

Catalyst



Accelerating the pace of transportation innovation

June 2018

POTHOLE PREVENTION

page 2

EQUITY & SELF-DRIVING VEHICLES

page 3

CYCLISTS & PASSING DISTANCE

page 4

CTS SEED-FUNDED PROJECTS

page 5

NSF EARLY CAREER AWARD

page 5

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Freeway laboratory aids development of connected vehicles, improves traffic safety

Using cutting-edge technology and the close-to-campus location of a Twin Cities crash hot spot, University of Minnesota researchers have successfully transformed a high-crash stretch of interstate into a testbed for the connected vehicles that could help eliminate these crashes in the future.

“We now have high-resolution radar sensors covering two-thirds of a mile on I-94, giving us nearly continuous coverage of the trajectories of 85,000 vehicles a day, along with cameras

Freeway continued on page 6

Autonomous bus demo showcases innovative transportation technology

On Monday, April 30, an innovative demonstration of a self-driving EZ10 All Electric Autonomous Bus offered free rides to students, staff, faculty, and the public across the Washington Avenue Bridge on the University of Minnesota campus.

More than 450 people took a three-minute ride across the bridge during the demo, which was organized by the U of M’s Parking & Transportation Services, CTS, the Humphrey School’s State and Local Policy Program, the University Office of Sustainability, and First Transit, Inc.

AV continued on page 7



Taking on potholes with new prevention and repair strategies

Potholes are one of the biggest and most costly ongoing maintenance challenges faced by many highway agencies. Despite considerable progress in pavement materials and mechanics, pothole repair has remained an area in which little progress has been made.

To make headway in this area, U of M researchers studied critical factors in pothole formation and repair in order to identify solutions that would reduce the occurrence of potholes and increase the durability of repairs. They also investigated the potential of newer materials, such as taconite and graphite nanoplatelets (GNP), in repair mixes.

activities. They also surveyed MnDOT maintenance superintendents and local engineers on current repair practices.

Next, the research team conducted simulations of square, diamond, and round pothole repair shapes to determine if some shapes were more conducive to reducing stress in repair materials. This stress analysis included the use of different common pothole filling mixes and their interface with existing pavement materials.

In the next stage of research, the team evaluated six asphalt mixes for relevant mechanical properties: four winter mixes, a polymer-modified hot-mastic asphalt

repairs only slow pothole development.

Durable winter repairs require expensive patching materials and on-site heating technologies such as truck-mounted microwaves. “To make winter repairs last longer, you need to provide an external source of heat to cure winter patching materials,” Marasteanu says.

Taconite-based materials activated chemically or by heating potholes before and after filling offer promise for more durable repairs. GNP modifiers improved compaction, tensile strength, fracture energy, and fracture resistance in the summer mix.

Pothole repair samples performed poorly in water penetration tests, which suggests that most mixes will perform poorly under seasonal freeze-thaw stresses.

Also of note, the study’s exploration of pothole repair shapes found that circular repairs offer the best filling and compacting performance; repair materials cannot fill corners, even with significant compaction.

“We had been squaring off potholes, making sure patches were all at right angles,” says Todd Howard, Dakota County’s assistant county engineer. “In this study, we found that square patches actually increase stresses at the boundaries. The ideal is a circular patch.”

As a whole, Marasteanu concluded, “the only prevention for potholes is a solid pavement structure and timely preservation activities.”

This research is part of a larger effort by MnDOT to improve pothole repair approaches and develop pothole repair guidance for crews throughout the state.



Mihai Marasteanu, a professor in the Department of Civil, Environmental, and Geo-Engineering, was the principal investigator. “Our goal was to provide a scientific assessment of pothole repair materials and practices,” he says. Project sponsors were the Minnesota Department of Transportation (MnDOT) and the Minnesota Local Road Research Board.

Researchers began by reviewing national and international literature about pothole causes and repair

mix suitable for winter and summer use, and a summer mix in two forms modified with GNP. Mixes were evaluated for compaction and bonding, tensile strength, and water penetration.

Finally, researchers studied national and international pavement preservation and pothole prevention practices and the cost-effectiveness of pothole repair.

