Institute research is centered on safety-critical technologies and systems for efficiently moving people and goods in the following areas:

• human performance and behavior
• technologies for modeling, managing, and operating transportation systems
• computing, sensing, communications, and control systems
• social and economic policy issues related to ITS technologies

The Institute’s research program joins technologists—for example, engineers and computer scientists—with those who study human behavior to ensure that new technologies adapt to human capabilities, rather than requiring human capabilities to adapt to technology.

The Institute’s geographic location gives it a unique advantage for developing research applicable to transportation in a northern climate and transportation in the rural environments that lie beyond the Twin Cities metropolitan area.

The ITS Institute research program includes research projects funded by various partners, including federal funds from both ISTEA and TEA-21 legislation and the Federal Highway Administration. Other funding partners include the Minnesota Department of Transportation (Mn/DOT) and the Minnesota Local Road Research Board, in addition to local governments, agencies, and private companies who contribute funding and in-kind match.

Activities undertaken by the Institute support all current ITS-related research projects, including those that began under the ISTEA-funded Institute. The research section of this Annual Report comprises three parts. The first highlights a selection of projects underway, while the second briefly describes other projects in progress. The third part reports on the projects selected to begin this coming year.

Clockwise from bottom left: Osama Masoud, Professor Nikolaos Papanikolopoulos, Benjamin Maurin, Harini Veeraraghavan, and Robert Martin
Highlighted Research in Progress

Human Performance and Behavior

Psychological and Roadway Correlates of Aggressive Driving

Aggressive driving has received much attention in the popular press and from organizations such as AAA, which call it an increasing threat to the safety of future roadway environments.

So principal investigator Kathleen Harder of the Human Factors Research Laboratory (HFRL), Terry Kinney of the Department of Speech Communication, and Darcia Narvaez of the Department of Psychology, University of Notre Dame (formerly of the Department of Educational Psychology, University of Minnesota), are seeking to identify and understand the psychological, emotional, and behavioral factors that contribute to aggressive driving (e.g., acceleration, braking, lane changes, speed, and tailgating) in order to reduce and prevent it.

In the first phase of the project, the team surveyed 300 University of Minnesota students in order to investigate the relationship between personality, emotional, and behavioral variables and self-reported driving behavior. Students were targeted because their age range (16–35) demonstrates high levels of anger and hostility and a willingness to engage in riskier behaviors, relative to older adults.

In the survey, the researchers measured gender and age; personality characteristics such as hostility, anger expression, aggressiveness, competitiveness, and empathy; emotional states such as anger-provoking experiences, ability to “let go” of hostility, and negative thought patterns; and behavioral tendencies when driving, such as speeding, driving under the influence of alcohol, and risk taking.

According to the responses, participants who were more distrustful of others, suspicious, and prone to hostility were classified as “high hostiles.”

The results of a subsample (216 respondents) of the survey show that high hostiles reported more driving after drinking alcohol, more speeding, and more risk-taking than low hostiles. They also reported more anger in the presence of police, more anger toward slow drivers and discourteous drivers, and more anger from roadway obstacles than low hostiles reported.

Males reported more confrontational aggressiveness and more illegal and risky driving behavior than females did. Females reported greater anger by other drivers’ rude behavior.

In the second phase of the research, planned for winter 2002, the researchers will run a driving simulator experiment at the Institute’s HFRL to validate the self-reported driving behavior.
15

Research behaviors. Subjects will include both high hostiles and low hostiles who will be put into situations of either high emotional manipulation or low emotional manipulation before going into the simulator. When driving, subjects will navigate through several virtual traffic events and environments, including rural and urban settings, congestion, and road construction.

Results of the experiments should give the researchers the ability to link personality traits and styles to types and levels of driving behavior under various traffic events and environments, thereby allowing them to gain some understanding as to what type of person may be “at risk” for aggressive driving.

This may lead to strategies for preventing and reducing aggressive driving, they say. One example of such a strategy might be the use of persuasive messages (e.g., bumper stickers, billboards, radio ads) to target, then calm, high hostiles in their vehicles.

Reducing Crashes at Controlled Rural Intersections by Identifying Effective Countermeasures

Right-angle crashes at controlled (thru/STOP control) rural intersections in Minnesota account for nearly 71 percent of all fatalities at this type of intersection. Further, right-angle crashes account for 62 percent of serious injury crashes and nearly half of property damage crashes at this type of intersection, say Institute researchers who are studying this issue.

Principal investigator Kathleen Harder of the Human Factors Research Laboratory (HFRL), along with Howard Preston, transportation engineer and senior project manager at Howard R. Green Company, want to find out why these crashes occur as well as what can be done to reduce their numbers.

According to Harder, some traffic engineers feel they have exhausted their “toolbox” of strategies for ways to improve safety at controlled rural intersections. Responding to a request from the Minnesota Department of Transportation and the Minnesota Local Road Research Board, researchers are studying the problem by assessing crash record databases, visiting sites to assess the physical

Males reported more confrontational aggressiveness and more illegal and risky driving behavior than females did. Females reported greater anger by other drivers’ rude behavior.

HFRL researchers Peter Easterlund, Kathleen Harder, Selma de Ridder, and Nicholas Ward

Right-angle crashes at controlled rural intersections are a significant safety issue for traffic engineers.
Research

limitations of the intersections, and running driver simulator tests to identify strategies to mitigate the problem, Harder says. Right angle crashes occur either when drivers fail to stop, or do stop but then pull out into oncoming traffic. Of the 768 right-angle crashes examined, approximately 57 percent of the drivers stopped, then pulled out, and 26 percent of the drivers ran the stop sign (17 percent fall into the unknown/other category). “It was somewhat surprising to learn that running stop signs does not seem to be the major problem at rural controlled intersections in Minnesota,” Harder says. Although the research is not far enough along to allow for causal analysis, Harder says that the right-angle crashes do seem to be more prevalent in drivers who are 19 years of age and under and those who are 85 and older. Whether the problem is perceptual, or whether it involves not looking, delayed reaction times, or some combination of these factors is not yet known.

Researchers are conducting on-site field analyses this summer to look at the physical characteristics at these intersections and consider how those features might contribute to safety problems. Once field inspections and a subsequent focus group session are completed, researchers will develop a method for studying the problem in the HFRL's driving simulator using a computer-generated virtual intersection and a number of alternative solutions. “We hope that our results will allow us to develop strategies that will result in safer rural controlled intersections,” Harder says.

Computing, Sensing, Communications, and Control Systems

IVI Specialty Vehicle Field Operational Test

For snowplow operators and drivers of other specialty vehicles, such as police cars and ambulances, winter driving is difficult and dangerous. During the winter, these drivers routinely navigate in poor driving conditions while trying to avoid moving and parked cars, bridge end treatments, signs, guardrails, and any number of other obstacles.

