2016

Challenges of the Day-to-Day Operation of a Traffic Monitoring Program

Prepared By: Kiisa Wiegand, Business Analyst
Prepared For: Paul Tanner,
State Transportation Data Administrator
Document Last Updated: 04/29/2016

Georgia Department of Transportation
Office of Transportation Data
600 W. Peachtree Street, N.W.
9th, 18th, 19th (Main Office 1934), and 20th Floors
Atlanta, Georgia 30308

GDOT
Georgia Department of Transportation

CONTENTS

1 ABSTRACT

Over the last decade, the Georgia Department of Transportation's (GDOT's) Office of Transportation Data (OTD) has continuously strived to improve our Traffic Monitoring Program through multiple approaches, ranging from changing business practices to implementing new technology. The demand by both internal and external customers for traffic data in all formats has been increasing, while many state Department of Transportations (DOTs) have significantly reduced personnel and funding resources. State DOTs are strategically planning their programs, revising traffic collection activities and seeking innovative counting methods.

Increased communication among the state DOTs could provide information on new initiatives, successful technology, and other perspectives on how to solve common problems. State DOTs collect, process, and distribute traffic data in ways that are unique to each state, but there is more in common among the states than there is different. There is regular communication from the Federal Highway Administration (FHWA) to the state DOT's through training, documents and data submittal reviews, but the communication between states is typically limited, based upon resource availability, to an occasional conference or in-common vendor dialog. Often, vendors are the source of information on new initiatives that other state DOTs are undertaking.

This research focuses on the challenges of the day-to-day operation of a Traffic Monitoring Program. As part of this research, OTD has conducted a survey of other state DOT's Traffic Monitoring Programs regarding types of software, equipment, installations, data sharing efforts, quality assurance, quality control, use of new technology, and other information related to the general state of their program. Managing a Traffic Monitoring Program requires balancing resources, strategic planning for future years, adjustments to meet changing data needs, skilled data management, adjustments to meet field conditions, and ensuring worker safety.

2 INTRODUCTION

2.1 BACKGROUND

OTD has an extensive, quality driven Traffic Count Program in compliance with all Federal regulations and guidelines. FHWA requires that all states collect traffic data on the Federal-Aid System and provide Vehicle Miles Traveled (VMT) estimates for the local Functional Classification (FC) Systems as directed by Federal regulations. The Traffic Collection Program provides statistically valid data for the Highway Performance Monitoring System (HPMS) report required by the FHWA on an annual basis. The design of the program closely follows the guidelines of the FHWA's *Traffic Monitoring Guide* (TMG) (*1*).

Traffic count data is collected using permanent and portable traffic monitoring sites, short-term counts, portable weigh-in-motion (WIM) sites, and continuous WIM sites. As of January 2016, Georgia's Traffic Monitoring Program consists of approximately 30 non-permanent WIM sites collected annually, 12 permanent WIM sites, approximately 8,500 portable traffic sites collected annually, and 230 Continuous Count Station (CCS) sites.

Annually, OTD establishes a traffic count collection plan, implements the plan, collects the traffic data, reviews/processes the annual traffic data, calculates the estimates and traffic factors, creates the reports, updates the systems, and publishes the data. OTD processes all incoming data with defined and established quality assurance and control measures. OTD performs quality control reviews on a daily or weekly basis and conducts a comprehensive review as part of the end-of-the-year data processing.

The FHWA's TMG (*1*) states, "Each State has its own traffic data collection needs, priorities, budgets, geographic and organization constraints. These differences cause agencies to select different equipment for data collection, use different data collection plans, and emphasize different data reporting outputs." Each State must consider multiple aspects, such as finances, personnel, equipment, and goals, when establishing and executing the plan for their Traffic Monitoring Program.

2.2 SURVEY

OTD conducted a single-round survey of other state DOT's Traffic Monitoring Programs regarding types of software, equipment, installations, data sharing efforts, quality assurance, quality control, use of new technology, and other information related to the general state of their program. There were 47 responses to the survey by January 2016. Five anonymous responses were not included in the analysis in this document. This document will refer to data collected by Georgia's Traffic Monitoring Program Survey (simply referred to as the *survey*). To view the complete results, please visit the following website: https://www.surveymonkey.com/results/SM-TX8LLLBJ/.

2.3 ORGANIZATION OF MATERIAL

Although traffic monitoring discussions encompass a wide array of knowledge from technical equipment specifications to statistical calculations, this document focuses on the management challenges of a state DOT's Traffic Monitoring Program and is primarily written to increase information sharing among the state DOTs. It assumes a basic knowledge of traffic data collection and familiarity with the industry. The material presented in this document begins with an overview of the program challenges. This document will discuss strategies for adapting to budget and resource changes; meeting customer's data needs; integrating data processing, maintenance and publication; changing field conditions and increasing worker safety.

3 PROGRAM CHALLENGES

In a world not constrained by funding or other resources, every Traffic Count (TC) segment on every road would have actual traffic count available every year. Perhaps, in a small geographical area with a large budget this is an actual possibility. However, most state DOTs continually balance budget constraints with resources (time, funds, and available staff) and needs (quantity and quality of traffic counts). It is the classic paradox of project management. The top challenges cited by state DOTs in the survey are a lack of resources; meeting data needs; data processing, maintenance, and publication; field challenges; and worker safety (Figure 1). Survey respondents could cite more than one challenge.

Figure 1 Top Traffic Monitoring Program Challenges Cited by State DOTs.

If given unlimited funds to improve their Traffic Monitoring Programs, the state DOTs would spend the funds on all areas ranging from site communication to personnel, but the greatest focus would be on increasing the amount of traffic data collection, specifically vehicle classification (Figure 2).