Through this work, researchers learned that pothole prevention requires repairing pavement cracks as they develop—and sometimes, even timely

Researchers explore equity issues of self-driving vehicles

Momentum for self-driving vehicles (SDVs) is on the upswing this year in Minnesota, including a demonstration on the U of M Twin Cities campus (see article on page 1) and the formation of a governor's advisory council. Researchers in the U's Transportation Policy and Economic Competitiveness (TPEC) Program have also been active, focusing on the important issue of equity in the development and implementation of SDVs.

"We've taken the message of our SDV Task Force on the road during the past year," says Adeel Lari, research fellow at the Humphrey School of Public Affairs and a TPEC researcher. "We're hearing valuable feedback from colleagues, local politicians, and communities throughout Greater Minnesota."

The task force was formed in the spring of 2017. Its intent was to identify how various SDV deployment strategies could improve mobility and access for transportation-dependent Minnesotans: seniors, people with disabilities, and others who are not able to drive themselves.

Among the conclusions of the task force is that deployment models would likely vary across the state. "For example, we found that simple policy incentives could lead the private market to provide a variety of innovative services in urban areas," says Frank Douma, director of the State and Local Policy Program at the Humphrey School and a TPEC researcher. "However, government intervention would likely be needed to ensure significant enhancements to transportation in small towns and rural areas."

As follow-up to the task force, TPEC initiated a number of public engagement sessions. In Grand Rapids, Minnesota, the researchers held two meetings with representatives from foundations and public agencies, people with disabilities, and others. "We found the participants to be very interested in the subject," Lari says. "They wanted to know how self-driving vehicles can be used to improve transit. They also wanted to know what the implementation of driverless vehicle



Researchers are studying deployment strategies for those not able to drive.

technology could or would look like in the community."

One of the participants was former teacher Myrna Peterson, co-director of Mobility Mania, a Grand Rapids nonprofit. Peterson, who has used a wheelchair since she was seriously injured in a 1995 car crash, is an advocate for more accessible transportation in her community. She also served on the SDV Task Force.

"We have very limited affordable, accessible transportation after 8 p.m. on weekdays and all weekend hours in rural areas," Peterson said. "That limits social and work opportunities for those with physical, mental, and financial needs. I see self-driving vehicles as a positive step to assist that population especially. The key stakeholders in Grand Rapids are all supportive and excited about the potential of being a pilot site."

This year, TPEC researchers engaged

the Region 9 Board of Directors and other local groups in Mankato and met with Saint Cloud's area planning organization. An additional presentation is planned for July in Fergus Falls to the West Central Initiative (a foundation and regional development organization).

Douma and Lari will use the findings of these sessions to help better articulate the best methods for deploying these technologies in different parts of the state.

TPEC will continue this work later this year by starting a similar initiative in transportation-disadvantaged urban areas, Lari adds.

TPEC is a program of the Humphrey School and CTS. Learn more about TPEC's work at tpec.umn.edu.

Video showcases TPEC accomplishments



The work of the Self-Driving Vehicle Task Force is one of the accomplishments featured in a new video from the Transportation Policy and Economic Competitiveness (TPEC) Program. The video also touches on TPEC's work in two other research areas: freight and industry clusters, and finance and funding. Watch the video at tpec.umn.edu.

What affects passing distance between vehicles and cyclists?



Transportation infrastructure that encourages bicycling without interfering with traffic flow or exceeding budgets is a key issue for many state and local governments. Ensuring the safety of bicyclists is a central part of this challenge.

One factor that may influence a cyclist's sense of safety is the distance maintained by passing vehicles. As part of a recent capstone project, a team of graduate students at the Humphrey School of Public Affairs partnered with Hennepin County to investigate the factors that affect vehicle passing distance (VPD) on different bicycle facilities across the county's network. The researchers also examined vehicular encroachment—when a vehicle fails to meet the minimum three-foot VPD required by Minnesota statute.

The team used Hennepin County's C3FT bike-mounted radar and a GoPro video camera to capture VPD during nearly 3,000 passing events. Roads used as part of the study included the following categories of bicycle facilities: buffered bike lane (painted), protected (bollard) bike lane, no facility, shoulder, standard bike lane, and bike boulevard.

One male and one female researcher executed test rides during the evening rush hour, when vehicle traffic was

typically highest. Researchers then reviewed the video footage and documented the VPD, whether or not there was a car in the adjacent lane, and the vehicle type.

