University of Minnesota

ROADWAY SAFETY INSTITUTE

Human-centered solutions to advance roadway safety

Program Progress Performance Report for University Transportation Centers

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200 Oak Street SE; Suite 450
Minneapolis, MN 55455-2070

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Max Donath, Director
Roadway Safety Institute,
University of Minnesota
donath@umn.edu, 612-625-2304

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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

As our grant ends, we offer the following summary statistics representing the last six years:

- The Institute funded 35 projects and used 33 MnDOT-projects as match. On our website, you'll find project descriptions and links to final reports.
- We worked with 26 faculty and research staff. They not only conducted timely and relevant research into roadway safety, but also taught 221 instances of transportation-related courses to undergraduate and graduate students at five universities.
- Our researchers published 82 peer-reviewed journal articles and gave 228 presentations related to their RSI research.
- Our work was featured in over 170 media stories delivered via television, radio, newspaper, or web.
- The Institute and its researchers delivered 31 events aimed at a K-12 audience, reaching over 3,400 students. This number does not include the children who interact with our permanent museum exhibit at The Works Museum in Bloomington, Minnesota.
- The Institute and its researchers delivered 71 events aimed at a professional audience, reaching approximately 2,900 transportation professionals.

Research

Our consortium draws on our members' safety-related expertise and complementary research strengths to achieve measurable gains in safety.

Programmatic research accomplishments from this reporting period include:

- We published 18 final research reports for federally funded projects and one research report for match projects.

Notable highlights from active research projects:

- *Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers*: Stephen Burks completed his analysis of the differences in costs for medical insurance claims, comparing both control drivers with those diagnosed with obstructive sleep apnea (OSA) and those within the diagnosed group who have positive adherence with those who have no adherence to treatment. Burks also completed his fourth revision of the project's final paper, which is now under review. At the request of the publishing journal and its referees, Burks revised several features of the research team's statistical approach in a manner that strengthens the paper by improving the statistical model for one of two hypotheses addressed in the paper.
- *The Screening Effectiveness of the Commercial Driver's Medical Examination*: Stephen Burks submitted his project's final paper to an appropriate medical journal and is now working on a series of minor changes and elaborations for resubmission by October 1, 2019. The research team also completed exploratory work on operational and human resource data samples for drivers; medical diagnosis data on sleep apnea; and recent commercial driver medical examination forms.
- *Development of an Automated Vehicles Programming Class*: Brian Davis held a pilot workshop May 16-17, 2019, at the University of Minnesota, to teach participants about enabling technologies for connected and automated vehicles using both lecture material and interactive demonstrations. Participant feedback was positive, with most attendees noting that the material was interesting and applicable to their work and many saying they would recommend the workshop or a similar workshop to their co-workers. Davis' work was documented in the project's final published report.
- *Teen Driver Support System (TDSS) Technology Transfer*: Brian Davis completed a final report, documenting the history of the Road Coach smartphone app and the enhancements that were made as a part of this project to help prepare it for the Older Driver Support System, a technology transfer project.
- *Mapping and Tag Deployment System:* John Hourdos has submitted a final report, created additional test beacons, and updated and refined the Statewide Work Zone Information System software.

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 May 29, Frank Douma gave a presentation on the future of transportation to approximately forty-five 4th and 5th grade students at Clear Springs Elementary School. The presentation related to his recent RSI work on automated vehicles.
- In August, Brian Davis taught a session for 25 high school students in Discover STEM, a week-long summer camp offered by the U of M's College of Science and Engineering. Students in this camp learned about both automated vehicles and human factors; activities included calculating GPS distances and accuracy, watching a demo of a small automated vehicle, and taking a spin in the HumanFIRST Lab's driving simulator.

