CAMBRIDGE SYSTEMATICS

The Countywide Truck Travel Demand Model

final

report

prepared for

Alameda County Congestion Management Agency

prepared by

Cambridge Systematics, Inc.

Dowling & Associates

Quality Counts, Inc.

June 2010

www.camsys.com

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date

June 2010

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Executive Summary

Alameda County faces a critical need for forecasting truck impacts. The Port of Oakland and Oakland Airport are the commercial hubs for truck traffic. Alameda County has five of the top 10 most congested corridors in the Bay Area, and each of these corridors is major truck routes.

The current Alameda County Congestion Management Agency (ACCMA) truck model comes from a nearly 20-year old truck model originally developed by the Metropolitan Transportation Commission (MTC). Also, it was not validated with truck counts. Therefore, the current model greatly under-predicts the number of trucks operating on Alameda County roadways. The new model shows a more realistic picture of actual truck travel in Alameda County. The overall improvement of the model in terms of forecasting trucks is shown below in Table ES.1.

Table ES.1 Existing and New ACCMA Truck Model 2005 Daily Volumes

Performance Measure	Old Model	New Model
Sum of Observed Truck Volumes	321,800	321,800
Sum of Modeled Truck Volumes	139,000	310,400
Percent Error	-57%	-4%

The truck model project consisted of a number of elements, starting with a review of the existing ACCMA truck model (Chapter 3). The project team, with support from the Model Task Force, also conducted an analysis of peer agency (large county transportation agencies and metropolitan planning organizations (MPO)) truck models (Chapter 4). Armed with an understanding of the existing truck model and informed about the range of potential truck model improvements, the set of preferred model enhancements for ACCMA was formulated (Chapter 6) based on available project resources.

New truck traffic counts were collected throughout Alameda County, and off-the-shelf truck traffic data were assembled for the other counties in the model coverage area (the eight other Bay Area counties, plus San Joaquin County) (Chapter 6). The new counts were used for model development and model validation activities (Chapter 7). Also included for this project are future year traffic forecasts for 2015 and 2035 (Chapter 8).

The project also includes recommendations for a next generation ACCMA truck and freight model system. Because the long-distance nature of commercial goods movement, an initial suggestion is to monitor and perhaps partner with MTC and the State of California truck and goods movement model development efforts.

The Countywide Travel Demand Model Update to Improve Modeling Truck Impacts Project was funded by a California Department of Transportation (Caltrans) Fiscal Year (FY) 2007/2008 Partnership Planning Grant. The new ACCMA truck model now includes a number of new enhancements, including the following:

- **New truck counts collected at key locations throughout Alameda County**. The foundation of any model system lies in the data. For this project, new truck counts were collected at one dozen highway locations and at 50 arterial locations. In addition, Performance Measurement System (PeMS) data were examined throughout Alameda County, with an emphasis on including locations where new data was collected. These data were supplemented with published Caltrans documents.
- **Updated classifications of trucks that dovetail with truck counts**. The existing truck model has a separate classification for very small trucks (vans and pickups). The problem with this classification is separating out vans and pickups used for personal purposes from those used for commercial purposes. Therefore, Very Small Trucks classification is not included in the new truck model. The new truck model resolved some of these inconsistencies, although additional research into understanding very small trucks would be a potentially useful future model enhancement. It is important to note, however, that the issue of very small trucks is unresolved across nearly every regional travel model in North America as essential new data collection efforts would be very expensive.
- **A special truck trip generator for the Port of Oakland Seaport.** It was found that the existing truck model underestimated truck trips to the Port of Oakland by 90 percent. A new special generator model was created to more accurately predict truck trips to and from the Port of Oakland. A review of the Oakland Airport area showed the new truck model adequately predicts trucks so an additional special generator was not required.
- **An innovative and cost-effective approach to estimating observed truck trip generation rates and travel patterns using new truck count data.** A key problem with commercial travel (i.e., truck trips) is the lack of knowledge on actual travel patterns. Truck counts provide a snapshot of truck activity at specific locations, but by themselves do not inform where truck trips start and end. In addition, there is no real observed knowledge about truck trip generation rates, or how long each truck trip is in miles or minutes (or hours).

  The project team developed an innovative methodology to estimate observed truck trip rates and travel patterns as a cost-effective response given overall project resources and objectives. (This methodology is described in detail in Chapter 7, Section 1). Given observed trip generation and distribution data, the project team was able to develop appropriate models. This methodology

used here was the subject of a paper presented to the Innovations in Travel Modeling Conference held in May 2010 in Tempe, Arizona[1].

- **Separation of short-distance (intraregional) truck trips from long-distance (interregional) truck trips**. A key problem with the older version of the truck model was that trucks were not permitted to leave the Bay Area. It is well understood that many trucks travel long distances to out-of-state and out-of-region locations. Thus, the new truck trip tables were split into intraregional and interregional components.
- **Traffic assignment improvements that accurately reflect differential capacities of trucks and automobiles**. The new truck model provides for direct accounting of truck-based congestion through reporting passenger car equivalents (PCEs). PCEs calculate the specific congestion impacts of trucks versus automobiles; whereas, the prior model considered autos and trucks as generic vehicles. PCEs have an important practical application through direct representation of the amount of roadway capacity each type of vehicle consumes. An added feature is the traffic assignment now reports three classes of trucks; whereas, the older version of the model reported total trucks.
- **Base year model validation and future year forecasts to be used as starting points for upcoming ACCMA studies**. The end product of this project was development of base and future year forecasts of Alameda County travel demand for trucks and automobiles. These forecasts, and underlying input data, are ready for use in a variety of applications, ranging from localized traffic studies to the countywide planning analyses.

In all, these enhancements represent a significant upgrade in ACCMA truck modeling capabilities. The following report covers all details of the truck model development efforts.

The overall documentation for this project include this project report, network plots available at the ACCMA web site. The detailed link-level validation results for all count locations and model time periods included in Appendix B is also available in the model DVDs as electronic workbook.

[1] http://itm2010.fulton.asu.edu/ocs/index.php/itm/itm2010/index.

1.0 Introduction

The objective of the study has been to enhance the ACCMA Travel Demand Model to better forecast truck travel and truck impacts in congested corridors. Although ACCMA has had an existing truck model system, based on the model developed by MTC, it is inadequate for current analytical needs. ACCMA needs to evaluate truck and freight projects the same way it does other roadway and transit projects in the Countywide Transportation Plan (CTP). The Port of Oakland's sea and airport are regional commerce hubs that have significant transportation impacts. In addition, there are numerous goods movement-related businesses spread throughout the County. MTC's Regional Goods Movement Study (RGMS) estimated that, in terms of volume, about 80 percent of goods are moved by trucks. There is also a need to model truck activity in congested corridors of Alameda County. Alameda County is one of the largest counties in California, and one of its most congested. The County had six of the top 10 most congested corridors in the Bay Area in 2007. The RGMS also determined that I-880 receives the highest amount of truck traffic in the Bay Area, and I-580 is the primary connection between the Bay Area and the national interstate truck network.[2]

Analysis of freight and goods movement has become a major concern in the transportation community. Our economy depends on the fast and reliable delivery of goods. In addition, trucks contribute a large amount of vehicle miles of travel (VMT) and emissions to statewide travel. Also, the need for infrastructure improvements to facilitate goods movement far outpaces available funding. Enhanced goods movement and freight modeling systems will be required to address the complex policy questions that confront policy-makers these days throughout the United States.

A Task Force consisting model experts from MTC, Santa Clara Valley Transportation Authority (VTA), and Caltrans, and staff from local agencies (including Alameda-Contra Costa Transit District (AC Transit); Port of Oakland; and Cities of Alameda, Oakland, Fremont, San Leandro, and Livermore) provided guidance throughout the process of truck model development. The Task Force met on a monthly basis throughout the project.

[2] Metropolitan Transportation Commission, Regional Goods Movement Study, 2004, http://www.mtc.ca.gov/planning/rgm/background.htm.

1.1 OVERVIEW

The ACCMA Truck Model project included the following tasks. Each of these tasks serves as separate chapters in the body of this report.

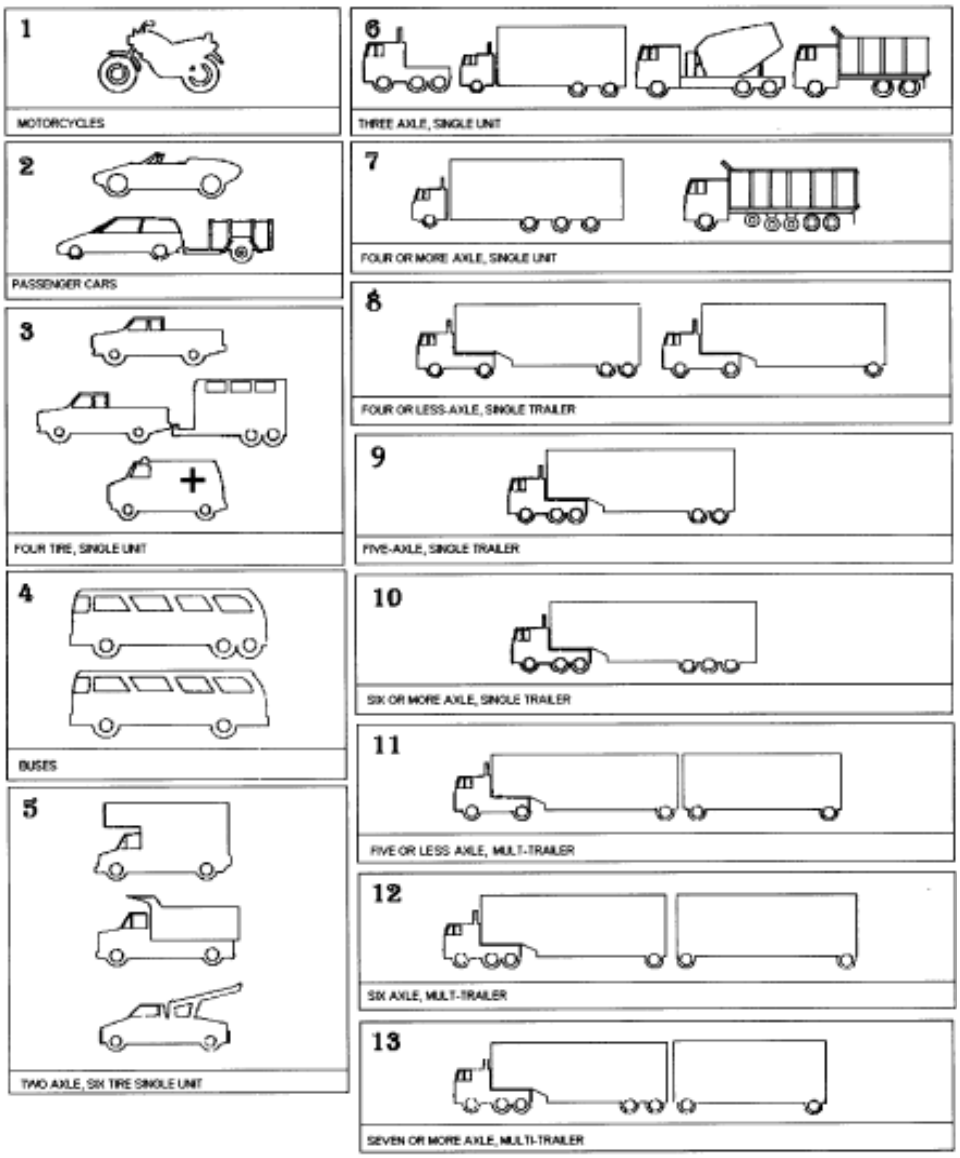
- Review of state-of-the-practice truck and freight models;
- Applicable enhancements to be applied to the ACCMA truck model;
- Data needs/data collection;
- Truck model development approach;
- Model calibration and validation; and
- Future year forecasts.

However, before delving into the individual chapters of this report, it is worthwhile to examine what the definition of a truck is. A number of schemes have variously been used throughout the nation in terms of a definition of a truck in the development of truck/freight models:

- Truck classification schemes;
- Number of axles;
- Number of units;
- Gross vehicle weight rating;
- Loaded weight;
- Vehicle length; and
- The Federal Highway Administration (FHWA) 13-class scheme (see Figure 2.1, below).

After considering the various options above, the project team ultimately settled on the FHWA 13-class scheme as the most logical way of defining and grouping trucks for the ACCMA model, which was consistent with the classification counts gathered for use in validation, and for which crosswalks to groupings for other purposes; for example, gross vehicle weight (GVW) used for emissions analysis are most readily available.

Figure 1.1 FHWA 13-Class Vehicle Scheme



Review of State of the Practice in Truck/Freight Models

The objective of this task was to review the state of the practice of regional and local truck and freight models to identify approaches that may be applicable for the ACCMA model. A number of resource documents were first identified that cover the latest trends in truck and freight forecasting. These resources included:

- The National Cooperative Highway Research Program (NCHRP) Report 606, *Forecasting Statewide Freight Toolkit*;
- The NCHRP Synthesis 298, Truck Trip Generation Data;

- The 1996 and 2008 editions of the FHWA's Quick Response Freight Manual (QRFM);
- The National Highway Institute's (NHI) Course 139002 – Freight Forecasting in Transportation Planning; and
- The FHWA's Accounting for Commercial Vehicles in Urban Transportation Models.

The Cambridge Systematics (CS) team (including Dowling & Associates and Quality Counts as subcontractors) also has developed truck and/or freight models for many state departments of transportation (DOT) and MPOs; and has extensive experience with local truck analysis projects. With that experience, a number of truck models were evaluated, including:

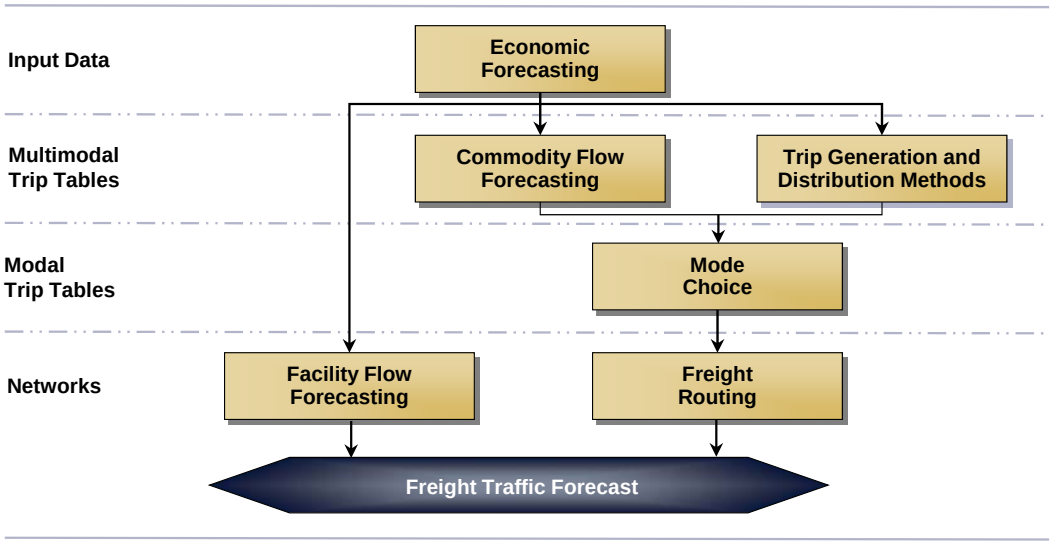
- Santa Clara VTA Truck Model
- Los Angeles County (Metro) Cube Cargo Model;
- Southern California Association of Governments (SCAG) heavy-duty truck model;
- San Joaquin Valley Goods Movement Study; and
- Maricopa Association of Governments (MAG) Truck Model.

Truck and freight modeling techniques can be classified broadly into the following eight categories based on objective, methodology, and data requirements:

1. Link-based factoring;
2. Origin-destination (O-D) factoring;
3. Freight truck models;
4. Four-step commodity models;
5. Economic activity models;
6. Hybrid models;
7. Logistics/supply chain models; and
8. Tour-based models.

Given the resources available for this study, the project team decided early on to concentrate on truck model systems. This flow of potential activities is shown in Figure 2.2, below. It was not anticipated that commodity flow forecasting and mode choice models could be developed within the project budget, so efforts were concentrated on trip generation and distribution methods along with traffic assignment.

Figure 1.2 Elements of Freight Forecasting



Source: NHI Course 139002 – Freight Forecasting in Transportation Planning.

Applicable Enhancements for the ACCMA Truck Model

The tasks identified here were the types of enhancements that would meet the needs of ACCMA, assist ACCMA in reviewing those enhancements, and recommend the improvements that implemented in subsequent tasks.

The CS team met regularly with ACCMA staff and the Model Task Force to cover existing and emerging issues that could be better addressed by an improved truck model. Among the relevant documents considered for this effort included various plans in Alameda County, including the ACCMA Community-Based Transportation Plans; the MTC planning documents, including the Transportation 2030 Plan: Mobility for the Next Generation, draft Transportation 2035 Plan: Change in Motion, and the Regional Goods Movement Study for the San Francisco Bay Area; and transportation planning documents from other agencies to document the truck issues wherein the analysis would be improved by an enhanced ACCMA truck model.

The framework for considering model enhancements was considered according to the framework established in Figure 1.2. An advantage of grouping by model component, as shown in Figure 1.2, is that certain model components (for example, truck assignment) may be common to many different model types (for example, trip-based or commodity-based).

Ultimately, it was decided that improvements to trip generation, distribution and assignment methods, combined with new roadway data collection efforts, constituted the best approach given the limited available resources. Long-term enhancements were also examined, and these are discussed in Chapter 8.

Identify Data Needs and Collect Data

This task included identification of data needs to support the modeling efforts and to collect the identified data. Quality Counts was hired to collect freeway and arterial counts at a number of locations throughout Alameda County.

A number of methods for collecting trucks were considered. In the end, a combination of hose counts, manual classification counts, and radar detector units were used (This technology is discussed in more detail in Chapter 5.).

Some issues were encountered during data collection; and Chapter 5 examines how these issues were first identified, and then resolved. In the end, a useful database of functional counts was collected and utilized throughout the model development and, particularly model validation efforts.

Model Development Approach

It is useful to consider travel model systems from a life-cycle perspective. There are four basic stages of a model system: 1) development, 2) validation, 3) application, and 4) maintenance. This project concerns are primarily the development and validation stages; although application and maintenance are critical components and were continuously considered.

The model development began with using innovative origin-destination matrix estimation (ODME) process as a means for creating synthetic truck trip tables, which could be used as observed trip tables for the different truck types. These ODME matrices were used extensively in the model development and validation process, but were not used in the actual trip generation or distribution models.

A number of model development tasks were completed for this project. These included estimating new trip generation and distribution models, and significantly improving the traffic assignment process to more directly respond to truck traffic impacts. In addition, a new special generator model was developed for the Port of Oakland Seaport.

Travel Model Development

The new truck model system included model calibration and validation efforts. Key features of the new truck model include splitting trip generation and distribution models between trips internal to the 10-county model coverage area, and external trips that have either one trip end outside the model coverage area (internal to external or external to internal) or both ends outside the model coverage age (through trips).

In addition, traffic assignment was modified to calculate PCEs. PCEs are used to recognize that trucks take up more roadway capacity than do automobiles. Total volumes are also reported.

Future year forecasts were also prepared as part of this project. Forecasts for ACCMA model time periods were prepared for 2015 and 2035.

2.0 Review of Existing Truck Model

The existing ACCMA truck model, which is a component of the Alameda countywide travel demand model, was initially developed by the MTC, first in 1997[3]. This model was based on two sources: 1) a truck corridor study model for I-880 conducted by Barton Aschman, and 2) the FHWA's QRFM.

The Barton-Ashman model was based on a series of truck travel surveys, including a vehicle intercept survey, employer surveys, truck classification counts, and surveys and interviews conducted at the Port of Oakland.

Trip generation estimates productions and attractions for each of the truck types (very small [2-axle, 4 tires]; small [2-axle, 6 tires]; medium [3-axle]; and combo [4-axle +]) separately. The gravity model is used to distribute productions and attractions between zones for each truck type. However, all model steps after trip distribution are performed with the four truck classifications aggregated to total trucks. Therefore, the final loaded network from the travel demand model did not distinguish between truck type and only contained four vehicle types (drive alone, shared ride (2 persons), shared ride (3 or more persons), and truck). The model script was modified to maintain separate truck classes through the assignment stage in order to evaluate the truck model's performance.

Analyses from previous truck modeling studies[4,5] confirm that the ability to accurately predict truck volumes in the lighter weight categories, which are mostly standard pickups and vans, is one of the most serious shortcomings in an urban truck model. These trucks are considered "very small" trucks or the FHWA Class 3 vehicles in the current ACCMA truck model. Many of these trucks are used as personal vehicles and thus, are already captured in the ACCMA passenger travel model. It is extremely difficult, when conducting vehicle classification counts to distinguish the commercial use vehicles from the personal use vehicles, which fall under the FHWA Class 3. This leads to poor results when validating the truck model for Class 3 vehicles. For this freight model, "very small" trucks

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[3] Metropolitan Transportation Commission, 1997, Internal Memorandum from Rupinder Singh to Chuck Purvis, Model Development, Technical Memorandum #43: 1990 Truck Trip Table.

[4] Meyer Mohaddes Associates, *SCAG Heavy Duty Truck (HDT) Model*, prepared for Southern California Association of Governments, 1999.

[5] Cambridge Systematics, Inc., *SCAG Truck Count Study: Truck Classification System*, prepared for Southern California Association of Governments, August 2001.

will be modeled in the passenger travel modeling framework, but excluded from the truck modeling framework.

A basic visual evaluation of assigned total truck trips from the existing model reveal zero truck trips at external stations, as well as underestimated volumes on major truck corridors outside of Alameda. This issue was identified as a key element to be added to the development of the freight model.

2.1 EXISTING TRUCK MODEL COMPONENTS

Trip Generation Models

Trip generation models included in the existing ACCMA model are described here. These equations come from the original Bay Area truck model developed by MTC[6]. As mentioned above, the MTC truck model itself came from a study conducted in 1990 by Barton Ashman Associates, based on a series of four truck surveys conducted for the I-880 Intermodal Corridor Study. That model includes trip generation models for nongaraged and for garaged trucks[7]. The equations in the existing ACCMA model are shown below.

Linked Trips (Productions and Attractions)

2 Axle Trips = 0.0324 * Total Employment

3 Axle Trips = 0.0039 * Total Employment

4+ Axle Trips = 0.0073 * Total Employment

Garage-Based Trip Productions

2 Axle Trips = 0.011 * Manufacturing Employment + 0.014 * Retail Employment + 0.0105 * Service Employment + 0.046 * (Other Employment + Wholesale Employment + Agricultural Employment

3 Axle Trips = 0.014 * Manufacturing Employment + 0.012 * Retail Employment 0.0037 * (Other Employment + Wholesale Employment + Agricultural Employment

4+ Axle Trips = 0.0044 * Manufacturing Employment + 0.0027 * Retail Employment 0.0084 * (Other Employment + Wholesale Employment + Agricultural Employment

[6] Ibid 1.

[7] Garage trips go back and forth between their base location and delivery/customer locations; lined trips make intermediate stops before returning to their home base.

Garage-Based Trip Attractions

2 Axle Trips = 0.234 * Total Employment

3 Axle Trips = 0.0046 * Total Employment

4+ Axle Trips = 0.0136 * Total Employment

Trip Distribution

Trip distribution is from the MTC model for four truck classes: very small, small, medium, and large trucks. Truck trip tables were created used standard gravity models for truck trips solely within the model coverage area.

Traffic Assignment

For traffic assignment, the four truck classes are summarized into one truck trip category. Total vehicles are assigned, so there is no method for accounting that trucks take up more roadway capacity than automobiles.

2.2 EXISTING MODEL VALIDATION

The results of the existing 2005 ACCMA model's daily assigned trips were compared to the observed counts. It should be noted that the validation statistics reported here are only for roadways in Alameda County. Table 2.1 provides validation statistics for the overall model and by vehicle class. As expected, the assigned total vehicles and auto trips meet the acceptable target for percent Root Mean-Square Error (RMSE).

Table 2.1 – Existing ACCMA Model Validation Summary Statistics

Performance Measure	Total Vehicles	Autos	Total Trucks	Small Trucks	Medium Trucks	Combo Trucks
Sum of Observed Volumes	3,406,000	3,084,000	322,000	70,000	77,000	176,000
Sum of Modeled Volumes	2,993,000	2,732,000	139,000	5,000	25,000	179,000
Percent Error	-12%	-11%	-57%	-92%	-67%	-38%
Percent RMSE	41%	38%	147%	132%	164%	164%
R-squared	0.88					

3.0 Review of Other Truck/Goods Movement Models

Prior to developing the modeling framework for the new ACCMA model, it is useful to review existing literature on freight and truck travel modeling. This reveals conceptual frameworks that may be useful in the current effort, as well as pitfalls that should be avoided. In the recent past, CS conducted extensive reviews of both the state-of-the-practice and the state-of-the-art modeling techniques as part of another study[8]. The ensuing sections provide a brief description of the various techniques identified in those reviews.

The modeling techniques can be classified broadly into the following eight categories based on objective, methodology, and data requirements:

1. Link-based factoring techniques;
2. Origin-destination (O-D) factoring;
3. Three-step freight truck models;
4. Four-step commodity flow models;
5. Economic activity models;
6. Hybrid models;
7. Logistics/supply chain models; and
8. Tour-based models.

3.1 STATE-OF-THE-PRACTICE MODELS

Link-Based Factoring Techniques

Link-based factoring techniques begin with existing truck volumes on a facility, on a modal network link, or at a freight-related terminal. Factors are developed to estimate changes in truck volumes due to changes in transportation service on the facility or on an alternative facility of the same or different mode. For example, to develop truck counts in a future year, observed truck counts on a specific highway are increased by three percent per year. The three-percent value may

[8] Fischer, M. J., M. L. Outwater, L. L. Cheng, D. N. Ahanotu, and R. Calix, Cambridge Systematics, Inc., *An Innovative Framework for Modeling Freight Transportation in Los Angeles County*, prepared for Los Angeles County Metropolitan Transportation Authority, January 2005.

be derived from historical truck volume growth, or based on another surrogate variable such as employment or economic growth. This simplified method permits existing data to be applied rapidly, and is usually intended for short-term forecasts. Many assumptions are needed to make these methods work, and the range of applicability is limited. The QRFM, developed for the FHWA, describes methods of applying growth factors to traffic volumes that are applicable to urban highways. Only two model components are required for the simplified method: 1) observed link traffic volumes, and 2) methods to factor these flows.

Origin-Destination Factoring

Origin-Destination (O-D) factoring forecasts truck flows by factoring a base year truck O-D table of truck flows and assigning the new truck O-D tables to the highway network. This method differs from the link-based method; in that, truck volumes are not directly observed, but produced by assigning a truck O-D table to a highway network. A variation on this approach is the factoring of commodity flow tables that provide tonnage flows by commodity between origins and destinations, splitting these flows among the available modes (using a mode choice model or fixed modal shares from the base year), and converting the truck flows to truck trips. The commodity O-D factoring approach is frequently used for statewide freight models, which generally focus on long-haul freight movement. Long-haul movement is well characterized in commodity flow datasets, such as the Commodity Flow Survey[9] and the Global Insight (formerly known as Reebie) TRANSEARCH database[10].

Three model components are required for the O-D factoring forecast method: 1) a base year O-D trip table for trucks (or a commodity flow table), 2) growth factors for the table, and 3) methods to assign the truck table to the highway network. The growth factors can be based on economic output, employment, or other growth indicators at the zonal level. The growth rates are often developed by using simple economic models. They are then applied to the base year O-D truck trip tables using iterative proportional fitting techniques to balance production and attraction growth rates. The iterative proportional fitting technique commonly used in transportation planning is known as Fratar factoring. Software to implement this technique is usually available in travel demand model packages (CUBE, TRANPLAN, TP+, EMME/2, and TransCAD). Methods to

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[9] The Commodity Flow Survey is a survey conducted by the U.S. Bureau of the Census every five years based on a survey of establishments. The resulting database provides commodity flows at the national, state, and metropolitan level. Commodity flows are reported in tons, ton-miles, and value, and by mode.

[10] TRANSEARCH is a proprietary commodity flow database that provides information on tons moved by mode. O-D information is provided at the county level. Reebie Associates originally developed TRANSEARCH, and the database is often called Reebie data. Reebie Associates was acquired by Global Insights in 2006.

assign truck tables to the highway network depend on the availability of other data and are not limited by the O-D factoring models.

Base year O-D truck trip tables can be estimated in a variety of ways, depending on the availability of data. One approach that has been used with some success is the ODME process. This method utilizes observed truck counts and partial O-D data (usually from O-D surveys) to estimate a truck trip table. Nonlinear programming techniques are used to estimate a trip table that, when assigned to the network, minimizes the difference between predicted and observed truck volumes. The partial O-D data and best judgment estimates for the unknown O-D information are used to construct a "seed" table. The nonlinear programming process then adjusts the trip table to obtain the best fit with the truck count data. The base year table produced from the ODME method can then be factored to a forecast year using the methods described previously. ODME models for trucks have been developed in the New York City region by List and Turnquist.[11] The ODME process is available as a standard module in the CUBE and TransCAD travel demand model packages.

Three-Step Freight Truck Models

Freight truck models develop highway freight truck flows by assigning an O-D table of freight truck flows to a highway network. This is the class of truck model currently included in the ACCMA travel demand model. The O-D truck table is produced by applying truck trip generation and distribution steps to existing and forecast employment and/or other variables of economic activity for analysis zones. This method differs from O-D factoring; in that, the O-D table is estimated directly using trip generation rates/equations and trip distribution models at the traffic analysis zone (TAZ) level. The mode choice step is unnecessary since truck trips are estimated directly, and there is no need for the consideration of other possible modes for moving freight. The components required for this modeling technique include existing and forecast zonal employment data, methods to generate zonal freight productions and attractions by using truck trip generation rates, methods to generate truck O-D flows by applying trip distribution procedures to truck productions and attractions, and methods to assign the O-D freight truck flows to a highway network.

Freight truck models usually attempt to account for shipment of goods, including local delivery. Because these models are focused exclusively on the truck mode, they cannot analyze shifts between modes. Truck models are usually part of a comprehensive model that forecasts both passenger and freight movement, and consequently will often use a simultaneous assignment of truck trips with auto trips.

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[11]List, George F., and Mark A. Turnquist, 1995, "Estimating Truck Travel Patterns in Urban Areas," Transportation Research Record 1430.

As noted above, freight truck models follow a three-step process of trip generation, trip distribution, and traffic assignment. Trip generation estimates the number of trips either produced in each zone or attracted to each zone; and is usually a function of socioeconomic characteristics of the zone (employment by industry, population, or number of households). Trip generation is accomplished using truck production and attraction equations, whose coefficients are estimated based on local commercial vehicle surveys or by using parameters borrowed from other sources such as the QRFM. Trip distribution determines the connection between trip origins and trip destinations. Trip distribution is generally accomplished using a gravity model similar to that used in a passenger model. In the gravity model, the number of trips that travel between one zone and another is a function of the number of trip attractions in the destination zone, and is inversely proportional to a factor measuring the impedance between the two zones. (The gravity model is usually related to the travel time between two zones (i.e., the longer it takes to get from one zone to another, the less attractive trips to that destination zone become).) Parameters in the gravity model can be developed from local surveys or borrowed from other sources, such as the QRFM. The route that trucks use to get from origin to destination is a function of network characteristics, taking into account traffic conditions on each route. Network assignment of the truck trips is usually based on a multiclass equilibrium highway assignment that includes passenger cars; in other words, the model looks for the shortest time path for all trips simultaneously. Freight truck models can take into account the different classes of trucks and their impact on congestion compared to automobiles (large trucks cause more congestion because they occupy more space than autos). In addition, the networks can be coded so that any specific link can either allow only truck trips, or can exclude the use of truck trips.

Four-Step Commodity Flow Models

The four-step commodity flow model is similar in structure to the four-step passenger model. Both the four-step commodity flow models and the four-step passenger models require the development of a network and zone structure. Since a larger percentage of freight trips in an urban area are long haul than is the percentage of passenger trips that are long haul, a skeletal highway network external to the region is usually appended to a local passenger network to allow for assignment of these long-haul freight trips. Commodity models can analyze the impact of changes in employment, trip patterns, and network infrastructure.

The commodity-based "trip" generation model actually estimates the tonnage flows between origins and destinations. These flows are converted to vehicle trips after the mode choice step in the process. The trip generation models include a set of annual or daily commodity tonnage generation rates or equations by commodity group that estimate annual or daily flows as functions of TAZ, or county population and disaggregated employment data. Base year commodity flow data at the zonal level are used to estimate the trip rates or trip generation equations. The O-D tables for these flows are typically estimated using gravity

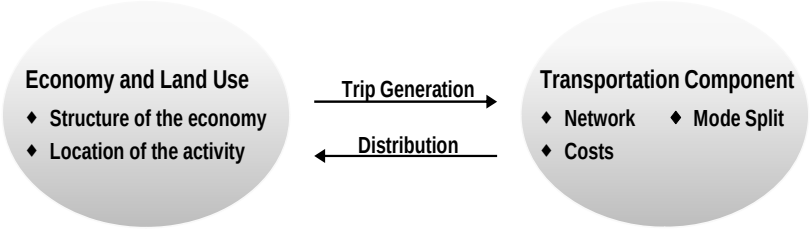
models similar to the trip distribution step in four-step passenger models. Trip distribution models are estimated separately for each different commodity group. The unit of flow in the O-D table is typically tons shipped. The distribution of freight is to a national system of zones, recognizing the large average trip lengths in this class of models. Mode split is a necessary component because O-D patterns are developed for particular commodities rather than for trucks. Quite often, the mode split step simply assumes that the base year mode share of each commodity flow stays the same in the future. The conversion of commodity truck tonnage to daily freight truck trips uses the application of payload factors (average weight of cargo carried per vehicle load). Payload factors can be estimated on a commodity-by-commodity basis using locally collected survey data (e.g., roadside intercept surveys) or national surveys (e.g., the U.S. Census Bureau Vehicle Inventory and Use Survey). The assignment of truck freight will typically use either a freight truck only or multiclass assignment model.