Key findings include:

- The overall encroachment rate was low. Of the total 33 encroachments measured, 64 percent occurred on the road with no bicycle facility, giving it the highest encroachment rate of about 5.7 percent. All other roads had encroachment rates of less than or near 1 percent.
- VPD was greatest on the bollard bike lane and lowest on the roads with no facility and the standard bike lane. Protected or buffered bicycle facilities are best at reducing VPD and the rate of encroachment, but bike lanes and wide shoulders also reduce the likelihood of encroachment.
- In general, as vehicle size increases, average VPD decreases. Buses and large trucks had the highest likelihood of encroachment.
- VPD was smaller for the female rider, and she experienced 73 percent of all encroachments.
- Excluding facility type, the presence of an adjacent vehicle played the largest role in reducing VPD.

According to the research team, these findings confirm that road design and traffic planning decisions affect how vehicles and cyclists interact. The team also suggests that additional research is needed to understand how VPD and encroachment are related to a feeling of safety for cyclists.

The research was conducted by graduate students Josh Pansch, Isaac Evans, and Lila Singer-Berk and advised by Professor Greg Lindsey. Study results were published in the May 2018 *ITE Journal*.

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for links to research reports and other resources.

CTS-funded projects will explore autonomous vehicles, equity, and more

CTS has awarded seed funding to five new transportation-related projects that will explore a variety of topics, including autonomous vehicles (AVs), equity, and shared mobility.

The seed funding, awarded biennially, aims to help CTS Scholars develop expertise in emerging areas and foster strategic relationships that position them for future funding opportunities.

One project, led by Professor Jason Cao and Senior Fellow Frank Douma at the Humphrey School of Public Affairs, will examine the challenges and opportunities of autonomous vehicles (AVs) related to urban planning. The researchers will explore such issues as the effects of AVs on transit supply and demand in urban neighborhoods, potential equity concerns, and the influence of AVs on the demand for on- and off-street parking.

Professor Thomas Fisher with the Minnesota Design Center and Humphrey School assistant professor Fernando Burga will investigate the implications of potential changes in transportation, mobility, and the nature of work caused by AVs, changing consumer patterns, and the rise of virtual retail. The project will focus on the impact of AVs on job access and explore the tensions that may arise as new technologies are introduced in neighborhoods with historically disadvantaged residents.

A project led by civil, environmental,



and geo- engineering (CEGE) assistant professor Alireza Khani and industrial and systems engineering professor Saif Benjafaar will provide insights on how collaborative consumption and mobility-as-a-service can help improve transportation systems. The project will study the impacts of new mobility solutions such as transportation network companies on travel behavior and the cost-effectiveness of transit systems.

CEGE assistant professor Michael Levin and mechanical engineering professor Rajesh Rajamani will conduct a project that links AV technology development with traffic planning research to potentially improve both safety and traffic flow. Their work will develop a spacing policy for adaptive

cruise control that can be used for shared-road platooning and create planning models to study the effects of platooning on citywide congestion.

In previous research, CEGE professor Mihai Marasteanu found that small additions of a new material, graphene nanoplatelets (GNP), can reduce the compaction effort required for hot-mix asphalt. As part of his new project, Marasteanu will work with international collaborators in Italy and Sweden to test asphalt mixture compaction using a new approach based on tribology—the science of friction, lubrication, and wear of contact surfaces in relative motion. The approach will specifically be used to better understand the effects of the GNP modification on compaction.



U of M faculty member receives NSF early career award

Civil, environmental, and geo- engineering assistant professor Lauren Linderman has received an award from the National Science Foundation (NSF) designed to support early career faculty.

The NSF Faculty Early Career Development (CAREER) Program grant will provide Linderman with \$500,000 over five years for a project titled “Multi-objective Optimization of Sensor Placement for Reliable Monitoring and Control.” The project aims to help sustain the long-term performance of civil infrastructure by identifying the most effective measurement types and locations for monitoring and isolating structural response.

The integration of sensor networks and physical systems

is essential for maintaining the continued performance of civil structures while facing challenges in aging, energy, and the environment, Linderman says. Her research project will identify optimal network systems for infrastructure applications through the integration of virtual and physical sensors and actuators. The framework of this research will also be used as part of student design projects to develop experimental modules and an interactive outreach platform for secondary school students.

According to the NSF, CAREER grants are the organization’s most prestigious awards in support of early career faculty.



