

BEST PRACTICES GUIDEBOOK:

COLLECTING SHORT DURATION MANUAL VEHICLE CLASSIFICATIONS COUNTS ON HIGH VOLUME URBAN FACILITIES

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**DIVISION OF TRANSPORTATION DEVELOPMENT
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INTRODUCTION

This guidebook is a direct result of the research described in the report, “Validation of Urban Vehicle Classification Sampling Methodology” (1). The Mobility Analysis Section of the Colorado Department of Transportation (CDOT) Division of Transportation Development (DTD) funded this research study to develop a short duration manual count method that would be statistically reliable for estimating the 13 Federal Highway Administration (FHWA) vehicle classifications on urban roadways with average daily traffic volumes exceeding 15,000 vehicles per day. Since vehicle classification is expensive to perform by manual observation over long periods of time, a statistically reliable method of estimating vehicle classification percentages on urban roadways using a less time consuming method was desirable. There are electronic methods of estimating vehicle classifications; using tube counters, automated traffic recorders (ATR), radar, and image processing. There are several problems with these electronic counters in an urban setting; they are either permanent systems, dangerous for workers to install temporarily, they require calibration and maintenance, and they are less accurate when speeds are low or queuing occurs due to incidents or congestion which is most likely to occur in urban areas.

During this research, the study panel evaluated numerous methods for performing vehicle classification counts to identify methods that provided good statistical accuracy at a reasonable cost. 24-hour vehicle classification data were collected for multiple days at 14 sites around Denver, Colorado that represented different roadway classes and volume levels. To assist in selecting the best vehicle classification method, the panel ranked the three most accurate methodologies and a manual 24-hour count according to three weighted criteria: accuracy, cost and ease of implementation.

As a result of the study, the recommended short duration vehicle classification methodology requires vehicle counts to be performed for 15-minutes every hour for a continuous 24-hour period. This method exhibits strong statistical similarity to the 24-hour classification counts for all roadway classes and study sites included in this analysis. This collection method is

statistically accurate, easy for field personnel to understand and collect, and is about one-third of the cost of a manual 24-hour count.

This guidebook discusses the recommended procedures for planning, collecting, processing, and quality control procedures for short duration classification counts. The most important factors for a short duration sample to statistically represent a 24-hour period include the time span of the sample (24-hours), the duration of each count (15-minutes), and the quality of each count (correct vehicle classifications)

METHODOLOGY

The 15-minute every hour method for collecting classification data was determined to be a statistically reliable method of estimating 24-hour vehicle classifications for the facility and ADT categories shown in Table 1 and the 13 vehicle classes described in the following section, Vehicle Classification Standards.

Table 1: Facility/ADT Categories

Facility/ADT Category
Lower Volume Urban Arterial ($15,000 \geq \text{ADT} < 30,000$)
Higher Volume Urban Arterial ($\geq 30,000$ ADT)
Urban Expressway
Urban Freeway

Vehicle Classification Standards

Class 1- Motorcycles: All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handle bars rather than wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheeled motorcycles.

Class 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.

Class 3- Other Two-Axle, Four-Tire, Single Unit Vehicles: All two-axle, four-tire, vehicles other than passenger cars. Included in this classification are sport utility vehicles (SUV), 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.

