Human Performance and Behavior

Janet Creaser, Department of Mechanical Engineering
Evaluation of Minnesota’s NightCAP
Status: In progress
Discussions with Minnesota’s Office of Traffic Safety indicate a strong need for an analysis of Minnesota’s saturation patrol enforcement strategy to reduce alcohol-related crashes. With 82, 100 DWI citations and alcohol-related crashes costing $360 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. 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.

Since its inception no formal, rigorous analysis of Operation NightCAP has been conducted. Moreover, little research has been conducted on saturation patrols in general as an enforcement tool against drunk driving.

This project aims to describe the potential effect of saturations on DWI offenses and alcohol-related crashes in Minnesota, conduct a survey of Minnesota drivers to learn what they know about DWI enforcement and the NightCAP program, and conduct a brief survey of enforcement officers involved with NightCAP to identify any potential issues associated with conducting saturations.

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

Kathleen Harder, College of Architecture and Landscape Architecture
Low-Cost Innovative Approaches to Improve Safety at Unsignalized Intersections on Four-Lane Highways
Status: In progress

The study had two phases: In Phase I, survey data was 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 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 research 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 to determine strategies for mitigating aggressive driving behavior.

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

Stephen Simon, Law School
In-Vehicle Driver Assistance for Teenagers
Status: In progress

See page 15 for coverage of this project.

Thomas Smith, School of Kinesiology
Warning Efficacy of Active Versus Passive Warnings for Unsignalized Intersection and Mid-Block Pedestrian Crosswalks
Status: Newly funded
Results of past research on the efficacy of active warnings show that, relative to passive warnings, active warnings at railroad crossings and in advance of signalized intersections are clearly more effective. In contrast, results regarding the relative efficacy of active versus passive pedestrian crosswalk warnings are mixed. Given that the cost of active crosswalk warnings is substantially higher, relative to passive warnings, further research is needed to ascertain the comparative warning effectiveness of active versus passive pedestrian crosswalk warnings, and explore low-cost alternative designs for pedestrian crosswalk warnings.

This project will carry out 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/2007Projects/WarningEfficacy.html

Nic Ward, Department of Mechanical Engineering
Driving Performance During 511 Information Retrieval and Cell Phone Conversation Tasks
Status: In progress
Minnesota currently has a 511 service that users can access while driving. There is considerable debate about cell phones as a risk factor in traffic crashes. In 2003, Phase I research assessed the relative risk of cell phone use compared with other common risk factors, including existing in-vehicle tasks and alcohol. As a necessary extension of that research, this new project will assess the distractibility of low-cost alternatives for pedestrian crosswalk warnings at selected pedestrian crosswalks; and a design analysis of low-cost alternatives for pedestrian crosswalk warnings.
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 personalities and attitudes of rural drivers toward safety and the higher rural crash rate and driving style relative to the urban context. This project attempts 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.pl?id=2005058

**Albert Yonas**, Institute of Child Development
**Chromatic Perception Effects on Collisions with Snowplows**
**Status:** Completed

See page 16 for coverage of this project.

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

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 greatly decreases a driver’s ability to perceive approach. In a low-contrast, equiluminant 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 plan to characterize completely 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 will use a computer-controlled laboratory simulation, and well-understood psycho-physical methods, to investigate the effect of vehicle color and lighting enhancements. Results will make it possible to form recommendations to increase the safety of Minnesota drivers.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2005023

Computing, Sensing, Communications, and Control Systems

Mohamed-Slim Alouini, Department of Electrical and Computer Engineering
**Bandwidth and Power-Efficient Modulations for Multimedia Transmissions over Wireless Links**
**Status:** Completed

This project was motivated by the demand of spectrally and power-efficient transmission systems of multimedia traffic data (image and video as well as voice) over wireless links. The main objective was to design and evaluate the performance of hierarchical constellation systems that have the advantage of offering different degrees of error protection and/or different rates for various bit streams.

Research achievements include the development and performance analysis of a variable rate non-coherent M-PSK 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 also pursued several applications of hierarchical constellations—in particular, for simultaneous voice and data transmission over fading channels, multi-resolution data transmission, and multi-user opportunistic scheduling.

