

# ROADWAY SAFETY INSTITUTE

Human-centered solutions to advance roadway safety

## Program Progress Performance Report for University Transportation Centers

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Max Donath, Director, Roadway Safety Institute

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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.

We are pursuing this objective by meeting the following goals in research, education and workforce development, and technology transfer activities. We are also collaborating with stakeholders across our region and promoting diversity in our educational initiatives.

#### ***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 should 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 demonstrating safe driving concepts to students in STEM summer camps; developing a roadway-safety-themed museum exhibit to be displayed at a STEM-related museum; and partnering with WTS's Transportation YOU program to encourage young female students to pursue transportation-related degrees.

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 multiple seminars and webinars; connecting practitioners and researchers to facilitate discussion and encourage implementation; 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 are developing versions of research hardware and software that can be deployed through collaboration with state DOTs, 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 brings 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 draws on and expands 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 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 20 federally funded research projects and 38 match 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:

- We have allocated a third year of funding to another 5 of our federally funded projects and have also funded 2 new projects by current RSI researchers.
- We've confirmed funds to meet the full match requirement of \$7.72 million. Sources include MnDOT-funded projects related to roadway safety as well as match contributions from our consortium partners.
- We have developed a final report publication process for the Institute's federally funded projects. Three final reports are under way and should be published in the next reporting period. Additionally, 23 of our match projects have produced final reports, 3 of them in the last reporting period.
- Nichole Morris and Ron Van Houten received funding from the Minnesota Department of Transportation for a new project called *Evaluation of Sustained Enforcement, Education, and Engineering Measures on Pedestrian Crossings*. The project is a result of Van Houten's visit to St. Paul, Minnesota, in August 2016, and marks the first research collaboration between two of our partner institutions.

## Highlights from active research projects:

- *Examining the Relationship Between Speed Enforcement Laws and Traffic Safety*: Frank Douma collected state crash data and documented state speed laws for Region 5 in an effort to understand speed enforcement regimes and acquire the necessary data to determine whether a correlation exists between speed laws and crash data.
- *Development and Demonstration of a Cost-Effective In-Vehicle Lane-Departure and Advanced-Curve-Speed Warning System*: Imran Hayee has made considerable progress on the development of a lane-departure warning system and expects to begin developing an advanced-curve-speed warning system in June. The research team has developed the algorithm for the lane-departure warning system and is testing it on actual lane-departure data collected on a local road in Duluth, Minnesota.
- *Using GIS to Improve Tribal Traffic Safety*: Tom Horan conducted a detailed spatial analysis of Minnesota tribal safety trends, comparing crashes on tribal lands and on adjacent rural areas. His analysis indicates certain tribes may be more prone to an increased number of fatal crashes. He also used several statistical techniques to identify hot spots and cold spots and initiated a tribal governance framework that potentially could engage tribal interest in traffic data.
- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: John Hourdos implemented several improvements to the queue warning system, which has been online since April 2016 and operates by displaying messages on MnDOT's intelligent lane control signs. The system uses a dynamic algorithm that could eventually be used to trigger warnings in instrumented vehicles. Since mid-November 2016, seven radar stations between the Chicago Avenue and 3rd Avenue overpasses have been deployed and are now fully operational; initial results of the evaluation show that the system responds to approximately 80 percent of observed crash-prone conditions and resulted in a 22 percent reduction in crashes for the months observed compared to the same period in 2013.
- *Investigate the Effectiveness of Using Bluetooth Low-Energy (BLE) Technology to Trigger In-Vehicle Messages at Work Zones*: Chen-Fu Liao completed this project in December 2016, and the results show that the current system (a smartphone app) has demonstrated that it is capable of providing in-vehicle messages to motorists approaching a work zone at highway speeds using a geo-fencing technique and Bluetooth low-energy (BLE) technology.
- *Directional Rumble Strips for Reducing Wrong-Way-Driving Freeway Entries*: Albert Luo's research team designed and manufactured the mold and the final products for the Pattern E directional rumble strips (DRS) to get a general idea about the manufacturing process. Luo also conducted verification field tests in Auburn, Alabama; performed statistical analysis to evaluate each of the three recommended DRS configurations in terms of the sound and vibration they generated; and set up video cameras in locations determined to be potential areas for wrong-way driving to record and monitor speeds for both right-way- and wrong-way-driving vehicles.
- *Older Driver Support System (ODSS) Usability and Design Investigation*: Nichole Morris completed both the driving video test with 10 older drivers, which yielded important findings for system design and development, and the controlled field test with 11 older drivers, which showed these drivers were highly satisfied with the ODSS app and that the market for adult drivers (especially older drivers) appears ripe for further development.
- *Improving Railroad Grade Crossing Safety: Positioning, Planning, and Operation of Emergency Response Resources and Coordination Between Jurisdictions*: Yanfeng Ouyang developed new mathematical models to study how deployment and utilization of emergency response resources (e.g., fire stations, surveillance points) should be coordinated across various jurisdictions in case these resources need to be used collectively to cover emergency incidents.

