

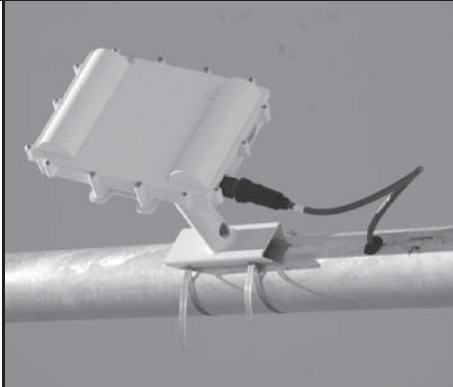


AASHTO Guidelines for Traffic Data Programs



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AASHTO Guidelines for Traffic Data Programs

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CHAPTER 1

Introduction



1.1 Introduction

1.1.1 Objective

The objective of the guidelines is to improve the quality of the traffic information that supports decisions at all levels of the transportation profession. Traffic data programs are essential for state Departments of Transportation to accomplish their mission of ensuring safety and mobility to the traveling public. Traffic data supports capital investment programs and budgets, as well as effective design and maintenance programs.

This document is a reference for professional traffic monitoring and establishes recommended national traffic monitoring practices that reflect current practice and advances made in the past several years.

1.1.2 Background

The first edition of the American Association of State Highway and Transportation Officials (AASHTO) *Guidelines for Traffic Data Programs* was developed by an AASHTO Task Force that was formed in 1990 and was composed of members of two AASHTO Committees and representatives of the Federal Highway Administration (FHWA) and the Strategic Highway Research Program. That edition built upon and supplemented the 1985 edition of FHWA's *Traffic Monitoring Guide* (TMG).

Since publication of the first edition of the guidelines in 1992, many advances have been made in traffic monitoring procedures, and updated editions of the TMG were published in 1994 and 2001. This new edition of the Guidelines represents a general updating of all material so the content reflects the current state of the art and complements the TMG.

The guidebook is intended for use by state and local transportation agencies, as well as others involved in traffic data programs.

1.2 Principles, Themes, and Emerging Issues for Guidelines

Principles underlying the development of the *Traffic Data Guidelines* include:

- **A Common Traffic Monitoring Practice**—It is the intent of these guidelines to document common practices for establishing and operating a traffic monitoring program. The intent also is to document common and best procedures, processes, and methods related to all aspects of a traffic data collection program.
- **Practical and Capable Implementation**—The guidelines allow for agencies to easily apply some or all portions to their program. Not all of the documented approaches are appropriate for every traffic program.
- **Oriented Toward Providing Quality Data for Decision-Making**—In designing and implementing a traffic data program, managers should always ensure that quality data are being provided to support decision-making in a transportation agency.
- **A Dynamic Approach to Traffic Data Programs**—Traffic data programs need to be tailored to the needs of customers and applications. The program must be flexible and improved as appropriate while keeping in close contact with users of the data.

In addition to these principles, the new edition of the guidelines highlights:

- **Data Business Plans to Identify Changing Needs for Traffic Data Programs**—Many transportation agencies have recognized that traffic data programs support a growing variety of functions within their agencies. These include performance monitoring and asset management. As these needs grow, so does the potential for conflicting requests from a variety of customers as well as competing needs for more, higher quality traffic data. These needs must be balanced against available resources to implement the traffic data program. An approach to systematically identify all existing and future customer needs and make recommendations as to how to balance these needs with available resources is being used by many agencies.
- **Quality Assurance Throughout the Life Cycle of Traffic Data Programs**—Quality assurance should include actions taken throughout the design, implementation, operation, and maintenance of the traffic monitoring program to ensure that traffic data meet or exceed customer expectations. Data quality actions that are restricted to simply fixing data that already have been collected (referred to as “scrap-and-rework”) are ineffective in the long term because they address the symptom but not the root cause of poor data quality.

1.3 Summary of Traffic Data Programs

Traffic data programs have many facets that can generally be described under the following headings:

- **Who**—Traffic Data Office with assistance from contractors;
- **Why**—To support transportation agency programming, planning, design, and evaluation as well as to meet Federal requirements;
- **What**—Collection of volume, classification, speed, and weight data; and
- **Guidance**—Traffic Monitoring Guide (TMG), Highway Performance Monitoring System (HPMS) Guidance, AASHTO guidelines, other state documents.

Figure 1-1 shows a summary of traffic data programs.

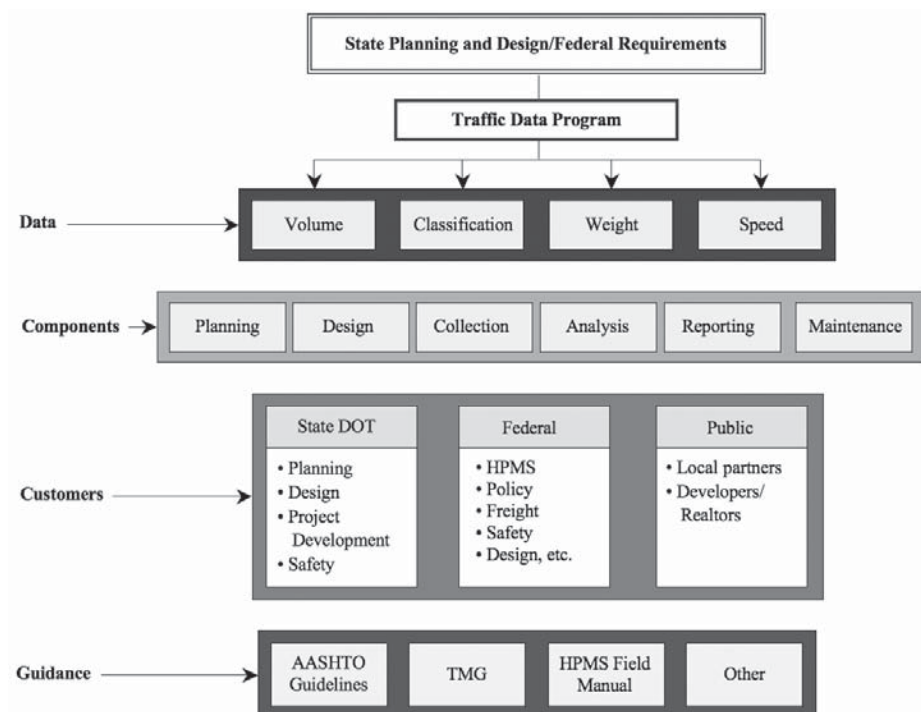


Figure 1-1. Summary of Traffic Data Programs.

1.3.1 Types of Traffic Data

The four principal types of traffic data collected by state data programs are:

1. Volume counts;
2. Classification counts;
3. Speed data; and
4. Weight data.

A combination of the four types of data are collected throughout the year at some sites (continuous) and for shorter periods of time at larger numbers of sites (short-duration).

In the case of volume and classification counts, data at selected sites are collected as nearly continuously as practical throughout the year in order to develop factors (or ratios) that reflect seasonal and day-of-week (DOW) variation in total volume and in truck volume. These factors are then used to convert short-duration counts (or “short counts”) to estimates of annual average daily traffic (AADT) and AADT by vehicle class. In this way, AADT and AADT by vehicle class can be estimated for a large number of roads and used for a variety of purposes while continuous counts are collected at a much smaller, and more manageable, number of continuous count sites.

To provide information about how vehicle weights and axle weights vary over the course of the year, weigh-in-motion (WIM) monitoring is used to collect weight data. However, in the case of weight data, current practice is to obtain detailed data for every vehicle weighed and to limit data-storage requirements by only collecting and saving data for one week each month. Also, procedures for adjusting weight data for seasonal and DOW variations are less developed than those for adjusting vehicle counts;¹ and so annual WIM data are most frequently used only to provide an indication of how weights vary rather than to adjust short-duration data for these variations. WIM data also could provide traffic volume and vehicle classification information if all lanes are instrumented.

Other types of traffic data collected by state and local data programs include speed, travel time, lane occupancy, and vehicle occupancy data. Data collected by these programs are discussed further in Chapter 2.

¹ Procedures for adjusting axle-load data for seasonal and DOW variation have been recently developed under NCHRP Project 1-39. These procedures are described in NCHRP Report 538 (*Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design*, 2005) and incorporated in the TrafLoad software, available from NCHRP.

1.3.2 Components of a Traffic Data Program

Consideration of all components as integral parts of an overall data program is essential for the production of quality traffic data. All of these components are considered in the guidelines:

- **Planning of Program**—The program must take into account the customer's traffic needs and available resources for the program. Once a program is in place, it must be managed and monitored on a continuous basis. Chapter 2 provides more detail.
- **Design of Program**—The design of a traffic data program needs to take into account a variety of details. These include equipment, quality control, summarizing, reporting, and managing the data. These are covered in Chapters 3, 4, 5, and 6 of the guidelines.
- **Collection**—Issues related to the actual collection of data are covered in Chapters 3 and 4.
- **Analysis**—The use of factors and the assurance of quality are covered in Chapters 4 and 5.
- **Reporting**—Methods of reporting data for customer use are covered in Chapter 6.
- **Maintenance**—Data collection devices must be maintained to ensure quality data. This is addressed in Chapters 3 and 6.