To increase safety for these drivers, researchers at the ITS Institute’s Intelligent Vehicles (IV) Laboratory—in cooperation with other University researchers, including those from the Human Factors Research Laboratory (HFRL) and the University of Minnesota Duluth’s Electrical and Computer Engineering Department—have been developing and testing a variety of vehicle-guidance and collision-avoidance technologies.

From November 2000 through January 2001, HFRL researchers field-tested some of these technologies, including a head-up display (HUD) system that allows drivers to “see” the road via images projected onto a combiner mounted close to the windshield. Lane-departure warnings are provided by a “virtual rumble strip,” the result of a combina-
tion of haptic and auditory signals that simulates a physical rumble strip with a vibration in the driver’s seat and an auditory signal.

Tests were conducted at the University’s Rosemount research facility with the Mn/DOT “SAFEPLOW,” which was equipped with a vehicle data acquisition unit to collect data representative of drivers’ responses. During the study period, 16 Mn/DOT snowplow operators drove the vehicle with opaque curtains completely obscuring the front and side windows. “They weren’t able to see the actual roadway but could drive anyway because of the virtual roadway displayed on the HUD,” says Kathleen Harder, HFRL research associate. She and John Bloomfield, another HFRL researcher, ran the study, which is one of several HFRL research projects exploring driver-assistive technologies and their effects on drivers. Results will be incorporated into the final version that will be deployed for testing next winter.

Researchers are now preparing for operational testing by outfitting four snowplows, one state patrol car, and one ambulance with driver-assistive systems. The team hopes to have all the vehicles ready by the end of the summer of 2001. Once installed on the vehicles, the systems and subsystems will be tested to make sure they work as intended, and drivers will be trained to use the technology. The operational testing is scheduled to begin in October 2001 and will run for six months.

A prerequisite for the operations test is the completion of infrastructure requirements for the project. The team is in the process of installing six weather stations along Highway 7 between Hutchinson, Minn., and I-494 in the Twin Cities metropolitan area. Team members are also preparing to install three GPS correction base stations. Once the GPS base stations are operational, the team will begin mapping Highway 7, creating a map from which all DGPS-based vehicle guidance will operate.

This research is part of the Intelligent Vehicle Initiative (IVI) Field Operational Test Program, funded by the Federal Highway Administration, Mn/DOT, and industry partners. The ITS Institute is leading the research effort for the program, under which the University is receiving $2.65 million over three years. Mn/DOT, McLeod County, the city of Hutchinson, the Minnesota State Patrol, and private industry partners are providing additional resources and funding for this $6.5 million project.

With additional funds from the Minnesota Local Road Research Board, the team is now working towards having this new technology used and evaluated at the county level. Researchers also hope to explore how these systems can be applied to transit vehicles, particularly to help drivers navigate on narrow bus-only shoulders.
Wireless Transmission of Image and Video Data

The trend toward wireless transmission of traffic information poses difficult problems for transmission systems that operate over low-speed wireless channels like CDPD (Cellular Digital Packet Data). This project, led by Associate Professor Vladimir Cherkassky of Computer Science, is part of an overall ITS Lab strategic focus on spatially meaningful presentation of traffic information. A prototype wireless network housed in the Institute’s ITS Laboratory serves as the testing environment and will also be used for future research in this area.

Cherkassky’s work focuses on technical and system-integration issues related to the practical implementation of wireless video/image transmission. The Minnesota Department of Transportation (Mn/DOT) is currently investigating wireless traffic data transmission, and the results of the current research project will assist Mn/DOT in implementing an effective wireless data system.

This project encompasses two main areas of research: 1) compression and denoising of digital video/image signals, and 2) dynamic allocation of network resources in a wireless video/image transmission system.

In the area of compression and denoising, Cherkassky’s research team will assess the performance of a typical “commercial off-the-shelf” (COTS) video/image compression product based on wavelet-thresholding algorithms, giving particular attention to the tradeoff between the amount of signal compression and the visual quality of the decompressed image.

In addition, the project incorporates research on a new compression and denoising methodology developed by Cherkassky during 2000. Comparison to existing commercial systems will uncover potential improvements that can be achieved with more research.

The second research area, allocation of network resources, presents major challenges in the implementation of a wireless image-transmission system; efficient resource allocation can significantly increase system performance. Here Cherkassky will build on a separate research project in which he is currently involved with FireSummit, a Minnesota company developing software for dynamic allocation of priorities in different types of computer networks.

Because computer networks and the wireless networks under study make use of the same Internet Protocol (IP) methodology for transmitting data, the resource-allocation system under development can be utilized for both. By using this software in combination with router/switching hardware, the researchers are able to model different levels of wireless service with varying bandwidth and latency. The prototype wireless system will be tested under varying loads of compressed image/video traffic to quantify the effects of video/image compression and dynamic allocation of network priorities.

Based on Cherkassky’s results, the researchers will make recommendations on commercial compression products for use by Mn/DOT and will provide an assessment of the usefulness of network prioritization software for practical implementation of wireless transmission within Mn/DOT.
Comparative Analysis of Operational Algorithms for Traffic Responsive Coordinated Metering

Methodology for Evaluating Ramp Control and Implementation in Two Twin Cities Freeways

Measuring the Equity and Efficiency of Ramp Meters

Although the use of ramp metering as part of an overall traffic management strategy has been a subject of long-term study by University researchers, over the last year it was in the spotlight due to the Twin Cities’ “ramp meter shutoff” mandated by the state legislature. During that time, the Minnesota Department of Transportation (Mn/DOT) turned off the metro area’s 430 ramp meters for nearly two months in order to observe the results.

Simultaneously, three Institute projects examined Mn/DOT’s use of ramp metering from three different perspectives.

Dr. Eil Kwon, program director of the ITS Institute’s Advanced Traffic Systems Program, led a project comparing the performance of the Mn/DOT ramp metering algorithm with alternative algorithms used elsewhere around the country.

Kwon’s key findings were:

- Among 24 cities with ramp meters, five have on-line coordinated methods to maximize system-wide flow while minimizing delay. Washington, D.C., and Minnesota have control designed to maximize bottleneck flows with section-wide explicit coordination.
- Simulation analysis showed that the Minnesota approach distributed traffic flows more evenly on the mainline, but had more ramps with higher waiting times than the other approaches.
- Most metering systems, except Minnesota and San Diego, implement a “ramp queue override” method to reduce ramp waiting time even if it results in increased delay on the mainline.