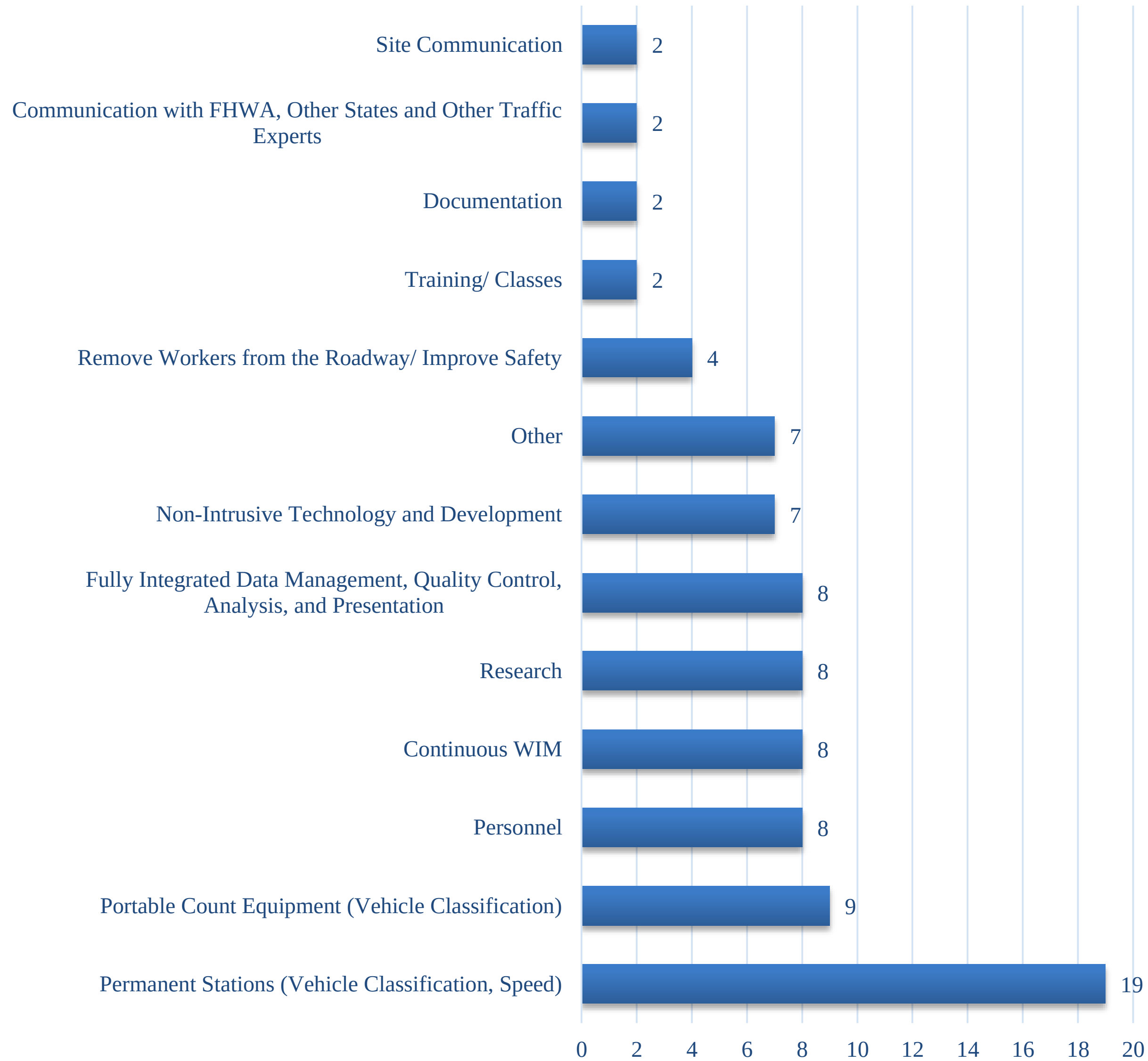


Figure 2 Improvement Areas If Provided with Unlimited Funding.

3.1 Resources

The greatest challenge reported by the state DOTs is a general lack of resources, including funds, staff, and internal support for their Traffic Monitoring Programs. Seventeen percent (17%) of the survey respondents stated that their agency gave 'Average', 'Low,' or 'No Importance' to their Traffic Monitoring Program (Figure 3). Several respondents mentioned that it was difficult to garner internal support, which in turn translated into budget cuts. One state provided the following statement: "Traffic data does not have an immediate impact. It's easy to cut the data collection budget and staff when the data won't be missed until the next [year's] program is planned."

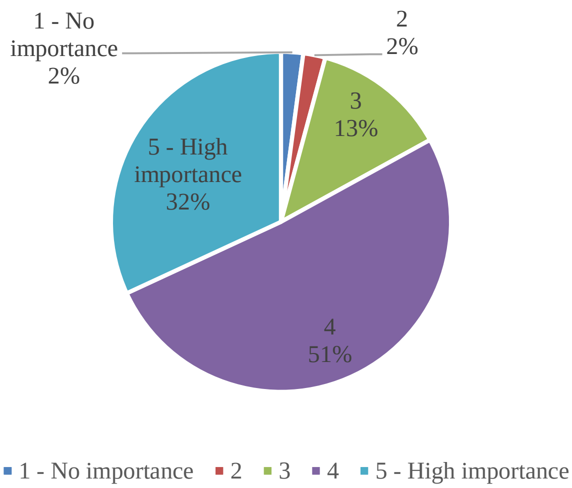


Figure 3 Importance Given by State DOTs to their Traffic Monitoring Programs

Twenty survey participants specifically mentioned lack of staff. Several states mentioned decentralized traffic collectors and maintenance personnel that had little incentive to follow the main office's directions. Low retention and high retirement are leading to staffing shortages and constant training efforts. Texas' traffic monitoring team stated that the top challenge was "hiring and training qualified people to perform the varied aspects of data collection, installation, maintenance, and repair to ensure the future viability of the program and prevent the undermining of the system integrity." Florida's traffic monitoring team stated, "It is sometimes difficult to keep up with the many different contractors around the state and their lack of communication to our central office can make it a challenge."

OTD's traffic monitoring team consists of approximately 20 internal employees and consultants who perform the required daily tasks. Employees nail the pneumatic tubes to the ground; oversee CCS installations/repairs; spend numerous hours methodically studying numbers on a screen; create maps using geographic information system (GIS) software; create reports; and numerous other quality control and administrative tasks. Over the years, OTD has found that the employee knowledge transfer is a constant need to be addressed due to lack of staff, retention, and high retirement. In summary, OTD has tried various strategies over the years to provide assistance with staffing and training (Table 1).

Table 1 Strategies for Lack of Staff

Strategy	**Pro(s)**	**Con(s)**
Regularly Scheduled Internal Office Training	• New employees learn the basics • Existing employees are made aware of new changes • Employees get experience by giving presentations	• Additional individual training is needed • Requires staff/manager time to develop and present information
Mentoring	• New employees gain organizational and job knowledge	• Mentors need to spend time on training versus regular work assignments
Job Rotation	• Increased employee knowledge, skills, and perspective • Broad base of organizational knowledge	• Additional time required by managers and workers for training • Some employees are not a good fit in other areas
Documentation	• New employees have basic process documentation	• Business processes and software are constantly changing
Outsourcing	*Discussed in Section 3.1.1*	*Discussed in Section 3.1.1*

3.1.1 Outsourcing Versus In-House

In 2008, GDOT senior management requested that OTD examine outsourcing traffic data collection and prepare a detailed report discussing what functions can potentially be outsourced and how to implement those recommendations. At the time, OTD was already contracting a majority of the CCS installation and maintenance activities. The analysis, which did not include retirement benefits, showed that it was eight percent (8%) more cost effective to outsource the portable traffic data collection. In 2010, OTD eliminated 14 Field Technician positions and hired a contracting firm to fulfill most of the portable traffic data collection needs. Several intangible operational factors could not be calculated in the analysis, such as time spent on contract management, training, field knowledge, etc.

OTD currently has a successful hybrid portable traffic data collection program. The in-house Field Technicians collect portable traffic data, including ramp traffic volume counts, vehicle classifications near bridges, and non-directional and directional traffic volume. They also collect Portable Traffic Monitoring Station (PTMS) data, and supervise CCS maintenance/installations. In order to keep fuel costs to a minimum and for practical purposes, they are mostly constrained to counties local to their home base. The two in-house Field Technicians were the highest performing employees and it has been cost effective to retain their positions.

Twenty-one states indicated in the survey that they had at least some portion of the traffic data collected by a third party company and/or purchased or leased equipment from that company. In recent years, OTD has also shifted towards requiring the traffic data collection consultant to provide and maintain permanent CCS traffic data collection equipment (i.e., the ownership has been transferred from OTD to the consultant). Outsourcing has allowed greater flexibility for adding special counts and adjusting portable traffic data collection. OTD has outsourced the collection of traffic data services to supplement internal resources (Table 2).

