University of Minnesota

CENTER FOR TRANSPORTATION STUDIES

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CTS Catalyst

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Accelerating the pace of transportation innovation

Research examines drivers' mental workload to improve safety for left-turning buses

In the United States between 1999 and 2005, more than 40 percent of all pedestrian fatalities occurred as a result of collisions with transit buses. The risk of collision is highest for buses making left turns, which are four times more likely to collide with pedestrians than buses passing straight through an intersection.

According to researchers from the HumanFIRST Program at the Intelligent Transportation Systems (ITS) Institute, left turns are more dangerous because of the increased mental workload experienced by bus drivers during the turning maneuver. By conducting an in-depth analysis of

***Bus** continued on page 7*

Estimating winter road recovery time with traffic data

In Minnesota, the most common measure for snow management performance is "time to bare pavement," or the time it takes to completely clear a roadway after a snow event ends. Currently, the Minnesota Department of Transportation (MnDOT) relies on visual inspections by its field crews to estimate this bare pavement recovery time.

To help MnDOT more accurately and reliably estimate the performance of its snow management activities, researchers from the University of Minnesota Duluth (UMD) have developed a prototype process that uses traffic data to help determine the roadway recovery time.

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New energy sources mean big changes for freight industry

The rise of new energy sources is having a seismic impact on Upper Midwest transportation networks and goods movement, according to speakers at the 16th Annual Freight and Logistics Symposium in December.

The advent of hydraulic fracturing—or fracking—techniques has transformed shale deposits such as the Bakken area in North Dakota from marginal sources of hydrocarbon fuel to global game changers, said Robert Henry, vice president of operations with Dakota Plains Holdings Inc. Since much of the Bakken oil is destined for the East Coast, where there are no crude oil pipelines, rail has emerged as the preferred transport mode. "Today, pipelines take 39 percent of the oil to market, with 51 percent going on rail. A year ago, 67 percent of crude went by pipeline and a measly 17 percent by rail," Henry explained.

The Bakken boom has created significant challenges for the rail industry, including a lack of tank-car availability. "The current order backlog for tank cars extends to the second quarter of 2014," Henry said. "This tight market has also led to tank-car lease rates four to five times higher than any other rail car."

Shale-related traffic also is having a major impact on county highways and local roads. Fracking a shale oil well requires approximately 1,150 one-way truck trips to bring in—and then remove and relocate—thousands of tons of sand and millions of gallons of water and chemical solvents, explained Jack Olson, Planning and Asset Management Division assistant director with the North Dakota DOT. Thanks to the surging economy, the state has money available for road infrastructure improvements. "We're looking at $500 million a year in roads in North Dakota above the levels at which we used to fund them," he said.

Other speakers discussed the increased use of natural gas as a freight transportation fuel. In January 2012, Clean Energy Fuels Corporation announced it would build 70 liquefied natural gas fueling stations across the country, said Don Horning, vice president of sales, and the firm has plans for another 80 stations in 2013. "We're looking at stations every 250 to 300 miles on the major interstates."

The Kwik Trip Inc. convenience store chain plans to have 30 compressed natural gas (CNG) stations up and running in Wisconsin, Iowa, and Minnesota by the end of this year, said Joel Hirshboek, superintendent of transportation operations. Kwik Trip fuels a portion of its own fleet vehicles with CNG, Hirshboek said, adding that the company does not plan to purchase any more diesel equipment in the future. "So far we've displaced more than 78,000 gallons of diesel," he said.

Other symposium topics included frac sand mining in Wisconsin, energy-related cargo (such as wind turbine components) at the Port of Duluth-Superior, and efforts to "green" shipping using alternative fuels. Summaries of the presentations are in the symposium proceedings, online at **cts.umn.edu/Events/Freight**.

The symposium is sponsored by CTS in cooperation with MnDOT, the Minnesota Freight Advisory Committee, the Council of Supply Chain Management Professionals Twin Cities Roundtable, the Metropolitan Council, and the Transportation Club.

