traffic counts from the various roadway systems throughout the state. The traffic reporting system — mainly developed by the Traffic Forecasting and Analysis Section (TFAS) of Mn/DOT — has been used in several federal programs, internal Mn/DOT applications, and by the private sector. This project sought to continue TFAS automation efforts by automating the TMC portion of traffic data (ITS-generated data) contributed to Mn/DOT's Traffic Monitoring System.

The focus was to develop an Internet-based system that produces computerized reports on continuous and short-duration count data. One of the challenges was in dealing with missing and incorrect data produced by faulty conditions of traffic data collection systems, including detectors and communication links. This study found that data imputation techniques based on spatial and temporal inferences of traffic flow can overcome the difficulties and produce accurate statistical data. One unresolved issue in this project was dealing with the stations in which nearly no data are available for the entire year, which was observed from two to three percent of the short-duration count stations. This problem is left for future work.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2001033

Integration of RTMS and SQL to Mn/DOT Next Generation R/WIS (Phase II)

Status: In progress

In the past, Road/Weather Information Systems (R/WIS) data and traffic data have mostly been managed in isolation, and thus the benefits attainable by correlating both types of data have not been realized. The researchers believe that correlating historical and real-time traffic data with R/WIS data can lead to better information. The objective of this project is to bridge the gap between R/WIS and traffic data by developing a new data collection and SQL database model that provides seamless integration. The goals for the developed model include reliable data collection, efficient data mining, and uniform data access for integrated R/WIS and traffic data applications.

For the choice of traffic sensors, a radar-based non-intrusive method called Remote Traffic Monitoring Sensor (RTMS) was originally proposed based on the advantage that it does not require lane closures or cutting into the roadways. However, this new project will add the available loop detector data located near R/WIS sites to the RTMS data in order to increase the number of integrated base stations. This addition will complement the limited number of the present RTMS installations (two) and expand the data flow from more diverse types of data sources. The loop detector data will be collected from the Transportation Data Research Laboratory data archive through online automation and loaded into the project’s data model.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2005046

Section Travel-Time Measurement and Vehicle Classification Using Inductance Signatures of Loop Detectors

Status: In progress

In Twin Cities’ metro-area freeways, loop detector stations have been installed at a half-mile spacing, forming sections. Each section thus consists of two sets of detector stations: one at the section entrance (upstream) and the other at the section exit (downstream). This research is studying a new way of measuring the average section travel time by tracing inductance signatures of vehicles from a pair of locations, the section entrance and exit. The basic methodology applied in this research is a blind de-convolution of inductance signatures that are directly obtained from loop detectors. From a system point of view, loop detector outputs can be considered as a result of convolution between the true vehicle inductance signature and the loop detector system function. Blind de-convolution is an attempt to restore the features of the original inductance waveform by reversing the loop convolution process. Time-stamped features of the upstream station and re-identification of those features at the downstream station enable the computation of travel time. As a preliminary study of hardware implementation, the researchers developed a “hardware-in-loop” system that interfaces a Canoga card with actual loops.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003027

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

Status: Newly funded

Weigh-in-Motion (WIM) data have been key to the design of pavement structures. Recently, Mn/DOT has begun to expand WIM equipment installations using quartz Lineas technologies to extend the present WIM bases to major roadways in the state. However, systems available from WIM vendors lack any capability of analyzing the raw WIM analog signals. Therefore, it has been difficult to determine how much the sensor readings are trustworthy, since the only available outputs from the existing systems are the final converted weight and axle data.

This research seeks to develop an eight-channel portable WIM analysis system that can simultaneously probe and analyze eight analog channels and thus be used as a system diagnostic tool. This new system will be designed as an advanced version of the two-channel system developed earlier in 2003 by the present researcher. The new system will have 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, and report the analysis results. The test report will include faulty channel conditions, signal...
health state, noise level, and signal deviations from the normal level from which data quality can be assessed or respective maintenance can be activated. In the data-collection mode, the system will have a real-time weight translation and recording capability so that it can serve as a portable WIM data acquisition system for up to eight channels (four lanes). Such a function not only helps explore development of portable WIM sensors but also provides a temporary replacement for malfunctioning WIM equipment units.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2006022

Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

Finding What the Driver Does

Status: Completed (in FY05)

Most research depends on detecting driver alertness by monitoring a driver’s eyes, face, head, or facial expression. This research presents methods for recognizing and summarizing driver activities by using the appearance of the driver’s position, and changes in position, as fundamental cues, based on the assumption that periods of safe driving are periods of limited motion in the driver’s body. The system uses a side-mounted camera and uses silhouettes obtained from skin color segmentation for detecting activities. The unsupervised method uses agglomerative clustering to represent driver activity throughout a sequence, while the supervised learning method uses a Bayesian eigen image classifier to distinguish between activities. The results validate the advantages of using driver appearance obtained from skin color segmentation for classification and clustering purposes. Advantages include increased robustness to illumination variations and elimination of the need for tracking and pose determination.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004038

Recognition of Human Activity in Metro Transit Spaces

Status: Completed (in FY05)

This research introduces a vision-based system to monitor for suspicious human activities at a bus stop. The system currently examines behavior for drug dealing activity, which is characterized by individuals loitering at a bus stop. To accomplish this goal, the system must measure how long individuals loiter at or near the bus stop. To facilitate this, the system tracks individuals from the video feed, identifies them, and records how long they spend at the bus stop.

