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**Engines lab receives $1.4 million to improve delivery vehicle energy efficiency**

The University of Minnesota’s Thomas E. Murphy Engine Research Laboratory (MERL) has received $1.4 million to research ways to boost the energy efficiency of cloud-connected delivery vehicles. The funding was awarded by the NEXTCAR Program of the U.S. Department of Energy’s Advanced Research Projects Agency-Energy.

The U’s NEXTCAR project researchers are partnering with UPS and electric vehicle manufacturing...-

**In-vehicle warnings show promise for improving work-zone safety**

Work zones can be dangerous for both drivers and the work crew—but U of M researchers are working on innovative ways to lessen these risks and lower the rate of work-zone crashes. In a new study funded by the Minnesota Department of Transportation (MnDOT), researchers investigated the potential advantages and possible disadvantages of vehicle-to-infrastructure (V2I) in-vehicle messages to communicate to drivers.

“When we started this project, we saw a potential for drivers to become more aware and responsive to hazards within the work-zone by presenting the information directly to them through...-

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Work zones continued on page 6
Construction on Twin Cities freeways gives drivers plenty of chances to try alternative routes—and sometimes, find that those routes are under construction, too. In a project funded by the Minnesota Department of Transportation (MnDOT), U of M researchers evaluated the capabilities of simulation software packages that could be used to improve construction project staging and, ultimately, help minimize disruption from overlapping projects in a region.

“Traffic modeling is a valuable transportation planning tool for predicting the impacts of new construction or maintenance projects,” says John Hourdos, director of the U of M’s Minnesota Traffic Observatory and the project’s principal investigator. “However, it is often only available in two scales: microscopic or macroscopic.”

Microscopic-scale traffic simulation emulates real-world conditions, including behaviors such as acceleration rates, but it isn’t feasible for inter-corridor or regional analysis because of the large amount of data and computing power required. Macroscopic-scale planning tools predict driver route choice and travel demand, but only for static traffic conditions.

To bridge these two scales, MnDOT is developing a mesoscopic, traffic-simulation-based, dynamic traffic-assignment model for the Twin Cities. “Large-scale mesoscopic traffic simulation is a newly adopted tool made possible by recent advancements in traffic modeling and computer hardware,” Hourdos says. “A mesoscopic model can be used to stage construction seasons to minimize the disruption caused by multiple large projects or to coordinate traffic modeling across the road networks operated by the state, counties, and cities.”

For the project, researchers evaluated the capabilities of currently available simulation software packages to meet MnDOT’s needs. “Dynamic traffic assignment is an emerging methodology, and there are a lot of software platforms with different implementations,” says Jim Henricksen, traffic forecaster with MnDOT’s Metro District. “MnDOT was interested in reviewing their pros and cons.”

Investigators interviewed stakeholders who have used or requested traffic simulation information about their understanding of and need for mesoscopic traffic simulation. In addition, they reviewed four case studies of mesoscopic simulations used in Manhattan, San Francisco, Detroit, and Jacksonville, Florida. Next, they conducted a comprehensive review of six commercially available traffic simulation software packages to identify limitations of their methods and whether those methods are applicable to MnDOT’s needs.

To compare the capabilities of the simulation software packages, the team created a compatibility matrix that identifies dozens of components necessary for accurate models, then analyzed how each of these features are handled by the different software systems. “Our matrix produced some interesting insights: for example, some software packages claim to model actuated signals, but they create models based on assumptions rather than real-world conditions,” Hourdos says.

Based on the results of this effort, researchers identified two software packages—TransModeler and AIMSUN—that stood out from the rest. Then, they leveraged significant pro bono work from the software developer to build out and test the foundation of a mesoscopic model for the Twin Cities in TransModeler.

“Our findings lay the groundwork and procedures for MnDOT or other agencies to create a mesoscopic-scale traffic modeling system for the Twin Cities,” Hourdos says. “Moving forward, MnDOT can use the information gathered in this project to determine which approach is more practical for the agency and its consultants based on cost, capabilities, and data availability.”
U of M researchers are helping the Minnesota Department of Transportation (MnDOT) evaluate a repair method that could reduce traffic interruptions caused by infrastructure repairs by bringing real-world bridge girders into their lab.