The Field Lab on I-94 in Minneapolis includes cameras, radar stations, and other technologies.

giving us real-time verification of that information. It is an amazing amount of data," says John Hourdos, director of the U's Minnesota Traffic Observatory (MTO). "This is the highest resolution of traffic data I can imagine at a location that experiences at least one crash every two days, and a lot of valuable research can be done with it."

New disruptive technologies such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication have the potential to change the future of transportation in a revolutionary way. Much like the seat belt and airbags in

the past, V2V/V2I-equipped vehicles are quickly becoming an industry standard with the aim of further improving driver safety. Unlike seat belts and airbags, however, the aim of V2V/V2I communication is not to help drivers survive crashes but to avoid them. V2V/V2I-capable vehicles—often referred to as connected vehicles (CVs)—capitalize on technologies including GPS, in-vehicle sensors, roadway sensors, and wireless communication to broaden the information available to the driver/vehicle unit.

"Just a few decades ago even the idea that we could prevent crashes was a dream, and now with connected vehicles we have seen wonderful uses such as intelligent emergency braking, which could effectively be the end of rear-end collisions," Hourdos says. "However, the development of these systems, applications, and vehicles requires testing, and in order to test them we need data."

To aid research in this groundbreaking field, Hourdos has spearheaded the development and deployment of instrumentation and software to create a laboratory for CV application development and testing as well as fundamental research on driver behavior and traffic flow theory. Capitalizing

on the existing I-94 Field Lab located in the I-94/I-35W "commons" in downtown Minneapolis—and with the support of the Roadway Safety Institute and the Minnesota Department of Transportation—a new, radar-based vehicle detection and traffic measurement collection infrastructure was established. Specifically, the objective of this effort was to create a testbed for CVs and expand infrastructure-based systems into the CV realm.

As part of this effort, seven radar stations have been deployed along a half-mile stretch of I-94 westbound. The stations collect high-resolution vehicle trajectory data for every vehicle that passes through the corridor. Each radar station is paired with a dedicated camera for calibration and validation purposes, and also to allow development of hybrid vehicle detection and tracking algorithms in the future. The data-collection infrastructure is supported by a comprehensive data warehousing and dissemination software architecture, which allows continuous collection and storage of all collected measurements in an efficient online database as well as a real-time shared memory space used by real-time applications.

Future plans for the CV testbed include partnering with other organizations, research institutions, and the federal government to help advance the development of CV technology, Hourdos says. In addition, MTO researchers plan to use the wealth of data to extend the existing I-94 queue warning system and adapt the system to traffic pattern changes resulting from construction on I-94 that is currently under way.



A radar station

The EZ10 Autonomous Shuttle is an all-electric, 12-passenger vehicle that operates along a pre-set route using GPS and other technology to guide its path. Sensing technology installed in the vehicle ensures a smooth and safe ride even in heavy pedestrian/vehicle traffic.

The maximum vehicle speed is 25 miles per hour, but it traveled at about 6 miles per hour during the demo. The bus is also fully accessible for passengers of all abilities.

"It's sort of surreal seeing the technology that's been talked about actually happening in real life," one student rider said.

"I thought it was really impressive that it stops in the same spot," said U of M junior Pheyln Anderson. "You can see the tracks from it having taken the same exact route every time."

In addition to showcasing the latest in self-driving technology, the demo also allowed riders to learn more about how autonomous vehicles may be used



The EZ10 Autonomous Shuttle

to deliver future transportation services and provide sustainable linkages to other transportation modes and facilities.

Anderson said he could envision the technology being applied on campus. "Because of its size, it could get into the

areas of campus that buses currently can't...especially if they designated lanes for them."

The bus is in Minnesota as part of the Automated Shuttle Bus Pilot Project led by the Minnesota Department of Transportation (MnDOT). Since last December, MnDOT has been working with 3M, bus manufacturer EasyMile, and First Transit to test the bus in Minnesota's harsh winter conditions—the first cold-weather test of an EasyMile vehicle.

While the University of Minnesota has no specific plans to implement this technology, learning about its possible benefits and showcasing its potential supports research already under way to further develop autonomous vehicle systems at the U of M and around the world.



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AUTONOMOUS

BUS DEMO

showcases innovative
transportation technology.

page 1

Taking on

POTHOLES

with new prevention and
REPAIR STRATEGIES.

page 2

Researchers explore

EQUITY

issues of self-driving vehicles.

page 3



**Freeway lab aids development of
connected vehicles, improves traffic safety.**

page 1