

# ROADWAY SAFETY INSTITUTE

Human-centered solutions to advance roadway safety

## Program Progress Performance Report for University Transportation Centers

**Recipient Organization**

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**Recipient Identifying Number**

CON# 042705

**DUNS and EIN Numbers**

DUNS: 55-591-7996  
EIN: 41-6007513

**Federal Grant Number**

DTRT13-G-UTC35

**Submitted to:**

Amy Stearns, Grant Manager  
Office of the Assistant Secretary for  
Research and Technology  
US Department of Transportation

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**Grant Period:** 9/30/13 – 9/30/19

**Reporting Period:** 10/1/2018 – 3/31/2019

**Report term:** Semiannual

**Submission Date:** 4/30/2019

**Signature of Submitting Official:**



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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 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 35 federally funded research projects (20 active, 15 completed) and 33 match projects (3 active, 30 completed). Descriptions of all projects are available on our website, and all active projects have records in the Transportation Research Board (TRB)'s Research in Progress (RiP) database.

Programmatic research accomplishments include:

- Two researchers received prestigious awards from the University of Minnesota for work related to their RSI projects.
  - On February 20, Stephen Burks (“Exploring Links Between Medical Conditions and Safety Performance in Tractor Trailer Drivers”) received the Robert C. Johns 2019 Research Partnership Award from the Center for Transportation Studies, which is presented annually to a team of individuals who have collaboratively drawn on their diverse expertise to achieve significant impacts on transportation. The award honored Dr. Burks' previous and current work with Harvard Medical School, Precision Sleep Solutions, Schneider National, Inc., and Virginia Tech Transportation Institute on the link between medical conditions and safety performance in tractor trailer drivers.
  - On April 4, Greg Lindsey (“Performance Measures for Bicycle and Pedestrian Safety: Methodologies for Monitoring Traffic Volumes and Assessing Exposure to Risk”) was named the winner of the 2019 University of Minnesota President's Community-Engaged Scholar Award. The award recognizes University faculty who demonstrate academically

relevant work that advances scholarship in one or more academic disciplines, is conducted in partnership with external entities, and addresses critical societal issues. Lindsey was chosen from six finalists by a committee of peers. At least 10 public agencies, including the Minnesota Department of Transportation, the Department of Natural Resources, and Hennepin County, have implemented new monitoring programs to measure bicycling and pedestrian traffic volumes, based on USDOT- and MnDOT-funded research by Lindsey and his students.

- We published 4 final research reports for federally funded projects and one research report for a match project.

Notable highlights from active research projects:

- *The Screening Effectiveness of the Commercial Driver's Medical Examination*: Stephen Burks and the rest of the core analysis team at the University of Minnesota Morris have completed the first draft of the commercial driver's medical examination (CDME), and medical co-authors have completed an initial review of the paper. Burks has also conducted exploratory work on two data sets, one related to operational and human resource data and the other on medical diagnosis data on sleep apnea.
- *Development of an Automated Vehicles Programming Class*: Brian Davis evaluated existing and open source software and developed new software necessary to operate a small unmanned robot vehicle for demonstrations and workshop exercises. The demonstrations and exercises will focus on light detection and ranging (LIDAR) and global navigation satellite system (GNSS) sensor technology and how these sensors enable vehicle localization and navigation. The research team also designed the curriculum and format for a professional course, which will be shared with project stakeholders for feedback and used to recruit course participants.
- *Vehicle Automation and Transportability of Crash Modification Factors*: After developing and applying a methodology for stating and testing explanatory hypotheses, Gary Davis has concluded that the transferability of a crash modification factor can be assessed if one has a causal model that explains how crash modification works. Over the past six months, Davis has reviewed how and why the processes underlying crash modification factors are explained, connected the transferability problem to recent work in evidence-based policymaking, and developed a detailed example explanation of how pedestrian hybrid beacons achieve their reported crash modification effects.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota*: Frank Douma has been interacting with Minnesota communities to raise awareness about the future impact of automated vehicles (AVs) and create a demonstration plan to serve the actual needs of small and/or rural communities. Douma identified 10 Minnesota communities that fit predetermined criteria, before choosing two, White Bear Lake and Fergus Falls. The team put together a task force of local stakeholders in White Bear Lake to map out a route that would service the target population. City engineers approved the route as feasible, and the city council approved the AV demonstration plan. Douma is still working out details of the route in Fergus Falls but received approval from the city council to work with city officials on a potential plan. Douma has concluded that when creating a route and demonstration plan, communities should engage with an array of local stakeholders to develop a plan that addresses the entire community's needs and concerns.
- *Developing GPS Antenna Error Models for Improved Centimeter Level Positioning*: Rhonda Franklin collected navigation data on the low-performance u-Blox ANN-MS antenna for position data to compare with the baseline high-performance Navcom Ant3001 GNSS Rover antenna and began analysis of the position and radiation pattern data to correlate phase center similarities and differences between both antenna systems. Comparing these systems will help Franklin to develop