U.S. rails carried about

200,000

TANK-CAR LOADS OF CRUDE OIL

last year, up from

9,500

in 2008, according to the Association of American Railroads.

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Researcher aims to turn wood waste into diesel fuel

Rising oil prices and the need for energy security have sparked interest in biofuels. David Kittelson, a mechanical engineering professor and CTS Scholar, is working with international partners on a promising option: biodiesel fuel from wood waste.

Kittelson's research team is developing an efficient, clean, potentially carbon-neutral substitute for diesel fuel known as DME, short for dimethyl ether. Though usually refined from fossil fuels, DME can also be produced from biological sources. As such, it is more efficient than nearly all other biofuels and produces about 10 times the energy it takes to make.

DME has other advantages as well. It's a known commodity with properties nearly identical to propane, which is already used in vehicle engines. DME has high power output in a modified diesel engine while burning with no soot and producing very little pollution of any kind. That solves one of diesel's bugaboos—emission of hazardous fine particles that must be captured with expensive exhaust filters.

Kittelson's partners include GM, Volvo (one of the world's largest manufacturers of truck engines), Chemrec (a Swedish biorefining company), and the Institute on the Environment's Initiative for Renewable Energy and the Environment at the U of M. "They're betting on DME as a future diesel fuel," Kittelson says.

Already the project has launched several patent applications on new-generation fuel systems, Kittelson says.

Kittelson's lab is examining the economics and life-cycle greenhouse gas emissions of producing DME from a wood waste known as black liquor at a northern Minnesota pulp plant, then using the fuel as a substitute for conventional diesel. Such production is already underway in Sweden. DME from Minnesota mills could meet up to 10 percent of the state's diesel fuel needs, Kittelson estimates.

Kittelson and colleagues are also trying to produce a better DME engine from state-of-the-art diesel engines donated by GM. One of Kittelson's students, David Bennett, is leading work on a new generation of fuel injection to work with either propane or DME. (Bennett received a Matthew J. Huber Award from CTS in 2012 for outstanding academic achievement.) "We've got this fantastic combination here of somebody who can develop both fuel systems," Kittelson says.

More about Kittelson's work is on the CTS research page.

(Article by Greg Breining; edited and reprinted with permission of the Institute on the Environment: environment.umn.edu.)

U of M offers new sustainable transportation course

Sustainability is becoming the driving force for thousands of new jobs in many fields, including transportation. To secure these jobs, students need an education that can help them become leaders in developing and maintaining sustainable practices. This semester, the U of M's Humphrey School of Public Affairs began offering a new course in sustainable transportation.

The purpose of the graduate-level course is to explore concepts of sustainability in the movement of people and goods in cities, and to learn techniques, best practices, and methods for planning and implementing interventions that improve the social, economic, and environmental sustainability of communities.

"We have many students interested in sustainability and bike/pedestrian issues, so this course is a way to respond to that interest," says Carissa Schively Slotterback, associate professor and director of the Master of Urban and Regional Planning (MURP) program in the Humphrey School and a CTS Scholar.

"If we're able to get sufficient enrollment, it's possible that we could offer this course at least every other year," Schively Slotterback says.

The instructor for the new course is Antonio Rosell, a MURP graduate and adjunct professor in the Humphrey School. He also is founder and principal of Community Design Group, LLC, a local planning, policy, and design consulting firm.

Rosell provides more information about the course:

What is sustainable transportation?

"Sustainable transportation refers to the range of measures, methods, and practices for facilitating mobility within our cities and landscapes while

***Course** continued on page 5*

App turns smartphone into driving coach—and rewards good behavior

Most drivers could use a little help to keep their eyes on the road and drive more safely. DriveScribe, a mobile and web app that uses technology developed at the U of M, turns a smartphone into a personal safe driving coach and lets users track their performance—and earn points they can redeem at popular retailers.