The system is broken into three distinct portions: background subtraction, object tracking, and human recognition. The background subtraction and object tracking modules use off-the-shelf algorithms and are shown to work well following people as they walk around a bus stop. The human recognition module segments the image of an individual into three portions corresponding to the head, torso, and legs. Using the median color of each of these regions, two people can be quickly compared to see if they are the same person.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003039

Deployment of a Tracking-Based Monitoring and Data-Collection System

Status: In progress

This project is working toward the development and deployment of a flexible, portable, and reliable intersection-monitoring and data-collection system, based on vehicle-tracking methodologies implemented on one or more video cameras. Research activities include computation of a variety of traffic and behavior data such as turning-vehicle counts, vehicle trajectories, vehicle classes, delays, lane changes, gap acceptance behavior by turning vehicles, speed variations, safety-related data, and other types of intersection data as needed by traffic engineers. The proposed system could be used for assessing the effectiveness of existing signal timing plans and operational methods and the level of intersection safety. The researchers’ approach includes developing a user-friendly interface and employing existing camera hardware. The researchers also envision using the proposed system as the main tool for before/after study of the effectiveness of intersection and local-area improvement treatments.

Project URL: www.its.umn.edu

Freeway Network Traffic Detection and Monitoring Incidents

Status: Newly funded

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 areas like weaving sections, freeway bridges, tunnels, and freeway segments around airports and rail and bus stations. Vehicular—and even pedestrian—traffic is present in most of the sites. Collecting traffic data and recognizing patterns or events of interest is a complex process, since it often involves crowded scenes. This project is investigating the use of cameras in the visible range in order to collect data such as vehicle trajectories in the freeway system and classify certain events as ones that merit further examination by the operator. One example is a car stalled/stopped on a bridge or a car driving erratically. Right now, several states or federal agencies use humans to observe these events and collect data. This research will explore the development of an automated system to collect traffic data and notify human operators about interesting data or events in the general vicinity of the freeway network.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003042

Multi-Camera Monitoring of Human Activities at Critical Transportation Infrastructure Sites

Status: Newly funded

This research will investigate the use of multiple cameras for monitoring human activities at
Critical transportation infrastructure sites. This work leverages work performed under the researchers’ recent Department of Homeland Security contract. In particular, novel methods for employing image-based rendering to extend the range of applicability of human-motion recognition systems in transportation settings will be developed. The researchers also plan to demonstrate the use of image-based rendering to generate additional training sets for view-dependent human-motion recognition systems with direct applicability to critical transportation sites. Input views that are orthogonal to the direction of motion will be created automatically to construct the proper view from a combination of non-orthogonal views taken from several cameras.

To extend the capabilities of motion-recognition systems, image-based rendering will be utilized. The proposed methods will further be developed to automatically detect and spatially estimate an occlusion (common in crowded outdoor scenes) in world coordinates. The algorithms will be tested at a Mn/DOT-selected site (bridge, airport, or tunnel) or alternatively at two transit stations, one located in the Uptown (Minneapolis) area and the other at the Mall of America. The proposed methods are directly applicable to a wide variety of transportation infrastructure sites.

Project URL: [www.its.umn.edu/research/workplan/P2006009. html](http://www.its.umn.edu/research/workplan/P2006009. html)

**Portable Traffic Video Data Processor**

**Status:** Newly funded

The ultimate goal of this project is to produce a traffic vision data processor—in other words, a PC-based system that will accept videotapes from intersections, weaving sections, etc., and produce a certain set of desirable traffic data or other interesting traffic events. Depending on the traffic domain, interesting events might range from being clear cut and easily pre-specified by the user to being more abstract and defined as those events that deviate from normal behavior by some user-specified threshold. In general, for uncontrolled environments such as traffic sites where the target behaviors vary depending on the type, location of intersection, camera-viewpoint, etc., it makes more sense for the system to learn normal target behavior patterns from previously observed target trajectories for ease of portability.

Extracting target trajectories from image sequences in unconstrained environments such as outdoors is hard due to the dynamic nature of the scene that affects accurate target registration. Without a good estimate of target trajectories, it is impossible to derive any usable information about the target’s behavior in a scene. Hence, the main challenge in an application such as vision-based control is achieving robust target tracking.

Although several vision-based trackers with emphasis on outdoor scenes exist, most trackers make use of a single visual cue that can provide good target detection as long as certain constraints are satisfied. As soon as the scene changes in ways that violate the assumptions, the cues fail to provide any useful information, thereby rendering the tracker inaccurate in its objective. Hence, the researchers propose to make use of multiple visual cues so that the range of successful operation of the tracker can be increased by reducing the scene constraints. Finally, the proposed system will include mosaicking tools.

Project URL: [www.its.umn.edu/research/workplan/P2006055. html](http://www.its.umn.edu/research/workplan/P2006055. html)

Rajesh Rajamani and Lee Alexander, Department of Mechanical Engineering

Automated Winter Road Maintenance Using Road Surface Condition Measurements

**Status:** In progress

This project aims to develop an automated 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: 1) Improvement of an existing tire-road friction measurement system on the SAFEPLOW by using additional piezo sensors mounted on the inside of the tires of the snowplow. These additional sensors will help improve the accuracy and reliability of the friction measurement system. 2) Automation of the snowplow sander using real-time measurements from the friction measurement system and a pavement temperature measurement sensor, and experimental evaluation of the performance of the automated system on the SAFEPLOW.

