

ROADWAY SAFETY INSTITUTE

Human-centered solutions to advance roadway safety

Program Progress Performance Report for University Transportation Centers

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ACCOMPLISHMENTS

Major goals and objectives of the program

The Roadway Safety Institute (RSI) draws on highly innovative researchers located across Region 5 to focus on targeted research, education, and technology transfer activities aimed at determining and delivering the next wave of transportation safety improvements.

Our objective is simple: improve safety for those who use the network, regardless of where they live or how they travel on it. To that end, user-centered transportation systems are being developed and deployed to focus our work on specific users of the system and on how systematic improvements can affect both key user groups and broader groups of travelers.

This objective will be accomplished by meeting the following goals in research, education and workforce development, and technology transfer activities as well as through collaboration and diversity.

Research

The Institute is focusing on traffic safety system approaches by researching design- and operation-related safety solutions that reduce fatalities and life-changing injuries across the nation. In addition, the Institute is addressing the following MAP-21 priorities to improve highway safety: rural road safety measures, human factors and behavior risk metrics, data collection and analysis, and safety policy studies. The Institute is also focusing on high-risk road users by addressing key safety issues for these groups through research and by examining public engagement strategies to help improve safety on tribal lands.

Countermeasures are effective tools for practitioners to use to improve roadway safety, and our research is working to develop strategies that can be put to use. In addition, our research is investigating methodologies and metrics, in particular related to pedestrian and bicycle travel. Results of this work will provide practitioners with tools for better decision making, ultimately improving safety for those roadway users.

Education and workforce development

The Roadway Safety Institute is developing a variety of activities targeted to primary and secondary students throughout Region 5 that raise awareness of transportation safety topics and identify exciting career opportunities in related fields. Goals include partnering with WTS's Transportation YOU program to encourage young female students to pursue transportation-related degrees; demonstrating safe driving concepts to students in STEM summer camps; and developing a roadway-safety-themed museum exhibit to be displayed at a STEM-related museum.

We will continue to demonstrate a commitment to workforce development through activities that engage both practicing professionals and students. For practitioners, we are providing continuing education through seminars and webinars; developing an online repository of safety tools for local engineers in our region; and delivering pedestrian safety workshops to professionals in Region 5 states.

Technology transfer

We are working to expand our existing partnerships to foster research innovation and deployment that includes increasing public agency and private sector partners, and we will develop versions of research hardware and software that can be deployed through collaboration with public safety agencies, foundations,



and the private sector. We are also communicating research findings to the transportation community for their successful implementation, and we have created a consortium website, an electronic newsletter, topical briefs, research videos, and an Institute biennial report.

Collaboration

The Institute is bringing together the diverse strengths, knowledge, and experience of our consortium members to work toward the shared goal of reducing fatalities and injuries on our roadways. Through collaboration, RSI will draw on and expand our many successful partnerships with public, private, academic, and not-for-profit entities. Our goal is to advance the roadway safety knowledge base, address critical workforce needs, implement research activities, and transfer research findings using our established relationships.

Diversity

We are working to broaden participation and enhance diversity in the transportation sector by supporting female and minority STEM faculty, leveraging the existing Transportation YOU programs in our region, and expanding STEM opportunities for American Indians. Efforts include developing and delivering a day of safety curriculum for the White Earth Summer Camp; hosting tours and demonstrations for students in WTS's high school mentoring program; and identifying ways to support leadership development for female and minority STEM graduate students and faculty.

Accomplishments

Research

Our consortium draws on our members' safety-related expertise and complementary research strengths to achieve measurable gains in safety. The Institute currently has 19 federally funded research projects. Descriptions of all active projects are available on our website and in the Transportation Research Board (TRB)'s Research in Progress (RiP) database.

Programmatic research accomplishments include:

- Rajesh Rajamani and RSI director Max Donath have secured a nearly \$1 million grant from the National Science Foundation. This "Partnerships for Innovation: Building Innovation Capacity" grant awards funding to academe-industry partnerships whose proposals move research toward implementation. In this new project, Rajamani and Donath will partner with Quality Bicycle Products (QBP) to develop, test, and potentially commercialize a bicycle sensor that can monitor nearby vehicles on the road and detect the possibility of an imminent bicycle-car collision. Rajamani initially developed this technology in his Institute-funded research project; the next step is to improve the warning system via human factors studies conducted by Dr. Nichole Morris and the HumanFIRST Lab that will lead to specific and effective audio-visual cues. QBP's roles include advising the research team on installation of the instrumentation, assisting with field operational tests, providing a cost estimate for eventual retail sale, and helping with a market analysis for the proposed collision-prevention system.
- We have allocated a third year of funding to seven of our federally funded projects; more projects will receive continued funding in the next reporting period.
- To date, we have secured \$6,463,803 in match funding, which includes 38 MnDOT-funded projects related to roadway safety as well as match contributions from our consortium partners. Descriptions of these match projects can be found on our website.

