SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS

SCAG 2008 Regional Model

SCAG Regional Travel Demand Model and 2008 Model Validation

June 2012

Compiled and Edited by:

LSA
LSA ASSOCIATES, INC.

Model Enhancement Consulting Team:

CAMBRIDGE SYSTEMATICS
PARSONS BRINCKERHOFF
WilburSmith ASSOCIATES
CDM

SCAG Regional Travel Demand Model and 2008 Model Validation

June 2012

Funding: The preparation of this report was financed in part through grants from the United States Department of Transportation (DOT). The contents of this report do not necessarily reflect the official views or policy of the U.S. Department of Transportation.

SCAG Regional Travel Demand Model and 2008 Model Validation

June 2012

Table of Contents

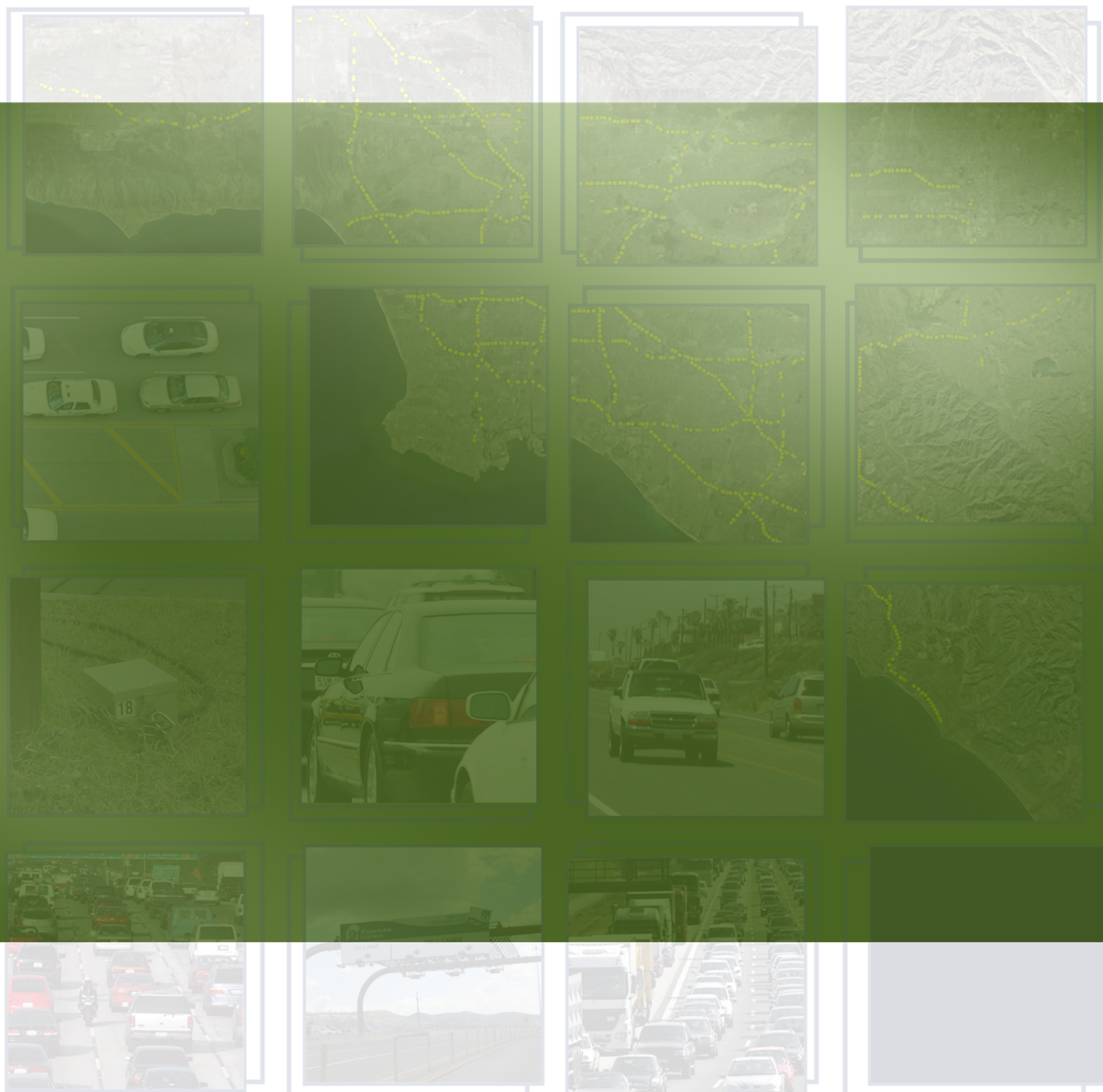
TABLE OF CONTENTS – EXPANDED

List of Tables

List of Figures

THIS PAGE LEFT INTENTIONALLY BLANK

PREFACE



PREFACE

Questions about the content of this report, as well as requests for more detailed information, should be directed to Jonathan Nadler, SCAG's Manager of Regional Transportation Modeling, at (213) 236-1884 or via e-mail at nadler@scag.ca.gov.

The Southern California Association of Governments (SCAG) is a voluntary association of six counties - Los Angeles, Orange, Ventura, Riverside, San Bernardino, and Imperial - and of 191 cities within those counties. SCAG's organizational purpose is cooperative planning and governmental coordination at the regional level. SCAG is mandated by State and federal law to plan and implement a Regional Transportation Plan (RTP) (updated every four years), a bi-annual Federal Transportation Improvement Program (FTIP), and to identify and analyze Transportation Control Measures (TCMs) and Transportation Strategies for incorporation into the South Coast Air Quality Management Plan (AQMP).

This report describes how SCAG forecasts travel behavior for the Southern California Region using computer-based software programs also known as the Regional Transportation Model. The specific focus of this report is on the transportation modeling procedures that have been used to produce travel forecasts for the Year 2008, including recent enhancements to the model to augment its capabilities in addressing policy directives and other transportation programs.

Year 2008 is the base year for the transportation planning period and the Regional Transportation Model. This model base year is also being applied as part of the RTP, the AQMP update, and in Congestion Management Programs (CMPs) prepared by individual counties within the Southern California Region.

The Regional Transportation Model provides a common foundation for transportation planning and decision-making by SCAG and other agencies within the Region. The Year 2008 base year travel data contained in this report will be referenced by, and of interest to, the general public, as well as local, State, and federal agencies involved in transportation planning and traffic engineering. A number of State, sub-regional, and local agencies in the SCAG Region also perform travel demand model forecasting for their own transportation planning and engineering purposes. These modeling programs require a high degree of coordination and cooperation with SCAG's Regional modeling program.

State agencies involved in travel forecasting include the California Department of Transportation (Caltrans) Districts 07, 08, 11, and 12. Sub-regional agencies include the Los Angeles County Metropolitan Transportation Authority (LACMTA), the Orange County Transportation Authority (OCTA), the Riverside County Transportation Commission (RCTC), San Bernardino Associated Governments (SANBAG), the Ventura County Transportation Commission (VCTC), the Imperial County Transportation Commission (ICTC), the County of Orange Environmental Management Agency, and other regional and local transportation agencies. Local agencies include cities and counties within the Region also maintain transportation modeling programs. Several of these agencies have contributed directly to preparation of SCAG's Year 2008 Model Validation.

This report summarizes the enhancement, calibration, and validation of the SCAG Regional Transportation Model to the new 2008 base year. This model update was performed in preparation for the development and evaluation of the SCAG 2012-2035 Regional Transportation Plan/Sustainable Communities Strategies (RTP/SCS). The new modeling capabilities introduced as part of this update address the need for evaluating a wide variety of projects and transportation policies, including the addition of highway pricing strategies, expansion of existing transit services, introduction of new types of transportation services (such as bus rapid transit and high speed rail), and land use policies. This updated model has enhanced sensitivities to evaluate the land use and transportation policy scenarios that are envisioned by California's greenhouse gas (GHG) emission reduction legislation, Senate Bill (SB) 375, and meets the requirements and recommendations in the California Transportation Commission's 2010 RTP Guidelines.

The 2012 RTP Model exhibits several new features, relative to the previous model:

- Trip market strata defined by car sufficiency and household income groups,
- Updated auto ownership model, sensitive to transit and non-motorized accessibility, multi-dwelling family housing, and residential and employment mixed use densities,
- Added auto ownership sensitivity in the destination choice and mode choice models,
- Updated HBW trip production cross-classification model,
- Destination choice model, replacing the previous gravity models for all purposes except home-based college and school trips,
- Re-designed and re-calibrated mode choice model,
- Multi-tiered zone system, consisting of approximately 11,267 zones used thru mode choice, and 4,109 zones used for time-of-day and assignment,
- Addition of a binary toll/no toll choice model to the mode choice model,
- Enhanced sensitivity to housing and employment density, mixed land use development, and accessibility to destinations by transit and non-motorized travel in trip distribution and mode choice models, and
- Ability to forecast intra-regional high-speed rail ridership,
- An HOV diversion model applied prior to highway assignment to split carpool trips between vehicles that use the HOV lanes and vehicles that remain on the general purpose flow lanes,
- Updates to the Heavy-Duty Truck Model, and
- Refinement of congestion and pricing components in the model.

The Year 2008 model results have been compared to independent sources of travel data within the Region, such as auto and truck traffic counts, transit boarding counts, Vehicle Miles of Travel (VMT) from Highway Performance Monitoring System (HPMS), speed data from Freeway Performance Measurement System (PeMS), and other travel survey data. The Regional Transportation Model sufficiently replicates the observed validation data as described herein. As such, the model is validated for use in preparing travel forecasts for the SCAG 2012-2035 RTP/SCS.

Chapter 1 – Overview

Contents

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Chapter 1 – Overview

Introduction

This Validation Summary Report combines information from several documents and other sources related to the enhancement and validation of the 2008 Regional Travel Demand Model (Regional Model) for Southern California. The Regional Model is managed and operated by the SCAG with development assistance from private consulting firms and academic institutions. Expert panels have overseen the development/enhancement of specific modeling components, and a Peer Review panel was assembled to review the model enhancements and validation. This report assisted the Peer Review panel in their efforts as it summarizes all of the validation material in one document for easy reference. A summary of the Peer Review is included at the end of this Report.

SCAG has evolved over the past four decades into the largest of nearly 700 councils of government in the United States. SCAG functions as the Metropolitan Planning Organization for six counties: Los Angeles, Orange, San Bernardino, Riverside, Ventura, and Imperial. The region encompasses a population exceeding 18 million persons in an area of more than 38,000 square miles.

SCAG is the primary agency responsible for the development and maintenance of travel demand forecasting models for the SCAG region. SCAG has been developing and improving these travel demand forecasting models since 1967. SCAG applies the models to provide state of the practice quantitative analysis for the RTP, the FTIP, and AQMPs. The Regional Model is also used to evaluate other transportation proposals within the region. The model is based on Caliper Corporation's TransCAD modeling software.

One of the key factors behind the current model update is California's SB 375 that requires metropolitan areas, such as the SCAG region, to meet regional GHG emission reduction targets for 2020 and 2035. The requirements of SB 375 and the model's implementation and function in this regard were key topics for the Peer Review.

SCAG updated the Regional Travel Demand Model for use in the 2012 RTP/SCS analysis, including a major enhancement to the mode choice model component. Enhancements to the Heavy Duty Truck Model and the sensitivities to pricing strategies of the Regional Transportation Demand Model were developed as part of SCAG's Comprehensive Goods Movement Study and Congestion Pricing Study, respectively.

California Senate Bill 375 and Sustainable Communities Strategies

SB 375 became law in California effective January 1, 2009. This law requires California's Air Resources Board (ARB) to develop regional greenhouse gas emission reduction targets for passenger vehicles for 2020 and 2035 for each region covered by one of the State's 18 MPOs, including SCAG. SB 375 was adopted as an "implementation mechanism" for California's Assembly Bill (AB) 32, the Global Warming Solutions Act, which requires 2020 greenhouse gas emissions statewide to be no higher than 1990 levels.

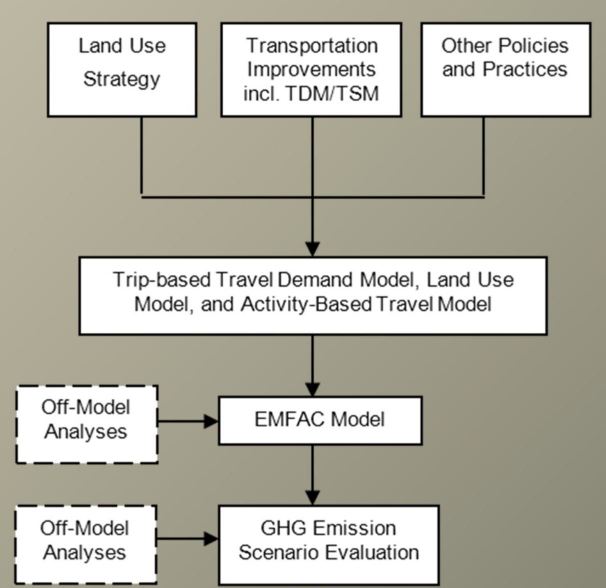
Each MPO is required to develop a Sustainable Communities Strategy that demonstrates how the region will meet the greenhouse emission reductions specified by the ARB targets through an integrated process that combines land use, housing, and transportation planning. The SCS becomes part of the Regional Transportation Plan.

SCAG's SCS scenarios comprise seven elements of strategies:

- Land Use and Growth
- Highways and Arterials
- Transit
- Travel Demand Management
- Non-Motorized Transportation System
- Transportation System Management
- Pricing

ARB's website for SB 375 is located at:
www.arb.ca.gov/cc/SB 375/SB 375.htm

Proposed Technical Methodology for Estimating GHG Emissions



Technical Approach of the Validation Process

Model validation is defined as the process by which base year model results are compared to known sources of data such as traffic counts and transit ridership data. SCAG performs a validation of its transportation model at the beginning of each planning cycle for the Southern California region. A planning cycle is typically four years, corresponding to the update of the RTP. The "base year" for the current planning period and model is 2008; and 2035 is the forecast year.

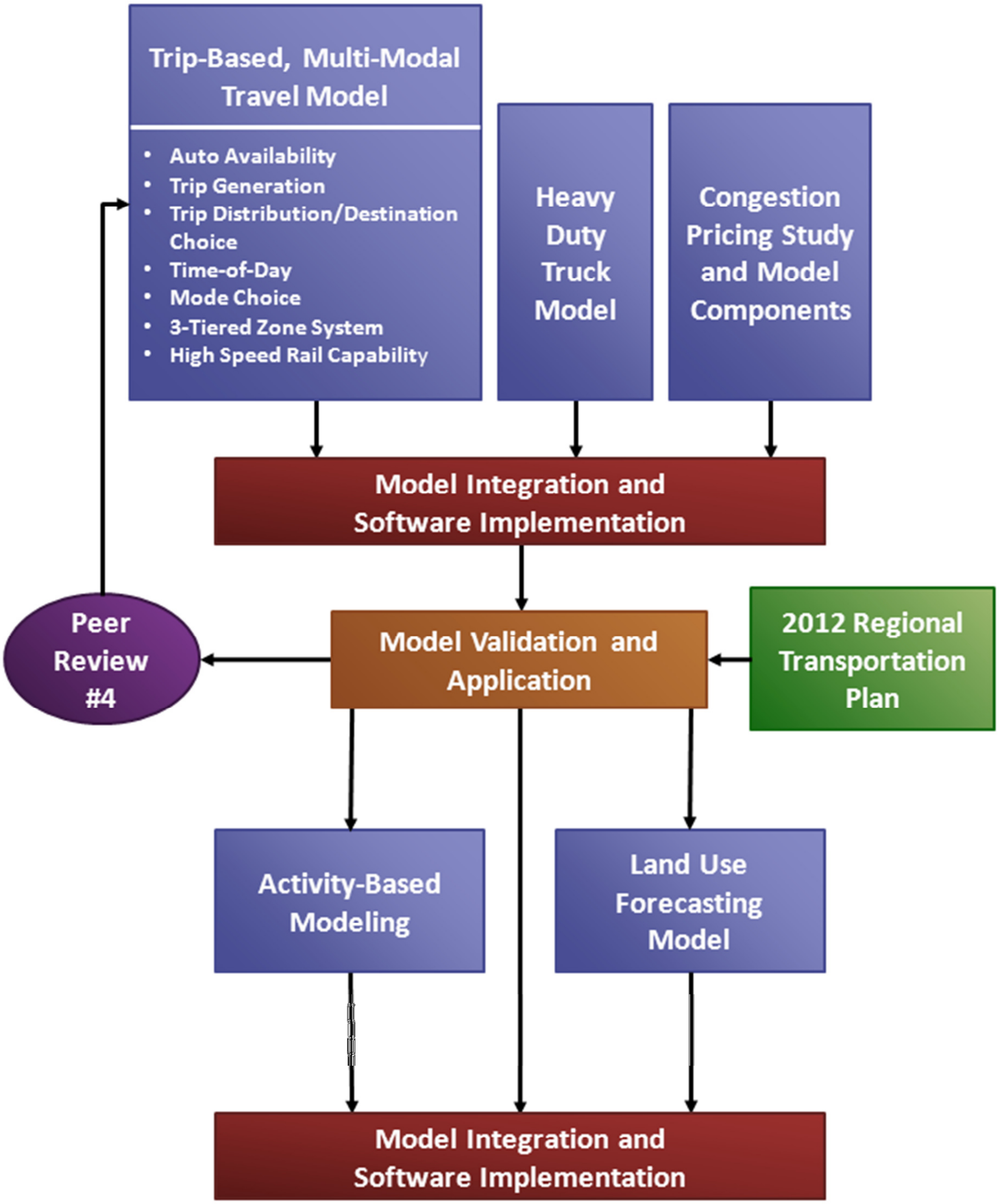
Model validation is a regular and essential modeling process that supports the development of the RTP, RTIP, and AQMPs. In the past, SCAG has prepared a model validation report for each of the previous planning cycle model base years: 1980, 1984, 1987, 1990, 1994, 1997, 2000, and 2003. The base year of 2008 in the current model replaces the previous base year of 2003.

Overview of Model Enhancements

SCAG's model improvement program, shown in Figure 1-1, is an ongoing process. Specific improvements to update the SCAG model to the 2008 base year and to enhance the model's operation and performance have been conducted over the past three years. These enhancements include:

1. The 2012 RTP Model exhibits several new features relative to the previous 2008 RTP Model, including:
    a. Trip market strata defined by car sufficiency and household income groups;
    b. Updated auto ownership model, sensitive to transit and non-motorized accessibility, multi-dwelling family housing, and residential and employment mixed use densities;
    c. Added auto ownership sensitivity in the destination choice and mode choice models;
    d. Updated HBW trip production cross-classification model;
    e. Destination choice model, replacing the previous gravity models for all purposes except home-based college and school trips;
    f. Re-designed and re-calibrated mode choice model;
    g. Multi-tiered zone system, consisting of approximately 11,267 zones used through mode choice, and 4,109 zones used for time-of-day choice and assignment;
    h. Addition of a binary toll/no toll choice model to the mode choice model;
    i. Enhanced sensitivity to housing and employment density, mixed land use development, and accessibility to destinations by transit and non-motorized travel in trip distribution and mode choice models;
    j. Ability to forecast intra-regional high-speed rail ridership and its impact on the region's other transit systems;
    k. An HOV diversion model applied prior to highway assignment to split carpool trips between vehicles that use the HOV lanes and vehicles that remain on the general purpose flow lanes;
    l. Updates to the Heavy-Duty Truck Model; and
    m. Refinement of congestion and pricing components in the model.

Figure 1-1: SCAG Model Enhancement Program



Below is a list of critical model improvements and database development projects which supported the Year 2008 Model Validation. Many of these projects were consultant aided. Completed projects include:

- Development of a Tiered Zone System (July 2010)
- Regional Highway Network Inventory (June 2009)
- Base Year Highway Network (Sept. 2010)
- Transit LOS Data Collection (June 2010)
- Base Year Transit Network (Sept. 2010)
- Arterial Speed Study (Feb. 2010)
- Screenline Traffic Count database (March 2010)
- Sustainability Tool (June 2010)
- Trip-Based Model Update / Validation (June 2011)
- Heavy Duty Truck Model Updates / Validation (June 2011)
- Congestion Pricing Study and Model Updates / Validation (June 2011)
- Land Use Model - Phase I (June 2011)
- Peer Review (June 2011)

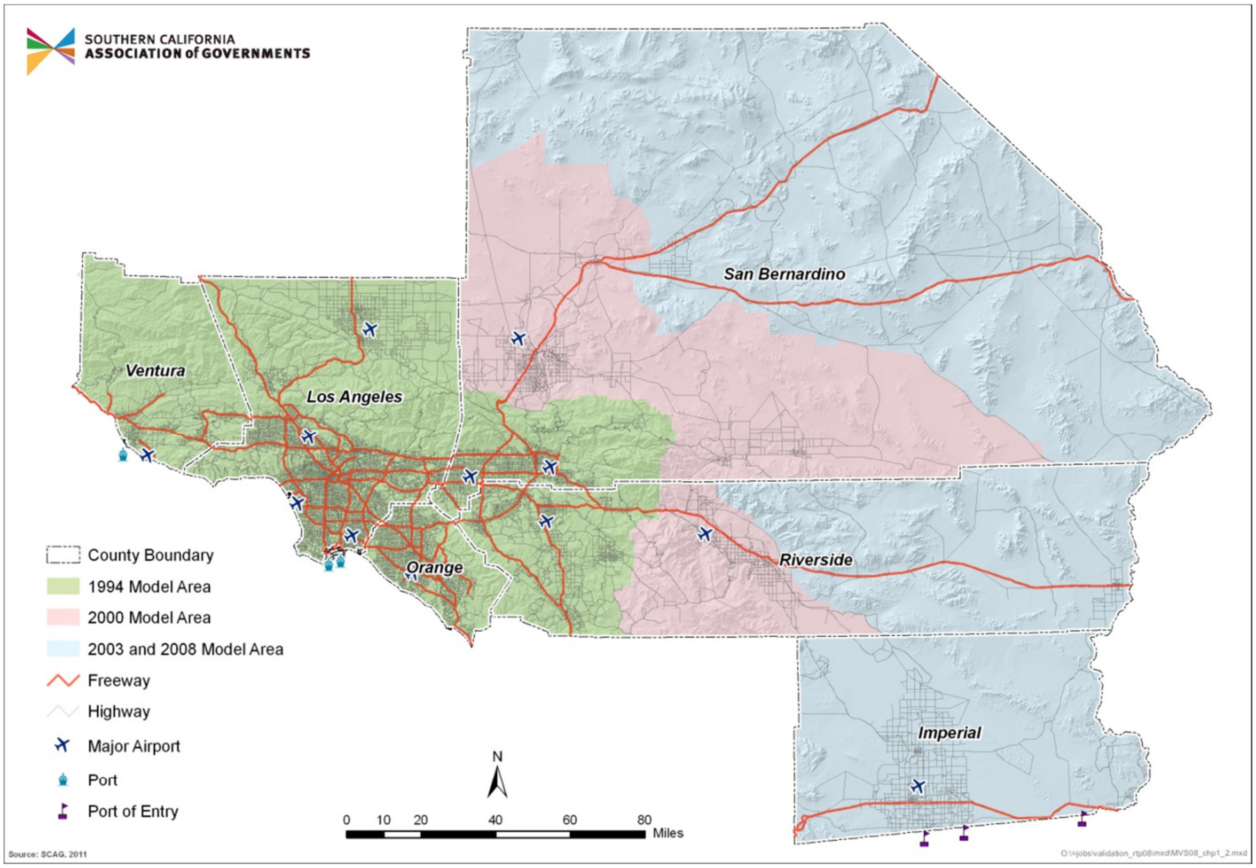
Modeling Area

The modeling area of the 2008 SCAG Regional Travel Demand Model covers the following six counties in their entirety:

- Imperial County,
- Los Angeles County,
- Orange County,
- Riverside County,
- San Bernardino County, and
- Ventura County.

Figure 1-2 shows the Modeling Area. The figure also indicates how the modeling area has expanded over time.

Figure 1-2: Modeling Area



Zone System

Socioeconomic data and other information for the model are contained in geographically defined areas known as Transportation Analysis Zones (TAZ). The TAZs are attached to the networks using centroid connectors that allow travelers (trips) access to the transportation system by simulating local and neighborhood streets. They provide the spatial unit (or geographical area) within which travel behavior and traffic generation are estimated. TAZs are ideally but not always sized and shaped to provide a relatively homogeneous amount and type of activity.

The SCAG model uses a tiered zone system structure as shown in Figure 2-2 that allows for micro (i.e., neighborhood) and macro-scale (i.e., regional) analysis and reporting.

In order to more accurately model detailed travel movements throughout the region for the base and horizon years, the TAZ structure has been modified to enhance the precision of micro-level land use and smart growth analysis for the RTP/SCS. In addition, The Model contains 40 external stations to facilitate modeling of trips to, from, and through the region. The TAZ modification process involved extensive coordination with sub regional modeling agencies throughout the region. The Regional Model includes two tiers of TAZ. The first tier contains 4,109 internal zones, while the second tier contains 11,267 internal zones. All Tier 2 zones nest within Tier 1 zones. Table 1-1 and Figure 1-3 provide statistical information and a graphical display of the zone structure.

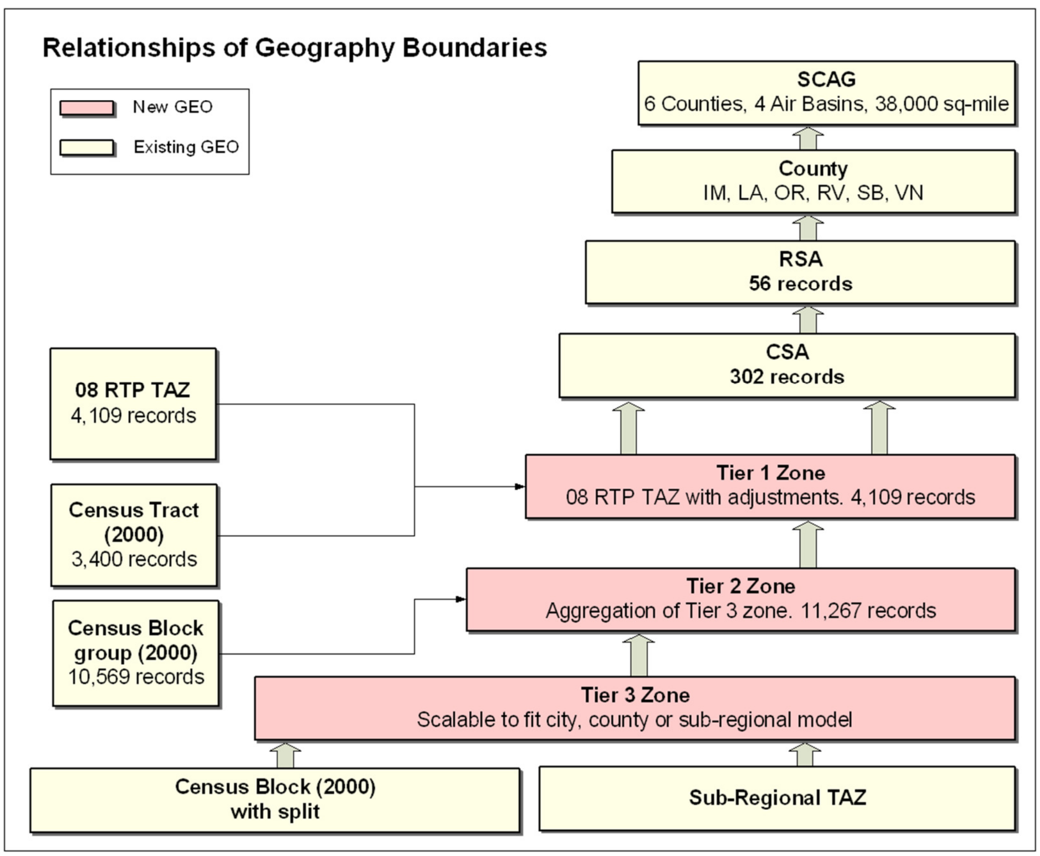
Table 1-1: Summary of TAZ Statistics

Modeling Area	2000 Census Tract	2000 Census Block Group	RSA *	CSA**	08 RTP TAZ (Internal)	Tier 1 Zone (Internal)	Tier 2 Zone (Internal)
Imperial County	29	105	1	15	110	110	239
Los Angeles County	2,052	6,345	21	155	2,243	2,243	5,697
Orange County	577	1,826	10	43	666	666	1,741
Riverside County	343	804	11	38	478	478	1,532
San Bernardino County	244	1,099	7	34	402	402	1,395
Ventura County	155	390	6	17	210	210	663
Total	**3,400**	**10,569**	**56**	**302**	**4,109**	**4,109**	**11,267**

**RSA – Regional Statistical Area*

***CSA - Community Statistical Area*

Figure 1-3: Structure of the Tiered Zone System in the SCAG Model



Methodology

A tiered TAZ system was jointly developed by SCAG and its member agencies, based on sub-regional TAZs and SCAG MPUs (Minimum Planning Units). MPUs are based on 2009 Census Block data with some splits added according to major road, natural and artificial barriers, satellite photo, land use, and local inputs. The TAZ Tier 1 is an aggregation of TAZ Tier 2 zones, which matches the total number and general geography of the previous Regional TAZs.