Economic Activity Models

An economic activity model includes an economic or land use model as a step before the traditional four steps. Economic activity models are the freight equivalent of the integrated land use transportation models used in the analysis of urban passenger travel. They require specific data concerning the availability of land and the rules governing the development and location of certain industries, and an understanding of the interdependencies between industries.

Economic activity models estimate the flows of commodities between economic sectors and between zones. They assume that the zonal employment or economic activity is not directly supplied to the model, but is created by applying an economic or land use model. The modeling technique used for economic activity models is known as a spatial input-output (I-O) model. The spatial I-O model distributes household and economic activity across zones, uses links and nodes of a transportation network to connect the zones and model the transportation system, and then calculates transportation flows on the network. It uses a land use component to generate and distribute trips and a transportation component to generate mode split and network assignments. The two sides of the model inform each other, resulting in a dynamic model, as shown in Figure 3.1.

Figure 3.1 Economic Activity Model Process



The model uses an I-O structure of the economy to simulate economic transactions that generate transportation activity. A spatial I-O model identifies

economic relationships between industries and between industries and households, accounting for the geographic or spatial relationships associated with the economic relationships (origins and destinations of the economic flows). In future years, the spatial allocation of economic activity, and thus trip flows, is influenced by the attributes of the transport network in previous years. Thus, the model is dynamic with respect to land use and transportation. The economic activity model differs from the four-step commodity class of models as it uses an economic or land use model to forecast zonal employment or economic activity prior to the trip generation step. The freight component of the Oregon DOT's statewide travel demand model is an example of an economic activity model.

Hybrid Models

State-of-the-practice metropolitan truck models are hybrids that blend commodity flow modeling techniques with freight truck modeling techniques. Commodity flow databases tend to be relatively accurate for intercounty flows, but undercount intracounty flows because commodity flow databases rely in part on economic input-output data that ultimately are based on financial transactions between producers and consumers of goods. However, in an urban area many truck moves are not easily traced to such transactions. Moves from warehouses and distribution centers, repositioning of fleets, drayage moves, parcel delivery, and the like are generally short-distance trips in which there may not be an economic exchange of the goods from one party to another. To compensate for the undercounting of the shorter distance trips, local truck trips are generated based on local employment and economic factors using trip generation rates. These trips are usually generated at the zone level, and trip distribution uses methods such as gravity models. The trip rates are calibrated so that the truck traffic volumes that are generated from the combined commodity flow and locally-generated truck trips match those from available truck counts. Several terms are used to refer to these two trip types, including commodity flow trips versus locally generated trips, external versus internal truck trips, and long haul versus local truck trips.

Hybrid models most often forecast Internal-Internal truck trips through the use of a simple truck model, as shown in the three step truck model described above; and forecast the trucks with at least one external trip end (External-Internal, Internal-External, and External-External) through the use of a commodity process. The forecasting of the external trips may be through importing and factoring a commodity flow survey (e.g., SCAG), or by using a commodity flow survey to develop external model equations (e.g., MAG in Phoenix, Houston-Galveston Area Council (HGAC) in Houston).

3.2 STATE-OF-THE-ART MODELS

Research programs throughout North America and Europe are presently developing a new generation of freight models. Two techniques in particular are

receiving widespread interest: 1) logistics/supply chain models, and 2) tour-based models. The logistics/supply chain models borrow techniques from industrial supply chain planning in an effort to track goods as they move along the supply chain from producer to consumer. The tour-based models focus on the trip chain characteristics of intra-metropolitan trucks. Examples of these model types are presented below.

Logistics/Supply Chain Models

GoodTrip Model[12]

The GoodTrip model combines features of logistics chain models and tour-based models to analyze urban goods movement flows. The model defines a set of activity types, which when linked together may describe either a logistical chain or a set of stops on a vehicle tour (or in some cases, a combination of both). Activity types include:

- Consumers,
- Supermarkets,
- Teleshop,
- Hypermarkets,
- Urban distribution centers, and
- Factories.

The model starts its calculations at the consumption end of the chain, and estimates the demand for goods by goods type (analogous to commodity) for each zone in the model. The share of this demand allocated to each of the activity types in each zone is also estimated based on models developed from survey data. The model then uses information about the spatial and functional relationships of each of the activity types and probabilities to estimate flows by activity type and zone. The goods flows are then assigned to vehicle tours for each origin-destination pair. The origin's activity type determines the transport mode, vehicle capacity, vehicle loading factor, and number of stops per tour. This conversion of goods flows to vehicle tours establishes the trip table for assignment to a network.

This modeling approach is of particular interest because of its urban focus and its ability to analyze how changes in logistics organization affect vehicle traffic.

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[12] Boerkamps and van Binsbergen, "GoodTrip – A New Approach for Modeling and Evaluation of Urban Goods Distribution," Delft University of Technology, and The Netherlands Research School for Transport, Infrastructure and Logistics.

SMILE[13]

Researchers at the Transport Research Centre of the Netherlands Ministry of Transport, Netherlands Economic Institute, and TNO Inro have developed a logistics chain model called Strategic Model for Integrated Logistics Evaluation (SMILE) that can be used as a decision support system for freight transportation policy evaluations. This model begins with an economic input-output modeling approach that calculates supply and demand for each economic sector based on industry production functions. This establishes the economic trade flows for the region of interest. The logistics module assigns each goods flow to a logistics family with common characteristics. The assignment of goods to logistics families is based on the spatial patterns of supply and demand options for the good. The common characteristics for each logistics family are those that define the type of inventory control and logistics system that will be used to distribute the product. A series of logistics models are developed that define the distribution systems that are used by each logistics family and the spatial organization of warehousing and distribution systems for product delivery and supply chain management. The information about logistics chains is then fed into a transport model that determines the modes of transport used and the optimum modal network paths from origins to destinations.

Tour-Based Models

University of Calgary[14]

Researchers at the University of Calgary have developed an approach that applies tour-based microsimulation modeling concepts to urban goods movement modeling, which was originally developed for passenger modeling. However, in their approach, they define the tours for vehicles rather than for passengers. The model recognizes that many commercial vehicles conduct activities in tours – that is, a series of linked trips that do not necessarily involve a return to home base on every trip. In the model, a synthetic population of business establishments is developed from aggregate data, and these are used to estimate the number of tours generated for a particular commercial activity. The business establishments are the operators of the vehicles that conduct the tours and the approach can be applied to retail establishments, service businesses, or any other type of commercial vehicle operation.

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[13] Tavasszy, Smeenk, and Ruijgrok, "A DSS for Modeling Logistics Chains in Freight Transport Policy Analysis," Seventh International Conference of IFORS, 1997.

[14] Hunt, Stefan, and Abraham, "Modeling Retail and Service Delivery Commercial Movement Choice Behaviour in Calgary," Tenth International Conference on Travel Behaviour Research, 2003.

Stops on the tours are generated based on traditional variables used in trip generation (population, households, employment by business sector). For each vehicle tour, a series of choice models are employed in order to determine the type of vehicle that will be used to conduct the business of the tour, the purpose of each stop (goods pickup or delivery, service, return to home), and the location of the next stop. The choice models are logit choice models that use variables related to what has happened previously on the tour, the attractiveness of zones that could include the next stop on the tour (measured in terms of the number of trip attractions estimated for the zone), and the location of the stops relative to home base (taking into account travel times from zone to zone). The choice models are estimated from travel diary data and have been applied successfully to simulate retail and service trips.

3.3 SUMMARY OF PROS AND CONS OF VARIOUS MODELING APPROACHES

Each of the modeling techniques described in the previous sections has strengths and weaknesses. The state-of-the-art-practice commodity flow models have the advantage of being based on extensive and readily-available multimodal freight flow and economic activity data. On the other hand, many local truck moves, including trips from warehouses and distribution centers, fleet repositioning, empty return trips and truck drayage moves, as well as service, utility, and construction trucks, are not accounted for in these models. Many of these missed truck trips are short trips within urban areas. Therefore, truck models based exclusively on commodity flow data tend to underestimate truck trips in the urban area. In addition, the commodity flow data are generally not available at the TAZ level, and techniques of questionable accuracy must be used to disaggregate county-level data.

Models built exclusively from truck trip generation and attraction rates based on local economic activity have the advantage of being tailored to the economic activity data of the study area. Truck trip generation rates can be estimated from local data that include all truck moves, not simply moves based on commodity flows. These models can be made more responsive to changes in local economic activity and population relative to truck models based on commodity flow data. However, truck models based on locally-generated truck trips do not incorporate goods movement factors for external regions. Therefore, external and through truck trips are not well modeled. In addition, changes in external regions over time cannot easily be incorporated into truck model forecasts. The behavioral basis of these models is crude; they cannot reflect changes in the structure of truck operations over time, and they do not accurately account for the trip chain characteristics of many urban truck trips. Finally, the data required to estimate accurate trip generation and distribution models given the variety of truck trip types are very extensive. Collecting sufficient data of this type from private businesses has proven to be very difficult in past studies.

Hybrid models, which take advantage of the benefits of the commodity flow and local truck models, including freight and other non freight truck purposes, have proven to be the most effective modeling framework to date. Long-haul truck trips are modeled using the commodity flow database, which can be adjusted over time based on economic factors. Short-distance truck trips can be estimated as a function of local employment characteristics. The hybrid models are used in several metropolitan areas, and therefore have a theoretical framework that has proven applicable to metropolitan and regional models.

Despite their proven benefits and usefulness, hybrid models lack the ability to fully track logistics chains that have mixed long-haul and local components. The commodity flow data accurately estimate primary movements – that is, the flow from producers to consumers. The extensive information available on the amount of goods produced and consumed in the economy and the location of production and consumption sites help ensure the accuracy of primary commodity flow data. However, not all of the secondary moves – the intermediate handling of goods at warehouses, distribution centers, and truck terminals – are effectively captured in commodity flow data. Sources such as the Bureau of Transportation Statistics/Bureau of Census Commodity Flow Survey, which surveys warehouses about commodity moves, do not distinguish primary and secondary flows. It is, therefore, impossible to associate these secondary flows with warehouse locations or warehouse activities. The hybrid models attempt to fill this gap by estimating all local truck trips through three-step trip generation and distribution models. However, these models lack explicit links between the primary flows generated by the commodity flow data and the local truck trips. It is impossible to track flows of goods throughout the entire logistics chain to ensure consistency of the two approaches. The hybrid models do not allow for analysis of how changes in logistics patterns affect transportation demand.

Another disadvantage of the hybrid model is that it does not account for the trip-chaining characteristics associated with several different types of local truck moves. Both the commodity flow truck trips and the local truck trips are generated based on a trip being a single origin with a single destination. However, several types of trips (particularly those made within the metropolitan area) are by trucks that utilize a "sequentially unloading, return empty" truck trip pattern. Trucks leave their origins with a full load, make several stops to deliver partial loads, and return empty to their point of origin. Some trucks follow the reverse pattern, leaving their origin empty and returning with a full load after making pickups at multiple locations. These truck trip types are not well captured by the hybrid model. Service trucks also exhibit this trip chaining characteristic.

For the ACCMA truck model improvement project, a commodity flow survey was not available to use as a direct import, or to serve as the basis for the development of commodity based external trip equations. The inclusion of external truck trips, without the use of commodity trucks, using the Santa Clara VTA methods is discussed in Chapter 6.

4.0 New Truck Modeling Approach

This chapter examines important issues that were considered for developing the truck modeling approach for ACCMA. This chapter also discusses enhancements to the ACCMA truck model included in this approach. The analysis framework and set of model improvements were selected in consultation with the Model Task Force (MTF).

4.1 ANALYSIS FRAMEWORK

In planning for the development of the new truck model system, key considerations were evaluated. Those included the following:

- **Input Data.** Some of the truck forecasting methods require data that might not be readily available to ACCMA. Our review examined the availability of base year and forecast employment information.
- **Performance Outputs.** The units of performance of the various forecasting methods vary in terms of the units of flow, the facilities included, the time period covered, and the types of vehicles provided. We understand that ACCMA needs to analyze volumes and speeds of different types of trucks and made sure outputs of forecasting methods were not inconsistent with those needs.
- **Calibration and Validation Data.** The methods need to produce data, which is adjusted to reflect local conditions. Our review indicated what data was needed to calibrate the parameters of the methods (for example truck surveys); and what data is needed to validate the link volume forecasts (for example, truck classification counts).
- **Geographic Scale.** The extent and detail of the forecasting methods may vary considerably. Freight trucks may travel hundreds of miles and the geographic coverage needed to address those issues may be inappropriate for ACCMA's needs. Although the ACCMA model coverage area is extensive – it covers the entire nine-county San Francisco Bay Area plus San Joaquin County – freight and goods movement model coverage areas often include entire states, or the entire United States, plus Canada and Mexico.
- **Integration with other Models.** The ACCMA truck model will not exist in a vacuum. It does need to be consistent and share information with the MTC truck model.
- **Ease of Use.** The methods reviewed vary considerably in the data, manpower, and computer resources required; the updating and maintenance

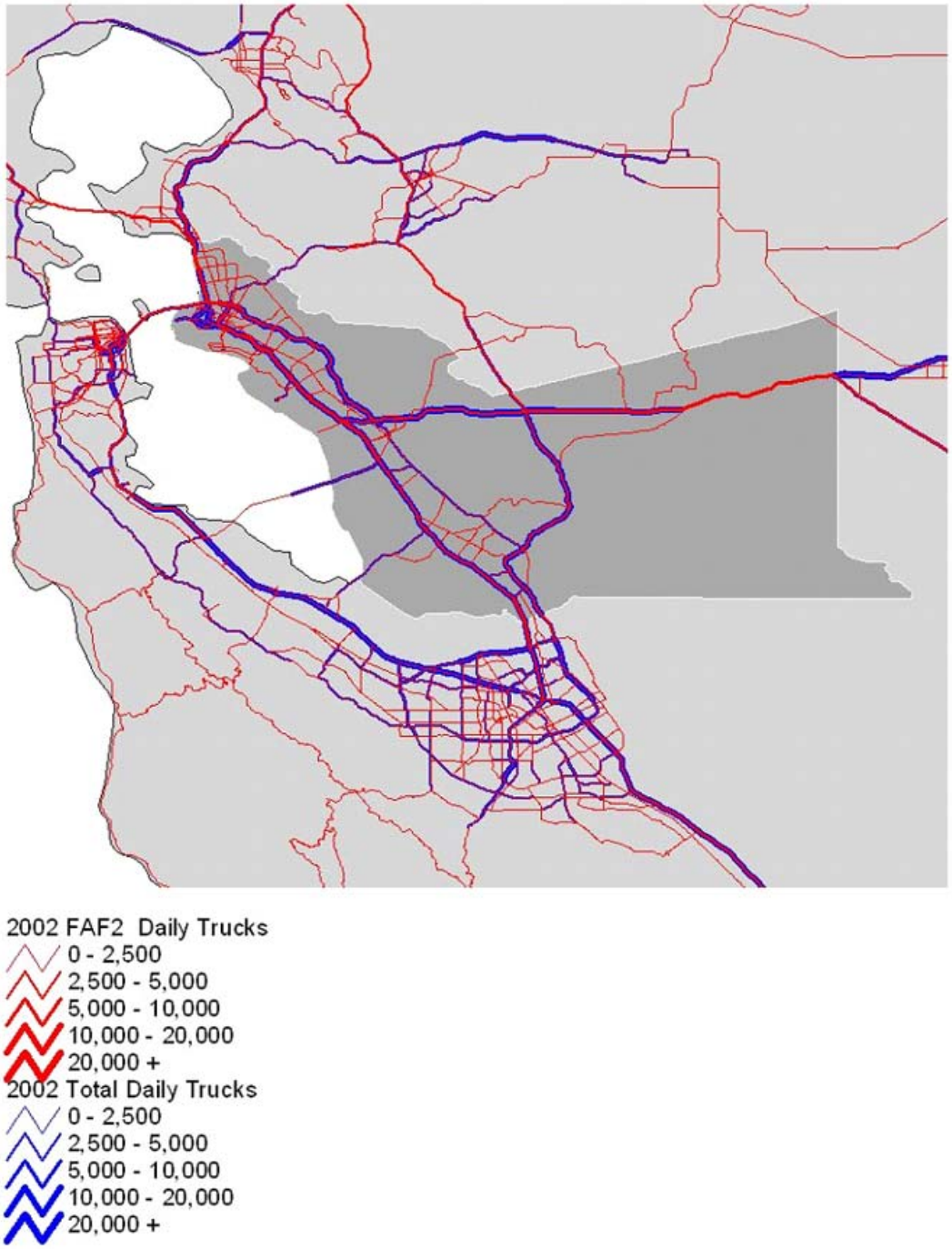
required; and the schedule time required to complete a forecast. The resources of any method must be judged against the availability of those resources for ACCMA.

An issue which we believe is overarching and relevant to the review is an understanding that all trucks are included in these forecasting methods. While it is true that all freight on the highway moves in trucks, it is not true that all trucks carry freight. As defined by the organizations concerned with evaluating and forecasting freight, freight trucks typically do not include trucks carrying construction material or equipment, service, and utility trucks; and may not include trucks delivery goods locally to retail, commercial, or residential buildings. As shown in Figure 4.1 from the FHWA's Freight Analysis Framework (FAF), the estimates of freight trucks are concentrated on the major interstates and principal arterials. The FAF acknowledges that those freight truck flows are a small percentage of the truck flows on other highways in Alameda County and the East Bay area. In fact, according to the FAF2 Highway Link and Truck Data and Documentation: 2002 and 2035, the freight truck VMT in Alameda County represents only 25 percent of the total truck VMT on the roads included in the FAF2 network[15].

We estimate that much of the nonfreight truck volumes will grow at a rate in accordance with freight trucks, and understanding freight truck volumes is important to understanding the flow of all trucks; however, methods that provide forecast only of freight trucks may be inadequate for ACCMA's needs. For ACCMA's purposes, understanding all truck travel and not just freight-related truck movements is important.

[15]FAF and FAF2 technical documentation is available from FHWA at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_tech_document.htm.

Figure 4.1 FAF Freight and All Trucks Volumes in the East Bay Area



Source: Cambridge Systematics from FAF2 Highway Link and Truck Data: 2002.

4.2 CURRENT TRUCK MODEL STRUCTURE

The current ACCMA model truck trip generation models use the six employment categories contained in the Association of Bay Area Governments (ABAG) socioeconomic database. These employment categories are:

1. Retail
2. Service
3. Other
4. Wholesale
5. Agricultural
6. Other employment groups

In terms of vehicle class for trucks, the original ACCMA model divided trucks into four vehicle classes:

1. **Very small trucks.** Two-axle, four tires;
2. **Small trucks.** Two-axle, six tires;
3. **Medium trucks.** Three-axle; and
4. **Combo.** Four-axle+.

For traffic assignment, trucks are grouped into a single category. Four vehicle classes are currently included in traffic assignment: drive alone vehicles, shared ride two person carpools, shared rider three or more person carpools, and trucks. Total vehicles are included in the volume-delay function.

4.3 IMPROVEMENTS MADE TO THE TRUCK MODEL STRUCTURE

A number of improvements have been made to the ACCMA truck model system. These improvements are introduced here in this section, and applications are described in Chapter 7.

Trip Generation Model

Socioeconomic Data

The socioeconomic data that is typically used to estimate internal trip generation in a truck model is more detailed than those data being used in the auto passenger model. Ideally, the employment data should be stratified into more employment categories. This process would provide more accuracy for truck travel, and allows for a direct relationship between the industrial sectors being represented in the internal trip model and the allocation of trucks generated from these industries to TAZs within the region.

At the beginning of the project, the lack of sufficient detail in the employment data was identified as a drawback. Truck trip generation should typically be land use based or industry based, and not occupation based as it is right now. Therefore, a truck model that uses more detailed employment data, such as the North American Industry Classification System (NAICS) 2-digit employment, was proposed. However, upon further research and discussions CS had with MTC and ABAG, it was learned that NAICS 2-digit employment data does not exist for the base year at the TAZ zone level, and cannot be projected to future years. Therefore, it was decided that the current model structure must be retained until new detailed employment data can be obtained.

Truck Trip Rate Calibration

Truck trip generation models use economic variables to forecast truck flows to and from a geographic area using equations. These trip generation equations are typically developed using the truck travel information obtained through truck travel surveys. As recent surveys are not available, the ODME-based truck trip table will be used as an observed data source for validating the truck trip generation model. (Please refer to Chapter 6 for a more detailed description of the ODME process.) The outcome of trip generation is the number of vehicles that comes into or goes from a TAZ in a specified unit of time.

The current truck trip generation rates (or equations) are used to determine the daily truck flows originating or terminating in TAZs as a function of zonal industry sector employment data. In other words, employment data are the essential input data required for computing truck trip generation. These independent variables, such as different types of employment, dictate the level of detail the truck flows can be generated using the trip generation model.

The current trip rates were calibrated based on truck assignment results where the truck model volumes was compared against the truck table developed by counts from ODME by truck type.

Since the TAZ-level employment data is available for only six categories – manufacturing, retail, service, wholesale, agriculture, and other – the new model will estimate truck trip estimates using only these six categories of land uses/sectors. These new trip rates are separate for production and attraction models, and are described in detail in Chapter 6.

Very Small Trucks

In the new truck model, Class 3 vehicles are not included; however, this vehicle class is included in the passenger model[16]. Therefore, the three truck types that

[16]Truck modeling studies conducted for SCAG confirm that the ability to accurately predict truck volumes in the lighter weight categories is one of the most serious shortcomings in an urban truck model. Trucks less than 10,000 pounds are considered

Footnote continued

will be part of the new improved truck model are: Class 5 (two-axle, six tires); Class 6 (three-axle, single units); and Classes 7 through 13 (combo units). Please refer back to Figure 1.1.

Since the original ACCMA passenger model keeps truck types separate for trip generation and trip distribution, no changes were made to these steps of the model to modify truck types. For all steps after trip distribution, two sets of changes were made to the Cube script:

1. Very small trucks were not included in the aggregated one truck type (i.e., Truck = Small trucks + medium trucks + combo trucks); and
2. Very small trucks, small trucks, medium trucks, and combo trucks were considered and outputted separately throughout the entire modeling process.

Special Generators

Special generators are those facilities that do not share the same economic relationships as other TAZs in the region. That is, these facilities will either have to be modeled separately based on more local and survey data, or existing traffic counts can be used to account for truck trips originating and ending at various special generators in the region. In the Bay Area, truck vehicle traffic has the greatest impact on Alameda County, as this County contains both the Port of Oakland and Oakland Airport, which is the primary air cargo airport in the Bay Area. Accordingly, the new model will include a Seaport Model as a special generator. In the new improved model, truck counts at the Port of Oakland Seaport will serve as the primary sources of truck trip generation data. For forecast years, growth factors will be applied to these two facilities to produce forecast year truck trip estimates.

The approach to application of the Port of Oakland special generator model was first described by Santa Clara VTA staff in a 2008 Transportation Research Board (TRB) paper. The issue at the Port of Oakland is the trip-based truck trip generation rates underestimate truck trips by as much as 90 percent. Thus, traffic

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to be "very small" trucks or the FHWA class 3 vehicles. Many of these trucks are used as personal vehicles and thus, are already captured in the ACCMA passenger travel model. It is extremely difficult, if not impossible, when conducting vehicle classification counts to distinguish those pickups and vans that should be included in the truck model from those that should not. That is, there is no clear way to distinguish the commercial use vehicles from the personal use vehicles that fall under the FHWA Class 3. This leads to poor results when validating the truck model for Class 3 vehicles.

Meyer Mohaddes Associates, SCAG Heavy Duty Truck (HDT) Model, prepared for Southern California Association of Governments, 1999.

Cambridge Systematics, Inc., SCAG Truck Count Study: Truck Classification System, prepared for Southern California Association of Governments, August 2001.

counts were collected at the Port of Oakland Seaport gateways and used as input into the special generator model.[17]

Trip Distribution Model

In trip distribution, the truck flow linkages are captured between origin and destination for those land uses that are developed in trip generation. A gravity model is typically used for trip distribution, and this is a statistical process that has been found useful to explain the relationship between transportation zones. The considerations are the total trips that begin in the first zone, the number ending in the second zone, and the impedance or difficulty to travel (such as cost or time) between them. These gravity models or trip distribution equations are typically developed using the trip diary surveys by truck type. The average trip lengths needed to obtain trip length frequency distributions and friction factors are obtained from surveys as well. The degree of difficulty of travel, which is represented as a function of congested travel time used in the distribution model, is matched with the survey data; and the calculation of the degree of difficulty is called the friction factor. Because no survey information is available, the ODME-based truck trip table will be used here to develop gravity models.

The friction factors are calculated as a negative exponential function of the average trip time from origin TAZ to destination TAZ. The parameters in the exponential function are calculated from the trip length frequency distribution, which is summarized by the average trip length. These parameters are adjusted to provide the best fit with the average trip lengths. The default gravity model techniques with different parameters by truck type, are shown below.[18]

For single unit trucks (6+ tires):

$$F_{ij} = e^{-0.10 * t_{ij}}$$

For combination truck:

$$F_{ij} = e^{-0.03 * t_{ij}}$$

Where:

F_{ij} = friction factor for O-D pair ij, and

t_{ij} = congested travel time for O-D pair ij.

The exponent in these equations is a reflection of the observed average trip length. For example, -0.10 coefficient in the small truck default equations from the QRFM can be considered to reflect a 10-minute average trip length (0.10 = 1/10 minutes), while the -0.03 coefficient in the combination truck default

[17] Chen, P., and G. Naylor, Santa Clara Valley Transportation Authority, Development of a Regional Truck Model for the Santa Clara, January 2009.

[18] Quick Response Freight Manual, 1996.

equations can be considered to reflect a 33-minute average trip length (0.03 = 1/33 minutes).

Gravity Model Calibration

The average trip lengths are estimated from the ODME-based truck trip table using information on the truck trip ends in each row of truck trip table data, the TAZ location of each truck trip end, and a TAZ to TAZ congested travel time matrix from the model. The TAZ to TAZ trip time matrix is linked to the ODME-based trip table using the TAZ location of the truck trip ends as the common data field. After performing this linkage, the average trip lengths are calculated for different types of trucks.

The trip distribution procedure be different for different truck types as the trip exchange patterns vary by size of the truck. Therefore, the new improved truck model has a separate friction factor-based gravity model for each truck type, as well as separate friction factors for internal trips versus external trips. The model will be based on congested highway skims, and will account for feedback loops in the model.

Each gravity model by truck type was calibrated based on truck trip length frequency distributions. These distributions were compared against that of the ODME-generated truck trip table.

Trip Assignment Model

Multiclass Assignments

Trip assignment of the truck trips will be completed using an equilibrium highway assignment. Truck trips are assigned simultaneously with the passenger model, because congestion has a significant impact on travel times experienced by trucks. Truck trips, for the ODME process, were already assigned separately by type using the multiclass assignment technique for five vehicle types:

1. Single-occupant passenger vehicles;
2. High-occupant passenger vehicles;
3. Small trucks;
4. Medium trucks; and
5. Combination trucks.

Passenger Car Equivalents

The truck model was developed to permit conversion of truck volumes to PCEs for assignment purposes. PCEs are used in recognition that larger trucks take up more roadway capacity on the roads than passenger cars. PCEs of 1.0, 1.5, and 2.0 for small, medium, and combo trucks, respectively, are employed. These PCE factors now used in the ACCMA model are the same as used in other truck

models, such as used in the SCAG heavy-duty truck model. The current application of the truck assignment allows the model user to output both vehicle volumes and PCEs.

Truck Classifications

The CS team collected vehicle classification counts on Alameda County arterials and freeways for more than 60 locations. This count database has been set up based on the FHWA classification scheme, and the counts for Classes 5 through 17 were separated out for the truck model validation. Truck volumes output from the ACCMA traffic assignment were directly compared against the counts. The new ACCMA model divides trucks into three vehicle classes. In all, the ACCMA model now has the following vehicle classes:

- Single-occupant autos;
- Shared ride – 2;
- Shared ride – 3;
- Small trucks;
- Medium trucks; and
- Combination trucks.

5.0 Data Collection

Data collection has been an integral part of the ACCMA truck model improvement project. This chapter covers truck data collection efforts used for model development and model validation/calibration. New count data were collected at one dozen highway locations, and at 50 arterial locations. In addition, PeMS data were examined throughout Alameda County, with an emphasis on including locations where new data was collected[19]. Collectively, these data elements comprised a substantial resource of information. Newly-collected data, PeMS data, and information from other published sources, such as the Caltrans Traffic Count Book and Truck AADT reports, were combined to create a database of information to be used for both model development, as well as for model validation[20].

Although the ACCMA model has an official year 2000 base year, the truck model has a 2005 base year. Since year 2005 data were spot checked with ground counts, and a number of project efforts have been conducted for year 2005, the project team determined 2005 would be the more appropriate base year. More specifically, the model system predicts year 2005 mid-spring, mid-week weekday travel conditions, since spring or fall represents average conditions less influenced by holidays and school breaks.

Truck data collection efforts, however, were conducted during the year 2009. As such, a method for factoring 2009 observed data to the Truck Model base year of 2005 was required. The PeMS data were also useful for developing 2009 to 2005 truck trip conversion factors.

5.1 METHODS OF COUNTING TRUCKS

A substantial amount of truck count data analysis was conducted. This analysis centered on making comparative cross-checks of all data sources for reasonableness and consistency. Some issues with the data were discovered and subsequently resolved. A key element of this data analysis involved adjustments to the year 2009 truck counts to year 2005 base year model conditions. Methods of Counting Trucks

The project team considered a number of methods for counting trucks, including hose counts, manual classification counts, video counts, and radar detector

[19] PeMS data can be accessed at: https://pems.eecs.berkeley.edu/?redirect=%2F%3Fdnode%3DState.

[20] Caltrans traffic reports can be accessed from the Traffic Data Branch web site: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/.

counts. Ultimately, the team decided upon using a combination of radar counts and manual classification counts for freeways, and hose counts for arterial (conventional) roadways. Radar counts were selected as more cost-effective than manual classification counts. With manual classification counts, the project budget would only permit a few hours during each peak to be collected, whereas 24 hours worth of data were collected at each location. However, since the radar counts are a somewhat newer technology, some radar count stations were augments with manual classification counts as a cross-check.

Table 5.1 provides a comparison of alternative truck data collection methods. This table includes advantages and disadvantages of each approach and provides generalized costs.

5.2 NEW DATA COLLECTION

Locations for the new truck counts were selected based on covering key Alameda County truck routes, as well as for overall coverage throughout the County. Location selections were approved by the Model Task Force.

Truck traffic counts were performed by a subconsultant firm, Quality Counts. Highway truck counts at locations shown in Table 5.2 were conducted using Wavetronix Radar Units. Counts were collected for 24 hours on a Tuesday, Wednesday, or Thursday during the months of May and June 2009. Arterial counts were collected at 52 locations, and are shown in Tables 5.3 and 5.4

Highway Counts

Wavetronix radar detector counts were collected for 12 Alameda County highway locations and classified by three vehicle lengths: less than 31 feet, 31 to 61 feet, and more than 61 feet. Data was reported at 15-minute intervals for both directions over 24 hours. Only Tuesday, Wednesday, or Thursday traffic information was collected.

Strictly speaking, PeMS data should not be considered new data collection; new data mining would be the more appropriate terminology. Nonetheless, PeMS data were examined for years 2005 and 2009 conditions at a number of Alameda County locations. The project team also examined the Caltrans Truck Count book for additional information on truck counts – particularly for locations outside of Alameda County.

Table 5.1 Comparison of Truck Count/Vehicle Classification Methods

Collection Method	Applicability/Suitability			Advantages	Disadvantages/Limitations/ Problems	Cost Per Count Location (Approximate for Budget Purposes)
	State Highways		Other (e.g., CMP System)			
	Freeways	Conventional				
Pneumatic tube "hose" counts		X Requires encroachment permit	X	Easiest; Classification is by number of axles; time resolution can be hourly or quarter hours, 24 hours/day possible.	Hoses can get torn up on very high volume and/or high speed roads; accuracy TBD.	~$200 for bi-directional for ~48 hours.
Manual counts	X Must be below or at-grade	X	X	Accuracy; can get detailed classification to FHWA F-system.	Higher cost; fatigue limits length of surveyor shifts (eight hours or less?).	~$50/hour per surveyor; freeway ~$200/hour – depends on whether truck or all volumes are needed.
PeMS Data (Performance Monitoring System)	X			Data already being collected; available on-line. Continuous measurement over many days/hours.	May be miles between loops. Must be double-loop detectors. "Truck" is defined vehicle >60 feet; detailed classifications not available.	~$150 per bidirectional location – mainly for in-office analysis time.
Video Counts (video recording)	X Generally below or at-grade	X	X	Permanent record; accuracy (tape can be backed up, recounted); moderate number of classification categories.	Daylight only; limited camera battery life; cost/time. More expensive than manual counts.	~$300 to $500/hour Hiring specialty sub might be more than this.
Radar Detectors	X Generally below or at-grade	X	X	Lower-cost method of gaining differential vehicle lengths; Time resolution can be hourly or quarter hours; 24 hours/day possible; Can be used at high traffic areas in lieu of hose counts	Does not collect axle data; Accuracy issues for six-plus lane facilities	$500-$800for bi-directional counts, higher cost reflects multiple units needed for freeways of six or greater lanes.
Ramp Counts (at on- and off-ramps)	X Requires encroachment permit			Accuracy; classification by number of axles. Collects lots of data. Use of machine counters possible, but requires encroachment permit.	Expensive; Flow checks at start and end points needed. More data processing; Larger field crew.	~ Varies. Estimated at $800 per hour counted, could be more if many ramps at each inter-change; machine counts cost less.

