University of Minnesota

CENTER FOR TRANSPORTATION STUDIES

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Accelerating the pace of transportation innovation

Charting a path toward automated speed enforcement

In the United States, speeding is by far the leading factor in fatal crashes—equivalent to the use of drugs, alcohol, medication, and distracted driving combined. But although automated speed enforcement (ASE) is a promising countermeasure shown to reduce speeding and crashes, the idea remains contentious.

"Despite the demonstrated safety benefits of ASE, we've seen its deployment continue to be

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In memoriam: Richard P. Braun

Richard P. Braun, the founding director of CTS and a champion of transportation innovation, died April 11 at the age of 91.

"The CTS family mourns his passing," says CTS director Laurie McGinnis. "Thirty years ago, the University of Minnesota established the center to bridge a gap Dick identified while serving as MnDOT commissioner. He recognized that it was critical to strengthen the connection between the professionals working at MnDOT and the faculty conducting transportation research at the University. This partnership and collaboration launched Minnesota's reputation as an incubator for transportation innovation, a designation that remains true today. We will always remember Dick

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Reducing speeds to improve safety for work-zone flaggers

When drivers approach a roadway work zone at high speeds, they put the lives of work-zone flaggers at risk. To keep flaggers safe on the job, U of M researchers are looking for better ways to capture drivers' attention—and compel them to slow down—as they approach flagger-controlled work zones.

Kathleen Harder, director of the Center for Design in Health, and John Hourdos, director of the Minnesota Traffic Observatory, identified and tested new work-zone warning elements to more effectively capture and sustain driver attention. The project was funded by the Minnesota Department of Transportation and the Minnesota Local Road Research Board.

The project began with a simulator study in which participants completed three drives, each featuring a work zone with different warning treatments. One condition was a traditional four-sign configuration currently used to warn drivers approaching work zones. The other two conditions featured a variety of new elements, including signage with new messaging such as a "one-lane road ahead" sign with flashing LED lights, a dynamic speed warning sign equipped with a loud warning horn that sounded if drivers exceeded the speed limit, and portable rumble strips.

"Overall, we found that the new set of elements is more effective than the elements currently used to reduce driving speeds on the approach to a flagger-controlled work zone," Harder says.

Although adding LED lights to the one-lane road sign had no significant effect on drivers' speeds, findings indicated that the dynamic speed sign coupled with the horn was more effective than the dynamic sign alone.

To test these new elements under real-world conditions, the researchers conducted field tests evaluating two configurations in Minnesota work zones. The first configuration followed the minimum standards outlined in the *Minnesota Manual on Uniform Traffic Control Devices*. The second deployed signs employing new messaging and attention-getting devices, including a dynamic speed warning sign, horn, and rumble strips.

Findings showed that the combination of the dynamic speed warning sign and the horn successfully reduced the overall speed of vehicles approaching the work zone. The portable rumble strips did not cause any significant speed reduction, but this may have been related to their location downstream from the dynamic speed sign and horn.

"Our findings reveal that the new set of elements designed to capture driver attention—including new messaging, a dynamic speed trailer, and horn—had a significant influence on reducing driver speed," Harder says. "The experimental layout practically eliminated high-speed outliers and successfully reduced the approach speed to the flag operator."

From 2003–2014,

1,435

workers lost their lives
at road construction sites
IN THE U.S.

Source: Bureau of Labor Statistics

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Taking the uncertainty out of vibration-based bridge monitoring

The St. Anthony Falls Bridge, lit in purple in honor of a famous Minneapolitan, is instrumented with a robust monitoring system.

Maintaining the safety of bridges in the United States is a top concern for the transportation community. To improve bridge health monitoring, researchers have been seeking more effective technologies and methods. Using vibration measurements is one promising approach, especially as the required data acquisition and analysis systems become more affordable to deploy.

For this approach to be effective, the relationship between environmental factors and natural vibrations must be understood. U of M researchers led by Lauren Linderman, an assistant professor in the Department of Civil, Environmental, and Geo- Engineering (CEGE), recently completed a study that greatly increases knowledge of this relationship.

Others on the team included Professor Carol Shield and research assistant Karl Gaebler. Their project was sponsored by the Minnesota Department of Transportation.

"Using vibration data, it's possible to monitor changes in the dynamic signature of a bridge to detect changes in the structure," Linderman says. "However, this approach to monitoring has proven difficult because environmental factors, such as temperature, have been shown to cause variation in a bridge's dynamic signature, effectively masking changes due to damage."

Researchers began with data collected by a robust monitoring system on the I-35W St. Anthony Falls Bridge, which crosses the Mississippi River in Minneapolis. The system has been collecting vibration and temperature data since the bridge opening in 2008, providing a uniquely large data set—in a climate that sees extreme variation in temperature—to test the relationship between the dynamic signature of bridges and temperature.