The following provides a description of the principles that guided the development of the new Regional TAZ System. These principles follow standard modeling practice.

- ***Consistency with 2009 TIGER/Line Tract Boundaries*** – Both tiers of the Regional TAZs are consistent with Census 2009 TIGER/Line Tract boundaries. Regional TAZs are either entire census tracts or are wholly contained within a census tract. Some exceptions occur where census tracts consist of multi-part polygons or local inputs provide better boundaries.

- ***Consistency with 2009 TIGER/Line Block Group or Sub-regional TAZ Boundaries*** – The Tier 2 of the Regional TAZs is consistent with Census 2009 TIGER/Line block group or sub-regional TAZ boundaries. A Tier 2 zone is either an entire census block group or an aggregation of census block groups. When a sub-regional zone is available and provides a better representation, the Tier 2 zone for that area is either an entire sub-regional zone or an aggregation of sub-regional zones.

- ***Consistency between the Two Tiers of the Regional TAZ System*** – The Tier 2 zones of the Regional Model's TAZ system are consistent with the Tier 1 zones. Tier 2 zones consist either of an entire Tier 1 zone or are wholly contained within a Tier 1 zone.

- ***Consistency with 2009 TIGER/Line Block Boundaries*** –To ease data collection and creation, zonal boundaries generally do not cross Census 2000 Blocks (updated boundary in 2009). Some exceptions occur where Census Blocks consist of multi-part polygons or local inputs provide better boundaries.

- ***Complement the Transportation System*** – A critical step in developing the TAZ system is defining the level of roadway facilities for which accurate forecasts are desired. To ensure an accurate distribution and traffic assignments, existing and future freeways and principal arterials are generally represented as regional TAZ boundaries, consistent with other zonal creation criteria.

- ***Homogeneous Land Use*** – Land use maps and general plan maps were used to identify existing and future land use. Ideally, it is best to limit the number of different land uses contained within a zone. However, given the geographic size of the regional TAZs and the mixed-use development patterns within the urban area, creating zones with uniform land uses was often difficult.

- ***Similar Population/Employment Size*** – Zones were developed to represent similar levels of future development (population and employment). This parameter was not strictly enforced given the sparse development of some areas, the intensity of nonresidential land uses within urban areas, and consideration for special generators (example - universities and airports).

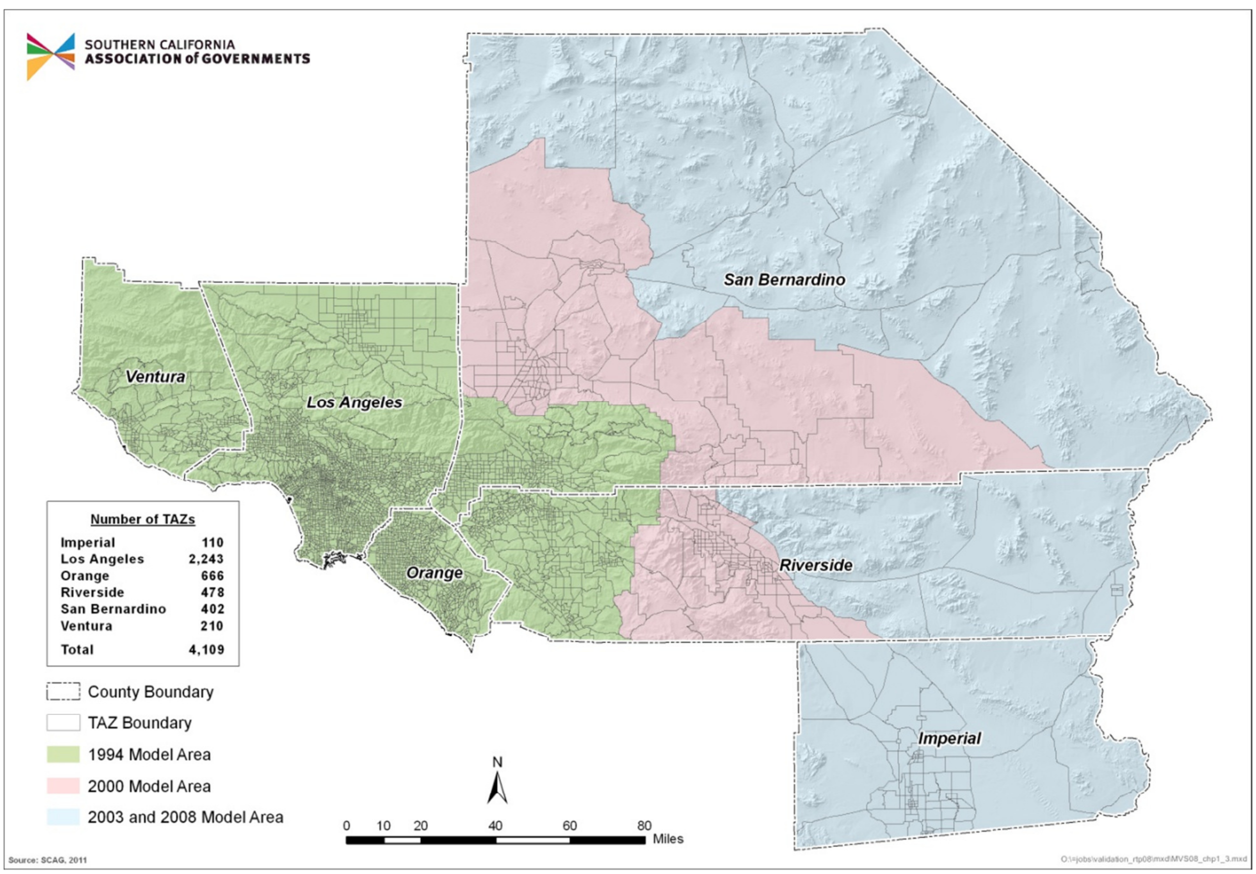
- ***Other Considerations*** – Natural and man-made boundaries are also considered in the definition of the zone system. Political jurisdictions, railroad lines, rivers, mountain ranges and other topographical barriers were considered in developing the two tiers of regional TAZs.

Procedures

Tier 2 zones originated from the 2009 TIGER/Line block group and sub-regional TAZ boundary files. ESRI ArcGIS was used to overlay these original maps with the existing TAZs, the highway network, land use maps, and satellite images. Then, the principles described above were applied. Where a Tier 2 zone needed to be subdivided, the 2009 TIGER/Line boundaries were followed. A tool, TAZDK, was developed in ArcGIS to assist data processing and quality control. Several analyses were undertaken to ensure that all Tier 2 zones were reasonable and that the entire SCAG area was covered by the new zones without slivers or overlaps.

Once a clean Tier 2 TAZ map was created, the final Tier 2 zones were aggregated into 4,109 Tier 1 zones based on the pattern of the previous regional TAZs. Before finalizing the new regional TAZ system, automatic and manual examinations were conducted to ensure consistency with the above principles. The draft and final zone systems were shared with sub regional modeling agencies for their review and concurrence. Figure 1-4 shows the Tier 1 TAZs.

Figure 1-4: Transportation Analysis Zone System (Tier 1)



Overview of the Peer Review Process

A robust peer review process is an important component of the SCAG model development program. SCAG's peer review process involves two levels of review and comment:

1) ***Expert Panels*** – SCAG assembled panels of experts for each of the major model improvement projects to provide review and guidance; and

2) ***Peer Review*** – Academic, MPO, Federal and other modeling experts to review SCAG's overall modeling program and modeling results to determine if they are satisfactory to support regional transportation planning analysis.

As stated previously, this is the fourth in a series of Peer Review panels convened by SCAG for regional travel model validations. Previous efforts occurred in January 2002 for the 1997 base year model; November 2003 for the 2000 base year model; and January 2006 for the 2003 base year model.

In 2002, SCAG initiated an effort to use new data to update and recalibrate its travel demand model. In January of that year, the first Peer Review of SCAG's model was conducted. At that time, the panel concluded that SCAG's model was at the leading edge of the state of the practice. The panel recommended several changes, including adding trip purpose, creating a vehicle availability model, and modifying the mode choice model. SCAG has implemented many of these recommendations.

The second Peer Review was held in November 2003. Topics reviewed during this meeting included validation targets, the revised vehicle availability model, trip generation, external trips, and the selection of variables for the mode choice model. At this same time, Cambridge Systematics was awarded a contract to address these concerns and update the travel demand model.

The third Peer Review in January 2006 focused on the previously updated model components, especially trip distribution, mode choice, and trip assignment. The panel determined that SCAG had developed a "state-of-the-practice" model. The panel highlighted several strengths, including the freight model, the strategic work trips, and the use of four time periods in assignment. The panel felt that SCAG had done a particularly good job with data collection, and that the planned speed study was a good next step.

Peer Review Panel #4

SCAG's 2008 Regional Travel Model Peer Review Panel was comprised of nationally-recognized experts in the fields of travel demand modeling and data collection and analysis. The panel members are shown in Table 1-2. A summary of the panel's recommendations are included in Appendix C –SCAG Model Peer Review #4.

Table 1-2: 2011 Regional Travel Model Peer Review Panel #4
(June 27-28, 2011)

Name	Organization
Guy Rousseau (Chair)	Atlanta Regional Commission
Chaushie Chu, Ph.D.	Los Angeles County Metropolitan Transportation Authority (Metro)
Chris Forinash	U.S. Environmental Protection Agency (EPA)
David Levinson, Ph.D.	University of Minnesota
David Ory, Ph.D.	Metropolitan Transportation Commission (MTC)
Eric Pihl	Federal Highway Administration (FHWA)
Kara M. Kockelman, P.E., Ph.D.	University of Texas, Austin; Expert Panel – Congestion Pricing
Ken Cervenka	Federal Transit Administration (FTA)
Mark Bradley	Mark Bradley Research and Consulting

Overview of Report

The input data, model enhancements, calibration, validation, and results of each of the modeling components of the SCAG 2008 Regional Model are summarized in the respective chapters:

- Chapter 1 – Overview
- Chapter 2 – Socioeconomic Input Data
- Chapter 3 – Trip Generation
- Chapter 4 – Transportation Networks
- Chapter 5 – Trip Distribution
- Chapter 6 – Mode Choice
- Chapter 7 – Heavy Duty Truck Model
- Chapter 8 – Trip Assignment

Supplemental information is contained in the following appendices:

- Appendix A - Highway Network Coding Conventions
- Appendix B – Auto Operating Costs
- Appendix C –SCAG Model Peer Review #4

THIS PAGE LEFT INTENTIONALLY BLANK

Chapter 2 - Socioeconomic Input Data

Contents

CHAPTER 2 – SOCIOECONOMIC INPUT DATA

Introduction

Socioeconomic data, which describes both demographic and economic characteristics of the region by TAZ, is used as major input to SCAG's travel demand model. Travel demand analysis is based on the concept that travel is a derived demand of activity participation. Zonal demographic data, such as population, households, and income, is directly related to demand for activity participation of the area; economic characteristics, such as jobs by industry, are linked with supply of an activity.

The socio-economic input data for year 2008 consists of various marginal and joint distributions of population and households for each TAZ. A total of 62 socio-economic variables and 7 joint distributions of two or more variables are developed as model inputs (see Tables 2-1 and 2-2). Those variables include population, households, school enrollments, household income, workers, and employment, etc. These variables are available for 4109 Tier 1 TAZs and 11,267 Tier 2 TAZs, respectively.

The marginal and joint distributions of socio-economic variables were developed by SCAG forecasting staff using diverse public and private sources of data and advanced estimation methods. The major data sources include 2000 and 2010 Census, 2000 Census Transportation Planning Package (CTPP), American Community Survey (ACS), California Department of Finance (DOF), California Employment Development Department (EDD), InfoUSA, 2008 Existing Land Use, 2008 County Assessor's Parcel Database.

The socio-economic input data at the TAZ level is estimated using three major processes: 1) development of three major variables (population, households, employment); 2) development of secondary variables (attributes of three major variables and workers); 3) development of joint distributions of population/households/workers by selected attributes.

Development of Three Major Variables

The household estimates at the TAZ level were initially derived by summing the Minimum Planning Unit (MPU) level household estimates within the TAZs. The MPUs are generally equivalent to parcels. The MPU level household estimates are derived using the following process: (1) add the new residential construction between 2000 and 2008 to 2000 MPU level housing estimates from 2000 Census; and (2) convert housing units into households using the 2000 vacancy rate. The MPU level household estimates are controlled to the 2008 city level household estimates.

TAZ population and household forecasts are derived with the housing unit (HU) method used in the city forecasts. The first step of the housing unit method is to project housing units at the TAZ level. Since SCAG focuses on the household forecast, SCAG derives initial TAZ household forecasts by reflecting growth patterns incorporated in the 2008 RTP forecasts, recent estimates and trends, and updated city household forecasts. The TAZ household forecast is converted into population by using the group quarters population plus the product of households and average persons per household (PPH).

Table 2-1: Description of Socio-Economic Variables

1.	**Population (8 variables)**
1.1.	Total Population: total number of people living within a zone. Total population is composed of residential population and group quarters population.
1.2.	Group Quarters (Non-Institutional) Population: is primarily comprised of students residing in dormitories, military personnel living in barracks, and individuals staying in homeless shelters. Group quarters (non-institutional) population does NOT include persons residing in institutions.
1.3.	Residential Population: the number of residents NOT living in “group quarters.”
1.4.	Group Quarters Population living in student dormitories: Population living in college dormitories (includes college quarters off campus).
1.5.	Population by Age (4 variables): the number of population for different age groups: 5-17, 18-24, 16-64, and 65+.
2.	**Households (26 variables)**
2.1.	Total Households: Household refers to all of the people who occupy a housing unit. By definition there is only one household in an occupied housing unit.
2.2.	Households by Household Size (4 variables): the number of one-person households, two-person households, three-person households, and four or more person households.
2.3.	Households by Age of Householder (4 variables): the number of households with age of householder between 18 and 24 years old, 25 and 44, 45 and 64, and 65 or older.
2.4.	Households by Number of Workers (4 variables): the number of households with no worker, with one worker, with two workers, and with three workers or more.
2.5.	Households by Household Income (4 variables): the number of households with annual household income (in 1999 dollars) of less than $24,999, $25,000-$49,999, $50,000-$99,999, and $100,000 or more.
2.6.	Households by Type of Dwelling Unit (2 variables): the number of households living in single-family detached housing, and living in other housing.
2.7.	Households by Number of College Students (3 variables): the number of households with no college student, with one college student, with two college students or more.
2.8.	Households by Number of Children age 5-17 (4 variables): the number of households with no child, with one child, with two children, and three children or more.
3.	**School Enrollment (2 variables)**
3.1.	K-12 School Enrollment: the total number of K-12 (kindergarten through 12th grade) students enrolled in all public and private schools located within a zone. All elementary, middle (junior high), and high school students are included. This variable represents “students by place of attendance.”
3.2.	College/University Enrollment: the total number of students enrolled in any public or private post-secondary school (college or university) that grant an associate degree or higher, located within a zone. This variable also represents "students by place of attendance."
4.	**Workers (4 variables)**
4.1.	Total Workers: total number of civilian workers residing in a zone. Workers are estimated by the place of residence.
4.2.	Workers by earning level (3 variables): the number of workers with earnings of less than $24,999, $25,000-$49,999, $50,000 or more.
5.	**Median Household Income (5 variables)**
5.1.	Median Household Income: Median Household Income is the median value of household income for all households within a zone. Household Income includes the income, from all sources, for all persons aged 15 years or older within a household.
5.2.	Median Household Income by Income Categories (4 variables): The median income is estimated for each of four different income categories: less than $24,999, $25,000-$49,999, $50,000-$99,999, and $100,000 or more.

6.	**Employment (17 variables)**
6.1.	The employment variables represent all jobs located within a zone (i.e., employment by place of work). Jobs are composed of wage and salary jobs and self-employed jobs. Jobs are categorized into 13 sectors based on North American Industry Classification System (NAICS) code definition.
6.2.	Total Employment: total number of jobs within a zone.
6.3.	Employment by 13 Industries: the number of total jobs for 1) agriculture & mining, 2) construction, 3) manufacturing, 4) wholesale trade, 5) retail trade, 6) transportation, warehousing, and utility, 7) information, 8) financial activities, 9) professional and business services, 10) education and health services, 11) leisure and hospitality services, 12) other services, and 13) public administration.
6.4.	Employment by wage level (3 variables): total number of jobs by three wage levels: of less than $24,999, $25,000-$49,999, $50,000 or more.

Table 2-2: Joint Distributions of Population/Households/Workers by Selected Attributes

1.	**Joint distribution of households by**
1.1.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+),
1.2.	Household size (1,2,3,4+ persons in household),
1.3.	Number of workers (0,1,2,3+ workers in household),
1.4.	Type of dwelling unit (single-family detached, other)
2.	**Joint distribution of households by**
2.1.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
2.2.	Number of workers (0,1,2,3+ workers in household),
2.3.	Age of head of household (18-24, 25-44, 45-66, 65+ years old)
3.	**Joint distribution of households by**
3.1.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
3.2.	Household size (1,2,3,4+ persons in household)
4.	**Joint distribution of persons by**
4.1.	Number of college students (0, 1, 2+),
4.2.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
5.	**Median household income by**
5.1.	Number of children age 5-17 (0,1,2,3+),
5.2.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
6.	**Joint distribution of households by**
6.1.	Age (0-4, 5-17, 18-24, 25+)
6.2.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
7.	**Joint distribution of households by**
7.1.	Worker's earnings (less than $24,999, $25,000-$49,999, $50,000+)
7.2.	Household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)

The average number of persons per household is projected using recent estimates and trends, and is constrained by the updated city PPH. Group quarters population is projected using the TAZ share of the city population from the 2000 Census and 2008 California Department of Finance (DOF). These shares are assumed to remain constant during the projection horizon. Finally, the adjusted TAZ level population and household estimates for the year 2008 were updated by backcasting the 2010 Census data (Redistricting Data [P.L. 94-171]) published in March 2011.

The employment estimates at the TAZ level were initially derived by using 2000 Census Transportation Planning Package (CTPP) and 2008 InfoUSA data, and controlled to the 2008 county level employment estimates from CA EDD. The employment estimates were projected using a constant-share method. The current TAZ share of employment for each sector remains constant during the forecast years. By using the constant share method, the TAZ job growth by sector is determined by the growth of the specific sector by city.

Development of Secondary Variables

Three major variables are further disaggregated into necessary attributes (e.g., age, persons per household, industry sectors, etc.), as required in the transportation demand model. The additional attribute variables are defined as the secondary variables. These secondary variables at the TAZ level are estimated using the Small Area Secondary Variables Allocation Model (SASVAM). SASVAM is generally based on the probabilistic choice model reflecting the temporal change of the individual attribute and the changing relationship of the related attributes.

Development of Joint Distributions of Population / Households / Workers by Selected Attributes

The marginal distribution of population/households/workers by selected attributes processed by SASVAM is further developed into joint distribution of population/households/workers by selected attributes using the Population Generator (PopGen) 1.1, developed by Arizona State University. PopGen 1.1 generates a synthetic population by expanding existing disaggregate sample data (from 2000 Census PUMS) to mirror known aggregate distributions of household and person attributes. A set of population and household variables of interest are used as control variables in the population synthesizer.

Socioeconomic Input Data Summary

The selected socioeconomic data inputs to the Year 2008 Model Validation process are presented in the following tables and figures. Table 2-3 presents a summary of socioeconomic data totals by county and for the SCAG Region. Figures 2-1 to 2-3 show 2008 population density, household income distributions, and employment density for the Tier 2 level TAZs.

Table 2-3: Year 2008 SCAG Model Socioeconomic Input Data

Population and Workers				
County	**Resident Population**	**Group Quarters Population (Non - Institutional)**	**Total Population**	**Resident Workers**
Imperial	158,302	0	170,003	52,187
Los Angeles	9,591,794	41,105	9,771,251	4,090,911
Orange	2,945,448	9,625	2,989,426	1,442,442
Riverside	2,092,986	4,010	2,128,305	720,480
San Bernardino	1,963,758	1,988	2,015,863	725,124
Ventura	799,146	1,373	813,037	369,128
Total	**17,551,434**	**58,101**	**17,887,885**	**7,400,272**

Households						
County	**Below 25k**	**25k - 50k**	**50k-100k**	**100k Over**	**Total Household**	**Household Size**
Imperial	23,649	12,755	10,008	2,199	48,611	3.26
Los Angeles	1,060,758	900,989	849,456	415,199	3,226,402	2.97
Orange	213,982	254,876	318,439	199,807	987,104	2.98
Riverside	205,951	196,439	202,302	74,075	678,767	3.08
San Bernardino	182,964	185,359	181,582	56,013	605,918	3.24
Ventura	57,510	66,392	91,364	50,251	265,517	3.01
Total	**1,744,814**	**1,616,810**	**1,653,151**	**797,544**	**5,812,319**	**3.11**

Employment				
County	**Retail**	**Service**	**Other**	**Total**
Imperial	8,162	29,508	23,834	61,504
Los Angeles	443,997	2,353,174	1,538,796	4,335,967
Orange	165,661	877,482	580,918	1,624,061
Riverside	90,684	354,700	218,566	663,950
San Bernardino	89,569	374,342	236,692	700,603
Ventura	40,519	170,071	137,130	347,720
Total	**838,592**	**4,159,277**	**2,735,936**	**7,733,805**

School Enrollment		
County	**K Thru 12 Enrollment**	**College and University Enrollment**
Imperial	37,962	11,234
Los Angeles	1,991,198	730,381
Orange	576,343	230,736
Riverside	434,335	107,644
San Bernardino	454,237	135,407
Ventura	164,848	52,495
Total	**3,658,923**	**1,267,897**

Figure 2-1: Population Density (2008)

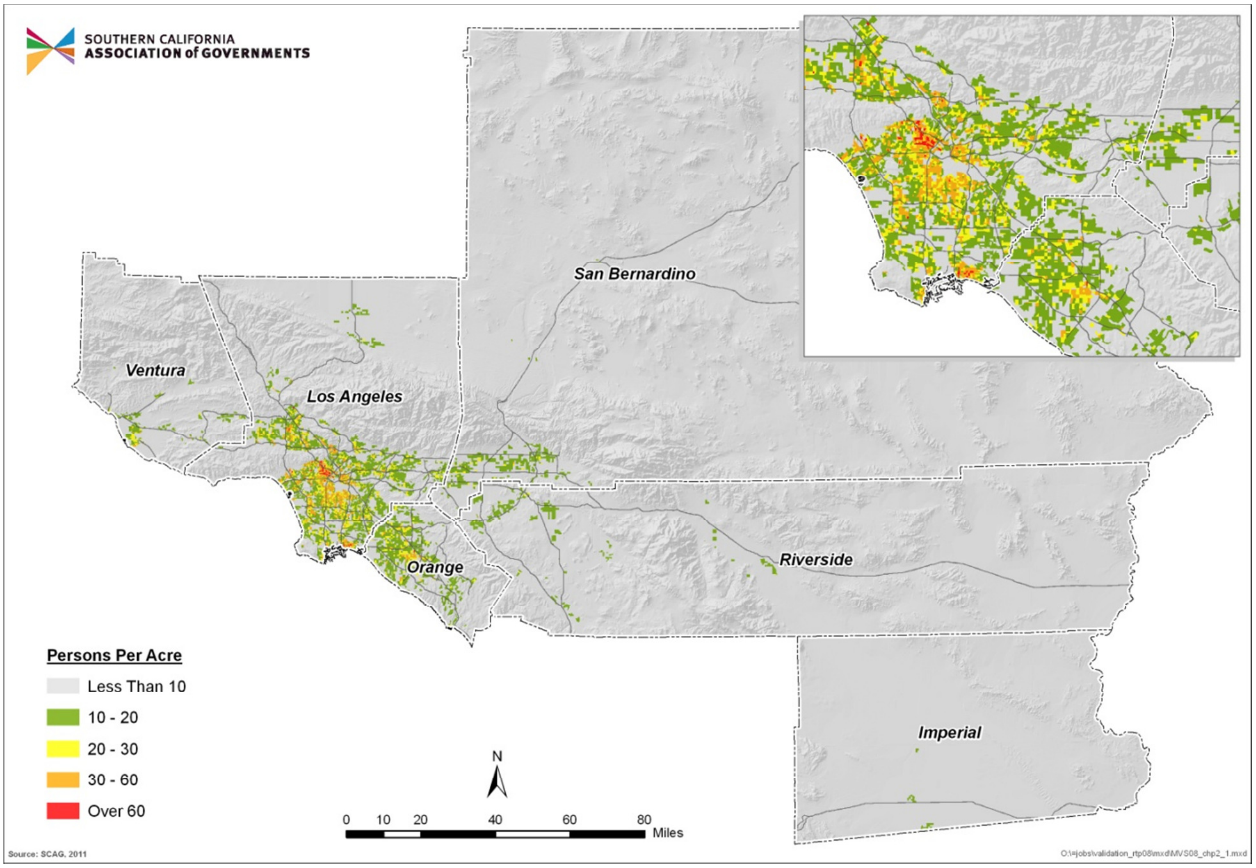


Figure 2-2: Household Income Distributions (2008)