- *Alcohol-Related Hot-Spot Analysis and Prediction for Improving DWI/OVI Law Enforcement:* William Schneider has successfully completed both the research project and a final report, which determined the movement of hot spots through time and identified the relationship of spatial autocorrelation to geographic attributes. This information was then used to develop new methods of patrolling for law enforcement officers aimed toward reducing the number of intoxicated drivers. The results allow for more efficient educational, enforcement, and engineering safety efforts by removing unnecessarily patrolled roadways from enforcement campaigns, identifying when and where safety campaigns should be located, and determining how to identify the ideal location for different types of safety campaigns by studying various aspects of crashes.
- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Ron Van Houten successfully completed the study, which validated and refined a new tool for increasing drivers' yielding right-of-way to pedestrians at crosswalks; because the treatment is also associated with a reduction in speed, further work will likely show a crash modification factor associated with its use. All objectives were achieved, including documentation that the large increase in the percentage of drivers yielding right-of-way to pedestrians produced by the gateway was maintained over time; demonstration that the gateway was associated with a decrease in speed at the crosswalk and at the dilemma zone in advance of the crosswalk when pedestrians were not present and that this effect was maintained over time; and determination of the types of signs and configurations that survive over time.

### ***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.

- RSI completed its Pedestrian Safety Workshop series by sponsoring a workshop in Schaumburg, Illinois, on February 23. Ron Van Houten and Max Donath presented to 68 attendees representing several public agencies, nonprofits, and consultants.
- In December, we celebrated RSI's museum exhibit grand opening with approximately 50 attendees at The Works Museum in Bloomington, Minnesota. The exhibit, called Be Safe, Be Seen, is a permanent installation at the museum and uses a variety of hands-on activities to teach preteens about reflectivity and safety. It features videos, interpretive signage, engineer and researcher profiles, a microscope area for examining reflective materials up close, and a dark room where children can try out reflective clothing and see how visible they are in simulated headlights.
- RSI participated in Tech Fest at The Works Museum on February 25, which drew more than 800 people. RSI's activities drew attention to and supported the permanent Be Safe, Be Seen exhibit that RSI recently sponsored at the museum. Staff members heard a great anecdote from one of the attendees; a woman told her husband about the exhibit, who promptly went out and bought her reflective clothes to wear while running!
- The Fall 2016 RSI Seminar Series concluded with its final seven events, reaching an additional 260 participants from October through December.
- Several RSI-affiliated students received awards during this reporting period:
  - Twelve students working on RSI research projects were awarded travel funding to attend the Transportation Research Board Annual Meeting in January. Nine of these students were from the University of Minnesota Twin Cities, one was from the University of Minnesota Duluth, and one was from Auburn University.
  - RSI awarded its 2017 Student of the Year to William Barbour of the University of Illinois at Urbana-Champaign. Advised by Daniel Work, Barbour expects to complete his master's degree in civil engineering in May 2017. Barbour received a \$2,000 award from the Institute

