

CTS Catalyst

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Accelerating the pace of transportation innovation

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Smartphone app collects detailed data about travel behavior

Transportation agencies need travel behavior data to plan changes to their networks, systems, and policies. A new smartphone application developed by a University of Minnesota research team makes it easier and less costly to collect this important information and provides richer, more accurate data than traditional methods.

The Daynamica open-source app provides an efficient approach for collecting and processing detailed data regardless of travel mode—driving or walking, biking or taking transit. It combines

Daynamica continued on page 7

Unmanned aircraft systems could help monitor traffic, infrastructure

Recently, unmanned aircraft systems (UAS) have been making headlines for their wide-ranging applications—from aerial photography to package delivery for major retailers—and for their accompanying regulatory, safety, and privacy concerns.

In an October 15 Roadway Safety Institute seminar, Associate Professor Demoz Gebre-Egziabher of the U of M's aerospace engineering and mechanics department reviewed some UAS-related opportunities and challenges. He also reviewed some of the UAS research being conducted at the U of M's Uninhabited Aerial Vehicle (UAV) Laboratories.

UAS continued on page 6



National Freight Economy Atlas illustrates freight flows

Freight rail has a profound effect on the economic vitality and competitiveness of Minnesota and, in particular, some of its most important industries. To better understand freight flows and foster the growth of freight infrastructure, U of M researchers are creating a new online platform—the National Freight Economy Atlas.

The project is a combined effort of the U's Transportation Policy and Economic Competitiveness Program (TPEC), Esri (a geographic information systems company), and the Center for Information Systems and Technology at Claremont Graduate University. Additional funding for the project was provided by BNSF Railway.

"The project is dedicated to analyzing the connections between freight movement and industry cluster development," says Lee Munnich, TPEC senior fellow at the Humphrey School of Public Affairs. The atlas allows users to analyze the freight infrastructure at the national, regional, state, and metropolitan/combined statistical areas.

"One of our goals for this project

and for other recent work has been to reach out to a variety of stakeholders in the freight and rail industries," says TPEC visiting research scholar Tom Horan, also a professor at Claremont Graduate University. "We want to engage Minnesota's transportation policy community in understanding how to leverage the dynamics of freight rail to add value to the state's economy and transportation planning."

The atlas incorporates data from the US Census 2012 Commodity Flows Survey, the Federal Highway Administration Freight Analysis Network, and the Bureau of Economic Affairs.

"We use unique methodological approaches to analyze the freight infrastructure," Horan says. "In particular, we incorporate the use of the location quotient to better understand commodity movements between regions."

The location quotient (LQ) is an economic formula used to compare various regional attributes to the national average. It can quantify how concentrated a particular industry or

cluster is and reveal what distinguishes a particular region. "Using this formula, our research team developed an LQ for freight flows," he says.

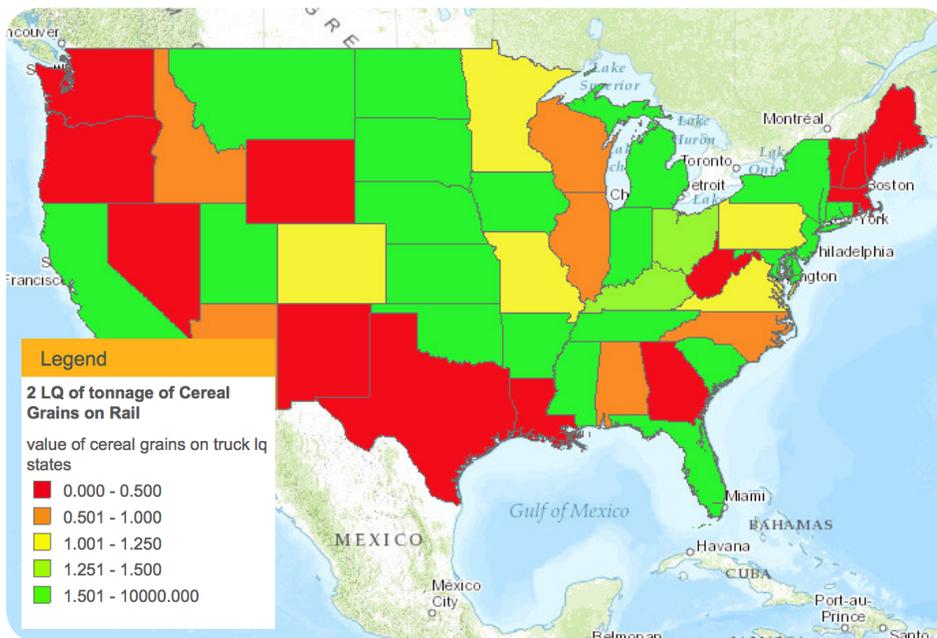
The atlas displays information in a series of interactive maps. National and regional maps provide detailed analysis of freight and economic clusters. These interactive applications allow users to maneuver between different regions, pick various attributes to display, and adjust to different levels of data.