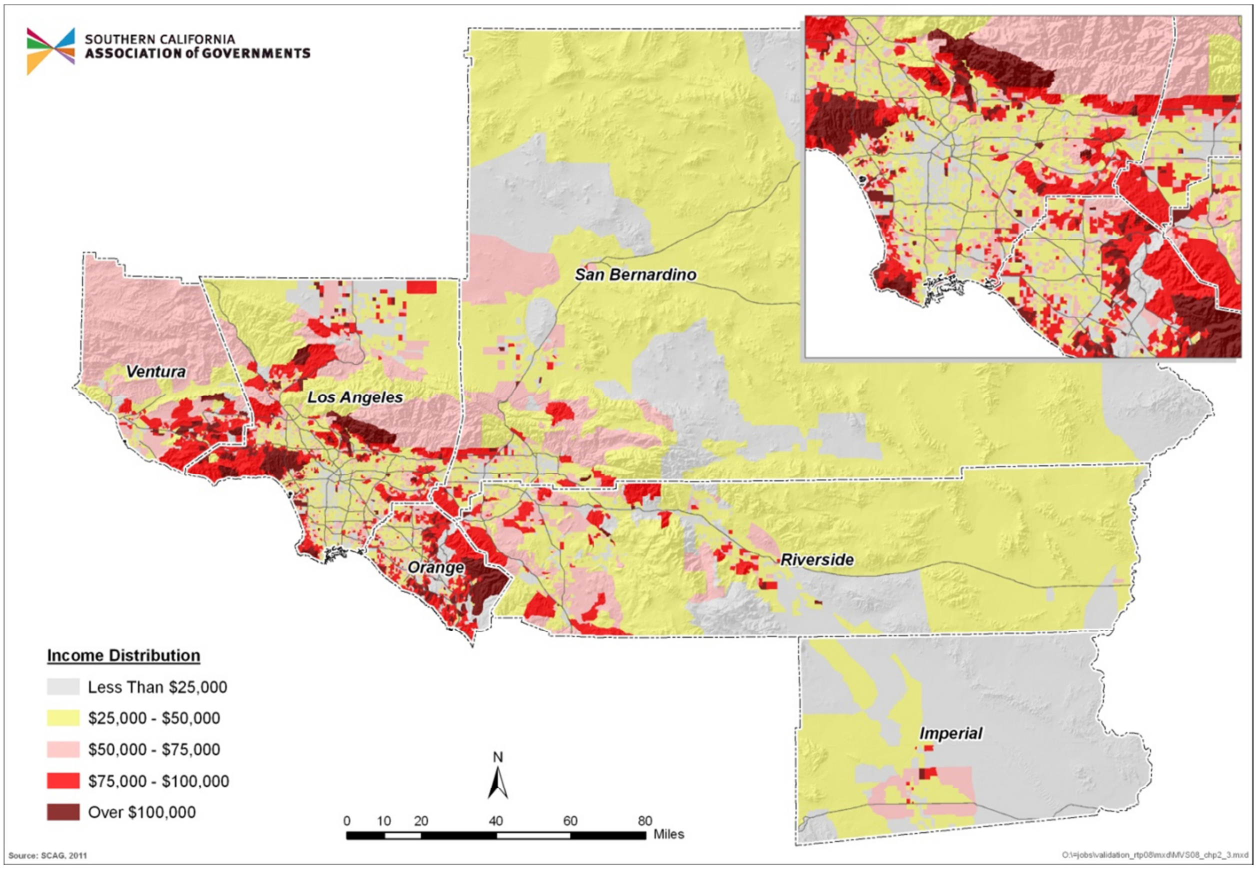
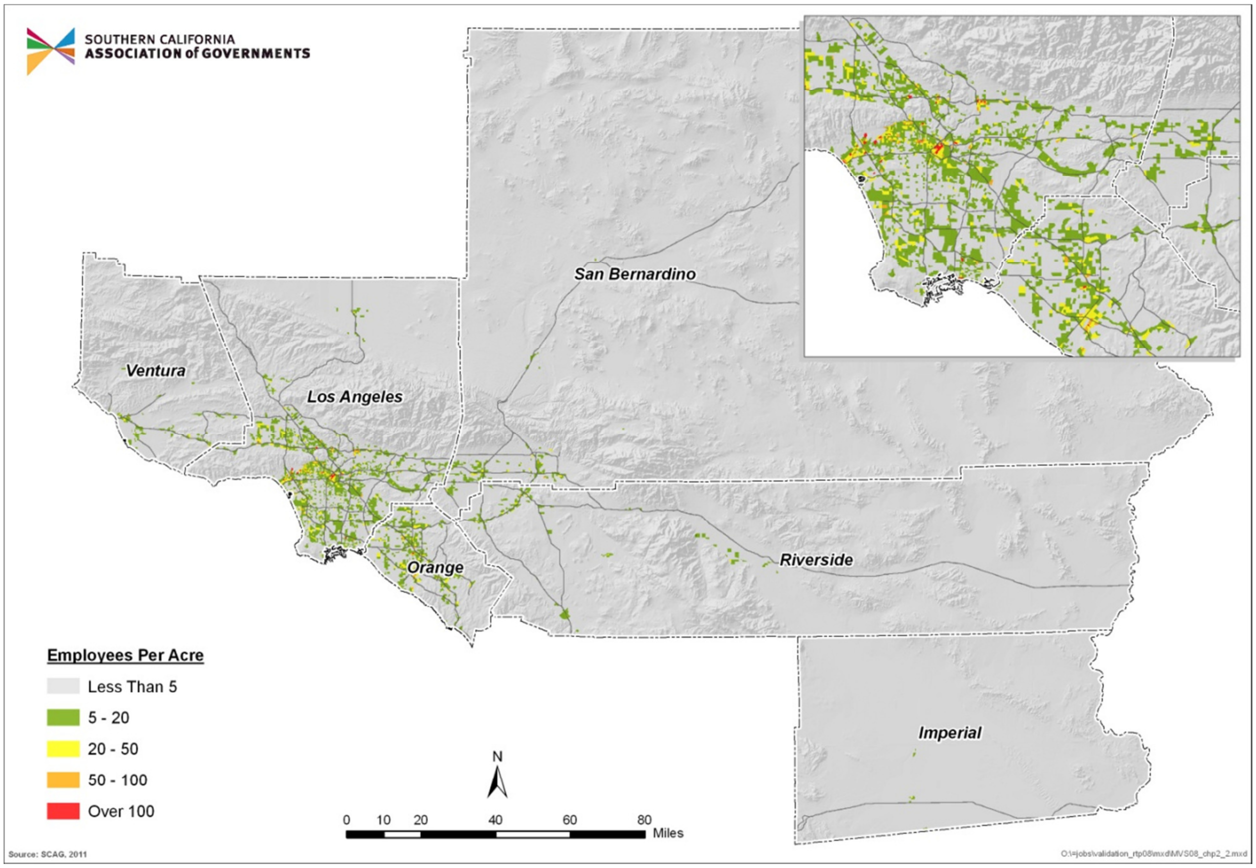


Figure 2-3: Employment Density (2008)



CHAPTER 3 – TRIP GENERATION

Contents

CHAPTER 3 – TRIP GENERATION

Introduction

Trip generation is the process of estimating daily person trips for an average weekday generated by households within each TAZ. The Year 2008 Model contains a series of models to estimate trip productions and trip attractions by trip type. The trip production models estimate the number of person trips generated in each TAZ, and trip attraction models estimate the number of person trip attracted to each TAZ. Trip generation estimates trip production and attraction at the Tier 2 zonal level. The trip generation component includes an Auto Availability model, which forecasts the number of vehicles available to each household in the region. Auto availability, along with household income, household size, number of workers and other variables are used to forecast trip productions, while trip attractions are a function of land use activity measures such as employment, residential households, and school enrollment.

Trip Purpose

The model uses an expanded set of trip purposes. This was done to improve trip distribution and mode choice estimates, and to more accurately link trip productions and trip attractions. The model contains 10 trip purposes, each subdivided into different household markets. Total trips produced by TAZ were estimated for each of the following trip purposes and household segments:

1. Home-Based Work

There are two types of home-based work trips: "direct" home-based work trips and "strategic" home-based work trips. "Direct" home-based work (HBWD) trips are trips that go directly between home and work, without any intermediate stops. "Strategic" home-based work (HBWS) trips are trips between home and work that include one or more intermediate stops, such as to drop-off or pick-up a passenger, to drop-off or pick-up a child at school, or for other reasons. The trip generation model estimates HBWD and HBWS trips for five household markets, which are carried through trip distribution and mode choice:

- Zero Car Households
- Car Insufficient Households
- Car Sufficient Households, Low Income (less than $25,000)
- Car Sufficient Households, Medium Income ($25,000 to $49,999)
- Car Sufficient Households, High Income ($50,000 or greater)

2. Home-Based School

Home-based school (HBSC) trips include all student trips with an at-home activity at one end of the trip and a Kindergarten through 12th grade (K-12) school activity at the other end. This purpose does not include trips in the college/university category, which follows.

3. Home-Based College and University

Home-based college and university (HBCU) trips include all trips made by persons over the age of 18 with an at-home activity at one end of a trip and a college or university activity at the other end.

4. Home-Based Shopping

Home-based shopping (HBSH) trips include all person trips made with a home activity at one end of a trip and a shopping activity at the other end. The trip generation model estimates HBSH trips for the same five household markets used for HBW trips. This auto sufficiency / household income segmentation is maintained in trip distribution and mode choice. Auto sufficiency is measured differently for work and non-work trips, as described in Table 3-12 below.

5. Home-Based Social-Recreational

Home-based social-recreational (HBSR) trips include all person trips made with a home activity at one end of a trip and a visiting or recreational activity at the other end. The model estimates HBSR trips for the five household markets used for HBSH trips, maintained through trip distribution and mode choice.

6. Home-Based Serving-Passenger

Home-based serve passenger (HBSP) trips include all person trips made with a home activity at one end of a trip and a passenger serving activity, such as driving someone to somewhere, at the other end. Trips that serve passengers while on the way to work are classified as home based work strategic trips rather than serve passenger trips because they are part of a work trip chain. The model estimates HBSP trips for the five household markets used for HBSH trips, also maintained through trip distribution and mode choice.

7. Home-Based Other

Home-based other (HBO) trips include all other home-based (with a home activity at one end of a trip) trips that are not already accounted for in any of the home-based trips categories described above. The model estimates HBO trips for the five household markets used for HBSH trips, also maintained through trip distribution and mode choice.

8. Work-Based Other

Work-based other trips are non home-based trips where at least one end of a trip is from/to a work location. An example of such a trip would be, "running an errand during lunch hour" from one's place of employment.

9. Other-Based Other

Other-based other trips are all other trips that do not begin or end at a trip-maker's home or place of work.

Vehicle Availability Model

Introduction

The auto availability model predicts the number of households with 0, 1, 2, 3, and 4 or more available vehicles. The model was estimated in a multinomial logit form using the ALOGIT software. This model is the first model applied in the model chain. As is customary, the model was estimated using household records, and then applied at the aggregate, TAZ level. The auto availability model includes indicators for household size, household income, number of workers, type of housing unit, residential and employment density, and transit and non-motorized accessibilities.

Estimation Dataset

The SCAG 2000 household travel survey final sample consists of 16,939 households. After excluding records with unknown or invalid household income, the estimation dataset comprises 14,878 household records. Table 3-1 shows the number of sample households by auto availability and by the four household attributes included in the estimation file.

Table 3-1: Observed Household Frequencies

	Count	Percent
Auto Availability		
Zero vehicle	1,059	6%
One	5,977	35%
Two	6,745	40%
Three	2,232	13%
Four or more	926	5%
Household Size		
One person	5,108	30%
Two	5,929	35%
Three	2,393	14%
Four or more	3,509	21%
Household Workers		
Zero workers	4,055	24%
One	7,214	43%
Two	4,848	29%
Three or more	822	5%
Household Income		
0 - $25K	3,386	20%
$25K- $50K	4,111	24%
$50K - $100K	5,215	31%
$100K or more	2,166	13%
unknown	2,061	12%
Type of Housing Unit		
Single family detached	10,585	62%
Other	6,354	38%

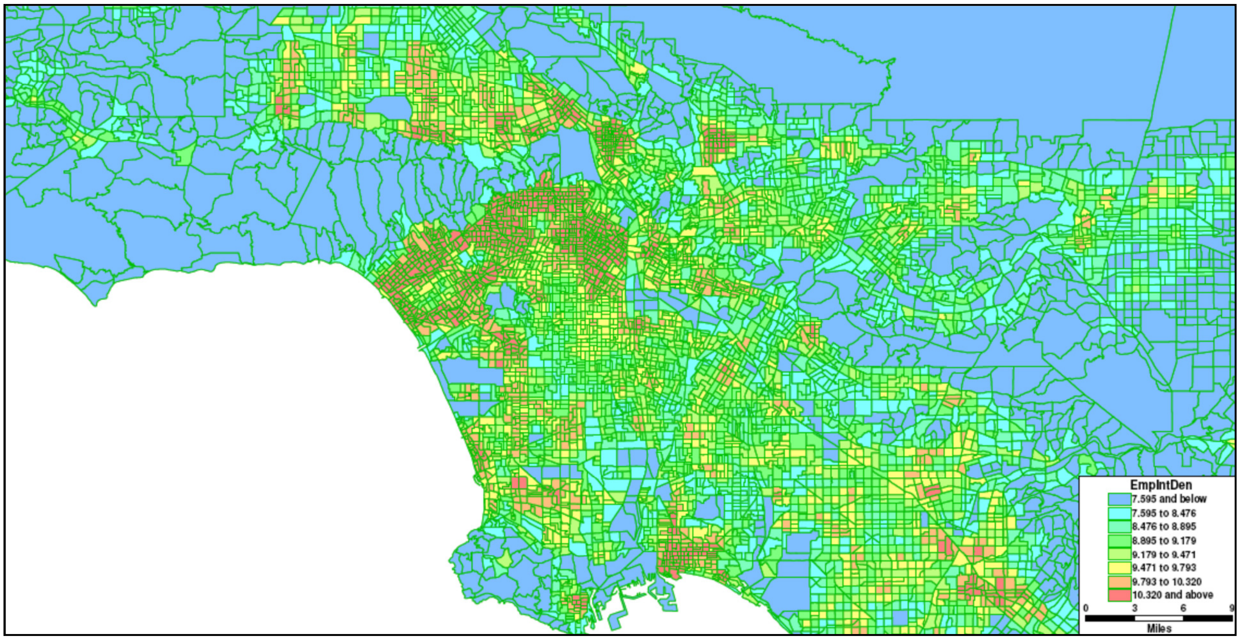
The survey observations were joined with multiple measures of residential density, employment density, and transit and non-motorized accessibility. Table 3-2 shows a complete list and definitions of all the density and accessibility measures examined during model estimation.

Table 3-2: Land Use Form and Accessibility Measures

Measure	Description and Formulas
Density Measures	Density measures are calculated over a 1/2 mile radius of the TAZ centroid. These densities are based on total area, instead of developed area.
Household Density	Total Households / Area
Retail Employment Density	Retail Employment / Area
Total Employment Density	Total Employment / Area
Diversity Measures	The indicators of diversity may be proportional to geometric averages of various land uses. These variables take the highest values when all the uses are high and equally allocated. Diversity can also be expressed as the relative difference between various land uses. The highest diversity occurs when the two land uses are equal, lowest when one or the other dominates. These measures are calculated over a one-half mile radius of the TAZ centroid.
Retail Employment (RE) and Household (HH) Diversity	0.001 x RE x HH / (RE + HH)
Retail/Service Employment (RSE) and Household (HH) Diversity	0.001 x RSE x HH / (RSE + HH)
Jobs/Housing diversity (SACOG)	1- [ABS(b*HH - EMP)/(b*HH + EMP)], where b = regional employment / regional households
Job Mix Diversity	1-[ABS(b*RE - NRE) /(B*RE + NRE)], Where NRE is non-retail employment and b = regional non retail employment / regional retail employment
Design Measures	The only available urban design indicator is the number of intersections, calculated using the Tele Atlas street network.
Mix Employment, Household and Intersection Density	Ln {[Int*(Emp*a) * (HH*b)] /[Int + (Emp*a) + (HH*b)]}, where: Int= Number of local intersections in 1/2 mile of centroid Emp= Employment within 1/2 mile of centroid HH= Households within 1/2 mile of centroid a= average Int / average Emp b= average Int / average HH
Intersection Density	3-way + 4-way intersections / Area
Street Density	Total street length in 1/2 mile radius
Connectivity Index	Proportion of 4-way intersections
Accessibility Measures	Accessibility variables are proportional to the number of opportunities (such as jobs or retail opportunities) that can be reached by auto, transit or walk means.
Transit Accessibility Logsum	$TrLogsum_p = Ln\left(\sum_q exp\left(-0.025 * Time_{pq} + ln(Emp_q)\right)\right)$ Where $Time_{pq}$ is total transit time including a weight of 2 on all out-of-vehicle time components.
Transit Accessibility to Jobs	Employment within x minutes of transit (walk access), where x is a category 0-30mins, 30-60mins etc.
Transit Accessibility to Retail	Retail employment within 30 minutes of transit (walk)
Transit Stop Density	Number of transit stops / Area
Non-Motorized Accessibility	$WalkAcc_p = Ln\left(\sum_q exp\left(-2.0 * Distance_{pq} + ln(Emp_q)\right)\right)$

The mix employment, household and intersection density indicator proved to be the strongest design and density indicator for this region. Figure 3-1 shows how this mix density measure varies over the most urbanized areas in the SCAG region. It is highest in areas that combine high residential, employment and intersection density –Los Angeles CBD, Santa Monica and Wilshire Boulevard, West Hollywood, Burbank, Glendale, Long Beach, and parts of Santa Ana and Orange.

Figure 3-1: Mixed Employment, Residential and Intersection Density



Utility Structure

The utility (U_{az}) of having (a) autos available for a household of type (h) located in zone (z) is given by

$$U_{az} = \alpha_a + \sum\sum \beta_{hk} \times N_{hk} + \delta_{az} \times LS_z + \gamma_{az} \times MixDen_z + \theta_{az} \times WlkAcc_z$$

All household attributes, listed below, are entered in the utility function as indicator variables; the density and accessibility terms are all linear in the parameters. The following variables were examined, proved to be significant in the utility functions, and were selected for the final model:

- Household Size – 1, 2, 3, 4 or more persons
- Household Income
    - Low income (less than $25,000)
    - Medium income ($25,000-$50,000)
    - High income ($50,000-$100,000)
    - Very high income ($100,000 or more)
- Number of Workers in Household – 0, 1, 2, 3 or more workers

- Type of Housing Unit
    - Single-Family Detached
    - Multi-Family (duplex, apartment, and condominium)
- Transit Accessibility Logsum (LS)
- Mix Household, Employment, and Intersection Density (MixDen)
- Non Motorized Accessibility (WlkAcc)

Estimation Results

Table 3-3 shows the final auto availability model estimation results. All variables show expected, logical signs, and most are significant at 95% confidence. Auto availability increases with household size, household income and the number of workers in the household, and decreases for households living in multi-family housing. Auto availability decreases with increasing transit and walk accessibility to employment, and also decreases with increasing mix density.

Many of the candidate density and design variables showed logical, statistically significant effects on their own, but they tended to be correlated with each other. The mix density measure was preferred because it responds to changes in residential and employment density, as well as urban form density (as measured by the number of intersections).

Table 3-3: Auto Availability Estimation Results

	Auto Availability Choice							
	1 Car		2 Cars		3 Cars		4+ Cars	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Household Income								
Low	-2.8138	-6.8	-4.7168	-11.3	-5.5354	-12.9	-6.1442	-13.4
Medium	-1.3453	-3.2	-2.6003	-6.2	-3.0210	-7.1	-3.6313	-8.3
High	-0.3288	-0.7	-0.7827	-1.8	-0.9589	-2.1	-1.1941	-2.6
Household Size								
2 Person HH			2.0175	33.1	1.9849	18.5	1.4450	8.8
3 Person HH			1.8057	22.6	2.4022	19.7	1.6413	8.9
4+ Person HH			2.0975	27.8	2.3327	19.5	2.3295	13.6
Workers in HH								
1 Worker HH	0.8839	10.5	1.0585	10.9	1.1472	9.2	1.3116	7.1
2 Workers HH	0.4965	3.5	1.5991	10.9	1.8583	11.1	2.1258	9.8
3+ Workers HH			0.7428	4.1	2.7108	14.1	3.7370	15.6
Multi-Family Housing	-0.3262	-3.9	-1.0705	-11.6	-1.7900	-15.6	-2.1969	-13.2
Mix Emp, Hhld. And Int. Density	-0.0494	-2.2	-0.0731	-3.2	-0.1034	-4.3	-0.1181	-4.5
Non Motorized Accessibility					-0.3820	-2.0	-0.6870	-2.0
Transit Accessibility Logsum	-0.0884	-3.9	-0.0853	-3.6	-0.0853		-0.0853	
Constant	4.3911	9.9	4.2830	9.6	3.3968	7.4	2.8727	5.9

Notes:

Observations:	*14,868*
Final log likelihood:	*14,940*
Rho-Squared (zero):	*0.376*
Rho-Squared (constants):	*0.245*

Model Calibration

The model was first applied to a Year 2000 base scenario and calibrated to match the auto availability shares observed in the CTPP 2000 dataset. Subsequently the model was applied to the 2008 base year, with all density measures computed at the Tier 2 zone level. The 2008 model forecast was validated to ACS 2005-2009 release data. A comparison of the model forecast to CTPP 2000 and ACS 2005-2009 data, for each county in the SCAG region, is shown in Table 3-4 and Table 3-5.

Table 3-4: Year 2000 Auto Availability Forecast - County of Residence Validation

CTPP 2000 Auto Availability						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	4,215	13,365	14,355	5,495	2,000	**39,430**
Los Angeles	391,135	1,154,740	1,084,325	355,510	150,570	**3,136,280**
Orange	53,695	289,380	400,395	134,615	58,070	**936,155**
Riverside	36,035	174,860	199,405	68,340	28,145	**506,785**
San Bernardino	41,710	170,245	205,325	78,625	32,935	**528,840**
Ventura	12,075	67,720	105,805	40,210	17,690	**243,500**
Total	**538,865**	**1,870,310**	**2,009,610**	**682,795**	**289,410**	**5,390,990**
2000 Model Forecast						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	3,305	15,270	13,811	5,035	1,959	**39,380**
Los Angeles	398,994	1,139,639	1,090,195	353,769	149,865	**3,132,462**
Orange	57,848	287,477	397,136	133,240	59,577	**935,279**
Riverside	33,236	180,446	190,541	72,527	29,468	**506,218**
San Bernardino	35,491	178,883	207,274	76,055	30,833	**528,537**
Ventura	11,900	70,027	101,855	40,853	18,596	**243,232**
Total	**540,775**	**1,871,742**	**2,000,811**	**681,481**	**290,299**	**5,385,108**
Forecast Difference						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	(910)	1,905	(544)	(460)	(41)	**(50)**
Los Angeles	7,859	(15,101)	5,870	(1,741)	(705)	**(3,818)**
Orange	4,153	(1,903)	(3,259)	(1,375)	1,507	**(876)**
Riverside	(2,799)	5,586	(8,864)	4,187	1,323	**(567)**
San Bernardino	(6,219)	8,638	1,949	(2,570)	(2,102)	**(303)**
Ventura	(175)	2,307	(3,950)	643	906	**(268)**
Total	**1,910**	**1,432**	**(8,799)**	**(1,314)**	**889**	**(5,882)**

Table 3-5: Year 2008 Auto Availability Forecast – County of Residence Validation

ACS 2005-2009 Auto Availability						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	5,022	14,658	16,371	6,919	3,435	**46,405**
Los Angeles	300,094	1,105,169	1,123,597	430,792	216,026	**3,175,678**
Orange	45,379	279,591	407,333	159,368	81,130	**972,802**
Riverside	29,360	191,759	254,724	112,203	57,038	**645,084**
San Bernardino	30,030	162,589	224,543	112,044	59,681	**588,887**
Ventura	10,497	67,105	103,869	49,793	25,876	**257,140**
Total	**420,382**	**1,820,871**	**2,130,438**	**871,119**	**443,186**	**5,685,995**
2008 Model Forecast						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	6,748	19,223	14,134	6,631	3,264	50,000
Los Angeles	297,797	1,170,600	1,175,672	463,590	273,449	3,381,108
Orange	42,906	308,147	419,677	161,550	100,608	1,032,887
Riverside	40,717	245,517	236,917	108,850	67,435	699,436
San Bernardino	36,317	195,893	213,705	110,543	75,214	631,672
Ventura	11,953	79,085	100,319	51,354	31,586	274,297
Total	**436,438**	**2,018,465**	**2,160,424**	**902,517**	**551,556**	**6,069,400**
Forecast Difference (%), County Normalized						
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	2.67%	6.86%	-7.01%	-1.65%	-0.87%	0.0%
Los Angeles	-0.64%	-0.18%	-0.61%	0.15%	1.29%	0.0%
Orange	-0.51%	1.09%	-1.24%	-0.74%	1.40%	0.0%
Riverside	1.27%	5.38%	-5.61%	-1.83%	0.80%	0.0%
San Bernardino	0.65%	3.40%	-4.30%	-1.53%	1.77%	0.0%
Ventura	0.28%	2.74%	-3.82%	-0.64%	1.45%	0.0%
Total	**-0.20%**	**1.23%**	**-1.87%**	**-0.45%**	**1.29%**	**0.0%**

An important validation measure is to ascertain whether the model matches the observed pattern of auto availability level by urban form geographies. A comparison of auto availability obtained from ACS data to the model estimates, classified into density or accessibility bins, shows that the model reproduces the observed patterns, in the aggregate. Similarly, a comparison of zero car households at the Regional Statistical Area (RSA) level shows that the model predicts well the number of zero-car households and the total number of available vehicles. Tables 3-6 to 3-8 and Figures 3-2 and 3-3 provide more information.

Table 3-6: Auto Availability Validation to Mix Employment, Household and Intersection Density

Auto Availability	Share of Households by Mix Density Level							
	ACS 2005-2009				Model 2008 Estimate			
	7 or less	7 to 8.5	8.5 to 9.5	9.5 +	7 or less	7 to 8.5	8.5 to 9.5	9.5 +
0	3%	4%	7%	13%	4%	5%	7%	13%
1	24%	27%	32%	43%	29%	29%	33%	41%
2	42%	40%	37%	32%	37%	39%	37%	31%
3	20%	19%	15%	9%	19%	17%	15%	10%
4+	10%	10%	8%	4%	12%	10%	9%	6%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3-7: Auto Availability Validation to Non Motorized Accessibility

Auto Availability	Share of Households by Non Motorized Accessibility							
	ACS 2005-2009				Model 2008 Estimate			
	6 or less	6 to 8	8 to 10	10 +	6 or less	6 to 8	8 to 10	10 +
0	4%	8%	13%	25%	4%	7%	13%	22%
1	25%	33%	43%	43%	29%	33%	41%	44%
2	41%	37%	32%	26%	37%	36%	30%	23%
3	20%	15%	9%	4%	18%	14%	10%	7%
4+	10%	8%	4%	2%	11%	9%	6%	4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3-8: Auto Availability Validation to Transit Accessibility Logsum

Auto Availability	Share of Households by Transit Accessibility Logsum							
	ACS 2005-2009				Model 2008 Estimate			
	9 or less	9.5 to 12	12 to 13.5	13.5 +	9 or less	9.5 to 12	12 to 13.5	13.5 +
0	5%	5%	7%	17%	6%	4%	7%	16%
1	29%	27%	33%	42%	36%	28%	33%	43%
2	40%	40%	38%	29%	32%	40%	38%	25%
3	18%	19%	15%	8%	16%	17%	14%	10%
4+	9%	9%	8%	4%	11%	10%	8%	7%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Figure 3-2: Validation of Zero Car Households for Regional Statistical Areas

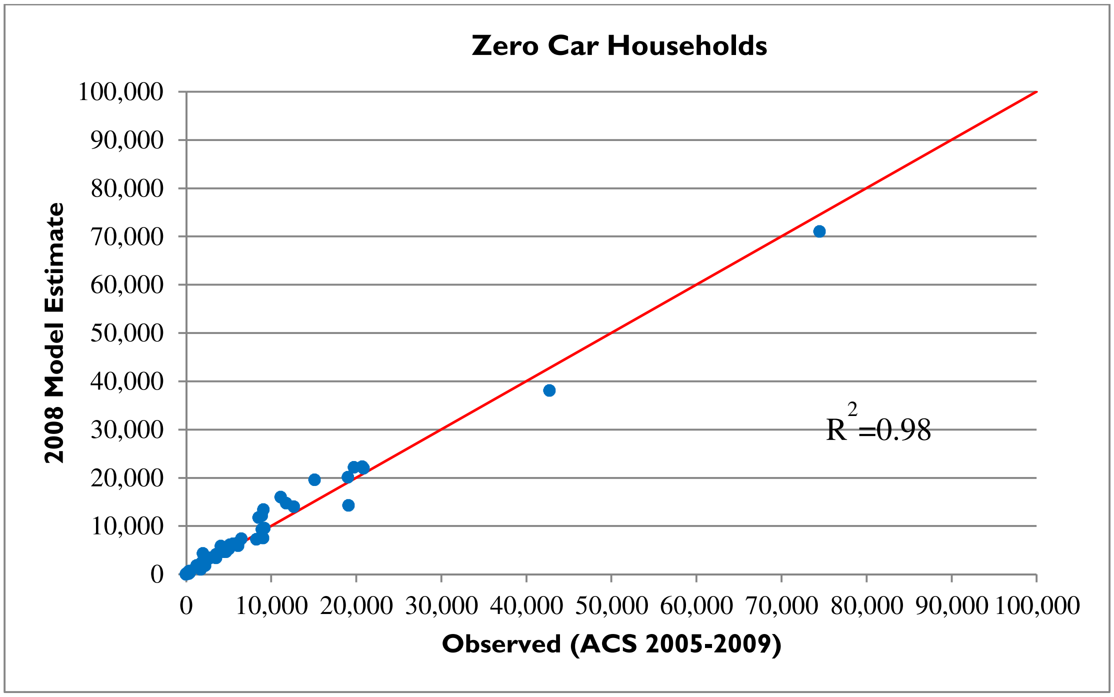
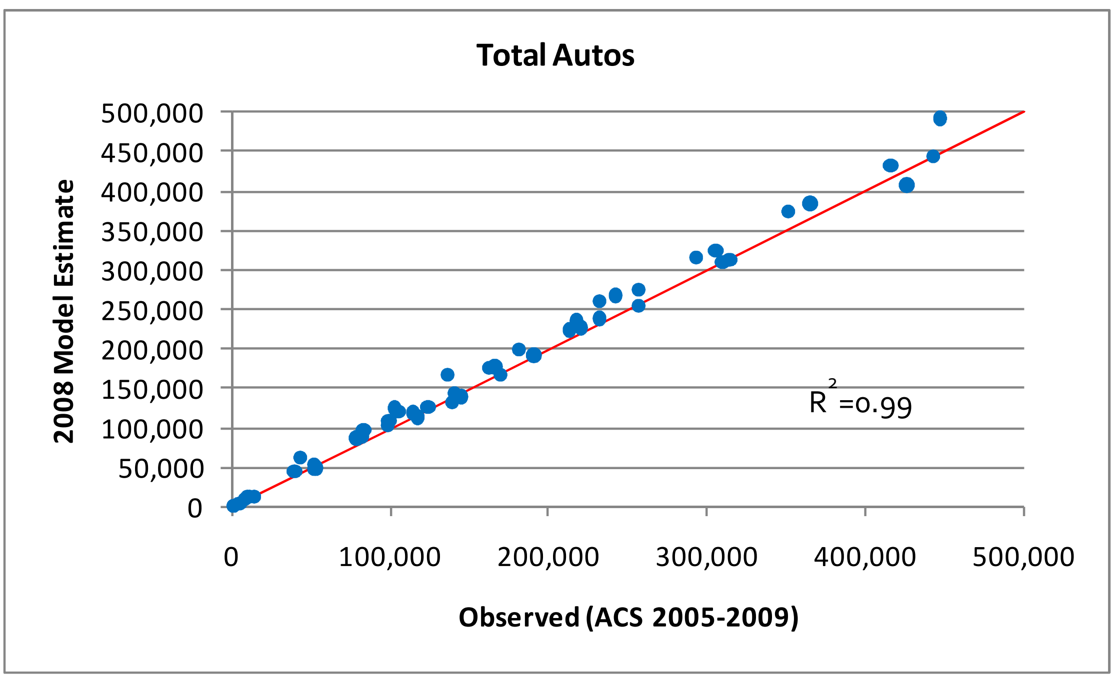


Figure 3-3: Validation of Total Auto Availability for Regional Statistical Areas



Trip Market Segmentation

Market segmentation is the technique used in trip-based model to subdivide the population into groups expected to exhibit similar travel behavior. The model segmentation is partly determined by the availability of survey and census data to identify specific markets or population subgroups and support the estimation and validation of separate models for each subgroup.

