

# Catalyst



Accelerating the pace of transportation innovation

JANUARY 2020

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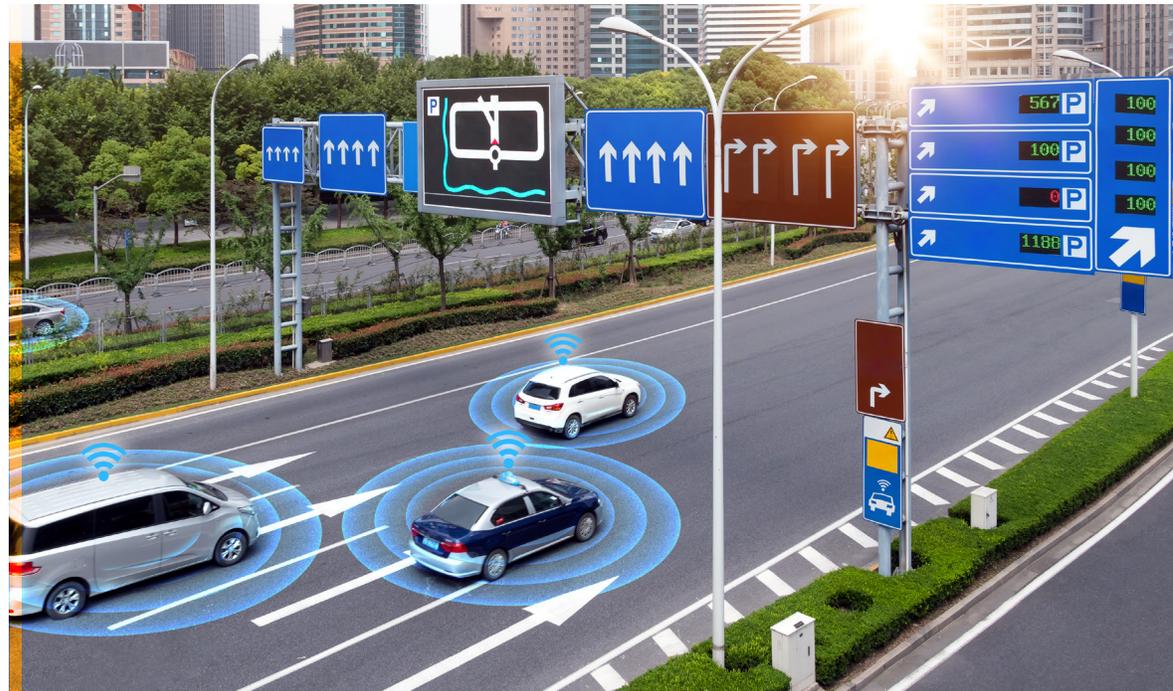
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## How can local agencies prepare for connected and automated vehicles?

Experts predict the implementation of connected and automated vehicles (CAVs) will soon be widespread, leaving local agencies in need of guidance to plan for CAV roadway needs. To help transportation agencies prepare for this change, U of M researchers have developed a reference tool and compiled a literature review that local agencies can use to anticipate the infrastructure

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## Crash risk for pedestrians, cyclists higher in less affluent neighborhoods

The crash risk for pedestrians and bicyclists is higher in Minneapolis neighborhoods that have lower household incomes and higher populations of minorities, according to U of M research. "In racially concentrated areas of poverty, predicted pedestrian and bicycle crashes are substantially higher than other areas of the city," says Greg Lindsey, a professor with the Humphrey School of Public Affairs and the project's principal investigator.

*Crash risk continued on page 6*



# U of M receives funding to improve efficiency of electric delivery trucks



In a new \$1.5 million project funded by the US Department of Energy (DOE), U of M researchers will aim to increase the driving range and lower the operating costs of electric heavy-duty delivery vehicles.

The three-year project, titled Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management, will focus on large-scale battery electric vehicles (BEVs)—in this case, semitrucks—that typically travel more than 250 miles each day between warehouses.

Vehicle manufacturer Volvo Group North America is leading the overall \$3.8 million project and providing equipment—two full-size battery electric Class 8 tractors—along with engineering integration and data collection.

