# TRAFFIC MONITORING GUIDE *SUPPLEMENT*

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**U.S. Department of Transportation**
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# Section 4S

# Vehicle Classification Monitoring

# *Supplement*

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# SECTION 4 *SUPPLEMENT*

## INTRODUCTION

The 2001 edition of the *Traffic Monitoring Guide* (TMG) expanded Section 4 on vehicle classification and promoted increased traffic monitoring by vehicle class. However, the emphasis was on monitoring truck movements and the special considerations that apply to monitoring motorcycles was not covered. This Supplement to Section 4 addresses this deficiency.

Motorcycles are the most dangerous motor vehicles for both operators and passengers of any age. Moreover, data from the NHTSA's Fatality Analysis Reporting System (FARS) indicate disturbing trends in motorcycle safety:

- In 2006, motorcycle rider fatalities increased for the ninth consecutive year since reaching the lowest level in 1997 from 2,116 in 1997 to 4,810 in 2006 – an increase of 127 percent.
- Trends accompanying the rising motorcyclist death toll include a dramatic increase in motorcycle ownership, particularly by riders over 40, along with changes in other factors such as motorcycle size.
- The rate of increase in fatalities has outpaced the rate of increase in motorcycle registrations.

In order to assess motorcycle safety it is necessary to know the number of crashes as well as the corresponding exposure to determine a fatality rate. One of the key exposures are the motorcycle miles traveled:

- Motorcycle exposure data are used to inform national decisions and establish motorcycle related policies and safety countermeasure programs.
- Motorcycle exposure data are an important part of current safety performance measures, which measure the number of motorcycle fatalities per vehicle registrations and per million miles traveled.
- Motorcycle travel data, especially by roadway functional system, helps the DOT to better understand the distribution of travel and devise effective design and operational measures for both reliable and safe travel of motorist. Motorcycle travel data is a critical element used in developing effective safety countermeasures.

The Highway Performance Monitoring System (HPMS) made it optional for the reporting of motorcycle travel before 2007. Historically, approximately 15% of the States did not report motorcycle travel, and the FHWA estimated for these missing data in the table VM-1, *Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type*. **This Supplement revises the TMG to provide guidance to States on the collection and accurate reporting of motorcycle classification data.**

## TRAFFIC DATA COLLECTION AND MOTORCYCLES

The *Traffic Monitoring Guide* recommends that a vehicle classification counting program should include both extensive, geographically distributed, short duration counts and a smaller set of permanent, continuous counters. **This guidance is extended to include motorcycle counts for both continuous and short duration counting.**

Permanent counters provide an understanding of how typical motorcycle travel varies by day of the week and season of the year. Permanent, continuously operating, vehicle classification counters (CVC) are the backbone of the vehicle classification program and should be maintained to a high degree of accuracy.

As with traditional traffic volume counting, continuous classifiers must be supplemented by classification coverage counts. A fairly large number of short duration vehicle classification counts should be performed to monitor movements of motorcycles and other vehicle classes on individual roads. They should include data for all lanes and directions for a given location.

Traffic is usually monitored during weekdays while a large portion of motorcycle travel may take place on weekends. The relationship based on continuous classification sites must be developed to adjust for motorcycle undercounting and estimate motorcycle AADT.

The travel patterns for motorcycles are usually different than those for cars or trucks but the data collection plans currently used tend to be structured around understanding the movements of cars and trucks. Motorcycle volume patterns are primarily recreational patterns although commuter travel may be significant in some cases. Motorcycle travel is heavily dependent on the day-of-week (higher on weekends), season (higher in summer), and special events (e.g., rallies).

Some short counts should be taken during rallies and in places where motorcyclists are known to travel. For example, two-lane rural roads without much truck traffic should be counted if there is reason to expect recreational travel. Special events and seasonal travel should be annualized to represent AADT and accounted for in VMT estimates. AVC systems should be placed on recreational routes with motorcycle travel.

Because of the difference between motorcycle travel and that of other vehicle classes, to better estimate the annual average travel by motorcycles on the roads, States should develop a process that factors short duration motorcycle counts, as well as the other vehicle classes. Without adjustment, short duration classification counts yield biased estimates.