The salting of bridge and roadway surfaces during Minnesota winters can create highly corrosive conditions that result in damage to bridges. Such was the case with the Trunk Highway 169 Nine Mile Creek Bridge near Edina and Minnetonka, where leaking expansion joints caused corrosion to elements responsible for the strength of bridge girders: shear reinforcement, prestressing strands, and the surrounding concrete. MnDOT repaired the damaged girder ends in 2013 by encasing them using a system of steel dowels, additional shear reinforcement, and sprayed concrete. MnDOT was able to make the repairs without traffic interruption.

Now, the bridge is being replaced, and U of M professor Carol Shield and her team of researchers are evaluating the effectiveness of the 2013 repair. The researchers’ goal is to determine if the repair strengthened the corrosion-damaged girders to a level similar to noncorroded girders. If proven effective, MnDOT could use this type of repair to lengthen the useful life of existing bridges and save travelers time and frustration caused by repair-related traffic delays.

When the southbound lanes of the bridge were taken out of service this spring, four prestressed girders were removed from the structure and brought to the U’s Theodore V. Galambos Structural Engineering Laboratory for testing.

“Two of the girders have ends that were repaired by MnDOT, and two girders have ends that never needed to be repaired,” Shield says. “We [are testing] the four girders and comparing their strengths to determine if the repair actually returned the girders to the strength they had prior to the corrosion-related damage.”

Once the girders arrived at the lab, new concrete decks were cast on them. The concrete deck ensures that the girder has sufficient flexural strength to guarantee a failure will occur near the repair under investigation. MnDOT provided the design and calculations for the required deck depth, width, and concrete strength.

The first girder end was tested in May. An external shear reinforcement system was placed on the “non-test” end to force the shear failure to the girder end of interest. Once the deck concrete reached sufficient strength, the girder was tested. Load was applied, increasing step-by-step so damage could be monitored. As the load increased, crack patterns were documented to help understand the behavior of the repaired girder under load. The girder finally failed—and as expected, the result was a shear fracture.

Testing of the other girder ends and subsequent data analysis has continued through the summer and early fall. Ultimately, a comparison of failure loads for the repaired and unrepaired girder ends will help determine if this repair method is able to safely restore strength to deteriorated girders.

(Adapted from an article previously published in CEGE, a publication of the Department of Civil, Environmental, and Geo-Engineering at the University of Minnesota.)

Don’t forget to register!
28th Annual CTS Transportation Research Conference
November 2
The Commons Hotel
Minneapolis, MN

Join us for a day of discovery and innovation on the U of M campus! Full program information is available at cts.umn.edu/events/conference/2017.
The Department of Civil, Environmental, and Geo-Engineering (CEGE) has added an assistant professor with interests related to autonomous vehicles. Michael Levin received a doctorate in civil engineering from the University of Texas at Austin in May 2017; his dissertation was titled “Modeling and optimizing network infrastructure for autonomous vehicles.” Learn more about Levin’s interests below.

Tell us about your plans for research at the U of M.
I plan to focus my research on modeling the traffic flow and planning effects of emerging transportation technologies. New technologies, such as autonomous vehicles, are largely driven by developments in the software and hardware systems. Many questions remain on how they will affect the transportation network, traffic congestion, and our daily commute. City planners look at these questions 20 to 25 years into the future to design for future infrastructure needs. With the rapid advancement of automated vehicle technology, we need to research them now to be prepared for their availability in the near future.

What work are you doing in the area of autonomous vehicles?
I currently focus on two areas in autonomous vehicles. First is modeling and optimizing new traffic flow behaviors and controls—maneuvers autonomous vehicles can perform but human drivers can’t. For instance, traffic signals could be replaced with high-speed coordination of vehicles at intersections, and platoons of autonomous vehicles could travel nearly bumper to bumper at highway speeds. The second is studying new options for traveler mobility. Autonomous Uber could have similar costs to private vehicle ownership and operation; in that case, would households still choose to own vehicles? If mobility-on-demand becomes a major form of transportation, how do we match travelers to vehicles, and route vehicles to reduce traffic congestion?

What excites you most about your work?
The opportunity to shape the future of transportation. Ultimately, the models researchers develop will be used to design transportation infrastructure for autonomous vehicles. Since the first private automobiles, transportation engineering has focused on designing road systems for human-driven vehicles. Autonomous vehicles open up so many new possibilities, some of which we have yet to imagine. My work allows me to study new ways to use autonomous vehicle technologies to determine which ones are practical and effective at improving traffic.