**Project URL:** www.its.umn.edu/research/projectdetail.pl?id=2003017

Max Donath and Craig Shankwitz, Department of Mechanical Engineering
**Toward a Multi-State Consensus on Rural Intersection Decision Support**

**Status:** In progress

Minnesota 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 Minnesota effort is focusing on rural intersection safety. Crashes at rural intersections, although less frequent than those at urban or suburban intersections, are often 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, 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 second facet is to develop 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. The third facet is to deploy the surveillance system at the identified intersection in each of the member states in order to determine if there are regional differences in how drivers accept gaps when entering the intersection.

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 but have been corrected. The next step is to acquire data in each of the partner states.

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

Ahmed El-Geneidy, Department of Civil Engineering
**Using Archived ITS Data to Improve Transit Performance Management**
**Status:** Newly funded

In the past, in order to measure transit performance, collecting the necessary data was difficult and costly. With the recent implementation of intelligent transportation systems (ITS)—and especially advanced public transit systems (APTS)—data collection is no longer an issue, but there is a concern with how this data can be meaningfully analyzed, creating information relevant for service planning and control.

Metro Transit, the local transit authority in the Twin Cities, has recently implemented an APTS, which it has been testing since 1999. Metro Transit uses the data obtained from the APTS for live transit operations through its transit management center to identify...
Abstractions

Development of Data Warehouse and Applications for Continuous Vehicle Class and Weigh-in-Motion (WIM) Data
Status: Newly funded
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. TDRL currently archives the statewide RAWIS data and the Twin Cities’ freeway traffic data. The addition of WIM and VC data would give Mn/DOT an easy single point of access to various types of transportation data and would increase the quality of

...
statistical data reports through inference by related data.

Project URL: www.its.umn.edu/research/2007Projects/DevData.html

Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

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

Status: Completed

This project developed a series of vision-based algorithms for data collection at traffic intersections. The researchers have proposed an algorithm for obtaining sound spatial resolution, minimizing occlusions through an optimization-based camera-placement algorithm. Along with this camera calibration algorithm, the research produced a camera calibration-guided user-interface tool and a computationally simple data collection system using a multiple cue-based tracker. Extensive experimental analysis of the system was performed using three different traffic intersections. The researchers propose solutions to the problem of reliable target detection and tracking in unconstrained outdoor environments as they pertain to vision-based data collection at traffic intersections.

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

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

Status: In progress

This research is investigating the use of multiple cameras for monitoring human activities at critical transportation infrastructure sites, leveraging work performed in the researchers' Department of Homeland Security (DHS) project. The methods deal with detecting specified activities and counting humans in crowded scenes. The researchers will further develop methods to automatically detect and spatially estimate an occlusion (common in crowded outdoor scenes) in world coordinates. The algorithms will be tested at the transit stations where the DHS system is currently deployed and will cover activities that are not of interest to the DHS but are of major interest to Metro Transit (e.g., loitering, graffiti, drug dealing). The proposed methods, which focus on human activities, are directly applicable to a wide variety of transportation infrastructure sites.

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

Portable Traffic Video Processor

Status: In progress

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.pl?id=2006018

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 meeting further examination by a human operator. Examples include a car stopped on a bridge or a car driving erratically.

Currently, 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 events or in the vicinity of the freeway network.

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

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 sanding 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: First is development of an improved tire-road friction measurement system. The researchers will further develop methods to automatically detect and spatially estimate an occlusion (common in crowded outdoor scenes) in world coordinates. As soon as the scene changes in ways that violate these assumptions, however, the cues fail to provide any useful information, thereby rendering the tracker inaccurate. This research will make use of multiple visual cues, so that the range of successful operation of the tracker can be increased by reducing the scene constraints.

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

Data Mining of Traffic Video Sequences

Status: Newly funded

This project proposes to address the problem of data extraction from traffic video sequences. The researchers plan to automatically learn the layout of a traffic site (e.g., an intersection) from trajectories of vehicles obtained by a vision tracking system. This approach will enable the automatic extraction of sophisticated and complex data such as unusual events, near misses, and vehicle trajectory clusters. The researchers will use a similarity measure that is suitable for use with spectral clustering in problems that emphasize spatial distinctions between vehicle trajectories. The researchers will evaluate the robustness of the method to small perturbations and its sensitivity to the choice of parameters, and will integrate the algorithms with a previous system recently delivered to MnDOT.