Table 2 Outsourced Traffic Data Services

Type	Details	Percentage Outsourced
Portable Traffic Data Collection	48-hour traffic counts	79%
Continuous Count Station (CCS)	Permanent traffic data collection, device installation, and maintenance	90%
Special Requests	Turning movement counts, portable volume and vehicle classification, etc.	100%
Weigh-In-Motion (WIM)	Data collection and reporting to the FHWA	100%

3.2 Program Planning to Meet Data Needs

Seventeen states stated providing accurate, timely, and adequate data to meet ever changing and increasing requirements is a major challenge. Despite budget constraints in recent years, the customers' demands for traffic data in all formats has not reduced. For example, the most recent HPMS reassessment requires additional traffic data collection on ramps. The new AASHTO *Mechanistic-Empirical Pavement Design Guide* (MEPDG) calls for Per Vehicle Record (PVR) data (*2*). Thirty-seven percent (37%) of the survey respondents did not collect PVR data. Special requests for traffic counts are also a competing factor with the portable traffic count program. Often, these traffic counts revolve around a special event and are not valid for use in an Annual Average Daily Traffic (AADT) calculation.

3.2.1 Program Management Strategies

All Traffic Monitoring Program managers must actively adjust their traffic program, based upon annual funding. Due to the Great Recession beginning in the later part of 2007, the state DOTs' funding decreased steadily for a number of years. Each subsequent year required additional reductions in many of the programs. OTD outlined strategies for adjusting the program, based upon different possible funding scenarios.

3.2.1.1 Maintain Traffic Monitoring Program

If funding for Georgia's Traffic Monitoring Program is maintained at the current level, OTD will maintain the traffic collection efforts at their current state (Table 3). If critical locations are needed for CCS installation, a maximum of 1 or 2 new CCS sites may be possible, depending upon external variables, such as construction, repairs, equipment failures, etc.

Table 3 Maintain Traffic Monitoring Program

Type of Traffic Data Collection	Strategy
Portable	• Maintain maximum 6-year cycle on less critical locations • Maintain a more frequent cycle on more critical locations • Maintain approximately 8,500 portable counts
CCS	• Add 1 or 2 critical sites (maximum) • Maintain existing 230 sites, if needed
WIM	• No additions or changes • 30 portable/12 permanent

3.2.1.2 Decrease Traffic Monitoring Program

If funding for Georgia's Traffic Monitoring Program is decreased, OTD will need to implement program changes (Table 4). These changes could encompass the following: adjusting count cycles to longer periods; decreasing the number of portable traffic counts collected; not repairing non-critical CCS sites; and adding more PTMS sites. For several years, OTD has been evaluating data sharing partnerships and other alternative traffic data sources, which will become more important, if funding is decreased.

Table 4 Decrease Traffic Monitoring Program

Type of Traffic Data Collection	**Strategy**
Portable	• Move additional traffic count sites to 6-year maximum cycle • Decrease the number of traffic count sites • Decrease the number of vehicle classification sites
CCS	• Non-critical sites are not repaired [while ensuring that these sites meet the standards of the FHWA's TMG (*1*)] • Convert additional sites to PTMS
WIM	• No additions or changes
Alternative Data Sources	• Explore Intelligent Transportation Systems (ITS) or data sharing

3.2.1.3 Increase Traffic Monitoring Program

If funding for Georgia's Traffic Monitoring Program is increased, OTD will implement program changes (Table 5). In 2015, the Georgia General Assembly passed House Bill 170 that allocated additional state motor fuel funds for transportation. Fortunately, OTD now has the opportunity to repair CCSs and return Georgia's Traffic Monitoring Program to a more desired level of operation. OTD will add data collection sites, including WIM, near areas of interest, such as shipping ports and freight corridors, to meet the needs of the upcoming Fixing America's Surface Transportation (FAST) Act (*3*). Finally, OTD may consider adding 1 or 2 CCSs in critical locations annually, as needed.

Table 5 Increase Traffic Monitoring Program

Type of Traffic Data Collection	**Strategy**
Portable	• Move to 4-year max count cycle • Add count sites at areas of interest or importance • Increase the number of vehicle classification sites
CCS	• All sites are repaired • Maintain PTMS • Install several CCSs at critical locations
WIM	• Add sites near critical freight locations
Alternative Data Sources	• Explore ITS or data sharing

3.2.2 Continuous Count Station Program Planning

3.2.2.1 Average Annual Maintenance Costs

OTD plans the CCS program to meet the required FHWA and GDOT traffic data needs. OTD considers the estimated cost to install a new traffic collection site and maintain the sites, the total budget, and operation. The target number of CCSs for GDOT is 230 to 260 CCSs. OTD expects about ten to twenty percent (10-20%) of the sites to be down due to construction and an additional five percent (5%) to be down due to other external factors.

Annually, OTD looks for which CCSs cost the most money to repair and the reasons behind the expenses. After installation, OTD expects minimal maintenance in the first two years. For the next 7-10 years, OTD expects an average annual cost to repair/maintain the CCS of approximately $3,000. After that time, sites typically reach a critical failure level requiring major repairs or reinstallation (Figure 4). Since OTD is invoiced separately for double-sided traffic collection sites, the costs reported in Figure 4 count the frequency of each side separately. Some of the installed CCSs have been operating without a need for a major repair for 12+ years.

Including the monthly phone service bill and leased site fees (i.e. CCS equipment and modems), if applicable, OTD estimates that adding a new CCS site requires approximately $5,500 per site per year. If the equipment is leased, OTD pays only for the collected traffic data that passes quality control, based upon a tiered scale. Of course, some sites will cost more or less, depending upon modem or cellular service, equipment failures, and the other factors discussed previously.

