Development of Congestion Factors for Adjusting Traffic Counts during Congested Periods: Phase 1 – Literature Review and Survey

Final Report

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by

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METRIC CONVERSION FACTORS

1 inch = 2.54 cm
1 mph = 1.609 km/h
1 pound = 0.4536 kg
Fahrenheit degrees = 9/5 x Celsius + 32
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16. Abstract
The inductive loop detectors (ILDs) have been used for many decades to monitor traffic on highways. They have proven to be highly reliable in collecting traffic volumes, traffic speeds, vehicle classes, and a slew of other important traffic variables. Traffic monitoring stations that utilize ILDs are generally installed at highway locations far away from congested areas characterized by slow speeds, tailgating, stop-and-go, as well as frequent lane changes. Despite DOT's best efforts to install traffic monitoring stations on free-flow highway sections, there are sites and occasions in which queues spill over to the ILD station, resulting in undercount of vehicles and misclassifications when congestion persists. The need for better quantification of traffic state and vehicle classification during congested periods is the motivating factor of this literature review and survey-based study.

The results of the literature review and survey showed that while states are in agreement that proper quantification of the number of vehicles and their classes in congested period is important, no state has undertaken efforts to develop congestion adjustment factors or to study the issue. As seen in the summary of the results of the states' survey, the majority of states, just like Florida, avoid installing traffic monitoring stations (that utilize ILDs) close to highway locations that are likely to experience congestion. The practice of avoiding the collection of traffic data in congested locations clearly represents a missed opportunity to properly characterize traffic on highway networks for the purposes of judicious planning and operations. Thus, efforts to study this issue and to conduct field evaluation of congestion factors development are timely and supported by both literature review and survey results.

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1. Purpose and Scope

Despite significant growth and improvement in alternative technologies for vehicular traffic detection over the last few decades, inductive loop detectors (ILDs) remain the most invested and deployed traffic sensing technology by practically all state departments of transportation. ILDs, when coupled with piezoelectric sensors in a specific setup, can capture many traffic flow parameters, including total traffic volume, speed, vehicle weight, vehicle length, occupancy, density, headways, and the number of vehicles belonging to a specific vehicle class. These traffic flow parameters are converted into data to be used by many stakeholders for planning, design, operation, and maintenance of the highway transportation system. Thus, accurate collection of traffic data by ILDs is of paramount importance for better decision making at various levels.

Unfortunately, the accuracy of the traffic data collected by ILDs declines during heavily congested periods characterized by stop-and-go traffic conditions and tailgating. During these periods, volume counts from loop detectors are known to underreport the actual volumes. In addition, the vehicle classification error rate goes up given that, in some situations, tailgating vehicles are combined with lead vehicles and thrown into a wrong category in the FHWA Vehicle Classification Scheme. The internal review by the Florida Department of Transportation's Transportation Data and Analytics (TDA) Office of the hourly counts collected from the continuous count sites suggests that there is need to quantify the degree of miscounts and misclassifications during congested periods and to develop congestion factors to improve the overall quality of the traffic data collected at the continuous and short-term traffic monitoring sites.

Consistent with the need to improve the quality of ILD data collected in congested periods, the major objective of Phase 1 of this project was to conduct a detailed search of both published and gray literature as well as to conduct a survey of state DOTs to solicit information on the state of art and the state of practice in traffic data collection using ILDs, particularly during congested periods. The end result was expected to be the discovery of innovative, yet practical, approaches in improving ILDs data collected in saturated traffic flow conditions.

2. Methodology and Report Setup

As mentioned in the preceding section, the determination of the state of art and state of practice in inductive loop detector data collection in congested traffic situations was to be realized through comprehensive literature review and survey of transportation professionals. This section summarizes the approach used in this study to perform literature review and to conduct a survey. The section also describes the overall organization of this report.

2.1 Literature Review

In conducting the literature search, important scientific research databases available to researchers were accessed, including *Scopus, IEEE Xplore, Web of Science (WoS), Google Scholar, TRID Database, WorldCat,* and *Wiley Online Library*. The majority of these databases was available through the FSU libraries (https://www.lib.fsu.edu), but some were accessed through other channels. Relevant keywords and phrases related to the title of the project were synthesized and used to extract and filter matching articles. The major keywords included inductive loop detectors, traffic detection, congestion monitoring, inductive loop signatures, traffic volume acquisition, traffic surveillance, highway automatic data collection systems, and vehicle classification. The review of literature targeted the most recent publications, i.e., published after year 2000, but as seen in the bibliography listing at the end of this report there were some very relevant research work related to inductive loop detectors that was undertaken prior to year 2000.

2.2 Survey

Appendix A shows the survey questionnaire that was synthesized and sent to traffic monitoring program managers and personnel to solicit information on ILDs data quality in congested situations. Both open-ended and closed-ended questions were used to allow for respondents to give insights on all aspects relevant to the main objective of this research study. Through web searches, a list of relevant personnel in all 50 states and the Federal Highway Administration (FHWA) was compiled as shown in Appendix B. The experts were contacted by email and asked to fill in the survey questionnaire that was administered online through Qualtrics licensed to the Florida State University (FSU). Follow up questions were synthesized and used to gather detailed information from those organizations that responded with promising material or where clarification was needed based on their initial survey response. Appendix C shows the summary of the survey results.

2.3 Organization of the Report

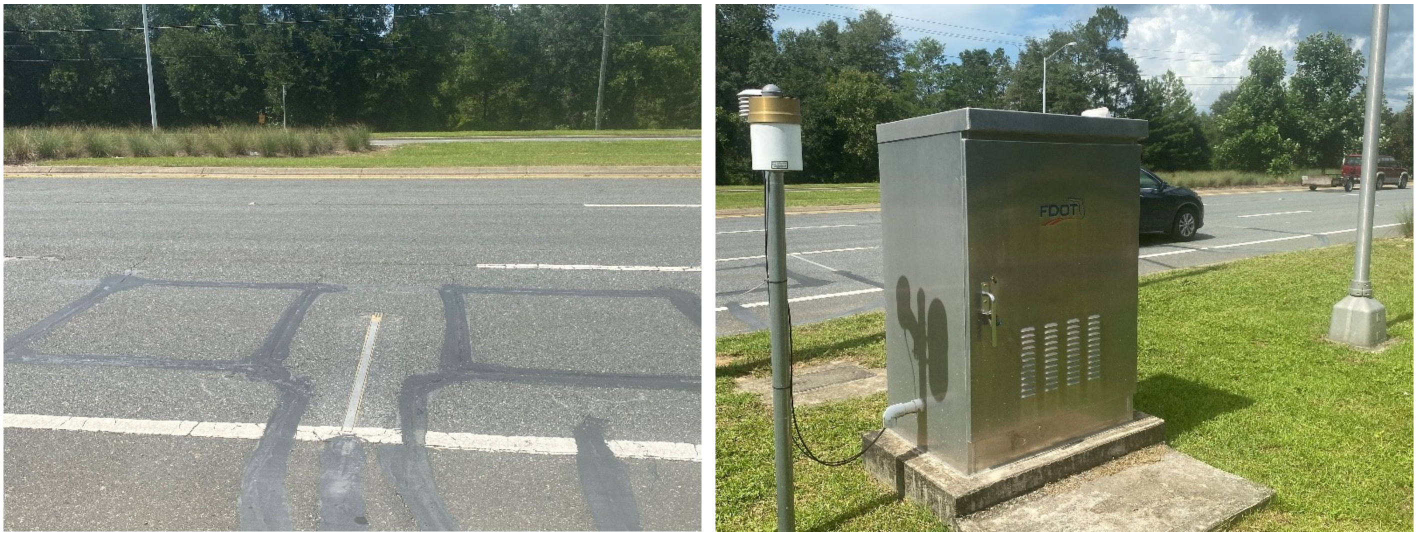
This report fuses together the results of the literature review and the survey in a number of sections. Section 3 discusses the principle of operation and the factors that affect the quality of ILDs data as revealed by the literature review and survey results. Section 4 delves deeper into the effect of congestion on volume counts and vehicle classification. Section 5 discusses the efforts made to improve ILDs data in congested situations as revealed by literature and survey of the experience and expertise of traffic data collection professionals around the country. Section 6 discusses innovative approaches that were found in literature and survey results aimed at generally improving ILDs data quality, not necessarily targeting congested situations. Conclusions and recommendations are discussed in Section 7.