Highlights from active research projects:

- *Estimation of Traffic Conflicts at Signalized Intersections Using High-Resolution Traffic Signal Data:* Gary Davis has developed and tested an algorithm for estimating frequency of red-light running events from high-resolution detector data. Preliminary results suggest that frequency of red-light running is a more reliable predictor of the frequency of angle crashes than is average annual daily traffic.
- *Identifying and Reconciling Stakeholder Perspectives in Deploying Automated Speed Enforcement:* Frank Douma, in an effort to determine support for automated speed enforcement (ASE) among Minnesota drivers, conducted 200 interviews exploring how views about ASE have changed in light of additional information. Douma has analyzed the results and completed a draft final report. The survey revealed that the lack of support for ASE could be due to the public perception that speed does not present a safety problem, rather than opposition to the technology itself.
- *Development and Demonstration of Merge-Assist System Using Connected Vehicle Technology:* Imran Hayee conducted field tests to statistically characterize the relative GPS accuracy of multiple GPS receivers. According to the field test evaluation and mathematical analysis, the relative GPS accuracy is much improved and sufficient to distinguish neighboring vehicles in the same or adjacent lanes of the freeway.
- *Using GIS to Improve Tribal Traffic Safety:* Tom Horan compiled multi-year severe- and fatal-crash data both within Minnesota tribal boundaries and in surrounding rural areas; performed spatial and hotspot analysis within and across Minnesota tribes; identified hotspots for consideration and findings related to the relative traffic safety across tribes and within Minnesota; and updated the GIS story map outline and applications on use of GIS to assist in tribal transportation safety planning. Horan has created a workflow outlining the best way to aggregate, analyze, and visually display traffic safety data and identified a process that can be implemented using crash data, tribal transportation reports, and qualitative transportation data to strengthen the argument for specific transportation improvements.
- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed:* John Hourdos implemented several improvements to the online V2I Highway Safety System and is now conducting an extensive evaluation of data collected in summer 2016. Hourdos also deployed an additional radar unit on one of MnDOT's camera poles, bringing the total deployed radar to four. The online queue warning algorithm developed by the Minnesota Traffic Observatory, which operates by displaying messages on MnDOT's intelligent lane control signs and can be used to drive warnings in instrumented vehicles, responds to approximately 80 percent of observed crash-prone conditions.
- *In-Vehicle Work Zone Messages:* Nichole Morris completed simulation development and data collection and successfully tested 48 participants in the driving simulator using the in-vehicle messaging system. A paper was accepted for poster presentation at the Human Factors and Ergonomics Society in Washington, D.C. regarding the findings of the safety culture survey.
- *Collaborating with American Indian Communities to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands:* Kathy Quick and Guillermo Narváez have scoped the study problem and selected case study sites; finalized research plans with partner communities for four study sites; started data collection and consultation; conducted more than 120 interviews; assisted the Federal Highway Administration (FHWA) Tribal Transportation Program in the elaboration of a Tribal Transportation Safety Survey; and assisted the FHWA Tribal Transportation Program in a survey and report, called Tribal Governments and Crash Data, by Adam Larsen and Greg Piland. The most significant results thus far have been the successful building of a set of relationships that will allow work to continue for the duration of this project and thereafter.

- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Ron Van Houten collected baseline data on the percentage of drivers yielding right-of-way to pedestrians at each study site and vehicle speed data when pedestrians were absent at each site before the gateway R1-6 sign treatment was installed last spring. Once the gateway treatment was installed, Van Houten collected monthly data at each site on driver yielding behavior and speed data every other month, which showed that the percentage of drivers yielding right-of-way increased after installation, while driver speeds when pedestrians were not present in the crosswalk decreased at all sites.
- *Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support:* Dan Work's graduate student, William Barbour, attended an internship at CSX Transportation from May 2016 through August 2016, an experience that leveraged CSX expertise for advancement of data methodologies used in the study's prediction framework; enabled the student to work closely with CSX researchers who are familiar with the datasets used in this project; allowed the research team to obtain all crossing information required for the next phase of the project; and generated several new algorithmic ideas to improve the ETAs at crossings. A detailed analysis of the CSX data indicates that external factors, such as network traffic or terminal congestion, play a critical role in determining arrival times.

Education and workforce development

During this reporting period, the following initiatives helped us meet our goals of attracting and preparing future transportation professionals and expanding the knowledge of current practitioners.

- In the past year, and as reported in our RSI Performance Indicators, we have conducted nearly 40 events for students and professionals. Between October 2015 and September 2016, we hosted 9 educational events for K-12 audiences, reaching approximately 950 attendees. We also hosted 29 professional development events for practicing professionals, attracting 1,363 attendees.
- We are nearing completion of our pedestrian safety and visibility exhibit at The Works Museum in Bloomington, MN. Nichole Morris has been serving as a research advisor, consulting with Works staff on exhibit set-up and interpretive signage. After a summer of exhibit building and pilot testing, we held a soft opening on September 17 at The Works' Girl Time event, which is aimed at young girls interested in engineering. This special event allowed RSI staff to show the partially-installed exhibit to the public and gather visitor feedback about the exhibit concepts. Visitors were enthusiastic about the exhibit and easily grasped its teachings, even without the installation being finalized. The exhibit will be fully operational by late October, and we'll host a grand opening event on December 9, 2016.
- On August 31, Ron Van Houten led a pedestrian safety workshop at the American Public Works Association's annual Public Works Expo (PWX) in Minneapolis. The workshop, sponsored by the Roadway Safety Institute, attracted 15 participants as well as a wait-list of other interested attendees. During the event, Van Houten gave a presentation about research-based pedestrian safety improvements. Then, with assistance from the City of Minneapolis, he led a walking tour to a nearby intersection, where he demonstrated the installation and impact of a gateway R1-6 sign treatment. Participants observed driver behavior and pedestrian crossings before and after the temporary gateway installation.
- In June, RSI director Max Donath participated in the Knowledge Exchange on Undergraduate STEM Education workshop. The event was a collaboration between the USDOT, the White House Office of Science and Technology Policy, and the Subcommittee on Federal Coordination in STEM



Education. The purpose was to gather high-level researchers to share effective strategies for improving undergraduate STEM education.