Project URL: www.its.umn.edu/research/2007Projects/DataMining.html
made on both of the above project activities. 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.pl?id=2002037

**Lateral Stability of a Narrow Commuter Vehicle**

**Status:** In progress

See page 20 for coverage of this project.

**Craig Shankwitz, Department of Mechanical Engineering**

**Driver-Assistive Systems for Rural Applications: A Path to Deployment**

**Status:** Completed

Deployment of any system is driven by market demand and system cost. Initial deployment of the Intelligent Vehicle Lab’s Snowplow Driver-Assistive System (DAS) was limited to a 45-mile section of Minnesota Trunk Highway 101; and 3) propose a system architecture for gangs of more than two vehicles and document its potential performance through simulation. Project URL: www.its.umn.edu /research/projectdetail.pl?id =2000209

**Quick Edge: Rapid Underbody Plow Cutting Edge Changing System**

**Status:** Completed

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.

To improve the gang-plowing process, a DGPS-based gang-plowing system has been developed. This system uses advanced technology to allow a trailing snowplow to automatically follow a lead snowplow at an operator-specified lateral and longitudinal offset. The system is designed to improve both safety and productivity.

Results of this research are described in a final report in which the researchers 1) describe an implementation of a virtual mirror to the left side of the trailing plow in order to improve driver visibility; 2) describe the lateral and longitudinal performance of a two-vehicle gang on Minnesota Trunk Highway 101; and 3) propose a system architecture for gangs of more than two vehicles and document its potential performance through simulation. Project URL: www.its.umn.edu /research/projectdetail.pl?id =2002038

**Advanced BRT: Innovative Technologies for Dedicated Roadways**

**Status:** In progress

In the United States, a number of transit agencies are either currently 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.

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.

This work aims to augment the present IV Lab lane-assist system with ranging and positioning technology that will allow the system to operate in difficult environmental conditions (e.g., urban canyons, roads with tall trees located close to the roadway, bridges). Alternative ranging and positioning sensors will be analyzed, modeled, and eventually incorporated into the IV Lab lane-assist system.

Researchers will address technologies that help drivers deal with traffic adjacent to or crossing over the dedicated bus lanes as a first step to move BRT operations from dedicated to mixed-traffic environments. As a means to this end, the IV Lab will 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.

To date, position-sensing methodologies have been developed; a vehicle positioning system (VPS) has been installed on vehicles and tested at the MnROAD low-volume pavement test facility. Researchers have applied for a patent on this technology. A second system, using an array of laser scanners to detect the known entities in the local landscape, has also been developed and briefly tested on the University of Minnesota Transitway.

The remote sensing system designed to ease a bus driver’s task of dealing with merging and exiting traffic at entrance and exit ramps will be tested in live traffic in 2006. In addition, because the Minnesota Valley Transit Authority (MVTA) has shown an interest in field testing a number of buses on the Cedar Avenue corridor, researchers have mapped a section of the corridor.
Researchers have evaluated as they are deployed in the future. It is important to ensure of comprehensive driver-assistive systems deployed prior to the deployment it may be that imaging systems are deployment timelines and budgets, driver-assistive system. Based on sensor integrated into the IV Lab for general spe sensors for use as a driver-assist This research project is investigating clearly complement one another. This research project is investigating the applicability of infrared imaging sensors for use as a driver-assist display interface for general spe -tivity vehicle operations and as a sensor integrated into the IV Lab driver-assistive systems. Based on development timelines and budgets, it may be that imaging systems are deployed prior to the deployment of comprehensive driver-assistive systems. It is important to ensure that these imaging systems work well alone and that they can be inte-grated into driver-assistive systems as they are deployed in the future.

As a means to this end, the researchers have evaluated and selected a camera and are working on the integration of the IR Image with geospatial data provided by database queries. OpenSceneGraph will be used to streamline the integration of visual data from these two sources. Technically, the primary challenge is to merge images of two different resolutions, and this work is currently under way. Once lab work is complete, the system will be implemented on the SAFEPLow research vehicle, tested, and demonstrated on-road.