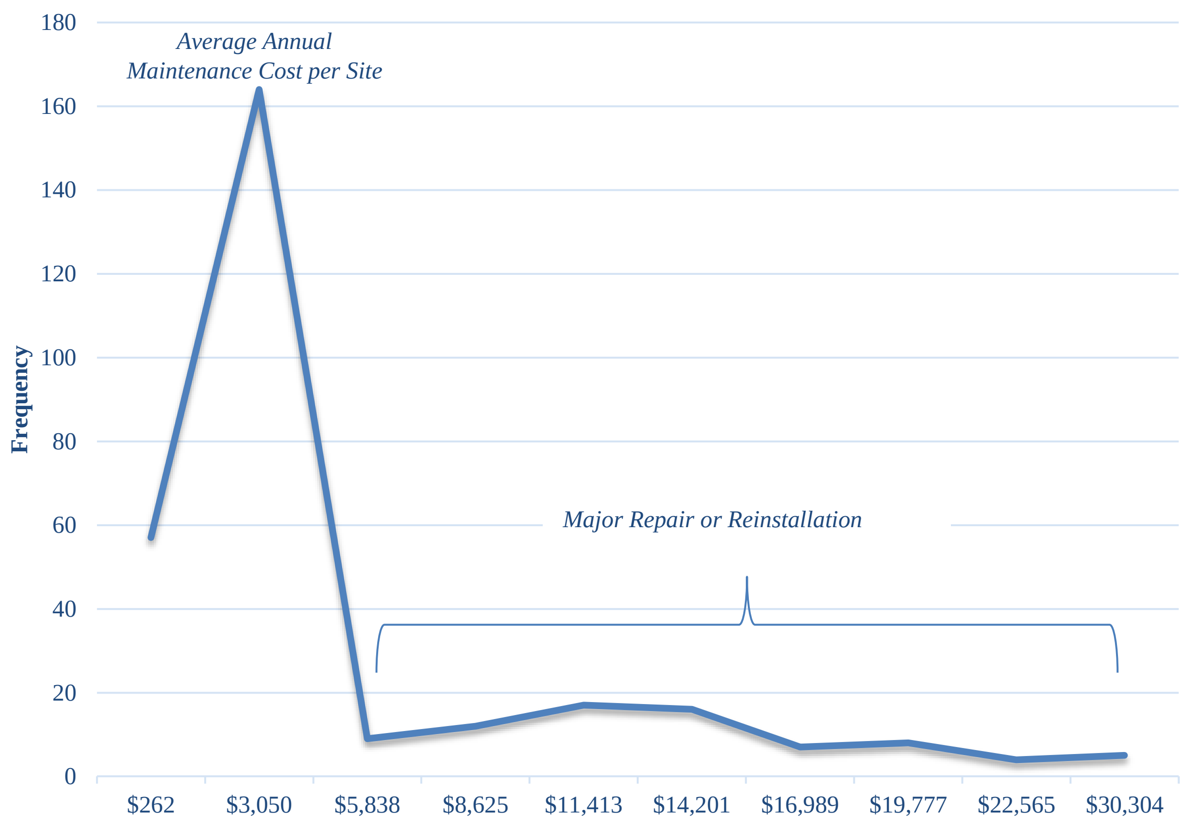


Figure 4 FY 2015 CCS Installation/Maintenance Costs

3.2.2.2 Selection Criteria

When funding allows for the installation of a new CCS, OTD selects a potential new CCS site, based upon defined selection criteria. A field inspection of any recommended new CCS site is performed to ensure site feasibility and optimal placement for the physical installation of the CCS equipment within the traffic count road segment. OTD reviews the results of the field inspection and approves the installation. The TMG (*1*) states, "The main objectives of installing and operating CCSs are to provide highly accurate vehicle classification, track changes in volume over time, determine travel patterns, and create adjustment factors and factor groups."

The following is a list of the selection criteria:

- Minimum of five to eight CCS sites per Traffic Adjustment Factor Group, depending upon the traffic patterns and precision desired
- Critical nodes on high volume roads that are used in a ramp counting procedure, referred to as the Step Down Method, also known in some states as Ramp Balancing, described in FHWA's TMG (*1*) to estimate AADT volumes for Interstates and freeways
- All Interstates must have a CCS site near a State Line
- Adequate coverage on Hurricane Evacuation Routes or Emergency Operation Center (EOC) roads

Other GDOT considerations include:

- Adequate coverage in each of the seven GDOT Districts to ensure geographic differences in travel trends are captured
- Minimum of one operational CCS site on other major grade-separated arterials (e.g., SR-400 and SR-316 – NOTE: both of these State Routes are in the Atlanta metropolitan area and serve as critically important arterials for the region)
- Area of particular interest to GDOT management for planning purposes or to meet specific Federal requirements [e.g., located near shipping ports or recommended by the *Mechanistic-Empirical Design Pavement Guide of New and Rehabilitated Pavement Structures (4)*]

The following is a list of the field inspection considerations:

- Research upcoming construction projects
  - 5 years without a planned construction project is the minimum
  - 7 years without a planned construction project is preferred
  - 10 years without a planned construction project is excellent
- Field investigation
  - Pavement condition
  - Roadway segment characteristics
    - Tangent
    - Flat
    - Smooth
  - Adequate shoulder space
  - Strength of cellular signal
  - Speed limit
  - Number of lanes
  - Low amount of lane switching
  - Free flowing traffic/lack of traffic queuing

- Sunlight for solar panel usage
- Visibility of all traffic lanes from proposed site cabinet location
- Power source/transformer availability (if using AC power)
- Pedestrian/bicycle traffic is not affected by the sensors, cabinet, and pull boxes

3.2.3 Continuous Count Stations versus Portable Traffic Data Collection

With limited funds, OTD carefully considers allocating expenditures on the installation of a new CCS site versus increasing the total number of portable traffic data sites collected. CCS sites provide valuable, year round traffic data including vehicle classification data. While portable traffic data collection provides a quick snapshot of the traffic, it requires a low investment in funds and resources. How do you decide where funds are spent?

At the minimum end of the cost scale, the installation cost of a CCS site on a rural, two-lane roadway is approximately $25,000. A 48-hour vehicle classification count site is $196.00 for a 2-lane, non-directional count. Only considering monetary value and just for analysis purposes, a 48-hour vehicle classification site with data collected for 365 days per year in the same location on a two-lane roadway would cost $35,770.

At the maximum end of the cost scale, one installation on a metropolitan Interstate was approximately $80,000 (e.g., I-85 near Jimmy Carter Boulevard). This included the police services; milling and grinding of pavement; inlay of piezoelectric loops, and overlay of pavement; and set-up of the cabinet. It is not possible to set a portable tube for traffic data collection on Interstates and other Freeways due to worker safety, high traffic volume, and the number of lanes. However, just considering monetary value, a 48-hour vehicle classification site with data collected for 365 days at the 10-lane location ($590.00 per 5-lanes) would cost $215,530.

The main factors in the decision to install a new CCS site versus increasing the total number of portable traffic data collection sites are:

- Critical location
- Additional CCS sites are needed in a specific Traffic Adjustment Factor Group
- Funds available for installation
- Long-term CCS site maintenance funds are available

OTD must consider that adding a new CCS site will increase the annual CCS maintenance expenses. After installation, there are additional long-term maintenance costs to consider. In recent years, OTD has not re-installed a couple low volume, lower FC CCS sites, because there was more than adequate coverage in the Traffic Adjustment Factor Group.

3.2.4 Portable Traffic Program Planning

GDOT has approximately 27,000 TC sites throughout the state. Collecting traffic data on every road segment in Georgia every year is not possible, due to practical limitations. Therefore, portable traffic data counts (8,500) are collected on a defined section of roadway (TC segment) on an annual or cyclical basis, depending upon various internal and external reporting requirements and unit needs. Collection intervals range from two, four, or six years. Traffic counts that are collected on a cyclical basis are adjusted with growth factors in years when they are not counted and marked as *Estimated*. AADT data is marked as either *Estimated* or *Actual* for each collection year for each TC site.

Planning the annual Portable Traffic Count Program starts with a reconciliation with the roadway changes. Three main variables have a significant impact on the costs of portable traffic collection that may be directed by the office management personnel, but are also dependent upon actual field conditions:

- Directional Versus Non-directional
- Volume Only Versus Vehicle Classification
- Count Accepted on First Attempt Versus Assigned for a Re-count

As a rule, any traffic data collection site with three or more lanes is collected as a directional count. In 2015, approximately 14% of the volume-only portable counts were directional counts. If a portable traffic count value is not accepted in accordance with established quality control rules, the consultant or OTD Field Technician is sent out for a second attempt (i.e., re-count) or, in rare cases, for a third attempt. The percentage of re-counts is approximately 2-3% of the total traffic counts collected annually.

