New Technology and Existing Equipment Improve Statewide Vehicle Classification Counting Process

What Was the Need?
Knowing the volumes and types of vehicles that roads carry is imperative to MnDOT for many reasons, such as planning for transportation infrastructure needs, anticipating demand and congestion, and applying for federal funding among others. Minnesota has historically used several methods to count and classify traffic in its 13-vehicle classification system.

MnDOT manages 24 weigh-in-motion recorders that capture weight and vehicle classification, but these systems are expensive. Over 60 automatic traffic recorders (ATRs)—operated with traditional induction loop detectors or piezoelectric sensors—collect volume and some classification information, depending on the equipment. Additionally, over 300 sites on mainline roadways use loop detectors to collect traffic volumes. With the limited number of permanent devices collecting classification data, the agency spends significant funding, time and effort on other shorter-term methods to gather the needed information.

Previously, MnDOT explored some promising traffic classification technology used in California and several other states. An inductive loop signature-based classification system pairs existing ATR equipment with signature cards that use computational firmware to produce unique electronic signatures or footprints for different classes of vehicles. The results in the previous research were mixed, however, so MnDOT wanted to further explore the technology.

What Was Our Goal?
Leveraging findings from the previous study and using existing loop detectors, MnDOT sought to refine loop signature technology to improve the process of collecting vehicle classification data at signals, freeways and ATRs on Minnesota's roadways.

What Did We Do?
Researchers first reviewed literature from other efforts to use inductive loop equipment for vehicle classification. Then, building on their previous research, they worked with the equipment vendor to upgrade the firmware on the signature detector cards to include more vehicle templates and an updated decision tree to boost classification performance.

Researchers installed the loop signature system in an ATR on U.S. Highway 169. After four months of data collection at that site, they moved the system to a permanent location on U.S. Highway 52 south of Coates, Minnesota, which has a higher volume of heavy commercial vehicles than the first site.

The classification system in each location was accompanied by a solar-powered video data collection system to validate the results from the loop signature technology. The research team manually observed each vehicle on a week's worth of video data from each site and compared it to the data from the system being tested.
Electronic signatures, or loops, can identify the classification of a vehicle, as in this Class 10 truck.

Following this data collection, the research team made refinements to the loop classification system and reevaluated vehicle classification accuracy by collecting two days of additional video data. The most significant refinement was an update to the vehicle class library, the component of the system that identifies the vehicle class. From the initial loop system and video data collection, researchers added the electronic signatures of 2,000 vehicles to the library.

**What Did We Learn?**

Researchers analyzed 10,837 vehicle loop signatures in this project. From the previous research, changing system parameters and improving the resolution of the tool have yielded a significant improvement.

Overall, the system accurately classified vehicle types 96% of the time. Some vehicle classes were more accurately identified than others:

- Cars (Class 2): 99%.
- Pickup trucks and vans (Class 3): 92.5%.
- Two-axle single-unit trucks (Class 5): 86.8%.
- Three-axle single-unit trucks (Class 6): 51.6%.
- Five-axle semitrucks (Class 9): 85.9%.

Some misclassifications occurred, for example, when pickup trucks were pulling trailers. Larger trucks were also misclassified, particularly Class 6 trucks (which were identified as Class 5) and Class 9 trucks (which were classified as Class 8 or 10). Many of the misidentified trucks have retractable or lift axles.

While the overall accuracy applies to all the vehicles in the data sets, certain vehicle classes did not have large enough sample sizes to draw conclusions on those classes individually:

- Buses and pickup trucks with trailers (Class 4).
- Four or more axle single-unit trucks (Class 7).
- Three- and four-axle semitrucks (Class 8).
- Six or more axle and twin trailer semitrucks (Classes 10-13).

**What’s Next?**

Given the promise of this project’s results, MnDOT plans an implementation project to install loop signature classification systems in many ATR locations where there is already inductive loop equipment. Additional data will improve the accuracy of classification by adding more signature profiles—particularly for heavy commercial vehicles—to the classification library.

Ultimately, MnDOT intends a multiphase or multiyear implementation program to incorporate the systems into all existing loop ATR stations based on a prioritized list of locations where classification data is most needed to support planning and operations.