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) geo-spatial 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 unsignal-ized 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 applica-tions 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 (e.g., the need to integrate high-accuracy geospatial data into a driving simu-lator, the desire by departments of transportation to more accurately represent roads), a more “global” approach to the design of the existing geospatial database is required. This research is attempting 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

Documentation of Crash Character-istics and Safety Strategies at Horizontal Curves on Rural Highways Status: Newly funded

Forty percent of fatal crashes in Minnesota involve road departure crashes; of these, 40 percent appear to have occurred on horizon-tal curves. This research intends to develop an understanding of the crash differences between tangent sections and horizontal curves specific to Minnesota’s rural two-lane highways. With a better understanding of the crash problem on Minnesota’s horizontal curves, Mn/DOT and its safety partners can be more effective at addressing the state’s crash problem, accelerating the Toward Zero Deaths initiative. Researchers will conduct a survey to identify locations where a safety countermeasure was applied to a horizontal curve and will review the crash records to determine actual performance. Knowledge of the actual effectiveness is important to highway agencies, especially if they are to use their limited resources effectively and proactively, as suggested by the Minnesota Comprehensive Highway Safety Plan. Based on the understand-ing of the Minnesota horizontal crash problem and the effective-ness of traditional countermeasures, alternative countermeasures will be proposed and their potential effec-tiveness analyzed. These alternati-ves may include infrastructure- or vehicle-based active curve-ahead or curve speed warnings.

Project URL: www.its.umn.edu /research/2007Projects/ RuralDocumentation.html

Safety Effectiveness of Narrow Paved Shoulders: Development Strategies to Reduce Lane De-parture Crashes and Fatalities Status: Newly funded

Run-off-the-road crashes constitute a considerable portion of Minnesota’s traffic fatalities. One traditional solution to this problem has been to pave and/or widen shoulders. Many highway agen-cies are adding shoulder rumble strips, while some agencies are experimenting with shoulder rumble strips combined with narrow paved shoulders. In Minnesota, the state-of-the-practice is to pave shoulders if at least six feet can be provided.

This research begins by quantify-ing the difference in crash charac-teristics for shoulders with different pavement types and widths. This will quantify the additional safety benefit associated with widened shoulders. Researchers will conduct a before-and-after analysis for tradi-tional and innovative shoulder treat-ments for Minnesota’s highways, allowing engineers to better select the appropriate shoulder treatment given the usual constraints (e.g., cost, right-of-way, environmental impact). Finally, the costs and benefits of adding shoulders to Minnesota’s roads will be compared to the cost and benefit of deploying an in-vehicle lane-departure warning capability. Minnesota is deploying a wide-area, high-accuracy GPS correction network that could be used as a basis for an in-vehicle lane-departure system. Comparing improved road shoulders to in-vehicle solutions will produce an optimal deployment strategy leading to improved safety.

Project URL: www.its.umn.edu /research/2007Projects/ EffectiveShoulder.html

Shashi Shekhar, Department of Computer Science and Engineering

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

See page 21 for coverage of this project.
Access to Destinations: Estimation of Arterial Travel Times

Status: In progress

This project aims to develop, test, and recommend methods for network-wide estimation and prediction of travel time on arterials. The researchers expect the recommended method to produce plausible default estimates when given predicted demand flows and to update these default estimates where and when field measurements are available.

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

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 controls 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=2001032

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=2005033

Cross-Median Crashes: Identification 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 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=2005057

Safety Effect of Left-Turn Phasing Schemes at High-Speed Intersections

Status: In progress

In recent years increased attention has been given to predicting the effects of roadway improvements on traffic safety. Tools have been developed in cooperation with the Federal Highway Administration and the Transportation Research Board that attempt to predict crash experience, and these require estimates of crash modification factors (CMF) to produce predicted reductions in injury benefits. The tools make use of empirical Bayes statistics, which currently require that crash data be overdispersed. This research illustrates an alternative method for estimating CMFs that can be applied whether the crash data are overdispersed or not. The method combines the hierarchical Bayes model with a model that allows for
temporal changes in the covariates. The method was used to compute estimates for the CMFs associated with signalizing or changing the left-turn phasing of sets of non-rural intersections.

This research was especially interested in the effect on left-turn crashes. Marginally significant results found that signalization does not produce a definite effect on major-approach left-turn crashes; phase-changes on the major approaches from permitted/protected to protected phasing decreases the number of major-approach left-turn crashes; and phase-changes on the minor approaches from permitted to permitted/protected did not significantly affect the number of minor-approach left-turn crashes.