Trip Purposes

The internal person trip market is stratified into the ten purposes listed in Table 3-9. The external trip market is segmented into internal-external (IE/EI) and external-external trips.

Table 3-9: Trip Purposes

Purpose	Description
HBWD	Home Based Work - Direct
HBWS	Home Based Work - Strategic
HBCU	Home Based College and University
HBSC	Home Based School
HBSH	Home Based Shop
HBSR	Home Based Social and Recreation
HBSP	Home Based Serve Passenger
HBO	Home Based Other
WBO	Non Home Based Work
OBO	Non Home Based Other

Time Periods

As is customary in a trip-based model, the SCAG model segments the demand models (auto ownership, trip generation, trip distribution, and mode choice) into two time periods - peak and off-peak. The peak periods are 6:00 AM to 9:00 AM in the morning and 3:00 PM to 7:00 PM in the evening. The transit assignments are also performed for these two time periods.

The model uses five periods for highway assignment. The five highway assignment time periods are:

- AM Peak: 6:00 AM to 9:00 AM
- Midday: 9:00 AM to 3:00 PM
- PM Peak: 3:00 PM to 7:00 PM
- Evening: 7:00 PM to 9:00 PM
- Night: 9:00 PM to 6:00 AM

A representative peak period travel time is fed back from the highway assignment to the demand model. This representative time is a weighted average of the AM peak travel time and the PM peak travel time, where the weights equal the proportion of peak period trips that occur in the AM and PM periods respectively.

Household Classifications

In addition to trip purpose and time period, the trip market is further defined by household attributes. The proposed classifications for each model component are summarized in Table 3-10. The groups to be used for each household classification variable are the following:

- Household Income: low (less than $20,000, medium ($20,000 to $49,999), high ($50,000 to $99,999) and very high (more than $100,000), in $1999.
- Household Size: one, two, three, four or more persons in household.
- Workers in Household: zero, one, two, three or more workers in household.
- Auto Availability: zero, one, two, three, and four or more autos in household.
- Type of Housing Unit: single-family detached unit, all other unit types.
- Age of Head of Household: 18 to 24, 25 to 44, 45 to 64, 65 years old or older.
- Age: number of household members younger than 5, 5 to 17, 18 to 24, 25 years old or older.

Table 3-10: Person and Household Attributes

Model	Hhld. Income	Hhld. Size	Hhld Workers	Auto Availability	Type of Housing Unit	Age of Head of Hhld.	Age
Auto Ownership	X	X	X		X		
Trip Production							
HBW, WBO	X		X	X		X	
HBSC, HBCU							X
HBO, OBO	X	X		X			
Trip Distribution							
HBW, WBO	X		X	X			
HBO, OBO	X	X		X			
Mode Choice	X						
HBW, WBO	X		X	X			
HBO, OBO	X	X		X			

The household income segments were defined to approximately match the household income quintiles used by SCAG in their environmental justice analyses, without significantly deviating from the subgroups used to report income in the various regional surveys (see Table 3-11). Because of the disparity of income ranges used by the different surveys, it was necessary to impute some of the aggregate income data, and/or merge the high and very high income groups in the model estimation work. The specific strategy used to overcome the survey income disparities is discussed separately for each model component in the following sections.

Table 3-11: Survey Household Income Classifications

<table>
<tr><th>Annual Household Income</th><th>Households</th><th>Quintiles</th><th>1999 Census</th><th>2001 HIS</th><th>2001 MTA</th><th>2006 MTA</th><th>2010 OCTA</th><th>2008 Metrolink</th></tr>
<tr><td>Less than $7,500</td><td rowspan="2">481,452</td><td rowspan="4">Less than $19,360</td><td rowspan="2">X</td><td rowspan="2">X</td><td>X</td><td>X</td><td rowspan="4">X</td><td rowspan="4">X</td></tr>
<tr><td>$7,500 to $10,000</td><td rowspan="2">X</td><td rowspan="2">X</td></tr>
<tr><td>$10,000 to $14,999</td><td>316,692</td><td>X</td><td rowspan="3">X</td></tr>
<tr><td>$15,000 to $19,999</td><td>311,115</td><td>X</td><td rowspan="2">X</td><td rowspan="2">X</td></tr>
<tr><td>$20,000 to $24,999</td><td>325,475</td><td rowspan="3">$19,361 to $36,340</td><td>X</td><td rowspan="2">X</td><td rowspan="2">X</td></tr>
<tr><td>$25,000 to $29,999</td><td>310,709</td><td>X</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="2">X</td></tr>
<tr><td>$30,000 to $34,999</td><td>313,862</td><td>X</td><td rowspan="4">X</td><td rowspan="2">X</td></tr>
<tr><td>$35,000 to $39,999</td><td>290,243</td><td rowspan="4">$36,340 to $57,323</td><td>X</td><td rowspan="3">X</td><td rowspan="3">X</td><td rowspan="3">X</td></tr>
<tr><td>$40,000 to $44,999</td><td>277,669</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>$45,000 to $49,999</td><td>244,079</td><td>X</td></tr>
<tr><td>$50,000 to $59,999</td><td>455,185</td><td>X</td><td rowspan="2">X</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="3">X</td><td>X</td></tr>
<tr><td>$60,000 to $74,999</td><td>560,767</td><td rowspan="2">$57,324 to $91,402</td><td>X</td><td>X</td></tr>
<tr><td>$75,000 to $99,999</td><td>601,404</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>$100,000 to $149,999</td><td>525,328</td><td rowspan="3">$91,403 or more</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>$150,000 to $200,000</td><td rowspan="2">342,916</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="2">X</td><td>X</td></tr>
<tr><td>$200,000 or more</td><td>X</td></tr>
</table>

The trip production, destination choice and mode choice models use a market stratification defined by household income and car sufficiency. Car sufficiency is defined relative to household workers for HBW trips, and relative to household size for HBO trips. The specification of each stratum is shown in Table 3-12.

Table 3-12: Trip Market Strata

Trip Market	HBW Trips	HBO Trips
1	Zero car households, all incomes	Zero car households, all incomes
2	Households with fewer cars than workers, all incomes	1 car, 2+ person households, all incomes
3	Equal or more cars than workers, income less than $25,000	1 car, 1 person households or 2+ car households, and income less than $25,000
4	Equal or more cars than workers, income equal or higher than $25,000 and less than $50,000	1 car, 1 person households or 2+ car households, and income equal or higher than $25,000 and less than $50,000
5	Equal or more cars than workers, and income equal or higher than $50,000	1 car, 1 person households or 2+ car households, and income equal or higher than $50,000

Trip Productions Model

Introduction

The trip productions model predicts average weekday trip frequency for each household trip type. It takes the form of a cross-classification model. The productions represent total daily trips on all travel modes (auto, transit and non-motorized). Trip rates per household are applied to the estimate of households classified across various attributes. The household classifications vary with the trip purpose. Unlike previous versions of the SCAG model, these classifications are now prepared off-model using a population synthesizer. The relationship between trip frequency and land use density was explored during the trip rate estimation process; no consistent, statistically significant relationship was found between total daily person trips and various measures of land use density and diversity, after controlling for household attributes such as income, size and vehicles available.

Estimation Dataset

The SCAG 2000 household travel survey provided the data for the trip rate estimation. The trip sample size by purpose is shown in Table 3-13.

Table 3-13: Trip Sample Size

Trip Purpose	Count	Percentage
HBWD	21,336	18%
HBWS	6,498	6%
HBSC	6,872	6%
HBU	2,048	2%
HBSH	11,386	10%
HBSR	10,559	9%
HBSP	12,276	10%
HBO	17,699	15%
WBO	7,386	6%
OBO	21,471	18%
Total	**117,531**	**100%**

Home-Based Work (HBW) Trip Productions Models

The household classification variables chosen for the HBW trip productions model are number of workers, household income, and age of the head of household. Other classification variables were tested, including household size and auto availability. Separate trip rates were estimated for direct and strategic trips. Household classes with few observations were collapsed to obtain a large enough sub-sample. Table 3-14 shows the HBWD trip production rates; Table 3-15 shows the HBWS trip production rates. As expected, the HBW trip rates increase with the number of workers in the household. Households headed by young (18-24 years old) and senior (66 years old or older) persons exhibit lower trip rates than other households. HBW trip rates tend to increase with household income. The rates shown in Table 3-14 are applied separately by auto availability, so that the HBW trip productions can be reported over car sufficiency and income groups, for input to the trip distribution and mode choice models.

Table 3-14: HBWD Trip Production Rates

Workers	Age of Head of Household	Household Income ($1999)			
		<25K	25K-50K	50K-100K	>100K
1	18-24	1.098	1.383	1.540	1.463
1	25-44	1.164	1.383	1.540	1.463
1	45-65	1.310	1.326	1.428	1.409
1	66+	0.842	1.260	1.401	1.401
2	18-24	1.986	2.292	2.292	2.292
2	25-44	2.101	2.336	2.590	2.720
2	45-65	2.150	2.600	2.710	2.713
2	66+	2.099	2.304	2.304	2.304
3+	18-24	3.015	3.015	3.015	3.015
3+	25-44	3.424	3.458	3.945	3.945
3+	45-65	3.608	3.514	3.749	3.942
3+	66+	3.353	3.353	3.655	3.655

Table 3-15: HBWS Trip Production Rates

Workers	Age of Head of Household	Household Income ($1999)			
		<25K	25K-50K	50K-100K	>100K
1	18-24	0.260	0.260	0.260	0.260
1	25-44	0.306	0.426	0.514	0.514
1	45-65	0.369	0.379	0.452	0.468
1	66+	0.229	0.253	0.348	0.363
2	18-24	0.573	0.788	0.788	0.788
2	25-44	0.696	0.775	1.005	1.005
2	45-65	0.677	0.780	0.922	0.993
2	66+	0.386	0.386	0.749	0.866
3+	18-24	0.769	0.769	0.769	0.769
3+	25-44	0.909	0.909	0.940	1.103
3+	45-65	0.853	0.853	0.918	1.103
3+	66+	0.726	0.726	0.726	0.726

Home-Based School (HBSC) and Home-Based College (HBCU) Trip Productions Models

The HBSC trip productions were estimated based on the number of school-age children in a household. A classification of households by the number of children aged 5 to 17 years old is prepared off-model, along with all the other household classifications. The HBSC trip rates are shown in Table 3-16.

The HBCU trip productions are estimated based on the number of college-age persons in the household, household income, and the group quarters population. The HBCU trip rates are shown in Table 3-17.

Table 3-16: HBSC Trip Production Rates

Number of Household Members 5-17 years old	Trip Rate
0	0.038
1	1.252
2	2.466
3+	4.028

Table 3-17: HBCU Trip Production Rates

Household Income ($1999)	Number of Household Members 17 to 25 years old		
	0	1	2+
0-25K	0.076	0.357	0.686
25K-50K	0.068	0.266	0.469
50K-100K	0.056	0.246	0.487
100K+	0.032	0.284	0.782

Home-Based Non-Work (HBNW) Trip Productions Models

The household classification variables chosen for the HBNW trip productions model are household size, income and auto availability. Separate trip rates were estimated for HBSH, HBSR, HBSP, and HBO trips. Household classes with few observations were collapsed to obtain a large enough sub-sample. The HBNW trip production rates are shown in Table 3-18. As expected, the HBNW trip rates increase with household size and with auto availability. The HBNW trip rates do not vary much with household income, but the income classification was kept so it is available for trip distribution and mode choice.

Table 3-18: HBNW Trip Production Rates

Auto Availability	Household Income	Household Size	Trip Production Rates			
			HBSH	HBSR	HBSP	HBO
0	0-25K	1	0.340	0.202	0.059	0.319
		2	0.664	0.452	0.111	0.506
		3	0.782	0.606	0.850	0.715
		4+	0.960	0.863	2.489	0.940
	25K-50K	1	0.306	0.224	0.033	0.356
		2	0.616	0.463	0.079	0.506
		3	0.735	0.611	0.758	0.715
		4+	0.912	0.866	2.388	0.940
	50K-100K	1	0.299	0.232	0.009	0.356
		2	0.604	0.466	0.058	0.506
		3	0.717	0.599	0.691	0.715
		4+	0.894	0.855	2.313	0.940
	100K+	1	0.294	0.241	0.002	0.356
		2	0.593	0.461	0.052	0.506
		3	0.699	0.602	0.688	0.716
		4+	0.890	0.868	2.296	0.940

Auto Availability	Household Income	Household Size	Trip Production Rates			
			HBSH	HBSR	HBSP	HBO
1	0-25K	1	0.560	0.379	0.501	0.640
		2	0.888	0.649	0.784	0.924
		3	0.995	0.815	1.416	1.427
		4+	1.164	1.070	3.009	1.978
	25K-50K	1	0.504	0.420	0.279	0.640
		2	0.824	0.664	0.558	1.216
		3	0.935	0.821	1.263	1.498
		4+	1.106	1.075	2.886	2.074
	50K-100K	1	0.491	0.436	0.080	0.671
		2	0.809	0.668	0.407	1.322
		3	0.912	0.805	1.151	1.569
		4+	1.085	1.060	2.796	2.486
	100K+	1	0.484	0.452	0.018	0.723
		2	0.804	0.686	0.368	1.361
		3	0.906	0.814	1.146	1.569
		4+	1.080	1.077	2.776	2.486
2	0-25K	1	0.588	0.442	0.260	0.640
		2	0.931	0.717	0.714	1.072
		3	1.042	0.897	1.333	1.427
		4+	1.214	1.152	2.930	2.036
	25K-50K	1	0.529	0.490	0.144	0.640
		2	0.863	0.734	0.508	1.130
		3	0.979	0.904	1.189	1.639
		4+	1.153	1.156	2.810	2.104
	50K-100K	1	0.516	0.508	0.041	0.671
		2	0.847	0.738	0.371	1.337
		3	0.955	0.886	1.083	1.743
		4+	1.130	1.141	2.722	2.616
	100K+	1	0.509	0.528	0.009	0.723
		2	0.842	0.759	0.335	1.378
		3	0.948	0.896	1.079	1.754
		4+	1.125	1.159	2.703	2.741
3+	0-25K	1	0.599	0.533	0.158	0.676
		2	0.940	0.819	0.191	1.072
		3	1.058	1.007	0.993	1.427
		4+	1.230	1.261	2.629	2.036
	25K-50K	1	0.539	0.590	0.088	0.676
		2	0.871	0.839	0.136	1.130
		3	0.994	1.015	0.885	1.639
		4+	1.168	1.266	2.522	2.104
	50K-100K	1	0.526	0.611	0.025	0.676
		2	0.855	0.843	0.099	1.337
		3	0.969	0.995	0.807	1.743
		4+	1.145	1.249	2.443	2.616
	100K+	1	0.518	0.635	0.005	0.723
		2	0.850	0.866	0.090	1.378
		3	0.962	1.006	0.803	1.754
		4+	1.140	1.269	2.425	2.741

Non-Home Based (NHB) Trip Productions Models

The household classification variables chosen for the NHB trip productions are income, workers and age of householder for work-based trips; and income, size and auto availability for all other non-home based trips Table 3-19 and Table 3-20 show the WBO and OBO trip rates, respectively.

Table 3-19: WBO Trip Production Rates

Workers in Household	Household Size	Household Income ($1999)			
		<25K	25K-50K	50K-100K	>100K
1	1	0.381	0.715	0.919	1.316
	2	0.354	0.665	0.855	1.224
	3	0.241	0.453	0.582	0.834
	4+	0.203	0.381	0.489	0.701
2	1				
	2	0.732	1.072	1.252	1.577
	3	0.607	0.889	1.038	1.308
	4+	0.574	0.840	0.982	1.237
3+	1				
	2				
	3	0.672	0.998	1.189	1.541
	4+	0.629	0.934	1.112	1.441

Table 3-20: OBO Trip Production Rates

		Trip Production Rates			
Household Income	Household Size	Auto Availability			
		0	1	2	3+
0-25K	1	0.416	1.297	1.355	1.399
	2	0.989	1.870	1.912	1.958
	3	1.422	2.317	2.367	2.412
	4+	2.586	3.482	3.513	3.553
25-50K	1	0.453	1.414	1.478	1.525
	2	1.049	1.984	2.029	2.078
	3	1.499	2.443	2.496	2.543
	4+	2.690	3.622	3.654	3.696
50K-100K	1	0.437	1.364	1.425	1.470
	2	1.030	1.948	1.992	2.039
	3	1.461	2.380	2.431	2.478
	4+	2.656	3.576	3.607	3.649
100K+	1	0.444	1.387	1.449	1.495
	2	1.052	1.990	2.035	2.083
	3	1.481	2.413	2.465	2.512
	4+	2.687	3.617	3.649	3.691

Trip Attractions Model

The trip attraction models are linear regression models that estimate attractions for each trip purpose, and then allocate total attractions to car ownership/income markets in proportion to the share of productions by household income in each car ownership market. The models are applied in two steps. First, total attractions for each purpose are calculated using the attraction equations shown in Table 3-21. For HBSH trips, attractions are estimated by applying a trip rate R to the zonal retail employment. The steps for calculating R are as follows:

Step 1: Calculate regionwide resident population to retail employment ratio, R1.
Step 2: Calculate the same ratio for each RSA, R2.
Step 3: Calculate for each RSA the relative retail service index RSI = R2/R1.
Step 4: Range bracket RSI to 0.5 – 1.5.
Step 5: Assign this RSI to each TAZ of that RSA
Step 6: Apply the equation R = 2.105 + 4.108*RSI to estimate the attraction rate

The trip attraction regression models forecast total attractions by TAZ and by household income for HBW trips, and by TAZ total for all other purposes. An allocation process is applied to segment these attractions into the household markets used by the trip distribution and mode choice models -- zero cars all income, car insufficient all income, car sufficient low income, car sufficient medium income and car sufficient high income. This allocation process works as follows:

- The HBW zero car and car insufficient trip attractions are computed as a weighted average of the income group attractions. The weights reflect the share of trips of each income group in each of these two household markets.
- The HBW car sufficient attractions are set to the corresponding household income segment attractions.
- Then the HBW attractions are balanced to the trip productions in each market.
- For HBSH, HBSR, HBSP and HBO, total attractions are allocated to household trip markets in proportion to the share of trip productions in the market.

The HBSC and HBCU attraction models are based on school and university enrollment, respectively. The trip attraction rates are shown in Table 3-22. In application, the school productions get allocated to school attractions within the same school district. This is accomplished by balancing the trips at the school district level. Similarly, the group quarters population is assigned to a college location, to keep the model from assigning some of these students to the wrong campus. There are several instances of student dormitories located on a TAZ adjacent to the campus TAZ, so not all of the group quarters population HBCU trips are intra-zonal trips.

Table 3-21: HBSC and HBCU Trip Attraction Rates

Trip Purpose	Trip Attraction Rate (attractions per enrolled student)	R^2
Home-Based School	1.326	0.84
Home-Based College, non GQ	0.549	0.77
Home-Based College, GQ	1.500	n/a

Table 3-22: Trip Attraction Model Regression Coefficients

Trip Purpose	Households	Total Employment	Residential Population	Low-Wage Employment	Medium-Wage Employment	High-Wage Employment	Retail	Information	Professional Services	Education & Health Services	Arts, Entertainment, Accommodations and Food Services	Other Services	Public Administration	K12 Enrollment	College Enrollment
HBWD1 Low Inc.				1.181											
HBWD2 Med Inc.					1.040										
HBWD3 High Inc.						1.040									
HBWS1 Low Inc.				0.324											
HBWS2 Med Inc.					0.339										
HBWS3 High Inc.						0.347									
HBCU															0.549
HBSC														1.326	
HBO			0.270				0.993			0.544	0.993	0.993	3.439		
HBSR		0.367						0.578				0.578	0.578		
HBSP		0.388						0.454			0.449				0.453
OBO Attraction	0.508	0.180					4.678			0.698	3.136	3.303			
WBO Attraction	0.036	0.202					0.513				1.147				
OBO Production	0.538	0.162					4.393			1.118	2.568	3.784			
WBO Production		0.137						0.227	0.250			5.743			

Trip Production Model Validation

The model was validated to the expanded SCAG 2000 household travel survey and the NHTS 2008 dataset.

The expansion factors of the SCAG 2000 household survey were adjusted to account for two instances of trip under-reporting. A comparison of trip rates between a GPS-based sample and the diary-based sample showed that households who completed a diary under-reported home-based trips by 12% and non-home-based trips by nearly 40%. Furthermore, a comparison of trip rates among households that completed the 2-day diary showed that households assigned to Friday/Saturday or Sunday/Monday combinations under-reported their trips on the non-weekend day of their 2-day diary.

Table 3-23 shows a comparison of total trips by purpose for the years 2000 and 2008. As shown, the model applied with the 2000 inputs generates trips by purpose within 5% of the observed trips, and within 1% overall of the total observed trips. When applied to 2008, the model forecasts a 6% increase in total trips, reflecting a 6% increase in home-based work trips, approximately 2% increase in home-based school trips, and between 15% to 20% increase in other trips. The same trip rates were applied in 2000 and 2008, therefore the differences in trip generation are due to changes in the socio-economic composition of the region's households, including auto availability.

An additional validation point is provided by the National Household Travel Survey (NHTS). The 2008 NHTS estimates total trip productions in the SCAG region at nearly 60.5 million trips, which is close to the model estimate of 62.0 million trips (see Table 3-23). Note that the NHTS trips have not been linked in the same manner as the household survey trips; for this reason the NHTS HBW trips are shown as direct trips only. On the other hand, if trips were linked NHTS would exhibit an even lower share of non-home-based trips. The NHTS SCAG sample consists of 6,700 households, some of which did not report a full day's worth of travel for all household members-- NHTS accepted households when at least half of its adult members completed the trip diary. The SCAG household survey, in contrast, gathered trip data for over 16,000 households and required that all members report a completed diary to be accepted as a valid observation. Given these and other methodological differences, the validation of the 2008 model estimates to NHTS is considered adequate (see Tables 3-23 and 3-24).

Table 3-23: Trip Production Validation to Household Survey, 2000 and 2008

Trip Purpose	2001 Household Survey	2000 Model Estimate	% Diff.	2008 Model Estimate	2008 to 2000 Change
HBWD	7,951,000	8,245,000	4%	8,964,000	1.09
HBWS	2,496,000	2,575,000	3%	2,738,000	1.06
HBSc	4,605,000	4,755,000	3%	4,852,000	1.02
HBU	662,000	667,000	1%	688,000	1.03
HBSh	4,446,000	4,710,000	6%	5,360,000	1.14
HBSR	4,242,000	4,362,000	3%	4,934,000	1.13
HBO	7,598,000	7,965,000	5%	8,939,000	1.12
HBSP	6,595,000	6,720,000	2%	7,618,000	1.13
OBO	11,233,000	12,709,000	13%	14,543,000	1.14
WBO	3,248,000	3,433,000	6%	3,524,000	1.03
Total	**53,078,000**	**56,341,000**	6%	**62,160,000**	1.10

Table 3-24: HBW Trip Production Validation to NHTS 2008

Trip Purpose	2008 Model Estimate	2008 NHTS
HBWD	8,964,000	7,908,000
HBO	35,127,000	36,813,000
NHB	18,067,000	15,658,000
Total	**62,064,000**	**60,380,000**

The validation of Year 2000 HBW trips by household income level is shown in Table 3-25. No comparable Year 2008 data is available to validate the 2008 model estimates.

Table 3-25: HBW Trip Production Validation

Trip Purpose and Household Income	2001 Household Survey	2000 Model Estimate	% Difference
HBWD 0-25K	950,780	980,934	3%
HBWD 25-50K	2,024,579	2,077,394	3%
HBWD 50-100K	3,086,696	3,342,825	8%
HBWD over 100 K	1,889,752	1,869,919	-1%
HBWS 0-25K	267,693	273,565	2%
HBWS 25-50K	556,251	608,686	9%
HBWS 50-100K	1,023,915	1,076,878	5%
HBWS over 100K	649,042	623,449	-4%

Tables 3-26 and 3-27 provide summary statistics for person trips, by county and for the SCAG region. Table 3-26 shows the share of trips by county and purpose, compared to the 2008 household survey. Table 3-27 identifies selected comparative statistics, such as trips per household, trips per vehicle, and trips per capita (resident person).

