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Mining of Florida ITS Data for Transportation Planning Use

Volume 1: Refinement of the Florida DOT Vehicle Classification Table

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16. Abstract

The Federal Highway Administration (FHWA) Office of Highway Planning requires states to furnish vehicle classification data as part of the Highway Performance Monitoring System (HPMS). "Scheme F", used by most states to classify vehicles, can also be used to develop the required load spectra. Unfortunately, the scheme is difficult to automate and is prone to errors resulting from imprecise demarcation of class thresholds. A probabilistic neural networks (PNN) model was developed, trained, and applied to field data composed of individual vehicle's axle spacing, number of axles per vehicle and overall vehicle weight. The PNN reduced the error rate from 9.7 percent to 6.1 percent compared to an existing classification algorithm used by the State of Florida Department of Transportation (FDOT). The inclusion of overall vehicle weight as a classification variable further reduced the error rate from 6.2 percent to only 3.0 percent. The promising results from the neural networks were used to set up new thresholds that reduce classification error rate. The new and improved classification table is currently being tested in the field by the Florida Department of Transportation.

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EXECUTIVE SUMMARY

1. Introduction

To automatically classify a vehicle, the information provided in "Scheme F" need to be interpreted and presented in a format suitable for the automatic classifiers. The number of axles and the axle spacing are the primary inputs that are used to classify a vehicle using certain predefined decision tree. In Florida, different vendors supply the Florida Department of Transportation with vehicle classification equipment. Prior to the start of this research, the classification algorithm used in each vendor-supplied equipment was unique to that vendor. A preliminary comparative analysis by the Florida Department of Transportation showed that different vendor algorithms produced different error rates in vehicle classification. In order to harmonize the classification algorithms, the Florida Department of Transportation developed a common decision tree that could be used in all classification equipment throughout the state. However, the common decision logic developed was deemed not to be optimum. The field evaluation of the developed decision logic revealed many misclassifications associated with overlap in axle spacing. Therefore, in order to optimally automate "Scheme F" guidelines, a new approach that could minimize classification errors and establish optimum thresholds was needed.

Another reason for the desire to improve vehicle classification stems from national efforts of using load spectra analysis in designing pavements. Prior to 2002, the American Association of State Highway and Transportation Officials (AASHTO) was recommending the use of the Equivalent Single Axle Load (ESAL) approach for the design of flexible and rigid pavements *(*AASHTO, 1986). In this approach, wheel loads of various magnitudes and repetitions from mixed traffic were converted into ESAL of 18,000 pounds. The 2002 AASHTO Pavement Design Guide developed under the National Cooperative Highway Research Program (NCHRP) Project No. 1-37A was proposing the use of load spectra approach for the design of flexible and rigid pavements. The load spectra approach uses the same traffic data as that used by the ESAL approach but it does not require conversion of the loads into ESALs; instead, the data are categorized by axle configurations and weight. In general, the traffic data collected in compliance with FHWA guidelines will fully support the load spectra approach requirements. Since vehicle classification data will be the major input into the 2002 Pavement Design Guide, it is important that the accuracy of vehicle classification using "Scheme F" should be increased.

Furthermore, improving vehicle classification is needed because changes in profile in the vehicle population have resulted in overlapping axle spacing between certain vehicle categories as defined under "Scheme F". This is particularly true with larger pickups, sports utility vehicles (SUVs) and vans which comprise axle spacings similar to single unit trucks. To reduce errors resulting from these overlaps, there is a need to tighten the threshold margins and optimize the decision boundaries of a classification decision tree.

2. Objectives and Scope of the Study

The main objective of the study was to develop an optimum vehicle classification table and decision tree specific for Florida highways that was capable of working with all vendor supplied equipment. The second objective was to propose an optimum approach for vehicle classification. Specifically, this study was aimed at accomplishing the following:

- comparing vehicle classification decision trees used by different vendors' classification equipment,
- evaluating the existing vehicle classification table developed by the Florida Department of Transportation more than 15 years ago,
- proposing an optimum vehicle classification table, and
- testing/validating the developed optimum classification table.

3. Methodology

The methodology used to achieve the above research objectives involved conducting a detailed search of literature, selecting study sites, collecting quality data from the selected sites, applying neural networks principles to develop optimum classification thresholds, and validation of the proposed optimum thresholds. A detailed search of literature on published and unpublished information on vehicle classification was conducted. The background of vehicle classification schemes and algorithms was reviewed. Reports from various studies involved in developing the guidelines used for vehicle classification were acquired and reviewed. The study sites were selected from the calibrated Weigh-In-Motion (WIM) sites. Among of the criteria considered in selecting sites were the geographical location, road geometry, functional classification, and traffic characteristics. To ensure quality, data were collected only from WIM sites that were recently calibrated. A test vehicle was used to verify calibration of the site. A vehicle with known axle spacing was run over the sensors several times prior to data collection. The vehicle was run at different speeds to study the effect of vehicle speed on the accuracy of detected axle spacing. Error analysis of the recorded axle spacing of the test vehicle was carried out to verify calibration of the site. The ground truth data were collected at the vicinity of WIM sites using a video camera. Synchronization of the video camera time with the system time in the automatic data recorder (ADR) was done prior to data collection to enable vehicle matching during data processing. Individual vehicle records for the time when the video was logged on were downloaded from the computers installed at the WIM sites using polling software and modem connection. The ground truth data were compared with machine classification to identify errors in vehicle classification. Classification using ground truth data followed the guidelines provided in "Scheme F". A probabilistic neural networks (PNN) model was developed, trained, tested and used to classify the same data set. The classification error obtained from the use of neural networks was compared to the classification error obtained from field machine classification, which was based on FDOT decision tree. The results obtained from the neural network were used to set the optimum axle spacing thresholds for the

classification decision tree. The validation data were collected and, in addition to the individual vehicle records acquired, the actual axle spacings were determined from video images. This was done in order to verify the accuracy of axle spacing, in addition to the use of test vehicle, and to allow enough data collection from remote sites.

4. Findings

The efficacy of PNN in improving vehicle classification was evaluated in two stages. In stage 1, the PNN acted on a data set comprised of two variables only—that is, axle spacings and number of axles. This is the same data set that the FDOT classification table was applied on. In the second stage, the PNN acted on the same data set but with the overall gross vehicle weight added as a variable. It was thought that the additional of vehicle weight would assist in improving the demarcation of the thresholds. The results showed that the PNN classification technique has better performance than the current FDOT table. The inclusion of the vehicle weight as a classification variable reduced the percent of vehicle misclassified by the PNN from 6.2 percent to 3.0 percent. It is worth noting that most FDOT traffic monitoring sites are not capable of collecting vehicle weight; thus, the inclusion of vehicle weight in the PNN analysis was important only as far as refining the thresholds was concerned. Once new thresholds are proposed, it won't be important to include the weight variable in the new and revised classification algorithm. It should also be noted that some classes had fewer number of vehicles observed compared to others. This is generally due to traffic distribution existing on the roadways in which vehicles in some classes, particularly Class 7 and Class 13, are fewer on the road.

One of the intended outcomes of this study was to develop new and improved thresholds for the FDOT decision tree. The adjustment of the thresholds was to be based on extensive field evaluation of the PNN and engineering judgment. Preliminarily, the PNN gave some insights of how best the thresholds in the current FDOT look up table could be adjusted to reduce the error rate. The word "reduce" is hereby used judiciously as it is clear that it is almost impossible to have a 0 percent error rate because of the field overlap of axle spacing of vehicles that are supposed to belong to different classes. There were two guiding principles that were invoked in trying to find optimal threshold values that would reduce the misclassification error rate. First, the research team considered the end use of the classification data. As an input to a pavement management process, vehicles in higher classes—generally Class 4 and above—have a more damaging loading effect on the pavement. Thus, it was crucial for these upper classes to be better classified than the lower classes. Second, since automatic vehicle classifiers have difficulty distinguishing Class 3 from Class 2, FHWA reporting requirements generally allows these two classes to be combined; hence misclassification between these classes was not that critical.

The thresholds were calculated from the correctly classified vehicles' axle spacings. No change is proposed for Class 1 since no misclassification was observed in this class. The proposed axle spacing range for Class 2 vehicles is 6.01 - 8.49 ft and for Class 3 vehicles is 8.50 - 11.9 ft instead of 6.01-10.0 ft and 10.01 - 13.30 ft, respectively.

The statistical analysis indicated that these new thresholds will reduce the misclassification error rate between Class 2 and Class 3 from 7.1 percent to 2.2 percent. No change in thresholds is proposed for Class 4 vehicles because statistical analysis indicated that the misclassified Class 4 vehicles were vista type school buses, which are relatively short compared to other Class 4 vehicles (buses). It was also found that the distribution for axle spacing for Class 5 vehicles lies in the positive tail of the distribution (Skewness = 3.09). To classify all vista type school buses as Class 4, the lower boundary for Class 4 should be changed from 23.01 ft to 17.00 ft. This would cause 35% of Class 5 vehicles to be misclassified as Class 4. Since the number of vista school buses in the traffic composition is lower than single unit trucks, the thresholds for Class 4 were proposed to remain the same but allow the shorter vista style school bus be classified as Class 5.

Furthermore, the analysis indicated that changing axle spacing threshold of Class 5 vehicles from 13.31 – 23.0 ft to 12.0 – 23.0 ft would reduce Class 5 vehicles misclassified as Class 3 by 18.8 percent. Specifically, with the new proposed thresholds for Class 3 and Class 5 vehicles, less than 8.2 percent of Class 5 vehicles will be misclassified as Class 3. It should be noted here that the number of single unit trucks (Class 5) in the traffic stream was observed to be smaller than Class 3 vehicles. To completely eliminate the misclassification of Class 5 into Class 3, the lower boundary for Class 5 need to be as low as possible to accommodate all short single unit trucks. This would cause the number of Class 3 vehicles misclassified as Class 5 to increase. Therefore, the new proposed thresholds for Class 5 and Class 3 vehicles considering the traffic composition in the field and the classification errors allowed between these two classes is the minimum one can statistically have based on PNN results while favoring higher classes.

Statistical analysis of Class 6 vehicles showed that the axle spacings for this class do not overlap with any vehicle class. Therefore, no changes in the axle spacing thresholds for Class 6 vehicles were proposed. The sample size for Class 7 vehicles was too small to justify any change of the thresholds. However, all 19 Class 7 vehicles observed revealed no overlap between their axle spacings and the axle spacings for other vehicle classes. Data analysis revealed overlaps in axle spacing for Class 8 and Class 3 (large pickups) vehicles. However, the misclassification was one-way; that is, only Class 3 vehicles were misclassified as Class 8 and not vice versa. This might be caused by the wider range for Class 8 axle spacings. No change in axle spacing thresholds for Class 8 was proposed. Most of the trucks observed in Class 9 were correctly classified. Therefore, the axle spacings for Class 9 should remain the same.

The analysis further indicated no misclassifications for Class 10 vehicles. However, the FDOT decision tree allows overlaps among Class 10 (7 axles) and Class 13 (7 axles) vehicles, which may introduce classification errors. The available data for Class 13 vehicles did not indicate classification error and thus the axle spacing thresholds for Class 10 should not change. There was no misclassification observed for Class 11 and Class 12 and therefore, the axle spacing thresholds should remain the same. The sample size for Class 13 vehicles was not sufficient to justify any adjustment in the FDOT thresholds.

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CHAPTER 1—INTRODUCTION

1.1 Background

Federal, state, metropolitan planning organizations and various other agencies in charge of overseeing transportation facilities use vehicle classification data for planning, designing, operating, and maintaining highways. Classification data are used for predicting and planning commodity flows and freight movement as well as provision of design inputs relative to the current and predicted capacity of highways. In the planning stage, vehicle classification data are important in conducting environmental impact analysis. In operational activities, classification data are used to analyze alternative highway regulatory and investment policies and for developing weight enforcement strategies. Furthermore, vehicle classification data are crucial in analysis of highway crashes as vehicles of different classes have different operating characteristics. In maintenance activities, vehicle classification data are used to schedule the resurfacing and reconstruction of existing highways based on projected remaining pavement life. The data is required in different formats depending on its intended use by transportation agencies. Typical formats include vehicle type, number of axles, vehicle length but other formats desired by the responsible agency may be used.

Vehicle classification data are extremely important as transportation departments and state legislatures grapple with the need to determine and allocate the monies (e.g., between private autos and large commercial vehicles) associated with maintaining the country's extensive highway system and to prioritize the improvements that can be afforded (Lyles and Wyman, 1982). Common uses of classification data include the following:

- design and management of pavements;
- scheduling the resurfacing, reconditioning, and reconstruction of highways based on projected remaining pavement life;
- prediction and planning for commodity flows and freight movements;
- provision of design inputs relative to the current and predicted capacity of highways;
- analysis of alternative highway regulatory and investment policies;
- developing weight enforcement strategies;
- environmental impact analysis; and
- accident record analysis.

Each state can collect and analyze vehicle classification data using its own standards. This is due to the fact that vehicle characteristics differ from one state to another, especially since truck type patterns are heavily influenced by local economic activities, weight limits and truck size specifications imposed by the states. For example, multi-trailer trucks are common in most western states, while they make up a much smaller percentage of the trucking fleet in many eastern states. Also, some trucks are designed to carry commodities that are specific to certain local areas only, for example,

coal trucks are common in Kentucky and Pennsylvania because of coal mining in these states (Federal Highway Administration, 2001). The Federal Highway Administration (FHWA) Office of Highway Planning requires various states to furnish vehicle classification data as part of the Highway Performance Monitoring Systems (HPMS) reports (Wyman *et al*, 1984). All states report their vehicle classification data using a common format, which follows the guidelines issued by FHWA and popularly known as "Scheme F". This is a visual classification scheme in which vehicles are visually classified based on their body types and axle configurations.

1.2 Problem Statement

Traditionally, vehicle classification was done visually using the information provided in "Scheme F". Visual classification was both inefficient and inaccurate due to inconsistency of observers. In order to increase the accuracy and efficiency, automated vehicle classifiers were developed. To automatically classify a vehicle, the information provided in "Scheme F" need to be interpreted and presented in a format suitable for the automatic classifiers. Normally, the number of axles, and axle spacing are used as inputs to the computer that classifies a vehicle using certain predefined decision tree. In Florida, different vendors supply the Department of Transportation with vehicle classification equipment. Prior to the start of this research, the algorithm used in each equipment was unique to that vendor. Comparison of the algorithms for different classification equipment revealed many discrepancies, which may be contributing to vehicle classification errors. Appendix A shows the results of comparing algorithms used in Florida. In order to harmonize the classification algorithms, the Florida Department of Transportation (FDOT) developed a common decision tree that could be used in each vendor's equipment throughout the state. However, the decision logic developed was not optimum. Field evaluation of the developed decision logic revealed many misclassifications associated with overlap in axle spacing. Therefore, in order to optimally automate the "Scheme F" guidelines, a new approach that could minimize classification errors and establish optimum thresholds was required.

Prior to the year 2002, the American Association of State Highway and Transportation Officials (AASHTO) was recommending the use of the Equivalent Single Axle Load (ESAL) approach for the design of flexible and rigid pavements *(*AASHTO, 1986). In this approach, wheel loads of various magnitudes and repetitions from mixed traffic were converted into ESAL of 18,000 pounds. The AASHTO's 2002 Pavement Design Guide being developed under the National Cooperative Highway Research Program (NCHRP) Project No. 1-37A is proposing the use of load spectra approach for the design of flexible and rigid pavements. The load spectra approach uses the same traffic data as that used by the ESAL approach but it does not require conversion of the loads into ESALs; instead, the data are categorized by axle configurations and weight. This approach will require the input of specific data for each axle type and axle group for three hierarchical input levels *(*Cottrell *et al.*, 2003*)*. Design Level 1 will require site-specific traffic axle load spectra information, which includes axle loading by vehicle classification, and vehicle classification counts at the project location. In Design Level 2, regional factors and site-specific data will be used; the traffic data required for this level

will be similar to site-specific data but with regional coverage. The default values and estimated site-specific data will be used for Design Level 3. In general, the traffic data collected in compliance with FHWA guidelines will fully support the load spectra approach requirements. Since vehicle classification data will be the major input into the 2002 Pavement Design Guide, it is paramount that the accuracy of vehicle classification using "Scheme F" need to be high.

Another reason for improving vehicle classification arise from the fact that changes in vehicle profile in the driving population have resulted in overlapping axle spacing between certain vehicle categories as defined under "Scheme F". This is particularly true with larger pickups, sports utility vehicles (SUVs) and vans which comprise axle spacings similar to single unit trucks. To reduce errors resulting from these overlaps, there is a need to tighten the threshold margins and optimize the decision boundaries of a classification decision tree.

1.3 Objective and Scope of the Study

The main objective of the study was to develop an optimum vehicle classification table and decision tree specific for Florida highways and that is capable of working with all vendor supplied data collection equipment. The study was aimed at collecting data from major highways on rural areas. The second objective was to propose an optimum approach for vehicle classification. Specifically, this study was aimed at accomplishing the following tasks:

- Comparing vehicle classification decision trees used by different vendors' classification equipment,
- Evaluating the existing vehicle classification table developed by Florida Department of Transportation more than 15 years ago,
- Proposing an optimum vehicle classification table, and
- Testing/validating the developed optimum classification table.

1.4 Methodology

In order to achieve the objectives of the study, the following tasks were undertaken:

- A detailed search of literature on published and unpublished information on vehicle classification was conducted. The background of vehicle classification schemes and algorithms was reviewed. Reports from various studies involved in developing the guidelines used for vehicle classification were acquired and reviewed.
- Study sites were selected from calibrated Weigh-In-Motion (WIM) sites. Among of the criteria considered for site selection were geographical location, road geometry, functional classification, and traffic characteristics.
- To ensure good quality, data collection was done only at the WIM sites that were recently calibrated. A test vehicle was used to verify calibration of the site. A vehicle with known axle spacing was run over the sensors several times during data collection. The vehicle was run at different speeds to study the effect of

vehicle speed on the accuracy of detected axle spacing. Error analysis of the recorded axle spacing of the test vehicle was carried out to verify calibration of the site.

- Ground truth data were collected at the vicinity of WIM sites using video camera. Synchronization of video camera time with the system time was done prior to data collection to enable vehicle matching during data processing. Individual vehicle records for the time when the video was logged on were downloaded from the computers installed at the WIM sites using polling software and modem connection.
- The ground truth data were compared with machine classification to identify errors in vehicle classification. Classification using ground truth data followed the guidelines provided in "Scheme F".
- A neural network model was developed, trained, tested and used to classify the same data set. The classification error obtained from the use of neural networks was compared to the classification error obtained from field machine classification, which was based on FDOT decision tree.
- The results obtained from the neural network were used to set the optimum axle spacing thresholds for the classification decision tree.
- Validation data were collected and, in addition to the individual vehicle records acquired, the actual axle spacings were determined from video images. This was done in order to verify the accuracy of axle spacing, in addition to the use of test vehicle, and to allow enough data collection from remote sites.

CHAPTER 2—LITERATURE REVIEW ON VEHICLE CLASSIFICATION

2.1 Background

In the past, vehicle classification could only be done visually by counting vehicles in a traffic stream, traditionally known as manual counts. The major criterion for classification was the vehicle's body type. Manual classification of the traffic stream had several advantages including ability to classify trucks on the basis of a vehicle's body style, for instance tank trucks, dump trucks, flat bed trucks and delivery trucks (Federal Highway Administration 2001). Visual classification can also increase the accuracy with which an individual vehicle is classified as being either "potentially heavy" or "not likely to be heavy". Additionally, a human observer can easily determine the difference between a car pulling a light trailer and a tractor pulling a semi-trailer when these two vehicles have the same number of axles and possibly even similar axle spacing characteristics. However, manual classification counts have some disadvantages; they are expensive and prone to error due to observer's fatigue over extended periods of time, which can cause inconsistency in concentration. Thus, substantial supervision may be required to ensure good quality of the collected data. For instance, under high traffic volume or multi-lane conditions, an additional observer may be required to take care of occlusion that can increase the number of errors. This increases the cost of collecting data. To overcome these limitations, automated classifiers were developed.

Automated classifiers are composed of two axle sensors, which must be carefully spaced to count vehicle axles. Other components associated with the automated classifier are:

- A detector, which receives the signals from the sensors, and amplifies and interprets them on to a recorder;
- A recorder, which performs the basic calculation of vehicle length, number of axles, or whatever data is being produced; and
- A processor, which manipulates the basic information data into the presentation format.

In addition to these automated classifiers, vehicle length based classifiers and machine vision-based equipment also are used. Vehicle length based classifiers use two inductance loops to estimate the vehicle length. This is done by first determining the vehicle speed, which is accomplished by calculating the difference in time for vehicle to be detected by the two inductance loops. Since the spacing between the two inductance loops is known, the speed is calculated by dividing this spacing to the time taken for the vehicle to pass the first loop and the second loop. The vehicle length is then calculated by determining the time taken by the vehicle to cross the loop divided to the calculated vehicle speed.

Automated classifiers and vehicle length based classifiers must be placed in or on the roadway. The installation process involves cutting the pavement. Due to the desire

by many transportation agencies to use vehicle detectors that do not have to be placed in or on the roadway pavement, machine vision systems have been developed (Federal Highway Administration, 2001*)*. Most of these systems were based on video image processing. The systems are suitable for places where accessibility to the roadway is limited due to high traffic volume, for example on the high volume urban freeways. They can be placed above or beside the roadway, in a location that is more accessible to maintenance crews.

Of these classification methods, the machine vision system is the newest and is still being tested. However, other new technologies and methods for vehicle classification also are under development; for instance, range sensors are tested for vehicle classification. These sensors are thought to have advantages over video image processing method since they are not as sensitive to lighting and other environmental conditions as video cameras are. A study sponsored by the Louisiana Transportation Research Center indicated that classification accuracy obtained by using a range sensor classifier was 92% for the fifteen vehicle classes tested (Harlow and Peng, 2003).

2.2 Vehicle Classification Schemes

Different vehicle classification schemes exist. The classification schemes are dependent upon the available equipment for collecting vehicle classification data. Most of these equipments collect data in terms of the number of axles, axle spacing, axle weight and the length of the vehicle. Two major types of the sensors used by these classification equipments are axle sensor, which senses the hit of a vehicle axle; or presence sensor, which senses the presence of a vehicle by sensing metallic parts of a vehicle. A combination of the two sensors can also be used. Bending plates, piezoelectric sensors and load cells are commonly used for vehicle weight detection.

Using the information from the sensors, vehicle classification can be done by implementing certain schemes. The simplest classification scheme that a highway agency can use has only three vehicle classes which are passenger vehicles, single unit trucks, and combination trucks. Figure 2.1 shows such types of vehicles observed on Florida highways. The expansion of these classes into more detailed classes has been implemented in most of the existing vehicle classification methods. However, this increased the difficulty of differentiating between the classes. As the number of classes increase, also a demand of more sophisticated data collection system and detailed decision scheme with more vehicle characteristics criteria increase. For example, in the early 1990's, Canada investigated the creation of a classification scheme that would have included the type of hitch used between tractors and trailers (Federal Highway Administration, 2001). Unfortunately, the available data collection technology could not accurately classify vehicles by hitch type.

2.2.1 HPMS Vehicle Classification Scheme

One major effort of separating vehicles into different categories was performed by Mactavish and Neumann (1982) in their Highway Performance Monitoring System

(HPMS) Vehicle Classification study conducted from late summer of 1980 to early fall of 1981. Five agencies, i.e, the Delaware Valley Regional Planning Commission and the States of Arkansas, Iowa, Minnesota, and Washington, were involved in the study. Vehicles were divided into 13 categories as follows:

Passenger Car

Single Unit Truck

Combination Truck

Figure 2.1: Simplest Vehicle Classes Observed in Florida Highways

From September 1980 to July 1982, Maine Facility Laboratory, M & R Division Maine DOT conducted an Evaluation of Vehicle Classification Equipment study for the Federal Highway Administration (FHWA) (Lyles and Wyman, 1982*)* In this study, vehicle classification schemes were sequentially developed from Scheme A to Scheme F. The following sections give the details of these schemes.

2.2.2 Vehicle Classification Scheme A

Under this scheme, vehicles were categorized into 7 classes as shown in Table 2.1. Field evaluation revealed several problems associated with the use of this scheme. The most noticeable shortcoming was in differentiating between standard/compact vehicles and sub-compact vehicles due to the advent of the auto industry moving to smaller cars. In addition, all vans and delivery trucks were compressed into one category. This resulted in classification errors that were independent of the equipment

used. Another problem was with the differentiation between 2-axle 4-tire (in the first category) and 2-axle 6-tire (in the fourth category) due to overlap of the axle distributions.

Table 2.1: Details of Scheme A (Reproduced from Lyles and Wyman, 1982*)*

Vehicle Category	Description	Decision Rule
A-1	Standard and compact passenger vehicles (including pick-ups, panels, vans, and other 2-axles, 4-tire vehicles)	100″ ≤ Wheelbase < 144″ and Length ≥ 180″
A-2	Subcompact vehicles (including light pick-ups)	Wheelbase < 100″ and Length <180″
A-3	Motorcycles	Not discussed
A-4	2-axle, 6-tire, single-unit trucks	2-axle and wheelbase > 12′
A-5	3 or more axle, single-unit trucks	3-axle or 4-axle and wheelbase ≤ 26′.
A-6	3 or 4-axle combinations	3-axle or 4-axle and wheelbase ≥ 26′
A-7	5 or more axle combinations	5 or more axles.

2.2.3 Vehicle Classification Scheme B

Scheme B was developed as an improvement of Scheme A. This scheme consisted of 13 vehicle categories. The scheme consisted of 13 vehicle categories and was slightly different from the one proposed by Mactavish and Neumann (1982) in their Highway Performance Monitoring System (HPMS) Vehicle Classification Study. Among the differences was that, in HPMS, standard/compact cars were separated from other 2-axle 4-tire vehicles (e.g., vans, pick-up trucks) except sub-compacts. Another major difference was that HPMS differentiated only between 3-axle tractor 2-axle semi-trailer (3S2) vehicles and all other five-axle combinations. This scheme provided for the potential of more detail in differentiating buses, and for three or more axle vehicles. Table 2.2 shows the details of Scheme B.

Several problems were associated with Scheme B, for example, separation of two-axle buses from two-axle single unit trucks and to separate three-axle buses from three-axle single unit trucks. This was due their similarities in axle spacing. No decision rule was recommended for differentiating buses from other vehicles.

2.2.4 Vehicle Classification Scheme C

Scheme C was developed as an improvement of Scheme B and Scheme A. It consisted of 19 vehicle categories as shown in Table 2.3. The scheme provided more details that defined buses into two categories and differentiated between explicit types of trucks with three or more axles. Two-axle buses were separated from three-axle buses. The problem

with this scheme was lack of details that could be used to distinguish between the car and light truck vehicles with trailers.

Table 2.2: HPMS Vehicle Classification Scheme (Mactavish and Neumann, 1982)

Category	Vehicle Type and Description
1	Standard and Compact Passenger Car (Standard Car): All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers with shipping weights of 3000 pounds or greater, overall lengths of 15 ft or more, and wheelbase of 100 inches or more.
2	Subcompact Passenger Cars (Small Car): Similar to category 1 but with wheelbase less than 100 inches.
3	Motorcycles: All two- or three- wheeled motorized vehicles.
4	Buses: All vehicles manufactured as traditional passenger carrying buses with two axles and six tires or three or more axles.
5	Pickup, Panels, Vans and Other Two-Axle, Four-Tire Trucks (Pickup): All two-axle, four-tire, camping vehicles, motor homes, vans, etc.
6	Two-Axle, Six-Tire, Single-Unit Trucks (SU2A6T): All trucks, camping and recreation vehicles, motor homes, etc., having two axles and dual rear wheels.
7	Three or More Axle, Single-Unit Trucks (SU3A): All vehicles on a single frame with three or more axles in any configuration. Included in this group are concrete mixer trucks, heavy dump trucks, large motor homes, etc., having three axles or more.
8	Three-Axle Combination Trucks (Comb 3A): All vehicles consisting of two units, one of which is a power unit, which have a total of three axles.
9	Two-Axle Tractor with Two-Axle Semitrailer Trucks (Comb 2S2): Only those vehicles consisting of a two-axle tractor, and a two-axle semitrailer.
10	Other Four-axle Combination Trucks (Comb 4A): All vehicles consisting of two or more units having a total of four axles in any configuration except the 2S2.
11	Three-Axle Tractor with Two-Axle Semitrailer Trucks (Comb 3S2): Only those vehicles consisting of a three-axle tractor with a two-axle semitrailer.
12	Other Five-Axle Combination Trucks (Comb 5A): All vehicles consisting of two or more units with five axles in any configuration except the 3S2.
13	Six or More Axle Combination Trucks (Other Comb): All vehicles consisting of two or more units with six or more axles in any configuration.

Table 2.3: Details of Scheme B (Reproduced from Lyles and Wyman, 1982*)*

Vehicle Category	Description	Decision Rule
B-1	Standard and compact vehicles (includes most pick-ups, panels, vans and other 2-axle, 4-tire vehicles)	100″ ≤ Wheelbase ≤ 144″ and Length ≥ 180″
B-2	Sub-compact vehicles (includes light pick-ups)	Wheelbase < 100″ and Length <180″
B-3	Motorcycles	Not discussed
B-4	Buses (option-replace buses with 4 or more axle, single unit trucks)	None recommended
B-5	2-axle, 6-tire, single unit trucks (2A SU)	2-axle and wheelbase > 12′ (144″)
B-6	3-or more-axle, single unit trucks (3A SU)	3-axle or 4-axle and wheelbase ≤ 26′ and 3′ ≤ 2, 3 spacing ≤ 5′
B-7	3-axle, combination truck	3-axle and not classified as B-6
B-8	2-axle tractor with 2-axle semi-trailer (2S2)	4-axle and wheelbase > 26′ and 3′ ≤ 3, 4 spacing ≤10′
B-9	Other 4-axle combinations	4-axle and not classed as B-6 or B-8
B-10	3-axle tractor with 2-axle semi-trailer (3S2)	5-axle and 2′ ≤ 4,5 spacing ≤ 10′
B-11	2-axle tractor with 1-axle semi-trailer, 2-axle full-trailer (2S1-2)	5-axle and not B-10 or B-12
B-12	Other 5-axle combinations	5-axle and not B-10 and 3′ ≤ 2,3 spacing ≤ 5′
B-13	6-or-more axle combination trucks	6-axles.

Note: 2, 3 spacing means the spacing between axles 2 and 3

Table 2.4: Details of Scheme C (Reproduced from Lyles and Wyman, 1982*)*

Vehicle Category	Description
C-1	Standard and compact passenger vehicles (includes most pick-ups, panels, vans, and other two-axle, four tire-vehicles)
C-2	Sub-compact passenger vehicles (including light pick-ups)
C-3	Motorcycles
C-4	Two-axle buses
C-5	Three-or-more axle buses
C-6	Two-axle, six-tire, single-unit trucks
C-7	Three-axle, single-unit trucks
C-8	Four-or-more axle, single-unit trucks
C-9	Three-axle, single-unit truck with two-axle trailers
C-10	Three-axle, single-unit trucks with three-axle full-trailers
C-11	Three-axle combinations

C-12	Two-axle tractors with two-axle semi-trailers
C-13	Three-axle tractors with one-axle semi-trailers
C-14	Other four-axle combinations
C-15	Three-axle tractors with two-axle semi-trailers
C-16	Two-axle tractors with one-axle semi-trailers and two axle full-trailers
C-17	Other five-axle combinations
C-18	Six-axle combinations
C-19	Seven-or-more axle combinations

2.2.5 Vehicle Classification Scheme D

In efforts to improve Scheme C performance, another scheme was developed, and later known as Scheme D. This scheme consisted of 32 vehicle categories as shown in Table 2.5. In order to provide more details on the car and light truck vehicles with trailers, two additional categories, D-2 and D-3, were added. The problem with this classification scheme was in differentiating between standard/compact and sub-compact cars.

Table 2.5: Details of Scheme D (Reproduced from Lyles and Wyman, 1982*)*

Vehicle Category	Description
D-1	Standard and compact passenger vehicles (includes most pick-ups, panels, vans, and other two-axle, four tire-vehicles)
D-2	Standard and compact vehicles with one-axle trailers
D-3	Standard and compact vehicles with two-or-more-axle trailers
D-4	Sub-compact vehicles (including light pick-ups)
D-5	Sub-compact vehicles with one-or-more-axle trailers
D-6	Motorcycles
D-7	Two-axle buses
D-8	Three-or-more-axle buses
D-9	Two-axle, four-tire, single-unit trucks
D-10	Two-axle six-tire, single-unit trucks
D-11	Two-axle, single-unit trucks with one-axle trailer
D-12	Two-axle, single-unit trucks with two-or-more-axle trailer
D-13	Three-axle, single-unit trucks
D-14	Three-axle, single-unit trucks with one-axle trailers
D-15	Three-axle, single-unit trucks with two-or-more-axle trailers
D-16	Four-or-more-axle, single-unit trucks
D-17	Four-or-more-axle, single-unit trucks with trailers
D-18	Two-axle tractors with one-axle semi-trailer
D-19	Other three-axle combinations
D-20	Two-axle tractor with two-axle semi-trailers
D-21	Three-axle tractors with one-axle semi-trailers
D-22	Other four-axle combinations
D-23	Three-axle tractors with two-axle semi-trailers

D-24	Three-axle tractors with three-axle semi-trailers
D-25	Two-axle tractors with 1-axle semi-trailers and 2-axle full-trailers
D-26	Other five-axle combinations
D-27	Three-axle tractors with one-axle semi-trailers and two-axle full-trailers
D-28	Other six-axle combinations
D-29	Seven-axle combinations
D-30	Three-axle tractors with two-axle semi-trailers and three-axle full-trailers
D-31	Other eight-or-more-axle vehicles
D-32	Unknown vehicles

2.2.6 Vehicle Classification Scheme E

Scheme E was developed as an improvement of Scheme D. The categories defined in this scheme were similar to those defined in Scheme B and HPMS categories with the addition of combination trucks with seven-or-more axles. However, the scheme did not provide sufficient details in the lower categories (e.g., there were no separate category for sub-compacts and motorcycles) although it provided more details in the higher categories than Scheme B and HPMS categories. One notable problem with this classification scheme was that some vehicle categories, such as buses, were not included. The scheme focused on those differentiations that could be accurately made as well as on which categories were important. Although this scheme was never tested as stand alone scheme, its vision on the shifting trends in some vehicle types was acknowledged; for instance, it noted the emerging similarities between different types of automobiles, the difficulty in making some differentiations, and the utility in making some finer decisions among different types of trucks. The scheme was therefore offered as a compromise between the rather simplistic schemes incorporated into most equipment that existed and the overly detailed 32-category scheme, which, in some instances, might be ideal. Thus, the scheme was subject to further refinement as a result of a more thorough review of vehicle and trailer manufacturers' specifications and from input from users of vehicle classification data. Table 2.6 shows the details of Scheme E.

2.2.7 Vehicle Classification Scheme F

Scheme F was developed for correcting the limitations found in Scheme E and also making changes dictated by the review of Scheme E, among which were the addition of Class 1, motorcycles; and Class 4, buses (Wyman *et al*, 1984). It was developed in the 1980's to compromise among several factors such as (Federal Highway Administration, 2001*)*:

- the manual (vision based) classification used before that time,
- the need to create a nationally consistent classification scheme,
- the automated counters being developed at that time, and
- the need to provide basic information on different truck types as input to a variety of policy issues.

Scheme F is the current and most used vehicle classification scheme. Under this scheme, vehicles are categorized into 13 categories shown in Table 2.7.

Table 2.6: Details of Scheme E (Reproduced from Lyles and Wyman, 1982)

Vehicle Category	Description	Decision Rule
E-1	Passenger cars, light trucks, vans	Two-axles and wheelbase ≤ 10′
E-2	Heavy-duty pick-ups, delivery trucks, 2-axle 6-tire vehicles	Two axle and wheelbase > 10′
E-3	Cars and light trucks with one-or-two-axle trailers	3-axle or 4 and 1, 2 spacing ≤ 10′ and 5.5′ < 2, 3 spacing < 22′
E-4	Three-axle SU trucks	Three-axle and not E-3
E-5	Trucks and semi-trailers – 2S2	4-axles and not E-3 and 3′ ≤ 3, 4 spacing ≤ 10′
E-6	Four-axle SU trucks	4-axle and not E-3 and 3′ ≤ 2, 3 spacing ≤ 5′
E-7	Other four-axle combinations	4-axle and not E-3, E-5 or E-6
E-8	Trucks and semi-trailers	5-axle and 2′ ≤ 4, 5 spacing ≤ 10′
E-9	Other five-axle combinations	5-axle and not E-8 and 3′ ≤ 2, 3 spacing ≤ 5′
E-10	Trucks and semi-trailers plus full-trailers-2S1-2	5-axle and not E-8 or E-9
E-11	Trucks and semi-trailers plus full-trailers-3S1-2	6-axle and 5, 6 spacing > 7′
E-12	Trucks and semi-trailers – 3S3	6-axle and not E-11 and 4, 5 spacing ≤ 6′
E-13	Other six-axle combinations	6-axle and not E-11 or E-12
E-14	Other seven-or-more-axle combinations	Seven-or-more-axle

All states use classification Scheme F or one of its variants. However, regardless of the type of the scheme used by state, Scheme F is used to report the vehicle classification to FHWA.

Table 2.7: Vehicle Classification Scheme F (Federal Highway Administration, 2001)

Vehicle Class	Description
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. This vehicle type may be reported at the option of the state.
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.
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.
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.
6	**Three-axle Single unit Trucks:** All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.
7	**Four or More Axle Single Unit Trucks:** All trucks on a single frame with four or more axles.
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.
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 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
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.

As pointed out earlier, the classification scheme to be used is a function of the equipment available for data collection. Therefore, depending on the available equipment, a state decides on the scheme to use for vehicle classification as long as it is convertible to Scheme F categories for reporting. Table 2.7 presented a tabular description of Scheme F vehicle categories while Appendix B shows the vehicle types defined under Scheme F by the Ohio Department of Transportation (ODOT, 2004).