- an algorithm that compensates for errors in the low-performance antennae. Enabling the use of a cheaper antenna in lane-keeping systems will make this technology more accessible to consumers.
- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: John Hourdos has succeeded in producing a record number of high-resolution vehicle trajectories as well as the infrastructure for warehousing and accessing information used in a fully functional connected vehicle (CV) testbed. Hourdos received comments from reviewers on the final report and implemented the requested revisions.
  - *Improving Intersection Safety Through Variable Speed Limits for Connected Vehicles*: Michael Levin and the project team calculated shockwave speeds for a variety of scenarios involving variable speed limits (VSLs), including different free-flow speeds, automated vehicle (AV) market penetrations, and demand (arrival rates), and then analyzed the impacts on shockwave speeds. VSLs were generally found to reduce the speed of congested shockwaves, and the effectiveness tended to improve as the AV market penetration increased. Levin's overall goal is to improve safety around intersections by using connected autonomous vehicles to reduce variations in traffic speeds.
  - *Pedestrian and Bicycle Safety, Equity, and Street Funding: New Criteria for Prioritizing Multimodal Street Projects in Minneapolis*: Greg Lindsey completed the project's draft final report. Results show that pedestrian and bicycle crash risk at intersections and mid-blocks is generally correlated with exposure; correlates of crash risk for different modes at intersections and mid-blocks differ, confirming that disaggregate analyses are needed to inform investments in improvements to increase safety of street networks; pedestrian and bicycle crash risk is distributed unevenly throughout the city, with higher risk in lower-income neighborhoods that have a majority of minority populations; and different rankings result when network segments in the city are ranked according to modeled pedestrian and bicycle crash risk rather than total crash rates based on historical numbers of crashes at particular locations.
  - *HumanFIRST Driving Simulation Educational Development*: Nichole Morris has constructed three simulated driving environments -- a cluttered urban environment, an open rural environment, and a multi-lane freeway environment -- to illustrate and educate the community on topics relating to automation, distraction, and speeding. The research team created demonstrations based on state and national crash statistics and emerging technologies and iterated them based on a series of early demonstrations with stakeholders and student groups and through structured usability testing. Morris then modified the final demonstrations to best demonstrate roadway-safety and technology topics to tour groups, including elementary, high school, and college students, and government and professional stakeholders.
  - *Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations*: Kathy Quick finalized the project's survey questions, based on a literature review and consultations with tribal transportation safety specialists, assembled four contact lists to maximize distribution of the survey to key stakeholders, and followed up with potential study participants to improve survey response rates. The team received 189 responses and completed the initial analysis of all survey data. More than half of respondents reported the time to transfer motor vehicle collision victims to a trauma center usually exceeded the critical "golden hour," with concerns being particularly acute in the Pacific Northwest and Alaska. Quick's work has been garnering media attention; the *Minneapolis Star Tribune* covered the case study research, and Civios produced a podcast about the study methods and findings.
  - *Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support*: Daniel Work aggregated the results of grade-crossing estimated time of arrival (ETA) prediction using machine learning regression, performing machine learning trials for all points applicable to grade crossing ETA

prediction in the area of study. Although the project's dataset is perhaps the largest U.S. freight rail dataset available to academic researchers, it does not contain spatiotemporal information sufficient to pinpoint the grade crossing time to the minute. The best available *known* information is the train crossing point at control points close to grade crossings. Therefore, the researchers assessed ETA values at these points.

