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Accelerating the pace of transportation innovation

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Photo: David Gonzalez, MnDOT

Major ramp-metering upgrade reduces freeway delays for Twin Cities motorists

Motorists are experiencing less delay on metro-area highways thanks to major changes to the Twin Cities' ramp-metering system.

The Minnesota Department of Transportation (MnDOT) has reconfigured ramp meters to be more in sync with real traffic conditions. Meters are now running for shorter periods of time and are activated only when needed.

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Investments in local roads and trunk highways show positive returns

Transportation engineers and planners see firsthand the many positive impacts of transportation investments on economic development. They are frequently challenged, however, to demonstrate that relationship to the public and to elected officials entrusted with prioritizing investment decisions for all their communities' needs.

"We don't have enough funding for transportation, in part because we don't have good evidence to show the benefits of transportation and give political leaders the incentive to invest,"

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How do trip rates change among different age cohorts?



The travel preferences of Millennials could influence future transportation policies.

One of the most striking findings from a recent travel survey by the Metropolitan Council was a marked decline in the rate of daily trips per household—from 11.1 in 2000 to 8.8 in 2010. The decrease could be partially attributed to the long-term trend toward smaller household size, but researchers immediately wondered what else could explain the decline: Rising fuel prices? An aging population? Or even the impact of shifting attitudes toward travel, such as the changing travel preferences of Millennials?

To sort out these factors, University of Minnesota researchers used “cohort analysis” to study travel behavior. Their goal was to determine whether preferences toward vehicle ownership and travel vary among different segments of the population based on their age and life experience. If such an effect does exist, as different age cohorts work their way through the population, they may have residual effects on the

demand for travel at various points in time.

“This topic was of particular interest because cohort effects have begun to take on increasing significance in policy debates, as speculation about the location and travel preferences of the Millennial generation informs proposals for various types of urban development and transportation policy,” says Michael Iacono, research fellow in the Department of Civil, Environmental, and Geo-Engineering (CEGE) and the report’s primary author.

The analysis yielded a number of interesting demographic findings. Older birth cohorts tended to have lower overall trip rates, and these rates have been falling over time. (The Met Council’s MetroStats report predicts that the age 65-and-older population will more than double by 2040.) “With larger segments of the population reaching retirement age, it will be worthwhile

to understand how they adjust their behavior as they age,” Iacono says.

In addition, there is a broader trend of declining trip rates across most cohorts during the past two decades. The most recent cohorts (1964 to 1973 and more recent) also seem to have lower trip rates across virtually all survey years, he says.

So, are the attitudes of the Millennial generation having an impact on declining trip rates? “This generation is still fairly young, and so we have little evidence on which to draw firm conclusions about their preferences relating to location and travel choices,” Iacono says. “Considering that many members of this group will soon be reaching their peak travel years, it will be important to stay abreast of their behavioral tendencies.”

Another key finding, Iacono notes, is that higher fuel prices had a significant effect on travel. “The roughly \$2 per gallon increase in fuel prices accounted for nearly all of the reduction in trip rates between 2001 and 2011—about 0.5 trips per day.”

This research is part of an extensive new five-part report sponsored by the Metropolitan Council and the Minnesota Department of Transportation based on the rich set of data produced by the council’s Travel Behavior Inventory household travel survey. David Levinson, RP Braun/CTS Chair in CECE, is the study’s principal investigator.

Additional components of the report examine how changing accessibility of destinations has affected travel behavior, changes in walking and biking, the effect of transit quality of service on people’s activity choices and time allocation, and transportation system changes.

Improving merging safety on freeway ramps with V2V technology

Merging onto a freeway can be a stressful experience for drivers, especially when weather conditions or complex road infrastructure result in poor visibility. If a driver on an entrance ramp can't clearly see the vehicles traveling on the freeway, it can be difficult to merge safely.

Researchers at the University of Minnesota Duluth (UMD) are investigating the use of dedicated short-range communications (DSRC) technology to make merging from freeway entrance ramps easier and safer for drivers. The team is using DSRC-based vehicle-to-vehicle (V2V) communications to collect real-time vehicle trajectories in these merging situations—a first step toward providing merge-assist information to drivers.

The project is being led by UMD electrical engineering professor M. Imran Hayee and funded by the Roadway Safety Institute.