1.3.3 Customers and Traffic Data Applications

Traffic data are essential elements in programming, planning, designing, and evaluating the performance of individual roads (AADT and axle-load data) and systems of roads (vehicle-miles of travel, or "VMT"). These elements support a variety of customers, including state department of transportation, metropolitan/local planning, Federal Highway administration (FHWA), and the public.

Specific applications of traffic data include:

- ♦ **Programming**—Traffic data are an important element in determining Federal funding allocations. Resource allocation decisions at the state level also rely heavily on traffic data.
- ♦ **Capacity and Congestion Analysis**—Estimates of hourly capacity for most roads are affected by the percentage of trucks that they carry, and, except for limited-access roads, by conflicting flows at intersections. Capacity estimates, in turn, are combined with estimates of AADT and peak-period traffic to: optimize signal timing; produce analytic estimates of speed, congestion, and delay; and identify roads on which measures to increase capacity warrant consideration.

- ♦ **Traffic Forecasts**—All forecasts of future traffic volumes on an individual road depend, at a minimum, on an estimate of the current traffic volume on the road. Forecasts developed using sophisticated Travel Demand Forecasting Models require estimates of current traffic on the entire system of roads represented in the model.
- **Project Evaluation**—Estimated traffic volumes are required for the evaluation of the expected speed, accessibility, safety, and ride benefits of any proposed improvement to a particular road, and in the comparison of these benefits to those of any alternative improvements to this road or to other roads in the highway system. Estimated traffic volumes are similarly required for the evaluation of the benefits of alternative alignments for any proposed new road.
- **Pavement Design**—Determining the appropriate thickness of a new pavement or an overlay requires a forecast of the total amount of stress to which the pavement will be subject over its life—both the number of heavy axles that are forecast to traverse the pavement, and the stress produced by these axles. In the recent past, data on axle loads were commonly collapsed into a single summary statistic, the “Equivalent Single-Axle Load” (ESAL), and used in that form. However, the new Mechanistic-Empirical Pavement Design Guide (MEPDG) requires more complete data about the numbers of heavy axles by axle type (single, tandem, tridem, etc.), seasonal and diurnal variations in these numbers, and the distribution of weights (or “load spectra”) of each type of axle.
- **Safety Analyses**—The basic statistic underlying nearly all analyses of highway safety is the crash rate—the number of crashes per unit of exposure. When examining all crashes on a road segment or on a road system, the relevant unit of exposure is AADT on the segment or VMT on the system. Similarly, when focusing on crashes involving a particular class of vehicles (e.g., triple trailers), the relevant unit of exposure is AADT (or VMT) of that vehicle class.
- **Emissions**—Vehicular emissions of any pollutant in any area are estimated by multiplying emission rates estimated for each of several classes of vehicle by VMT of that class of vehicle in the area and summing over the several vehicle classes. Techniques also are used to transform vehicle classification data into VMT mix and vehicle registration distributions.
- **Other Applications**—Other applications of traffic data include:
 - Cost Allocation Studies, which estimate the share of highway costs for which each class of vehicles is responsible;
 - Estimating the economic benefits of highways;
 - Preparing vehicle size and weight enforcement plans;
 - Pavement and bridge management systems;
 - Signal warrants;
 - Planning for mitigation of traffic noise; and
 - Site selection for private businesses.

1.3.4 Comparison to the Traffic Monitoring Guidelines (TMG)

The AASHTO guidelines are designed to complement the TMG, though there is a fair amount of intentional overlap between the two documents. The focus of the TMG is on characteristics of traffic data and *what* data to collect. The focus of the AASHTO guidelines is on *how* to collect the data and *how* to process and store it. The following table summarizes the difference between the two documents.

Table 1-1. Comparison of TMG to Guidelines

	Traffic Monitoring Guide	Updated AASHTO Guidelines
Intended Audience	State and local highway agencies.	State, MPO, county, and local governments' traffic agencies.
Focus	Meeting national data requirements.	Meeting customer needs (national, state, and local). Emphasis will be on state programs and coordination with others.
Author	FHWA (OHPI)	AASHTO
Contents	Introduction to traffic monitoring, traffic volume monitoring, vehicle classification monitoring, truck weight monitoring, and traffic monitoring data formats.	Same as existing, add: Integrating Operations Data.
Last Updated	First Edition—1985, based on a 1984 report, <i>“Development of a Statewide Traffic Counting Program Based on Highway Performance Monitoring System.”</i> Second Edition—1992 Third Edition—1995 Fourth Edition—2001	1992
Themes	Improve volume, vehicle classification, and truck-weight data and count programs.	Value/importance of traffic data in decision-making and performance monitoring, improving quality assurance throughout the life cycle of data programs, focus on client/customer needs, and maximizing other sources.

1.4 Structure of the Document

The guidelines are divided into seven chapters:

1. **Introduction**—This chapter describes traffic data programs in general and lays the framework for the guidelines.
2. **Traffic Data Collection Needs**—This chapter discusses the role of other traffic data collection guidance. It discusses the use of traffic count data and the specific types of data. The chapter also discusses high-level issues related to estimating.
3. **Traffic Monitoring Equipment**—This chapter describes issues related to purchasing, using, and maintaining equipment. It includes data collection procedures as well as potential equipment errors.
4. **Quality Control and Editing of Traffic Data**—This chapter deals with issues such as defining and assessing data quality, performing quality checks, data quality metrics, and describes the components of an effective quality assurance/quality control program.
5. **Summarizing Traffic Data**—This chapter describes factoring processes and methods to summarize short- and long-term counts.
6. **Reporting and Managing Traffic Data**—This chapter discusses details related to database tools and traffic data reporting. It also recommends best practices for disseminating traffic data to customers.
7. **Integrating Operations Data**—This chapter describes the key benefits, implementation issues, and ways of overcoming technical and institutional barriers to integrating operations data.

CHAPTER 2

Traffic Data Collection Needs



2.1 Introduction

Traffic data collection programs vary widely. The scope and execution of these programs are functions of both the needs of traffic data users and available resources. In order for traffic data programs to be run efficiently, annual estimates are needed of the traffic counts that are collected and of the field and office personnel required to collect and publish the data. Data collection agencies should document their needs and perform periodic reviews to identify and make process refinements. This chapter addresses how an agency should estimate its traffic data collection needs.

In designing and implementing a traffic data program, an agency must often balance Federal requirements for traffic data with customer needs while at the same time ensuring efficient resource allocation. The two principal guidance documents for traffic data collection at the national level are the *Traffic Monitoring Guide* (TMG) and the *Highway Performance Monitoring System* (HPMS) *Field Manual*. Both documents are typically referenced in or provide the foundation for a state's *Traffic Monitoring System for Highways* (TMS/H).

2.1.1 Role of the *Traffic Monitoring Guide* (TMG)

The TMG, published by the Federal Highway Administration's (FHWA) Office of Highway Policy Information, provides recommendations for developing new or refining current traffic data programs. The TMG's intended audience is state departments of transportation (DOT), with metropolitan planning organizations (MPO), and local transportation agencies as secondary users.

The TMG provides specific examples of how statewide data collection programs should be structured, describes the analytical logic behind that structure, and provides information highway agencies require to optimize the framework for their particular organizational, financial, and political structures. It is the basic document for providing guidance about what traffic data to collect. The TMG is not a prescriptive reference. Instead it recognizes states' uniqueness and provides a flexible framework for states to develop their programs in a sound statistical manner.

2.1.2 Role of the *Highway Performance Monitoring System (HPMS) Field Manual*

The HPMS is an integrated database that contains data describing the nation's highway system. It is used by FHWA for a variety of public purposes, including reports to Congress and the apportionment of Federal-aid highway funds to the states. Data in this database is provided primarily by the states, using procedures specified by FHWA in the *HPMS Field Manual*.¹ These data include summary traffic data for each state and more detailed data for a sample of highway sections in the state. The *HPMS Field Manual* is a procedural reference which defines the type of data to be collected, the data format for transmittal, and the sampling rate. Traffic monitoring procedures are based on those presented in the TMG and are discussed in one of the *Field Manual's* appendices.

2.1.3 Growing Importance of Operations and ITS Data

Since the 1990s, the role of traffic operations and traffic management and traveler information centers as data contributors to the statewide data collection program has increased. These centers collect large amounts of data in very small time increments—some under one minute. These data typically include volume data, but also may include speed or vehicle classification data. These data usually are not integrated into traffic planning databases. The integration of operations data presents both technical issues and institutional barriers and this lack of integration may represent opportunity losses and higher overall data collection costs as a result of duplication.

2.1.4 Chapter Organization

This chapter is organized into four topic areas: discussion of the types of traffic counts and needs (2.2); process and considerations in estimating the traffic count needs (2.3); mechanisms to reduce count needs (2.4); and estimation of staff and resource requirements (2.5).

2.2 Traffic Count Types and Needs

This section describes the reasons state departments of transportation need a traffic data collection program. It also discusses the basics related to specific types of counts.

Data characterizing the use of public roadways have wide application in engineering, planning, finance, and government. Agencies collect use characteristics by counting traffic volumes, classifying vehicle types, weighing trucks and their axles, and monitoring point speeds. Table 2-1 provides examples of some of the uses of this data.