What are the implications of your work?
Partially autonomous vehicles are already available to consumers (e.g., Teslas), and large-scale coordinated use could reduce the traffic congestion we experience in our daily commutes to work or school. Once fully autonomous vehicles become available, we could benefit from even larger improvements in traffic operations, but realizing these benefits requires engineering our transportation systems and controls to make use of these new technologies. Autonomous vehicles are likely to increase travel demand as well as the supply. The goal of my research is to learn how to use autonomous vehicles to reduce travel time and the environmental effects of transportation worldwide.

New researcher brings expertise in autonomous vehicles

READ Catalyst
ONLINE for links to research reports and other resources.
Guide offers simple, cost-effective methods for slope stabilization

In a recent project, University of Minnesota Duluth researchers determined effective methods for stabilizing slopes along Minnesota’s locally maintained roads and created a guide recommending slope stabilization methods for common site types. Previously, there was no guide for public works engineers to stabilize slopes of the scale typically seen along locally maintained roadways.

“We have recommended simple, effective methods for stabilizing at-risk sites and repairing common, recurring slope failures,” says David Saftner, an associate professor in UMD’s Department of Civil Engineering. “While no single method is appropriate for all situations, several methods have proven effective, and our guidebook succinctly summarizes those methods for local government engineers.”

Slope failures can block roads, cause safety hazards, and introduce preventable maintenance costs. When slope damage is severe, a geotechnical engineering firm must step in at some expense. But when damage is less severe, the county can often stabilize the slope using local materials and simple techniques. County road departments, however, often lack geotechnical expertise.

“This project created a user guide that local engineers can use right away to repair destabilized slopes,” says Blake Nelson, geotechnologies engineer in MnDOT’s Office of Materials and Road Research.

The project team followed a multi-step process combining site investigations, laboratory testing, and modeling. First, researchers identified and initially characterized slopes for further analysis using a survey sent to each county engineering department in the state; respondents identified stabilization methods and sites at which researchers could conduct field investigations to produce case studies. Next, the team identified and researched various stabilization methods, used laboratory testing to more accurately characterize soil collected from slopes of interest, and created models to investigate each slope stabilization method’s effect. Finally, researchers summarized the project’s findings and presented recommendations in their Slope Stabilization Guide.

Ultimately, this study and guide address the need for a consistent, logical approach to slope stabilization founded in research and experience. “Our guide was developed using resources not typically available to all county engineering and maintenance departments such as soils lab testing, advanced modeling, and geotechnical analysis,” Saftner says. “By implementing these recommendations, local government engineers can improve the stability of roadway embankments, minimize slope failure and associated damage, and decrease preventive maintenance costs.”

The Minnesota Local Road Research Board funded the project.

Report summarizes work on transportation policy and economic competitiveness

The U’s Transportation Policy and Economic Competitiveness (TPEC) Program was formed in 2013 to provide a better understanding of the impacts of transportation policies and innovations on Minnesota’s economy. A report of TPEC’s progress to date is available on the TPEC website: tpec.umn.edu.

Housed in the State and Local Policy Program (SLPP) of the Humphrey School of Public Affairs, TPEC creates objective knowledge to inform decision making. Researchers focus on three overarching topics: transportation finance, industry clusters and freight infrastructure, and technology.

“Our team examines current policies to create a baseline of knowledge and looks ahead to find solutions and opportunities,” says Frank Douma, SLPP director. “The tools we create, such as a transportation finance database and a national freight atlas, are a valuable resource for policymakers, not just in the Twin Cities metro but throughout the state and region.”

Work is continuing under the program, including plans for a task force that will examine the potential impacts of self-driving vehicles on people who are transportation disadvantaged.
in-vehicle messaging technologies," says Nichole Morris, director of the U’s HumanFIRST Laboratory, who led the project. “We also wanted to assess the extent to which this type of messaging could lead to driver distraction, as numerous studies have demonstrated the hazards of distracted driving, particularly from interacting with on-board technologies.”

The researchers began by identifying ideal design guidelines for any in-vehicle messaging system. Then, the team conducted a survey to uncover driver attitudes in Minnesota toward work-zone safety, smartphone use, and the potential for receiving messages through in-vehicle technologies such as smartphones.