### ***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.

- On December 5, the Institute hosted a seminar on the University of Minnesota campus called “Making Autonomous Vehicles a Reality: Precise Localization Using Precise GPS, Map, and Perception Sensors,” which was delivered by technical fellow Curtis Hay from General Motors (GM). Hay talked about his work developing the sensor technology used in GM's emerging lines of autonomous vehicles. Nearly 100 people (both in-person and online) attended the event.
- In the fall, the HumanFirst Laboratory hosted two events that allowed interested professionals to tour its driving simulators and Intelligent Vehicles Lab. On October 24, ITS Minnesota organized a two-hour tour of the facility for 14 people from the City of St. Paul, MnDOT, and private consulting firms. On December 18, HumanFIRST held an open house for members of the Center for Transportation Studies' Safety and Traffic Flow Research Council and other interested community members.
- On February 9, we participated in Tech Fest at The Works Museum, an annual STEM technology fair for kids. Institute staff interacted with about 300 children while drawing attention to and supporting the permanent Be Safe, Be Seen exhibit that we sponsored at the museum.
- Two RSI-affiliated students received awards during this reporting period:
  - The Institute awarded its 2019 Student of the Year to Jake Achtemeier of the University of Minnesota. Advised by Nichole Morris, Achtemeier is working towards a master's degree in human factors and ergonomics while also working as an assistant scientist in the HumanFIRST Laboratory. Achtemeier received a \$2,000 award from the Institute and was presented with a certificate from USDOT officials at a ceremony held in conjunction with the Transportation Research Board Annual Meeting in Washington, DC, in January.
  - William Barbour was named a 2019 Dwight David Eisenhower Transportation Fellow at the Transportation Research Board's 2019 Annual Meeting. Barbour is on Daniel Work's research team at Vanderbilt University.

### ***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:

- A summary report that highlighted the Institute's research, education, and technology transfer efforts was developed and distributed. The publication, which was shared at the TRB Annual Meeting in January and mailed out to more than 1,500 stakeholders, demonstrates the depth and breadth of the Institute's initiatives from 2013–2019. The report is also available on the Institute's website.
- We continue to maintain a news feed on the Institute's blog and home page and maintain our RSI Facebook, Twitter, LinkedIn, and YouTube accounts. Highlights from this reporting period include

more than 18,000 impressions on Twitter and more than 1,400 video views (totaling more than 15,200 minutes of watch time) on our YouTube channel.

### ***Collaboration***

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

- RSI Director Max Donath and Nichole Morris met with Colonel Matt Langer of the Minnesota State Patrol to discuss opportunities to investigate methods for reducing unsafe high speed pursuits, perhaps including simulation training. The discussion was part of a larger meeting that included other University of Minnesota researchers as well as members of both the Minnesota State Patrol and the Minnesota Department of Public Safety.

### ***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.

- Kathy Quick has discussed her work with the chair and several members of TRB's Standing Committee on Native American Transportation Issues (ABE80) on two occasions, both in preparation to deploy a survey. She is also in frequent contact with Adam Larsen, lead of the tribal transportation assistance program of the FHWA, regarding study questions and design.
- See the research accomplishments section for an update on the tribal safety research being conducted by 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.

- RSI researchers received several local and national media mentions for their safety-related work. For a full list of media stories, please visit [roadwaysafety.umn.edu/about/news/](http://roadwaysafety.umn.edu/about/news/).
- The Institute's website is the primary vehicle for distributing information to stakeholders. In this period, the site received approximately 2,016 site visits and 4,392 unique page views. The most popular pages were the home, seminar, and all research project search pages.