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- and was presented with a certificate from USDOT officials at a ceremony held in conjunction with the TRB Annual Meeting in Washington, D.C., in January.
- RSI co-investigator Hugo Zhou and his graduate student Lingling Yang won one of five Auburn University Graduate School's 2016 Master's Thesis Awards. The thesis, titled "A New Concept Design of Directional Rumble Strips for Deterring Wrong-way Freeway Entries," ties directly into the main RSI project being completed by Albert Luo and Hugo Zhou.
  - In January, Chen-Fu Liao was awarded the Milton Pikarsky Memorial Award for Outstanding Doctoral Dissertation in Science and Technology at the Council of University Transportation Centers Awards Reception held in conjunction with the TRB Annual Meeting. Liao received the award for his Ph. D. dissertation, "An Integrated Assistive System to Support Wayfinding and Situation Awareness for People with Vision Impairment." RSI director Max Donath served as Liao's Ph.D. advisor.
  - University of Minnesota Twin Cities student Jueyu Wang was awarded the Center for Transportation Studies' John S. Adams Award for her research work under RSI researcher Greg Lindsey. Wang is a Ph. D. candidate in public affairs with a concentration in urban planning.

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:

- Max Donath and Nichole Morris continued work on Road Coach, a smartphone app that alerts teen drivers and their parents when a driver engages in risky behavior. The goal is to move the product towards deployment and commercialization. During this reporting period, the team focused on updating the code for both the Android and iPhone versions of the app.
- In October, RSI director Max Donath presented seminars at three Australian transportation safety research centers regarding RSI work and his ongoing Teen Driver Support System research. He spoke at the Monash University Accident Research Centre in Melbourne, the Centre for Accident Research and Road Safety—Queensland in Brisbane, and the Transport and Road Safety Research Centre at The University of New South Wales in Sydney.
- On October 14, Chen-Fu Liao presented his research, published with both RSI director Max Donath and Nichole Morris of the HumanFIRST Laboratory, at the ITS World Congress in Melbourne, Australia.
- The Western TTAP newsletter published a reprint of the RSI youth summer camp outreach story in its fall edition. During the camp, more than 40 White Earth Nation (Minnesota) students were introduced to a variety of transportation topics in a daylong session last June.
- On November 30, Max Donath gave a presentation called "Human Centered Solutions to Advance Roadway Safety" to the staff of the Senate Committee on Commerce Science and Transportation. The presentation gave Donath the opportunity to educate congressional staffers about our work, and to share information about Rajesh Rajamani's research project.
- On December 1 and 2, three RSI researchers presented at the 10th University Transportation Centers Spotlight Conference on Pedestrian and Bicycle Safety, held in Washington, D.C. In a poster session, Chen-Fu Liao presented on his research on a wayfinding methodology for the



visually impaired. Greg Lindsey and Ph.D. student Jueyu Wang participated in a breakout session, sharing their work on bicyclists' exposure to risk. In another breakout session, Lindsey presented on his and John Hourdos's research project on the impacts of bicycle facilities.

- Researchers Kathryn Quick and Guillermo Narváez were both highlighted, along with the RSI program, in the January 2017 issue of the *UTC Spotlight*. The piece, featured on both the front page of the UTC website and in the TRB newsletter, detailed their ongoing efforts toward better transportation safety on reservations along with their work in American Indian communities.
- HumanFIRST principal researcher Nichole Morris was featured in the March 2017 issue of the *GAMTTEP Newsletter*, a publication of the Garrett A. Morgan Technology and Transportation Education Program Clearinghouse. Morris was in the professional spotlight for her work to improve traffic safety by helping engineers design better transportation systems.
- One issue of our e-newsletter was distributed in November 2016. Since the last reporting period, our subscriber base has grown to more than 1,975 people, and the average open rate remained steady, near 25 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 more than 1,295 views in the last six months, a 27 percent increase over the previous reporting period.

### **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 had a short meeting in conjunction with the grand opening of the Be Safe, Be Seen museum exhibit at The Works. They discussed future plans for the Institute and its research projects, including commercialization efforts and new funding sources.
- Max Donath met with Illinois's new state safety engineer to discuss potential future collaborations on projects related to safety.
- The Works Museum exhibit is the product of collaborations with several professionals who work with retroreflective materials. The exhibit itself features profiles and photos of RSI researcher Nichole Morris, Anne Goki of 3M, and Gerald Edwards of NSOD Clothing. All of these professionals participated in the grand opening event, and 3M and NSOD are now partnering on future design projects for retroreflective clothing/uniforms due to the connections made through this project.