In reporting information on trucks using Scheme F, the following criteria are used:

- truck tractor units traveling without a trailer will be considered single unit trucks,
- 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,

- the number of axles in contact with the roadway should define vehicles. Therefore, “floating” axles are counted only when in the down position, and
- the term “trailer” includes both semi- and full trailers.

CHAPTER 3—PATTERN RECOGNITION TECHNIQUES FOR CLASSIFICATION

3.1 Overview

The problem of classifying vehicles can be viewed as a pattern recognition problem. The vehicle classes manifest a pattern which can be processed to identify the different vehicle classes. Pattern recognition encompasses sub-disciplines like discriminant analysis, feature extraction, error estimation, cluster analysis (together sometimes called statistical pattern recognition), grammatical inference and parsing (sometimes called syntactical pattern recognition). The areas related to pattern recognition include neural networks, artificial intelligence, vision, cognitive and biological perception, mathematical statistics and non-linear optimization.

3.2 Pattern Classification Techniques

A number of pattern recognition techniques were reviewed to determine their suitability for use in vehicle classification. The methods that were reviewed include probabilistic neural networks (PNN), nearest-neighbor rule, *k*-nearest neighbor estimation and support vector machines (SVM).

A probabilistic neural network is a pattern classification network that is believed to provide a general method for pattern classification problems (Specht 1990a; 1990b; Tsoukalas and Uhrig 1997). It is a class of neural networks that combines some of the best attributes of statistical pattern recognition and feed-forward neural networks. Some of the advantages of the PNN techniques include its ability to perform a classification based on training data of actual vehicles obtained from the field, rapid training speed, guaranteed convergence to a Bayes classifier, and its ability for incremental training which is fast and robust against noisy examples.

In the nearest neighbor rule, a decision to classify an input **x** into class c_i depends only on a collection of correctly classified and labeled training data. Suppose $S^m = \{\mathbf{x_1}, \mathbf{x_2}, ..., \mathbf{x_m}\}$ is a set of *m* labeled training samples and $\mathbf{x'} \in S^m$ is the training sample nearest to an input **x**, then, the input **x** is classified by assigning it a label similar to $\mathbf{x'}$. However, the nearest neighbor rule is a suboptimal procedure because its use usually leads to an error greater than the minimum possible, that is, the Bayes rate (Duda *et al*., 2001). K-nearest-neighbor rule is an extension of the nearest-neighbor rule. In this approach, an input **x** is classified by assigning it the label most frequently represented among the k nearest training examples. This technique involves finding a hypersphere around the point **x** which contains k points and then assign **x** to the class having the largest number of representatives inside the hypersphere. The disadvantage of the k-nearest neighbor rule approach is that the resulting estimate is not a true probability density (Bishop, 1995). To obtain a true probability density, prior probability is required.

Support Vector Machines (SVM) map the input **x** into a high dimensional feature space through some nonlinear mapping chosen a priori (Vapnik, 2000). In this space, an

optimal separating hyperplane is constructed. If the training data is linearly separable, an optimal hyperplane separates the data without error and the distance between the hyperplane and the closest training point is maximal. The major limitation of the support vector machine is in the choice of the kernel for training the algorithm (Burges, 1998). Since the kernel is the big rug under which to sweep the parameters, a prior knowledge is required in order to choose the best function for a given problem. Speed, size, and general structural design for multi-class SVM also pose additional limitations that discourage the use of SVMs even with moderate classification problems.

By comparison of these methods, and analysis of the problem at hand, the probabilistic neural networks (PNN) technique was chosen. The following sections describe the details of the PNN model.

3.3 Probabilistic Neural Networks (PNN)

A Probabilistic Neural Networks (PNN) is a computationally efficient algorithm for a Bayesian-based function approximation. It has a multilayer feed forward structure with a Gaussian-shaped characteristic. Basically, the PNN is based on the classical Bayes classifier, which is statistically an optimal classifier that seeks to minimize the risk of misclassifications. The development of the PNN relies on Parzen windows probability estimation. Details of how this network works can be found in many literatures, for example (Bose and Liang, 1996; Michie et al, 1994; Tsoukalas and Uhrig, 1997). The following sections give a brief description of the PNN.

3.3.1 Bayes Method for Pattern Classification

Any pattern classifier places each observed vector of data **x** in one of the predefined classes c_i; $i = 1,2,\ldots,n$, where n is the number of possible classes in which **x** can belong. The effectiveness of any classifier is limited by the number of data elements that vector **x** can accommodate and the number of possible classes n. The classical Bayes pattern classifier implements the Bayes conditional probability rule that the probability $P(c_i/\mathbf{x})$ of **x** being in class c_i is given by

$$\boldsymbol{P(c_i / \mathbf{x}) = \frac{P(\mathbf{x} / c_i) P(c_i)}{P(x)}} \quad , \tag{3.1}$$

where $P(\mathbf{x}/c_i)$ is the conditional probability density function of **x** given set c_i, $P(c_i)$ is the probability of drawing data from class c_j and $P(x) = \sum_{j=1}^{n} P(\mathbf{x} / c_j) P(c_j)$. Vector **x** is said to belong to a particular class c_i if it has the highest conditional probability of being in this class compared to other classes, i.e., $P(c_i/\mathbf{x}) > P(c_j/\mathbf{x})$. This classifier assumes that the probability density function of the population from which the data were drawn is known a priori—this is one of the major limitations of implementing the Bayes classifier. The PNN simplifies the Bayes classification procedure by using a training set for which the desired statistical information for implementing the Bayes classifier can be drawn.

The desired probability density function for each class is approximated by using the Parzen windows approach (Parzen, 1962; Murthy, 1965; Cacoullous, 1966).

3.3.2 Parzen Window Method for Estimating Probability

The Parzen windows method is a non-parametric procedure that synthesizes an estimate of a probability density function by superposition of a number of windows, replicas of a function (often the Gaussian). Generally, the method estimates the average of normal densities centered at the samples as follows:

$$p_n(x/c_i) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{V_n}\varphi\left(\frac{x-x_i}{h_n}\right), \tag{3.2}$$

where n is the number of training samples, V_n is the volume of the region under which n samples fall, φ is the window function, and h_n is the window width.

3.3.3 Probability Estimation Using PNN

The PNN approximates the probability that vector **x** belongs to a particular class c_i as a sum of weighted Gaussian distributions centered at each training sample, i.e.,

$$\boldsymbol{P(\mathbf{x}/c_i)} = \frac{1}{(2\pi)^{\frac{N}{2}}\sigma^N \boldsymbol{n}_{t_i}}\sum_{j=1}^{n_{t_i}}\mathbf{exp}\left[-\frac{(\mathbf{x}-\mathbf{x}_j^i)^T(\mathbf{x}-\mathbf{x}_j^i)}{2\sigma^2}\right], \tag{3.3}$$

where $\mathbf{x}_j^i$ is the j-th training vector for the patterns in class i, σ is known as a smoothing factor which is approximately equal to the standard deviation of the Gaussian distribution of the population, N is the dimension of the input pattern, and n_{t_i} is the number of training patterns in class i. The smoothing factor defines the decision boundaries for the classes based on the training data. Nonlinear decision boundaries require the smoothing factor σ to be as small as possible since details of the probability density may be lost if the smoothing parameter is too large. However, too small values of the smoothing factor σ can cause spiky approximation of the decision boundary hence failing to fairly represent it. An appropriate deviation is chosen by trial and error method during the training of the PNN using the training data. In this study, the decision boundary was assumed to be highly nonlinear and σ was estimated as

$$\sigma = \frac{z}{\|\Sigma\|}, \tag{3.4}$$

where z is a real number selected by the experimenter and $\|\Sigma\|$ is the Frobenius norm of a matrix formed by concatenating the standard deviation vectors for each training set, which corresponds to the maximum standard deviation in the training patterns. Equation

(3.4) indicates that σ automatically becomes small when the training set has large variances. Generally, this situation calls for nonlinear decision boundaries.

3.3.4 PNN Layout

The PNN network is made up of four layers—an input layer, a pattern layer, a summation layer, and an output layer. The input layer receives data to be classified to belong among the predefined classes in the pattern layer, which contains patterns for each class. Figure 3.1 shows the topology of a PNN. From the input layer, this input is passed to each of the patterns in the pattern layer. For each class there are several pattern nodes made up of representative data for that class known as the training data. Each pattern computes the probability of data being in that pattern by using equation (3.3). The probabilities from all representative pattern in each class are summed up in the summation layer to determine the overall probability of the given input **x** to be in each of the classes represented by the patterns in the pattern layer. The output layer picks the class for which highest probability was obtained in the summation layer. The input is then classified to belong to this class.

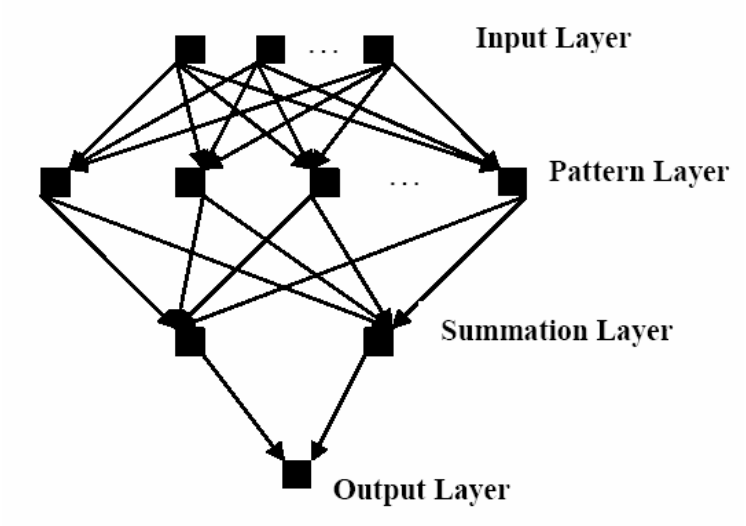


Figure 3.1: PNN Topology

The input **x** to the network is a vector defined as

$$\mathbf{x} \overset{\Delta}{=} [x_1, x_2, x_3, ...x_N]^T, \tag{3.5}$$

The effectiveness of the network in classifying input vectors depends highly on how the training patterns are chosen. The next chapter describes how the data were collected and how the training patterns for the vehicle classification problem were chosen.

3.3.5 PNN Algorithms

The PNN algorithm has two major parts; the training part and classification part. In order to train the PNN, each pattern $\mathbf{x}_j^i$ of the training example is first normalized to

have unit length. There are no weights necessary to link the input units and the first pattern units; the normalized input is used as an equivalent weight, that is $\mathbf{w}_j^i = \mathbf{x}_j^i$. The network is fully connected between input and pattern units when all the normalized training examples are set as equivalent modifiable weights. Therefore, the training part of the algorithm is generally used for converting normalized examples to equivalent modifiable weights which are used for linking the inputs and the pattern units.

The second part of the PNN algorithm is for classification. A net activation for the algorithm is obtained by calculating the inner product after placing the normalized test pattern $\mathbf{x}$ at the input units. A nonlinear function of net activation is calculated as $net_j = \mathbf{w}_j^i.\mathbf{x}$. In order to implement the Parzen Windows algorithm, the activation function must be exponential (Duda *et al.*, 2001). Each pattern unit contributes to its associated category unit a signal equal to the probability the test point was generated by a Gaussian centered on the associated training point. The Parzen Windows estimate of the underlying distribution is computed by summing all local estimates. The maximum calculated sum gives the desired class to which the test point $\mathbf{x}$ belongs. Appendix C shows the training and classification algorithms developed for vehicle classification.

CHAPTER 4—DATA COLLECTION

4.1 Introduction

The Statistics Office of the Florida Department of Transportation maintains more than 300 roadway traffic monitoring sites on the Florida state highway system. Over 40 sites are weigh-in-motion (WIM) sites capable of capturing vehicle weight as well as the number of axles and axle spacings. Traffic monitoring sites can be telemetered or portable. Telemetered sites are composed of sensors installed on the roadway, a power supply system, a telephone line, and a computer cabinet. Portable traffic monitoring sites are similar to telemetered traffic monitoring site except that they don't have telephone line or any power supply system. Figure 4.1 shows an example of a telemetered traffic monitoring site. The data for this research were collected from telemetered traffic monitoring sites.

Figure 4.1: Traffic Monitoring Site No. 9904 on I-75

Before collecting data for this research, it was necessary to ensure that the WIM sites are properly calibrated to reduce errors in extraction of vehicle features. A schedule for site calibration was obtained from Florida DOT Statistics Office charged with performing WIM calibration. Site calibration is normally done by using test trucks of known axle spacings and axle weights to determine adjustments to a WIM system's calibration factors such that the resulting WIM weight accurately represents an estimate of the static weight of the test truck, and the axle spacings are approximately equal to those of the test truck. A number of recently calibrated WIM sites were chosen as sources of field data along the major highways in the state of Florida. These WIM sites provided individual vehicle records that included the number of axles, axle spacing, vehicle length, the overall vehicle weight and the vehicle class assigned to a vehicle basing on the existing FDOT classification table.

4.2 Criteria for Selection of Study Sites

Highway vehicle distribution is affected by geographical location and highway functional classification. The accuracy of data collected from WIM sites depends on many factors; however, traffic characteristics such as vehicle speed, truck volume and calibration policies (Lew *et al*, 2000) have more impact on the data accuracy in comparison to other factors. In order to accommodate effects of vehicle distribution and data accuracy, other criteria considered for selection of WIM sites were their geographical location, road geometry, functional classification, and traffic characteristics in their vicinity. Following calibration, 12 WIM sites were selected for data collection. These sites were identified by numbers as 0352, 9901, 9936, 9904, 9907, 9913, 9935, 9920, 9919, 9921, 9923 and 9922. Figure 4.2 shows locations and distribution of the sites where data were collected.

4.3 Data Collection

Normally, the WIM site records are stored in computers at the sites. Individual vehicle records from selected sites were downloaded from these computers over telephone lines using a modem. In addition to individual vehicle records, video data were collected at the same sites simultaneously in order to establish ground truth data. In order to verify WIM calibration, a test vehicle of known axle spacing was run over the sensors during the time when the video was logged on for verification of the accuracy of the axle sensors in detecting axle spacing. The vehicle was run at different speeds to investigate the effect of the vehicle speed on the accuracy of calibrated WIM sites. Appendix D shows the analysis results for the test vehicle axle spacing detection errors. After matching the vehicles on the video with the downloaded records of the individual vehicles all vehicles were visually classified by using video data and compared to field machine classification that implements the FDOT decision tree. Visual classification was done in accordance with "Scheme F" guidelines as was indicated in Table 2.7 and Appendix B. Misclassified vehicles were identified and recorded as a percentage of the total number of vehicles observed in each class. More than 3,300 vehicles were randomly sampled in the process. Video data were collected in the vicinity of the 12 calibrated WIM sites. Summaries of the distribution of vehicle classifications by hour of the day for these sites were used to identify the peak time for the higher class vehicles (Class 4 and above) at the sites.

It was, however, found that the peak time for higher class vehicles at most sites occurred at night. Data could not be collected during the night due to darkness, which could affect visual classification. Therefore, video data were collected during the day peak time.

Figure 4.2: Map of Florida Showing Locations and Distribution of Sites Where Data Were Collected

CHAPTER 5—APPLICATION OF PROBABILISTIC NEURAL NETWORKS FOR VEHICLE CLASSIFICATION

5.1 Introduction

A probabilistic neural network was developed and coded using MATLAB computer language. After developing the neural network, its application involved three steps: training, testing and classification. There are two major ways of training a general neural network: supervised training and unsupervised training. In supervised training, the input category is known beforehand as well as the output. Actual outputs are compared with the desired outputs associated with the set of training patterns. In unsupervised training, often called clustering, training patterns are only used as inputs; the system is asked to cluster the inputs without indication of what is the correct or wrong response. Basically, unsupervised learning aims at finding a certain kind of regularity in the data represented by the training patterns (Bose and Liang, 1996).

5.2 Selection of Training Patterns

A PNN is trained by supervised learning since the output classes are known. Vehicles were required to be classified according to "Scheme F" categories shown in Appendix B. A training data set was formed by drawing representative vehicles for each vehicle class from the collected data. Different vehicles have a different number of axles. In order to create uniformity in the patterns, all vehicles were assumed to have 9 axles, which is the observed maximum number of axles for all vehicles recorded. Vehicles with less than 9 axles were assumed to have additional fictitious axles so that the total number is 9; axle spacing for the fictitious axles were specified as 0 ft. Some of the classes in "Scheme F" span over a different number of axles. For example, Class 2 covers vehicles with two to four axles while Class 3 and Class 5 cover vehicles with two to five axles depending on the number of axles per trailer while Class 13 covers multi-trailer trucks with seven or more axles. It is difficult to automatically classify the two axle vehicles in the same group as the four-axle vehicles. Because of this, such classes were broken down to simple subclasses and redefined as shown in Table 5.1. A total of 28 subclasses were defined based on the 13 predefined standard classes. Therefore, the PNN patterns were drawn to reflect these subclasses and the network was asked to classify each vehicle into one of these 28 subclasses. The resulting subclasses were then aggregated to their respective "Scheme F" standard classes.

The training patterns were chosen in such a way that the standard deviation was kept as minimum as possible in order to reduce chances of possible misclassification. Classes that involved wider axle spacing had more training patterns than those with narrow axle spacing. Two sets of training patterns were chosen; one with axle spacing and number of axles used as classification variables and the other set included overall vehicle weight in addition to number of axles and axle spacing. Table 5.2 shows the number of training patterns per vehicle category in each case. In total, there were 147 training patterns for the first case, which is about an average of 5 samples per class; the

training sample for second case had 235 training patterns, which is an average of about 12 patterns per class.

Table 5.1: Simple Vehicle Subclasses

Class	Subclass	Average Axle Spacing (ft)							
		Ax.1-2	Ax.2-3	Ax.3-4	Ax.4-5	Ax.5-6	Ax.6-7	Ax.7-8	Ax.8-9
1	1	2.95							
2	2a	8.50							
	2b	9.35	14.87						
	2c	9.4	18.7	2.56					
3	3a	12.0							
	3b	11.69	16.59						
	3c	11.75	19.47	2.53					
	3d	11.60	22.33	2.63	2.70				
4	4a	24.77							
	4b	25.40	4.06						
5	5a	18.61							
	5b	13.80	17.10						
	5c	13.88	20.90	2.78					
	5d	13.53	24.90	2.80	2.77				
6	6	18.77	4.27						
7	7	12.44	4.08	5.64					
8	8a	13.67	25.23						
	8b	17.14	4.26	31.04					
	8c	15.94	22.76	4.89					
9	9a	15.63	4.33	27.3	4.51				
	9b	16.17	3.47	14.67	19.00				
10	10a	17.83	4.48	29.31	4.15	4.11			
	10b	16.31	4.44	35.16	5.73	9.19	5.79		
11	11	14.13	21.33	9.52	22.25				
12	12	16.26	4.24	20.19	9.04	20.87			
13	13a	16.02	4.40	18.42	23.64	5.96	4.30		
	13b	17.15	4.30	8.45	8.20	7.90	8.35	8.95	
	13c	16.30	4.07	21.13	6.60	24.63	18.58	4.55	22.00

Appendix E shows the training data set that did not include vehicle weight while Appendix F shows an example of training data set for the case that involved axle spacing, number of axles and overall vehicle weight. Selection of training patterns was carefully done in order to pick the representative vehicles that would reflect all required vehicle characteristics in the class. Wide ranges of axle spacing values possible for a particular pattern were used in the training data set for the PNN.

Table 5.2: Number of Training Patterns per Vehicle Category for all Cases

Vehicle Type	**Class**	**Number of Axles**	**Description**	**Number of Training Patterns**	
				Without Weight	**With Weight**
1	1	2	Motorcycle	4	10
2	2	2	Auto, Pickup	4	14
3	3	2	Other (Limo, Van, RV)	5	5
10	4	2	Bus	3	7
20	5	2	2D	7	13

Table 5.2: (Cont'd)

Vehicle Type	Class	Number of Axles	Description	Number of Training Patterns	
				Without Weight	With Weight
3	2	3	Auto W/1 Axle Trailer	6	11
7	3	3	Other W/1 Axle Trailer	7	7
11	4	3	Bus	5	11
	5	3	2D W/1 Axle Trailer	4	4
24	6	3	3 Axles	6	8
30	8	3	2S1, 21	6	12
4	2	4	Auto W/2 Axle Trailer	7	8
9	3	4	Other W/2 Axle Trailer	6	9
	5	4	2D W/2 Axle Trailer	6	4
28	7	4	4 Axles	5	10
34	8	4	3S1, 31	5	9
38	8	4	2S2	7	11
	3	5	Other W/3 Axle Trailer	3	8
	5	5	2D W/3 Axle Trailer	3	5
40	9	5	3S2	8	13
44	9	5	32	3	2
60	11	5	2S12	6	11
50	10	6	3S3, 33	7	11
70	12	6	3S12	7	14
54	10	7		7	7
80	13	7	2S23, 3S22, 3S13	3	5
84	13	8	3S23	3	2
90	13	9	PERMIT	4	4
TOTAL TRAINING PATTERNS				**147**	**235**

5.3 Training the PNN

The PNN was trained using a training data set chosen as explained in the previous section. Two data sets were used in the training process. The performance of the PNN with respect to the training data set was tested using a test data set shown in Appendix G. This set comprised of vehicle data whose class was known from the video data.

The critical part in training the PNN is that of choosing the smoothing factor. An initial guess of the smoothing factor was done and the PNN was asked to classify the test data set. The performance of the PNN was monitored and the smoothing factor was changed until the optimum value was obtained. The smoothing factor was computed using equation (3.4). In order to vary the smoothing factor, the value of z was varied until the PNN was able to correctly classify all the test data.

After training the PNN and selecting the optimum value of the smoothing factor, the PNN was applied to the field data set for classification. The vehicle classes extracted from the videos were used as ground truth data to evaluate the performance of the PNN. In addition, classification results from the current classification table used by the Florida Department of Transportation were used for comparing the performance of the two methods.

5.4 Classification Results

Misclassifications by the PNN as well as the FDOT table were identified and recorded as a percentage of vehicles observed. Table 5.3 compares the PNN results and those of the FDOT table while Appendix H shows distribution of misclassified vehicles. The PNN is evaluated in two stages; in stage 1, the PNN acted on a data set comprised of two variables only—that is, the axle spacings and the number of axles, which are same variables used with the FDOT classification table. In the second stage, the PNN acted on another data set that used an overall gross vehicle weight as an additional variable. Use of overall vehicle weight was intended for assisting in improving the demarcation of the thresholds. It is noted that, in general, currently the use of vehicle weights in vehicle classification is not an option since most of the traffic monitoring sites are not capable of collecting vehicle weights.

Table 5.3: Results and Comparison of Performance between PNN and FDOT Table Classification Table

Vehicle Class	Total Vehicles Observed	FDOT Based Classification		PNN Based Classification Exclusive of Vehicle Weight		PNN Based Classification Including Vehicle Weight	
		Total Misclassified	Percentage Misclassified	Total Misclassified	Percentage Misclassified	Total Misclassified	Percentage Misclassified
1	20	0	0.0%	0	0.0%	0	0.0%
2	669	37	5.5%	23	3.4%	11	1.6%
3	603	133	22.1%	83	13.8%	41	6.8%
4	57	11	19.3%	3	5.3%	0	0.0%
5	329	130	39.5%	92	28.0%	46	14.0%
6	112	5	4.5%	3	2.7%	0	0.0%
7	19	0	0.0%	0	0.0%	0	0.0%
8	214	1	0.5%	0	0.0%	0	0.0%
9	1116	2	0.2%	0	0.0%	0	0.0%
10	57	5	8.8%	0	0.0%	0	0.0%
11	81	0	0.0%	0	0.0%	0	0.0%
12	37	0	0.0%	0	0.0%	0	0.0%
13	12	0	0.0%	0	0.0%	0	0.0%
Total	**3326**	**324**	**9.7%**	**204**	**6.1%**	**98**	**2.9%**

The results show that the classification error is higher for Class 5 and for lower classes (i.e., Class 2 and Class 3). Class 2 and Class 3 vehicles cannot be distinguished clearly due to the physical overlap in axle spacing. There is also a physical overlap between Class 4 (buses) and Class 5 (single unit trucks). Despite the physical overlaps among some vehicle classes, the results show that the PNN classification technique had better performance with a misclassification error of 6.1% compared to the current FDOT table, which had a misclassification error of 9.7%. Inclusion of the overall vehicle weight as a classification variable further reduced the percent of vehicle misclassified by the PNN to 2.9%. Since most traffic monitoring sites are not capable of collecting vehicle weight, the use of the vehicle overall weight in the PNN analysis was for increasing separability of vehicles only so that their axle spacing thresholds can be better defined. Once new thresholds are proposed, weight will not be used as a variable in the new and revised classification algorithm.

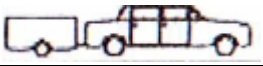
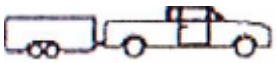
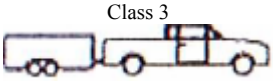
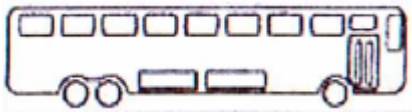
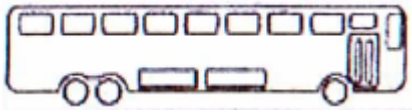
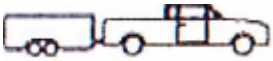
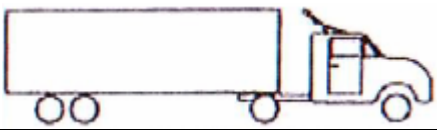
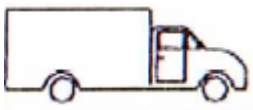
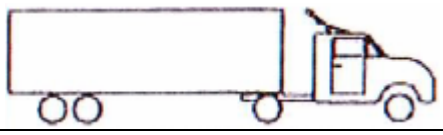
It was also found that some classes had fewer number of vehicles observed compared to others. This is generally due to the traffic distribution on the studied roadways in which vehicles in certain classes, particularly Class 7 and Class 13, are fewer.

CHAPTER 6—ANALYSIS OF FIELD CLASSIFICATION RESULTS

6.1 Introduction

In order to establish the causes of misclassifications observed in the data collected, a close analysis of classification results was carried out. Vehicles were separated into their respective actual categories using video data. Appendix J shows comparison of average axle spacing for classes based on FDOT table and the observed classes based on the ground truth data. Descriptive statistical analysis was carried on each category to establish their actual axle spacing ranges. Appendix K shows the descriptive statistical analysis results. Possible overlaps in the axle spacing for different vehicle categories due to similarity in axle configuration were identified. Table 6.1 shows the vehicle categories with similar axle configurations that could lead to overlap in their axle spacing.

Table 6.1: Vehicle Types with Similar Axle Configurations and Possible Number of Axles per Vehicle

Vehicle Classes	Description/Body Shape		Possible Number of Axles
2 and 3	Class 2 	Class 3 	2, 3 or 4
3 and 5	Class 3 	Class 5 	2,3 or 4
4 and 5	Class 4 	Class 5 	2 or 3
4 and 6			3
3 and 8	Class 3 	Class 8 	3 and 4
5 and 8	Class 5 	Class 8 	3 and 4

6.2 Statistical Analysis

6.2.1 Class 2 and Class 3

Class 2 vehicles are basically passenger cars while Class 3 vehicles include all other two-axle, four-tire single unit vehicles. All two-axle, four-tire vehicles other than passenger cars are included in Class 3. It is difficult to clearly distinguish between Class 2 and Class 3 vehicles as shown in Table 6.1. Figure 6.1 shows a comparison of the axle spacing for observed vehicles in Class 2 and Class 3. The overlap between the two classes' axle spacings is clearly discernable; the lower end of axle spacings for Class 3 vehicles overlaps with the upper end of axle spacings for Class 2 vehicles.

6.2.2 Class 3 and Class 5

Vehicles included in Class 3 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 also are included in this classification. Vehicles in Class 5 are all vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, and others, with two axles and dual rear wheels.

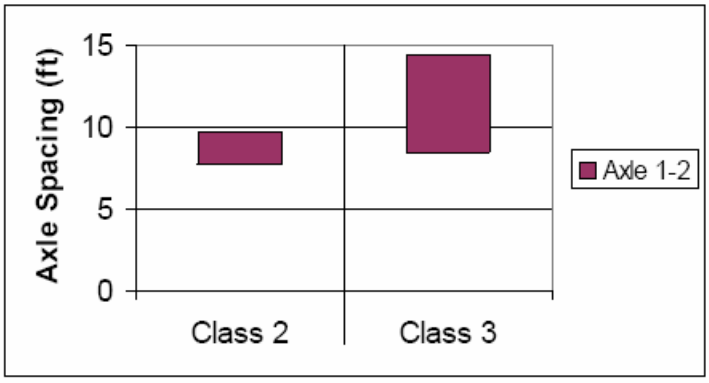


Figure 6.1: Comparison of Actual Axle Spacing for Class 2 and Class 3 Vehicles

It was observed that some vehicles with two axles and dual rear wheels, which are actually Class 5, are shorter than some of the other two–axle, four tire vehicles which are actually Class 3. For example, some pickups have wider axle spacing similar to single unit trucks while some single unit trucks have relatively narrow axle spacing. This has led into misclassification between Class 3 and Class 5 vehicles. Figure 6.2 shows the comparison of actual axle spacing of Class 3 and Class 5 vehicles; the lower end of axle spacings for Class 5 vehicles overlaps with the upper end of axle spacings for Class 3 vehicles.

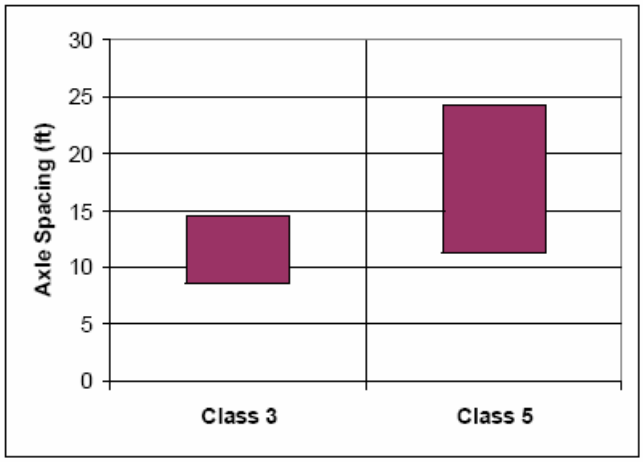


Figure 6.2: Comparison of Actual Axle Spacing for Class 3 and Class 5 Vehicles

Data analysis showed that the skewness for Class 3 vehicles was negative, indicating that the distribution tends to the negative values while the skewness for Class 5 was positive, indicating that the distribution tends to the positive tail. This means that, most vehicles in Class 3 fall towards the lower end while most vehicles in Class 5 fall towards the upper end.

6.2.3 Class 4 (Two-Axles Buses) and 5 (Single Unit Trucks)

Class 4 includes all vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or more axles. School buses are also included in this class. According to "Scheme F" guidelines, modified buses such as motor homes should be considered to be trucks and should be appropriately classified. In this evaluation, it was found that most of the misclassified school buses are vista style and not transit style. Most of these vista style buses are shorter compared to transit style such that they could not be distinguished from Class 5 vehicles which are single unit trucks with two axles and six tires. Figure 6.3 indicates the comparison of axle spacing for Class 5 and Class 4 vehicles; the axle spacings in the lower end of Class 4 overlaps with the axle spacing in the upper end of Class 5.

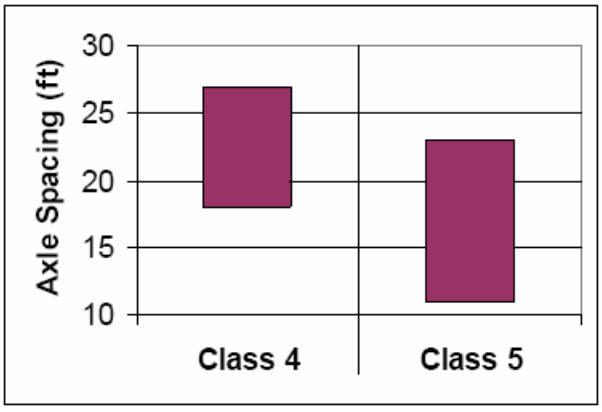


Figure 6.3: Comparison of Actual Axle Spacing for Class 4 and Class 5 Vehicles

6.2.4 Class 4 (Three-Axles Buses) and Class 6

Class 6 vehicles are those on a single frame including trucks, camping and recreational vehicles, and motor homes with three axles. A comparison of the actual axle spacing for vehicles in this class and those in Class 4 (three-axle buses) was performed. Figure 6.4 shows the results of this comparison. There is no overlap in the spacings between axle 1 and 2 for the two classes while there is a small overlap in the spacings between axle 2 and 3. Therefore, the two classes can be separated without misclassification due to a clear demarcation in their first axle spacing.

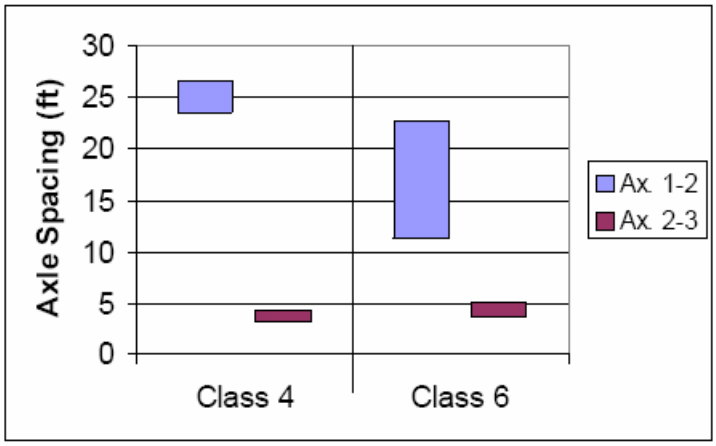


Figure 6.4: Comparison of Actual Axle Spacing for Class 4 and Class 6 Vehicles

6.2.5 Class 7(Four Axles or More)

Class 7 includes all trucks on a single frame with four or more axles. They have number of axles similar to Class 8 (four-axles) and therefore, axle spacings of vehicles in Class 7 were compared to those of vehicles in Class 8 (four-axles). Figure 6.5 shows comparison results. It can be seen that while there is overlap in axle spacings between axle 1 and 2, and axle 3 and 4, there is no overlap in axle spacing between axle 2 and 3. This makes chances of misclassification between these two classes to be small.

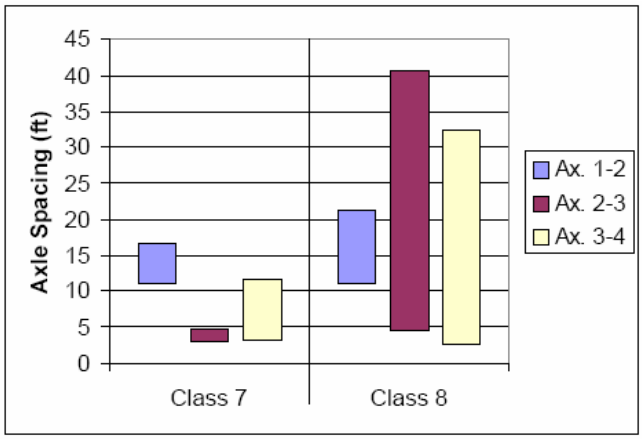


Figure 6.5: Comparison of Actual Axle Spacing for Class 7 and Class 8 (4 Axles) Vehicles

6.2.6 Class 8 and Class 3

Class 8 includes all vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit. This class has visual similarities with Class 3 especially the two-axle-four-tire vehicles pulling recreational vehicle or other light trailers. As such, automatic classifiers tend to misclassify vehicles between these two classes. However, no Class 8 vehicles were misclassified as Class 3; only vehicles in Class 3 (pickup trucks with trailers) were misclassified as Class 8. This was due to the classification order of the algorithm in which a vehicle is first tested whether it is Class 8 before being tested for Class 3. This algorithm is shown in Appendix L. Figure 6.6 shows a comparison for Class 8 (three-axles) and Class 3 (other with one-axle trailer). Figure 6.7 the comparison for Class 8 (four-axles) and Class 3 (other with two-axle trailer). As seen in these figures, it is clear that all axle spacings are overlapping. This is the cause of misclassification between the two classes.

