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Designing in-vehicle systems for teens and older drivers

The risk of dying or being seriously injured in a car crash varies with age; teens and older drivers are the two highest-risk populations on the road.

"Distracted driving is what we always hear about, but that is only one of the many risk factors," says Nichole Morris, director of the HumanFIRST Laboratory at the University of Minnesota. Other factors include seat belt use, alcohol, speeding, and teen passengers. "We also know that many of these feed into one another, so there is no silver-bullet solution," she says.

To help address teen driving dangers, HumanFIRST researchers developed a smartphone technology that improves safety by monitoring



risky behaviors such as speeding, stop sign violations, aggressive driving maneuvers, and seat belt use and notifying a parent about them. The technology was evaluated in a study with 300 newly licensed drivers and found to be highly successful in improving teens' driving.

Older drivers represent the second-highest injury and fatality rate, after younger drivers, and are first in fatalities per 100 million miles driven.

"With the success of [teen driver] technology, we wanted to see how we could capitalize on it with other groups, and older drivers were the natural next fit," Morris says. "We have a lot of older drivers on the roadway and the number will continue to grow as the Baby Boomer generation ages. So we wanted to know how we can adapt this system to meet the needs and limitations of an aging driver."

In RSI-funded research, the team began by conducting focus groups with technology-savvy drivers, age 65 and older, who seemed resistant to the idea of an "older driver support system." Instead, they advocated for a system that would be useful to all drivers. On the other hand, non-technology-savvy older drivers were far more accepting of such a system. "I believe that this group's participants were more open to the use of an older driver support system because they were starting to see the limit of their independence and were eager for a tool that could help them retain it," Morris says.

Next, researchers spoke in-depth with older drivers and experts in gerontology and occupational therapy to determine what types of modifications to the teen driver support system would be needed

for older drivers; these changes included more contextual information, current and upcoming speed information, and under-speed feedback. Once these changes were made, researchers conducted a driving simulation study and recorded user feedback—with surprising results.

“Older drivers really liked the system, but felt most of the additions we made to support older drivers were overkill,” Morris says. “At the end of the day, there was very little that needed to change between the teen and older driver versions, and we found that older drivers can best be supported with a universally designed system that addresses the needs and risks of all drivers, not a version specifically targeted for older drivers.”

Morris cites this study as a perfect example of the scientific process at work. “If you follow the science correctly, it doesn’t always give you what you start out looking for. Our result was not the tailored product I thought we were going to end up with, but rather a universally applied design.”

Researchers tested this universally designed driving application, called “RoadCoach,” in a controlled field test and found it had a high rate of acceptance among older drivers. Up next: A field operational test this spring of 30 older drivers to determine if risky behaviors can be reduced over a longer time period and if acceptance of the system remains high after prolonged use.

Truckers who disregard sleep apnea treatment show greater crash risk

In a study with implications for both trucking companies and policymakers, Roadway Safety Institute researchers have found that non-adherence with employer-mandated sleep apnea treatment increases the risk of serious truck crashes.



Photo: Shutterstock

“It’s well established that left untreated, obstructive sleep apnea is associated with higher crash risk in the general driving population, but relevant data about commercial drivers has been scarce,” says Stephen Burks, a professor of economics and management at the University of Minnesota Morris. “Our study examined the first-ever employer-mandated program for diagnosing and treating this dangerous disease among drivers and found a large and statistically significant association between non-adherence with treatment and preventable tractor-trailer crashes.”

Obstructive sleep apnea (OSA) is a disease in which the patient’s airway closes repeatedly during sleep, causing the brain to partially awaken to resume breathing; this prevents restful sleep, which in turn affects a person’s ability to maintain the type of alert attention required for driving. To help prevent crashes associated with OSA, major motor carrier Schneider became the first trucking company to institute a mandatory program to screen, diagnose, and treat this disease among its drivers in 2006; drivers diagnosed with sleep apnea are provided with an auto-adjusting positive airway pressure (APAP) treatment, at no out-of-pocket cost for those enrolled in the firm’s employee medical insurance program. Treatment adherence is required for continued employment.

Using the data collected through this employer-mandated program, Burks and his research team set out to identify exactly how risky truckers with untreated OSA are on the road. By comparing the relative crash rates for drivers who followed their OSA treatment plan with drivers who did not, researchers found that the non-adherent drivers had a risk about five times higher than the control group. Even after checking for other factors such as demographic characteristics and job type, they found that the non-adherent group had a significantly higher crash risk than the control group.