Project URL: www.its.umn.edu /research/2007Projects/BusSignal.html

Bus Signal Priority Based on GPS and Wireless Communications, Phase II: Signal Priority System Development

Status: Newly funded

Signal priority for transit has been implemented in various U.S. cities utilizing mostly 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 following detection. This research will take advantage of the GPS system installed on buses in Minneapolis and develop a signal priority strategy that could consider a bus’s schedule adherence, number of passengers, location, and speed.

The goal of Phase I of this study was to develop an adaptive signal priority strategy and to conduct an evaluation and simulation of the Franklin Avenue corridor from Dupont Avenue South to 27th Avenue South in Minneapolis. Preliminary data show that up to 20 percent of bus travel time along Franklin Avenue was the result of intersection signal delay during the morning and afternoon peak hours. This research project, Phase II, will develop a prototype system using GPS and wireless technologies to provide signal priority for buses.

Project URL: www.its.umn.edu /research/2007Projects/BusSignal.html

Toward the Next Generation of Traffic Counting and Prediction Methods, Phase I: Model Identification and Validation

Status: Newly funded

Estimates of life-cycle traffic volumes are frequently used in highway design, and the information relevant to these usually comes in three forms: continuous counts from permanent traffic counters, short-count samples from nearby or similar roads, and a short count from the road of interest. The ultimate goal of this project is to develop and deploy methods for combining these sources of information so as to produce optimal estimates of daily and annual traffic volume, by vehicle class, for any road segment in Minnesota. As with any statistical estimation procedure, the starting point is a defensible model of the processes generating these counts, and the goal of Phase I is to apply some recent advances in statistical estimation methodology to identify and validate the required model.

Project URL: www.its.umn.edu /research/2007Projects/NextGen.html

Demoz Gebre-Egziabher, Department of Aerospace Engineering and Mechanics

Methodology for Evaluating the Concept of Operation for Traffic Management and Infrastructure Security Using Remotely Operated Aerial Vehicles

Status: Newly funded

Recently, the idea of using remotely operated aerial vehicles (ROVs) for traffic management and infrastructure security has received a significant amount of 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 concept of 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/2007Projects/AerialVehicles.html

ROV Surveillance for Transportation Management and Security

Status: In progress

See page 17 for coverage of this project.

Henry Liu, Department of Civil Engineering

Development of a Platooning Prioritization Control Strategy and Smart Advance Warning Flashers for Isolated Intersections with High-Speed Approaches

Status: Newly funded

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 (AWF). A significant number of Mn/DOT signalized intersections operate under isolated control. At many of these signals, 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. In addition, Mn/DOT uses advance warning flashers—which warn motorists on high-speed approaches that the signal phase will be turning yellow—for selected intersections. However, the system introduces a trailing overlap of a fixed interval (leading flash) at the end of the arterial phase every cycle, which may cause some dilemma zone problems.

To address these issues, the researchers aim to develop an intelligent traffic control system for detecting vehicle platoons approaching a traffic signal with or without AWF to eliminate dilemma

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zone problems and adapt to time-variant traffic conditions. To evaluate and improve the proposed control system, the researchers will use hardware-in-the-loop simulation and quantify system performance improvements in terms of operational efficiency and safety.

Project URL: www.its.umn.edu/research/2007Projects/DevPlatoon.html

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

**Status:** Newly funded

As mandated in the new transportation bill, SAFETEA-LU, the USDOT will establish a real-time system management information program to provide the capability to monitor the traffic and travel conditions of the transportation network. Despite recent developments in the real-time measurement of freeway performance using routinely available loop detector data, no similar approaches exist for monitoring the performance of urban arterial street networks.

This project aims to fill in this gap. Its goal, therefore, is to develop a real-time online performance monitoring system for arterial streets. The arterial performance data will be also archived and made available to various stakeholders for operation, planning, research, and traveler information systems, similar to freeway performance data. In this project, the researchers will analyze data availability and requirements from the existing signal system, and will develop algorithms for estimating and predicting real-time arterial travel time and speed depending upon the data resolution. Researchers will first test these estimation algorithms with a microscopic simulation model, and, if successful, will field-test a prototype system.

