Getting The Most From Your Continuous Classification Data

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There are a number of areas that must be addressed in order to obtain the best continuous vehicle classification data possible. These issues include site selection, installation, the classification algorithm used by the classifier, the reliability of the sensors and classifier, data edit checking, knowledge of local conditions and what to do when problems arise. This paper will look at how the Wisconsin Department of Transportation addresses these issues and our experiences with continuous vehicle classification data.

WisDOT Classification Resources

The Wisconsin Department of Transportation (WisDOT) currently has 43 stations where continuous vehicle classification data is collected. These sites range from two to six lanes, and all lanes at a site are instrumented.

The typical WisDOT site layout is two inductance loops with a piezoelectric axle sensor between them. A few sites use two piezoelectric axle sensors with one, or no, inductance loop between them. We have also recently installed an IDRIS system that classifies using a special loop configuration.

Inductance loops are six feet square, and most piezos are six feet long, although some are up to 11 feet. The sensor lead-ins run through PVC conduit to pull boxes and then to a cabinet.

The cabinet contains a traffic classifier, a modem and telephone connection with lightning protection. At most sites a solar panel is mounted to power the classifier and modem.

Each station is automatically polled nightly from the central office to download the data. This process begins at 1:00 a.m., so that all of the stations will be downloaded by the time staff arrives in the morning.

How Classification Occurs

The first step in classifying a vehicle is to determine its speed. In the case of a loop-piezo-loop sensor configuration, this is done by dividing the distance between the leading edge of each loop by the difference between the activation times. The loops also are used to determine when the vehicle has left the station.

Axles are detected and counted by the piezo. The distance between consecutive axles is computed by dividing the vehicle speed by the time between axle detections.

Once the classifier has the number of axles and the axle spacings, it compares this information to the classification algorithm stored in its memory, and assigns the vehicle to the appropriate class.

Site Selection

When selecting the location for a continuous vehicle classification site, a straight and level pavement is desirable. This will be conducive to constant vehicle speed, which in turn leads to better classification. This is because the vehicle speed is determined when the vehicle first activates the loops. If the vehicle is accelerating, the time between successive axles will shorten, and therefore the computed axle spacings will be less than they actually are. This in turn could lead to a vehicle being misclassified. The same outcome can result if a vehicle decelerates as it passes over the site. In this situation, the computed axle spacings would be greater than they actually are. However, we have received good data from sites with some slope or curvature.

A smooth pavement is also desirable, since the shockwaves generated by a bouncing vehicle can generate false activations of the axle sensor.

Pavement cracking may also present a problem. If the pavement cracks around a sensor, the bond between the sensor and the pavement may weaken and the sensor may eventually come out of the pavement. We installed a six-lane station on USH 12/18 on the south side of Madison, a crack developed in the pavement and all six piezos were gone less than a year after the highway was opened to traffic.

The location should also have freely flowing traffic with speeds of 25 mph or more. Low speed or stop-and-go traffic can lead to tailgating and “trains” where the loops never lose presence and a single, many-axle vehicle is recorded instead of the actual stream of vehicles present at the site.

Installation

When installing sensors, follow the manufacturer's directions for the best results. Use an epoxy that you know works well for you. Be careful that the temperature of the epoxy as it hardens doesn’t melt the plastic on the piezo lead-in.

Once the sensors are in and connected to the classifier, calibrate the speed with a radar gun. Do not forget to calibrate the radar gun as well. Without good speed, you can not have good classification. Adjust the sensor spacing in the classifier, until the calculated speed and the recorded radar speed match. This must be done for each lane independently. Combining lanes during calibration can mask an undercounting lane (i.e., one that is missing axles) with one that overcounts (i.e., one that is getting “ghost” axles). If no radar gun is available, an alternative is to use a test vehicle with known axle spacings. In this case you would adjust the classifier until the calculated axle spacings matched the known axle spacings.

Ideally, the station should be recalibrated whenever equipment is replaced. At the very least, it should be recalibrated annually. We install most of our loops in PVC conduit to make them easier to work on, but this allows the wire to move slightly due to vibration in the road, temperature changes, etc. Also, different counters may act slightly differently due to different manufacturers’ components being used, or even different batches of components from the same manufacturer.

We keep a record of the calibration values in the cabinet so that they are readily available if the counter resets, or needs to be replaced.

Classification Algorithm

The Federal Highway Administration (FHWA) identifies 13 vehicle classifications. Almost all vehicles fit into one of these classifications. Exceptions to the classification scheme would include tracked vehicles (bulldozers) and some off-road vehicles (ATVs). Various parties have used these classifications to create vehicle classification algorithms based on the number of axles and their spacings.

However, these algorithms are not always sufficiently precise to classify all vehicles. For example, the default algorithm in the classifiers used by WisDOT does not account for five-axle, single-unit dump trucks or milk trucks. Depending on the exact spacings involved, the algorithm either calls one of these vehicles a three-axle semi being tailgated by a car, or it simply calls it “unclassified.”

Likewise, when the spread tandem axles first appeared on semi-trailers in Wisconsin, they were considered unclassified as well. These problems were corrected by revising the default algorithm to recognize these axle configurations.