### **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.

- On December 8, the RSI Seminar Series featured Patricia DeLucia, professor of psychological sciences and associate vice president for research at Texas Tech University. Along with giving a talk about collision perception and transportation safety, she led a Q&A session for grad students and faculty about women in academia and transportation. While in the Twin Cities, she met with RSI director Max Donath, state traffic safety engineer Brad Estochen, and department head of mechanical engineering Uwe Kortshagen, among other researchers. DeLucia also toured the HumanFIRST Laboratory, where Nichole Morris discussed some of the ways her lab is addressing the problem of attracting more females to STEM fields.

- RSI launched its “curriculum toolkit,” a webpage featuring several RSI-related lesson plans for K-12 students, in December of 2016. This website has been promoted to all Region 5 WTS chapters as well as to other educators and safety advocates throughout the region.
- Kathy Quick and Guillermo Narváz are supervising a tribal roadway safety project conducted by a graduate student in the Master of Public Policy program at the University of Minnesota. The purpose of the study, called “Safe Routes to School,” is to help the Red Lake School District (ISD #38) and the Red Lake Tribal Engineering Division improve traffic flow and pedestrian safety at school entrances in their region. The graduate student, Laura Dorn, is a member of the Red Lake Nation.
- See the research accomplishments section for an update on the tribal safety research being conducted by Tom Horan.

## 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 approximately 3,600 visits and more than 12,300 unique page views. The most popular pages were the home and seminar pages.
- RSI researchers received approximately 15 local and national media mentions for their safety-related work. For example, Imran Hayee’s RSI project on developing a warning system to improve safety for workers in highway work zones was featured in *Roads & Bridges* magazine. Our director, Max Donath, received international media coverage; he was interviewed by *The Sydney Morning Herald* about his work on the Teen Driver Support System and teen driving safety in general. For a full list of media stories, please visit [roadwaysafety.umn.edu/about/news/](http://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 (April 1, 2017–September 30, 2017).

## Research

- We will allocate a third year of funding to two more federally funded projects.
- We will publish at least five additional final reports: three from federally funded projects and two from match projects.
- Brian Davis will submit an Institutional Review Board request to conduct human subjects research, collect data on the St. Cloud test track in June 2017, and analyze the subjective and objective data collected from 24 research participants who experienced the system at different speed-tolerance levels. (*In-Vehicle Dynamic Curve Speed Warnings at High-Risk Rural Curves*)
- Gary Davis will completely reconstruct a sample of left-turn crashes from the NHTSA National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) database (including crashes from 2014 data), modify the simulation model to produce crash events consistent with the

reconstruction results, and begin work on rear-end crashes. (*Developing and Validating a Model of Left-Turn Crashes to Support Safer Design and Operations*)

- Imran Hayee will conduct field tests to confirm that two vehicles can be resolved with respect to their lanes regardless of whether they are on the same lane. These tests will be conducted in various environments to gain statistically significant results. (*Development and Demonstration of Merge-Assist System Using Connected Vehicle Technology*)
- Tom Horan will complete a statistical analysis, devise a tribal governance framework for traffic safety data, meet with tribal representatives to obtain feedback on analysis and the proposed framework, expand the study to greater Region 5 by contacting tribes and tribal representatives, and make recommendations for future geographic information system (GIS) use by tribes. (*Using GIS to Improve Tribal Traffic Safety*)
- Chen-Fu Liao plans to install solar-powered Bluetooth low energy (BLE) sensors on light posts to evaluate the robustness and reliability of the system. (*A Positioning and Mapping Methodology Using Bluetooth and Smartphone Technologies to Support Situation Awareness and Wayfinding for the Visually Impaired*)
- Greg Lindsey will improve the quality of facility demand models of bicycle traffic for Bemidji and Duluth and will estimate exposure to risk and assess crash risk for Duluth based on updated facility demand models. (*Performance Measures for Bicycle and Pedestrian Safety: Methodologies for Monitoring Traffic Volumes and Assessing Exposure to Risk*)
- Albert Luo will finalize the design for the directional rumble strips and identify locations for implementation. (*Directional Rumble Strips for Reducing Wrong-Way-Driving Freeway Entries*)
- Kathy Quick and Guillermo Narváz will conduct detailed data analysis and follow-up data collection, complete coding interview transcripts and field notes, conduct approximately 10 additional interviews to follow up on areas of interest, and complete geospatial analysis of the study areas. The research team will also continue to cultivate existing relationships with tribal transportation leaders and others involved in tribal injury prevention and transportation safety programs, policy, and research in Minnesota and elsewhere and check in with tribal governments with a draft final report customized for each location. (*Collaborating with American Indian Communities to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands*)
- Rajesh Rajamani will analyze and evaluate limitations in system performance due to bicycle tilt and yaw and conduct more tests of the side-impact and rear-collision warning systems in urban traffic as opposed to the earlier tests, which occurred under controlled conditions. (*Novel Collision-Avoidance System for Bicycles*)
- Dan Work will fine-tune the algorithm for grade-crossing prediction, continue to improve the online regression model for train delay estimation, and continue to develop the siding-use classifier. (*Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support*)