The U of M research team will be led by mechanical engineering professor Will Northrop of the T.E. Murphy Engine Research Laboratory and computer science professor Shashi Shekar, with assistance from Ph.D. student Matt Eagon.

Minnesota-based Murphy Warehouse

Company and Texas-based HEB Companies will serve as fleet partners, providing operating sites that vary from extreme heat in the summer to extreme cold in the winter. Los Angeles-based Greenlots, a provider of electric vehicle charging and energy management technologies, will provide the charging stations.

The U of M team has been developing an intelligent energy management system (i-EMS) in a project funded by the DOE's Advanced Research Projects Agency–Energy that is focused on extending the range of medium-duty hybrid-electric delivery vans (see [vpro.umn.edu/projects/codv](http://vpro.umn.edu/projects/codv)). This new Volvo i-EMS project will build on that work, developing algorithms for battery-electric trucks and improving the energy management performance for the Volvo FE electric Class 8 tractors—and subsequently, regional freight movement.

Northrop says he is excited to extend the i-EMS strategy to pure battery electric vehicles. “This is an opportunity to leverage our current research to improve the range and utility of electrified

vehicles in Minnesota and beyond,” he says.

The i-EMS will use real-time vehicle and operations data, along with models, from Murphy Warehouse and HEB trucks to predict energy use based on load, ambient temperature, planned route, and real-time traffic conditions. The U of M researchers will then analyze fleet partners' collected route data to determine optimal BEV routes to minimize energy use and predict the best locations for on-route charging of multiple BEV trucks, which could support future expansion of the BEV fleet.

Ultimately, the goal is to extend the driving range of the Volvo BEV trucks by 20 to 30 percent compared to the baseline and to improve operating cost efficiency by 50 percent.

Cory Milczark, director of operations for Murphy Warehouse, will be overseeing the project with the firm's transportation department. Milczark says the company has always been committed to cutting-edge technology and environmental sustainability, so the project seemed like a natural fit. While Murphy currently uses battery-electric forklifts, “We would be interested in using electric trucks if they are successful,” Milczark says.

READ  
Catalyst  
ONLINE

for links to research reports and other resources.

# Managing stormwater runoff with local materials shows cost-saving potential

Managing stormwater runoff from roadways is a top regulatory and environmental concern for highway departments. However, creating the installations needed to accomplish this goal often requires costly commercial materials and hauling operations. The Minnesota Department of Transportation (MnDOT) and U of M researchers are investigating the use of previously discarded natural materials close to construction sites for stormwater management, and a new study shows this approach has tremendous cost-saving potential.

"This project's results allow MnDOT to use onsite soil to build bioslopes and bioswales to retain the first inch of roadway runoff and associated pollutants," says David Saftner, head of the University of Minnesota Duluth's Department of Civil Engineering. "Using onsite materials rather than transporting new materials to the site will save taxpayer dollars."

In every construction project, MnDOT follows state regulations by designing and constructing roadways to contain and manage the "first flush"—the first inch of stormwater runoff flowing from the pavement. This is often accomplished with low-impact development practices such as bioslopes and bioswales (shallow ditches) along roadways that mimic the original landscape while absorbing runoff and filtering pollutants that wash from the roads.

"Typically, soils that are unsuitable for supporting pavements, such as peat and muck, are dug out and hauled away as waste while commercial compost mixtures are transported to the site for bioslope and bioswale construction," Saftner explains. "Our goal in this project was to apply the results of earlier research to the design and construction of bioswales and bioslopes using local materials to avoid these costly practices."

In this latest project phase, a multidisciplinary research team addressed all aspects of alternative filter material suitability, including water

retention and infiltration capacity, contaminant-filtering effectiveness, and the ability to grow and support vegetation. Researchers began by conducting a comprehensive literature review of bioslope and bioswale design and monitoring methods and examining best management practices and regulations.

Next, they tested on-location and lab materials from nine established and newly constructed biofilter sites from across Minnesota, monitored six established pilot test sites, and established and monitored a new peat-based biofilter stormwater system along a five-mile stretch of Minnesota roadway.