- In September, we held the first four events of the Fall 2016 RSI Seminar Series, drawing 154 local and online attendees who learned about safety-related research happening in Minnesota, Illinois, and Indiana. Seventeen University of Minnesota students are taking the course for credit, which is nearly double the number of students who took the course last fall. Hugo Zhou (Auburn University) also has six students taking the course for credit. Two of the seminars featured speakers from out of town; we arranged for a number of tours and meetings during their visits to facilitate regional connections between researchers and local practitioners.
- Over the summer, RSI staff and researchers participated in several summer camps around the Twin Cities, including EUREKA!, the National Summer Transportation Institute, the Minneapolis Parks and Recreation Board's Safety Camp, and Discover STEM. During the camps, we introduced nearly 300 K–12 students to concepts such as traffic engineering, distracted driving, pedestrian safety, and pedestrian/bicycle counting.
- In July and August, the Institute provided seminars and tours for 24 university students visiting from China. These students spent six weeks at the University of Minnesota as part of the Global Transit Innovations Summer Training Program. During their visit, they toured the Minnesota Traffic Observatory and the HumanFIRST Laboratory and met with Chen-Fu Liao and Greg Lindsey to learn more about their research.
- Institute educators now have access to an updated version of Gridlock Buster, an online educational game developed by the University of Minnesota that teaches K-12 students the basic principles of traffic engineering. The new version has updated graphics and can be played on a mobile device. Staff used Gridlock Buster at several of the summer camps listed in the previous bullet.
- Over the summer, the Institute placed two undergraduate student interns in MnDOT's Office of Traffic, Safety & Technology. One helped to review bicycle and pedestrian crash reports, while the other worked on a project related to rumble strips. The internships introduced the students to potential careers in transportation safety.
- We moved closer toward our goal of creating free online training resources for Region 5 LTAP/TTAP programs. During this reporting period, Institute staff developed a Request For Information (RFI) to be shared with potential consultants who can help us build and host online training modules. The finished resources will provide roadway safety training materials for local engineers to share with their maintenance staff.

See the Diversity section for further updates related to education and workforce development.

Technology transfer

Roadway users will be safer when our research findings are put into the hands of those who can use them to reduce fatalities and injuries. Toward that goal, we disseminated this information in varied ways to reach both specific groups and broad audiences—from conference presentations to social media. During this reporting period, we engaged in the following technology transfer activities:

- RSI staff developed a five-minute video titled “Roadway Safety Institute: Finding Solutions to Save Lives.” The video, available on the RSI home page, features interviews with RSI director Max Donath and researchers from across the region whose projects range from reducing crashes at rail grade crossings to investigating roadway safety issues on tribal lands. The video also gives a look at some of the Institute's education efforts, including the development of a museum exhibit designed to introduce preteens to safety concepts. We have publicized the video using our existing communication and social media channels along with targeted e-mails to key stakeholders.

- RSI director Max Donath and others are working to move the Teen Driver Support System—a smartphone app that alerts teen drivers and their parents when a driver engages in risky behavior—toward deployment and commercialization. The team is working with CloudLab LLC to enhance the performance and security of the current software. Going forward, the app will be called “Road Coach” and feature an updated logo and artwork. The Governor’s Highway Safety Representatives for Illinois, New Jersey, and New York have all expressed interest in testing the finished product.
- U.S. Senator Amy Klobuchar visited the University of Minnesota campus on May 5 to learn about the Roadway Safety Institute’s distracted driving research. The Institute, along with the Center for Transportation Studies (CTS), hosted the event. After giving a brief speech on the dangers of distracted driving, Klobuchar toured the HumanFIRST Laboratory, where Nichole Morris discussed some of the ways her lab is addressing this pressing issue. Also on the tour were RSI director Max Donath and CTS director Laurie McGinnis (RSI Advisory Board chair) as well as Minnesota high school students, safety leaders, researchers, and advocates.
- In August, the Institute hosted a visit for transportation staff from Representative Betty McCollum’s office. During the visit, Nichole Morris gave a tour of the HumanFIRST Laboratory, while Rajesh Rajamani presented findings from his RSI research project. McCollum, who represents Minnesota’s 4th District in the U.S. House of Representatives, serves on the House Appropriations Committee.
- In June, Institute staff member Gina Baas flew to Washington, D.C., and visited 9 out of 10 Minnesota congressional delegation offices. During her meetings, which were coordinated by the Minnesota Transportation Alliance, she shared updates on the Roadway Safety Institute’s initiatives and activities.
- Colonel Matt Langer, Chief of the Minnesota State Patrol, invited RSI personnel to attend the State Patrol Captain’s Meeting and share information about their roadway safety research. During the meeting on May 17, RSI director Max Donath gave an overview of the Institute; Chen-Fu Liao talked about his research on using Bluetooth technology to trigger in-vehicle warning signs in work zones; and Nichole Morris shared information about the crash report interface she recently redesigned, which is currently being used by Minnesota law enforcement agencies to log crashes.
- We continued our partnership with Iowa State University, the lead institution for the Region 7 UTC, and jointly delivered two more events in the series “Transportation Research Webinars: Moving Research into Practice.” The webinars, held in April and May, attracted over 200 attendees between them.
- Institute staff created a full-color brochure for the HumanFIRST Laboratory that describes the lab’s capabilities, research expertise, and example projects in the areas of human factors and transportation safety.
- Two issues of our e-newsletter were distributed, one in May 2016 and one in August 2016. Since the last reporting period, our subscriber base has swelled to over 1,900 people, and the average open rate has increased from 24.6 percent to 25.1 percent.
- To share our work as widely as possible, we continue to maintain a news feed on the Institute’s blog and home page and regularly maintain our RSI Facebook, Twitter, LinkedIn, and YouTube accounts. Our YouTube channel is doing especially well; our videos had over 1,000 views in the last six months, and we have 34 subscribers to the channel.