### ***Education and workforce development***

- In July, Institute staff will coordinate safety curriculum for the National Summer Transportation Institute at the University of Minnesota, a day camp for middle school students in the Twin Cities. We will also participate in summer camps hosted by the College of Science and Engineering.
- We will secure a paid summer internship for an undergraduate student in MnDOT's Office of Traffic Safety and Technology. The intern will receive hands-on experience working on transportation-related projects and learning from professionals in the field.

### Technology transfer

- The team working on the Road Coach smartphone app will conduct further testing on the Android and iPhone versions of the app, as well as develop a version for researchers that collects driving data without issuing driver warnings. Additionally, they will explore the possibility of adapting the tool for older drivers.
- In April, Max Donath will attend the third annual Summit of University Transportation Centers for Safety: Working in Partnership to Address Real-World Transportation Problems hosted by Carnegie Mellon University. He will serve as a panelist in a facilitated discussion titled “Safety Issues for Rural Transportation.”
- We will continue to regularly distribute our e-newsletter. E-announcements will be sent as appropriate, and we’ll continue to update our safety news feed, social media outlets, and other communication channels.

### Collaboration

- The RSI Advisory Board met on December 9 in conjunction with the RSI museum exhibit grand opening event. We anticipate a meeting of the RSI Advisory Board in the next reporting period.
- We anticipate a conference call meeting of the RSI University Partners Committee in the next reporting period.

### Diversity

- In June, Institute staff will deliver curriculum as a part of the White Earth Summer Camp, which is a longstanding partnership between the White Earth Nation and the University of Minnesota. Curriculum development is currently under way.

## PRODUCTS

### Publications, conference papers, and presentations

During this reporting period, 17 RSI researchers and staff gave 44 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/pppr7\\_presentations\\_list.pdf](http://roadwaysafety.umn.edu/publications/ostr/documents/pppr7_presentations_list.pdf).

RSI researchers published the following papers during this reporting period:

- Jeon, W., and R. Rajamani. 2016. “A Novel Collision Avoidance System for Bicycles.” *Proceedings of the 2016 American Control Conference*: 3474-3479.
- Jeon, W., and R. Rajamani. 2016. “Active Sensing on a Bicycle for Accurate Tracking of Rear Vehicle Maneuvers.” *Proceedings of the 2016 ASME Dynamic Systems and Control Conference*. doi: 10.1115/DSCC2016-9772.
- Liao, C.-F., M. Donath, and N. Morris. 2016. “Using Bluetooth Low Energy Technology to Trigger In-Vehicle Messages at Work Zones.” *Proceedings of the 23<sup>rd</sup> ITS World Congress*. Paper number AM-TP0091.
- Munnich, L. W., and M. Schmit. 2017. “Roadway Safety Policy and Leadership: Case Study of Six Midwest States.” *Transportation Research Record* 2635: 19-27.
- Yang, L., H. Zhou, L. Zhu, and H. Qu. 2016. “Operational Effects of Transverse Rumble Strips on Approaches to High-Speed Intersections.” *Transportation Research Record* 2602: 78-87.