Project URL: www.its.umn.edu/research/2007Projects/DevArterial.html

**Responding to the Unexpected: Development of a Dynamic Data-Driven Traffic Operation Model for Effective Evacuation**

**Status:** Newly funded

This project is in response to a request for innovative evacuation and incident operation strategies and evaluation of current evacuation planning models. The goal is to advance current state-of-the-art evacuation modeling from the planning stage to a real-time and dynamic operation stage by developing a suite of conceptual, analytical, and simulation models that function as real-time online tools for evacuation traffic management.

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. To “squeeze” the spare capacity out of the current traffic network system and fully utilize the available network capacity within the evacuation time window, the researchers will adjust the traffic operation strategies adaptively by comparing the difference between the system optimal states and real-world observations. The system optimal states will be generated using a reference model in a rolling horizon manner, and a feedback control mechanism will be developed using the data from real-world observations. The proposed model will be tested and evaluated using microscopic traffic simulation software with the network data set from the Twin Cities’ Metropolitan Council.

Project URL: www.its.umn.edu/research/2007Projects/ModelEvac.html

**Panos Michalopoulos, Department of Civil Engineering**

Development of Portable Wireless Measurement and Observation Station

**Status:** Completed

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 for construction of advanced traffic management systems, advanced traffic information systems, and other design and operational activities. Because traditional, permanent systems collect data by sensors in the pavement and transmit the data through land-based communications, the 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=2002030

**Employment of the Traffic Management Laboratory for the Evaluation and Improvement of Stratified Ramp Metering Algorithm through Microscopic Simulation**

**Status:** Completed

A new ramp metering strategy implemented on the Twin Cities freeway system to reduce ramp waiting times was evaluated through microsimulation of freeway activity. The study compared the stratified ramp metering strategy with the previous zone metering strategy and with no control strategy. Comparison with zone, which was designed to favor freeway activity, showed that the new strategy succeeded in greatly reducing ramp delays and lines. When compared to the results of no control strategy, it reduces freeway travel time, increases freeway speed, smooths the flow of traffic, and reduces the number of stops. However, travel time, fuel consumption, and pollutant emissions are unpredictable under the newer system. Compared to no control strategy, such measures of effectiveness may improve or worsen depending on the freeway patterns and demand. Based on these findings, the researchers will seek improvements to the design of the stratified ramp metering algorithm so as to factor in disruptive traffic patterns.

Project URL: www.its.umn.edu/research/projectdetail.pl?id=2001047

**Crash Prevention Based on Automatic Detection of Crash-Prone Traffic Conditions: Phase 1**

**Status:** In progress

See page 19 for coverage of this project.

**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 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 define relevant solutions based on available technologies.
Employment of the Traffic Management Laboratory for Improving the Stratified Metering Algorithm (Phase III)

**Status:** In progress

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. The project is focused on developing a 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 comparing with the current prototype version using microscopic simulation.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2005056](http://www.its.umn.edu/research/projectdetail.pl?id=2005056)

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

**Status:** In progress

In the past years, research has been conducted on replicating real-life car-following behavior while improving the microsimulation modeling to facilitate the assessment of freeway safety concepts at the high-definition microscopic level. The outcomes of this research will help advance the understanding of real-life car-following behavior while improving the microsimulation modeling to facilitate the assessment of freeway safety concepts at the high-definition microscopic level.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2006074](http://www.its.umn.edu/research/projectdetail.pl?id=2006074)

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2006043](http://www.its.umn.edu/research/projectdetail.pl?id=2006043)

Streamlining of the Traffic Modeling Process for Implementation in the Twin Cities Freeway Network

**Status:** Completed

This project sought to streamline the traffic modeling process for practical implementation, thereby improving MnDOT engineers’ productivity in view of the new federal requirements for the design and planning of roadway improvements. The result is the development of comprehensive methodologies for improving the quality of both freeway and arterial intersection traffic volumes for the purpose of enabling and improving traffic simulations. Specifically, established and enhanced procedures for checking and correcting freeway and arterial intersection traffic counts. Initial evaluations of these tools suggest that they could potentially reduce total modeling time by 25–30 percent while resulting in improved calibration of simulation models, more reliable analysis, and better use of MnDOT staff resources for meeting project deadlines.