*For example, an adjacent building that is above the elevated freeway section.

Table 5.2 Highway Count Locations

Route	Location	Jurisdiction
SR 13	Junction I-580	East Oakland
SR 24	Caldecott Tunnel	Oakland
I-80	University Avenue	Berkeley
I-680	South of SR 262	Mission Boulevard
I-680	Alcosta Blvd	Dublin
I-880	South of SR 262	Mission Boulevard
I-880	Industrial Blvd	Hayward
I-880	Hegenberger Road	Oakland
I-880	Between 5th & 10th Avenues	Oakland
I-980	14th Street Overpass	Downtown Oakland
I-580	Flynn Road	Eastern Alameda County
SR 238	Between I-580 and East 14th	Near Hayward

Table 5.3 Arterial Truck Count Locations

	On Road Name	Jurisdiction/Owner	Count Location (Between)
1	Ralph Appezzato Memorial Parkway	Alameda City	West Campus Dr & Webster St.
2	Buena Vista Avenue	Alameda City	Grand St. & Hibbard St.
3	Encinal Avenue	Alameda City	Grand St. & Paru St.
4	Park St.	Alameda City	Lincoln Avenue & Times Way
5	Broadway	Alameda City	Encinal Avenue & Central Av
6	Adeline St.	Berkeley	Ashby (SR 13) & ML King Jr. Way
7	MLK Jr. Way	Berkeley	Alcatraz Av. & Stanford Av
8	Shattuck Avenue	Berkeley	Bancroft Way & Durant Av
9	University Avenue	Berkeley	5th & 6th St
10	University Avenue	Berkeley	ML King Way & Grant St.
11	Hesperian Boulevard	County/San Lorenzo	Hacienda Av. & Bockman Road
12	Ardenwood Boulevard	Fremont	Ardenwood Terr. & Kaiser Dr.
13	Decoto Road	Fremont	Cabrillo Dr.& I-880 ramps
14	Decoto Road	Fremont	7th & 8th Streets
15	Mowry Avenue	Fremont	Fremont Blvd & Bell St.
16	A Street	Hayward	Mission Blvd & Watkins St.
17	Clawiter Road	Hayward	Industrial Blvd & West St

	On Road Name	Jurisdiction/Owner	Count Location (Between)
18	Hesperian Boulevard	Hayward	Hollow Avenue & SR 92 ramps
19	Hesperian Boulevard	Hayward/Union City	Bet. Kohoutek & Eden Park
20	Industrial Parkway	Hayward	Ruus Road & Huntwood Av.
21	Tennyson Road	Hayward	Ruus Road & Bruno St.
22	1st St	Livermore	N. Mines Road & Las Positas Rd
23	Stanley Blvd	County/Livermore	SR 84 (Isabel Av.) & Murdell Lane
24	N. Vasco Rd	Livermore	Near Dalton Avenue
25	Park Street Bridge	Oakland/Alameda	On/before Bridge
26	Fruitvale Avenue	Oakland	Near Alameda Ave
27	High Street	Oakland	Tidewater Avenue & Marina Dr
28	Hegenberger Road	Oakland	Edgewater Dr. & I-880 SB on ramp
29	73rd Avenue	Oakland	International Boulevard & Orral St.
30	San Leandro St.	Oakland	77th Avenue & 81st Avenue
31	W. MacArthur Blvd	Oakland	Market St. & Linden St
32	150th Avenue	San Leandro	Lark St.& SR 185 (E. 14th St.)
33	Lewelling Boulevard	San Leandro	Washington Av. & Woodgate Dr.
34	Hesperian Boulevard	San Leandro	I-238 & Springlake Dr
35	Maritime Street	Oakland	South of Grand Ave
36	7th Street	Oakland	West of I-880 (Port of Oakland)
37	Middle Harbor Road	Oakland	South of 3rd Street (Port of Oakland)
38	98th Avenue	Oakland	Between I-880 and Empire

Table 5.4 Conventional (Nonfreeway) State Highway Locations

	On Road Name	Jurisdiction	Count Location (Between)
39	Route 13 – Ashby Avenue	Berkeley	7th Street & UPRR tracks
40	Route 61 – Doolittle Drive	Oakland	Swan Way & Langley St.
41	Route 61 – Doolittle Drive	San Leandro	Davis Street & Eden Road
42	Route 84 – Thornton Avenue	Fremont	Dutra Way & Dondero Way
43	Route 84 – Mowry Avenue	Fremont	SR 238 & Thane St.
44	Route 84 – Niles Canyon Rd	Fremont	SR 238 & Old Canyon Road)
45	State Route 84 – Airway Boulevard	Livermore	Club House Dr. & Kitty Hawk Rd

	On Road Name	Jurisdiction	Count Location (Between)
46	Route 92 (Jackson St.)	Hayward	I-880 SB ramps & Santa Clara St.
47	Route 185 (International Boulevard)	Oakland	Miller Ave & 23rd Avenue
48	Route 185 (E. 14th Street)	San Leandro	Hesperian Avenue & 148th Ave
49a	Route 260 – Webster St. to Alameda	Oakland/Alameda	Tube portal
50b	Route 260 – Harrison St. to Oakland	Oakland/Alameda	Tube portal
51	Route 262 – Mission Blvd	Fremont	Kato Rd & Warm Springs Blvd
52	Route 61 – Doolittle Drive	San Leandro	Between Adams & Airport Drive

These data represented a significant upgrade over the data collection plan initially discussed with the Model Task Force – limited manual classification counts of only trucks at these freeway locations (two hours during the AM peak period and two hours during the PM peak period). Since there are conversion tables for converting vehicle length data into truck types, the Wavetronix data were collected instead of the manual classification counts. The Wavetronix Counts were also of total vehicles, so were deemed more useful than the truck-only counts collected as part of the manual counts. However, some manual classification highway counts were also collected as a cross-check on the accuracy of the Wavetronix units.

The three manual vehicle classification counts were collected at: I-80 at University Avenue, I-880 at Hegenberger Road, and I-580 at Flynn Road. Counts were collected between 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. on a Tuesday, Wednesday, or Thursday during May and early June 2009. These counts included all trucks, classified by number of axles (2, 3, 4, 5+) at 15-minute intervals. Auto traffic was not counted. Small trucks (like FedEx, UPS, etc.) were included in the truck count, but pick-up trucks, vans, etc. were not. Video cameras were used, and Quality Counts summarized the information according to the specifications described above.

Arterial Counts

Machine counters were set up at 52 arterial locations for at least one 24-hour count period on a Tuesday, Wednesday, or Thursday. These machine counts provided directional data and covered all lanes of traffic. Thirty-four locations were set on city streets, plus 12 locations on conventional state highways. The counts were classified using the FHWA "F" scheme; autos were included in these counts as one of the categories. Tables 6.3 and 6.4 show counter locations on local streets and Caltrans-owned facilities, respectively. Caltrans refers to arterial state highways as conventional highways.

PeMS Data

PeMS data are part of Caltrans traffic data collection efforts used to observe speed and volume along freeway segments in urbanized areas. Field data are collected using the loop detectors and reported electronically every 20 or 30 seconds. Detection station locations are identified by county/route/post mile. PeMS data are archived, with both "raw" and "cleansed" versions of the data available at five-minute intervals. The "cleansed" data includes five-minute moving averages to correct for traffic fluctuations. Vehicles are classified as either trucks or autos, and summarized for each traffic lane.[21]

A useful feature of the PeMS database is the ability to retrieve archived data going back a number of years. Archived PeMS data allows users to evaluate year-to-year and month-to-month changes.

In total, 29 PeMS data locations were selected throughout Alameda County based on the following three criteria:

1. The same locations where new highway truck traffic counts were collected (for the purpose of comparing PeMS counts to the new truck traffic counts);
2. Locations in-between where new highway truck traffic counts were collected (to provide for more comprehensive of truck traffic counts on county highways); and
3. Alameda County gateways (to help estimate truck travel that goes beyond Alameda County boundaries).

Table 5.5 lists all PeMS count station locations. More locations may have been selected; however, PeMS count stations were either not present, or the count stations did not provide complete or reliable information. We found many PeMS detectors were not functioning, or some key data points were missing. PeMS provides statistics on overall data reliability, and manual data reviews were conducted to determine reliability at each individual count station. Ten of the 12 Wavetronix Count stations had PeMS data available for comparison.

Trucks are not precisely defined at the PeMS web site. Autos are described as having an average length of 16 feet, while trucks have an average length of 60 feet[22]. Thus, any comparisons between PeMS reported truck volumes and the new truck counts were done solely based on total trucks.

[21] Caltrans Commercial Wholesale Web Portal, accessed, July 9, 2009.

[22] http://pems.eecs.berkeley.edu/?dnode=Help&content=help_calc#truck.

Table 5.5 PeMS Locations

Location	Area	New Truck Count Location?
I-80 at University Avenue (Berkeley)	North	Yes
I-880 close to West Oakland BART	North	
SR 13 near Junction 580 (East Oakland)	North	Yes
I-580 near Albany	North	
I-880 At Hegenberger Road	North	Yes
I-880 Between 5th and 10th Avenue	North	Yes
I-980 at 14th Street overpass (Downtown Oakland)	North	Yes
I-80 at base of the Bay Bridge	North	
SR 24 at Caldecott Tunnel	North	Yes
I-80 near Albany	North	
I-238 near I-880	Central	
I-880 at Industrial Parkway	Central	Yes
I-880 just north of I-238	Central	
I-880 near West Winton Avenue	Central	
San Mateo Hayward Bridge	Central	
I-580 near exit 32, near Castro Valley	Central	
I-580 at Grand Ave	Central	
Dumbarton Bridge	South	
I-880 South of SR 262 (Mission Blvd)	South	Yes
I-880 South of Eastbound Mowry Avenue	South	
I-680 at Scott Creek Rd	South	
I-880 at Dixon Landing Rd	South	
I-580- East of Airway Blvd	East	
I-680 at Alcosta Boulevard (near Contra Costa County line)	East	Yes
I-680 near I-580 between Dublin and Pleasanton	East	
I-580 near I-680 near Dublin/Pleasanton	East	
I-580 near Dublin/Pleasanton BART Station	East	
I-580 at Flynn Road	East	Yes

5.3 DATA ANALYSIS

Data analysis was conducted to evaluate the accuracy of the counts, to assess the consistency of counts across different stations and to determine methodology for factoring back new year 2009 counts to year 2005 model base year conditions.

PeMS Database

The first area of analysis was to summarize PeMS data, initially by adding up location-specific data to four county subareas. Subareas were defined because evaluation of data indicated that there have been differential changes in truck volumes between different parts of Alameda County. PeMS data is valuable in this regard for the ability to look at the same data points over different time periods.

Table 5.6 shows PeMS auto and truck volumes for three different time points – April 2005 to match the model base year, and two points in 2009 that correspond to the new truck count data collection periods. Please note the new truck counts were collected both before and after the Memorial Day holiday, so the project team felt it was important to understand same-year different-month truck volume differences.

The PeMS data were aggregated to four Alameda County subregions. The project team determined this level of detail was useful for creation of 2009 to 2005 factors. Subregional data was used for the factoring back to 2005 for two reasons – first, there was not enough confidence with individual PeMS location; and second, there were notable differences in the change in traffic volumes (for both autos and trucks) by subarea. For these reasons subareas were picked over individual locations and over the entire County as the point for factoring count data to 2005 conditions.

Table 5.6 PeMS Average Daily Traffic Volumes by Subarea and Time Period

	April 2005 Volumes			April 2009 Volumes			June 2009 Volumes		
Location	Total	Auto	Truck	Total	Auto	Truck	Total	Auto	Truck
North	172,000	163,300	8,700	158,700	151,200	7,500	165,100	158,000	7,200
South	183,300	171,100	12,200	166,800	157,700	9,000	171,800	162,700	9,100
Central	142,900	136,500	6,400	127,000	120,400	6,700	129,900	123,100	6,800
East	173,400	164,100	9,300	164,000	156,600	7,400	170,100	161,900	8,200
Change from April 2005									
North				-8%	-7%	-14%	-4%	-3%	-17%
South				-9%	-8%	-26%	-6%	-5%	-25%
Central				-11%	-12%	-7%	-9%	-10%	-18%
East				-5%	-5%	-20%	-2%	-1%	-12%

It is important to note that truck volumes declined between 2005 and 2009; in some cases quite substantially. For example, we found that truck volumes decline by one-fourth in the South County, although large decreases for all four subareas were identified in the PeMS analysis.

Table 5.7 examines individual PeMS locations. Note that even though 29 locations were identified, a number of the locations proved problematic in terms of comprehensive data analysis. Data were problematic in the following ways:

- Seven of the locations either had no counts for April 2005, or only contained total vehicles;
- Some locations showed extreme changes in truck volumes, between 2005 and April 2009 (examples include I-580 near Albany and the San Mateo-Hayward Bridge); and
- Some locations showed extreme changes in truck volumes between April and June 2009 (one examples is the Caldecott Tunnel).

For these reasons, PeMS data were used cautiously for factoring down the 2009 counts to 2005 conditions.

Published Caltrans Resources

Caltrans publishes two reports of interest that were useful in helping to determine the reasonableness of the new counts and the PeMS data. The sources are the Caltrans Traffic Count Book and the Caltrans Truck Count Book[23].

These datasets are not typically used as primary data sources. (Although for this project, the Caltrans Truck Count Book was used to populate counts for locations outside of Alameda County. See Chapter 6 for further discussion on locations outside of Alameda County.) However, the Caltrans published sources are useful in cases where primary data sources may be in conflict, or where there is doubt about the accuracy of the new data, or (in the case of this project) doubt regarding the proportions of trucks and autos.

[23] These sources are maintained by Caltrans at their Traffic Data Branch web site: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/.

Table 5.7 PeMS Average Daily Traffic Volumes and Percent Change from April 2005 by Individual Location and Time

Location	Subarea	April 2005 Volumes			April 2009 Volumes			June 2009 Volumes		
		Total	Auto	Truck	Total	Auto	Truck	Total	Auto	Truck
I-80 at University Avenue	North				200,100	191,800	8,200	200,300	192,500	7,800
I-880 near West Oakland BART	North	154,100	152,500	1,600	131,100	128,400	2,700	132,000	128,900	3,100
SR 13 near Junction 580	North	192,500	178,700	13,800	178,200	162,000	16,100	178,700	163,300	15,400
I-580 near Albany	North	94,300	81,700	12,600	92,600	87,100	5,500	95,000	89,100	5,900
I-880 at Hegenberger Road	North	247,800	227,100	20,700	209,600	194,500	15,100	213,900	198,500	15,400
I-880 between 5th and 10th Ave	North				179,900	170,700	9,300	196,100	182,000	14,100
I-980 at 14th Street overpass	North	130,300	124,700	5,600	119,200	116,800	2,400	120,300	117,900	2,400
I-80 Base of the Bay Bridge	North	209,100	205,000	4,100	217,900	213,500	4,400	243,500	239,100	4,400
SR 24 at Caldecott Tunnel	North	177,600	172,100	5,400	156,300	147,100	9,200	168,700	162,900	5,800
I-80 near Albany	North	170,500	164,800	5,800	164,700	159,900	4,800	168,900	164,000	4,900
I-238 near I-880	Central	101,900	88,800	13,000	77,000	76,400	600	85,200	84,300	900
I-880 At Industrial Parkway	Central	209,900	195,800	14,100	227,400	210,600	16,800	231,000	213,800	17,200
I-880 near I-238	Central	196,100	182,100	14,000	172,900	164,900	8,000	177,800	169,600	8,200
I-880at West Winton Blvd	Central	278,500	266,600	11,900	245,300	234,800	10,600	255,900	244,800	11,000
San Mateo Hayward Bridge	Central	121,000	114,400	6,500	99,600	97,600	2,000	102,300	100,300	2,000
I-580 near Exit 32	Central				168,300	160,800	7,500	175,900	167,800	8,100
I-580 at Grand Ave	Central	192,500	178,700	13,800	178,400	162,300	16,200	178,700	163,300	15,400
Dumbarton Bridge	South	74,500			73,600			76,200		
I-880 S of Junction SR 262	South	168,000	155,900	12,100	127,400	111,900	15,600	129,500	113,700	15,800
I-880 South of Junction SR 262	South	155,000	151,600	3,400	145,400	143,800	1,500	145,300	144,000	1,300
I-880 S: EB Mowry Ave	South	183,600	173,100	10,400	173,300	163,400	9,900	177,700	167,900	9,800

Location	Subarea	April 2005 Volumes			April 2009 Volumes			June 2009 Volumes		
		Total	Auto	Truck	Total	Auto	Truck	Total	Auto	Truck
I-680 at Scott Creek Rd	South	127,600			109,800			110,500		
I-880 at Dixon Landing Rd	South	148,500	144,000	4,600	132,800	125,800	6,900	139,900	137,300	2,600
I-580 East of Airway Blvd	East	185,800	175,700	10,100	190,000	184,300	5,700	191,800	185,900	5,900
I-680 at Alcosta Blvd	East	184,600	177,700	6,900	165,700	160,200	5,600	170,800	164,900	5,900
I-680 near I-580	East	96,200	93,300	2,900	108,600	104,600	4,000	115,000	110,600	4,400
I-580 near I-680	East				154,400	142,800	11,600	153,700	142,900	10,800
I-580 close to Dublin/Pl. BART	East				181,800	168,300	13,500	186,900	172,800	14,200
I-580 at Flynn Road	East	227,100	209,800	17,300	191,700	177,300	14,400	202,700	186,200	16,500
I-80 at University Avenue	North							0%	0%	-5%
I-880 near West Oakland BART	North				-15%	-16%	69%	1%	0%	15%
SR 13 near Junction 580	North				-7%	-9%	17%	0%	1%	-4%
I-580 near Albany	North				-2%	7%	-56%	3%	2%	7%
I-880 at Hegenberger Road	North				-15%	-14%	-27%	2%	2%	2%
I-880 between 5th and 10th Ave	North							9%	7%	52%
I-980 at 14th Street overpass	North				-9%	-6%	-57%	1%	1%	0%
I-80 Base of the Bay Bridge	North				4%	4%	7%	12%	12%	0%
SR 24 at Caldecott Tunnel	North				-12%	-15%	70%	8%	11%	-37%
I-80 near Albany	North				-3%	-3%	-17%	3%	3%	2%
I-238 near I-880	Central				-24%	-14%	-95%	11%	10%	50%
I-880 at Industrial Parkway	Central				8%	8%	19%	2%	2%	2%
I-880 near I-238	Central				-12%	-9%	-43%	3%	3%	2%
I-880 at West Winton Blvd	Central				-12%	-12%	-11%	4%	4%	4%

Location	Subarea	April 2005 Volumes			April 2009 Volumes			June 2009 Volumes		
		Total	Auto	Truck	Total	Auto	Truck	Total	Auto	Truck
San Mateo Hayward Bridge	Central				-18%	-15%	-69%	3%	3%	0%
I-580 near Exit 32	Central							5%	4%	8%
I-580 at Grand Ave	Central				-7%	-9%	17%	0%	1%	-5%
Dumbarton Bridge	South				-1%			4%		
I-880 S of Junction SR 262	South				-24%	-28%	29%	2%	2%	1%
I-880 South of Junction SR 262	South				-6%	-5%	-56%	0%	0%	-13%
I-880 S: EB Mowry Ave	South				-6%	-6%	-5%	3%	3%	-1%
I-680 at Scott Creek Rd	South				-14%			1%		
I-880 at Dixon Landing Rd	South				-11%	-13%	50%	5%	9%	-62%
I-580 East of Airway Blvd	East				2%	5%	-44%	1%	1%	4%
I-680 At Alcosta Blvd	East				-10%	-10%	-19%	3%	3%	5%
I-680 near I-580	East				13%	12%	38%	6%	6%	10%
I-580 near I-680	East							0%	0%	-7%
I-580 close to Dublin/Pl. BART	East							3%	3%	5%
I-580 at Flynn Road	East				-16%	-15%	-17%	6%	5%	15%

Highway Counts Analysis

In reviewing the new highway traffic counts, a problem was identified where one Wavetronix radar detection unit was used to cover all traffic lanes. In hindsight, two detectors would have done a more thorough job of data collection for freeways with eight or more lanes. It was anticipated that a single unit would work properly for up to eight lanes. The concern was that total vehicles were undercounted on the far side of the freeway in some instances. In the cases where collection accuracy was questionable, the data collection firm, Quality Counts, went back and collected additional Wavetronix counts plus conducted manual classification counts at the same locations. Table 5.8 summarizes how the checks on Wavetronix data were performed.

Data from all 12 highway locations with Wavetronix counts were examined for reasonableness. Caldecott Tunnel count data are presented in Table 5.9, which is an example of the decision-making process in determining the most appropriate truck count volumes. For the reasonableness checks, PeMS data, as well as published Caltrans sources such as The Caltrans Traffic Report for 2008 and the Annual Average Daily Traffic (AADT) Truck Count Report, were consulted. Some of the manual classification counts were collected to help check against the Wavetronix Counts. Thus, a number of separate data elements was consulted to ascertain whether the Wavetronix data were reasonable or needed to be adjusted.

Wavertronix counts were collected near the Caldecott Tunnel on May 28, the week after the Memorial Day holiday. The Wavetronix counts showed 159,200 vehicles; of which 5.5 percent were shown to be trucks greater than 35 feet in length. Data for peak hours and peak periods conforming to those used in the ACCMA model are also shown.

PeMS data was collected for midweek conditions for average days in April 2005, April 2009, and June 2009. According to the PeMS data, total daily Caldecott Tunnel traffic volumes ranged from 177,600 in April 2005 to 156,300 in April 2009 (June 2009 showed an increase in daily traffic to 168,700). One concern with the PeMS data was on the truck side. The percent trucks for April 2009 was double that of both April 2005 and June 2009. As such, the PeMS data shown in Table 5.9 were adjusted to rebalance trucks and autos in April 2009 (total vehicles were not altered).

Secondary data sources – the Caltrans Traffic Count Book and the Caltrans Truck Count Book – were also consulted. These source of information generally showed overall lower total vehicles and lower total percent trucks. These other Caltrans sources may or may not be reliable, but at least do provide a benchmark of reasonably expected values. In the case of the Caldecott Tunnel, the published Caltrans data are on the low end compared to the new Wavetronix Counts and to PeMS.

Caltrans Truck Count Book data were also used to for locations outside Alameda County. Other county truck volumes are discussed in more detail in Chapter 7.

Table 5.8 Assessment of Highway Truck Traffic Counts

Location	Initial Assessment of New Count Quality	Manual Class Counts Collected?	Additional Counts Collected?	Follow-Up Assessment
SR 13 near I-580	Good			Wavetronix data appears reasonable
SR 24 at Caldecott Tunnel			Yes	Wavetronix data appears reasonable
I-80 at University Ave		Yes		Truck count seems high; could be seasonal
I-680 Near SR 262			Yes	Adjustment of count data was required
I-680 At Alcosta Blvd			Yes	Adjustment of count data was required
I-880 South of SR 262	Good			Wavetronix data appears reasonable
I-880 at Industrial Pkwy			Yes	Wavetronix data appears reasonable
I-880 at Hegenberger Road		Yes		Wavetronix data appears reasonable
I-880 between 5th and 10th Ave				Wavetronix data appears reasonable
I-980 at 14th Street			Yes	Truck count may be high; PeMS not available
SR 238 bet I-880 & I-580	Good			Wavetronix data appears reasonable
I-580 Eastern Ala County		Yes		Adjustment of count data was required

Notes:

Initial assessment of new count quality showed good counts at three locations.

Manual truck classification counts were collected at three other locations, and were included as part of the approved scope of work for Quality Counts. The manual classification counts for the AM and PM peak two hours were compared against the Wavetronix counts to help determine data adequacy.

After consideration of potential problems with the Wavetronix counts, Quality Counts agreed to conduct additional Wavetronix Counts, as well as manual truck classifications counts at these same five locations. (Note that all manual classifications counts were collected at the same times Wavetronix counts were being collected).

Table 5.9 Traffic Count Data at SR 24
West Side of Caldecott Tunnel

	Vehicle Length			
	0-35 Feet	35-61 Feet	More Than 61 Feet	Total
Wavetronix Eastbound May 28, 2009				
Daily	76,300	2,500	800	79,600
AM peak hour	3,400	200	0	3,600
PM peak hour 1	5,600	400	100	6,100
PM peak 2 hours	11,600	600	200	12,400
PM peak 4 hours	28,900	1,200	300	30,400
Wavetronix Westbound May 28, 2009				
Daily	82,900	4,700	1,100	88,800
AM peak hour	5,400	600	100	6,200
PM peak hour 1	4,000	300	100	4,400
PM peak 2 hours	8,500	600	200	9,300
PM peak 4 hours	23,200	1,300	300	24,800
Wavetronix Both Directions May 28, 2009				
Daily	159,200	7,300	1,900	168,400
AM peak hour	8,900	800	200	9,900
PM peak hour 1	9,600	700	200	10,500
PM peak 2 hours	20,100	1,200	300	21,600
PM peak 4 hours	52,100	2,500	600	55,200
PeMS				
	Total	Auto	Truck	% Trucks
Apr-2005	177,600	172,100	5,400	3.0%
Apr-2009	156,300	147,100*	5,100*	3.3%
Jun-2009	168,700	162,900	5,800	3.4%
Caltrans Count Book				
	AADT			
2008	151,000			
2006	150,000			
Caltrans Truck Count Book				
	% Truck			
2007	2.2%			

*April 2005 PeMS Auto and truck volumes adjusted to better match April 2005 and June 2009 records.

Overall, the Wavetronix counts fall comfortably within the total traffic counts obtained from PeMS. There is not a direct correspondence between the Wavetronix Counts and the PeMS counts, as the definitions for trucks are somewhat different. However, this data review has allowed us to conclude the Wavetronix counts for the Caldecott Tunnel are indeed reasonable for use in the ACCMA truck model development efforts.

This station-by-station analysis revealed that seven of the highway count locations appear reasonable, while the following five have some issues:

1. **I-80/University Avenue.** High Wavetronix truck counts.
2. I-880 between 5th and 10th Streets. High Wavetronix truck counts.
3. **I-680/SR 262 (Mission Blvd).** Low Wavetronix truck counts; an adjustment of the Wavetronix data was required.
4. **I-680/Alcosta.** Low Wavetronix truck counts; an adjustment of the Wavetronix data was required.
5. **I-580/Flynn Road.** Low Wavetronix truck counts; an adjustment of the Wavetronix data was required.

In these latter three instances, far side highway volumes were quite a bit lower than on the near side (where the Wavetronix unit was placed). In these instances, the adjustment was made on a daily basis to have far side volumes equal near side volumes (with the assumption that near side volumes are accurate).

Table 5.10 presents side-by-side comparisons of the new count stations with PeMS and the Caltrans sources. This includes some additional locations where new truck counts were not collected, but considered useful from a data analysis standpoint. These other locations include important truck routes in-between the new count locations.

Overall, the comparison of the Wavetronix data to other data sources was useful. There is a much greater sense the Wavetronix data are reasonable, given the direct comparisons to PeMS and to other Caltrans published values. In some cases, the PeMS data did not appear to be reasonable at some individual locations – often with low volumes, or with auto/truck splits that were inconsistent with other data sources. In particular, it can be difficult to assess PeMS on a location-by-location basis. However, the exercise of comparing the various data sources provided the project team with good benchmarks for determining which data were most reasonable.

Arterial Counts Analysis

Arterial counts are summarized in Appendix A. Daily volumes range up to 64,000 total vehicles (at Mission Blvd between I-680 and I-880 in Fremont); and many locations have daily volumes in excess of 30,000 daily vehicles.

The arterials generally have less than 5 percent heavy trucks, except for the three locations near the Port of Oakland. At these locations, percent heavy trucks range from 20 to 40 percent. Total trucks generally range between 6 and 10 percent of total traffic. As noted earlier, it is not possible from these data to distinguish pickup trucks and vans (part of the autos category) as being for personal use or commercial use.

Table 5.10 Summary of Daily Freeway Traffic and Truck Counts

Location	Daily Wavetronix Counts				PeMS				Caltrans Resources		
	Total	Autos	Trucks	% Trucks	Total	Auto	Trucks	% Trucks	2008 AADT	% Truck	Derived Trucks
ACCMA Truck Model Count Stations											
SR 13 near Junction 580		51,600	500	0.9%	–	–	–	–	50,000	1%	600
SR 24 at Caldecott Tunnel	168,400	159,200	9,200	5.5%	156,300	151,200	5,100	3.3%	160,000	2%	3,800
I-80 at University Ave	261,400	246,700	14,600	5.6%	200,100	191,800	8,200	4.1%	270,000	4%	10,800
I-680 Near SR 262	140,000	132,900	7,100	*5.1%*	127,600	121,400	6,200	4.9%	135,000	7%	9,600
I-680 At Alcosta Blvd	162,000	155,700	6,300	*3.9%*	170,800	164,900	5,900	3.5%	170,000	5%	9,000
I-880 South of SR 262	206,800	198,900	7,900	3.8%	–	–	–	–	175,000	4%	7,700
I-880 At Industrial Pkwy	212,400	200,600	11,800	5.6%	231,000	213,800	17,200	7.4%	200,000	6%	11,800
I-880 At Hegenberger Road	210,400	193,800	16,600	7.9%	213,900	198,500	15,400	7.2%	200,000	8%	15,200
I-880 bet 5th and 10th Avenue	216,500	195,000	21,500	9.9%	–	–	–	–	225,000	11%	24,100
I-980 at 14th Street	79,200	77,900	1,200	1.5%	–	–	–	–	75,000	7%	4,900
SR 238 bet I-880 and I-580	141,100	122,100	19,000	13.5%	–	–	–	12.5%	130,000	12%	15,300
I-580 Eastern Alameda County	143,600	125,600	18,000	*12.5%*	–	–	–		138,000	13%	17,300
Non-Counted Locations of Interest											
I-880 near West Oakland BART					132,000	128,900	3,100	2.3%	125,000	–3	–
I-580 near Dublin/Pleasanton BART					186,900	172,800	14,200	7.6%	193,000	7%	13,100
I-580 Albany near I-80					95,000	89,100	5,900	6.2%	85,000	6%	5,200
I-80 Bay Bridge					243,500	239,100	4,400	1.8%	255,000	3%	7,100
SR 92 Dumbarton Bridge					76,200	66,000	10,300	13.5%	62,000	7%	4,000
SR 84 San Mateo Bridge					102,300	100,300	2,000	2.0%	93,000	6%	5,400

Notes:

Daily radar detector traffic counts (using Wavetronix units) were collected directly for the ACCMA truck model update. Counts were collected at each location by direction and grouped into three vehicle classification bins – under 35 feet (autos), 35 to 61 feet, and less than 61 feet (trucks). Counts were collected over 24 hours over a Tuesday, Wednesday, or Thursday. Counts were collected in May and June 2010.

PeMS data are averages for June 2009 mid-week weekdays, and represent daily conditions.

Caltrans Resources are 2008 Caltrans Traffic Count Book for 2008, and Caltrans Average Annual Daily Truck Count book.

6.0 Model Development and Validation

In this chapter, new trip generation, distribution and assignment models are described. New truck traffic count data were very useful for overall model validation. However, counts at selected locations do not provide the necessary data on total trips and travel patterns. Observed data needed to be augmented. For trip generation and distribution models, models were calibrated to synthesized ODME-derived observed trip ends and trip length frequency distributions. Model validation efforts for traffic assignment are also covered here.

For the purposes of delivering a new truck model system for ACCMA, observed data needed to be augmented. Although new traffic count data was boon for overall model validation, total trip and travel pattern data were nonexistent.

6.1 ODME-DERIVED TRIP TABLES

ODME trip tables were developed with new traffic counts. The purpose of the ODME application was to create observed truck trip tables to evaluate model validation efforts. The ODME trip tables are *not* used as the model-developed trip tables.

Traffic counts at selected locations provide good information on the trucks crossing a specific point in the network. The specific traffic counts do not provide an overall total of truck trips generated in Alameda County. The traffic counts also do not identify the origins and destinations or trip lengths for the truck trips, as a truck crossing a specific count location could be making a very long trip to Los Angeles or a short trip to the next city. In order to provide a modeling system, which can work for forecast scenarios, a set of equations need to be developed that estimate total truck trips and origins and destinations; and then this set of equations can be validated by comparing the model estimates to the actual traffic counts.

There were no additional survey data or other sources that could be used to create an observed set of total truck trip generation and origin-destination patterns. However, total trips and origin-destination patterns can be estimated using a mathematical process that fits an estimated starting trip matrix to the observed traffic counts. The ODME was selected to provide a target for calibrating modeled trip ends (trip generation) and trip length frequency distributions (trip distribution). This was seen as a cost-effective solution for development of observed data for which trip generation and distribution models could be developed.

The process starts with the existing model truck trip table as a "seed" (initial estimate) to ODME, and uses the observed truck counts as constraints. The ODME process adjusts the seed trip table until the assignment of that trip table most closely matches the counts. By comparing the results of the adjusted table to the estimate table from the prior iteration, we can see how and where to make adjustments. Two examples are given below for better understanding of the need for ODME and what it does here:

- **Example 1.** Assume the numbers of trips in the new table (excluding intra-zonals, which are not assigned by the model and are not adjusted by ODME) are exactly twice that in the old table. Also, assume that the ratios comparing row and column sums between the new and old tables are all exactly twice the sums in the old table. The simple interpretation would be that the trip rates in the old model were all exactly 50 percent of what they should be to be validated against the counts. Double the trip rates and the new model that will be used in forecasting, when given base year employment data, will validate as closely as possible to counts, since that is what ODME does.
- **Example 2.** Assume the observations are more complicated. The total truck trips ODME are twice the number of total truck trips in the old model, but the ratios of row and columns are not 2 to 1, and that is because some O-D pairs are not 2 to 1. For widely separated O-D pairs the ratio is 3, and for close in zones the ratios is 1. That is an indication that the friction factors are underestimating long-distance trips (it is one-third of what it should be), and are underestimating short-distance trips (the O-D pair ratio is only 1.0, while total trips have a ratio of 2.0). While the math is not as clean since the friction factors are an inverse exponential function, ODME adjusts the equations until the model closely matches the observed truck counts.