The implications, Kwon says, are that system-wide efficiency needs to be balanced with ramp queue delay, and a new algorithm for Minnesota should target corridor-wide traffic management by explicitly reflecting conditions at the mainline, ramp queues, and adjacent intersections.

Assistant Professor David Levinson of the

Because ramp metering affects more than the freeway, it should be approached from a corridor-wide perspective so that diversion onto arterials is taken into account.
Department of Civil Engineering (CE) led an effort to identify and develop performance measures that evaluate the equity as well as the efficiency of the metering strategy to determine overall effectiveness.

Levinson’s key findings were:
- Freeway speeds and flows are consistently higher with ramp metering than without.
- Overall trip speeds (including both the freeway and the ramp) are not uniformly higher with ramp metering than without. Long trips benefit from metering at the expense of short trips.
- If people value their time differently (e.g., waiting on a ramp versus waiting on the mainline), a ramp metering system that satisfies users must consider ramp delay in addition to freeway throughput.

This leads to two key implications, Levinson says: equity and efficiency performance measures (e.g., mobility, accessibility, productivity) can and should be used when testing new algorithms, and a limit on individual delay, even at the expense of overall freeway efficiency, may be necessary for the ramp metering system to satisfy equity considerations.

The goal of the project led by Professor Panos Michalopoulos, also of CE, was to enhance and validate a simulation model that allows new or modified metering strategies to be tested and evaluated before being deployed on the road network.

Michalopoulos’s key findings were:
- Simulation results are consistent with the findings from Mn/DOT’s Twin Cities Ramp Meter Evaluation Study.
- The implementation of ramp metering should be site and time specific.
- The simulation demonstrated that Mn/DOT’s metering strategy was beneficial overall on the mainline system, but adversely affected the ramps themselves by creating queues and delays.
- Simulation will allow new strategies to be tested and existing ones to be fine-tuned before deployment.

The implications, he says, are twofold: First, the Mn/DOT metering strategy should be modified to take ramp conditions into account. And second, because ramp metering affects
more than the freeway, it should be approached from a corridor-wide perspective so that diversion onto arterials is taken into account.

Next steps and further research include development of a modified algorithm for use by Mn/DOT that incorporates ramp-queue management; development of performance measures and tools that allow evaluation of efficiency and equity; and use of the simulation lab to test alternative metering strategies for potential deployment on Twin Cities freeways.

Social and Economic Policy Issues Related to ITS Technologies

Sustainable Technologies Applied Research

Researchers at the Humphrey Institute of Public Affairs’ State and Local Policy Program (SLPP) are investigating sustainable transportation technologies by systematically examining the impacts of ITS and telecommunications along five dimensions: spatial location, community design, accessibility, network performance, and productivity.

The major theme for SLPP’s work is the relationship between technological networks and places. This theme is being explored in an interdisciplinary fashion with perspectives ranging from urban development to network analysis. Over the next several years, Sustainable Technologies Applied Research (STAR) will explore the community and regional impacts of advanced transportation technologies such as ITS and telecommunications, placing special emphasis on their transportation and environmental impacts.

The first year’s research activities range from theoretical reviews to applied analysis of local systems in Minnesota. Leading the theoretical work is Professor Emeritus Richard Bolan, who has conducted a review of network theory and application. Based on advances in complexity theory, there is a new body of research to help understand how networks such as ITS perform and change. In a related vein, visiting scholar Tom Horan is

Top: Humphrey planning faculty Karen Chapple (left) and Richard Bolan
Bottom: Research assistant Ramachandra Karamalaputi (left) and Assistant Professor David Levinson
Research assistants Marcus Martin and Greg Schrock examine data on home-based businesses.

conducted a review of information design theory and how it can guide review and analysis of community information systems, including locally-based ITS systems. SLPP Director Lee Munnich is conducting industry cluster analyses on how economic networks drive and benefit from transportation and related networks. Professor Ken Keller is serving as an advisor and reviewer of these research elements. Assistant Professors Karen Chapple, Humphrey Institute, and David Levinson, Civil Engineering, are leading the way in creating robust databases to examine the intersection of people and networks.

As part of the spatial location research, Chapple is investigating the issues of employment, transit use, and technology for the North Metro I-35W Corridor Coalition, a joint powers organization uniting seven communities along I-35W north of St. Paul and Minneapolis. For this project, SLPP is teaming with the Minnesota Center for Survey Research and Demographic Technologies, Inc., a consulting firm specializing in demographic applications of geographic information systems (GIS) technology.

In year two, researchers will conduct a labor force assessment to determine the extent of underemployment in the I-35W corridor, as well as the potential for deploying high technology infrastructure (including ITS) to assist both employers and workers in the Twin Cities and in greater Minnesota.

The data collection process began in May 2001 and includes a mail survey to 11,000 area households, follow-up focus groups with area residents, and interviews with local employers. Information collected from the surveys and interviews will allow researchers to examine the extent to which resident workers are underemployed or dissatisfied with their employment and the problems employers experience in recruiting and retaining a qualified workforce. In addition, the team will use survey and interview data to examine the potential use of transit, ITS, and telecommunications technologies to improve the labor force situation.

Survey analysis will take place in late 2001, the results of which will be used to design workforce development programs to help underemployed persons seek more appropriate employment; to support the efforts of local businesses at attracting a trained workforce; and to develop strategic transit improvements in the corridor communities. The survey findings will be maintained and refreshed as additional data, such as the 2000 Census results, become available.
Another dimension of the STAR research involves examining ITS in relation to transportation network performance. A team of University of Minnesota researchers led by Levinson is conducting an empirical investigation of transportation network characteristics and is exploring the impact of intelligent transportation systems, such as ramp meters and changeable message signs, on those networks. Currently the team is working to develop specific measures to evaluate the effects that transportation investments, including ITS, have had on transportation productivity in the Twin Cities. In the subsequent phases, Levinson will explore new models of how to accurately predict traffic demand and public supply responses and will develop a more theoretical network simulation framework.

In the ensuing five years of the research program, the entire SLPP research team will extend their research to encompass a range of urban and rural settings, as well as several distinct technological platforms. The research promises to substantially increase the field knowledge about how ITS and other technologies impact social, economic, and environmental dimensions of communities.

The research promises to substantially increase the field knowledge about how ITS and other technologies impact social, economic, and environmental dimensions of communities.
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Abstracts of Other Selected Research Projects in Progress

Human Performance and Behavior

Effectiveness of In-lane Rumble Strips
Principal Investigator: Kathleen Harder, Human Factors Research Laboratory

This work stems from a request by SRF Consulting Inc. for human factors experiments investigating the effect of rumble strips on stopping behavior at rural controlled intersections. The experiment, which will be conducted in the wrap-around driving simulator, will involve rural controlled intersections both with and without rumble strips.