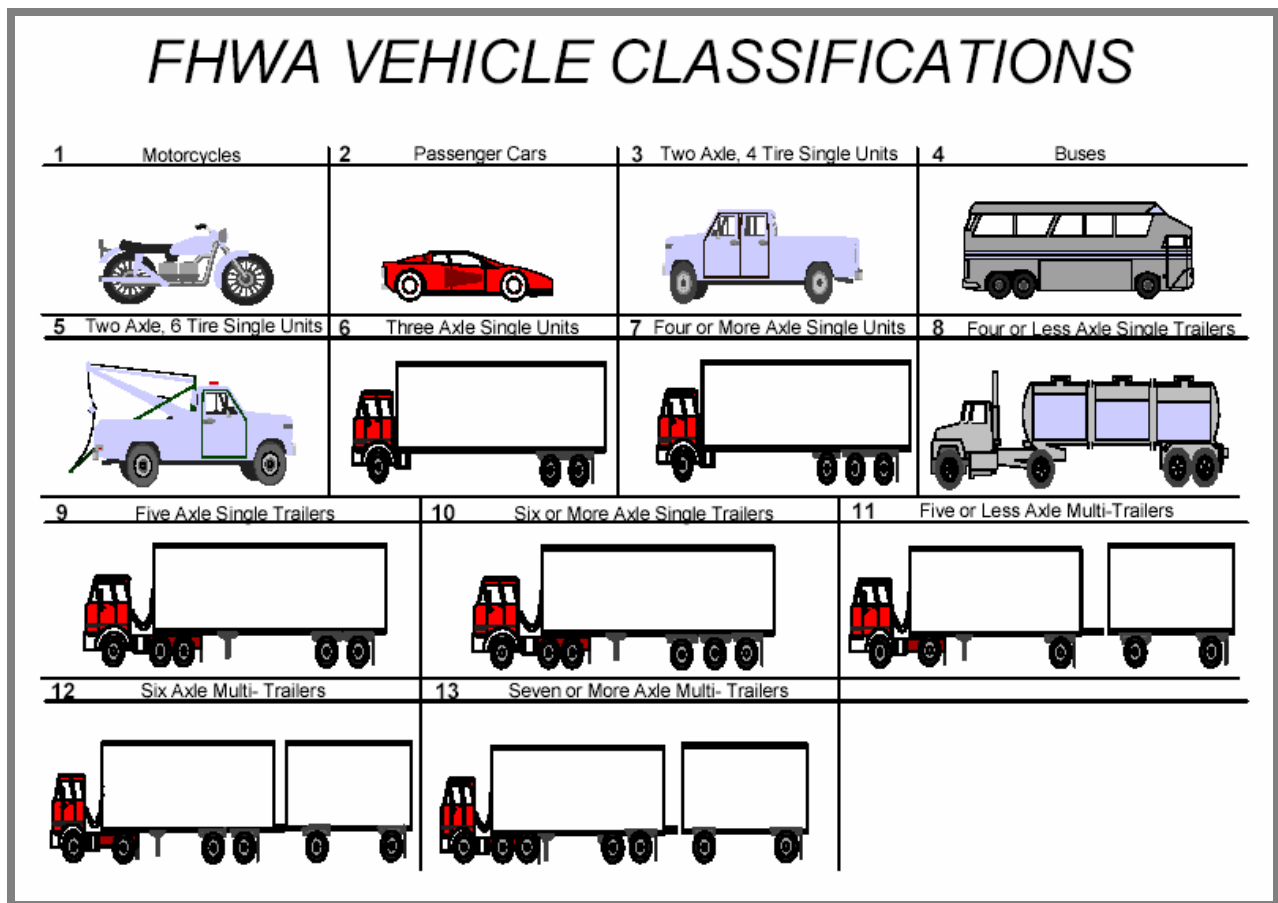


Figure 1: FHWA Vehicle Classifications

Class 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 trucks and 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 as one single unit truck and will be defined only by axles on the pulling unit.
- c. Vehicles shall be defined by the number of axles in contact with the roadway. Therefore, “floating” axles are counted only when in the down position.
- d. The term “trailer” includes both semi- and full trailers.

Class 5- Two-Axle, Six-Tire, Single Unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.

Class 6- Three-axle Single unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.

Class 7- Four or More Axle Single Unit Trucks: All trucks on a single frame with four or more axles.

Class 8- Four or Less Axle Single Trailer Trucks: All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit.

Class 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.

Class 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.

Class 11- Five or Less Axle Multi-Trailer Trucks: All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power unit

Class 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.

Class 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.

Short Duration Count Methodology – 15-Minutes Every Hour

A 15-minute classification count is performed approximately every hour for a continuous 24-hour period. The count can be started at any time during the day as long as the counts continue for 24-hours. Vehicles are classified simultaneously for each direction at a site and then the technicians move to the next site to perform 15-minute counts. It is possible to repeat this at a third site if the sites are close enough to each other such that all three sites can be counted within an hour. It is possible for a technician to count both directions simultaneously if the equipment can record two different directions and the technician is proficient enough to accurately classify two directions (or the volumes are lower enough). A count can start anytime between the start of the hour and 45 minutes past the hour providing two short duration counts performed at the same site are separated by a minimum of 15-minutes. For example, a continuous 30-minute count from 1:45 PM to 2:15 PM will not be accepted as two 15-minute counts for the hours of 1:00 – 2:00 PM and 2:00 – 3:00 PM. If a couple of count periods are missed at a site, the CDOT project manager should be contacted to determine if the remaining counts should be collected to complete the 24-hour period or if the count should be redone. If the project manager cannot be reached, assume the 24-hour count period should be completed and the project manager will decide whether to use that data at a later time.