A State DOT should be able to provide users with an estimate of the amount of traffic by vehicle class by road segment. Motorcycle volume and percentage estimates should be available for the date when data were collected and as annual average estimates corrected for seasonal and day-of-week variation.

This data collection effort yields the basic motorcycle traffic statistics needed on any given road including the geographic variability and the time-of-day distribution at a variety of locations.

Sufficient locations must be monitored to meet HPMS requirements. Motorcycle travel is reported under the HPMS summary travel as a proportion of total travel by roadway functional class. The State should have motorcycle and other vehicle class travel data for all of the roadway functional classes. If the stations are sufficiently distributed according to road type and by traffic volume, a simple average of the observed proportions from all stations can be reported on the summary travel table (see *HPMS Field Manual*).

In addition to the State and Metropolitan planning and research funds available for traffic monitoring, because of their importance for safety, other funding sources are available under SAFETEA-LU for collecting motorcycle travel data:

- Section 402, State and Community Highway Safety Grants: funds may be used for any highway safety purpose under Title 23.
- Section 406, Safety Belt Performance Grants: funds may be used for any highway safety purpose under Title 23, or for improvement of hazardous roadway locations or features.
- Section 408, State Traffic Safety Information System Improvement Grants: funds may be used only to improve State Traffic Safety Information Systems.

Axle, visual, and presence sensors are most frequently used for collecting vehicle class volume information and each provide a different mechanism for classifying vehicles. Within each of these three broad categories are an array of sensors with different capabilities, levels of accuracy, performance capabilities within different operating environments, and output characteristics. Each type of sensor works well under some conditions and poorly in others. For example:

- Light axle weights, low metal masses, and narrow footprint make motorcycles harder to detect;
- Motorcycles in parallel or staggered formation may confuse detectors;
- Adjusting detector sensitivity for trucks may lead to reduced detection of motorcycles;
- Some combination trucks may be misclassified as a single-unit truck followed by a motorcycle (the rear tandem axle).

Road tubes are relatively inexpensive and provide short, sharp signals but may have a problem with groups of motorcycles. Side looking radar provides length-based classification and detects motorcycles. Inductive loops can work well if properly installed and maintained but they have problems with motorcycles in groups or staggering and are hard to tune for motorcycles. Accuracy can be improved by using inductive loop signature technology. Quadrupole loops also known as figure “8” style loop detectors have enhanced sensitivity for detecting motorcycles, bicycles, and smaller cars.

Sensors that cover a small area such as magnetometers have problems detecting motorcycles or groups of motorcycles. For axle sensors which are staggered a motorcycle will usually hit one sensor but not both; the system will likely record this as a vehicle with a missing axle detection and classify it as a passenger car by default.

All vehicle classifiers need to be calibrated and tested, and it is a good idea to involve motorcycles traveling in groups to ensure that motorcycles are properly counted. It is also advisable to use a test standard such as ASTM E2532-06, "Standard Test Methods for Evaluating Performance of Highway Traffic Monitoring Devices."

If length-based classification is used, it should accommodate motorcycle identification as one of the groups. Axle sensors, loops, and road tubes which detect the presence of vehicles should be placed in the travel way of motorcycles to assure their detection. Sensors which detect vehicles over the width of a lane are preferable to those that are partial lane.

There are several vendors who claim their automatic vehicle classification (AVC) equipment will detect motorcycles. The proper installation and calibration of the AVC device may be a critical component in its ability to count motorcycles. All vehicle classes are important; no vehicle class should be shortchanged. **It is the responsibility of each agency to make the best decision as to the types of automatic vehicle classifiers to purchase, install, calibrate, and maintain.**

# MOTORCYCLE CORRECTION FACTORS

Current practice applies seasonal adjustments to the total volume and then estimates volumes for vehicle types using the observed classification proportions. This will work fine if the traffic profile of all vehicle types is the same as the total volume profile. Otherwise, traffic volume for some vehicle types will be under-estimated or over-estimated.

