Northland Advanced Transportation Systems Research Laboratories (NATSRL), founded in 2000, pursue research in the areas of intelligent transportation systems (ITS) at the University of Minnesota Duluth (UMD). The primary mission of NATSRL is to develop innovative technologies that can be directly applicable in making the transportation systems in northern areas safe, efficient, and sustainable.

Research
The research focus areas in NATSRL are:

- Advanced sensing technologies for detecting and measuring traffic, driver, pedestrian, and pavement condition
- Traffic and driver safety technologies through vehicle and infrastructure integration with wireless communication
- Winter road snow and ice management decision-support strategies
- Advanced traffic operations and management strategies under various traffic and weather conditions

Recent Projects
- Carbon-nanotube-based intelligent concrete pavement for traffic detection
- A non-intrusive sensing system to detect driver drowsiness
- A snow and ice detection system for bridge decks and road surfaces with time domain reflectometry (TDR) technology

Staff
Eil Kwon, Director

www.its.umn.edu/ProgramsLabs/NATSRL
• Traffic detection and monitoring based on customized vision-processing hardware
• A realistic snow-rendering graphic simulation model that can be used to visualize and assess the effects of alternative snowplow truck lighting and coloration designs
• A dedicated short-range communications (DSRC)-based work-zone traveler information system
• A fuel-cell-based alternative power system for operating ITS devices
• A robotic painter for pavement marking
• An infrared thermal-camera-based deer detection system with automatic tracking
• A decision-support system for proactive deployment of ITS safety strategies
• A road-departure warning system with automatic identification of vehicle location

Capabilities
All research projects supported by NATSRL are performed in individual departments at the University of Minnesota Duluth, with a common facility that includes a driving simulator and an outdoor laboratory where new hardware for traffic, snow, and ice detection can be tested.

NATSRL has also been developing cooperative research activities in transportation with foreign research institutes and universities. These include a visiting researcher and graduate student exchange program and joint research projects. Currently one international graduate student and one faculty member are working at NATSRL as visiting scholars.

Partners
NATSRL has formed a strong partnership with its key stakeholders by developing a Research Advisory Panel (RAP) and Advisory Board structure whose membership includes experts from the following partnership agencies:
• U.S. Department of Transportation–Research and Innovative Technology Administration
• Minnesota Department of Transportation
• St. Louis County, Minnesota
• City of Duluth

The RAP, which meets every semester, plays a major role in managing and guiding NATSRL research activities as the ongoing communication channel between NATSRL faculty and local transportation practitioners. The strategic directions and the yearly research programs of NATSRL are discussed and finalized at an annual Advisory Board meeting.
Intelligent Vehicles Laboratory
www.ivlab.umn.edu | www.bus2.me.umn.edu

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Purpose
The Intelligent Vehicles Laboratory (IV Lab) develops and tests innovative, human-centered technologies that improve the operational safety, mobility, and productivity of the transportation network in general, and highway vehicles in particular. These human-centered technologies integrate sensors, actuators, computer processors, and custom human interfaces to provide drivers with needed information under difficult driving conditions such as low visibility, severe weather, and narrow and congested roadways.

Although the IV Lab is focused primarily on vehicles, it also considers the roadway, supporting infrastructure, and electronic wireless communication as part of the transportation network and uses all of these elements in generating solutions to transportation problems.

Research
The University of Minnesota is recognized as a leader in developing and testing driver-assistive systems and is one of a small number of universities nationwide conducting this work. Current research topics include the design and testing of custom human interfaces, technologies to assist and monitor inexperienced teen drivers, collision-avoidance sensors and algorithms, intersection surveillance systems, and wireless communication (vehicle–vehicle and vehicle–infrastructure).