## **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 final reporting period (April 1- September 30, 2019).

### ***Research***

- We anticipate the publication of at least 18 final reports: 15 from federally-funded projects and 3 from match projects.
- Stephen Burks will complete the second draft of the driver's medical examination (CDME) screening effectiveness paper and submit it to the appropriate medical science journal. Burks will

also continue exploratory work on new data (past the project end date), negotiate a final Data Use Agreement with the medical insurance program manager, and begin acceptance of new generation medical insurance claims data. (*The Screening Effectiveness of the Commercial Driver's Medical Examination*)

- Brian Davis plans to finalize the demonstrations and exercises according to the developed curriculum. On May 16 and 17, Davis will also hold a workshop for a small number of MnDOT and other transportation professionals and solicit their feedback. He will then document the project in a final report. (*Development of an Automated Vehicles Programming Class*)
- Rhonda Franklin will continue to identify connections between electromagnetic phase center and navigation position data. Currently, the response between the two GPS antennas differs and the research team will work to determine what factors lead to this outcome. The researchers are also planning to build and test a similar antenna structure to determine if they can isolate factors that may cause the phase center locations to vary as much as they do. Franklin has submitted a conference paper based on the work. (*Developing GPS Antenna Error Models to for Improved Centimeter Level Positioning*)
- John Hourdos will finish implementing the Statewide Work Zone Information System (SWIS) server and ship a beta version of the server and beacons. He will also begin extensive field testing and file for a provisional patent for the inspection algorithm (inspecting of work zones) and sanity-check algorithm, which determines whether it makes sense to inspect a particular work zone. (*Work Zone Mapping and Tag Deployment System*)
- Albert Luo and Hugo Zhou will continue monitoring wrong-way incidents at two locations and develop general implementation guidelines for direction rumble strips (DRS). (*Field Implementation of Direction Rumble Strips for Detering Wrong-Way Entries*)
- Nichole Morris plans to implement the final iterative design recommendations for the project's three simulated environments from the usability testing and continue education and outreach activities. (*HumanFIRST Driving Simulation Educational Development*)
- Kathy Quick will complete the study's final report in response to peer review comments, submit the paper to the Transportation Research Board for a podium presentation and consideration for publication in the *Transportation Research Record*. The team is also formulating a sampling strategy, based on the survey responses, to conduct 12-15 follow-up interviews to deepen data in key areas. The team will develop two papers for peer-reviewed journals and write a book chapter on lessons learned from the study. (*Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations*)
- Daniel Work will calibrate the project's single-track rail dispatch optimization model, using continuous space black-box optimization (such as NOMAD). (*Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support*)

### **Education and workforce development**

- RSI researchers and staff will participate in the University of Minnesota's National Summer Transportation Institute in July.
- We plan to secure an internship for an undergraduate student in MnDOT's Office of Traffic Engineering.

### *Technology transfer*

- We will distribute one issue of the RSI e-newsletter. In addition, we will send several e-mail announcements to publicize the availability of new research reports during the final months of the grant.

### *Collaboration*

- Nothing to report.

### *Diversity*

- Kathy Quick will give a presentation at the UTC Spotlight Conference in May 2019 titled “Collaborating to advance roadway safety in American Indian reservations.” In her talk, she will detail the work she has done with tribal governments in Minnesota to improve roadway safety on reservations.

## **PRODUCTS**

### **Publications, conference papers, and presentations**

During this reporting period, RSI researchers and staff gave 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. Presentations include:

- Barbour, W. “Data-Driven Methods in Rail Operations.” Presentation at the Smart Rail Workshop at the 21<sup>st</sup> IEEE International Conference on Intelligent Transportation Systems, Maui, Hawaii, November 4, 2018.
- Barbour, W., C. Samal, S. Kuppa, A. Dubey, and D. Work. “On the Data-Driven Prediction of Arrival Times for Freight Trains on U.S. Railroads.” Presentation at the 21<sup>st</sup> IEEE International Conference on Intelligent Transportation Systems, Maui, Hawaii, November 6, 2018.
- Carlson, K., A. Ermagun, B. Murphy, A. Owen, and D. Levinson. “Safety in Numbers for Bicyclists and Motorists at Urban Intersections: A Two-Part Model of Crashes.” Lectern presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 15, 2019.
- Davis, B., J. Achtemeier, N. Morris, and B. Patzer. “In-Vehicle Dynamic Curve Speed Warnings.” Lectern presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 16, 2019.
- Davis, G., and J. Gao. “Transferability of Crash Modification Factors via Graphical Causal Models.” Poster presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 16, 2019.
- Dirks, P. “Assessing the Impacts of Pedestrian-Activated Crossing Systems.” Presentation at the Annual CTS Research Conference, Minneapolis, MN, November 1, 2018.
- Donath, M., C.-F. Liao, and N. Morris. “Driver Assist Systems to Support Lane-Keeping in Poor Visibility Conditions.” Presentation to the CTS Executive Committee, Minneapolis, MN, November 29, 2018.
- Faizan, M, M. I. Hayee, and S. Hussain. “Design and Development of an In-Vehicle Lane Departure Warning System.” Poster presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 15, 2019.

- Malinoff, S. “Roadway Safety Institute: Past, Present, and Future.” Presentation to the CTS Scholars, Minneapolis, MN, December 19, 2018.
- Mathew, J., and R. Benekohal. “Empirical Bayes Method for Highway-Rail Grade Crossing Accident Prediction.” Poster presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 15, 2019.
- Parikh, G. “Evaluation of the Smart Work Zone Speed Notification System.” Presentation at the Annual CTS Research Conference, Minneapolis, MN, November 1, 2018.
- Quick, K.S., A. Larsen, and G.E. Narváez. “Tribal transportation specialists’ roadway safety priorities: findings of a national survey.” Poster presentation at the 98<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, January 16, 2019.
- Quick, K.S., and G.E. Narváez. “Pedestrian road safety in reservations: key findings of a national survey and collaborative research with 4 Minnesota tribes.” Presentation in a national webinar hosted by America Walks, March 19, 2019.
- Quick, K.S., and G.E. Narváez. “Reservation roadway safety: key findings of collaborative research with 4 Minnesota tribes.” Podium presentation at the Lifesavers Annual Conference, Louisville, KY, March 31, 2019.
- Tao, T., G. Lindsey, J. Cao, and J. Wang. “Methods and Measures for Assessing Exposure to Risk, Crash Risk, and Equity.” Presentation at the Annual CTS Research Conference, Minneapolis, MN, November 1, 2018.
- Tao, T., G. Lindsey, J. Cao, and J. Wang. “Methods and Measures for Assessing Exposure to Risk, Crash Risk, and Equity.” Presentation at Minnesota’s Transportation Conference, Minneapolis, MN, March 13, 2019.

RSI researchers published the following papers during this reporting period:

- Hussain, S., M. Faizan, and M. I. Hayee. 2018. “Real-Time Relative Lane and Position Identification of Surrounding Vehicles Using GPS and DSRC Based Vehicle-to-Vehicle Communication.” *Proceedings of the 2018 IEEE International Conference on Communications (ICC)*: 1-7.
- Jeon, W., and R. Rajamani. 2018. “Rear Vehicle Tracking on a Bicycle Using Active Sensor Orientation Control.” *IEEE Transactions on Intelligent Transportation Systems* 19.8: 2638-2649.
- Murphy, B., and A. Owen. 2019. “Implementing Low-Stress Bicycle Routing in National Accessibility Evaluation.” *Transportation Research Record*, available online March 28, 2019.

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

- Faizan, M., S. Hussain, and M. I. Hayee. *Development and Demonstration of a Cost-Effective In-Vehicle Lane Departure and Advanced Curve Speed Warning System*. MnDOT report number 2018-34.
- Horan, T., B. Hilton, J. Robertson, and J. Mbugua. *Using GIS to Improve Tribal Safety: Applications, Trends, and Implementation Dimensions*. Roadway Safety Institute report number 18-19.
- Liao, C.-F. *A Positioning and Mapping Methodology Using Bluetooth and Smartphone Technologies to Support Situation Awareness and Wayfinding for the Visually Impaired*. Roadway Safety Institute report number 18-21.
- Mathew, J., R. F. Benekohal, and J. C. Medina. *Accident Prediction Models using Macro and Micro Scale Analysis: Dynamic Tree and Zero Inflated Negative Binomial Models with Empirical Bayes Accident History Adjustment*. Roadway Safety Institute report number 19-02.