Another unclassified vehicle type is the “one axle” vehicle that results when a lane change is made as a vehicle passes over the sensors. This can either be left as an unclassified vehicle, or the algorithm can be modified to consider it a car.

The sensors may be detecting accurately, and the classifier may be accurately recording the detections, but if the algorithm does not recognize the number and spacing of the axles, the vehicle will still be unclassified.

Hardware Reliability

An important component of accurate vehicle classification is accurate and reliable equipment. The sensor must generate a signal at the proper time only.

Extraneous piezo signals can lead to phantom axle recordings that result in the misclassification of the vehicle. This is why a smooth pavement is preferred.

Also, the classifier must accurately record and time stamp the sensor detections. Given the high speeds and small distances involved, even a small error in recording can lead to missed or improperly classified vehicles.

Another problem can occur with newer, more sensitive piezos. These sensors can generate a voltage so much greater than the voltage generated by previous sensors that it can interfere with the proper operation of the classifier. This may even result in the classifier resetting itself.

Data Edit Checking

Our traffic data processing software generates daily reports that are examined to see if problems exist. The system generates a warning or error message if the percentage of unclassified vehicles in a lane exceeds a preset threshold. WisDOT uses threshold values of six percent unclassified vehicles for a warning, and ten percent for an error message. Data that generates an error message is not used in generating monthly or annual reports or factors. A warning message can be overridden and the data used for additional reports and factors.

In addition to the messages generated by the system, the data is reviewed on a weekly basis to look for other problems that may exist. For example, a site may have zero percent unclassified vehicles, but if 100 percent of the vehicles are classified as cars, then you know there is a problem at the site. This is where a knowledge of local conditions becomes important.

Knowledge of Local Conditions

Sometimes while reviewing the data, a potential problem will be detected. For example, the number and percentage of motorcycles may increase dramatically or traffic volumes could increase greatly over what is expected. This could be a sign of a problem at the station, or it could be caused by a special event. Examples of special events are the annual Harley-Davidson rally in Milwaukee, Wisconsin, professional or college sporting events and the Experimental Aircraft Association Fly-In in Oshkosh, Wisconsin.

Highway construction, especially detours, may also lead to suspicious looking data. For example, a higher percentage of trucks may appear on bypass routes, while the percentage of trucks decreases on the route under construction.

The key to knowing whether you have bad data or a special event is a knowledge of local conditions. At WisDOT, we rely on the Transportation District offices to provide the central office with this information.

If a question with the data arises, the district office staff are contacted to see if they are aware of any special event, construction, weather or other condition that may have existed at the time the data was collected. If such a cause can be determined, then the data is considered valid because it reflects the actual conditions that existed on the highway.

Troubleshooting Problems

When a problem with the data is identified, a field technician needs to visit the site to determine the cause of the problem. Often the problem can be solved by the technician, but other times a repair crew will have to be sent to fix the problem.

The most common task of the repair crew is to replace one or more piezos at a site.

The life of a piezo can vary widely. We have a few that have been operational for nearly ten years, while others have failed in less than six months. Likewise, there are a wide variety of potential causes for piezo failure: the piezo element can break, the epoxy holding the piezo in place can fail, the connection between the piezo element and the lead-in cable can break, the lead-in can be chewed up by animals, etc. In addition, the problem may not be with the sensor, but with the classifier. The technician must be able to examine a problem site and determine which cause is present.

Prompt service is essential because of the limited memory capacity of the classifier. If communication with the site is not restored in a few days, newly collected data will begin to overwrite the oldest data files. At a two-lane station collecting volume, speed and classification data by lane, data is overwritten after five days; and at a four-lane station the data is overwritten after only two days. At six-lane sites we use a different type of counter with enough memory to store seven days of volume, speed and classification data plus weigh-in-motion data.

The Results

On June 1, 2000, WisDOT had 43 stations (144 lanes) collecting continuous vehicle classification data. Discounting stations where the data had not been processed or that were under construction, we had 39 stations (130 lanes) where we should have had data. Of that total we had data from 25 stations (76 lanes).

For those 25 stations (76 lanes):

- the average percentage of unclassified vehicles was 1.64%,
- the individual lanes ranged from zero to 30.29% unclassified vehicles,
- eight lanes had more than three percent unclassified vehicles, and
- four lanes had more than six percent unclassified vehicles.

Omitting one obviously bad station (4 lanes), the other 24 stations (72 lanes) had even better results:

- the average percentage of unclassified vehicles was 0.84%,
- the individual lanes ranged from zero to 10.19% unclassified vehicles,
- there were five lanes had more than three percent unclassified vehicles, and
- only one lane with more than six percent unclassified vehicles.

We are very pleased with these results. What we are not pleased about is that 14 stations (54 lanes) were missing data for June 1, 2000.

Of those 14 stations (54 lanes):

- six stations (20 lanes) were lost because a field technician hadn't been able to make a service call to determine and possibly fix a problem;
- four stations (18 lanes) were lost because the telephone connection wasn't restored before data was overwritten;
- two stations (8 lanes) were lost because piezos needed to be replaced; and
- two stations (8 lanes) were lost for unspecified reasons.

This lost data emphasizes the need to properly install, and promptly maintain and repair your continuous vehicle classification data collection stations.