¹ FHWA. *Highway Performance Monitoring System Field Manual*, December 2000.

State traffic data programs collect and publish information for many customers. Customers range from Federal, state, and local governments to the general public. The primary source of data for these customers is the coverage count program. The coverage count program is the predominant traffic count need. Other needs include Federal/state research initiatives, project-related counts, special count requests, performance measurement counts, and data obsolescence counts. Table 2-2 shows examples of the types of data used by various customers.

2.2.1 Coverage Counts

The coverage count program involves the collection of short-term and continuous vehicle weight, classification, volume, and speed data for the production of system-level traffic estimates. System-level refers to traffic estimation for the road system and classifications of roadways, rather than for site-specific traffic estimates. The TMG and HPMS *Field Manual* provide requirements and guidance for structuring the coverage count program.

Coverage count programs typically include weigh-in-motion, vehicle classification, volume, and speed data collection programs. The short-term coverage count sample size recommended for traffic volume and vehicle classification, is based on a system-wide statistical sample. The short-term volume, vehicle classification, and weigh-in-motion counts, and supplemental counts taken within the special needs part of the program comprise the coverage count program.

Weigh-in-Motion (WIM)

Weigh-in-motion systems record dynamic (in-motion) vehicle weights, vehicle classification, volume, and speed. WIM systems require a significant investment relative to other traffic data collection systems. WIM investments include the pavement structure, sensors and electronics, and equipment calibration and maintenance. This automated equipment can collect data continuously or for short-term periods.

Table 2-1. Examples of Highway Traffic Data Uses*

Highway Activity	Traffic Counting	Vehicle Classification	Truck Weighing	Speed Monitoring
Engineering	Highway Geometry	Pavement Design	Pavement Design	Traffic Control Devices
Engineering Economics	Benefit of Highway Improvements	Cost of Vehicle Operation	Benefit of Truck Climbing Lane	Costs Associated with Congestion
Finance	Estimates of Highway Revenue	Highway Cost Allocation	Highway Cost Allocation	User Travel-Time Costs
Legislation	Selection of Highway Routes	Speed Limits and Oversize Vehicle Policy		Speed Limits
Maintenance	Selecting the Timing of Maintenance	Selection of Maintenance Activities	Pavement Management	Work Zone Safety Measures
Operations	Signal Timing	Development of Control Strategies	Weight Enforcement Activities	Setting Speed Limits
Planning	Location and Design of Highway Systems	Forecasts of Travel by Vehicle Type		Congestion Monitoring Systems
Environmental Analysis	Air Quality Analysis	Forecasts of Emissions Type of Vehicle		Project-level Analyses
Safety	Design of Traffic Control Systems and Accident Rates	Safety Conflicts Due to Vehicle Mix and Accident Rates		Design of Safety Systems
Statistics	Average Daily Traffic	Travel by Vehicle Type	Average Weight by Vehicle Class	85th Percentile
Private Sector	Location of Service Areas	Marketing Keyed to Particular Vehicle Types	Trends in Freight Movement	Accessibility to Service Areas

*Adapted from FHWA, *Traffic Monitoring Guide*, May 2001.

Table 2-2. Examples of Customer Needs for Traffic Data

Customer	Traffic Counting	Vehicle Classification	Truck Weighing	Speed Monitoring
General Public	Site-Specific AADT	Vehicle Mix	Overweights	Speed Distributions
Businesses	Site-Specific AADT	Percent Heavy Commercial		
Advertising Agencies	AADT Travel Peaks			Speed Distributions
Realtors	Site-Specific AADT			
Journalists	Busiest Roads/ Times of Year			
Developers	Peak-Hour Data			
Tourism Bureau	AADT Travel Peaks	Vehicle Mix		
Economic Development Agencies	AADT			
Chambers of Commerce	Count Maps			
Consulting Engineers	AADT Turning Movements	Vehicle Mix		Speed Distribution 85th Percentile
University Researchers	Hourly Volumes Adjustment Factors	Axle Factor Vehicle Mix	Load Spectra	Speed Distributions
Traffic Engineers	Hourly Volume	Hourly Vehicle Mix		85th Percentile 10 mph Pace
Highway Designers	DHV Directional Factor	Vehicle Mix		
Safety Engineers	AADT			Speed Distributions
Transportation Planners	AADT			
Pavement Designers	Future AADT Future AADT/T	Truck Mix	Load Spectra 18K ESAL	
Motor Carrier	AADT/T	Percent Heavy Commercial	Overweights	
Emergency Operations Centers	Real-Time Volumes			Real-Time Speeds
Metropolitan or Rural Planning Organizations	AADT, AAWDT, AAWET	Percent Heavy Commercial		Speed Distributions
Road and Bridge Authorities	AADT	Vehicle Mix	Load Spectra	
State Environmental Agency	VMT	Truck Classes		Speed Distributions
State Highway Patrols	Truck ADT	Vehicle Mix	Overweight Vehicles	Speed Profiles
State Parks/ Wildlife Agency	AADT	Vehicle Mix	Load Spectra	
Legislatures or Assemblies	VMT		Axle and Gross Vehicle Weights	85th Percentile
Tribal Nations	VMT	Vehicle Mix	Load Spectra	
Federal	VMT	Vehicle Mix	Load Spectra	85th Percentile

Vehicle Classification

The vehicle stream is classified through either manual observation or use of automated equipment. Manual observation by its nature is short-term and is based on the number of axles and the vehicle's body style. Automated equipment can be used continuously or for short-term periods and classifies vehicles through either axle distances or total vehicle length. Vehicle classification data also can be aggregated to fulfill a volume count requirement. Some automated vehicle classification systems also can provide speed data.

Volume

The most basic form of traffic data collection is the volume count. Volume counts are collected as a combination of continuous counts and short-term counts. Continuous counts are collected from permanently installed equipment in, along, or above the road bed that are operated continuously. Short-term counts frequently are collected through the use of pneumatic tubes gathering axle impulses that are later factored. Short-term volume counts, which can number in the thousands annually, represent the bulk of any coverage count program. Both on- and off-state system roadways should be measured. A more thorough discussion is available in Section 3.3.4.

It is recommended that, when physically and financially possible, vehicle classification counts be taken in place of simple volume counts. While this may slightly increase the cost per count for data collection, the need for truck volume data continues to grow. Most agencies will be well served to collect classification data instead of simple volume data whenever the marginal cost difference between these two data collection efforts is small. (See "Count Nesting" in Section 2.3.1 below.) While in many cases, collecting classification data is not an acceptable option—and therefore a simple volume count is the appropriate data collection choice—agencies are encouraged to increase the percentage of count locations at which classification data are collected in place of simple volume count data.

Speed

Speed data can be captured through automated systems collecting weigh-in-motion, vehicle classification, and some volume data (depending on the equipment used), or by using trailer-mounted radar systems or floating car techniques. Speed data could be reported as an average speed for periods of the day (e.g., morning peak) by day of week, month, or annual average. These would be calculated directly as a weighted average of the daily averages. Speed distributions also can be reported, including percent of traffic exceeding the speed limit. Speed data may be binned when collected and the volume within each speed bin would be used to represent the distribution. Speed data also can be aggregated so that it fulfills a volume count requirement.

2.2.2 Federal or State Research Initiatives

States may participate in cooperative research conducted by the state or Federal government. A Federal example is the Long-Term Pavement Program (LTPP). The data collection discussion presented here for this particular program could be applied to all cooperative data collection efforts supporting research.

Data reported for LTPP include the measurement of traffic on the pavement research lane. For many state agencies, the benefit of acquiring data from all lanes of traffic at a site *will* outweigh the additional expense of permanent sensor installation or field work on all lanes at the site. LTPP traffic counts, if not included in the coverage count sample, *will have* to be added separately to the traffic data program. Some states install permanent equipment and other states use portable equipment for LTPP and other ongoing traffic monitoring.

The importance of LTPP to the state's count program depends on the number of general and specific project sites in each state. It is possible to add LTPP sites to the coverage count sample. For states that have not incorporated LTPP counts into their coverage count program, some or all of the LTPP sites will be an element of the count program.

2.2.3 Project-Related Counts

Agencies typically conduct traffic studies for project-level design if the project is not included in the coverage count program. This effort is an important function of the traffic monitoring program. A shared concern among agencies is to provide the needed quality and quantity of counts to support road project development. Project-related counts are made beyond the needs of the coverage count program. Project-related traffic counts are used widely from planning studies and preliminary engineering to final geometric and pavement design.

To estimate the number of project-related counts, traffic data collection programs should open and foster communications with project development and design engineers. The agency's annual and multi-year plan (Transportation Improvement Program, Statewide Transportation Improvement Program, Long-Range Plans, or Metropolitan Transportation Plans) for upcoming projects should be reviewed. Input should be sought from the project development and design engineers for the type and timing of traffic data collection needed to support project development. Their responses will provide an indication of the number of counts needed and the general timeframe in which they should be completed. Existing traffic data may be used rather than recounting for highway projects if data have been collected within a reasonable time and can be factored for growth. In most instances, agencies will collect vehicle volume and vehicle classification data. It also should be noted that there is an increasing interest not only in site-specific volume and classification counts, but also in site-specific vehicle weight counts in support of the *Mechanistic-Empirical Pavement Design Guide*. Successful planning and collection for this component of the count program is dependent upon communication with project personnel.