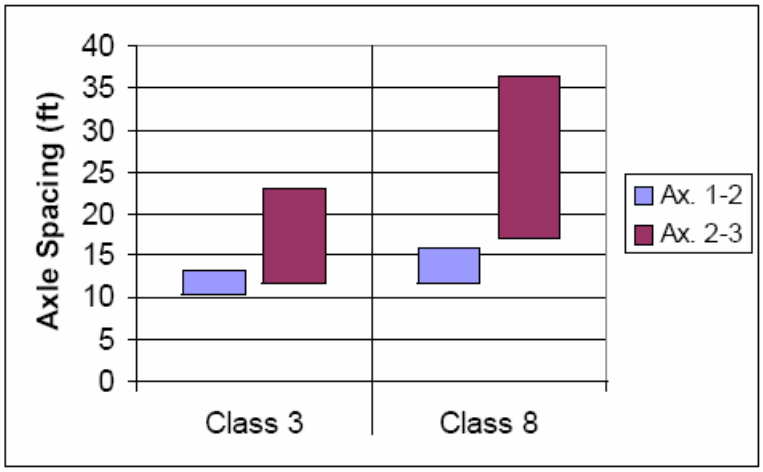


Figure 6.6: Comparison of Actual Axle Spacing for Class 8 (three-axles) and Class 3 (others with one-axle trailer)

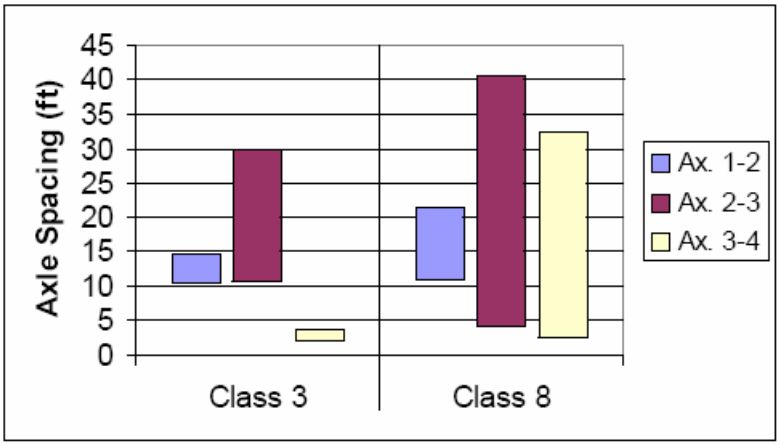


Figure 6.7: Comparison of Actual Axle Spacing for Class 8 (four-axles) and Class 3 (others with two-axle trailer)

6.2.7 Class 8 and Class 5

Similar to Class 3, there is a visual similarity between Class 8 and Class 5 especially the two-axle six-tire single unit trucks pulling one- or two-axle light trailers. As such, automatic classifiers tend to misclassify vehicles between these classes. However, no Class 8 vehicles were misclassified as Class 5; only Class 5 (single unit trucks with trailers) were misclassified as Class 8 due to the order of classification defined in the algorithm. Figure 6.8 shows comparison results for Class 8 (three-axles) and Class 5 (single unit truck with one-axle trailer). Figure 6.9 shows comparison results for Class 8 (four-axles) and Class 5 (single unit truck with two-axle trailer). These figures clearly show the overlaps in all axle spacings, which cause misclassification between the two classes.

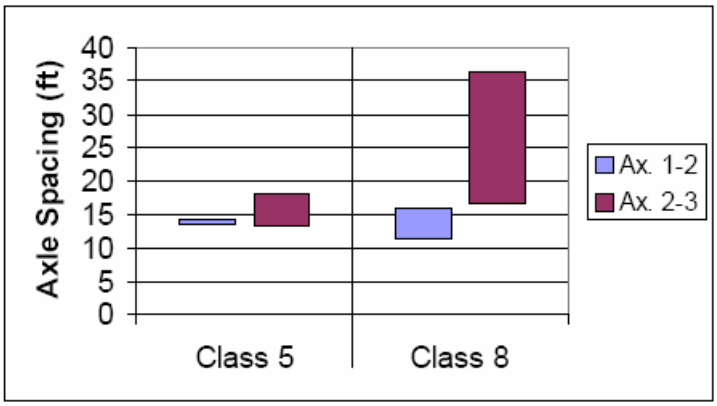


Figure 6.8: Comparison of Actual Axle Spacing for Class 8 (three-axles) and Class 5 (single unit trucks with one–axle trailer)

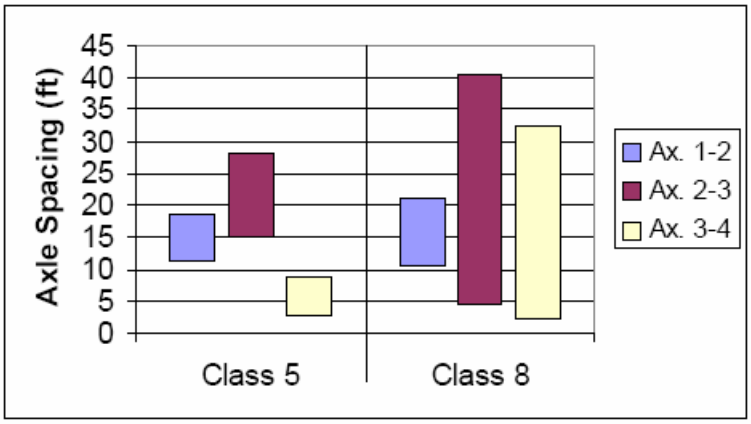


Figure 6.9: Comparison of Actual Axle Spacing for Class 8 (four-axles) and Class 5 (single unit trucks with two-axle trailer)

6.2.8 Class 9 (Five-Axle-Single-Trailer Trucks) and Class 11

Class 9 covers all five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit while Class 11 includes all vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power

unit. The two classes have same number of axles and therefore, their axle spacings were compared. Figure 6.10 shows comparison of class 11 (five-axles) with Class 9 (five-axles). It can be seen from the figure that there are overlaps in axle spacings between axles 1 and 2 and axles 3 and 4 while there is a clear demarcation in axle spacings between axles 2 and 3 and axles 4 and 5. Therefore, there is no chance of misclassification between the two classes.

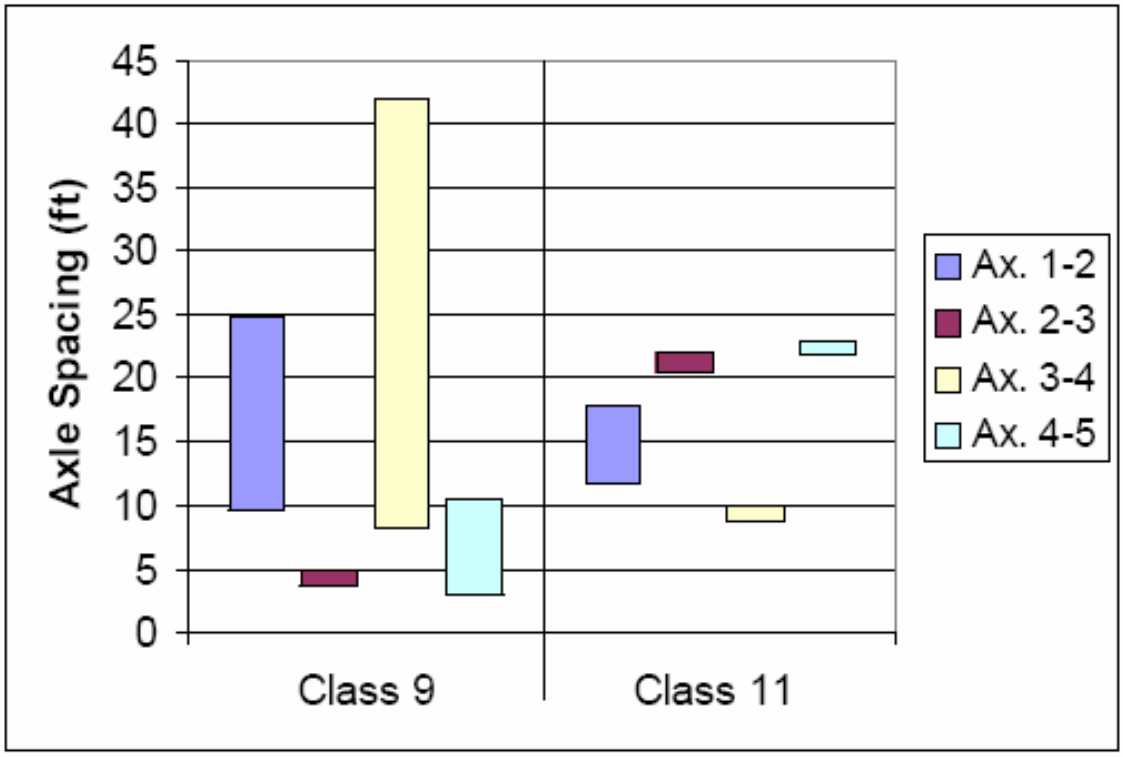


Figure 6.10: Comparison of Actual Axle Spacing for Class 11 (five-axles) and Class 9 (five-axles)

6.2.9 Class 10 (Six Axles) and Class 12 (Six Axles)

Class 10 includes all trucks with six or more axles consisting of two units, one of which is a tractor or straight truck power unit while Class 12 covers all six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit. The two classes have similar axle number and therefore comparison of their axle spacings. Figure 6.11 shows a comparison of Class 12 (six-axles) with Class 10 (six-axles). The figure shows that while there are overlaps in all other axle spacings of the two classes, there is a clear demarcation in the spacings between axles 4 and 5. Therefore, no misclassification between the two classes is expected.

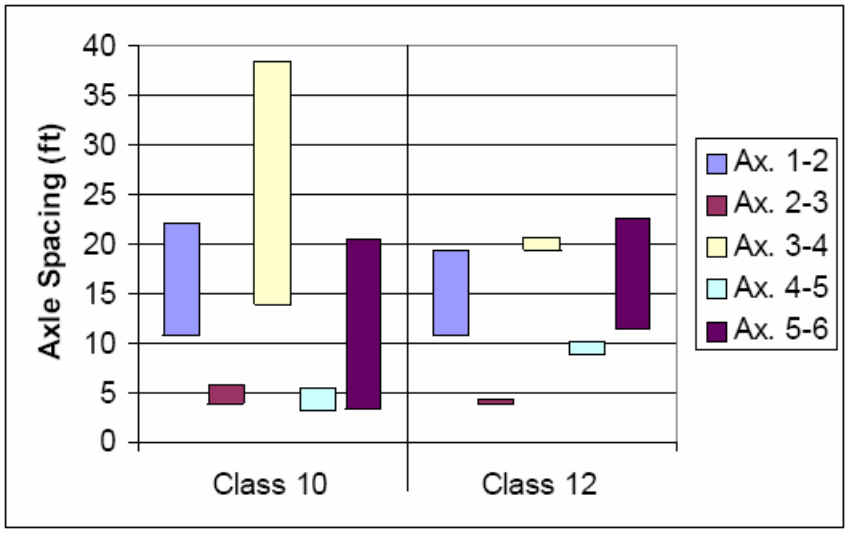


Figure 6.11: Comparison of Actual axle Spacing for Class 10 (six-axles) and Class 12

6.2.10 Class 13

Class 13 includes all vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit. Figure 6.12 shows graphical representation of actual axle spacing for Class 13 (seven-axles) while Figure 6.13 shows graphical representation of actual axle spacing for Class 13 (eight-axles).

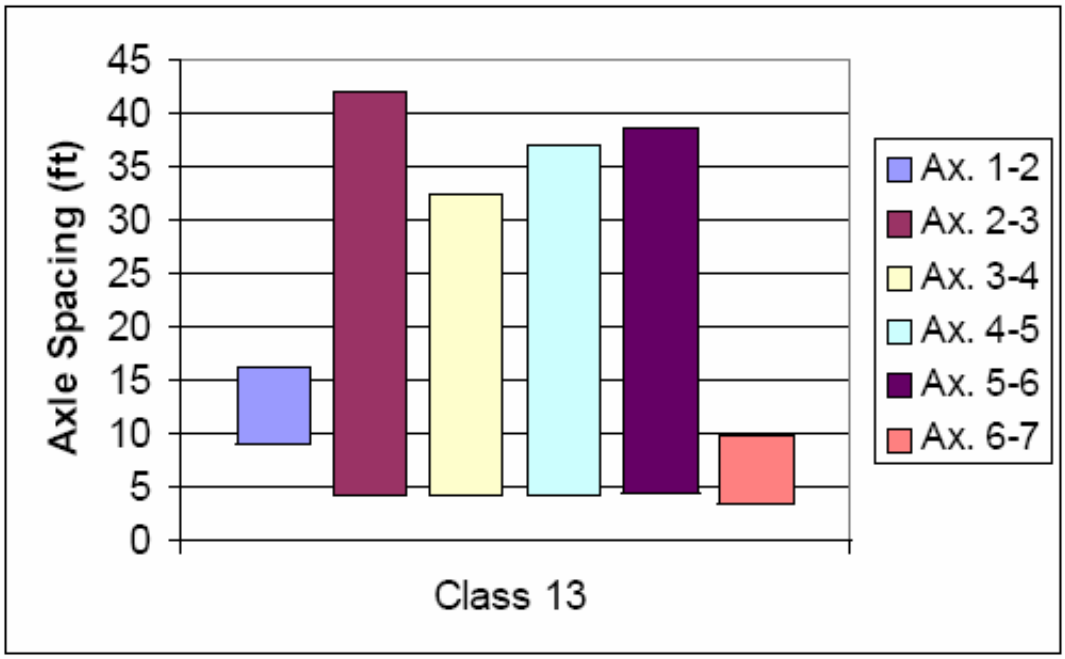


Figure 6.12: Graphical Representation of Actual Axle Spacing for Class 13 (seven-axles)

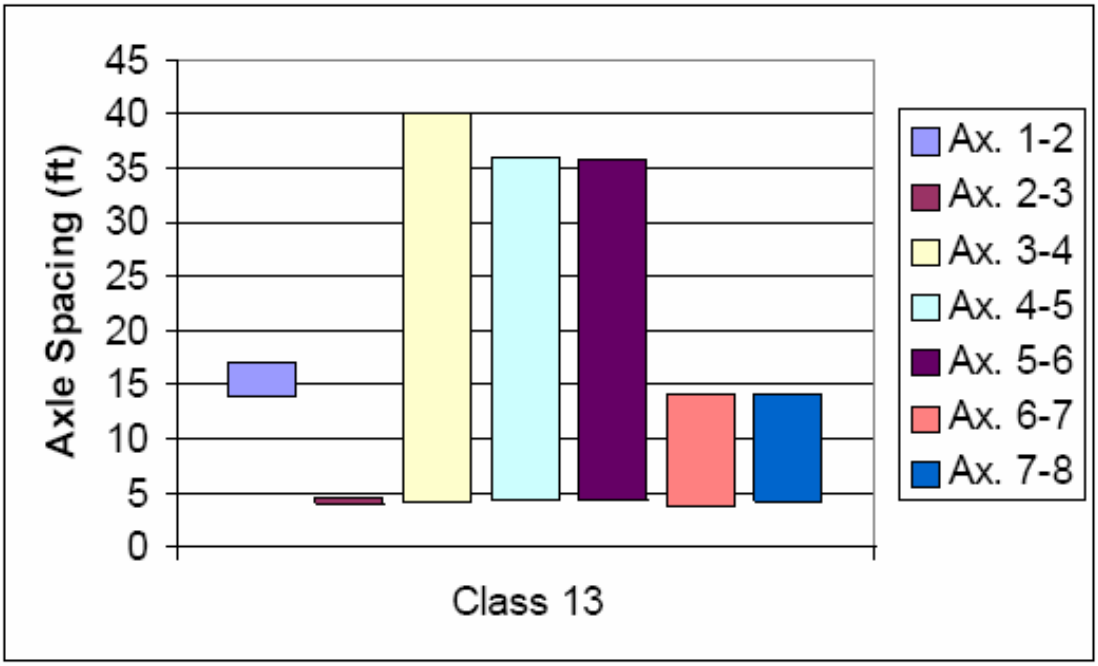


Figure 6.13: Graphical Representation of Actual Axle Spacing for Classes 13 (eight-axles)

CHAPTER 7—SETTING NEW AXLE SPACING THRESHOLDS

7.1 Introduction

Initially, the PNN results gave an insight of how best the thresholds in the current FDOT classification table could be adjusted to reduce the error rate. In this study, two guiding principles were followed in trying to find optimal threshold values that would reduce the classification error rate. First, the end use of the classification data was considered. As an input to a pavement design and management process, vehicles in higher classes—generally Class 4 and above—have a more damaging loading effect on the pavement. Thus, it is more crucial for these upper vehicle classes to be properly classified than the lower classes. Second, since automatic vehicle classifiers have difficulty distinguishing Class 3 from Class 2, FHWA reporting requirements ("Scheme F" guidelines) generally allows these two classes to be combined; hence misclassification between these classes is not critical. Therefore, though this work also addressed the axle spacing limits for these two classes, they can be combined in one class.

7.2 Proposing the Thresholds

Following the two principles outlined above and the results obtained from the PNN, a new set of thresholds was proposed. Table 7.1 shows proposed thresholds for the FDOT vehicle classification table in red color. Since no misclassifications were observed for Class 1 vehicles, it was proposed not to change threshold for this class. The axle spacing range for Class 2 vehicles was proposed to be in the range of 6.01-9.49 ft instead of 6.01-10.0 ft; and similarly for Class 3 vehicles, it was proposed to be 9.50 – 12.70 ft instead of 10.01 - 13.30 ft. Statistical analysis indicated that these new thresholds would reduce the misclassification error rate between Class 2 and Class 3 from 7.1 percent to 2.2 percent.

As can be seen in Table 7.1, no changes in thresholds were proposed for Class 4 vehicles; this is because field results showed that the only vehicles that were misclassified in this class were the vista type school buses, which are relatively short, compared to other Class 4 vehicles (buses). Statistical analysis showed that the distribution for axle spacing for Class 5 vehicles lies in the positive tail of the distribution with a skewness of 0.37. In order to correctly classify all vista type school buses and shorter transit buses as Class 4, the lower boundary for Class 4 would need to be changed from 23.01 ft to 18 ft, which would cause more than 35% of Class 5 vehicles to be misclassified as Class 4. Since the number of vista school buses in the traffic composition is lower than single unit trucks, the thresholds for class 4 were proposed to remain the same (23.01 – 40.0 ft) but allow the shorter vista style school bus be classified as Class 5.

Table 7.1: Proposed Thresholds for the FDOT Vehicle Classification Table

Vehicle Type	Order	Class	Num. Axles	Description	Axle Spacing (ft)							
					Ax.1-2	Ax.2-3	Ax.3-4	Ax.4-5	Ax.5-6	Ax.6-7	Ax.7-8	Ax.8-9
1	1	1	2	Motorcycle	0.10-6.00							
2	**2**	**2**	**2**	**Auto, Pickup**	**6.01-9.49**							
20	**3**	**5**	**2**	**2D**	**12.71-23.00**							
3	**4**	**3**	**2**	**Other (Van, RV)**	**9.50-12.70**							
10	5	4	2	Bus	23.01-40.00							
30	1	8	3	2S1, 21	6.01-23.00	11.00-40.00						
11	2	4	3	Bus	23.01-40.00	0.10-6.00						
24	3	6	3	3 Axles	6.01-23.00	0.10-5.99						
	4	**5**	**3**	**2D W/1 Axle Trailer**	**12.71-23.00**	**6.00-28.40**						
7	**5**	**3**	**3**	**Other W/1 Axle Trailer**	**9.50-12.70**	**6.00-28.40**						
3	**6**	**2**	**3**	**Auto W/1 Axle Trailer**	**6.01-9.49**	**6.00-28.40**						
38	1	8	4	2S2	6.01-23.00	11.00-40.00	0.10-10.99					
34	2	8	4	3S1, 31	6.01-23.00	0.10-6.00	6.01-44.00					
28	3	7	4	4 Axles	6.01-23.00	0.10-6.00	0.10-13.00					
	4	**5**	**4**	**2D W/2 Axle Trailer**	**12.71-23.00**	**6.00-28.40**	**0.10-8.70**					
9	**5**	**3**	**4**	**Other W/2 Axle Trailer**	**9.50-12.70**	**6.00-28.40**	**0.10-8.70**					
4	**6**	**2**	**4**	**Auto W/2 Axle Trailer**	**6.01-9.49**	**6.00-28.40**	**0.10-8.70**					
40	1	9	5	3S2	6.01-26.00	0.10-6.00	6.01-46.00	0.10-10.99				
44	2	9	5	32	6.01-26.00	0.10-6.00	6.01-23.00	11.00-27.00				
	3	**9**	**5**	**2S3**	**6.01-26.00**	**6.01-46.00**	**0.10-6.00**	**0.10-6.00**				
60	4	11	5	2S12	6.01-26.00	11.00-26.00	6.10-20.00	11.01-26.00				
	5	**5**	**5**	**2D W/3 Axle Trailer**	**12.71-23.00**	**6.00-28.40**	**0.10-8.70**	**0.10-8.70**				
	6	**3**	**5**	**Other W/3 Axle Trailer**	**9.50- 12.70**	**6.00-28.40**	**0.10-8.70**	**0.10-8.70**				
50	1	10	6	3S3, 33	6.01-26.00	0.10-6.00	0.10-46.00	0.10-11.00	0.10-11.00			
70	2	12	6	3S12	6.01-26.00	0.10-6.00	11.01-26.00	6.01-24.00	11.01-26.0			
54	**1**	**10**	**7**	**3S4**	**6.01-16.70**	**0.10-6.00**	**13.30 – 40.00**	**0.10-6.00**	**0.10-6.00**	**0.10-6.0**		
54	**2**	**10**	**7**	**4S3**	**6.01-16.70**	**0.10-6.00**	**0.10- 6.00**	**13.30 – 40.00**	**0.10- 6.00**	**0.10- 6.0**		
80	3	13	7	2S23, 3S22, 3S13	1.00-45.00	1.00-45.00	1.00-45.00	1.0-45.0	1.00-45.00	1.0-45.0		
	1	**10**	**8**	**4S4**	**6.01-16.70**	**0.10-6.00**	**0.10- 6.00**	**13.30 – 40.00**	**0.10- 6.00**	**0.10- 6.0**	**0.10- 6.0**	
84	2	13	8	3S23	1.00-45.00	1.00-45.00	1.00-45.00	1.00-45.00	1.00-45.00	1.0-45.0	1.0-45.0	
90	1	13	9	PERMIT	1.00-45.00	1.0045.00	1.00-45.00	1.00-45.00	1.00-45.00	1.0-45.0	1.0-45.0	1.0-45.0
		15		ERRORS OR UNCLASSIFIED VEHICLES NOT MEETING AXLE CONFIG. FOR CLASS 1 THROUGH 13								

Most of the misclassifications that occurred in Class 5 were in the lower range of axle spacing, and they placed Class 5 vehicles in Class 3. The only adjustment that could be done to curb this error was to lower the lower boundary of Class 5. Statistical analysis indicated that changing the axle spacing of Class 5 vehicles from 13.31 – 23.0 ft to 12.71 – 23.0 ft would reduce Class 5 vehicles being misclassified as Class 3 by 18.8 percent. Specifically, with the new proposed thresholds for Class 3 and Class 5 vehicles, only less than 8.2 percent of Class 5 vehicles would be misclassified as Class 3. In order to completely eliminate the misclassification of Class 5 into Class 3, the lower boundary for Class 5 need to be as low as possible to accommodate all short single unit trucks. This would cause the number of Class 3 vehicles misclassified as Class 5 to be very high. Since the number of Class 5 single unit trucks in the traffic composition is lower than Class 3 vehicles, then the number of single unit trucks missed under the new proposed threshold would be relatively low and can be neglected. In general, the new proposed thresholds for Class 5 and Class 3 vehicles do take into consideration the traffic composition in the field and the classification errors allowed between these two classes is the minimum one can statistically have based on PNN results while favoring the higher classes.

Statistical analysis of Class 6 vehicles showed that the axle spacings for this class do not overlap with any vehicle class. The axle spacing for Class 6 vehicles were therefore proposed to remain the same. The sample size for Class 7 vehicles was too small to justify any change of the thresholds in this class. However, all observed Class 7 vehicles revealed no overlap between their axle spacings and the axle spacings for other vehicle classes. According to FHWA guidelines, Class 7 vehicles are all 4 or more axle single unit trucks. Field results identified one single unit truck with 5 axles. This suggests that a subclass of Class 7 with 5 axles may be required when the number of trucks of this type justifies the need. In this proposed thresholds, the number of such truck type was not sufficient to justify establishment of the subclass.

As shown in the previous Chapter, there were overlaps in axle spacing for vehicles in Class 8 and in Class 3 (other two-axle vehicles towing trailers). However, the misclassification was one-way, in which, only Class 3 vehicles were misclassified as Class 8. This was caused by the sequence of classification of the decision tree which favored Class 8 than Class 3. Field data analysis showed that the minimum axle spacing for vehicles observed in Class 8 was 11 ft and the minimum axle spacing for Class 3 vehicles that were misclassified as Class 8 was 11.2 ft. Because of this physical overlap there was no adjustment that could be made to reduce the number of Class 3 vehicles that are misclassified as Class 8 without causing misclassification of Class 8 as Class 3. In line with the need to properly classify higher classes better than the lower classes, it was proposed to retain the existing axle spacing thresholds for Class 8 and maintain the current order of classification in order to have all Class 8 trucks classified correctly.

Since all of Class 9 trucks were correctly classified, it was unnecessary to change the existing thresholds. However, a new type of Class 9 truck that was not specified by the FDOT decision tree was observed in the field and needed to be accommodated in the classification algorithm. Therefore, it was proposed to retain the same axle spacings for Class 9, but establish a new subclass that would accommodate the new type of truck. Figure 7.1 illustrates the type of truck that was not accommodated in the current FDOT decision tree. Figure 7.2 shows another type of truck (2S2-1) which was observed in the field but was not accommodated in the current FDOT

classification table. However, only one such truck was observed and therefore no adjustment in the FDOT decision tree was suggested in order to include this type of truck.

There were misclassifications that led vehicles in Class 10 (7 axles and 8 axles) being classified as Class 13. This was caused by the improper axle spacing thresholds for Class 13 vehicles, which is 1 – 45 ft. Any misclassified truck in Class 10 with seven or eight axle spacing happened to have axle spacing in the range of Class 13, hence it was thrown into Class 13.

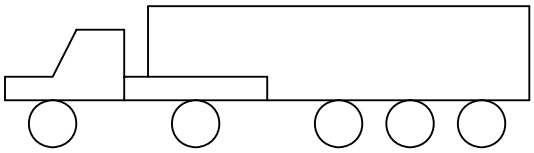


Figure 7.1: New Truck Type (2S3)

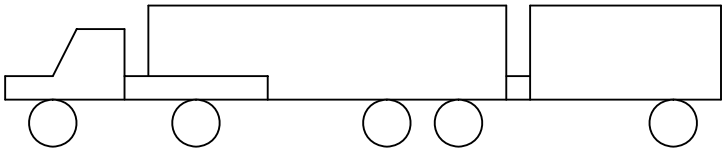


Figure 7.2: New Truck Type (2S2-1)

The analysis showed two configurations for Class 10 (7-axles); a three-axle tractor with four-axle trailer (3S4) and a four-axle tractor with three-axle trailer (4S3). These two configurations have different axle spacing between the third and the fourth axles. In order to accommodate these differences, the thresholds for third axle spacing were proposed to be changed from 13.3 – 40.0 ft to 0.1 – 40.0 ft while the fourth axle spacing thresholds were proposed to be changed from 0.1 – 13.3 ft to 0.1 – 40.0 ft. It was further observed that the current FDOT table does not accommodate Class 10 with 8 axles which are trucks with four-axle tractor with four-axle trailer (4S4). To address this deficiency, a new subclass that accommodates such trucks was proposed as shown in Table 7.1.

No misclassifications were observed for Class 12; therefore, it was proposed to maintain the same thresholds. There was insufficient number of Class 13 vehicles observed to justify any adjustment of the thresholds and therefore, it was decided to retain their current FDOT thresholds.

CHAPTER 8—VALIDATION OF PROPOSED AXLE SPACING THRESHOLDS

8.1 Introduction

There were two ways available for validating the proposed axle spacing; offline or online. Online validation means that the decision tree with proposed axle spacing could be installed in the machines at the traffic monitoring sites. Video data could be taken and compared with the machine classification to evaluate the performance. This would be the best way since it performs vehicle classification in real time. However, from the experience gained during the data collection phase of the research, it is difficult to capture all vehicle types at a single WIM station. For reliable validation, data needed to be collected from several location/traffic monitoring sites, which made online validation infeasible. It was decided to perform offline validation by collecting axle spacing and video data from several sites; vehicle weight was not needed in the validation stage. The video image processing technique was used in collection of data for validation. One of the advantages of this method was the collection of data from sites where the systems could not provide individual vehicle records for all lanes (for example Site number 9923 lanes 2 and 3), but still be able to get the axle spacing form the video images collected. The next section describes the procedure for image processing technique for data collection and axle spacing extraction.

8.2 Validation Data Collection Setup

Validation data were collected from three locations; two of which are the same WIM sites (9904 and 9901) where initial data were collected and the third location was a new location deemed to have a good hourly distribution of higher class vehicles. This third location is in the vicinity of site number 9923 on I-95 and it has the WIM capability on the outer lanes only. These are also the same lanes that one can obtain records of individual vehicle.

Two variables were important for measurement of axle spacing from frozen video images. The field of view and the distance from the object affect the measurement of distance between two points on the image. In order to measure the distance between two points (in this case, the axle spacing), these factors were controlled. Field of view is measured in degrees and depends on the zooming capacity of the camera. The maximum zoom has the minimum field of view and vice versa.

Software accepting two parameters (field of view and object distance) from the user was used. Figure 8.1 shows the field set up, which involved establishing two reference points with known distance apart at a known distance from the camera. The reference points were used to measure the field of view that was later used during extraction of axle spacings. With known field of view, a single parameter required as an input was the distance from the object to the camera.

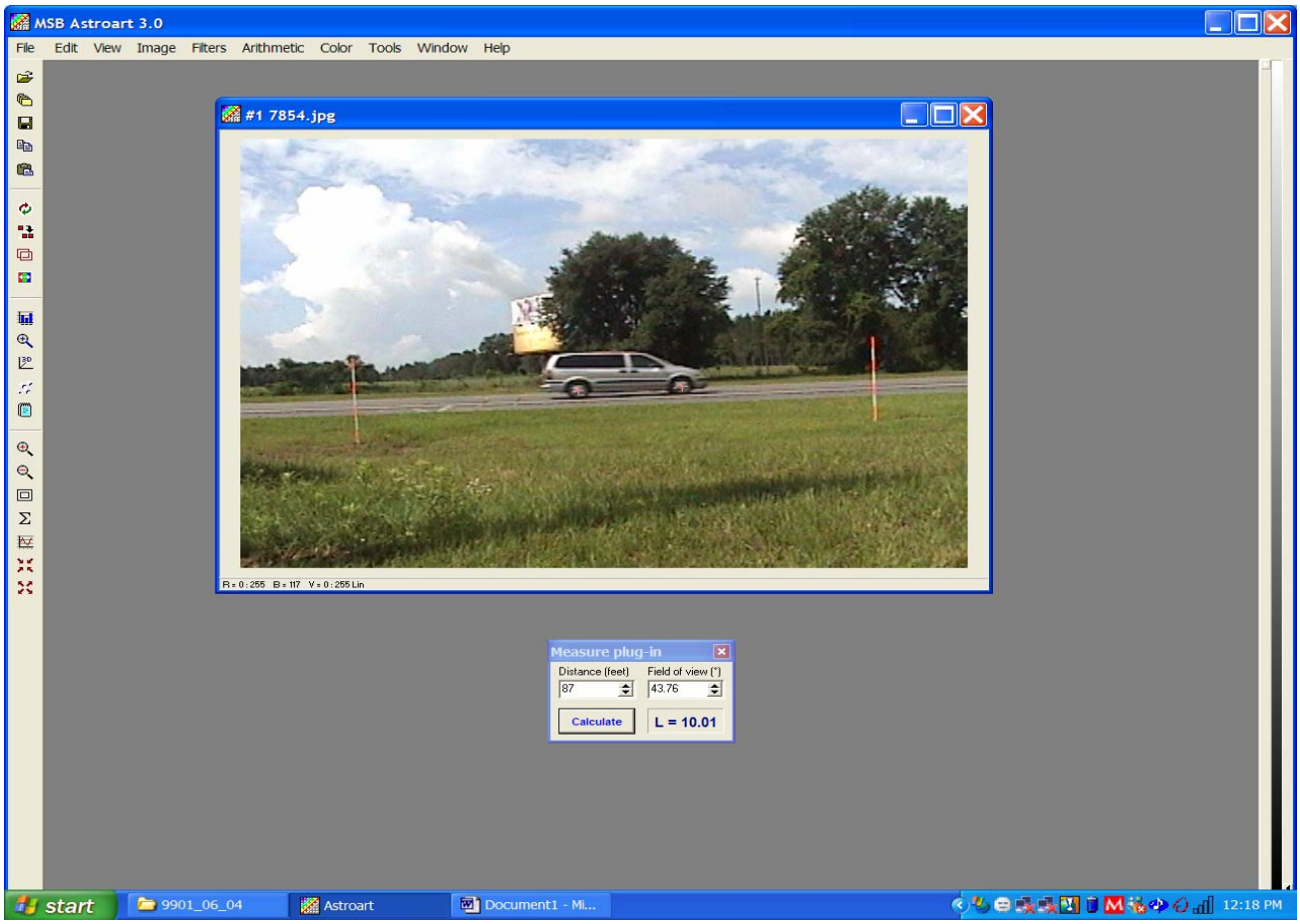


Figure 8.1: Field Setup of Data Collection for Video Image Processing

In order to determine the distance from the camera to the vehicle, a test vehicle with known axle distance was used. The distance to the vehicle was adjusted until the actual axle spacing was obtained from the frozen video images. This distance was used as an approximate distance from the vehicle to the video camera. Since vehicles do not use the same wheel path, the error introduced by varying the distance from the vehicle to the video camera was quantified by running a test vehicle along different wheel paths. It was observed that an error of 1 ft in horizontal distance caused an error of less than 0.03 ft in the measured axle spacing, which was acceptable in the analysis results.

8.3 Validation Data Analysis Results

Axle spacings were extracted from the images for each sampled vehicle. Classification was done using the proposed axle spacing by implementing the "IF THEN" rules. Table 8.1 shows the results obtained by using the proposed axle spacing thresholds compared to the existing FDOT thresholds.

Table 8.1: Validation Results

Vehicle Class	Total Vehicles Observed	FDOT Based Classification		New Threshold Based Classification	
		Total Misclassified	Percentage Misclassified	Total Misclassified	Percentage Misclassified
1	0	0			
2	119	2	1.68%	10	8.40%
3	121	67	55.37%	49	40.50%
4	45	16	35.56%	0	0.00%
5	88	13	14.77%	6	6.82%
6	104	0	0.00%	0	0.00%
7	21	0	0.00%	0	0.00%
8	56	0	0.00%	0	0.00%
9	313	0	0.00%	0	0.00%
10	17	5	29.41%	0	0.00%
11	24	0	0.00%	0	0.00%
12	10	0	0.00%	0	0.00%
13	2	0	0.00%	0	0.00%
Total	**920**	**103**	**11.20%**	**65**	**7.07%**

The results show that the proposed new axle spacing thresholds improved overall classification. There was a major improvement in classification among Class 3 and 5, which is critical since it involves misclassification between lower vehicle classes and higher vehicle classes which are of higher interest for highway planning and operation purposes. The misclassifications are still higher in Class 2, Class 3, and Class 5. However, analysis of misclassified vehicles indicated that the number of Class 5 vehicles misclassified as Class 3 was reduced. In particular, there were more vehicles in Class 3 that were misclassified as Class 2, and vice versa; however, since the FHWA allows Class 2 vehicles to be combined with Class 3 vehicles, the increased error in Class 2 classification had no practical significance.

CHAPTER 9—CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

This research was aimed at improving vehicle classification using the "F Scheme" guidelines. The "F Scheme" is a visual classification scheme that has been adopted by most highway agencies, including the Florida Department of Transportation, for reporting vehicle classification data to the Federal Highway Administration (FHWA) as part of the Highway Performance Monitoring Systems (HPMS). A probabilistic neural network (PNN) approach was used in an attempt to reduce misclassification between various classes in the "F Scheme." The network uses information on the number of axles, axle spacing, and vehicle weight to determine the class in which a vehicle belongs. Field data of these three variables were collected on Florida highways.

The performance of the PNN depended on both its design—that is, the selection of the smoothing factor (σ), and the selection of representative training patterns. The smoothing factor was selected as a function of the variances of the training patterns. It defines the decision boundaries for the classes. Non-linear decision boundaries require the smoothing factor to be as small as possible. Details of the probability density may be lost with too large value of smoothing factor while too small values of the factor cause spiky approximation of the decision boundary. The optimum value was be selected by trial and error. The pattern set for each class was chosen to have a sufficiently small variance and a mean that is suitably far from the mean of the pattern for the adjacent class.

The evaluation of the performance of the PNN showed that the overall classification error rate was reduced from 9.7% to 6.1% when only axle spacing and number of axles were considered as decision variables. The error rate was further reduced to 2.9% when the gross vehicle weight was added as a third decision variable. Since most of the traffic monitoring sites do not have capability of weighing vehicles in motion, the vehicle weight was only used for establishing optimum axle spacing thresholds. The PNN results gave an insight of how best the thresholds in the existing FDOT classification table could be adjusted in order to minimize the error rate. The results were used to propose new thresholds for the look up table currently being used by FDOT for vehicle classification.

While it is clear that improvements can be made to the table, it is impossible to entirely eliminate all errors because of inherent weaknesses in the "F Scheme." The most single problematic weakness is the fact that the scheme does not recognize the real life overlap of axle spacings for vehicles that the scheme wants to belong to different classes. The scheme considers number of axles the vehicle has and the number of units per vehicle. It defines the vehicles' body type since its guidelines were mostly intended for visual classification of vehicles. To automate vehicle classification, a number of vehicle features such as axle spacing and number of axles are required. Thus, defining the thresholds for each vehicle class as given in Scheme F guidelines is difficult.

9.2 Recommendations

Further research is needed to explore the use of additional variables for vehicle classification. The variables that can be used include overall vehicle length, number of tires per vehicle, and vehicle height. However, the classification scheme depends on the existing technology for extraction of vehicle features. Non-intrusive technologies can be used for extracting vehicle features that can be used for vehicle classification. The technologies include passive infrared, active infrared, microwave and Doppler radar. With many vehicle features, vehicles can be separated into Scheme F classes with minimum error.

A study on highway vehicle classification in urban areas is needed. Urban traffic operation is characterized with slow speed and "stop and go" behavior which may affect the accuracy of detection of vehicle features using loop detectors and other intrusive detection systems. Non-intrusive traffic detection systems can be used for extraction of vehicle features in urban areas.

The use of PNN gave an insight on how a vehicle classification table that minimizes classification error can be developed. Errors in vehicle classification process following "Scheme F" guidelines generally are produced by two sources. One source of error is the vehicle detection equipment not properly recording the axle spacing or the number of axles a vehicle has. This error generally occurs when two vehicles are following too closely or when a vehicle change lanes close to the detector locations. If this happens, the classification table can throw a vehicle into a wrong class or, as in most cases, the vehicle is thrown into Class 15, which is a "capture all" class for unclassified vehicles. Another source of error is lack of decision tree with clear and optimum margins between thresholds of axle spacing for vehicles in different classes. In this study, all vehicle records with detection errors were treated as outliers and were removed from the data set. A further research is needed to quantify the influence of these errors and how PNN can be trained to anticipate these errors thus further improving the vehicle classification process.