DriveScribe was commercialized by Minneapolis-based Drive Power LLC using research from the Intelligent Transportation Systems (ITS) Institute (a part of CTS) and is now being brought to market and operated by Augeo, a nationally recognized engagement and loyalty firm. Consumers can download the app for free—something thousands of users have done since the product's launch last June.

People are

23 TIMES

MORE LIKELY TO CRASH IF THEY TEXT WHILE DRIVING.

"I tend to text while driving. I know I need to be a smarter driver, and DriveScribe can help me be one."
—Rachel D., student

DriveScribe blocks calls, e-mails, and text messages while the vehicle is in operation. It also provides automated real-time feedback to drivers, telling them they're speeding or braking too hard, for example, or warning of potential problems such as a sharp curve ahead.

DriveScribe keeps track of performance so drivers can see how they performed and how they can do better. A comprehensive web dashboard provides stats such as weekly and lifetime driving scores, allowing users to compare and compete through social media. Drivers earn points each time they use the app and can cash them in to get free gift cards and discounts at retailers like Amazon.com and Sports Authority.

"The ability to take the very device that is distracting most teen drivers and turn it into something that not only coaches them but offers a path to rewards is a game changer," says David Kristal, CEO of Augeo. "While the app limits distractions and monitors performance, it also guides and encourages users to drive more safely by rewarding smart driving."

Augeo and Drive Power have developed a customizable version of DriveScribe that can be used by consumers and organizations to reduce insurance liabilities; it can also be deployed to manage commercial fleets. Augeo is implementing a pilot program with Saudi Aramco (one of the world's largest oil companies) and partnering with GMAC Insurance to enhance numerous customer offerings.

The technology was developed by U of M mechanical engineering department researchers Alec Gorjestani, Arvind Menon, Eddie Arpin, Craig Shankwitz, Janet Creaser, Michael Manser, and Max Donath. The research was funded by the Minnesota Department of Transportation and the ITS Institute.

For more about the app, see **DriveScribe.com.**

***Winter** from page 1*

The process uses data on traffic speed, flow, and density collected by loop detectors in the Twin Cities metro area to estimate the point at which traffic patterns return to normal—an indicator that the roadway surface has "recovered."

The project, led by UMD civil engineering professor Eil Kwon and sponsored by MnDOT, began with an evaluation of common traffic patterns during a snow event. Findings indicate that drivers travel below the speed limit during a snow event until the roadway has recovered enough to comfortably increase speed to normal levels.

The team also identified two common speed recovery patterns following a snow event. In the first pattern, speed recovery is affected only by road condition, meaning that traffic gradually returns to free-flow conditions as the road is cleared. In the second, recovery is affected by both road condition and traffic flow. In this case, speed may not reach the posted limit even with a completely clear roadway because of "normal" heavy traffic conditions (e.g., during rush hour).

For each of the two patterns, the researchers developed an automatic process that identifies specific points at which traffic speed changes during winter maintenance activities, indicating changes in the condition of the road surface. The last significant change before speed returns to normal is defined as the "road condition recovered" point.

To test the prototype process, the researchers used data from two snow-removal routes collected during the 2011–2012 season in the Twin Cities. Results from four different snow events show that the process was able to successfully identify speed changes and estimate road condition recovery points.

In the second phase of the project, currently under way, the researchers are refining the prototype so it can more accurately identify traffic flow recovery patterns under various conditions.

Improving safety with alternative snowplow lighting designs

Traveling in snowy conditions can be dangerous for drivers, especially when following a snowplow.

Although white snow is different in hue from a snowplow's bright orange paint, the two colors are similar in luminance, or brightness. According to researchers at the University of Minnesota Duluth (UMD), this "low-luminance contrast" can make it difficult for drivers to perceive distance and detect motion—and ultimately lead to rear-end collisions.

To help improve safety on winter roadways, the UMD research team has been testing alternative lighting configurations for the backs of snowplows. The team's goal was to develop a configuration that increases drivers' ability to detect a plow's movements in low-visibility conditions.