This project will lead to the development of valuable winter maintenance technology in which knowledge of pavement conditions is used to keep roads in safe condition. The technology will help reduce material costs, help better utilize maintenance crews, and lead to safer roads in winter.

Project URL: [www.its.umn.edu/research/projectdetail. p?id=2005037](http://www.its.umn.edu/research/projectdetail. p?id=2005037)

**Lateral Stability of a Narrow Commuter Vehicle**

**Status:** In progress

A relatively unexplored but very promising solution to the problem of traffic congestion is the adoption of narrow vehicles for commuter travel. Narrow vehicles like motorcycles can significantly increase highway capacity by the use of half-width lanes. However, for the general public to adopt this form of personal transportation, narrow vehicles should perceptibly provide the same ease of use and the same level of safety as passenger sedans.

The research team has developed a new concept vehicle that is relatively tall compared to its track width so as to provide a travel height that is comparable to that of other vehicles on the highway. To help the driver balance a relatively tall, narrow vehicle, it incorporates an electronic tilt control system that ensures tilt stability. The tilt control system balances the vehicle and improves ease of use, especially on curves where the vehicle must lean into the curve to ensure tilt stability.

For this project, the design and implementation of a control system that ensures the tilt stability of the prototype narrow vehicle is presented. The control system—called Steering Tilt Control (STC)—uses steer-by-wire operation in which the front wheel steering angle controls tilt while perceptibly allowing the driver to use the steering angle for lateral control. A novel innovative algorithm was developed for STC that satisfies both the driver handling and tilt stability requirements.

The project includes significant detail on the design of the prototype narrow vehicle constructed by the research team, including dynamic modeling for narrow tilting vehicles. It also includes experimental results on the performance of the control system. The simulated system and the experimental vehicle are compared to illustrate the simulation limitations and also show similarities that validate the model. Experimental results show that the vehicle is stabilized very well by the controller within the limitations of its prototype hardware.

Project URL: [www.its.umn.edu](http://www.its.umn.edu)
Craig Shankwitz, Department of Mechanical Engineering
Bus Rapid Transit Technologies: Assisting Drivers Operating Buses on Road Shoulders
Status: Completed (in FY05)
The Federal Transit Administration (FTA) has identified bus rapid transit (BRT) as a means to increase the efficiency of transit operations while maintaining the transit's proven safety record. Because of the limited right-of-way available to build new (and possibly dedicated) lanes for BRT operations, the FTA has identified lane assist as an emerging technology that will enable deployment of BRT systems. The premise behind lane-assist technology is to increase the safety of BRT vehicles as they operate in the more unique environments, such as narrow lanes. Lane-assist technology will allow BRT vehicles to operate at the desired higher operating speeds while maintaining the safety of the passengers, BRT vehicle, and other public. Advanced BRT: Innovative Technologies for Dedicated Roadways
Status: In progress
In the United States, a number of transit agencies are either operating bus rapid transit (BRT) systems or are in the process of initiating this service. For example, Twin Cities Metro Transit operates a BRT system using a network of 200 miles of road shoulders to allow bus passage during periods of high traffic congestion. Lane Transit in Eugene, Oregon, and the Cleveland Regional Transit Authority are considering a BRT system, both of which are likely to use lane-assist technology on dedicated, narrow lanes. The present Intelligent Vehicles (IV) Lab lane-assist system is based on precise vehicle positioning technology and a high-accuracy digital road “map.” This system requires a reasonably clear view of the sky overhead in order to receive GPS satellite information. Without a clear view of the sky, GPS information is unavailable, disabling the lane-assist system. Urban canyons, roads with tall trees located close to the roadway, bridges, and underpasses all represent areas where the IV Lab system cannot receive satellite signals, and therefore cannot operate. This research will explore augmenting the IV Lab lane-assist system with ranging and positioning technology that will allow the system to operate in the difficult environmental conditions described above. Alternative ranging and positioning sensors will be analyzed, modeled, and eventually incorporated into the IV Lab lane-assist system. Successful augmentation will result in a system that meets the operational and robustness needs of transit agencies as well as the cost-effectiveness and reliability needs of the bus manufacturer and its original equipment manufacturer (OEM) supplier. Technologies to help the driver deal with traffic adjacent to or crossing over the dedicated bus lanes are also addressed as a first step to move BRT operations from dedicated to mixed traffic environments.

The IV Lab intends to work with transit agencies and bus manufacturer(s) to deploy an augmented DGPS-digital map lane-assist system for BRT narrow-lane applications in the United States.

Driver-Assistive Systems for Rural Applications: A Path to Deployment
Status: In progress
The first component of this project is to develop and implement an automated means to collect geospatial data and process it in order to create a geospatial database suitable for use in driver-assistive systems. Researchers will equip a vehicle with DGPS, sensing systems, image-capture hardware, image-processing software, and data-acquisition equipment that will facilitate the real-time determination of the global position of a paint stripe as a vehicle travels on a lane. With this sensory and data-acquisition system, the location of all paint markings on the roadway can be accurately determined and used as the basis of a multipurpose high-accuracy geospatial database.