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Appendix A: Comparison of Algorithms Used in Florida

		PAT		Peek		Diamond					
Number	Axle Spacing in Feet								Vehicle	Default	Gross
of Axles	A - B	B - C	C - D	D - E	E - F	F - G	G - H	H - I	Type	Type	Weight
0										15	
										2	
1										15	
										2	
2	0.1 - 6.0								1		100 - 3000
	0.0 - 6.0										
	1.0 - 5.8										
	6.01 - 10.29								2		1000 - 7990
	6.0 - 10.2										
	5.9 - 9.9										
	10.3 - 13.30								3	15	0 - 10000
	10.2 - 13.0									2	
	10.0 - 15.0										
	23.01 - 40.0								4		<10000
	20.0 - 40.0										
	24.1 -99.9										
	13.31 - 23.00								5		<8000
	13.0 - 20.0										
	15.1 - 24.0										
3	6.01 - 10.29	6.0 - 18.00							2		>1000<9990
	6.0 - 10.2	6.0 - 18.0									
	5.9 - 9.9	10.0 - 18.0									
	10.3 - 13.30	6.0 - 18.0							3		>1000<11990
	10.2 - 13.0	6.0 - 18.0									
	10.0 - 15.0	10.0 - 18.0									
	23.01 - 40.0	0.1 - 6.0							4	15	
	20.0 - 40.0	0.0 - 6.0								2	
	24.1 -99.9	0 - 199.9									
	6.01 - 23.00	0.1 - 6.0							6		
	6.0 - 23.0	0.0 - 6.0									
	0 - 199.9	3.5 - 8.0									
	6.01 - 23.00	11.0 - 40.0							8		<10000
	6.0 - 17.0	14.0 - 40.0									
	0 - 199.9	18.1 - 99.9									
4	6.01 - 10.29	6.0 - 18.00	0.1 - 6.0						2		>1000<10000
	6.0 - 10.2	6.0 - 18.0	0.0 - 6.0								
	1.0 - 9.9	0.0 - 199.9	0.1 - 3.4								
	10.3 - 13.30	6.0 - 18.0	0.1 - 6.0						3		>1000<11990
	10.2 - 13.0	6.0 - 18.0	0.0 - 6.0								
	10.0 - 15.0	0.0 - 199.9	0.1 - 3.4								
	6.01 - 23.00	0.1 - 6.0	0.1 - 13.0						7	15	>12000
	6.0 - 23.0	0.0 - 9.0	0.0 - 9.0							2	
	0 - 199.9	0.0 - 199.9	0.0 - 199.9								
	6.01 - 23.00	0.1 - 6.0	6.1 - 44.0						8		>20000
	6.01 - 23.00	11.0 - 40.0	0.1 - 10.99								>20000
	6.0 - 20.0	0.0 - 6.0	6.0 - 40.0								
	6.0 - 17.0	14.0 - 40.0	0.0 - 6.0								
	0 - 199.9	1.0 - 5.0	10.0 - 99.9								
	0 - 199.9	5.1 - 99.9	3.5 - 99.9								

		PAT		Peek		Diamond					
Number	Axle Spacing in Feet								Vehicle	Default	Gross
of Axles	A - B	B - C	C - D	D - E	E - F	F - G	G - H	H - I	Type	Type	Weight
5	9.9 - 14.9	0 - 199.9	0 - 199.9	1.0 - 3.4							
	15.1 - 24.0	0 - 199.9	0 - 199.9	1.0 - 3.4					5		
	6.01 - 26.0	0.1 - 6.0	6.1 - 46.0	0.1 - 10.9					9		>10000
	6.0 - 22.0	0.0 - 6.0	6.0 - 40.0	0.0 - 14.0							
	6.0 - 22.0	0.0 - 6.0	6.0 - 23.0	6.0 - 23.0						15	
	0 - 199.9	1.0 - 6.0	0 - 199.9	3.5 - 11.0							
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9							
	6.1 - 26.0	11.1 - 26.0	6.1 - 20.0	11.1 - 26.0					11	9	>10000
	6.0 - 17.0	11.0 - 25.0	6.0 - 16.0	11.0 - 25.0							
	0 - 199.9	6.1 - 99.9	0 - 199.9	0 - 199.9							
	6.1 - 23.0	3.5 - 6.0	6.1 - 23.0	11.0 - 27.0					14		>12000
6	6.1 - 26.0	0.1 - 6.0	0.1 - 46.0	0.1 - 11.0	0.1 - 11.0				10		>10000
	6.0 - 22.0	0.0 - 6.0	6.0 - 40.0	0.1 - 11.0	0.1 - 11.0					15	
	0 - 199.9	3.5 - 8.0	3.5 - 8.0	0 - 199.9	8.1 - 99.9						
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9	3.5 - 8.0						
	6.1 - 26.0	0.1 - 6.0	11.1 - 26.0	6.1 - 24.0	11.1 - 26.0				12	10	>10000
	6.0 - 22.0	0.0 - 6.0	0.0 - 25.0	6.0 - 16.0	11.0 - 25.0						
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9	8.1 - 99.9						
7	6.0 - 22.0	0.0 - 6.0	0.0 - 40.0	0.0 - 13.0	0.0 - 12.0	0.0 - 12.0			10	15	
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9	3.5 - 8.0	3.5 - 8.0					
	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0			13	13	>10000
8	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0		10	15	>12000
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9	3.5 - 8.0	3.5 - 8.0	3.5 - 8.0		13	15	
9	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	13	15	>12000
	0 - 199.9	0 - 199.9	0 - 199.9	0 - 199.9	3.5 - 8.0	3.5 - 8.0	3.5 - 8.0	3.5 - 8.0	10	15	

PAT Algorithms are for a DAW 200 WIM system that uses Gross Weight in classification

Peek Class 15 only includes vehicles with 8 or more axles

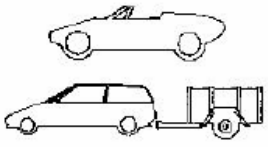
Diamond No Class 15. Class 13 consists of any vehicle with spacing not included in the above table

Appendix B: Scheme F Vehicle Types As Defined by Ohio DoT

1

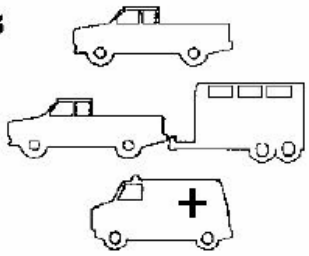
MOTORCYCLES

2



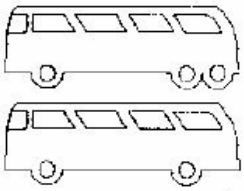
PASSENGER CARS

3



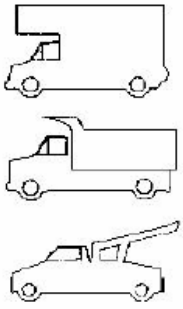
FOUR TIRE, SINGLE UNIT

4



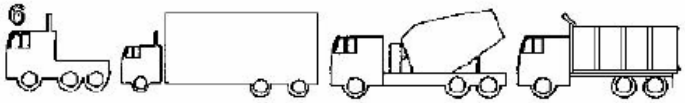
BUSES

5



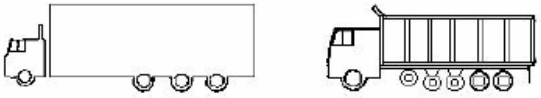
TWO AXLE, SIX TIRE SINGLE UNIT

6



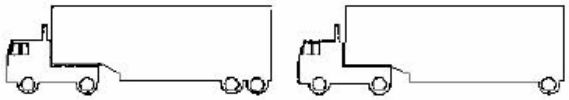
THREE AXLE, SINGLE UNIT

7



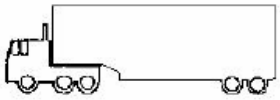
FOUR OR MORE AXLE, SINGLE UNIT

8



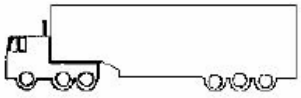
FOUR OR LESS AXLE, SINGLE TRAILER

9



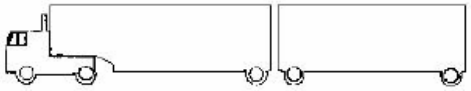
FIVE-AXLE, SINGLE TRAILER

10



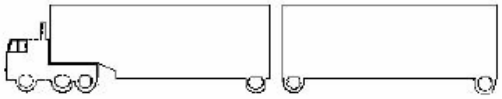
SIX OR MORE AXLE, SINGLE TRAILER

11



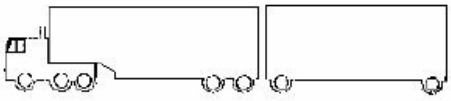
FIVE OR LESS AXLE, MULT-TRAILER

12



SIX AXLE, MULT-TRAILER

13



SEVEN OR MORE AXLE, MULTI-TRAILER

Appendix C: PNN Training and Classification Algorithms

```
clc;
clear all;
close all;
trainingdata3;
Sigma=[];
CLASSDATA=[];
classes=28;
cases=zeros(classes,1);
for i=1:classes
    ind=find(Y==i); %Counts Y for each class
    cases(i)=length(ind);%Returns # of training samples per class
    if i==1
        starting=1;
    else
        starting=sum(cases(1:i-1))+1;%Point where a new class starts in training sample
    end
    Xtr=X(starting:starting+cases(i)-1,:);%Reads X observations for class i in training data

    %The above process is for reading training sample

    Sigma=[Sigma;std(Xtr)];%Returns std for each axle spacing of all X's in a case
end
Sigma=40/norm(Sigma); %Estimates the smoothing parameter

%The above process is for estimating parameters!!
fielddata5
for test=1:size(FD,1)%Initiate a loop that goes through all data in fielddata*.m
    xtest=FD(test,:);%Reads a test observation xtest from field data FD
    [Y,ind]=sort(Y);
    X=X(ind,:);
    ctr=1;
    M=max(size(xtest));
    for i=1:classes
        ex_sum=0;
        for j=1:cases(i)
           X(ctr,:);
            ex_sum=(exp((-(xtest-X(ctr,:))*(xtest-X(ctr,:))')/(2*Sigma^2)))+ex_sum;
            ctr=ctr+1;
         end
        ex_sum;
        w_dist(i)=ex_sum/(((2*pi)^(M/2))*(Sigma^(M))*cases(i));%Calculates the probability
     end
    dist=max(w_dist);
    class=find(w_dist==max(w_dist));
    numaxles=max(find(xtest));
    xf=xtest(:,1:numaxles);
if (class==1)
    class=1;
elseif ((class>1)&(class<5))
    class=2;
elseif ((class>4)&(class<9))
    class=3;
elseif ((class>8)&(class<11))
    class=4;
elseif ((class>10)&(class<15))
    class=5;
elseif (class==15)
    class=6;
elseif (class==16)
    class=7;
elseif ((class>16)&(class<20))
    class=8;
elseif ((class>19)&(class<22))
    class=9;
elseif ((class>21)&(class<24))
    class=10;
elseif (class==24)
    class=11;
elseif (class==25)
    class=12;
elseif ((class>25)&(class<29))
    class=13;
else
    class=15;end;
class
w_dist;
```

Appendix D: Analysis Results for Test Vehicle Axle Spacing Detection Errors

Site No. 0352 (Eastbound)

Run	Sensor	Actual	Difference	%Error
1	9.1	9.30	-0.20	-2.15
2	9.2	9.30	-0.10	-1.08
3	9.4	9.30	0.10	1.08
4	9.3	9.30	0.00	0.00
5	9.2	9.30	-0.10	-1.08

Max	9.40
Average	9.24
Min	9.10

Avg %Error	0.65

Site No. 9901 (Westbound)

Run	Sensor	Actual	Difference	%Error
1	9.00	9.00	0.00	0.00
2	9.00	9.00	0.00	0.00
3	9.10	9.00	0.10	1.11
4				

Max	9.10
Average	9.03
Min	9.00

Avg %Error	0.37

Site No. 9904 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.80	10.00	-0.20	-2.00
2	9.90	10.00	-0.10	-1.00
3	9.80	10.00	-0.20	-2.00
4	9.90	10.00	-0.10	-1.00
5	10.00	10.00	0.00	0.00

Max	10.00
Average	9.88
Min	9.80

Avg %Error	**1.2**

Site No. 9904 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.80	10.00	-0.20	-2.00
2	10.00	10.00	0.00	0.00
3	9.90	10.00	-0.10	-1.00

Max	9.10
Average	9.90
Min	8.90

Avg %Error	1

Site No 9907 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.10	9.00	0.10	1.11
2	9.10	9.00	0.10	1.11
3	9.10	9.00	0.10	1.11
4	9.00	9.00	0.00	0.00
5	9.00	9.00	0.00	0.00
6	8.90	9.00	-0.10	-1.11

Max	9.10
Average	9.03
Min	8.90

Avg %Error	**0.74**

Site No. 9907 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.10	9.00	0.10	1.11
2	9.10	9.00	0.10	1.11
3	9.10	9.00	0.10	1.11
4	9.00	9.00	0.00	0.00
5	9.00	9.00	0.00	0.00

Max	9.10
Average	9.06
Min	9.00

Avg %Error	0.67

Site No 9913 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.10	9.00	0.10	1.11
2	8.90	9.00	-0.10	-1.11
3	9.00	9.00	0.00	0.00
4	8.90	9.00	-0.10	-1.11
5	9.10	9.00	0.10	1.11
6	9.00	9.00	0.00	0.00

Max	9.10
Average	9.00
Min	8.90

Avg %Error	**0**

Site No 9913 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.11	9.00	0.11	1.22
2	8.90	9.00	-0.10	-1.11
3	9.00	9.00	0.00	0.00
4	8.90	9.00	-0.10	-1.11
5	9.10	9.00	0.10	1.11
6	9.00	9.00	0.00	0.00

Max	9.10
Average	9.00
Min	8.90

Avg %Error	**0**

Site No 9922 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9	9.00	0.00	0.00
2	8.9	9.00	-0.10	-1.11
3	9	9.00	0.00	0.00
4	9.1	9.00	0.10	1.11
5	9.1	9.00	0.10	1.11
6	9.1	9.00	0.10	1.11

Max	9.10
Average	9.03
Min	8.90

Avg %Error	**0.3**

Site No 9922 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.1	9.00	0.10	1.11
2	8.9	9.00	-0.10	-1.11
3	9	9.00	0.00	0.00
4	9.1	9.00	0.10	1.11
5	9	9.00	0.00	0.00
6	9.1	9.00	0.10	1.11

Max	9.10
Average	9.03
Min	8.90

Avg %Error	**0.3**

Site No 9936 (Westbound)

Run	Sensor	Actual	Difference	%Error
1	9.3	9.30	0.00	0.00
2	9.3	9.30	0.00	0.00
3	9.1	9.30	-0.20	-2.15
4	9.3	9.30	0.00	0.00
5	9.4	9.30	0.10	1.08
6	9.4	9.30	0.10	1.08

Max	9.40
Average	9.30
Min	9.20

Avg %Error	0.00

Site No 9936 (Eastbound)

Run	Sensor	Actual	Difference	%Error
1	9.3	9.30	0.00	0.00
2	9.4	9.30	0.10	1.08
3	9.2	9.30	-0.10	-1.08
4	9.3	9.30	0.00	0.00
5	9.4	9.30	0.10	1.08

Max	9.40
Average	9.32
Min	9.20

Avg %Error	**0.22**

Site No 9921 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.00	9.00	0.00	0.00
2	9.00	9.00	0.00	0.00
3	9.00	9.00	0.00	0.00
4	8.90	9.00	-0.10	-1.11
5	9.10	9.00	0.10	1.11
6	9.00	9.00	0.00	0.00

Max	9.10
Average	9.00
Min	8.90

Avg %Error	**0**

Site No 9921 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.00	9.00	0.00	0.00
2	9.10	9.00	0.10	1.11
3	9.00	9.00	0.00	0.00
4	9.00	9.00	0.00	0.00
5	9.10	9.00	0.10	1.11
6	8.90	9.00	-0.10	-1.11

Max	9.10
Average	9.02
Min	8.90

Avg %Error	**0.18**

Site No. 9935 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.10	9.00	0.10	1.11
2	9.00	9.00	0.00	0.00
3	9.00	9.00	0.00	0.00
4	9.10	9.00	0.10	1.11
5	9.00	9.00	0.00	0.00
6	8.90	9.00	-0.10	-1.11

Max	9.10
Average	9.02
Min	8.90

Avg %Error	**0.18**

Site No. 9935 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.10	9.00	0.10	1.11
2	8.90	9.00	-0.10	-1.11
3	8.90	9.00	-0.10	-1.11
4	9.10	9.00	0.10	1.11
5	9.00	9.00	0.00	0.00
6	9.10	9.00	0.10	1.11

Max	9.10
Average	9.02
Min	8.90

Avg %Error	**0.18**

Site No. 9919 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.5	9.30	0.20	2.15
2	9.2	9.30	-0.10	-1.08
3	9.2	9.30	-0.10	-1.08
4	9.3	9.30	0.00	0.00
5	9.4	9.30	0.10	1.08

Max	9.50
Average	9.32
Min	9.20

Avg %Error	**0.65**

Site No. 9919 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.5	9.30	0.20	2.15
2	9.3	9.30	0.00	0.00
3	9.3	9.30	0.00	0.00
4	9.2	9.30	-0.10	-1.08
5	9.4	9.30	0.10	1.08

Max	9.50
Average	9.34
Min	9.20

Avg %Error	**0.43**

Site No. 9920 (Northbound)

Run	Sensor	Actual	Difference	%Error
1	9.1	9.30	-0.20	-2.15
2	9.4	9.30	0.10	1.08
3	9.4	9.30	0.10	1.08
4	9.1	9.30	-0.20	-2.15
5	9.2	9.30	-0.10	-1.08

Max	9.40
Average	9.24
Min	9.10

Avg %Error	**0.22**

Site No 9920 (Southbound)

Run	Sensor	Actual	Difference	%Error
1	9.3	9.30	0.00	0.00
2	9.5	9.30	0.20	2.15
3	9.2	9.30	-0.10	-1.08
4	9.1	9.30	-0.20	-2.15
5	9.2	9.30	-0.10	-1.08

Max	9.50
Average	9.26
Min	9.10

Avg %Error	**0.22**

Appendix E: Distribution of Vehicle Classification by Hour of the Day

Site No 9904

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 004 Location : I-75, Alachua County Lane(s) : 1 2 3 4 5 6
DATE : 07/08/04 County : 026 State-ID : 12 Direction : 1 1 1 5 5 5

	HOURLY SUMMARY								VEHICLE COUNTS						
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	439	122	3	72	1	0	12	412	0	24	18	0	0	19	1123
1- 2	2	320	87	4	40	4	1	9	319	0	21	16	1	0	11	835
2- 3	0	255	61	6	33	0	0	8	303	0	19	17	0	0	8	710
3- 4	1	233	50	6	29	6	0	14	337	0	41	11	0	0	9	737
4- 5	1	250	69	5	36	2	0	15	324	1	33	25	0	0	7	768
5- 6	2	419	135	3	69	6	0	27	310	2	36	12	0	0	13	1034
QTR TOTALS	7	1916	524	27	279	19	1	85	2005	3	174	99	1	0	67	5207
6- 7	1	860	299	6	114	7	0	34	396	1	23	15	0	0	21	1777
7- 8	1	1522	443	5	190	14	3	43	365	1	13	4	2	0	32	2638
8- 9	5	1837	540	8	186	15	3	56	405	2	17	6	4	0	34	3118
9-10	4	1946	522	9	268	8	5	67	444	5	15	4	3	0	52	3352
10-11	10	2079	564	17	367	13	2	52	433	3	16	5	1	0	53	3615
11-12	3	2482	646	11	362	15	1	49	509	1	13	15	2	0	46	4155
QTR TOTALS	24	10726	3014	56	1487	72	14	301	2552	13	97	49	12	0	238	18655
12-13	8	2656	636	12	376	16	5	60	587	5	13	10	15	0	88	4487
13-14	4	2390	636	8	440	22	3	51	478	5	11	10	2	0	45	4105
14-15	4	2481	625	22	526	14	4	61	545	4	11	8	0	0	40	4345
15-16	7	2426	682	11	584	11	5	46	539	3	19	7	1	0	49	4390
16-17	6	2303	660	12	467	12	1	39	525	2	17	7	2	0	35	4088
17-18	10	2177	629	14	474	14	1	42	512	3	10	5	4	0	48	3943
QTR TOTALS	39	14433	3868	79	2867	89	19	299	3186	22	81	47	24	0	305	25358
18-19	11	1669	545	9	491	7	0	39	559	3	6	6	0	0	64	3409
19-20	9	1487	419	11	372	6	0	39	529	0	16	8	0	0	45	2941
20-21	5	1292	423	8	296	8	0	42	547	1	22	6	0	0	36	2686
21-22	7	1153	307	8	225	8	1	38	496	1	30	10	0	0	35	2319
22-23	6	976	268	7	130	11	0	27	502	0	55	7	1	0	19	2009
23-24	3	697	210	5	101	3	1	21	410	0	34	19	0	0	23	1527
QTR TOTALS	41	7274	2172	48	1615	43	2	206	3043	5	163	56	1	0	222	14891

	DAILY SUMMARY								VEHICLE COUNTS						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	111	34349	9578	210	6248	223	36	891	10786	43	515	251	38	0	832	64111
PERCENT	0.2	53.6	14.9	0.3	9.7	0.3	0.1	1.4	16.8	0.1	0.8	0.4	0.1	0.0	1.3	100.0

Site No 9904

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 004 Location : I-75, Alachua County Lane(s) : 1 2 3 4 5 6
DATE : 07/16/04 County : 026 State-ID : 12 Direction : 1 1 1 5 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	7	553	171	9	61	2	0	12	380	0	22	21	0	0	24	1262
1- 2	1	405	114	3	35	6	0	13	397	0	22	12	0	0	19	1027
2- 3	0	348	87	4	34	1	0	6	340	0	16	13	0	0	7	856
3- 4	1	310	87	7	47	0	0	15	318	1	42	13	0	0	8	849
4- 5	0	311	105	9	53	1	0	21	343	0	29	16	0	0	10	898
5- 6	3	549	183	12	73	11	0	17	345	1	34	17	0	0	14	1259
QTR TOTALS	12	2476	747	44	303	21	0	84	2123	2	165	92	0	0	82	6151
6- 7	5	964	354	15	126	10	0	26	330	0	22	18	0	0	18	1888
7- 8	6	1697	533	13	181	21	6	42	385	1	18	9	1	0	41	2954
8- 9	9	2024	582	10	247	14	3	48	385	4	10	5	1	0	39	3381
9-10	7	2305	671	9	313	21	3	46	411	1	15	7	1	0	51	3861
10-11	10	2780	789	13	426	13	2	51	473	2	12	14	1	0	43	4629
11-12	3	3170	864	14	483	16	2	43	513	7	10	13	0	0	41	5179
QTR TOTALS	40	12940	3793	74	1776	95	16	256	2497	15	87	66	4	0	233	21892
12-13	8	3245	892	16	592	18	5	48	488	3	9	15	6	0	56	5401
13-14	6	3180	955	10	667	22	5	53	482	1	13	8	3	0	59	5464
14-15	9	3356	987	27	713	22	1	34	456	1	11	10	2	0	58	5687
15-16	10	3372	1029	6	791	21	1	49	511	4	14	11	1	0	68	5888
16-17	7	3039	976	64	869	26	0	27	431	2	19	7	1	0	73	5541
17-18	7	2830	995	21	767	18	1	56	416	1	5	6	3	0	89	5215
QTR TOTALS	47	19022	5834	144	4399	127	13	267	2784	12	71	57	16	0	403	33196
18-19	4	2731	881	12	565	15	0	32	378	2	5	6	1	0	50	4682
19-20	8	2559	710	8	438	11	0	25	406	0	5	4	0	0	68	4242
20-21	4	2018	608	12	389	12	0	22	340	1	7	4	0	0	43	3460
21-22	4	1734	521	23	300	8	0	25	350	0	18	7	0	0	58	3048
22-23	3	1399	393	15	247	5	0	17	290	1	20	7	0	0	51	2448
23-24	1	1132	329	11	180	3	0	18	257	0	37	16	0	0	27	2011
QTR TOTALS	24	11573	3442	81	2119	54	0	139	2021	4	92	44	1	0	297	19891

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	123	46011	13816	343	8597	297	29	746	9425	33	415	259	21	0	1015	81130
PERCENT	0.2	56.7	17.0	0.4	10.6	0.4	0.0	0.9	11.6	0.0	0.5	0.3	0.0	0.0	1.3	100.0

Site No 9904

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 004 Location : I-75, Alachua County Lane(s) : 1 2 3 4 5 6
DATE : 07/18/04 County : 026 State-ID : 12 Direction : 1 1 1 5 5 5

	HOURLY SUMMARY / VEHICLE COUNTS															
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	2	690	170	11	72	4	0	6	100	0	5	3	0	0	11	1074
1- 2	1	464	110	5	37	6	0	8	91	0	8	4	0	0	12	746
2- 3	2	391	81	12	39	0	0	8	80	0	6	3	0	0	9	631
3- 4	2	339	72	3	28	3	0	2	61	0	3	5	0	0	7	525
4- 5	1	295	64	5	42	3	0	5	76	0	6	3	0	0	6	506
5- 6	1	401	83	4	35	2	0	2	77	0	3	2	0	0	14	624
QTR TOTALS	9	2580	580	40	253	18	0	31	485	0	31	20	0	0	59	4106
6- 7	1	677	163	5	54	4	0	3	79	1	5	2	0	0	4	998
7- 8	5	1068	237	3	79	3	0	6	108	0	4	6	0	0	10	1529
8- 9	4	1490	419	8	148	6	0	14	133	2	4	2	0	0	15	2245
9-10	4	2079	544	5	249	2	1	20	145	1	2	4	0	0	23	3079
10-11	5	2788	713	15	436	8	0	29	209	0	5	1	0	0	27	4236
11-12	6	3178	902	9	601	6	0	32	197	0	3	3	0	0	40	4977
QTR TOTALS	25	11280	2978	45	1567	29	1	104	871	4	23	18	0	0	119	17064
12-13	10	3329	949	25	778	6	0	23	233	2	5	6	6	0	94	5466
13-14	17	3381	958	12	784	10	0	30	229	1	7	2	0	0	70	5501
14-15	8	3181	906	35	924	8	1	20	247	0	4	4	0	0	50	5388
15-16	12	3865	1045	44	1138	5	0	30	292	1	7	2	0	0	79	6520
16-17	14	3392	975	29	1135	7	0	28	311	0	13	5	0	0	55	5964
17-18	8	3093	913	42	943	14	0	25	298	0	10	0	2	0	51	5399
QTR TOTALS	69	20241	5746	187	5702	50	1	156	1610	4	46	19	8	0	399	34238
18-19	14	2991	876	13	826	13	0	25	373	1	9	3	2	0	54	5200
19-20	14	2374	632	13	521	10	0	21	391	1	4	0	0	0	39	4020
20-21	5	2215	496	21	402	10	0	22	385	2	10	3	0	0	28	3599
21-22	4	1469	355	12	210	5	0	12	358	0	8	3	1	0	14	2451
22-23	5	1194	295	7	195	7	0	16	368	0	13	3	1	0	20	2124
23-24	4	882	217	8	154	1	1	14	314	1	12	2	0	0	20	1630
QTR TOTALS	46	11125	2871	74	2308	46	1	110	2189	5	56	14	4	0	175	19024

	DAILY SUMMARY / VEHICLE COUNTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	149	45226	12175	346	9830	143	3	401	5155	13	156	71	12	0	752	74432
PERCENT	0.2	60.8	16.4	0.5	13.2	0.2	0.0	0.5	6.9	0.0	0.2	0.1	0.0	0.0	1.0	100.0

Site No 9923

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 023 Location : I-95, Jacksonville Lane(s) : 1 2 3 4
DATE : 06/24/04 County : 072 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	687	164	5	21	12	0	13	179	1	5	6	0	0	2	1095
1- 2	0	456	115	3	16	8	0	13	172	1	6	8	0	0	3	801
2- 3	0	363	93	4	14	12	0	18	133	1	4	1	0	0	4	647
3- 4	1	264	86	3	14	9	0	12	174	0	5	5	0	0	0	573
4- 5	1	502	137	4	21	10	0	27	187	3	9	8	0	0	3	912
5- 6	0	1099	357	4	54	26	0	22	190	3	4	3	1	0	2	1765
QTR TOTALS	2	3371	952	23	140	77	0	105	1035	9	33	31	1	0	14	5793
6- 7	3	2617	833	12	80	50	0	39	228	7	5	8	2	0	3	3887
7- 8	4	3334	934	13	94	55	5	45	228	8	2	2	0	0	4	4728
8- 9	4	2979	927	9	123	48	3	48	282	7	6	4	2	0	6	4448
9-10	4	2798	956	12	105	55	3	68	296	3	3	2	0	0	8	4313
10-11	5	3087	934	12	120	60	0	73	302	6	7	1	2	0	9	4618
11-12	3	3112	1108	12	124	53	1	58	293	6	7	3	5	0	8	4793
QTR TOTALS	23	17927	5692	70	646	321	12	331	1629	37	30	20	11	0	38	26787
12-13	4	3319	1076	12	122	54	2	69	283	4	5	5	3	0	9	4967
13-14	5	3265	1053	10	135	53	6	73	286	4	1	2	0	0	12	4905
14-15	2	3556	1087	16	138	55	1	70	304	6	6	2	3	0	11	5257
15-16	9	3990	1207	13	120	56	4	59	265	5	5	3	4	0	13	5753
16-17	1	4110	1211	11	112	45	3	48	256	5	2	2	0	0	15	5821
17-18	5	4083	1102	15	95	41	5	49	194	1	1	1	2	0	4	5598
QTR TOTALS	26	22323	6736	77	722	304	21	368	1588	25	20	15	12	0	64	32301
18-19	3	3081	855	15	82	30	5	46	230	2	5	2	2	0	8	4366
19-20	6	2445	631	12	80	22	0	38	282	0	2	2	0	0	10	3530
20-21	3	2148	554	6	53	13	0	30	253	0	1	1	1	0	6	3069
21-22	1	2003	490	7	46	13	0	33	281	1	2	5	2	0	6	2890
22-23	1	1725	418	11	29	12	0	29	218	0	7	0	0	0	5	2455
23-24	1	1225	294	2	22	13	0	11	193	2	10	1	0	0	7	1781
QTR TOTALS	15	12627	3242	53	312	103	5	187	1457	5	27	11	5	0	42	18091

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	66	56248	16622	223	1820	805	38	991	5709	76	110	77	29	0	158	82972
PERCENT	0.1	67.8	20.0	0.3	2.2	1.0	0.0	1.2	6.9	0.1	0.1	0.1	0.0	0.0	0.2	100.0

Site No 9923

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 023 Location : I-95, Jacksonville Lane(s) : 1 2 3 4
DATE : 07/08/04 County : 072 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	663	175	8	27	8	0	18	218	1	8	5	0	0	3	1135
1- 2	1	432	119	4	14	7	0	18	197	0	8	6	0	0	3	809
2- 3	0	375	98	4	16	7	0	11	146	0	3	3	0	0	1	664
3- 4	0	318	109	5	14	8	0	13	167	1	3	7	0	0	1	646
4- 5	3	470	151	9	27	5	0	15	186	2	6	11	0	0	2	887
5- 6	0	1110	353	6	41	26	0	26	178	0	3	6	1	0	5	1755
QTR TOTALS	5	3368	1005	36	139	61	0	101	1092	4	31	38	1	0	15	5896
6- 7	1	2602	852	10	84	73	0	37	194	3	6	5	3	0	6	3876
7- 8	3	3178	884	15	119	65	3	40	195	1	2	4	4	0	25	4538
8- 9	2	2942	864	11	117	63	6	58	244	9	4	3	1	0	8	4332
9-10	2	2823	928	15	131	66	6	60	279	8	2	2	1	0	2	4325
10-11	2	3122	1059	11	139	59	5	63	308	9	6	5	3	0	6	4797
11-12	4	3261	1038	16	147	50	3	64	345	5	3	0	3	0	10	4949
QTR TOTALS	14	17928	5625	78	737	376	23	322	1565	35	23	19	15	0	57	26817
12-13	5	3411	1110	19	122	47	5	60	274	4	7	3	2	0	19	5088
13-14	6	3390	1113	12	115	49	5	63	304	1	0	4	4	0	11	5077
14-15	0	3263	1138	14	107	53	5	59	269	6	3	3	0	0	8	4928
15-16	2	3863	1296	16	136	36	2	74	274	1	5	4	2	0	13	5724
16-17	2	3775	1125	18	97	30	0	51	223	3	4	1	2	0	8	5339
17-18	2	3053	782	7	77	28	0	33	188	4	3	0	2	0	4	4183
QTR TOTALS	17	20755	6564	86	654	243	17	340	1532	19	22	15	12	0	63	30339
18-19	0	2954	844	12	74	14	0	45	287	6	2	0	1	0	6	4245
19-20	1	2376	622	13	61	14	0	35	280	2	4	1	0	0	5	3414
20-21	2	1964	468	6	49	19	0	35	257	0	1	2	1	0	3	2807
21-22	2	1637	449	7	33	16	0	32	252	1	3	7	0	0	9	2448
22-23	0	1360	342	10	30	1	0	19	237	1	4	3	0	0	6	2013
23-24	0	1230	287	3	22	5	0	22	193	0	9	1	0	0	3	1775
QTR TOTALS	5	11521	3012	51	269	69	0	188	1506	10	23	14	2	0	32	16702

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	41	53572	16206	251	1799	749	40	951	5695	68	99	86	30	0	167	79754
PERCENT	0.1	67.2	20.3	0.3	2.3	0.9	0.1	1.2	7.1	0.1	0.1	0.1	0.0	0.0	0.2	100.0

Site No 9920

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 020 Location : I-75, Sumter County Lane(s) : 1 2 3 4
DATE : 09/15/03 County : 018 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	283	75	1	8	6	0	7	219	0	6	0	0	0	9	614
1- 2	4	185	42	1	12	12	0	6	207	1	8	4	0	0	8	490
2- 3	1	131	38	1	11	5	1	8	205	0	7	3	0	0	7	418
3- 4	4	99	44	0	18	9	0	7	261	1	7	2	0	0	13	465
4- 5	4	189	75	3	22	17	1	14	279	1	15	2	0	0	9	631
5- 6	3	308	169	0	21	13	1	24	320	3	2	0	0	0	21	885
QTR TOTALS	16	1195	443	6	92	62	3	66	1491	6	45	11	0	0	67	3503
6- 7	5	646	261	5	43	15	4	24	312	0	2	1	0	0	11	1329
7- 8	4	923	310	3	45	20	10	27	319	1	6	0	0	0	23	1691
8- 9	4	988	301	5	63	22	10	29	344	3	1	0	0	0	27	1797
9-10	6	1069	329	2	88	29	7	41	402	7	5	1	1	0	38	2025
10-11	1	1284	389	1	69	19	7	39	476	1	5	2	2	0	28	2323
11-12	7	1309	375	3	90	22	9	31	455	1	1	0	0	0	38	2341
QTR TOTALS	27	6219	1965	19	398	127	47	191	2308	13	20	4	3	0	165	11506
12-13	6	1199	350	8	92	36	7	33	481	1	2	3	0	0	38	2256
13-14	1	1136	321	2	74	15	9	30	471	4	13	0	5	0	33	2114
14-15	2	1141	339	6	79	22	16	32	420	3	1	0	1	0	35	2097
15-16	4	1138	366	2	74	23	7	31	389	2	1	0	2	0	34	2073
16-17	1	1186	375	6	61	22	5	23	451	6	5	0	0	0	38	2179
17-18	3	1115	292	5	65	24	0	19	357	4	5	1	0	0	29	1919
QTR TOTALS	17	6915	2043	29	445	142	44	168	2569	20	27	4	8	0	207	12638
18-19	4	878	287	3	50	20	0	21	378	2	1	1	1	0	29	1675
19-20	1	641	194	2	35	14	0	21	339	3	4	2	0	0	18	1274
20-21	0	540	164	1	24	17	0	9	296	0	16	1	0	0	20	1088
21-22	3	413	110	3	16	10	1	15	265	1	26	4	0	0	13	880
22-23	2	336	70	1	17	6	0	9	270	1	28	8	0	0	12	760
23-24	3	243	62	2	12	3	0	7	247	1	15	9	0	0	12	616
QTR TOTALS	13	3051	887	12	154	70	1	82	1795	8	90	25	1	0	104	6293

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	73	17380	5338	66	1089	401	95	507	8163	47	182	44	12	0	543	33940
PERCENT	0.2	51.2	15.7	0.2	3.2	1.2	0.3	1.5	24.1	0.1	0.5	0.1	0.0	0.0	1.6	100.0