3. Use of Inductive Loops for Traffic Monitoring

According to the Traffic Detector Handbook (FHWA, 2006) inductive loop detectors are by far the most widely used sensor technology for monitoring traffic in the United States. The ILDs were introduced in the United States in the early 1960s and have gained widespread application for detecting vehicle's presence and passage at signalized intersections and for monitoring traffic flow on roadway sections. For instance, the Florida Department of Transportation has installed ILDs in over 330 locations across the state on permanent basis to collect traffic data all year round. These sites are commonly known as continuous traffic monitoring sites. In addition to the continuous traffic monitoring sites, there are many short-term traffic monitoring sites operating in the state that also utilize ILDs. To gain a deeper understanding of what causes inaccuracies in ILDs traffic data particularly during saturated flow conditions, it is important to first describe the principle of operation of ILDs and the factors that directly contribute to the reliability of ILDs output data. The following section briefly delves into these issues.

3.1 Principle of Operation

The name inductive loop detector captures the fact that a vehicle is detected by the change in inductance in a loop slotted in a pavement on a highway. Figure 1 shows a typical dual-loop installation on a highway. The Traffic Detector Handbook (FHWA, 2006, p. 1-11) indicates that an inductive loop detector station generally consists of four parts: (i) a loop of one or more turns of wire embedded in the roadway pavement, (ii) a lead-in wire running from the wire loop to a pull box, (iii) a lead-in cable connecting the lead-in wire at the pull box to the controller, and (iv) an electronics unit housed in the controller cabinet. The detector powers the loop causing a magnetic field in the loop area. The loop resonates at a constant frequency which the detector monitors. A base frequency is established when there is no vehicle over the loop. When a large metal object, such as a vehicle, moves over the loop, the resonant frequency increases. This increase in frequency is sensed and, depending on the design of the detector, forces a normally open relay to close. The relay will remain closed until the vehicle leaves the loop and the frequency returns to the base level.



(a) In-pavement loops and piezo (b) Roadside electronics cabinet

Figure 1. Dual Loop Detector Installation with Piezo

What is seen in Figure 1 is a typical setup at the majority of continuous monitoring sites on Florida highways. It is worth noting that single loop installations are also widely used in signalized intersection approaches and for traffic monitoring particularly on freeways for incident detection. In addition, the configuration shown in Figure 1 is commonly known as loop-piezo-loop (LPL) configuration. There are other configurations such as PLP and PLPL that are mainly used with weigh-in-motion (WIM) equipment but can also collect volume counts and vehicle classification, among others. When the LPL configuration is used at permanent or short-term traffic monitoring sites, the 2018 Florida Traffic Monitoring Handbook specifies that the dual loops should be installed 16 feet apart from leading edge to leading edge (FDOT, 2018). According to Nihan *et al.* (2002), the principle of operation of a dual inductive loop detector station is that when the leading edge of the first loop (also called the “M loop”) detects a vehicle, a timer is started for the dual-loop system. The timer is active until the same vehicle is detected at the leading edge of the trailing detector (also called the “S loop”). The vehicle speed is calculated by dividing the separation distance to the travel time between M loop and S loop.

The first loop, M loop, is also used to detect lane-occupancy (i.e., the percent of time a vehicle occupies the detector) and to calculate the vehicle length. Both M loop and S loop can aggregate the number of vehicles passing over each loop in a specified time period, e.g., 20-second interval. The volume data collected by the two single loops (M and S) should generally be the same. However, studies show that there could be some differences between the two volumes (Nihan *et al*., 2002). Because a vehicle is observed twice at dual loop detector stations, it is unclear to the authors how most jurisdictions count the number of observed vehicles in a time interval, i.e., whether the volume is counted from M loop or S loop or the average of the two.

The piezoelectric sensor installed in the middle of M and S loops in Figure 1 is used to detect axles. The piezoelectric axle sensor consists of a long strip of piezoelectric material that is imbedded in a pavement. When a vehicle’s axle passes over it, compressing the piezoelectric material, a voltage is produced and recorded by the roadside automatic data recorder (ADR). The piezoelectric sensor has the advantage that it records exactly where and when a vehicle’s axle passed by because it is a line sensor installed perpendicular to the path of the vehicle. Vehicle classification into 13 categories of the FHWA F-Scheme is achieved in the following way. When an inductive loop detects a vehicle by measuring changes in magnetic field responding to vehicle metal a circuit is opened. As each axle passes on the piezoelectric axle sensor, the force exerted by the axle weight results in that axle being sensed. Having a vehicle trigger two sensors indicates total number of axles and facilitates the calculation of vehicle speed and inter-axle distance. The roadside automatic data recorder (ADR) has an algorithm that places each vehicle in the correct class according to the F-Scheme based on the measured axle spacing and based on the number of axles each vehicle has. As seen in Figure 1 it is not necessary to have a piezo extend the whole lane width. Half-lane piezoelectric sensors installed on the roadway at a preset distance from one another can accomplish the desired classification.

3.2 Factors Affecting ILDs Data

There are many documented factors that can contribute to the accuracy of ILDs data. These factors range from the quality of the installation, the quality of the selected installation site, traffic composition, and traffic volume. When installing an ILDs station, considerable care need to be taken in material handling (loops, piezos, and adhesives), groove cutting, sensor placement in the groove, sealing of the groove, and testing of the detectors (Moses & Sando, 2003). Testing of the detector output at the end of installation will involve diagnostics, sensitivity analysis, calibration, and fine-tuning to ensure that the detector does not report false detections or miss detections. In a sense, good traffic data quality begins with the quality of lower sensor data (Lu *et al.,* 2010).

Site selection for permanent installation of ILDs monitoring station is of paramount importance. The 2018 Traffic Monitoring Handbook (FDOT, 2018) notes that a monitoring site should be located where free flow traffic is prevalent as slow-moving traffic may limit accurate data collection. The Handbook further stipulates that areas of high traffic with queuing traffic are not recommended collection locations. Additional guidelines and best practices for site selection and ILD installation, among others, include:

- in-road sensors permanently installed in smooth structurally sound pavements (Transportation Research Board, 2017),
- sites with good geometric characteristics related to horizontal curvature, roadway grade, cross slope, and lane width (Liu *et al.*, 2006), and
- to protect the integrity of the pavement and loop installation, cracks and joints in the roadway pavement should not be located closer than 18 in. upstream or downstream of the inductive loop detector being installed ASTM E2561 (2018).