“In short, we found that if we followed 1,000 drivers of each type driving for one year, the control and treatment-adherent groups would both have 14 preventable, reportable crashes while the non-adherent group would have 70 such crashes,” Burks says.

An employer-mandated OSA program that includes required treatment adherence could improve safety because it effectively sorts the workforce—it retains those drivers who are adherent and safer while filtering out those who are not adherent and much riskier, thereby improving the preventable crash performance of the entire fleet, Burks says.

However, the research results also carry significant public policy implications. Under current regulations, drivers with OSA who are non-adherent can be hired by a firm that does not have an OSA program by keeping their diagnosis private.

“Every commercial driver has a screening exam at least every two years to determine their medical fitness to drive, but there is no test given to diagnose sleep apnea—that requires a measurement that takes at least overnight,”

Burks says. Currently, medical examiners are not required to ask for the extra information to screen for possible sleep apnea in order to decide who should get such a test, and truck drivers know not to say anything about conditions that might jeopardize their driving careers. “As a result, drivers that have been diagnosed with OSA and who are not adherent with treatment can go to work for another company and be back out on the highway with you,” Burks says.

The USDOT began an exploratory rulemaking on OSA screening for truck drivers in 2016, but it was withdrawn by the new administration in 2017, Burks notes. “Our study suggests that mandating screening in the commercial vehicle drivers’ biennial medical exam is worth revisiting.”



Photo: Shutterstock

System to provide data on risky work-zone incidents

Work-zone intrusions—in which vehicles breach the boundaries of roadway construction or maintenance operations—are a serious safety concern. From 2005 to 2010, 733 road workers were killed in work zones in the United States, with about half struck by motorists, according to the Federal Highway Administration. Motorists themselves are also injured or killed by intrusion crashes.

To address this safety risk, it’s critical to understand what contributes to work-zone intrusions. Yet little is known because the methods and standards for capturing data around these events are not well established.

To fill this gap, researchers with the University of Minnesota’s HumanFIRST Laboratory created a system for road crew workers to report work-zone intrusions. The data collected could then be used to examine risk factors, provide feedback to workers and the Minnesota Department of Transportation (MnDOT), and provide an empirical basis for future policy recommendations to the state.

Research associate Curtis Craig says that in aiming to make the system comprehensive yet efficient

and user friendly, the researchers needed to first learn about the work zone crews—what they knew, the context of their work, and how they carried it out. “And we wanted to make sure we were testing [the system] in ways that reflect how they would use it in the real world,” Craig says.

The researchers interviewed workers across Minnesota in both urban and rural settings. They found that workers understood an intrusion as a vehicle entering the area cordoned off by cones, but they felt it was practical to report an intrusion only when there was an actual increased risk to the



Photo: David Gonzalez, MnDOT

workers onsite. “Whenever there were high risks, they were more likely to want to report it,” Craig says.

During testing of the initial design, researchers asked potential users to input either a researcher-generated intrusion scenario or an actual one from their experience—“and they all had experiences that they were scared by or that were very memorable to them,” Craig says.

Workers and supervisors were asked to “think aloud” as they interacted with the interface and were timed as they completed the reports. “We wanted to make sure it wasn’t taking too much time out of their day. And we wanted to get a feeling for how usable the interface was,” Craig says.

The second phase of testing showed that workers struggled with whether they would use the report to record minor intrusions that they personally didn’t feel at risk for, Craig says. “Like a car coming in to

Work Zone Intrusion Report Form

Basic Intrusion Report | Vehicle Information | Vehicle Event | Work Zone Information | Environmental Condition | Administrative Information

Layout Type (ex. 6K-65 Exit Loop Closure) *

Layout Location

Modification to Layout

If Yes, Please Describe

Work Zone Type *

- Mobile
- Moving
- Shoulder Moving
- Temporary Lane Closure
- Permanent WZ Closure
- Ramp/Lane Closure
- Road Closure
- Other

Traffic Control Present (select ALL applicable)

- Arrow Board
- Flagger
- Automated Flagger
- Railway Crossing Device
- Stop Sign
- Traffic Control Signal
- Work Zone Warning Sign
- Yield Sign
- Channelizers
- Other

* Required for report

and out of the work zone and knocking over a few cones. They could just go put the cones back up and get on with their workday. So that was an ongoing tension between what we wanted, which was to get as much data as possible, and what they felt they needed to provide," he says.