Site No 9920

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 020 Location : I-75, Sumter County Lane(s) : 1 2 3 4
DATE : 09/16/03 County : 018 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	167	44	0	9	8	0	9	202	0	12	14	0	0	10	475
1- 2	2	106	34	0	14	4	0	6	198	0	12	7	0	0	10	393
2- 3	3	83	28	2	7	6	0	13	186	0	11	6	0	0	10	355
3- 4	2	98	29	0	18	4	1	14	244	0	20	5	0	0	14	449
4- 5	3	132	50	1	26	8	0	26	272	0	15	2	0	0	12	547
5- 6	1	271	117	1	30	9	3	31	289	4	23	9	0	0	10	798
QTR TOTALS	11	857	302	4	104	39	4	99	1391	4	93	43	0	0	66	3017
6- 7	5	488	226	3	43	15	2	26	298	3	10	5	2	0	15	1141
7- 8	2	747	264	1	63	11	1	25	302	2	6	4	0	0	22	1450
8- 9	2	796	325	2	102	16	6	39	352	4	6	1	4	0	27	1682
9-10	4	964	321	5	63	12	7	34	378	4	3	2	1	0	39	1837
10-11	3	1037	299	3	107	16	7	36	457	9	3	1	1	0	21	2000
11-12	5	1033	326	4	97	24	5	40	459	8	2	0	2	0	45	2050
QTR TOTALS	21	5065	1761	18	475	94	28	200	2246	30	30	13	10	0	169	10160
12-13	8	957	283	3	74	25	8	31	479	4	3	2	0	0	25	1902
13-14	6	1007	306	2	100	18	7	33	427	10	6	0	1	0	30	1953
14-15	3	1035	309	3	83	13	9	43	443	6	1	0	1	0	25	1974
15-16	4	1111	333	5	69	25	6	37	423	1	0	0	1	0	41	2056
16-17	2	1190	341	3	72	16	5	33	391	1	1	4	0	0	38	2097
17-18	6	1117	308	5	61	18	0	24	377	2	10	4	1	0	25	1958
QTR TOTALS	29	6417	1880	21	459	115	35	201	2540	24	21	10	4	0	184	11940
18-19	7	810	220	4	59	28	1	14	379	3	4	1	0	0	19	1549
19-20	3	649	229	2	45	7	0	16	328	0	1	1	0	0	13	1294
20-21	1	490	151	2	32	9	0	10	271	1	9	3	0	0	23	1002
21-22	2	418	133	3	19	7	0	15	303	0	24	4	0	0	15	943
22-23	4	298	72	3	23	9	0	8	304	0	28	11	0	0	15	775
23-24	3	257	53	0	17	11	0	18	274	0	20	11	0	0	13	677
QTR TOTALS	20	2922	858	14	195	71	1	81	1859	4	86	31	0	0	98	6240

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	81	15261	4801	57	1233	319	68	581	8036	62	230	97	14	0	517	31357
PERCENT	0.3	48.7	15.3	0.2	3.9	1.0	0.2	1.9	25.6	0.2	0.7	0.3	0.0	0.0	1.6	100.0

Site No 9920

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 020 Location : I-75, Sumter County Lane(s) : 1 2 3 4
DATE : 09/17/03 County : 018 State-ID : 12 Direction : 5 5 1 1

	HOURLY SUMMARY								VEHICLE COUNTS						
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	6	153	46	0	9	7	0	9	219	0	8	8	0	0	10	475
1- 2	3	107	28	1	6	9	0	4	233	0	9	5	0	0	7	412
2- 3	3	95	27	1	8	7	0	16	197	0	17	16	0	0	8	395
3- 4	4	95	34	2	13	7	0	16	230	0	12	1	0	0	11	425
4- 5	2	111	32	1	10	8	1	19	285	2	11	4	0	0	19	505
5- 6	0	249	111	0	29	12	1	26	310	1	26	3	1	0	8	777
QTR TOTALS	18	810	278	5	75	50	2	90	1474	3	83	37	1	0	63	2989
6- 7	6	562	260	2	39	20	6	31	350	4	8	3	0	0	10	1301
7- 8	1	774	280	3	60	14	1	28	372	2	6	6	0	0	19	1566
8- 9	0	803	303	5	80	11	6	29	358	3	4	2	0	0	30	1634
9-10	5	941	310	1	91	12	6	29	398	2	1	0	1	0	37	1834
10-11	10	1006	336	4	73	25	5	26	480	2	6	2	0	0	33	2008
11-12	3	1050	302	4	83	23	6	35	465	6	5	0	0	0	47	2029
QTR TOTALS	25	5136	1791	19	426	105	30	178	2423	19	30	13	1	0	176	10372
12-13	5	963	263	7	58	17	7	35	503	3	3	2	0	0	40	1906
13-14	7	978	308	3	83	25	6	44	511	3	5	1	0	0	28	2002
14-15	4	1098	360	4	86	30	6	32	415	2	3	2	0	0	30	2072
15-16	6	1182	373	1	74	28	7	39	448	2	0	2	2	0	34	2198
16-17	4	1185	364	3	76	18	2	31	410	3	2	3	1	0	28	2130
17-18	5	1119	361	0	66	31	0	23	423	2	6	3	2	0	34	2075
QTR TOTALS	31	6525	2029	18	443	149	28	204	2710	15	19	13	5	0	194	12383
18-19	4	913	244	5	33	13	0	24	381	4	1	0	0	0	23	1645
19-20	2	708	211	3	32	9	0	18	298	1	7	3	2	0	27	1321
20-21	3	552	170	1	30	11	0	14	317	0	8	5	0	0	22	1133
21-22	4	457	112	2	30	6	0	14	260	2	20	6	0	0	22	935
22-23	2	354	82	3	22	5	0	9	273	1	32	11	0	0	20	814
23-24	1	220	68	0	14	4	0	12	285	0	17	12	0	0	12	645
QTR TOTALS	16	3204	887	14	161	48	0	91	1814	8	85	37	2	0	126	6493

	DAILY SUMMARY								VEHICLE COUNTS						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	90	15675	4985	56	1105	352	60	563	8421	45	217	100	9	0	559	32237
PERCENT	0.3	48.6	15.5	0.2	3.4	1.1	0.2	1.7	26.1	0.1	0.7	0.3	0.0	0.0	1.7	100.0

Site No 0352

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 352 Location : I-10, Suwannee Lane(s) : 1
DATE : 07/14/03 County : 037 State-ID : 12 Direction : 3

	HOURLY SUMMARY								VEHICLE COUNTS							
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	80	28	0	2	0	0	2	106	0	0	1	0	0	2	221
1- 2	0	66	17	3	2	2	0	2	80	0	0	1	0	0	4	177
2- 3	0	50	14	1	3	1	0	0	96	1	2	0	0	0	0	168
3- 4	0	42	18	3	3	1	0	1	74	0	1	1	0	0	1	145
4- 5	0	54	18	0	4	1	0	2	85	0	1	0	0	0	0	165
5- 6	0	67	28	4	3	1	0	5	76	0	2	0	0	0	6	192
QTR TOTALS	0	359	123	11	17	6	0	12	517	1	6	3	0	0	13	1068
6- 7	1	108	37	5	3	2	0	4	87	0	1	0	0	0	0	248
7- 8	0	159	47	2	7	3	0	2	91	2	0	2	0	0	0	315
8- 9	0	219	54	1	6	4	0	9	82	0	1	0	0	0	4	380
9-10	4	282	57	0	17	6	0	8	72	0	1	1	1	0	1	450
10-11	1	305	89	2	14	3	0	8	80	1	1	1	0	0	3	508
11-12	3	300	78	1	7	3	0	10	98	0	2	1	1	0	4	508
QTR TOTALS	9	1373	362	11	54	21	0	41	510	3	6	5	2	0	12	2409
12-13	0	361	76	2	19	3	0	10	75	2	3	1	0	0	2	554
13-14	1	360	108	2	9	3	1	5	83	0	2	0	2	0	2	578
14-15	0	359	92	2	10	3	0	7	92	2	2	2	0	0	2	573
15-16	2	315	108	0	22	3	0	5	70	0	2	0	0	0	4	531
16-17	2	324	90	0	23	3	0	10	90	1	1	0	0	0	2	546
17-18	0	296	97	1	18	1	0	7	76	0	1	1	0	0	0	498
QTR TOTALS	5	2015	571	7	101	16	1	44	486	5	11	4	2	0	12	3280
18-19	0	246	68	2	17	2	0	9	88	1	2	2	0	0	2	439
19-20	0	196	59	1	11	3	0	4	86	0	7	0	0	0	1	368
20-21	3	135	45	1	6	4	0	4	118	0	4	1	0	0	1	322
21-22	1	128	39	2	17	1	0	6	74	0	5	0	0	0	4	277
22-23	4	98	33	0	3	4	0	4	87	0	3	1	0	0	2	239
23-24	2	65	15	4	1	2	0	5	81	0	2	2	0	0	1	180
QTR TOTALS	10	868	259	10	55	16	0	32	534	1	23	6	0	0	11	1825

	DAILY SUMMARY							VEHICLE COUNTS							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	24	4615	1315	39	227	59	1	129	2047	10	46	18	4	0	48	8582
PERCENT	0.3	53.8	15.3	0.5	2.6	0.7	0.0	1.5	23.9	0.1	0.5	0.2	0.0	0.0	0.6	100.0

Site No 0352

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 352 Location : I-10, Suwannee Lane(s) : 1
DATE : 07/15/03 County : 037 State-ID : 12 Direction : 3

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	51	16	0	4	2	6	2	88	0	1	1	0	0	1	173
1- 2	0	39	16	0	8	2	0	1	53	0	1	0	0	0	1	121
2- 3	0	36	14	3	1	0	0	5	55	1	1	0	0	0	0	116
3- 4	0	35	10	0	3	2	1	1	62	0	2	1	0	0	1	118
4- 5	1	29	11	0	3	2	1	5	65	0	4	5	0	0	5	131
5- 6	1	47	14	1	3	1	2	5	69	1	1	0	0	0	0	145
QTR TOTALS	3	237	81	4	22	9	10	19	392	2	10	7	0	0	8	804
6- 7	0	75	31	0	5	1	0	7	63	2	3	1	0	0	1	189
7- 8	1	112	45	2	8	2	0	7	82	1	2	1	1	0	1	265
8- 9	0	167	48	2	13	3	2	6	82	2	0	0	0	0	0	325
9-10	1	199	55	1	8	2	0	8	99	0	5	0	0	0	0	378
10-11	3	259	52	5	19	7	0	9	85	0	0	0	0	0	2	441
11-12	3	256	78	4	14	3	0	14	100	2	2	0	0	0	0	476
QTR TOTALS	8	1068	309	14	67	18	2	51	511	7	12	2	1	0	4	2074
12-13	2	286	85	4	17	4	0	9	85	1	2	1	1	0	3	500
13-14	0	308	75	1	15	0	0	10	108	0	1	1	0	0	2	521
14-15	0	313	72	0	25	2	0	15	92	1	3	0	1	0	3	527
15-16	1	270	81	2	18	4	0	14	92	1	4	1	0	0	3	491
16-17	2	303	93	1	10	4	0	3	122	0	3	0	2	0	5	548
17-18	1	279	84	2	16	4	0	6	106	2	2	1	1	0	0	504
QTR TOTALS	6	1759	490	10	101	18	0	57	605	5	15	4	5	0	16	3091
18-19	5	225	55	1	16	7	0	4	99	0	2	1	1	0	3	419
19-20	1	172	52	3	15	2	0	5	116	1	4	3	0	0	3	377
20-21	1	148	55	0	10	2	0	6	105	0	6	5	0	0	1	339
21-22	0	105	31	0	12	0	0	5	109	0	6	1	1	0	4	274
22-23	2	95	19	0	5	4	0	1	100	1	1	2	0	0	1	231
23-24	2	63	20	1	8	4	1	5	104	3	3	2	1	0	2	219
QTR TOTALS	11	808	232	5	66	19	1	26	633	5	22	14	3	0	14	1859

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	28	3872	1112	33	256	64	13	153	2141	19	59	27	9	0	42	7828
PERCENT	0.4	49.5	14.2	0.4	3.3	0.8	0.2	2.0	27.4	0.2	0.8	0.3	0.1	0.0	0.5	100.0

Site No 0352

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 352 Location : I-10, Suwannee Lane(s) : 1
DATE : 07/16/03 County : 037 State-ID : 12 Direction : 3

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	51	13	0	2	1	0	0	93	0	1	1	0	0	3	165
1- 2	0	45	10	3	2	0	0	5	80	0	2	0	0	0	2	149
2- 3	0	30	8	0	3	0	0	7	69	0	2	3	0	0	0	122
3- 4	0	36	10	0	1	0	0	3	58	0	2	1	0	0	3	114
4- 5	0	36	10	0	3	1	0	1	83	1	2	1	0	0	0	138
5- 6	0	43	20	1	5	0	0	4	79	0	6	2	0	0	1	161
QTR TOTALS	0	241	71	4	16	2	0	20	462	1	15	8	0	0	9	849
6- 7	1	72	35	1	8	3	0	2	81	3	1	0	0	0	1	208
7- 8	1	106	50	4	7	1	0	8	77	2	4	1	0	0	1	262
8- 9	0	147	51	0	6	0	0	5	90	1	2	1	0	0	3	306
9-10	0	196	69	2	9	2	0	6	102	0	3	2	0	0	4	395
10-11	0	219	73	2	11	3	0	5	106	0	0	1	0	0	2	422
11-12	2	271	73	2	17	5	0	11	84	1	1	0	0	0	3	470
QTR TOTALS	4	1011	351	11	58	14	0	37	540	7	11	5	0	0	14	2063
12-13	1	247	68	1	19	5	0	12	100	1	6	0	1	0	2	463
13-14	1	316	86	2	17	3	0	5	60	3	3	0	0	0	5	501
14-15	0	306	89	2	28	0	0	6	72	0	2	0	1	0	3	509
15-16	3	321	97	0	12	9	0	7	96	0	3	0	0	0	1	549
16-17	1	317	79	2	20	2	0	5	106	3	3	1	0	0	7	546
17-18	2	256	81	2	22	6	0	5	112	2	3	2	0	0	4	497
QTR TOTALS	8	1763	500	9	118	25	0	40	546	9	20	3	2	0	22	3065
18-19	0	243	53	2	12	1	0	9	94	0	1	1	0	0	2	418
19-20	2	208	56	2	7	2	0	4	105	1	10	4	0	0	3	404
20-21	1	144	45	0	7	2	0	5	101	0	7	1	0	0	2	315
21-22	0	114	35	0	9	3	0	4	103	2	7	3	0	0	1	281
22-23	2	104	26	0	7	3	1	4	81	0	3	1	0	0	1	233
23-24	2	83	24	1	5	4	1	6	103	1	2	2	0	0	3	237
QTR TOTALS	7	896	239	5	47	15	2	32	587	4	30	12	0	0	12	1888

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	19	3911	1161	29	239	56	2	129	2135	21	76	28	2	0	57	7865
PERCENT	0.2	49.7	14.8	0.4	3.0	0.7	0.0	1.6	27.1	0.3	1.0	0.4	0.0	0.0	0.7	100.0

Site No 9901

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 001 Location : I-10, Jefferson County Lane(s) : 1 2 3 4
DATE : 07/14/03 County : 054 State-ID : 12 Direction : 3 3 7 7

	HOURLY SUMMARY / VEHICLE COUNTS															
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	279	73	2	9	2	0	7	140	1	1	2	0	0	7	524
1- 2	0	169	46	6	7	2	0	1	147	1	2	0	0	0	1	382
2- 3	0	139	57	3	4	0	0	1	123	0	3	0	0	0	6	336
3- 4	0	142	46	6	9	2	0	3	117	0	0	1	0	0	2	328
4- 5	1	137	41	5	14	2	0	8	125	0	3	0	0	0	3	339
5- 6	0	178	94	9	10	2	0	11	137	0	2	1	0	0	4	448
QTR TOTALS	2	1044	357	31	53	10	0	31	789	2	11	4	0	0	23	2357
6- 7	0	322	111	4	26	1	0	17	107	1	3	2	0	0	6	600
7- 8	0	524	173	0	26	6	0	19	133	0	1	0	0	0	5	887
8- 9	0	655	211	2	40	4	0	21	149	0	7	3	0	0	3	1095
9-10	5	820	253	6	49	14	0	22	145	4	3	0	0	0	4	1325
10-11	0	920	305	6	46	9	0	17	170	1	4	2	1	0	5	1486
11-12	0	1104	324	6	48	5	0	22	178	2	5	2	0	0	8	1704
QTR TOTALS	5	4345	1377	24	235	39	0	118	882	8	23	9	1	0	31	7097
12-13	2	1148	356	5	45	3	0	21	192	3	6	1	2	0	10	1794
13-14	0	1091	333	6	46	3	1	31	222	2	3	2	1	0	7	1748
14-15	2	1123	365	2	60	5	0	18	224	2	5	0	0	0	8	1814
15-16	0	1161	376	4	50	5	0	18	212	3	4	2	1	0	10	1846
16-17	2	1080	296	2	44	3	1	15	231	1	1	0	0	0	8	1684
17-18	0	913	274	5	49	2	0	22	220	1	3	3	0	0	6	1498
QTR TOTALS	6	6516	2000	24	294	21	2	125	1301	12	22	8	4	0	49	10384
18-19	1	774	220	5	37	6	0	17	279	2	4	1	1	0	7	1354
19-20	1	576	186	2	27	5	0	13	275	0	12	1	0	0	9	1107
20-21	1	472	142	6	24	0	0	10	261	0	4	1	0	0	11	932
21-22	1	430	109	4	19	4	0	11	218	0	5	2	1	0	2	806
22-23	0	273	95	7	9	1	0	7	216	2	2	1	0	0	5	618
23-24	0	212	63	6	10	0	1	12	198	0	8	2	0	0	1	513
QTR TOTALS	4	2737	815	30	126	16	1	70	1447	4	35	8	2	0	35	5330

	DAILY SUMMARY / VEHICLE COUNTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	17	14642	4549	109	708	86	3	344	4419	26	91	29	7	0	138	25168
PERCENT	0.1	58.2	18.1	0.4	2.8	0.3	0.0	1.4	17.6	0.1	0.4	0.1	0.0	0.0	0.5	100.0

Site No 9901

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 001 Location : I-10, Jefferson County Lane(s) : 1 2 3 4
DATE : 07/15/03 County : 054 State-ID : 12 Direction : 3 3 7 7

	HOURLY SUMMARY / VEHICLE COUNTS															
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	153	43	1	12	2	5	8	154	0	6	1	0	0	4	390
1- 2	0	111	22	5	3	2	0	12	134	1	6	4	0	0	2	302
2- 3	0	104	30	1	8	1	2	6	118	0	3	3	0	0	4	280
3- 4	0	77	25	0	11	3	0	9	119	0	9	5	0	0	0	258
4- 5	0	91	28	3	12	3	3	10	119	0	6	3	0	0	2	280
5- 6	1	116	52	3	15	2	0	5	126	0	7	3	0	0	3	333
QTR TOTALS	2	652	200	13	61	13	10	50	770	1	37	19	0	0	15	1843
6- 7	0	237	99	1	22	3	0	14	145	3	7	2	0	0	2	535
7- 8	1	399	125	4	31	3	3	15	169	2	10	3	0	0	4	769
8- 9	0	543	189	2	33	7	0	18	195	2	9	0	0	0	5	1003
9-10	0	644	229	2	48	5	0	22	197	0	2	0	1	0	9	1159
10-11	2	746	221	8	47	7	0	23	214	2	1	1	2	0	6	1280
11-12	0	885	256	7	49	0	0	25	214	2	8	3	0	0	7	1456
QTR TOTALS	3	3454	1119	24	230	25	3	117	1134	11	37	9	3	0	33	6202
12-13	0	931	285	2	43	3	0	22	238	4	6	2	1	0	10	1547
13-14	0	1041	261	3	45	6	0	22	241	2	6	2	1	0	9	1639
14-15	1	979	287	2	66	4	0	31	229	2	7	0	0	0	12	1620
15-16	1	1026	311	1	49	4	0	19	259	3	5	5	2	0	7	1692
16-17	0	952	290	1	46	10	0	13	264	4	3	2	1	0	7	1593
17-18	1	849	259	5	41	9	0	22	237	1	6	1	2	0	7	1440
QTR TOTALS	3	5778	1693	14	290	36	0	129	1468	16	33	12	7	0	52	9531
18-19	1	688	204	3	38	7	0	17	300	4	2	2	0	0	7	1273
19-20	1	564	178	3	30	4	0	15	275	2	7	6	1	0	11	1097
20-21	2	407	127	3	23	1	0	12	273	3	5	2	0	0	5	863
21-22	2	328	117	5	17	8	0	11	250	1	7	2	1	0	5	754
22-23	0	286	87	4	18	6	0	7	213	1	1	4	1	0	5	633
23-24	0	218	66	2	6	1	0	8	210	2	7	3	0	0	4	527
QTR TOTALS	6	2491	779	20	132	27	0	70	1521	13	29	19	3	0	37	5147

	DAILY SUMMARY / VEHICLE COUNTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	14	12375	3791	71	713	101	13	366	4893	41	136	59	13	0	137	22723
PERCENT	0.1	54.5	16.7	0.3	3.1	0.4	0.1	1.6	21.5	0.2	0.6	0.3	0.1	0.0	0.6	100.0

Site No 9901

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 001 Location : I-10, Jefferson County Lane(s) : 1 2 3 4
DATE : 07/16/03 County : 054 State-ID : 12 Direction : 3 3 7 7

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	148	37	4	8	3	0	8	160	0	10	2	0	0	2	382
1- 2	0	98	42	5	4	1	0	8	142	0	7	2	0	0	5	314
2- 3	0	79	25	1	9	1	0	7	121	0	1	6	0	0	7	257
3- 4	0	80	26	2	6	3	0	5	109	0	7	2	0	0	1	241
4- 5	0	81	29	4	12	0	0	6	138	0	7	4	0	0	4	285
5- 6	0	105	45	3	12	1	0	10	156	1	7	2	0	0	3	345
QTR TOTALS	0	591	204	19	51	9	0	44	826	1	39	18	0	0	22	1824
6- 7	0	224	98	1	16	2	0	11	154	3	9	1	1	0	4	524
7- 8	0	412	134	4	28	0	0	9	160	3	6	2	0	0	8	766
8- 9	0	518	193	4	37	0	0	19	191	2	9	0	1	0	4	978
9-10	1	638	219	3	39	9	0	12	196	5	2	4	0	0	9	1137
10-11	1	785	233	4	45	12	0	20	228	2	4	2	0	0	8	1344
11-12	0	859	291	5	47	4	0	19	226	0	9	4	1	0	9	1474
QTR TOTALS	2	3436	1168	21	212	27	0	90	1155	15	39	13	3	0	42	6223
12-13	2	977	311	0	43	9	0	17	233	2	11	2	1	0	8	1616
13-14	0	1024	286	5	54	4	0	13	230	3	8	1	1	0	11	1640
14-15	0	1052	369	6	48	6	0	20	238	1	3	2	1	0	6	1752
15-16	2	1031	323	5	55	6	0	17	276	4	5	4	0	0	10	1738
16-17	1	985	315	3	52	7	0	14	264	1	2	1	0	0	11	1656
17-18	1	933	284	2	46	5	0	18	293	2	4	3	0	0	5	1596
QTR TOTALS	6	6002	1888	21	298	37	0	99	1534	13	33	13	3	0	51	9998
18-19	0	809	216	5	34	0	0	16	264	3	6	2	0	0	5	1360
19-20	4	557	177	1	22	4	0	12	267	0	8	2	0	0	5	1059
20-21	2	495	148	0	20	3	0	15	240	3	9	4	0	0	6	945
21-22	0	390	93	3	18	7	1	7	226	0	7	3	0	0	4	759
22-23	0	289	89	4	18	4	1	15	210	2	4	2	0	0	4	642
23-24	0	264	65	4	14	1	0	12	182	0	3	4	0	0	9	558
QTR TOTALS	6	2804	788	17	126	19	2	77	1389	8	37	17	0	0	33	5323

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	14	12833	4048	78	687	92	2	310	4904	37	148	61	6	0	148	23368
PERCENT	0.1	54.9	17.3	0.3	2.9	0.4	0.0	1.3	21.0	0.2	0.6	0.3	0.0	0.0	0.6	100.0

Site No 9907

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 007 Location : US-231, Bay County Lane(s) : 1 2 3 4
DATE : 06/09/03 County : 046 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	94	22	0	2	0	0	2	8	0	0	0	0	0	2	130
1- 2	0	43	8	0	1	0	0	0	11	0	0	0	0	0	1	64
2- 3	0	45	7	0	2	0	0	0	7	0	0	0	0	0	2	63
3- 4	0	38	11	0	3	1	0	1	11	0	0	0	0	0	2	67
4- 5	0	89	32	0	5	1	0	0	29	1	0	0	0	0	0	157
5- 6	0	286	93	0	14	2	0	2	46	0	1	0	0	0	4	448
QTR TOTALS	0	595	173	0	27	4	0	5	112	1	1	0	0	0	11	929
6- 7	0	556	166	2	25	4	0	12	43	0	0	0	0	0	14	822
7- 8	0	611	153	1	28	7	0	9	59	0	0	0	0	0	19	887
8- 9	0	536	190	2	22	3	3	12	53	0	1	0	0	0	15	837
9-10	1	585	246	3	43	2	3	14	71	2	0	0	0	0	30	1000
10-11	0	623	259	7	40	5	0	10	55	0	0	0	0	0	16	1015
11-12	0	610	247	2	22	4	0	12	59	1	0	0	0	0	13	970
QTR TOTALS	1	3521	1261	17	180	25	6	69	340	3	1	0	0	0	107	5531
12-13	0	640	248	1	28	5	0	4	44	2	0	0	0	0	6	978
13-14	0	587	231	1	20	9	0	8	38	0	0	0	0	0	6	900
14-15	0	658	231	0	34	7	0	12	48	1	0	0	0	0	15	1006
15-16	0	652	271	2	28	2	0	16	52	0	0	0	0	0	16	1039
16-17	0	711	271	1	23	5	0	16	41	1	0	0	0	0	14	1083
17-18	1	701	267	1	29	5	0	4	37	1	0	0	0	0	13	1059
QTR TOTALS	1	3949	1519	6	162	33	0	60	260	5	0	0	0	0	70	6065
18-19	0	553	178	0	22	3	0	6	30	2	2	0	0	0	13	809
19-20	0	374	130	2	7	0	0	3	18	0	0	0	0	0	9	543
20-21	0	275	72	0	10	1	0	1	21	1	1	0	0	0	3	385
21-22	1	209	58	0	8	0	0	2	16	0	0	0	0	0	8	302
22-23	0	150	47	0	5	0	0	3	11	0	0	0	0	0	3	219
23-24	0	122	38	1	1	0	0	3	13	0	0	0	0	0	3	181
QTR TOTALS	1	1683	523	3	53	4	0	18	109	3	3	0	0	0	39	2439

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	3	9748	3476	26	422	66	6	152	821	12	5	0	0	0	227	14964
PERCENT	0.0	65.1	23.2	0.2	2.8	0.4	0.0	1.0	5.5	0.1	0.0	0.0	0.0	0.0	1.5	100.0

Site No 9907

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 007 Location : US-231, Bay County Lane(s) : 1 2 3 4
DATE : 06/10/03 County : 046 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	62	18	0	0	0	0	0	11	0	0	0	0	0	1	92
1- 2	0	48	8	0	1	0	0	2	13	0	1	0	0	0	0	73
2- 3	0	35	7	0	1	0	0	2	7	0	0	0	0	0	0	52
3- 4	0	58	15	0	3	0	0	0	21	0	1	0	0	0	3	101
4- 5	0	88	22	0	3	1	0	2	19	0	0	0	0	0	5	140
5- 6	0	262	91	1	12	3	0	2	40	0	1	0	0	0	7	419
QTR TOTALS	0	553	161	1	20	4	0	8	111	0	3	0	0	0	16	877
6- 7	1	539	148	1	29	1	0	7	56	0	0	0	0	0	16	798
7- 8	0	575	175	0	24	6	0	7	62	2	0	0	0	0	19	870
8- 9	1	495	151	3	34	3	6	9	73	2	0	0	0	0	15	792
9-10	0	554	200	2	27	4	0	12	79	0	0	0	0	0	11	889
10-11	0	557	192	2	26	3	0	6	65	0	1	0	0	0	11	863
11-12	0	507	234	3	30	2	0	16	61	2	1	0	0	0	15	871
QTR TOTALS	2	3227	1100	11	170	19	6	57	396	6	2	0	0	0	87	5083
12-13	0	509	207	1	32	1	0	9	53	0	0	0	0	0	17	829
13-14	1	548	212	4	32	2	0	13	46	1	0	0	0	0	6	865
14-15	1	555	214	0	25	6	0	13	41	2	0	0	0	0	12	869
15-16	0	586	246	2	31	5	0	10	45	1	0	0	0	0	2	928
16-17	0	662	264	0	28	6	0	11	40	1	1	0	0	0	1	1014
17-18	2	651	224	0	41	5	0	12	33	1	1	0	0	0	5	975
QTR TOTALS	4	3511	1367	7	189	25	0	68	258	6	2	0	0	0	43	5480
18-19	0	525	192	2	16	2	0	9	23	0	0	0	0	0	7	776
19-20	0	408	136	0	4	3	0	3	30	0	0	0	0	0	3	587
20-21	1	286	88	0	6	0	0	3	11	0	1	0	0	0	5	401
21-22	0	220	79	1	5	2	0	2	11	0	0	0	0	0	5	325
22-23	0	137	45	0	1	0	0	0	17	0	0	0	0	0	1	201
23-24	0	110	34	0	3	0	0	3	14	0	0	0	0	0	3	167
QTR TOTALS	1	1686	574	3	35	7	0	20	106	0	1	0	0	0	24	2457

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	7	8977	3202	22	414	55	6	153	871	12	8	0	0	0	170	13897
PERCENT	0.1	64.6	23.0	0.2	3.0	0.4	0.0	1.1	6.3	0.1	0.1	0.0	0.0	0.0	1.2	100.0

Site No 9907

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 007 Location : US-231, Bay County Lane(s) : 1 2 3 4
DATE : 06/11/03 County : 046 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	60	14	0	5	0	0	1	10	0	0	0	0	0	2	92
1- 2	0	49	16	0	3	0	0	2	10	0	1	0	0	0	4	85
2- 3	0	34	8	0	2	0	0	0	4	0	0	0	0	0	2	50
3- 4	0	53	13	0	2	0	0	2	7	0	1	0	0	0	2	80
4- 5	0	97	21	0	7	0	0	1	19	0	0	0	0	0	2	147
5- 6	0	250	87	1	16	8	0	1	29	0	2	0	0	0	8	402
QTR TOTALS	0	543	159	1	35	8	0	7	79	0	4	0	0	0	20	856
6- 7	1	556	148	1	33	5	0	11	45	1	0	0	0	0	14	815
7- 8	0	561	156	0	26	4	0	10	51	1	0	0	1	0	17	827
8- 9	2	526	170	1	30	2	6	12	49	0	0	0	1	0	12	811
9-10	0	550	221	2	34	11	1	10	76	0	0	0	0	0	14	919
10-11	0	621	228	1	31	5	2	13	68	1	0	0	0	0	17	987
11-12	0	589	238	3	35	6	0	11	65	1	0	0	0	0	15	963
QTR TOTALS	3	3403	1161	8	189	33	9	67	354	4	0	0	2	0	89	5322
12-13	1	575	213	0	37	5	1	10	50	0	0	0	2	0	9	903
13-14	0	519	223	1	24	5	1	8	42	0	0	0	1	0	9	833
14-15	0	611	228	0	33	9	0	15	43	1	0	0	0	0	10	950
15-16	1	657	263	0	21	6	0	11	39	1	0	0	0	0	9	1008
16-17	0	704	271	0	42	1	0	8	41	1	0	0	0	0	14	1082
17-18	0	720	260	0	30	3	0	11	31	0	1	0	0	0	15	1071
QTR TOTALS	2	3786	1458	1	187	29	2	63	246	3	1	0	3	0	66	5847
18-19	0	546	187	0	16	4	0	2	21	1	0	0	0	0	13	790
19-20	0	361	106	0	13	2	0	3	21	0	0	0	0	0	4	510
20-21	0	301	95	2	5	1	0	4	15	0	1	0	0	0	10	434
21-22	0	231	58	1	9	0	0	4	27	0	0	0	0	0	11	341
22-23	0	169	45	0	4	0	0	0	17	0	0	0	0	0	3	238
23-24	0	121	23	0	2	0	0	2	10	0	0	0	0	0	2	160
QTR TOTALS	0	1729	514	3	49	7	0	15	111	1	1	0	0	0	43	2473

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	5	9461	3292	13	460	77	11	152	790	8	6	0	5	0	218	14498
PERCENT	0.0	65.3	22.7	0.1	3.2	0.5	0.1	1.0	5.4	0.1	0.0	0.0	0.0	0.0	1.5	100.0

Site No 9913

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 013 Location : Turnpike, St. Lucie Count Lane(s) : 1 2 3 4
DATE : 06/02/03 County : 094 State-ID : 12 Direction : 5 5 1 1

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	3	389	67	0	6	4	0	3	20	0	1	2	2	0	2	499
1- 2	1	218	44	2	8	2	0	0	30	0	0	0	2	0	2	309
2- 3	0	142	23	0	9	4	0	4	22	1	8	2	3	0	2	220
3- 4	3	129	32	5	12	1	0	12	32	0	6	0	4	0	3	239
4- 5	3	185	75	0	14	5	0	12	41	0	6	0	1	0	3	345
5- 6	9	584	183	1	32	9	0	20	58	0	0	3	1	0	2	902
QTR TOTALS	19	1647	424	8	81	25	0	51	203	1	21	7	13	0	14	2514
6- 7	12	1523	409	2	60	13	0	20	66	0	1	0	2	0	6	2114
7- 8	16	2125	437	23	66	22	0	17	56	1	3	0	3	0	15	2784
8- 9	6	1876	394	4	48	14	10	16	71	0	1	0	1	0	10	2451
9-10	7	1545	316	8	46	9	3	17	55	1	0	0	1	0	9	2017
10-11	10	1581	311	2	52	11	1	18	69	0	0	0	3	0	13	2071
11-12	17	1677	240	5	31	25	0	22	46	0	1	0	2	0	8	2074
QTR TOTALS	68	10327	2107	44	303	94	14	110	363	2	6	0	12	0	61	13511
12-13	9	1608	160	2	30	11	1	16	52	1	0	0	2	0	6	1898
13-14	18	1680	311	0	54	21	0	24	58	0	0	1	6	0	9	2182
14-15	10	1801	360	4	64	23	0	10	54	0	1	0	5	0	13	2345
15-16	11	1890	371	3	48	19	0	18	59	1	1	1	2	0	15	2439
16-17	0	2086	442	5	53	16	0	18	53	1	0	0	2	0	17	2693
17-18	9	2426	428	3	54	12	0	21	49	0	3	0	6	0	14	3025
QTR TOTALS	57	11491	2072	17	303	102	1	107	325	3	5	2	23	0	74	14582
18-19	9	1627	242	3	31	10	0	9	28	0	0	1	5	0	9	1974
19-20	7	1149	217	7	27	13	1	17	28	0	1	0	4	0	8	1479
20-21	9	913	182	13	28	15	0	10	46	0	8	4	4	0	7	1239
21-22	7	749	143	4	27	14	0	10	40	0	14	7	6	0	9	1030
22-23	2	512	110	4	13	3	0	5	44	0	25	5	5	0	2	730
23-24	5	363	70	1	12	6	0	2	45	0	13	9	5	0	8	539
QTR TOTALS	39	5313	964	32	138	61	1	53	231	0	61	26	29	0	43	6991

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	183	28778	5567	101	825	282	16	321	1122	6	93	35	77	0	192	37598
PERCENT	0.5	76.5	14.8	0.3	2.2	0.8	0.0	0.9	3.0	0.0	0.2	0.1	0.2	0.0	0.5	100.0

Site No 9913

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 013 Location : Turnpike, St. Lucie Count Lane(s) : 1 2 3 4
DATE : 06/10/03 County : 094 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	2	239	58	0	6	3	0	2	34	0	11	6	4	0	2	367
1- 2	0	153	35	2	6	1	0	3	41	0	5	12	5	0	2	265
2- 3	5	91	32	5	10	7	1	7	44	0	10	5	5	0	0	222
3- 4	9	89	23	0	15	8	0	13	55	0	16	6	3	0	3	240
4- 5	2	152	44	1	17	2	0	18	47	0	14	9	1	0	2	309
5- 6	10	494	134	3	35	10	0	27	39	0	16	4	4	0	5	781
QTR TOTALS	28	1218	326	11	89	31	1	70	260	0	72	42	22	0	14	2184
6- 7	12	1293	380	3	61	18	0	22	57	0	5	3	3	0	9	1866
7- 8	14	1925	421	6	48	17	0	22	59	0	2	3	2	0	16	2535
8- 9	16	1698	382	2	36	19	1	24	60	0	1	2	2	0	10	2253
9-10	16	1499	332	3	56	17	2	19	71	2	0	1	1	0	12	2031
10-11	8	1498	283	5	65	16	0	21	63	0	0	0	5	0	5	1969
11-12	14	1521	258	7	47	20	0	19	66	0	0	0	3	0	8	1963
QTR TOTALS	80	9434	2056	26	313	107	3	127	376	2	8	9	16	0	60	12617
12-13	15	1543	316	3	50	22	1	28	76	0	0	0	3	0	11	2068
13-14	19	1589	312	2	54	20	0	30	75	0	0	2	4	0	13	2120
14-15	14	1714	321	7	57	20	0	37	67	3	0	0	1	0	10	2251
15-16	13	1967	260	4	35	13	0	11	39	2	0	1	0	0	10	2355
16-17	16	2308	424	0	63	20	2	25	41	3	1	0	2	0	10	2915
17-18	8	2441	432	2	66	13	0	19	52	0	0	0	9	0	10	3052
QTR TOTALS	85	11562	2065	18	325	108	3	150	350	8	1	3	19	0	64	14761
18-19	10	1597	342	4	35	13	0	12	36	1	1	1	4	0	5	2061
19-20	3	1116	219	1	36	7	0	15	40	0	0	4	4	0	5	1450
20-21	8	870	156	1	22	10	0	8	49	0	5	2	6	0	7	1144
21-22	13	742	130	6	15	10	0	9	53	0	13	5	7	0	4	1007
22-23	3	529	92	2	13	6	0	5	36	0	27	11	2	0	6	732
23-24	4	374	68	0	14	8	0	6	48	0	18	7	5	0	3	555
QTR TOTALS	41	5228	1007	14	135	54	0	55	262	1	64	30	28	0	30	6949

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	234	27442	5454	69	862	300	7	402	1248	11	145	84	85	0	168	36511
PERCENT	0.6	75.2	14.9	0.2	2.4	0.8	0.0	1.1	3.4	0.0	0.4	0.2	0.2	0.0	0.5	100.0