- Zegeer, C., C. Lyon, R. Srinivasan, B. Persaud, B. Lan, S. Smith, D. Carter, N. Thirsk, J. Zegeer, E. Ferguson, R. Van Houten. 2017. “Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments.” *Transportation Research Record* 2636: 1-8.

Federally funded and match projects produced the following final reports during this reporting period:

- Liao, C.-F., and M. Donath. 2016. *Investigating the Effectiveness of Using Bluetooth Low Energy Technology to Trigger In-Vehicle Messages in Work Zones*. MnDOT report number 2016-38.
- Morris, T., V. Morellas, D. Canelon-Suarez, and N. Papanikolopoulos. 2017. *Sensing for HOV/HOT Lanes Enforcement*. MnDOT report number 2017-05.

## Websites or other Internet sites

The Roadway Safety Institute website ([roadwaysafety.umn.edu](http://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](http://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](http://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](http://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/](http://d.umn.edu/ee/cvrl/)) includes information on the research of Imran Hayee.
- The Midwest Tribal Safety website (<http://tribalsafety.maps.arcgis.com/home/gallery.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.
- The Truckers & Turnover Project website ([morris.umn.edu/academics/truckingproject](http://morris.umn.edu/academics/truckingproject)) features the research of Stephen Burks, including a link to his recent paper in the journal *Sleep* on crash risk and obstructive sleep apnea among truck drivers.
- The Transportation Research Board website contains a link to the recording of a webinar ([trb.org/ElectronicSessions/Blurbs/173634.aspx](http://trb.org/ElectronicSessions/Blurbs/173634.aspx)) given by Kathy Quick and Guillermo Narváez in February 2016. The webinar is titled “New Methods for Assessing and Addressing Roadway Safety Priorities in American Indian Reservations.”

## Technologies or techniques

John Hourdos’s project “Implementation of a V2I Highway Safety System and Connected Vehicle Testbed” has produced a real-time queue warning system, which was developed for the project’s test site on I-94 in Minneapolis. MnDOT has integrated the technology with its IRIS traffic control system, and Hourdos’s system now controls two variable message signs on the interstate, upstream from the area with

the highest crash frequency in the Twin Cities. Barring any performance issues, the system will remain in operation for the foreseeable future.

### **Inventions, patent applications, and/or licenses**

Chen-Fu Liao, Nichole Morris, and Max Donath filed a provisional patent application in October 2016 titled “In-Vehicle Work Zone Communication.”

Imran Hayee, Max Donath, and graduate student Zhiyuan Peng filed a provisional patent application in December 2016 titled “Real-Time Relative Vehicle Trajectories Using Vehicle-to-Vehicle Communication.”

Chen-Fu Liao and Max Donath filed a provisional patent application in February 2017 titled “Integrated Assistive System to Support Wayfinding and Situation Awareness for People with Vision Impairment.”

### **Other products**

John Hourdos has created a database that collects and stores vehicle trajectories from seven radar sensors at his test site. As soon as the raw data has been processed, Hourdos will develop a plan to share the data.

## **PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS**

### **Organizations that have been involved as partners**

The Roadway Safety Institute is actively in partnership with 44 organizations across 8 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/pppr7\\_partners\\_list.pdf](http://roadwaysafety.umn.edu/publications/ostr/documents/pppr7_partners_list.pdf).

### **Other collaborators or contacts**

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

- In January, Max Donath, Laurie McGinnis, Gina Baas, and Nichole Morris met with Lewis-Burke Associates, a government relations firm that specializes in advocating for the public policy interests of higher education institutions. Nichole Morris informed the representative from the firm about her work so that he can look for future funding and partnership opportunities.
- On September 28, John Hourdos met with representatives of Ramsey County TZD to discuss driver compliance with pedestrian right-of-way laws.
- Tom Horan has added Joseph Robertson to his research team. Robertson is an enrolled member of the Sisseton Wahpeton Oyate on the Lake Traverse Reservation in South Dakota and is currently pursuing a Ph.D. in computational science and statistics. His role will be to lead development of the project’s tribal safety governance framework.