Table 3-26: Year 2008 Trip Generation Summary by Trip Purpose and by County

Trip Purpose	Person Trip Productions						
	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Model Area Total
HBWD No Cars	1,525	104,225	19,104	5,908	7,744	3,546	142,053
HBWD Car Competition	8,229	701,643	225,525	82,579	76,300	44,901	1,139,178
HBWD Car Suf. 0-25K	8,807	502,192	139,909	74,080	81,629	29,643	836,260
HBWD Car Suf. 25-50K	14,055	1,082,396	310,261	190,094	215,160	74,397	1,886,363
HBWD Car Suf. over 50K	23,499	2,601,126	1,039,312	495,089	517,598	283,207	4,959,830
HBWS No Cars	481.0586	29,311	5,365	1,614	2,075	981.8732	39,828
HBWS Car Competition	2,628	197,562	64,234	23,920	21,236	12,961	322,539
HBWS Car Suf. 0-25K	2,798	140,504	39,228	21,383	22,634	8,510	235,057
HBWS Car Suf. 25-50K	4,467	312,070	89,737	57,651	62,345	21,991	548,261
HBWS Car Suf. over 50K	8,355	825,520	335,981	166,803	163,046	92,339	1,592,044
Total Home Based Work	**74,845**	**6,496,549**	**2,268,655**	**1,119,120**	**1,169,768**	**572,476**	**11,701,413**
HBSC	50,335	2,640,303	764,232	575,933	602,315	218,587	4,851,705
HBCU	5,208	393,249	116,703	72,040	72,418	28,114	687,732
HBSH	45,764	2,938,417	916,603	629,609	583,684	245,468	5,359,545
HBSR	32,644	2,700,173	854,227	572,722	546,212	228,435	4,934,414
HBSP	71,460	4,145,896	1,268,159	909,989	888,091	334,645	7,618,240
HBO	56,880	4,848,026	1,578,344	1,044,550	990,877	419,856	8,938,534
Total Home Based Non Work	**262,291**	**17,666,064**	**5,498,269**	**3,804,844**	**3,683,597**	**1,475,106**	**32,390,170**
WBO	19,677	2,036,727	727,957	295,030	298,288	146,744	3,524,422
OBO	108,913	8,024,250	2,846,199	1,487,903	1,426,096	649,672	14,543,033
Total Non-Home Based	**128,590**	**10,060,978**	**3,574,156**	**1,782,933**	**1,724,384**	**796,416**	**18,067,456**
Total Person Trips	**465,726**	**34,223,590**	**11,341,079**	**6,706,897**	**6,577,749**	**2,843,998**	**62,159,039**

Table 3-27: Year 2008 Trip Generation Comparative Statistics

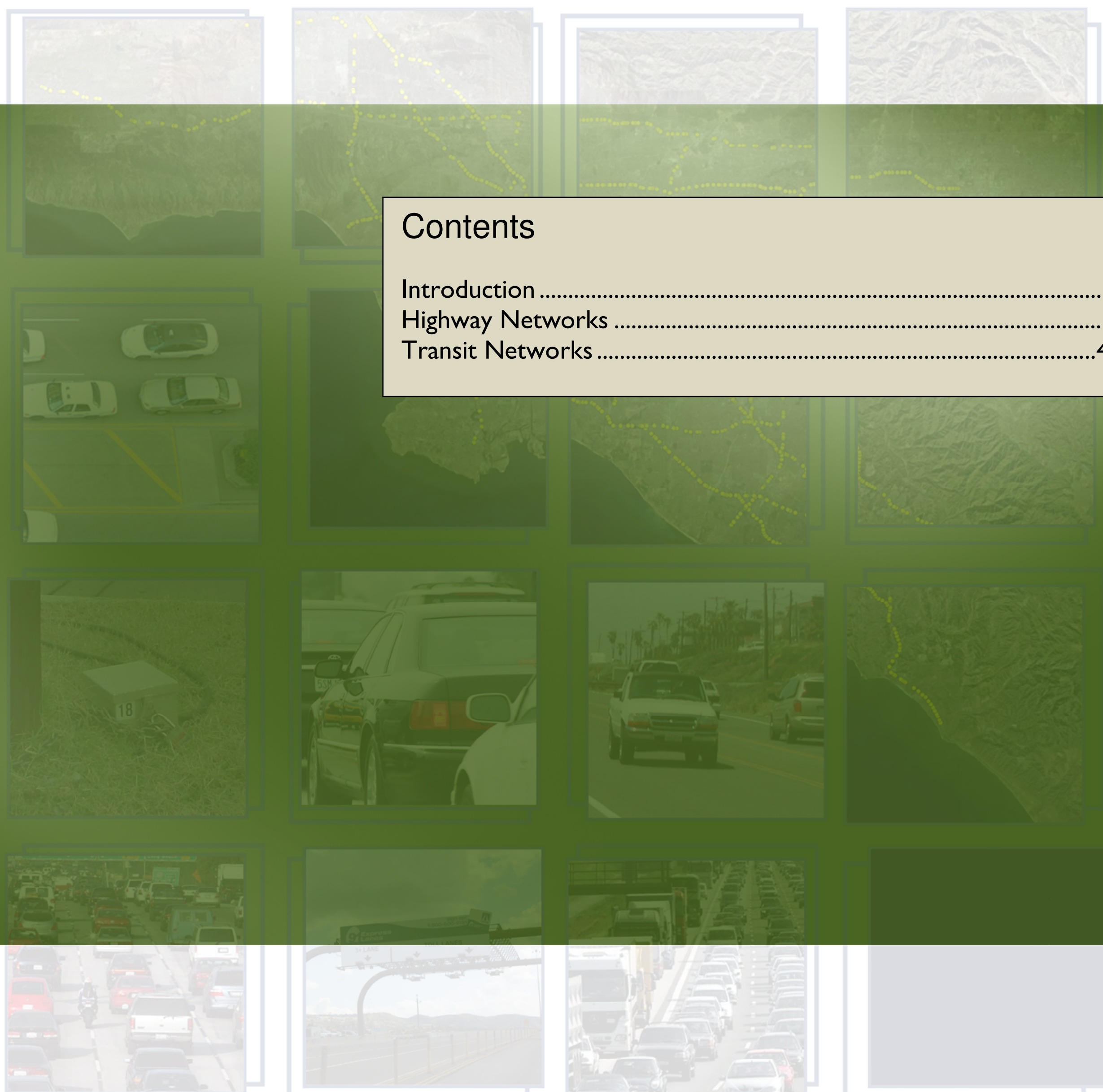
Home Based Work Trips	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Model Area Total
Trips	74,845	6,496,549	2,268,655	1,119,120	1,169,768	572,476	11,701,413
Trips per Household	1.54	2.01	2.30	1.65	1.93	2.16	2.01
Trips per Vehicle	0.97	1.15	1.18	0.90	0.99	1.08	1.10
Trips per Worker	1.43	1.59	1.57	1.55	1.61	1.55	1.58
% Home Based Work Trips	16.1%	19.0%	20.0%	16.7%	17.8%	20.1%	18.8%
Home Based Non Work Trips	**Imperial**	**Los Angeles**	**Orange**	**Riverside**	**San Bernardino**	**Ventura**	**Model Area Total**
Trips	262,291	17,666,064	5,498,269	3,804,844	3,683,597	1,475,106	32,390,170
Trips per Household	5.40	5.48	5.57	5.61	6.08	5.56	5.57
Trips per Vehicle	3.40	3.13	2.87	3.05	3.12	2.79	3.06
Trips per Person	1.54	1.81	1.84	1.79	1.83	1.81	1.81
% Home Based Non Work Trips	56.3%	51.6%	48.5%	56.7%	56.0%	51.9%	52.1%

Table 3-27: Year 2008 Trip Generation Comparative Statistics (continued)

Non Home Based Trips	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Model Area Total
Trips	128,590	10,060,978	3,574,156	1,782,933	1,724,384	796,416	18,067,456
Trips per Household	2.65	3.12	3.62	2.63	2.85	3.00	3.11
Trips per Vehicle	1.67	1.78	1.87	1.43	1.46	1.51	1.70
Trips per Person	0.76	1.03	1.20	0.84	0.86	0.98	1.01
% Home Based Non Work Trips	27.6%	29.4%	31.5%	26.6%	26.2%	28.0%	29.1%
Total Trips	**Imperial**	**Los Angeles**	**Orange**	**Riverside**	**San Bernardino**	**Ventura**	**Model Area Total**
Trips	465,726	34,223,590	11,341,079	6,706,897	6,577,749	2,843,998	62,159,039
Trips per Household	9.58	10.61	11.49	9.88	10.86	10.71	10.69
Trips per Vehicle	6.03	6.05	5.92	5.38	5.57	5.38	5.86
Trips per Person	2.74	3.50	3.79	3.15	3.26	3.50	3.47

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 4 - TRANSPORTATION NETWORKS



Contents

CHAPTER 4 – TRANSPORTATION NETWORKS

Introduction

This section summarizes the highway, transit, toll, and heavy-duty truck networks used in the Year 2008 Regional Travel Model Validation.

The Year 2008 highway network went through an extensive review to examine network coding accuracy and to ensure proper network connectivity. Once complete, the transit network was built directly off of the highway network ensuring an integrated network approach.

Attributes for the Year 2008 highway network were determined based on the Federal Highway Functional Classification system, SCAG highway network, and inputs from sub-regional and regional agencies. SCAG conducted an extensive review of the Year 2008 highway network using aerial photography to examine network coding accuracy and ensure proper network connectivity. The new highway network was distributed to interested transportation commissions and Caltrans districts for further review. Several meetings of these agencies were conducted to discuss coding conventions and to accept comments.

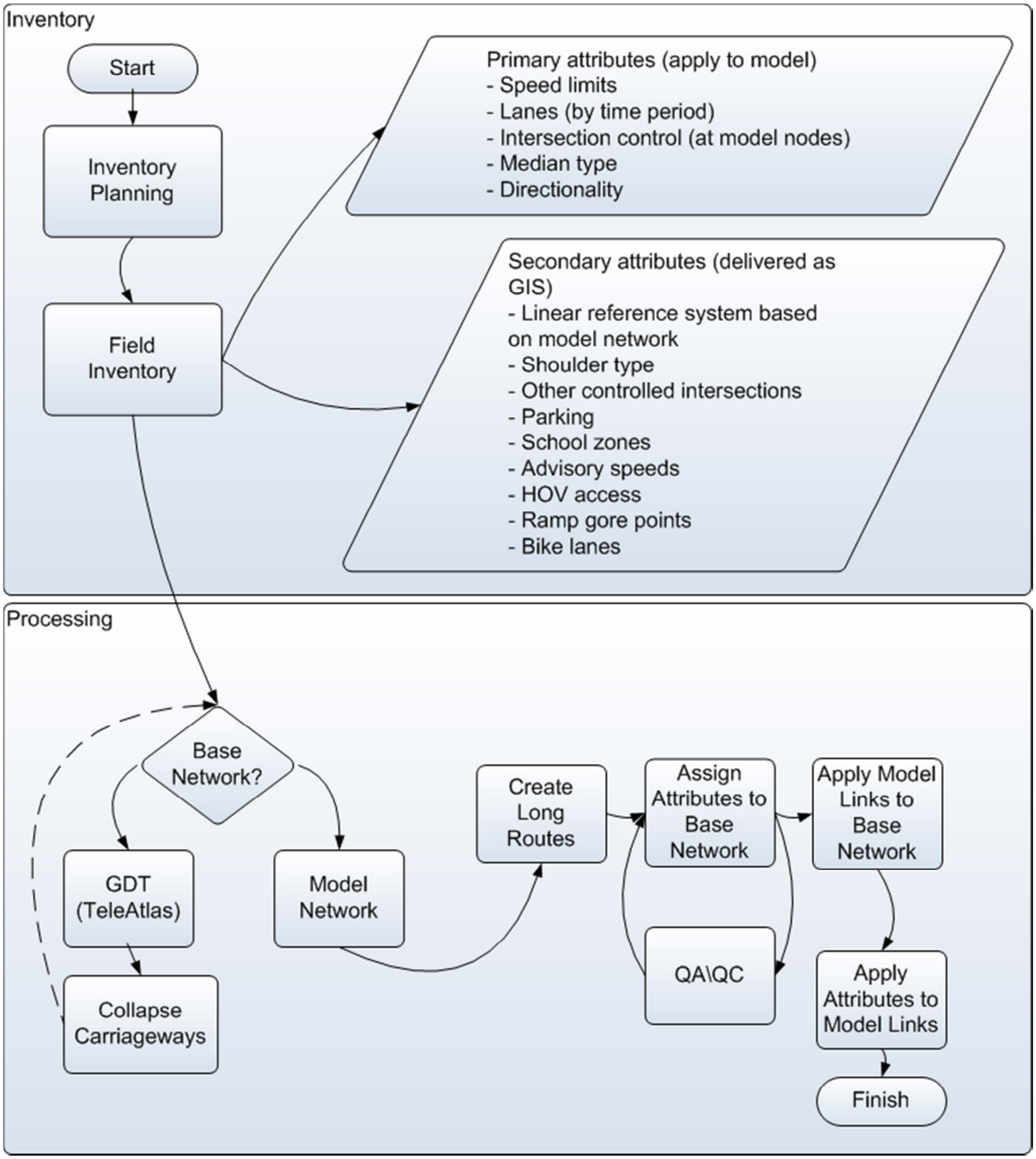
Sensitivity model runs using the new networks were performed, and loaded volumes plots were carefully examined to ensure proper network flows and connectivity. A summary of the number of links, roadway centerline miles, and number of lane miles in the highway network is provided later in this chapter (see Table 4-1). The free flow speed and roadway capacity used by trip distribution and assignment were assigned to the network using speed/capacity lookup tables (see Tables 4-2 through 4-7).

Once complete, the transit network was built directly off of the highway network to ensure an integrated network approach. The transit network is a key input to the mode choice model and is used in the transit trip assignment process. All elements used to determine level of service for transit mode choice calculations are identified and defined in this section. The various transit modes (e.g., Metrolink, local bus) that constitute the mode choice set are also identified.

Highway Networks

In 2007-08, SCAG conducted an extensive Highway Network Inventory program to gather information on the regional highway network and to transfer attributes to SCAG's TransCAD network. The Highway Inventory was built on a very detailed GIS network that included over 21,000 centerline miles for all freeways, arterials, and urban major collectors. This GIS data was later transferred to the TransCAD-based 2008 highway network. Figure 4-1 shows the process that comprised the Highway Network Inventory program and network attribute update tasks.

Figure 4-1: Flowchart of the Highway Network Inventory Program



As part of the network inventory, primary and secondary attributes were geo-coded. Primary attributes were identified as critical to the performance of the travel demand model and include:

- Speed Limits
- Number of Lanes (by time period)
- Intersection Control (at model nodes)
- Median Type
- Directionality (one-way versus two-way streets)

Secondary attributes include:

- Linear Reference System Based on Model Network
- Shoulder type
- Other Controlled Intersections
- Parking
- School Zones
- Advisory Speeds
- HOV Access
- Ramp Gore Points
- Bike Lanes

The highway network was developed and coded using the TransCAD Transportation Planning Software. TransCAD uses a GIS-based network approach to ensure geographic accuracy and provide enhanced editing capabilities. The GIS-based database structure allows for an almost unlimited number of attributes and is very flexible. The Year 2008 highway network includes detailed coding of the region's freeway system (e.g., mixed-flow lane, auxiliary lane, HOV lane, toll lane, and truck lane), arterials, major collectors, and some minor collectors. To simulate roadside parking restrictions and other lane changes during the day, separate networks were developed for each of the following five modeling time periods:

- AM peak period (6:00 AM to 9:00 AM)
- PM peak period (3:00 PM to 7:00 PM)
- Midday period (9:00 AM to 3:00 PM)
- Evening period (7:00 PM to 9:00 PM)
- Night period (9:00 PM to 6:00 AM)

Facility Types

The facility type (FT) definitions used in SCAG's Year 2008 highway network are generally consistent with the Federal Functional Highway Classification system. The major categories used for defining facility type are as follows:

- FT 10 - Freeways
- FT 20 - HOV
- FT 30 - Expressway/Parkway
- FT 40 - Principal Arterial
- FT 50 - Minor Arterial
- FT 60 - Major Collector

- FT 70 - Minor Collector
- FT 80 - Ramps
- FT 90 - Truck lanes
- FT 100 - Centroid connector

Area Types

The area types (AT) used in the highway network were prepared based on development density (population and employment density) and other land use characteristics. The area types used in the highway network are:

- AT 1 - Core
- AT 2 - Central Business District
- AT 3 - Urban Business District
- AT 4 - Urban
- AT 5 - Suburban
- AT 6 - Rural
- AT 7 - Mountain

Free Flow Speeds and Capacities

Free-flow speeds and capacities assigned to each link in the highway network were determined based on the posted speed (PS), facility type and area type (AT) of each link. Free flow speeds and capacities are presented in Tables 4-1 through 4-6.

Table 4-1: Year 2008 Freeway/Expressway Free-Flow Speed

Functional Class	AT1	AT2	AT3	AT4	AT5	AT6	AT7
Freeway	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5
HOV	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5
Expressway (Limited Access)	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5	PS+5
Fwy-Fwy Connector	45	45	50	50	55	55	55
On-Ramp (peak)	15	15	20	20	30	35	35
On-Ramp (off-peak)	25	25	30	30	35	35	35
Off-Ramp	25	25	30	30	35	35	35

Notes:
AT1: Core *AT3: Urban Business District* *AT5: Suburban* *AT7: Mountain*
AT2: Central Business District *AT4: Urban* *AT6: Rural* *PS = Posted Speed*

Table 4-2: Year 2008 Arterial Free-Flow Speed

Posted Speed		AT1	AT2	AT3	AT4	AT5	AT6	AT7
		-- Principal Arterial --						
20		21	22	22	24	25	27	27
25		23	24	25	27	28	31	31
30		25	26	27	29	31	34	34
35		27	28	29	32	35	38	38
40		28	30	32	34	37	41	41
45		30	32	34	37	40	45	45
50		33	35	37	41	45	51	51
55		34	38	39	44	49	56	56
		-- Minor Arterial --						
20		19	20	21	23	24	27	27
25		21	22	23	25	27	30	30
30		22	24	25	28	30	34	34
35		24	26	27	30	33	37	37
40		25	28	29	32	36	41	41
45		27	29	31	34	38	44	44
50		29	32	33	38	43	50	50
55		30	33	35	40	46	55	55
		-- Major Collector --						
20		17	18	19	21	23	26	26
25		18	20	21	23	26	30	30
30		19	21	22	25	28	33	33
35		20	22	24	27	31	36	36
40		21	24	25	28	33	39	39
45		22	25	26	30	35	43	43
50		23	27	28	33	39	48	48
55		24	28	30	35	42	52	52

Notes: *Add 4% for divided streets*

AT1: Core
AT2: Central Business District
AT3: Urban Business District
AT4: Urban
AT5: Suburban
AT6: Rural
AT7: Mountain

Table 4-3: Year 2008 Arterial / Expressway Capacity (Signal Spacing <2 miles)

On\Crossing		2-Lane	4-Lane	6-Lane	8-Lane
		-- AT1_Core --			
2-Lane		475	425	375	375
4-Lane		650	600	500	500
6-Lane		825	700	600	550
8-Lane		825	700	650	600
		-- AT2_Central Business District --			
2-Lane		575	525	475	475
4-Lane		725	675	550	550
6-Lane		875	750	650	600
8-Lane		875	750	700	650
		-- AT3_Urban Business District --			
2-Lane		600	525	475	475
4-Lane		750	675	575	575
6-Lane		900	775	675	625
8-Lane		900	775	725	675
		-- AT4_Urban --			
2-Lane		625	550	500	500
4-Lane		800	725	600	600
6-Lane		950	825	700	650
8-Lane		950	825	775	700
		-- AT5_Suburban --			
2-Lane		675	600	525	525
4-Lane		825	750	625	625
6-Lane		975	850	750	675
8-Lane		975	850	800	750
		-- AT6_Rural --			
2-Lane		675	600	525	525
4-Lane		825	750	625	625
6-Lane		975	850	750	675
8-Lane		975	850	800	750
		-- AT7_Mountain --			
2-Lane		575	500	425	425
4-Lane		750	675	550	550
6-Lane		925	800	700	625
8-Lane		925	800	750	700

Notes: Capacities are in passenger car per lane per hour (pcplph).
Lanes are mid-block 2-way lanes.
Add 20% for one-way streets.
Add 5% for divided streets.

Table 4-4: Year 2008 Arterial / Expressway Capacity (Signal Spacing >=2 Miles)

Type	Posted Speed	Capacity (Per Lane)
Multi-Lane Highway	45	1,600
	50	1,700
	55	1,800
	60	1,900
2-Lane Highway	--	1,400

Table 4-5: Year 2008 Freeway Capacity

Type	Posted Speed (mile per hour)	Capacity (passenger car per lane per hour)
Freeway/HOV	55 and below	1,900
	60 and 65	2,000
	70 and above	2,100
Freeway-Freeway Connector	40 and below	1,400
	45	1,600
	50	1,700
	55	1,800
	60 and above	1,900
Auxiliary Lane	--	1,000

Table 4-6: Year 2008 Ramp Capacity

	AT1	AT2	AT3	AT4	AT5	AT6	AT7
On-Ramp (first lane)	720	720	720	720	1,400	1,400	1,400
On-Ramp (additional lane)	480	480	480	480	600	1,400	1,400
On-Ramp (off-peak)	1,300	1,300	1,300	1,300	1,400	1,400	1,400

Notes: Use arterial/expressway capacity estimation procedure for off-ramps.
AT1: Core
AT2: Central Business District
AT3: Urban Business District
AT4: Urban
AT5: Suburban
AT6: Rural
AT7: Mountain

Toll Roads

The 2008 highway network incorporates all toll facilities, including the SR- 91 Express Lanes and the San Joaquin Eastern and Foothill Toll Roads developed by the Transportation Corridor Agency (TCA). All toll facilities are located in Orange County.

Heavy Duty Truck Designation

The Year 2008 highway network incorporates special network coding that allows for heavy-duty trucks to be converted into Passenger Car Equivalents (PCEs). This conversion enables the model to account for the effects of trucks on link capacity in the mixed flow vehicle traffic stream. The highway network also includes coding to identify truck-only lanes and truck climbing lanes.

Freeway Lane Type

For the purpose of the Regional Mode, the Year 2008 highway network includes a detailed coding of the region's freeway system. Freeway lanes are identified by the following three lane types:

- ***Freeway Main Lane*** (Through Lane) includes continuous freeway lanes that extend more than 2 miles and that pass through at least one interchange.
- ***Freeway Auxiliary Lane*** (Auxiliary Lane of Capacity Significance) includes auxiliary freeway lanes that extend more than one mile or that extend from interchange to interchange.
- ***Freeway Acceleration/Deceleration Lane*** (Other Freeway Lane) includes all types of acceleration and deceleration lanes or freeway widening that do not satisfy the conditions for main lane and auxiliary lane classifications.

Year 2008 Highway Network Summary

Table 4-7 summarizes the Year 2008 Highway Network by tallying the number of highway facility routes and lane-miles represented in the network for each county and facility type. The route mile summary includes both directions of travel, even if the roadway is represented by two separate one-way links in the coded network. Figures 4-2 through 4-4 depict the Year 2008 highway network by facility type and area type. Figure 4-5 shows the locations of the external cordon sites on the network at the modeling area's boundary.

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Table 4-7: Year 2008 Highway Network Summary

County	Centerline Miles	Lane Miles				
		AM Peak	Midday	PM Peak	Evening	Night
Freeway (Mixed-Flow)						
Imperial	95	379	379	379	379	379
Los Angeles	637	4,582	4,582	4,582	4,582	4,582
Orange	167	1,290	1,290	1,290	1,290	1,290
Riverside	308	1,698	1,698	1,698	1,698	1,698
San Bernardino	471	2,470	2,470	2,470	2,470	2,470
Ventura	94	503	503	503	503	503
Subtotal	**1,771**	**10,921**	**10,921**	**10,921**	**10,921**	**10,921**
Toll						
Imperial	0	0	0	0	0	0
Los Angeles	0	0	0	0	0	0
Orange	61	322	322	322	322	322
Riverside	0	0	0	0	0	0
San Bernardino	0	0	0	0	0	0
Ventura	0	0	0	0	0	0
Subtotal	**61**	**322**	**322**	**322**	**322**	**322**
Major Arterial						
Imperial	111	400	399	400	400	400
Los Angeles	2,268	8,775	8,770	8,775	8,769	8,769
Orange	657	3,150	3,150	3,150	3,150	3,150
Riverside	354	1,167	1,168	1,167	1,168	1,168
San Bernardino	608	1,824	1,824	1,824	1,824	1,824
Ventura	264	886	886	886	886	886
Subtotal	**4,262**	**16,202**	**16,196**	**16,203**	**16,197**	**16,197**
Minor Arterial						
Imperial	333	669	669	669	669	669
Los Angeles	2,968	9,076	9,073	9,075	9,070	9,070
Orange	902	3,152	3,152	3,152	3,152	3,152
Riverside	1,120	3,094	3,093	3,094	3,092	3,092
San Bernardino	1,614	4,266	4,266	4,266	4,267	4,267
Ventura	360	966	966	966	966	966
Subtotal	**7,297**	**21,223**	**21,220**	**21,222**	**21,216**	**21,216**
Collector						
Imperial	1,205	2,464	2,464	2,464	2,464	2,464
Los Angeles	1,720	3,816	3,815	3,816	3,814	3,814
Orange	217	621	621	621	621	621
Riverside	1,604	3,809	3,809	3,809	3,809	3,809

County	Centerline Miles	Lane Miles				
		AM Peak	Midday	PM Peak	Evening	Night
San Bernardino	2,809	6,041	6,041	6,041	6,041	6,041
Ventura	314	684	684	684	684	684
Subtotal	**7,870**	**17,435**	**17,434**	**17,434**	**17,433**	**17,433**
Freeway (HOV)						
Imperial	0	0	0	0	0	0
Los Angeles	227	468	468	468	468	468
Orange	119	243	243	243	243	243
Riverside	37	77	77	77	77	77
San Bernardino	48	95	95	95	95	95
Ventura	0	0	0	0	0	0
Subtotal	**431**	**883**	**883**	**883**	**883**	**883**
Total All Facilities						
Imperial	1,743	3,912	3,911	3,912	3,911	3,912
Los Angeles	7,820	26,716	26,708	26,716	26,702	26,702
Orange	2,124	8,777	8,777	8,777	8,777	8,777
Riverside	3,423	9,845	9,845	9,845	9,844	9,843
San Bernardino	5,550	14,696	14,696	14,696	14,696	14,696
Ventura	1,032	3,039	3,039	3,039	3,039	3,039
Total	**21,692**	**66,985**	**66,976**	**66,985**	**66,971**	**66,971**