User-Centered Auditory Warning Signals in Snowplows
Principal Investigator: Kathleen Harder, Human Factors Research Laboratory

Given the visually demanding work environment of snowplow drivers, the Mn/DOT Office of Advanced Transportation Systems has identified a need for human factors research into the type of auditory warning signal that most effectively communicates the intended message. This project is developing a virtual snowplow environment to investigate the effect of in-vehicle auditory warning signals on driver behavior with the goal of improving safety for snowplow drivers and other drivers on the roadway. The study addresses the following objectives: replicate a snowy roadway in Minnesota in a virtual environment, use the wrap-around driving simulator to determine the optimal acoustic features of various warning signals and their placement in the vehicle, and analyze the ways in which auditory cues affect the behavior of snowplow drivers. The chief benefit will be the information gained from identifying which auditory warning signals most completely and effectively convey the intended message in snowplow environments.

Orientation and Navigation in Elderly Drivers
Principal Investigator: Herb Pick, Institute of Child Development

This research seeks to determine how elderly drivers—in comparison to young and middle-aged drivers—navigate and spatially orient themselves while driving, and explores difficulties faced by elderly drivers operating their vehicles in different driving environments. By identifying specific issues that impact elderly drivers, such as way finding, this research may help reduce the accident rate among them.

To evaluate young and elderly drivers’ ability to learn and integrate spatial information when driving, testing has been carried out both on the road and in a virtual-reality driving simulator. Comparison of data from the real and simulated driving tasks has confirmed that drivers exhibit similar performance patterns in both environments. Thus from this point on, the simulator can be used to perform more detailed experiments on how drivers’ ability to orient themselves is affected by the nature of the driving task.

A survey questionnaire has also been administered to considerable numbers of young, middle-aged, and elderly drivers. The results of the questionnaire are still being analyzed and the results will be correlated with performance on the two driving tasks described above. However, preliminary analysis of survey data suggests that elderly persons drive differently than younger persons; they make shorter trips, drive less at night and in heavy traffic, and report more distress after losing their way, rather than the frustration typical of younger drivers. The results of the actual and simulated driving tasks also support the original hypothesis that acquiring and maintaining spatial orientation is more problematic for elderly than young drivers and hence could be a distracting factor.

The Effects of Vision Enhancement Systems (VES) on Older Drivers’ Ability to Drive Safely at Night and in Inclement Weather
Principal Investigator: Tom Smith, School of Kinesiology and Leisure Studies

This project is examining the efficacy of vision enhancement systems (VES) that are being developed to help the driver “see” by using sensors in the ultra-violet and infrared spectra and displaying the information as visible light in a head-up display that is overlaid on the traffic environment. The purpose of VES displays are to assist the driver at night, dusk, and in inclement weather.
**Eliminating Driver Blind Spots at Rural Intersections: Effects of Signage and Vehicle Velocity**  
*Principal Investigator: Michael Wade, School of Kinesiology and Leisure Studies*

This study seeks to determine the impact of signage and vehicle velocity on collisions or near collisions as a function of blind spots generated by the width of the front doorpost of an automobile. Traffic engineers have reported this problem, especially at rural intersections where the signage employed is often a yield sign on the minor road intersecting the major road. In many instances, collisions or near collisions occur and drivers report “failure to see the other vehicle.” The speed of the vehicle, the use of signage, and the failure by drivers to orient about the sight line on either side of the blind spot generated by the doorpost may all be candidates for investigation. Via simulation, this research seeks to determine the frequency of accident-likely events caused by such blind spots. The research will also evaluate strategies that drivers may use to check for approaching vehicles coming at right angles to their trajectory path in such a way as to avoid potentially fatal accidents.

**Computing, Sensing, Communications, and Control Systems**

**Lateral Stability of Narrow Commuter Vehicles**  
*Principal Investigators: Lee Alexander and Rajesh Rajamani, Department of Mechanical Engineering*

The inevitable increase in metropolitan traffic congestion creates a need for commuter vehicles that take up less space on the road than the standard automobile. Since the majority of the cars on the road during rush hour have only one or two occupants, one approach is to design a narrow vehicle that can carry one passenger in a seat directly behind the driver. The width of this vehicle, about 1 meter (3.3 feet), would be such that two vehicles would be able to drive side by side down a standard 12-foot-wide (3.7-meter-wide) traffic lane, thereby substantially increasing the number of vehicles per hour that the lane can handle.

A practical narrow vehicle of this type will have to be stable at all speeds and on all surfaces (including snow and ice), be temperature-controlled on the inside, and be easy to get into and out of. The roll stability of this vehicle when cornering will depend on an active suspension control system that will allow it to react to lateral forces by leaning like a motorcycle even though it has more than two wheels. The researchers propose to extend the work of earlier researchers in this field by testing modern sensors, actuators, and control design methodologies on a large-scale model of this type of vehicle, and then design and build a full-sized vehicle to be used for continuing research.

The researchers will explore control strategies that will allow such a vehicle to operate on slippery roads without requiring undue skill from the driver. Future work should include the study of human-machine interfaces (including drivability and comfort), the safety envelopes, and collision avoidance for such a machine.

**A New Approach to Assessing Road User Charges**  
*Principal Investigators: Max Donath and Pi-Ming Cheng, Department of Mechanical Engineering*

This research is evaluating a design for a road user charge system that avoids the problems and shortcomings of current mechanisms while having the following attributes: low collection costs for both agency and user; a stable revenue stream; higher user charges for users who impose higher costs (e.g., road damage by heavy vehicles and contributions to congestion delays by autos); a low evasion rate; incentives for users to travel on appropriate roads and at different time periods; the ability to remain unaffected by the method of vehicle propulsion; and a sufficiently fine-grained structure to allow segment-specific pricing. The approach should not be burdensome to road users and should be tamperproof, highly reliable, and flexible enough to be a useful tool for achieving a variety of policy objectives through road pricing.

Technologies that are being investigated are differential GPS integrated with digital maps. To carry out the study objective, the researchers, together with the University of Iowa, are addressing a series of institutional and technological issues, ranging from the accuracy of vehicle-positioning technologies to public policy considerations such as phase-in measures and data privacy.