Short duration counts could also be collected from video recordings for a 24-hour period or to supplement manual counts. Video can be recorded where location and lighting permit. All lanes in each direction must be visible on the video recording for the entire count duration. The best vantage point for video is often on a rooftop where streetlights sufficiently illuminate all lanes of traffic and vehicle axle and trailer configurations can be seen. Short duration counts reduced from video should follow the same guidelines as described in the previous paragraph: a count for each direction should have the same start time and a minimum of 15-minutes between consecutive counts should exist for a site. CDOT will check manual and video reduction counts by using video recordings at random sites as part of the quality control program, which is described on page 11.

Collection Days

Vehicle classification data should be collected on Tuesdays, Wednesdays, or Thursdays to avoid potential end of week variations. Data should not be collected on days adjacent to work week holidays. Data should not be collected in a construction zone, during adverse weather conditions, or any other situation that adversely affects traffic patterns.

Classification Equipment

The type of equipment used to record vehicle classification is the choice of the data collector.

The only guidance is the delivery format of the data to CDOT; 24, 15-minute counts for 13 vehicle classes by direction for each site (48 vehicle classification records per site). The equipment should be capable of storing 13 vehicle classes that can be summarized into 15-minute intervals.

An optional feature would be a direction switch for counting two directions at once. Figure 2 shows an example of an electronic count board that is compatible with the methodology presented in this guidebook. A similar electronic count board or custom software could be



Figure 2: Example Count Board with FHWA 13-Bin Classification Template

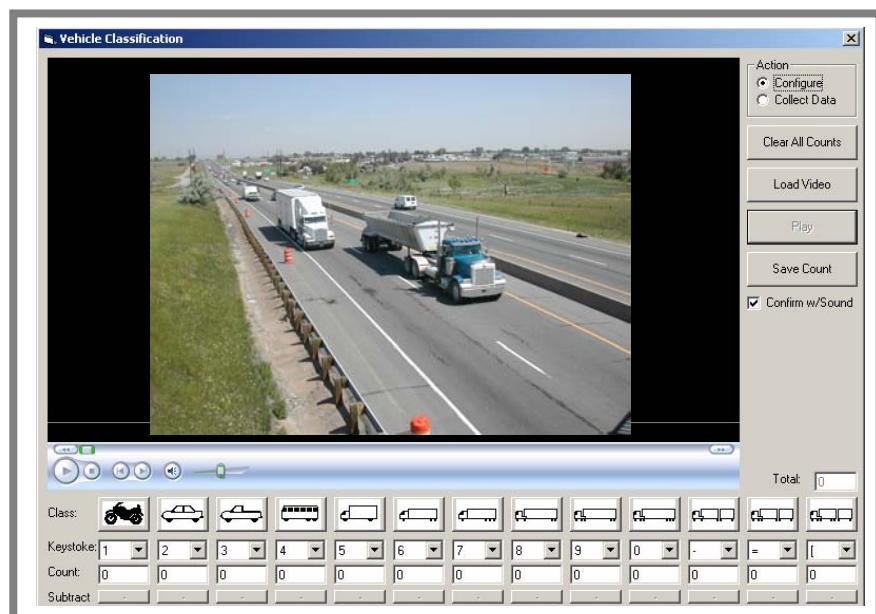


Figure 3: VehicleClassifier Program

used for video reduction. Figure 3 shows a screenshot of VehicleClassifier, a video reduction program that was developed as part of the short duration count research. The time of day on all electronic equipment will be synchronized with Coordinated Universal Time, Mountain Time Zone, available at <http://www.time.gov/>.