Figure 4-2: Year 2008 Network by Facility Type

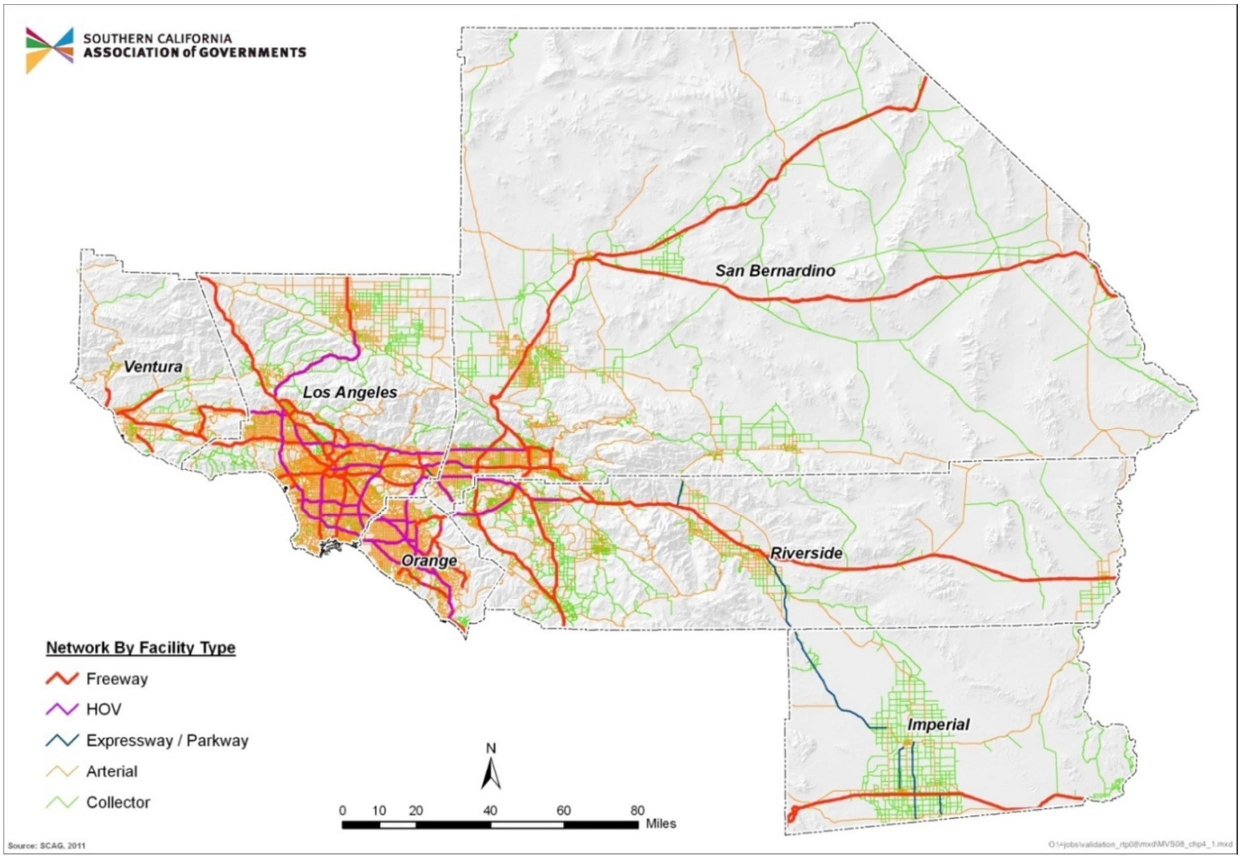


Figure 4-3: Year 2008 Modeling Area by Area Type

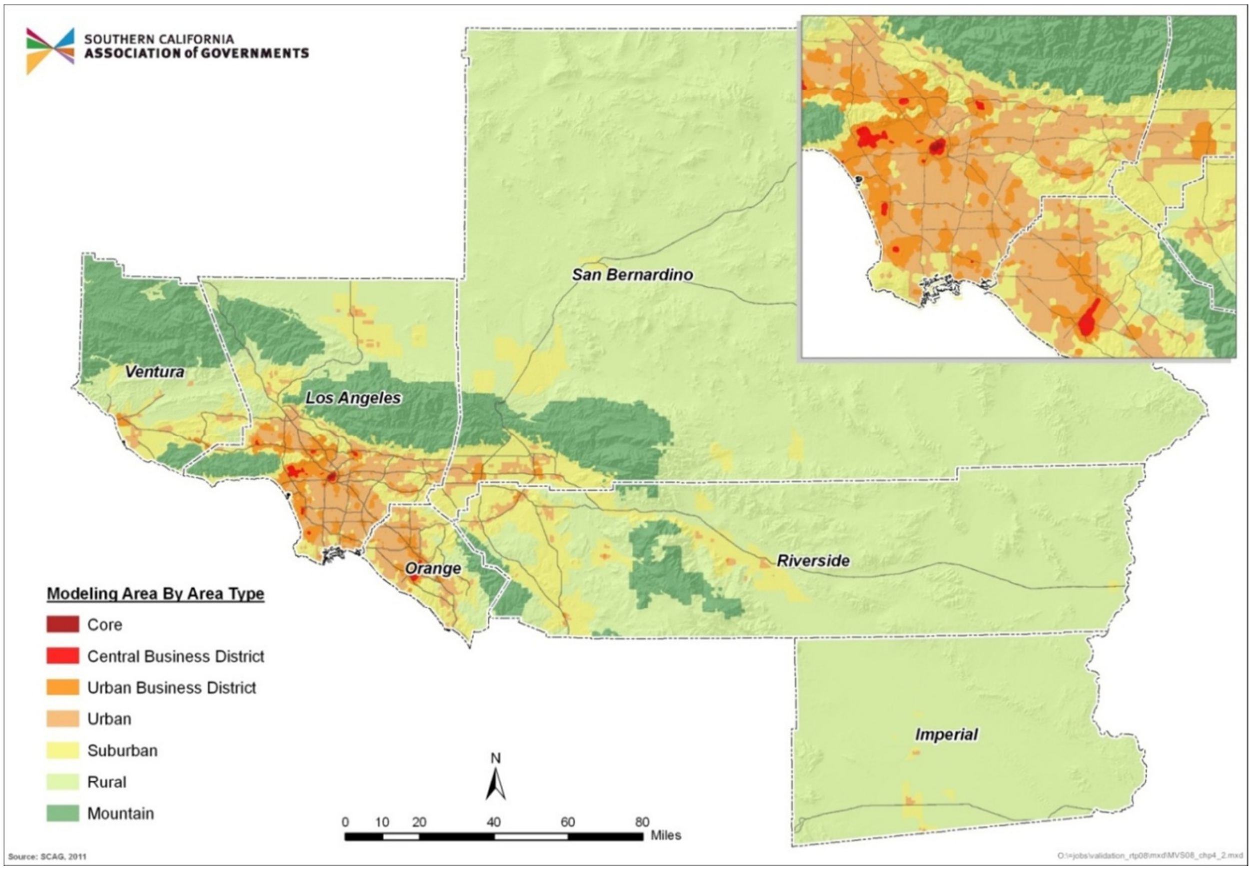


Figure 4-4: Year 2008 Network by Area Type

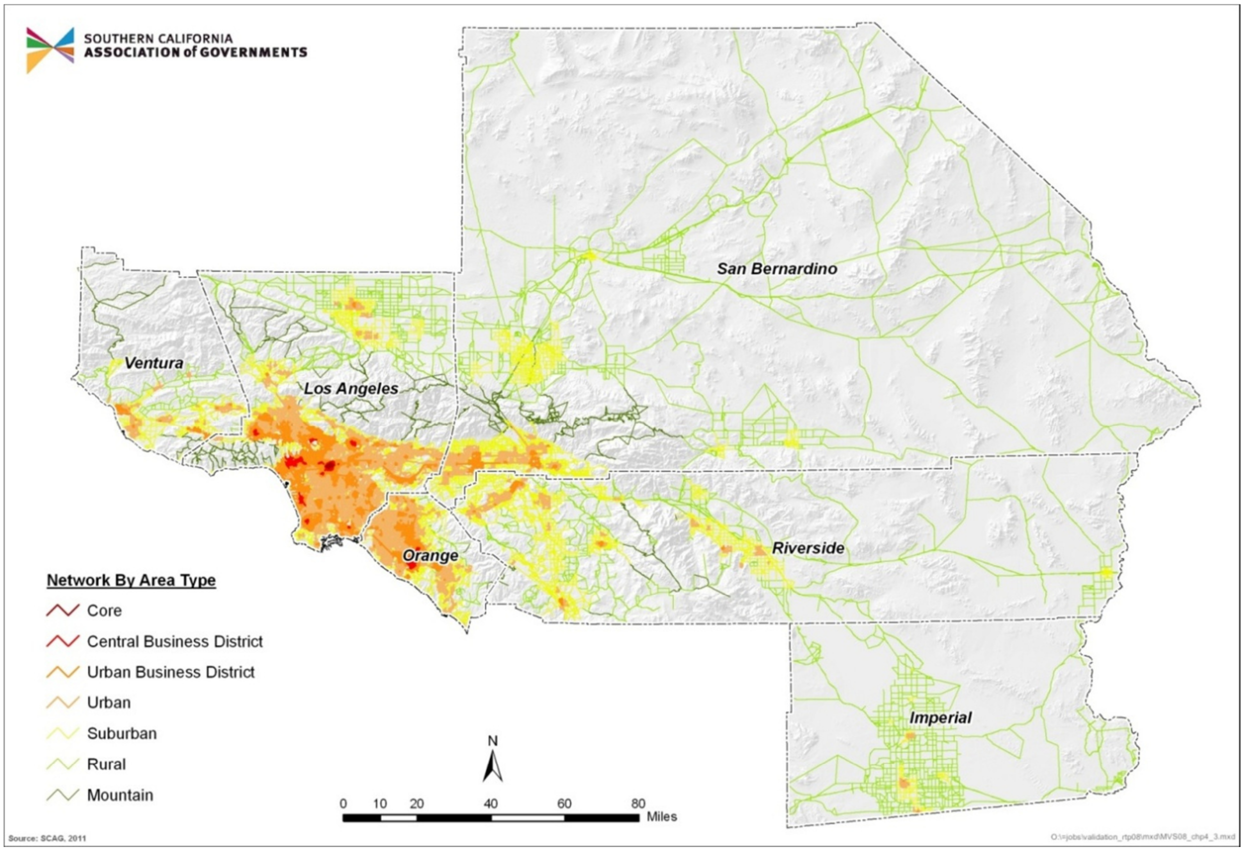
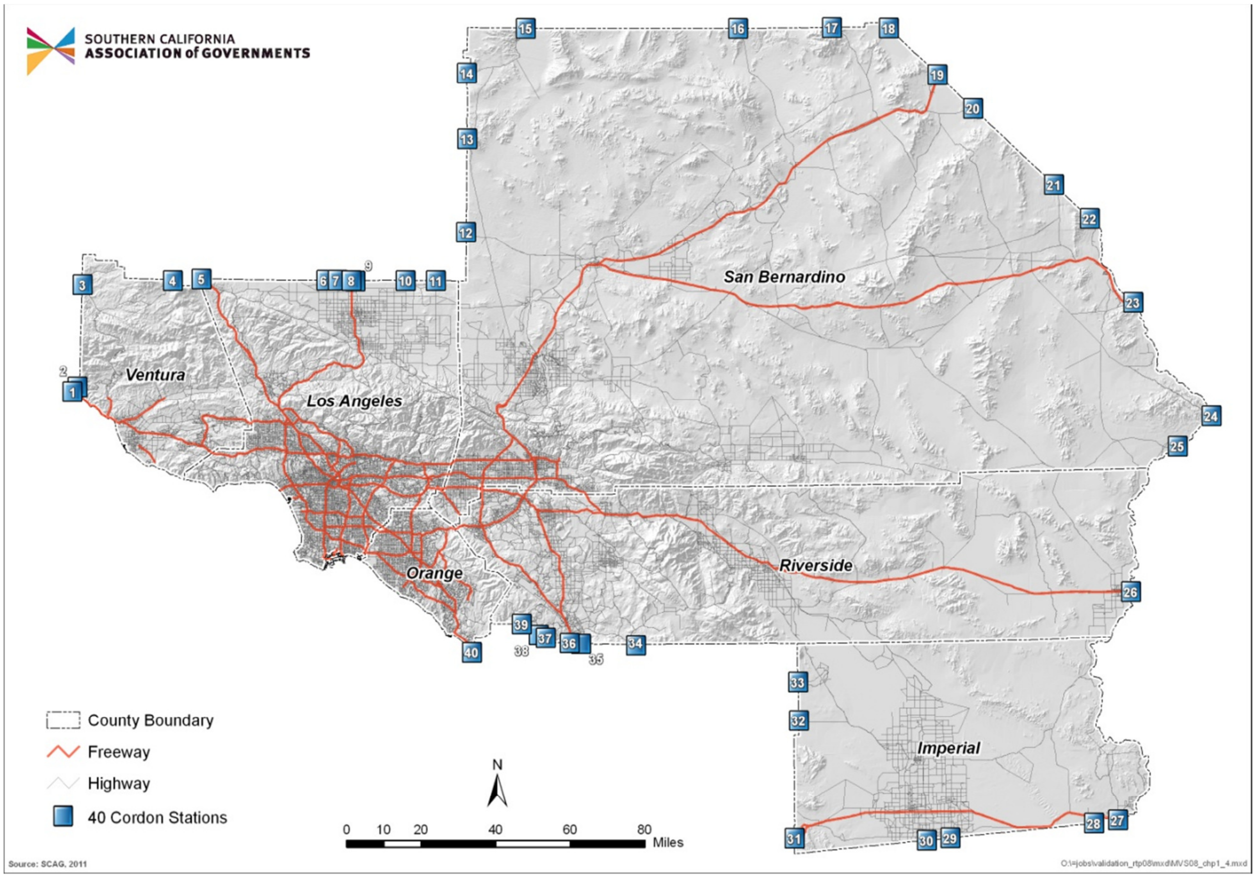


Figure 4-5: Modeling Area External Cordon Locations



Transit Networks

Consistent with the Regional Model highway network, the Year 2008 transit network covers the entire SCAG region, with nearly 3,400 transit route patterns for more than 65 transit carriers in six counties. Compared to the Year 2003 transit network, the Year 2008 transit network includes the following enhancements:

- Based on a more comprehensive transit database that covers key attributes of the Los Angeles County Metropolitan Transit Authority (LACMTA) TripMaster and FTA National Transit Database (NTD) for the SCAG region.
- Developed a program to automatically separate out all route patterns that have different pairs of start and end stops to calculate headways more accurately.
- Developed a tool to automatically convert TripMaster into the TransCAD transit network.
- Fixed problematic routes and stops not addressed by automation.
- Coded in fares at the route level and fare factors at the carrier level.
- Developed 15 transit networks to reflect transit operations by five times of day (AM, MD, PM, EV, NT) and three days of week (Mon-Fri, Sat, Sun) with detailed service hours (start time and end time).
- Used TeleAtlas to associate census block level data to develop walk access links.

For the Year 2008 transit network, transit services in the SCAG region are grouped into seven transit modes and four non-transit modes, according to their service characteristics and fare structures. An additional mode, High Speed Rail, has been added to future year transit networks. The Year 2008 transit network covers only fixed-route transit services. It does not include dial-a-ride, charter services, airport shuttles, limousines, or taxicabs.

Transit routes in each transit network are characterized by attributes such as route ID, route name, route head sign, transit operator, route distance, direction, transit modes, and fares. The transit network also includes detailed headway, frequency, start time and end time of the service for each of the five time periods.

Stops are placed along the route with information such as route ID, stop coordinates, milepost, and corresponding highway node ID. For rail transit (commuter rail and local rail), station-to-station rail time, rail station information, and Metrolink's fare zone are also coded in the network.

Transit Modes

The following seven transit modes are included in the Year 2008 transit network.

1. Commuter Rail is defined as transit service that has a fixed-guideway, traverses long-distances, has distinctive branding and vehicles, and is mostly used by commuters. In the SCAG region, commuter rail includes Metrolink and Amtrak.
2. Local Rail also has a fixed-guideway, but mainly refers to subway and light rail. Currently, LACMTA runs two subway lines (the red and purple lines) and three light rail lines (the Blue, Gold, and Green lines).
3. Express bus is defined as transit service with limited stops and a limited span of service that operates partly in mixed-flow freeway traffic and may require an additional fare. Many transit operators in the SCAG region have express bus service.
4. Rapid bus has limited stops and distinctive branding, but usually does not operate on freeways.
5. Local bus is the most common bus service that uses local streets and makes frequent stops. Almost every operator runs local bus service.
6. Transitway bus is similar to the express bus but operates on a semi-dedicated right of way (busway, HOV lanes) with limited stops at freeway stations. In the SCAG region, transitway bus refers to any express bus that uses either El Monte Busway or Harbor Transitway.
7. Bus Rapid Transit (BRT) has limited stops, a dedicated guideway, distinctive branding and vehicles. Currently, only the LACMTA Orange line is considered BRT.

Non-Transit Modes / Transit Access Links

Two types of transit access links are coded in the Year 2008 transit network and described as follows:

- Walk access and egress links - coded as two-way links between a zone centroid and a transit stop location

- Park-and-ride lot to stop and transfers between stations links - coded as two-way walk links between a park-and-ride lot and a transit stop location, and connections between stations

Transit Fares

The Year 2008 transit network includes three types of transit fares: base boarding fares, zone fares, and transfer fares; and two types of fare factors: base fare factor and transfer fare factor. Fare values were collected through the Transit Level of Service Data Collection program and are represented in 2008 dollars. Considering the complex fare structure for most carriers only published full cash fares for initial boarding and transfers are used to represent the base fare and transfer fare. To account for the revenue composition of different fare types, such as one-way walkup fares, daily/weekly/monthly passes, Senior/Student/Disabled fares, and other special fares, base fare factors and transfer fare factors are estimated from the boarding and revenue data provided by transit operators. By applying fare factors to the published full cash fare, the resulting fares represent actual fares paid by an average passenger. Finally, all boarding fares (base fare and transfer fare) are converted to 1999 dollars using a CPI adjustment factor derived from the CPI factor published by the US Department of Labor for the Los Angeles-Riverside-Orange County metropolitan area.

The fare structure varies significantly by operator and by service for the same operator. For example, LACMTA has both local and express bus service. For local bus, the general fare is a flat rate of $1.25. For express bus, there is a surcharge of $0.60 for each zone in addition to the $1.25 fare. However, OCTA, another major operator in the region, charges a general fare of $1.50 for local bus. For express bus, the fare is a flat rate of $3.00 or $4.50 depending on the route. To accommodate variations in the fares for different routes, the Year 2008 transit network codes general flat fares (i.e., base fares, transfer fares) at the route level, while the fare factors are calculated at the carrier level.

Two other major operators, Metrolink and Amtrak, follow a zone-based fare structure. For example, Metrolink fares are calculated with a distance-based formula using the shortest driving distance between stations, with an 80-mile maximum charge. To capture the published cash fare between two station pairs, a fare matrix was developed for Metrolink and Amtrak. Similarly, the LACMTA Express bus and LADOT Commuter Express bus that have zone-based fare are also included as a zone-to-zone fare matrix.

Similar to the development of fare factors for flat-rate routes, a fare factor matrix was developed based on Metrolink sales and boarding data to represent the weighted average fare for each station pair. In addition, regression analysis was conducted to generate the relationship between the distance and fares for Metrolink to predict future fares for new stations.

Year 2008 Transit Network Summary

Table 4-8 summarizes the number of transit patterns/routes represented in the peak and off-peak transit network, by "transit mode" as defined above. Figure 4-6 shows the geographic distribution of the existing rail transit network (Metrolink and Local Rail). Figure 4-7 shows the entire Year 2008 transit network.

Table 4-8: Year 2008 Transit Network Route Patterns and Route Miles

Mode ID	Mode Number	Description	Route Patterns		Route Pattern Miles	
			Peak	Off Peak	Peak	Off Peak
10	1CR	Commuter Rail	33	25	2,864	2,495
13	2LR	Local Rail	14	12	206	184
14	3EX	Express Bus	147	98	4,209	2,669
22	4RB	Rapid Bus	83	70	1,230	1,035
11	5LB	Local Bus	1,681	1,382	22,201	18,967
30	6TW	Transitway	67	40	1,704	1,121
31	7BR	Bus Rapid Transit	2	2	28	28
Total			**2,027**	**1,629**	**32,442**	**26,499**

Figure 4-6: Year 2008 Metrolink and Local Rail Network

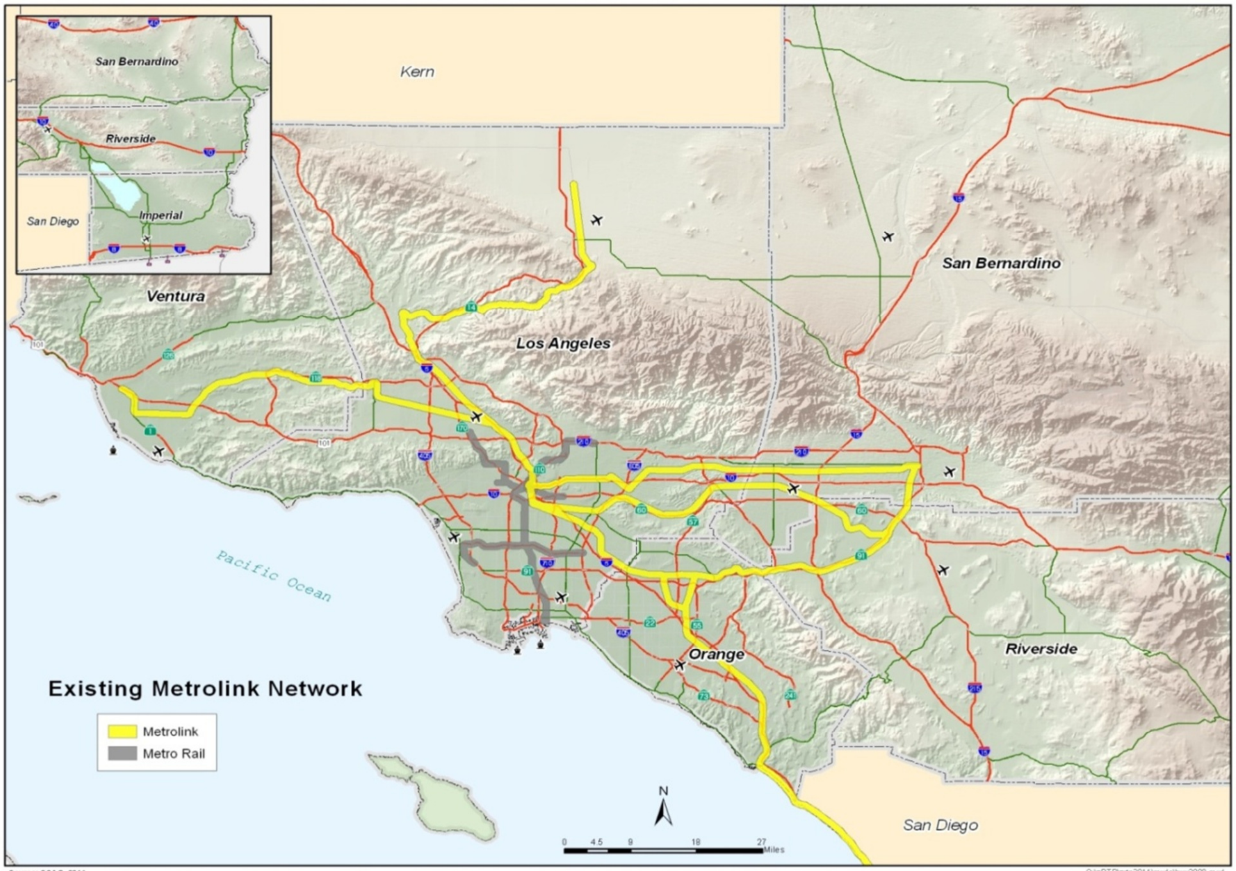
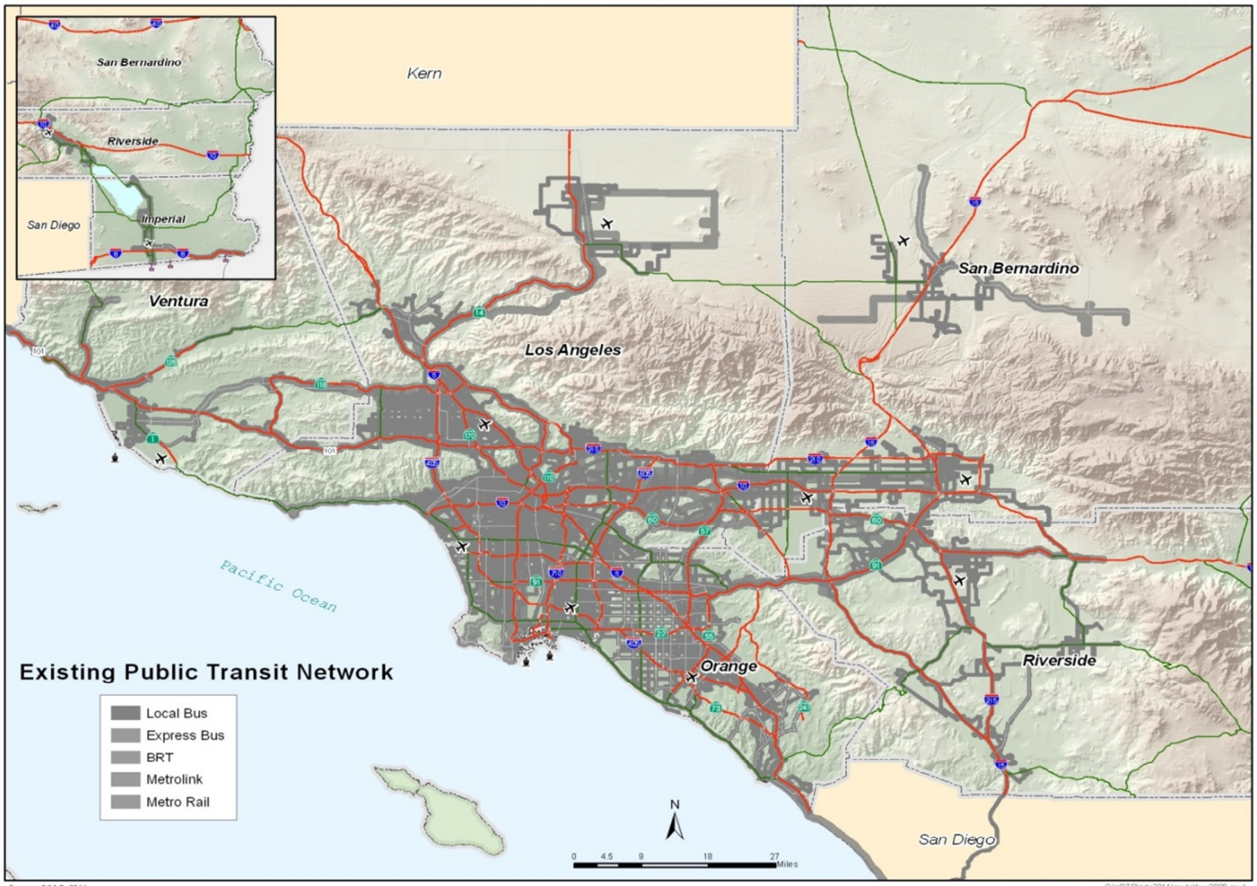


Figure 4-7: Year 2008 Public Transit Network



This Page Left Intentionally Blank

Chapter 5 - Trip Distribution

Contents

Chapter 5 – Trip Distribution

Introduction

The SCAG model uses two types of trip distribution models. The HBSC and HBCU distribution models are gravity models. The HBWD, HBWS, HBSH, HBSR, HBSP, HBO, WBO and OBO distribution models are destination choice models.

The destination choice models were estimated in multinomial logit form using the ALOGIT software. These estimated models are stratified by household income, and by auto availability in the case of non-work trips. In application the models are stratified by the car sufficiency/income market segments shown in Table 3-12.

The models were developed in phases, corresponding to the availability of data required to estimate and calibrate the models. First, the models were estimated and calibrated using the SCAG 2000 household survey and corresponding 2000 mode choice logsums and distance skims. The models were then applied and initially calibrated to a 2000 scenario built using Tier 2 zones. Then, the models were applied and re-calibrated using the 2008 Tier 2 model setup. Lastly, the car sufficiency stratification was introduced and the 2008 calibration was refined at the Tier 2 level.

Estimation Dataset

The SCAG 2000 household travel behavior survey provided the trip records for model estimation. Because of the large number of destination alternatives (4,109 in the Tier 1 zone system), it is impractical to include all alternatives in the estimation dataset. A sampling-by-importance approach, combined with an exploded sample, was used to choose alternative sets for each trip observation. Each trip record was duplicated 10 times and different choice sets with 30 alternatives each were selected based on the size term and distance. A weight of 1/10 is applied to each observation to scale the standard error. This approach has been shown to produce results that are nearly statistically equivalent to selecting 300 alternatives for the choice set.

The importance function gives the probability of selecting a zone (j) for the choice set, and is defined as:

$$W_j = A_j \times exp\left(-2D_{ij}/D\right)$$

$$P_j = \frac{W_j}{\sum_j W_j}$$

Where *D* is the regional observed average distance, *Aj* is a size variable, and *Dij* is the distance to each zone.

Main Explanatory Variables

The mode choice logsum coefficients were constrained to a value consistent with utility maximization theory. The following variables were examined and proved to be significant in the utility functions:

- Mode choice logsum
- Distance between production zone and potential attraction zone destinations
  - Linear distance
  - Distance squared
  - Distance cubed
- Household income interacted with distance
- Mix employment, household and intersection density (mix density) interacted with distance
- Intra-zonal indicator interacted with mix density
- Auto availability interacted with distance
- Employment by industry

Utility Structure

The utility (U_{ij}) of choosing destination (j) for a trip (m) produced in zone (i) is given by:

$$U_{ijm} = \theta \times L_{ijm} + \sum_k \beta^k D_{ij}^k + \sum_k \delta_m^k N_m^k D_{ij}^k + \sum_k \gamma_m^k M_i^k IZ_j + Ln(A_{jm}) + C_{jm}$$

Where:

- L_{ijm} is the mode choice logsum corresponding to trip market (m);
- $\beta^k D_{ij}^k$ are the terms of a distance polynomial; N_m^k represents attributes of the trip market (m), such as income or auto availability, used for creating interaction terms with distance;
- M_i^k represents attributes of the trip production zone, such as density, interacted with the intra-zonal alternative; and
- A_{jm} is the size variable; and C_{jm} is a sampling correction term.

