Improving Weigh-in-Motion Sensor Accuracy Between Calibrations

What Was the Need?
Weigh-in-motion sensors have been widely used in Minnesota to weigh and classify vehicles. Accurate data about the types of vehicles that travel on a given road is valuable for design purposes, allowing MnDOT to save money by designing pavements more precisely for their desired life span. This information is also important as a screening tool to identify vehicles that might exceed vehicle weight restrictions, which helps to protect pavements and bridges from unnecessary damage.

WIM sensors lose accuracy over time, however, because of weather, pavement conditions, plowing, the impact of vehicles driving over the pavement and other factors. Calibrating the sensors requires a fully loaded truck at the MnROAD testing facility to drive over a sensor several times at a precise speed. Because of the time and expense required, MnDOT calibrates its sensors only twice a year.

As part of an ongoing effort to improve its data quality, MnDOT wanted a way to identify when a WIM sensor’s calibration drifts.

What Was Our Goal?
The objective of this research was to develop a quality control methodology that can compare WIM data at any given time to data from the same sensor immediately after it has been calibrated to identify when the sensor has lost accuracy.

What Did We Implement?
This project implements principles from the ITS Institute Report CTS 12-26, Traffic Data Quality Verification and Sensor Calibration for Weigh-In-Motion (WIM) Systems, which evaluated methodologies for identifying when a sensor drifts out of calibration based on the data it collects.

How Did We Do It?
Researchers developed a methodology for using a cumulative sum (CUSUM) chart to analyze WIM measurements. CUSUM is a common quality-control method for identifying data that varies from benchmark values. In a WIM context, CUSUM can identify instances where the data reported by a WIM sensor varies greatly from the learning data set—the data collected immediately after the sensor is calibrated. The learning data set serves as baseline data so that later variances from this data may indicate that the sensor has drifted out of calibration.

Researchers developed an analysis tool in Microsoft Visual Studio. After extracting heavy vehicle data, MnDOT can load a sensor’s learning data set into the software and then months of later data from that sensor. The tool will evaluate that data and determine if it suggests that the sensor is generating biased and inaccurate measurements.
What Was the Impact?

MnDOT is currently implementing the analysis tool. Based on CUSUM analysis done so far, researchers found some sensors in Minnesota that were off by more than 10 percent between calibrations.

Full implementation is anticipated within three to six months and will require installation of the software, which requires use of a Microsoft .NET Framework and open-source R statistical software. File configurations also need to be set up, and the analysis needs to be incorporated into MnDOT’s workflow.

One particularly valuable impact will be the ability to identify and address sensors that develop problems before the end of MnDOT’s normal construction season. If a sensor develops a fault in late autumn, after construction season ends, then MnDOT usually cannot replace or repair it until spring. Without the analysis tool, the sensor could collect several months of inaccurate data before MnDOT discovers the fault.

What’s Next?

The software should help MnDOT identify and address issues with its WIM sensor system performance as quickly as possible by either calibrating with the MnROAD truck or using another source of static and dynamic weight data. MnDOT plans to continue implementing the analysis tool and using it to monitor the WIM sensor data it collects, which will feed into efforts to improve pavement design.

MnDOT will work with the state patrol to better use WIM sensor data as a screening tool for enforcing vehicle weight restrictions. MnDOT is also asking the state patrol to share data when it pulls trucks over and collects static weights, which may be used to help calibrate and verify the analysis tool.

A recently initiated research project has installed WIM sensors from two manufacturers at MnROAD to monitor them for 10 years or until their failure. MnDOT will compare the quality of their weight data and their service life to determine which has a lower lifecycle cost and better overall value.