The literature review and the results of the survey show that through collective experience gained by highway agencies over the last 50 years of installing ILDs the installation and site selection factors do not contribute much to errors related to ILDs data. Loops are very well installed and sites are judiciously selected to ensure the reliability of ILDs data. Traffic flow dynamics including traffic composition and saturation flow are the main cause of concern of the reliability of ILDs data. These issues are discussed in detail in the following section based on the literature review results and the results of the survey.

4. Effect of Congestion on Loop Data

Despite highway agencies best efforts to install traffic monitoring sites away from areas that traffic experience frequent acceleration and deceleration conditions, e.g., driveways and intersections, still there are periods in which downstream congestion reaches the monitoring station resulting in stop-and-go traffic movement. The challenges associated with collecting traffic data in stop-and-go traffic conditions as well as magnified errors of classification counts in congested traffic are not new and are mainly associated with technological limitations of ILDs (Fekpe *et al.,* 2004). The following sections discuss the mechanisms that cause inaccuracies in volume counts and classification during congested periods.

4.1 *Effect on Volume Counts*

The setup of ILDs at traffic monitoring sites works well in free flowing traffic when speeds are high, i.e., ≥ 15 mph. The vehicle's distance headways are generally long enough for the majority of the vehicles to trigger the loop on and off resulting in correct passage detection. Thus, in free flowing traffic, the dwell time, i.e., occupancy time, on a loop detection area is low. As explained in *Section 3.1—Principle of Operation*, a vehicle is detected when a loop circuit opens (based on inductance change) and passage is recorded when the loop circuit closes again after the vehicle leaves the loop influence area. Based on the understanding of this principle of operation, it is easy to fathom what happens when a vehicle follows another vehicle too closely, i.e., short distance headways, as characteristically found in congested traffic situations when speeds are very low and stop-and-go is commonplace. The result is that the loop circuit will remain open and the following vehicle mass will be detected as belonging to the front vehicle mass resulting in undercounting of vehicles in congested traffic situations. This is clearly a technological limitation of ILDs that can be overcome by changes in the principles of operation and circuitry or probably the development of factors to adjust volumes upwards when congestion is detected.

4.2 *Effect on Vehicle Classification*

The same mechanism that causes volume undercounting at the ILD stations in congested periods also causes misclassification of vehicles. The number of axles assigned to a passing vehicle after each of its axles has hit the piezoelectric axle sensor in the middle of the two loops (refer to Figure 1) depends on whether the leading loop (M loop) circuit is terminated or still open because a tailgating vehicle is too close to the lead vehicle. If the loop circuit is kept open by a tailgating vehicle being too close to the lead vehicle, the sensed axles of the tailgating vehicles will be combined with those of the lead vehicle. This is how a single-unit Class 5 vehicle (according to FHWA F-Scheme) with 2 axles pulling a trailer can be misclassified as a Class 8 vehicle (2-axle tractor, 1-axle trailer) or a Class 3 vehicle (a pick-up truck pulling a trailer). Again, as with volume adjustments in congested conditions, creative solutions will be needed to overcome misclassifications inherent in saturated traffic conditions.

5. Efforts to Properly Capture Congested Traffic Data

The literature review and the survey of the traffic monitoring program personnel around the country have revealed that concern for the proper capture of traffic data in congested situations is widespread across many states besides Florida. The results of the literature review and the survey showed that efforts to improve traffic monitoring does not only encompass congested situations but the overall capture of traffic data in all traffic situations. While the use of congestion factors is almost non-existent based on the information obtained thus far, there are other efforts to improve traffic data collection through alternative data sources. The following sections describe these efforts.

5.1 *Use of Congestion Adjustment Factors*

First, it is important to mention that the use of adjustment factors for all kinds of purposes is well recognized in traffic monitoring programs as espoused in the federal Traffic Monitoring Guide (FHWA, 2016). A factor is a number that represents a ratio of one number to another number. The Traffic Monitoring Guide (TMG) indicates the existence of factors such as K, D, T, and peak hour factor that are computed from data collected at continuous count stations for use in analyses. There are other factors as well, such as axle, seasonal, monthly, and day-of-week factors derived from continuous count stations for use in adjusting short-term traffic counts to estimate average annual daily traffic (AADT).

The development of adjustment factors to adjust counts in congested conditions can follow the same rigorous guidelines in the TMG used to develop other factors mentioned in the preceding paragraph. Obviously, the need for baseline data will be of paramount importance. Similar to Florida, most states report that they install traffic monitoring sites in free-flow sections away from congested areas close to intersections and other traffic choke areas. Thus, efforts to develop these factors can be targeted to a few count sites that occasionally experience traffic back-ups. Similar to the methodologies to get other adjustment factors, video data can be used to determine volume counts at those sites and compared with IDL station data to develop adjustment factors. It is expected that the adjustment will be upward as volumes tend to be undercounted by ILDs counts site due to the principle of operation of ILDs as discussed in *Section 4.1—Effect on Volume Counts*.

5.2 Use of Alternative Data Sources

The attractiveness of using ILDs to collect traffic data is based on the fact that they have proven reliable over the years, have the ability to continuously operate (24/7), and can collect data in each lane of a highway in both directions. However, recent advances in microcomputing and mobile technologies have resulted in rapid growth in the use of alternative methods to survey and monitor traffic on highways. According to Cvetek *et al.* (2021), the emerging technologies can be grouped into three categories: (1) point sensors, (2) point-to-point sensors, and (3) areawide sensors. Besides ILDs, other point sensors installed at a fixed location include video imaging, radar, acoustic, infrared, magnetic, and piezoelectric sensors. Point-to-point sensing generally involves automatic identification of a vehicle through Bluetooth detectors, Wi-Fi detectors, RFID detectors, and automatic license plate recognition. Areawide sensors include cellular floating car data, airborne imagery, and crowdsourced data. For principle of operation, advantages, and disadvantages of each type of sensor, the reader is referred to Cvetek *et al.* (2021) and other sources.

Recently, private companies have taken advantage of the advancement of alternative sources to collect traffic data to sell to their private customers and in some cases to public agencies. The literature review showed that companies such as INRIX, CITILABS Streetlytics, and HERE Technologies provide traffic data acquired through smartphone applications, in-vehicle OEM navigational devices, and data from fleet telematics and connected vehicles (Mauch & Skabardonis, 2020). While initially the traffic data provided by these companies were mainly speed and travel time data, of late some companies such as STREETLIGHT Insights are venturing into providing vehicular AADTs and pedestrian AADTs in some jurisdictions. Recognizing these efforts, the FHWA is currently engaged in a validation study for alternatives data sources for HPMS reporting. The project number and title are "693JJ319C000015 for the Non-Traditional Methods to Obtain Annual Average Daily Traffic (AADT) Evaluation and Analysis".

5.3 Data Fusion

Fusion of data from a multitude of sources to more accurately estimate or predict traffic conditions is evolving rapidly. As indicated in the preceding section, there is increased use of alternative sources to capture various traffic flow variables at a fixed location, between locations, and areawide. The major traffic data collected at traffic monitoring sites are volume, speed, and vehicle classification. The review of literature and survey focused on efforts, if any, to fuse data for proper estimation of the three data types.