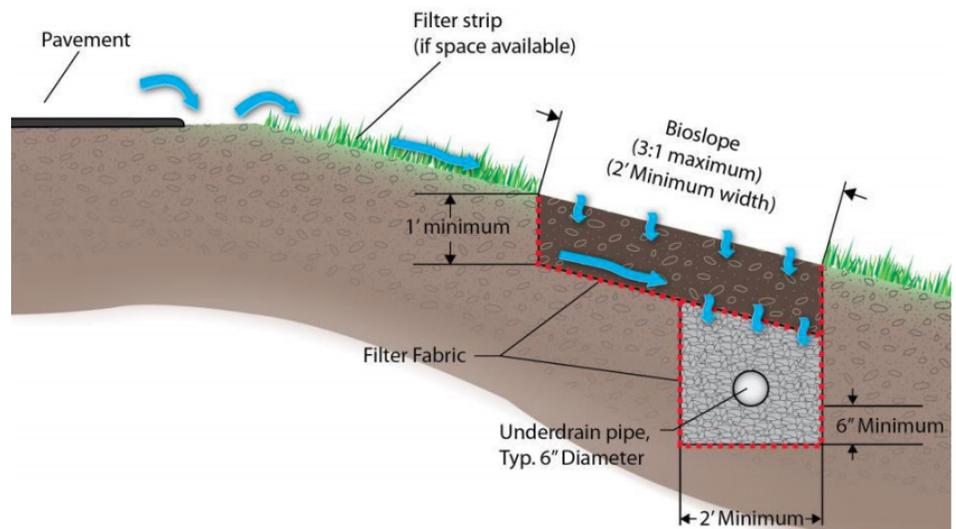
"Our lab and field investigations

showed the salvage and reuse benefits of muck and other organic materials for slope and ditch topdressing to retain the first flush of rain from roadways," says Dwayne Stenlund, an erosion control specialist with MnDOT's Office of Erosion Control and Stormwater Management.

Alternative local filtration media such as peat and muck show great promise in stormwater management bio-installations, so the research team is eager to continue this potentially cost-saving research. The next phase of the project will gather additional data from all plots to more fully assess the alternative media's capabilities over time.



*A bioslope near Brainerd*



*This cross section of a common engineered bioslope shows the position of a vegetation filter strip, a section of biofiltration material, and an underdrain pipe beneath it. The blue arrows indicate the flow of water.*

# Disrupting bacteria's communication pathways may thwart harbor infrastructure decay

The visitors who marvel at the Duluth Aerial Lift Bridge are unaware of a real drama unfolding below the surface.

Bacteria, algae, and other organisms vie for space and frequently settle on steel structures. Steel makes an appealing home for these bacteria, and their growth alters the steel's surface. In severe cases the process, known as biocorrosion, can turn docks into sheets resembling swiss cheese. The drama takes place in every harbor worldwide, and a \$60 billion coating industry aims to thwart it.

A coating that dominates the market is effective but contains copper oxide. Heavy metals leach from the coating to keep bacteria from aggregating, but this also negatively impacts aquatic life in harbors. Despite these known impacts and harsh regulation on copper-containing coatings, no environmentally friendly and scalable alternative exists.

Mikael Elias, a College of Biological Sciences and BioTechnology Institute assistant professor at the U of M Twin Cities campus, reached out to Randall Hicks after reading an article about

ongoing research in the harbor. Hicks, a professor at the University of Minnesota Duluth, studies microbial communities in the Duluth–Superior Harbor and has worked for nearly a decade to address biocorrosion rates there.

Elias saw a potential application for an enzyme—a molecule that drives chemical reactions—his lab recently modified. These enzymes prevent bacteria from communicating and grouping together. This creative approach could potentially stop bacteria in the harbor from grouping up on steel structures without negatively impacting aquatic life.

“Now [the enzymes] are so stable that we can use them in application fields that were not possible before. Where the typical enzyme is too unstable to use it outside of a test tube, our enzymes are so stable that we can dilute them into paint,” Elias says.