As a result, the researchers revised the earlier reporting logic by splitting it into an immediate "minor" report and a more comprehensive "major" report for higher-risk incidents. Users also

tested different modes of the interface with a laptop, a tablet, and a paper form.

Work crew supervisors noted that the final version of the system should provide a clear explanation and rationale, which would help them motivate their crews to reliably report intrusions, Craig says. The success of the reporting system will depend not only on workers using it, he adds, but on a sustained dialogue between the users and the administrators of the system, adding that this engagement will help users feel "they're in the process of improving safety culture."

According to Craig, MnDOT staff are currently reviewing ways in which the intrusion reporting system could be integrated into the agency's operations.

Researchers funded for new roadway safety projects

Ten new projects aimed at advancing roadway safety have received funding from the Roadway Safety Institute (RSI) for the next 12 months. Topics range from developing a course in automated vehicle technologies to improving EMS response on American Indian reservations.

In a request for proposals issued in October 2017, the Institute solicited projects that would move current RSI research toward implementation or position its researchers and the Institute for future funding. The Institute also considered funding for educational initiatives such as the development of curriculum, training materials, or instructional labs.

Projects were required to fall under the Institute's research focus areas of rail-crossing safety, safety on tribal lands, bicycle and pedestrian safety, connected vehicles, or safety policy.

An external review panel of five experts from across the country reviewed and provided input, considering the proposed projects' uniqueness, innovativeness of approach, potential for deployment within five years, potential for partnerships with government agencies or industry, and likely impact in terms of lives saved or contributions to knowledge, among other criteria.

The selected projects, along with their principal investigators and affiliated universities, are:

- The Screening Effectiveness of the Commercial Driver Medical Examination: Stephen Burks, University of Minnesota Morris
- Development of a Course on Automated Vehicle Technologies: Brian Davis, University of Minnesota Twin Cities (UMN)
- Vehicle Automation and Transportability of Crash Modification Factors: Gary Davis, UMN
- Developing GPS Antenna Error Models for Improved Centimeter Level Positioning, Rhonda Franklin, UMN
- Improving Intersection Safety Through Variable Speed Limits for Connected Vehicles: Michael Levin, UMN
- Test and Evaluate a Bluetooth Based In-Vehicle Message System to Alert Motorists in Work Zones: Chen-Fu Liao, UMN
- Pedestrian and Bicycle Safety, Equity, and Street Funding: New Criteria for Prioritizing Multimodal Street Projects in Minneapolis: Greg Lindsey, UMN



- Field Implementation of Direction Rumble Strips for Deterring Wrong-Way Entries: Albert Luo, Southern Illinois University Edwardsville
- HumanFIRST Driving Simulation Educational Development: Nichole Morris, UMN
- Improving Emergency Medical Service Response to Motor Vehicle Crashes in American Indian Reservations: Kathy Quick, UMN

Institute awards Student of the Year, other awards



Frank Douma and Frank Alarcon

Each year, the Roadway Safety Institute selects one graduate student for its Outstanding Student of the Year Award, sponsored by the U.S. Department of Transportation (USDOT). This year's recipient is Frank Alarcon of the University of Minnesota's Humphrey School of Public Affairs. He is advised by Frank Douma, director of the Humphrey School's State and Local Policy Program (SLPP).

Alarcon is a research assistant with the SLPP, where he has researched automated speed enforcement and speed regulation. He is also a planning intern for Ramsey County, MN, and serves as president of the board of a community nonprofit in Minneapolis.

Alarcon's thesis, "Toward Greater Understanding of the Relationship Between Public Perceptions of Speed, Speed Laws, and Safety," examined state speed laws, crash data, and public perception of speed data from USDOT Region 5 to explore how these variables may relate to one another. The research concluded that better data and data reporting practices are needed for definitive conclusions to be made, but also identified a strong possibility that state speed laws that are not well understood or widely obeyed by the public may be related to higher

crashes, injury, and fatality rates on roads.

Alarcon 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 (TRB) Annual Meeting in Washington, DC, in January.

In addition to Alarcon's award, 10 graduate students received travel awards from the Institute to attend the TRB Annual Meeting, where they presented research and networked with other attendees. Seven of these students were from the University of Minnesota Twin Cities, one was from the University of Illinois at Urbana-Champaign, and two were from Auburn University (a partner of Southern Illinois University Edwardsville).