Safety

Any activity involving work along a roadway has inherent risks. This section of the manual is intended to provide an overview of the types of hazards and of the type of response to these hazards with which any personnel involved with data collection should be aware. Any organization involved with manual classification or video camera setup is responsible for the maintenance of workplace safety in accordance with the Federal Occupational Safety and Health Administration's (OSHA) requirements. Key to those requirements is the avoidance of traffic accidents by ensuring that people and equipment, including vehicles, used in data collection are visible to drivers and that drivers have sufficient warning and information about the presence of personnel and equipment along the roadway.

Procedures for properly identifying the presence of work zones in which short duration counts are taking place are covered by the Federal Highway

Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD). Section 6 of

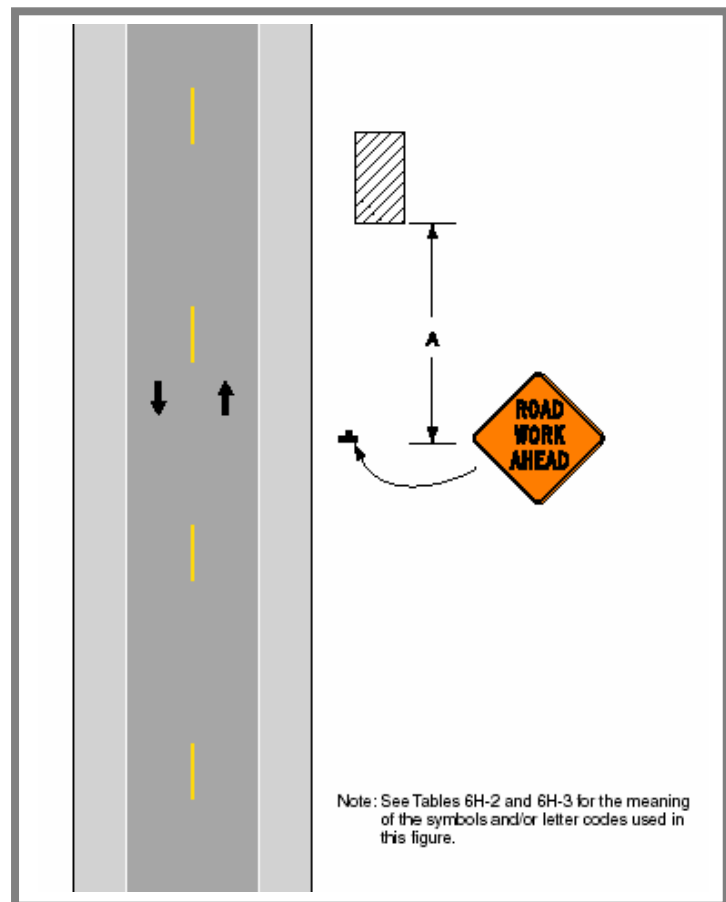


Figure 4: Typical application for Work Beyond the Shoulder from MUTCD, Section 6

the MUTCD covers temporary traffic control measures, including the use of signs and equipment to alert drivers to the presence of personnel working along the roadway in work beyond the shoulder as will be required for the short duration counts. Any sites where video cameras will be used within CDOT right-of-way (ROW) should have a vehicle with high-intensity rotating, flashing or oscillating overhead light or strobe light parked off the shoulder, a ‘Survey Crew’ sign (W21-6 or similar) displayed. An example of the proper use of indicators and signs is shown in Figure 4.

Personal safety equipment compliant with OSHA regulations is a requirement for field personnel during data collection. Minimum recommendations include highly reflective clothing, hard hats and appropriate footwear that may include steel-toed boots. Personal safety may also be enhanced through the use of hand-held radios or mobile phones to allow collection teams to communicate with each other on site.

Public Relations

The CDOT Public Relations Office, CDOT maintenance patrol, private property owners, the Colorado State Patrol and relevant law enforcement agencies shall be contacted at the beginning of a study to keep them informed of data collection efforts within the CDOT right-of-way (ROW). If required, a ROW or traffic count permit should be obtained from the City planning office. A list of contacts and a letter from CDOT stating the purpose of the project should be included in the study design document. Each field technician should be given a copy of the approved study design for reference in the field should questions arise.

DATA MANAGEMENT AND QUALITY CONTROL

Quality control procedures have been adopted by CDOT to ensure the quality of the short duration classification counts and the statistical reliability of estimating a 24-hour classification count.