Varieties of different types of adjustments were made, but these examples are given to make the point of how the ODME trip tables will be used in the modeling. The idea is that ODME can show in what direction the truck model parameters need to be adjusted. However, once those adjustments are made, there is never a need to use ODME again.

A number of ODME applications has been tested for this project. Evaluation of the different ODME applications is based on resultant traffic assignment validation results against observed truck traffic counts. However, CS has found a method to create ODME-based trip tables for truck classes only. Previously, total vehicles were being subjected to ODME, and then truck trips (by class) were factored out.

Input Data

Truck counts collected within Alameda County were supplemented with other count data for other ACCMA model coverage areas outside Alameda County and used in the ODME procedure. The 2005 Caltrans Truck Count book was used to collect estimated total traffic and truck counts for a limited number of

locations in San Francisco, San Mateo, Santa Clara, Contra Costa, Solano, Napa, Sonoma, Marin, and San Joaquin Counties. Central locations were selected within each of these counties, as were external gateways (such as I-80 at the Solano/Napa county line and U.S. 101 at the Santa Clara/San Benito county line.

Figure 6.1 shows the geographic spread of the traffic and truck counts on freeways, expressways, arterials, and collectors. The observed count database includes total daily traffic by vehicle class (automobile, small truck, medium truck, and combo truck). Table 6.1 shows the total number of count locations throughout the 10-county model coverage area and the number of new count locations within Alameda County. All of the compiled traffic and truck counts were used in the ODME procedure.

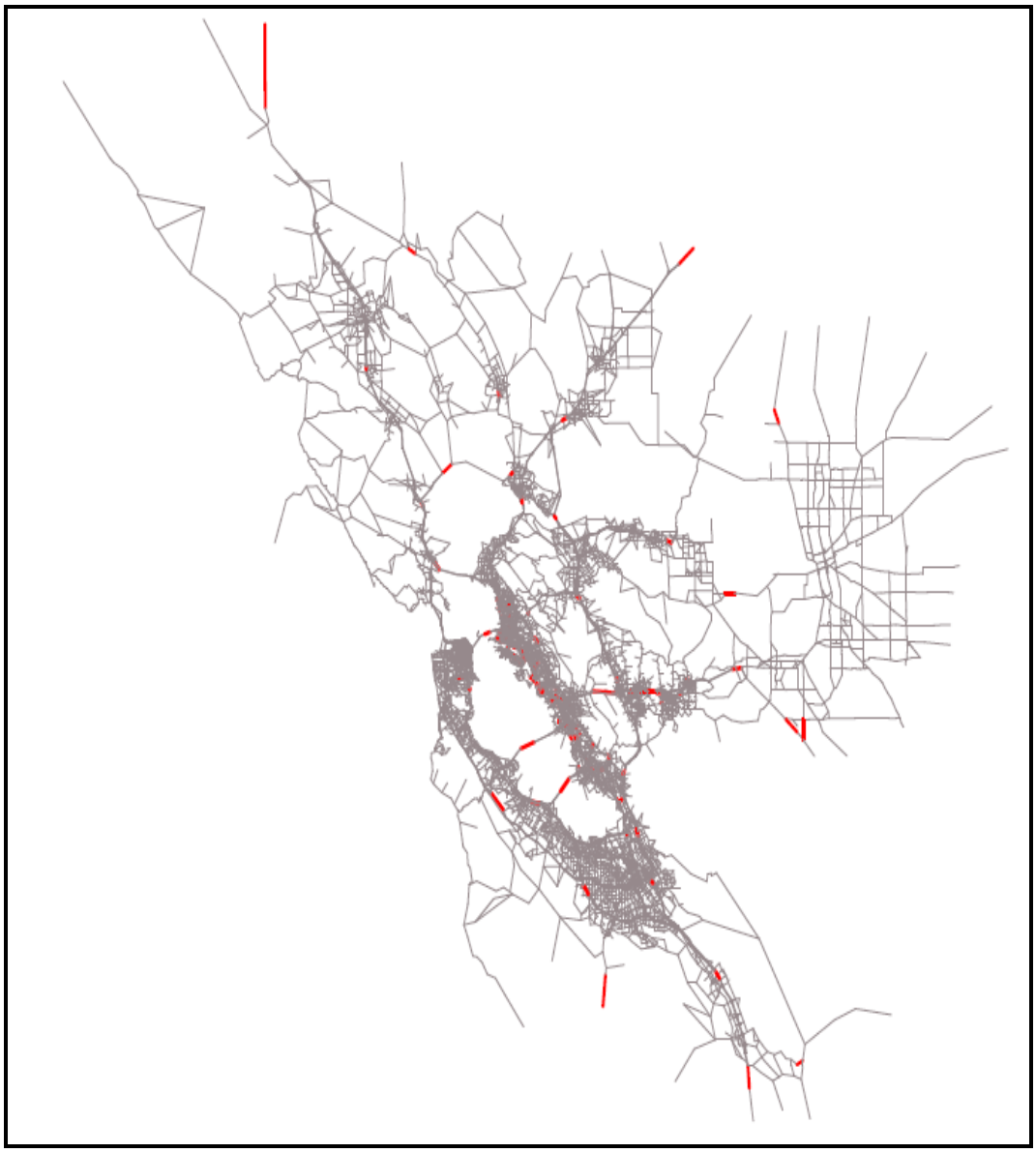
Methodology

The ODME procedure is an accepted practice that estimates trip tables based on traffic count data. Inputs include observed truck traffic counts on selected directional links an initial estimate or "seed" matrix; in this case, the estimated truck O-D trip tables from the existing model. Using the seed matrix as a starting point and the observed volumes as control totals, the ODME process is executed within Cube Analyst to estimate O-D trip tables, which, when assigned to the network, produce link flows that optimally match the observed counts.

CS developed a process within Cube Analyst to preload auto trips into the traffic assignment, and therefore estimated only an ODME truck trip table. The assigned ODME-adjusted trips were being used as a validation check by comparing summary statistics for each identified network link with observed counts, as well as by volume group and facility type. However, the existing truck trip tables estimated by the ODME process were not used as the final model result. Rather, they were used as a guide to calibrate the truck trip generation and distribution models.

Traffic counts at selected locations provide good information on the trucks crossing a specific point in the network. The specific traffic counts do not provide an overall total of truck trips generated in Alameda County. The traffic counts also do not identify the origins and destinations or trip lengths for the truck trips, as a truck crossing a specific count location could be making a very long trip to Los Angeles or a short trip to the next city. In order to provide a modeling system, which can work for forecast scenarios, a set of equations need to be developed that estimate total truck trips and origins and destinations, and then this set of equations can be validated by comparing the model estimates to the actual traffic counts.

Figure 6.1 Bay Areawide Count Locations used for ODME-based Trip Tables



Sources: New data collected for this study, and PeMS within Alameda County and Caltrans Truck Count Book for locations outside Alameda County.

Table 6.1 Observed Count Data by Facility Type*

Facility Type	New Alameda County Count Locations		Total 10-County Coverage Area Locations	
	Sum of Volumes	Number of Observations	Sum of Volumes	Number of Observations
Freeway	2,097,900	24	6,773,100	88
Expressway	170,900	12	358,300	20
Arterial	1,096,700	80	1,259,200	98
Collector	40,400	8	40,400	8
All	3,406,000	124	8,431,000	214

* New Alameda County Count Locations included are only those were new counts were collected within Alameda County. Other locations include Caltrans Truck Count Book volumes – outside Alameda County only.

There were no additional survey data or other sources that could be used to create an observed set of total truck trip generation and O-D patterns. However, total trips and O-D patterns can be estimated using a mathematical process, which fits an estimated starting trip matrix to the observed traffic counts. The ODME was selected to provide a target for calibrating modeled trip ends (trip generation) and trip length frequency distributions (trip distribution). This was seen as a cost-effective solution for development of observed data for which trip generation and distribution models could be developed.

The process starts with the existing model truck trip table as a "seed" (initial estimate) to ODME, and uses the observed truck counts as constraints. The ODME process adjusts the seed trip table until the assignment of that trip table most closely matches the counts. By comparing the results of the adjusted table to the estimate table from the prior iteration, we can see how and where to make adjustments.

A number of ODME applications has been tested for this project. Evaluation of the different ODME applications is based on resultant traffic assignment validation results against observed truck traffic counts. However, CS has found a method to create ODME-based trip tables for truck classes only. Previously, total vehicles were being subjected to ODME, and then truck trips (by class) were factored out.

Input Data

Truck counts collected within Alameda County were supplemented with other count data for other ACCMA model coverage areas outside Alameda County and used in the ODME procedure. The 2005 Caltrans Truck Count book was used to collect estimated total traffic and truck counts for a limited number of locations in San Francisco, San Mateo, Santa Clara, Contra Costa, Solano, Napa, Sonoma, Marin, and San Joaquin Counties. Central locations were selected

within each of these counties, as were external gateways (such as I-80 at the Solano/Napa county line and U.S. 101 at the Santa Clara/San Benito county line.

Figure 6.1 shows the geographic spread of the traffic and truck counts on freeways, expressways, arterials, and collectors. The observed count database includes total daily traffic by vehicle class (automobile, small truck, medium truck, and combo truck). Table 7.1 shows the total number of count locations throughout the 10-county model coverage area and the number of new count locations within Alameda County. All of the compiled traffic and truck counts were used in the ODME procedure.

Methodology

The ODME procedure is an accepted practice that estimates trip tables based on traffic count data. Inputs include observed truck traffic counts on selected directional links and initial estimate or "seed" matrix; in this case, the estimated truck O-D trip tables from the existing model. Using the seed matrix as a starting point and the observed volumes as control totals, the ODME process is executed within Cube Analyst to estimate O-D trip tables, which, when assigned to the network, produce link flows that optimally match the observed counts.

CS developed a process within Cube Analyst to preload auto trips into the traffic assignment, and therefore estimated only an ODME truck trip table. The assigned ODME-adjusted trips were being used as a validation check by comparing summary statistics for each identified network link with observed counts, as well as by volume group and facility type. However, the existing truck trip tables estimated by the ODME process were not used as the final model result. Rather, they were used as a guide to calibrate the truck trip generation and distribution models.

Performance Measures

Model validation performance measures selected for this report were standard measures used for traffic assignment analysis. These measures included:

- Simple difference between model volumes and observed counts.
- Percent difference between model volumes and observed counts (or percent error).
- Percent RMSE. This is an aggregate measure of all links; whereas, the difference measures above are based on individual links.

For trip generation and distribution, aggregate measures were used to evaluate model validation. There was no real observed data to compared trip rates or trip length frequency distributions against; thus, ODME results were used to compare total truck trips by truck class.

For trip distribution, manual observations of the trip length frequency distributions were used to for validation purposes. However, for both generation and distribution models, traffic assignment results were also evaluated.

- Overall goodness of fit measure (R-squared) for the assigned total volumes. R-squared and RMSE values are based on standards developed from the FHWA Travel Model Validation and Reasonableness Checking Manual, and from the Travel Model Improvement Program White Paper on Model Validation[24].

ACCMA Model Validation Results

The results of the 2005 Base Year ACCMA model's daily assigned trips were compared to the observed counts. It should be noted that, while traffic counts inside and outside of Alameda County are used in the ODME process, the validation statistics reported here are only for roadways in Alameda County. All presented results are given for total volumes. Daily volume aggregate performance of the current ACCMA model is summarized in a series in Tables 6.2 and 6.3.

Table 6.2 Existing Truck Model Validation
Automobiles

	Observed		2005 Base Year ACCMA Model – Auto Volumes			Target* % Error	
Facility Type	Sum of Volumes	No. of Obs.	Estimated	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	1,866,100	24	1,745,900	18%	-6%	+/-7%	+/-6%
Expressway	159,800	12	116,700	41%	-27%	+/-7%	+/-6%
Arterial	1,029,900	80	1,190,400	62%	16%	+/-15%	+/-10%
Collector	28,400	8	15,900	97%	-44%	+/-25%	+/-20%
All	3,084,200	124	3,068,800	36%	0%	N/A	N/A

[24] National Cooperative Highway Research Program Report 255, *Calibration and Adjustment of System Planning Models, 1990; Travel Model Improvement Program*, Federal Highway Administration, Model Validation and Reasonableness Checking Manual, 1997; and Travel Model Improvement Program, Federal Highway Administration, Travel Model Validation Practice Peer Exchange White Paper, December 3, 2008.

Table 6.3 Existing Truck Model Validation
Trucks

	Observed		2005 Base Year ACCMA Model – Truck Volumes			Target * % Error	
Facility Type	Sum of Volumes	No. of Obs.	Estimated	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	231,900	24	240,436	55%	4%	+/-7%	+/-6%
Expressway	11,100	12	4,600	67%	-59%	+/-7%	+/-6%
Arterial	66,800	80	59,600	99%	-11%	+/-15%	+/-10%
Collector	12,100	8	5,800	69%	-52%	+/-25%	+/-20%
All	321,800	124	310,400	93%	-4%	N/A	N/A

Detailed, link-level model validation results for various time periods (AM one-hour, PM one-hour, PM two-hour, and PM four-hour) were also generated as part of this project. These tables are included in the report under Appendix B.

The percent error and percent RMSE values are higher than preferred for both automobiles and total trucks – with the exception of freeways. However, there are data issues that make producing significantly better results an extremely difficult task. One issue is a standard one with any count program – there is significant daily variation in observed trucks or automobiles.

In addition, the 2009 counts were scaled back to 2005 conditions. Although there is a lot of supporting data for this conversion, undoubtedly errors were introduced as a result of this conversion. Finally, expressways and collectors represent very small sample sizes with correspondingly low volumes. These sample sizes are too small to produce reliable RMSEs.

As such, we believe these ODME values produce reasonable results; short of actually collecting new O-D data on truck travel patterns. However, the errors tend to be larger than were targeted.

6.2 TRIP GENERATION

This section examines trip generation models that exist in the current ACCMA model, and new truck model options explored by the project team for the new truck model.

CS evaluated a number of new trip generation models for the ACCMA's truck model project. These model types are described as follows:

- Truck trip generation rates for internal[25] trips only;
- Use of PCEs are used in place of total (auto plus truck) volumes;
- Port of Oakland considered a separate special generator; and
- External truck trips modeled explicitly.

Various combinations of these factors were examined, and ultimately the final model included separate trip generation models for internal (i-i) trips apart from external trips (i-x, x-i, x-x). The Port of Oakland Seaport was treated as a special generator (with higher truck trip rates, and the use of PCEs rather than total vehicles). Table 6.4 summarizes the trip generation model coefficients.

Table 6.4 Truck Trip Generation Model Coefficients

	Production & Attraction Models		
LU/Sector	Small	Medium	Combo
Internal-Internal Trips			
Manufacturing employment	0.0356	0.04459	0.02417
Retail employment	0.0387	0.03511	0.03736
Service employment	0.0351	0.06838	0.02239
Other employment	0.0719	0.06169	0.03021
Wholesale employment	0.0719	0.06169	0.03021
Agriculture employment	0.0719	0.06169	0.03021
Internal-External/External-Internal/External-External			
Manufacturing employment		0.00610	0.01860
Retail employment			
Service employment			
Other employment	0.00130	0.00050	0.01180
Wholesale employment		0.00050	0.01260
Agriculture employment			

The existing model was developed using separate trip generation rates for garage-based trucks versus nongaraged trucks. The new model does away with that distinction, as there is no new data on such distinctions.

[25] Internal refers to travel solely within the 10-county model coverage area. External refers to truck travel outside these 10 counties. External trips either stop within the model coverage area, or pass through the area.

Truck and total trip generation model validation results are summarized in Table 6.5. Total trucks are within two percent of the ODME-based truck trip ends, which are a substantial improvement over the existing model (see again Table 6.2).

Table 6.5 Trip Generation Model Validation Summary

Performance Measures	ODME	Final Trip Generation Rates
Total Volumes		
Sum of Observed Volumes	3,406,000	3,406,000
Estimated Volumes	3,905,600	3,792,400
Percent Error	15%	11%
Percent Root-Mean-Square-Error	44%	39%
R-Squared	.87	.90
Auto Volumes		
Sum of Observed Volumes	3,084,200	3,084,200
Estimated Volumes	3,367,400	3,243,600
Percent Error	9%	5%
Percent Root-Mean-Square-Error	36%	37%
Truck Volumes		
Sum of Observed Volumes	321,800	321,800
Estimated Volumes	400,200	327,300
Percent Error	24%	2%
Percent Root-Mean-Square-Error	103%	82%
Small Truck Volumes		
Sum of Observed Volumes	69,594	69,594
Estimated Volumes	215,282	68,270
Percent Error	209%	-2%
Percent Root-Mean-Square-Error	523%	127%
Medium Truck Volumes		
Sum of Observed Volumes	76,500	76,525
Estimated Volumes	93,800	74,780
Percent Error	23%	-2%
Percent Root-Mean-Square-Error	120%	112%
Combination Truck Volumes		
Sum of Observed Volumes	175,700	175,700
Estimated Volumes	91,100	184,200
Percent Error	-48%	5%
Percent Root-Mean-Square-Error	112%	93%

Although there are still some problems with the data (percent RMSE levels are higher than would be desired), the close matches of total trucks for each of the three vehicle classes do show a substantial improvement over the existing model.

Port of Oakland (Seaport) and Oakland Airport Special Generators

Special generators are usually added to travel demand models, where trip generation rates applied to typical socioeconomic data, such as employment, will not produce reasonable trip productions and attractions for the nontypical location. For example, special generators for truck volumes are often used for seaports and airports. The major flows of goods are exchanged with no or very low manufacturing, industrial, and/or warehouse employment, which is typically the basis for estimating truck trip productions and attractions. Possible applications of special generators into the updated ACCMA truck model for the Oakland International Airport and the Port of Oakland were investigated

Port of Oakland

Table 6.6 and Figure 6.2 provide observed counts and estimated model volumes (without a special generator component) for locations at the Port of Oakland. The model, using only employment at the port zones to estimate truck productions and attractions, significantly underestimates truck volumes at these locations, estimating volumes of only approximately 10 percent of actual counts.

Since the model shows that employment is not a good indicator of truck flow, a special generator at this location was recommended to provide improvement to the model. The Port of Oakland special generator model created truck trip rates to match the base year count volumes at the three port gateways at Maritime Street, 7th Street, and Middle Harbor Way.

Table 6.7 and Figure 6.3 provide observed counts and estimated model volumes with a Port of Oakland special generator of 2,556 trucks produced and 2,556 trucks attracted. The addition of a special generator reduces error to -3% in the Port, a reduction of 87 percent of the error at the Port of Oakland Seaport without the added special generator truck trips.

Table 6.6 Port of Oakland Locations
Count and Estimated Volumes Without 2005 Special Generator

Location	Dir.	Total Truck Volumes		
		Count	Estimated	%Error
Maritime St south of Grand Ave	SB	1,400	250	-82%
Maritime St south of Grand Ave	NB	1,280	200	-82%
7th St west of I-880	WB	3,000	210	-93%
7th St west of I-880	EB	2,590	230	-91%
Middle Harbor Rd south of 3rd St	SB	1,410	110	-92%
Middle Harbor Rd south of 3rd St	NB	1,660	110	-94%
Total		11,340	1,130	-90%

Percent differences based on actual, not rounded, values.

Figure 6.2 Port of Oakland Locations
Count and Estimated Volumes without 2005 Special Generator

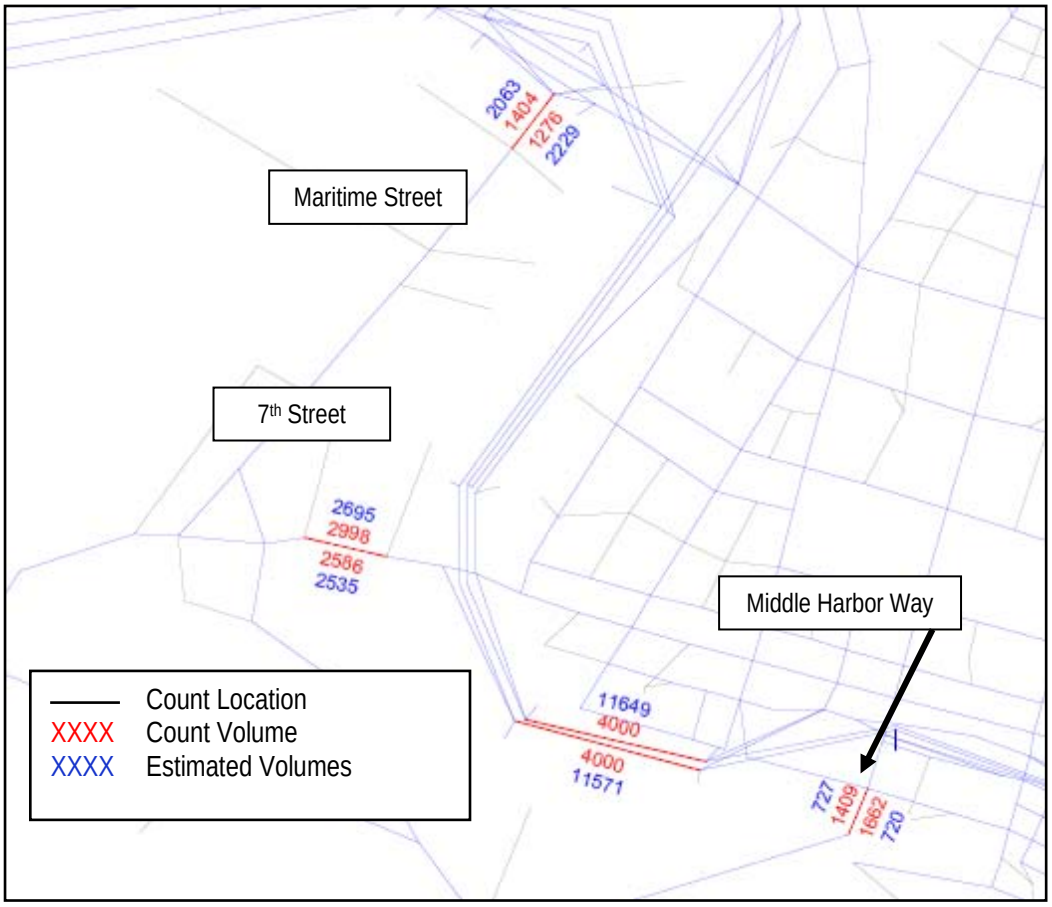
Note: Percent differences based on actual, not rounded, values.

Table 6.7 Port of Oakland Locations
Count and Estimated Assigned Volumes with 2005 Special Generator

Location	Dir.	Total Truck Volumes		
		Count	Estimated	%Error
Maritime St south of Grand Ave	SB	1,400	2,100	47%
Maritime St south of Grand Ave	NB	1,300	2,200	75%
7th St west of I-880	WB	3,000	2,700	-10%
7th St west of I-880	EB	2,600	2,500	-2%
Middle Harbor Rd south of 3rd St	SB	1,400	700	-48%
Middle Harbor Rd south of 3rd St	NB	1,700	700	-57%
Total		11,300	11,000	-3%

Percent differences based on actual, not rounded, values.

Figure 6.3 Port of Oakland Locations
Count and Estimated Assigned Volumes with 2005 Special Generator



Oakland Airport

While there are air cargo and distribution center facilities near airports, standard practice for the development of airport special generators limit the area to actual airport grounds within the gated areas of the airport, where there is otherwise no reason to produce and generate trucks based on employment. Nearby facilities related to the airport, such as air cargo and distribution centers, generally have employees for which their trips are more typically modeled in the traditional trip generation phase.

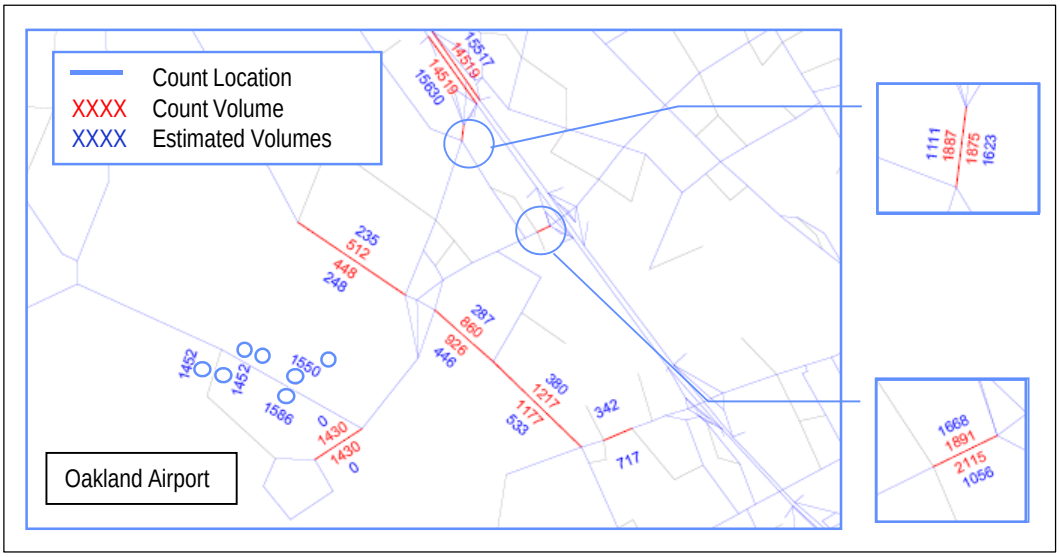
Table 6.8 and Figure 6.4 provide observed counts and estimated model volumes without an airport special generator. As shown in Figure 6.4, the model outputs show 0 (zero) truck volume on Airport Drive, south of Ron Cowan Parkway, but there are 1,450 model-estimated trucks just west of Airport Drive on a centroid connector where Air Cargo Way is actually located. The centroid that represents the Airport is simply placed further west, thus creating the shortest path when accessed via Ron Cowan Parkway and Air Cargo Way, and all trips (including auto trips) load onto that route. For the purposes of this analysis, those 1,450 model-estimated trucks can be compared to the 1,430 Airport Drive observed counts, as shown in Table 6.8.

Table 6.8 Oakland Airport
Count and Estimated Assigned Volumes Without a Special Generator for Year 2005

Location	Dir.	Total Truck Volumes		
		Count	Estimated	%Error
Hegenberger Rd btwn Edgewater Dr & I-880 SB On-Ramp	SB	1,900	1,100	-41%
Hegenberger Rd btwn Edgewater Dr & I-880 SB On-Ramp	NB	1,900	1,600	-13%
SR 61 (Doolittle Dr) between Swan Way & Langley St	SB	400	200	-45%
SR 61 (Doolittle Dr) between Swan Way & Langley St	NB	500	200	-54%
SR 61 (Doolittle Dr) between Davis St & Eden Rd	SB	1,200	500	-55%
SR 61 (Doolittle Dr) between Davis St & Eden Rd	NB	1,200	400	-69%
98th Ave between I-880 & Empire	WB	1,900	1,700	-12%
98th Ave between I-880 & Empire	EB	2,100	1,100	-50%
Doolittle Dr between Adams & Airport Dr	SB	900	400	-52%
Doolittle Dr between Adams & Airport Dr	NB	900	300	-67%
Airport drive south of Ron Cowan Parkway	NB	1,400	1,500	2%
Airport drive south of Ron Cowan Parkway	SB	1,400	1,500	2%
Total		15,767	10,491	-33%

Percent differences based on actual, not rounded, values.

Figure 6.4 Oakland Airport
Count and Estimated Assigned Volumes Without a Special Generator



Overall, the percent errors may seem high for locations near the Airport, but it is important to note the low volumes of these facilities. Regional models generally do not perform well in small areas with large zones, and are not developed with the intention to accurately forecast low-volume facilities. For facilities with less than 10,000 average daily traffic, industry standards mark the acceptable percent error to be ±50 percent, and the preferable percent error to be ±25 percent.[26] Here, all count locations have daily volumes much less than 10,000 vehicles. It should also be noted that model volumes at the actual airport access road are estimated at a 2-percent difference from the observed counts, indicating well-modeled volumes to and from the airport.

Truck modeling sometimes utilizes special generators for facilities that with little or no socioeconomic data for which to project trip productions and attractions. For the updated ACCMA truck model, it was determined that Port of Oakland locations were not being modeled sufficiently; and a special generator was developed and implemented to produce more accurate results.

Without an airport special generator, the model performed well for truck trips directly in and out of the Airport. Some nearby locations, however, produced less than preferable estimated volumes, but are still within acceptable ranges. Regional models are not intended to produce highly accurate volumes within small areas and on low-volumes roads.

[26] Florida DOT Model Calibration and Validation Standards Final Report 2008.

The recommended course of action is to compare the model's network and traffic analysis zones with actual conditions and possibly move centroid connectors, which is often a source of error in small areas with large zones. A review of the socioeconomic data in the area may also be warranted. An airport special generator, however, is not recommended because the employment-based truck trip ends appear to reasonably match the observed counts to and from the airport cargo gate (refer back to Table 6.8 and Figure 6.4).

6.3 TRIP DISTRIBUTION

Trip Length Frequency Distributions (TLFD) were prepared and examined for the original and the ODME tables. A comparison of these distributions guided not only changes to the friction factors, but also changes to the use of impedance variables. Changes to the TLFD for IE/EI and I-I truck trips can be seen in Figures 6.5 through 6.10. The existing model TLFD using the AM skim times, which were the impedances used in the auto distribution, differed considerably from the distribution of the ODME-adjusted table for IE/EI trips. When the off peak skims were used as the impedance variable, as well as minor changes to the friction factors, the TLFD more closely matched that of the ODME table. While the adjustment was not as dramatic for other trips types, the ODME table was used to determine what changes should be made to the trip distribution process.

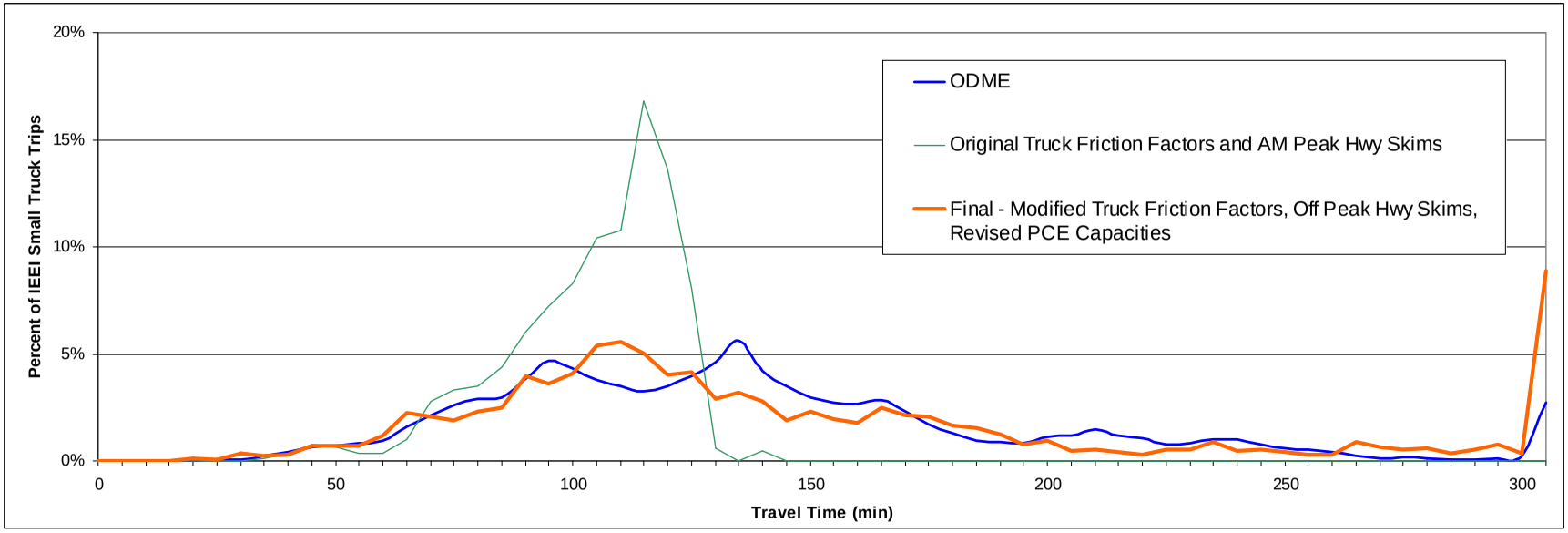
6.4 TRAFFIC ASSIGNMENT

While not actually an adjustment which was guided by the ODME, the original model's assignment was of vehicles and the link capacities were expressed in terms of vehicles per hour, with a truck being one vehicle. An improvement was made by applying a PCE, factors of 1.5 for medium trucks and 2.0 for combo trucks, to the truck tables and expressing the link capacities in terms of passenger cars per hour. This was done in a multiclass assignment with autos, which changed the assignment of all vehicles.

The rationale for this change is that since trucks are longer than average automobiles, they use more roadway, and thus take up more available capacity. For this reason, PCE factors have been used during the assignment step of the ACCMA travel demand model.