Project-related counts should be retained and used to produce system-level estimates. If these counts are not used to supplement the coverage count program, greater benefits from investments in these counts are lost.

2.2.4 Special Count Requests

Agencies receive requests for counts which are not directly related to coverage, research initiatives, or road projects. Special count requests include rail crossing studies, bridge crossing studies, legislative requests, air quality impact studies, signal timing, traffic flow maps, traffic simulation calibration and validation, signal warrants, site impact studies, and capacity analyses.

It is recommended that state agencies include site-specific traffic data collection as part of all contract and in-house pavement and materials research. If this decision has been or will be reached, these counts should be included in the estimate of special count requests.

A three-year average of the number of special counts taken is recommended to estimate an annual need. To estimate the annual number of special counts:

- List the types of special count requests made of the collection program;
- Record the number of special counts by type and by year within the past three years;
- Average the sums of the past three years of special counts requests; and
- This three-year average of requests is used to anticipate this portion of the count program.

If an agency has changed its policies (such as counts in support of materials research) or cyclical counts are not accounted in the three-year average, these additional requests should be estimated and added to the three-year average.

2.2.5 Performance Measurement

Performance measures are “objective measurements and observations to determine the degree of success a project, program, or initiative has had in achieving its stated goals and objectives.”² Measures are usually focused on tracking inputs, outcomes, or outputs of individual day-to-day elements.³ Traffic data collection programs may already, or may soon, be asked to support monitoring these measures.

² Southwestern Pennsylvania Commission. *Congestion Management Process Glossary*. Pittsburgh, Pennsylvania, August 2006.

³ TransTech Management, Inc. *Strategic Performance Measures for State Departments of Transportation: A Handbook for CEOs and Executives*, Final Report, NCHRP Project 20-24(20). NCHRP, Washington, DC, June 2003.

Data Types

There are three classes of performance measures. First, input performance measures relate to the quantities of resources used to produce goods or services and the demand for those goods and services. Outcome measures are indicators of the actual impact or public benefit of a service. Finally, output performance measures gauge the actual service or product delivered by an agency.⁴

Traffic data collection programs are likely resources to collect performance data for input and outcome measures. Table 2-3 displays a sampling of the performance measures agencies may be interested in tracking. The performance measures also are classified by type: input, outcome, or output. Some measures may be viewed as satisfying more than one performance type.

When agencies initiate performance measurement, the data collected to support them are considered part of the special count program. Because of the regular monitoring frequency required for these counts, the measurement needs should become part of the annual count projection.

Examples

Florida's traffic data collection program contributes to several performance measures reported by Florida's Mobility Performance Measures Program. Some of these measures include person-miles traveled, truck-miles traveled, vehicle-miles traveled, maneuverability, and vehicles per lane-mile.

A regional congestion management process may identify volume/capacity (V/C) ratios as a performance measure. Segment volumes are required to generate these measures. The Southwestern Pennsylvania Commission Congestion Management Process monitors travel time in peak periods, average speeds, delay per vehicle-mile, total delay, and total delay per mile.

An NCHRP report provides additional examples. Washington State monitors system performance for daily vehicle hours of delay per mile, sample commutes measured by delay, and time-of-day distributions of delay. Measuring reductions in peak-period work zone lane restrictions is important to Pennsylvania. Finally, Minnesota monitors their interregional corridors to measure the percent of corridor miles meeting speed targets, and hours and miles of congestion per day.

⁴ Florida Department of Transportation. *FDOT Long-Range Program Plan for Fiscal Years 2006–2007 Through 2010–2011*, revised September 28, 2005.

Table 2-3. Sample Performance Measures by Type

Agency Type	Sample Performance Measures	Performance Measure Class	
		Output	Outcome
State Transportation Agency	Vehicle miles traveled	•	
	Vehicles per lane-mile	•	
	Truck miles traveled	•	
	Person miles traveled	•	
	Average travel time		•
	Person-miles of travel in congested ranges	•	•
	Average travel rate		•
	Growth in annual delay per peak road traveler		•
Metropolitan Planning Region	Average travel time		•
	Travel reliability		•
	Person-miles of travel in congested ranges	•	
	Person-hours of travel in congested ranges	•	
	Person movement speed		•
	Total delay	•	
	Person movement	•	
	Delay per vehicle-mile	•	
	Total delay	•	
	Total delay per mile	•	
	V/C ratios		•
Municipalities	Average travel time		•
	Accident reduction		•
Managed/HOT/HOV Lane Operator	Person movement	•	
	Vehicle occupancy data		•
	Average travel time		•
	Travel reliability		•
	Revenue	•	
Traffic Management Centers	Lane occupancy data		•
	Average travel time		•
	Duration of incident		•
	Time to incident detection	•	

2.3 Estimating Traffic Data Collection Needs

An effective traffic-monitoring program includes the collection of short-duration traffic counts, or “*short counts*,” at a relatively large number of sites, and collection of *continuous counts* at a much smaller number of sites. Short counts provide information about traffic volumes on a large number of road segments, or “traffic count segments,” over a short time period, typically a 48-hour weekday period, but they do not provide information on average volumes over the course of a year. The principal purpose of the continuous counts is to provide the basis for converting short counts to estimates of annual average conditions at the short-count sites.

Volume counts are collected at all short- and continuous-count sites. Classification counts should be collected at all continuous-count sites and at a significant share of the short-count sites. WIM data should be collected at a more limited number of sites, most or all of which are continuous sites, and all of which also are used to produce volume and classification counts.

The use of one site to produce multiple types of traffic data (volume, classification, and WIM) is referred to as “count nesting.” Count nesting makes efficient use of traffic monitoring resources, since it allows a single site to be used to produce multiple types of data. Also, the more sophisticated equipment used at WIM sites produces more accurate counts than equipment used at other sites (and classification counters frequently produce more accurate counts than volume counters), so count nesting has the additional benefit of improving the quality of counts collected at nested sites.

The first part of this section discusses the data collection sampling plan, the second discusses continuous counts and seasonal factor groups, and the third discusses short counts.

2.3.1 The Sampling Plan

Agencies benefit from having well documented data collection procedures. One document is a formal sampling plan. This document serves as a basis for future program revisions and as a support tool for acquiring and retaining the resources needed. Good process documentation also provides for consistency through periods of staff turnover. A sampling plan for the coverage count program, for instance, should be based on statistical analysis of the system-level data and should properly document the target statistical confidence and precision levels for all relevant systems and for more discrete analysis units (e.g., seasonal factor groups).

The Development Process

In general the steps for developing or refining the sample size for each data type within the coverage count program are:

- **Define the Test Statistic**—In creating or refining any sampling plan, the test statistic must be identified first. For volume counts, the appropriate test statistic is annual average daily traffic (AADT). Other test statistics of interest include: monthly or seasonal factors from continuous volume sites; axle correction factors for vehicle classification; or, for WIM, gross vehicle weight (GVW) or equivalent single-axle loads (ESAL) for a specified vehicle class. Agencies should seek input from their customers to help define test statistics.
- **Define Stratification Groups**—Stratification groups may be structured by geography, area type, roadway use, functional classification, volume group, or other criteria important to the agency. Deciding the stratification groups will have a direct effect on the total sample size.
- **Define the Statistical Confidence and Precision for the System and Subsystems of Interest**—For each test statistic, a statistical confidence interval and precision should be selected. The HPMS Field Manual provides guidance for these levels.⁵ Agencies should decide on the confidence and precision levels that they desire to attain for the entire system and for the subsystems of interest. The precision of estimates obtained for an entire system of roadways will be greater than the precision obtained for any subsystems. Estimates obtained for individual strata may be of no interest in themselves, in which case there is no need to specify confidence or precision levels for the strata.
- **Process the Test Statistic's Average and Standard Deviations**—Currently available data should be used to estimate averages and standard deviations for the test statistic.
- **Calculate the Required Sample Size**—The test statistic's average and standard deviations with the statistical confidence and precision levels are required to calculate the required sample size.
- **Determine Additional Sampling Needs for Failed Counts**—The required sample size estimates should be slightly inflated to allow for samples that may not be available for the production of system-level estimates due to roadway construction or equipment maintenance. This number is then added to the calculated sample size. Methods are presented later in this section.

Statistical Basis

Many agencies collect traffic counts on a 100 percent sample of the higher functional systems and on smaller samples of the lower systems. In both cases, the sample of segments consists of both segments having sites that are continuously monitored and those at which only short counts are collected. That is, for the purpose of understanding traffic (e.g., estimating VMT) on a particular system of roads, data from both types of sites are used.

A particular concern in the sampling of road systems is that the sample be created and maintained in a way that minimizes any bias in the resulting estimates of VMT for the state's entire road system and for

⁵ FHWA. *HPMS Field Manual*, 2000, Appendices C and D.

all subsystems of interest. For this purpose, stratified sampling is useful. The strata that are used should distinguish all subsystems of interest as well as other characteristics that are likely to have significant influences on traffic volumes. Potentially useful strata include:

- Functional system;
- Geographic jurisdictions (such as counties or highway districts);
- Highway ownership (state, county, local, etc.); and
- Number of lanes.⁶

One of the advantages of stratification is that the strata can be designed to have more uniform values of traffic volume and AADT than the system or subsystems to which they belong.⁷ This property means that, for a given sample size, a stratified random sample generally will produce better estimates of average AADT for the system and subsystems than will a simple random sample. Also, when stratified random sampling is used, there is no disadvantage to increasing the sample size of certain strata of interest (such as those corresponding to the State Highway System), as long as the sample sizes of the other strata are maintained.