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:

- The spring issue of our Institute newsletter was distributed in May, with an open rate of 23 percent. We sent additional e-announcements to our subscribers in July and September that alerted them to recently published final research reports available on our website.
- We continued 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 12,000 impressions on Twitter and more than 1,000 video views and 21 new subscribers 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:

- Max Donath is beginning a new collaboration with Rutgers University's Center for Advanced Infrastructure and Transportation (CAIT), a Region 2 UTC, regarding the deployment of his snowplow driver assist system in New York. In December 2019, Donath will present to DOT staff in New York and New Jersey.

Diversity

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

- In June, Brian Davis introduced automated vehicles concepts to 25 ninth-grade girls in the Eureka! Program. This partnership between the U of M's College of Science and Engineering and YWCA Minneapolis helps girls explore STEM-related careers and prepare for next steps in their education. During the session, Davis conducted his GPS activity, which included using smartphones to find GPS coordinates on campus.

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/.
- The Institute's website is the primary vehicle for distributing information to stakeholders. In this period, the site received approximately 1,448 site visits and 2,869 unique page views. The most popular pages were the home, all research projects, and faculty pages.

Plans for next reporting period

Nothing to report, as the Roadway Safety Institute grant ends on September 30, 2019.

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., S. Kuppa, and D. Work. "Data driven calibration for optimal dispatching." Presentation at the 8th International Conference on Railway Operations Modelling and Analysis, Linköping, Sweden, June 18, 2019.
- Davis, G., and J. Gao. "Transferability of crash modification factors via graphical causal models: an introduction." Presentation at the Joint Statistical Meeting, Denver, CO, July 30, 2019.
- Donath, M. and N. Morris. "Lane Boundary Guidance System for Snowplow Operations." Presentation at the Minnesota County Engineers Association Meeting, Alexandria, MN, June 14, 2019.
- Douma, F. "The Future of the Commute (and more!)." Presentation to the Minnesota Spring Corporate Bike Forum, St. Paul, MN, May 22, 2019.
- Douma, F. "How Can Automation Improve Rural Accessibility and Mobility?" Presentation and panel discussion at the Automated Vehicles Symposium, Orlando, FL, July 15, 2019.
- Liao, C.-F. "Using a Bluetooth Based In-Vehicle Message System to Alert Motorists Approaching Work Zones." Presentation at the 2019 ITS America Annual Meeting, Washington, DC, June 4, 2019.
- Morris, N. "Older Drivers – A Panel Discussion to Address the Silver Tsunami." Invited panel speaker, South Central Toward Zero Deaths Workshop, Mankato, MN, April 18, 2019.
- Morris, N. "Older Drivers – A Panel Discussion to Address the Silver Tsunami." Invited panel speaker, Southwest Toward Zero Deaths Workshop, Granite Falls, MN, April 23, 2019.
- Morris, N. "Human Factors Technical Tour." Presentation and facility tour at the AASHTO/FHWA National Safety Engineer Peer Exchange, University of Minnesota, Minneapolis, MN, July 11, 2019.
- Quick, K.S. and G.E. Narváez. "Key reservation roadway safety issues in Minnesota: results of four collaborative studies with Minnesota tribes." Presentation to the Minnesota Advocacy Coalition for Tribal Transportation, Red Lake, MN, May 2019.
- Quick, K.S. and G.E. Narváez. "Collaborating to advance roadway safety in American Indian reservations." Poster presentation to Congressional staff, sponsored by the Council of University Transportation Centers, Washington, DC, May 14, 2019.

RSI researchers published the following papers during this reporting period:

- Carlson, K., A. Ermagun, B. Murphy, A. Owen, and D. Levinson. 2019. "Safety in Numbers for Bicyclists at Urban Intersections." *Transportation Research Record* 2673 (6): 677-684.
- Craig, M., N. Morris, R. Van Houten, and D. Mayou. 2019. "Pedestrian Safety and Driver Yielding Near Public Transit Stops." *Transportation Research Record* 2673 (1): 514-523.
- Davis, G. 2019. "Explaining crash modification factors: Why it's needed and how it might be done." *Accident Analysis & Prevention* 131: 225-233.
- Faizan, M., S. Hussain, and M. I. Hayee. 2019. "Design and Development of In-Vehicle Lane Departure Warning System using Standard Global Positioning System Receiver." *Transportation Research Record* 2673 (8): 648-656.