The use of cell phones and navigational devices is leading to increased research on estimating traffic volume based on probe vehicles. A research conducted by Anuar *et al.* (2015) evaluated the concept of estimating traffic flow rate based on the speed of probe vehicles using the traditional speed-flow-density fundamental diagram. The authors indicated that the methodology performed better in congested traffic flow conditions than in free-flow conditions.

The literature review revealed that studies have been conducted to fuse speed data collected by ILDs with toll ticket data (Soriguera *et al.,* 2007), with Bluetooth data (Bachmann , 2011), and with floating car data (Wolfermann *et al.,* 2011). The estimation of travel speeds and travel times across highway corridors is the main focus of the majority of these studies that attempt to fuse ILDs speed data with alternative data sources. Speed data collected by ILDs are referred to as time mean speeds as they reflect speeds collected at a specific point. Thus, to gain better estimation of speeds (and travel times) in a corridor (i.e., space mean speed), fusion of heterogenous speed data from independent data sources is being pursued.

The improvement of vehicle classification through data fusion is mainly focused on video imaging technology, inductive loop signature technology, and length-based classification technique. Using video imaging technology, vehicle images collected by surveillance cameras are processed using advanced algorithms to extract the type of a vehicle in order to classify it. Efforts related to inductive loop signature technology and length-based classification are discussed in sufficient detail in Section 6 below.

6. Innovative Approaches in Improving IDLs Data Quality

As discussed earlier, the majority of the studies on the efficacy of ILDs cited in the literature were conducted a number of decades ago primarily because this technology has been in use for over 60 years and has proven effective at traffic monitoring sites. However, the review of literature found that there is a number of studies that focused on the overall improvement of the quality and quantity of traffic data collected by IDLs under normal traffic operations. By normal operations, it is implied that these studies did not specifically focus on a particular traffic state whether free-flowing or congested. The following sections discusses the innovative approaches encountered in literature.

6.1 Inductive Loop Signature Technology

The literature search has revealed several studies that have evaluated the efficacy of inductive loop signature in improving various traffic parameters collected by the traditional ILDs traffic monitoring sites. An advanced detector card is placed in a roadside counter. In addition to the advanced detector indicating the presence of a vehicle, it measures and outputs inductance change in an ILD (Jeng & Chu, 2015). This series of inductance changes caused by each traversing vehicle produces an analog waveform output and is referred to as the inductive loop signature or inductive vehicle signature. At the onset of this technology, it was thought that it will improve ILD vehicle count, classification and speed data. It was also touted that it will enable vehicle reidentification when a vehicle crosses another ILD station (Jeng & Chu, 2014).

6.2 Length-Based Vehicle Classification

According to the 2018 FDOT Traffic Monitoring Handbook presently, length-based classifications are not used by FDOT to report to FHWA arguing that "due to limitations in collected data, this type of classification is still under research." Indeed, research on length-based classification is ongoing as revealed by the results of literature search. The use of dual IDL setup has the advantage of determining vehicle length by dividing the distance between the two loops to detector occupancy time. Wu & Coifman (2014) argued that any change in speed will affect the occupancy time measurements. At free-flow speeds, the impacts from acceleration are negligible, but in stop-and-go traffic, the estimation of vehicle length can result in inaccurate values. To correct these inaccuracies, Wu & Coifman suggested a different method of measuring vehicle length that takes into account accelerations and decelerations of vehicles in congested traffic situations. However, the authors acknowledge that higher error rates in both length-based vehicle classification and axle-based vehicle classification should be expected when vehicles stop over the dual loops. The authors suggest that a methodology should be developed that identifies stopped vehicles so that they can be removed from classification analysis.

7. Conclusions and Recommendations

The inductive loop detectors (ILDs) have been used for many decades to monitor traffic on highways. They have proven to be highly reliable in collecting traffic volumes, traffic speeds, vehicle classes, and a slew of other important traffic variables. Traffic monitoring stations that utilize ILD are generally installed at highway locations far away from congested areas characterized by slow speeds, tailgating, stop-and-go, as well as frequent lane changes. Despite DOTs best efforts to install traffic monitoring stations on free-flow highway sections, there are sites and occasions in which queues spill over to the ILD station resulting in undercount of vehicles and misclassifications when congestion persists. The need for better quantification of traffic state during congested periods is the motivating factor for this study.

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The results of the literature review and survey show that while states are in agreement that proper quantification of the number of vehicles and their classes in congested period is important, no state has undertaken efforts to develop congestion adjustment factors or to study the issue. As seen in the summary of the results of the states' survey the majority of state, just like Florida, avoid installing traffic monitoring stations (that utilize ILDs) close to highway locations that are likely to experience congestion. The practice of avoiding the collection of traffic data in congested locations clearly represents missed opportunity to properly surveil highway networks for the purposes of judicious planning and operations. Thus, efforts to study this issue and to conduct field evaluation of congestion factors development is timely and supported by both literature review and survey results.

Based on the results of the literature review and states' survey, it is recommended that a properly designed congestion factors field study be implemented. A number of interesting facts were learned from the survey results that could be beneficial to FDOT following a carefully designed field review. First, the use of inductive loop signature technology to improve vehicle counting and classification is worth further experimentation as it has been asserted in the survey responses that it can work down to very low stop-and-go speeds (as low as 1 mph). Second, some states have implemented checks within their roadside counting devices to flag a warning when stop and go conditions are sensed so that congested data that does not reflect reality are removed from the counts. A field study comparing the performance of a normal loop card to inductive signature loop card side by side with video data collected as ground truth is recommended. An existing continuous traffic monitoring site that experiences congestion should be picked for the field study. In this study, the primary objective of researching the development of congestion factors as well as researching various software-based congestion detection strategies can be pursued.

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APPENDIX A – The Survey Questionnaire

A NATIONWIDE SURVEY ON TRAFFIC MONITORING IN CONGESTED SITUATIONS

This survey is being conducted by researchers from Florida State University for Florida DOT, Transportation Data and Analytics Office.

Survey Purpose
The survey is aimed at determining how agencies nationwide process volume and vehicle classification data collected by inductive loop detectors in heavily congested traffic situations characterized by the stop-and-go phenomenon and tailgating. It is well known that during these periods, volume counts from loop detectors underreport the actual volumes and the vehicle classification error rate goes up given that in some situations, tailgating vehicles are combined with lead vehicles and thrown into a wrong category in the FHWA-Scheme.

Survey Results
The information collected from your agency will be valuable for Florida DOT in developing strategies, including congestion factors to adjust loop traffic data to correctly reflect field conditions in congested traffic flow situations. The final report produced from this study will be shared with all respondents upon request. All responses are completely confidential.

Sharing the Survey
You can share this survey with other people in your organization using the following link: https://fsu.qualtrics.com/jfe/form/SV_eED9N8AdNRV0Jro

The survey should take about **15** minutes to complete.

If you have any questions or need more information about the survey, please contact the Principal Investigator of this project, Professor Ren Moses at moses@eng.famu.fsu.edu or through phone call at 8504106191. Thanks in advance for your participation!

PART 1: CONTACT INFORMATION
1. Please provide the name and email address of the person responding to this survey.
2. Please indicate if you would like to receive the final report related to this project.
3. If you want this survey sent to other people in your organization, please provide their names and email addresses.