Hicks included coatings with the bioengineered enzymes from Elias in his trials. He found that they outperformed others in the lineup to inhibit biocorrosion.

Researchers continue to study how the enzymes impede biocorrosion, including how enzymes impact surface-colonizing bacteria. They also continue to examine how long the coatings can remain viable in harbors. In order to replace the pervasive toxic copper-oxide coating, the alternative must be scalable and relatively long lasting.

The potential to join the coating industry's worldwide market with an environmentally sustainable alternative is not lost on the researchers. The team recently patented the engineered enzyme and continue to work with industrial partners.

“The new coating offers another arrow in the quiver to battle biocorrosion,” Hicks says. “Potential applications are way beyond Lake Superior, and the market could be potentially unlimited if this coating works well in marine systems.”

*(By Claire Wilson; adapted and reprinted with permission from the College of Biological Sciences blog, Sept. 2019.)*



# Roadway Safety Institute efforts make practical, lasting impact

For the past six years, researchers from universities across the Midwest have been working to improve transportation safety through their efforts with the Roadway Safety Institute.

The Institute was the Region 5 University Transportation Center funded through the 2012 federal transportation bill. Led by the University of Minnesota, the Institute also included partners at the University of Akron, the University of Illinois at Urbana-Champaign, Southern Illinois University Edwardsville, and Western Michigan University. Its grant period ended in September 2019.

Driven by the goal of preventing crashes to reduce fatalities and life-changing injuries, the Institute focused on research that could make a real impact on the number of lives lost on our roads. In total, 26 faculty and research staff conducted 68 projects that employed varied approaches to improve safety for all types of roadway users.

Highlights include:

- A collaboration with American Indian communities across Minnesota to explore unique tribal safety issues. After findings identified pedestrian safety as a critical and under-recognized priority, the research team went on to assess pedestrian safety at four reservations and to develop recommendations for countermeasures that were then used by at least one tribal community to secure funding for safety improvements.
- A study exploring the link between obstructive sleep apnea (OSA) and crash risk for truck drivers. Researchers found that drivers who fail to adhere to OSA treatment are five times more likely to be involved in serious, preventable crashes.
- The creation of a bicycle collision-warning system that provides auditory alerts to motorists, helping them keep a safe distance from cyclists and reducing the risk of crashes. This project led to a nearly \$1 million NSF grant to



## The Institute by the numbers:

**26 faculty and research staff conducting 68 projects**

**31 activities held for K-12 students with 3,400 participants**

**71 events aimed at a professional audience, reaching 2,900 people**

**140 undergraduate and graduate students supported**

**170 media stories referencing RSI research or activities**

explore the implementation and commercialization of the system with Quality Bicycle Products.

- A transdisciplinary effort involving researchers from two universities collaborating with the City of St. Paul, Minnesota, on a project aimed at reminding drivers to watch out for pedestrians. At project sites where feedback signs were installed to display the weekly percentage of drivers who stopped for pedestrians, the average compliance rate jumped from around 32 percent to as high as 78 percent.
- The expansion of a freeway laboratory in downtown Minneapolis, Minnesota, to facilitate the study, development, and testing of connected vehicle technology as well as fundamental research on driver behavior and traffic flow.

Over the last six years, the Institute also developed a variety of activities targeted to K-12 students to raise awareness of transportation safety topics and career opportunities in related fields. This work included creating a permanent exhibit at The Works Museum in Bloomington, Minnesota, focused on teaching kids and their parents how to “be safe and be seen” while walking or biking in the dark, and developing

safety-focused lesson plans on topics ranging from distracted driving to retro-reflectivity.

The Institute also conducted technology transfer initiatives to bring its research results to a wider audience. This included developing workshops on automated vehicle technologies designed to give transportation professionals foundational knowledge and show them how related research can be useful in practice. The Institute also hosted pedestrian safety workshops where practitioners across the region learned about proven, cost-effective ways to improve safety and a community’s safety culture.