A complement to the image-processing task will be the use of paint striping machines to collect geospatial data. The image-based system will be modified so that the global location of the paint nozzle can be determined from a sensor suite and a DGPS receiver located on the paint striping machine. Sensors will be used to determine when the paint is applied, and raw data from these systems will be converted into geospatial information.

The second component of this project is to form partnerships with county engineers who are responsible for snow removal in difficult environmental and visibility conditions. Two Minnesota counties (Polk and St. Louis) agreed to work with the Intelligent Vehicles Lab to test these systems. Initially, the goal was to map 22 miles of road in each county and train drivers to operate the system on these roads prior to the commencement of plowing operations. The Polk County system was based on a DGPS system that employs GPS corrections provided by a geosynchronous communications satellite. Such systems obviate the need for a local, ground-based GPS base station and the wireless communication equipment needed to get the correction to the roving vehicle, thereby offering sufficient performance at a much lower cost. However, satellite-based correction systems are slower to recover if satellite information or corrections are lost. Testing in Polk County will provide the opportunity to explore the tradeoffs between conventional and satellite-based correction systems. The GPS component
of the St. Louis County system was based on a conventional RTK system. During the winter of 2003–2004, operators in St. Louis County determined that they didn’t require a vision-enhancement system, due to the presence of dense conifer forests adjacent to the roads that block blowing snow and provide a solid visual reference. However, Polk County, which is flat, has few trees, and suffers from significant white-out events, was very pleased with its driver-assistive system and requested St. Louis County’s when they found out it was available. A second plow in Polk County was equipped with the technology, and an additional 150 miles of roads were mapped. Its system has been operational since October 2004 and has been used regularly throughout the winter of 2004–2005.

Gang Plowing Using DGPS

Status: In progress

Gang plowing is one method used by Mn/DOT to increase the productivity of snowplow operations. However, these gains in productivity often come at the expense of increased driver stress. These higher stress levels are the result of the low visibility caused by the snow clouds created by the lead snowplow and by anxious drivers trying to pass between the slower-moving plows. This research aims to improve gang plowing through the use of a driver-assistive system combining tactile steering feedback with throttle and brake actuators to help the driver of the following vehicle maintain the proper distance and lane position behind the lead vehicle.

The driver-assistive package improves safety on two fronts. First, driver stress and therefore driver fatigue will be reduced; alert drivers are in better control of their vehicles. Second, the driver-assistive system allows a tighter formation for the plows, reducing the opportunity for a rogue motorist to try to squeeze in between the ganged snowplows. A side-scanning laser sensor and a “virtual mirror” are also used to detect the rogue motorist trying to violate the gang formation.

This research builds on the driver-assistive work done under the Specialty Vehicle Initiative pooled-fund project. The results of the work performed under this project will be demonstrated on an actual road, Minnesota Trunk Highway 101 between Rogers and Elk River.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2002005

Infrared Sensors for Driver-Assistive Systems for Specialty Vehicles, Including Snowplows

Status: In progress

This research is investigating the applicability of infrared imaging sensors for use as a driver-assistive display interface for general specialty vehicle operations and as a sensor integrated into the University of Minnesota Intelligent Vehicles Lab’s driver-assistive system. This system, which includes radar-based obstacle detection, has been proven in several tests: in snowplows on Trunk Highway 101 between Elk River and Rogers, Minn.; in snowplows in field tests at the Rosemount Research Station; and on a fleet of vehicles including a Minnesota State Patrol car operating on T.H. 7 between Hutchinson, Minn., and I-494 in the Twin Cities.

Automotive radar suffers two fundamental shortcomings. The first is its inability to detect and “follow” obstacles moving perpendicular to the vehicle direction of travel. In contrast, the human visual processor driven by an imaging sensor (i.e., infrared sensors) is very sensitive to cross-track motion. The second shortcoming is that automotive radar will provide information pertaining to where an obstacle is (range, range rate, and azimuth angles) but not information regarding what the obstacle is. Infrared sensors can provide information regarding what is detected, but unless stereo sensors are used, cannot provide accurate information regarding where an obstacle is. Clearly, imaging and radar technologies complement one another. It is important to ensure that these imaging systems work well alone and that they can be integrated into driver-assistive systems as they are deployed. Camera systems including forward-looking infrared (FLIR) and Super Dynamic Range Camera (SDRC) have been evaluated, with the conclusion that inexpensive camera systems cannot compete with infrared systems. Recent work focuses on integration of infrared (IR) data with global positioning system (GPS) data provided by geospatial database queries using OpenSceneGraph. The primary challenge of this work is to integrate two image sources with different resolutions. When the system is complete, it will be tested on the SAFEPLOW research vehicle.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2004056

Multiuse, High-Accuracy, High-Density Geospatial Database

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 been used in other applications—for instance, for a new intersection decision support (IDS) project in which 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 unsignalized intersection. For this application, the geospatial database is used 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 as such it provides real-time access to extremely accurate, dense geospatial data. Because of this optimization, however, its functionality in other applications is somewhat limited. As new applications arise (e.g., the need to integrate high-accuracy geospatial data into a driving simulator), a more “global” approach to the geospatial database is required. This project proposes 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.pl?id=2005047