Industry cluster maps provide freight economy information geared to specific characteristics of industry clusters, such as cereal grains or base metals. "For example, users can see the proportion of cereal grains sent on rail compared with the national average," Horan says.

Story maps provide insights into supply chains enhanced by freight transportation. "A story map is a strategy that uses a graphic organizer to help users provide a narrative of elements or a topic through a story," Horan explains. "Many different types of stories can be geographically organized and easily understood using the story map graphic organizer. One example on the atlas is a story map of the transport of agricultural products originating in Minnesota and distributed across the Great Northern Corridor."

Moving forward, the research team will assess public and private stakeholder uses of the atlas, including specialized analyses for planning, policy, and private-sector considerations. Other future directions are to host a forum on economic competitiveness and supply chains, conduct case studies of locally linked supply chains, and assess the value-added benefits of industry clusters to state and regional transportation planning and development, Horan says.

The atlas is located at freighteconomyatlas.org.



This map shows the proportion of cereal grains sent on rail compared to the national average.

Choosing cost-effective culverts **using service-life maps**



To allow water to flow beneath roads, engineers use culverts. Steel culverts, however, corrode over time, and their service lives depend on the properties of the soil that surrounds them.

To help engineers choose the appropriate steel pipe materials for culverts in different parts of the state, U of M researchers collected soil data and developed a series of steel pipe service-life maps for Minnesota. The project, funded by the Minnesota Local Road Research Board and the Minnesota Department of Transportation (MnDOT), will help agencies save on costs while developing longer-lasting infrastructure.

Two important soil properties affect steel culvert longevity: pH (a measure of the soil's acidity and corrosiveness) and

resistivity (a measure of how much the soil resists the flow of electricity, which is usually related to the cohesiveness of the soil but also to moisture and temperature).

"Because these and other soil properties vary significantly across Minnesota, engineers must select the appropriate type of steel pipe material for the expected environmental conditions," says Jeff Marr, associate director for engineering and facilities at the St. Anthony Falls Laboratory and the study's principal investigator.

Steel pipe differs in gage, or wall thickness, and in the coatings used to reduce corrosion (aluminum, zinc, or polymeric). While aluminum coating provides superior corrosion protection

compared to the zinc coating of galvanized pipes, Marr says, it is also more expensive—but may still be the most cost-effective choice.

Marr's team collected more than 560 soil resistivity and pH samples statewide during the summer of 2014. Roughly 50 to 90 sample sites were selected per MnDOT district, with samples taken from the embankments of state trunk and county highways. The researchers then used the data, along with other observations, to calculate the service-life estimates for different types of steel pipe.

"This project was eye-opening, showing that you can double the service lives of steel culverts just by changing the coating of the pipe at little extra expense," says Andrea Hendrickson, state hydraulic engineer with MnDOT's Office of Bridges and Structures.

MnDOT will use the results of this project to update its drainage manual and is sharing steel pipe service-life maps with MnDOT and county maintenance personnel.

(Adapted from MnDOT technical summary 2015-31TS.)

**READ
CATALYST
ONLINE**

for links to research reports and other resources.

DON'T FORGET TO REGISTER!

Freight and Logistics Symposium: Thinking Globally, Acting Locally

December 4 | Minneapolis

At this year's symposium, Adie Tomer, a fellow at the Brookings Institution Metropolitan Policy Program and a member of the Metropolitan Infrastructure Initiative, will give the keynote presentation on economic competitiveness and freight's metropolitan future. Tomer will use economic trends at the local and global scale to raise important questions that statewide and metropolitan leaders should be thinking about as they map their freight-related future.

The second portion of the symposium will feature a presentation and panel discussion on the implementation of Minnesota's new statewide freight plan and action agenda.

More information and registration: cts.umn.edu/events/freight/2015



New chair shares thoughts on Minnesota's transportation priorities



Jay Cowles, the co-chair of the Itasca Project Transportation Committee, became the chair of the CTS Executive Committee in August. The Itasca Project is an employer-led alliance that seeks to address regional economic issues that affect competitiveness and quality of life in the Twin Cities region. Previously, Cowles held several positions with Cowles Media Company.