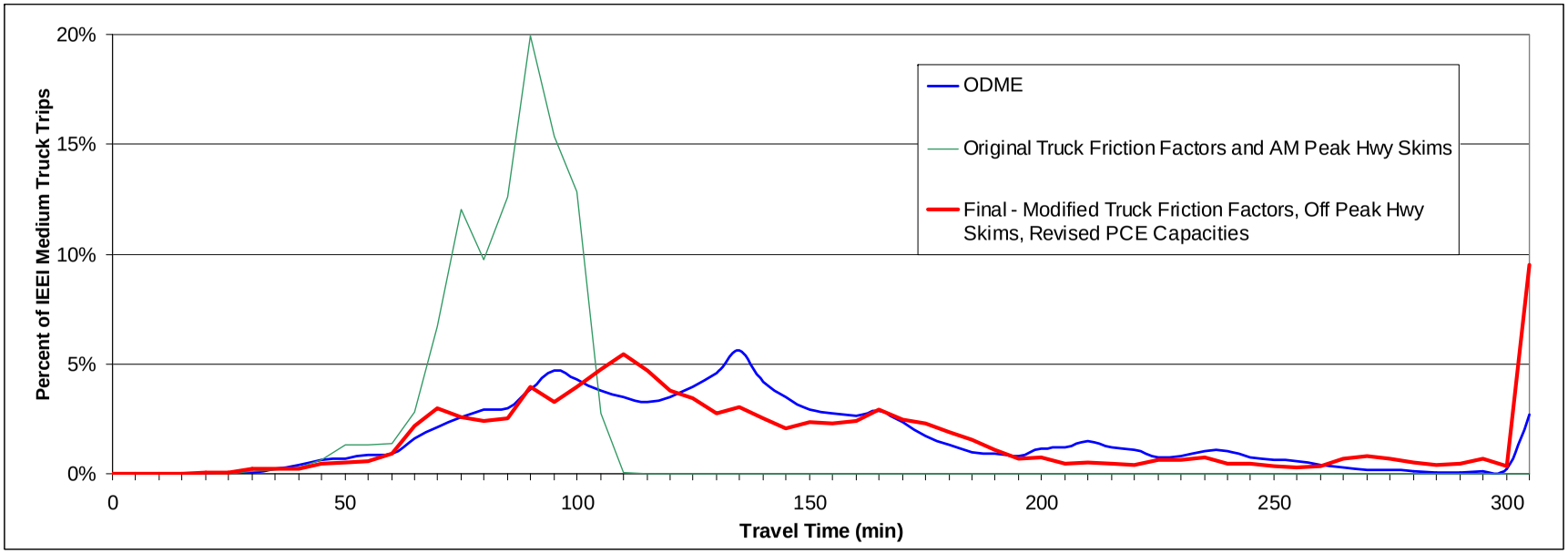
The final selected PCEs convert to the exact same roadway volumes. However, the PCEs provide a better way to account for the differential capacities between trucks and automobiles. In particular, the use of PCEs recognizes the impacts of trucks on high-truck volume facilities from low-truck volume facilities. Put another way, Consider two freeways with equal traffic volumes per lane per hour. A freeway with a high number of trucks (example, I-880 in Oakland) will show a worse level of service than a facility with low-truck volumes (for example, SR 31 in Oakland). This differentiation can only be observed through a PCE analysis.

Figure 6.5 Trip Length Frequency Distribution for IE/EI Small Truck Trips



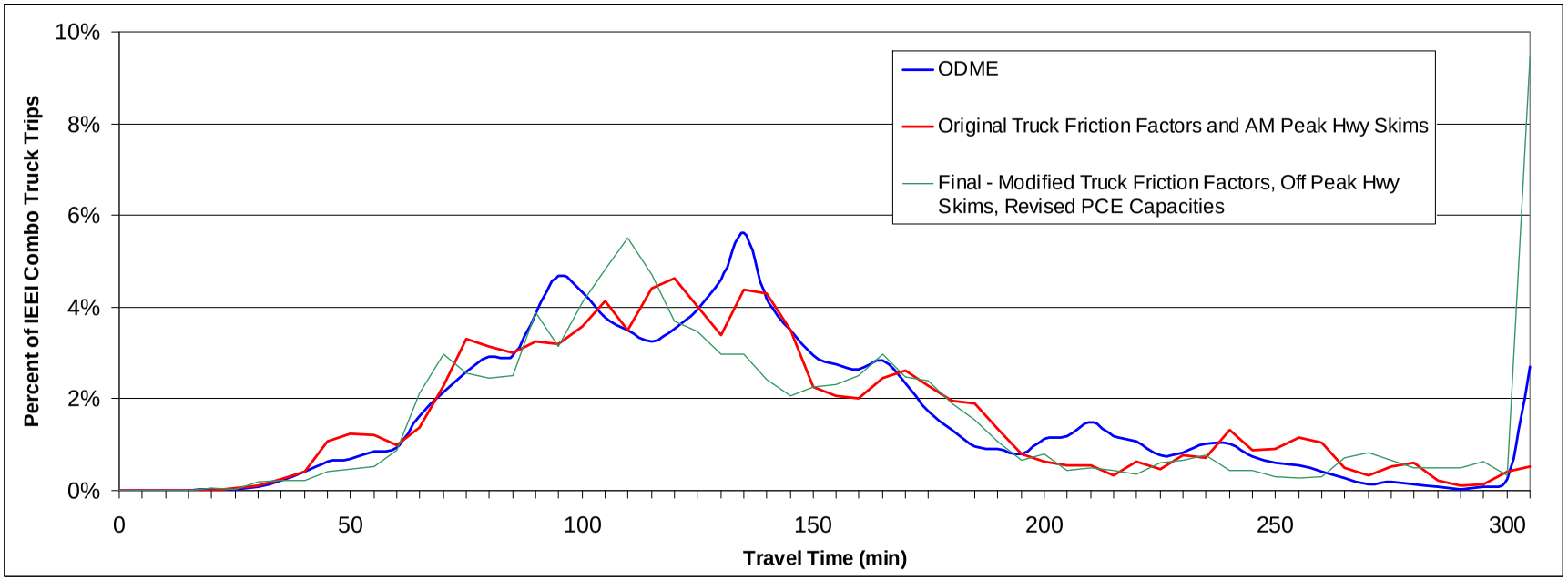
Note: External trips can have one leg (origin or destination) within model coverage area or can be through trips.

Figure 6.6 Trip Length Frequency Distribution for IE/EI Medium Truck Trips



Note: External trips can have one leg (origin or destination) within model coverage area or can be through trips.

Figure 6.7 Trip Length Frequency Distribution for External Combination Truck Trips



Note: External trips can have one leg (origin or destination) within model coverage area or can be through trips.

Figure 6.8 Trip Length Frequency Distribution for Internal-Internal Small Truck Trips

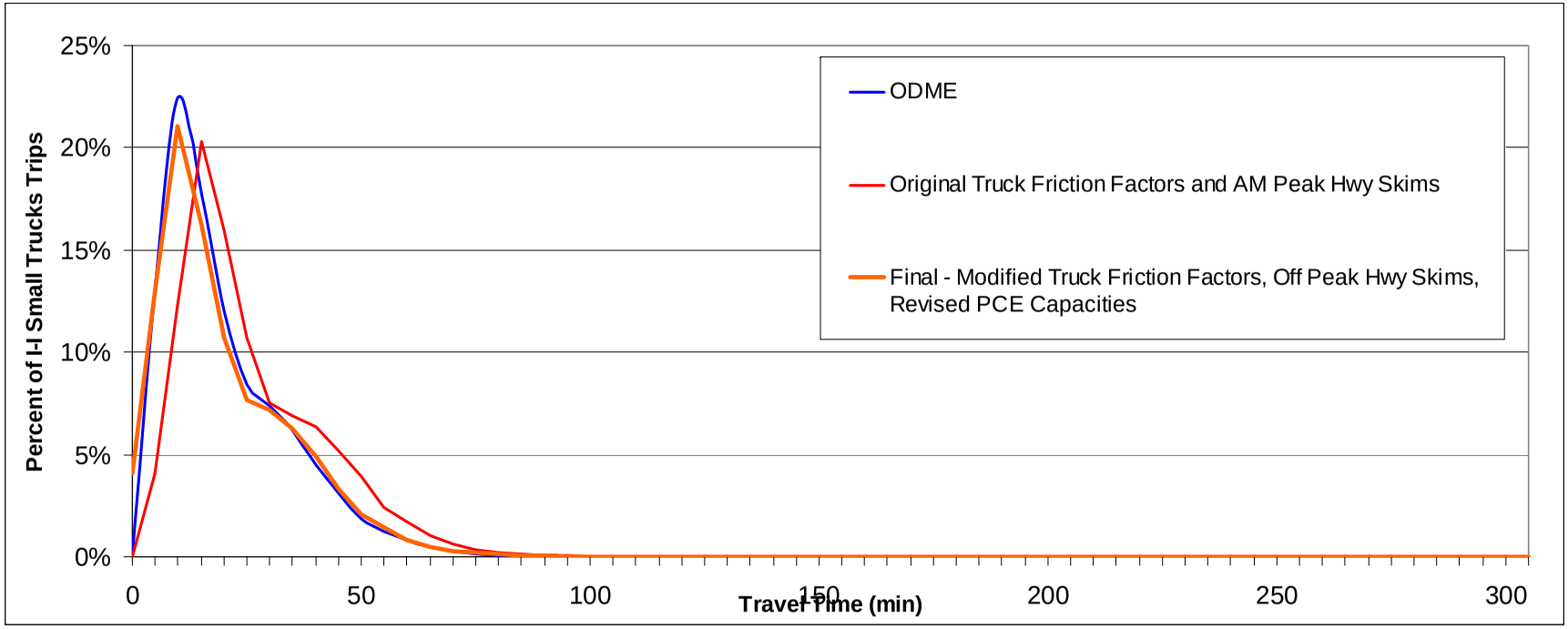


Figure 6.9 Trip Length Frequency Distribution for Internal-Internal Medium Truck Trips

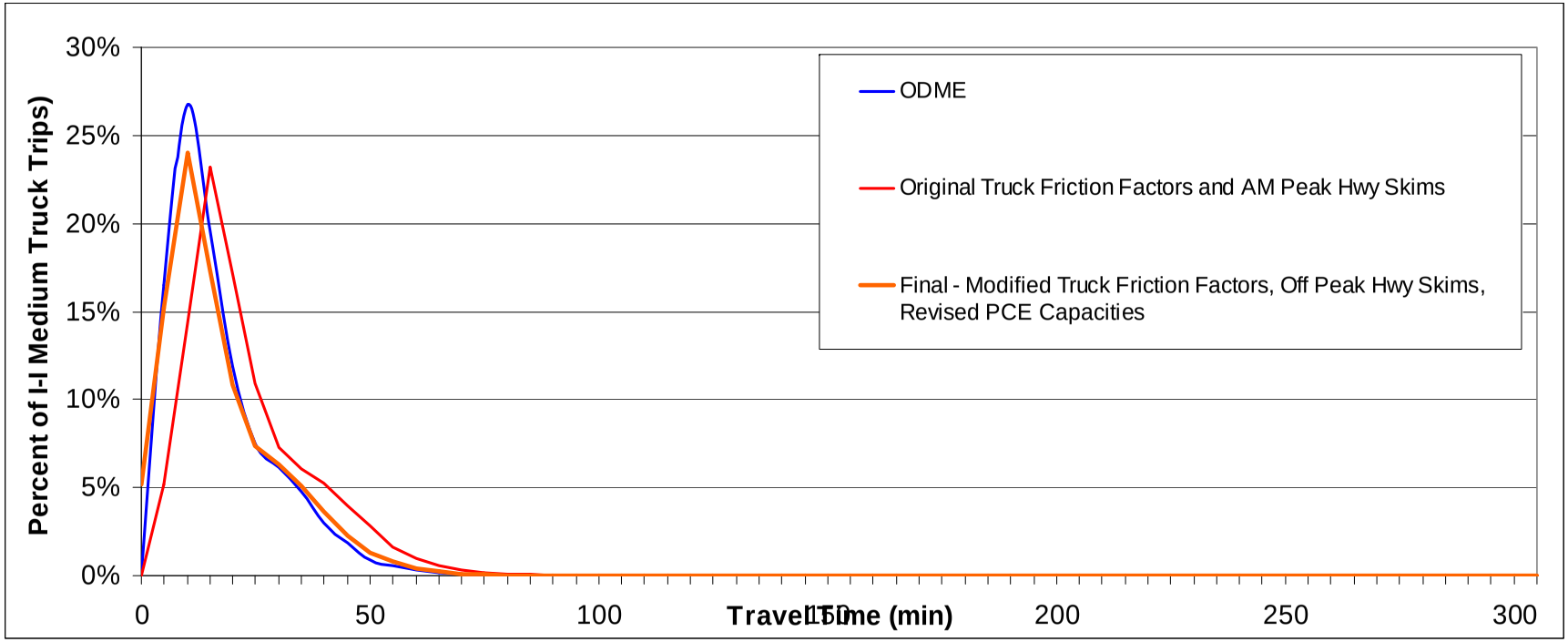
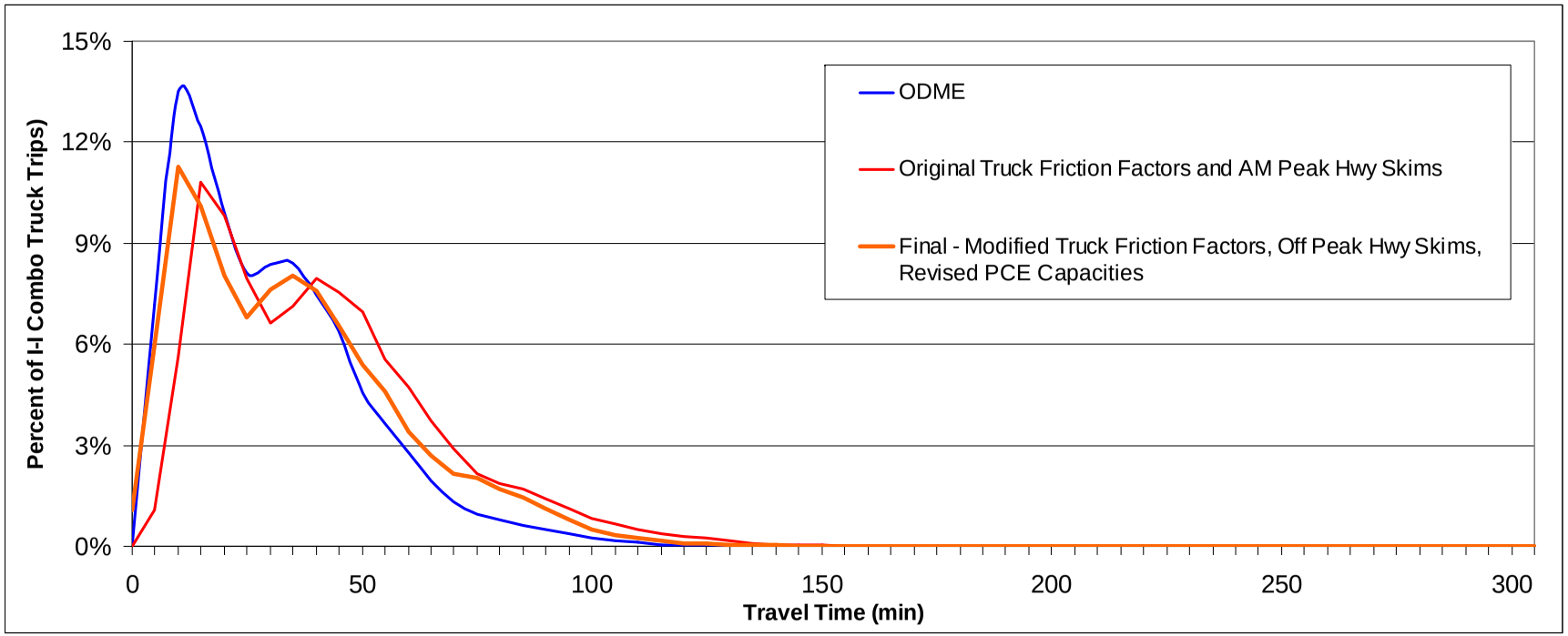


Figure 6.10 Trip Length Frequency Distribution for Internal-Internal Combination Truck Trips



Tables 6.9 through 6.13 present the final year 2005 traffic assignment validation results. Each table shows one of the five ACCMA model time periods – Daily, AM peak hour, PM peak hour, PM peak two hours, and PM peak four hours. Each of the tables presents the three truck classes, as well as total vehicles (including all trucks and autos).

Truck Prohibitions

Jurisdictions have imposed truck prohibitions on a number of area roadways, notably I-580 through Oakland. These bans also apply to a number of local roads. A review of truck bans was summarized during this study, and is included in roadway maps that include trucking designations along with other data (such as count station locations relevant for this study). Please see Appendix B for these maps.

The project team considered adding the truck prohibitions to the model system, but with the exception of I-580 they were not included. There were a number of reasons for not including the truck prohibitions. First, there are various definitions of truck prohibitions across different jurisdictions. In addition, the truck bans tend to be applied to roadways that would not generally have much, if any, heavy truck traffic (the bans tend to be applied in residential locations). In one case – the Caldecott Tunnel – the prohibition is a time period restriction to a class of trucks not distinguished in the ACCMA truck model. Finally, and of greatest concern was applying the prohibitions could result in trucks not being able to get on or off the network, depending on how travel analysis zone centroids were coded.

Table 6.9 Year 2005 Daily Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No. of Obs.	Small Trucks				Medium Trucks				Combo Trucks			
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error
Freeway	24	31,900	48,400	124%	52%	60,700	49,700	66%	-18%	139,300	142,400	56%	2%
Expressway	12	4,900	1,600	76%	-68%	2,200	1,900	77%	-14%	4,100	1,200	84%	-71%
Arterial	80	31,400	17,300	91%	-45%	11,200	18,500	175%	65%	24,100	23,700	159%	-2%
Collector	8	1,400	500	82%	-65%	2,400	1,200	79%	-50%	8,200	4,000	73%	-51%
All	124	69,600	67,800	138%	-3%	76,500	71,300	122%	-7%	175,700	171,300	103%	-2%

Facility Type	No. of Obs.	Total Autos and Trucks				Target % Error	
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	24	2,097,900	1,986,400	17%	-5%	+/-7%	+/-6%
Expressway	12	170,900	121,300	42%	-29%	+/-10%	+/-7%
Arterial	80	1,096,700	1,250,000	60%	14%	+/-15%	+/-10%
Collector	8	40,400	21,600	76%	-46%	+/-25%	+/-20%
All	124	3,405,900	3,379,300	34%	-1%	N/A	N/A

Table 6.10 Year 2005 AM Peak-Hour Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No. of Obs.	Small Trucks				Medium Trucks				Combo Trucks			
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error
Freeway	24	1,900	2,900	176%	51%	3,600	3,000	79%	-17%	8,100	8,100	63%	2%
Expressway	12	300	200	57%	-31%	100	200	108%	56%	300	200	105%	-71%
Arterial	80	2,000	1,400	119%	-29%	700	1,500	301%	106%	1,600	1,800	276%	-2%
Collector	8	100	–	77%	-63%	200	100	102%	-51%	600	300	82%	-51%
All	124	4,300	4,500	190%	6%	4,600	4,800	149%	3%	10,600	10,400	121%	-2%

Facility Type	No. of Obs.	Total Autos and Trucks				Target % Error	
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	24	131,400	123,600	27%	-6%	+/-7%	+/-6%
Expressway	12	10,700	14,100	59%	32%	+/-10%	+/-7%
Arterial	80	66,100	86,400	80%	31%	+/-15%	+/-10%
Collector	8	2,800	2,100	35%	-26%	+/-25%	+/-20%
All	124	211,000	226,200	49%	7%	N/A	N/A

Table 6.11 Year 2005 PM Peak-Hour Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No. of Obs.	Small Trucks				Medium Trucks				Combo Trucks			
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error
Freeway	24	1,900	2,400	133%	26%	3,700	2,700	79%	-27%	8,300	7,800	68%	-6%
Expressway	12	300	300	52%	-9%	200	300	115%	82%	300	300	94%	-21%
Arterial	80	1,800	1,200	139%	-34%	800	1,400	201%	71%	1,600	1,900	283%	23%
Collector	8	100	–	87%	-56%	200	100	99%	-37%	400	300	84%	-17%
All	124	4,100	3,900	161%	-4%	4,900	4,500	143%	-7%	10,600	10,300	131%	-2%

Facility Type	No. of Obs.	Total Autos and Trucks				Target % Error	
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	24	128,500	128,000	25%	0%	+/-7%	+/-6%
Expressway	12	13,500	18,700	55%	39%	+/-10%	+/-7%
Arterial	80	77,200	96,100	72%	24%	+/-15%	+/-10%
Collector	8	2,800	1,800	56%	-37%	+/-25%	+/-20%
All	124	222,000	244,600	46%	10%	N/A	N/A

Table 6.12 Year 2005 PM Peak Two Hours Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No. of Obs.	Small Trucks				Medium Trucks				Combo Trucks			
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error
Freeway	24	3,800	5,200	139%	36%	7,300	5,800	82%	-21%	16,400	15,000	69%	-8%
Expressway	12	600	500	56%	-12%	300	600	115%	84%	600	500	87%	-22%
Arterial	80	3,600	2,400	136%	-33%	1,600	2,800	199%	75%	3,000	3,700	264%	21%
Collector	8	200	100	86%	-57%	300	200	102%	-42%	800	600	85%	-26%
All	124	8,200	8,200	165%	0%	9,500	9,400	146%	-2%	20,800	19,800	131%	-5%

Facility Type	No. of Obs.	Total Autos and Trucks				Target % Error	
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	24	252,400	250,000	23%	-1%	+/-7%	+/-6%
Expressway	12	28,500	38,200	48%	34%	+/-10%	+/-7%
Arterial	80	162,600	196,500	67%	21%	+/-15%	+/-10%
Collector	8	7,000	3,900	59%	-44%	+/-25%	+/-20%
All	124	450,500	488,600	43%	8%	N/A	N/A

Table 6.13 Year 2005 PM Peak Four Hours Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No. of Obs.	Small Trucks				Medium Trucks				Combo Trucks			
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Observed Volume	Estimated Volume	Percent RMSE	Percent Error
Freeway	24	7,700	10,900	132%	41%	14,700	11,700	77%	-21%	33,700	30,400	65%	-10%
Expressway	12	1,100	1,100	36%	-3%	600	1,300	148%	112%	1,200	1,300	107%	5%
Arterial	80	7,100	5,000	132%	-30%	3,100	5,700	194%	81%	5,900	7,900	242%	33%
Collector	8	300	100	82%	-50%	600	400	90%	-35%	1,500	1,100	67%	-24%
All	124	16,200	17,100	157%	5%	19,000	19,100	139%	0%	42,300	40,700	124%	-4%

Facility Type	No. of Obs.	Total Autos and Trucks				Target % Error	
		Observed Volume	Estimated Volume	Percent RMSE	Percent Error	Accept.	Pref.
Freeway	24	520,500	476,800	22%	-8%	+/-7%	+/-6%
Expressway	12	53,600	71,300	48%	33%	+/-10%	+/-7%
Arterial	80	313,300	379,300	63%	21%	+/-15%	+/-10%
Collector	8	12,900	6,500	65%	-49%	+/-25%	+/-20%
All	124	900,300	933,900	41%	4%	N/A	N/A

7.0 2015 and 2035 Forecasts

This section examines forecasts of truck volumes by class of truck and time period for the years 2015 and 2035. Also shown are forecasts of Port of Oakland Seaport growth assumptions, as used for the special generator model.

7.1 TRUCK FORECASTS

ACCMA truck forecasts were created for years 2015 and 2035. As with the year 2005 base year, forecasts were prepared for five time periods: Daily, AM peak hour, PM peak hour, PM peak two hours, and PM peak four hours.

Overall traffic is projected to increase between 10 and 17 percent over the 10-year period between 2005 and 2015. Truck traffic, in aggregate, is projected to grow at roughly the same rate as total traffic, including autos. Growth in combo trucks is projected to rise somewhat faster than for small and medium trucks, and for autos, as shown in Table 7.1.

For 2035, growth rates range roughly between 40 and 60 percent – depending on time of day. Overall, the rate of growth to 2035 is projected to be faster beyond 2015 than between 2005 and 2015. There is little difference in growth between peak periods and daily conditions, as shown in Table 7.2.

Figures 7.1 through 7.4 display validation and forecast results for the a.m. peak hour at four specific areas in Alameda County. Locations selected include I-80 in Berkeley near University Avenue, I-880 in Oakland near Oakland Airport, I-880 in Hayward and Union City near Industrial Boulevard, and I-580 in eastern Alameda County.

Table 7.3 examines annualized rates of growth for each vehicle class. As noted above, growth rates are somewhat higher after 2015 than between 2015 and 2035. This is true for small and medium trucks, and for autos. Combo trucks have consistent rates of growth. Overall growth rates range from 1.0 percent to 1.6 percent per year, depending on time period and vehicle type.

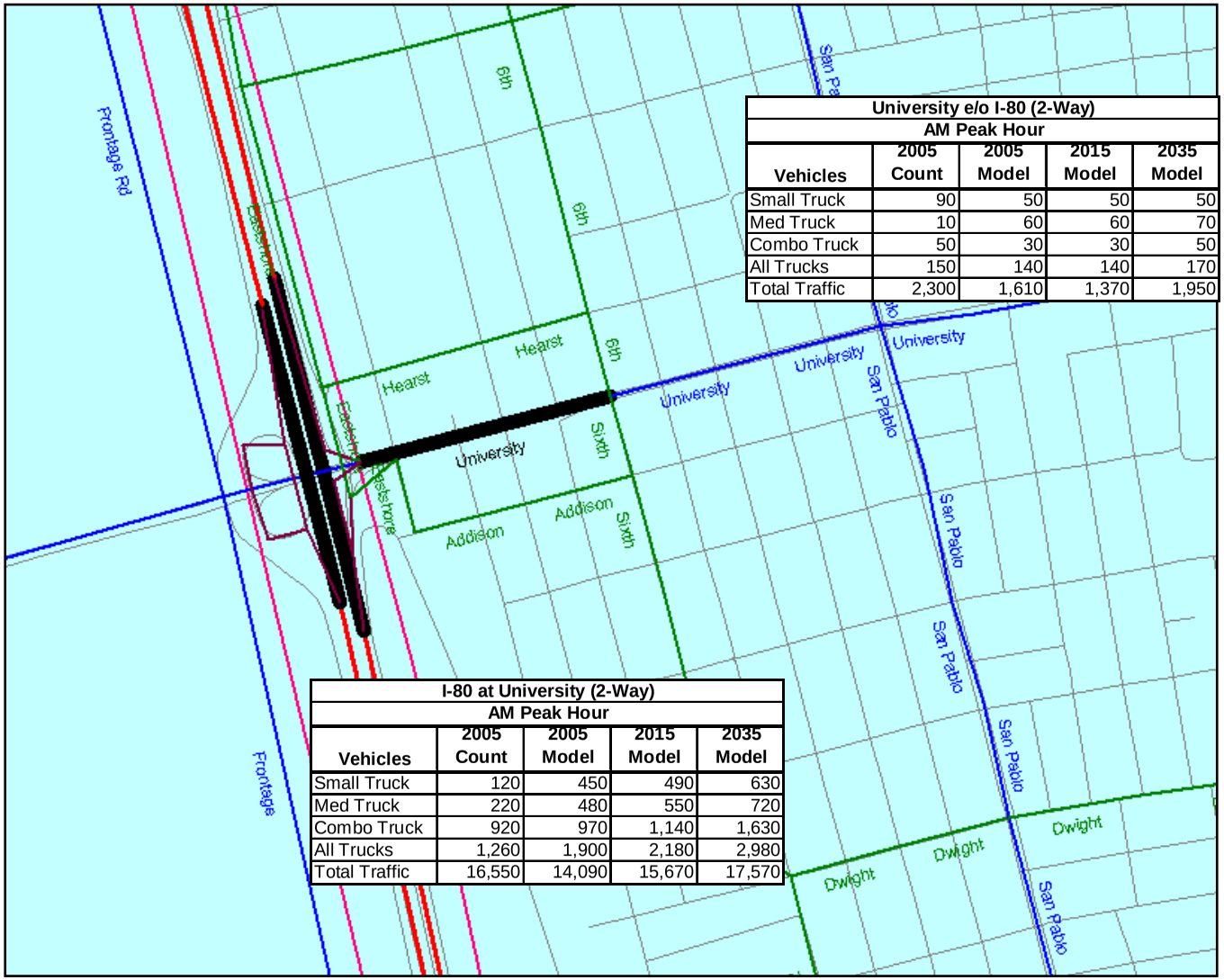
Table 7.1 Year 2015 Traffic Assignment Validation by Vehicle Class and Facility Type

Facility Type	No.of Obs.	Small Trucks Year 2005 Volume	Small Trucks Year 2015 Volume	Small Trucks Cha	Small Trucks % Cha	Medium Trucks Year 2005 Volume	Medium Trucks Year 2015 Volume	Medium Trucks Cha	Medium Trucks % Cha	No.of Obs.	Combo Trucks Year 2005 Volume	Combo Trucks Year 2015 Volume	Combo Trucks Cha	Combo Trucks % Cha	Total Autos and Trucks Year 2005 Volume	Total Autos and Trucks Year 2015 Volume	Total Autos and Trucks Cha	Total Autos and Trucks % Cha
Daily																		
Freeway	24	48,600	53,000	4,400	9%	50,200	56,000	5,800	12%	24	146,900	169,200	22,300	15%	1,985,100	2,150,400	165,300	8%
Expressway	12	1,500	2,600	1,100	73%	1,900	3,000	1,100	58%	12	1,200	3,200	2,000	167%	121,100	178,000	56,900	47%
Arterial	80	17,300	19,600	2,300	13%	18,500	21,100	2,600	14%	80	22,900	26,700	3,800	17%	1,246,200	1,372,900	126,700	10%
Collector	8	1,000	1,200	200	20%	2,300	2,800	500	22%	8	7,700	9,800	2,100	27%	27,000	42,900	15,900	59%
All	**124**	**68,300**	**76,400**	**8,100**	**12%**	**72,800**	**82,900**	**10,100**	**14%**	**124**	**178,500**	**208,900**	**30,400**	**17%**	**3,379,500**	**3,744,200**	**364,700**	**11%**
AM Peak 1 Hour																		
Freeway	24	2,900	3,100	200	7%	3,100	3,400	300	10%	24	8,400	9,400	1,000	12%	123,500	137,400	13,900	11%
Expressway	12	200	300	100	50%	200	300	100	50%	12	200	400	200	100%	14,200	19,900	5,700	40%
Arterial	80	1,400	1,600	200	14%	1,600	1,800	200	13%	80	1,900	2,100	200	11%	86,700	97,800	11,100	13%
Collector	8	100	100	-	0%	200	300	100	50%	8	600	800	200	33%	2,600	3,400	800	31%
All	**124**	**4,600**	**5,200**	**600**	**13%**	**5,100**	**5,800**	**700**	**14%**	**124**	**11,100**	**12,700**	**1,600**	**14%**	**227,000**	**258,500**	**31,500**	**14%**
PM Peak 1 Hour																		
Freeway	24	2,400	2,700	300	13%	2,700	3,100	400	15%	24	8,100	9,700	1,600	20%	127,900	138,600	10,700	8%
Expressway	12	300	300	-	0%	300	400	100	33%	12	300	400	100	33%	18,600	23,400	4,800	26%
Arterial	80	1,200	1,300	100	8%	1,400	1,600	200	14%	80	2,000	2,000	-	0%	97,700	106,400	8,700	9%
Collector	8	100	100	-	0%	200	300	100	50%	8	600	800	200	33%	2,200	3,200	1,000	45%
All	**124**	**4,000**	**4,500**	**500**	**13%**	**4,700**	**5,300**	**600**	**13%**	**124**	**11,000**	**12,900**	**1,900**	**17%**	**246,400**	**271,600**	**25,200**	**10%**
PM Peak 2 Hour																		
Freeway	24	5,200	5,700	500	10%	5,800	6,600	800	14%	24	15,600	18,500	2,900	19%	250,100	270,900	20,800	8%
Expressway	12	500	600	100	20%	600	700	100	17%	12	500	800	300	60%	38,400	47,100	8,700	23%
Arterial	80	2,400	2,700	300	13%	2,900	3,200	300	10%	80	3,700	3,800	100	3%	196,800	216,000	19,200	10%
Collector	8	100	200	100	100%	400	500	100	25%	8	1,100	1,400	300	27%	4,700	7,200	2,500	53%
All	**124**	**8,200**	**9,300**	**1,100**	**13%**	**9,700**	**11,100**	**1,400**	**14%**	**124**	**20,900**	**24,500**	**3,600**	**17%**	**490,000**	**541,200**	**51,200**	**10%**
PM Peak 4 Hour																		
Freeway	24	11,000	11,700	700	6%	11,800	12,900	1,100	9%	24	31,300	36,000	4,700	15%	473,900	514,000	40,100	8%
Expressway	12	1,100	1,500	400	36%	1,300	1,600	300	23%	12	1,300	1,900	600	46%	71,300	86,100	14,800	21%
Arterial	80	5,000	5,600	600	12%	5,700	6,400	700	12%	80	8,000	8,300	300	4%	381,000	416,100	35,100	9%
Collector	8	300	400	100	33%	700	900	200	29%	8	2,100	2,700	600	29%	8,000	13,400	5,400	68%
All	**124**	**17,300**	**19,100**	**1,800**	**10%**	**19,500**	**21,900**	**2,400**	**12%**	**124**	**42,700**	**48,900**	**6,200**	**15%**	**934,200**	**1,029,600**	**95,400**	**10%**

Table 7.2 Year 2035 Traffic Assignment Validation by Vehicle Class and Facility Type