PART 2: PROBLEMS ASSOCIATED WITH DATA COLLECTION ON CONGESTED ROADWAYS
4. Does your agency use loops in collecting data on congested roadway sections?
5. Has your agency conducted a study to determine the accuracy of data collected in congested stop-and-go situations?
   a. What methods does your agency use to verify data collected by loop detectors in congested conditions? Do you use any other detection system, e.g., video, to verify the accuracy of loop data from those locations?
   b. What types of errors have your agency found?
   c. Can you quantify the level of degradation (in percent) of the accuracy of volume counts and vehicle classification in congested conditions?
6. Can you share with us any documents or reports related to this study?

PART 3: MEASURES TAKEN
7. What measures has your agency taken to improve the accuracy of data under congested conditions?

8. What were the advantages of implementing those measures?
9. To what percentage did the accuracy of data improve?
10. What were the disadvantages/challenges of implementing the measures, e.g. cost, easiness, etc.?
11. Have your agency developed adjustment factors to be applied to congested raw data?
12. Can you share with us any documents or reports on congestion factor adjustments?

PART 4: STATISTICAL METHODOLOGIES

13. What statistical methodologies do you use to adjust loop volume counts collected in stop-and-go traffic situations?
14. What statistical methodologies do you use to adjust loop/piezo vehicle classification data collected in stop-and-go traffic situations?

PART 5: ALTERNATIVE DATA SOURCES & DATA FUSION

15. To accurately quantify congestion, does your agency employ other data sources such as
    (a) Video imaging?
    (b) Bluetooth detectors?
    (c) Wi-Fi detectors?
    (d) Crowd-sourced data?
16. To what degree do you fuse the data from loop/piezo set-up with alternative data sources to accurately depict actual traffic flow conditions?

PART 6: ADDITIONAL/GENERAL COMMENTS

In this section, please provide any additional insights on this issue that might assist Florida DOT in developing analytical tools to accurately quantify volume and classification data in stop-and-go traffic situations.

APPENDIX B – List of Survey Recipients / Respondents

Table B1. Survey Contact List

No#	State	Name	Title	Telephone	Email	Responded to Survey
1	Alabama	Roby Blankenship	Assistant Bureau Chief, Traffic Monitoring Administrator	334-242-6393	Blankenshipr@dot.state.al.us	✓
		Ronny Pouncey	Deputy State Maintenance Administrator	334-242-6408	Pounceyr@dot.state.al.us	
2	Alaska	Jill Melcher	Transportation Data Programs Manager	907-465-8592	jill.melcher@alaska.gov	✓
		Matt Murphy	Highway Data Manager (Central Region)	907-269-0876	matt.murphy@alaska.gov	
		Scott Vockeroth	Highway Data Manager (Northern Region)	907-451-2251	scott.vockeroth@alaska.gov	
		Jennifer Anderson	Regional Program Planner (Northern Region)	907-451-2385	jennifer.anderson@alaska.gov	
		Derrick Grimes	Highway Data Manager (Southcoast Region)	907-465-6993	derrick.grimes@alaska.gov	
3	Arizona	Marissa Abeyta	Traffic Monitoring Manager	602-712-8232	mabeyta@azdot.gov	✓
		Samuel Alemu		602-712-6172	salemu@azdot.gov	
		James Meyer, GISP	Data Analytics Manager and HPMS Coordinator Data Management	602-712-8037	jmeyer@azdot.gov	
4	Arkansas	Michael Henry	Staff Traffic Information Engineer	501- 569-2111	michael.henry@ardot.gov	✓
5	California	Cindy Pribyl	Traffic Census Program	916-654-4578	Cindy.Pribyl@dot.ca.gov.	✓
		Stanley Norikane			stanley.norikane@dot.ca.gov	
		Thomas Ainsworth			thomas.ainsworth@doot.ca.gov	
		Ton Myhoa			Myhoa.ton@dot.ca.gov	
6	Colorado	Aaron Moss	Year End Process & Factoring / Traffic Analyst	303-757-9805	aaron.moss@state.co.us	
		Steve Abeyta	Traffic Analysis Unit Manager	303-537-3470	steve.abeyta@state.co.us	
		Phyllis Snider	Data Management Unit Manager	303-757-9805	plyllis.snider@state.co.us	
7	Connecticut	Bradley Overturf	Transportation Supervising Planner	860-594-2089	Bradley.Overturf@ct.Gov	
8	Delaware	Michael DuRoss	Planner	302-760-2110	Michael.Duross@state.de.us	
9	Georgia	Paul Tanner	State Transportation Data Administrator	404-347-0699	paul.tanner@dot.ga.gov	✓
		Eric Conklin			eric.conklin@dot.ga.gov	
10	Hawaii	Ken Tatsuguchi	Head Planning Engineer	808- 587-1830	ken.tatsuguchi@hawaii.gov	✓
		Goro Sulijoadikusumo	Highways Planning Survey Engineer		goro@hawaii.rr.com	
11	Idaho	Margaret Pridmore	Manager	208-334-8221	Margaret.Pridmore@itd.idaho.gov	✓
		Tony Grange	Manager	208-334-8221	Tony.Grange@itd.idaho.gov	
		Jack Helton			jack.helton@itd.idaho.gov	
		Vicky Calderon	Analysis and Reports	208-334-8218	Vicky.Calderon@itd.idaho.gov	

Table B1, continued

No#	State	Name	Title	Telephone	Email	Responded to Survey
		Raymond Wong	Short Term Vehicle Count and Studies	208-334-8216	Raymond.Wong@itd.idaho.gov	
12	Illinois	Jessica Keldermans	Bureau of Data Collection - Bureau Chief		Jessica.Keldermans@Illinois.gov	✓
		Bill Morgan	Planning & Systems Section Chief	217-782-6289	william.morgan@illinois.gov	
13	Indiana	Gregory Katter	Traffic Statistics Supervisor	317-232-6779	GKatter@indot.in.gov	✓
		Marc Antich	WIM & ATR Maintenance Manager		MAntich@indot.in.gov	
14	Iowa	Mark Hansen	Team Leader	515-239-1990	Mark.Hansen@iowadot.us.	✓
		Noah Fegter	Traffic Analyst-Traffic data collection	515-239-1045	noah.fegter@iowadot.us	
		Zach Thompson	Traffic Analyst-Traffic data collection	515-239-1717	Zachary.Thompson@iowadot.us	
		Doug Westvold	Traffic Analyst-Traffic data collection	515-239-1073	Doug.Westvold@iowadot.us	
		Vesper Brace	Traffic Analyst-Traffic sample processing	515-239-1246	vesper.brace@iowadot.us	
		Aaron Koethe	Traffic Analyst-Traffic sample processing	515-239-1122	aaron.koethe@iowadot.us	
		Chris Capaldo	Traffic Scheduling Analyst	515-239-1130	chris.capaldo@iowadot.us	
		Ron Bunting	Office of Systems Planning	515-239-1323	ronald.bunting@dot.iowa.gov	
15	Kansas	Alan Spicer	Assistant Bureau Chief - Data	785-296-3470	alan.spicer@ks.gov	✓
		Bill Hughes	Traffic Data	785-296-6863	bill.hughes@ks.gov	
16	Kentucky	Robert Brown	Traffic and Equipment Management	502 782-5526	Robertf.Brown@ky.gov	✓
		Mark Walls	Transportation Engineer Branch Manager	502.782.5150	mark.walls@ky.gov	
		Melissa Brown	Traffic and Equipment Management	502 782-5049	Melissa.Brown@ky.gov	
		Crystal Casey	Traffic and Equipment Management	502 782-5050	Crystal.Casey@ky.gov	
17	Louisiana	George Chike	Manager, Traffic Monitoring and Data Collection Program	225-242-4557	george.chike@la.gov	✓
		Candis Washington	QA/QC Engineer / Data Management	225-242-4556	candis.washington@la.gov	
		Joshua Albritton	Traffic Monitoring Supervisor / Data Management	225-242-4560	joshua.albritton@la.gov	
18	Maine	David Bernhardt	Director	207-624-3600	David.Bernhardt@maine.gov	✓
		Aaron Buotte			aaron.c.buotte@maine.gov	
		Debbie Morgan		207-624-3606	Deborah.Morgan@maine.gov	
19	Maryland	Abhay Nigam		410-545-5506	anigam@sha.state.md.us	
20	Massachusetts	David Mohler	Office of Transportation Planning		david.mohler@state.ma.us	✓
		Jonathan Gulliver	Highway Administrator		Jonathan.Gulliver@state.ma.us	
21	Michigan	Chris Hundt	Supervisor - Travel Information and Electronic Services Unit		HundtC@michigan.gov	✓