Cowles succeeds Jeff Hamiel, chair of the Metropolitan Airports Commission, who stepped down as chair after four years of dedicated service.

Below, Cowles shares his thoughts on how transportation research can help address future priorities, support growth, and guide decision making. For an extended version of this Q&A, please visit the CTS website.

What transportation challenges do you think should be prioritized for Minnesota's success?

One of our challenges as a state is how best to provide transportation systems that support economic growth—specifically a 30 percent projected jump in freight traffic—and that allow flexible movement for

residents. This is a particular challenge when there are fiscal constraints and many competing demands for government investment.

More than ever, there is a need to understand the many dimensions of our transportation investments so we can be confident that our spending is achieving the greatest results for our businesses and communities. Commute time and congestion are familiar measures of efficiency, but trends toward denser downtowns, interest in more choices in transportation modes, significant growth in freight movement, and dynamic technology impacts all require careful and fact-based understandings of our transportation choices.

How can U of M research help leaders address these challenges?

The U of M is a critical partner to the state's leaders in providing timely, relevant research. For example, the groundbreaking Accessibility Observatory provides a compelling analysis of how transportation shapes real behavior. CTS enables a close partnership between the research resources at the U and the continually evolving needs of agencies such as MnDOT and Metro Transit, allowing them to adapt best practices with confidence. CTS also helps by reaching creatively and effectively across disciplines to better address the complex issues facing our communities.

How can the U of M and the private sector collaborate to improve transportation?

The University has developed a strong reputation for independent credible research and is invaluable in providing reliable facts and insights to the community. This is especially important to business leaders as they contemplate making their own investments in buildings and facilities. They need

to know that the transportation infrastructure they are relying on will perform, that their employees and customers can get to stores, offices, and facilities easily, and that their goods and services can be delivered efficiently in a timely manner.

What role does the Executive Committee play in guiding and advancing the CTS mission?

The members of the Executive Committee come from many industry and agency sectors, and each person brings unique contributions. We regularly inform CTS and one another about the latest transportation-related ideas, successes, and concerns occurring in our diverse worlds. We also work to connect the U of M with emerging thought leaders, prospective research sponsors, and key transportation decision makers. By learning from research presentations and participating in events honoring outstanding students and researchers, members also show their personal support for the value of student and faculty work.

In recent months, the CTS Executive Committee welcomed six new members:

- Nicole Griensewic Mickelson, Executive Director, Region Nine Development Commission
- Arlene Kocher, Minnesota Division Administrator, Federal Highway Administration
- Matt Kramer, President, Saint Paul Area Chamber of Commerce
- Kjersti Monson, Director, Long-Range Planning, City of Minneapolis
- Dave Montebello, President and CEO, SRF Consulting Group Inc.
- Megan Selby, Global Business Director, 3M

State and Local Policy Program celebrates '25 Years and Change'

The Humphrey School of Public Affairs hosted a reception on October 2 to celebrate "25 Years and Change" of the State and Local Policy Program (SLPP). The event recognized the work of outgoing SLPP director Lee Munnich and welcomed incoming director Frank Douma.

"Since 1991, Lee has led SLPP with distinction and has played a critical role in advancing the quality of policy formulation and implementation for states and local communities," said Humphrey School dean Eric Schwartz. "The results of Lee's work include a greater appreciation for the ways that transportation contributes to the economic vitality of the state, new methods for measuring that contribution, and so much more. Perhaps most importantly, SLPP has become the key venue for important public discussions that lead to the implementation of policy innovations."

Laurie McGinnis, director of CTS, noted that "many successful collaborations have come out of the strong partnership between SLPP and CTS," including research in areas such as congestion pricing and outreach to policy leaders through forums and seminars. "Together we have established the U of M as a trusted resource for transportation policy issues," she said. "I look forward to what the future brings."

In his remarks, Munnich said SLPP research is having an impact now on the area's transportation systems—MnPASS is one example—and will continue to do so over time. "Ultimately," he added, "the real change SLPP made over the years is



Frank Douma, Lee Munnich, and Laurie McGinnis

through the students in our program. By latest count, 192 graduates have worked as research assistants over the years. This is the change that may be most important."

Munnich will continue his research on policy innovations through the Transportation Policy and Economic Growth program (tpec.umn.edu) during a phased retirement.