**Project URL:** [www.its.umn.edu/research/projectdetail.pl?id=2004030](http://www.its.umn.edu/research/projectdetail.pl?id=2004030)
Social and Economic Policy Issues Related to ITS Technologies

Frank Douma, Humphrey Institute of Public Affairs
Developing ITS to Serve Diverse Populations
Status: In progress

In 2003, the State and Local Policy Program at the University of Minnesota’s Humphrey Institute of Public Affairs began research into how ITS technologies can be used to deliver transportation services to an increasingly diverse population in Minnesota. The research objective is to identify the nature of the gap between 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. This project continues that

Further research will continue to improve urban transportation mobility and accessibility by developing an agent-based model of network growth that integrates land use, travel demand, cost functions, pricing schemes, and investment rules to simulate the growth (and decline) of urban transportation networks. The following objectives will guide the research work in year six: refine the cost functions and the land use module of the network growth model; apply the network growth model to evaluate alternative policies (in addition to those already tested) using the Twin Cities road network as a case study; develop an agent-based travel demand model and demonstrate it on the Twin Cities road network; and replace the sequential trip-based demand model with the new behavioral demand model in the network growth simulator.

Lee Munnich, Humphrey Institute of Public Affairs
Sustainable Technologies Applied Research (STAR) Initiative
Status: In progress

The STAR project is investigating the intersection of various networks—including ITS-infused transportation networks—and how they interact with physical places, as well as the changes that are occurring among and between networks and the dimensions (e.g., access, activity) that concern the STAR researchers. Year five activities have led to the following focus areas for year six (FY 06):

Spatial Impacts
With the rapidly increasing penetration of the Internet in day-to-day activities, its ability to affect travel behavior either in the form of increasing or decreasing travel demand may have a considerable impact on transportation policies. Work is now under way for the final phase of this task—the development of an approach based on systems theory and complexity theory. In the coming year a survey of various model forms, including system models, cellular or Markov models, and agent-based models will be completed. Other objectives include working to refine a multinomial logit model to better understand the reasons that lead to varying frequencies of buying products online; tracking changes in use, attitudes, and ICT-use-penetration from a 1998 study completed by Handy and Yantis; and producing an academic paper on the browse-to-buy aspect of this research.

Modeling of Wireless Rural EMS Performance
With the rapid growth in mobile-based 911, specific research objectives are to design a system architecture that characterizes rural EMS; examine the rural EMS system architecture within the context of an embedded case study in rural Minnesota; devise an end-to-end performance metric that characterizes overall system performance, including simulation of performance; use a framework to outline operational, organizational, and governance issues that could affect EMS use in Minnesota; conduct case studies and expert interviews that examine these dimensions to EMS performance; and conduct local presentations and national workshops. Year six of this project will conclude with an academic paper summarizing research results or a comparable product. A key result of this research will be an institutional framework for deploying ITS in support of collaborative EMS activities in Minnesota.

Privacy and ITS
See page 23 for coverage of this project.

Networks and Productivity
Further research will continue to improve urban transportation mobility and accessibility by developing an agent-based model of network growth that integrates land use, travel demand, cost functions, pricing schemes, and investment rules to simulate the growth (and decline) of urban transportation networks. The following objectives will guide the research work in year six: refine the cost functions and the land use module of the network growth model; apply the network growth model to evaluate alternative policies (in addition to those already tested) using the Twin Cities road network as a case study; develop an agent-based travel demand model and demonstrate it on the Twin Cities road network; and replace the sequential trip-based demand model with the new behavioral demand model in the network growth simulator.

Education Forums, Outreach
Planned activities include a variety of roundtables, conferences, workshops, and forums. These will include participation in the annual TRB, CTS, and ITSAs conferences as well as selected specialty workshops. Working in collaboration with the ITS Institute, noteworthy speakers will be invited to the University to speak to faculty and students. Year six will see the formation of the University Consortium on Metropolitan Studies, and contributions to regional policy development, in addition to other outreach and activities that will occur during the year.

Kevin Krizek, Humphrey Institute of Public Affairs
Understanding the Potential Market of Metro Transit’s Ridership and Services
Status: In progress
See page 22 for coverage of this project.

Abstracts