Table B1, continued

No#	State	Name	Title	Telephone	Email	Responded to Survey
		Kevin Krzeminski	Transportation Planner Specialist Data Inventory and Integration Division	517-335-2274	KrzeminskiK@Michigan.gov	
		Edward Potter	Transportation Planner		PotterE@Michigan.gov	
		Melissa Carswell		517-373-2662	CarswellM@Michigan.gov	
22	Minnesota	Christy Prentice	Traffic Counts/AADT 1st Contact	651-366-3844	christy.prentice@state.mn.us	✓
		Darin Mertig	Traffic Counts/AADT 2nd Contact	651-366-3858	darin.mertig@state.mn.us	
		Andy Tschida	Traffic Counts/AADT 3rd Contact	651-366-3890	andrew.tschida@state.mn.us	
		Alex Ferkinhoff	Traffic Counts/AADT 4th Contact	651-366-3853	alexandra.ferkinhoff@state.mn.us	
		John Hackett	Vehicle Classification/HCAADT 1st Contact	651-366-3851	john.hackett@state.mn.us	
		Gene Hicks	Vehicle Classification/HCAADT 2nd Contact	651-366-3856	gene.hicks@state.mn.us	
23	Mississippi	Susannah Seal	On Contract	601-359-7685	sseal@mdot.ms.gov	
24	Missouri	Robinson Spencer	Transportation Management System (TMS) Administrator	573-526-4906	spencer.robinson@modot.mo.gov	✓
		Britni O'Connor	Transportation Planner	573-751-6550	Britni.OConnor@modot.mo.gov	
		Mike Henderson	Transportation Planner	573-522-6214	Michael.Henderson@modot.mo.gov	
25	Montana	Becky Duke	Traffic Data Collection Section Supervisor	406-444-6122	bduke@mt.gov	✓
		Peder Jerstad			pjerstad@mt.gov	
26	Nebraska	David Schoenmaker	Traffic Data Collection Engineer	402-479-3924	dschoenm@dor.state.ne.us	✓
27	Nevada	Mark Wooster	Traffic Information Division	775-888-7156	mwooster@dot.state.nv.us	
28	New Hampshire	William Lambert	Traffic Division, administrator	603-271-2291	William.Lambert@dot.nh.gov	✓
29	New Jersey	Chris Zajac	Bureau of Transportation Data & Support, Section Chief	609-963-1893	chris.zajac@dot.nj.gov	
30	New Mexico	Alicia Ortiz	Data Management Bureau Chief	505-660-3304	alicia.ortiz@state.nm.us	✓
31	New York	Michael Rossi	Highway Data Services Bureau, Director	518-457-1965	mrossi@dot.state.ny.us	✓
		Andrew Haynes			andrew.haynes@dot.ny.gov	
		Kurt Matias	Traffic Monitoring Section, Manager	518-457-1965	kmatias@dot.state.ny.us	
32	North Carolina	Jamie Viera	Traffic Analysis Engineer	919-707-0937	jlviera@ncdot.gov	✓
		Kerry Morrow	Traffic Survey Group Supervisor	919-707-0924	kmorrow@ncdot.gov	
		Mike Cook	Electronic Systems Supervisor	919-814-6101	mlcook3@ncdot.gov	
		Kent Taylor	Traffic Survey Engineer	919-707-0935	kltaylor@ncdot.gov	
33	North Dakota	Terry Woehl	Planning & Programming Division	701-328-3531	twoehl@nd.gov	✓

Table B1, continued

No#	State	Name	Title	Telephone	Email	Responded to Survey
34	Ohio	Sandra Mapel	Traffic Monitoring Manager	614-644-0291	Sandra.Mapel@dot.ohio.gov	✓
		David Gardner		614-752-5740	Dave.Gardner@dot.ohio.gov	
35	Oklahoma	Jennifer Sebesta	Transportation and Planning Services (TPS) Manager	(405) 234-2264	jsebesta@acogok.org	
		Don Crownover	Transportation Systems Monitoring Unit Team Leader	503-986-4132	don.r.crownover@odot.state.or.us	✓
		Jennifer Cambell	36	Oregon	jennifer.k.campbell@odot.state.or.us	
37	Pennsylvania	Andrea Bahoric	Planning Division Manager		abahoric@pa.gov	✓
38	Rhode Island	Robert Shawver	Senior Transportation Planner		Robert.Shawver@dot.ri.gov	
		Lori Fisette			lori.fisette@dot.ri.gov	
39	South Carolina	Todd Anderson	Chief, Road Data Services		andersonrt@scdot.org	✓
		Angela Hance	Assistant Chief, Road Data Services	803-737-1466.	hancema@scdot.org	
40	South Dakota	Jeff Brosz	HPMS/Traffic Studies Specialist	605-773-5439	Jeff.Brosz@sd.gov	
41	Tennessee	Casey Langford	Planning Manager	615.532.5824	Casey.Langford@tn.gov	✓
		Randall Emilaire	Road Inventory Office	615.253.2143	Randall.Emilaire@tn.gov	
		Stanley Dunn	Traffic Data Collection Office	615.350.4571	Stanley.Dunn@tn.gov	
42	Texas	Jessica Butler	Director of Transportation Planning and Programming	512) 486-5001	Jessica.Butler@tcdot.gov	
44	Utah	Jamie Mackey	Freeway Operations Manager	(801) 514-9782	jamiemackey@utah.gov	✓
		Rikki Sonnen	Statewide Traffic Performance Engineer		rikkisonnen@utah.gov	
45	Vermont	Maureen Carr	Traffic Research Supervisor	(802) 522-2645	maureen.carr@vermont.gov	
46	Virginia	Dan Dunnavant	Traffic Engineering Division	804-786-7013	dan.dunnavant@vdot.virginia.gov	✓
		Mena Lockwood		804-786-7779	mena.lockwood@vdot.virginia.gov	
47	Washington	Mark Finch	Transportation Data, GIS & Modeling Office Manager	360-570-2369	FinchM@wsdot.wa.gov	✓
		Joe St Charles			stcharj@wsdot.wa.gov	
		Natarajan Janarthanan	Travel Data, Modeling & Analysis Branch Manager	206-464-1274	janartn@wsdot.wa.gov	
48	West Virginia	Hussein Elkhansa	Chief Data Officer	304-414-6911	Hussein.S.Elkhansa@wv.gov	✓
		Gehan M. Elsayed	Travel Monitoring	304-558-9626	GEHAN.m.elsayed@wv.gov	
49	Wisconsin	Tom Ries	Data Management Section Chief		tom.ries@dot.wi.gov	✓
		Chad Bigler			chad.bigler@dot.wi.gov	
		William R. McNary	State Traffic Engineer		william.mcnary@dot.wi.gov	
50	Wyoming	Sherman Wiseman		307-777-4190	sherman.wiseman@dot.state.wy.us	
51	FHWA	Steven Jessberger			Steven.Jessberger@dot.gov	✓