Daily																		
		Small Trucks				Medium Trucks					Combo Trucks				Total Autos and Trucks			
Facility Type	No.of Obs.	Year 2005 Volume	Year 2035 Volume	Cha	% Cha	Year 2005 Volume	Year 2035 Volume	Cha	% Cha	No.of Obs.	Year 2005 Volume	Year 2035 Volume	Cha	% Cha	Year 2005 Volume	Year 2035 Volume	Cha	% Cha
Freeway	24	48,600	61,700	13,100	27%	50,200	64,200	14,000	28%	24	146,900	198,600	51,700	35%	1,985,100	2,558,500	573,400	29%
Expressway	12	1,500	6,800	5,300	353%	1,900	7,100	5,200	274%	12	1,200	9,800	8,600	717%	121,100	334,700	213,600	176%
Arterial	80	17,300	31,500	14,200	82%	18,500	33,900	15,400	83%	80	22,900	58,800	35,900	157%	1,246,200	1,938,400	692,200	56%
Collector	8	1,000	2,600	1,600	160%	2,300	5,600	3,300	143%	8	7,700	18,600	10,900	142%	27,000	93,100	66,100	245%
All	**124**	**68,300**	**102,500**	**34,200**	**50%**	**72,800**	**110,700**	**37,900**	**52%**	**124**	**178,500**	**285,800**	**107,300**	**60%**	**3,379,500**	**4,924,800**	**1,545,300**	**46%**
AM Peak 1 Hour																		
Freeway	24	2,900	4,400	1,500	52%	3,100	4,600	1,500	48%	24	8,400	13,100	4,700	56%	123,500	165,100	41,600	34%
Expressway	12	200	500	300	150%	200	500	300	150%	12	200	600	400	200%	14,200	26,800	12,600	89%
Arterial	80	1,400	2,300	900	64%	1,600	2,600	1,000	63%	80	1,900	3,200	1,300	68%	86,700	133,100	46,400	54%
Collector	8	100	200	100	100%	200	500	300	150%	8	600	1,500	900	150%	2,600	6,200	3,600	138%
All	**124**	**4,600**	**7,400**	**2,800**	**61%**	**5,100**	**8,300**	**3,200**	**63%**	**124**	**11,100**	**18,400**	**7,300**	**66%**	**227,000**	**331,100**	**104,100**	**46%**
PM Peak 1 Hour																		
Freeway	24	2,400	3,700	1,300	54%	2,700	4,100	1,400	52%	24	8,100	12,200	4,100	51%	127,900	168,400	40,500	32%
Expressway	12	300	500	200	67%	300	600	300	100%	12	300	600	300	100%	18,600	29,600	11,000	59%
Arterial	80	1,200	1,900	700	58%	1,400	2,300	900	64%	80	2,000	3,000	1,000	50%	97,700	135,600	37,900	39%
Collector	8	100	200	100	100%	200	600	400	200%	8	600	1,600	1,000	167%	2,200	6,900	4,700	214%
All	**124**	**4,000**	**6,300**	**2,300**	**58%**	**4,700**	**7,500**	**2,800**	**60%**	**124**	**11,000**	**17,400**	**6,400**	**58%**	**246,400**	**340,500**	**94,100**	**38%**
PM Peak 2 Hour																		
Freeway	24	5,200	7,500	2,300	44%	5,800	8,500	2,700	47%	24	15,600	23,400	7,800	50%	250,100	326,200	76,100	30%
Expressway	12	500	1,000	500	100%	600	1,200	600	100%	12	500	1,300	800	160%	38,400	59,300	20,900	54%
Arterial	80	2,400	3,700	1,300	54%	2,900	4,500	1,600	55%	80	3,700	5,500	1,800	49%	196,800	270,500	73,700	37%
Collector	8	100	400	300	300%	400	1,000	600	150%	8	1,100	2,700	1,600	145%	4,700	14,300	9,600	204%
All	**124**	**8,200**	**12,600**	**4,400**	**54%**	**9,700**	**15,100**	**5,400**	**56%**	**124**	**20,900**	**32,900**	**12,000**	**57%**	**490,000**	**670,300**	**180,300**	**37%**
PM Peak 4 Hour																		
Freeway	24	11,000	15,300	4,300	39%	11,800	16,800	5,000	42%	24	31,300	45,700	14,400	46%	473,900	631,300	157,400	33%
Expressway	12	1,100	2,000	900	82%	1,300	2,200	900	69%	12	1,300	2,600	1,300	100%	71,300	108,300	37,000	52%
Arterial	80	5,000	8,200	3,200	64%	5,700	9,600	3,900	68%	80	8,000	13,000	5,000	63%	381,000	533,600	152,600	40%
Collector	8	300	800	500	167%	700	1,800	1,100	157%	8	2,100	5,100	3,000	143%	8,000	25,800	17,800	223%
All	**124**	**17,300**	**26,300**	**9,000**	**52%**	**19,500**	**30,300**	**10,800**	**55%**	**124**	**42,700**	**66,400**	**23,700**	**56%**	**934,200**	**1,299,000**	**364,800**	**39%**

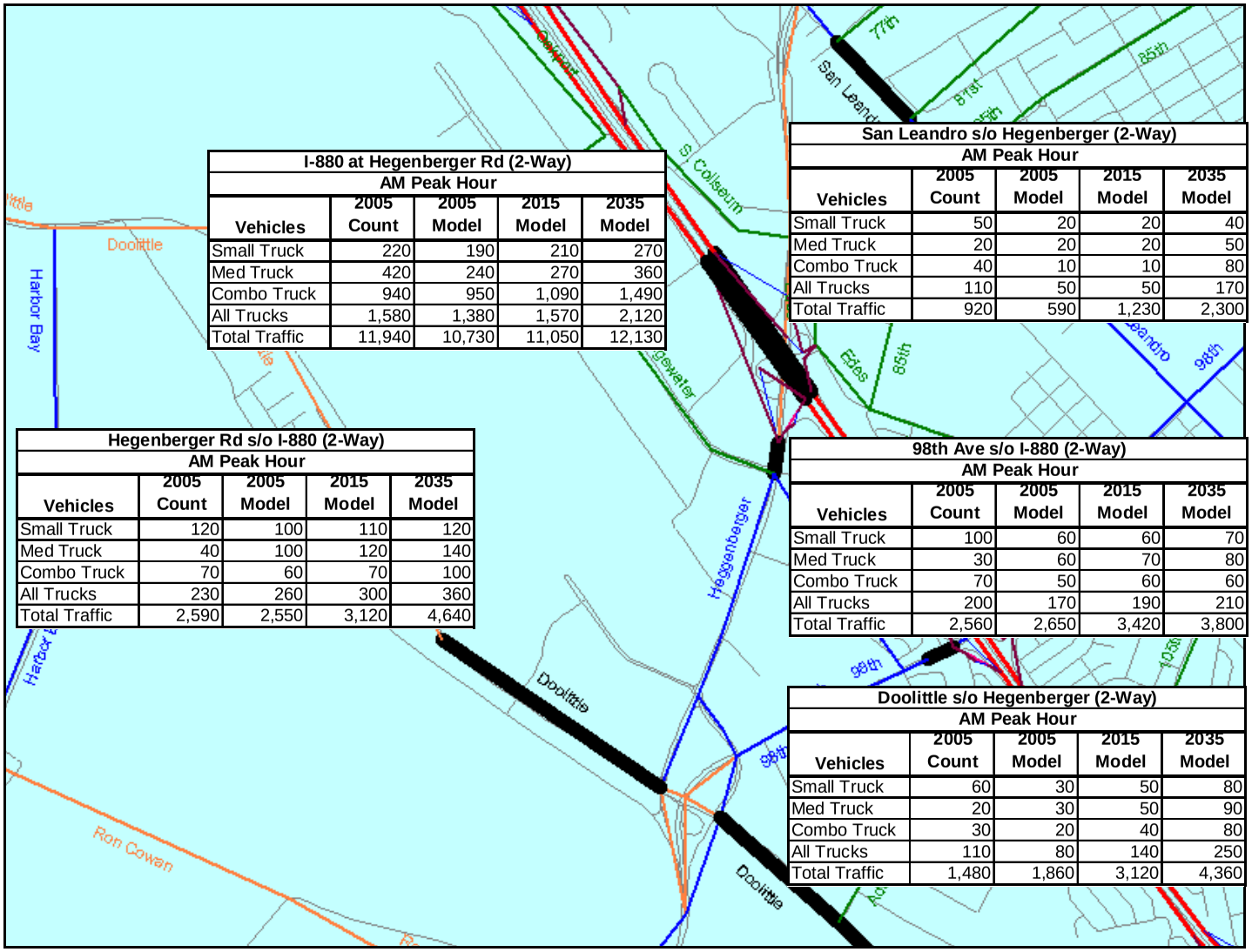
Figure 7.1 Truck Forecasts – A.M. Peak Hour – I-80 at University Avenue



University e/o I-80 (2-Way) AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	90	50	50	50
Med Truck	10	60	60	70
Combo Truck	50	30	30	50
All Trucks	150	140	140	170
Total Traffic	2,300	1,610	1,370	1,950

I-80 at University (2-Way) AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	120	450	490	630
Med Truck	220	480	550	720
Combo Truck	920	970	1,140	1,630
All Trucks	1,260	1,900	2,180	2,980
Total Traffic	16,550	14,090	15,670	17,570

Figure 7.2 Truck Forecasts – A.M. Peak Hour – I-880 near Oakland Airport



I-880 at Hegenberger Rd (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	220	190	210	270
Med Truck	420	240	270	360
Combo Truck	940	950	1,090	1,490
All Trucks	1,580	1,380	1,570	2,120
Total Traffic	11,940	10,730	11,050	12,130

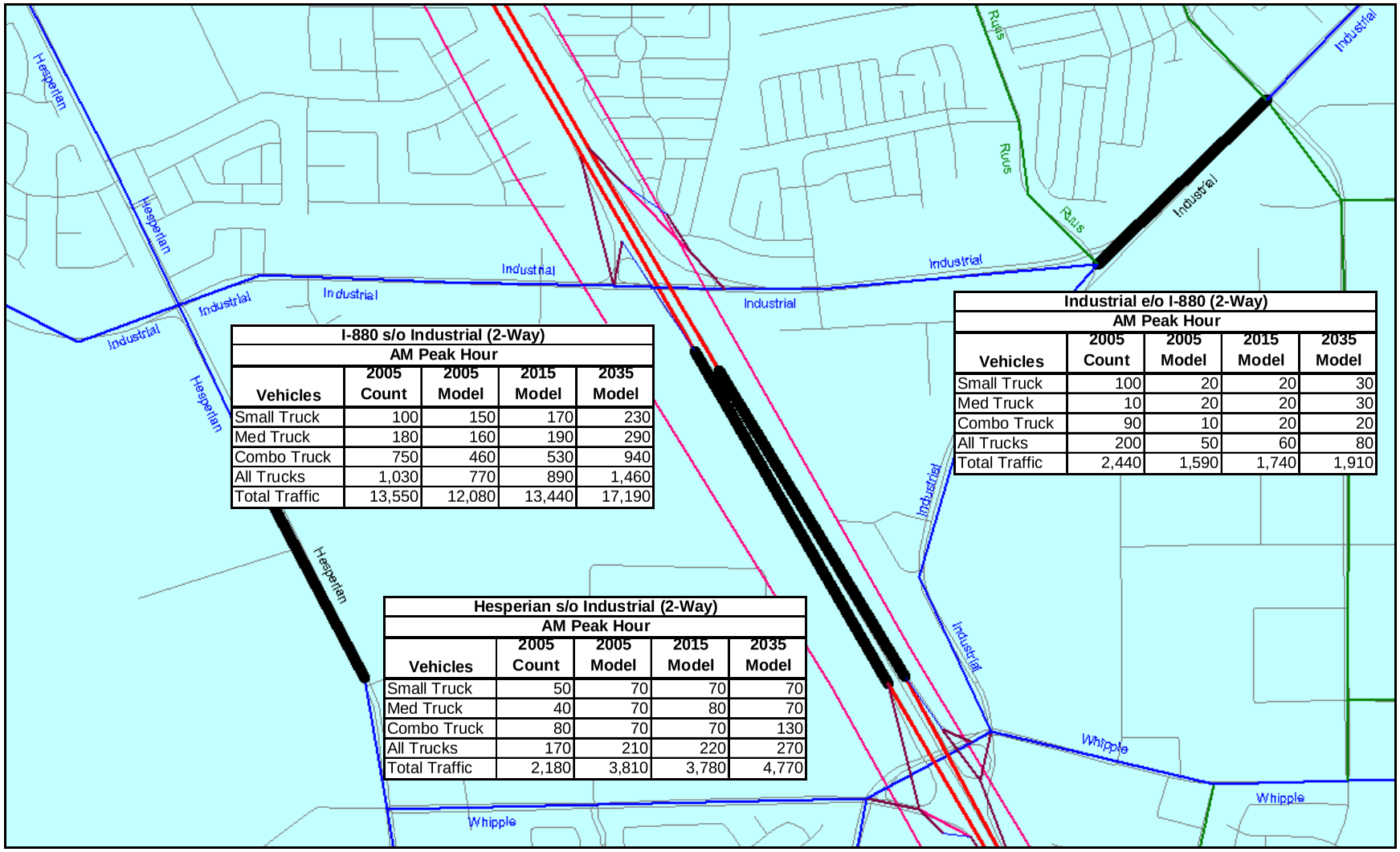
San Leandro s/o Hegenberger (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	50	20	20	40
Med Truck	20	20	20	50
Combo Truck	40	10	10	80
All Trucks	110	50	50	170
Total Traffic	920	590	1,230	2,300

Hegenberger Rd s/o I-880 (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	120	100	110	120
Med Truck	40	100	120	140
Combo Truck	70	60	70	100
All Trucks	230	260	300	360
Total Traffic	2,590	2,550	3,120	4,640

98th Ave s/o I-880 (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	100	60	60	70
Med Truck	30	60	70	80
Combo Truck	70	50	60	60
All Trucks	200	170	190	210
Total Traffic	2,560	2,650	3,420	3,800

Doolittle s/o Hegenberger (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	60	30	50	80
Med Truck	20	30	50	90
Combo Truck	30	20	40	80
All Trucks	110	80	140	250
Total Traffic	1,480	1,860	3,120	4,360

Figure 7.3 Truck Forecasts – A.M. Peak Hour – I-880 at Industrial

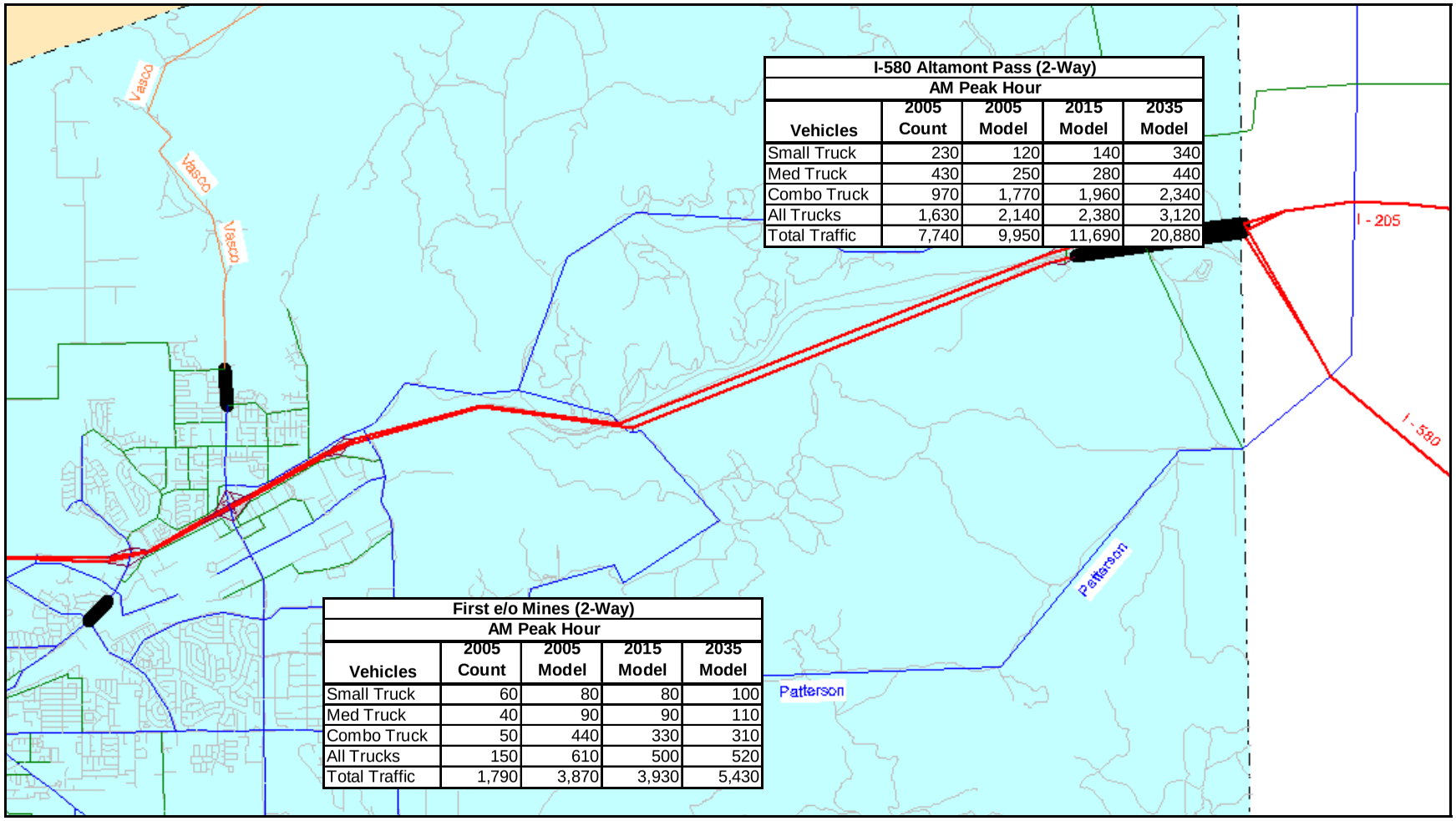


I-880 s/o Industrial (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	100	150	170	230
Med Truck	180	160	190	290
Combo Truck	750	460	530	940
All Trucks	1,030	770	890	1,460
Total Traffic	13,550	12,080	13,440	17,190

Industrial e/o I-880 (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	100	20	20	30
Med Truck	10	20	20	30
Combo Truck	90	10	20	20
All Trucks	200	50	60	80
Total Traffic	2,440	1,590	1,740	1,910

Hesperian s/o Industrial (2-Way)				
AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	50	70	70	70
Med Truck	40	70	80	70
Combo Truck	80	70	70	130
All Trucks	170	210	220	270
Total Traffic	2,180	3,810	3,780	4,770

Figure 7.4 Truck Forecasts – A.M. Peak Hour – Eastern Alameda County



I-580 Altamont Pass (2-Way) AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	230	120	140	340
Med Truck	430	250	280	440
Combo Truck	970	1,770	1,960	2,340
All Trucks	1,630	2,140	2,380	3,120
Total Traffic	7,740	9,950	11,690	20,880

First e/o Mines (2-Way) AM Peak Hour				
Vehicles	2005 Count	2005 Model	2015 Model	2035 Model
Small Truck	60	80	80	100
Med Truck	40	90	90	110
Combo Truck	50	440	330	310
All Trucks	150	610	500	520
Total Traffic	1,790	3,870	3,930	5,430

Table 7.3 Compounded Annualized Rate of Growth by Vehicle Type

Vehicle Type	Annualized Rate of Growth		
	2005-2015	2005-2035	2015-2035
Small Trucks	1.1%	1.4%	1.5%
Medium Trucks	1.3%	1.4%	1.5%
Combination Trucks	1.6%	1.6%	1.6%
Total Trucks	1.4%	1.5%	1.5%
Total Autos	1.0%	1.2%	1.4%
Total All Vehicles	1.0%	1.3%	1.4%

7.2 PORT OF OAKLAND SEAPORT GROWTH PROJECTIONS

The updated ACCMA Truck Model includes a special generator for the Port of Oakland, based on observed counts in the area. For future year analyses, cargo forecasts are needed to project the inputs for the special generator trips. *The San Francisco Bay Area Containerized Cargo Outlook*, prepared by The Tioga Group, Inc. for the San Francisco Bay Conservation and Development Commission (BCDC) in July 2009, was consulted for this task. The report includes containerized cargo historical data and growth projections for the Port of Oakland.

The BCDC report notes two changes in port cargo projections: First, 2009 cargo is about equal to 2003 cargo; thus, growth has been set back about six years due to the recession. Second, growth rates between 2010 and 2020 are now forecast to be higher than previous port cargo forecasts.

Table 7.4 provides historical data for containerized cargo at the Port of Oakland from 1990 to 2008. The average annual percent growth was calculated and shown in Table 7.4.

Table 7.5 provides projected data for containerized cargo at the Port of Oakland from 2005 to 2030, as published in the report. For the horizon years of 2015 and 2035, growth factors of 1.20 and 2.37, respectively, were applied to the existing Port of Oakland Special Generator to forecast cargo growth in the area.

Projected cargo for 2035 was extrapolated assuming linear growth based on containerized cargo data from 2005 to 2030, as displayed on Figure 7.5. This linear growth calculation, shown as a solid line on Figure 7.5 will serve as the 2035 projection used for the ACCMA model. The dashed line shows actual cargo growth projections from the BCDC report. The linear growth method was used as it produces a more conservative estimate of cargo growth than a five-year extrapolation from year 2030 data.

Table 7.4 Port of Oakland Containerized Cargo Historical Data

Year	Containerized Cargo (in TEUs)*	Average Annual Percent Growth
1990	1,124	N/A
1992	1,291	7%
1994	1,491	8%
1996	1,498	0%
1998	1,575	3%
2000	1,777	6%
2001	1,644	-7%
2002	1,708	4%
2003	1,923	13%
2004	2,048	7%
2005	2,274	11%
2006	2,392	5%
2007	2,388	0%
2008	2,234	-6%

Source: The San Francisco Bay Area Containerized Cargo Outlook, July 2009.

* Twenty-foot Equivalent Unit (TEU). One TEU represents the cargo capacity of a standard intermodal container, 20 feet (6.1 meters) long and 8 feet (2.4 meters) wide.

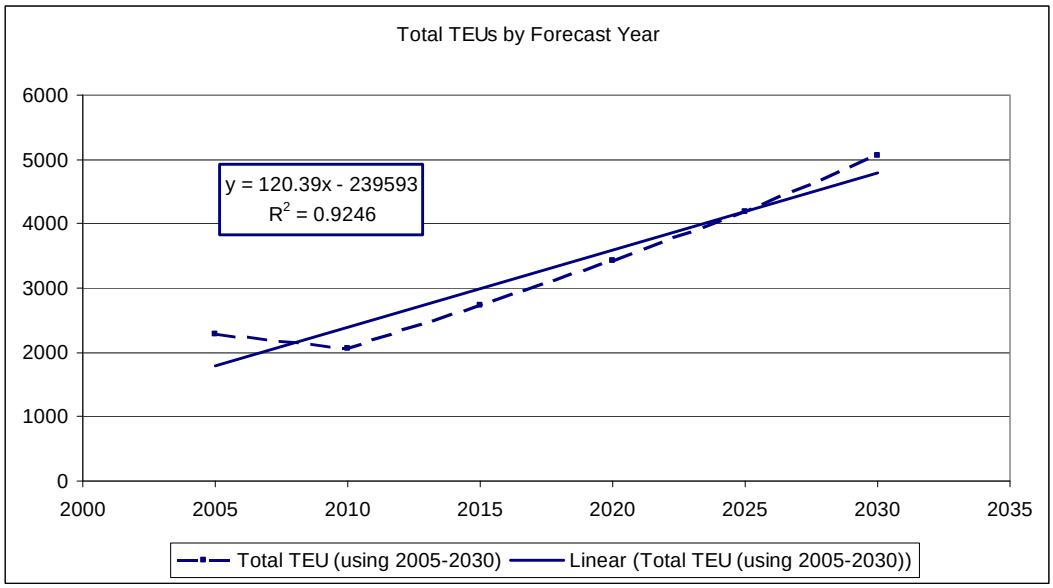
Table 7.5 Port of Oakland Containerized Cargo Projected Future Data

Future Year	Total TEU	Growth (TEUs/Year)	Percent Growth per Year	Growth Since 2005 (TEUs)	Percent Growth Since 2005	Resultant Growth Factor to be Applied to 2005 Data
2005	2,274					
2010	2,061	-43	-2%	-213	-9%	0.91
2015	2,723	132	6%	449	20%	1.20
2020	3,427	141	5%	1,153	51%	1.51
2025	4,194	153	4%	1,920	84%	1.84
2030	5,067	175	4%	2,793	123%	2.23
2035	5,401*	67	1%	3,127	137%	2.37

Source: The San Francisco Bay Area Containerized Cargo Outlook.

*Extrapolated Volume

Figure 7.5 Port of Oakland Containerized Cargo Projected Growth



Note: This linear growth calculation, shown as a solid line will serve as the 2035 projection used for the ACCMA model. The dashed line shows actual cargo growth projections from the BCDC report.

8.0 Recommendations

The new ACCMA Truck Model represents a significant level of improvement over the existing truck model. Improvements to the truck modeling system were appropriate given available resources for this project, and based on the consensus of the project team and the ACCMA Model Task Force.

It is important to recognize the improvements developed for this project were designed to serve ACCMA's needs for the next 5 to 10 years. At a minimum, new truck counts could be periodically collected, and the model components could thus be recalibrated and revalidated, thus, potentially expanding the effective life cycle of the new truck model.

In addition, ACCMA may decide to improve any of the individual model components or add new components. The model system has been designed in a modular format, so new individual improvements could be adopted without having to scrap the entire truck model system – so long as the improvements are incremental in nature. An entirely new approach to truck or goods movement modeling could require the development of an entirely new model system.

Chapter 3 examined a range of model approaches. A number of advanced modeling systems were described, including commodity flow models and economic activity models. Specific recommendations are not proposed here with regards to ACCMA adopting an advanced goods movement model system, given the speculative nature of any such recommendation.

However, it is strongly recommended that ACCMA consider adopting truck or goods movement modeling activities undertaken by MTC or Caltrans. Given the long-distance nature of many trucking activities, goods movement models are often better suited for development at the statewide or regional level. ABAG is currently developing a state-of-the-practice land use/economic model system that will eventually be integrated with the MTC travel demand model. At that time, creation of an advanced regional goods movement model could be directly created. Such a model system, however, is still a number of years away from implementation and use by ACCMA.

As one example, Caltrans' Office of Transportation Systems Information is developing a commercial vehicle model that can distinguish Class 3 (pickups and vans) personal versus commercial vehicles. Related to this, Class 3 vehicles are almost always service vehicles (as opposed to goods movement-related vehicles). Understanding goods movement commercial vehicles from service vehicles may be another area of interest as ACCMA delves more deeply into truck modeling issues.

In the meantime, it is recommended that ACCMA carefully consider what types of truck- and goods movement-related policy analyses will be required over the near- and mid-term horizon (i.e., over the next three to five years). If the policy

questions are centered around understanding impacts of trucks on specific roadways (or throughout Alameda County), then the current model system can serve those needs.

However, if there is greater interest in examining goods movements – a more fundamental understanding how and why good are transported across different modes – then more robust models will be required. In the very near term, ACCMA should look for opportunities to expand the number of truck counts (by truck classification).

It was noted above that ACCMA should check on MTC and Caltrans truck model developments on a regular or periodic basis. One weakness of the current model is the complete lack of observed trip rate and trip table data. It is possible either MTC or Caltrans may develop observed trip generation and distribution data. If so, these datasets would be indispensible for any refresh of the truck model system.

ACCMA may consider following up with a special generator for Oakland Airport. For this project, the need for an Oakland Airport special generator could not be justified from a model validation standpoint. However, there is still interest in having better tools for examining airport- and seaport-based commercial travel.

In addition, ACCMA may also consider developing special generators for other important truck trip generators. These would include major warehouse operations and distribution centers, as well as special truck generators (one such example would be a waste disposal operation, such as a landfill).

There was interest in understanding truck prohibitions – particularly on specific arterials throughout the County. (Chapter 7 provided an explanation why these prohibitions were not coded in the roadway network.) ACCMA may consider at some point examining each specific truck prohibition for its inclusion in the truck model system. Such a study may be conducted as part of particular corridor or roadway study.

Appendix A. Arterial Counts

Location	Dir	Daily	Autos	Small	Medium	Combo	Truck
Atlantic Ave between College & Webster St	WB	7,689	7,364	225	25	75	326
Atlantic Ave between College & Webster St	EB	8,656	8,261	266	33	96	395
Buena Vista Ave between Grand & Hibbard St	WB	6,169	5,926	174	21	48	243
Buena Vista Ave between Grand & Hibbard St	EB	5,139	4,885	149	19	87	254
Encinal Ave between Grand St & Paru St	WB	3,215	3,086	60	54	15	129
Encinal Ave between Grand St & Paru St	EB	4,035	3,890	70	55	18	144
Park St between Lincoln Ave & Times Way	SB	10,919	10,419	190	82	228	500
Park St between Lincoln Ave & Times Way	NB	10,048	9,616	246	6	180	432
Broadway between Encinal Ave & Central Ave	SB	5,950	5,762	114	40	32	187
Broadway between Encinal Ave & Central Ave	NB	5,786	5,569	117	28	73	217
Adeline St between Ashby & MLK Jr Way	SB	8,032	7,492	199	198	144	541
Adeline St between Ashby & MLK Jr Way	NB	7,287	6,930	111	132	114	357
ML King Jr Way between Alcatraz & Stanford	SB	17,515	16,723	243	212	337	792
ML King Jr Way between Alcatraz & Stanford	NB	17,010	16,318	243	220	228	691
Shattuck Ave between Bancroft Way & Durant	SB	14,306	13,519	421	33	333	787
Shattuck Ave between Bancroft Way & Durant	NB	11,505	11,068	269	9	158	436
University Ave between 5th St & 6th St	WB	25,828	24,705	806	21	296	1,123
University Ave between 5th St & 6th St	EB	19,956	19,163	495	60	239	793
University Ave between MLK Jr & Grant	WB	12,509	11,647	357	290	216	863
University Ave between MLK Jr & Grant	EB	11,779	10,956	359	247	217	824
Hesperian between Hacienda & Bockman	SB	12,216	11,424	230	244	318	792
Hesperian between Hacienda & Bockman	NB	11,542	10,769	225	156	392	773
Ardenwood Blvd between Ardenwood & Kaiser	WB	12,631	12,161	182	110	177	469
Ardenwood Blvd between Ardenwood & Kaiser	EB	10,813	10,343	179	92	198	469
Decoto Rd between Cabrillo Dr & I-880 Ramps	SB	12,875	12,031	296	240	307	843
Decoto Rd between Cabrillo Dr & I-880 Ramps	NB	17,205	16,141	324	299	442	1,064
Decoto Rd between 7th St & 8th St	SB	10,924	10,183	362	137	242	741
Decoto Rd between 7th St & 8th St	NB	10,094	9,394	329	152	218	700
Mowry Ave between Fremont Blvd & Bell St	SB	21,667	20,827	460	41	339	840
Mowry Ave between Fremont Blvd & Bell St	NB	24,273	23,255	424	278	316	1,018
A' Street between Mission & Watkins	WB	10,298	9,736	237	92	232	562
A' Street between Mission & Watkins	EB	9,018	8,436	191	126	264	582

Location	Dir	Daily	Autos	Small	Medium	Combo	Truck
Clawiter Rd between Industrial Blvd & West St	SB	7,670	6,793	519	98	260	876
Clawiter Rd between Industrial Blvd & West St	NB	10,590	9,389	641	145	414	1,200
Hesperian Blvd between Hollow & SR 92 Ramps	SB	17,266	16,552	293	113	308	714
Hesperian Blvd between Hollow & SR 92 Ramps	NB	18,089	17,169	428	156	336	920
Hesperian Blvd between Kohoutek & Eden Park	SB	13,124	12,228	300	177	420	897
Hesperian Blvd between Kohoutek & Eden Park	NB	16,377	15,227	384	198	568	1,150
Industrial Pkwy between Ruus & Huntwood	SB	18,870	17,366	732	104	669	1,505
Industrial Pkwy between Ruus & Huntwood	NB	20,265	18,822	743	100	599	1,443
Tennyson Rd between Ruus Rd & Bruno St	WB	15,380	14,947	286	42	106	433
Tennyson Rd between Ruus Rd & Bruno St	EB	14,321	13,422	199	286	414	899
1st St between N Mines Rd & Las Positas Rd	WB	14,671	13,573	494	224	379	1,097
1st St between N Mines Rd & Las Positas Rd	EB	14,399	13,188	532	335	343	1,211
Stanley Blvd between Isabel Ave & Murdell	WB	11,797	10,947	386	181	283	850
Stanley Blvd between Isabel Ave & Murdell	EB	10,553	9,819	354	93	288	734
N Vasco Rd near Dalton Ave	SB	10,788	9,755	648	153	231	1,032
N Vasco Rd near Dalton Ave	NB	10,869	9,787	654	158	270	1,082
Park St Bridge on or before	SB	14,397	13,609	275	186	327	788
Park St Bridge on or before	NB	22,234	19,114	2,441	159	520	3,120
Fruitvale between Alameda Ave & Tidal Canal Br	WB	12,533	11,903	224	166	240	631
Fruitvale between Alameda Ave & Tidal Canal Br	EB	8,737	8,342	173	81	141	395
High St between Tidewater Ave & Marina Dr	WB	9,366	8,995	192	84	95	371
High St between Tidewater Ave & Marina Dr	EB	10,509	10,172	186	100	50	336
Hegenberger between Edgewater & I-880 SB On	SB	27,811	25,923	896	371	620	1,887
Hegenberger between Edgewater & I-880 SB On	NB	23,227	21,353	864	234	776	1,875
73rd Ave between International & Orral St	SB	13,596	12,889	245	173	289	707
73rd Ave between International & Orral St	NB	12,598	11,885	251	192	270	713
San Leandro St between 77th Ave & 81st Ave	WB	9,622	8,593	421	236	371	1,029
San Leandro St between 77th Ave & 81st Ave	EB	9,197	8,192	372	207	426	1,005
W MacArthur Blvd between Market & Linden	WB	5,832	5,654	94	45	39	178
W MacArthur Blvd between Market & Linden	EB	5,982	5,805	106	29	42	177
150th Ave between Lark St & E 14th St (SR 185)	SB	10,076	9,769	174	72	61	307
150th Ave between Lark St & E 14th St (SR 185)	NB	9,229	8,867	169	86	108	362
Lewelling Blvd between Washington & Woodgate	WB	11,579	10,931	192	195	261	648
Lewelling Blvd between Washington & Woodgate	EB	11,135	10,704	213	102	116	431
Hesperian Blvd between I-238 & Springlake Dr	SB	19,970	18,952	422	181	415	1,018
Hesperian Blvd between I-238 & Springlake Dr	NB	17,237	16,471	296	165	304	766

Location	Dir	Daily	Autos	Small	Medium	Combo	Truck
SR 13 (Ashby Ave) between 7th St & UPRR tracks	WB	18,258	17,204	464	230	359	1,053
SR 13 (Ashby Ave) between 7th St & UPRR tracks	EB	18,902	17,781	449	303	370	1,122
SR 61 (Doolittle Dr) between Swan Way & Langley St	SB	10,737	10,289	273	61	114	448
SR 61 (Doolittle Dr) between Swan Way & Langley St	NB	10,728	10,217	337	58	117	512
SR 61 (Doolittle Dr) between Davis St & Eden Rd	SB	12,630	11,454	488	290	399	1,177
SR 61 (Doolittle Dr) between Davis St & Eden Rd	NB	11,527	10,311	419	375	422	1,217
SR 84 (Thornton) between Dutra & Dondero	SB	19,473	18,728	448	43	255	745
SR 84 (Thornton) between Dutra & Dondero	NB	19,713	18,958	513	73	170	755
SR 84 (Mowry Ave) between Mission & Thane	SB	11,754	11,212	300	100	143	543
SR 84 (Mowry Ave) between Mission & Thane	NB	10,979	10,440	336	69	134	539
SR 84 (Niles Cyn) between Mission & Old Canyon	SB	9,828	9,192	373	63	201	636
SR 84 (Niles Cyn) between Mission & Old Canyon	NB	10,639	9,827	425	36	351	813
SR 84 (Airway) between Club House & Kitty Hawk	SB	10,912	10,174	452	53	233	738
SR 84 (Airway) between Club House & Kitty Hawk	NB	8,630	7,958	411	32	228	672
SR 185 (International) between Miller & 23rd	WB	7,936	7,263	481	21	172	674
SR 185 (International) between Miller & 23rd	EB	8,570	7,950	204	163	254	620
SR 185 (E 14th) between Hesperian & 148th Ave	WB	13,618	12,662	293	228	435	956
SR 185 (E 14th) between Hesperian & 148th Ave	EB	13,035	12,324	280	79	352	710
SR 260 Tube Portal	SB	28,957	27,354	561	300	742	1,603
SR 260 Tube Portal	NB	27,387	25,879	603	273	632	1,507
SR 262 (Mission) btwn Kato Rd/Warren & Warm Spr	WB	34,633	32,679	763	48	1,144	1,954
SR 262 (Mission) btwn Kato Rd/Warren & Warm Spr	EB	33,502	31,339	975	74	1,114	2,163
Martime St south of Grand Ave	SB	3,887	2,483	181	273	950	1,404
Martime St south of Grand Ave	NB	4,047	2,771	212	248	817	1,276
7th St west of I-880	WB	5,267	2,269	173	661	2,164	2,998
7th St west of I-880	EB	4,596	2,010	162	432	1,992	2,586
Middle Harbor Rd south of 3rd St	SB	3,071	1,662	103	415	892	1,409
Middle Harbor Rd south of 3rd St	NB	3,196	1,534	98	333	1,231	1,662
98th Ave between I-880 & Empire	WB	19,818	17,927	833	271	787	1,891
98th Ave between I-880 & Empire	EB	22,748	20,634	842	497	775	2,115
Doolittle Dr between Adams & Airport Dr	SB	11,409	10,483	464	183	279	926
Doolittle Dr between Adams & Airport Dr	NB	10,885	10,025	439	157	264	860
Total		1,308,058	1,218,100	37,707	15,817	36,433	89,957

Note: Counts were collected in May 2009.