The day of week traffic pattern for motorcycles differs from that of other vehicle types so short counts for motorcycles need to be factored. The TMG allows flexibility in the creation of day-of-week factors (see page 3-20 of the TMG). It suggests that factors may be computed on an individual basis (seven daily factors) or as combined weekday (Monday, Tuesday, Wednesday, and Thursday) and weekend (Friday, Saturday and Sunday) factors.

In practice, few counts are taken on weekends so the only data available for weekends are from permanent traffic counters and classifiers. This is a problem for motorcycles which may have significant weekend travel on routes or areas that are not near a permanent classifier. **The solution is either to install additional permanent vehicle classifiers or to take class counts on weekends.**

***Example***

The following example shows how to estimate correctly the annual average daily motorcycle traffic (AADMT). First, take the data from a permanent automatic vehicle classifier and determine the monthly average daily traffic (MADT) for the total volume. The seasonal (monthly) factors are the ratio of the MADTs with the AADT.

| Month | Monthly ADT | Monthly Factor |
|---|---|---|
| Jan | 47,376 | 1.05 |
| Feb | 45,285 | 1.10 |
| Mar | 50,574 | 0.99 |
| Apr | 51,040 | 0.98 |
| May | 51,662 | 0.97 |
| Jun | 52,320 | 0.95 |
| Jul | 51,320 | 0.97 |
| Aug | 52,416 | 0.95 |
| Sep | 50,824 | 0.98 |
| Oct | 51,564 | 0.97 |
| Nov | 49,188 | 1.02 |
| Dec | 45,806 | 1.09 |
| AADT | 49,948 | 1.00 |

Next calculate the average daily traffic by vehicle type for each day of the week for the year. Then compute day-of-week motorcycle correction factors (MCF) as the ratio of the annual ADMT and the day-of-week ADMT.

The table shows an example of the annual ADMT by day of week:

| **Day** | **ADMT** |
|---|---|
| Monday | 396 |
| Tuesday | 403 |
| Wednesday | 405 |
| Thursday | 428 |
| Friday | 655 |
| Saturday | 725 |
| Sunday | 483 |
| *ADMT* | 499 |

1. For the weekday ADMT, add the motorcycle counts for Monday, Tuesday, Wednesday, and Thursday; then divide by four.
2. For the weekend ADMT, add the motorcycle counts for Friday, Saturday, and Sunday; then divide by three.
3. Compute the weekday MCF = ADMT / weekday ADMT.
4. Compute the weekend MCF = ADMT / weekend ADMT.

In this example:

1. Weekday ADMT = (396 + 403 + 405 + 428) / 4 = 408
2. Weekend ADMT = (655 + 725 + 483) / 3 = 621
3. Weekday MCF = 499 / 408 = 1.22
4. Weekend MCF = 499 / 621 = 0.80

So a short class count would first be factored for seasonality and then for the day of week. As an example, at a short term monitoring site on the same route as the above site 10 miles to the south, two class counts were taken on weekdays in August with the following results for motorcycles:

| **Date** | **ADMT** | **ADT** |
|---|---|---|
| Aug. 14 | 518 | 50,761 |
| Aug. 15 | 494 | 51,231 |
| *Average* | 506 | 50,996 |

The average of the two counts is adjusted by the seasonal factor for August, which is 0.95:

$$506 \times 0.95 = 481$$

However, this result is low unless it is adjusted by the weekday MCF:

$$481 \times 1.22 = 586$$

So weekday motorcycle counts are increased to estimate the annual ADMT. This takes into account the likelihood of higher weekend motorcycle travel. The other vehicle classes would need to be adjusted for the day of week, too, so that the total volume is correct.

## TRAFFIC MONITORING DATA FORMATS

Travel monitoring data should be submitted to the FHWA via the Travel Monitoring Analysis System (TMAS). TMAS includes the monthly volume data for the Traffic Volume Trends and will include vehicle classification and truck weight data that in the past were processed with the Vehicle Travel Information System (VTRIS).