## 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 risk, 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:

- *Alcohol-Related Hot-Spot Analysis and Prediction for Improving DWI/OVI Law Enforcement:* William Schneider's work is leading to advancements in the field of crash mapping. Schneider has developed new, more accurate hot-spot mapping techniques that improve the calculation of crash cluster locations, the identification of patterns over space and time, and the influence of geographical patterns on the locations of crashes.
- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Ron Van Houten's work is having an impact on traffic control. Based on his work, the National Committee on Uniform Traffic Control Devices (NCUTCD) has made changes to the *Manual on Uniform Traffic Control Devices* related to the gateway treatment. The NCUTCD is seeking interim approval, which means that the changes would be in compliance prior to any experiments being conducted—a step that will still be necessary prior to final approval.
- *Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support:* Dan Work anticipates an impact on the field of railroad engineering and operations. His project makes use of machine learning classification to determine probabilistic instances of freight train re-crewing far before they happen, which is an important factor for estimating arrival times at grade crossings.

### 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:

- *Identifying and Reconciling Stakeholder Perspectives in Deploying Automated Speed Enforcement:* Frank Douma's project has the potential to impact public health. Framing the use of automated speed enforcement (ASE) as a clear and effective safety tool to address the profound public health problem of roadway fatalities and injuries would likely increase public support for ASE deployment.
- *Alcohol-Related Hot-Spot Analysis and Prediction for Improving DWI/OVI Law Enforcement:* Schneider expects his work to have an impact on law enforcement. His hot-spot maps show where intoxicated drivers are likely to be present, and route optimization models can help guide officers to



these locations. By using these methods, enforcement agencies can make better decisions about where to patrol to effectively execute campaigns aimed at reducing alcohol-related crashes.

### **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:

- *Collaborating with American Indians to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands:* Kathy Quick and Guillermo Narváez are leveraging the opportunities provided by this project to support ongoing University of Minnesota efforts to improve relationships, strengthen models and patterns of engaged scholarship, and provide training opportunities for American Indian tribal governments and community members.
- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Western Michigan University has expressed interest in implementing Van Houten's gateway treatment at crosswalks on its campus.

### **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 twenty federally funded projects have enlisted undergraduate or graduate student assistants. During this reporting period, these jobs provided 38 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, Greg Lindsey, Albert Luo, Nichole Morris, Yanfeng Ouyang, Andrew Owen, Kathy Quick, Rajesh Rajamani, William Schneider, Ron Van Houten, and Dan 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.

New impacts from this reporting period:

- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* The City of St. Paul, Minnesota, introduced new pedestrian safety changes based on Van Houten's work. While Van Houten was not cited directly as the source of these new safety measures, the implementation came shortly after he gave both a walking tour and follow-up presentation to representatives of the city in late August 2016, and they are almost exactly the recommendations he proposed.

- *Collaborating with American Indians to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands:* Data collected as part of Quick and Narváez’s project is already leading to practical safety improvements in some tribal communities. For example, the Red Lake Nation has used the information to develop a comprehensive tribal transportation safety plan and to identify specific pedestrian safety concerns along a main highway through the reservation. The tribe used the study data to apply for and receive funding from the State of Minnesota to develop a new walking trail and street lighting on that highway to provide a safer walking environment for the reservation’s residents.

## 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:

- *Older Driver Support System (ODSS) Usability and Design Investigation:* Nicole Morris’s project has the potential to shift societal perceptions and attitudes about older drivers by changing the information available about their driving habits and abilities.
- *Collaborating with American Indians to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands:* Through its commitment to sustained relationship building and a collaborative research approach, Quick and Narváez’s project has contributed to an improvement in the historically troubled relations between the University of Minnesota and American Indian tribes in Minnesota.
- *Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* This project has the potential to improve pedestrian safety and therefore enhance the attractiveness of walking as a mode choice. The gateway treatment is an order of magnitude less expensive than the Rectangular Rapid Flashing Beacon and two orders of magnitude less expensive than the Pedestrian Hybrid Beacon, which means it can be installed at many sites even with limited funding.
- *Alcohol-Related Hot-Spot Analysis and Prediction for Improving DWI/OVI Law Enforcement:* Schneider’s project could improve safety for the traveling public by reducing the number of alcohol-impaired drivers on the road. Using his hot-spot maps, enforcement agencies will be able to pass through more alcohol-related crash hot spots per minute and mile. By improving how officers patrol, more people may be deterred from intoxicated driving and alcohol-related crashes may ultimately be reduced.