The technology works by enabling vehicles equipped with DSRC devices to communicate important details about their location, direction of travel, and speed to each other. Using that information, the system developed by the research team calculates the relative trajectories of the vehicles in real time. Eventually, these trajectories will be used to predict the optimal time and trajectory for the vehicle attempting to merge.

"The information and technology developed in this project could pave the way for providing merge assistance to drivers on the merging ramp," says Hayee.



"It could also help facilitate automatic merging of vehicles when the DSRC market penetration reaches necessary levels."

So far, the researchers have developed software for transmitting and receiving vehicle information using the two DSRC devices, and they are working on making the technology usable across multiple devices. They have also conducted an initial round of field tests using two DSRC-equipped vehicles on regular streets and freeways to test the system's accuracy.

Initial results were promising, Hayee says, indicating that the system is capable of producing the lane-level accuracy needed for future implementation of this project.

Going forward, the team plans to continue refining communication protocol and to conduct additional field tests on freeways. These field tests will include at least three vehicles, allowing the researchers to test the system's ability to collect trajectories of vehicles in multiple lanes at the same time.



Minnesota LTAP provides hands-on maintenance training

The Minnesota Roadway Maintenance Training and Demo Day, an annual offering from the Minnesota Local Technical Assistance Program (LTAP), was held this year in Rosemount on May 13. In classroom sessions and outdoor demonstrations, 200 students learned about gravel road maintenance, cargo securement requirements, and much more. Minnesota LTAP is housed within CTS.

Bridge abutments protected from river scour using new strategy

Research at the University of Minnesota's Saint Anthony Falls Laboratory (SAFL) has revealed a promising way to protect spill-through bridge abutments while reducing project costs.

Spill-through abutments are used frequently in Minnesota's waterway bridges, says Jeff Marr, principal investigator and associate director of engineering and facilities at SAFL. Abutments are the vertical substructures at bridge ends; spill-through (open) abutments, which only partially retain the embankment soil, need protection from river erosion and scour.

Riprap cover—rock or other material—is often used to protect the side slopes of spill-through abutments. Obtaining large enough stone, however, can dramatically increase project construction costs in some regions of the state. "The results of our study show that using smaller stones and applying the techniques associated with partially grouted riprap allows protection of the abutments from river scour and can likely reduce the costs associated with bringing in large pieces of riprap," Marr says.

In addition, he says, this method of riprap installation may provide greater protection for bridge abutments: laboratory testing showed that, for the same size stone, the strength of partially grouted riprap was more than three times greater than conventional riprap.



Photo: SAFL

Partially grouted riprap, or matrix riprap, is installed by placing conventional riprap material and then "welding" contact points with a specialized grout mixture. The grout covers and penetrates the riprap and bonds neighboring stones together, forming a "matrix" armor layer that serves to protect the structure.

The MnDOT-sponsored study was conducted in several phases, including site visits and observation of matrix riprap installation, laboratory experiments to evaluate matrix riprap

application and installation, experiments to test matrix riprap on a prototype abutment, and hydraulic experiments focused on measuring matrix riprap strength.

"The results of our study can be used to support the use of matrix riprap in place of larger stone on bridge abutments, providing valuable savings for transportation organizations while delivering results that are as good as, or better than, other abutment-protection measures," Marr says.



Photo: SAFL

Using a grouted riprap can reduce costs and provide protection from scour.

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Helping bicycle riders avoid crashes with collision-prediction warning systems



Just nine months into the project, researchers have taken a Schwinn bicycle equipped with the new warning system out for tests on the U of M campus—and seen promising results. Preliminary experiments have shown that the sensor suite on the bicycle can accurately estimate vehicle position and orientation for scenarios involving vehicles approaching cyclists from behind and vehicles turning right at intersections.

“If our final results demonstrate that the system works reliably and performs effectively, it could be commercialized into an inexpensive product sold to bicycle riders,” Rajamani says. “In addition, the technology we’re developing has the potential to be extended to motorcycles and pedestrians in the future.”

More than 48,000 bicycle–motorist crashes happen each year in the United States. Many of these crashes occur because either the driver does not see the bicyclist or the bicyclist behaves in an unpredictable manner.