The sampling correction term compensates for the sampling error in the model estimation (i.e., represents the difference between the sampling probability and final estimated probability for each alternative). This sampling correction term is not included in the utility function when the model is applied.

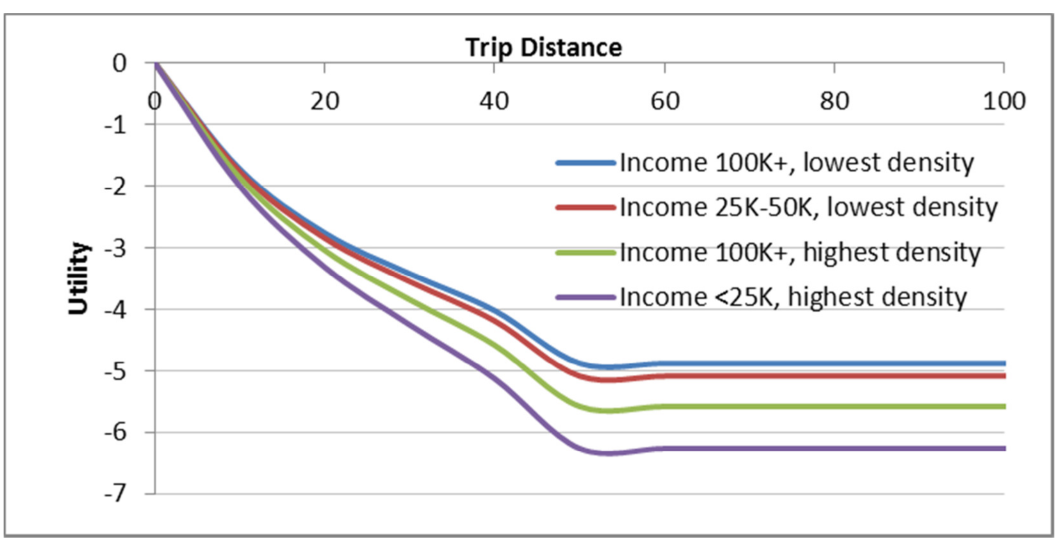
Estimation Results

Table 5-1 and Figure 5-1 show the final HBW estimation results. The coefficient on mode choice logsum was constrained to 0.6, because it was consistently estimated to be larger than 1 across several different specifications. The distance polynomial results in a monotonically decreasing utility. The distance disutility was capped at 50 miles, to avoid a very large negative coefficient on the linear term, and/or non-monotonic disutility specifications. The mix density variable exhibited logical effects: higher mix density results in a higher likelihood of an intra-zonal trip, and a decrease in average trip length. The estimation results also show that average trip length increases with household income, all else equal.

Table 5-1: HBW Destination Choice Estimation Results

Explanatory Variable	HBWD		HBWS	
	Coefficient	t-Stat	Coefficient	t-Stat
Mode Choice Logsum	0.60	n/a	0.60	n/a
Distance	-0.2178	-24.5	-0.1803	-15.1
Distance Squared	0.005025	10.5	0.003363	5.2
Distance Cubed	-0.000052	-6.8	-0.000028	-2.7
Distance Squared, Off-Peak	--	--	-0.001256	-3.1
Distance Cubed, Off-Peak	--	--	0.000029	2.9
Intra-Zonal Indicator	0.404	4.4	0.533	3.9
Intra-Zonal, Off-Peak	--	--	0.328	2.1
Intra-Zonal, if IZ distance > 1.5 mi	0.023	0.6	--	--
Intra-Zonal * Density				
Low Density	0.5295	3.7	0.4857	2.5
Medium Density	0.9060	5.7	0.7056	3.1
High Density	1.0247	7.3	0.9439	5.0
Distance * Density				
Low Density	-0.0108	-2.9	--	--
Medium Density	-0.0158	-3.4	-0.00376	-0.8
High Density	-0.0140	-3.4		
Distance * Household Income				
Low Income	-0.0135	-2.4	0.0344	5.0
Medium Income	-0.0041	-1.0	-0.0095	-1.7
High Income	-0.0015	-0.4	-0.0051	-1.1
Observations	9322(x10)	--	4458(x10)	--
Final Log-Likelihood	-29210	--	-13965	--
Rho-Squared (Zero)	0.0248	--	0.0270	--
Rho-Squared (Constants)	0.0284	--	0.0282	--

Figure 5-1: HBW Distance Decay Functions



Alternative values for the mode choice logsum coefficient and for the distance disutility cap were explored, as well as alternative ways to represent the utility of an intra-zonal trip. Varying the logsum coefficient between 0.6 and 0.9 resulted in practically no change in the other parameter estimates. The cap on distance disutility, on the other hand, has a strong effect on the other parameter estimates. A completely un-constrained model resulted in very short trip lengths, when applied to the entire region. Conversely, capping the disutility at 30 or 40 miles resulted in a much larger than observed share of trips 50 miles long or longer.

The likelihood of choosing the same attraction zone as the production zone is partly a function of zone size, and partly a function of the mix of residential and employment locations within the zone. Even though the zone system consists of more than 11,000 TAZs, the SCAG region is so large that in rural areas the zones are still quite large. The estimation results showed that the likelihood of an intra-zonal trip increases with zone size, and decreases with neighborhood density.

Separate models were estimated for peak and off-peak period trips, but because the differences between them were small, the observations were pooled to estimate the final model. Observed time-of-day differences in average trip lengths were captured in the distance polynomial parameters during model calibration.

The final estimation results for the home-based non-work models are shown in Table 5-2. Overall similar relationships were observed as in the HBW models. In all cases the mode choice logsum coefficient was constrained because its estimated values were greater than 1.0. A value of 0.9 was chosen to reflect greater elasticity of demand with respect to changes in levels of service than assumed for the HBW models. Higher density at the production zone end results in a higher likelihood of an intrazonal trip. Unlike the HBW models, the coefficient on the density and household income terms interacted with distance appear to show increasing trip distance with density and lower income. However, since the transit utilities are a function of residential and employment density, the combined effect will need to be examined during model application. HBSH, HBSR and HBO all exhibit a negative coefficient for 0-car household trips, indicating that these households tend to make shorter trips, on average, than other households.

The final estimation results for the non-home based models are shown in Table 5-3. No household attributes were explored since they cannot be used in model application. The distance decay and intrazonal effects are similar to those estimated for the home-based models. The density effect on trip lengths proved to be insignificant, except for signaling a higher likelihood of an intrazonal trip with increasing production zone density.

Table 5-2: Home-Based Non-Work Destination Choice Estimation Results

Explanatory Variable	HBSH		HBSR		HBSP		HBO	
	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat
Mode Choice Logsum	0.9	n/a	0.9	n/a	0.9	n/a	0.9	n/a
Distance	-0.6482	-62.9	-0.4220	-48.8	-0.5814	-58.7	-0.1896	-21.1
Distance Squared	0.019043	32.9	0.009845	23.3	0.013799	25.1	0.003422	12.0
Distance Cubed	-0.000183	-20.3	-0.000076	-13.0	-0.000107	-12.6		
Intra-Zonal Indicator	-0.268	-3.6	0.081	1.0	0.100	1.7	0.670	7.8
Intra-Zonal * Density								
Low Density	0.469	4.0	0.676	5.5	0.584	6.2	0.456	3.3
Medium Density	0.947	7.3	0.724	4.8	1.107	10.0	0.194	1.1
High Density	1.159	9.4	1.141	8.5	1.146	10.6	1.053	7.1
Distance * Density								
Low Density	--	--	0.0146	5.2	0.0188	4.6	-0.050	-7.5
Medium Density	--	--	--	--	0.0254	6.3	-0.064	-8.2
High Density	--	--	--	--	--	--	-0.036	-5.7
Distance * Household Income								
Low Income	0.0330	5.8	0.0385	8.6	0.0616	11.7	0.003	0.4
Medium Income	0.0040	0.8	0.0088	2.2	0.0104	2.0	-0.062	-9.6
High Income	-0.0017	-0.3	-0.0015	-0.4	0.0060	1.2	-0.072	-12.6
Distance * No Car Availability	-0.0604	-3.3	--	--	-0.0483	-2.7	-0.0363	-2.2
	--	--	--	--	--	--	--	--
Observations	7,614(x10)	--	6,698(x10)	--	8,762(x10)	--	5,045(x10)	--
Final Log-Likelihood	-18712	--	-18880	--	-21442	--	-14320	--
Rho-Squared (Zero)	0.2275	--	0.1340	--	0.2437	--	0.1247	--
Rho-Squared (Constants)	0.2119	--	0.1295	--	0.2286	--	0.1173	--

Table 5-3: Non-Home Based Destination Choice Estimation Results

Explanatory Variable	WBO		OBO	
	Coefficient	t-Stat	Coefficient	t-Stat
Mode Choice Logsum	0.90	n/a	0.90	n/a
Distance	-0.1114	-50.9	-0.4608	-45.0
Distance Squared	--	--	0.012248	20.6
Distance Cubed	--	--	-0.000103	-11.2
Intra-Zonal Indicator	0.981	12.5	0.267440	2.7
Intra-Zonal * Density				
Low Density	0.5630	4.5	0.4400	4.1
Medium Density	0.7423	5.5	0.7954	6.4
High Density	1.3055	11.4	1.1159	9.6
Distance * Density				
Low Density	--	--	-0.0024	-0.5
Medium Density	--	--	-0.0038	-0.7
High Density	--	--	-0.0024	-0.5
Observations	-5,762(x10)	--	6,207(x10)	--
Final Log-Likelihood	-17172	--	-16477	--
Rho-Squared (Zero)	0.0801	--	0.1824	--
Rho-Squared (Constants)	0.0787	--	0.1702	--

Gravity Models (HBSC and HBCU Trip Purposes)

The gravity model is used to distribute HBSC and HBCU trips from origin zone to each destination zone in the region. It is based on Newton's law of gravity, which describes the gravitational force between two bodies. The number of trips between zones in transportation models is a function of the attractiveness of a zone and the travel impedance between zones:

$$T_{ij} = \frac{P_i * (A_j * F(I_{ij}) * K_{ij})}{\sum_j (A_j * F(I_{ij}) * K_{ij})}$$

where, Tij is the number of trips produced in zone i and attracted to zone j;
Pi is the number of trips produced in zone i;
Aj is the number of trips attracted to zone j;
Iij is a measure of impedance of travel from i to j;
F is a friction factor, which is a function of the impedance that represents the disutility of travel between i and j; and
Kij is the zone-to-zone adjustment factor, which takes into account the effect of undefined socioeconomic linkages not otherwise incorporated in the gravity model.

The gravity model in this application will apportion the trips produced at each production zone among attraction zones according to the attractiveness of each zone and the disutility of travel for each trip interchange. The SCAG gravity models are doubly constrained, which means that the program will iterate until the trips produced from and attracted to each zone are consistent with the trip productions and attractions forecasted in trip generation.

The friction factors for were derived by fitting the trip length frequency distributions to the observed HBSC and HBCU distributions for each time period (peak and off-peak). The basic formula for the friction factors is given by the gamma function below.

$$f(x) = ax^{-b}e^{-cx}$$

where a, b, and c are parameters to be calibrated, and x is the trip impedance.

Two exponential decay parameters (c parameter) were calibrated, to better match the tail of the trip length distribution. The calibrated gamma function parameters, and the travel time that corresponds to the change from c1 to c2 (curve inflection) are shown in Table 5-4.

Table 5-4: Trip Distribution Gamma Function Parameters by Time Period

Purpose	Time Period	Gamma a	Gamma b	Gamma c1	Gamma c2	Inflection (travel time)
HBSC	Peak	650,000	1.4352	0.2198	0.0276	15.00
	Off-peak	6,500,000	2.0889	0.2184	0.0192	13.00
HBCU	Peak	500,000	1.4066	0.1148	0.0681	15.00
	Off-peak	500,000	2.4734	0.1474	0.0580	15.00

Model Application and Calibration

In application the destination choice models are stratified by five trip markets, defined by car sufficiency and income levels. Since the mode choice models are similarly stratified, the mode choice logsums are matched at the trip market level. The estimated size variables were replaced with the attraction models described above. The household income interaction terms were expanded to represent trip market interaction terms, with values established as part of the model calibration.

The calibration of the destination choice models consisted of adjusting the distance polynomial until the estimated trip lengths and trip flow matrices reproduce the observed CTPP and household survey patterns. Several different measures of the fit of the model to the observed data were examined, including average trip length by trip purpose, time period and trip market level, average trip length by trip purpose market and density level, trip length distribution and coincidence ratio, ACS 3-year county-level worker flow patterns, and NHTS 2008 county-level trip flow patterns.

Below the county level, the only sources of trip flow data are the 2000 SCAG household travel survey, and an adjusted CTPP 2000 worker flow matrix. Due to the varying rates of growth across the SCAG region between 2000 and 2008, these observed trip patterns are not entirely comparable to the 2008 conditions. Keeping these differences in mind, a district-level comparison of trip patterns for HBW, HBNW and NHB trips was performed to look for systematic geographic biases in the forecast.

Table 5-5 shows the validation of average trip lengths by trip purpose, time period and household market. The estimated trip length is typically within 10% of the observed trip length, except in a few cases where the observed values appear biased by small sample sizes in the observed data. In such instances the model was calibrated to exhibit a logical progression of average trip lengths across household markets.

Table 5-5: Average Trip Distance Validation, Household Income Levels

Purpose	Period	Household Segment	Number of Obs.	Average Distance (mi)		
				Observed	Estimated	Ratio
HBWD	Peak	Zero [1]	247	6.4	7.6	1.19
		Insuf	995	11.9	12.5	1.05
		Suf/Low	1124	13.2	11.1	0.84
		Suf/Med	2451	14.1	14.3	1.02
		Suf/Hi	7168	16.4	16.1	0.98
	Off-Peak	Zero	150	6.8	6.6	0.97
		Insuf	644	11.5	11.0	0.95
		Suf/Low	718	10.9	9.6	0.88
		Suf/Med	1537	12.1	11.7	0.97
		Suf/Hi	3533	14.2	13.3	0.94
HBWS	Peak	Zero	108	10.2	10.0	0.98
		Insuf	326	13	13.1	1.01
		Suf/Low	306	11	10.7	0.97
		Suf/Med	797	15.2	13.8	0.91
		Suf/Hi	2450	17.6	17.4	0.99
	Off-Peak	Zero	59	10.6	10.1	0.96
		Insuf	154	14.4	13.4	0.93
		Suf/Low	164	13.8	11.3	0.82
		Suf/Med	354	15.4	14.8	0.96
		Suf/Hi	999	16.9	16.9	1.00
HBSH	Peak	Zero	114	2.9	3.2	1.11
		Insuf	593	6.6	6.5	0.99
		Suf/Low	390	6.3	4.9	0.77
		Suf/Med	799	5.3	6.4	1.21
		Suf/Hi	1745	8.9	8.5	0.96
	Off-Peak	Zero	198	2.8	2.7	0.97
		Insuf	970	5.5	6.1	1.11
		Suf/Low	696	8.4	4.7	0.56
		Suf/Med	1251	7.2	6.4	0.89
		Suf/Hi	2722	6.8	7.4	1.08
HBSR	Peak	Zero	81	8.8	6.0	0.68
		Insuf	478	10.2	10.3	1.01
		Suf/Low	295	11.4	7.3	0.64
		Suf/Med	652	9.8	9.7	0.99
		Suf/Hi	1727	10.7	12.4	1.16
	Off-Peak	Zero	136	12.7	5.7	0.45
		Insuf	784	10.5	10.3	0.98
		Suf/Low	440	13	7.8	0.60
		Suf/Med	1074	10.7	10.5	0.98
		Suf/Hi	2659	12	12.6	1.05

(1)*See Table 3-12 for the household market segments definitions.*

Purpose	Period	Household Segment	Number of Observations	Average Distance (mi)		
				Observed	Estimated	Ratio
HBSP	Peak	Zero	126	3.9	3.2	0.81
		Insuf	1535	5.9	6.4	1.09
		Suf/Low	650	8.5	5.6	0.66
		Suf/Med	1281	4.6	6.6	1.43
		Suf/Hi	2944	6.1	8.1	1.32
	Off-Peak	Zero	108	2.4	3.0	1.26
		Insuf	950	6.3	6.3	1.00
		Suf/Low	452	8.2	5.8	0.71
		Suf/Med	807	7.2	7.0	0.98
		Suf/Hi	1710	7.1	8.8	1.24
HBO	Peak	Zero	222	4.5	4.8	1.07
		Insuf	1045	7.6	8.0	1.05
		Suf/Low	581	10.6	9.0	0.85
		Suf/Med	1291	9.1	9.9	1.09
		Suf/Hi	3189	10.5	10.4	0.99
	Off-Peak	Zero	311	4.6	5.1	1.11
		Insuf	1361	8.5	8.4	0.99
		Suf/Low	915	7.9	7.5	0.95
		Suf/Med	1692	9.3	9.5	1.02
		Suf/Hi	3760	9.2	10.1	1.10
WBO	Peak	All	1483	9.8	9.0	0.92
	Off-Peak	All	4478	8.2	8.2	1.00
OBO	Peak	All	6471	7.2	8.0	1.11
	Off-Peak	All	10015	7.3	6.6	0.90
HBCU	Peak	All	631	9.2	9.8	1.06
	Off-Peak	All	605	8.7	9.4	1.08
HBSC	Peak	All	4733	3.8	3.8	1.01
	Off-Peak	All	1887	3.3	3.3	1.01

Table 5-6 shows the coincidence ratio for each trip purpose. The coincidence ratio is a measure of the goodness of fit of the calibrated trip length distribution compared to the observed trip length distribution.

Table 5-6: Trip Length Distribution Coincidence Ratios

Trip Purpose	Coincidence Ratio
HBW	0.91
HBSH	0.87
HBSR	0.85
HBSP	0.86
HBO	0.89
HBSC	0.89
WBO	0.83
OBO	0.88
All Purposes	0.92

Table 5-7 shows the validation of the estimated 2008 county-to-county HBW trip flows. Note that the ACS data show worker flows, not trip flows. Figures 5-2 to 5-9 show a comparison of observed and estimated trip length frequency distributions for each trip purpose. The observed trip lengths were obtained from the most recent region-wide household survey, conducted in 2000.

Table 5-7: County-To-County HBW Trip Validation

Worker Flows, 2006-2008 ACS								
	County	**25**	**37**	**59**	**65**	**71**	**111**	**SCAG**
25	Imperial	50,095	110	55	1,180	100	-	51,540
37	Los Angeles	440	4,091,655	187,305	15,960	59,690	37,335	4,392,385
59	Orange	30	176,265	1,206,415	15,390	12,070	600	1,410,770
65	Riverside	540	46,615	67,595	608,895	92,430	450	816,525
71	San Bernardino	150	126,095	36,735	71,540	592,570	745	827,835
111	Ventura	-	66,630	1,255	195	440	292,115	360,635
	SCAG Region	**51,255**	**4,507,370**	**1,499,360**	**713,160**	**757,300**	**331,245**	**7,859,690**
HBW Trips, 2008 Model Estimate								
	County	**25**	**37**	**59**	**65**	**71**	**111**	**SCAG**
25	Imperial	73,006	230	160	1,321	109	18	74,846
37	Los Angeles	16	5,782,959	508,313	30,616	105,241	69,413	6,496,559
59	Orange	6	383,227	1,831,667	25,750	27,432	577	2,268,659
65	Riverside	328	63,687	135,662	756,757	162,185	506	1,119,124
71	San Bernardino	56	184,563	93,864	137,795	752,588	905	1,169,771
111	Ventura	1	167,341	1,749	208	413	402,767	572,478
	SCAG Region	**73,414**	**6,582,006**	**2,571,416**	**952,447**	**1,047,968**	**474,186**	**11,701,437**
Forecast Difference (%), Trips vs. Worker Flow, County Normalized								
	County	**25**	**37**	**59**	**65**	**71**	**111**	**SCAG**
25	Imperial	0.3%	0.1%	0.1%	-0.5%	0.0%	-	0.0%
37	Los Angeles	0.0%	-4.1%	3.6%	0.1%	0.3%	0.2%	0.0%
59	Orange	0.0%	4.4%	-4.8%	0.0%	0.4%	0.0%	0.0%
65	Riverside	0.0%	0.0%	3.8%	-7.0%	3.2%	0.0%	0.0%
71	San Bernardino	0.0%	0.5%	3.6%	3.1%	-7.2%	0.0%	0.0%
111	Ventura	-	10.8%	0.0%	0.0%	0.0%	-10.6%	0.0%
	SCAG Region	**0.0%**	**-1.1%**	**2.9%**	**-0.9%**	**-0.7%**	**-0.2%**	**0.0%**