TMAS is accessed via the FHWA's User Profile and Access Control System (UPACS). The UPACS link is: https://fhwaapps.fhwa.dot.gov. For further information on accessing TMAS, contact your FHWA Division Office or the FHWA Travel Monitoring Team.

The record formats are specified in Section 6 of the *Traffic Monitoring Guide*. It is important that the *Station Description Record* be filled out completely because it is required by TMAS. Fields that are not applicable should be blank. In particular, if field 13 is zero, then fields 12, 14, 15, and 16 may be blank; if field 18 is zero, then fields 17, 19, and 20 may be blank.

Field 16 of the *Station Description Record*, the Vehicle Typology (formerly the Classification System for Vehicle Classification), is now a critical field because it will be used to determine the number of vehicle types in the corresponding *Vehicle Classification Records*. A typology is simply the total number of vehicle types with a description of how each vehicle type relates to the FHWA 13-class typology.

For example, a typology based on vehicle length may have 3, 4, or 5 vehicle types, whereas a typology based on axle spacings should have at least the 13 FHWA vehicle classes. *The implied typology for 5 vehicle types now classifies motorcycles as a separate vehicle type.*

16. **Vehicle Typology** (Columns 24-25) - *Critical*

This field indicates the total number of vehicle types used at the station and an implied description of what the vehicle types are. The default value is 13 which indicates the standard FHWA 13-class typology. The value for Vehicle Typology will determine the number of count fields needed on the *Vehicle Classification Records* for that station. If a typology is used that does not match one of these, attach a description of the typology and how it relates to the FHWA 13-class typology.

In the following table the numbers in parentheses refer to the FHWA 13-class typology:

| Code | Description |
|---|---|
| 01 | One vehicle type: total volume |
| 02 | Two vehicle types as follows:<br>Type 1 = passenger vehicles (classes 1-3)<br>Type 2 = trucks (classes 4-13) |
| 03 | Three vehicle types as follows:<br>Type 1 = passenger vehicles (classes 1-3)<br>Type 2 = buses and single-unit trucks (classes 4-7)<br>Type 3 = combination trucks (classes 8-13) |
| 04 | Four vehicle types as follows:<br>Type 1 = passenger vehicles (classes 1-3)<br>Type 2 = buses and single-unit trucks (classes 4-7)<br>Type 3 = single-trailer trucks (classes 8-10)<br>Type 4 = multi-trailer trucks (classes 11-13) |

| | |
|---|---|
| 05 | Five vehicle types as follows (*revised*):<br>Type 1 = motorcycles (class 1)<br>Type 2 = two-axle, four-tire vehicles (classes 2-3)<br>Type 3 = buses and single-unit trucks (classes 4-7)<br>Type 4 = single-trailer combination trucks (classes 8-10)<br>Type 5 = multiple-trailer combination trucks (classes 11-13) |
| 06 | Six classes as follows (*cf. HPMS Summary Travel form*):<br>Type 1 = motorcycles (class 1)<br>Type 2 = two-axle, four-tire vehicles (classes 2-3)<br>Type 3 = buses (class 4)<br>Type 4 = single-unit trucks (classes 5-7)<br>Type 5 = single-trailer combination trucks (classes 8-10)<br>Type 6 = multiple-trailer combination trucks (classes 11-13) |
| 07 to 11 | Number of vehicle classes in the typology (attach a description of how it relates to the 13 classes) |
| 12 | FHWA’s 13-class typology except class 3 is missing (i.e., classes 2 and 3 are combined) |
| 13 | FHWA's 13-class typology |
| 14 | FHWA's 13-class typology plus a class 14 (attach a description) |
| 15 | FHWA's 13-class typology plus classes 14 and 15 (attach a description) |

## FHWA VEHICLE CLASSES

The FHWA vehicle typology separates vehicles into categories depending on whether they carries passengers or commodities. Non-passenger vehicles are further subdivided by the number of axles and the number of units, including both power and trailer units. Note that the addition of a light trailer to a vehicle does not change the classification of the vehicle.