In recent years, manufacturers have begun equipping many new motor vehicles with collision-prediction systems that warn motorists of possible collisions and help them take actions to avoid a crash. Now, researchers at the Roadway Safety Institute are investigating the use of similar technology on bicycles to predict impending crashes and warn both riders and drivers.

“In this project, we are working to develop a sensor system for a bicycle that can predict imminent bicycle–motorist crashes and provide an audio warning of the bicycle’s presence to nearby drivers by sounding a loud horn,” says Rajesh Rajamani, professor of mechanical engineering at the University of Minnesota and the lead investigator on the project.

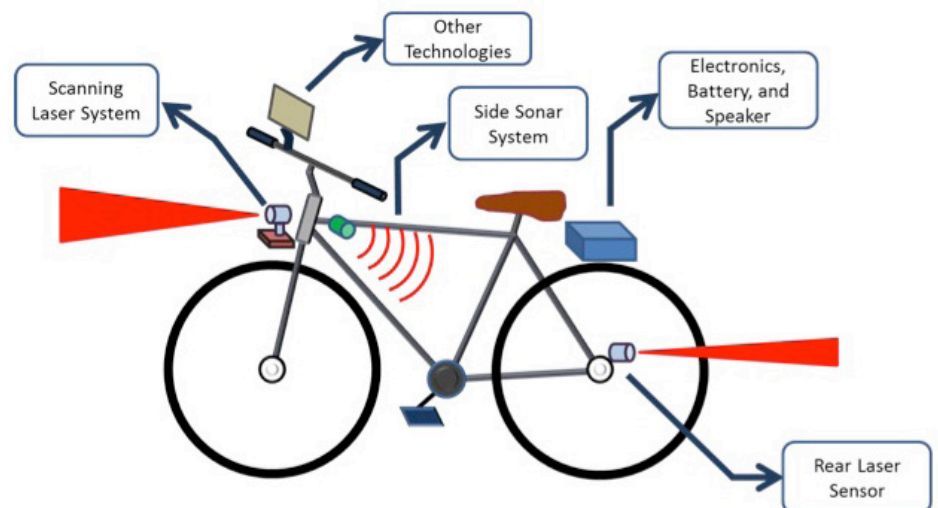
The warning system focuses on predicting two of the most common types of bicycle–motorist crashes: rear-end collisions on urban roads in which the vehicle is approaching the bicyclist from behind and collisions at traffic intersections.

Rajamani and doctoral student Woongsun Jeon are currently developing a sensor system and collision-prediction

algorithm and testing the algorithm in simulation studies. The researchers have also built an instrumented bicycle with sensors, electronics, and a small computer for evaluation.

“This project is unique in many ways,” Rajamani says. “Previous projects on vehicle tracking have been developed only for cars and have mostly focused on highway scenarios. This is perhaps the first research project where tracking of vehicles at a traffic intersection has been developed and also the first project for a bicycle collision-warning system that goes beyond rear or straight-frontal collisions.”

In 2013, there were
862
**BICYCLE-
MOTORIST**
**CRASHES IN
MINNESOTA.**



The instrumented bicycle includes laser and sonar systems, electronics, and a small computer for evaluation.



Local roads from page 1

says Jerry Zhao, an associate professor with the University of Minnesota Humphrey School of Public Affairs.

Local agencies in particular need a way to demonstrate the value of transportation investment by showing its impact on economic development. To accomplish this goal, Zhao led a research project to quantify the relationship between transportation investment and economic development, represented by the effect of investment on a county's property tax base.

Researchers began by examining county-level transportation financial data from several sources, and then analyzing data about property tax capacity, levies, and revenues to quantify the benefits while controlling for unrelated factors that would affect tax revenues. Next, they applied the model to calculate the impact of both local road and trunk highway investment on the property tax values of the county and its neighboring counties.

According to the research findings, long-term accumulated investments in both local roads and trunk highways have positive returns—though the two types of roads affect regions differently, Zhao says. On average, \$1 of local road investment within a county increases total assessed property value by \$1.25 for the county. However, while the overall impact of these investments is still positive, they can have a negative impact on the property values of neighboring counties as the result of inter-local competition.