- Quick, K. and G. Narváez. Understanding Roadway Safety in American Indian Reservations: Perceptions and Management of Risk by Community, Tribal Governments, and Other Safety Leaders. Roadway Safety Institute report number 18-20.

## 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 titled “New Methods for Assessing and Addressing Roadway Safety Priorities in American Indian Reservations.”
- The Humphrey School of Public Affairs hosts a podcast called Civios; their episode about Kathy Quick and Guillermo Narváez’s research on roadway safety in reservations can be found at [civios.umn.edu](http://civios.umn.edu).

## Technologies or techniques

Nothing to report.

## Inventions, patent applications, and/or licenses

Nothing to report.

## Other products

John Hourdos developed a database of vehicle trajectories to be used in a vehicle to infrastructure highway safety system. (*Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*)

John Hourdos developed data filtering and mining applications as well as data visualization software. (*I-94 Connected Vehicles Testbed Operations and Maintenance*)

Michael Levin developed software for modeling variable speed limits, which is now available for future research. (*Improving Intersection Safety Through Variable Speed Limits for Connected Vehicles*)

## PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

### Organizations that have been involved as partners

The Roadway Safety Institute is actively in partnership with 54 organizations across 12 states and the District of Columbia. For more information on these partners—including their names, locations, and contribution types—please see pages 16 and 17.

### Other collaborators or contacts

Brian Davis, who is working on an automated vehicles programming workshop, collaborated with Professor Brandon Englot at the Stevens Institute of Technology by sharing some relevant software with each other.

Nichole Morris spoke with representatives from the CINTAS Corporation about opportunities for future driver safety training, including simulation training.

Since taking a position at Vanderbilt University, Dan Work has been in contact with colleague Professor Craig Philip, director of the Vanderbilt Center for Transportation and Operational Resilience. Work hopes to leverage Philip's expertise as they try to improve ETAs at grade crossings.

## 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, safer intersections and rail-grade crossings, and reduced 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:

- *Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations*: Kathy Quick reports that this exploratory study will have an impact on public health. Based on the research team's analysis of survey data, six recommendations have been made related to scoping, research questions, and methodologies for additional research to develop knowledge on this topic.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota*: Frank Douma expects this project to have an impact on policy development and implementation, specifically in the area of stakeholder and community engagement. As part of their work, the researchers learned that it is important to include a variety of people who hold differing positions within the community when planning an automated vehicle demonstration. These individuals provide unique perspectives and help to create a plan that is realistic and accommodates a wide set of needs within the community.

### **Impact on other disciplines**

- *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed*: According to John Hourdos, the project will have an impact on the discipline of traffic engineering. The data collected in the Connected Vehicle Testbed have already shed light on driver behavior and characteristics such as response time and preferred deceleration. The project has also validated existing traffic flow models of shockwave propagation.

### **Impact on physical, institutional, and information resources**

- *Developing GPS Antenna Error Models for Improved Centimeter Level Positioning*: Rhonda Franklin reports that this project resulted in the acquisition of calibration horn antennas that allow researchers to make radiation pattern measurements down to 1 GHz—an improvement over the previous lower end threshold of 2 GHz.
- *Development of an Automated Vehicles Programming Class*: The main goal of this project, according to Brian Davis, is to develop a workshop for transportation professionals interested in learning about the technology that enables connected and automated vehicles (CAVs). The workshop materials are being designed to be interesting, applicable, and useful for the professionals who will be planning for CAVs as they begin to enter the fleet.