Recent Projects
- Advanced Bus Rapid Transit: Innovative Technologies for Dedicated Roadways
- Infrared Sensing for Driver-Assistive Systems
- Multiuse, High-Accuracy, High-Density Geospatial Databases
- In-Vehicle Driver Assistance for Teenagers
- Motorcycle Riding Impairment at Different BAC Levels
- Guidance Augmentation for Transit Applications
- GPS Augmentation for Robust Lane Assistance
- Analysis of Highway Design and Geometric Effects on Crashes

Capabilities
IV Lab research focuses on increasing driver safety in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. Several vehicles serve as experimental testbeds for these technologies, including two passenger cars, the SAFEPLOW (an International 2540 crew-cab snowplow), a state highway patrol car, and a Minnesota Valley Transit Authority (MVTA) bus used for transit research. Using these vehicles, IV Lab researchers are developing, testing, and integrating advanced technologies, including:

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- Centimeter-level differential global positioning systems (DGPS)
- High-accuracy digital-mapping systems
- Range sensors, including radar and laser-based sensors
- A head-up display (HUD), virtual rear-view mirror, and other graphical displays
- Haptic and tactile feedback

The IV Lab’s partnership with the Minnesota Department of Transportation provides access to roads and other infrastructure, including the Minnesota Road Research Project (MnROAD) test track, which consists of a freeway and a low-volume road pavement test track with 40 different road material test sections, 4,500 electronic sensors, a weigh-in-motion scale, a weather station, and DGPS correction signals.

The core staff of the IV Lab consists of engineering professionals who work closely with an interdisciplinary team of specialists, including cognitive psychologists specializing in human factors from the ITS Institute’s HumanFIRST Program. The staff has developed expertise in wireless communications, embedded computing, visibility measurement and quantification, geospatial databases, virtual environments, image processing, driver-assistive technologies, control systems, and sensors.

**Deployment**

Four vehicles with driver-assistive technology have been deployed in Alaska, where high snowfall rates and blowing snow routinely cause whiteout conditions and zero visibility. Because of its success with the IV Lab, the state of Alaska has ordered three new driver-assistive systems and two upgrade kits for its systems that operate near Valdez. The kits will provide new computation capability not provided by the current computers.

The Minnesota Mobile Intersection Surveillance System (MMISS), developed under the auspices of the IV Lab’s rural intersection crash reduction research program, has collected data on driver behavior at rural expressway through-stop intersections in Wisconsin, Iowa, Michigan, North Carolina, Georgia, Nevada, and California. Data collection in a broad array of states supports the development of a nationally deployable intersection safety system designed to save lives among rural drivers. This technology is also being deployed at a rural expressway intersection (U.S. 53 and County 77 in Minong, Wis.) through the USDOT’s Rural Safety Improvement Program (RSIP).

**Partners**

- U.S. Department of Transportation
  - Federal Highway Administration
  - Federal Transit Administration
  - Research and Innovative Technology Administration
- Minnesota Department of Transportation
- Minnesota Local Road Research Board
- Hennepin County
- Minnesota Valley Transit Authority
- Twin Cities Metro Transit
- Other local and regional agencies

Technology developed by the IV Lab will help bus drivers maintain reliable schedules while operating safely on narrow bus-only highway shoulders. A fleet of 10 buses equipped with the driver-assistive technology will go into service in the Twin Cities in 2010.
Minnesota Traffic Observatory

www.mto.umn.edu

Staff
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Purpose
The Minnesota Traffic Observatory (MTO), a joint effort of the ITS Institute and the Department of Civil Engineering, supports a wide range of research in monitoring, management, and simulation of traffic systems. The observatory combines real-time traffic data with state-of-the-art simulation systems, giving researchers and engineers the ability to analyze existing conditions and compare real-world observations with the results of simulated conditions.

Research
MTO research focuses on testing and evaluating new transportation management and operational strategies and traveler information technologies. Specific focus areas include microscopic simulation, traffic model calibration, and incident detection and prevention.