Collaboration

Solving the problem of roadway injuries and fatalities requires multiple approaches from multidisciplinary perspectives. To help the Institute meet this challenge:

- The RSI Advisory Board met on April 12 for its biannual meeting. The group discussed freight issues, and Stephen Burks presented his research on fatigue and safety among commercial-vehicle

drivers. The Board also had two changes in membership: Jay Hietpas (MnDOT) replaced Sue Porter, while Brian Funk (Metro Transit) replaced Jan Homan.

- The RSI University Partners Committee, made up of researchers from all five partner universities, met via conference call on May 11. During the call, the group discussed how the RSI Seminar Series, currently housed at the University of Minnesota, might be offered for credit at other partner institutions.

Diversity

The Institute is committed to broadening participation and enhancing diversity in the transportation sector through all our activities. Here are some ways we're working to increase participation by groups currently underrepresented in STEM fields.

- In June, more than 40 White Earth Nation (Minnesota) students were introduced to a variety of transportation topics in a daylong session offered by the Roadway Safety Institute. The session was part of the White Earth Indian Reservation Summer Academy of Math and Science, a two-week day camp for reservation youth in grades 4 to 8. The camp focuses on hands-on learning and uses Indian culture and heritage as a vehicle for studying math, science, and engineering. This year, Institute staff led students through interactive activities related to road sign design and driver distraction to spark their interest in transportation, engineering, and safety.
- On August 2, RSI director Max Donath presented an overview of relevant Institute activities to Gwen Salt, Transportation Director at the Embassy of Tribal Nations, and leaders from the Tribal Transportation Program in the Office of Federal Lands Highways.
- On September 29, the RSI Seminar Series featured Dona Rae Sapp, Senior Policy Analyst at Indiana University–Purdue University Indianapolis's Public Policy Institute. She gave a talk about using crash data to inform traffic safety policy and program development. Her visit helped to meet our goal of supporting females working in STEM disciplines and sparking interest among female students to pursue transportation safety careers.
- See the research accomplishments section for an update on the tribal safety research being conducted by Tom Horan, Guillermo Narváez, and Kathy Quick.

Opportunities for training and professional development

Accomplishments are reported in the Education and Workforce Development section.

Dissemination

For the results of Institute work to effect positive change—specifically, safer roadways—they must be delivered to those who can effectively implement them in everyday practice. We strive to communicate this information broadly and purposefully through the following activities.

- The Institute's website is the primary vehicle for distributing information to stakeholders. In this period, the site received 6,224 visits and 13,055 unique page views. The most popular pages were the home, research, and seminar pages.
- RSI researchers continue to receive local and national media attention for their safety-related work. Highlights during this reporting period include continued coverage of Stephen Burks's study on truck drivers with untreated sleep apnea, as well as *ITS International* articles featuring Chen-Fu Liao and Kathy Quick. For a full list of media stories, please visit roadwaysafety.umn.edu/about/news/.

Plans for next reporting period

There have been no changes to the Roadway Safety Institute's approved application plans. We anticipate the following activities will take place in the next reporting period (October 1, 2016 – March 31, 2017).

Research

- We will allocate a third year of funding to ten existing projects and fund at least one new project by a current Institute researcher.
- Two projects will conclude and produce final reports.
- We will secure additional match funding by continuing to work with MnDOT to identify safety-related projects for our researchers.
- Stephen Burks will further develop the legal and contractual conditions for new data to flow from the study's participating motor carrier and its medical service providers, and he'll explore the feasibility of a paper on the effectiveness of the commercial motor vehicle driver's medical examination based on existing data. (*Exploring Links Between Medical Conditions and Safety Performance in Tractor Trailer Drivers*)
- Tom Horan will conduct additional analysis to confirm, refine, or augment the preliminary spatial analysis findings, use comparison analysis to identify tribes and adjacent areas with high rates of fatal crashes, and conduct interviews with stakeholders on the value of applications and data for tribal safety. Horan will then correlate the data and results with actual information from specific tribal transportation plans to create a set of recommended improvements. (*Using GIS to Improve Tribal Traffic Safety*)
- John Hourdos will conclude deployment of the full complement of sensors, implement the V2I queue warning system, and demonstrate its operation with one test vehicle. (*Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*)
- Albert Luo will compare field-testing results and data analysis methods used by Auburn University and Southern Illinois University Edwardsville, identifying any inconsistencies. Longer term, Luo will develop design guidelines for the use of directional rumble strips by state and local agencies. (*Directional Rumble Strips for Reducing Wrong-Way-Driving Freeway Entries*)
- Nichole Morris will conduct the controlled field test and commence work on technology development with contract development staff. (*Older Driver Support System [ODSS] Usability and Design Investigation*)
- Yanfeng Ouyang will explore the possibility of developing a real-world case study in Minnesota or Illinois called Coordination Across Jurisdictions that develops a model, algorithm, and solution methods and delivers case-study results. (*Improving Railroad Grade Crossing Safety: Positioning, Planning, and Operation of Emergency Response Resources and Coordination Between Jurisdictions*)
- Kathy Quick will conduct detailed data analysis and follow-up data collection and continue to cultivate existing and new relationships with tribal transportation leaders and others involved in tribal injury prevention and transportation safety programs, policy, and research in Minnesota and elsewhere. Quick will also work with the safety management committee of Lifesavers and the Tribal Technical Assistance Program (TTAP) to design a national survey on tribal transportation safety priorities, which TTAP will administer and Quick will analyze. (*Collaborating with American Indian Communities to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands*)
- Rajesh Rajamani will next analyze and evaluate the performance limitations of the collision-avoidance system due to bicycle tilt and yaw. Rajamani will also evaluate the ability of the rear

laser sensor system to reliably track real-world rear vehicles. (*Novel Collision-Avoidance System for Bicycles*)

