2021-08TS
Published April 2021

DEPARTMENT OF TRANSPORTATION

OFFICE OF RESEARCH & INNOVATION

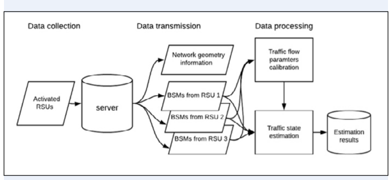
TECHNICAL SUMMARY

Questions?
Contact research.dot@state.mn.us.

Technical Liaison:
Ray Starr, MnDOT
Ray.Starr@state.mn.us

Investigators:
Michael Levin, John Hourdos and Melissa Duhn, University of Minnesota

PROJECT COST:
$249,994



Using BSMs for traffic management will require infrastructure that can manage data collection, transmission and processing.

MnDOT Prepares to Use Future Vehicle-to-Vehicle Data Streams

What Was the Need?

Vehicle manufacturers are developing vehicles that will "talk" to each other to avoid crashes. By broadcasting basic safety messages (BSMs), vehicles will be able to convey their position, speed and acceleration. Sending these messages to other vehicles and to relevant infrastructure should enhance highway safety. As more vehicles with this capability travel Minnesota's roadways, MnDOT's Regional Transportation Management Center (RTMC) could potentially acquire significantly more reliable data for traffic operations.

Messaging from connected vehicles could provide more reliable real-time data for use in traffic operations. Researchers combined real traffic data with microsimulation models of expected basic safety messages from connected vehicles to develop a new methodology for managing traffic.

The RTMC oversees systems that control nearly a million vehicles daily in the Twin Cities area. It uses data from loop detectors in pavement, freeway cameras, radar detectors and other sources to determine estimated traffic states and make traffic operation decisions. However, loop detectors can fail and cameras can be obscured, making it difficult to measure traffic density. Better real-time traffic data would allow the RTMC to improve traffic flow, enhancing safety and saving money.

While it may be a decade before vehicle-to-vehicle BSMs are common on roadways, MnDOT wanted to learn how it could prepare for and use this messaging for traffic management before connected vehicles become the norm.

What Was Our Goal?

This project's primary objective was to use BSMs within a model to create a traffic state estimator that could provide traffic measurements at high resolution. The overall goal was to provide MnDOT with tools and methodology to use BSMs for traffic management as soon as they are available and minimize the transition time required to shift to a data system based on connected vehicles.

What Did We Do?

Data sources and methodologies for traffic state estimation have changed with the rapid evolution of communications technologies. Researchers initially conducted a literature search of recent publications to examine methods of traffic state estimation.

Using raw data from the Minnesota Traffic Observatory, researchers translated hundreds of thousands of vehicle trajectories from I-94 in downtown Minneapolis to emulate BSMs. With this extensive library of traffic conditions, researchers developed a traffic state estimation algorithm using a Kalman filter technique that combines information from a prediction model and real-world measurement, which is more accurate than using a model or measures alone. The cell transmission model was used with speed measures extracted from BSMs and data from loop detectors. This type of model divides a target road section into short segments, or cells—the basic unit for this project's traffic state estimator. The output is the density, speed and exiting flow of each cell.

Researchers used several test data sets, including other computer models and radar data, to evaluate how accurately the traffic state estimator generated estimated density, speed, flow, travel times and queue lengths. They also conducted analyses that predicted the filter's sensitivity as increasingly more BSM-equipped vehicles use the roadway (from 20% to 100% market penetration).

continued

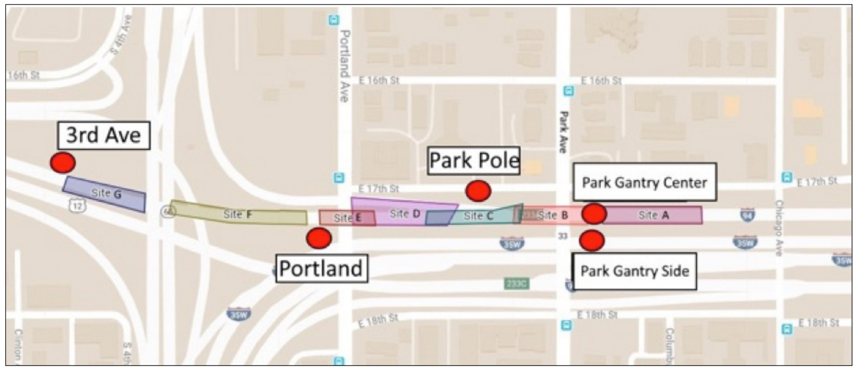
"This project helped us understand how we might use messaging from connected vehicles to improve our estimates of travel times and other traffic measures."

—Ray Starr,
Assistant State Traffic Engineer, MnDOT Office of Traffic Engineering

"We developed and tested a novel methodology for using basic safety message transmissions from connected vehicles to estimate the traffic state, which could be used to augment or replace current sensors used for traffic controls and traffic information displays."

—Michael Levin,
Assistant Professor, University of Minnesota Department of Civil, Environment and Geo-Engineering

Produced by CTC & Associates for:
Minnesota Department of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research



The new traffic state estimator was evaluated on a section of I-94 in Minneapolis. This map shows the location of radar sensors (red circles) and the area monitored by each device (overlapping colored rectangles).

To understand the computing power this system would require, researchers constructed a traffic monitoring system that consisted of robust data collection, transmission and processing modules. Finally, researchers determined the kind of infrastructure the traffic state estimator would require in the field and the benefits MnDOT would gain from using the system.

What Was the Result?

A traffic state estimator based upon selected BSMs is within reach for MnDOT. The literature search revealed that the Kalman filter used for this project is widely accepted as more accurate than predictive models or direct measures alone, and that cell transmission models are widely used.

Researchers were able to scale up their model to represent a 20% to 100% presence of BSM vehicles on Minnesota roadways. The evaluations of the project's traffic state estimator results compared to other traffic models, radar data and actual roadway situations were very promising. The project also showed where further improvements could be made. Most important, researchers presented a workable methodology and steps the agency can take to make full use of data from connected vehicles.

They also identified infrastructure additions that would be required to use a BSM-based traffic state estimator for traffic management. These additions include many roadside units to collect BSM data and robust computing power to quickly run the appropriate algorithms on an ever-increasing rush of real-time data. RTMC would be able to translate this new data to improve traffic operations wherever the new system could be implemented.

What's Next?

The project showed proof of concept and generated much useful data and questions for the future. MnDOT does not have current plans for further research in this area but will consider the results of this as well as national research such as NCHRP 03-137, Algorithms to Convert Basic Safety Messages Into Traffic Measures, in future planning.

This Technical Summary pertains to Report 2021-08, "Generating Traffic Information From Connected Vehicle V2V Basic Safety Messages," published April 2021. The full report can be accessed at mndot.gov/research/reports/2021/202108.pdf.