Recent Projects
• A Predictive Study of Use Impacts on the Denali Park Road
• Bus Signal Priority Based on GPS and Wireless Communications
• Enhanced Micro-Simulation Models for Accurate Safety Assessment
• Identification and Simulation of Common Freeway Accident Mechanisms
• Accident Prevention Based on Automatic Detection of Accident Prone Traffic Conditions
• Evaluation and Improvement of the Stratified Ramp Metering Algorithm through Microscopic Simulation

Capabilities
The MTO offers researchers the ability to study large traffic systems where many different parts interact. Video feeds flow into the observatory from an extensive network of traffic cameras. The observatory is connected by fiber-optic lines to the Minnesota Department of Transportation’s Regional Traffic Management Center, allowing the MTO to capture up to 16 live feeds at a time from the 400 cameras the agency uses to monitor the metropolitan freeway system. In addition, the observatory operates a dedicated system of cameras overlooking the I-94/I-35W Commons interchange in Minneapolis—turning one of the most crash-prone intersection areas in the state into a real-world laboratory for the study of traffic flows and vehicle crashes.

The availability of a wealth of high-quality video data allows researchers to conduct experiments and simulations that cannot be performed in the real world. This data provides valuable insights into traffic patterns and behaviors, helping to inform policies and strategies that can improve transportation systems.
data is ideal for the use of machine-vision systems to monitor and categorize vehicle movements. Computer image-processing algorithms developed by University of Minnesota researchers enable the observatory to track and analyze complex traffic patterns at intersections, on freeway interchanges, and in other areas that are difficult to study using other data sources.

Another key component of the MTO is a virtual traffic control center and simulation lab. Interfacing traffic signal control hardware with realistic traffic network models creates a powerful hardware-in-loop simulation tool for examining system performance under a variety of conditions.

Several traffic simulation packages are used in the MTO, primarily AIMSUN-NG for “microscopic” simulation based on individual vehicles, and the KRONOS 9 package, developed at the University of Minnesota, for macroscopic (platoon-based) simulations.

Given the complexity of the traffic issues that the observatory is designed to study, robust visualization tools are critical. In addition to a large projection wall, two innovative pieces of equipment provide researchers with powerful interactive visualization capabilities.

The GIS/MAP table combines the large horizontal working surface of a traditional drafting table with the interactive capabilities of geographic information systems technology. Two ceiling-mounted digital projectors create a seamless image covering the entire conference-table-sized surface, which can be manipulated using a tabletop pointing device to pan and zoom in on specific areas. In contrast to traditional ways of viewing digital maps and models on a desktop monitor, the table allows users to comfortably survey the entirety of a large traffic system and quickly focus in on areas of interest.

The DEN (Digital Immersive ENvironment) is a high-fidelity 3D interactive immersive display system that allows researchers to observe and explore traffic flow scenarios within any environmental context and from any fixed or moving perspective. Three sides of the cubical structure are formed by large rear-projection screens presenting polarized images from two slightly different sources; a user wearing specially designed glasses sees a different image with each eye, producing a realistic sense of three-dimensional space. A tracking system mounted in the DEN’s ceiling monitors the position of the user’s head and adjusts each projector to provide an accurate perspective.

Outreach and Education

The MTO is dedicated to supporting transportation education at the University. MTO facilities are used by faculty and students in civil, mechanical, and electrical engineering, computer science, and affiliated disciplines, and MTO staff work with faculty to develop interactive laboratory modules that help students understand advanced topics in traffic management. The MTO also hosts training events for transportation professionals, covering topics such as the effective use of traffic simulations for capacity analysis and planning.

Partners

- U.S. Department of Transportation
  - Federal Highway Administration
  - Research and Innovation Technology Administration
- Minnesota Department of Transportation
- University of Vermont
- National Park Service
- Next Generation SIMulation (NGSIM) Community
- Other local and regional agencies
HumanFIRST Program

www.humanfirst.umn.edu

Staff
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Purpose
The Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program applies human factors principles to improve scientific understanding of driver behavior and supports the design and evaluation of usable intelligent transportation systems.