Education and workforce development

- We will hold a grand opening celebration for our finished pedestrian safety exhibit at The Works Museum on December 9.
- In late 2016 or early 2017, Institute staff will work with Ron Van Houten to deliver the final Region 5 pedestrian safety workshop. At the event, which will likely be held in Chicago, Van Houten will present research findings and recommendations from several pedestrian safety treatment studies.
- We will deliver the remaining seven events in the Fall 2016 RSI Seminar Series.
- By the end of the year, we will issue a Request For Information (RFI) to identify consultants who can help us build online training modules related to roadway safety. The finished product will eventually be shared with Region 5 LTAPs and TTAPs.

Technology transfer

- We will distribute two issues of our e-newsletter, one in November 2016 and one in February 2017. E-announcements will be sent as appropriate, and we'll continue to update our safety news feed, social media outlets, and other communication channels.
- The team working on the Teen Driver Support System—now called “Road Coach”—will finish development work on the new app and demonstrate the finished product to agencies, companies, and other groups who may want to partner on implementation. In October, RSI director Max Donath will meet with researchers in Australia who have developed a similar smartphone app that is directed toward getting all drivers to reduce excessive speed.
- In December, John Hourdos, Chen-Fu Liao, and Greg Lindsey will give presentations at the 10th UTC Spotlight Conference on Bicycles and Pedestrians in Washington, D.C.
- Institute staff are currently drafting an article that will be featured in the January 2017 issue of the UTC *Spotlight* newsletter. The article will highlight Kathy Quick and Guillermo Narváez's tribal research.

Collaboration

- The RSI Advisory Board will meet on December 9 in conjunction with the grand opening of our exhibit at The Works Museum. After a brief meeting, board members will tour the exhibit and celebrate this achievement with other Institute stakeholders.
- The Region 5 state safety engineers will work with their respective departments to review the two proposed pooled-fund projects and secure funding.

Diversity

- We will support female STEM faculty by collaborating with the University of Minnesota's College of Science and Engineering (CSE) on its Distinguished Scientists from Underrepresented Groups Speaker Series. Planning is underway to bring Patricia DeLucia, head of the Human Factors Psychology Program and Associate Vice President for Research/Faculty Affairs at Texas Tech, to campus in December. During her visit, DeLucia will participate in the RSI Seminar Series and attend a CSE event aimed at female students and faculty.
- We will start developing a “curriculum toolbox” to be shared with Region 5 WTS chapters. Over the past two years, we have developed tools, relationships, and activities that may be useful to others who aim to support and encourage women to enter the transportation field.

PRODUCTS

Publications, conference papers, and presentations

During this reporting period, 16 RSI researchers and staff gave 23 presentations to local, regional, and national audiences. The settings, ranging from national conferences to local meetings, introduced a wide variety of stakeholders to our work. For a full list of presentations, please visit roadwaysafety.umn.edu/publications/ostr/documents/pppr6_presentations_list.pdf.

RSI researchers published the following papers during this reporting period:

- Achtemeier, J., and N. Morris. 2016. "An Assessment of Safety Culture While Navigating Work Zones: Attitudes and Behavior on In-Vehicle Messaging Technologies." *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 60(1): 1499–1503.
- Baratian-Ghorghi, F., H. Zhou, and I. Wasilefsky. 2016. "Effect of Red-Light Cameras on Capacity of Signalized Intersections." *Journal of Transportation Engineering* 142(1).
- Davis, B., and M. Donath. 2016. "Development of a Sensor Platform for High-Accuracy Mapping of Roadway Lane Markings." *Transportation Research Record: Journal of Transportation Research Board* 2551: 45–51.
- Davis, G., V. Moshtagh, and J. Hourdos. 2016. "Safety-Related Guidelines for Time-of-Day Changes in Left-Turn Phasing." *Transportation Research Record: Journal of the Transportation Research Board* 2557: 100–107.
- Davis, G., and A. Mudgal. 2016. "Bayesian Uncertainty Quantification for Planar Impact Crashes via Markov Chain Monte Carlo Simulation." SAE Technical Paper 2016-01-1481.
- Ghasemi, S., M. Jalayer, M. Pour-Rouholamin, A. Nowak, and H. Zhou. "State-of-the-Art Model to Evaluate Space Headway Based on Reliability Analysis." *Journal of Transportation Engineering* 142(7).
- Hajbabaie, A., and R. Benekohal. 2015. "A Program for Simultaneous Network Signal Timing Optimization and Traffic Assignment." *IEEE Transactions on Intelligent Transportation Systems* 16(5): 2573–2586.
- Jalayer, M., F. Baratian-Ghorghi, and H. Zhou. 2015. "Identifying and Characterizing Secondary Crashes on the Alabama State Highway System." *Journal of Advances in Transportation Studies* 37: 129–40.
- Jalayer, M., and H. Zhou. 2016. "Overview of Safety Countermeasures for Roadway Departure Crashes." *ITE Journal* 86(2): 39–46.
- Maistros, A., W. Holik, W. Schneider, and P. Savolainen. 2016. "A Comparison of Contributing Effects on 2-Vehicle Alcohol-Related Crashes Between Impaired and Nonimpaired Operators." *Traffic Injury Prevention* 17(7): 668–75.
- Maistros, A., and W. Schneider. 2015. "Preliminary Investigation of Circumstances Contributing to Fatal Crashes Involving Law Enforcement Officers." *Transportation Research Record* 2516: 53–57.
- Van Houten, R., G. DeLaere, J. Morgan, and J. Shurbutt. 2015. "Countdown Pedestrian Signals: Legibility and Comprehension Without Flashing Hand." *Transportation Research Record* 2519: 10–16.
- Wang, R., and D. Work. 2016. "Multiple Model Particle Smoothing for Traffic Incident Detection." *IEEE Transactions on Intelligent Transportation Systems*. Published online June 6, 2016.

