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### Improving work-zone safety with connected vehicles

Hundreds of motorists and highway workers are killed in work zones every year, and many more are seriously injured. Though the number of work-zone deaths has been declining in recent years, more than 600 motorists and 100 workers died in work-zone crashes in 2012—the last year for which fatality data is available.

“Though we have seen a decline in work-zone fatalities, even one death is too many,” said Imran Hayee, a professor of electrical engineering at the University of Minnesota Duluth and Roadway Safety Institute researcher. “We believe there is an opportunity to use connected vehicle technology to help achieve the goal of zero deaths.”

In recent years, the U.S. Department of Transportation has made the development of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication a major research priority. At a Roadway Safety Institute seminar, Hayee described how his research team has been working to develop a variety of uses for this new technology, including a series of recent projects focused on work-zone safety.

“In the work-zone environment we know that one or two lanes are typically closed, resulting in congestion and increased travel times,” Hayee said. “However, the start of the congestion is variable, and by warning drivers in advance about the exact location of congestion and providing travel time information, we can help improve safety.”

In the initial project, funded by the ITS Institute at the University of Minnesota, Hayee’s team developed

a portable roadside unit to use as a V2I traffic information system. The unit uses Dedicated Short-Range Communication (DSRC) to monitor a selected vehicle's progress through the work zone, then transmits the information it collects at the start of congestion and travel time to all other vehicles equipped with connected vehicle technology in the area. The portable unit proved effective in field tests but had a limited range. Hayee wanted a way to extend it to a more typical work-zone length of several miles.

To that end, the team developed a V2V-assisted V2I system. "With this system, instead of using the portable unit to track the vehicle through the entire length of the work zone, we use the vehicles in the work zone equipped with smart vehicle technology to 'hop' the message back to the portable unit," Hayee explained. "This way, we can cover a work zone of two to five miles and communicate messages to vehicles more than five miles away from the start of the congestion, giving drivers time to seek an alternative route."

It will be many years before all vehicles are equipped with V2V communication capabilities, so the next challenge was creating a way to disseminate this information to all motorists. To accomplish this, Hayee's team designed a smart portable message sign that can pick up delay and travel time information from connected vehicles and display it along the roadside.

Hayee's current research, sponsored by the Minnesota Department of Transportation, focuses on developing a system that will collect and disseminate work-zone congestion and travel time information solely through V2V communication and eliminate the need for a portable roadside unit. In addition, road geography data are being incorporated into these systems to ensure the information is communicated only to vehicles traveling on the road affected by the work zone.

Though these technologies may seem futuristic, Hayee's research shows they may not be far off. "We found that during rush hour, just 20 percent of vehicles would need to be equipped with vehicle-to-vehicle communication capabilities to make these systems work," he said.

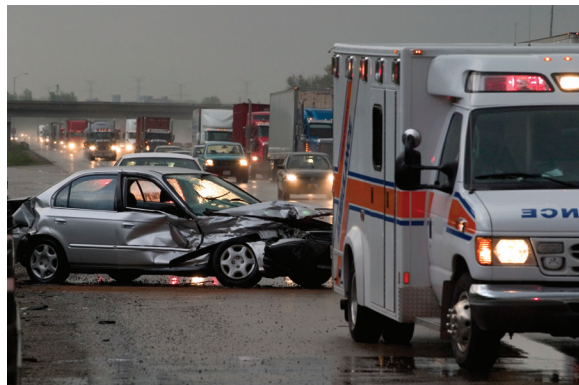
### Pinpointing crash 'hot spots' through mapping

Reducing crash-related injuries and fatalities is a major focus of every law enforcement agency and countless education campaigns, but the resources available for those efforts are finite. One question is how to use these limited resources to make the biggest impact.

"Building a better map to identify crash hot spots is essential," said William Schneider, an assistant professor in the University of Akron Department of Civil Engineering and Roadway Safety Institute (RSI) researcher. "Law enforcement organizations and motorist education campaigns have a set amount of money, and optimizing hot-spot mapping for these groups allows them to better manage their resources and improves both education and enforcement."

Traditionally, crash-mapping techniques have been either point-, segment-, or zonal-based. Each of these techniques has advantages and disadvantages, and often these basic statistical tools provide only preliminary results. During an RSI seminar, Schneider discussed his research that is focused on overcoming the disadvantages of these methods through advanced statistical techniques, increased computing power, and improvements in crash location technologies.

"By combining traditional crash-mapping techniques into a more advanced analysis, we can overcome many of the weaknesses of these basic analysis methods," Schneider said. "For example, we are using the exact same crash data but joining both point- and zonal-based analysis to remove ambiguous zonal borders and improve the accuracy of crash hot-spot identification."



Schneider's research also addresses a number of other crash-mapping challenges by looking at clustering of high-frequency crashes, examining the relationships between crash clusters, calculating the statistical significance of crash clusters, and developing better models through estimation and testing. Current and future research projects will further refine these models by improving crash cluster identification, developing new methods to correlate multiple data sets, improving model estimation, and using multiple variables to pinpoint crash clusters.