Appendix B. ACCMA Truck Model Instructions

The Alameda Countywide travel demand model runs the standard travel demand modeling steps of trip generation, trip distribution, mode choice, and trip assignment. It produces traffic estimates on road network segments for five time periods, and estimates of ridership on transit network segments for two time periods (peak and off-peak service).

The Alameda Countywide model estimates truck trips for four classes (very small, small, medium, and large/combo). In the current model (without the enhanced truck model), the four truck classes are kept separate starting with the trip generation step through the trip distribution and mode choice steps; and then the four classes are summed and assigned in total as truck trips to the roadway network during trip assignment.

The truck modeling uses factors and process from the MTC travel model for the San Francisco Bay Area without adjustment. The truck volumes from this process were never validated against actual truck counts.

The Alameda Countywide model estimates truck trips in San Joaquin County using the MTC equations applied to San Joaquin employment estimates. The model did not include estimates of truck trips to and from areas beyond San Joaquin County, such as I-5 and SR 99.

Updated Truck Model

The updated truck model is set up to run after the full countywide model. It uses many of the inputs and interim calculations from the full countywide model. The truck model includes the following steps that update and replace calculations in the countywide model:

1. **Road Network.** Adjusts the freeway capacities in the road network to reflect PCEs rather than average capacities with assumed truck percentages
2. **Trip Generation.** Recalculates truck trip generation for small, medium, and large (combo) trucks.
3. **External Trips.** Applies separate truck trip generation formulas for truck trips within the county model region (internal-internal) and truck trips outside the 10 counties (internal-external and external-internal). Applies estimates of truck percentages at the "gateways" beyond the San Joaquin County line.

4. **Trip Distribution.** Recalculates truck trip distribution for small, medium, and large (combo) trucks, with separate distributions for internal-internal, internal-external and external-internal trips.
5. **Vehicle Trips.** Combines the updated truck trips with the other vehicle types (autos and very small trucks) as they were output from the mode choice step in the full countywide model run.
6. **Peaking.** Applies updated peaking factors for the small, medium, and large (combo) truck trips.
7. **Traffic Assignment.** Runs new traffic assignments for five time periods using the combination of the auto and very small truck trips from the full countywide model run and the updated trips for small, medium and large trucks. The truck model assignments include separate tracking of the route assignments for small, medium, and large trucks, in addition to the separate tracking of drive alone, shared ride two-person, and shared ride three-plus person vehicles included in the full countywide model

The truck model does not recalculate trip generation, trip distribution, mode choice, or peaking factors for trip purposes other than small, medium, and large trucks. These trips are all obtained from the full countywide model run, and are combined with the updated truck trips just prior to traffic assignment.

The truck model does not overwrite any of the interim or output data files created by the original countywide model. In most cases, it creates duplicate files with "TRK" added to the file name.

Input Files

In addition to the standard Alameda Countywide model input and output files, the following inputs are required.

The symbol "xxyy" is a placeholder for a four-character prefix that identifies the files for a specific scenario, such as AC35.

Scenario Directory

RunACCMA_Truck_100126.S Model run script for truck model.

\Inputs Subdirectory

xxyyIXXI.DBF External trips generated by "Gateways_ACCMA_Trucks(date).XLS".

xxyySG.DBF Special truck generators (daily truck trips to/from a TAZ that are not generated by employment based in the TAZ), in particular for the Port of Oakland seaport.

IXXI_Adjust.DBF Adjustment factors for gateways if original model run did not include trucks.

SpdCap_Lookup_PCE Lookup of road capacities considering PCEs.

\TripDistribution\Calib Subdirectory

TRUCKFF_II.DAT Friction factors for internal truck trips.

TRUCKFF_IEEI.DAT Friction factors for internal-external truck trips.

Run Truck Model

The following steps are used to run the truck model:

1. **Full Model Run.** Ensure that all files from a full run of the Alameda Countywide travel model are available. If you are starting a new scenario, you will need to complete the full model run before applying the truck model.

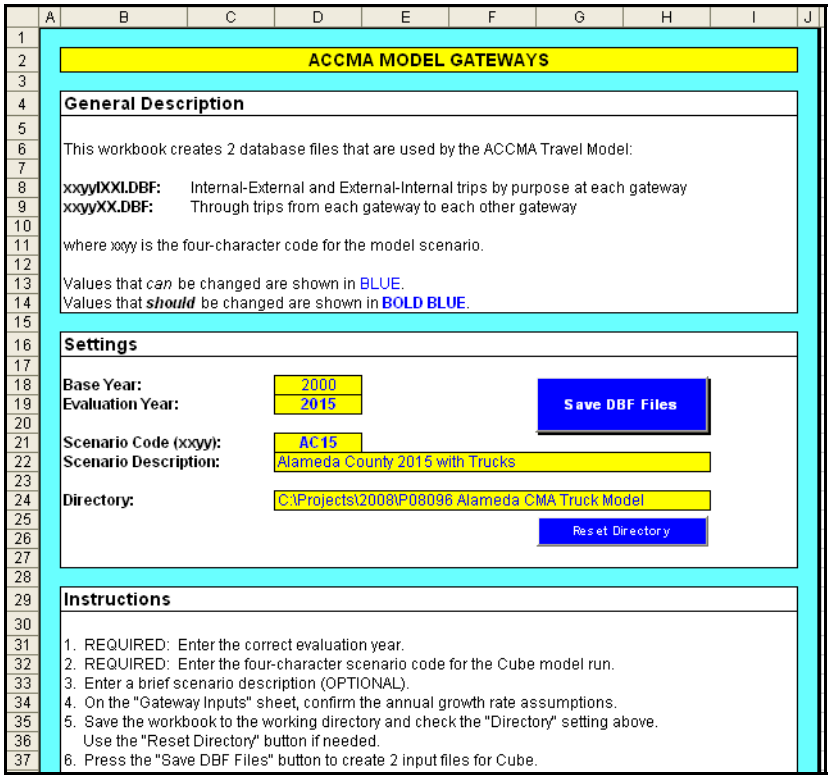
2. **Input Files.** Copy the input files listed above into the appropriate subdirectories.

3. **Special Generators.** If necessary, edit the special generator file ____SG.DBF for the specific scenario (____ indicates that an file name can be used). A DBF type file can be opened in Microsoft Access or any other database program. A DBF file can be opened in Microsoft Excel, but only versions of Microsoft Excel from Microsoft Office 2003 or earlier can save the file as a DBF. It is possible to use Microsoft Access to read an edited Microsoft Excel workbook and convert it back to a DBF format using the "File Save As" command.

   The special generator trips in the ____SG.DBF file are based on estimated amounts required to match the observed 2005 truck trips counted at the three cordon points to and from the Port of Oakland seaport area. They may not precisely match the container and truck activity in each TAZ recorded from other sources. Therefore, the best way to adjust the special generators is to apply factors to the 2005 levels based on projected changes in seaport truck activity (for example, for a 2025 scenario where port activity is projected to be 70 percent higher than 2005 levels, apply a factor of 1.70 to each value in the 2005 special generator file). It is not recommended to replace the values with precise estimates of container or truck activity.

4. **Gateway Inputs.** If you are running the truck model for one of the three years provided (2005, 2015, or 2035), there is no need to change the gateway inputs from those provided (AC05IXXI.DBF, AC15IXXI.DBF, AC35IXXI.DBF).

   If you are running the model for an interim year such as 2020, you will need to generate new input files for the gateways to the 10-county model area. Use Microsoft Excel to read "Gateways_ACCMA_Trucks(date).XLS":



ACCMA MODEL GATEWAYS

General Description

This workbook creates 2 database files that are used by the ACCMA Travel Model:

xxyyIXXI.DBF: Internal-External and External-Internal trips by purpose at each gateway
xxyyXX.DBF: Through trips from each gateway to each other gateway

where xxyy is the four-character code for the model scenario.

Values that *can* be changed are shown in BLUE.
Values that ***should*** be changed are shown in **BOLD BLUE**.

Settings

Base Year: 2000
Evaluation Year: 2015

Save DBF Files

Scenario Code (xxyy): AC15
Scenario Description: Alameda County 2015 with Trucks

Directory: C:\Projects\2008\P08096 Alameda CMA Truck Model

Reset Directory

Instructions

1. REQUIRED: Enter the correct evaluation year.
2. REQUIRED: Enter the four-character scenario code for the Cube model run.
3. Enter a brief scenario description (OPTIONAL).
4. On the "Gateway Inputs" sheet, confirm the annual growth rate assumptions.
5. Save the workbook to the working directory and check the "Directory" setting above. Use the "Reset Directory" button if needed.
6. Press the "Save DBF Files" button to create 2 input files for Cube.

Enter the appropriate year and four-character prefix in the "Instructions" sheet. The workbook will calculate the auto trips by purpose and truck trips based on growth factors from 2000 traffic counts and input percentages.

Save the Excel workbook in the appropriate directory, using an updated date and/or name in the file name. Use the "Save DBF Files" button to run a macro to save the files (make certain that the Microsoft Office security setting allows Excel macros). If the macro does not work with your computer system, manually save the xxyyIXXI and xxyyXX sheets as DBF files.

Copy the xxyyIXXI.DBF and xxyyXX.DBF files to the \Inputs subdirectory. The XX file will already be there if the full model run has been completed for the particular study year.

5. **Edit Script Input List.** Use the Cube text editor or another text editor to edit the User Input section at the top of the script file RunACCMA_Truck_100126.S:

```
;==============================================================================
; Set User Inputs
;==============================================================================

; Network Input Files

NumZones        = 4500

INP_TurnPen = 'TURNPEN2000.PEN'           ; Use appropriate turn penalty file for network year (2000 for 2000/2005, 2015 for 2015/2035)
INP_SaveTurns     = 'SAVE_TURNS.DAT'            ; Use to define nodes at which to save assigned turn volumes

; Land Use Input Files

INP_Landuse       = 'ZMAST05.DBF'               ; Land use scenario for alternative being analyzed
INP_SG                  = 'port_sg.DBF'               ; Special generators for port truck trips, etc...
INP_IX_Ptrips     = 'AC05IXXI.DBF'        ; Internal/external P/A person trips with trucks
INP_IXXI_Adjust = 1                               ; 1 if full model run did not include trucks in INP_IX_Ptrips

; Trip Distribution Iterations

; Number of gravity model iterations (standard is 99 for non-truck, 20 for truck)
INP_Iter_TripDist   = 20

; Traffic Assignment Iterations

; Number of assignment iterations for AM and PM 1-Hour and PM 2-Hour assignments (standard is 50)
INP_Iter_Peak   = 50

; Number of assignment iterations for Daily, PM 4-Hour and AM 2-Hour temporary assignment (standard is 20)
INP_Iter_Other  = 20
;
; Run Cube Cluster
;
INP_RunCluster = 'Y'
;
```

The inputs are described in the following table:

Input Name	Value
NumZones	4500 – Should not be changed
INP_TurnPen	Use same file name as the full model run
INP_SaveTurns	Use same file name as the full model run or change to a new file name if the user has created a new list of intersections to report turns from the truck model assignments
INP_Landuse	Use same file name as the full model run
INP_SG	User must insert file name for truck special generators
INP_IX_PTrips	User must insert file name for gateway trips (file generated by the truck version of the gateway Excel workbook)
INP_IXXI_Adjust	1 if the full model run did not use a new xxyyIXXI.DBF from the truck version of the gateway Excel workbook 0 if a new full model run was done using a new xxyyIXXI.DBF from the truck version of the gateway Excel workbook
INP_Iter_TripDist INP_Iter_Peak INP_Iter_Other	The number of iterations should generally be kept at the values used for model validation. They should only be changed for temporary test runs.
INP_RunCluster	Y if Cube Cluster is available on the computer N if Cluster is not available

6. **Run Cube.** Read the script into the Cube text editor (if it is not already open) and use the standard Cube Run File command to start the model run. **Enter the 4-character prefix that is consistent with the full model run for the same scenario.**

The truck model run will require a minimum of five hours due to the length of time required for each of the five traffic assignments. If all time periods are not required for analysis, the user can modify the script to eliminate some time periods. However, the final step, which combines the five time periods into one output file would also require modification.

Output Files

The truck model does not overwrite any of the files generated by the full model run. The truck model generates the following files which may be useful to the user:

Scenario Directory

Xxyynnnn.PRN The most current .PRN file will have the printed report from the truck model. This would mostly be used for debugging purposes.

\Assignment Subdirectory

xxyy_MERGE_TRK.NET Road network file containing results for all five time periods, including traffic volumes on each segment for total vehicles and each of the six vehicle types.

xxyy_*period*_TRK.NET Individual road network assignments for each time period. In these outputs, the traffic volumes are listed by number and have not been given more descriptive names as in the MERGE file.

\NetUpdate Subdirectory

xxyy_AM_PCE.NET Road networks used as input to traffic assignment, with freeway capacities in PCE values.

xxyy_PM_PCE.NET

\PostProcess Subdirectory

xxyy_Volumes_TRK.DBF Database file of traffic volumes for all five time periods on selected segments used for model validation.

\PT2VT Subdirectory

xxyy_*period*_ADJ_TRK.MAT Cube matrix files for each of the five time periods with TAZ-TAZ trips used for traffic assignments (The daily trip file does not include the ADJ.).

\TripDistribution Subdirectory

xxyy_TRUK.MAT Cube matrix with output from truck trip distribution step for small, medium, and large trucks.

xxyy_CO2CO_TRK.MAT Cube matrix with truck trip distribution compressed to county-to-county for the 10 counties included in the model plus six groupings of external gateways.

xxyy_SD2SD_TRK.MAT Cube matrix with truck trip distribution compressed to the 34 MTC "superdistricts" plus San Joaquin County and six groupings of external gateways.

\TripGeneration Subdirectory

xxyy_TRTGPA.DBF Database file of truck trip generation by TAZ.

Appendix C

Truck Volume Validation 2005

Daily Total Truck Volume Validation – Year 2005

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 13 near Junction 580	SB	250	1,027	777	311%
	NB	250	772	522	209%
	Total	**500**	**1,799**	**1,299**	**260%**
SR 24 at Caldecott Tunnel	WB	7,175	3,770	(3,405)	-47%
	EB	6,431	3,111	(3,321)	-52%
	Total	**13,606**	**6,881**	**(6,725)**	**-49%**
I-80 at University Avenue	EB	10,361	15,206	4,845	47%
	WB	10,361	14,913	4,553	44%
	Total	**20,722**	**30,120**	**9,398**	**45%**
I-680 Near SR 262	SB	5,656	20,075	14,419	255%
	NB	5,656	18,452	12,796	226%
	Total	**11,311**	**38,527**	**27,215**	**241%**
I-680 At Alcosta Blvd	SB	6,390	8,488	2,098	33%
	NB	6,390	8,533	2,143	34%
	Total	**12,780**	**17,021**	**4,241**	**33%**
I-880 South of SR 262	NB	8,064	7,859	(204)	-3%
	SB	8,647	8,744	97	1%
	Total	**16,711**	**16,603**	**(108)**	**-1%**
I-880 At Industrial Parkway	SB	8,823	6,831	(1,992)	-23%
	NB	8,823	7,402	(1,421)	-16%
	Total	**17,647**	**14,233**	**(3,414)**	**-19%**
I-880 At Hegenberger Road	NB	14,519	14,599	80	1%
	SB	14,519	14,410	(109)	-1%
	Total	**29,038**	**29,008**	**(30)**	**0%**
I-880 bet 5th and 10th Avenue	WB	18,805	16,216	(2,589)	-14%
	EB	18,805	16,429	(2,376)	-13%
	Total	**37,610**	**32,645**	**(4,965)**	**-13%**
I-980 at 14th Street	EB	3,139	2,412	(728)	-23%
	WB	3,139	2,385	(754)	-24%
	Total	**6,278**	**4,796**	**(1,482)**	**-24%**

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 238 bet I-880 and I-580	EB	15,919	9,069	(6,850)	-43%
	WB	18,867	8,671	(10,196)	-54%
	Total	**34,787**	**17,740**	**(17,046)**	**-49%**
I-580 Eastern Alameda County	WB	15,441	18,078	2,637	17%
	EB	15,441	18,122	2,681	17%
	Total	**30,882**	**36,200**	**5,318**	**17%**
Atlantic Ave btwn College Way & Webster St	WB	326	37	(289)	-89%
	EB	395	19	(376)	-95%
	Total	**721**	**56**	**(665)**	**-92%**
Buena Vista Ave btwn Grand St & Hibbard St	WB	243	122	(121)	-50%
	EB	254	148	(106)	-42%
	Total	**497**	**270**	**(227)**	**-46%**
Encinal Ave btwn Grand St & Paru St	WB	129	53	(76)	-59%
	EB	144	62	(83)	-57%
	Total	**274**	**115**	**(159)**	**-58%**
Park St btwn Lincoln Ave & Times Way	SB	500	583	83	17%
	NB	432	669	237	55%
	Total	**931**	**1,251**	**320**	**34%**
Broadway btwn Encinal Ave & Central Ave	SB	187	24	(163)	-87%
	NB	217	10	(207)	-95%
	Total	**404**	**34**	**(370)**	**-92%**
Adeline St btwn Ashby (SR13) ML King Jr Way	SB	541	965	425	79%
	NB	357	1,005	648	181%
	Total	**897**	**1,970**	**1,073**	**120%**
ML King Jr Way btwn Alcatraz Ave & Stanford Ave	SB	792	1,569	777	98%
	NB	691	1,373	681	98%
	Total	**1,484**	**2,942**	**1,458**	**98%**
Shattuck Ave btwn Bancroft Way & Durant Ave	SB	787	1,212	424	54%
	NB	436	588	152	35%
	Total	**1,224**	**1,800**	**576**	**47%**

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
University Ave btwn 5th St & 6th St	WB	1,123	1,240	117	10%
	EB	793	553	(240)	-30%
	Total	**1,916**	**1,793**	**(123)**	**-6%**
University Ave btwn ML King Jr Way & Grant St	WB	863	1,157	295	34%
	EB	824	1,162	338	41%
	Total	1,686	2,319	633	38%
Herperian Blvd btwn Hacienda Ave & Bockman Rd	SB	792	727	(65)	-8%
	NB	773	1,355	583	75%
	Total	**1,565**	**2,083**	**518**	**33%**
Ardenwood Blvd btwn Ardenwood Terr & Kaiser Dr	WB	469	343	(127)	-27%
	EB	469	387	(83)	-18%
	Total	**939**	**729**	**(210)**	**-22%**
Decoto Rd btwn Cabrillo Dr & I-880 Ramps	SB	843	539	(305)	-36%
	NB	1,064	766	(298)	-28%
	Total	**1,908**	**1,305**	**(603)**	**-32%**
Decoto Rd btwn 7th St & 8th St	SB	741	126	(615)	-83%
	NB	700	158	(542)	-77%
	Total	**1,441**	**284**	**(1,157)**	**-80%**
Mowry Ave btwn Fremont Blvd & Bell St	SB	840	285	(555)	-66%
	NB	1,018	268	(749)	-74%
	Total	**1,858**	**553**	**(1,304)**	**-70%**
A' Street btwn Mission Blvd (SR185) & Watkins St	WB	562	253	(308)	-55%
	EB	582	165	(417)	-72%
	Total	**1,143**	**418**	**(725)**	**-63%**
Clawiter Rd btwn Industrial Blvd & West St	SB	876	381	(495)	-56%
	NB	1,200	396	(805)	-67%
	Total	**2,077**	**777**	**(1,300)**	**-63%**
Hesperian Blvd btwn Hollow Ave & SR 92 Ramps	SB	714	806	92	13%
	NB	920	1,158	237	26%
	Total	**1,634**	**1,963**	**329**	**20%**

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
Hesperian Blvd btwn Kohoutek Way & Eden Park Pl	SB	897	1,019	122	14%
	NB	1,150	1,018	(131)	-11%
	Total	**2,046**	**2,037**	**(9)**	**0%**
Industrial Pkwy btwn Ruus Rd & Huntwood Ave	SB	1,505	411	(1,094)	-73%
	NB	1,443	431	(1,012)	-70%
	Total	**2,948**	**841**	**(2,106)**	**-71%**
Tennyson Rd btwn Ruus Rd & Bruno St	WB	433	97	(336)	-78%
	EB	899	95	(804)	-89%
	Total	**1,332**	**192**	**(1,140)**	**-86%**
1st St btwn N Mines Rd & Las Positas Rd	WB	1,097	2,929	1,831	167%
	EB	1,211	3,192	1,981	164%
	Total	**2,308**	**6,121**	**3,812**	**165%**
Stanley Blvd btwn Isabel Ave (SR84) & Murdell Ln	WB	850	1,459	608	72%
	EB	734	1,435	700	95%
	Total	**1,585**	**2,893**	**1,309**	**83%**
N Vasco Rd near Dalton Ave	SB	1,032	141	(892)	-86%
	NB	1,082	140	(942)	-87%
	Total	**2,115**	**280**	**(1,834)**	**-87%**
Park St Bridge on or before	SB	788	736	(52)	-7%
	NB	3,120	1,151	(1,969)	-63%
	Total	**3,907**	**1,887**	**(2,020)**	**-52%**
Fruitvale Ave btwn Alameda Ave & tidal canal bridge	WB	631	530	(101)	-16%
	EB	395	155	(240)	-61%
	Total	**1,026**	**685**	**(341)**	**-33%**
High St btwn Tidewater Ave & Marina Dr (Alameda)	WB	371	458	88	24%
	EB	336	451	115	34%
	Total	**707**	**909**	**202**	**29%**
Hegenberger Rd btwn Edgewater Dr & I-880 SB On-Ramp	SB	1,887	1,132	(755)	-40%
	NB	1,875	1,584	(290)	-15%
	Total	**3,762**	**2,716**	**(1,045)**	**-28%**
73rd Ave btwn International Blvd (SR185) & Orral St	SB	707	394	(313)	-44%
	NB	713	247	(466)	-65%
	Total	**1,419**	**641**	**(779)**	**-55%**

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
San Leandro St btwn 77th Ave & 81st Ave	WB	1,029	153	(876)	-85%
	EB	1,005	190	(815)	-81%
	Total	**2,034**	**343**	**(1,691)**	**-83%**
W MacArthur Blvd btwn Market St & Linden St	WB	178	165	(13)	-7%
	EB	177	270	94	53%
	Total	**355**	**435**	**81**	**23%**
150th Ave btwn Lark St & E 14th St (SR 185)	SB	307	218	(89)	-29%
	NB	362	207	(156)	-43%
	Total	**669**	**425**	**(244)**	**-36%**
Lewelling Blvd btwn Washington Ave & Woodgate Dr	WB	648	198	(450)	-69%
	EB	431	142	(289)	-67%
	Total	**1,079**	**340**	**(739)**	**-68%**
Hesperian Blvd btwn I-238 & Springlake Dr	SB	1,018	616	(402)	-39%
	NB	766	387	(379)	-49%
	Total	**1,784**	**1,003**	**(781)**	**-44%**
SR 13 (Ashby Ave) btwn 7th St & UPRR tracks (overhead)	WB	1,053	619	(434)	-41%
	EB	1,122	953	(168)	-15%
	Total	**2,175**	**1,572**	**(602)**	**-28%**
SR 61 (Doolittle Dr) btwn Swan Way & Langley St	SB	448	217	(231)	-52%
	NB	512	231	(281)	-55%
	Total	**960**	**448**	**(512)**	**-53%**
SR 61 (Doolittle Dr) btwn Davis St & Eden Rd	SB	1,177	148	(1,029)	-87%
	NB	1,217	355	(861)	-71%
	Total	**2,393**	**503**	**(1,890)**	**-79%**
SR 84 (Thornton Ave) btwn Dutra Way & Dondero Way	SB	745	143	(602)	-81%
	NB	755	130	(625)	-83%
	Total	**1,500**	**273**	**(1,227)**	**-82%**
SR 84 (Mowry Ave) btwn Mission Blvd (SR238) & Thane St	SB	543	178	(364)	-67%
	NB	539	177	(361)	-67%
	Total	**1,081**	**355**	**(726)**	**-67%**
SR 84 (Niles Canyon Rd) btwn Mission Blvd (SR238) & Old Canyon Rd	SB	636	135	(501)	-79%
	NB	813	102	(710)	-87%
	Total	**1,449**	**237**	**(1,211)**	**-84%**

Daily Total Truck Volume Validation - Year 2005					
		Daily Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 84 (Airway Blvd) btwn Club House Dr & Kitty Hawk Rd	SB	738	228	(510)	-69%
	NB	672	139	(533)	-79%
	Total	**1,410**	**366**	**(1,044)**	**-74%**
SR 185 (International Blvd) btwn Miller Ave & 23rd Ave	WB	674	83	(590)	-88%
	EB	620	109	(511)	-82%
	Total	**1,294**	**193**	**(1,101)**	**-85%**
SR 185 (E 14th St) btwn Hesperian Ave & 148th Ave	WB	956	147	(809)	-85%
	EB	710	193	(518)	-73%
	Total	**1,666**	**340**	**(1,326)**	**-80%**
SR 260 Tube Portal	SB	1,603	1,182	(421)	-26%
	NB	1,507	1,138	(369)	-24%
	Total	**3,110**	**2,320**	**(790)**	**-25%**
SR 262 (Mission Blvd) btwn Kato Rd/Warren Ave & Warm Springs Blvd	WB	1,954	4,876	2,923	150%
	EB	2,163	5,908	3,746	173%
	Total	**4,116**	**10,785**	**6,668**	**162%**
Martime St south of Grand Ave	SB	1,404	2,182	778	55%
	NB	1,276	2,334	1,057	83%
	Total	**2,680**	**4,516**	**1,835**	**68%**
7th St west of I-880	WB	2,998	2,479	(520)	-17%
	EB	2,586	2,343	(243)	-9%
	Total	**5,584**	**4,822**	**(763)**	**-14%**
Middle Harbor Rd south of 3rd St	SB	1,409	766	(643)	-46%
	NB	1,662	750	(912)	-55%
	Total	**3,071**	**1,516**	**(1,555)**	**-51%**
98th Ave btwn I-880 & Empire	WB	1,891	1,642	(250)	-13%
	EB	2,115	1,407	(707)	-33%
	Total	**4,006**	**3,049**	**(957)**	**-24%**
Doolittle Dr btwn Adams & Airport Dr	SB	926	137	(789)	-85%
	NB	860	282	(578)	-67%
	Total	**1,786**	**419**	**(1,366)**	**-77%**
GRAND TOTAL		**321,828**	**319,699**	**(2,130)**	**-1%**

AM and PM 1 - Hour Truck Volume Validation - Year 2005

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 13 near Junction 580	SB	22	39	16	73%	22	35	13	62%
	NB	27	26	(1)	-5%	22	26	4	19%
	Total	**49**	**64**	**15**	**30%**	**43**	**61**	**17**	**40%**
SR 24 at Caldecott Tunnel	WB	493	188	(305)	-62%	356	214	(141)	-40%
	EB	291	128	(163)	-56%	493	87	(406)	-82%
	Total	**784**	**317**	**(467)**	**-60%**	**848**	**301**	**(547)**	**-65%**
I-80 at University Avenue	EB	631	1,147	516	82%	505	715	211	42%
	WB	631	753	122	19%	505	1,081	576	114%
	Total	**1,262**	**1,900**	**638**	**51%**	**1,009**	**1,796**	**787**	**78%**
I-680 Near SR 262	SB	480	914	434	90%	365	1,532	1,167	319%
	NB	480	1,927	1,447	302%	365	831	466	127%
	Total	**960**	**2,841**	**1,881**	**196%**	**731**	**2,363**	**1,632**	**223%**
I-680 At Alcosta Blvd	SB	480	441	(39)	-8%	452	518	66	15%
	NB	480	744	264	55%	452	509	57	13%
	Total	**960**	**1,184**	**224**	**23%**	**904**	**1,027**	**123**	**14%**
I-880 South of SR 262	NB	448	431	(17)	-4%	639	387	(252)	-39%
	SB	671	520	(152)	-23%	543	506	(37)	-7%
	Total	**1,119**	**951**	**(168)**	**-15%**	**1,183**	**893**	**(289)**	**-24%**
I-880 At Industrial Parkway	SB	527	383	(144)	-27%	534	350	(184)	-34%
	NB	506	397	(109)	-22%	432	250	(182)	-42%
	Total	**1,033**	**779**	**(253)**	**-25%**	**966**	**601**	**(365)**	**-38%**
I-880 At Hegenberger Road	NB	642	562	(80)	-12%	887	754	(133)	-15%
	SB	942	812	(129)	-14%	919	564	(355)	-39%
	Total	**1,584**	**1,375**	**(210)**	**-13%**	**1,807**	**1,318**	**(489)**	**-27%**
I-880 bet 5th and 10th Avenue	WB	943	730	(212)	-23%	925	938	13	1%
	EB	1,095	1,033	(61)	-6%	1,151	797	(354)	-31%
	Total	**2,037**	**1,764**	**(274)**	**-13%**	**2,076**	**1,735**	**(341)**	**-16%**
I-980 at 14th Street	EB	185	62	(123)	-67%	269	86	(182)	-68%
	WB	266	120	(146)	-55%	163	68	(95)	-58%
	Total	**451**	**181**	**(270)**	**-60%**	**431**	**154**	**(277)**	**-64%**