- Zhou, H., C. Hongyun, and F. Baratian-Ghorghi. 2016. “Prediction of Intermittent Sight Distance Obstruction at Unsignalized Intersections with Conventional Right-Turn Lanes.” *Journal of Transportation Safety and Security*. Published online March 4, 2016.
- Zhou, H., J. Zhao, M. R. Gahrooei, and P. Tobias. 2016. “Identification of Contributing Factors for Wrong-Way Crashes on Freeways in Illinois.” *Journal of Transportation Safety and Security*. Published online February 25, 2016.

Websites or other Internet sites

The Roadway Safety Institute website (roadwaysafety.umn.edu) includes information on research activities, events, news, and key personnel. Each active research project has a web page that includes both the research project description and a downloadable UTC Project Information Form. We will post final research reports on the RSI website as they are completed.

In addition:

- The Institute’s website reaches a wider audience through links to it from the Center for Transportation Studies (CTS) at the University of Minnesota. CTS (cts.umn.edu) strives to solve persistent transportation problems in innovative ways by convening diverse communities to brainstorm, debate, share, learn, and act.
- The Minnesota Traffic Observatory (MTO) website (mto.umn.edu) notes its affiliation with RSI on its home page. RSI researcher John Hourdos directs MTO, a facility that is used frequently by other RSI personnel.
- The HumanFIRST website (humanfirst.umn.edu) features the work of RSI principal investigators who use the laboratory to conduct psychology and human factors research.
- The website of the Connected Vehicles Research Laboratory at the University of Minnesota Duluth (d.umn.edu/ee/cvrl/) includes information on the research of Imran Hayee.
- The Midwest Tribal Safety website (tribalsafety.maps.arcgis.com/home/organization.html), a product of Tom Horan’s research, serves as an online collaborative interface for stakeholders working in tribal transportation safety or with tribal community leaders.

Technologies or techniques

Gary Davis’s project “Development of Guidelines for Permitted Left-Turn Phasing Using Flashing Yellow Arrows” has produced a spreadsheet tool to help traffic engineers determine when it’s safe to use flashing yellow arrows. The SRF Consulting Group has also produced an instructional video for the tool, which has been viewed more than 350 times since July. The project’s final report has been downloaded more than 300 times since it was published last year.

Inventions, patent applications, and/or licenses

Two researchers have filed invention disclosures with the University of Minnesota’s Office of Technology Commercialization. Imran Hayee’s relates to findings from his project “Development and Demonstration of Merge-Assist System Using Connected Vehicle Technology.” Chen-Fu Liao’s disclosure is called “In-Vehicle Work Zone Communication” and describes an in-vehicle mobile device that can scan for Bluetooth work zone tags.

Rajesh Rajamani filed a provisional patent application called “Collision Detection” on July 1, 2016. The patent includes two technologies suited for bicycles: an inexpensive target vehicle tracking system and a

black box recorder. These technologies are a direct result of his project “Novel Collision Avoidance System for Bicycles.”

Ryan Rosandich has secured a license with Epic Solutions for a robotic message painter. The technology, developed in the project “Robotic Roadway Message and Symbol Painter Implementation,” consists of a robotic device that can be mounted on the front of a vehicle to paint messages and symbols on the roadway. The device improves the safety, efficiency, and flexibility of roadway painting operations.

Other products

Nothing to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

Organizations that have been involved as partners

The Roadway Safety Institute is actively in partnership with 44 organizations across eight states and the District of Columbia. For more information on these partners—including their names, locations, and contribution types—please visit roadwaysafety.umn.edu/publications/ostr/documents/pppr6_partners_list.pdf.

Other collaborators or contacts

The following organizations have been in collaboration or contact with the Institute during this reporting period.

- In September, Chen-Fu Liao and RSI director Max Donath flew to New York City to meet with several groups interested in Liao’s smartphone technology for helping visually impaired pedestrians safely navigate streets and work zones. Meeting attendees included Ernest Athanailos and John Ornas from the NYC DOT and Elena Prassas and Gerard Soffian of New York University’s Tandon School of Engineering. While in New York, Liao and Donath also met with Dr. Gene Bourquin, an orientation and mobility specialist with the Helen Keller National Center for Deaf-Blind Youth and Adults, as well as with representatives from the PASS (Pedestrians for Accessible and Safe Streets) Coalition and the Lighthouse Guild, which provides health services to the visually impaired. Since the visit, Profess Prassas has requested that Liao propose a budget to deploy his technology in one intersection in NYC.
- Ron Van Houten recently offered his pedestrian safety expertise to representatives from the City of St. Paul. On August 29, Van Houten accompanied approximately 15 St. Paul staff on a bus tour of some key pedestrian conflict sites in the city. The next day, he gave a follow-up presentation to 33 attendees, including City of St. Paul and MnDOT staff and citizen representatives. The presentation focused on Van Houten’s research findings about effective and low-cost ways to improve pedestrian safety at street crossings.
- On August 3, RSI director Max Donath met with Scott Belcher, CEO of the Telecommunications Industry Association (TIA), to discuss potential collaborations on preventing texting and driving, as well as the “Road Coach” app for teenage drivers currently under development. Donath also met with Kevin Doport of the USDOT’s Intelligent Transportation Systems Joint Program Office (ITS JPO) to exchange ideas and coordinate activities on ITS, teenage driving, connected vehicles, and roadway safety research.