When stratified random sampling is used, the preferred procedure for estimating (daily or annual) VMT for an entire system of roads involves the use of *expansion factors*. For this purpose, for each stratum, an expansion factor is calculated by dividing the total length of roadway in that stratum by the total length of the stratum's traffic count segments that have been sampled (and, on which, traffic has been counted). Multiplying AADT on each of the sampled segments by segment length produces estimated (daily) VMT on the segment. Adding the resulting estimates of VMT for all segments in a stratum and multiplying by the stratum's expansion factor then produces estimated VMT for the stratum. Finally, an unbiased estimate of VMT for the subsystem (or for the entire highway system) is obtained by summing the VMT estimates for all strata of the subsystem.

Count Nesting

As noted above, the use of higher data collection systems to provide information for lower data collection systems is termed count nesting. For example, weigh-in-motion systems collect data on weight, speed, total traffic volume, and volume by vehicle class. Thus, in addition to providing WIM data, a weigh-in-motion system can be used to provide a set of speed data, a volume count, and a classification

⁶ An alternative to stratification by ownership and number of lanes is stratification by volume group (as required by HPMS). However, stratification by volume group presumes knowledge of the volume group to which all traffic segments belong, which may not hold for the lower functional classes.

⁷ As an example, consider a road system that has 500 miles of four-lane road and 500 miles of two-lane road. An unstratified random sample is likely to be split close to 50/50 between miles of four-lane road and miles of two-lane road, but, most likely, the split will not be precisely 50/50. Such a slightly uneven split is likely to introduce a small amount of bias into the resulting estimate of VMT for the road system. On the other hand, a stratified random sample can be constructed to have exactly a 50/50 split between the two types of road, thus avoiding this bias. Alternatively, a stratified random sample can be used in conjunction with "expansion factors" (described below) that adjust for any over or undersampling of any of the strata.

count. Likewise, vehicle classification counts also provide volume counts.

Florida uses a simple graphic to convey this nesting, the size of the count program, and method of data collection, as shown in Figure 2-1. The right side, or white area, of the pyramid represents permanent data collection sites in, alongside, or above the road bed that can remotely transmit data back to the office. The left side, or shaded area, of the pyramid represents short-term data collection sites that may use portable equipment or manual data collection. Because WIM is able to collect weight, classification, and count data, it resides at the top and signifies that the information collected can be used for both the classification and count programs. The volume or coverage count program is limited to vehicle volume and cannot be used to supplement the classification or WIM programs, thus representing the basic foundation for traffic data collection.

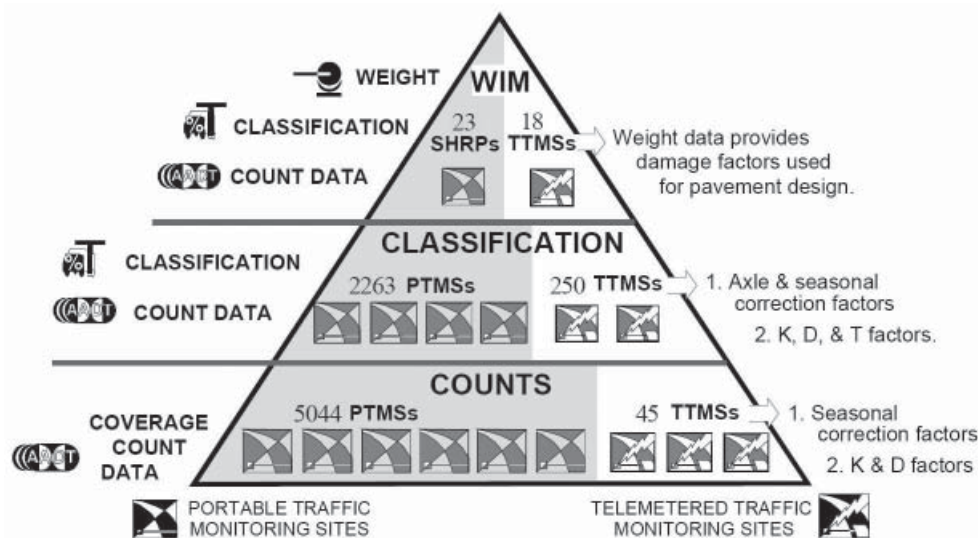


Figure 2-1. Example of Count Nesting.⁸

Count nesting allows the number of required counts to be reduced, eliminating redundancy, improving overall efficiency of the traffic data collection program, and freeing resources to be invested elsewhere.

Random Selection

Sample bias is eliminated through random selection of traffic count segments. Random selection is performed most efficiently using electronic maps that provide the necessary roadway attributes. These attributes include functional class, ownership (state, county, city, etc.), and area type (rural, small urban, or urbanized). If key attributes are not available electronically, the process becomes less efficient, and comparisons of hard copy maps may be required. The random selection process also may be structured

⁸ Florida Department of Transportation. *Florida Project Traffic Forecasting Handbook*, October 2002.

so that road segments are numbered, and a random number generator used to select potential segments for the sample.

The list of potential segments may be reported as randomly selected. If random selection is automated, sample selections should be spatially sorted in sequence by road. As an example, the sample may be printed by road and milepoint. This will facilitate the review of the potential segments, selection of the final sample, and scheduling of coverage counts.

There are cases in which random selection cannot be used. The phrase “potential segments” is used to emphasize that the randomly selected segments must be reviewed for appropriate field data collection. Effort is required to validate the physical condition of randomly selected segments for their appropriateness for data collection. Most potential segments will include sites that are appropriate for use as volume-count sites, but not necessarily for WIM sites or even for classification sites (as discussed in the next subsection). It may be prudent to generate 10 percent more potential segments than that indicated by the sample size determination. Alternatively, roadway segments may be sampled without replacement, and additional segments randomly selected if required.

Classification Sites and WIM Sites

The above discussion of selecting sample segments and monitoring sites ignores some practical considerations that affect WIM and classification sites.

Classification Counts and Classification Sites. The principal purposes of classification counts are to learn how vehicles are distributed among vehicle classes and for developing *axle factors* for converting axle counts collected using road tubes into vehicle counts. For these purposes, the best information is road-specific information.

Ideally, all traffic counts would be classification counts, so that roadway agencies can fully understand the truck volumes on their roadways. While this is currently impractical, classification count data should be collected whenever practical. At a minimum, classification counts should be collected periodically on all roads in the higher functional systems. In the case of longer roads on which vehicle-class distributions are likely to change over the length of the road, these counts should be collected at multiple sites on the road. Short-duration classification counts should be factored using class-specific seasonal and day-of-week (DOW) factors (as described in Section 5.3.3) to produce estimates of AADT by vehicle class (VC). For each classification count, these estimates, in turn, are used to produce distributions of AADT by VC that are used on the same road (or on nearby parts of the road) to distribute estimates of total AADT over the vehicle classes.

For the lower functional systems, it may be impractical to collect classification counts on all roads. For such roads, the recommendation is that roads in a given area and functional system that are believed to

have reasonably similar vehicle-class distributions be grouped. For each of these groups, one classification count site should be identified and measured to derive a group axle factor and a set of distributions of AADT by VC for use at other short-term volume count sites within the same group.

The above discussion has some implications for selecting sites within a traffic count segment at which volume and classification counts are collected. Accuracy requires that continuous classification counting be performed only at locations where vehicle speeds are as constant as practical (minimum acceleration and deceleration). Although this requirement is less applicable to short-count sites where only volume counts are collected, it is still desirable to apply it, if practical, when selecting a site for volume counting on a traffic count segment. Such a site would have the advantage of also being usable for classification counting if it is subsequently decided to collect classification counts on the segment.

WIM Sites. The considerations affecting WIM sites are somewhat more complex. It generally is inefficient to select WIM sites at random. WIM sites are relatively expensive to establish and maintain, and they require strong, smooth, level pavement and straight sections of road. For this reason, it is generally efficient to install new WIM sites only as part of resurfacing projects, and the particular sites considered for such use should be limited to those that meet the criteria for producing reliable WIM data. Once WIM equipment has been installed at a particular site, it generally should be used as a source of WIM data as long as the site continues to meet the data accuracy criterion set by the collecting agency and is confirmed by periodic calibration validation tests.

In order to make the maximum use of data from a new WIM site, any such new site should be used to provide volume and class data as well as WIM data. If a new WIM site is located on a traffic segment which is already part of a volume-count sample, then the new site simply replaces the existing site in the sample. If not, it is recommended that the new site replace an existing site belonging to the same stratum and, to the extent practical, having seasonal and day-of-week variations in traffic volume that are similar to the new site.

Since WIM equipment generally produces higher quality classification data, WIM sites should be operated as continuous classification sites. For this purpose, the WIM sites are simply added to the appropriate classification-count seasonal factor group. Also, if the data collection sensors continue to function correctly, WIM sites should continue to be used as sources of continuous classification data after being retired as WIM sites.