**An Automatic Visibility Measurement System Based on Video Cameras (Phase 2)**  
*Principal Investigator: Taek Mu Kwon, Department of Electrical and Computer Engineering, UMD*

This research will continue to develop and refine the automatic visibility measurement...
Research methods developed based on image processing of video images in Phase I. Study of basic measurement principles is being expanded to include a single target (multiple-target approaches were used in Phase I) for easier implementation. Video image characteristics can vary drastically depending on the types of cameras, digitizers, lighting conditions, bit resolutions, etc. A new image calibration approach will be developed to cope with the differences in imaging characteristics. In addition, night visibility will be further studied in the visible and near infrared spectrum regions through design of different types of light sources and targets. The main benefit of this research is that video images produced by many surveillance video cameras will be further utilized to determine visibility conditions.

Algorithms of Vehicle Classification (Phase 2)
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

This research will continue the work of Phase 1 and show more strongly the potential of laser scanners, CCD cameras, and infrared sensors as vehicle classification devices. The ultimate goal is to develop an inexpensive multi-sensory portable unit that can classify vehicles quickly, safely, and accurately. The researchers plan, based on the work of Phase 1, to improve the vision-based vehicle classification algorithms and adapt them to infrared images and images that are the output of laser scanners. The final step is to implement these algorithms in real-time computing hardware. The research during Phase 2 consists of the following tasks: dynamical statistical pressure snakes for vehicle classification, neural-network based classification, comparison of the results of Phase 1 with other vehicle classification sensors and techniques, evaluation of laser scanners for vehicle classification, and development of a small prototype unit.

Handling Pedestrian Control Issues at Busy Intersections and Monitoring Large Crowds
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

This project provides a new way of looking at pedestrian control issues at busy intersections. Furthermore, the proposed techniques can be used to monitor large crowds. The researchers are using their experience in handling scenes with a small number of pedestrians to handle cluttered scenes at busy intersections. Instead of focusing on the detection or tracking of single pedestrians, they are focusing on the detection and tracking of crowds. They plan to illustrate their approach to busy (with respect to the number of pedestrians) intersections; the development will be on a PC-based system with a C80 board. Finally, they will illustrate their approach in video sequences of large crowds (athletic events, schools, underground scenes, etc.).

Managing Suburban Intersections Through Sensing
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

Since traffic lights guide but do not monitor the traffic situation at an intersection, they do not offer the users much protection against aberrant behaviors such as red light violations by cars or by pedestrians. Neither do they take into consideration the special needs of users such as older pedestrians, parents with small children or infants, and large trucks, all of which may require a longer time to cross the street or make a turn. Traffic lights should discourage behaviors that do not follow rules.

With this project, the researchers are developing an intelligent monitoring system for suburban intersections equipped with vision modules to monitor the traffic conditions and use such information to dynamically adjust the duration of the signal periods. The objectives are to improve the safety of crossings for pedestrians as well as for cars and to reduce unnecessary traffic holding time.

Sensor-Based Ramp Monitoring
Principal Investigator: Nikolaos Papanikolopoulos, Department of Computer Science and Engineering

This work describes a methodology for integrating sensing (in this case, a vision sensor or a laser scanner) with discrete control. Moreover, the proposed approach can accommodate a moving sensor in order to improve the accuracy of the measurements. The researchers are adapting the algorithms developed for work zone monitoring and pedestrian detection in order to analyze the ramp queue. Their philosophy is to treat traffic objects as entities with specific but diverse characteristics. After the detection and tracking, the relevant information can then be fed to the controller. Their “true” tracking approach can detect and track vehicles (vehicle classification is even possible) and monitor their status (e.g., velocity, changes in lanes). The proposed system can
also monitor traffic speed on the freeway. As the freeway becomes less congested, the ramp meter rate can be adjusted to address the new situation. Thus, adaptive ramp control can use a combination of traffic data from the freeway as well as the ramps by using a simple and flexible PC-based approach. Furthermore, an adaptation mechanism may be used to compute the appropriate action of the traffic controller. Finally, the camera model and the noise characteristics of the vision measurements can be included in the design of the traffic controller.

GPS-Based Failure Identification System for Intelligent Vehicles
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project is working to develop and implement a fault diagnostic system for intelligent vehicles that can monitor the health of the sensors and actuators on a vehicle and identify the source of a malfunction as soon as a malfunction occurs.

Two key technical challenges need to be addressed in the design of the fault diagnostic system: 1) vehicle dynamic models are nonlinear, but fault diagnostic methods based on analytical redundancy exist in literature primarily for linear time-invariant systems; and 2) automated vehicles utilize sensors that measure inter-vehicle and vehicle-road variables. The first of these challenges is being addressed through the development of a systematic fault diagnostics methodology for nonlinear systems. The second technical challenge is addressed through the formulation of solutions specific to the automated vehicle application domain.

Thus far, the project has developed and implemented a fault diagnostic system on the SAFETRUCK that can effectively monitor the health of the GPS system, the lateral accelerometer, and the yaw-rate gyroscope which constitute the set of lateral dynamic sensors and the forward-looking radar that measures distance, relative velocity, and azimuth angle to other vehicles and objects on the highway.

The immediate benefit of this project is that the fault diagnostic system will enhance the safety of the SAFETRUCK and also help improve its control system performance. The longer term benefits arise from the fundamental need for fault tolerance in both partially and fully automated vehicles.

Model-Based Intelligent Vehicle Control System
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project will develop and implement an intelligent cruise control (ICC) system on a Volvo truck that is being donated to the University of Minnesota (U of M). The ICC system would automatically monitor vehicles on the same and adjacent lanes on the highway, detect vehicles that “cut in” from adjacent lanes, switch from speed control to spacing control when necessary, and provide safe and comfortable driving in the presence of moderately dense traffic. The work is being done in collaboration with Volvo, which will provide detailed engine maps, vehicle parameters, and access to existing sensors and actuators on the truck. The project is being cost-shared by using funds from a U of M Grants-in-Aid research grant and indirectly through engineering person-hours contributed by the U of M Center for Diesel Research and by Volvo. The immediate benefit of the ICC system would be to enable a Mobile Emissions Laboratory on the Volvo truck to safely and accurately follow vehicles on the highway and make reliable exhaust plume measurements. The long-term benefits of the research include the improvement of safety in highway driving, the development of a test-bed for future research related to vehicle automation, the potential use of the vehicle monitoring system for driver assistance in poor visibility, and the reduction of fuel consumption by 25 percent in the case of trucks operating as a fleet by the use of ICC.

Automated Vehicle Control Algorithms and Their Influence on Traffic Flow
Principal Investigators: Rajesh Rajamani, Department of Mechanical Engineering, and David Levinson, Department of Civil Engineering

This project will concentrate on development of new vehicle-following algorithms and on a rigorous analysis of such algorithms in a unified framework. The researchers will analyze vehicle-following algorithms from the perspectives of: 1) the individual vehicle, wherein safety, comfort, and time-to-destination resulting from the algorithm are of importance, and 2) highway utilization, wherein higher traffic flow and stable traffic patterns are of importance. An evaluation of standard adaptive cruise control algorithms demonstrates how individual vehicle benefits are often obtained at the cost of highway traffic flow. Preliminary results on new vehicle-following algorithms indicate that better traffic flow patterns can be promoted without any deterioration in individual vehicle safety or comfort.