- During the 2016 MAASTO (Mid-America Association of State Transportation Officials) conference in Minneapolis, Ray Benekohal and Dan Work made connections with local officials interested in rail safety. Accompanied by RSI director Max Donath, Benekohal and Work met with Bill Gardner (Director, MnDOT Office of Freight and Commercial Vehicle Operations) and Alene Tchourumoff (Rail Director, Office of Governor Mark Dayton) to discuss their research.
- As part of the National Summer Transportation Safety Institute, held at the University of Minnesota, Institute staff collaborated with the HumanFIRST Laboratory, the University of Minnesota Police Department, the Minnesota Toward Zero Deaths program, and the Minnesota Department of Transportation on “Safety Day.” The day included a human factors presentation by Nichole Morris and a safety demonstration (including distracted driving pedal carts, goggles to simulate impairment, and touring a police car) put on by Regional TZD Coordinator Susan Youngs and UMPD Investigator Aaron Churness.
- On September 23, RSI director Max Donath, Nichole Morris, and Brian Davis met with Metro Transit (Minneapolis/St. Paul) to discuss collaborating on an RFP issued by the Federal Transit Administration. The proposal would focus on improving pedestrian safety in relation to buses.

IMPACT

Impact on the development of the principal discipline(s) of the program

The outcomes of our work will give society ways to improve safety and public health for everyone who uses our region’s and nation’s roadways. By identifying critical areas of focus such as the effect of medical conditions on crash risks, improved crash reporting, intersections, rail grade crossings, and speeding, our efforts will help prevent fatal and serious-injury crashes for those users who have a greater propensity for risk. Specific guidance will be created to help state and national agencies address these priorities. Our work will also help state departments of transportation and other agencies implement design- and operation-related safety improvements. Specifically, we are focusing on issues that have been inadequately addressed to date through projects that examine policy issues, operational safety, rail grade crossings, and automated speed enforcement.

New impacts from this reporting period include:

- *Developing and Validating a Model of Left-Turn Crashes to Support Safer Design and Operations:* Gary Davis reports potential impacts on the following disciplines:
 - Crash reconstruction: Davis’s methodology for reconstructing planar impact crashes is the first to support uncertainty quantification while combining data from event data recorders, vehicle damage, and the crash scene.
 - Human factors and traffic engineering: Davis’s research has shown that the best predictor of gap acceptance is the logarithm of the gap. This knowledge should advance the next generation of methods for predicting the capacity of permissive left-turn treatments.
 - Traffic safety and simulation: Davis has developed a methodology for using NHTSA’s NASS/CDS database to estimate driver behavior data. This should support the development of a new database on driver behavior, which is needed to develop the next generation of safety prediction tools.
- *Using GIS to Improve Tribal Traffic Safety:* Tom Horan’s work is bringing insights from spatial statistics to transportation safety analysis, impacting the fields of both GIS and transportation.

- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: John Hourdos reports an impact on traffic engineering. His project has developed the first-of-its-kind, real-time shockwave and queue warning system.
- *Performance Measures for Bicycle and Pedestrian Safety: Methodologies for Monitoring Traffic Volumes and Assessing Exposure to Risk*: MnDOT traffic engineers and local bicycle, planning, and health staff are interested in the results of Greg Lindsey's study. The data and models developed in the project have already been used in local decision-making contexts and are being incorporated and replicated in other research projects.
- *Older Driver Support System (ODSS) Usability and Design Investigation*: Nichole Morris anticipates an impact on human factors investigations. Her research will provide use cases on the type of driving support that older drivers without cognitive impairment prefer.
- *Collaborating with American Indians to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands*: Kathy Quick and Guillermo Narváez report an impact on tribal safety. The preliminary data collected in their case studies reveal important divergences in perceptions of risk among tribal governments and others with direct knowledge of the reservation environments as compared with transportation safety experts from outside the reservations.

Impact on other disciplines

The interdisciplinary nature of our research means outcomes will reach beyond our core focus areas to impact safety approaches in other disciplines.

New impacts from this reporting period include:

- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: Hourdos's research has impacted the field of human factors. The sensor systems developed for this project have since been used to evaluate work zone traffic control layouts and their effect on drivers.
- *Older Driver Support System (ODSS) Usability and Design Investigation*: Morris's project may impact gerontology by providing an understanding of the kind of technological assistance older drivers can use to improve their quality of life.

Impact on physical, institutional, and information resources

Our work's impact on physical, institutional, and information resources enables stakeholders to access training and better perform their jobs.

New impacts from this reporting period include:

- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: Hourdos's project has enhanced the capabilities of the Minnesota Traffic Observatory facility to analyze data, especially vehicle trajectories. Several other research projects have already benefited by the acquisition of his radar sensors and the accompanying software development.