Munnich will be succeeded by Frank Douma, currently SLPP's associate director. An alumnus of the Humphrey School, Douma has been an "important public voice on transportation policy issues, particularly as they relate to innovations in technology," Schwartz said. Also trained as an attorney, Douma has been engaged in the MnDOT Telework Program, is one of the leading national experts on the legal issues related to self-driving cars, and has played a key role in

keeping issues related to transportation safety and equity as part of the policy dialogue. Douma will also take on the role of coordinator of the Master of Urban and Regional Planning degree program at the Humphrey School.

"I'm excited to build on the SLPP legacy and build new relationships," Douma said. "I'm pleased that Lee will continue his work in economic development and transportation finance, which will continue to be the cornerstones of SLPP's work. But I also look forward to collaborating with faculty and research staff at the Humphrey and other parts of the University to develop new research programs in transportation and planning policy."



Reminder: Submit a Research Partnership Award nomination

There's still time to submit a nomination for the 2016 Research Partnership Award. The award honors research projects within the CTS program that have resulted in significant impacts on transportation. The award will be presented at the CTS annual awards ceremony in April 2016.

The submission deadline is December 18. For more information or to submit a nomination, please visit cts.umn.edu/about/awards/rpa.

Gebre-Egziabher focused on small UAS—systems with aircraft that weigh less than 50 pounds and fly slower than 100 mph and lower than 500 feet.

“There are all kinds of envisioned applications for UAS,” Gebre-Egziabher said. “They’re particularly being envisioned for use in what are called the three Ds—or the dangerous, the dirty, and the dull activities.”

These applications could include flight testing, environmental monitoring, and—in the transportation industry—traffic and infrastructure monitoring activities, such as inspecting bridges and railways.

“Most everyone is convinced that there’s great economic benefit in using UAS in infrastructure surveillance and management,” Gebre-Egziabher said.

atrocious side,” Gebre-Egziabher said. “This is partly because a lot of the hardware that goes into these small UAS comes from the hobbyist or remote-control aircraft community. They were never intended to be reliable, industrial-grade systems.”

But the primary issue, according to Gebre-Egziabher, is that almost all on-board control systems of UAS rely heavily on GPS.

“Whenever there is a denial, a stressing, or a spoofing of GPS, bad things happen,” Gebre-Egziabher said. Position, velocity, and attitude (orientation) measurements can all be negatively affected if a GPS signal fails.

“So, if you’re operating next to a large metallic structure like a bridge that’s reflecting or blocking GPS signals,

be particularly relevant for bridge-inspecting UAS. This project tested a fleet of seven vehicles, with two of them operating beneath a bridge without access to a GPS signal.

Findings showed that this network configuration could help keep positioning errors in check for several minutes of operation, which would work well in situations where vehicles are traveling in and out of GPS signals for short periods of time. However, the networking system would be less effective if the GPS signal loss was prolonged.

“The bottom line is that there won’t be one silver bullet,” Gebre-Egziabher said. “The best solution will have to depend on the UAS application.”

The U of M isn’t alone in exploring the use of UAS for infrastructure monitoring. The Minnesota Department of Transportation (MnDOT) recently conducted its own project investigating the feasibility of using UAS to inspect Minnesota bridges. The project and its findings were outlined in a recent post on the CTS/MnDOT *Crossroads* blog.

“[The project gave] us an idea of what a drone could provide, what the limitations were, and what features we would like to see on newly available UAV models,” said Jennifer Zink, MnDOT bridge inspection engineer.

A second phase of the project is set to begin before the end of the year. If the project is successful, the future use of UAS could potentially decrease MnDOT’s costs and increase bridge inspection abilities, Zink said. “It could improve inspection data collection for local agencies as well.”



Photo: Collins Engineers

MnDOT is one agency investigating the potential use of UAS for bridge inspection.

For example, small UAS can be equipped with cameras and used to inspect bridges, improving efficiency and safety for inspectors and reducing the need for specialized inspection equipment. They could also be used to inspect other hard-to-access infrastructure, such as railway tracks in remote areas.

However, cautioned Gebre-Egziabher, many technical issues must be addressed to make the widespread use of UAS in these situations safer and more reliable.

“Right now, reliability is on the

you’re going to start getting degraded performance,” he said.

Therefore, the challenge is to develop a back-up system that allows UAS to continue operating in these situations. Potential solutions include vision- or camera-based navigation systems and cooperative or networked navigation, in which a group of vehicles working together could exchange information to maintain positioning accuracy even in the absence of GPS.