### **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.

During this reporting period, 16 RSI projects enlisted undergraduate or graduate student assistants. These jobs provided 38 students with research and practical work experience related to roadway safety. PIs supervising students include Ray Benekohal, Stephen Burks, Brian Davis, Gary Davis, Frank Douma,

Rhonda Franklin, John Hourdos, Michael Levin, Greg Lindsey, Albert Luo, Nichole Morris, Kathy Quick 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:

- *Identifying and Reconciling Stakeholder Perspectives in Deploying Automated Speed Enforcement:* The findings of this project contributed to a current bill in the Minnesota Legislature that would authorize the use of automated speed enforcement in work zones, thus providing additional protection for workers in areas where people travel at excessive speeds.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota:* The cities of White Bear Lake, MN, and Fergus Falls, MN, now have detailed plans for automated vehicle demonstrations as a result of their collaboration with Douma and his research team.

## 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:

- *Development of an Automated Vehicles Programming Class:* The project's final workshop will improve public knowledge, skills, and abilities by providing high-quality education to transportation professionals about connected and automated vehicles and the technologies that enable them to function.
- *Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations:* Quick believes this study has had an impact on both the public's and policymakers' knowledge and attitudes regarding the importance and complexity of roadway safety issues in reservations. She also says that the data her team has provided to document these concerns will support the improvement of social and health conditions in reservations.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota:* This work included engaging with stakeholders in small Minnesota cities about planning for the future of automated vehicles (AVs) and hosting a potential AV demonstration. This brought an array of community members into the conversation and sparked ideas of how a demonstration could benefit the local school system, the elderly community, tourism, and more. The project also developed a framework for a realistic demonstration plan that similar communities may use when looking to host an AV demonstration in their area.

## CHANGES/PROBLEMS

### Changes in approach and reasons for change

Stephen Burks revised and clarified two statistical hypotheses as well how he presented the evidence relevant to both. (*Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers*)

Gary Davis identified that the main obstacle to assessing transferability of crash modification factors was a lack of understanding about how these factors work. As a result, the research team shifted its focus to developing and testing explanatory hypotheses regarding crash modification factors. (*Vehicle Automation and Transportability of Crash Modification Factors*)

The researcher originally in charge of the *Work Zone Mapping and Tag Deployment System* project left the Minnesota Traffic Observatory, and that affected the project timeline. Andrew Loutfi has since taken over the project. (*Work Zone Mapping and Tag Deployment System*)

The U.S. government shutdown delayed Kathy Quick's access to some email distribution lists, postponing deployment of the survey. The team has since deployed the survey and analyzed the responses. However, because of the delay, Quick was unable to conduct interviews as planned and instead will perform them after the study period is completed. (*Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations*)

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

Stephen Burks will address additional changes requested by the journal that is expected to publish the project's final report. (*Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers*)

Brian Davis received a no-cost extension to his project due to the temporary unavailability of a research team member who had a family emergency. Davis anticipates the new timeline will be met. (*Development of an Automated Vehicles Programming Class*)

Brian Davis' project was delayed due to staff unavailability unrelated to this project. Davis received an extension and expects the project to be completed on time. (*Improvement of Driving Simulator Eye Tracking Software*)

A hearing on a bill to permit testing of automated vehicles (AVs) on all Minnesota roads led to an amendment that prohibits the testing of AVs on public roads. While no binding action was taken, the proposed amendment could discourage communities in Minnesota from hosting an AV demonstration. Frank Douma will need to mention this major legislative change in his final report and inform the communities he is working with about the change, but he does not expect it to delay the project. (*Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota*)

John Hourdos' project was delayed because creating the *Manual on Uniform Traffic Control Devices* (MUTCD) compliance decision algorithms took longer than originally anticipated. Due to this delay, there

is a possibility that the final report will not be published by the end of the grant. Institute staff are in touch with the USDOT about how to best handle this delay. (*Work Zone Mapping and Tag Deployment System*)

The motion base of the driving simulator being used in Nichole Morris' project had a major design flaw that the vendor had to rebuild, creating a delay in the simulation lab as well as some of the work on this project. However, Morris expects the project to be completed on time. (*HumanFIRST Driving Simulation Educational Development*)

The graduate research assistant working with Nichole Morris was doing this project in conjunction with his PhD dissertation at Wichita State University. Some timeline issues for approval to begin data analysis from his dissertation committee delayed the projects' data analysis for several months. However, the student's dissertation proposal and the commencement of data analysis has since been approved. (*Older Driver Support System (ODSS)*)

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

Nothing to report.