Researchers faced a unique challenge of sorting through nearly 1.5 terabytes of high-quality vibration data to pinpoint the sections that would yield the most information about the bridge's health. To solve this problem, Linderman's team tested various signal-quality parameters and was able to identify a method that provides a strong indicator of a good signal.

"We developed an algorithm for identifying and sorting the natural frequencies and vibrations, then analyzed and tested nearly 30,000 unique data segments to demonstrate the viability of using the technique for systematic system identification with the available vibration measurements," Linderman says.

The analysis allowed the researchers to draw several useful conclusions based on the variation of the natural frequencies with temperature. "This includes the finding that natural vibrations appear to generally decrease as temperature increases and that the magnitude of change in natural frequency as temperature varies is too great to attribute to temperature changes alone—meaning other factors, such as humidity, are likely at play," Linderman says.

Moving forward, the researchers plan to identify and sort the vibrations resulting from temperature changes and other natural vibrations from those resulting from damage.

Researchers analyzed and tested nearly

30,000

UNIQUE DATA SEGMENTS

to demonstrate the viability of the technique.

Minnesota transportation funding: How are federal, state dollars redistributed?

Transportation funding comes from all levels of government—federal, state, and local. Funding that is directly generated by local taxes and fees stays in corresponding local jurisdictions (counties, cities, and townships, for example). Federal and state transportation funding, however, is allocated through certain budgetary procedures and may not be used in the original point of collection. How are these transportation funds redistributed in Minnesota? An analysis from U of M researchers offers new perspectives.

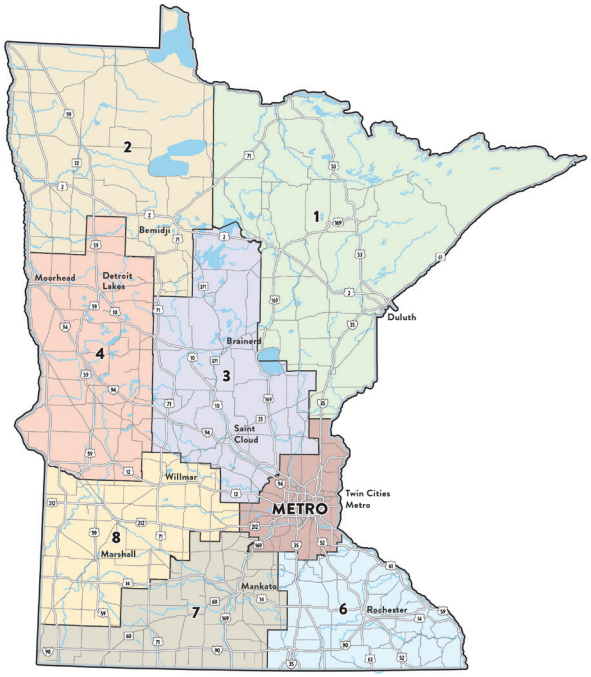
For the study, which looked at the six-year period between 2009 and 2014, the researchers analyzed funding revenues and expenditures at the district level (see map of Minnesota's eight districts) for both roadways and transit.

"We chose this approach for several reasons," says principal investigator Jerry Zhao, associate professor in the Humphrey School of Public Affairs. "Federal and state transportation grants to local governments are often distributed to transportation districts before they are used in different counties. In addition, our approach smooths out annual fluctuations associated with transportation grants to individual counties."

Others on the research team included Adeel Lari, director of innovative financing in the Humphrey School's State and Local Policy Program, and research assistant Shengnan Lou.

The analysis included three steps. First, the researchers calculated the share of transportation revenues contributed from different localities. Second, they examined the share of federal and state transportation expenditures across different localities. Third, they compared the expenditure share and the revenue share for each district to see what areas contribute more than they receive, or vice versa.

"When we include both roadways and public transit, our findings indicate that the Metro district contributes about 48 percent of federal and state transportation revenues and receives about 51 percent of federal and state transportation expenditures," Zhao says. "However, the expenditure-to-revenue ratio changes when we separate roads and transit. Metro counties receive about 88 percent of transit funding but 36 percent of highway funding."



Other districts show different patterns. "Among eight districts, we expect to see higher and lower ratios of revenues and expenditures," Zhao says. "For example, District 2 and District 1 receive more than they contribute, mainly because they receive a higher

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A history of funding and finance expertise

Transportation funding and finance have long been topics of U of M studies. For example, Herbert Mohring, a transportation economist who taught at the University from 1961–1994, helped lay the theoretical groundwork for congestion pricing. "His thinking contributed to the opening of the I-394 MnPASS express lanes in 2005," says Lee Munnich, senior fellow and former director of the State and Local Policy Program at the Humphrey School of Public Affairs.