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
SR 238 bet I-880 and I-580	EB	854	498	(356)	-42%	957	287	(670)	-70%
	WB	970	309	(662)	-68%	1,190	575	(615)	-52%
	Total	**1,825**	**807**	**(1,018)**	**-56%**	**2,147**	**862**	**(1,285)**	**-60%**
I-580 Eastern Alameda County	WB	816	864	48	6%	898	1,271	373	42%
	EB	816	1,277	461	56%	898	863	(35)	-4%
	Total	**1,633**	**2,141**	**508**	**31%**	**1,796**	**2,134**	**338**	**19%**
Atlantic Ave btwn College Way & Webster St	WB	26	14	(13)	-48%	19	2	(17)	-92%
	EB	24	10	(14)	-58%	25	8	(16)	-67%
	Total	**50**	**24**	**(26)**	**-53%**	**43**	**10**	**(34)**	**-78%**
Buena Vista Ave btwn Grand St & Hibbard St	WB	30	12	(18)	-60%	8	11	3	36%
	EB	14	12	(2)	-15%	15	12	(2)	-16%
	Total	**45**	**24**	**(20)**	**-45%**	**23**	**24**	**1**	**3%**
Encinal Ave btwn Grand St & Paru St	WB	16	6	(11)	-65%	4	6	2	40%
	EB	10	7	(4)	-37%	14	9	(5)	-39%
	Total	**27**	**12**	**(14)**	**-54%**	**19**	**15**	**(4)**	**-20%**
Park St btwn Lincoln Ave & Times Way	SB	29	22	(7)	-25%	26	32	5	21%
	NB	22	40	18	80%	18	26	8	48%
	Total	**51**	**62**	**10**	**20%**	**44**	**58**	**14**	**32%**
Broadway btwn Encinal Ave & Central Ave	SB	10	1	(9)	-88%	17	1	(16)	-93%
	NB	14	1	(12)	-91%	15	1	(14)	-93%
	Total	**24**	**2**	**(21)**	**-90%**	**32**	**2**	**(30)**	**-93%**
Adeline St btwn Ashby (SR13) ML King Jr Way	SB	24	81	57	239%	42	51	8	20%
	NB	27	64	36	133%	23	46	22	97%
	Total	**51**	**145**	**94**	**183%**	**66**	**96**	**31**	**47%**
ML King Jr Way btwn Alcatraz Ave & Stanford Ave	SB	42	124	82	195%	61	92	30	50%
	NB	53	90	37	69%	54	78	24	44%
	Total	**95**	**214**	**119**	**125%**	**115**	**169**	**54**	**47%**
Shattuck Ave btwn Bancroft Way & Durant Ave	SB	48	106	57	119%	43	63	20	46%
	NB	40	30	(10)	-25%	19	16	(4)	-19%
	Total	**88**	**135**	**47**	**54%**	**62**	**78**	**16**	**26%**

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
University Ave btwn 5th St & 6th St	WB	78	117	39	51%	55	67	13	24%
	EB	71	24	(47)	-66%	27	37	10	36%
	Total	**148**	**141**	**(8)**	**-5%**	**81**	**104**	**23**	**28%**
University Ave btwn ML King Jr Way & Grant St	WB	47	115	68	147%	50	75	25	49%
	EB	60	95	35	58%	43	95	51	119%
	Total	**107**	**209**	**103**	**97%**	**94**	**170**	**76**	**81%**
Herperian Blvd btwn Hacienda Ave & Bockman Rd	SB	70	76	5	7%	51	52	2	3%
	NB	46	63	17	36%	58	116	58	100%
	Total	**116**	**138**	**22**	**19%**	**109**	**169**	**60**	**55%**
Ardenwood Blvd btwn Ardenwood Terr & Kaiser Dr	WB	27	17	(9)	-35%	63	49	(14)	-22%
	EB	46	47	1	3%	40	29	(10)	-26%
	Total	**72**	**64**	**(8)**	**-11%**	**103**	**79**	**(24)**	**-23%**
Decoto Rd btwn Cabrillo Dr & I-880 Ramps	SB	66	37	(29)	-44%	17	74	57	331%
	NB	48	47	(2)	-3%	75	70	(5)	-6%
	Total	**114**	**83**	**(31)**	**-27%**	**92**	**144**	**52**	**56%**
Decoto Rd btwn 7th St & 8th St	SB	71	34	(37)	-51%	42	8	(34)	-82%
	NB	41	7	(34)	-83%	62	15	(46)	-75%
	Total	**112**	**41**	**(70)**	**-63%**	**103**	**23**	**(81)**	**-78%**
Mowry Ave btwn Fremont Blvd & Bell St	SB	43	21	(23)	-52%	53	20	(33)	-63%
	NB	64	17	(47)	-73%	66	29	(37)	-56%
	Total	**107**	**38**	**(69)**	**-65%**	**119**	**49**	**(70)**	**-59%**
A' Street btwn Mission Blvd (SR185) & Watkins St	WB	42	23	(20)	-46%	37	5	(32)	-86%
	EB	34	3	(31)	-90%	50	32	(18)	-36%
	Total	**76**	**26**	**(50)**	**-66%**	**87**	**37**	**(50)**	**-58%**
Clawiter Rd btwn Industrial Blvd & West St	SB	104	22	(81)	-78%	52	42	(10)	-19%
	NB	80	35	(45)	-56%	84	53	(31)	-37%
	Total	**184**	**57**	**(127)**	**-69%**	**135**	**95**	**(41)**	**-30%**
Hesperian Blvd btwn Hollow Ave & SR 92 Ramps	SB	44	87	42	96%	48	70	22	46%
	NB	78	67	(12)	-15%	66	69	3	4%
	Total	**123**	**154**	**31**	**25%**	**114**	**139**	**25**	**22%**

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
Hesperian Blvd btwn Kohoutek Way & Eden Park Pl	SB	65	146	82	126%	72	81	10	13%
	NB	101	50	(52)	-51%	77	81	5	6%
	Total	**166**	**196**	**30**	**18%**	**149**	**163**	**14**	**10%**
Industrial Pkwy btwn Ruus Rd & Huntwood Ave	SB	115	23	(92)	-80%	63	30	(33)	-53%
	NB	88	27	(62)	-70%	101	24	(77)	-76%
	Total	**204**	**50**	**(154)**	**-75%**	**164**	**54**	**(110)**	**-67%**
Tennyson Rd btwn Ruus Rd & Bruno St	WB	40	10	(29)	-74%	27	5	(22)	-82%
	EB	60	4	(56)	-94%	67	12	(56)	-83%
	Total	**99**	**14**	**(85)**	**-86%**	**95**	**16**	**(78)**	**-83%**
1st St btwn N Mines Rd & Las Positas Rd	WB	99	183	84	85%	49	411	362	739%
	EB	53	427	375	711%	85	226	141	166%
	Total	**152**	**610**	**459**	**303%**	**134**	**638**	**504**	**376%**
Stanley Blvd btwn Isabel Ave (SR84) & Murdell Ln	WB	144	183	39	27%	14	283	269	1962%
	EB	27	247	220	802%	96	199	103	107%
	Total	**172**	**430**	**258**	**150%**	**110**	**482**	**372**	**339%**
N Vasco Rd near Dalton Ave	SB	102	4	(98)	-96%	32	7	(24)	-78%
	NB	60	13	(47)	-79%	90	4	(85)	-95%
	Total	**162**	**17**	**(145)**	**-90%**	**121**	**11**	**(110)**	**-91%**
Park St Bridge on or before	SB	39	34	(5)	-14%	46	42	(4)	-9%
	NB	57	66	9	17%	281	42	(239)	-85%
	Total	**96**	**100**	**4**	**4%**	**326**	**84**	**(243)**	**-74%**
Fruitvale Ave btwn Alameda Ave & tidal canal bridge	WB	49	25	(24)	-50%	42	35	(6)	-15%
	EB	30	22	(8)	-27%	25	16	(9)	-37%
	Total	**79**	**47**	**(32)**	**-41%**	**67**	**51**	**(16)**	**-23%**
High St btwn Tidewater Ave & Marina Dr (Alameda)	WB	27	28	1	3%	28	19	(9)	-31%
	EB	24	24	(1)	-2%	21	31	10	45%
	Total	**51**	**51**	**0**	**0%**	**49**	**50**	**1**	**2%**
Hegenberger Rd btwn Edgewater Dr & I-880 SB On-Ramp	SB	109	114	6	5%	108	139	31	29%
	NB	117	145	27	23%	105	139	33	32%
	Total	**226**	**259**	**33**	**15%**	**213**	**278**	**64**	**30%**

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
73rd Ave btwn International Blvd (SR185) & Orral St	SB	57	25	(32)	-56%	43	26	(17)	-39%
	NB	45	21	(24)	-54%	46	24	(22)	-48%
	Total	**103**	**46**	**(56)**	**-55%**	**90**	**51**	**(39)**	**-44%**
San Leandro St btwn 77th Ave & 81st Ave	WB	65	24	(41)	-64%	84	26	(59)	-70%
	EB	51	19	(32)	-63%	81	46	(35)	-43%
	Total	**116**	**43**	**(74)**	**-63%**	**165**	**72**	**(94)**	**-57%**
W MacArthur Blvd btwn Market St & Linden St	WB	12	11	(1)	-5%	15	16	1	7%
	EB	12	18	6	55%	15	17	2	12%
	Total	**23**	**29**	**6**	**25%**	**30**	**33**	**3**	**9%**
150th Ave btwn Lark St & E 14th St (SR 185)	SB	15	8	(7)	-49%	26	10	(16)	-62%
	NB	24	10	(14)	-60%	36	12	(24)	-66%
	Total	**39**	**17**	**(21)**	**-55%**	**61**	**22**	**(39)**	**-64%**
Lewelling Blvd btwn Washington Ave & Woodgate Dr	WB	41	15	(26)	-63%	49	5	(44)	-91%
	EB	38	3	(36)	-93%	29	13	(15)	-53%
	Total	**80**	**18**	**(62)**	**-78%**	**78**	**18**	**(60)**	**-77%**
Hesperian Blvd btwn I-238 & Springlake Dr	SB	71	19	(52)	-74%	66	35	(31)	-47%
	NB	62	22	(41)	-65%	56	13	(43)	-77%
	Total	**133**	**40**	**(93)**	**-70%**	**122**	**48**	**(74)**	**-61%**
SR 13 (Ashby Ave) btwn 7th St & UPRR tracks (overhead)	WB	57	50	(6)	-11%	68	36	(32)	-47%
	EB	79	39	(39)	-50%	45	104	58	128%
	Total	**135**	**90**	**(45)**	**-34%**	**114**	**140**	**26**	**23%**
SR 61 (Doolittle Dr) btwn Swan Way & Langley St	SB	24	23	(2)	-7%	31	27	(4)	-14%
	NB	38	23	(16)	-41%	31	26	(5)	-15%
	Total	**62**	**45**	**(17)**	**-28%**	**62**	**53**	**(9)**	**-14%**
SR 61 (Doolittle Dr) btwn Davis St & Eden Rd	SB	59	25	(33)	-57%	86	112	26	31%
	NB	67	76	9	13%	60	78	17	29%
	Total	**126**	**102**	**(24)**	**-19%**	**146**	**190**	**44**	**30%**
SR 84 (Thornton Ave) btwn Dutra Way & Dondero Way	SB	63	19	(44)	-70%	38	12	(27)	-70%
	NB	52	7	(44)	-86%	41	17	(25)	-60%
	Total	**115**	**26**	**(88)**	**-77%**	**80**	**28**	**(52)**	**-65%**

AM 1-hour and PM 1-hour Truck Volume Validation - Year 2005									
		AM - 1hr Total Truck Volume Statistics				PM - 1hr Total Truck Volume Statistics			
Location	**Dir**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**	**Observed Truck Counts (C)**	**Estimated Truck Volume (V)**	**Error (V-C)**	**Percent Error [(V-C)/C]**
SR 84 (Mowry Ave) btwn Mission Blvd (SR238) & Thane St	SB	46	19	(27)	-59%	28	10	(18)	-64%
	NB	31	9	(21)	-70%	35	16	(20)	-55%
	Total	**77**	**28**	**(49)**	**-63%**	**63**	**26**	**(38)**	**-59%**
SR 84 (Niles Canyon Rd) btwn Mission Blvd (SR238) & Old Canyon Rd	SB	70	174	104	148%	42	41	(1)	-3%
	NB	54	17	(37)	-69%	65	129	64	98%
	Total	**124**	**191**	**67**	**54%**	**107**	**170**	**63**	**59%**
SR 84 (Airway Blvd) btwn Club House Dr & Kitty Hawk Rd	SB	48	13	(35)	-73%	47	12	(35)	-74%
	NB	37	22	(15)	-40%	40	11	(29)	-73%
	Total	**85**	**35**	**(50)**	**-59%**	**87**	**23**	**(64)**	**-73%**
SR 185 (International Blvd) btwn Miller Ave & 23rd Ave	WB	47	9	(38)	-82%	39	12	(27)	-70%
	EB	26	7	(19)	-74%	42	27	(15)	-36%
	Total	**72**	**15**	**(57)**	**-79%**	**81**	**39**	**(42)**	**-52%**
SR 185 (E 14th St) btwn Hesperian Ave & 148th Ave	WB	54	9	(45)	-84%	65	7	(58)	-90%
	EB	37	8	(29)	-78%	54	23	(31)	-57%
	Total	**91**	**17**	**(74)**	**-81%**	**119**	**30**	**(89)**	**-75%**
SR 260 Tube Portal	SB	105	63	(43)	-40%	136	109	(28)	-20%
	NB	108	87	(21)	-20%	86	71	(15)	-17%
	Total	**214**	**150**	**(64)**	**-30%**	**222**	**179**	**(42)**	**-19%**
SR 262 (Mission Blvd) btwn Kato Rd/Warren Ave & Warm Springs Blvd	WB	90	212	122	135%	57	516	459	803%
	EB	91	788	697	768%	82	254	172	209%
	Total	**181**	**1,000**	**820**	**453%**	**139**	**770**	**630**	**453%**
Martime St south of Grand Ave	SB	99	222	123	124%	45	236	191	426%
	NB	92	185	93	101%	83	197	114	136%
	Total	**191**	**407**	**216**	**113%**	**128**	**433**	**305**	**237%**
7th St west of I-880	WB	259	167	(93)	-36%	95	178	83	87%
	EB	155	189	34	22%	211	196	(15)	-7%
	Total	**415**	**356**	**(59)**	**-14%**	**306**	**374**	**68**	**22%**
Middle Harbor Rd south of 3rd St	SB	118	57	(61)	-52%	30	62	33	109%
	NB	139	56	(84)	-60%	137	59	(78)	-57%
	Total	**258**	**113**	**(145)**	**-56%**	**167**	**121**	**(46)**	**-27%**
98th Ave btwn I-880 & Empire	WB	109	77	(31)	-29%	92	90	(2)	-3%
	EB	87	89	2	3%	86	56	(30)	-35%
	Total	**195**	**166**	**(29)**	**-15%**	**178**	**146**	**(32)**	**-18%**
Doolittle Dr btwn Adams & Airport Dr	SB	50	20	(30)	-61%	76	105	30	39%
	NB	58	70	12	20%	45	71	26	57%
	Total	**108**	**90**	**(19)**	**-17%**	**121**	**177**	**56**	**46%**
GRAND TOTAL		**19,635**	**20,672**	**1,036**	**5%**	**19,479**	**19,675**	**196**	**1%**

PM 2 and 4 Hour Truck Volume Validation – Year 2005

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 13 near Junction 580	SB	42	88	46	108%	79	187	108	137%
	NB	42	58	16	38%	79	171	92	116%
	Total	**85**	**147**	**62**	**73%**	**158**	**358**	**200**	**126%**
SR 24 at Caldecott Tunnel	WB	751	455	(297)	-39%	2,004	905	(1,099)	-55%
	EB	1,002	195	(807)	-81%	2,456	512	(1,945)	-79%
	Total	**1,753**	**650**	**(1,103)**	**-63%**	**4,460**	**1,417**	**(3,043)**	**-68%**
I-80 at University Avenue	EB	1,024	1,552	528	52%	2,122	2,932	810	38%
	WB	1,024	2,140	1,116	109%	2,122	3,951	1,828	86%
	Total	**2,048**	**3,692**	**1,644**	**80%**	**4,245**	**6,883**	**2,638**	**62%**
I-680 Near SR 262	SB	560	3,058	2,498	446%	1,362	5,937	4,574	336%
	NB	560	1,752	1,192	213%	1,362	3,920	2,558	188%
	Total	**1,119**	**4,809**	**3,690**	**330%**	**2,725**	**9,857**	**7,132**	**262%**
I-680 At Alcosta Blvd	SB	882	1,046	164	19%	1,702	2,163	460	27%
	NB	882	1,017	135	15%	1,702	2,172	469	28%
	Total	**1,765**	**2,064**	**299**	**17%**	**3,405**	**4,334**	**929**	**27%**
I-880 South of SR 262	NB	1,273	675	(598)	-47%	2,442	1,888	(554)	-23%
	SB	1,047	1,016	(31)	-3%	2,013	2,175	162	8%
	Total	**2,320**	**1,691**	**(629)**	**-27%**	**4,455**	**4,063**	**(392)**	**-9%**
I-880 At Industrial Parkway	SB	1,018	767	(251)	-25%	2,017	1,611	(407)	-20%
	NB	996	553	(443)	-44%	2,141	1,233	(908)	-42%
	Total	**2,014**	**1,320**	**(694)**	**-34%**	**4,159**	**2,844**	**(1,315)**	**-32%**
I-880 At Hegenberger Road	NB	1,691	1,534	(157)	-9%	3,351	2,949	(402)	-12%
	SB	1,836	1,204	(632)	-34%	3,679	2,761	(918)	-25%
	Total	**3,527**	**2,737**	**(789)**	**-22%**	**7,030**	**5,710**	**(1,320)**	**-19%**
I-880 bet 5th and 10th Avenue	WB	2,022	1,841	(181)	-9%	4,262	3,393	(869)	-20%
	EB	2,233	1,629	(604)	-27%	4,537	3,483	(1,054)	-23%
	Total	**4,255**	**3,470**	**(785)**	**-18%**	**8,799**	**6,876**	**(1,923)**	**-22%**
I-980 at 14th Street	EB	512	191	(320)	-63%	970	411	(559)	-58%
	WB	324	143	(181)	-56%	625	364	(262)	-42%
	Total	**836**	**335**	**(501)**	**-60%**	**1,596**	**775**	**(821)**	**-51%**

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 238 bet I-880 and I-580	EB	1,889	609	(1,280)	-68%	3,755	1,425	(2,330)	-62%
	WB	2,378	1,127	(1,251)	-53%	4,553	1,774	(2,779)	-61%
	Total	**4,266**	**1,736**	**(2,530)**	**-59%**	**8,308**	**3,199**	**(5,109)**	**-61%**
I-580 Eastern Alameda County	WB	1,760	2,400	640	36%	3,417	3,727	310	9%
	EB	1,760	1,617	(143)	-8%	3,417	4,027	610	18%
	Total	**3,519**	**4,017**	**498**	**14%**	**6,835**	**7,754**	**919**	**13%**
Atlantic Ave btwn College Way & Webster St	WB	37	6	(31)	-84%	70	10	(61)	-86%
	EB	49	15	(33)	-68%	104	23	(81)	-78%
	Total	**85**	**21**	**(64)**	**-75%**	**174**	**33**	**(142)**	**-81%**
Buena Vista Ave btwn Grand St & Hibbard St	WB	16	28	12	71%	46	48	2	5%
	EB	29	29	(1)	-2%	62	58	(4)	-6%
	Total	**46**	**57**	**11**	**24%**	**108**	**106**	**(2)**	**-1%**
Encinal Ave btwn Grand St & Paru St	WB	9	14	5	49%	28	27	(0)	-1%
	EB	29	19	(10)	-35%	51	33	(18)	-34%
	Total	**38**	**33**	**(6)**	**-15%**	**79**	**61**	**(18)**	**-23%**
Park St btwn Lincoln Ave & Times Way	SB	50	68	18	36%	117	124	7	6%
	NB	35	56	21	60%	78	130	52	66%
	Total	**85**	**124**	**39**	**46%**	**195**	**255**	**59**	**30%**
Broadway btwn Encinal Ave & Central Ave	SB	33	3	(31)	-91%	61	7	(54)	-89%
	NB	29	3	(26)	-91%	55	6	(49)	-89%
	Total	**62**	**5**	**(57)**	**-91%**	**117**	**13**	**(104)**	**-89%**
Adeline St btwn Ashby (SR13) ML King Jr Way	SB	84	88	4	4%	178	179	2	1%
	NB	45	82	37	83%	88	152	64	73%
	Total	**129**	**170**	**41**	**32%**	**266**	**331**	**66**	**25%**
ML King Jr Way btwn Alcatraz Ave & Stanford Ave	SB	122	174	52	43%	215	333	117	55%
	NB	106	157	50	47%	213	287	74	35%
	Total	**228**	**331**	**103**	**45%**	**428**	**620**	**192**	**45%**
Shattuck Ave btwn Bancroft Way & Durant Ave	SB	85	125	40	47%	158	199	41	26%
	NB	39	36	(3)	-8%	83	72	(11)	-14%
	Total	**124**	**161**	**37**	**30%**	**241**	**271**	**30**	**12%**

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
University Ave btwn 5th St & 6th St	WB	109	158	49	45%	220	286	66	30%
	EB	53	77	24	46%	111	139	28	25%
	Total	**161**	**235**	**74**	**46%**	**331**	**424**	**93**	**28%**
University Ave btwn ML King Jr Way & Grant St	WB	98	141	43	44%	219	237	18	8%
	EB	88	171	83	95%	155	250	95	62%
	Total	**186**	**312**	**126**	**68%**	**374**	**487**	**113**	**30%**
Herperian Blvd btwn Hacienda Ave & Bockman Rd	SB	101	97	(4)	-4%	187	297	110	59%
	NB	116	192	76	66%	214	538	324	152%
	Total	**217**	**289**	**72**	**33%**	**401**	**834**	**434**	**108%**
Ardenwood Blvd btwn Ardenwood Terr & Kaiser Dr	WB	126	73	(53)	-42%	211	175	(36)	-17%
	EB	78	51	(27)	-35%	133	126	(7)	-5%
	Total	**203**	**124**	**(80)**	**-39%**	**344**	**300**	**(44)**	**-13%**
Decoto Rd btwn Cabrillo Dr & I-880 Ramps	SB	34	149	115	341%	74	274	200	270%
	NB	151	158	7	5%	295	330	35	12%
	Total	**184**	**307**	**122**	**66%**	**369**	**604**	**235**	**64%**
Decoto Rd btwn 7th St & 8th St	SB	84	18	(66)	-79%	165	36	(130)	-78%
	NB	123	12	(111)	-90%	219	72	(148)	-67%
	Total	**207**	**30**	**(177)**	**-86%**	**385**	**107**	**(277)**	**-72%**
Mowry Ave btwn Fremont Blvd & Bell St	SB	105	36	(69)	-66%	208	80	(128)	-62%
	NB	133	44	(89)	-67%	276	95	(181)	-66%
	Total	**238**	**79**	**(158)**	**-67%**	**484**	**175**	**(309)**	**-64%**
A' Street btwn Mission Blvd (SR185) & Watkins St	WB	72	17	(55)	-76%	144	46	(98)	-68%
	EB	101	65	(37)	-36%	175	261	86	49%
	Total	**173**	**82**	**(92)**	**-53%**	**319**	**307**	**(12)**	**-4%**
Clawiter Rd btwn Industrial Blvd & West St	SB	93	79	(14)	-16%	154	188	35	22%
	NB	183	70	(113)	-62%	343	317	(26)	-8%
	Total	**277**	**149**	**(127)**	**-46%**	**497**	**505**	**9**	**2%**
Hesperian Blvd btwn Hollow Ave & SR 92 Ramps	SB	96	154	58	61%	190	335	145	77%
	NB	131	147	16	12%	238	329	91	38%
	Total	**227**	**301**	**74**	**33%**	**428**	**664**	**236**	**55%**
Hesperian Blvd btwn Kohoutek Way & Eden Park Pl	SB	143	137	(6)	-4%	243	386	143	59%
	NB	154	153	(1)	-1%	290	370	79	27%
	Total	**297**	**290**	**(7)**	**-2%**	**533**	**755**	**222**	**42%**
Industrial Pkwy btwn Ruus Rd & Huntwood Ave	SB	125	58	(67)	-54%	268	112	(156)	-58%
	NB	202	50	(152)	-75%	391	101	(289)	-74%
	Total	**327**	**108**	**(219)**	**-67%**	**658**	**214**	**(445)**	**-68%**
Tennyson Rd btwn Ruus Rd & Bruno St	WB	54	11	(43)	-80%	110	47	(63)	-57%
	EB	135	22	(113)	-83%	272	75	(197)	-72%
	Total	**189**	**33**	**(156)**	**-82%**	**383**	**122**	**(260)**	**-68%**
1st St btwn N Mines Rd & Las Positas Rd	WB	97	751	654	671%	200	1,183	983	493%
	EB	169	439	270	159%	360	997	637	177%
	Total	**267**	**1,190**	**923**	**346%**	**559**	**2,180**	**1,620**	**290%**

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
Stanley Blvd btwn Isabel Ave (SR84) & Murdell Ln	WB	27	529	502	1883%	74	919	844	1137%
	EB	191	379	187	98%	329	909	580	176%
	Total	**218**	**908**	**690**	**316%**	**404**	**1,828**	**1,424**	**353%**
N Vasco Rd near Dalton Ave	SB	64	15	(48)	-76%	121	38	(83)	-69%
	NB	179	9	(170)	-95%	340	23	(317)	-93%
	Total	**242**	**24**	**(218)**	**-90%**	**461**	**61**	**(400)**	**-87%**
Park St Bridge on or before	SB	90	110	20	22%	184	179	(5)	-3%
	NB	561	100	(462)	-82%	1,116	233	(883)	-79%
	Total	**651**	**210**	**(442)**	**-68%**	**1,299**	**411**	**(888)**	**-68%**
Fruitvale Ave btwn Alameda Ave & tidal canal bridge	WB	83	72	(11)	-14%	144	161	16	11%
	EB	50	32	(18)	-35%	89	89	0	0%
	Total	**133**	**104**	**(29)**	**-22%**	**233**	**250**	**17**	**7%**
High St btwn Tidewater Ave & Marina Dr (Alameda)	WB	54	43	(12)	-22%	97	87	(10)	-11%
	EB	44	48	4	9%	83	123	40	48%
	Total	**98**	**91**	**(8)**	**-8%**	**180**	**210**	**30**	**16%**
Hegenberger Rd btwn Edgewater Dr & I-880 SB On-Ra	SB	215	250	35	16%	439	416	(23)	-5%
	NB	210	272	62	29%	422	431	9	2%
	Total	**425**	**522**	**97**	**23%**	**860**	**846**	**(14)**	**-2%**
73rd Ave btwn International Blvd (SR185) & Orral St	SB	87	66	(21)	-24%	165	140	(25)	-15%
	NB	91	47	(44)	-48%	196	132	(65)	-33%
	Total	**178**	**113**	**(65)**	**-36%**	**362**	**272**	**(89)**	**-25%**
San Leandro St btwn 77th Ave & 81st Ave	WB	169	42	(127)	-75%	309	127	(182)	-59%
	EB	140	70	(70)	-50%	260	158	(102)	-39%
	Total	**309**	**112**	**(197)**	**-64%**	**569**	**285**	**(284)**	**-50%**
W MacArthur Blvd btwn Market St & Linden St	WB	31	27	(5)	-15%	51	82	31	62%
	EB	30	34	4	12%	61	84	23	37%
	Total	**61**	**60**	**(1)**	**-1%**	**112**	**166**	**54**	**48%**
150th Ave btwn Lark St & E 14th St (SR 185)	SB	51	27	(24)	-47%	93	58	(35)	-37%
	NB	71	18	(53)	-75%	119	41	(79)	-66%
	Total	**122**	**45**	**(77)**	**-63%**	**213**	**99**	**(114)**	**-53%**

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
Lewelling Blvd btwn Washington Ave & Woodgate Dr	WB	97	16	(81)	-84%	222	68	(154)	-69%
	EB	56	25	(31)	-55%	131	73	(58)	-44%
	Total	**153**	**41**	**(112)**	**-73%**	**352**	**141**	**(211)**	**-60%**
Hesperian Blvd btwn I-238 & Springlake Dr	SB	131	76	(55)	-42%	267	182	(85)	-32%
	NB	112	36	(76)	-68%	203	96	(107)	-53%
	Total	**243**	**112**	**(131)**	**-54%**	**470**	**278**	**(192)**	**-41%**
SR 13 (Ashby Ave) btwn 7th St & UPRR tracks (overhe	WB	136	73	(63)	-46%	254	181	(73)	-29%
	EB	90	193	102	114%	198	424	226	115%
	Total	**226**	**266**	**39**	**17%**	**452**	**605**	**154**	**34%**
SR 61 (Doolittle Dr) btwn Swan Way & Langley St	SB	61	60	(1)	-2%	129	133	3	2%
	NB	62	54	(8)	-13%	106	126	20	19%
	Total	**124**	**114**	**(9)**	**-8%**	**236**	**259**	**23**	**10%**
SR 61 (Doolittle Dr) btwn Davis St & Eden Rd	SB	171	236	65	38%	348	405	58	17%
	NB	121	157	36	30%	272	392	121	45%
	Total	**292**	**393**	**101**	**35%**	**619**	**798**	**179**	**29%**
SR 84 (Thornton Ave) btwn Dutra Way & Dondero Way	SB	76	25	(51)	-67%	168	45	(122)	-73%
	NB	81	32	(49)	-60%	171	59	(113)	-66%
	Total	**158**	**57**	**(100)**	**-64%**	**339**	**104**	**(235)**	**-69%**
SR 84 (Mowry Ave) btwn Mission Blvd (SR238) & Than	SB	55	24	(31)	-56%	109	54	(55)	-51%
	NB	70	50	(20)	-29%	139	135	(4)	-3%
	Total	**125**	**74**	**(51)**	**-41%**	**248**	**189**	**(59)**	**-24%**
SR 84 (Niles Canyon Rd) btwn Mission Blvd (SR238) &	SB	85	77	(8)	-10%	156	152	(4)	-3%
	NB	130	148	18	14%	270	727	457	169%
	Total	**215**	**225**	**10**	**5%**	**426**	**879**	**453**	**106%**
SR 84 (Airway Blvd) btwn Club House Dr & Kitty Hawk	SB	73	26	(47)	-64%	158	65	(93)	-59%
	NB	81	20	(60)	-75%	148	52	(96)	-65%
	Total	**153**	**46**	**(107)**	**-70%**	**306**	**117**	**(189)**	**-62%**
SR 185 (International Blvd) btwn Miller Ave & 23rd Ave	WB	78	16	(62)	-80%	180	69	(111)	-62%
	EB	82	48	(34)	-42%	167	130	(38)	-22%
	Total	**160**	**64**	**(97)**	**-60%**	**347**	**199**	**(149)**	**-43%**

PM 2-hour and PM 4-hour Truck Volume Validation - Year 2005									
		PM - 2hr Total Truck Volume Statistics				PM - 4hr Total Truck Volume Statistics			
Location	Dir	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]	Observed Truck Counts (C)	Estimated Truck Volume (V)	Error (V-C)	Percent Error [(V-C)/C]
SR 185 (E 14th St) btwn Hesperian Ave & 148th Ave	WB	129	17	(111)	-86%	255	48	(207)	-81%
	EB	106	41	(65)	-61%	197	129	(68)	-34%
	Total	**235**	**59**	**(176)**	**-75%**	**452**	**178**	**(274)**	**-61%**
SR 260 Tube Portal	SB	271	215	(56)	-21%	482	393	(89)	-18%
	NB	170	151	(19)	-11%	349	326	(23)	-7%
	Total	**441**	**366**	**(75)**	**-17%**	**830**	**718**	**(112)**	**-13%**
SR 262 (Mission Blvd) btwn Kato Rd/Warren Ave & Wa	WB	115	958	843	733%	221	1,767	1,546	699%
	EB	164	479	315	192%	394	1,130	736	187%
	Total	**279**	**1,437**	**1,158**	**415%**	**615**	**2,897**	**2,282**	**371%**
Martime St south of Grand Ave	SB	89	415	326	366%	197	768	571	291%
	NB	166	347	181	109%	288	649	361	126%
	Total	**255**	**761**	**506**	**198%**	**484**	**1,417**	**933**	**193%**
7th St west of I-880	WB	191	317	127	67%	437	569	133	30%
	EB	422	349	(72)	-17%	686	689	3	0%
	Total	**612**	**667**	**55**	**9%**	**1,123**	**1,258**	**135**	**12%**
Middle Harbor Rd south of 3rd St	SB	59	110	51	87%	150	205	55	37%
	NB	273	105	(168)	-62%	416	207	(209)	-50%
	Total	**331**	**215**	**(117)**	**-35%**	**566**	**412**	**(154)**	**-27%**
98th Ave btwn I-880 & Empire	WB	184	179	(5)	-3%	395	248	(147)	-37%
	EB	172	102	(70)	-40%	345	184	(161)	-47%
	Total	**355**	**281**	**(74)**	**-21%**	**741**	**432**	**(309)**	**-42%**
Doolittle Dr btwn Adams & Airport Dr	SB	151	221	69	46%	288	381	93	32%
	NB	91	143	52	57%	198	369	171	86%
	Total	**242**	**363**	**121**	**50%**	**486**	**750**	**264**	**54%**
GRAND TOTAL		**38,497**	**38,832**	**335**	**1%**	**77,628**	**79,496**	**1,869**	**2%**

Appendix D. Glossary

Acronym	Definition of Acronym
AADT	Annual Average Daily traffic
ABAG	Association of Bay Area Governments
CFS	Commodity Flow Survey
CS	Cambridge Systematics, Inc.
CTP	Countywide Transportation Plan
DOT	Department of Transportation
EI-IE-EE	External Internal/Internal External/External External
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
GVW	Gross Vehicle Weight
HGAC	Houston-Galveston Area Council
IE/EI	Internal External/External Internal
I-O	Input-output Model
LAMTA/MTA/Metro	Los Angeles Metropolitan Transit Authority
MPO	Mariposa Association Government
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
NAICS	North American Industries Classification System
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
O-D table	Origin-Destination table
ODME	Origin Destination Matrix Estimation
PCE	Passenger Car Equivalents
pcphpl	passenger car per hour per lane
PeMS	Performance Management System
QRFM	Quick Response Freight Manual

Acronym	Definition of Acronym
RMSE	Root Mean Square
R-squared	overall goodness of fit measure
SCAG	Southern California Association of Governments
SMILE	Strategic Model for Integrated Logistics Evaluation
TAZ	Traffic Analysis Zone
TLFD	Trip Length Frequency Distribution
TNO Inro	Dutch organization for scientific research
VMT	Vehicle Miles of Travel
VTA	Santa Clara Valley Transportation Authority