In a current project for the Roadway Safety Institute, Schneider is building on this research to identify geospatial trends in alcohol-related crashes to help law enforcement target efforts for preventing them.

Ultimately, better crash mapping will not only lead to more targeted education and enforcement efforts, but also help improve long-term resource allocation for highway safety stakeholders.

"This information can guide decisions about long-term budgeting," said Schneider. "It will help organizations manage their resource allocation to do more with less and offer a non-biased way to justify why those dollars are being spent in a certain location instead of somewhere else."

### **Making crash data easier to collect—and more accurate**

The data collected at the scene of a crash by law enforcement officers are important for more than just drivers and their insurance companies. The information is also used on a much larger scale by state agencies and researchers to analyze and evaluate crashes, trends, and potential countermeasures.

"Big decisions get made based on that data—million-dollar decisions," said Nichole Morris, a research associate at the University of Minnesota's HumanFIRST Laboratory and Roadway Safety Institute (RSI). "So you have to be sure that what goes in to that report is high quality and reflects what actually happened at the scene of the crash."

To improve this data quality in Minnesota, Morris is leading a team of researchers in a project to redesign the electronic crash report interface used by law enforcement officers. The team's goal is to create a new interface that improves the accuracy, speed, reliability, and meaningfulness of crash report data. Morris presented the work at one of a series of Roadway Safety Institute seminars last fall.

The project is occurring in conjunction with a redesign of Minnesota's crash records database and is being sponsored by the Traffic Records Coordinating Committee (TRCC) at the Minnesota Department of Public Safety (DPS) and by the Minnesota Department of Transportation (MnDOT).

"In industry, they do this work all the time, looking at usability and design. But when you think about what a state does in terms of usability, nothing like this, to our knowledge, has ever been done. This makes it a very exciting and revolutionary project for Minnesota," Morris said.

In the first phase of the project, the researchers completed a human factors analysis on the existing crash report interface, identifying several areas they hoped to improve. For instance, they wanted the new interface to be smarter, making better use of autofill features to reduce the amount of data entry for the officer. Based on feedback from officer interviews, the researchers also decided to change the order in which data are entered to make the process more intuitive.

Following the analysis, the team built two versions of a mock crash report interface for usability testing: a wizard and a form. The wizard prompts the user with a limited number of questions, one screen at a time, similar to the interface users see when installing new computer software. The form is similar to the current crash report interface and contains many questions and data entry points on each page.





The researchers then conducted four rounds of usability testing with law enforcement officers for both the wizard and the form. Results were split: half the officers preferred the wizard and half preferred the form.

Because of these findings, the TRCC is planning to build full versions of both, Morris said, which will allow officers to use the version they prefer.

Going forward, the researchers plan to make a few more adjustments to the research prototype before handing it off to the state vendor. The new interface is expected to launch in January 2016.

“The results of the HumanFIRST prototypes are being combined with the vendor’s prior experience for a best-of-breed approach,” said Kathleen Haney, traffic records coordinator at DPS. “This is a fantastic project, and the results will be relevant for years to come.”

### Researcher spotlight: M. Imran Hayee

Imran Hayee is a professor and director of graduate studies in the electrical and computer engineering department at the University of Minnesota Duluth (UMD) and a researcher for the Roadway Safety Institute. Hayee has worked at UMD since 2004 and conducts research in the areas of communication systems, optical fiber communication, digital signal processing, and intelligent transportation systems.

Hayee also oversees the Connected Vehicles Research Laboratory (CVRL) at UMD, where he and his team of students research and develop vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communication technology to improve driver safety and traffic mobility.



M. Imran Hayee

Through an Institute-funded project, Hayee is conducting research using V2V wireless communication to improve safety around merge points between two roadways, such as at freeway entrance ramps.

Hayee and his research team are working to design a mechanism incorporating dedicated short-range communications (DSRC) to acquire and compute real-time relative trajectories of vehicles traveling toward a merging junction. The DSRC-equipped vehicles traveling on the freeway and on the merging ramp will periodically communicate important information to each other, such as location, direction of travel, and speed.

This project could eventually provide merge assistance to drivers, or even facilitate automatic merging of vehicles when DSRC technologies become more readily available.

“This is emerging technology that directly impacts public safety,” Hayee says. “That’s what drives me most towards it—that it can directly benefit the public.”

Hayee believes the most pressing transportation issue in the United States is subjective thinking when making transportation decisions. For example, he says when choosing a vehicle, drivers should focus less on what specific model or style they want, and more on whether or not the car is safe, good for the environment, and good for roadways.

“I think the whole idea of intelligent transportation systems and vehicle-to-vehicle communication is really going to bring more objectivity to transportation,” he says.

Hayee holds 15 U.S. patents and has published more than 50 articles for engineering journals and conferences. He is a senior member of the Institute of Electrical and Electronics Engineers and received UMD’s Chancellor’s Award for Distinguished Research for 2011–2012. Hayee holds a master’s degree and a Ph.D. from the University of Southern California.