Site No 9913

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 013 Location : Turnpike, St. Lucie Count Lane(s) : 1 2 3 4
DATE : 06/11/03 County : 094 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	2	209	52	1	3	5	0	2	24	0	7	7	4	0	1	317
1- 2	2	139	31	2	6	3	0	5	38	0	7	5	3	0	2	243
2- 3	3	93	28	1	11	3	1	7	39	0	14	3	5	0	1	209
3- 4	2	70	23	1	7	2	0	9	43	0	16	7	4	0	1	185
4- 5	4	169	49	2	17	5	0	19	57	0	13	10	2	0	1	348
5- 6	7	449	127	3	24	11	2	21	56	0	15	12	3	0	4	734
QTR TOTALS	20	1129	310	10	68	29	3	63	257	0	72	44	21	0	10	2036
6- 7	12	1300	372	5	50	23	1	21	52	0	7	2	4	0	8	1857
7- 8	7	2022	459	18	63	19	0	18	67	1	2	2	4	0	13	2695
8- 9	12	1836	378	8	59	18	1	28	65	1	0	2	2	0	11	2421
9-10	12	1590	307	6	65	20	0	24	71	0	0	0	5	0	11	2111
10-11	7	1579	290	5	42	12	0	18	81	0	0	0	1	0	4	2039
11-12	12	1540	308	4	50	20	0	15	63	0	1	1	4	0	11	2029
QTR TOTALS	62	9867	2114	46	329	112	2	124	399	2	10	7	20	0	58	13152
12-13	30	1676	252	3	35	34	0	15	44	2	0	0	3	0	6	2100
13-14	11	1771	325	0	53	16	0	15	64	0	0	2	6	0	11	2274
14-15	14	1807	351	2	61	16	1	31	67	1	1	0	3	0	14	2369
15-16	9	2118	386	5	55	13	0	16	63	4	0	2	3	0	12	2686
16-17	10	2437	324	0	47	15	0	22	27	0	1	1	3	0	13	2900
17-18	9	2624	419	1	53	12	0	13	39	1	0	1	5	0	18	3195
QTR TOTALS	83	12433	2057	11	304	106	1	112	304	8	2	6	23	0	74	15524
18-19	5	1881	322	2	49	4	1	20	49	0	1	2	6	0	11	2353
19-20	2	1188	235	6	38	7	0	11	36	0	1	4	3	0	10	1541
20-21	3	931	203	9	33	6	0	11	37	1	8	5	5	0	3	1255
21-22	10	778	133	9	24	14	0	5	49	0	16	6	5	0	7	1056
22-23	8	601	106	6	9	10	0	8	70	0	30	10	7	0	3	868
23-24	5	397	64	1	7	9	0	3	44	0	16	7	3	0	2	558
QTR TOTALS	33	5776	1063	33	160	50	1	58	285	1	72	34	29	0	36	7631

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	198	29205	5544	100	861	297	7	357	1245	11	156	91	93	0	178	38343
PERCENT	0.5	76.2	14.5	0.3	2.2	0.8	0.0	0.9	3.2	0.0	0.4	0.2	0.2	0.0	0.5	100.0

Site No 9921

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 021 Location : US-1, Hobe Sound Lane(s) : 1 2 3 4
DATE : 07/14/03 County : 089 State-ID : 12 Direction : 1 1 5 5

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	61	6	0	0	0	0	1	0	0	0	0	0	0	0	68
1- 2	0	18	6	0	0	0	0	1	1	0	0	0	0	0	0	26
2- 3	0	16	1	0	3	0	0	0	0	0	0	0	0	0	0	20
3- 4	0	14	6	0	0	0	0	0	1	0	0	0	0	0	0	21
4- 5	0	33	10	0	0	0	0	0	0	0	0	0	0	0	0	43
5- 6	0	117	41	0	2	5	0	0	0	0	0	0	0	0	0	165
QTR TOTALS	0	259	70	0	5	5	0	2	2	0	0	0	0	0	0	343
6- 7	1	565	189	1	1	12	0	1	3	0	0	0	0	0	2	775
7- 8	5	987	335	0	23	6	0	10	1	0	0	0	0	0	2	1369
8- 9	0	960	266	0	26	5	0	9	1	0	0	0	0	0	2	1269
9-10	3	706	260	3	33	3	0	2	3	0	0	0	0	0	2	1015
10-11	2	603	187	0	27	2	0	17	2	0	0	0	0	0	1	841
11-12	3	657	216	1	37	4	0	8	2	0	0	0	0	0	3	931
QTR TOTALS	14	4478	1453	5	147	32	0	47	12	0	0	0	0	0	12	6200
12-13	1	719	219	0	26	4	1	6	4	0	0	0	0	0	1	981
13-14	0	679	223	0	21	7	0	7	1	0	0	0	0	0	0	938
14-15	2	776	231	0	27	6	0	11	5	0	0	0	0	0	3	1061
15-16	1	858	301	1	17	5	0	11	3	0	0	0	0	0	3	1200
16-17	3	999	326	0	19	10	0	6	1	0	0	0	0	0	3	1367
17-18	3	1240	292	0	16	7	0	5	0	0	0	0	0	0	3	1566
QTR TOTALS	10	5271	1592	1	126	39	1	46	14	0	0	0	0	0	13	7113
18-19	1	793	186	0	10	3	0	5	1	0	0	0	0	0	0	999
19-20	2	490	112	0	6	2	0	2	1	0	0	0	0	0	2	617
20-21	0	376	76	0	7	0	0	2	0	0	0	0	0	0	0	461
21-22	2	262	39	0	2	0	0	0	1	0	0	0	0	0	2	308
22-23	3	184	33	0	6	0	0	1	0	0	0	0	0	0	0	227
23-24	0	103	25	0	1	0	0	0	0	0	0	0	0	0	0	129
QTR TOTALS	8	2208	471	0	32	5	0	10	3	0	0	0	0	0	4	2741

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	32	12216	3586	6	310	81	1	105	31	0	0	0	0	0	29	16397
PERCENT	0.2	74.5	21.9	0.0	1.9	0.5	0.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.2	100.0

Site No 9921

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 021 Location : US-1, Hobe Sound Lane(s) : 1 2 3 4
DATE : 07/15/03 County : 089 State-ID : 12 Direction : 1 1 5 5

	HOURLY SUMMARY / VEHICLE COUNTS															
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	65	9	1	0	0	0	0	0	0	0	0	0	0	0	75
1- 2	0	32	5	0	2	0	0	0	0	0	0	0	0	0	0	39
2- 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QTR TOTALS	0	97	14	1	2	0	0	0	0	0	0	0	0	0	0	114
6- 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8- 9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QTR TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QTR TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QTR TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	DAILY SUMMARY / VEHICLE COUNTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	0	97	14	1	2	0	0	0	0	0	0	0	0	0	0	114
PERCENT	0.0	85.1	12.3	0.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Site No 9921

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 021 Location : US-1, Hobe Sound Lane(s) : 1 2 3 4
DATE : 07/16/03 County : 089 State-ID : 12 Direction : 1 1 5 5

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	56	9	1	0	0	0	0	1	0	0	0	0	0	0	67
1- 2	0	35	5	0	0	0	0	2	0	0	0	0	0	0	0	42
2- 3	0	16	4	0	1	1	0	0	0	0	0	0	0	0	0	22
3- 4	0	21	6	0	0	1	0	0	1	0	0	0	0	0	0	29
4- 5	0	43	10	0	0	0	0	1	0	0	0	0	0	0	0	54
5- 6	0	119	45	0	1	2	0	0	0	0	0	0	0	0	0	167
QTR TOTALS	0	290	79	1	2	4	0	3	2	0	0	0	0	0	0	381
6- 7	1	594	200	0	9	7	0	2	1	0	0	0	0	0	1	815
7- 8	1	1010	328	1	25	9	0	10	1	0	0	0	0	0	4	1389
8- 9	4	1026	283	0	38	1	1	12	1	0	0	0	0	0	4	1370
9-10	0	739	230	0	32	5	0	4	4	0	0	0	0	0	1	1015
10-11	5	699	201	0	35	4	1	5	4	0	0	0	0	0	2	956
11-12	4	754	236	0	37	1	0	5	4	1	0	0	0	0	3	1045
QTR TOTALS	15	4822	1478	1	176	27	2	38	15	1	0	0	0	0	15	6590
12-13	1	758	219	1	19	5	0	8	4	1	0	0	0	0	3	1019
13-14	1	763	222	0	30	7	0	6	4	0	0	0	0	0	1	1034
14-15	3	853	246	0	30	8	3	8	0	0	0	0	0	0	1	1152
15-16	3	984	341	0	34	2	1	6	1	0	0	0	0	0	1	1373
16-17	5	1160	341	0	40	4	0	5	2	0	0	0	0	0	5	1562
17-18	5	1223	325	1	17	9	0	3	0	0	0	0	0	0	0	1583
QTR TOTALS	18	5741	1694	2	170	35	4	36	11	1	0	0	0	0	11	7723
18-19	4	791	170	0	9	2	0	4	1	0	0	0	0	0	2	983
19-20	7	522	121	0	7	4	0	1	0	0	0	0	0	0	1	663
20-21	0	440	73	0	8	2	0	0	0	0	0	0	0	0	0	523
21-22	3	380	79	0	2	2	0	1	1	0	0	0	0	0	0	468
22-23	0	262	49	0	2	0	0	1	0	0	0	0	0	0	0	314
23-24	0	123	25	0	3	0	0	0	0	0	0	0	0	0	0	151
QTR TOTALS	14	2518	517	0	31	10	0	7	2	0	0	0	0	0	3	3102

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	47	13371	3768	4	379	76	6	84	30	2	0	0	0	0	29	17796
PERCENT	0.3	75.1	21.2	0.0	2.1	0.4	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.2	100.0

Site No 9935

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 035 Location : US-27, South Bay, Lane(s) : 1 2 3 4
DATE : 07/14/03 County : 093 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	3	38	16	0	3	4	0	4	28	0	1	0	0	0	0	97
1- 2	0	18	9	0	0	0	0	0	45	0	2	0	0	0	0	74
2- 3	0	13	7	0	1	1	0	2	39	0	2	1	0	0	1	67
3- 4	0	13	7	0	1	0	0	5	66	1	2	0	0	0	0	95
4- 5	1	27	11	0	4	3	0	9	111	0	3	0	0	0	2	171
5- 6	1	65	48	0	9	3	0	14	121	0	0	0	0	0	5	266
QTR TOTALS	5	174	98	0	18	11	0	34	410	1	10	1	0	0	8	770
6- 7	1	148	99	0	23	4	0	14	127	1	0	0	0	0	4	421
7- 8	1	156	70	0	13	4	0	13	142	1	3	0	1	0	2	406
8- 9	1	155	74	0	9	6	0	12	125	1	0	0	0	0	5	388
9-10	3	152	65	0	13	7	0	18	157	1	1	0	0	0	0	417
10-11	3	161	69	1	13	8	0	17	161	1	2	0	0	0	7	443
11-12	1	170	92	1	27	14	0	16	200	0	1	1	0	0	6	529
QTR TOTALS	10	942	469	2	98	43	0	90	912	5	7	1	1	0	24	2604
12-13	3	177	60	1	15	3	1	17	181	2	2	0	0	0	1	463
13-14	1	170	68	1	22	7	1	15	176	2	0	0	1	0	0	464
14-15	5	173	63	1	11	11	1	13	155	4	0	0	0	0	2	439
15-16	1	204	82	0	17	5	0	6	147	3	0	0	1	0	3	469
16-17	2	198	79	1	16	5	1	6	123	0	2	0	1	0	1	435
17-18	4	188	109	0	13	8	0	7	116	0	0	1	0	0	3	449
QTR TOTALS	16	1110	461	4	94	39	4	64	898	11	4	1	3	0	10	2719
18-19	0	190	67	1	15	3	0	9	107	0	2	6	0	0	2	402
19-20	1	138	44	0	10	5	0	3	87	0	0	0	0	0	2	290
20-21	1	92	32	2	10	1	0	3	66	0	1	3	0	0	1	212
21-22	0	77	21	1	3	0	0	3	61	0	2	2	0	0	1	171
22-23	0	91	23	1	2	1	0	2	57	0	2	2	1	0	0	182
23-24	2	54	16	0	3	3	0	4	42	1	4	2	0	0	1	132
QTR TOTALS	4	642	203	5	43	13	0	24	420	1	11	15	1	0	7	1389

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	35	2868	1231	11	253	106	4	212	2640	18	32	18	5	0	49	7482
PERCENT	0.5	38.3	16.5	0.1	3.4	1.4	0.1	2.8	35.3	0.2	0.4	0.2	0.1	0.0	0.7	100.0

Site No 9935

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 035 Location : US-27, South Bay, Lane(s) : 1 2 3 4
DATE : 07/15/03 County : 093 State-ID : 12 Direction : 5 5 1 1

	HOURLY SUMMARY								VEHICLE COUNTS						
HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	32	11	0	0	1	0	0	45	0	6	3	0	0	2	100
1- 2	0	20	2	0	3	0	0	1	47	0	4	6	0	0	1	84
2- 3	0	10	2	0	1	0	0	1	53	0	1	4	0	0	1	73
3- 4	0	12	3	0	1	0	0	12	74	0	2	3	0	0	0	107
4- 5	0	15	14	0	2	1	0	4	113	0	2	0	0	0	0	151
5- 6	0	58	39	0	6	4	1	14	133	0	3	1	0	0	2	261
QTR TOTALS	0	147	71	0	13	6	1	32	465	0	18	17	0	0	6	776
6- 7	0	150	89	0	18	1	1	22	125	1	0	0	0	0	6	413
7- 8	1	127	68	1	14	5	0	12	137	1	2	0	0	0	0	368
8- 9	1	130	69	1	19	6	0	13	153	2	1	0	0	0	6	401
9-10	1	139	65	0	23	9	0	16	163	0	0	0	1	0	1	418
10-11	3	158	60	0	27	7	0	18	170	0	0	0	1	0	3	447
11-12	1	151	63	0	24	6	0	10	161	1	0	0	0	0	5	422
QTR TOTALS	7	855	414	2	125	34	1	91	909	5	3	0	2	0	21	2469
12-13	3	148	62	2	20	7	2	13	160	0	0	0	0	0	1	418
13-14	1	124	69	0	15	6	1	10	196	3	1	0	1	0	2	429
14-15	2	166	64	0	26	3	1	18	150	2	0	0	0	0	2	434
15-16	1	177	83	1	24	7	1	14	111	3	0	0	0	0	1	423
16-17	1	162	86	2	17	6	0	9	141	2	0	0	1	0	5	432
17-18	2	213	100	0	20	8	0	9	100	1	0	5	0	0	1	459
QTR TOTALS	10	990	464	5	122	37	5	73	858	11	1	5	2	0	12	2595
18-19	0	150	60	1	9	2	0	5	92	1	3	5	0	0	4	332
19-20	0	126	55	0	9	0	0	3	98	1	0	2	0	0	2	296
20-21	0	86	25	2	4	2	0	4	66	0	1	2	0	0	1	193
21-22	0	63	26	1	6	2	0	3	51	0	1	1	0	0	2	156
22-23	1	47	23	1	1	1	0	3	42	0	7	6	0	0	2	134
23-24	1	46	16	0	0	1	0	1	55	0	2	0	0	0	3	125
QTR TOTALS	2	518	205	5	29	8	0	19	404	2	14	16	0	0	14	1236

	DAILY SUMMARY								VEHICLE COUNTS							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	19	2510	1154	12	289	85	7	215	2636	18	36	38	4	0	53	7076
PERCENT	0.3	35.5	16.3	0.2	4.1	1.2	0.1	3.0	37.3	0.3	0.5	0.5	0.1	0.0	0.7	100.0

Site No 9935

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 035 Location : US-27, South Bay, Lane(s) : 1 2 3 4
DATE : 07/16/03 County : 093 State-ID : 12 Direction : 5 5 1 1

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	26	3	0	2	0	0	2	44	0	1	2	0	0	0	80
1- 2	0	8	5	0	2	1	0	0	56	0	4	8	0	0	4	88
2- 3	1	9	6	0	1	0	0	2	49	0	2	3	0	0	1	74
3- 4	0	11	1	0	1	1	0	10	80	0	0	5	0	0	2	111
4- 5	2	21	3	0	2	3	0	4	122	1	2	0	0	0	2	162
5- 6	1	62	35	0	10	2	0	20	135	0	2	2	0	0	2	271
QTR TOTALS	4	137	53	0	18	7	0	38	486	1	11	20	0	0	11	786
6- 7	1	137	107	1	26	4	0	16	157	0	2	0	0	0	1	452
7- 8	2	140	64	0	22	10	0	6	109	1	0	0	0	0	2	356
8- 9	3	131	59	1	19	7	1	15	157	0	1	0	0	0	1	395
9-10	4	173	62	0	18	12	1	18	198	1	0	0	1	0	5	493
10-11	1	169	68	1	15	10	0	27	171	2	0	0	0	0	2	466
11-12	1	171	89	0	19	9	0	12	205	1	1	0	0	0	5	513
QTR TOTALS	12	921	449	3	119	52	2	94	997	5	4	0	1	0	16	2675
12-13	4	151	75	1	21	13	0	9	178	4	0	0	0	0	3	459
13-14	1	168	76	0	26	9	1	18	151	2	1	0	0	0	2	455
14-15	3	162	86	1	32	9	1	12	153	2	0	0	2	0	5	468
15-16	1	218	71	0	28	6	0	11	144	3	0	0	0	0	4	486
16-17	0	209	112	1	23	11	0	12	138	2	2	0	1	0	4	515
17-18	0	221	110	0	18	7	0	10	98	0	1	3	0	0	2	470
QTR TOTALS	9	1129	530	3	148	55	2	72	862	13	4	3	3	0	20	2853
18-19	0	151	76	0	15	2	0	10	94	0	0	5	0	0	2	355
19-20	0	123	61	0	9	1	0	6	81	1	2	4	0	0	0	288
20-21	2	82	39	1	5	1	0	5	61	1	1	1	0	0	0	199
21-22	0	63	21	0	6	0	0	2	64	1	2	3	0	0	1	163
22-23	0	60	13	1	1	2	0	2	53	1	4	0	0	0	0	137
23-24	1	48	15	0	1	2	0	0	54	1	1	2	0	0	0	125
QTR TOTALS	3	527	225	2	37	8	0	25	407	5	10	15	0	0	3	1267

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	28	2714	1257	8	322	122	4	229	2752	24	29	38	4	0	50	7581
PERCENT	0.4	35.8	16.6	0.1	4.2	1.6	0.1	3.0	36.3	0.3	0.4	0.5	0.1	0.0	0.7	100.0

Site No 9936

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 036 Location : I-10, Columbia County Lane(s) : 1 2 3 4
DATE : 07/14/03 County : 029 State-ID : 12 Direction : 3 3 7 7

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	0	188	55	0	15	1	0	1	112	0	7	1	0	0	4	384
1- 2	1	151	35	0	2	4	0	2	107	0	1	0	0	0	2	305
2- 3	1	112	36	1	3	3	0	3	86	0	1	1	0	0	2	249
3- 4	3	111	31	2	6	3	0	2	106	0	2	3	0	0	3	272
4- 5	1	131	39	5	15	6	0	8	128	0	9	1	0	0	2	345
5- 6	4	211	85	1	16	6	0	11	129	0	3	2	0	0	4	472
QTR TOTALS	10	904	281	9	57	23	0	27	668	0	23	8	0	0	17	2027
6- 7	4	294	111	1	27	7	0	13	147	0	4	0	0	0	2	610
7- 8	1	423	158	1	23	5	0	10	171	2	9	0	0	0	6	809
8- 9	3	543	182	3	40	10	2	10	162	5	5	1	0	0	7	973
9-10	2	641	206	1	32	13	12	14	178	0	8	2	0	0	3	1112
10-11	1	803	252	3	35	20	3	14	227	2	6	6	0	0	12	1384
11-12	5	809	232	1	41	18	4	15	232	2	6	1	0	0	12	1378
QTR TOTALS	16	3513	1141	10	198	73	21	76	1117	11	38	10	0	0	42	6266
12-13	5	744	246	1	27	14	6	18	242	3	4	1	0	0	10	1321
13-14	2	782	231	0	37	14	0	13	218	5	4	2	0	0	9	1317
14-15	1	823	239	3	33	5	0	13	210	1	5	7	0	0	10	1350
15-16	0	848	273	0	37	5	0	23	210	3	2	0	1	0	13	1415
16-17	4	732	241	1	47	9	0	15	198	4	6	1	0	0	14	1272
17-18	0	741	185	0	36	7	0	12	206	3	4	0	1	0	9	1204
QTR TOTALS	12	4670	1415	5	217	54	6	94	1284	19	25	11	2	0	65	7879
18-19	2	572	189	2	30	5	0	16	222	2	1	1	0	0	11	1053
19-20	1	527	138	1	25	1	0	4	209	2	9	2	0	0	6	925
20-21	0	380	105	1	14	5	0	7	167	1	5	2	1	0	5	693
21-22	0	285	97	4	11	4	0	3	159	1	9	5	0	0	4	582
22-23	4	249	86	1	14	2	0	11	148	2	13	9	1	0	5	545
23-24	1	203	51	2	7	3	0	7	144	0	15	3	0	0	7	443
QTR TOTALS	8	2216	666	11	101	20	0	48	1049	8	52	22	2	0	38	4241

DAILY SUMMARY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	46	11303	3503	35	573	170	27	245	4118	38	138	51	4	0	162	20413
PERCENT	0.2	55.4	17.2	0.2	2.8	0.8	0.1	1.2	20.2	0.2	0.7	0.2	0.0	0.0	0.8	100.0

Site No 9936

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 036 Location : I-10, Columbia County Lane(s) : 1 2 3 4
DATE : 07/15/03 County : 029 State-ID : 12 Direction : 3 3 7 7

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	2	137	23	0	3	2	0	2	119	0	9	7	0	0	6	310
1- 2	0	99	15	2	5	0	1	3	93	0	9	3	0	0	6	236
2- 3	0	77	21	1	10	1	0	7	105	3	7	4	0	0	6	242
3- 4	1	81	26	2	5	3	0	5	106	0	11	5	0	0	3	248
4- 5	3	76	23	2	11	3	0	5	141	1	24	8	0	0	5	302
5- 6	0	159	51	1	16	1	0	8	139	0	5	9	1	0	7	397
QTR TOTALS	6	629	159	8	50	10	1	30	703	4	65	36	1	0	33	1735
6- 7	1	267	75	0	23	2	0	12	143	3	7	4	0	0	5	542
7- 8	4	343	122	1	20	3	1	11	152	3	10	11	0	0	9	690
8- 9	2	431	145	0	26	4	0	12	144	2	6	1	1	0	15	789
9-10	1	563	173	2	36	12	8	19	209	2	9	2	0	0	19	1055
10-11	10	621	177	1	34	9	0	18	225	5	9	2	3	0	30	1144
11-12	20	668	162	1	35	11	4	17	243	9	5	2	1	0	35	1213
QTR TOTALS	38	2893	854	5	174	41	13	89	1116	24	46	22	5	0	113	5433
12-13	21	619	175	4	41	6	4	13	261	4	6	3	2	0	34	1193
13-14	47	550	199	1	38	14	0	17	225	1	2	3	5	0	53	1155
14-15	41	680	188	2	32	10	4	14	215	5	5	3	3	0	49	1251
15-16	49	689	180	0	38	12	3	18	205	5	2	1	3	0	47	1252
16-17	44	650	191	1	43	17	2	15	225	1	5	3	3	0	43	1243
17-18	5	701	153	1	24	12	1	10	218	9	8	0	2	0	10	1154
QTR TOTALS	207	3889	1086	9	216	71	14	87	1349	25	28	13	18	0	236	7248
18-19	1	590	138	3	35	9	0	13	189	5	6	2	2	0	11	1004
19-20	0	459	122	2	23	5	1	11	198	4	6	2	2	0	7	842
20-21	1	341	79	3	15	1	0	6	187	2	9	4	0	0	8	656
21-22	3	270	74	1	8	3	0	2	136	0	5	7	0	0	15	524
22-23	1	219	57	2	7	3	0	7	168	0	24	7	1	0	11	507
23-24	0	192	41	2	9	1	0	8	133	1	9	5	0	0	10	411
QTR TOTALS	6	2071	511	13	97	22	1	47	1011	12	59	27	5	0	62	3944

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	257	9482	2610	35	537	144	29	253	4179	65	198	98	29	0	444	18360
PERCENT	1.4	51.6	14.2	0.2	2.9	0.8	0.2	1.4	22.8	0.4	1.1	0.5	0.2	0.0	2.4	100.0

Site No 9936

DISTRIBUTION OF VEHICLE CLASSIFICATIONS BY HOUR OF DAY

SITE NO : 036 Location : I-10, Columbia County Lane(s) : 1 2 3 4
DATE : 07/16/03 County : 029 State-ID : 12 Direction : 3 3 7 7

HOURLY SUMMARY — VEHICLE COUNTS

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
0- 1	1	160	28	0	5	2	0	3	132	3	13	4	0	0	5	356
1- 2	2	109	16	2	5	3	0	1	101	0	2	5	0	0	5	251
2- 3	0	81	17	3	7	1	0	10	108	0	9	6	0	0	10	252
3- 4	0	66	13	2	6	1	0	6	102	1	11	5	0	0	6	219
4- 5	3	84	25	2	14	5	0	3	138	1	18	7	0	0	7	307
5- 6	2	140	49	1	9	2	0	9	127	1	9	8	0	0	5	362
QTR TOTALS	8	640	148	10	46	14	0	32	708	6	62	35	0	0	38	1747
6- 7	6	243	90	1	20	9	6	6	164	0	9	10	0	0	16	580
7- 8	0	365	113	1	27	4	2	12	198	3	6	5	0	0	14	750
8- 9	1	474	140	1	23	13	1	13	175	3	9	2	1	0	4	860
9-10	3	585	161	3	32	13	3	13	235	2	9	5	1	0	9	1074
10-11	24	709	192	5	33	19	3	13	246	2	10	2	3	0	29	1290
11-12	16	719	191	2	43	8	1	23	272	1	8	1	1	0	29	1315
QTR TOTALS	50	3095	887	13	178	66	16	80	1290	11	51	25	6	0	101	5869
12-13	4	703	196	5	50	9	1	21	233	4	5	5	0	0	10	1246
13-14	2	810	242	1	34	10	4	22	230	2	7	1	1	0	7	1373
14-15	4	845	168	5	38	9	2	22	230	5	1	2	0	0	24	1355
15-16	2	820	212	1	32	14	3	16	241	2	6	3	1	0	18	1371
16-17	2	726	206	2	31	12	0	13	222	6	3	2	0	0	10	1235
17-18	1	737	195	1	53	9	3	15	214	3	7	1	3	0	14	1256
QTR TOTALS	15	4641	1219	15	238	63	13	109	1370	22	29	14	5	0	83	7836
18-19	2	635	159	2	22	8	5	13	227	1	5	2	1	0	20	1102
19-20	1	479	119	1	19	12	0	10	186	0	5	4	1	0	9	846
20-21	1	379	99	2	11	4	0	7	148	0	8	1	0	0	11	671
21-22	0	341	81	0	11	2	0	8	156	1	5	3	3	0	9	620
22-23	1	292	59	3	14	4	0	7	176	0	23	9	0	0	6	594
23-24	0	203	45	1	8	0	0	8	116	2	16	6	0	0	9	414
QTR TOTALS	5	2329	562	9	85	30	5	53	1009	4	62	25	5	0	64	4247

DAILY SUMMARY — VEHICLE COUNTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTALS
TOTAL	78	10705	2816	47	547	173	34	274	4377	43	204	99	16	0	286	19699
PERCENT	0.4	54.3	14.3	0.2	2.8	0.9	0.2	1.4	22.2	0.2	1.0	0.5	0.1	0.0	1.5	100.0

Appendix F: Example of Training Data Set (Without Vehicle Weight)

```
X=[ 1.10, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    2.70, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    3.20, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    4.80, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
%% Class 1 =
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    7.20, 0.0,  0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    8.00, 0.0,  0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.00, 0.0,  0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.80, 0.0,  0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
%% Class 2a=2
%%=====================================================
    8.40, 13.30, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.20, 15.40, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.30, 11.00, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.60,  6.10, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.60, 21.00, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    10.00,22.40, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0;

%% Class 2b=3
%%=====================================================
    8.30, 13.40, 2.50, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.40, 21.20, 2.70, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.60, 24.50, 2.70, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.80, 20.90, 2.50, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    9.90, 14.90, 2.80, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    10.00,16.20, 2.10, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    8.90, 19.80, 2.60, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
%% Class 2c=4
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    10.10, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    11.00, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    12.60, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    13.00, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
    13.30, 0.0,  0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0;
%% Class 3a=5
%%=====================================================
    10.01, 13.70, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    10.10, 20.10, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    10.60, 15.00, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    11.80, 20.00, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    12.80, 12.60, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.20, 20.00, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.30, 14.70, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 3b=6
%%=====================================================
    10.20, 10.40, 2.30,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    10.70, 24.00, 2.70,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    11.00, 17.70, 2.60,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    12.50, 17.80, 2.50,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    12.90, 23.60, 2.40,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.20, 23.30, 2.70,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 3c=7
%%=====================================================
```

```
    10.20, 19.10, 2.30,  2.50,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.00, 24.90, 2.80,  2.70,  0.0,  0.0,  0.0,  0.0,  0.0;
    11.60, 23.00, 2.80,  2.90,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 3d=8
%%=========================================================
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    23.10,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    24.20,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    27.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 4a=9
%%=========================================================
    23.50,  4.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    24.50,  4.40,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    26.00,  3.80,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    26.30,  4.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    26.70,  4.10,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 4b=10
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    13.90,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    15.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    17.30,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    18.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    20.90,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    22.20   0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    23.00,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 5a=11
%%=========================================================
    14.20,  13.40,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.50,  16.30,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    14.00,  16.30,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.50,  22.40,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 5b=12
%%=========================================================
    14.00,  18.90,  2.70,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.50,  22.40,  2.70,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    14.30,  21.40,  2.80,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.80,  24.40,  2.80,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    14.30,  22.30,  2.90,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
    13.40,  16.00,  2.80,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 5c=13
%%=========================================================
    11.50,  20.70,  2.60,  2.50,  0.0,  0.0,  0.0,  0.0,  0.0;
    14.50,  20.70,  2.80,  2.70,  0.0,  0.0,  0.0,  0.0,  0.0;
    14.60,  33.30,  3.00,  3.10,  0.0,  0.0,  0.0,  0.0,  0.0;
%% Class 5d=14
  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    11.40, 4.40, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    16.90, 4.50, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    19.30, 4.60, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    20.80  4.30, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    21.20, 3.60, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    23.00, 4.20, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 6=15
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
    10.30, 4.50, 4.50, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    10.80, 3.70, 3.40, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    11.70, 3.70, 4.20, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    12.80, 3.90, 4.40, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    16.60, 4.60,11.70, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
% Class 7=16
   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    11.30, 14.70, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    12.00, 31.70, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    13.20, 14.00, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    14.70, 19.80, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    14.90, 36.40, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    15.90, 34.80, 0.0, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 8a=17
%%=====================================================
    18.00, 4.20, 28.90, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    16.10, 4.20, 37.30, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    11.20, 4.30, 19.30, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    20.80, 4.30, 28.80, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    19.60, 4.30, 40.90, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 8b=18
%%=====================================================
    11.50, 13.00,  3.00, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    14.50, 14.80,  8.90, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    13.60, 15.80,  2.70, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    19.90, 16.40,  9.10, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    21.90, 21.70,  2.90, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    13.90, 37.00,  4.20, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
    16.30, 40.60,  3.40, 0.0, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 8c=19
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    9.20,  4.20, 36.00, 3.90, 0.0, 0.0,  0.0,  0.0,  0.0;
   15.20,  4.20, 32.10, 4.00, 0.0, 0.0,  0.0,  0.0,  0.0;
   24.80,  4.40, 33.20, 4.00, 0.0, 0.0,  0.0,  0.0,  0.0;
   16.40,  3.20, 25.00, 3.90, 0.0, 0.0,  0.0,  0.0,  0.0;
   13.60,  5.10, 28.70, 4.10, 0.0, 0.0,  0.0,  0.0,  0.0;
   17.00,  4.80, 42.10, 4.80, 0.0, 0.0,  0.0,  0.0,  0.0;
   13.30,  4.20,  7.80, 8.70, 0.0, 0.0,  0.0,  0.0,  0.0;
   15.50,  4.50, 13.50, 2.70, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 9a=20
%%=====================================================
   6.01,  0.1, 6.01, 11.00, 0.0, 0.0,  0.0,  0.0,  0.0;
   16.50,  4.30, 15.00, 19.00, 0.0, 0.0,  0.0,  0.0,  0.0;
   26.00,  6.00, 23.00, 27.00, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 9b=21
 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
   12.00,  4.40, 14.60, 4.20, 4.00, 0.0, 0.0,  0.0,  0.0;
   22.10,  4.30, 38.00, 4.50, 4.50, 0.0, 0.0,  0.0,  0.0;
   15.60,  4.40, 13.90, 4.20, 4.10, 0.0, 0.0,  0.0,  0.0;
   17.50,  4.20, 33.50, 3.90, 4.00, 0.0, 0.0,  0.0,  0.0;
   17.50,  4.20, 33.50, 3.90, 4.00, 0.0, 0.0,  0.0,  0.0;
   19.40,  4.30, 44.20, 4.00, 4.00, 0.0, 0.0,  0.0,  0.0;
   20.60,  5.70, 21.00, 5.50, 5.40, 0.0, 0.0,  0.0,  0.0;
   17.90,  4.30, 35.80, 3.00, 2.90, 0.0, 0.0,  0.0,  0.0;
%% Class 10a=22
%%=========================================================
   10.70,  4.00, 32.20, 4.00, 5.80, 4.10, 0.0,  0.0,  0.0;
   13.80,  4.50, 30.30, 4.00, 6.80, 4.20, 0.0,  0.0,  0.0;
   17.80,  4.00, 35.80, 4.60, 5.30, 4.60, 0.0,  0.0,  0.0;
   17.30,  4.00, 36.40, 4.60, 8.50, 4.60, 0.0,  0.0,  0.0;
   17.30,  4.00, 36.40, 4.60, 20.50, 4.70, 0.0,  0.0,  0.0;
   16.70, 6.0, 40.0, 13.3, 13.30, 13.30, 0.0,  0.0,  0.0;
   20.60,  4.60, 35.00, 5.00, 4.10, 5.00, 0.0,  0.0,  0.0;
%% Class 10b=23
   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
   11.80,  20.60, 9.10,  21.50, 0.0, 0.0,  0.0,  0.0,  0.0;
   17.90,  21.70, 10.00,  22.80, 0.0, 0.0,  0.0,  0.0,  0.0;
   12.60,  20.10, 9.70,  21.70, 0.0, 0.0,  0.0,  0.0,  0.0;
   13.10,  22.20, 9.90,  22.50, 0.0, 0.0,  0.0,  0.0,  0.0;
   16.30,  21.50, 8.70,  22.10, 0.0, 0.0,  0.0,  0.0,  0.0;
   13.10,  21.90, 9.70,  22.90, 0.0, 0.0,  0.0,  0.0,  0.0;
%% Class 11=24
  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  10.60,  4.30, 19.80,  10.10, 22.20, 0.0, 0.0,  0.0,  0.0;
  19.80,  4.30, 20.40, 9.00, 22.80, 0.0, 0.0,  0.0,  0.0;
  15.30,  4.20, 19.10, 8.80, 21.90, 0.0, 0.0,  0.0,  0.0;
  17.90,  4.30, 21.30, 8.90, 22.90, 0.0, 0.0,  0.0,  0.0;
  19.30,  4.30, 20.60, 8.50, 22.40, 0.0, 0.0,  0.0,  0.0;
  11.60,  4.00, 19.50, 9.50, 11.50, 0.0, 0.0,  0.0,  0.0;
  19.30,  4.30, 20.60, 8.50, 22.40, 0.0, 0.0,  0.0,  0.0;
%% Class 12=25
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
  1.00,   1.00, 1.00,  1.00,  1.00,   1.00, 0.0,  0.0,  0.0;
  22.50, 22.50,22.50, 22.50, 22.50,  22.50, 0.0,  0.0,  0.0;
  45.00, 45.00,45.00, 45.00, 45.00,  45.00, 0.0,  0.0,  0.0;
%% Class 13a=26
%%=========================================================
   1.00,  1.00,  1.00, 1.00,  1.00,  1.00, 1.00,  0.0,  0.0;
  16.50,  4.00,  4.40, 33.80, 4.50,  4.60, 4.50,  0.0,  0.0;
  45.00, 45.00, 45.00, 45.00,45.00, 45.00,45.00,  0.0,  0.0;

%% Class 13b=27
%%=========================================================
  15.10,  4.00, 33.30, 4.10, 27.80, 18.60, 4.50, 31.90,  0.0;
  11.30, 23.0,  33.30, 4.10, 15.10, 12.10, 14.90, 4.10,  0.0;
  17.00,  4.40, 13.40, 4.50, 35.50,  4.50, 4.60, 2.90,  0.0;
  17.50,  4.40, 39.90, 5.00, 45.00,  5.10, 4.00, 5.00,  0.0;
%% Class 13c=28
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
];
```

```
Y=[1,1,1,1,...
       2,2,2,2,...
       3,3,3,3,3,3,...
       4,4,4,4,4,4,4,...
       5,5,5,5,5,...
       6,6,6,6,6,6,6,...
       7,7,7,7,7,7,...
       8,8,8,...
       9,9,9,...
       10,10,10,10,10,...
       11,11,11,11,11,11,11,...
       12,12,12,12,...
       13,13,13,13,13,13,...
       14,14,14,...
       15,15,15,15,15,15,...
       16,16,16,16,16,...
       17,17,17,17,17,17,...
       18,18,18,18,18,...
       19,19,19,19,19,19,19,...
       20,20,20,20,20,20,20,20,...
       21,21,21,...
       22,22,22,22,22,22,22,...
       23,23,23,23,23,23,23,...
       24,24,24,24,24,24,...
       25,25,25,25,25,25,25,...
       26,26,26,...
       27,27,27,...
       28,28,28,28,...
     ];
```