RSI researchers highlight work at TRB

Roadway Safety Institute researchers shared their work at nine sessions at this year's Transportation Research Board Annual Meeting in Washington, DC, January 7–11, 2018. This year's presenters and topics were:

- Md Atiqzaman and Huaguo Zhou: Modeling the Risk of Wrong-Way Driving Entry at the Exit Ramp Terminals of Full Diamond Interchanges
- Raghunandan Baireddy, Huaguo Zhou, and Mohammad Jalayer: Identification of Factors Contributing to Pedestrian Crashes in Rural Illinois Using Multiple Correspondence Analysis
- Rongsheng Chen and John Hourdos: Evaluation of Roundabout Capacity Model in HCM 6th Edition and HCM 2010 on a Multilane Roundabout
- Gary Davis, Jingru Gao, and John Hourdos: Safety Impacts of Priced Dynamic Shoulder Lanes on I-35W, and Nonlinear Effect of Traffic Congestion
- Mahdi Pour-Rouholamin and Huaguo Zhou: Single-Vehicle Crashes on Rural Two-Lane Highways and Injury Severity—Does the Age Matter?
- Matt Schmitt and Lee Munnich: Factors Influencing Policy and Political Leadership in Improving Roadway Safety
- Disi Tian and Nichole Morris: Comparing Novice Teenage Drivers to Experienced Middle Aged Drivers: Trust, Mental Workload, and Driving Behavior Towards a Rural Intersection Collision Warning System



Photo: Shutterstock

- Ron Van Houten: An Examination of the Effects of the Gateway R1-6 Treatment on Driver's Yielding Right-of-Way to Pedestrians, Speed at Crosswalk, and Sign Durability Over Time
- Jin Wang and Huaguo Zhou: Using Naturalistic Driving Study Data to Evaluate the Effects of Intersection Balance on Driver Behavior at Partial Cloverleaf Interchange Terminals



Stephanie Malinoff, Max Donath, King Gee, Chelsea Arbury, Laurie McGinnis, Jean Wallace, and Clayton Chen at MnROAD

Advisory board rides autonomous shuttle

On December 14, 2017, members of the Roadway Safety Institute (RSI) Advisory Board, along with staff from the Minnesota Department of Transportation (MnDOT), the Center for Transportation Studies (CTS), and the Institute, took a tour of the EasyMile autonomous shuttle at MnDOT's closed-loop testing facility near Monticello, MN.

The group included King Gee of the American Association of State Highway and Transportation Officials, Clayton Chen of the Federal Highway Administration, Jean Wallace of MnDOT, RSI director Max Donath, and Laurie McGinnis, Stephanie Malinoff, and Chelsea Arbury of CTS.

Cory Johnson of MnDOT gave attendees an overview of the project, then riders climbed aboard the bus as it made two passes of the tour route. The shuttle demonstrated its ability to slowly stop

when someone walks in front of the vehicle and when an individual approaches the side of the vehicle while it's in motion. The shuttle runs on a pre-programmed GPS route, with stop signs programmed into the route. When reaching the end of the route, the shuttle runs in the other direction, similar to a train car, without having to turn around.

Autonomous vehicle (AV) technology is rapidly developing around the world, and Minnesota offers unique climate challenges that differ significantly from others currently testing these technologies. Deploying an AV pilot project in Minnesota will better position the state to influence national policy and prepare Minnesota transportation owners and stakeholders for the future.

MnDOT is working with project partners 3M, vehicle manufacturer EasyMile, and First Transit to operate and test the vehicle at MnDOT's MnROAD test facility and other locations around the state. At MnROAD, the vehicle will undergo a series of winter weather conditions such as snow, ice, cold weather, and salt-covered road conditions typical during a Midwest winter.

Institute work recognized in ITS MN achievement award



The Center for Transportation Studies (CTS), which houses the Roadway Safety Institute, received the 2017 Local Agency Technology Initiative Award from ITS Minnesota at the organization's Fall Forum on October 17. RSI director Max Donath accepted the award.

The annual award recognizes achievements in advancing ITS technology in Minnesota. According to ITS Minnesota, the 2017 award was given for outstanding contributions to the ITS community through the research and development of new strategies to improve the safety and efficiency of travel throughout the state. The award specifically highlighted three projects:

- The development of a queue warning system on I-94 and I-35W
- Policy studies related to self-driving vehicles
- The development of a smartphone application for warning drivers about upcoming work zones

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