The team, which included computer science associate professor Peter Willemsen and professor Albert Yonas, used a previously developed snow simulation system to conduct the study. The system displays millions of snow particles in a realistic environment and accurately reproduces the effects of wind, light, and other factors on falling snow. It also includes a three-dimensional model of a snowplow and a roadway.

Using the simulation system, the researchers conducted a series of experiments comparing several lighting options, focusing on designs that could be practically applied to real-world plows. In the simulated environment, participants were placed behind a snowplow and asked to identify when the plow was moving toward or away from them.

Findings indicate that accentuating the plow truck's frame with vertical bars of non-flashing lights helped drivers detect changes in motion more quickly. Flanking each bar of light with dense black bars to maximize contrast improved driver reaction time even more.

During the 2010–2011 winter season, there were

72 COLLISIONS

involving vehicles and MnDOT plows.

The recommended design features vertical bars of light flanked by dense black material to maximize contrast with the plow's paint.

Test results show that the average participant reaction time was 1.76 seconds for the recommended design, compared to 1.91 seconds for the standard lighting configuration currently in use.

Ideally, the researchers say, the light bars would be bright, LED-based fixtures on the exterior of the plow truck's bed. For optimal results, the black material surrounding the lights should be heated to reduce snow and ice buildup.

This research was the third and final phase of a study sponsored by the Intelligent Transportation Systems Institute.

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minimizing costs—including economic, social, and environmental impacts," Rosell says. "These measures have the potential to bring about important benefits for our communities, including more connected and convivial cities and public spaces, more efficient land-use patterns, and improvements in the general health of our populations through greater use of active transportation. Walking and biking, for example, are two modes of sustainable active transportation that require virtually no additional energy inputs and that can be used to get us to our daily destinations."

What does the course include?

"This course is about learning from examples and tools from other cities to make our cities better places to live—by making our modes of mobility within them more efficient and sustainable," Rosell says. "Many cities in Europe, for example, rely on bicycling for transportation to an extent that we in the U.S. can't even comprehend. Bus rapid transit systems in Latin America and Asia are being planned and implemented virtually overnight and are moving hundreds of thousands of people from day one."

How can potential students learn more?

"If students want to start on their own, one of the texts we'll be using—and a great manual—is the *Model Design Manual for Living Streets*, online at **modelstreetdesignmanual.com**," Rosell says.

Minnesota grad, technology featured at national meetings

Recent University of Minnesota graduate Saif Jabari received the Milton Pikarsky Memorial Award from the Council of University Transportation Centers in January. Presented in Washington, D.C., the prestigious award recognizes students for their accomplishments in transportation research and education. Jabari, who was advised by civil engineering associate professor Henry Liu, was honored for his Ph.D. dissertation: "A Stochastic Model of Macroscopic Traffic Flow: Theoretical Foundations."

During his doctoral study, Jabari received the 2010 Outstanding Student of the Year Award from the Intelligent Transportation Systems (ITS) Institute. His research was supported by the Minnesota Department of Transportation, CTS, and the ITS Institute and contributed to the development of the SMART Signal system, which traffic engineers can use to reduce congestion on roads controlled by traffic lights.

Jabari now is a post-doctoral researcher in the Business Analytics and Mathematical Sciences Department at the IBM Thomas J. Watson Research Center in New York.

"Through my master's-level research while at the University of Minnesota, I gained hands-on experience working with large traffic networks, which is something I have to deal with on a daily basis at IBM," Jabari says. "My doctoral research was closely related to real-time traffic estimation, which is the main theme of my current work. In general, my research experience at the University of Minnesota and the coursework I had have enabled me to hit the ground running with my current position at IBM."

SMART Signal was one of the deployment success stories featured at this year's Transportation Research Board (TRB) annual meeting, also in January in Washington, D.C.. A video about SMART Signal was shown at the TRB Video Theater supporting the spotlight theme: "Deploying Transportation Research: Doing Things Smarter, Better, Faster." The video, created by the ITS Institute, is online at **its.umn.edu**.

