Minnesota researchers add their expertise to federal intersection safety initiative

CICAS brings together federal agencies, vehicle manufacturers, and university researchers

Death waits at the crossroads. Intersections make up only a small part of the U.S. highway network, but intersection crashes comprise more than 30 percent of all vehicle crashes nationwide. In rural Minnesota, crash records show that approximately one-third of all crashes occur at intersections—and research has found that failure to select a safe gap in traffic is a factor in more than three-quarters of these incidents.

Researchers from the ITS Institute’s Intelligent Vehicles Lab, the HumanFIRST Program, and the Minnesota Department of Transportation recently announced their participation in the Cooperative Intersection Collision Avoidance Systems (CICAS) initiative, a new national research effort to develop technologies that will reduce intersection crashes. The Minnesota researchers will focus on infrastructure-based solutions.

In 2002, the ITS Institute began an ambitious research effort to develop infrastructure-based technologies capable of reducing driver error at unsignalized rural highway intersections where a high-speed rural expressway intersects a low-speed, low-volume rural road. Historically, installing a traffic signal has been seen as the only recourse in locations with high crash rates, but research has indicated that adding a traffic signal to rural highway intersections often brings a new set of safety problems as well as disrupting high-speed express traffic.

The Institute’s Intersection Decision Support (IDS) research has focused on giving drivers stopped on secondary roads better information about traffic approaching on the main road. Researchers led by Intelligent Vehicles Laboratory director Craig Shankwitz have designed a sensor network that can track approaching vehicles and determine if gaps between them will be sufficient for a stopped vehicle to safely enter or cross the highway. Nic Ward, director of the HumanFIRST Program in human factors engineering, has led other researchers developing electronic signage that effectively communicates critical information to motorists. The ITS Institute has also taken the IDS concept beyond Minnesota’s borders, through a pooled-fund partnership with other state departments of transportation.

In the past two years, IDS research has accomplished several important research goals that will contribute to CICAS research, including:

- developing advanced traffic sensor networks
- developing an advanced vehicle trajectory measurement and recording system
- studying driver gap acceptance behavior on a microscopic level using traffic simulation
- testing new active displays in a driving simulator to determine what information a driver needs to safely maneuver through rural unsignalized intersections

CICAS continued on page 3

An experimental sensor installation at a rural highway intersection in western Wisconsin. Research partnerships with other states enabled researchers to gather data under a variety of intersection conditions.

INSIDE

2008 Student of the Year .......................... 2
RFID tags for safer roads .......................... 2
Students attend TRB annual meeting .......... 4
Recently published research reports .......... 4
Upcoming events ................................. 4

Winter Luncheon highlights safety of teen drivers

Inexperience is the root of the young driver problem—and the most promising ways to solve it are graduated licensure and more effective parent involvement, said Bruce Simons-Morton at the Center for Transportation Studies’ Winter Luncheon on February 8, 2007. The annual event is sponsored by the ITS Institute.

Simons-Morton is the chief of the Prevention Research Branch in the Division of Epidemiology, Statistics, and Prevention Research at the National Institute of Child Health and Human Development, National Institutes of Health.

“Crash rates are extremely elevated for newly licensed drivers,” Simons-Morton said. The rate in the first two weeks of driving is 20 times higher than it is six months later, and even after two years of driving, it is double of those aged 25–35. (A similar pattern exists for novice drivers at any age.)

Conventional wisdom blames much of the problem on the risk-taking behavior of teens, Simons-Morton said, but studies indicate inexperience and lack of exposure to real-road conditions play a much bigger role.

The crash rate picture looks very similar to the learning curves of other activities such as golfing or learning a new language—errors decrease with practice. With driving, however, other factors—rare events, complexity, and cognitive capacity—affect the error rate.

Luncheon continued on page 4
“Tags” in the road hold promise for smarter vehicle location systems

What makes intelligent vehicles smart? The ability of a vehicle to “know” where it is at any given moment is one measure of intelligence that enables a host of intelligent transportation systems applications, from basic navigation assistance to automatic collision warning.