Appendix G: Example Training Data Set (With Vehicle Weight)

```
X=[
1.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,7.40;
1.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,2.60;
1.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,7.40;
2.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,16.90;
3.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,5.50;
4.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,8.40;
4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,6.30;
4.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,4.70;
4.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,6.90;
4.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,5.50;
%%%%Class 1=1
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

8.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,12.90;
10.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,14.60;
7.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,11.30;
7.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,11.10;
8.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,12.60;
9.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,15.30;
7.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,11.20;
9.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,14.30;
8.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,12.10;
8.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,11.90;
8.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,16.70;
9.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,16.20;
8.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,20.40;
9.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,15.10;
%%%%%Class 2a=2
%%====================================================
8.20,8.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,28.90;
8.50,8.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,29.50;
7.80,11.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,24.20;
8.40,12.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,20.70;
10.00,12.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00,26.70;
9.40,13.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,29.50;
9.50,16.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,32.90;
8.80,16.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,29.30;
8.80,17.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,34.70;
10.00,18.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,32.80;
10.00,20.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,35.60;
%%%Class 2b=3
%%======================================================

8.00,8.00,2.10,0.00,0.00,0.00,0.00,0.00,0.00,24.40;
9.30,15.90,2.40,0.00,0.00,0.00,0.00,0.00,0.00,36.00;
9.50,19.70,2.70,0.00,0.00,0.00,0.00,0.00,0.00,42.40;
9.60,20.20,2.70,0.00,0.00,0.00,0.00,0.00,0.00,37.80;
9.90,14.50,2.80,0.00,0.00,0.00,0.00,0.00,0.00,31.70;
9.90,14.90,2.80,0.00,0.00,0.00,0.00,0.00,0.00,33.10;
9.20,14.00,2.90,0.00,0.00,0.00,0.00,0.00,0.00,31.70;
9.80,21.10,3.00,0.00,0.00,0.00,0.00,0.00,0.00,43.90;
%%%Class 2c=4
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
10.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,14.60;
11.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,16.40;
12.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,20.90;
13.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,17.10;
13.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,18.80;
%%%Class 3a=5
%%=====================================================
11.60,12.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,27.60;
10.40,12.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,28.40;
12.80,12.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,30.60;
10.90,13.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,28.00;
11.80,16.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,34.60;
13.20,20.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.30;
12.00,22.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.90;
%%Class 3b=6
%%=====================================================
10.20,10.40,2.30,0.00,0.00,0.00,0.00,0.00,0.00,29.60;
11.30,17.50,2.10,0.00,0.00,0.00,0.00,0.00,0.00,37.40;
11.70,21.10,2.30,0.00,0.00,0.00,0.00,0.00,0.00,40.40;
10.90,24.10,2.40,0.00,0.00,0.00,0.00,0.00,0.00,40.60;
13.20,11.10,2.70,0.00,0.00,0.00,0.00,0.00,0.00,30.80;
10.70,24.00,2.70,0.00,0.00,0.00,0.00,0.00,0.00,47.10;
12.90,24.30,2.80,0.00,0.00,0.00,0.00,0.00,0.00,52.30;
12.10,19.00,3.00,0.00,0.00,0.00,0.00,0.00,0.00,37.40;
12.70,23.50,3.80,0.00,0.00,0.00,0.00,0.00,0.00,41.40;
%%%%Class 3c=7
%%====================================================

11.60,24.20,2.60,2.60,0.00,0.00,0.00,0.00,0.00,53.30;
13.00,21.20,2.70,2.70,0.00,0.00,0.00,0.00,0.00,52.90;
10.90,23.00,2.70,2.80,0.00,0.00,0.00,0.00,0.00,52.00;
10.10,24.00,2.70,2.70,0.00,0.00,0.00,0.00,0.00,52.60;
13.10,19.20,2.80,2.90,0.00,0.00,0.00,0.00,0.00,48.80;
11.50,23.00,2.80,2.80,0.00,0.00,0.00,0.00,0.00,47.80;
10.80,23.50,2.80,2.90,0.00,0.00,0.00,0.00,0.00,42.40;
11.10,15.70,3.00,3.10,0.00,0.00,0.00,0.00,0.00,39.30;
%%%Class 3d=8
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
23.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,34.20;
23.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,37.70;
23.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.70;
23.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,39.70;
24.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.90;
25.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.10;
26.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,36.30;
%%Class 4a=9
%%%===================================================
```

```
26.30,3.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,44.20;
26.50,3.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,44.10;
26.60,3.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,44.80;
26.60,3.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,45.50;
23.30,4.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,59.50;
26.10,4.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,44.70;
23.90,4.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,40.00;
27.70,4.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,46.20;
23.60,4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,44.90;
24.00,4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,40.20;
24.30,4.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00,64.40;
%%%Class 4b=10
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
13.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,18.50;
13.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,24.10;
14.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,20.10;
14.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,23.10;
15.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,25.40;
17.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,25.60;
18.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,53.50;
19.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,32.20;
21.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,56.70;
21.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,52.10;
22.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,31.80;
22.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,34.40;
23.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,36.50;
%%Class 5a=11
%%==================================================
14.60,15.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,33.60;
14.60,18.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,39.80;
14.60,19.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.40;
14.30,20.20,0.00,0.00,0.00,0.00,0.00,0.00,0.00,38.40;
%%%Class 5b=12
%%%==================================================

14.20,16.90,2.60,0.00,0.00,0.00,0.00,0.00,0.00,42.10;
13.60,17.70,2.70,0.00,0.00,0.00,0.00,0.00,0.00,39.60;
13.40,18.70,2.80,0.00,0.00,0.00,0.00,0.00,0.00,40.10;
14.20,18.20,2.90,0.00,0.00,0.00,0.00,0.00,0.00,43.10;
%%%Class 5c=13
%%==================================================
14.50,24.20,2.60,2.80,0.00,0.00,0.00,0.00,0.00,58.20;
13.30,20.80,2.80,2.80,0.00,0.00,0.00,0.00,0.00,51.30;
13.40,22.00,2.80,2.90,0.00,0.00,0.00,0.00,0.00,51.60;
14.80,22.20,2.80,2.90,0.00,0.00,0.00,0.00,0.00,49.80;
16.40,20.90,3.10,3.30,0.00,0.00,0.00,0.00,0.00,50.50;
%%Class 5d=14
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
20.90,4.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,39.40;
22.40,4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,37.50;
11.00,4.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,18.20;
21.80,4.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00,42.00;
17.60,4.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,26.30;
21.20,4.10,0.00,0.00,0.00,0.00,0.00,0.00,0.00,39.90;
15.30,4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,31.40;
15.90,4.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,24.90;
%%Class 6=15
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

13.70,4.30,3.90,0.00,0.00,0.00,0.00,0.00,0.00,55.10;
13.80,3.40,4.30,0.00,0.00,0.00,0.00,0.00,0.00,29.60;
11.00,3.90,4.10,0.00,0.00,0.00,0.00,0.00,0.00,24.20;
11.30,3.90,4.10,0.00,0.00,0.00,0.00,0.00,0.00,23.20;
22.20,3.90,8.50,0.00,0.00,0.00,0.00,0.00,0.00,57.40;
12.60,4.30,4.40,0.00,0.00,0.00,0.00,0.00,0.00,32.80;
18.40,4.20,4.40,0.00,0.00,0.00,0.00,0.00,0.00,32.00;
17.20,4.00,2.70,0.00,0.00,0.00,0.00,0.00,0.00,57.30;
22.40,3.70,8.80,0.00,0.00,0.00,0.00,0.00,0.00,58.60;
13.50,2.90,2.90,0.00,0.00,0.00,0.00,0.00,0.00,54.00;
%%%Class 7=16
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
14.60,11.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,29.90;
11.00,12.30,0.00,0.00,0.00,0.00,0.00,0.00,0.00,28.40;
12.80,14.40,0.00,0.00,0.00,0.00,0.00,0.00,0.00,36.00;
10.20,18.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,35.70;
13.50,20.90,0.00,0.00,0.00,0.00,0.00,0.00,0.00,39.00;
13.00,22.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00,40.50;
12.50,26.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,43.00;
21.60,29.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00,68.70;
11.90,29.70,0.00,0.00,0.00,0.00,0.00,0.00,0.00,46.60;
17.90,37.60,0.00,0.00,0.00,0.00,0.00,0.00,0.00,61.10;
19.80,37.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,67.30;
17.00,38.80,0.00,0.00,0.00,0.00,0.00,0.00,0.00,68.90;
%%Class 8a=17
%%%==================================================
17.20,4.00,17.70,0.00,0.00,0.00,0.00,0.00,0.00,41.80;
12.00,4.20,19.20,0.00,0.00,0.00,0.00,0.00,0.00,38.40;
17.40,4.20,19.60,0.00,0.00,0.00,0.00,0.00,0.00,46.20;
11.80,4.30,20.00,0.00,0.00,0.00,0.00,0.00,0.00,40.00;
18.50,4.30,20.30,0.00,0.00,0.00,0.00,0.00,0.00,49.70;
15.70,4.20,21.20,0.00,0.00,0.00,0.00,0.00,0.00,45.00;
10.30,4.30,34.00,0.00,0.00,0.00,0.00,0.00,0.00,51.20;
12.10,4.20,36.30,0.00,0.00,0.00,0.00,0.00,0.00,61.40;
19.80,4.30,38.60,0.00,0.00,0.00,0.00,0.00,0.00,66.10;
%%class 8b=18
%%%==================================================
```

```
12.80,14.60,2.30,0.00,0.00,0.00,0.00,0.00,0.00,39.20;
14.60,13.00,2.40,0.00,0.00,0.00,0.00,0.00,0.00,36.00;
13.00,16.20,2.50,0.00,0.00,0.00,0.00,0.00,0.00,37.60;
12.90,23.20,2.70,0.00,0.00,0.00,0.00,0.00,0.00,45.00;
17.70,28.10,4.00,0.00,0.00,0.00,0.00,0.00,0.00,60.20;
18.50,19.40,8.40,0.00,0.00,0.00,0.00,0.00,0.00,50.50;
13.10,11.40,8.60,0.00,0.00,0.00,0.00,0.00,0.00,37.80;
22.80,18.80,8.90,0.00,0.00,0.00,0.00,0.00,0.00,55.50;
11.30,17.40,9.30,0.00,0.00,0.00,0.00,0.00,0.00,44.40;
16.30,29.10,9.80,0.00,0.00,0.00,0.00,0.00,0.00,63.30;
20.90,17.00,10.70,0.00,0.00,0.00,0.00,0.00,0.00,53.60;
%%%Class 8c=19
%%%=================================================
20.90,3.60,20.70,2.50,0.00,0.00,0.00,0.00,0.00,55.90;
19.40,4.20,37.40,3.10,0.00,0.00,0.00,0.00,0.00,74.20;
19.90,4.20,31.10,4.00,0.00,0.00,0.00,0.00,0.00,62.80;
15.60,4.20,32.20,4.00,0.00,0.00,0.00,0.00,0.00,67.20;
17.00,4.30,34.20,4.00,0.00,0.00,0.00,0.00,0.00,70.20;
15.20,4.30,34.00,4.00,0.00,0.00,0.00,0.00,0.00,66.70;
20.00,4.20,34.50,4.10,0.00,0.00,0.00,0.00,0.00,71.40;
16.90,4.10,27.50,10.00,0.00,0.00,0.00,0.00,0.00,62.60;
16.90,4.20,30.40,10.00,0.00,0.00,0.00,0.00,0.00,64.50;
17.80,4.20,28.90,10.10,0.00,0.00,0.00,0.00,0.00,65.70;
17.40,4.20,27.00,10.80,0.00,0.00,0.00,0.00,0.00,63.20;
21.10,4.30,29.90,10.80,0.00,0.00,0.00,0.00,0.00,69.70;
22.80,4.20,30.10,10.90,0.00,0.00,0.00,0.00,0.00,71.30;
%%%Class 9a=20
%%================================================
13.50,4.30,18.20,14.90,0.00,0.00,0.00,0.00,0.00,54.00;
16.70,4.50,17.90,20.60,0.00,0.00,0.00,0.00,0.00,67.00;
%%%Class 9b=21
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
17.40,4.10,34.60,2.80,2.70,0.00,0.00,0.00,0.00,73.10;
25.50,3.80,24.00,3.00,3.00,0.00,0.00,0.00,0.00,74.00;
12.80,4.20,32.20,4.00,4.00,0.00,0.00,0.00,0.00,60.40;
13.70,4.20,38.50,3.90,4.00,0.00,0.00,0.00,0.00,67.60;
21.30,4.20,45.10,4.40,4.40,0.00,0.00,0.00,0.00,82.10;
21.60,4.30,45.60,4.50,4.40,0.00,0.00,0.00,0.00,83.80;
21.30,4.20,37.60,4.00,4.60,0.00,0.00,0.00,0.00,74.30;
17.80,4.10,28.50,4.80,4.90,0.00,0.00,0.00,0.00,71.10;
19.90,4.30,31.30,5.00,5.10,0.00,0.00,0.00,0.00,70.20;
17.70,4.20,40.10,4.50,7.90,0.00,0.00,0.00,0.00,76.50;
20.40,4.30,34.50,4.50,9.00,0.00,0.00,0.00,0.00,75.60;
%%%Class 10a=22
%%%=================================================
10.70,4.00,32.20,4.00,5.80,4.10,0.0,0.0,0.0,72.3;
13.80,4.50,30.30,4.00,6.80,4.20,0.0,0.0,0.0,75.2;
17.80,4.00,35.80,4.60,5.30,4.60,0.0,0.0,0.0,83.2;
17.30,4.00,36.40,4.60,8.50,4.60,0.0,0.0,0.0,86.4;
17.30,4.00,36.40,4.60,20.50,4.70,0.0,0.0,0.0,98.0;
16.70,6.00,40.00,13.3,13.30,13.30,0.0,0.0,0.0,113.6;
20.60,4.60,35.00,5.00,4.10,5.00,0.0,0.0,0.0,85.3;
%%%Class 10b=23
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

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11.80,20.60,9.00,20.20,0.00,0.00,0.00,0.00,0.00,67.00;
11.90,20.30,9.40,21.10,0.00,0.00,0.00,0.00,0.00,67.70;
17.30,21.80,8.20,21.10,0.00,0.00,0.00,0.00,0.00,71.80;
11.80,20.40,9.30,21.50,0.00,0.00,0.00,0.00,0.00,66.00;
12.90,21.40,9.40,21.50,0.00,0.00,0.00,0.00,0.00,71.10;
12.00,22.20,8.70,22.20,0.00,0.00,0.00,0.00,0.00,69.70;
12.90,21.80,10.00,22.20,0.00,0.00,0.00,0.00,0.00,71.30;
12.50,22.00,8.80,22.30,0.00,0.00,0.00,0.00,0.00,68.20;
16.70,22.50,8.80,22.40,0.00,0.00,0.00,0.00,0.00,74.10;
12.80,22.00,9.90,22.50,0.00,0.00,0.00,0.00,0.00,71.70;
12.20,22.40,8.90,22.50,0.00,0.00,0.00,0.00,0.00,70.10;
%%%Class 11=24
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
10.50,4.20,19.80,9.80,21.90,0.00,0.00,0.00,0.00,72.30;
16.80,4.40,19.50,9.50,21.40,0.00,0.00,0.00,0.00,75.90;
10.30,4.30,19.00,9.90,21.80,0.00,0.00,0.00,0.00,71.00;
18.50,4.30,18.80,9.50,21.40,0.00,0.00,0.00,0.00,75.90;
17.30,4.10,19.20,9.40,20.90,0.00,0.00,0.00,0.00,75.20;
16.90,4.20,20.80,8.50,22.30,0.00,0.00,0.00,0.00,78.70;
14.70,4.20,20.40,8.40,21.50,0.00,0.00,0.00,0.00,72.50;
19.40,4.30,21.40,9.10,22.10,0.00,0.00,0.00,0.00,79.10;
19.20,4.20,20.10,8.60,22.10,0.00,0.00,0.00,0.00,78.80;
16.10,4.20,17.70,11.80,13.60,0.00,0.00,0.00,0.00,67.20;
19.90,4.20,20.30,8.80,22.40,0.00,0.00,0.00,0.00,80.50;
19.50,4.30,20.10,8.70,22.50,0.00,0.00,0.00,0.00,79.70;
10.40,4.30,19.70,9.50,21.80,0.00,0.00,0.00,0.00,71.70;
17.40,4.10,20.20,8.60,22.20,0.00,0.00,0.00,0.00,77.80;
%%%Class 12=25
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
16.20,4.30,4.40,32.90,4.40,4.40,0.00,0.00,0.00,69.50;
13.40,4.20,43.10,2.90,2.90,2.80,0.00,0.00,0.00,81.50;
17.20,4.20,4.30,35.60,3.90,4.50,0.00,0.00,0.00,72.80;
14.30,4.40,4.50,42.30,4.90,4.90,0.00,0.00,0.00,77.60;
19.00,4.90,35.80,4.50,13.70,4.90,0.00,0.00,0.00,84.90;
%%Class 13a=26
%%%=====================================================
14.80,4.30,9.40,9.10,7.90,8.50,13.90,0.00,0.00,83.10;
19.50,4.30,7.50,7.30,7.90,8.20,4.00,0.00,0.00,87.50;
%%%Class 13b=27
%%=======================================================
15.10,4.20,33.30,4.10,27.80,18.60,4.50,31.90,0.00,147.60;
18.10,4.50,14.30,4.40,42.20,4.50,4.70,9.70,0.00,104.30;
16.60,4.10,32.70,3.90,24.00,16.80,4.50,32.30,0.00,201.20;
15.40,3.50,4.20,14.00,4.50,34.40,4.50,14.50,0.00,102.50;
%%Class 13c=28
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
];
```

```
Y=[
        1,1,1,1,1,1,1,1,1,1,...
        2,2,2,2,2,2,2,2,2,2,2,2,2,2,...
        3,3,3,3,3,3,3,3,3,3,3,...
        4,4,4,4,4,4,4,4,...
        5,5,5,5,5,...
        6,6,6,6,6,6,6,...
        7,7,7,7,7,7,7,7,7,...
        8,8,8,8,8,8,8,8,...
        9,9,9,9,9,9,9,...
        10,10,10,10,10,10,10,10,10,10,10,...
        11,11,11,11,11,11,11,11,11,11,11,11,11,...
        12,12,12,12,...
        13,13,13,13,...
        14,14,14,14,14,...
        15,15,15,15,15,15,15,15,...
        16,16,16,16,16,16,16,16,16,16,...
        17,17,17,17,17,17,17,17,17,17,17,17,...
        18,18,18,18,18,18,18,18,18,...
        19,19,19,19,19,19,19,19,19,19,19,...
        20,20,20,20,20,20,20,20,20,20,20,20,20,...
        21,21,...
        22,22,22,22,22,22,22,22,22,22,22,...
        23,23,23,23,23,23,23,...
        24,24,24,24,24,24,24,24,24,24,24,...
        25,25,25,25,25,25,25,25,25,25,25,25,25,...
        26,26,26,26,26,...
        27,27,...
        28,28,28,28,...
      ];
```

Appendix H: Example of Test Data Set

								Visual Class
9.16,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.29,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.48,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.09,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.01,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.37,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.23,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.34,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.34,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.13,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.11,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.48,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.68,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.68,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.57,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.21,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.26,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.06,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.08,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.96,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
9.19,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.42,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.38,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.21,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.57,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.97,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
8.28,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 2
10.73,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.41,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.59,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.83,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.47,	13.93,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.05,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.09,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.06,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.44,	12.61,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.17,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.32,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.40,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.91,	32.04,	2.73,	2.63,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.59,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.19,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.40,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.82,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.78,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.74,	14.51,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.69,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.81,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.21,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
11.29,	13.25,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.73,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3
10.81,	13.93,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00,	0.00; 3

```
11.38,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
11.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
13.06,  14.90, 3.17,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.08,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.20,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.08,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.95,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.75,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
12.27,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.88,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.97,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
10.01,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.74,  14.15, 0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.75,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.75,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 7.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 8.80,  12.88, 0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 8.91,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 8.78,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.27,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 8.59,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
14.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 9.25,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 8.39,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
 7.69,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    3
25.59,  3.70,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
27.48,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
23.84,  4.28,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
23.61,  3.74,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
26.50,  3.84,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
23.39,  3.85,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
25.93,  3.85,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
26.81,  3.85,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
26.60,  3.85,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
27.02,  3.85,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
26.49,  3.86,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
27.39,  3.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
23.50,  3.96,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
23.61,  3.96,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.35,  4.06,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.46,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.92,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.18,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.46,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.55,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
24.46,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    4
10.91,  24.46, 2.75,  3.02,  0.00,  0.00,  0.00,  0.00,  0.00;    5
 9.54,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
10.99,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
11.29,  32.11, 3.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
11.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
10.91,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
12.87,  12.97, 2.77,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.16,  17.26, 2.77,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
```

```
13.16, 29.47,  3.05,  2.96,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.07,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.05,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
12.88,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
12.96,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.74, 14.18,  6.97,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
14.72, 16.56,  8.28,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
21.33, 16.77,  9.83,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
18.02, 17.53,  9.93,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
22.49, 18.04,  8.96,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
18.70,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
18.61, 18.90,  8.77,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
16.06, 18.92,  8.77,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.34, 19.38,  2.92,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
19.37, 19.49,  8.95,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.42, 20.94,  3.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.40, 21.48,  3.22,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
16.05, 18.10,  8.66,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
15.86,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
22.18, 18.59,  8.86,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
14.69, 35.32,  2.63,  2.63,  0.00,  0.00,  0.00,  0.00,  0.00;    5
16.83, 17.71,  8.66,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
20.14, 16.38,  7.63,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
15.86, 18.78,  8.76,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
19.38,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
18.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
17.82,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
17.29,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
18.40,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.43,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
14.90,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.53,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
17.04,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
19.87,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.54,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
21.62,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    5
13.93,  4.21,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.11,  4.21,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.21,  4.13,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.79,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.67,  4.13,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
18.97,  4.41,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.12,  4.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.21,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.84,  4.58,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.38,  4.17,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.47,  4.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.48,  4.14,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
14.57,  4.40,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.47,  4.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
21.35,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
12.09,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.47,  4.40,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
14.02,  4.21,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
```

```
14.02,  4.58,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
14.11,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
14.84,  4.49,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
19.87,  4.38,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
13.74,  4.12,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
15.17,  4.38,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
18.96,  4.31,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    6
10.90,  4.03,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
11.32,  4.28,  4.27,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
11.27,  4.12,  3.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
11.65,  4.27,  4.27,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
10.90,  3.94,  3.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
10.90,  4.12,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
11.45,  4.03,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    7
12.36, 33.08,  4.28,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.82, 33.43,  3.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.09, 34.81,  3.94,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
9.08,  36.64,  3.95,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
13.78, 31.73,  3.95,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
11.64, 31.83,  3.95,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
14.63, 19.66,  3.96,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.83, 34.54,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
11.36, 27.02,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.46, 27.66,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
11.27, 32.06,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
16.03, 32.34,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
14.20, 19.60,  4.03,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
14.63, 19.65,  4.06,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
16.24, 35.03,  4.06,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
13.91, 4.48,  27.05,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
16.13, 4.27,  21.15,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
11.29, 4.38,  20.33,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.46, 35.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
11.27, 21.53,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.50, 25.63,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.73, 21.25,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.28, 21.36,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
12.19, 19.97,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
14.01, 25.83,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
13.24, 30.59,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00;    8
16.85, 4.48,  26.59,  4.08,  0.00,  0.00,  0.00,  0.00,  0.00;    9
11.48, 4.38,  24.33,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.82, 4.48,  33.60,  4.18,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.47, 4.38,  34.29,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.96, 4.48,  31.85, 10.42,  0.00,  0.00,  0.00,  0.00,  0.00;    9
20.15, 4.39,  33.01,  4.18,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.85,4.48,  28.80,  10.61,  0.00,  0.00,  0.00,  0.00,  0.00;    9
21.21,4.48,  29.48,  10.31,  0.00,  0.00,  0.00,  0.00,  0.00;    9
16.93, 4.38,  36.20,  4.19,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.97,4.28,  30.94,  10.41,  0.00,  0.00,  0.00,  0.00,  0.00;    9
16.35,4.28,  29.38,  10.12,  0.00,  0.00,  0.00,  0.00,  0.00;    9
13.04,4.57,  30.46,  10.31,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.59,4.32,  30.87,  10.18,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.10, 4.28,  29.38,  8.17,  0.00,  0.00,  0.00,  0.00,  0.00;    9
```

```
20.63,4.18,  31.04,  10.31,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.03, 4.38,  31.82,  8.47,  0.00,  0.00,  0.00,  0.00,  0.00;    9
15.86,4.09,  30.26,  10.22,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.75,4.19,  30.94,  10.22,  0.00,  0.00,  0.00,  0.00,  0.00;    9
13.06,4.32,  30.54,  10.07,  0.00,  0.00,  0.00,  0.00,  0.00;    9
13.52,4.29,  29.68,  10.22,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.88,4.28,  27.15,  10.22,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.00,4.18,  29.09,  10.41,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.10,4.28,  30.75,  10.41,  0.00,  0.00,  0.00,  0.00,  0.00;    9
14.11, 4.57,  29.00,  8.66,  0.00,  0.00,  0.00,  0.00,  0.00;    9
22.96,4.38,  29.77,  10.02,  0.00,  0.00,  0.00,  0.00,  0.00;    9
20.58,  4.40,  28.77,  10.51,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.27,   4.43,  31.34,  3.86,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.52,   4.48,  33.40,  4.18,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.60,   4.44,  32.78,  4.00,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.62,   4.38,  31.65,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
20.25,  4.26,  30.38,  10.42,  0.00,  0.00,  0.00,  0.00,  0.00;    9
15.05,   4.32,  30.45,  4.10,  0.00,  0.00,  0.00,  0.00,  0.00;    9
20.94,   4.28,  34.47,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.72,   4.29,  33.01,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.27,  4.29,  31.26,  10.32,  0.00,  0.00,  0.00,  0.00,  0.00;    9
15.00,   4.48,  29.79,  4.19,  0.00,  0.00,  0.00,  0.00,  0.00;    9
10.91,   4.48,  29.32,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
11.29,   4.33,  28.90,  3.99,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.39,   4.32,  31.33,  4.10,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.22,   4.48,  35.55,  4.20,  0.00,  0.00,  0.00,  0.00,  0.00;    9
10.72,   4.48,  34.77,  4.19,  0.00,  0.00,  0.00,  0.00,  0.00;    9
11.98,   4.49,  35.35,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
18.01,   4.29,  34.27,  3.99,  0.00,  0.00,  0.00,  0.00,  0.00;    9
11.86,   4.32,  29.68,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
16.57,   4.38,  29.72,  3.99,  0.00,  0.00,  0.00,  0.00,  0.00;    9
15.88,  4.77,  27.77,  10.43,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.45,   4.19,  30.98,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
17.45,   4.48,  34.48,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
14.61,   4.38,  30.09,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
20.54,   4.57,  34.08,  4.09,  0.00,  0.00,  0.00,  0.00,  0.00;    9
19.67,  4.29,  28.62,  10.14,  0.00,  0.00,  0.00,  0.00,  0.00;    9
15.45,   4.39,  34.05,  3.91,  4.01,  0.00,  0.00,  0.00,  0.00;    10
14.27,   4.32,  14.38,  4.54,  3.87,  0.00,  0.00,  0.00,  0.00;    10
16.80,   4.29,  34.28,  4.27,  4.10,  0.00,  0.00,  0.00,  0.00;    10
13.52,   4.57,  14.59,  4.48,  4.09,  0.00,  0.00,  0.00,  0.00;    10
11.52,   4.22,  32.09,  3.87,  4.21,  0.00,  0.00,  0.00,  0.00;    10
17.39,   4.21,  33.45,  4.21,  4.11,  0.00,  0.00,  0.00,  0.00;    10
19.44,   4.17,  35.68,  4.59,  4.49,  0.00,  0.00,  0.00,  0.00;    10
13.16,  21.61,  9.45,  23.27,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.02,  21.27,  9.63,  21.55,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.68,  21.36,  9.35,  21.55,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.30,  21.27,  9.25,  21.74,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.94,  21.40,  9.73,  22.38,  0.00,  0.00,  0.00,  0.00,  0.00;    11
17.80,  21.11,  9.54,  22.47,  0.00,  0.00,  0.00,  0.00,  0.00;    11
13.25,  21.82, 10.04,  22.20,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.94,  21.02,  9.34,  23.35,  0.00,  0.00,  0.00,  0.00,  0.00;    11
12.61,  21.69,  9.73,  22.33,  0.00,  0.00,  0.00,  0.00,  0.00;    11
14.59,  4.32,  20.03,  9.19,  22.35,  0.00,  0.00,  0.00,  0.00;    12
```