On the other hand, trunk highways yield a somewhat lower return on investment for the county where they are made but generate significant benefit spillovers to neighboring counties, he says. On average, trunk highway investments produce about \$3 in assessed property values in the region for every \$1 invested.

“There’s been an understanding for years that investment in roads and bridges pays by facilitating economic development, serving citizens, and promoting safety,” says Alan Forsberg, an engineer in Blue Earth County, Minnesota. “This study provides objective data that shows that investment does in fact pay.”

The results of this research are statewide averages, but the benefits of investment for individual projects may vary. “While our research shows that trunk highways generally have greater regional benefits than local roads, individual projects will still need to be assessed for their specific impacts,” Zhao says. “For example, some local roads function more like trunk highways in the way they connect communities. This research shows that roads with the most regional significance provide the greatest benefits.”

The project was sponsored by the Minnesota Local Road Research Board. Researchers believe the results of the project will provide a valuable tool for local agencies and the Minnesota Department of Transportation to use in communicating the economic value of transportation investments and gaining support for these investments from elected officials and the general public.

On average,
TRUNK HIGHWAY INVESTMENTS
 produce about
\$3 in assessed property values
 in a region for every **\$1** invested.

Ramp metering from page 1

According to MnDOT, the system is operating better because of changes implemented approximately one year ago based on results of a 2012 MnDOT-sponsored study by U of M researchers.

Led by Eil Kwon, a professor of civil engineering at the University of Minnesota Duluth, the study included the development of new software algorithms for the ramp-metering system.

Under the old system, the criteria for ramp meters to turn on were easily met, causing them to turn on too soon. In addition, the old system had no turn-off criteria; once activated, the meters would run until a pre-set time of day.

The system upgrade included improvements to the turn-on criteria, so meters come on only when needed. In addition, turn-off criteria were added, allowing meters to shut off when traffic conditions improve. As a result, the new metering system is particularly effective at reducing the number of meters operating on light traffic days.

“On days like the ones leading up to Thanksgiving, where traffic may be 10 to 15 percent less than normal, instead of, say, 150 ramp meters being on at a particular time, now maybe only 50 ramp meters will be operating,” explains MnDOT freeway system operations engineer Jesse Larson.

The upgraded ramp-metering system also allows for a better picture of what traffic is like at a given moment, because it’s now based on corridor density rather than traffic flow.

Using traffic flow—the number of vehicles passing a given point—was flawed because similar traffic flows can occur at different speeds. For example, the old system couldn’t differentiate between 1,000 cars passing by at 20 miles per hour versus 60 miles per hour.



Photo: David Gonzalez, MnDOT

Corridor density, on the other hand, is the number of vehicles per lane per mile. By measuring density instead of traffic flow, the system can more accurately detect current conditions on the freeway.

Another benefit: ramp meters no longer release a group of cars simultaneously once an entrance ramp fills up. The system can now detect the ramp filling up and releases the extra cars gradually instead.

Following the implementation of the new system, a U of M team led by Kwon conducted a case study of Highway 100 to evaluate the benefits of the upgrade. Results show that the delay on the mainline dropped by nearly half after the metering changes were implemented.

On northbound Highway 100, the amount of “delayed vehicle hours”—vehicle hours of traffic flow with speeds less than 45 mph—that motorists experienced dropped 48 percent during October and November of 2012 (compared to the same period in 2011). During that time, total volume on that section of northbound Highway 100

increased by 2.7 percent, Kwon says. In spring 2013, the amount of delayed vehicle hours had been reduced by 17 percent.

These results are preliminary, and additional analysis is needed to determine if these results are typical throughout the system on other freeway corridors. However, based on a savings of \$16.50 per hour per motorist, this scenario represents a total cost savings for all motorists of \$1,353 to \$3,447 per day (depending on the season). That’s as much as \$339,150 to \$861,640 per year for just a six-mile stretch of highway.

(Adapted from an article published on the joint CTS/MnDOT Crossroads blog.)

There are approximately

440

RAMP METERS

around the

TWIN CITIES.

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**INVESTMENTS IN LOCAL ROADS
 and trunk highways show
 POSITIVE RETURNS.**

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TRIP RATES
 change among different
AGE COHORTS?

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A new system could make
MERGING
 onto the freeway
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**Ramp-metering upgrade
 reduces delays on Twin Cities' freeways.**

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