High-Performance Spatial Visualization of Traffic Data
Principal Investigator: Shashi Shekhar, Department of Computer Science and Engineering

High-performance visualization techniques are becoming crucial as the wealth of traffic data collected by an ever-increasing network
A Case-Control Study of Driving Speed and Crash Risk
Principal Investigator: Gary Davis, Department of Civil Engineering

This study will investigate the role of vehicle speed as a risk factor in traffic crashes. A case-control study design will be used in which the estimated speeds of vehicles involved in crashes will be compared with the speeds of appropriately selected control vehicles. Accident reconstruction methods will be used to estimate the speeds of the vehicles involved in the crash, and methods for assessing uncertainty in accident reconstructions, recently developed by the principal investigator, will be employed. At present the researchers have obtained crash records on 60 fatal crashes from Mn/DOT and have developed a modeling structure for run-off-road and pedestrian crashes. They are currently working on the modeling structure for two-vehicle crashes.

Bus Rapid Transit Technologies: Assisting Drivers Operating Buses on Road Shoulders
Principal Investigators: Craig Shankwitz and Max Donath, Department of Mechanical Engineering

Metro Transit and Mn/DOT currently are cooperatively operating a BRT-like capability throughout the Twin Cities metro area. Buses operate in HOV lanes and on specially designated bus-only road shoulders, albeit at speeds significantly lower than limits posted for the adjacent highway. By enhancing bus-only shoulders, they become a more viable component to be integrated in future BRT systems.

Although the bus-only shoulder policy continues to be a very successful program, emerging driver-assistive technology developed at the University of Minnesota can be used to solve problems associated with driving on bus-only shoulders. For instance, most of the shoulders on which transit buses operate require that a driver maintain a lateral error of less than one-half foot to avoid collisions. This is a difficult task under the best conditions, and degrades to impossible during conditions of bad weather, low visibility, high traffic congestion, etc.

This work is the first phase of a plan to adapt and develop driver-assistive technology optimized for bus operations, focusing primarily on lane keeping and forward collision-avoidance driver-assistive technologies originally developed for snowplows. The secondary (and long term) focus is on collision avoidance for the rear and sides of transit vehicles.

Technologies for Modeling, Managing, and Operating Transportation Systems

Capacity Analysis for Dynamic Bottlenecks and Alternative Concepts for Coordinated Ramp Metering Operations
Principal Investigator: Eil Kwon, ITS Institute

Freeway bottlenecks are, in general, caused by physical geometry changes and/or by conflicting flow patterns, such as merging or weaving flows, which reduce the maximum amount of flow that can pass a given location. While the capacity of conflict-based bottlenecks is heavily dependent upon the time-variant traffic patterns within bottleneck areas, a geometry-based bottle-neck, e.g., a lane-drop or a bridge with narrow shoulder, can also be wiped out by a downstream queue that grows past the bottleneck location. The capacities of both types of bot-
Traffic congestion is further affected by continuously changing weather conditions. This project will address the above issues by developing a dynamic procedure to update capacity values for given bottlenecks. Further, as a first step toward developing a next-generation metering algorithm incorporating ITS technologies, alternative concepts for coordinated ramp metering will be formulated. Detailed algorithms with real-time operational capability will be developed in the subsequent phase of this research.

**Dynamic Estimation of Freeway Weaving Capacity for Traffic Management and Operations (Phase 2)**

*Principal Investigator: Eil Kwon, ITS Institute*

Understanding the behavior of weaving flows and estimating the effects of time-variant traffic conditions on the capacity of weaving areas is important for developing effective operational strategies, which can achieve the maximum utilization of existing capacity for a given freeway system. The previous phase of this research identified and classified the major weaving areas in the Twin Cities’ metro freeway network. Further, the traffic behavior and the factors affecting capacity in a Type A ramp-weave section, the most common type of weaving area in the Twin Cities metro freeway system, were analyzed. An online model was developed to estimate the time-variant capacity of Type A ramp-weave sections. This research is expanding the previous work by testing and refining the online estimation model with an expanded data set. The variation of Effective Weaving Zone, identified in the previous phase, will also be modeled and tested with real data. In addition, the incorporation of the online capacity model into the current ramp metering algorithm will be studied. Finally, the traffic behavior of multi-lane ramp-weave sections will be analyzed and the variation of capacity in those areas will be modeled with data from selected weaving sites.

**Signal Operations Research Laboratory for Development and Testing of Advanced Control Strategies (Phase 2)**

*Principal Investigator: Eil Kwon, ITS Institute*

A virtual network environment where new advanced control concepts can be refined and tested prior to field implementation is critical for developing an efficient network control strategy that has real-time operational capability. The previous phase of this research developed a pseudo real-time testing environment for a single intersection by integrating an advanced traffic controller and the newly developed microscopic traffic simulator through the signal converter that was also developed in the previous phase. The resulting virtual intersection environment is being used to improve traffic models and refine and test a new adaptive control strategy for an intersection. Phase 2 is expanding the current research effort by developing a pseudo real-time testing environment for a network of intersections and freeway ramps. Further, alternative concepts for optimal management of corridors will be formulated based on the capabilities of state-of-the-art control hardware and sensor technologies. The new control method will be based on adaptive system identification and will make control decisions using section-wide system performance directly quantified with detector measurements. The ultimate goal of this research is to develop a next-generation, adaptive management strategy that can be implemented in real time for a network of intersections and freeway ramps. The final product, a virtual network laboratory, will also be used as an education and training tool for undergraduate and graduate students and practicing engineers.

**Improving the Estimation of Travel Demand for Traffic Simulation**

*Principal Investigators: David Levinson, Gary Davis, and Panos Michalopoulos, Department of Civil Engineering*

Traffic simulation is only as good as its input data. Unfortunately, it is impossible to directly measure entry ramp to exit ramp flows, which would be particularly useful for testing ramp metering control strategies. In the past, research supported by Mn/DOT and the Center for Transportation Studies has produced a viable method for estimating freeway origin-destination (O-D) patterns from loop detector data. This research will further develop and apply this method to estimate O-D demand for use in traffic simulation of freeway sections and corridors. The objective is to estimate the traffic from each on-ramp to each downstream off-ramp in short time intervals. This research will include development and implementation of software to enable the method to be used conveniently with easy-to-collect data. It will then apply the method to selected corridors.