Axle-based automatic vehicle classifiers need an algorithm or “scheme” to interpret axle spacing information and correctly classify vehicles into these classes. The FHWA does not endorse any algorithm or scheme for interpreting axle spacings. Axle spacing characteristics for different vehicle classes are known to change from State to State. As a result, no single algorithm is best for all cases. It is the responsibility of each agency to test and calibrate the classification algorithm they use.

### *FHWA VEHICLE CLASSES WITH DEFINITIONS*

1. ***Motorcycles*** -- All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles. *Note that this vehicle class is now required*.

2. ***Passenger Cars*** -- All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.

3. ***Other Two-Axle, Four-Tire Single Unit Vehicles*** -- All two-axle, four-tire, vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single-unit vehicles pulling recreational or other light trailers are included in this classification. *Because automatic vehicle classifiers have difficulty distinguishing class 3 from class 2, these two classes may be combined into class 2.*

4. ***Buses*** -- All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and should be appropriately classified.

   **NOTE:** In reporting information on trucks the following criteria should be used:

   a. Truck tractor units traveling without a trailer will be considered single-unit trucks.

   b. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered one single-unit truck and will be defined only by the axles on the pulling unit.

   c. Vehicles are defined by the number of axles in contact with the road. Therefore, "floating" axles are counted only when in the down position.

   d. The term "trailer" includes both semi- and full trailers.

5. ***Two-Axle, Six-Tire, Single-Unit Trucks*** -- All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with two axles and dual rear wheels.
6. ***Three-Axle Single-Unit Trucks*** -- All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with three axles.
7. ***Four or More Axle Single-Unit Trucks*** -- All trucks on a single frame with four or more axles.
8. ***Four or Fewer Axle Single-Trailer Trucks*** -- All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.
9. ***Five-Axle Single-Trailer Trucks*** -- All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.
10. ***Six or More Axle Single-Trailer Trucks*** -- All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.
11. ***Five or fewer Axle Multi-Trailer Trucks*** -- All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.
12. ***Six-Axle Multi-Trailer Trucks*** -- All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.
13. ***Seven or More Axle Multi-Trailer Trucks*** -- All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

## RESOURCES ON TRAFFIC DATA COLLECTION

FHWA Travel Monitoring webpage
http://www.fhwa.dot.gov/policy/ohpi/travel/index.htm

*Traffic Monitoring Guide* (TMG)
http://www.fhwa.dot.gov/ohim/tmguide/index.htm

*Traffic Detector Handbook: Third Edition*
http://www.tfhrc.gov/its/pubs/06108/index.htm

Detector Technology Evaluation (2003)
http://www.ndsu.nodak.edu/ndsu/ugpti/MPC_Pubs/pdf/MPC03-154.pdf

Vehicle Detector Evaluation (2002)
http://tti.tamu.edu/documents/0-2119-S.pdf
http://tti.tamu.edu/documents/2119-1.pdf

Portable Non-Intrusive Traffic Detection System (PNITDS)
http://www.dot.state.mn.us/guidestar/projects/pnitds.html

Non-Intrusive Traffic Detection – Phase II Final Report (2002)
http://www.dot.state.mn.us/guidestar/projects/nitd.html

Traffic Monitoring Standards from ASTM International:

- E1318-02 Standard Specification for Highway Weigh-in-Motion (WIM) Systems with User Requirements and Test Methods
- E1957-04 Standard Practice for Using Pneumatic Tubing for Roadway Traffic Counters and Classifiers
- E2259-03a Standard Guide for Archiving and Retrieving ITS-Generated Data
- E2300-06 Standard Specification for Highway Traffic Monitoring Devices
- E2415-05 Standard Practice for Installing Piezoelectric Highway Traffic Sensors
- E2467-05 Standard Practice for Developing Axle Count Adjustment Factors
- E2468-05 Standard Practice for Metadata to Support Archived Data Management Systems
- E2532-06 Standard Test Methods for Evaluating Performance of Highway Traffic Monitoring Devices
- E2561-07a Standard Practice for the Installation of Inductive Loop Detectors