- Jeon, W., and R. Rajamani. 2019. "Active Sensing on a Bicycle for Simultaneous Search and Tracking of Multiple Rear Vehicles." *IEEE Transactions on Vehicular Technology* 68 (6): 5295–5308.
- Quick, K.S., A. Larsen, and G.E. Narvaez. 2019. "Tribal Transportation Specialists' Priorities for Reservation Roadway Safety: Results of a National Survey." *Transportation Research Record* 2673 (7): 652-661.

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

- Chen, R., M. Levin, C.-F. Liao, and T. Zhang. 2019. *Improving intersection safety through variable speed limits for connected vehicles.* Roadway Safety Institute report number 19-12.
- Dave, A., R. Saborio, K. Sun, R. Sainati, D. Gebre-Egziabher, and R.Franklin. 2019. *Characterizing Phase-Center Motion of GNSS Antennas Used in High-Accuracy Positioning.* Roadway Safety Institute report number 19-17.
- Davis, B. 2019. *Teen Driver Support System Technology Transfer.* Roadway Safety Institute report number 19-24.
- Davis, B., and R. Johnson. 2019. *Development of a Workshop on Automated Vehicle Technologies.* Roadway Safety Institute report number 19-23.
- Davis, B., N. Morris, J. Achtemeier, and P. Easterlund. 2019. *Improvement of Driving Simulator Eye Tracking Software.* Roadway Safety Institute report number 19-14.
- Davis, G., and J. Gao. *Vehicle Automation and Transportability of Crash Modification Factors.* Roadway Safety Institute report number 19-21.
- Douma, F., and E. Petersen. 2019. *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota*. Roadway Safety Institute report number 19-18.
- Duhn, M., G. Parikh, and J. Hourdos. 2019. *I-94 Connected Vehicles Testbed Operations and Maintenance.* Roadway Safety Institute report number 19-16.
- Hourdos, J., G. Parikh, P. Dirks, and D. Lehrke. 2019. *Implementation of a V2I Highway Safety System and Connected Vehicle Testbed.* Roadway Safety Institute report number 19-07.
- Hourdos, J., G. Parikh, P. Dirks, D. Lehrke, and P. Lukashin. 2019. *Evaluation of the Smart Work Zone Speed Notification System*. MnDOT report number 2019-21.
- Hussain, S., Z. Peng, and M.I. Hayee. 2019. *Development and Demonstration of Merge Assist System using Connected Vehicle Technology.* Roadway Safety Institute report number 19-06.
- Liao, C.-F. 2019. *Test and Evaluate a Bluetooth Based In-Vehicle Message System to Alert Motorists in Work Zones.* Roadway Safety Institute report number 19-09.
- Libby, D. L., N. L. Morris, and C. M. Craig. 2019. *Older Driver Support System Field Operational Test.* Roadway Safety Institute report number 19-13.
- Lindsey, G., T. Tao, J. Wang, and J. Cao. 2019. *Pedestrian and Bicycle Crash Risk and Equity: Implications for Street Improvement Projects.* Roadway Safety Institute report number 19-15.
- Luo, A., C. Guo, S. Xing, Y. Xu, S. Guo and C. Liu. 2019. Directional Rumble Strips for Reducing Wrong-Way-Driving Freeway Entries. Roadway Safety Institute report number 19-25.
- Morris, N. L., C. M. Craig, J. Achtemeier, and P. Easterlund. 2019. *HumanFIRST Driving Simulation Educational Development.* Roadway Safety Institute report number 19-11.
- Quick, K., S. Dufour, and G. Narváez. 2019. *Emergency Medical Services in American Indian Reservations and Communities: Results of a National Survey.* Roadway Safety Institute report number 19-10.