Field Review for Site Adequacy

Site adequacy is a paramount consideration in the deployment of both permanent and short-term data collection devices. The field crew manager or assigned staff should review the randomly selected potential sample segments to determine if they contain sites that are adequate for field data collection. It is important to recognize that simply identifying a road segment for sampling does not guarantee that an

appropriate traffic count site exists on the segment. Agencies should develop a list of minimum standards for each data type. These minimum standards may be based on manufacturer specifications or organized technical standards, such as those produced by the American Society for Testing and Materials.

The field review should evaluate the geometric and operational characteristics of the roadway. Randomly selected segments may be on a horizontal curve, making them unsuitable for vehicle classification. Similarly, the speed of vehicles on part or all of a randomly selected segment of roadway may be outside the manufacturer-specified speed range for some vehicle classification devices. As previously noted, many automated data collection systems do not collect accurate data under congested traffic conditions. These conditions are unsuitable for vehicle classification and WIM systems. Site reviews should also include roadway surface characteristics. Other considerations that should be included in site review may include equipment tie-down, and the availability of telephone lines and power supply. Safety and equipment limitations also should be reviewed on a site-by-site basis.

The site review can use existing engineering plans and other sources, but physical inspection of potential sites is recommended. A photo video system may be helpful in the process of reviewing randomly selected traffic monitoring segments, but such a system is not an adequate replacement for physical inspection of the segment.

Based on the review, the field crew manager or assigned staff may delete potential segments which do not contain any acceptable sites. The reason for deleting potential segments must be documented and provided to the Traffic Data Program Manager. Documentation can be via a printed form or via other recorded notes identifying the characteristics that failed to meet minimum standards. The end product of this process will be a randomly selected sample acceptable for field data collection.

Failed Counts—Machine/Collector Error or Malfunction

Sampling plans should provide for extra samples so that the desired statistical confidence and precision can be maintained even if there are a few failed counts. It is not uncommon for machines or staff to generate data errors.

The number of failed short counts must be estimated so that these counts may be rescheduled without disrupting the data collection program. Existing records should be used to estimate the rate of failed counts for both short-term and continuous data collection. Estimates of failed short-term counts can be derived from completed schedules, contractor invoices, or machine repair logs. Estimates of extra samples for failed counts can be made from these historical records; e.g., by using a three-year average of the failure rate.

Periodic Review

The goal of every traffic data collection program is the production of useful data for its customers. Periodic adjustments to the plan are necessary to reflect the effects of changes in the highway system and in the use of various roads and also to incorporate improvements in traffic monitoring procedures. It is recommended that traffic monitoring plans be reviewed at least once every five years. These reviews should include a review of the seasonal factor groups and factoring procedures used, the continuous monitoring sites providing data for these procedures, and the size and distribution of the short-count sample.

2.3.2 Continuous Counts

The principal purpose of continuous counts is to provide data on how traffic volumes vary by time of year and by day of week. These data are used to convert short counts into estimates of AADT and AADT by vehicle class (AADT by VC). Continuous counts also are used to produce estimates of growth in traffic that are used to adjust AADT estimates developed in one year for growth in subsequent years.

In order to obtain reliable estimates of the seasonal and DOW patterns in traffic volume (or truck volume), continuous counts should be collected on roads that have moderate to high traffic volumes. Patterns on roads that have low traffic volumes are more likely to be affected by random events than patterns on higher volume roads.

For the purpose of estimating AADT, each continuous count site and each short-count site is assigned to one of several seasonal “factor groups.” Data from continuous counts collected at sites in a given group is then used to develop a set of seasonal and DOW adjustment factors that are used to convert short counts obtained at other sites in the group into estimates of AADT and AADT by VC. Current procedures for forming seasonal factor groups focus on total traffic volume and estimates of total AADT, although the same factor groups usually are also used for developing factors to be used in developing estimates of AADT by VC.

The development of seasonal and DOW factor groups is discussed below. The computation and application of seasonal and DOW volume and vehicle-class factors and ratios is discussed in Section 5.2.1.

In developing factor groups, two goals should be kept in mind:

- To the extent practical, all sites in a given seasonal factor group should have reasonably similar seasonal and DOW patterns in traffic volume; and
- To the extent practical, factor groups should be distinguished from each other on the basis of roadway characteristics (such as functional class, location, or roadway direction) that can be applied to road segments for which little or no previously collected traffic pattern data are available.

It is recommended that most seasonal factor groups contain five to eight continuous count sites. However, seasonal factor groups, such as recreational groups, that contain relatively few short-count sites may be defined using data from fewer continuous count sites. In order to minimize the number of continuous count sites required, seasonal factor groups should only be distinguished from each other if they have seasonal and/or DOW traffic patterns that are at least moderately different from each other.

Developing Seasonal Factor Groups

In defining a set of seasonal factor groups, the principal goal is to group sites that have seasonal patterns in traffic volume that are as similar as practical and DOW patterns that are as similar as practical.⁹ Factors developed using data from continuous sites at which traffic volumes drop on weekends (typical of rural roads carrying relatively little long-distance traffic) should not be applied to short counts collected at sites at which volumes tend to rise on weekends (typical of rural roads carrying significant amounts of long-distance traffic).

Some observations that are useful in defining seasonal factor groups are:

- In rural areas, DOW variation usually differs between the interstate system, which tends to have high through volumes) and the non-interstate system (with lower through volumes);
- Differences between seasonal and DOW patterns on the various non-interstate system rural functional systems are small and probably do not warrant separate seasonal factor groups for the different functional systems;
- In some large states, seasonal variations in volume on rural roads may differ in different parts of the state and may warrant separate rural factor groups that are defined geographically;
- Roads in recreational areas usually have seasonal and DOW patterns that warrant separate factor groups. In some states, these roads warrant separate recreational groups for different peak travel periods (summer, winter, fall foliage, etc.);
- In urban areas, interstate system and non-interstate system roads are frequently assigned to separate factor groups, though the seasonal and DOW variations on the two systems usually are quite similar;
- In urban areas, it may be worth distinguishing between roads that tend to have relatively low weekend volumes (e.g., those serving employment centers that have little activity on weekends) from roads serving shopping areas and other areas with significant weekend activity; and

⁹ This goal suggests that it might be desirable to assign road segments to factor groups on the basis of the predominant use(s) of the segments. However, such a system of assignments is relatively difficult to implement because roadway uses generally do not correlate with readily observable roadway characteristics (such as functional class). Also, it should be observed that similar road uses (such as transport of different crops) do not necessarily mean that seasonal patterns of traffic will be the same (since different crops may have different harvest seasons).

- There may be some value in establishing separate (“semi-urban”) factor groups for small urban areas and/or for the urban fringe of major urbanized areas; the latter groups might include roads located near the edge of urbanized areas and on either side of the boundaries of these areas.

Issues Relating to the Development of Seasonal Factor Groups

Similarity of Seasonal and DOW Patterns

Factoring procedures work best when all sites assigned to a given seasonal factor group have seasonal and DOW patterns of traffic volume that are reasonably similar. However, in practice, this degree of similarity is not always attainable. There will almost always be some sites that have volume patterns that do not fit well in any group; and some short-count sites may be inadvertently assigned to the wrong group. Such poor assignments have disadvantages for both short-count sites and continuous count sites.

In the case of short-count sites, a poor assignment adversely affects the quality of the AADT estimates that are produced for the site by the factoring procedure. For example, if a site at which traffic volumes rise on weekends is assigned to a group that otherwise consists entirely of sites at which volumes drop on weekends, AADT estimates produced by factoring weekday counts collected at the site will be downwardly biased.

As a somewhat different example, consider a site on a recreational road on which traffic peaks during the fall foliage season and assume that this site is assigned to a recreational group whose factors were developed from continuous count sites on roads with summer peaks. For such a site, AADT estimates produced from factored counts taken during the summer will be downwardly biased, while AADT estimates produced from factored counts taken during the fall peak will be upwardly biased. For such a site, AADT estimates produced from factored counts taken during the spring are likely to be better; but, for various reasons, these estimates also may not be very good.

In the case of continuous count sites, poor assignments indicate a factor group that has been defined in a way that results in the inclusion of sites that have moderately dissimilar seasonal and/or DOW patterns of traffic volume. For such a group, it may not be possible to achieve the precision level for the seasonal and/or DOW factors recommended by the TMG (pages 3-47 to 3-48) without increasing the number of continuous monitoring sites above eight. This deficiency can be addressed either by redefining the factor group (possibly by splitting it) in order to increase the similarity of the seasonal and DOW patterns, by increasing the number of continuous sites belonging to the group or by forming different factor groups for seasonal versus DOW factor types.

If practical, it is preferable to redefine the factor group. Increasing the similarity of the traffic patterns will reduce or eliminate the number of short-count sites in the group that have seasonal or DOW traffic patterns that are atypical of the group. Since poor estimates of AADT are more likely for sites with atypical traffic patterns, reducing the number of such sites is a desirable goal of any traffic monitoring program.

The second alternative, increasing the number of continuous count sites belonging to the group, improves the precision of the factors used for the group and thus improves the resulting estimates of AADT. However, only slight changes are likely in the AADT estimates for sites with atypical traffic patterns, and not all of these changes will be improvements.