Researchers at the U of M’s UAV Laboratories have conducted research on the latter solution, which could

The FAA estimates that
7,500
SMALL COMMERCIAL
UAS
will be operating by
2018.

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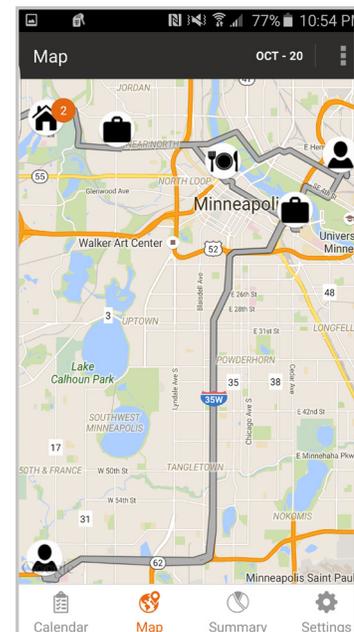
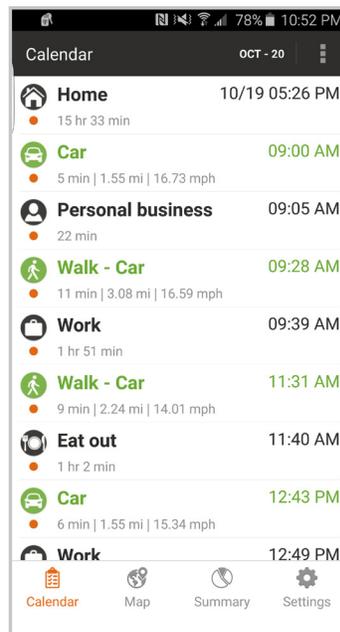
smartphone GPS sensing with advanced statistical and machine-learning techniques to automatically detect, identify, and summarize attributes of daily activity and travel episodes. The app then allows users to view and annotate information at their convenience.

In contrast, traditional travel survey methods—commonly, paper diaries—are often burdensome to study subjects and increasingly impractical for use, says Yingling Fan, associate professor in the Humphrey School of Public Affairs and the principal investigator for the work.

And while GPS sensing tools can collect data about travel mode, position, and route, they are unable to obtain key dimensions such as trip purpose, travel experience, and travel companionship. “All of these factors are critical for understanding people’s travel choices,” Fan says. “Daynamica gives us the best of both worlds: It captures many more dimensions of travel behavior data than either GPS sensing or travel surveys can alone.”

Daynamica places a much lower burden on users to recall and record their activities compared with traditional surveys, resulting in more accurate and detailed data. Lower user burden could also allow agencies to lengthen the time studied. “Many traditional surveys track only a single day,” Fan says. “It would be better to collect a whole week of data to see how travel varies between weekdays and weekends. We could also look at seasonal variations and other factors. The more data, the better.”

Unlike other apps, Daynamica hosts both the data obtained from sensors and the data entered by users in a single device and enables interaction between the two data sources in real time. This



The app can display travel behavior data in calendar and map formats.

in turn allows for data calibration and processing refinements over time. “The algorithm learns from past mistakes,” Fan explains. “As it gets smarter, users need to make fewer corrections. After about a week of use, most data collection is automated. It learns what your location is—home, job, day care, or grocery store, for example—and remembers it.”

Daynamica offers several other advantages, Fan says. It is easier to distribute and manage than other technologies because it does not involve providing additional devices or instruments to respondents if they already own a smartphone. Users only need to download the Daynamica app and install it on their phone, and updates can be provided to users quickly and easily. In addition, Daynamica collects data in a way that reduces the need for post-processing, she says, saving time and expense for agencies.

Although currently targeted for

agency use only, plans are to form a start-up company to commercialize the app for the general public, says Chris Ghre, technology strategy manager at the U of M’s Office for Technology Commercialization.

Daynamica was developed by a multidisciplinary team including Fan, Assistant Professor Julian Wolfson (School of Public Health), Professor Gediminas Adomavicius (Carlson School of Management), and computer science students Yash Khandelwal and Jie Kang. Daynamica expands on the previous SmarTrAC app developed by the team under contract with the Volpe Center at the U.S. Department of Transportation in support of the Intelligent Transportation Systems Joint Program Office. Funding was also provided by CTS.

More information will be available soon on a new website: daynamica.umn.edu.

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