Today, the Global Positioning System, a network of satellites broadcasting navigation signals from fixed points in space, is the backbone of many systems that require constant navigational information. University of Minnesota researchers have developed several advanced driver-assistive systems using GPS technology. But by its very nature, GPS suffers from limitations that keep it from being the ideal single solution to the location needs of intelligent vehicles.

Intelligent Vehicles Laboratory director Craig Shankwitz and graduate student Matthew Bevilacqua are among the researchers developing new technologies that will augment GPS, in order to meet the need for more robust location information in tomorrow’s intelligent vehicles. Recently the researchers have examined the potential use of a technology commonly seen outside of transportation—RFID, or radio frequency identification.

Most people today are familiar with RFID through the use of small RFID tags as theft-deterrent devices that must be removed or deactivated before leaving a store. But the technology actually has a long history in transportation: as early as 1973, a prototype system was developed with possible applications including automatic vehicle identification and toll collection.

A passive RFID system works by encoding information on small, unpowered electronic circuits that can be embedded in tags or capsules. When these circuits are close to a specially designed radio transmitter, the power from the transmitter produces a signal from the RFID circuit; these signals can transmit a small amount of unique information that has been encoded within them, such as an identification code.

Why use RFID at all? Using satellites gives GPS great advantages, like the ability to cover the entire surface of the planet. But in order to determine a position accurately, GPS receivers require direct line-of-sight signal paths to at least three GPS satellites at all times. For a ship cruising on the open ocean, this is usually no problem, but for a bus navigating urban freeways, many obstacles can interfere with the GPS signal—even passing under a bridge can disrupt the signal, forcing the receiver to spend crucial seconds re-acquiring the satellites in order to compute a new position. Other factors, such as confusing signal reflections from the sides of tall buildings in “urban canyons,” also impede the effectiveness of GPS.

For some applications, such as guiding a driver along a route to a destination, the minor disruptions caused by signal loss may be tolerable. But for other safety-critical tasks such as helping a bus driver operate on narrow road shoulders or collision avoidance on congested urban roads, temporary
signal loss can spell disaster.

In the IV Lab’s vehicle positioning system (VPS), RFID tags would be embedded at regular intervals along the center of highway lanes. A tag reader antenna mounted along the front bumper of a vehicle would activate the tag as it passes, retrieving the encoded data and passing it to an onboard computer.

The positional information provided by the RFID system is very different from that provided by GPS—instead of coordinates on the surface of the Earth, it shows a vehicle’s position as a distance along a roadway. This is actually not a disadvantage, because lane position and linear distance on a road is precisely the information required by many ITS applications. In order to get this information, GPS coordinates must be matched against high-accuracy digital maps of the road network, requiring more computation and introducing additional possibilities for error.

But the greatest promise of this new system may not be as a replacement for GPS, but rather as a complementary technology. VPS could provide high-accuracy positioning in areas where GPS cannot achieve the required accuracy.

To demonstrate the possible use of RFID-based positioning, the IV Lab researchers implemented a basic collision-avoidance system using the technology.

Several academic and industry groups are currently researching “electronic brake light” systems that warn drivers when they are in danger of striking a leading vehicle that has suddenly slowed down. The IV Lab system combines RFID positioning with inter-vehicle communication using the emerging Digital Short-Range Communications (DSRC) standard now under development by a consortium of vehicle manufacturers, researchers, and federal transportation agencies.

In the experimental system, a lead vehicle was equipped with an inertial sensor that registered any sudden deceleration. An onboard DSRC unit then transmitted a braking warning, which would be received by all vehicles in the immediate area, along with the position of the braking vehicle. Because the warning would only be useful to a vehicle following close behind the lead vehicle, the following vehicle in this experiment was equipped with a computer system that compared the location of the braking vehicle with its own location, and activated a warning buzzer if it determined that the two vehicles were close enough to create a dangerous situation.

The researchers note that the experimental electronic brake light system developed during their research is intended to demonstrate a potential application of VPS technology—not to serve as a real-world safety system. Following successful tests of the experimental system, the research team continued to explore ways to make the system more robust. By incorporating additional information from onboard sensors and using more advanced computational techniques, they developed a second generation approach to identifying potential crash risks for platoons of moving vehicles.