Research
As implied by its name, the program's research strategy is based on a driver-centered approach, considering the "human first" within the transportation system. Research seeks to propose, design, and evaluate innovative methods to improve transportation safety based on a scientific understanding of driver performance and the psychological processes associated with traffic crashes. It considers how a driver will accept and use a proposed system while also considering the possibility of its producing undesirable driver responses and adaptation (e.g., distraction, complacency, fatigue, risk-taking) that could undermine the system goal of improved safety. Specific research topics include:

- Driver distraction from in-vehicle tasks and cell phones
- Driver-assistive systems to reduce teen-driver-related fatal crashes
- Rural and urban driver attitudes and crash risk
- Interventions for crash reduction at rural intersections
- Intelligent driver-support technologies such as vision-enhancement, collision-avoidance, hazard-awareness, and lane-keeping systems for passenger and special-purpose vehicles
- Alcohol impairment, including motorcycle safety

Recent Projects
- Smartphone-Based Novice Teenage Driver Support System
- Vehicle-Based Teen Driver Support Systems
- Rural Intersection Decision Support
- CICAS Stop Sign Assist (SSA) System
- Effects on Driver Performance of Advanced Traveler Information Systems and 511 Information Retrieval
- Motorcycle Riding Impairment at Different BAC (Blood Alcohol Concentration) Levels
- Generational Perspectives on Teen and Older Drivers on Traffic Safety in Rural and Urban Communities
- The Use of Video Feedback in Urban Teen Driving

A new bus driving simulator installed at the Minnesota Valley Transit Authority garage allows program staff to test and evaluate bus driver-support systems and bus driver training protocols.
Capabilities
The centerpiece of the facility is a state-of-the-art driving simulator engineered specifically for human factors research in surface transportation. This versatile simulator consists of a full-cab Saturn SC2 vehicle and software capable of creating virtual environments that precisely reproduce any geospecific location. In addition, specialized visual-effect software can produce realistic weather and lighting—including light and shadow that correspond with season and time of day—as well as vehicle headlights with nighttime glare and water reflections.

The visual environment is generated with high-resolution images (1.97 arcmin per pixel) over a wide field of view (FOV): 210-degree forward field of view, 50-degree rear FOV, and two 20-degree FOV side mirror images. This immersive driving experience is enhanced by realistic motion generated by a three-axis motion base and both high- and low-frequency vibration units, including a surround-sound system. With multiple sound systems, configurable touch panel displays (including head-up displays), haptic feedback through the seat and accelerator pedal, and a head-free eye-tracker that can detect in real time what a driver is looking at, this simulator supports the investigation of a wide range of interface options for ITS development, design, and assessment. These features make it one of the premier driving simulators in North America and Europe.

The HumanFIRST Program also has access to a new bus driving simulator installed at the Minnesota Valley Transit Authority garage, where program staff can test and evaluate bus driver-support systems and bus driver training protocols. Additionally, for real-world testing and validation, the program has access to a variety of test track and operational research settings in which participants can drive the program’s fleet vehicles in a wide range of normal driving situations.

The HumanFIRST facility includes equipment for basic research on driver psychological functioning including a vision tester, DOT-certified breath alcohol analyzer, mobile psychophysiological recording system, mobile eye-tracking system, video editing and behavior analysis suite, and a comprehensive psychometric test battery validated for traffic psychology. A strength of this equipment is that it can be employed in the driving simulator, test track, or on-road research facilities.

The program’s core staff of transportation research specialists, made up of psychologists and engineers, provides a well-established base of content expertise. This core group is linked to a broad interdisciplinary network of experts in advanced, basic, and applied sciences throughout the University to provide a flexible and comprehensive research capacity. This network is supported by affiliations with additional University research units, which allows the program to create interdisciplinary teams to investigate a range of complex human factors research issues in transportation safety.

The program has close relationships with the Minnesota Departments of Transportation and Public Safety, private industry, traffic engineering consultants, and other related entities. These connections provide support for implementing research that will influence transportation policy in response to real-world problems both regionally and nationally. In addition, to ensure that research takes into account developments on the world stage, the program’s work is supported by international collaborations with experts in relevant disciplines.

Partners
- United States Department of Transportation
  - Federal Highway Administration
  - National Highway Traffic Safety Administration
  - Research and Innovative Technology Administration
- Minnesota Department of Transportation
- Minnesota Local Road Research Board
- Minnesota Valley Transit Authority
- Other local and regional agencies

Simulated view of the I-35W corridor in which buses outfitted with driver-assistive technology will operate. The simulator is being used to train MVTA bus drivers in using the technology to safely operate in the narrow bus-only shoulder lane.