“Our survey found that a significant number of drivers use their smartphone while driving—for navigation, talking, and even texting—and that they place them in a variety of locations throughout the vehicle, rarely in a mount,” says Morris. The survey revealed positive attitudes toward the use of a V2I work-zone messaging system but concern over its distraction potential. The researchers also found that many drivers distrust the accuracy of roadside signs for work zones and were receptive to using an electronic messaging system.

Following the survey, researchers designed the in-vehicle messages and conducted a simulated driving study to test the effectiveness of the system on driving safety. During the simulation, participants drove through two different types of work zones three times, each with different work-zone events and messaging interfaces. These included a portable roadside message sign, a smartphone presenting only audio messages, and a smartphone presenting audio-visual messages. The smartphones were either mounted on the dashboard or placed on the passenger seat to reflect real-world conditions.

“The main goal was to determine whether in-vehicle warnings conveyed through smartphones would be distracting to the driver. We found that wasn’t the case," says Ken Johnson, work-zone, pavement marking, and traffic devices engineer at MnDOT.

Findings showed that there appeared to be no effect of distraction as long as in-vehicle messages were delivered in a controlled and driving-relevant manner. In fact, after analyzing the simulation data, researchers found that driving performance improved—drivers using either type of in-vehicle messaging performed better than they did with the roadside warning signs. Furthermore, drivers had better vehicle control and reported significantly less mental workload, better usability, and greater work-zone-event recall.

“Using eye-tracking technology, we can see that participants took their gaze off the road less often with the in-vehicle messages," says Morris. “In addition, the positive effects of in-vehicle messages appear to be elevated for the more difficult drive, suggesting that in-vehicle messages were helpful for more challenging roadway conditions.”

The study also found that placement of the messaging interface did not appear to be a significant factor for driving performance when the messages contained an audio component. Researchers hope to continue this work by field testing in-vehicle message systems and exploring possible avenues for broad implementation.
company Workhorse to improve the energy efficiency of medium-duty delivery vehicles through real-time powertrain optimization using two-way vehicle-to-cloud connectivity.

“UPS has more than 100,000 vehicles that drive 1.4 million miles per year. Small changes can make a big difference in vehicle efficiencies,” says Will Northrop, MERL director and mechanical engineering associate professor. “For example, in the past the company used big data analytics to study left turns. Developing routes for the delivery vehicles that avoided left turns saved 3 million gallons of fuel and 32,000 tons of carbon dioxide in one year.”

Large delivery fleet operators already use extensive data analytics to assign routes for minimizing energy consumption. In this project, the team will further improve the energy efficiency of UPS’s series hybrid-electric vehicles by optimizing battery state of charge and engine operating strategy in coordination with intelligent eco-routing.

Using cloud connectivity, the vehicle will periodically download the most efficient powertrain calibrations based on external data, like traffic and weather, collected while the vehicle is en route.

The interdisciplinary project team includes mechanical engineering researchers who will test the performance and efficiencies of the engine used in the vehicle and computer scientists who will examine the vast amounts of data.

“These engines generate a very large amount of data. There are hundreds of variables measured every second,” says Shashi Shekhar, a computer science and engineering professor and NEXTCAR team member. “If we can analyze the data, we can find very interesting and useful patterns, which can help us reduce fuel consumption and emissions.”

The overall goal of the research is to reduce energy usage in the Workhorse-produced UPS vehicles by 20 percent.

Much of the work on the project will be conducted at the MERL facility, which is dedicated to engines, alternative fuels, and emissions research. The newly renovated, 6,000-square-foot lab opened in 2013 and is located near the U’s East Bank campus. The lab is named in honor of former mechanical engineering professor Thomas E. Murphy, who was the founding director of the engines program at the U of M.

Northrop says that the U of M has long been a leader in engines research, but MERL brings it to a new level.

“A significant investment was made in our new facility to ensure that we stay at the forefront of technology needed to develop the next generation of clean and efficient engines,” he says. “Now that investment is paying off by bringing in federal funds and industry partnerships to address the global challenge of reducing energy usage.”
Engines lab receives $1.4 million to improve delivery vehicle efficiency.

More accurate TRAFFIC MODELING could improve planning FOR CONSTRUCTION PROJECTS.

U of M researchers ARE HELPING IMPROVE BRIDGE REPAIRS.

IN-VEHICLE WARNINGS show promise for improving WORK-ZONE SAFETY.