- Work, D., W. Barbour, and R.Wang. 2019. *Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support.* Roadway Safety Institute report number 19-03.
- Zhou, H., and C. Xue. 2019. *Field Implementation of Direction Rumble Strips for Deterring Wrong-Way Entries.* Roadway Safety Institute report number 19-21.

Websites or other Internet sites

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

In addition:

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

Technologies or techniques

Nothing to report.

Inventions, patent applications, and/or licenses

John Hourdos is working on a provisional patent application for the Work Zone Mapping and Tag Deployment System.

Other products

Nothing to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

Organizations that have been involved as partners

The Roadway Safety Institute is actively in partnership with 55 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 13 and 14.

Other collaborators or contacts

State agencies in Louisiana and Colorado reached out to Nichole Morris about using the materials she developed in the project "Computerized Crash Reports Usability and Design Investigation."

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 Railroad Grade Crossing Safety: Accident Prediction Models using Macro- and Micro-Scale Analysis:* Rahim Benekohal reports that this project will have an impact on traffic engineering. Transportation agencies such as DOTs or MPOs may use the accident prediction model developed in this project, along with the USDOT model, to study railroad crossing safety.
- *Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers:* Stephen Burks expects this project to have an impact on public policy, specifically through the Federal Motor Carrier Safety Administration. In the long run, the results may increase the likelihood that new federal regulations will require that commercial vehicle operators be screened for obstructive sleep disorder, as well as lessen motor carrier objections to required screening.
- *The Screening Effectiveness of the Commercial Driver's Medical Examination:* Burks reports that the work will have an impact on human factors and traffic engineering. It has the potential to influence revision of federal regulations requiring the screening of commercial vehicle operators using the Commercial Driver's Medical Examination.

- *I-94 Connected Vehicles Testbed Operations and Maintenance:* John Hourdos reports that this project had an impact on traffic engineering, since real-time trajectory information captured along the I-94 corridor was used for another RSI research project led by Michael Levin.
- *Pedestrian and Bicycle Safety, Equity, and Street Funding: New Criteria for Prioritizing Multimodal Street Projects in Minneapolis:* Greg Lindsey expects findings from this project to have an impact on transportation safety, planning, and management. The new models he developed show that measures of crash risk are higher in poor neighborhoods with larger populations of minorities and illustrate how these measures can be used to prioritize street improvement projects.
- *Older Driver Support System (ODSS):* Nichole Morris reports that this project will have an impact on human factors by promoting knowledge about the usefulness of in-vehicle, real-time coaching for older drivers.
- *Safety in Numbers? Accessibility, Traffic, and Safety of Nonmotorized Travelers:* Andrew Owen reports that the study had an impact on accessibility analysis. Results informed the development of bike accessibility metrics, which are now implemented nationwide.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota:* Douma's work led to an impact on public affairs and planning; he created a guide that describes the necessary elements for an automated vehicle demonstration in small towns and rural communities.

Impact on other disciplines

- *Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers:* Burks reports that the study may have an impact on managerial economics and the decisions of motor carriers. It has the potential to affect the likelihood that more motor carriers will unilaterally institute obstructive sleep apnea screening of their drivers.

Impact on physical, institutional, and information resources

- *Improvement of Driving Simulator Eye Tracking Softwar*e: Brian Davis reports that this project improved the eye tracking tools used with the HumanFIRST Lab's driving simulator. These tools will reduce the time required for eye tracking analysis by automating more of the process.
- *HumanFIRST Driving Simulation Educational Development:* Nichole Morris expects the results will improve demonstrations and the flow of tours and educational opportunities.
- *Safety in Numbers? Accessibility, Traffic, and Safety of Nonmotorized Travelers:* Owen reports that the project made the national bike accessibility dataset available through the University of Minnesota's data repository.

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.