## CHANGES/PROBLEMS

### Changes in approach and reasons for change

*Collaborating with American Indians to Re-Interpret and Strategize About Transportation Safety Risks in Tribal Lands:* Kathy Quick and Guillermo Narváez have expanded their field work beyond the original project scope. They have partnered with additional tribal governments, added another case study site, and conducted interviews with overlapping jurisdictions.

*Implementation of a V2I Highway Safety System and Connected Vehicle Testbed:* John Hourdos reports that this project did not fully accomplish its goal of evaluating the testbed's system operations because the full system was deployed only a few months prior to the official end of the project. Hourdos plans to attempt additional work; however, the area where the system is installed will soon become a work zone, so continued work may need to wait until the next period of stable geometric and traffic conditions.

*Older Driver Support System (ODSS) Usability and Design Investigation:* Based on the findings of Nichole Morris's research team that older drivers do not want a speed threshold change, the contract with engineering consultants must be reissued to remove that request. A new contract will be issued for the creation of a baseline version that allows for future field operational testing of the app.

### **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:* A personnel change in Gary Davis's department at the University of Minnesota resulted in Davis and his graduate student covering a double teaching load in Fall 2016. This resulted in less progress than expected being made on the project. As of January 2017, Davis has increased his student's effort on the project, which should get the project back on track.

*Exploring Links Between Medical Conditions and Safety Performance in Tractor Trailer Drivers:* Stephen Burks has done some exploratory work on a paper focused on the effectiveness of the commercial drivers' medical examination in diagnosing obstructive sleep apnea. This paper may not be completed during the current project year, but exploring its feasibility could assist Burks in the development of planned work with new data, the acquisition of which is part of his project's objectives.

*Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* One of Ron Van Houten's study sites was lost because all of the signs were struck by vehicles and destroyed. The site was then judged unsuitable for a reinstallation of the treatment. Van Houten resolved the issue by mounting the signs on flexible connectors, which hold up better than pivoting bases when struck by a vehicle. He has since created a new study site in Grand Rapids, Michigan.

*Older Driver Support System (ODSS) Usability and Design Investigation:* The final deliverable dates for Morris's project have been shifted to August 31, 2017, to account for delays in technology development under task 5 of the project.

*Performance Measures for Bicycle and Pedestrian Safety: Methodologies for Monitoring Traffic Volumes and Assessing Exposure to Risk:* Project collaborators in Duluth, Minnesota, have taken longer to compile their traffic counts than anticipated, but Greg Lindsey expects to have the project's facility demand models re-estimated by spring 2017.

*Safety in Numbers? Accessibility, Traffic, and Safety of Nonmotorized Travelers:* The full application of the risk model developed in the project has so far been limited to Minneapolis because of delays in acquiring complete input data from other cities. Andrew Owen plans to engage in continued communication with these cities to resolve the issue.



*Using GIS to Improve Tribal Traffic Safety:* Tom Horan reports a significant delay in this project as the result of his having to take a health-related leave of absence. The issue will be resolved by hiring a graduate assistant and extending the project's contract until late 2017.

### **Changes that have a significant impact on expenditures**

*Older Driver Support System (ODSS) Usability and Design Investigation:* Morris reports that the elimination of speed threshold changes will put the expenses for technology development back within budget.

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

Nothing to report.

### **Change of primary performance site location from that originally proposed**

*Long-Term Effects of Gateway R1-6 Treatment on Yielding to Pedestrians, Vehicle Speed, and Sign Survival:* Some of the study sites in Kalamazoo, Michigan, were dropped, but Van Houten added new sites in Grand Rapids. Since that time, Kalamazoo has expressed renewed interest in installing the treatment.