The Portable Traffic Count Program is adjusted, based upon feedback from the Field Technicians. Notes are maintained, stating if it is not possible to collect vehicle classification at a site. Field Technicians consider a number of factors when setting a portable vehicle classification site versus setting only a portable traffic volume site, such as:

- The number of lanes at the site
- The road operation type (1-way or 2-way)
- The type of road surface
- The presence of a HPMS Sample
- National Highway System route
- The presence of a bridge or railroad within the TC road segment
- On-hand equipment

3.2.5 Weigh-In-Motion (WIM) Program Planning

States DOTs that rated the importance placed on the WIM data collection as either a 4 or 5, also had customers interested in the WIM data (Figure 5). Many states use the WIM data to track heavy loads. Some states use the WIM data to screen trucks for mobile weight enforcement. Several states said that collection of WIM data near ports was an interest for their state. The main customers are internal pavement engineers, highway safety patrol, and the FHWA. Other states mentioned that WIM data is expensive, noted that the sites were ‘troublesome’, and they did not have a significant amount of demand for the data.

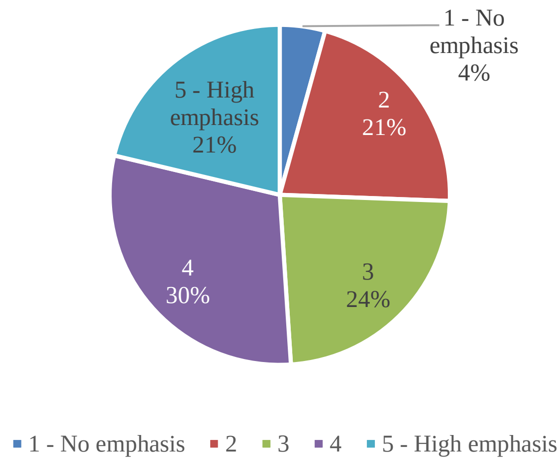


Figure 5 State DOT Emphasis on Weigh-In-Motion Data

3.3 DATA PROCESSING, MAINTENANCE AND PUBLICATION

Nine states listed challenges related to data processing, maintenance, and information sharing, specifically constant software updates, and the high technical expertise required to maintain the databases. It is an ever-evolving process to transmit, process, and store traffic data. How do you transfer large amounts of information from point A to point B in an efficient and timely manner? How do you analyze and display information? Most of the traffic data customers want an easy-to-use, simple interface that provides collected traffic data. Other customers want all types of traffic data in detail as soon as it is available to them.

For decades, OTD relied upon a mainframe database as the data repository for processing and storing all traffic data. That database could no longer adequately meet the evolving business requirements. Problems included: 1) increasing requests for customized traffic data that was time consuming to produce, 2) specialized skills were needed to write FORTRAN scripts to extract data; 3) quality control programs that were difficult to maintain or enhance due to the need for an unsupported programming language; 4) an aging hardware platform caused frequent service interruptions; and 5) the lack of security caused files to be deleted or changed without reason. In January 2008, OTD stopped using the mainframe database to store and process traffic data.

Since then, OTD has continuously tried to contract for a system that can ‘do everything’ and it has been a frustrating effort at a seemingly nebulous goal. The entire chain of information flow from the field to the final customer needs be seamless to maximize cost efficiency. OTD has transitioned through several custom-built databases and software applications to store, perform quality control, display, and report all types of traffic data. For reference, the survey respondents reported using custom software (29%), off-the-shelf software (38%), or a mixture of both (33%).

OTD has learned that the system needs to have quality control at the front end (i.e., the field) to catch data errors before they are loaded into the storage system. The system needs automatic quality control on data coming into the office; adjustable thresholds; flexibility to add, delete, or modify quality control rules; and reporting and analysis capabilities to extract the data. In the survey, the state DOTs listed the various quality control and assurance processes to verify traffic data prior to submitting it to the FHWA:

- Regular equipment checks
- Basic data validation at the site in the field
- Quality control checks on incoming traffic data
- Verification after loading the traffic data to the database
- End-of-year processing

OTD started with first building the foundation. Each subsequent development may not have been as successfully as originally planned, but they have provided a stepping-stone for the next development on our path to a fully integrated, high-capability system. One lesson learned is writing detailed task orders that focus on manageable goals.

3.4 FIELD CONDITIONS

Six survey respondents cited field concerns related to the physical site conditions, such as road construction, pavement deterioration, and weather. A northern state mentioned that they can only realistically collect at portable traffic collection sites and install/ repair CCS sites from April to November due to the weather, but their collection efforts are directly compared to southern states operating mainly year round. Other states mentioned deteriorating pavement conditions affecting the CCS sites.

There are a number of unpredictable, external factors that affect the CCS maintenance and installation costs: vehicles crash into equipment; extreme weather; weeding, edging, and clearing vegetation; damage from animals; phone line damage; equipment theft; and road construction.

Collecting traffic data in stop-and-go traffic conditions is a challenge due to equipment failures. Increased traffic congestion increases the difficulty in obtaining reliable vehicle classification counts. Construction and incidents also affect traffic data collection.

As mentioned previously, OTD expects about ten to twenty percent (10-20%) of the sites to be down due to construction and an additional five percent (5%) to be down due to other external factors. As of December 2015, 30 traffic collection sites were inoperable due to construction. Within the last couple of years, as sites have become inoperable, OTD has permanently removed eight traffic collection sites that did not meet any of the primary CCS criteria outlined above.