Munnich began his own extensive research on congestion pricing in the 1990s and was also instrumental in developing MnPASS. His work included evaluation of the institutional and political issues in congestion pricing as well as public engagement and stakeholder activities for MnPASS lane development on I-394, I-35W, and I-35E.

Other U of M research has looked at mileage-based user pricing, value capture mechanisms, and innovative parking pricing.

Rehabbing roads with full-depth reclamation is both cost-effective and durable

Full-depth reclamation (FDR) of asphalt pavement is often used on rural roadways to reduce costs for materials and hauling. New research from the U of M indicates that FDR is also a good option for rehabilitating urban and suburban roadways and most likely outperforms traditional mill-and-overlay in cost and durability.

With FDR, road builders use trains of recycling equipment to pulverize, lift, grind, remix, and repave asphalt in a single pass. This recycling puts less demand on petroleum resources and new aggregate. Despite its benefits, FDR has yet to be adopted widely by city and county public works departments. In part, this is due to the challenge of using trains of equipment on urban and suburban roads that feature curbs, manholes, and driveways. Mill-and-overlay also has lower initial costs.

"Our goal was to provide evidence of FDR's cost-effectiveness, guidelines for FDR project selection, and, ultimately, performance-based specifications," says Mihai Marasteanu, a professor with the Department of Civil, Environmental, and Geo- Engineering (CEGE) and the study's principal investigator.

Marasteanu and co-investigator Jialiang Le also sought to provide testing protocols, procedures for analyzing life-cycle costs of FDR compared with conventional rehabilitation methods, and ways to use the MnPAVE computer program to determine long-term performance expectations for FDR.

Mihai Marasteanu analyzes a sample in the U of M's pavement lab.

The project was sponsored by the Minnesota Local Road Research Board and the Minnesota Department of Transportation.

Researchers began by taking samples of asphalt pavement from an FDR construction site in Victoria, Minnesota, before and after emulsion was added and created four asphalt mixes: one was a site sample with emulsion added on-site and compacted in the lab; the other three were dry mixes from the field mixed and compacted in the lab with various versions of the field emulsion. The samples were then subjected to several mechanical tests, and the results were used in computer simulations to evaluate FDR's potential performance, design life, and life-cycle costs.

"When we compared the simulated life-cycle costs of FDR with known results for traditional mill-and-overlay mixtures, we found that FDR is more cost-effective over a 35-year period than traditional methods," Marasteanu says. "In addition, mill-and-overlay must be redone every 18 years, causing more inconvenience and costs for road users than the longer-lasting FDR."

The City of Shoreview has used FDR effectively by using individual machinery units rather than long, connected recycling trains. "This research helps us translate full-depth reclamation projects in Shoreview into hard cost-benefit, return-on-investment numbers," says Mark Maloney, Shoreview's public works director. "It validates what we've been doing and gives cities what they need to justify the cost of using FDR in urban settings."

"Before, all we had was anecdotal information," Marasteanu says. "Now we have laboratory testing methods that are easy to use and can be incorporated in performance prediction models."

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share of road expenditures than they contribute to road revenues. This is probably due to much lower population density in these counties."

District 3 receives less than it contributes. "This is probably because this district has high traffic volumes and thus a high contribution of fuel taxes, combined with a low level of transit expenditures," he says.

"The mechanisms by which we fund and finance transportation systems are complex," says Ken Buckeye, program manager in MnDOT's Office of Financial Management. "To be informed, it is essential that we know from a jurisdictional standpoint who pays and who benefits, and to understand this over time. This research is an important way to enhance the discussion about resource collections and redistribution in transportation and to help improve decision making."

The project was completed as part of the U's Transportation Policy and Economic Competitiveness Program. A paper summarizing the analysis is online at **tpec.umn.edu**.

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for his vision and are grateful that he remained engaged with the center for the rest of his life."

Braun was the sole employee of CTS when it opened its doors in 1987. The launch followed years of work by civil engineering professors Panos Michalopoulos and Yorgos Stephanedes to establish a transportation center at the University. They prepared a justification report and vision for a center, building on a cooperative transportation research agreement Michalopoulos had brokered with the University and MnDOT. Braun embraced their vision and secured initial funding of CTS with $3 million of what were known as oil-overcharge restitution funds, earning the support of then-governor Rudy Perpich.

During Braun's tenure, CTS issued its first request for proposals to University researchers, formed an advisory structure, and held its first annual research conference. In addition, two federally funded programs began operations as part of CTS: the Intelligent Transportation Systems Institute (a federal University Transportation Center) and the Minnesota Technology Transfer Program (now the Minnesota Local Technical Assistance Program). Braun retired as director in 1994.