**Evaluation of Ramp Control Strategies in the Twin Cities**

*Principal Investigator: Panos Michalopoulos, Department of Civil Engineering*

As freeway traffic congestion spreads, ramp metering is being implemented to address the problem. However, recently there is
increasing opposition to freeway ramp control because of excessive ramp delays. The objective of this research is to employ microsimulation through a recently developed tool called the Traffic Management Laboratory (TRAMLAB) for assessing the effectiveness of Mn/DOT’s control strategy in two Twin Cities freeway sections totaling approximately 35 miles (56 km). To take into account diversion through adjacent arterials, the feasibility of simulating a whole corridor section will be assessed. As a result of this testing, TRAMLAB will evolve into an effective tool for developing control strategies that could reduce ramp delays without excessively increasing freeway congestion. Finally, a new traffic management concept for early detection of incident-prone traffic conditions will be explored for traffic management through ramp metering and Variable Message Signs in order to smooth flow and prevent (to the extent possible) incident occurrence, thereby further reducing delays and improving safety.

Future TMC Operations System Prototype and Testing Facility (Phase 2)
Principal Investigator: Panos Michalopoulos, Department of Civil Engineering

This phase of the research is to develop an innovative and unique “Future TMC operations system prototype and testing facility.” The work has two major objectives. The first is to analyze and understand Mn/DOT’s current Traffic Management Center (TMC) control room operations. Based on the results of the analysis, the researchers will propose and develop alternative concepts for future control room operations. These concepts will be presented to the TMC for feedback and prioritization, with detailed design of the selected concepts and a user interface for their implementation to follow. The second objective is to expand the current TRAMLAB system by adding new components, such as ramp metering Variable Message Sign (VMS) control and simulation. The expanded TRAMLAB system will serve as a Traffic Management Laboratory able to evaluate operational control policies and objectives, new ramp metering control algorithms, and data/control parameter derivation rules. In short, in this phase a new incremental and component-independent facility will be developed for rapid development, testing, and deployment of the next generation TMC.

Traffic Flow Modeling and Simulation of the Miller Hill Corridor
Principal Investigator: Jiann-Shiou Yang, Department of Electrical and Computer Engineering, UMD

This project is studying the traffic flow modeling, simulation, and signal timing plans evaluation of the Miller Hill corridor along I-94 (Central Entrance-Miller Trunk Highway) between Haines Road and Arlington Avenue, one of the most heavily traveled and congested roadways in the Duluth area. Along this 2.3-mile (3.7-km) corridor, eight signalized intersections and seven road segments will be investigated. A real-time, non-intrusive data collection system will be used to collect traffic data on the corridor and provide useful data in some locations not currently covered by the existing loop detectors. Researchers will then model traffic flow using a macroscopic approach and, using the collected traffic data, will identify and properly tune the model parameters. Based on the dynamic models developed, a traffic-flow simulation system will be integrated and implemented to perform the traffic flow simulation study, and the results will be analyzed and used to evaluate alternative traffic signal timing on the corridor. The ultimate goal of this research is to provide a better signal timing plan to improve the efficiency of traffic movement in that area.

Social and Economic Policy Issues Related to ITS Technologies

Transportation Technologies for Sustainable Communities
Principal Investigator: Lee Munnich, Humphrey Institute of Public Affairs

Developing a sustainable transportation system is a key goal of Mn/DOT. While sustainability has many definitions, reducing negative environmental impacts, increasing multi-modalism, and improving safety are all elements of a sustainable system. The State and Local Policy Program (SLPP) at the Humphrey Institute of Public Affairs has examined many aspects of ITS and smart growth, including institutional and political issues related to telecommuting and development of indicators of sustainable transportation. Key technologies now in late stages of development and early stages of deployment include Global
Positioning Systems (GPS), telecommunication, and wireless technologies. Given the potential widespread impact, this study will examine the political, legal, and institutional issues raised by the application of GPS, wireless, and telecommunications technologies to transportation and will begin to investigate the question of what additional effects may result.

Abstracts of Newly Funded Research Projects

Human Performance and Behavior

Fatigue Detection: Can Fatigue Detection Devices Predict the Driving Performance of Sleep-Deprived Drivers?
Principal Investigator: John Bloomfield, Human Factors Research Laboratory

Driver fatigue is a contributing factor in highway crashes, and commercial motor vehicle (CMV) drivers are particularly vulnerable. The effects of fatigue on driving could be mitigated in a number of ways, such as by the use of testing instruments by law enforcement officers to determine when drivers are fatigued, by the use of monitoring systems that would warn a driver so that he or she could take corrective action, and through the dissemination of information both to CMV drivers and to the general public to make both groups more aware of the effects of fatigue on drivers. This proposal focuses on the first of these approaches by exploring the relationship between sleep deprivation, driving performance, and measurements obtained from a candidate-testing instrument.

Between 20 and 40 subjects will be kept awake and tested throughout a 20-hour period. Driving performance data will be collected while the subjects drive in a wrap-around driving simulator. Impairment will be assessed with various measurement instruments—including EyeCheck™, the psychomotor vigilance test (PVT), and the digit symbol substitutions test (DSST)—before and after each driving session. If it appears there is a reliable relationship between driving performance impairment and the output of the EyeCheck™ once the data are analyzed, then these data will be formulated in a way that facilitates use by law enforcement officers.

Accident Analysis for Low-volume Roads
Principal Investigator: Michael Wade, School of Kinesiology and Leisure Studies

This study seeks to determine, via meta-analysis of extant accident data for greater Minnesota township roads, whether or not design of low-volume roads, and/or existing standards relating to signage on them, are driven by decisions based on accident data. The researchers will analyze accident data in a typical out-state county to determine accident rates on low-volume township roads and discover if signage, seasonal variations, and other factors influence accident rates.

Deer Avoidance Research: Use of Motion Detector Flashing Light
Principal Investigator: Michael Wade, School of Kinesiology and Leisure Studies

Each year in Minnesota there are approximately 20,000 reported, and as many as 10,000 unreported, deer-vehicle collisions. These collisions result in personal injuries, costly vehicle damage, loss of wildlife, and two to three human deaths per year.

Various methods of deer control have been implemented in regions with high deer concentrations. All have had mixed results, and most have proven ineffective. This study seeks a driver-centered approach. Rather than attempt to manipulate fauna, which are unpredictable and quickly habituate to most control methods, this research seeks an effective method of manipulating driver behavior.