Site Information

CDOT will provide the known and historic information specified in Table 2 for each site and direction to the company performing field collection. The data collection company will be responsible for collecting and delivering all of the data specified as ‘Required’ in the deliverable column of Table 2. Unique records will exist for the combination of SiteID, Direction, and Collection Date.

Table 2: Site Information

DATA	TYPE	DESCRIPTION	DELIVERABLE
SiteID	integer	CDOT site identifier	Provided
Site Description	text	State highway number, name, and bounding cross streets or location on the highway	Provided, comment on changes
Direction	text	Northbound, southbound, eastbound, westbound	Provided
Highway	text	State highway number	Provided
RefPt	decimal	First milepost endpoint of a segment on a Route specifying the count location (between RefPt and EndRefPt)	Provided
EndRefPt	decimal	Second milepost endpoint of a segment on a Route specifying the count location (between RefPt and EndRefPt)	Provided
Facility Type	text	Arterial, expressway, freeway	Provided
AADT	integer	Annual Average daily traffic	Provided
Field Description	text	A description of the location where the count was performed (i.e. top of embankment, from car on shoulder)	Required
Longitude	decimal	Longitude for GPS coordinate taken at the count location in decimal degrees	Required
Latitude	decimal	Latitude for GPS coordinate taken at the count location in decimal degrees	Required
Digital picture and filename	text	A digital picture will be submitted for each site and direction where a short duration count is collected	Required
Collection Date	date	The date collection was started	Required
Lanes	integer	The number of lanes in this direction that were classified	Required

DATA	TYPE	DESCRIPTION	DELIVERABLE
Adjacent Site 1	text	SiteID and field description for the next closest site that can be counted within an hour	Suggestion provided, updates required
Travel Time to Adjacent Site 1	integer	Travel time (in minutes) from current site to adjacent site 1	Required if collected
Adjacent Site 2	text	SiteID and field description for the next closest site that can be counted within an hour (if possible)	Suggestion provided, updates required
Travel Time to Adjacent Site 2	integer	Travel time (in minutes) from adjacent site 1 to adjacent site 2	Required if collected
Comments	text	Any relevant field notes about a site that were not included with other data	Optional

Short Duration Count Information

The data collector is responsible for collecting and delivering all of the data specified in Table 3. Comments on unusual traffic conditions or unclassified vehicles should be included in the respective count record. A voice-activated tape recorder could be used to record technician comments during collection. 48 records will exist for each site per collection period; one per 15-minute count per direction. Unique records will exist for the combination of SiteID, Direction, and Start Date Time.

Table 3: Short Duration Count Information

DATA	TYPE	DESCRIPTION
SiteID	integer	CDOT site identifier
Site Description	text	State highway number, name, and bounding cross streets or location on the highway
Direction	text	Northbound, southbound, eastbound, westbound
TechnicianID	GUID	CDOT assigned certification identifier for the technician that collected vehicle classification data for this record
Technician Name	text	Name of the technician that collected vehicle classification data for this record
Start Date Time	date time	The date and time this count was started (mm/dd/yyyy hh:mm:ss)
End Date Time	date time	The date and time this count was ended (mm/dd/yyyy hh:mm:ss)
Class1	integer	Motorcycles
Class2	integer	Passenger Cars
Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
Class4	integer	Buses
Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
Class6	integer	Three-axle Single unit Trucks
Class7	integer	Four or More Axle Single Unit Trucks

DATA	TYPE	DESCRIPTION
Class8	integer	Four or Less Axle Single Trailer Trucks
Class9	integer	Five-Axle Single Trailer Trucks
Class10	integer	Six or More Axle Single Trailer Trucks
Class11	integer	Five or Less Axle Multi-Trailer Trucks
Class12	integer	Six-Axle Multi-Trailer Trucks
Class13	integer	Seven or More Axle Multi-Trailer Trucks
Comments	text	Comments on irregular traffic conditions such as an accident. Description of unknown or unusual vehicle classes and the number that occurred during this 15-minute count

Training and Certification

As an initial quality control measure, CDOT requires that all vehicle classification data collectors pass a test to demonstrate proficiency with correctly identifying vehicles based on the FHWA 13-Bin vehicle classification scheme. All vehicle classification training will be provided and conducted by the consultant. The test involves classifying vehicles by watching a video previously recorded on various facilities around the Denver area. The data collector is responsible for bringing data collection equipment to record their vehicle classifications during the test. Once data collectors have successfully passed the test they will be certified by CDOT to perform vehicle classification for the short duration manual count program. Please contact one of the CDOT study panel members listed on page ii for details on the certification program.