"Dick Braun influenced many transportation leaders," says Humphrey School of Public Affairs senior fellow Robert Johns, CTS director from 2001 to 2009 and former USDOT Volpe Center director. "He gave me tremendous leeway in building the CTS research, education, and outreach programs in the late 1980s and early 1990s. I think, like me, most people who moved on to leadership positions after working for him applied the knowledge they gained from him almost on a daily basis. He was a superb strategist on how to position an organization, select and motivate a team, develop political and stakeholder support, and attract resources. I do not know any transportation career leader as politically savvy as he was."

In 2006, CTS collaborated with the Department of Civil Engineering (now Civil, Environmental, and Geo-Engineering, or CEGE) to establish the Richard P. Braun/CTS Chair in Transportation Engineering. The purpose of the endowed faculty chair is to foster innovation in the academic program in transportation engineering.

Dick Braun, John Gulliver, Bob Roscoe, Robert Johns, and Doug Differt at the Braun Chair fundraiser in 2006.

CTS also presents the annual Richard P. Braun Distinguished Service Award in honor of Braun's leadership and contribution to research.

CEGE professor Catherine French received the Braun Award in 2005. "I am very grateful to Dick Braun for the impact he had on my career related to my contributions to bridge engineering and infrastructure issues," she says. "When I first came to the University of Minnesota as a faculty member in 1984, Dick helped to facilitate a relationship with MnDOT and the University with regard to research. He continued these efforts through the development of CTS in 1987. I will remember Dick for his positive 'can do' attitude, his ability to successfully work across both political parties throughout his career, and his drive for innovation, quick wit, genuineness, and warmth."

Braun served as commissioner of MnDOT from 1979–86. He also held a variety of high-level positions with state and national organizations, including chair of the Twin Cities Metropolitan Airports Commission.

A celebration of Braun's life will be held June 18 at the University of Minnesota. For more information, please visit **RichardBraun.net**. Memorial donations may be sent to the U of MN Foundation; Braun CTS Scholarship; P.O. Box 860266; Minneapolis, MN 55486-0266.

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people have received the **Richard Braun Distinguished Service Award** since it was first presented **in 1995.**

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a highly controversial issue," says Frank Douma, director of the State and Local Policy Program at the Humphrey School of Public Affairs. "Several states have enacted restrictions or even banned the use of ASE systems, and ASE has been rejected in a number of public referendums."

To chart a possible path to ASE deployment, U of M researchers have published a new study focusing on ASE in Minnesota. The research team included Douma, graduate research assistant Colleen Peterson with the Humphrey School, and Nichole Morris, principal researcher with the HumanFIRST Lab. The project was funded by the Roadway Safety Institute.

"We believe our state is a good candidate for ASE, because public support for ASE is strong and it has been listed as a potential strategy in previous state strategic highway safety plans," Douma says.

The study was conducted in three parts. First, investigators completed interviews with influential Minnesota stakeholders to better understand the arguments for and against ASE. The research team conducted 18 interviews within 4 stakeholder groups: public health, law enforcement, judicial, and government. Care was taken to create a varied pool of respondents within each category, across rural-suburban-urban divides, and from both political parties.

"Most of the interviewees suggested some level of support for ASE, especially if it is backed by strong data showing positive benefits and is implemented in a way that prevents abuse," says Douma. "We were also able to more clearly define the major issues surrounding ASE deployment by grouping them into 10 categories and figuring out which categories were deal breakers and which were up for discussion. For example, due process and improved safety are must-haves, while implementation options and financial structures are more flexible."

Next, they compared the rates of motor vehicle fatalities in states using ASE to Minnesota's rates. Finally, they evaluated public concerns about ASE to better understand the causes for continued conflict regarding ASE deployment among the general Minnesota population and to potentially identify avenues for reconciling this conflict.

"Negative perceptions of ASE are often related to misunderstandings about its constitutionality and the public safety threat posed by speeding," Douma says. "Concerns about big government and use of revenues generated by ASE are also fairly common."

Researchers say that framing the use of automated speed enforcement as a clear and effective safety tool to address a profound public health problem will increase public support for its deployment. In addition, because large majorities in several surveys approve of ASE in high-risk areas like school and work zones—where drivers often speed excessively—they say limited ASE deployment in those areas may be a beneficial foothold to build support for its use.

"Ultimately, connecting speed and its effects on road safety in the minds of the public will help create a conducive environment for the deployment of more effective enforcement tools, including automated speed enforcement," Douma says.

Deploying automated speed enforcement in school zones could help build support for its broader use.

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