APPENDIX C – Summary of Survey Results

1. Survey Purpose and Design

Based on the objective of project Phase 1, researchers from Florida State University (FSU) surveyed State DOTs to solicit information on the state of the art and the state-of-practice in traffic data collection using inductive loop detectors (ILDs) in congested situations. The survey was aimed at determining how agencies nationwide process volume and vehicle classification data collected by ILDs in heavily congested traffic situations characterized by the stop-and-go phenomenon and tailgating. It is well known that during these periods, volume counts from loop detectors underreport the actual volumes, and the vehicle classification error rate goes up given that in some situations, tailgating vehicles are combined with lead vehicles and thrown into a wrong category in the FHWA-Scheme.

Respondents were asked a set of questions grouped into six parts; Part 1: contact information; Part 2: problems associated with data collection on congested roadways; Part 3: measures taken; Part 4: statistical methodologies; Part 5: alternative data sources & data fusion; and Part 6: additional/general comments. The survey was designed to have both open-ended and closed-ended questions to allow for the respondents to give insights on all aspects relevant to the main objective of this research study. The survey questionnaire was administered online through Qualtrics licensed to FSU with a total of 21 questions.

Through web searches, a list of relevant personnel in all 50 states and the Federal Highway Administration (FHWA) was compiled. The list comprised of 115 traffic monitoring experts and program managers of State DOTs across the nation. All personnel were first contacted in June 2021 by email using Sendinblue platform and asked to fill in the online survey in Qualtrics. Sendinblue is a digital marketing platform that is used to send SMS messages and emails to a group number of people. The platform was chosen because of its easiness in sending emails and its automation features. The features included the ability to see the numbers of delivered emails, bounced emails, opened emails, and emails in which the survey link was clicked. Even though the platform was deemed useful, the response rate was low because several emails were sent to the spam folders and were not delivered to the intended personnel. Hence, the team decided to use Microsoft Outlook to send emails individually to all who did not receive emails sent through the Sendinblue platform. Follow-up reminder emails were sent out to the contact list consistently to the individuals who had not responded. The finally tally shows that the total number of responses received was 56, representing 36 states out of 50, for a response rate of 72%. The results of the survey are discussed in the following sections.

2. Problems Associated with Data Collection on Congested Roadways

As seen in Appendix A, Part 1 of the survey solicited respondents' contact information. Part 2 of the survey questionnaire dealt with the use of loops in collecting data on congested roadway sections; and if the responding state has conducted any study or performed analyses to determine the accuracy of data collected in congested stop-and-go situations. The results show that most agencies use inductive loops to collect traffic data on all types of roadways. However, very few agencies have conducted studies to determine the accuracy of data collected in stop-and-go situations. The following subsections provide additional insights on Part 2 questions.

2.1 Use of Loops in Congested Roadways

Over two-thirds (67%) of respondents reported that their agencies use loops to collect data on congested roadways sections, and only 21% of respondents reported not using loops. The 12% of respondents who reported other indicated that their agencies placed loops in non-congested roadway segments and/or avoided locations where congestion could cause an issue with the data. Figure 1 shows these results.

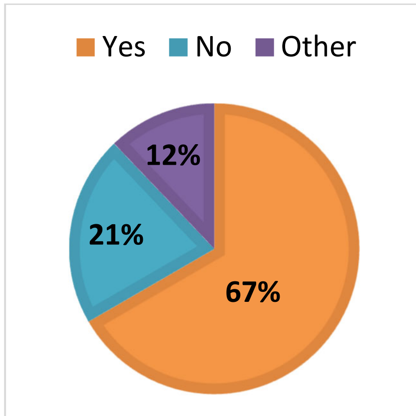

Figure C1. Respondents Use of Loops in Congested Roadways

2.2 Study on Data Collected under Congested Situations

Results showed that many agencies about 66% of respondents do not conduct studies or perform analyses to determine the accuracy of data collected in congested stop-and-go situations, and only 22% showed to have done a study. The other 12% of the respondents reported that no official study has been done, but for locations where congestion occurs, internal staff review the data daily and if data issues arise a restriction code is entered. New York DOT has indicated that they have performed a study to compare data collected by loop and non-intrusive type collectors, highlighting loop deficiencies. Figure 2 shows these results.

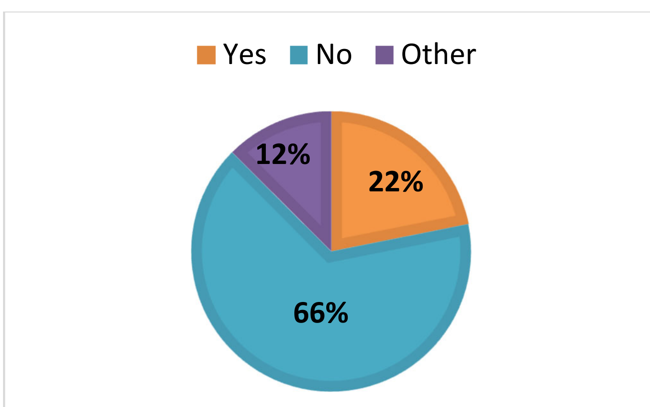

Figure C2. Responses on Study of Data Collected under Congested Situations

For all the agencies that indicated that they had done a study on data collected in congested situations, follow-up questions were asked on the methods they used to verify the data and the errors found. The following are summaries of the significant findings from the follow-up questions.

Methods Used to Verify Data:

- Inductive Signatures.
- Volume/Length/Speed Calibrations.
- Review the data against past years/historical numbers.
- Comparison with visual counts such as from video, Leetron and Miovision cameras for limited periods.
- Spot checks.
- Collect scheduled quality assurance (QA) counts through various methods, pneumatic tube counts, manual classification counts, and/or video collection equipment and then compared to the data from the permanent sites.
- Automated and manual checks of class count.
- Periodic on-site functional tests of the equipment to verify accuracy.
- Annual maintenance on permanently installed devices including testing and inspections, repairs, and validation of data collection through comparison to manual observations.
- Collecting longer-term counts with a different technology such as radar counters at the same location.
- Monthly site visit that also includes watching vehicles and guaranteeing that the data being collected is accurate.

Errors:

- Undercounting of volumes.
- Misclassifications.

3. Measures Taken

Part 3 of the survey inquired on what measures are being taken to improve the accuracy of the data collected under congested conditions. The states reported the following measures:

- Signature detection.
- Avoid collecting data in congested locations.
- Use advanced technologies, such as camera technology and AI, to collect data other than loops.
- Upgrade recording equipment and sensors, moving from square loops to round loops to reduce loop failures. Change tube spacing.
- Calibrate all sites to provide the most accurate daily statistics. Verifying data daily. A yearly check of the sensitivity of the loop detections and the timeout settings improves counter performance.
- Quality checks on data, use data processing software to red flags anomalies.
- Automatic warnings on data issues. Turn on tailgating detection in the traffic counter setup if available.