Impact on transportation workforce development and human resources

Our education and workforce development efforts, as described in the Accomplishments section, offer opportunities to engage future transportation professionals in safety-related concepts and careers, enrich the educational experience of university students, and provide professionals with the tools and resources they need to improve roadway safety. The results of these activities support the development of a diverse transportation workforce.



Eighteen out of nineteen federally funded projects have enlisted undergraduate or graduate student assistants. During this reporting period, these jobs provided 49 students with research and practical work experience related to roadway safety. PIs supervising students include Ray Benekohal, Stephen Burks, Gary Davis, Frank Douma, Imran Hayee, Tom Horan, John Hourdos, Chen-Fu Liao, Greg Lindsey, Albert Luo, Nichole Morris, Yanfeng Ouyang, Andrew Owen, Kathy Quick, Rajesh Rajamani, William Schneider, Ron Van Houten, and Daniel Work.

Impact on technology transfer

Our technology transfer activities will lead to the implementation of research results and promote a safer transportation system. Through partnerships, RSI faculty and researchers will be successful in technology transfer.

One shining example: Rajesh Rajamani's start-up company, Innotronics LLC, was named among the "Best University Startups 2016" in August by the National Council of Entrepreneurial Tech Transfer. Innotronics, based in Stillwater, MN, develops non-contacting position sensors for use in construction and agriculture vehicles and in industrial material handling systems. Rajamani conducted the original research behind this technology in a project funded by the Intelligent Transportation Systems (ITS) Institute, the University of Minnesota's previous UTC. In that project, Rajamani led the development of magnetic sensing technology that could be used to predict imminent collisions in passenger vehicles.

More impacts from this reporting period:

- *Improving Railroad Grade Crossing Safety: Positioning, Planning, and Operation of Emergency Response Resources and Coordination Between Jurisdictions:* Ouyang's team is sharing its research findings with the Illinois Fire Service Institute. The team is also in contact with the Minnesota National Guard about developing a full-scale case study as part of its "Vigilant Guard" program.
- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Ron Van Houten reports that the National Committee on Uniform Traffic Control Devices (NCUTCD) has expressed interest in his gateway treatments.

Impact on society beyond science and technology

The Institute's work will result in real-world applications—policy approaches as well as engineering and technology solutions—to mitigate the human and economic toll of traffic crashes and traffic-related fatalities by improving safety.

Impacts from individual projects:

- *Exploring Links Between Medical Conditions and Safety Performance in Tractor Trailer Drivers:* This project has the potential to help reduce the overall number of crashes involving heavy trucks. Untreated obstructive sleep apnea is one of the largest causes of excessive daytime sleepiness, and current research suggests that between 7% and 20% of all large truck crashes are due to drowsy or fatigued driving. Burks's research will impact the policy debate on whether motor vehicle operators should be required to undergo testing for obstructive sleep apnea.
- *Identifying and Reconciling Stakeholder Perspectives in Deploying Automated Speed Enforcement:* Frank Douma's project has the potential to shape public education on transportation safety by highlighting the importance of obeying the speed limit and the hazards of driving too fast.

CHANGES/PROBLEMS

Changes in approach and reasons for change

Exploring Links Between Medical Conditions and Safety Performance in Tractor Trailer Drivers: Stephen Burks has added another task to his project, this one a paper on the effectiveness of the commercial drivers' medical examination in diagnosing obstructive sleep apnea.

Using GIS to Improve Tribal Traffic Safety: Tom Horan found that his preliminary spatial analysis did not fully account for exposure, so he's had to pursue alternative data sources and statistical means.

Implementation of a V2I Highway Safety System and Connected Vehicle Testbed: MnDOT has requested that John Hourdos expand his team's infrastructure-based queue warning system to an additional freeway in Minneapolis and to maintain full functionality of the system during a three-year construction project that will begin next summer.

Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival: Ron Van Houten lost one of his gateway treatment installation sites because the signs were destroyed. Because the site was unsuitable for the treatment, new sites have been added in the city of Grand Rapids, MI.

Actual or anticipated problems or delays and actions or plans to resolve them

Developing and Validating a Model of Left-Turn Crashes to Support Safer Design and Operations: Gary Davis has found that his prototype crash simulation model tends to overpredict risk during higher volume periods. He's addressing the issue by using a different headway distribution for the opposing traffic, and doesn't anticipate needing to change the project's end date.

Using GIS to Improve Tribal Traffic Safety: Tom Horan reports a possible delay due to the departure of the project's primary doctoral student. He has recently recruited a doctoral student at another university to help with the project.

Older Driver Support System (ODSS) Usability and Design Investigation: Nichole Morris's research team experienced delays in receiving an official cost estimate on modifying their smartphone app. The estimate has now been received and the project can continue as planned.

Changes that have a significant impact on expenditures

Implementation of a V2I Highway Safety System and Connected Vehicle Testbed: John Hourdos has hired several undergraduate students to help with the reduction of video records. These records are necessary for the evaluation of his queue warning system.

Older Driver Support System (ODSS) Usability and Design Investigation: The cost estimate for app modification exceeded the original budget for technology development. Morris's research team may not be able to implement all requested changes and must prioritize features that are most important for the project's progress.



Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support: Daniel Work's graduate students have received some funding from internships and fellowships, which will reduce his overall student budget.

Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards

Collaborating with American Indian Communities to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands: Kathy Quick and Guillermo Narváez have renewed their existing IRB protocol for another year. They are abiding by the policy formulated by the IRB and the 11 tribal governments of Minnesota that stipulates that researchers must have an agreement with the tribal government to conduct in-depth data collection regarding tribal communities and affairs that involve human subjects.

Change of primary performance site location from that originally proposed

Nothing to report.