Quick Edge: Rapid Underbody Plow Cutting Edge Changing System

Status: In progress

Currently, cutting edges on snowplows are bolted to the plow blade with three or four fasteners. To ensure clear pavement plowing, substantial downward force is placed on the cutting edges, resulting in rapid wear and frequent replacement of the cutting edge. The process of changing cutting edges is time-consuming and tedious. Also, the limited space available forces mechanics to work in awkward positions and leads to back and joint injuries. This project explores an alternative to the current bolting process. The new system will be designed with the objective of reducing time and effort required in the change and decreasing the risk of injury compared to the current labor-intensive bolting
process. The alternative system has been designed and fabricated, and presented to the Minnesota Department of Transportation. Project URL: www.its.umn.edu /research/projectdetail .pl?id=2004058

Inexpensive Automated Bus Markup (Indoor Location) System

Shashi Shekhar, Department of Computer Science and Engineering

Decision Support System for Evacuation Route-Schedule Planning: Determining Optimal Network Configuration

Status: In progress

Evacuation route-schedule planning identifies paths to move populations to safe areas in the event of catastrophes, natural disasters, and terrorist attacks. Current approaches are based on assignment-simulation tools. However, the quality of solutions from these tools depends on the logical configuration of the transportation network. Currently, engineering judgment is used to select logical network configuration. This project aims to develop algorithms and software tools to determine effective logical network configuration given the physical transportation network and evacuation traffic demand—a challenging research problem due to the exponential combinatorial search space of possible solutions. The new algorithms will be integrated with assignment simulation tools and evaluated under specific scenarios. This research will provide new tools to help Mn/DOT find the optimal logical network configuration to supply to assignment simulation models toward effective evacuation route-schedule planning.

Recent research focuses on contraflow (reversing the direction of inbound roads) as a tool for reducing evacuation time. Contraflow is considered a potential remedy to solve congestion during evacuations. Currently available contraflow configuration algorithms only address a single-source/multiple-destinations situation. These approaches cannot handle a multiple-sources problem, which is harder due to conflicts across the optimal paths from different sources. In this project, evacuation situations are formally defined using graph and flow theory, and the contraflow problem is shown to be NP-complete. This research proposes two capacity-aware global contraflow heuristics that produce contraflow configuration in the presence of conflicts among routes preferred by different source nodes. These heuristics are evaluated using synthetic networks as well as real-world datasets. In addition, an algebraic cost model is developed. Experimental results show that these contraflow heuristics can reduce evacuation time by 30 percent or more.

Project URL: www.its.umn.edu /research/projectdetail .pl?id=2004059

Stephen Simon, Law School

In-Vehicle Driver Assistance for Teenagers

Status: In progress

Approximately 6,000 teenagers die on U.S. roads every year. Although teenagers make up only 4.6 percent of all licensed drivers, they are involved in nearly 13 percent of all fatal crashes. A possible approach to mitigating the incidence of teenage driver crashes and fatalities is through the use of in-vehicle technology. The Teen Driver Support System (TDSS) aims to address five primary contributing factors associated with the majority of teen fatal crashes: speeding, seat belt use, alcohol impairment, driver inattention/distraction, and driver inexperience. This will be implemented using a combination of what is called forcing, feedback, and/or reporting functions. Forcing functions will be in the form of ignition interlocks to enforce seat belt compliance and sober driving. A feedback function will provide real-time tutoring and warnings about illegal or unsafe speeds. A reporting function will record vehicle information for parents to review and supervise (and enforce) teen driver performance. An evaluation of past and present commercially available in-vehicle systems has identified a number of deficiencies; these systems are too passive and do not offer the best possible technological solution.

Validation of the TDSS will be accomplished over a three-phase program. The first phase of the project (design and development of a prototype TDSS system) is underway with funding from the ITS Institute. A speed-limit feedback and reporting system has been developed, and testing of the speed-limit notification system is currently underway. Alcohol interlock systems are commercially available and can be integrated into the system. Considering the cost, however, the alcohol interlock component would be reserved for teen drivers with preexisting alcohol-related convictions. Since seat belt interlock is no longer commercially available, a method of integrating a low-cost seat belt interlock is being explored. An outline has been drafted for two additional phases: 1) the design and evaluation of human interfaces for the selected feedback and reporting systems used to modify driving behavior (which will be based on a population of teenagers using a driving simulator), and 2) a subsequent multi-vehicle field operational test to evaluate the benefits of a TDSS. The goal of this research is to develop and validate a new support system that can be used by teen drivers, parents, the insurance industry, and government (through public policy, graduated licensing, etc.) to effect significant improvements in the near future.

Project URL: www.its.umn.edu /research/projectdetail .pl?id=2004057
Gary Davis, Department of Civil Engineering
A Case-Controlled Study of Driving Speed and Crash Risk
Status: In progress
In the United States, the imposition and subsequent repeal of the 55 m.p.h. speed limit has led to an increasingly energetic debate concerning the relationship between speed and the risk of being in a fatal crash. In addition, research done in the 1960s and 1970s suggested that crash risk is a U-shaped function of speed, with risk increasing as one travels both faster and slower than what is average on a road. Debate continues as to the causes of this relationship, and there is reason to suspect that it may be an artifact of measurement error and/or mixing of different crash types.