“We are very excited about the latest technologies, public policy issues, and improved understanding of human behavior that our researchers have explored and continue to pursue,” says RSI director Max Donath. “This work will likely have an impact on both reducing road fatalities and crashes and improving mobility options for all travelers well into the future.”

For more detailed information on the range of activities conducted during the Institute’s six-year grant period, view a complete summary report on [roadwaysafety.umn.edu](http://roadwaysafety.umn.edu).



The case study, sponsored by the Roadway Safety Institute, aimed to illustrate how information about crash risk and equity can help transportation managers prioritize investments in street networks. Jason Cao, an associate professor in the Humphrey School, was the co-investigator.

“Traffic crashes disproportionately affect people in neighborhoods with lower incomes, Native American residents, and people walking and bicycling,” says Ethan Fawley, Vision Zero coordinator for the City of Minneapolis. “This research provides valuable data that can help us be proactive in improving traffic safety and equity.” Minneapolis recently adopted a Vision Zero Action Plan, which outlines key steps over the next three years to advance the city’s goal of ending traffic deaths and injuries on city streets by 2027.

In the project, researchers determined crash numbers and frequencies for pedestrian and bicycle crashes at intersections and mid-blocks in Minneapolis between 2005 and 2017. They then developed new models of pedestrian and bicycle crash risk and used them to predict crashes at all of the city’s intersections and mid-blocks. Next, they used statistical tests to assess how equitably the estimated crash risk is distributed in the city.

They found that people in Minneapolis who live in lower-income neighborhoods in which more than

half the population is minority face higher crash risk than those individuals who live in more affluent, majority-white neighborhoods, especially at intersections. “The differences become even more pronounced when the central business district, which has the highest number of crashes, is excluded from the comparisons,” Lindsey says.

The team’s approach has distinct advantages over other models. First, it can estimate crash risk at sites regardless of whether crashes occurred there in the past. “We confirmed that crashes are distributed unevenly, and that crash risk is concentrated at a relatively small proportion of sites,” he says. Second, the approach incorporates measures of three transportation modes—vehicle, pedestrian, and bicycle—across an entire street network.

The models show that, in most cases, bike and pedestrian crash risks are higher—sometimes significantly—with more exposure to vehicles. The models also confirm that many different factors are associated with pedestrian and bicycle crashes, and that these factors differ for both modes at intersections and mid-blocks. For example, pedestrian intersection crashes are more likely in areas with a higher percentage of children nearby but less likely in neighborhoods with more elderly people. As a result, the researchers believe interventions and countermeasures should be separated out—and addressed simultaneously—to address the different risks of bicycling and walking.

The researchers then went on to develop new measures of crash risk. “We created two new indices and showed how they could complement or augment rankings currently used by the city to prioritize street improvement projects,” Lindsey says.

The results support efforts by the Minneapolis Department of Public Works to give more weight to equity and pedestrian and bicycle safety when it prioritizes street improvements. “If new criteria related to equity and active travel are used in project ranking, priorities for investment could change,” Lindsey says. “Our results provide additional evidence that the city can achieve its goals to increase pedestrian and bicycle safety.”

### Resources from Shared Mobility Collaborative now available

The Twin Cities Shared Mobility Collaborative has launched a new website for transportation practitioners and other professionals interested in meeting the mobility needs of people in the Minneapolis–Saint Paul metropolitan area. The website features event information, including a summary of a recent shared mobility data workshop, and other regional, state, and local resources.

The Shared Mobility Collaborative seeks to foster collaboration between government, nonprofits, and the private sector and expand and improve multimodal and shared transportation options in the Twin Cities. Through funding from the McKnight Foundation, CTS provides the collaborative with organizational, communications, and public engagement support.

If you’re interested in connecting with the collaborative or learning about its latest work, visit the website and sign up for the mailing list at [tsharedmobility.org](https://tsharedmobility.org).

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needs for connected and automated vehicles and plan for infrastructure upgrades and maintenance activities.

“This resource identifies the features currently being installed in cars and recommends the steps local agencies must take to be fully compatible with this technology,” says Debra Heiser, engineering director for the City of St. Louis Park.