- Using radar married to Diamond remote to get good volume in congested areas w/o closing the road to cut in loops, and/or piezo.

The table below summarizes the strengths and weaknesses of each measure as reported by the respondents.

Table C1. Respondents Measures Taken, Strengths and Weaknesses

No	Measure	Strengths	Weaknesses
1	Signature detection	Using signature data helps reduce the minimum speed in half, so the congestion issues are greatly reduced.	The cost of the signature card is $700 per lane and a little additional cost for processing signature vs. loop count data.
2	Avoid collecting data in congested locations.	Maintains accuracy of data typically within the five percent accuracy standards. Keeps counter personnel out of the heavy traffic.	Loss of data collection opportunities and flexibility. Limits where data is being collected, especially in heavily traveled areas during peak periods.
3	Use advanced technologies such as camera technology and AI that do not have issue with low speeds.	More accurate data during congestion periods. Data collection becomes safer and more viable at many congested locations.	Cost. Some systems do not provide speed data, only volume, and vehicle class.
4	Upgrade recording equipment and sensors, moving from square loops to round loops to reduce loop failures. Change tube spacing.	More accurate data, about 30% improvement in accuracy.	To replace load cell scales requires removing the scale frames, which needs replacing the conduit infrastructure and pavement patching/modifications - high upgrading cost.
5	Calibrate all sites to provide the most accurate daily statistics. Verifying data daily. A yearly check of the sensitivity of the loop detections and the timeout settings improves counter performance.	Moderate improvement in counts during congested periods.	It is time consuming to adjust and then retest to see if an adjustment made an improvement. It can take multiple attempts to dial a site into the best settings. The cost to field verify each sensor is cost-prohibitive.

Table C1, continued

No	Measure	Strengths	Weaknesses
6	Quality checks on data include screening for high number of unclassified vehicles and comparison of daily volume to expected or historical volume. Faulty data detected by the quality checks will trigger a warning and possible downgrade of data quality rating. Data processing software red flags anomalies.	Able to identify and downgrade bad data caused by excessive congestion.	Lack of availability of good data at some locations.
7	Automatic warnings on data issues. Turn on tailgating detection in the traffic counter setup if available.	Can flag bad data	
8	Using radar married to Diamond remote allows to get good volume in congested areas w/o closing the road to cut in loops, and/or piezo.	Fewer sensor misses and accurate speed and length data.	

3.1 *Development of Congestion Adjustment Factors*

The survey results showed that no agency has developed congested factors to apply on congested raw data, with 0% of the respondents saying yes to developing congestion adjustment factors and 85% of respondents said no. Among the 15% who responded other, there were individuals who indicated that this practice is explicitly forbidden within the Traffic Monitoring Guide. Others said FHWA has pretty well frowned on that historically. Figure 3 shows these results.

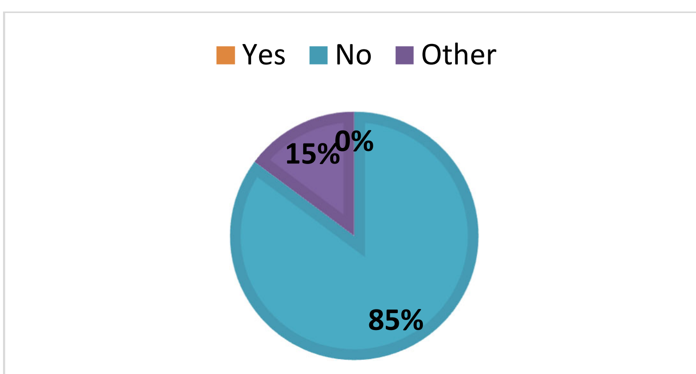

Figure C3. Respondents Development of Congestion Factors

4. Statistical Methodologies

When respondents were asked about statistical methodologies they use to adjust loop volume counts collected in stop-and-go traffic situations, all respondents indicated not using any statistical methods to adjust the data.

5. Alternative Data Sources & Data Fusion

In Part 5 of the survey, respondents were asked if they fuse the data from loop/piezo setup with alternative data sources such as video imaging, Bluetooth detectors, Wi-Fi detectors, and crowd-sourced data to quantify congestion accurately. The percentage distribution of the respondents was almost equally divided, with 31% of respondents saying yes to using other data, 38% of respondents said no, and 31% replied with other. Most respondents specified using other data sources such as video data, Bluetooth, and third-party probe data such as HERE and RITIS.

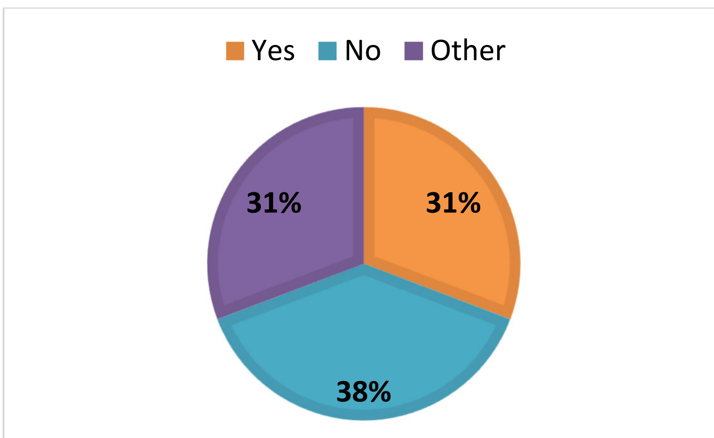

Figure C4. Respondents Alternative Data Sources & Data Fusion

6. General Comments and Conclusion

The last part of the survey asked the respondents to provide any additional insights on the issue discussed in the survey that might assist Florida DOT in developing analytical tools to quantify volume and classification data in stop-and-go traffic situations accurately. The following are the responses from the respondents;

- Get a free demo from CLR Analytics for signatures. There are signatures from loops or magnetometers. Also, increase the loop side to side width to 8' to improve its actual counts. Many DOTs do an 8' wide loop now.
- A process to adjust volume counts for congested conditions would be beneficial. There probably needs to be some accounting for the varying degrees of congestion. There likely needs to be a process of identifying congestion thresholds for each type of cross-section in the context of congestion that impacts the detection technology not the traditional measures of congestion.

- Analyzing the time of day when unclassified vehicles are detected can show periods where congestion affects classification accuracy. Per-vehicle records, if available, are a good source for this type of information.
- Use radar units in congested areas. Compare radar sites data with HERE (probe data) to draw conclusions on what is happening on the roadway.
- Looking into other forms of data collection for stop and go traffic, such as the leetron video classification system, which has been shown to be very accurate for both class and volume in stop and go traffic.

This survey brought to attention the collection of data using ILD in congested traffic situations. Many agencies reported that they avoid collecting data in congested areas. Moreover, agencies that collect data in congested areas have not developed adjustment factors or used statistical methodologies to adjust loop volume counts. However, the survey captured other efforts by State DOTs to improve the accuracy of the data such as the use of automatic warnings on data issues, regular quality checks, calibrations and upgrading equipment. Through this survey, a respondent from FHWA advised the use of signature detection to improve the accuracy of data collected by ILD under congested conditions. In general, many agencies expressed interest in this study and responded that the process to adjust volume counts and improve vehicle classification for congested stop-and-go situations would be beneficial.