For this study, the researchers undertook two case-control analyses of run-off-road crashes, one using data collected in Adelaide, Australia, and the other using data from Minnesota. In both analyses the speeds of the case vehicles were estimated using accident reconstruction techniques while the speeds of the control vehicles were measured for vehicles traveling the crash site under similar conditions. Bayesian relative risk regression was used to relate speed to crash risk, and uncertainty in the case speeds was accounted for by treating these as additional unknowns with informative priors. Neither data set supported the existence of a U-shaped relationship, although crash risk clearly tended to increase as speed increased. The resulting logit model was then used to estimate the probability that a given speed could be considered a causal factor for each of the 10 Minnesota crashes.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2001038

Bus Signal Priority Based on GPS and Wireless Communications
Status: In progress
The Minneapolis-St. Paul metropolitan transit agency has installed global positioning system (GPS) equipment in transit vehicles for the purpose of monitoring vehicle locations and schedules in order to provide more reliable transit services. This research project evaluates the potential use of vehicle-mounted GPS to develop a transit signal priority system that improves the efficiency of transit. Bus signal priority has been implemented in several U.S. cities to provide more reliable travel and improve customer ride quality. Current signal priority strategies implemented in various U.S. cities have mostly used sensors to detect buses at a fixed or at a preset distance away from the intersection. Signal priority is usually granted after a preprogrammed time offset after detection. The strategy developed in this research will consider the bus’s timeliness with respect to its schedule, location, and speed.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2003014

Identification of Causal Factors and Potential Countermeasures for Fatal and Severe Rural Crashes
Status: In progress
Developing effective strategies for achieving a zero-fatality goal requires understanding the exact causes of traffic crashes. This project addresses the issue of causation first by reconstructing a set of run-off-road crashes and determining if the presence of barriers compliant with NCHRP 350 Test level 3 would have prevented the crashes, and second, by conducting an expert assessment of the presence of specified causal factors (and susceptibility to countermeasures) for a larger sample of fatal rural crashes.

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

Cross-Median Crashes: Identification and Countermeasures
Status: Newly funded
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 prevention of 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 modeling of the frequency of median-crossing crashes in Minnesota, with the object of identifying those locations where countermeasure installation is most likely to pay off. Finally, this project will investigate method(s) for predicting the crash reduction benefits of median barrier treatments on particular highway sections.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2005005

Demoz Gebre-Egziabher, Department of Aerospace Engineering and Mechanics
RPV/UAV Surveillance for Transportation Management and Security
Status: In progress
This research is aimed at developing the capabilities required to investigate the technical and operational issues associated with 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 the capability to relay the information in real time to remotely located decision makers. To this end, the research team is developing a low-cost RPV instrumented with an inexpensive geo-referencing sensor suite and camera system. The geo-referencing sensor suite consists of a WAAS-enabled GPS receiver for generating estimates of position and velocity. Attitude determination will be performed by a multi-antenna carrier-phase-differential GPS system. A dual camera system will be used to capture video images.

ABSTRACTS
The geo-referencing data and video images are transmitted via a data-link to a ground station and used for real-time highway infrastructure monitoring and pilot-in-the-loop control of the RPV. The ground station includes geo-referencing and video data archiving capabilities for playback purposes. Operational procedures that ensure that operations occur outside controlled airspace at all times will be developed. By monitoring vehicle cohorts, traffic parameters useful to traffic management can be determined. The researchers will validate operation of the systems and procedures developed in a final capstone demonstration that will show how the navigation state vector of a ground vehicle can be estimated using remotely sensed data from an RPV.

David Levinson, Department of Civil Engineering, and Kathleen Harder, College of Architecture and Landscape Architecture
Ramp Meter Delays, Freeway Congestion, and Driver Acceptance
Status: Completed (in FY05)
For this study, the researchers conducted several experiments using both the Computer Administered Stated Preference, or CASP, and Virtual Experience, or VESP, methodologies. Nominally, the same combinations of ramp meter waiting time and freeway travel time were tested in the first two parts of the CASP experiment (CASP-a and CASP-b) and in the first two experiments (VESPM experiment #1 and VESP experiment #2). The combinations of time spent waiting at ramp meters and driving on the freeway that were presented in CASP-a were the same as the combinations of desired ramp meter waiting and driving times for VESP experiment #1. Similarly, the combinations of times presented in CASP-b were the same as the combined desired times for VESP experiment #2. However, it should be noted that there was some variation in the actual driving times from the desired times in the VESP experiments. This variation occurred because in the VESP experiments the driving time was manipulated by varying the congestion level of the traffic in which the participants drove.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2002018](http://www.its.umn.edu/research/projectdetail.pl?id=2002018)

David Levinson, Department of Civil Engineering
Improving the Estimation of Travel Demand for Traffic Simulation
Status: Completed (in FY05)
Many current traffic management schemes are tested and implemented using traffic simulation. An origin-destination (OD) matrix is an ideal input for such simulations. The underlying travel demand pattern produces observed link counts that could be used to reconstruct the OD matrix. An offline approach to estimate a static OD matrix over the peak period for freeway sections using these counts was proposed in this research. Almost all the offline methods use linear models to approximate the relationship between the on-ramp and off-ramp counts.