Quality Control Field Checks by CDOT

The additional site information data specified in Table 2 (field description, GPS position, digital pictures) provides CDOT an initial level of quality control. CDOT will conduct random field checks of vehicle classifications in an effort to ensure the quality of data collected. A minimum of 15-minutes for each data collector per study will be checked by manually classifying vehicles from video recorded by CDOT during the manual collection. If the data collectors use video to perform the manual classification, they will be required to provide the video to CDOT for quality control checks. CDOT will use the chi-square test for comparing the field counts to the quality control counts. The formula for the chi-square statistic is as follows:

$$X^2 = \sum_{i=1}^k \frac{(x_i - e_i)^2}{e_i}$$

Where:

k = number of vehicle classes (where the total count ≥ 5)

x = observed frequency in a vehicle class (field count)

e = expected frequency in a vehicle class (total field count times vehicle class percentage from quality control count, must be ≥ 5)

CDOT will also compare new vehicle classification data to historic data. If CDOT identifies errors, the data collector will be responsible for any recounts and field personnel may be required to retake the vehicle classification certification test.

STUDY DESIGN

At the beginning of a project, the data collector shall submit a study design to CDOT outlining field procedures, data management, and a quality control plan. The study design should include the following information:

- Classification collection method (manual, video, or a combination of both)
- Type of equipment that will be used to classify vehicles (count board, custom software)
- Safety plan
- A list of contacts including:
 - Data collection supervisors
 - Field technicians
 - CDOT project managers
 - CDOT Public Relations Office
 - CDOT Maintenance Patrol
 - Private property contact
 - City planning office (if a permit is required)
 - Colorado State Patrol
 - Law enforcement dispatch for each jurisdiction where vehicle classification occurs.
- Site information table (Table 2) with all available data populated.
- Quality control plan

The approval of this document by CDOT will serve as the notice to proceed with data collection. A copy of the approved study design should be given to each field technician as a reference that can be used in case of an emergency or if questions arise from authorities or the public.

FINAL REPORT

At the end of a project, the data collector will be required to submit a final report that summarizes the data collection. The report should discuss any problems that were encountered in the field, how the problems were addressed, and explanations for variations from the study design. New vehicle pictures can be submitted with the final report if the data collector identified new vehicles that were difficult to classify. The data collector should also make comments on any lessons learned, thoughts on improving the data collection methods, or other suggestions for improving the topics presented in this guidebook. All data should be submitted to CDOT electronically in the format specified in Tables 2 and 3 and the final report should include a description of all data.

REFERENCES

1. Colorado Department of Transportation, Research Branch. *Validation of Urban Vehicle Sampling Methodology*. May 2005.
2. Hayter, Anthony. *Probability and Statistics for Engineers and Scientists*. p. 518-532. PWS Publishing Company, 1996.
3. The Ohio Department of Transportation (ODOT) *FHWA Vehicle Classification Scheme F Report*. Available at http://www.dot.state.oh.us/techservsite/availpro/Traffic_Survey/SchemeF/FHWA_Scheme_F_Report.PDF (accessed 17 September 2003)
4. Federal Highways Administration. *Manual on Uniform Traffic Control Devices for Streets and Highways, 2003 Edition*. . Revision 1, July 21, 2004. Available at <http://mutcd.fhwa.dot.gov/>.

APPENDIX A – EXAMPLE VEHICLE CLASSIFICATIONS

Class 1- Motorcycles



Class 2- Passenger Cars



Class 3- Other Two-Axle, Four-Tire, Single Unit Vehicles



Class 4- Buses



Class 5- Two-Axle, Six-Tire, Single Unit Trucks



Class 6- Three-axle Single unit Trucks



Class 7- Four or More Axle Single Unit Trucks



Class 8- Four or Less Axle Single Trailer Trucks



Class 9- Five-Axle Single Trailer Trucks



Class 10- Six or More Axle Single Trailer Trucks



Class 11- Five or Less Axle Multi-Trailer Trucks



Class 12- Six-Axle Multi-Trailer Trucks



Class 13- Seven or More Axle Multi-Trailer Trucks

