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DEPARTMENT OF TRANSPORTATION

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TECHNICAL SUMMARY

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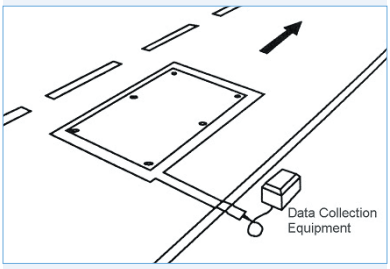
PROJECT COST:
$106,500



The NCRT system uses traffic flow data from loop detectors embedded in Minnesota highways.

Developing a Road Condition Recovery Time Estimation System for Snow Events

Researchers are developing a system that uses highway loop detector traffic flow and weather data to determine when road conditions have recovered from a snow event. The system will relieve snowplow drivers of the burden of estimating when roads are back to normal and will increase overall fleet efficiency.

What Was the Need?

After a snowfall, snowplow operators clear highways until traffic can resume normal speeds. Snowplow operators have been responsible for estimating how much plowing is needed, based on their observations as they clear the roads. But visual observation is a subjective and imperfect assessment of road conditions and puts an extra burden on operators as they work in often-hazardous conditions.

Highway loop detectors have been used for decades in Minnesota to measure traffic flow. Installed every half mile on freeways in the Twin Cities metro area, loop detectors collect traffic data every 30 seconds. Two previous MnDOT research projects looked at using data from loop detectors along with weather station data to develop an automated system that determines normal condition regain time (NCRT) based on changes in traffic flow. This system would improve the accuracy of road condition improvement estimates by giving dispatchers a "big picture" view of traffic flow so they can quickly shift plows to problem areas.

The first study established the feasibility of such a system; the second study produced a computer model using data from the highway detectors combined with historical traffic and weather data, and successfully tested it against road condition recovery time estimates from maintenance personnel. Further work was needed to transform the model into a user-friendly, integrated computer system and to test it again on several Minnesota highways during snowstorms.

What Was Our Goal?

The ongoing objective of this research has been to develop a system that could estimate NCRT at the detector stations on metro highways for a given snow event. The goal has been to match or exceed the accuracy of the time to bare pavement estimates of field crews. This phase of the project included two additional goals:

- Transform the computer model into an integrated system.
- Determine a data-derived definition of normal traffic flow for snow-cleared roadways.

What Did We Do?

Researchers closely examined traffic flow data from just-plowed roads to learn how speed-density patterns on roads that were cleared but still wet compared to speed-density patterns on dry roads. They looked for data patterns indicating that traffic flow had returned to stable speed-density relationships, which show generally shifted-down patterns of those under dry weather conditions at the same locations. Findings from previous study results were used to develop the design architecture for the overall NCRT estimation system:

- A data management module loads and integrates all data from other modules: traffic flow, freeway geometry, detector location and weather data.

continued

"This is a shift to different criteria. The bare lane regain time is now based on judgments from plow operators on the highways and phone calls to dispatchers. We could use the new system to quickly direct trucks to harder-hit areas within and between stations as they are needed."

—John Bieniek,
Maintenance Operations Engineer, MnDOT Metro District

"The system developed in this research can provide consistent and objective estimates of the normal condition regain time by utilizing the traffic flow data that are currently available from the existing detection systems in the metro area."

—Eil Kwon,
Professor, University of Minnesota Duluth Department of Civil Engineering

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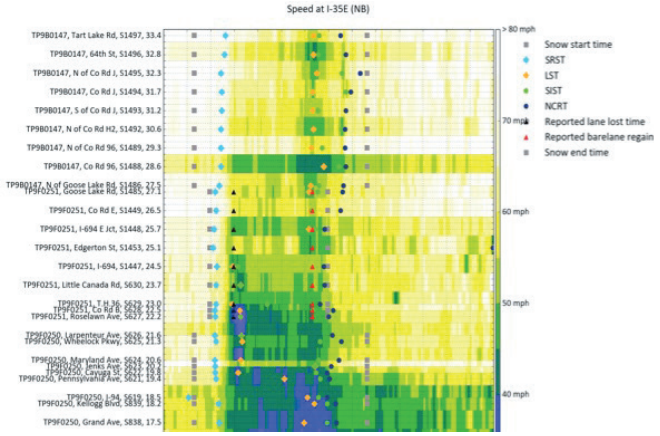

This speed contour map generated by the NCRT system shows the start of a snow event (gray squares), changes in traffic speed flow and reported bare lane regain times on I-35E northbound. Greater density of traffic appears in green and blue: Traffic speed on many roads was 40 mph or below soon after the snow began.

- A module for target detector station identification and speed recovery function first identifies a set of detectors with a record of both uncongested and congested traffic speed-density data under dry-day conditions. The data is then used to calibrate the normal-day speed-recovery function in a speed-density plane at each target detector station. Finally, the normal-day speed-recovery function is used to determine wet-normal speed-density patterns for each target station for a given snow event.
- An NCRT estimation module determines the NCRT at each target station using the wet-normal speed-density pattern generated in the previous module for a given snow event. It also identifies traffic flow phase change points, such as the point of speed reduction and the point of speed recovery.
- A map-based user-interface module allows the dispatcher to generate the estimated NCRT for an area. Dispatchers and supervisors can also use it to assess traffic flow variations, assign plows and generate reports for past snow events.

The system was tested on data gathered from two sections of Minnesota Interstate 494 (I-494) and I-694 during two snow events in 2015 and 2016.

What Did We Learn?

The integrated computer system generated NCRTs that met or exceeded the accuracy of maintenance personnel estimates. Like the results of the computer model, however, the results of this system were not generated in real time.

Working toward their second objective, researchers sought to redefine normal traffic condition with explicit data. They learned that traffic resumed a free flow after roads were cleared, but always slightly slower than dry-normal free-flow speed. They developed a process to determine the wet-normal free-flow speed at each detector station based upon the traffic flow pattern during a given snow event.

The system successfully produced accurate NCRTs with data from two snow events in 2015 and 2016.

What's Next?

The system works with past snow event data: Using traffic and weather data, it matches or exceeds the accuracy of observers in estimating time to normal traffic flow. However, its results come as post-event analyses. Research has been initiated that will incorporate big data tools to allow the system to operate in real time—as storms happen—to improve roadway snow operations.

This Technical Summary pertains to Report 2018-01, "Development of a Road Condition Recovery Time Estimation System for Winter Storm Events," published January 2018. The full report can be accessed at mndot.gov/research/reports/2018/201801.pdf.