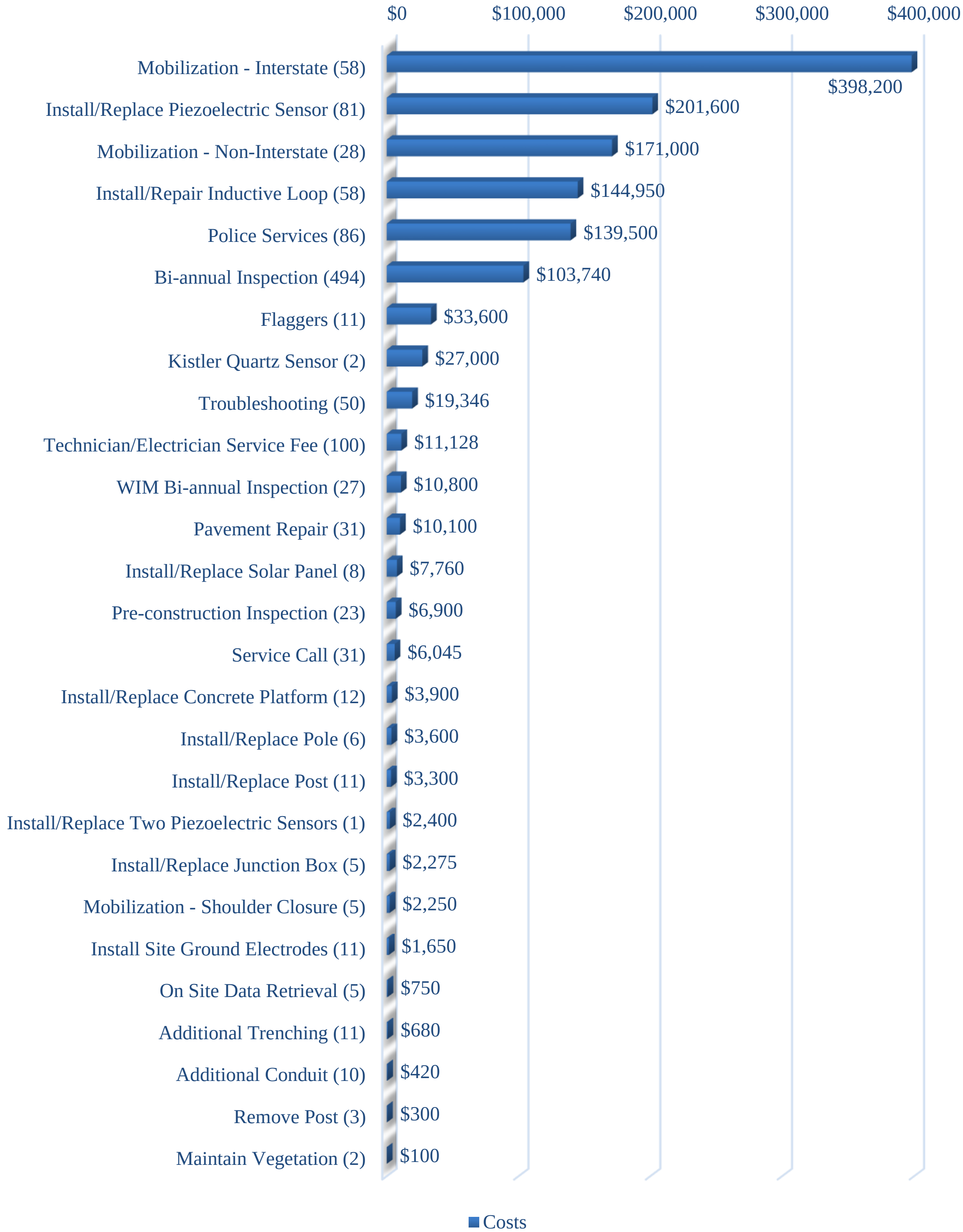
3.4.1 CCS Maintenance

The common misconception about permanent traffic data collection is that embedded sites do not last very long. In recent years, the new low-power usage devices, improved encapsulated inductive loop wire, improved sensor technology, cellular modems, and alternative energy products all allow the placement of collection sites in areas that were never available before. The new systems also allow the sensors to be embedded much deeper into the sub-course levels of asphalt and concrete roadways instead of the friction courses. By placing the sensors in the sub-courses of the asphalt, it greatly increases the longevity of a sensor and leads to a more approvable form of data collection without the higher cost of maintenance.

Repairs to existing traffic collection sites performed by OTD’s selected contractor normally consist of, but are not limited to, the replacement of defective piezo sensors or loop detectors. Complete installations consist of installing piezo sensors, loop detectors, foundations, junction boxes, conduits, electrical service, telephone service, cabinets, and other related construction activities as may be required to install a completely functional site.

In recent years, new advances in materials, electronics, and systems makes collecting data a much more economical platform than ever before for State and local government agencies. However, state DOTs must perform a general amount of infrastructure renewal annually. OTD is interested in tracking traffic collection sites that routinely present maintenance problems. OTD also tracks CCS installation and maintenance costs by type, to determine where the funds are spent (Figure 6). Due to the recent years of budget cuts, many state DOTs, including GDOT, extended the time between pavement resurfacing. Consequently, OTD has had a high number of CCS repairs on Interstates. Additionally, some CCS sites were not reinstalled or repaired due to the high level of pavement degradation.

Figure 6 FY2015 CCS Installation and Maintenance Costs by Type



In FY2015, the total CCS installation and maintenance costs were approximately $1.3 million.

3.4.2 CCS Installation

OTD asked the survey respondents how often CCS installation specifications are altered or adjusted to meet changes in roadway designs, varying types of road surfaces, new and improving technologies, materials, and product changes. Florida DOT stated, "We are constantly looking for new and improving technologies, materials and products. When a beneficial change is required we will work on enacting a revision on the next year's [specifications]." Some of the state DOTs indicated that they were constantly making adjustments while others were making adjustments every few years, or seldom made changes. Other states wait until after a new method has proven to be beneficial to other states before incorporating it into their program.

Minor changes in the CCS installation practices can have significant long-term results. In modified asphaltic mixes, GDOT's contractor recommends using 51-7 wire installed up to 5 inches deep. Fourteen-(14) gauge PVC jacketed wire allows a wire to avoid direct exposure to the asphalt and elements. Placement of sensors at 4 inches or deeper allows most 'milling' operations to be performed without damaging the inductive loop sensors. It has been a common industry practice to splice a loop at the closest pull box access off the roadway using a 50-2 Homerun cable and a gel-filled splice kit. GDOT's contractor has practiced not incorporating splices in projects for 12 years and the number of failures of inductive loops has significantly dropped when a splice is not used. The introduction of water and other elements creates 'failure points'. Failure points become time consuming for electronic technicians to detect and repair.

3.4.3 Pavement Conditions

Dealing with roadway failures is commonplace when collecting traffic data. Roadway failures may affect portable traffic collection tube placements as well as permanent traffic collection sensors. Understanding common failures and forecasting them will improve your data collection program and may assist in placement of data collection sites (Appendix A).

Road conditions are extremely important when placing road tubes for portable traffic data collection. Conditions, such as cracking, edge failures, alligator cracking, are all examples of pavement conditions that may negatively affect data collection at a location. Roadway cracking may cause the pavement to move and shift. Road tubes should not move, roll, or bounce on the road surface. Nails and road tape should secure the road tube. Field Technicians should not place road tubes on the areas of pavement with edge failure.

When selecting a CCS location, the condition of the roadway is a critical factor to consider. Alligator and block cracking, edge of roadway failures, rutting and longitudinal cracking will all shorten the life of the sensors in the roadway and may affect data collection. Cracking and rutting are initial indicators of a pavement failure. Vehicles primarily travel in the lane, but any deviation of the traffic due to pavement conditions will affect the continuous count data and the longevity of the sensors. The cracking in the roadway may allow water, ice, and contaminants under the roadway surface causing the roadway to act like a sponge. Water is the most constant damaging external element to traffic sensors. The impact of water to the pavement and the subsurface affects more sensors than any other item in the controlled environment of the traffic data collection system.

CCSs are expensive and ensuring the ideal placement is critical. The CCS should be installed in a cured asphalt roadway where the roadway is relatively new; there are no planned road projects; the surface is smooth; and the sensors can be placed in a tangent section of roadway. A high-quality sensor installation in a roadway in good condition should typically last from 8 to 12 years, if installed properly and the roadway continues to be in good condition. Minor maintenance of the sensors include resealing, crack sealing and debris removal, which are vital to a long-term CCS life cycle.