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20.19,  4.27,  20.83,  8.97,  22.86,  0.00,  0.00,  0.00,  0.00;    12
11.27,  4.31,  19.33,  9.25,  21.26,  0.00,  0.00,  0.00,  0.00;    12
16.49,  4.13,  19.05,  9.53,  21.43,  0.00,  0.00,  0.00,  0.00;    12
18.05,  4.13,  20.15,  8.80,  22.44,  0.00,  0.00,  0.00,  0.00;    12
19.12,  4.49,  20.72,  8.87,  22.64,  0.00,  0.00,  0.00,  0.00;    12
17.22,  4.13,  21.07,  8.70,  22.44,  0.00,  0.00,  0.00,  0.00;    12
19.55,  3.95,  20.61,  8.87,  22.32,  0.00,  0.00,  0.00,  0.00;    12
16.58,  3.95, 20.06,  10.17,  21.71,  0.00,  0.00,  0.00,  0.00;    12
17.51,  4.28,  20.72,  9.64,  22.96,  0.00,  0.00,  0.00,  0.00;    12
15.35,  4.29,  13.17,  4.10,  34.61,  4.01,  4.10,  0.00,  0.00;    13
16.67,  4.12,  13.01,  3.66,  8.34,  15.11,  3.94,  0.00,  0.00;    13
```
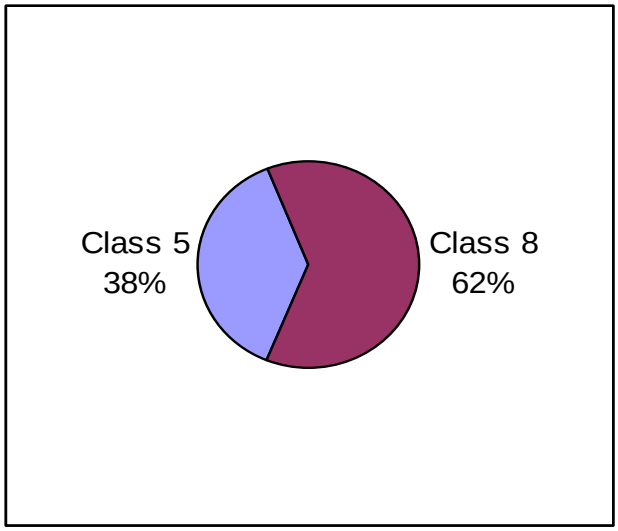
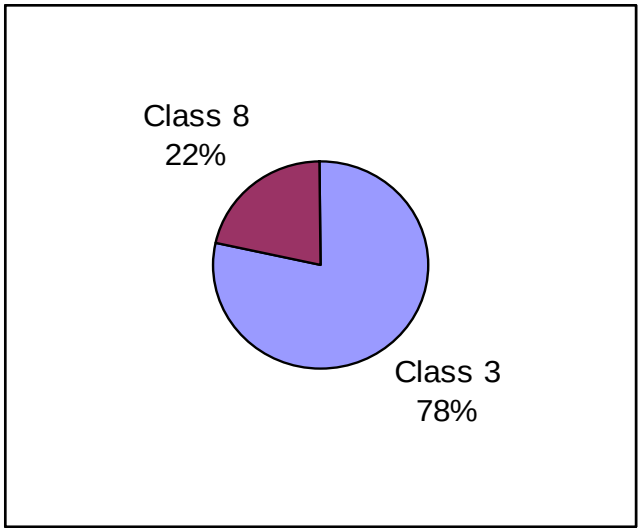

Appendix I: Distribution of Misclassified Vehicles

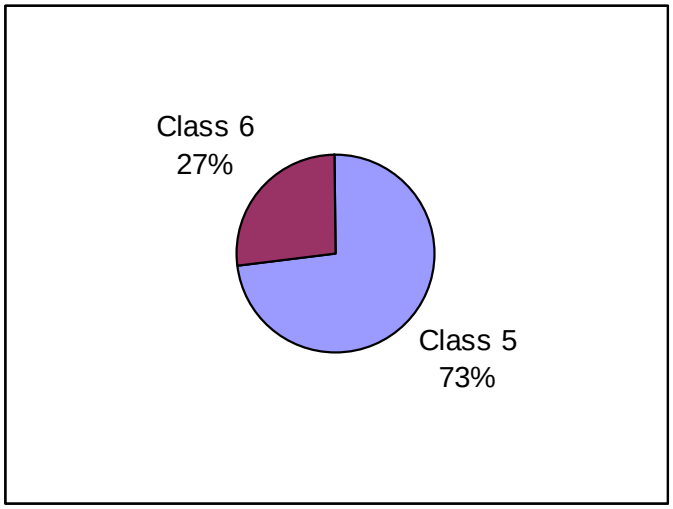
Class 3



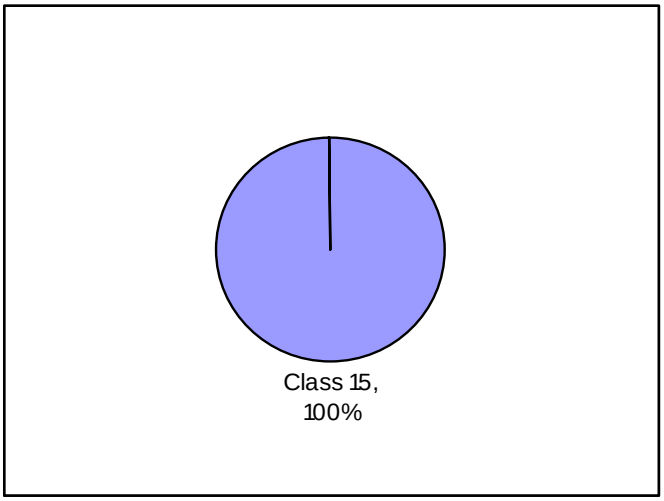
Class 5



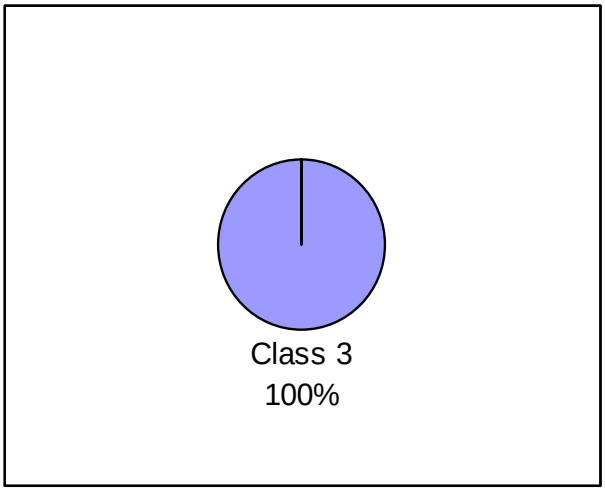
Class 4



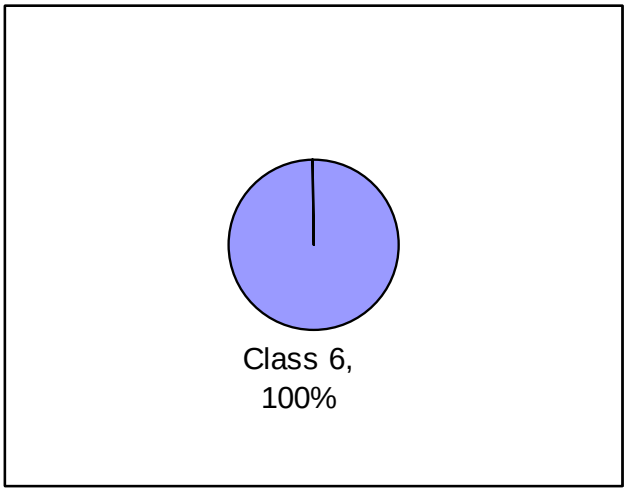
Class 6



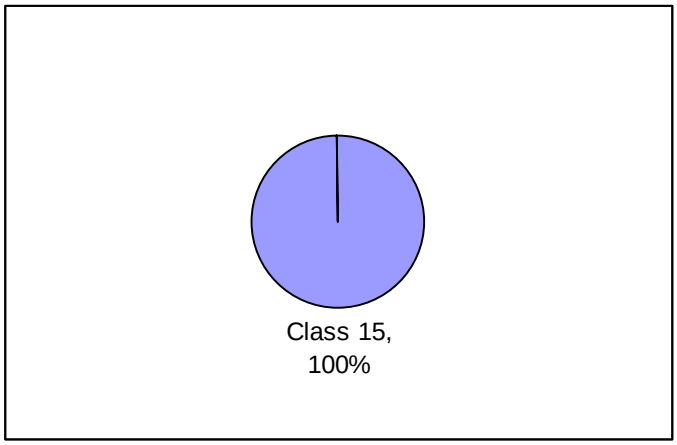
Class 2



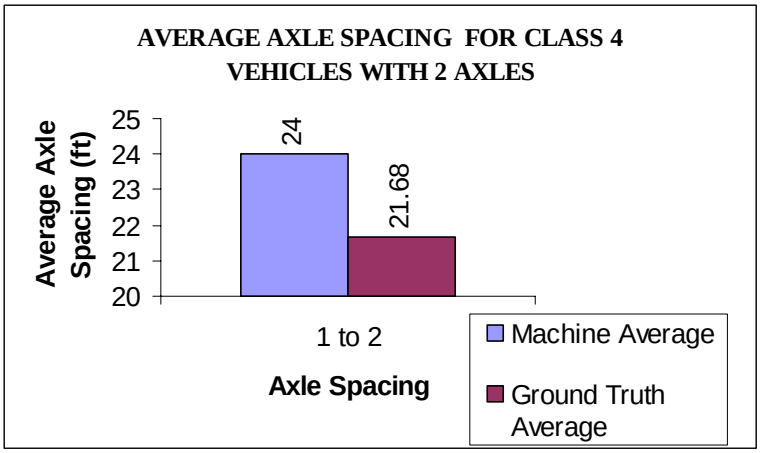
Class 8

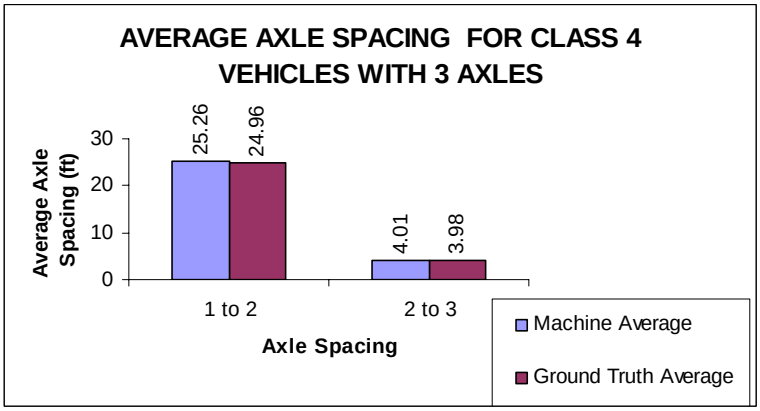


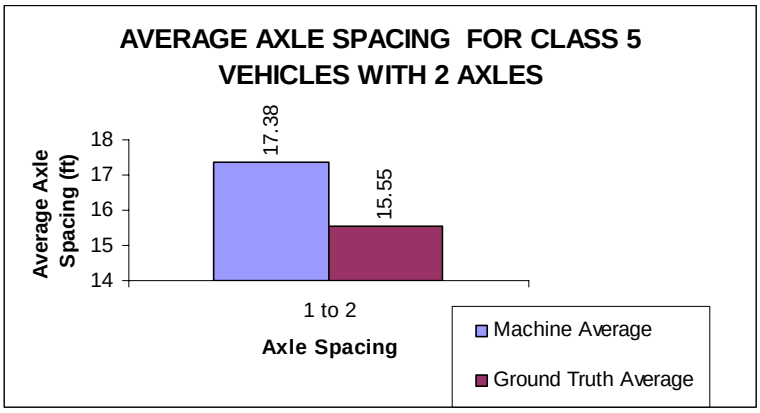
Class 9

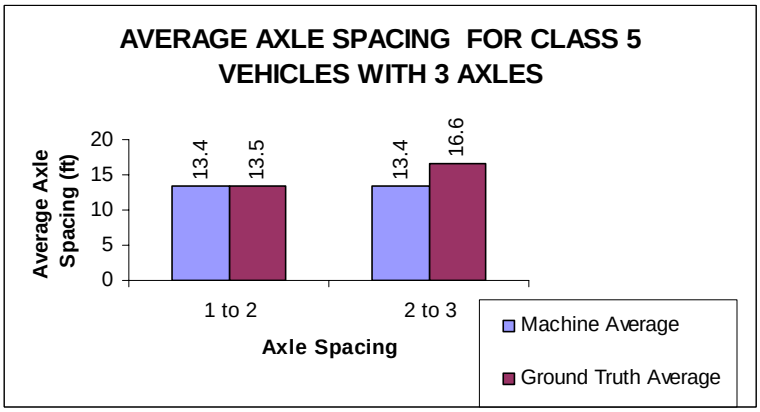


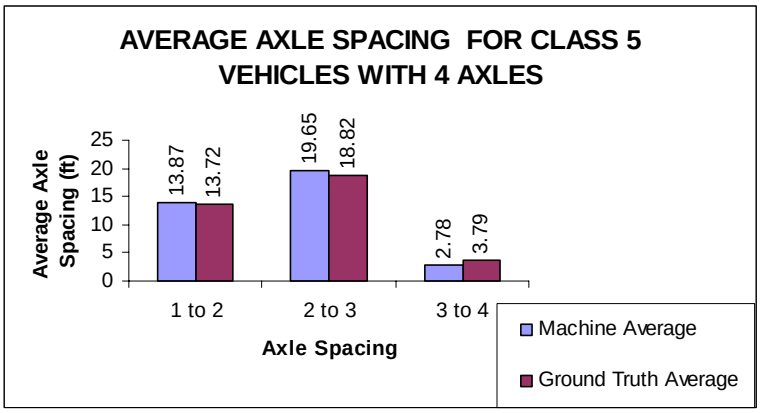
Appendix J. Comparison of Average Axle Spacing

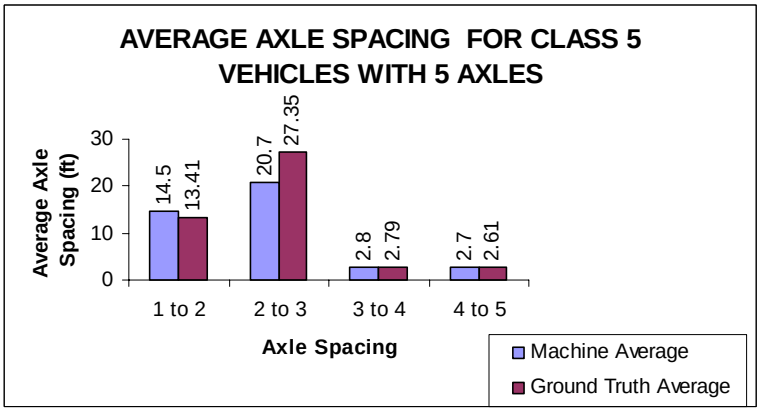

AVERAGE AXLE SPACING FOR CLASS 4 VEHICLES WITH 2 AXLES
Average Axle Spacing (ft)
25
24
23
22
21
20
24
21.68
1 to 2
Axle Spacing
Machine Average
Ground Truth Average

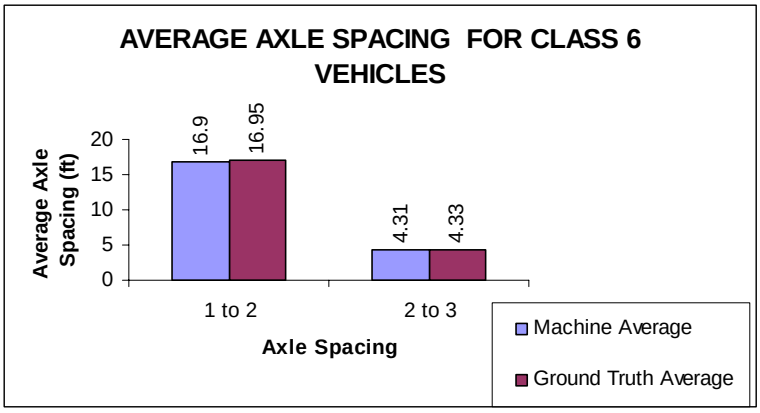

AVERAGE AXLE SPACING FOR CLASS 4 VEHICLES WITH 3 AXLES
Average Axle Spacing (ft)
30
20
10
0
25.26
24.96
4.01
3.98
1 to 2
2 to 3
Axle Spacing
Machine Average
Ground Truth Average

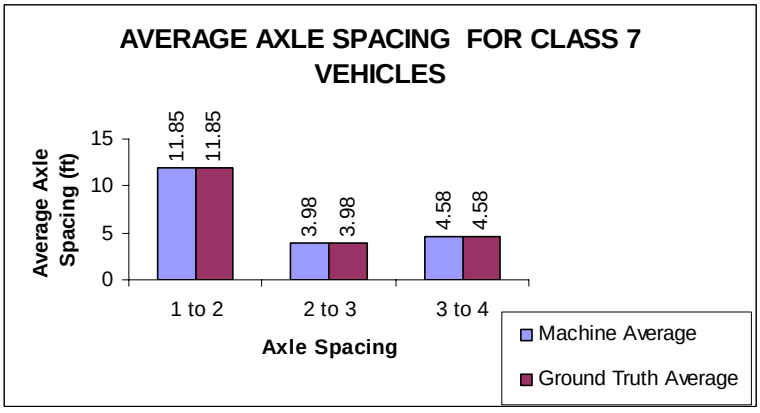

AVERAGE AXLE SPACING FOR CLASS 5 VEHICLES WITH 2 AXLES
Average Axle Spacing (ft)
18
17
16
15
14
17.38
15.55
1 to 2
Axle Spacing
Machine Average
Ground Truth Average

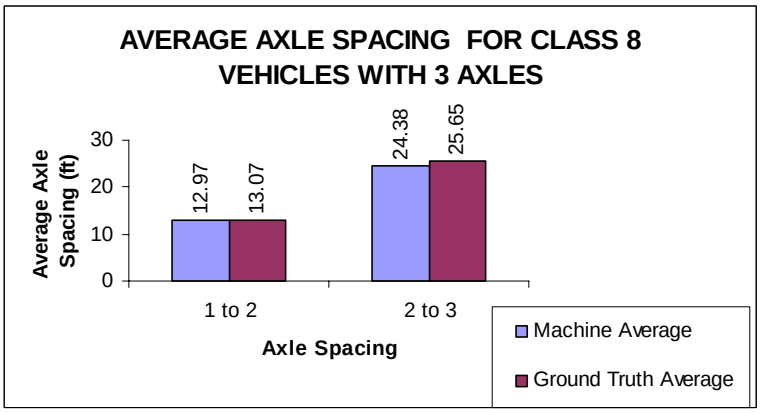

AVERAGE AXLE SPACING FOR CLASS 5 VEHICLES WITH 3 AXLES
Average Axle Spacing (ft)
20
15
10
5
0
13.4
13.5
13.4
16.6
1 to 2
2 to 3
Axle Spacing
Machine Average
Ground Truth Average

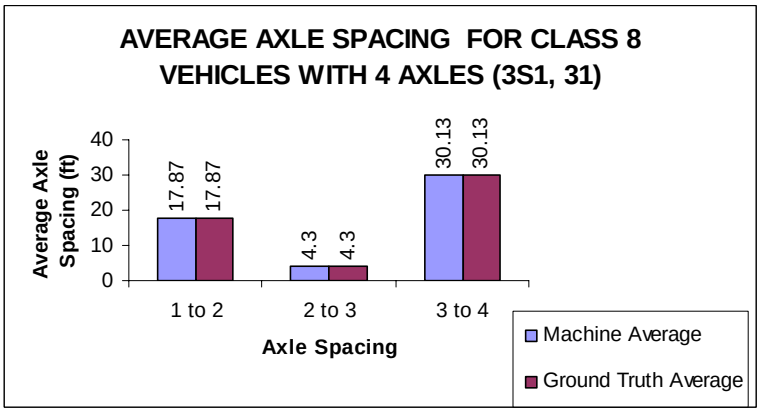

AVERAGE AXLE SPACING FOR CLASS 5 VEHICLES WITH 4 AXLES
Average Axle Spacing (ft)
25
20
15
10
5
0
13.87
13.72
19.65
18.82
2.78
3.79
1 to 2
2 to 3
3 to 4
Axle Spacing
Machine Average
Ground Truth Average

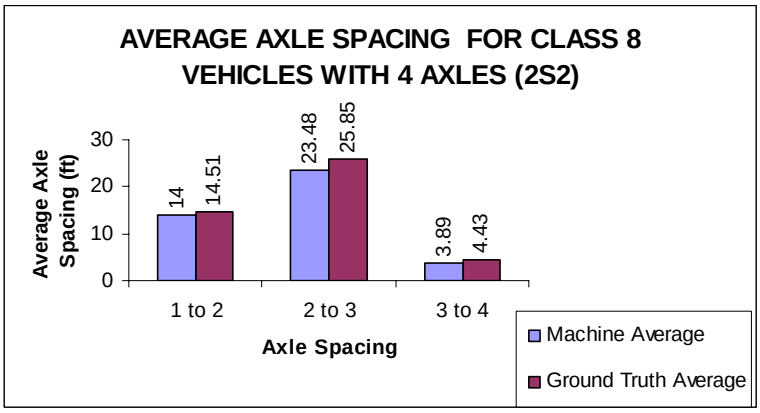

AVERAGE AXLE SPACING FOR CLASS 5 VEHICLES WITH 5 AXLES
Average Axle Spacing (ft)
30
20
10
0
14.5
13.41
20.7
27.35
2.8
2.79
2.7
2.61
1 to 2
2 to 3
3 to 4
4 to 5
Axle Spacing
Machine Average
Ground Truth Average

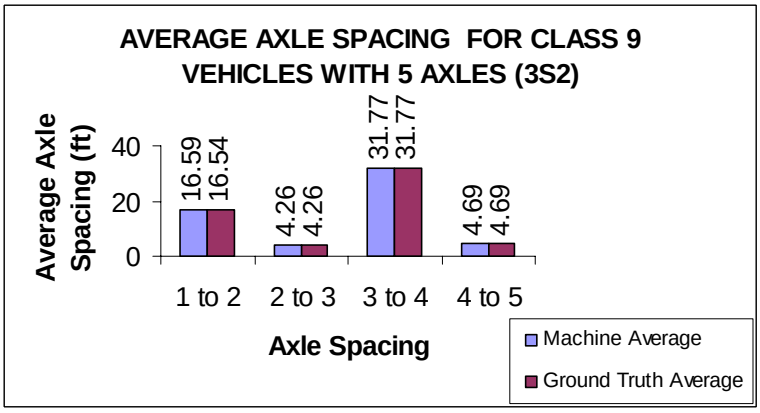

AVERAGE AXLE SPACING FOR CLASS 6 VEHICLES
Average Axle Spacing (ft)
20
15
10
5
0
16.9
16.95
4.31
4.33
1 to 2
2 to 3
Axle Spacing
Machine Average
Ground Truth Average

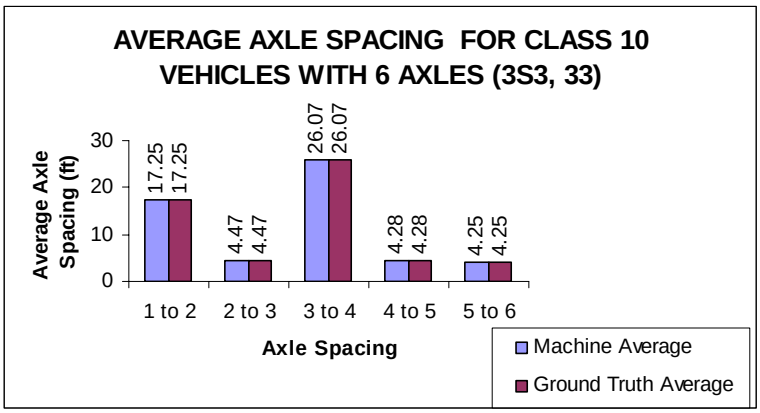

AVERAGE AXLE SPACING FOR CLASS 7 VEHICLES
Average Axle Spacing (ft)
15
10
5
0
11.85
11.85
3.98
3.98
4.58
4.58
1 to 2
2 to 3
3 to 4
Axle Spacing
Machine Average
Ground Truth Average

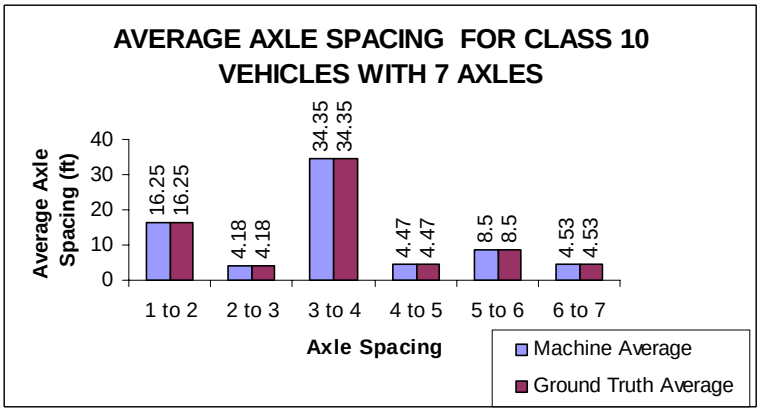

AVERAGE AXLE SPACING FOR CLASS 8 VEHICLES WITH 3 AXLES
Average Axle Spacing (ft)
30
20
10
0
12.97
13.07
24.38
25.65
1 to 2
2 to 3
Axle Spacing
Machine Average
Ground Truth Average

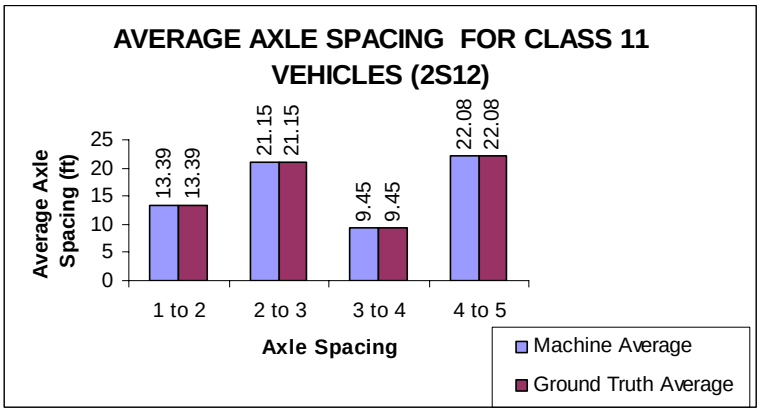

AVERAGE AXLE SPACING FOR CLASS 8 VEHICLES WITH 4 AXLES (3S1, 31)
Average Axle Spacing (ft)
40
30
20
10
0
17.87
17.87
4.3
4.3
30.13
30.13
1 to 2
2 to 3
3 to 4
Axle Spacing
Machine Average
Ground Truth Average

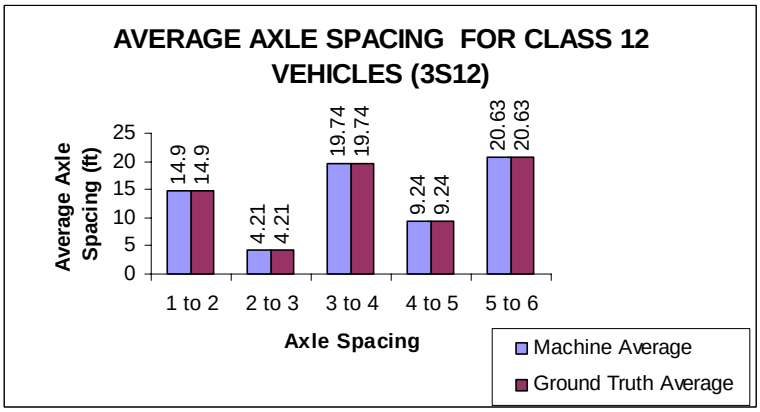

AVERAGE AXLE SPACING FOR CLASS 8 VEHICLES WITH 4 AXLES (2S2)
Average Axle Spacing (ft)
30
20
10
0
14
14.51
23.48
25.85
3.89
4.43
1 to 2
2 to 3
3 to 4
Axle Spacing
Machine Average
Ground Truth Average

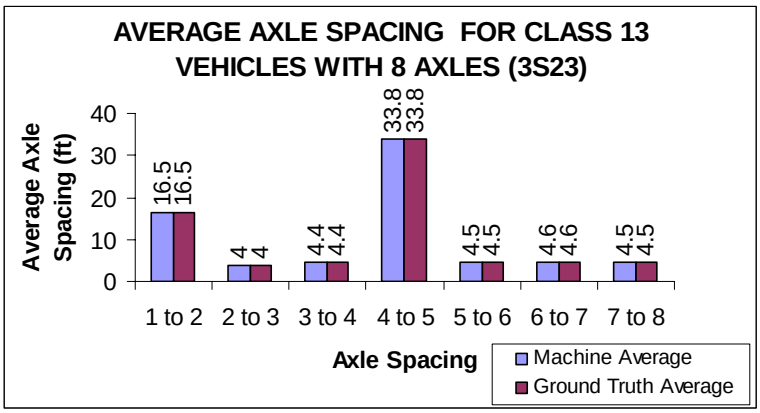

AVERAGE AXLE SPACING FOR CLASS 9 VEHICLES WITH 5 AXLES (3S2)
Average Axle Spacing (ft)
40
20
0
16.59
16.54
4.26
4.26
31.77
31.77
4.69
4.69
1 to 2
2 to 3
3 to 4
4 to 5
Axle Spacing
Machine Average
Ground Truth Average

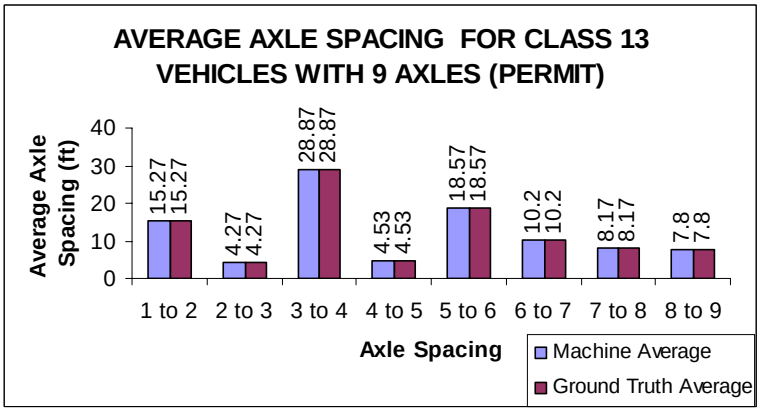

AVERAGE AXLE SPACING FOR CLASS 10 VEHICLES WITH 6 AXLES (3S3, 33)
Average Axle Spacing (ft)
30
20
10
0
17.25
17.25
4.47
4.47
26.07
26.07
4.28
4.28
4.25
4.25
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
Axle Spacing
Machine Average
Ground Truth Average


AVERAGE AXLE SPACING FOR CLASS 10 VEHICLES WITH 7 AXLES
Average Axle Spacing (ft)
40
30
20
10
0
16.25
16.25
4.18
4.18
34.35
34.35
4.47
4.47
8.5
8.5
4.53
4.53
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
Axle Spacing
Machine Average
Ground Truth Average


AVERAGE AXLE SPACING FOR CLASS 11 VEHICLES (2S12)
Average Axle Spacing (ft)
25
20
15
10
5
0
13.39
13.39
21.15
21.15
9.45
9.45
22.08
22.08
1 to 2
2 to 3
3 to 4
4 to 5
Axle Spacing
Machine Average
Ground Truth Average


AVERAGE AXLE SPACING FOR CLASS 12 VEHICLES (3S12)
Average Axle Spacing (ft)
25
20
15
10
5
0
14.9
14.9
4.21
4.21
19.74
19.74
9.24
9.24
20.63
20.63
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
Axle Spacing
Machine Average
Ground Truth Average


AVERAGE AXLE SPACING FOR CLASS 13 VEHICLES WITH 8 AXLES (3S23)
Average Axle Spacing (ft)
40
30
20
10
0
16.5
16.5
4
4
4.4
4.4
33.8
33.8
4.5
4.5
4.6
4.6
4.5
4.5
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
Axle Spacing
Machine Average
Ground Truth Average


AVERAGE AXLE SPACING FOR CLASS 13 VEHICLES WITH 9 AXLES (PERMIT)
Average Axle Spacing (ft)
40
30
20
10
0
15.27
15.27
4.27
4.27
28.87
28.87
4.53
4.53
18.57
18.57
10.2
10.2
8.17
8.17
7.8
7.8
1 to 2
2 to 3
3 to 4
4 to 5
5 to 6
6 to 7
7 to 8
8 to 9
Axle Spacing
Machine Average
Ground Truth Average

Appendix K: Descriptive Statistical Analysis Results for Actual Axle Spacing

Class 2	Axle 1-2
Mean	8.96
Standard Error	0.07
Median	8.86
Mode	8.86
Standard Deviation	0.81
Sample Variance	0.66
Kurtosis	49.79
Skewness	5.74
Range	8.17
Minimum	7.89
Maximum	9.74
Largest(5)	9.74
Smallest(5)	8.08
Confidence Level (95.0%)	0.15

Class 3	Axle 1-2
Mean	10.31
Standard Error	0.13
Median	9.97
Mode	10.41
Standard Deviation	1.39
Sample Variance	1.92
Kurtosis	0.49
Skewness	0.73
Range	6.69
Minimum	7.69
Maximum	14.38
Largest(5)	13.06
Smallest(5)	8.48
Confidence Level (95.0%)	0.25

Class 4 (Buses) with Three Axles		
	Axle 1-2	**Axle 2-3**
Mean	24.96	3.98
Standard Error	0.45	0.03
Median	26.00	4.00
Mode	26.10	4.00
Standard Deviation	1.85	0.11
Sample Variance	3.41	0.01
Kurtosis	2.36	-0.09
Skewness	-1.46	0.05
Range	6.90	0.40
Minimum	19.80	3.80
Maximum	26.70	4.20
Largest(3)	26.40	4.10
Smallest(3)	23.50	3.90
Confidence Level (95.0%)	0.88	0.05

Class 6		
Statistic	**Axle 1-2**	**Axle 2-3**
Mean	16.95	4.33
Standard Error	0.34	0.02
Median	16.50	4.30
Mode	15.60	4.30
Standard Deviation	3.00	0.22
Sample Variance	8.98	0.05
Kurtosis	-0.51	2.08
Skewness	0.26	0.06
Range	13.10	1.50
Minimum	11.40	3.60
Maximum	24.50	5.10
Largest(3)	22.70	4.60
Smallest(3)	12.10	4.00
Confidence Level (95.0%)	0.66	0.05

Class 7			
	Axle 1-2	**Axle 2-3**	**Axle 3-4**
Mean	11.85	3.98	4.58
Standard Error	0.31	0.09	0.41
Median	11.70	3.90	4.40
Mode	11.70	4.30	4.20
Standard Deviation	1.35	0.38	1.77
Sample Variance	1.82	0.14	3.12
Kurtosis	8.66	-1.50	16.92
Skewness	2.55	0.09	3.99
Range	6.30	1.20	8.40
Minimum	10.30	3.40	3.30
Maximum	16.60	4.60	11.70
Largest(3)	12.70	4.40	4.50
Smallest(3)	10.90	3.60	3.40
Confidence Level (95.0%)	0.61	0.17	0.79

Class 8 (Four Axles)			
	Axle 1-2	**Axle 2-3**	**Axle 3-4**
Mean	14.62	25.15	5.27
Standard Error	0.25	0.83	0.52
Median	14.00	24.80	4.00
Mode	13.20	20.00	4.00
Standard Deviation	2.44	7.93	4.95
Sample Variance	5.98	62.84	24.49
Kurtosis	-0.05	-0.32	20.00
Skewness	0.82	-0.33	4.34
Range	10.40	36.40	29.90
Minimum	10.90	4.20	2.50
Maximum	21.30	40.60	32.40
Largest(3)	20.70	37.00	28.80
Smallest(3)	11.20	4.40	2.60
Confidence Level (95.0%)	0.50	1.62	1.01

Class 3 (With One - Axle Trailer)		
	Axle 1-2	**Axle 2-3**
Mean	11.53	15.10
Standard Error	0.10	0.37
Median	11.60	14.00
Mode	11.70	14.70
Standard Deviation	0.80	2.91
Sample Variance	0.64	8.46
Kurtosis	-0.24	0.62
Skewness	0.53	1.21
Range	3.20	11.40
Minimum	10.10	11.50
Maximum	13.30	22.90
Largest(3)	13.20	22.50
Smallest(3)	10.30	12.00
Confidence Level (95.0%)	0.20	0.72

Class 8 (Three Axles)		
	Axle 1-2	**Axle 2-3**
Mean	13.07	25.65
Standard Error	0.25	1.32
Median	12.70	23.90
Mode	12.10	22.00
Standard Deviation	1.13	5.90
Sample Variance	1.29	34.79
Kurtosis	0.53	-1.13
Skewness	1.03	0.34
Range	4.20	19.40
Minimum	11.70	17.00
Maximum	15.90	36.40
Largest(3)	14.70	33.40
Smallest(3)	12.00	19.80
Confidence Level (95.0%)	0.50	2.59

Class 3 (With Two-Axle Trailer)			
	Axle 1-2	**Axle 2-3**	**Axle 3-4**
Mean	12.30	19.00	2.76
Standard Error	0.11	0.33	0.02
Median	12.00	18.70	2.80
Mode	11.60	17.50	2.80
Standard Deviation	1.11	3.52	0.22
Sample Variance	1.23	12.41	0.05
Kurtosis	0.59	-0.06	5.09
Skewness	0.75	0.34	0.70
Range	6.20	19.60	1.70
Minimum	10.20	10.40	2.10
Maximum	16.40	30.00	3.80
Largest(3)	14.60	25.00	3.20
Smallest(3)	10.80	13.00	2.30
Confidence Level (95.0%)	0.21	0.66	0.04

Class 5 (With One-Axle Trailer)		
	Axle 1-2	**Axle 2-3**
Mean	13.78	16.00
Standard Error	0.19	0.95
Median	13.75	16.30
Mode	#N/A	16.30
Standard Deviation	0.39	1.91
Sample Variance	0.15	3.65
Kurtosis	-4.41	1.97
Skewness	0.17	-0.91
Range	0.80	4.60
Minimum	13.40	13.40
Maximum	14.20	18.00
Largest(3)	13.50	16.30
Smallest(3)	14.00	16.30
Confidence Level (95.0%)	0.38	1.87

Class 5 (With Two - Axle Trailer)			
	Axle 1-2	**Axle 2-3**	**Axle 3-4**
Mean	13.72	18.82	3.79
Standard Error	0.29	0.65	0.44
Median	13.60	18.00	2.80
Mode	14.40	16.40	2.80
Standard Deviation	1.39	3.14	2.10
Sample Variance	1.92	9.84	4.39
Kurtosis	7.56	1.75	1.67
Skewness	1.79	1.19	1.85
Range	7.40	13.00	6.10
Minimum	11.30	15.00	2.70
Maximum	18.70	28.00	8.80
Largest(3)	14.40	22.40	7.80
Smallest(3)	12.70	15.60	2.70
Confidence Level (95.0%)	0.57	1.28	0.86

Class 9				
	Axle 1-2	**Axle 2-3**	**Axle 3-4**	**Axle 4-5**
Mean	16.59	4.26	31.77	4.69
Standard Error	0.06	0.00	0.09	0.05
Median	16.90	4.30	32.30	4.00
Mode	17.10	4.30	34.20	4.00
Standard Deviation	2.41	0.12	3.46	1.86
Sample Variance	5.81	0.01	11.98	3.44
Kurtosis	0.08	11.24	6.67	4.16
Skewness	-0.52	-0.52	-1.80	2.46
Range	15.10	1.80	34.30	7.80
Minimum	9.70	3.20	7.80	2.70
Maximum	24.80	5.00	42.10	10.50
Largest(1)	24.80	5.00	42.10	10.50
Smallest(1)	9.70	3.20	7.80	2.70
Confidence Level (95.0%)	0.13	0.01	0.18	0.10

Class 10 (Six Axles)					
	Axle 1-2	**Axle 2-3**	**Axle 3-4**	**Axle 4-5**	**Axle 5-6**
Mean	17.01	4.40	28.06	4.32	5.27
Standard Error	0.58	0.08	1.96	0.10	0.67
Median	17.50	4.30	33.50	4.20	4.20
Mode	17.30	4.40	36.40	4.60	4.10
Standard Deviation	2.92	0.39	9.80	0.48	3.36
Sample Variance	8.51	0.15	95.99	0.23	11.27
Kurtosis	-0.25	6.12	-1.60	2.12	19.33
Skewness	-0.38	2.30	-0.53	-0.11	4.23
Range	11.40	1.70	24.40	2.50	17.50
Minimum	10.70	4.00	13.90	3.00	3.00
Maximum	22.10	5.70	38.30	5.50	20.50
Largest(1)	22.10	5.70	38.30	5.50	20.50
Smallest(1)	10.70	4.00	13.90	3.00	3.00
Confidence Level (95.0%)	1.14	0.15	3.84	0.19	1.32

Class 11				
	Axle 1-2	**Axle 2-3**	**Axle 3-4**	**Axle 4-5**
Mean	13.39	21.15	9.45	22.08
Standard Error	0.34	0.11	0.07	0.08
Median	12.70	21.10	9.40	22.10
Mode	13.10	21.50	9.40	21.70
Standard Deviation	1.72	0.55	0.33	0.41
Sample Variance	2.96	0.30	0.11	0.17
Kurtosis	2.42	-1.02	0.46	-0.47
Skewness	1.93	-0.14	-0.75	0.65
Range	6.10	1.90	1.30	1.40
Minimum	11.80	20.10	8.70	21.50
Maximum	17.90	22.00	10.00	22.90
Largest(1)	17.90	22.00	10.00	22.90
Smallest(1)	11.80	20.10	8.70	21.50
Confidence Level (95.0%)	0.67	0.21	0.13	0.16

Class 12					
	Axle 1-2	**Axle 2-3**	**Axle 3-4**	**Axle 4-5**	**Axle 5-6**
Mean	14.91	4.21	19.74	9.24	20.63
Standard Error	0.83	0.03	0.14	0.16	1.05
Median	15.50	4.20	19.60	9.30	22.10
Mode	13.30	4.30	19.60	9.80	22.10
Standard Deviation	2.89	0.11	0.49	0.55	3.65
Sample Variance	8.34	0.01	0.24	0.30	13.32
Kurtosis	-0.98	0.68	-0.70	-1.56	3.55
Skewness	0.05	-1.22	0.58	0.06	-2.17
Range	8.70	0.30	1.50	1.60	11.10
Minimum	10.60	4.00	19.10	8.50	11.50
Maximum	19.30	4.30	20.60	10.10	22.60
Largest(1)	19.30	4.30	20.60	10.10	22.60
Smallest(1)	10.60	4.00	19.10	8.50	11.50
Confidence Level (95.0%)	1.63	0.06	0.28	0.31	2.06

Appendix L: FDOT Table Indicating Order of Classification

ORDER	CLASS	VECHICLE DESCRIPTION	# AXLE	SPACING	SPACING	SPACING	SPACING	SPACING	SPACING	SPACING	SPACING
1	1	MOTORCYCLE	2	0.1 - 6.0							
2	2	AUTO , PICKUP	2	6.00- 10.0							
3	3	OTHER (LIMO, VAN, RV)	2	10.00-13.30							
4	4	BUS	2	23.00-40.0							
5	5	2 D	2	13.30- 23.0							
1	**8**	**2S1, 21**	**3**	**10.00- 23.0**	**11.0 - 40.0**						
2	4	BUS	3	23.00-40.0	0.1 - 6.0						
3	6	3 AXLE	3	6.00 - 23.0	0.1 - 6.0						
4	**3**	**OTHER W / 1 AXLE TRLR**	**3**	**10.00-13.30**	**6.0 -25.0**						
5	2	AUTO W / 1 AXLE TRLR	3	6.00- 10.0	6.0 -25.0						
6	**5**	**2D W 1 AXLE TRLR**	**3**	**13.30-23.0**	**6.0 - 25.0**						
1	**8**	**2S2**	**4**	**10.00-23.0**	**11.0 - 40.0**	**2.0 - 12.0**					
2	8	3S1 , 31	4	6.00 - 23.0	0.1 - 6.0	6.00 - 44.0					
3	7	4 AXLE	4	6.00 - 23.0	0.1 - 6.0	0.1-6.0					
4	**3**	**OTHER W / 2 AXLE TRLR**	**4**	**10.00-13.30**	**6.0 - 25.0**	**0.1 - 6.0**					
5	**5**	**2D W / 2 AXLE TRLR**	**4**	**13.30 -23.0**	**6.0 - 25.0**	**0.1 - 6.0**					
6	2	AUTO W / 2 AXLE TRLR	4	6.00 - 10.0	6.0 - 25.0	0.1 - 6.0					
1	9	3S2	5	6.00 - 26.0	0.1 - 6.0	6.00 - 46.0	0.1 - 11.00				
2	9	32	5	6.00 - 26.0	0.1 - 6.0	6.00- 23.0	11.0 - 27.0				
3	11	2S12	5	6.00 - 26.0	11.0 - 26.0	6.00 - 20.0	11.00 - 26.0				
4	3	OTHER W / 3 AXLE TRLR	5	10.00-13.30	6.0 - 25.0	0.1 - 6.0	0.1 - 6.0				
5	5	2D W / 3 AXLE TRLR	5	13.30-23.0	6.0 - 25.0	0.1 - 6.0	0.1 - 6.0				
1	10	3S3 , 33	6	6.00 - 26.0	0.1 - 6.0	0.1 - 46.0	0.1 - 11.0	0.1 - 11.0			
2	12	3S12	6	6.00 - 26.0	0.1 - 6.0	11.00 - 26.0	6.00 - 24.0	11.00 - 26.0			
1	**10**		**7**	**6.00 - 16.7**	**0.1 - 6.0**	**13.3 - 40.0**	**0.1 - 13.3**	**0.1 - 13.3**	**0.1 - 13.3**		
2	**13**	**2S23,3S22,3S13**	**7**	**1.0 - 45.0**	**1.0 - 45.0**	**1.0 - 45.0**	**1.0 - 45.0**	**1.0 - 45.0**	**1.0 - 45.0**		
1	13	3S23	8	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	
1	13	PERMIT	9	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0	1.0 - 45.0
	15	ERROR / UNCLASSIFIED	ALL	**VEHICLES**	**NOT MEETING**	**AXLE CONFIG**	**SPACINGS**	**FOR CLASS 1**	**THROUGH**	**CLASS 13**	
		VEHICLE	**AXLE #**	**ONE-TWO**	**TWO-THREE**	**THREE-FOUR**	**FOUR-FIVE**	**FIVE-SIX**	**SIX-SEVEN**	**SEVEN-EIGHT**	**EIGHT-NINE**