Previous work indicates that the use of a traffic flow model embedded in a search routine performs better than these linear models. In this research, that approach was enhanced using a microscopic traffic simulator, AIMSUN, and a gradient-based optimization routine, MINOS, interfaced to estimate an OD matrix. The problem is highly non-linear and non-smooth, and the optimization routine finds multiple local minima but cannot guarantee a global minima. However, with a number of starting “seed” matrices, an OD matrix with a good fit in terms of reproducing traffic counts can be estimated. The dominance of the mainline counts in the OD estimation and an identifiability issue are indicated from the experiments. The quality of the estimates improves as the specification error, introduced due to the discrepancy between AIMSUN and the real-world process that generates the on-ramp and off-ramp counts, shrinks.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2001032](http://www.its.umn.edu/research/projectdetail.pl?id=2001032)

Measuring the Equity and Efficiency of Ramp Metering
Status: Completed (in FY05)
Ramp metering, which maintains smooth freeway mainline flow by limiting vehicle entry at entrance ramps, has been proposed and implemented in a number of metropolitan areas in and outside the United States to mitigate freeway congestion. This study sought to develop both efficient and equitable freeway ramp control strategies. Traffic conditions with and without ramp metering are evaluated on several representative freeways in the Twin Cities with a comprehensive set of performance measures. A unified theory for ramp metering is proposed based on a linear programming model of freeway traffic dynamics. The most efficient ramp control algorithm is found to be also the least equitable one. A novel control objective, minimizing weighted or perceived travel time, is therefore proposed to balance the efficiency and equity objectives of ramp metering. This research also developed a new family of applicable ramp metering strategies that consider both efficiency and equity and are demonstrated in a microscopic traffic simulator.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2001010](http://www.its.umn.edu/research/projectdetail.pl?id=2001010)

The Value of Traveler Information for Motorists
Status: Completed (in FY05)
While there is a sizable body of literature on the benefits of travel information, most of it is based on theory or on simulations. This experiment analyzed results based on a field test of 117 drivers completing the same point-to-point trip in their own vehicles via five different routes. Participants traveled both arterial and freeway routes, assessed the travel information that was provided, evaluated the importance of the accuracy of the information, and charted their route preferences for various trip purposes. Researchers were not looking merely for perceived time savings but also for driver perception of the value of the time saved in order to make projections about whether drivers would be willing to pay for accurate travel updates to reduce overall cost, anxiety, and uncertainty while driving. Knowledge of how much users want to pay for Advance Travel Information System (ATIS) services is necessary for the design of sustainable for-profit private services or private/public partnerships.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2004028](http://www.its.umn.edu/research/projectdetail.pl?id=2004028)

Panos Michalopoulos, Department of Civil Engineering
Accident Prevention Based on Automatic Detection of Accident-Prone Traffic Conditions (Phase I)
Status: In progress
Traditional measures to reduce crashes include improved geometric design, congestion management strategies, and better driver education and enforcement. While such measures can be effective, they are often not feasible or are prohibitively expensive to implement. This realization, along with the increasing need to reduce crashes and their side effects, has recently led to proactive approaches to avoid their occurrence.

One of the most promising options gaining wide acceptance in recent years is the concept of detecting crash-prone flow conditions in real time and warning drivers when the probability of a crash is high in order to increase their attentiveness. Evidence suggests that when driver
Development of Portable Wireless Measurement and Observation Station

Status: In progress

For this project, the researchers designed, assembled, and deployed a temporary detection and surveillance system to collect real-time data on traffic conditions. This information is critical in construction, advanced traffic management systems, traffic information systems, and other design and operational activities. Because traditional, permanent systems collect data by sensors in the pavement and transmit it through land-based communications, this equipment is subject to failure in construction areas. Through advancements in wireless technology, the developed system integrates machine vision sensors to collect data, compress digital video for surveillance, and use wireless communications for information retrieval and remote control. This new system can be added to current installations or used to create temporary traffic-monitoring systems.

Project URL: [www.its.umn.edu/research/projectdetail.pl?id=2002033](http://www.its.umn.edu/research/projectdetail.pl?id=2002033)

Development of Real-Time Traffic-Adaptive Crash Reduction Measures for the Westbound 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 will capitalize 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 will be to 1) define relevant solutions based on available technologies and site characteristics; 2) implement the designs in an appropriate visualization environment; and 3) perform a preliminary evaluation and prioritization of the proposed solutions. The most 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](http://www.its.umn.edu/research/projectdetail.pl?id=2005056)

Employment of the Traffic Management Laboratory for Improving the Stratified Metering Algorithm (Phase III)

Status: Newly funded

This project is a continuation of previous research related to testing and evaluating the effectiveness of the stratified ramp metering strategy through rigorous microscopic simulation. The stratified ramp metering strategy has been proven to be generally effective in keeping ramp wait times below the maximum allowed for each ramp after one year of field operation and a preliminary evaluation. However, some inherent limitations of the strategy need to be further explored. This research project aims to attack these limitations by developing a credible, efficient, and feasible methodology that can balance the control objectives of freeway performance and ramp delays and provide more accurate online ramp-queue size estimation. All the enhancements and improvements to the stratified ramp control strategy will be computationally feasible and their effectiveness will be assessed by comparison with the current prototype version using microscopic simulation.

Project URL: [www.its.umn.edu/research/projectdetail.pl?id=2005044](http://www.its.umn.edu/research/projectdetail.pl?id=2005044)

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

Status: Newly funded

This proposal is a continuation of the ongoing project related to improving and evaluating the effectiveness of Mn/DOT’s new stratified zone metering (SZM) strategy. From field operations and offline evaluation, the improved SZM strategy was deemed effective in meeting the maximum ramp delay objective, but at the expense of the freeway and system performance as expected. However, the strategy can be further improved in several ways. This research aims at addressing 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. Currently, these parameters are estimated by trial and error and are constant for the entire freeway system.