One of the biggest improvements in roadway safety in recent years is the ever-changing development of 'modified asphalt' and concrete roadway materials. The modified asphalt mixture allows water and other weather related issues to clear the surface area faster making it safer for the traveling public. While the advancement in modified asphalt roadways has made it much safer for the motorist, it also has made the installation of embedded sensors a much more detailed process. In previous years, some states required water to be applied to the cut, the blade and the slots to wash clear any debris when cutting a road for a sensor placement. New modified asphalt mixes now allow the water to move to the lowest point of the roadway. The sensor cut is the lowest open point in the roadway and water will now move to that point. The use of 'dry cutting' is the formal approach for GDOT's contractor currently, complimented with the use of vacuums for dust control, backpack blowers, and pneumatic air movers. The use of diamond blades also allow a safer cut for the roadway without the fear of blades breaking apart due to heat and abrasion. The use of applying denatured alcohol for cleaning the roadway cuts provides a much cleaner and less time-consuming approach for the installation process.

3.4.4 Equipment and Telecommunications

OTD has been shifting the traffic data collection equipment ownership to the contractor in recent years. However, this is opposite of the nationwide trend showing an overall shift in the last 5 years towards increasing the amount of state-owned traffic data collection equipment (Figure 7). Most states had multiple types of traffic data collection equipment. The most popular brands of traffic data collection hardware mentioned by the state DOTs included Wavetronix, Diamond Traffic Products, International Road Dynamics, Inc., and Peek Traffic Corporation. In contrast, Virginia DOT purchases the data and does not own any traffic data collection hardware.

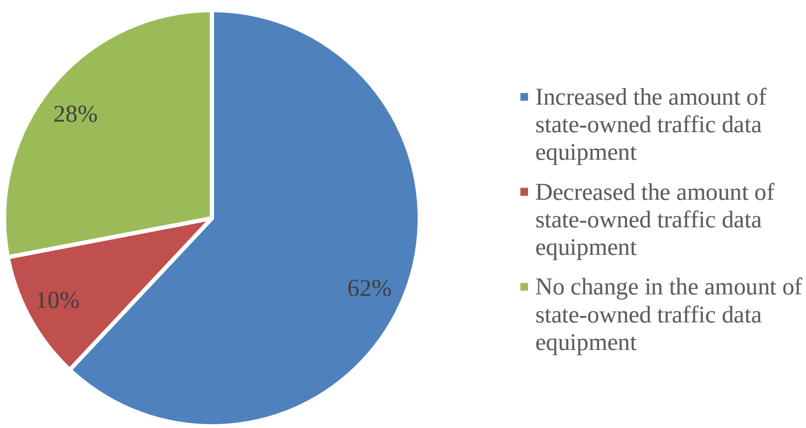


Figure 7 5-year Trend in State-Owned Traffic Data Equipment

In the last 10-15 years, there has been an evolution of power sources and telecommunications. In the past, CCS sites were carefully selected based upon access to a power source. Various types of power sources and telecommunications are used by state DOTs (Figure 8). GDOT does not use wind turbines as a power source or fiber optics for telecommunication. GDOT has two PTMSs, which use alternating current (AC) power.

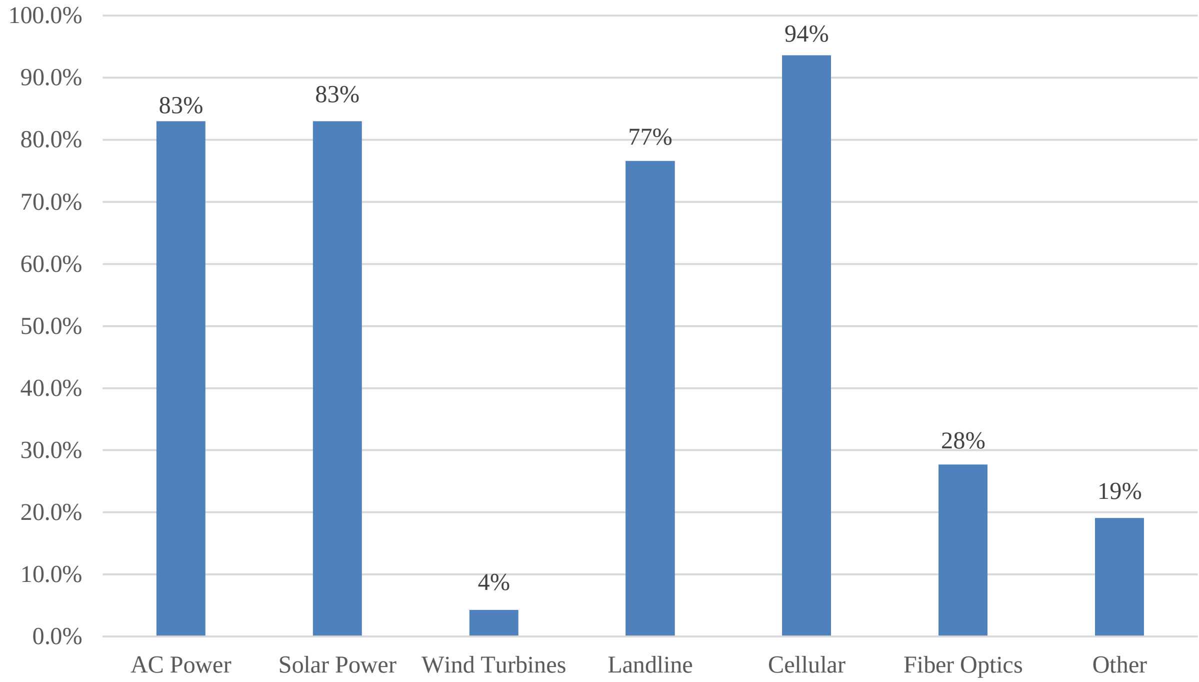


Figure 8 Types of Power and Telecommunications Systems Used by the State DOTs

With the exception of a handful of sites (4 landlines), the majority of OTD's 230 operational CCS sites have been converted to cellular communication. Cellular modems allow site placement without locating a phone terminal and phone service line. This means site placement is possible in most remote locations and reduces the need for long distance phone calls to connect to modems. Cellular service is less expensive than landline service, but the conversion has resulted in some difficulty polling the CCS sites. In addition, as fewer and fewer CCS sites remain on the landline plan, the phone company has raised the rates on the remaining sites.

The following is a list of basic, optional, and experimental materials used by the traffic monitoring industry:

Basic Materials in Use

- Measurement Specialist Brass Linguini Class I, Class II Piezoelectric Sensors
- Loop Wire with Jacketed Cover for Protection
- Flexible Epoxies, Grouts, Sealants
- Kistler Quartz Sensors
- Wavetronics Detectors
- RTMS Radar Detectors

Optional Materials in Use

- Cellular Modems
- Fiber Optics Modems
- Long Range Antennas
- Aluminum Poles with Breakaway Bases
- Solar Panels

- Wind Turbines
- Miniature Wind Turbines
- Composite Pull Boxes
- Grounding Electrodes
- Surge Protection
- Bending Plates

Materials Currently Being Tested

- Low Voltage Data Recorders
- Per Vehicle Event Recorders
- Vehicle Detection Cameras

3.5 Worker Safety

Five survey respondents cited worker safety as a major concern. Safety of the traffic data collection team is particularly a concern on high-volume routes. It is an ongoing effort to improve safety, and investigate innovative practices and technologies to protect workers in the field.