### **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**

Nothing to report.

## ORGANIZATIONS THAT HAVE BEEN INVOLVED AS PARTNERS

Organization Name	Organization Location	Type of Contribution				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
Advocacy Council for Tribal Transportation	Greater Minnesota				X	
American Association of State Highway and Transportation Officials	Washington, DC		X			
American Transportation Research Institute	St. Paul, MN		X			
Ann Arbor, City of	Ann Arbor, MI		X			X
Arrowhead Regional Development Commission	Duluth, MN		X		X	
Civil Engineering Department, Auburn University	Auburn, AL			X	X	
College of Science and Engineering, UMN	Minneapolis, MN	X				
CSX Corporation	Jacksonville, FL		X	X	X	X
Esri Corporation	Redlands, CA		X			
Federal Highway Administration	Washington, DC		X			
Federal Highway Administration, Minnesota Division	St. Paul, MN		X			
Fergus Falls, City of	Fergus Falls, MN					X
Fond du Lac Band of Lake Superior Chippewa	Cloquet, MN				X	
Grand Rapids, City of	Grand Rapids, MI		X			X
Harvard Medical School	Cambridge, MA				X	
Headwaters Regional Development Commission	Bemidji, MN		X		X	
Hennepin County	Minneapolis, MN		X		X	
Humphrey School of Public Affairs, UMN	Minneapolis, MN	X	X			
Leech Lake Band of Ojibwe	Cass Lake, MN				X	
Mayo Clinic	Rochester, MN				X	X
Mechanical Engineering Department, SIUE	Edwardsville, IL			X		
Metro Transit	St. Paul, MN		X			
Michigan Department of Transportation	Lansing, MI	X	X			X
Mille Lacs Band of Ojibwe	Onamia, MN				X	
Minneapolis Department of Public Works	Minneapolis, MN		X		X	X
Minneapolis Park and Recreation Board	Minneapolis, MN		X		X	
Minnesota Department of Public Safety	St. Paul, MN		X			
Minnesota Department of Transportation	St. Paul, MN	X	X	X	X	X
Minnesota Senate	St. Paul, MN		X			

NewTrax, Inc.	White Bear Lake, MN					X
Ohio Department of Transportation	Columbus, OH				X	
Otter Tail County	Fergus Falls, MN		X			
Quality Bicycle Products	Bloomington, MN				X	
Red Lake Nation	Red Lake, MN				X	
Region 9 Development Commission	Mankato, MN		X		X	
St. Paul, City of	St. Paul, MN		X			
Sawtooth Mountain Clinic	Grand Marais, MN		X		X	
Schneider Enterprise Resources, LLC	Green Bay, WI		X			
School of Nursing, UMN	Minneapolis, MN				X	X
Southern Illinois University Edwardsville (SIUE)	Edwardsville, IL	X		X		
The Works Museum	Bloomington, MN	X		X		
University of Akron	Akron, OH	X	X	X		X
University of Illinois at Urbana-Champaign	Urbana, IL	X				
University of Minnesota Duluth	Duluth, MN	X				
University of Minnesota Extension	St. Paul, MN				X	
University of Minnesota, Morris	Morris, MN	X	X	X	X	
Verizon Wireless	New York, NY		X		X	
Vice President for Research, UMN	Minneapolis, MN	X				
Virginia Tech Transportation Institute	Blacksburg, VA				X	
Western Michigan University	Kalamazoo, MI	X				
White Bear Lake, City of	White Bear Lake, MN				X	X
White Earth Nation	White Earth, MN			X		
Wichita State University	Wichita, KS		X	X	X	X
WTS Minnesota/Transportation YOU	Minneapolis, MN				X	