Additionally, 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 compared to the current prototype version through microscopic simulation to avoid costly, uncertain, and time-consuming field-testing as well as the disrupted traffic flow.
Streamlining of the Traffic Modeling Process for Implementation in the Twin Cities Freeway Network

Status: In progress

This project is attempting to streamline the traffic modeling process for practical implementation, thereby improving Mn/DOT engineers’ productivity in view of the new federal requirements for the design and planning of roadway improvements. Streamlining will also improve decision making and allow more widespread use of simulation internally for design, planning, operations, maintenance, and construction.

As part of this project, several rudimentary tools were developed to accelerate the simulation process; in the process, it became clear that better tools for obtaining high-quality data for simulation purposes were required. In collaboration with Mn/DOT’s modeling group, the research team has developed an efficient methodology for detecting and correcting erroneous freeway loop detector data (temporal outliers, spatial discrepancies, locked-on data, missing data, stuck data, etc.). This methodology includes an optimization-based algorithm for balancing freeway spatial discrepancies. The methodology has been successfully implemented as computer software called TradaX, which can greatly facilitate and streamline the traffic input preparation for microsimulation packages such as AIMSUN, CORSIM, or PARAMICS. The team is currently working with Mn/DOT engineers to enhance the TradaX program by extending its functionality and improving the user interface. The enhanced TradaX program will include an improved arterial intersection demand balancing algorithm, and will be extensively tested using various geometry configurations.

Project URL: www.its.umn.edu/research/projectdetail;pi?id=2004030

Enhanced Microsimulation Models for Accurate Safety Assessment of Traffic Management ITS Solutions

Status: Newly funded

Traffic simulation is increasingly becoming the tool of choice for evaluating new geometric designs as well as traffic control strategies. In fact, FHWA now requires every new project involving freeway reconstruction to be first evaluated through microscopic simulation. Unfortunately, where safety concepts are concerned, and even on evaluating the safety aspects of new geometric designs, current simulators are incapable of performing the task. The reason rests in the fundamental design of the underlying car-following models. All these different models have one common feature: they can only emulate the driving behavior of perfect drivers. It is impossible to emulate the actual “less than perfect” everyday driving behavior and the risk associated with the act of driving, therefore resulting in collision-free simulations.

The goal of this research is to expand, or create if necessary, traffic flow models capable of accurately replicating driving behavior with all its risks and imperfections. The research will capitalize on already collected detailed traffic data from actual freeway crashes. Concepts such as less-than-adequate reaction times, improper selection of headways, and poor visibility and distractions will be introduced to the improved car-following models. The outcome of this research will be used to emulate the occurrence of real-world crash-prone conditions as well as normative driving behaviors in collision-free situations, and thus facilitate the assessment of freeway safety concepts at the high-definition microscopic level.

Project URL: www.its.umn.edu/research/workplan/P2006033.html

Frank Douma, Humphrey Institute of Public Affairs

Developing ITS to Serve Diverse Populations

Status: In progress

In 2003, the State and Local Policy Program (SLPP) at the University of Minnesota’s Humphrey Institute of Public Affairs began research into how intelligent transportation systems (ITS) technologies can be used to deliver transportation services to an increasingly diverse population in Minnesota. The objective of this research is to identify the nature of the gap between the emerging needs and existing services, and to propose ways of using technology to bridge the gap, both in terms of providing better transportation options and in reducing the cost of these options.

Using the information obtained from emerging demographic data, the 2003 study focused on identifying transportation challenges and opportunities for several different populations, with a particular focus on those that do not or cannot drive. This project continues the theme through a series of analyses of ITS applications that appear most promising to improve mobility and access for Minnesota’s increasingly diverse population. These applications include technologically advanced community-based transit, car sharing, use of ITS to implement value pricing through conversion of a high-occupancy vehicle (HOV) lane to a high-occupancy toll (HOT) lane, and evaluation of Web-based Advanced Traveler Information Systems.

As of June 2005, work is ongoing in all of these tasks. Preliminary findings indicate that car sharing could have a positive impact on the transportation disadvantaged if subsidized. Work continues on the nature and size of that subsidy. In addition, a car-sharing program has started in the Twin Cities, and some data from that program are being collected. Other early findings show support for the HOV conversion across all income levels and gender. Analyses of a comprehensive survey on “non-traditional” community-based transit (CBT) providers continues, and innovations in CBT regulation that can promote collaboration have been reviewed. Finally, work continues on the ATIS evaluation.

Project URL: www.its.umn.edu/research/projectdetail;pi?id=2004047

Kevin Krizek, Humphrey Institute of Public Affairs

Understanding the Potential Market of Metro Transit’s Ridership and Services

Status: In progress

Metro Transit faces the challenge of serving a diverse audience that includes people of all ages and backgrounds with varying riding habits, needs, and preferences.

This research has two main goals. The first is to provide better knowledge of the composition of the travel market in the Twin Cities metropolitan area, in particular those inclined toward transit-related services. The foundation of this research comes from available data collected by Metro Transit, such as the rider and non-rider surveys that have been collected over the past several years. The former provides information on existing use; the latter gives insights into how to better attract