High traffic volumes and the design of the road can increase the safety risks. For example, the ramp designs have been changing in the past decade to long arching, banked curves, which allow traffic to maintain high speeds. This has had the unintended effect of increasing the danger of collecting ramp data for Field Technicians. While state DOTs estimate Interstate volumes, they may collect and report traffic data on roads that have higher volumes than portions of the Interstates. For example, Peachtree-Dunwoody Road, a principal arterial road near Atlanta, has AADTs near 80,000, which is collected with portable collection devices, while portions of rural I-75 have AADTs near 30,000.

Many of the survey comments indicated a strong interest in researching non-intrusive technologies that would remove the worker from the roadway as much as possible, due to safety concerns (Figure 9). Fifty-seven percent (57%) of the respondents who used non-intrusive devices to gather traffic data used the Wavetronix Radar devices. Thirty percent (30%) of the respondents indicated that they did not have non-

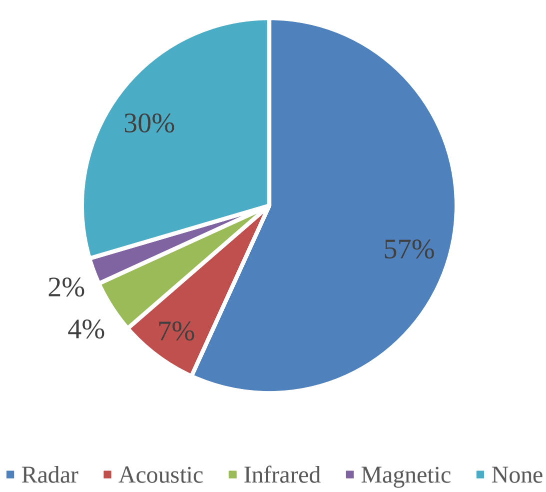


Figure 9 Types of Non-Intrusive Traffic Data Collection Used by State DOTs

intrusive technology other than the traditional CCSs. Traffic cameras were excluded from the survey results.

There are a number of practices that can be employed to increase worker safety. The top five areas that can improve safety in the field are 1) education, 2) the correct equipment, 3) technical training, 4) apprenticeship programs, and 5) the correct apparel. Employees should be offered extensive training on equipment, operation, and different field conditions. Providing employees with the correct tool to complete a task will drastically reduce unsafe practices. Employees who undergo technical training on an annual basis have a greater understanding of the elements that create incidents and how to avoid common mistakes. Experienced employees who train new employees and act as guardians provide a valuable hands-on approach to worker safety. State DOTs or their contractors should provide visually protective clothing and safety equipment to protect them from hazards.

4 CONCLUSIONS

Although eighty-five percent (85%) of the survey respondents stated that they had conversations about traffic data with other state agencies, fifteen percent (15%) of the states did not. OTD’s survey of other state DOT’s Traffic Monitoring Programs provided useful information regarding types of software, equipment, installations, data sharing efforts, quality assurance, quality control, and use of new technology. Increased communication among the state DOTs could provide information on new initiatives, successful technology, and other perspectives on how to solve common problems.

The management of a Traffic Monitoring Program requires balancing resources, strategic planning for future years, adjustments to meet changing data needs, skilled data management, adjustments to meet field conditions, and ensuring worker safety. Strategic planning has allowed OTD to use our resources efficiently. OTD is continuously striving to improve our Traffic Monitoring Program through multiple approaches ranging from changing business practices to implementing new technology.

5 ACKNOWLEDGEMENTS

The author expresses appreciation to Mr. R. Paul Tanner, State Transportation Data Administrator, for his input, guidance, and useful critiques of this research work. The author acknowledges the valuable contributions of Mr. Terry Robinson with Southern Traffic Services, Inc. to the Sections 3.4 Field Conditions and 3.5 Worker Safety, and Appendix A: Common Types of Roadway Failures. Finally, thank you to the states that took the time to respond to the survey.

6 REFERENCES

1. U.S. Department of Transportation, Federal Highway Administration, *Traffic Monitoring Guide*, September 2013.
2. American Association of State Highway and Transportation Officials (AASHTO). *A Policy on Geometric Design of Highways and Streets*, 6th Edition. AASHTO, Washington, D.C. 2011.
3. Fixing America's Surface Transportation Act (FAST Act), Enacted by the 114th United States Congress, Pub.L. 114-94, December 4, 2015.
4. National Cooperative Highway Research Program (NCHRP), Washington, D.C., Mechanistic-Empirical Design Guide (MEPDG), Retrieved on March 30, 2016 from http://onlinepubs.trb.org/onlinepubs/archive/mepdg/home.htm.

7 APPENDIX A: COMMON TYPES OF ROAD FAILURES

Alligator Cracking
Alligator cracking is a load associated structural failure. The failure can be due to weakness in the surface, base or sub grade; a surface or base that is too thin; poor drainage, or the combination of all three. It often starts in the wheel path as longitudinal cracking and ends up as alligator cracking after severe distress.

Block Cracking
Block cracks look similar to large interconnected rectangles. Block cracking is not load-associated, but can be caused by shrinkage of the asphalt pavement, due to an inability of asphalt binder to expand and contract with temperature cycles. This can be due to not enough moisture in the asphalt mix; a fine aggregate mix with low penetration asphalt and absorptive aggregates; poor choice of asphalt binder in the mix design; or aging dried-out asphalt.

Longitudinal (Linear) Cracking
Longitudinal cracking are cracks that are parallel to the pavements centerline or laydown direction. These cracks can be a result of both pavement fatigue, reflective cracking, and/or poor joint construction. Joints are generally the least dense areas of the pavement.

Transverse Cracking
Transverse cracks are single cracks perpendicular to the pavement's centerline or laydown direction. These cracks can be caused by reflective cracks from an underlying layer, daily temperature cycles, and poor construction due to improper operation of the paver.

Edge Cracks
Edge cracks travel along the inside edge of a pavement surface, within one to two feet. The most common cause for this type of crack is poor drainage conditions and lack of support at the pavement edge. As a result underlying base materials settle and become weakened. Heavy vegetation along the pavement edge and heavy traffic can also be the instigator of edge cracking.

Joint Reflection Cracks
Joint reflection cracks are cracks in a flexible pavement overlay of a rigid pavement (i.e., asphalt over concrete). They occur directly over the underlying rigid pavement joints. Joint reflection cracking does not include reflection cracks that occur away from an underlying joint or from any other type of base (e.g., cement or lime stabilized).

Pot Holes
Pot holes are small, bowl-shaped depressions in the pavement surface that penetrate all the way through the asphalt layer down to the base course. They generally have sharp edges and vertical sides near the top of the hole. Potholes are the result of moisture infiltration and usually the result of untreated alligator cracking. As alligator cracking becomes severe, the interconnected cracks create small pieces of pavement, which can be dislodged as vehicles drive over them. The remaining hole after the pavement is dislodged is called a pothole.

Rutting

Ruts in asphalt pavements are channelized depressions in the wheel-tracks. Rutting results from consolidation or lateral movement of any of the pavement layers or the subgrade under traffic. Insufficient pavement thickness; lack of compaction of the asphalt, stone base or soil; weak asphalt mixes; or moisture infiltration cause rutting.

Other

Other various types of roadway failures include concrete failures, shifting slabs, cracking of joint compound, etc.