The third alternative, forming separate seasonal and DOW factor groups, allows continuous count sites to be assigned independently to seasonal and DOW factor groups. This approach solves the problem of continuous count sites that have different seasonal and/or DOW characteristics from other sites within the group, while increasing the complexity of forming the groups.

The appropriate number of factor groups to establish depends on circumstances, including available resources and the degree to which different seasonal and DOW patterns in volume are readily distinguished.

Recreational Roads

The development of procedures for monitoring traffic on recreational roads presents some issues alluded to above that can only be partially solved under the typical resource constraints applied to Traffic Monitoring Systems.

One issue is the number of recreational groups to be distinguished. Recreational roads differ both in the timing of their recreation-season peaks and in the intensity of these peaks. Some states define two or three recreational groups representing the different peak seasons for recreational traffic in the state. Other states have only a summer recreational season, but define separate groups for “high summer” and “moderately high summer.” In concept, some states could create separate “high” and “moderately high” groups for each of several peak seasons, but establishing that many groups is likely to stretch available resources. In general, states simply accept AADT estimates for recreational roads that are less reliable than estimates for other roads. Since the resulting errors in AADT estimates for different recreational road sections are likely to partially cancel each other out, and since VMT on recreational roads generally is a fairly small part of statewide VMT, these errors are generally considered to have an acceptably small effect on estimates of statewide VMT.

A second issue relates to the assignment of sections of road containing short-count sites to recreational groups. These assignments generally are made on the basis of local knowledge of whether or not the peaking characteristics of traffic on these road sections follows a recreational pattern. In some cases, extending a short count to include a full weekend during the recreational season could be helpful in determining whether or not a site carries significant amounts of recreational traffic (and whether it should be classified as “high” or “moderately high” recreational); volumes on rural non-Interstate System roads generally drop on weekends, but, on recreational roads, these volumes rise on weekends during the recreational season.

Truck Weight Roadway Groups

For the purpose of collecting data on vehicle weights, the 2001 TMG recommends that each state divide its road system into *truck weight roadway groups* (TWRG) with the average gross weights of trucks in a given class being reasonably similar on all roads in the group. The TMG suggests establishing between 2 and 10 TWRGs, depending on the size and diversity of a state's roadway system.

A basic set of TWRGs for a state with relatively little geographic diversity might consist of three TWRGs: urban; rural Interstate System; and rural other. For this set of TWRGs, it is recommended that all WIM sites in the urban TWRG be located on the urban Interstate System, and all WIM sites in the rural other TWRG be located on the rural other principal arterial system. There are several reasons for this last pair of recommendations. In general, WIM data are of greatest interest when designing pavements for the higher functional systems. Also, axle loads and the resulting pavement stresses are likely to decline as one moves to lower functional systems, so it is a conservative approximation to use WIM data collected at sites on a high-functional system when analyzing pavement stresses at a site on a lower system. Finally, in urban areas, most of the appropriate locations for WIM sites are likely to be on the Interstate System. The formation of TWRGs is discussed further in Section 5 of the TMG and in NCHRP Report 538.¹⁰

If practical, there should be between three and eight WIM sites in a TWRG. However, one or two WIM sites may be used for some small TWRGs. Three sites is the minimum number necessary to provide some confidence that all sites in the TWRG have reasonably similar load spectra. On the other hand, as the number of WIM sites in a TWRG grows, opportunities also grow for splitting the TWRG so as to produce smaller TWRGs, each with more uniform sets of load spectra. Since it is difficult and expensive to calibrate portable WIM equipment, it is recommended that all WIM sites use in-pavement sensors. It also is recommended that the design lane of all WIM sites be monitored for at least one week per month throughout the year. The TMG recommends that all new WIM installations have WIM coverage in at least one lane in each direction, and that each TWRG contain a minimum of one site with WIM coverage in at least two travel lanes in each direction.

2.3.3 Short Counts

The two principal types of short count are *coverage counts* and *special counts*.

For purposes of traffic counting, all roads should be divided into *traffic count segments* (also called "traffic segments" or "traffic sections"), with traffic volumes on each segment being reasonably homogeneous. On limited access roads, traffic count segments should extend from interchange to interchange. On other

¹⁰ Cambridge Systematics, Inc. Washington State Transportation Center, and Chaparral Systems Corporation. *Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design*, NCHRP Report 538, 2005, pp. 2-19 to 2-20.

roads, the TMG recommends (pages 3-9 to 3-10) that, except in the case of the lowest volume roads, traffic volume on each segment remain within a range of plus or minus 10 percent. For very low-volume roads, the TMG suggests that a wider range may be appropriate. Traffic segments need *not* be broken at urban/rural boundaries or at jurisdictional boundaries. For the purpose of factoring, judgment should be used in choosing the seasonal factor group to which a segment that crosses an urban/rural boundary is assigned.

For each highway system and subsystem of interest, *coverage counts* are collected periodically on a sample of traffic count segments to estimate VMT on the system and to provide a more general understanding of traffic on the system. The size of each sample is determined by the highway agency and reflects both the availability of resources for collecting these counts and the agency's intended uses of the data. Many state highway agencies (SHA) collect coverage counts on a 100 percent sample of the interstate system, and a few collect coverage counts on a 100 percent sample of the entire State Highway System (SHS).

Although not explicitly stated, all traffic count segments on which continuous count sites are located are part of the coverage count sample. Most other traffic count segments in the coverage count program are counted for short periods of time ("short counts") once every few years, with growth factors used to adjust all estimates of traffic on the segment for changes in traffic volume that are likely to occur in intervening years. For specific segments, frequency of counting may vary with the importance of the segment. The TMG recommends that most segments be counted at least once every six years, with important segments and those experiencing unusual changes in traffic volume counted more frequently. FHWA requires that HPMS sample and universe sections be counted at least once every three years.

For planning or design purposes, agencies frequently require traffic data that are not produced by the coverage count program. These needs are met by collecting *special counts*. Such special counts may meet needs for: counts on segments on which coverage counts are not collected; detail that is not provided by the coverage counts (e.g., classification counts on segments on which only volume counts are available); or more accurate estimates of current traffic volume than can be obtained by applying a growth factor to a five-year-old count.

2.3.4 Estimating Overall Data-Collection Needs

In order to estimate the overall data collection needs, one should sum the count needs for the coverage count program defined by the sampling plan, research initiatives, roadway project development, special counts, performance measures, and replacement counts for field failures to estimate a comprehensive traffic count total for the year. The count needs should distinguish data type and collection method for later estimates of staff and resource needs.

2.4 Reducing Traffic Data Collection Needs

Traffic data collection needs can be reduced by means of count nesting and other multipurpose uses of sites, cooperative data sharing, identifying obsolete sites, and managing special counts. Count nesting was discussed earlier in this section, and cooperative data sharing (with substate jurisdictions and with neighboring states) is addressed in a subsequent section.

Over time, data collection sites may cease to meet their original mission. Texas aggressively reduced the number of its short-term volume counts.¹¹ Many of the short-term volume locations had been selected previously to fill needs that were rarely documented. Over time, these count locations were perpetuated through tradition, and their original purpose lost. Texas eliminated almost all sites having 24-hour volumes below 300 and not at bridges and at railroad at-grade crossings. These counts were replaced by volume counts at a statistical sample of sites in five types of area (rural unincorporated, rural incorporated, small urban, small urbanized, and large urbanized). The randomly selected count locations result in statistically valid mean values that are used to estimate volumes on road segments for which no counts are performed.

2.4.1 Managing Special Counts

A helpful way to manage demand for traffic data collection is to establish and enforce procedures for responding to special count requests. Some special requests may be satisfied by using existing traffic data without requiring a new traffic count. Prior to scheduling and collecting a special count it should be determined whether a count was taken recently on the same segment and if the customer will accept either observed data or estimated data from the past count. In general, except for areas with significant changes in traffic patterns and volumes and roadway characteristics, data from counts collected within the past three years and factored for growth should be adequate for most planning needs.

2.5 Estimating Staff and Resource Requirements for Traffic Data Collection

This section will assist in assessing current resources and guiding the delivery of new programs and resource needs. As discussed below, state traffic data programs use a mixture of agency and contract forces. In an ideal situation, an agency can design a program from scratch and estimate required resources accordingly. However, in most cases, a traffic count program manager is faced with tailoring the program's counting capacity to its available financial or FTE resources. This section suggests guidelines for estimating staff and contracting requirements for a typical count program. Needs will vary significantly for different programs. A careful assessment of customer needs for the traffic program is highly recommended.

¹¹ Frawley, W.E. Frawley. *A Methodology for Randomly Selecting Traffic Count Locations in Texas—Results and Benefits*. Presented at the North American Travel and Monitoring Exposition and Conference, June 27–July 1, 2004, San Diego, California.

2.5.1 Agency Forces

The types of staff required to manage a traffic count program include collection staff, inspectors, office support, and site installation/maintenance support. These positions are discussed in more detail below.

Collection Staff

The productivity of collection staff is influenced by several factors. Staff are limited in the number of counters they set each day by the complexity of the equipment, coordination with traffic control, travel time between count locations, and the crew vehicle's capacity for transporting counters and supplies. Efficient count scheduling can maximize staff productivity. The following subsections discuss the factors that must be considered in determining collection staff resources. The guidance could be used in establishing a new program or maximizing the productivity of an existing one.