## Engaging pre-college students with hands-on learning

As part of its outreach and education efforts, the Roadway Safety Institute is connecting students of all ages—particularly those underrepresented in the STEM workforce—to opportunities to meet researchers, explore careers, and learn about transportation safety.

The Minnesota chapter of WTS hosts programs for TransportationYOU, a national mentoring program that offers female high-school students activities that introduce them to careers in engineering, technology, and transportation. In an Institute-sponsored activity for TransportationYOU in December 2014, RSI researcher Janet Creaser discussed her work on the Teen Driver Support System (a smartphone-based application that warns teen drivers in real time about their risky driving behavior) and then invited participants to share their own ideas about how to promote safe driving behavior. Students explored this challenging issue through discussion, videos, and interactive activities.



At a January 14 event, the Institute presented a roadway safety activity to 90 students in grades 3 and 4. The Creativity Festival, a program of Success Beyond the Classroom, introduces students to the value of creative thinking across a wide array of fields ranging from engineering to art. During the RSI's presentation, students traveled on "roads" throughout a mock town, trying to reach various destinations. They were then given the opportunity to brainstorm and implement various ways to lower road crashes and congestion, such as changing the layout of the town, creating new navigational signage, and deploying traffic control officers. Through this hands-on activity, students explored how engineers, planners, and policymakers work creatively to promote safe roadways.

## Students take part in TRB thanks to travel awards

The Roadway Safety Institute provided 13 graduate students from its partner institutions travel awards to attend the Transportation Research Board annual conference in Washington, DC, January 11–15. As a result, students from the University of Minnesota Twin Cities, University of Minnesota Duluth, Auburn University, University of Akron, University of Illinois at Urbana-Champaign, and Western Michigan University had the opportunity to present research and network with other participants from across the country.

## Institute research in spotlight at traffic safety conference

Roadway Safety Institute researchers Janet Creaser and Frank Douma were among the presenters at the 2014 Toward Zero Deaths (TZD) Conference held in November in Duluth, MN. Creaser, with the HumanFIRST Lab at the University of Minnesota (U of M), presented on the Teen Driver Support System, a smartphone-based application that warns teen drivers in real time about their risky driving behavior and reports this to parents. The session showcased the results of a recent field operational test, including the role that feedback played in developing safe driving habits with teens. In a session titled "How Are We Doing? A Critical Look at Various TZD-related Efforts," Douma discussed the impacts to date of Minnesota's primary seat belt law, which was passed into law in 2009.



Max Donath

Also at the TZD conference, Institute director Max Donath received the 2014 Kathy Swanson Outstanding

Service Award. The award recognized Donath's exceptional leadership in efforts to improve traffic safety in Minnesota, build partnerships, and mentor others in the field. In addition to conducting numerous safety-focused research projects, Donath has worked with local, state, and national safety partners to ensure that his work produces real-world results that can be put into practice. Largely as a result of his efforts, the U of M is recognized nationally as one of the top universities in transportation safety.

### RSI researcher appointed scholar-in-residence

Professor Greg Lindsey was recently appointed as the first scholar-in-residence at the Minnesota Department of Transportation (MnDOT). Lindsey, who is spending his sabbatical from the University of Minnesota's Humphrey School of Public Affairs on bicycle and pedestrian counting research projects, will be working in the MnDOT Office of Transit's Bicycle and Pedestrian Section until June 2016. This is believed to be the first time MnDOT has appointed an in-house scholar.

"We'll be working on institutionalizing bicycle and pedestrian counting, so local engineers and planners have evidence for planning and investing in new facilities and establishing priorities for investments to increase safety," Lindsey says.

Lindsey specializes in environmental and transportation planning, policy, and management. Partners in his research include MnDOT, the Minneapolis Department of Public Works, Transit for Livable Communities, and the Minneapolis Parks and Recreation Board.

"My residency at MnDOT will advance a variety of initiatives, including my work for the Roadway Safety Institute on nonmotorized transportation monitoring and measurement of exposure to risk," Lindsey says. "One of our goals is to develop tools that practitioners can use to prioritize investments for infrastructure to increase biking and walking safety."

"[Lindsey's] work to institutionalize bicycle and pedestrian monitoring throughout Minnesota is central to our efforts to establish the evidence we need to maximize the efficiency of our investments in infrastructure and the safety of our transportation facilities," MnDOT Commissioner Charles Zelle wrote.

*(Adapted from an article published on the joint MnDOT/CTS Crossroads blog.)*



Greg Lindsey

### Save the Date: Roadway Safety Showcase

Mark your calendar for the Roadway Safety Showcase: Safety Innovations for Today and Tomorrow, to be held May 21, 2015, in St. Paul, MN. The latest findings from researchers at the Roadway Safety Institute will be showcased, along with safety-related projects from other academic institutions. Visit the event web page ([roadwaysafety.umn.edu/events](http://roadwaysafety.umn.edu/events)) for more details.

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