Liu led the research team that developed SMART signal, which has been deployed at more than 30 intersections in Minnesota and 6 in Pasadena, California. It has been commercialized by startup SMART Signal Technologies Inc.

The TRB meeting attracted 11,700 transportation professionals from around the world. CTS and the ITS Institute funded 21 students to attend the meeting.

U of M researchers presented more than

35 PAPERS

at the TRB conference on topics ranging from

PAVEMENT DESIGN TO ROUNDABOUT SAFETY TO TRANSIT CORRIDORS.

Laurie McGinnis, Saif Jabari, Henry Liu, and Max Donath

CTS WINTER LUNCHEON:

MAPPING THE WAY TO A BETTER DRIVING EXPERIENCE

February 28, Minneapolis | Details and registration: cts.umn.edu/Events

Jane MacFarlane, head of research location and commerce with Nokia, will discuss what's needed to leverage GPS navigation devices and in-vehicle sensors to better understand driver behavior.

NEW RESEARCH REPORTS

Recently published reports on transportation-related research at the University of Minnesota explore:

GPS POSITIONING PERFORMANCE AND SENSOR AIDING
(CTS 13-01)

INSTRUMENTING A NAVISTAR TRUCK FOR DATA COLLECTION
(MnDOT 2013-01)

DETECTING DEER TO REDUCE COLLISIONS WITH VEHICLES
(CTS 13-06)

Research reports are available at **cts.umn.edu/Publications/ResearchReports**.

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the tasks completed by bus drivers, the research team aims to identify countermeasures to reduce bus–pedestrian collisions. The project was sponsored by the ITS Institute.

Led by HumanFIRST director Mike Manser and research associate Ensar Becic, the research team created a detailed list of everything bus drivers do when making a left turn. To compile the list, the team conducted several interviews with bus drivers and trainers from Metro Transit.

Tasks identified by drivers included both tangible, observable behaviors—such as changing lanes or completing the turn—and internal tasks such as determining the status of the traffic signal or deciding how much time is needed to merge successfully. The researchers then classified the identified tasks into five categories—visual, working memory, executive, motor, or unplanned—to better understand the different types of demands placed on drivers.

The research team also divided the left-turn process into six separate stages, beginning with intersection approach and ending with the post-turn exit of the intersection. They then created a chart illustrating the specific tasks performed by drivers in each segment of the intersection, allowing them to see exactly how much drivers were doing and where.

Results show that drivers have the highest mental workload when entering the intersection and when completing the turning maneuver. During those times, drivers must complete many tasks in all five categories—while also attempting to detect and avoid collisions with pedestrians.

Identifying driver tasks in this stage-by-stage analysis was the most valuable aspect of the study for Metro Transit, according to Steve McLaird, assistant director of garage operations.

"It confirmed that there was an overload concerning the brain's ability to process information," McLaird says. "Knowing that, the message we want to get to bus operators is that you cannot be distracted by conversation, radio use, or looking at pieces of paper at that point in time. You have to be fully concentrated on making that turn and observing your surroundings."

Metro Transit also plans to use the task analysis results to evaluate its standard operating procedures and review training materials. The process will include an internal group of safety, instruction, and operations personnel.

"Can we take a second look and rethink the mechanics of making a left turn? Or we might identify tasks we can remove from a driver's workload," McLaird says.

The ultimate goal is to find ways to improve safety, heighten driver awareness, and reduce the likelihood of all types of collisions.

In the United States,

ONE PEDESTRIAN FATALITY OCCURS EVERY TWO HOURS, AND

24 PERCENT

OF THESE FATALITIES OCCUR AT INTERSECTIONS.

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TRAFFIC DATA

could help MnDOT estimate the time it takes to **CLEAR A WINTER ROADWAY.**

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Improving safety in intersections by examining the mental workload of bus drivers.

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