Findings from the experimental electronic brake light system are now being applied to the development of a system to assist bus drivers in maintaining position in a narrow shoulder lane when GPS signals are unavailable.

Although the development of RFID-based vehicle positioning systems offers great potential to enhance current positioning technologies, the researchers note that today’s commercial RFID systems may not be adequate for the development of robust solutions. Custom transportation-focused RFID systems could be developed to meet this need; however, the rapid advance of RFID technology may soon make RFID a viable tool for ITS applications.

CICAS from page 1

Max Donath, director of the ITS Institute, says that participation in CICAS is a direct outgrowth of the IDA research program.

“We see this as a tremendous opportunity to build on what our researchers have accomplished in the areas of sensing and driver interface design,” Donath said. “Making vehicle-based and infrastructure-based systems work together smoothly is a challenge, but the potential payoff in terms of road safety is enormous.”

The USDOT describes CICAS as a “cooperative” system, meaning it integrates data from both vehicle-based and infrastructure-based sensing systems via the newly allocated Dedicated Short-Range Communications (DSRC) portion of the radio spectrum. Warning display systems using these data are to be developed for both in-vehicle and outside-the-vehicle placement.

Although Minnesota’s research will focus on infrastructure-based solutions, the ability to receive data directly from vehicles opens up new possibilities. For example, commercial trucks require more time for starting and stopping than passenger cars; a system that knows the size and configuration of approaching vehicles, or relevant information about the driver, would be able to tailor its responses in order to help each driver find a safe gap in traffic. Alternatively, DSRC might make it possible to shift the computation of safe gap sizes to a computer on board the vehicle itself, thereby avoiding any need to transmit data about the vehicle and driver.

Minnesota’s CICAS research, expected to last five years, will include four main components:

1. A microscopic, in-vehicle measurement of driver gap acceptance at an instrumented intersection
2. Alert and warning algorithms to be used to appropriately inform drivers of dangerous conditions in a timely manner

Integrating in-vehicle and infrastructure-based technologies promises dramatic safety benefits.

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Travel awards enable students to attend TRB Annual Meeting

Several students from the University of Minnesota’s Department of Civil Engineering received ITS Institute travel awards to attend the January 2007 Annual Meeting of the Transportation Research Board in Washington, D.C. Every year, the Institute provides funding for students pursuing transportation-related degrees to attend the annual meeting, where they can participate in discussions of the latest issues in transportation and rub shoulders with researchers from around the world.

This year’s travel award recipients were:

- Feng Xie, Civil Engineering (CE)
- Shanjiang Zhu, CE
- Wuping Xin, CE
- Ryan Wilson, Humphrey Institute of Public Affairs and CE
- Wenteng Ma, CE
- Xiaozheng He, CE
- Saif Jabari, CE
- Xinkai Wu, CE

The issues highlighted by Simons-Morton are also the subject of research at the University Minnesota. With support from the ITS Institute, researchers are developing in-vehicle technology to help reduce unsafe driving by teens. Their research was featured in the Spring 2005 Sensor.

One solution is greater use of graduated driver’s licenses (GDLs). Used in many states, GDLs impose limits on night driving, passengers, and other behaviors. Substantial evidence shows GDLs improve the safety of independent driving, he said.

Another solution is more effective parent management. Risky driving declines when parents set limits—and some limits are better than others, Simons-Morton said. For example, parents commonly require teens to obtain permission before driving and to provide their destination and return time. “But these limits have no effect on safety,” he said, “and mainly serve to ease parents’ worry.”

What’s more effective is limiting night driving, passengers, and the types of roads novices can use (to those under 55 mph), “[Parents’] hearts are in the right place,” he said, “but they don’t know what to do, and they don’t do it long enough.”

Minneapolis research

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The prototype system is designed to monitor the vehicle’s location by linking Global Positioning System coordinates to an onboard digital map, and warn the driver if local speed limits are exceeded. Also included are ignition-interlock functions that require the use of seat belts and, if designated, alcohol-testing compliance.

Luncheon continued from page 1

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UPCOMING EVENTS


April 25  Graduate Certificate in Transportation Studies Information Session, Minneapolis. Contact Stephanie Jackson, 612-624-8398, sjackson@cts.umn.edu.


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