New impacts from this reporting period include:

- Greg Lindsey reports that two of his doctoral students learned new modeling techniques, served as co-authors of a technical report, and are co-authors of a manuscript now in review with TRB. Their

work also led to an internship for one of the students; he worked with MnDOT to model pedestrian and bicycle crashes on their Trunk Highways.
- Daniel Work, who moved from the University of Illinois to Vanderbilt University during the course of this grant, is introducing railroad engineering topics in the introductory transportation systems course in his new department.

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:

- *Development of an Automated Vehicles Programming Class:* The workshop offered as part of this project was a means to transfer information and bridge the gap between connected and automated vehicle research at the University of Minnesota and transportation professionals and practitioners interacting with this technology in practice.
- *Pedestrian and Bicycle Safety, Equity, and Street Funding: New Criteria for Prioritizing Multimodal Street Projects in Minneapolis:* The Minnesota Department of Transportation hired the doctoral student who worked on this project to conduct crash modeling and safety performance functions on trunk highways in the Twin Cities metro area because of the experience he gained on this project.
- *Older Driver Support System (ODSS)[Year 3 Project]:* Morris was contacted by U.S. Sen. Bob Casey (D-Pa) about this study and results because he wanted to integrate that information into the Senate's Special Committee on Aging.
- *Improving Railroad Grade Crossing Safety: Accurate Prediction of Train Arrival Times for Emergency Response Management and Driver Decision Support:* The close collaboration with CSX Transportation that was initiated on this project is now serving as a foundation for several future research activities.
- *Evaluation of the Effect MnPass Lane Design Has on Mobility and Safety.* The Minnesota Department of Transportation's Regional Traffic Management Center has implemented the results of this research to develop a reporting system to the FHWA and to generate analyses and recommendations for changing locations from open to closed access.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota:* Thanks to Douma's work, the City of White Bear Lake (Minn.) will develop a proposal for an automated vehicle demonstration in the city.

Impact on society beyond science and technology

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

Impacts from individual projects:

- *Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers:* Burks expects this work to influence managerial decisions of other motor carriers regarding

obstructed sleep apnea (OSA) among their drivers, as well as the public policy debate around the regulations for screening for OSA in the commercial driver's medical exam.

- *The Screening Effectiveness of the Commercial Driver's Medical Examination:* Burks anticipates that the study may increase the likelihood that federal regulations requiring the screening of commercial vehicle operators using the Commercial Driver's Medical Exam (CDME) will be revised. He anticipates that evidence showing the limited screening effectiveness of the pre-Registry CDME will increase interest in the relevant communities in funding an evaluation of the CDME post-Registry.
- *Older Driver Support System (ODSS) Usability and Design Investigation:* Nichole Morris reports that this project promotes universal design for supporting older drivers.
- *Older Driver Support System (ODSS) [Year 3 Project]:* Morris reports that the study results may improve public attitudes about older drivers' inclusion in technological advances for driving.
- *Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota:* Douma reports that his work has led to an increased understanding of the number of different entities that can be involved in supporting an automated vehicle demonstration plan.

CHANGES/PROBLEMS

Changes in approach and reasons for change

Exploring Links between Medical Conditions and Safety Performance in Tractor Trailer Drivers: Stephen Burks strengthened the project's results by improving the statistical model used for one of the two hypotheses being tested in this project.

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

The Screening Effectiveness of the Commercial Driver's Medical Examination: As of late summer, Stephen Burks was still in the process of submitting his fourth round of revisions on the project's final paper per the publishing journal's request. This journal article will serve as the project's final report; a link to the report will be added to the project's webpage and UTC Project Information Form as soon as it is available.

Work Zone Mapping and Tag Deployment System: Deploying equipment, testing existing field laboratory equipment, and creating Sanity Check algorithms all took longer than the Hourdos team expected. That said, Hourdos was still able to finish the project and submit his draft final report for peer review before the end of the grant. Institute staff are committed to completing the review and publishing the final report, even if the process extends beyond the end of our grant.

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 Bear Lake Schools	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	