New technologies have been developed using infrared motion detectors coupled with standard warning signage with the hope of improving both driver awareness in deer crossing zones and the ability to precisely indicate the location of the deer. For example, General Motors’s infrared detection system is mounted on a vehicle’s grill and detects long-range infrared signals, which are converted into a video signal and projected to the driver via a head-up display on the lower portion of the driver’s windshield. The effectiveness of this system has not been evaluated.

The researchers propose building a simulator model of a typical Minnesota road and incorporating existing signage and the proposed infrared deer warning systems to assess driver responses prior to real-world implementation.
Computing, Sensing, Communications, and Control Systems

GPS-based Real-time Identification of Tire-road Friction Coefficient
Principal Investigator: Rajesh Rajamani, Department of Mechanical Engineering

This project aims to develop a GPS-based system that can provide accurate real-time estimates of tire-road friction coefficients for a vehicle. The proposed system combines knowledge of vehicle dynamics with real-time measurements of the longitudinal and lateral motions of a vehicle in order to calculate the value of the friction coefficient at the tires.

The friction identification system would be useful to snowplows, since real-time knowledge of the friction coefficient could aid in snowplowing and salt-addition operations. Real-time identification of the friction coefficient would also be immensely valuable for driver-assistive safety systems, including ABS, skid control, collision avoidance, and adaptive cruise control.

Automated BRT: Innovative Technologies for Dedicated Roadways
Principal Investigator: Craig Shankwitz, Department of Mechanical Engineering

This research will develop safe, economical methods to implement fault-tolerant, robust driver-assistive systems that perform vehicle guidance and collision-avoidance tasks for heavy vehicles. At the conclusion of this work, the robustness and reliability (and therefore, safety) of the driver-assistive systems presently under development will be significantly increased.

The primary applications for this technology in Minnesota are for buses operating on bus-only shoulders and on dedicated bus ways. The main thrust of this research will use the Institute’s SAFETRUCK as a test bed to develop these robust, redundant vehicle guidance and collision-avoidance technologies. Once proven on the SAFETRUCK, the technology will be applied to transit buses and exhaustively tested, ideally in a field operational test scenario.

Driver-assistive Systems for Rural Applications
Principal Investigator: Craig Shankwitz, Department of Mechanical Engineering

This research is aimed at developing a deployment path for the driver-assistive system developed for snowplows over the next five years. This driver-assistive system uses high-accuracy DGPS, digital maps, radar, and a head-up display (HUD)-based graphical user interface to create a virtual view out the windshield when the normal view is obscured by snow, sleet, ice, rain, or darkness.

The research is separated into two components. The first aims at developing a technology to quickly and efficiently create digital maps using data collected during paint striping operations. Currently, the digital maps used for driver-assistive systems are created from photogrammetry, or vehicle “drive-over” data, which is then manually reduced, formatted, and placed in a geospatial database. These techniques are time consuming, labor intensive, and expensive. To automate the process, data acquisition equipment will be located on paint striping equipment and configured to measure precisely where the lane boundaries are placed. From that data, smoothing, feature extraction, and formatting software will be developed to automate the creation of the digital map.

The second component of this deployment path will give county engineers the opportunity to evaluate driver-assistive technology, provide feedback, and help improve the technology. The intent is to partner with a number of counties across Minnesota in order to get feedback on the deployment of these technologies in a variety of landscapes.

Technologies for Modeling, Managing, and Operating Transportation Systems

Gap Acceptance Model/Conflicts and Accidents at Merging and Turn Lanes
Principal Investigators: Gary Davis and David Levinson, Department of Civil Engineering

A recurring problem in intersection and interchange design involves assessing the tradeoffs between the geometric characteristics of ramps, turn lanes, or merge lanes and the potential for accidents during merging. This project will conduct an empirical investigation of merging behavior on selected Minnesota roads with the aim of developing a gap acceptance model that adequately describes driver behavior during merging. The gap acceptance model will then be used to predict the likelihood of “near misses” during merging as a function of 1) geometric characteristics such as design speeds and lengths of merging lanes, and 2) speed and gap distributions of oncoming traffic.

Finally, the near-miss model will be coupled with a model of braking, acceleration, and reaction time to predict the number and severity of rear-end collisions in the merge area. This will provide a tool for comparing the differences in expected merging accidents for different merging/turning lane designs.
Development of a Dynamic Route-Clearance Strategy
Principal Investigator: Eil Kwon, ITS Institute

Providing a safe and fast driving environment for emergency vehicles so they can reach their destinations in the least amount of time possible is vital for saving lives and reducing property loss. Although various types of signal preemption technologies have been developed to provide a green light for an emergency vehicle approaching an intersection, current state-of-the-art signal preemption in the United States has not reached the point where route-based signal clearance strategies can be automatically generated and implemented in real time.

This research will develop dynamic route-based signal preemption strategies by combining emerging technologies in wireless network communication and automatic vehicle location. The first phase of the research will formulate alternative strategies and conduct preliminary evaluation under the simulated environment. Further, a framework for an interface with the Traffic Operations Center of the city of Minneapolis, which operates the intersection signals for the University campus network, will also be developed with the participation of city traffic engineers. The results from the first phase of this research will be used to develop a prototype dynamic route-clearance system in the subsequent phase.

TMC Traffic Data Automation for Mn/DOT’s Traffic Monitoring Program
Principal Investigator: Taek Mu Kwon, Department of Electrical and Computer Engineering, UMD

Mn/DOT has been responsible for collecting, analyzing, and publishing traffic count data from the various road systems throughout the state. The traffic reporting system developed chiefly by the Traffic Forecasting and Analysis Section (TFAS) of Mn/DOT has been used in several federal programs, internal Mn/DOT applications, and the private sector. The objective of this project is to continue the TFAS’s automation efforts by computerized integration of the current manual effort to import, filter, and analyze the Traffic Management Center’s portion of traffic data contributed to Mn/DOT’s Traffic Monitoring System. The resulting system will allow users to specify the conditions for acceptance tests required by TFAS for both continuous- and short-duration-count volume data. Once the filtering procedures and parameters are set by an operator, the raw data can then be automatically processed by the system without human intervention.

Ramp Meter Delays, Freeway Congestion, and Driver Annoyance
Principal Investigators: David Levinson, Department of Civil Engineering, and Kathleen Harder, Human Factors Research Laboratory

Current ramp metering algorithms try to maximize capacity, implicitly minimizing total delay. If travelers value time at the ramp differently than time-in-motion, this time-minimizing strategy may not maximize utility for travelers. This research will attempt to quantify the importance travelers give to qualitatively different experiences of travel time: waiting at a ramp meter versus traveling at different freeway speeds requiring varying numbers of acceleration and deceleration shifts. This information will enable ramp meters to be better timed in a way that responds to individual perceptions.