Connected vehicles communicate wirelessly with one another and with elements of the highway infrastructure, while automated vehicles assume some tasks traditionally performed by drivers. These technologies pose a challenge for road agencies, as they will require unique features from the highway infrastructure for navigation, sign reading, safety, and other functions. Transportation planners often anticipate decades of service from infrastructure such as traffic signal control technology and signage, so the decisions they make today must anticipate the needs of CAV technologies.

“For example, when spending \$25,000 on a traffic signal controller and cabinet that is expected to provide 20 years or more of service, an agency will want to make sure it is anticipating future needs, including those presented by CAVs and vehicle-to-vehicle and vehicle-to-infrastructure communication platforms,” says John Hourdos, director of the U of M’s Minnesota Traffic Observatory.

To address this challenge, Hourdos’s team investigated the current state of CAV development and the expected technological platforms and needs these vehicles will require. The project was sponsored by the Minnesota Local Road Research Board.

Investigators began with an extensive literature review and then evaluated the technologies of currently available roadway infrastructure hardware. These findings were included in a survey of local agency infrastructure investment plans, turnaround plans for aging equipment, and priorities of potential CAV applications in their infrastructure. Finally, data on CAV systems and needs were compiled, and technologies that are currently used or close to implementation were identified.

Based on their findings, researchers developed recommendations for infrastructure planning and development and created a matrix of infrastructure applications to accompany the more detailed descriptions in the report; the matrix supplies the needs and cost

projections for each application.

“Local engineers can use this reference to make better planning and procurement decisions for investing in new infrastructure and personnel and to inform constituents,” Hourdos says.

Local agencies are encouraged to focus on five key recommendations to best prepare for CAVs:

- Maintain road markings for visibility.
- Maintain clear road signage.
- Modernize signal controller systems.
- Develop and update communication infrastructure where possible.
- Follow guidance from the USDOT and state agencies where available.



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Center for Transportation Studies  
University of Minnesota  
University Office Plaza, Suite 440  
2221 University Avenue S.E.  
Minneapolis, MN 55414

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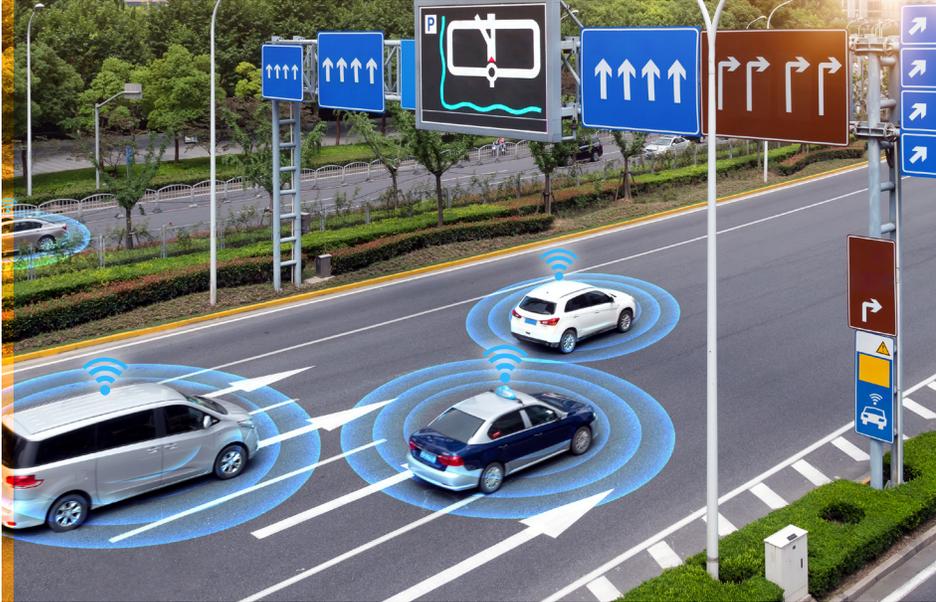
A publication of the Center for Transportation Studies  
University of Minnesota

JANUARY 2020

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