Counters Set per FTE

Short-term data collection relies on field staff to deploy and retrieve the equipment and the collected data. The number of full-time employees (FTE) required to conduct a given number of annual counts (agency productivity level) depends in part on the number of counts that each FTE can take in a week.

The agency productivity level is dependent on several factors, including the devices used, roadway cross section, safety factors, and even work schedules. Following are some examples:

- Multilane facilities require more than one counter for each data collection site.
- An agency estimate of field personnel productivity should consider the number of persons in a field crew.
- Vehicle classification devices require somewhat longer to set up, adjust sensor distance, and calibrate.
- Portable WIM devices are more difficult to set up and monitor, even if the devices have self-calibrating features.

After estimating unique agency productivity levels, the next step is to identify the number of weeks during the year in which traffic counts may be conducted. Because of different prevailing weather conditions, the available weeks will vary among states. The number of available weeks for counting establishes the number of weeks each year that each FTE may be employed in meeting traffic data collection needs.

The anticipated number of weekly FTE counts is then multiplied by the number of weeks available for counting during the year. This is the estimated annual productivity for each FTE. Separate estimates of FTE productivity should be developed for volume, classification, and WIM counts. Dividing the annual FTE productivity into the estimated number of traffic data counts produces the number of FTEs

needed to meet data collection needs. The benefit of this approach is that it ties traffic data collection FTEs to specific data collection needs. Increases or decreases in field personnel should be directly related to specific data collection needs rather than being adopted independently of specific elements of the traffic data program. Often agencies are faced with applying FTEs according to resource availability rather than having the luxury of assigning an unlimited number of FTEs.

Travel Time

Travel times between count locations directly influence the number of counts taken each day. Productivity can be enhanced by arranging count schedules that minimize distances between count locations. Because urban count locations are more closely spaced than rural locations, productivity in urban areas could be twice that in rural areas.

Agencies that operate centralized data collection systems—where collection staff are all based in a single central location—are subject to productivity losses due to the travel times between this location and the areas where the counts are to be collected. Lower travel times can be obtained if there are several separate data-collection teams based at district offices in various parts of the state.

Vehicle Capacity

Deployment of short-term data collection equipment is limited by several factors, including the cargo capacity of the transport vehicle and the size and number of counters and materials. A factor in weekly FTE count productivity is the vehicle fleet used to transport traffic volume and classification devices. For example, if an agency uses a van to transport traffic recorders, the vehicle may not be capable of hauling more than 50 portable devices, tubes, and tools for installation and calibration.

Inspectors

Inspectors are required to ensure that short-term data are collected on the scheduled dates, at the proper locations, with equipment that is properly placed, using appropriate worker safety procedures, and that data collection is properly performed.

Each agency should define the minimum level of inspection for their short-term counts and inspections should be scheduled randomly. This may include inspections during overnight periods if manual crews are responsible for data collection. Agencies may require more frequent inspection of new contractors, while the agency builds trust in the contractor's performance.

Safety Considerations

Attention should be given to all work schedules to guarantee worker safety. Additional staff may be warranted in certain conditions—high-volume roadways, high-crime locations, and under certain geometric sections where sight distance may be limited.

Office Support

Office support staff play an important role in traffic data collection. Office staff are responsible for scheduling routine traffic counts and special requests, for reviewing and processing incoming data, for generating reports, and for processing contractor billings. Central offices also typically have staff that repair equipment.

Count Scheduling

Efficient count scheduling is an important factor in maximizing field data collection productivity. Successful traffic data collection programs strive to improve the efficiency of their count scheduling process. Office staff are needed to produce annual and special count data collection and maintenance schedules for both state and contract forces. Constant communication between the staff scheduling counts and the data analysts is vital. Analysts and collection personnel should know and understand each others' needs and limitations. This communication will produce reasonable expectations and prevent misunderstandings.

To schedule traffic counts, agencies will find it helpful to map the count locations and to group all routine coverage counts by geography or roadway route and by time of year. Also, when practical, special counts should be scheduled to occur when coverage counts in the same area are being collected. If possible, deferring or advancing special counts for this purpose also will help to reduce program costs.

Schedules prepared by decentralized systems may have one FTE perform this function with other routine duties at each remote location.

Initial Processing of Data

Data collected either through machine or manual processes will be submitted to or retrieved by the agency. Though the use of computers and communications to poll telemetry sites is common, the data must be packaged, reviewed for completeness, screened for accuracy, and transmitted by data collection office staff to the data analysts. Problems or errors identified in this initial screening may be resolved by the screeners or passed on to others for further analysis and action.

The same staff also may be responsible for processing contractor billings. This function involves verifying contractor production against submitted bills, and approving bills for payment.

Production of Traffic Data

The staff resources required to produce and publish traffic data are as important as the resources dedicated to collecting the data. The number of office staff required are proportional to the number of traffic counts made annually. For comparison, data analysis and report production in one small state has six staff where in one large state eight staff are used.

Agencies maintain enough staff to produce annual reports, though agencies may desire additional staff to perform more in-depth research or studies of its traffic data to uncover new trends or identify unique characteristics. Without adequate analysis staff there is little or no time for these endeavors.

Agencies should strive to cross-train staff to avoid creating data analysis “silos.” This is especially important for agencies with a staff nearing retirement or where there is a trend of increasing turnover. Staff are one of an agency’s greatest assets and loss of institutional memory can have severe impacts on the program’s efficiency.

Agencies may find efficiency gains by assigning staff to defined regions. For example, Texas assigns two FTEs for each third of the state. There are several advantages to this staffing approach. Staff become familiar with the seasonal and annual characteristics within their assigned region. Staff work with all data types and gain proficiency. If vacancies occur on other regional teams, staff can be shared between regions to ease the vacancies’ impact. One disadvantage to consider for cross-training is that the ability to maintain analysis consistency, or to reduce the variability of professional judgment, is reduced or lost with many analysts if business rules for traffic monitoring are not developed and followed.

Some agencies are beginning to create large database systems with defined business rules to identify suspect data for further review. These systems free valuable staff time to concentrate on those counts that fall outside of normal ranges. Agencies should document the business rules used by staff when exercising their professional judgment. These documented business rules can then be programmed so that software programs or database queries can be built. These systems require a significant investment, but can provide agencies with greater staff productivity and the possibility of conducting nonroutine research work to improve their traffic data program.

Site Installation/Maintenance Support, Including Inspectors

High-quality traffic data are a product of both a strong sampling plan and aggressive maintenance programs for continuous count sites. Agencies should strive to identify mechanisms that promote efficiency and improve maintenance response. For centralized programs, efficiency can be gained through cooperative agreements with other agency staff in remote areas performing light maintenance work. Some states use a decentralized model where technicians are assigned regional work areas and are responsible for maintaining sites within their region. If contractors are used to perform maintenance, agencies will require a more modest level of resources for inspecting and verifying contractor performance.

Maintenance and repair of portable equipment is usually performed at a central facility.

States may benefit from support mechanisms, such as regional or district assistance from state DOT offices or the use of contractors, for data collection equipment installation and, more importantly, maintenance. The benefits of using local staff are travel time and overnight travel cost savings for centrally located staff to conduct minor or routine maintenance functions.

It is important to note that well-trained inspectors play just as an important role in monitoring the installation of permanent count stations installed by contractors. Remote staff that perform part-time inspector duties can be trained by central staff to ensure quality installation or maintenance is performed.

Estimation Procedure

The state force staff estimate is the sum of the field data collectors; field inspectors; office data collection support staff for scheduling, data processing, maintenance, installation and maintenance inspectors, and production staff. There are opportunities to reduce the number of FTEs through the use of contractors, and coordinated and cooperative data collection and sharing agreements. Use of these other available forces are discussed in the next section.

2.5.2 Other Available Forces

There are effective ways of reducing traffic data collection needs. Agencies should consider the efficiency benefits gained from using traffic data collected by other sources. Agencies may be hesitant to use data from other sources when they cannot confirm the data were collected in a manner consistent with the quality standards of their own agency. These issues should be identified and effort put toward their resolution. Other available sources for traffic data collection are use of contractors, urban traffic management centers, local agencies, and bordering states or countries.

Use of Contractors

Recent trends indicate that state traffic data collection programs will continue to use or shift more data collection responsibility to contractors. These contracts are necessary with reductions in state agency employees. Agencies cannot support the demand for traffic data collection with greatly reduced staff. Contractors frequently are used for the collection of short-term, volume, and vehicle-classification counts. Contractors also are used for the installation and maintenance of permanent sites.

Agencies should consider using performance-based specifications within their contracts where possible. Illinois, for example, issues payment only for accepted short-term volume counts. Texas operates under a similar payment policy but also includes provisions for half payments if it is not possible for the contractor to physically setup a count (e.g., count schedule for a roadway under construction) or if there is physical damage to the counter.

Installation or maintenance contracts can be structured in a similar manner. Installation contracts should base payment on a successful demonstration that the installed equipment is working properly. The demonstration method should be described in the contract. Maintenance contracts may be structured on a work order basis for on-demand repairs. Agencies should not guarantee quantities in the con-