Figure 5-2: HBW Trip Length Validation

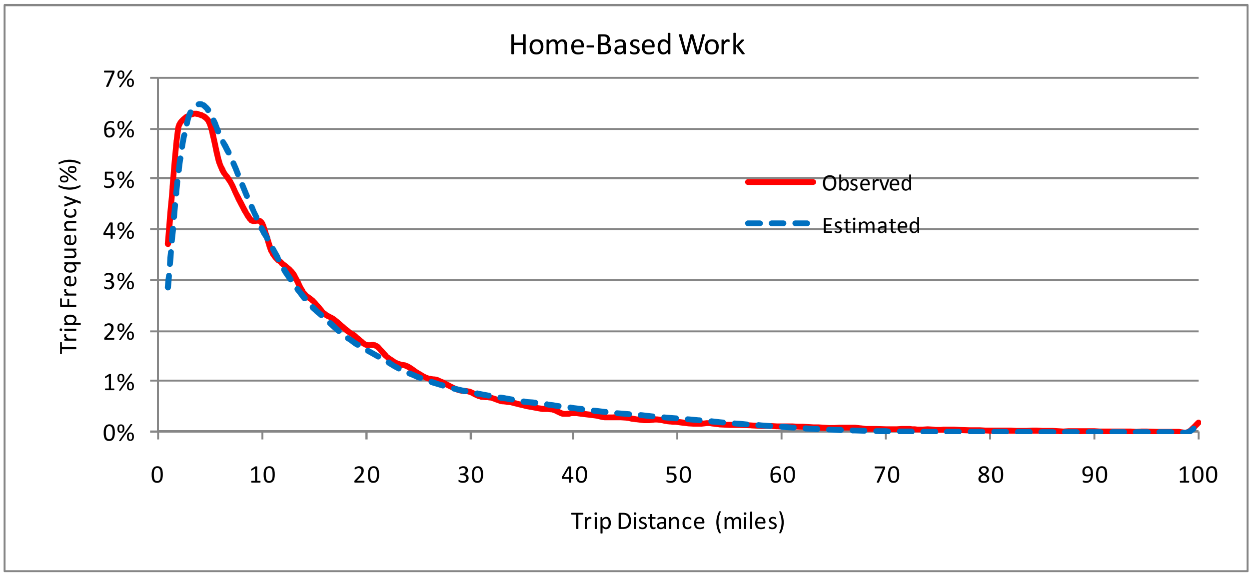


Figure 5-3: HBSH Trip Length Validation

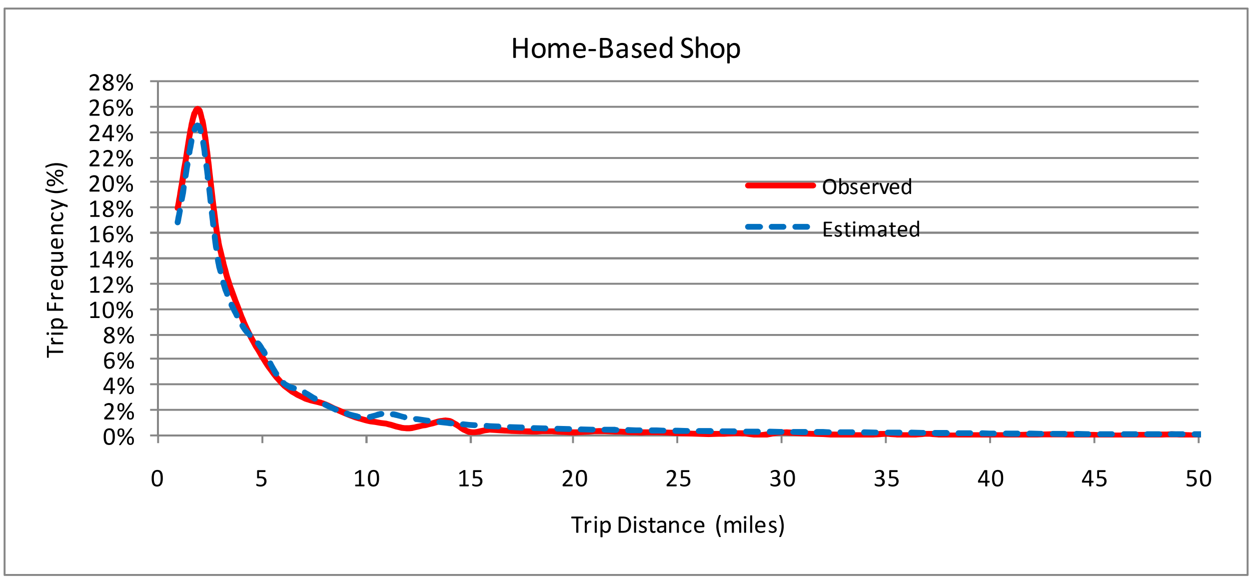


Figure 5-4: HBSR Trip Length Validation

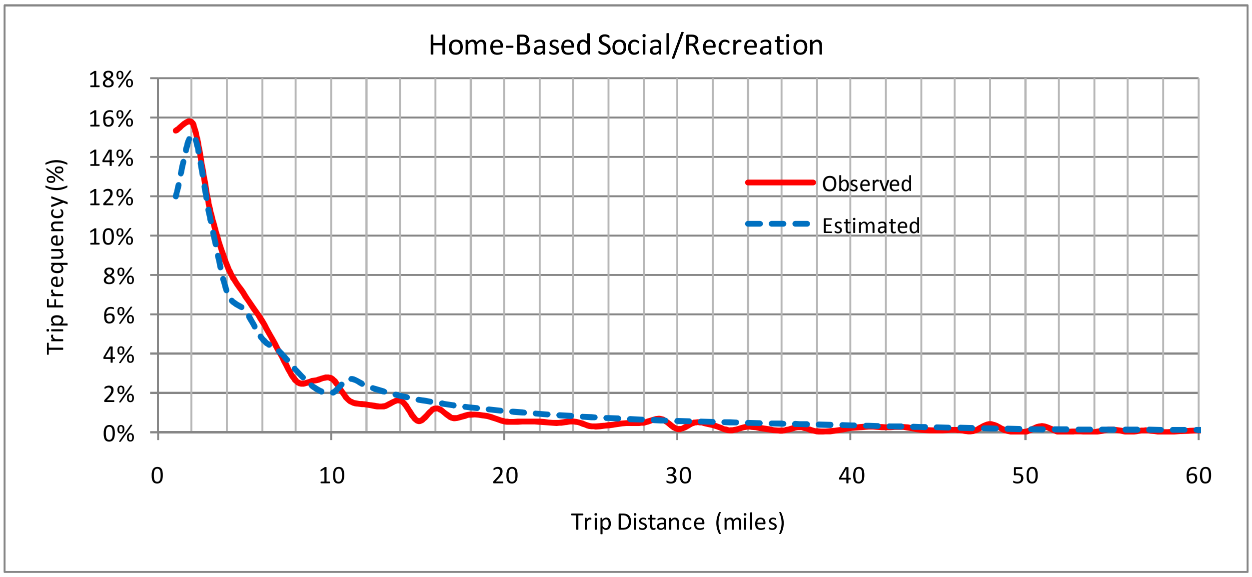


Figure 5-5: HBSP Trip Length Validation

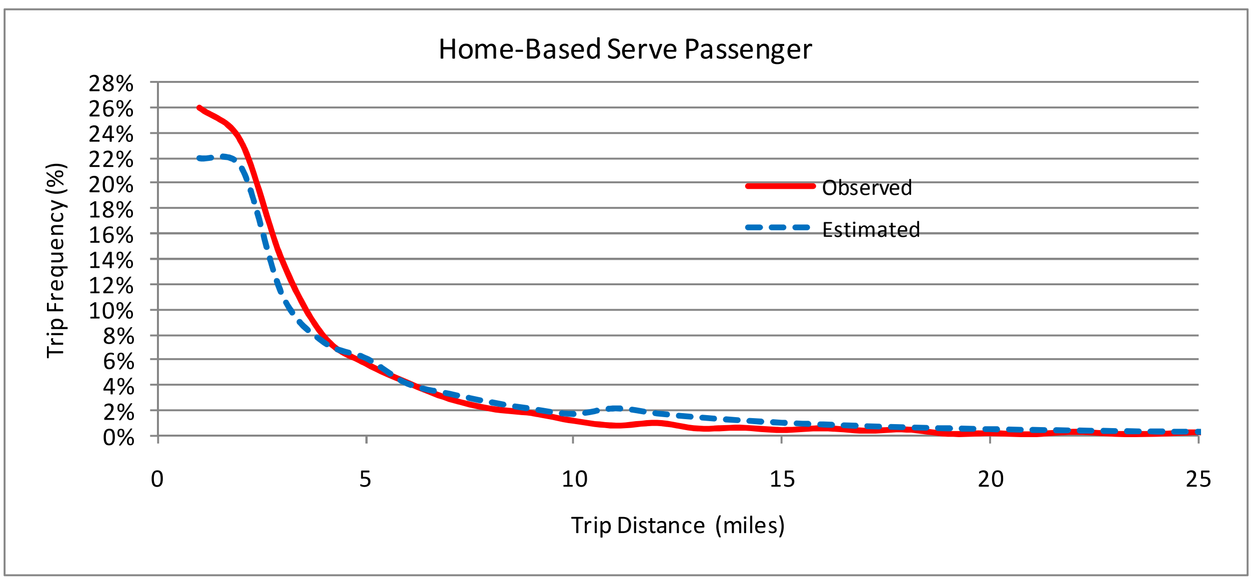


Figure 5-6: HBO Trip Length Validation

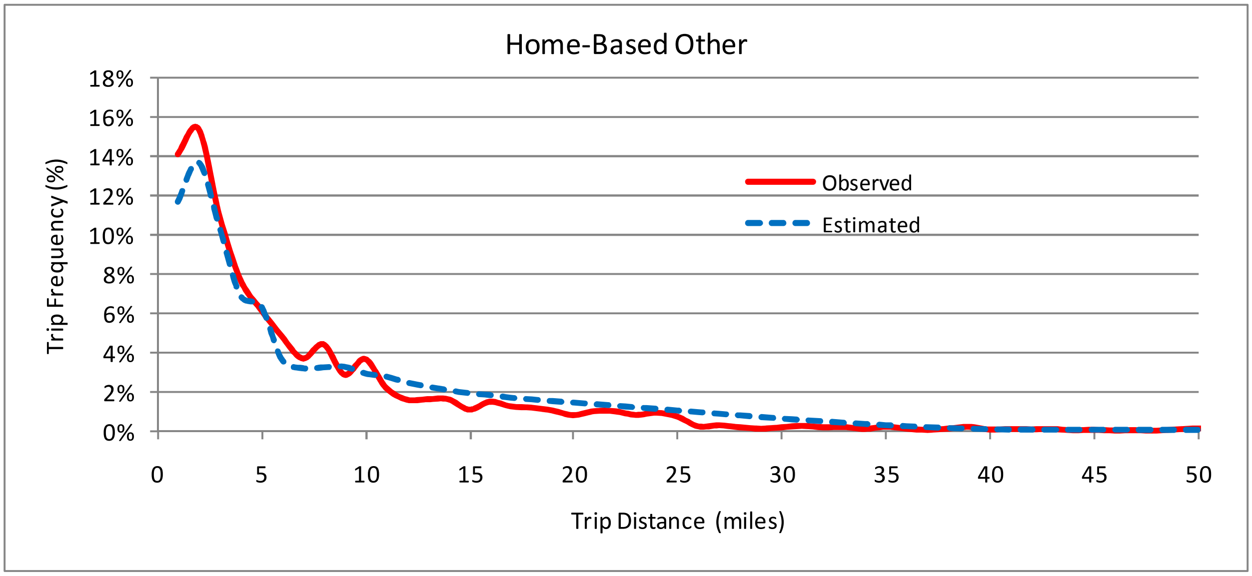


Figure 5-7: WBO Trip Length Validation

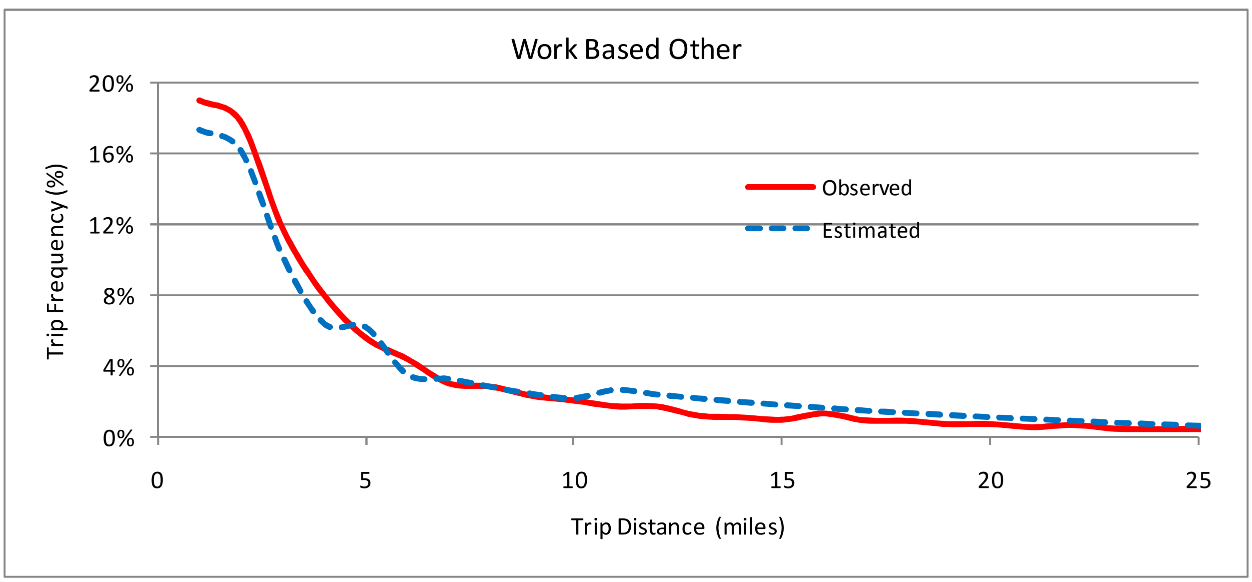


Figure 5-8: OBO Trip Length Validation

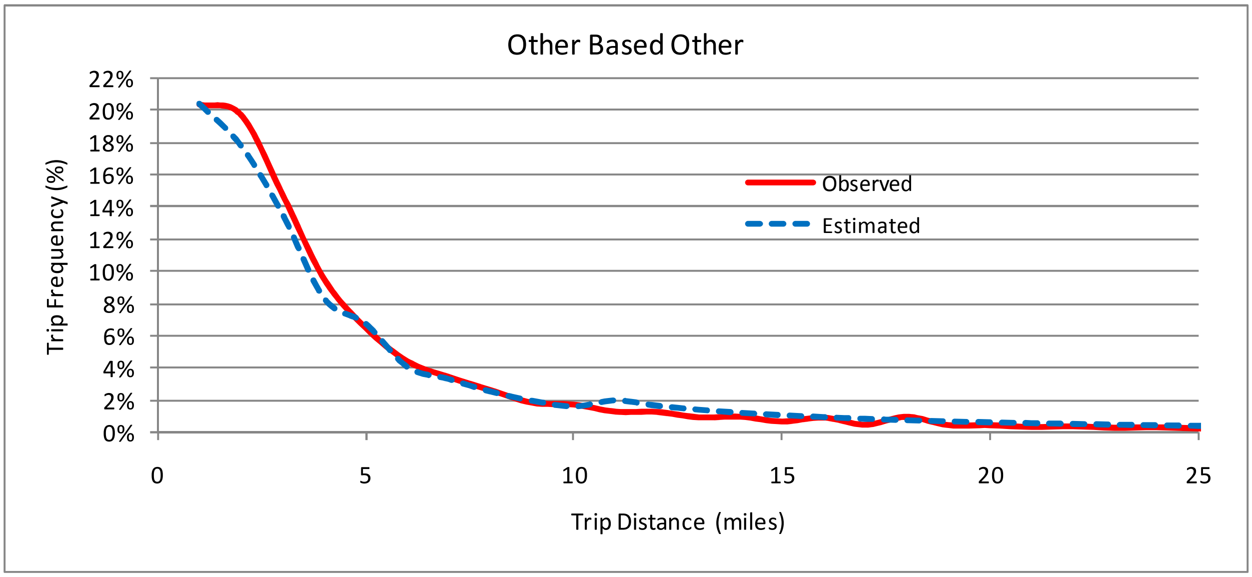
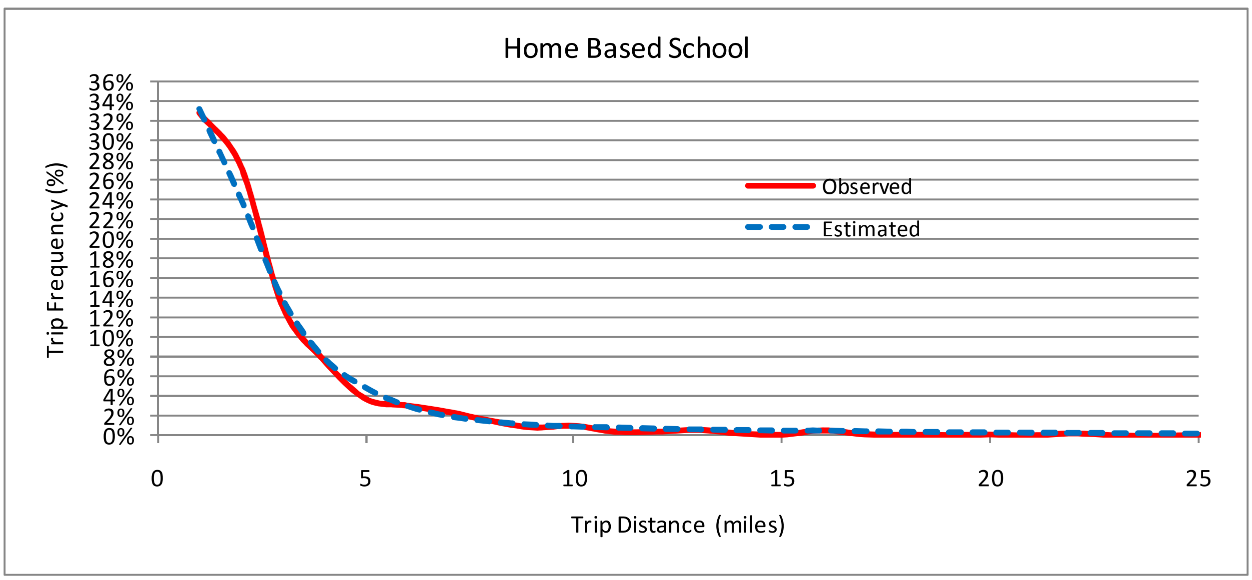


Figure 5-9: HBSC Trip Length Validation



Trip Distribution Model Results

Table 5-8: Year 2008 Home-Based Work Person Trip Distribution

From\To	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total Productions
Imperial	**73,006** **99.44%**	230 *0.00%*	161 *0.01%*	1,321 *0.14%*	109 *0.01%*	18 *0.00%*	74,846 *100.00%*
Los Angeles	16 *0.02%*	**5,782,960** ***87.86%***	508,313 *19.77%*	30,616 *3.21%*	105,241 *10.04%*	69,413 *14.64%*	6,496,560 *100.00%*
Orange	6 *0.01%*	383,227 *5.82%*	**1,831,667** ***71.23%***	25,750 *2.70%*	27,432 *2.62%*	577 *0.12%*	2,268,659 *100.00%*
Riverside	329 *0.45%*	63,687 *0.97%*	135,662 *5.28%*	**756,757** ***79.45%***	162,185 *15.48%*	506 *0.11%*	1,119,124 *100.00%*
San Bernardino	56 *0.08%*	184,563 *2.80%*	93,864 *3.65%*	137,795 *14.47%*	**752,588** ***71.81%***	905 *0.19%*	1,169,772 *100.00%*
Ventura	1 *0.00%*	167,341 *2.54%*	1,749 *0.07%*	208 *0.02%*	413 *0.04%*	**402,767** ***84.94%***	572,478 *100.00%*
Total Attractions	**73,414** **0.63%**	**6,582,007** **56.25%**	**2,571,416** **21.98%**	**952,447** **8.14%**	**1,047,968** **8.96%**	**474,186** **4.05%**	**11,701,438** **100.00%**

Table 5-9: Home-Based Work Person Trip Distribution (ACS*, Travel Survey and Model)

From\To	Source	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura
Imperial	ACS (2006-2010)	97.20%	0.21%	0.11%	2.29%	0.19%	0.00%
	Travel Survey (2001)	96.91%	0.49%	0.51%	1.89%	0.19%	0.00%
	Model (2008)	97.54%	0.31%	0.21%	1.77%	0.15%	0.02%
Los Angeles	ACS (2006-2010)	0.01%	93.15%	4.26%	0.36%	1.36%	0.85%
	Travel Survey (2001)	0.18%	92.93%	4.90%	0.34%	0.82%	0.82%
	Model (2008)	0.00%	89.02%	7.82%	0.47%	1.62%	1.07%
Orange	ACS (2006-2010)	0.00%	12.49%	85.51%	1.09%	0.86%	0.04%
	Travel Survey (2001)	0.02%	18.85%	78.87%	1.23%	0.97%	0.06%
	Model (2008)	0.00%	16.89%	80.74%	1.14%	1.21%	0.03%
Riverside	ACS (2006-2010)	0.07%	5.71%	8.28%	74.57%	11.32%	0.06%
	Travel Survey (2001)	0.02%	5.94%	11.67%	72.26%	9.82%	0.29%
	Model (2008)	0.03%	5.69%	12.12%	67.62%	14.49%	0.05%
San Bernardino	ACS (2006-2010)	0.02%	15.23%	4.44%	8.64%	71.58%	0.09%
	Travel Survey (2001)	0.00%	16.60%	4.71%	7.72%	70.98%	0.00%
	Model (2008)	0.00%	15.78%	8.02%	11.78%	64.34%	0.08%
Ventura	ACS (2006-2010)	0.00%	18.48%	0.35%	0.05%	0.12%	81.00%
	Travel Survey (2001)	0.04%	17.74%	0.39%	0.09%	0.17%	81.57%
	Model (2008)	0.00%	29.23%	0.31%	0.04%	0.07%	70.35%
SCAG Region	ACS (2006-2010)	**0.63%**	**59.03%**	**19.90%**	**7.39%**	**8.58%**	**4.48%**
	Travel Survey (2001)	**0.78%**	**59.52%**	**19.01%**	**7.83%**	**8.60%**	**4.27%**
	Model (2008)	**0.63%**	**56.25%**	**21.98%**	**8.14%**	**8.96%**	**4.05%**

(*) American Community Survey 2006-2008 Release

Table 5-10: Year 2008 Home-Based Non-Work Person Trip Distribution

From\To	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total Productions
Imperial	**269,343**	1,471	165	657	12,476	319	284,429
	95.34%	*0.01%*	*0.00%*	*0.02%*	*0.35%*	*0.02%*	*100.00%*
Los Angeles	471	**16,834,203**	592,342	67,222	187,215	98,016	17,779,468
	0.17%	***93.43%***	*10.76%*	*1.85%*	*5.21%*	*7.23%*	*100.00%*
Orange	12	624,198	**4,705,318**	74,783	52,025	4,012	5,460,348
	0.00%	*3.46%*	***85.45%***	*2.05%*	*1.45%*	*0.30%*	*100.00%*
Riverside	107	133,380	120,796	**3,290,136**	243,559	3,681	3,791,658
	0.04%	*0.74%*	*2.19%*	***90.34%***	*6.77%*	*0.27%*	*100.00%*
San Bernardino	11,686	247,796	77,842	205,953	**3,095,204**	3,979	3,642,459
	4.14%	*1.38%*	*1.41%*	*5.65%*	***86.05%***	*0.29%*	*100.00%*
Ventura	878	177,220	9,807	3,230	6,325	**1,245,026**	1,442,486
	0.31%	*0.98%*	*0.18%*	*0.09%*	*0.18%*	***91.88%***	*100.00%*
Total Attractions	**282,496**	**18,018,267**	**5,506,271**	**3,641,980**	**3,596,803**	**1,355,033**	**32,400,849**
	0.87%	**55.61%**	**16.99%**	**11.24%**	**11.10%**	**4.18%**	**100.00%**

Table 5-11: Year 2008 Non-Home Based Person Trip Distribution

From\To	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total Productions
Imperial	**128,153**	52	30	299	55	1	128,590
	99.96%	*0.00%*	*0.00%*	*0.02%*	*0.00%*	*0.00%*	*100.00%*
Los Angeles	1	**9,542,249**	337,934	29,077	102,177	49,540	10,060,978
	0.00%	***93.35%***	*9.37%*	*1.73%*	*6.05%*	*6.69%*	*100.00%*
Orange	1	358,490	**3,155,089**	29,102	29,753	1,721	3,574,156
	0.00%	*3.51%*	***87.49%***	*1.73%*	*1.76%*	*0.23%*	*100.00%*
Riverside	38	73,608	60,638	**1,535,442**	112,466	742	1,782,933
	0.03%	*0.72%*	*1.68%*	***91.26%***	*6.66%*	*0.10%*	*100.00%*
San Bernardino	6	145,008	47,692	87,815	**1,442,570**	1,294	1,724,384
	0.01%	*1.42%*	*1.32%*	*5.22%*	***85.42%***	*0.17%*	*100.00%*
Ventura	0	102,305	4,827	770	1,807	**686,706**	796,416
	0.00%	*1.00%*	*0.13%*	*0.05%*	*0.11%*	***92.80%***	*100.00%*
Total Attractions	**128,200**	**10,221,711**	**3,606,209**	**1,682,505**	**1,688,828**	**740,004**	**18,067,457**
	0.71%	**56.58%**	**19.96%**	**9.31%**	**9.35%**	**4.10%**	**100.00%**

Table 5-12: Year 2008 Total Person Trip Distribution

From\To	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total Productions
Imperial	**470,502**	1,753	355	2,277	12,641	338	487,865
	97.19%	*0.01%*	*0.00%*	*0.04%*	*0.20%*	*0.01%*	*100.00%*
Los Angeles	488	**32,159,410**	1,438,590	126,916	394,633	216,969	34,337,005
	0.10%	***92.35%***	*12.31%*	*2.02%*	*6.23%*	*8.44%*	*100.00%*
Orange	19	1,365,915	**9,692,074**	129,634	109,209	6,311	11,303,162
	0.00%	*3.92%*	***82.95%***	*2.07%*	*1.72%*	*0.25%*	*100.00%*
Riverside	474	270,674	317,096	**5,582,334**	518,209	4,928	6,693,716
	0.10%	*0.78%*	*2.71%*	***88.93%***	*8.18%*	*0.19%*	*100.00%*
San Bernardino	11,748	577,366	219,398	431,562	**5,290,362**	6,178	6,536,615
	2.43%	*1.66%*	*1.88%*	*6.88%*	***83.53%***	*0.24%*	*100.00%*
Ventura	879	446,866	16,383	4,209	8,545	**2,334,499**	2,811,380
	0.18%	*1.28%*	*0.14%*	*0.07%*	*0.13%*	***90.86%***	*100.00%*
Total Attractions	**484,109**	**34,821,983**	**11,683,895**	**6,276,932**	**6,333,599**	**2,569,223**	**62,169,742**
	0.78%	**56.01%**	**18.79%**	**10.10%**	**10.19%**	**4.13%**	**100.00%**

Table 5-13: Year 2008 Average Person Trip Lengths by County

AM-Peak Period:

County	Trip Purpose	Home-Based Work	Home-Based Non-Work	Home-Based School	Other-Based Others	Work-Based Others
Imperial	Time (minutes)	14.37	6.70	8.03	6.52	7.18
	Distance (miles)	11.27	4.77	5.93	4.47	5.10
Los Angeles	Time	29.29	17.51	9.61	15.96	18.62
	Distance	15.24	9.22	4.85	8.43	9.78
Orange	Time	23.85	15.92	8.79	14.81	16.41
	Distance	14.19	9.58	5.05	8.88	9.84
Riverside	Time	33.48	18.44	13.84	16.39	15.24
	Distance	20.79	11.36	9.19	10.08	9.46
San Bernardino	Time	33.91	18.24	11.65	17.21	16.34
	Distance	21.23	11.52	7.67	10.77	10.18
Ventura	Time	29.86	16.40	8.87	14.88	13.71
	Distance	17.59	9.82	5.28	8.76	8.26
All	**Time (min)**	**29.04**	**17.28**	**10.21**	**15.79**	**17.44**
	Distance (mi)	**16.30**	**9.80**	**5.81**	**8.90**	**9.71**

Table 5-13: Year 2008 Average Person Trip Lengths by County (continued)

Midday Period:

County	Trip Purpose	Home-Based Work	Home-Based Non-Work	Home-Based School	Other-Based Others	Work-Based Others
Imperial	Time (minutes)	12.94	6.51	9.74	5.85	6.78
	Distance (miles)	9.98	4.61	7.53	3.84	4.73
Los Angeles	Time	20.28	14.26	8.41	11.39	13.78
	Distance	13.87	9.50	5.17	7.22	8.93
Orange	Time	18.90	13.66	8.32	10.73	13.00
	Distance	13.75	9.67	5.36	7.30	9.15
Riverside	Time	20.33	14.41	13.86	11.27	13.94
	Distance	15.86	10.81	10.61	8.24	10.63
San Bernardino	Time	19.97	14.25	11.87	11.46	13.90
	Distance	15.87	10.92	8.75	8.57	10.76
Ventura	Time	18.10	12.94	8.60	10.26	13.36
	Distance	13.86	9.66	5.72	7.33	9.99
All	**Time (min)**	**19.82**	**14.06**	**9.54**	**11.17**	**13.58**
	Distance (mi)	**14.20**	**9.81**	**6.38**	**7.45**	**9.29**

Daily Period:

County	Trip Purpose	Home-Based Work	Home-Based Non-Work	Home-Based School	Other-Based Others	Work-Based Others
Imperial	Time (minutes)	12.80	6.36	9.36	6.14	7.06
	Distance (miles)	9.88	4.44	7.21	4.12	5.00
Los Angeles	Time	25.46	17.38	9.84	14.76	17.84
	Distance	13.78	9.33	5.03	7.70	9.12
Orange	Time	22.62	15.93	9.21	13.44	15.99
	Distance	13.93	9.64	5.35	7.96	9.53
Riverside	Time	25.06	17.34	14.63	14.89	17.45
	Distance	15.99	10.74	9.97	9.06	10.62
San Bernardino	Time	25.66	17.26	12.55	15.41	17.85
	Distance	16.41	10.93	8.42	9.56	10.93
Ventura	Time	23.09	15.63	9.29	13.68	16.76
	Distance	13.97	9.40	5.63	8.00	9.88
All	**Time (min)**	**24.66**	**16.95**	**10.65**	**14.47**	**17.32**
	Distance (mi)	**14.26**	**9.69**	**6.17**	**8.06**	**9.49**

THIS PAGE LEFT INTENTIONALLY BLANK

CHAPTER 6 – MODE CHOICE

Contents

Chapter 6 – Mode Choice

Introduction

Mode choice is the process of taking the zone-to-zone person trips by trip purpose from the trip distribution model and determining how many of those person-trips are made by the various travel modes: non-motorized modes (walk and bike), auto modes (driver alone or carpool), and transit modes (drive or walk access and drive or walk egress). The 2008 model incorporates a redefined and recalibrated mode choice model for the region.

This Chapter describes the development of the updated mode choice model. The various travel modes estimated by the model are also summarized and explained.

Model Specification

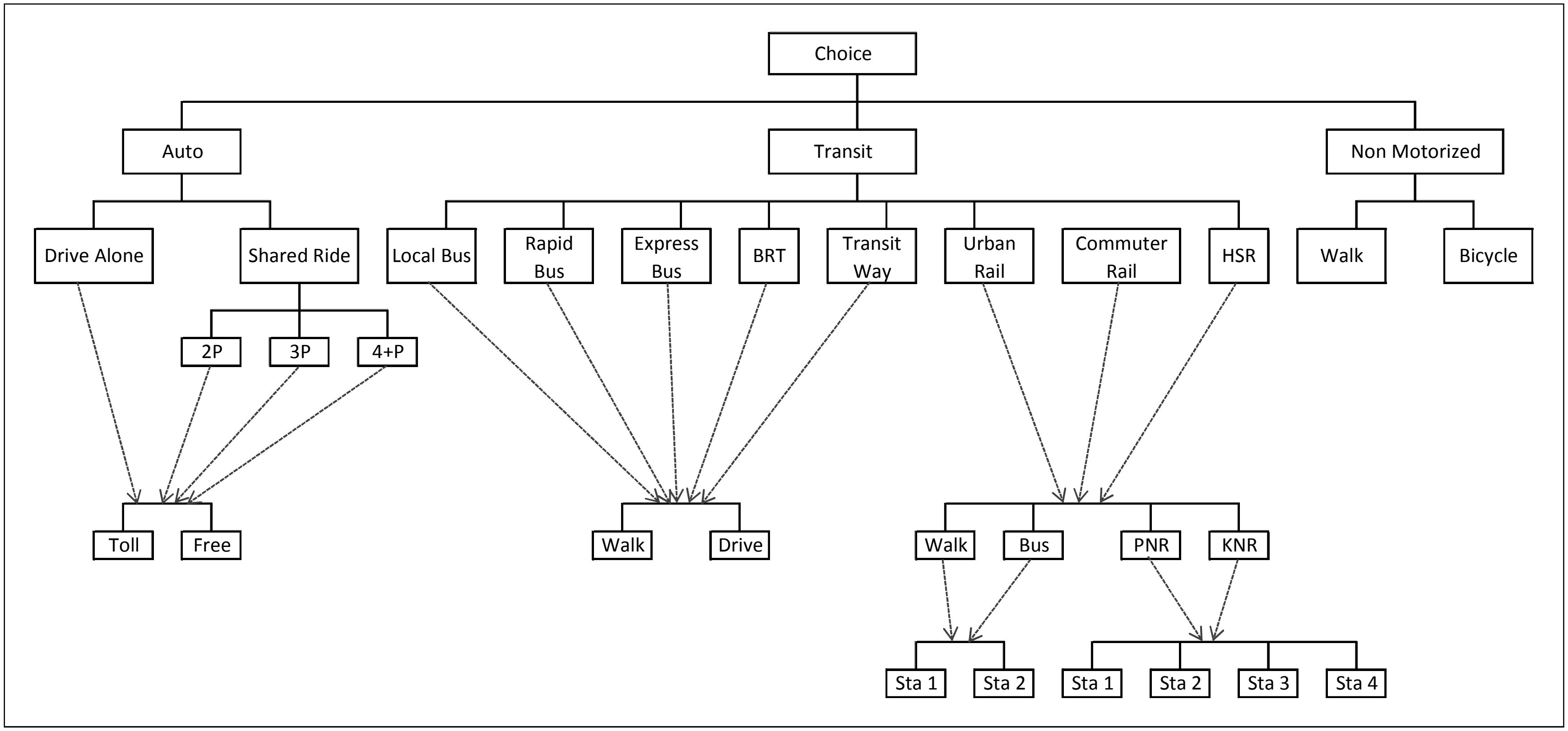
Elemental Choices

The SCAG mode choice model is a nested logit model, structured as shown in Figure 6-1. Among the auto choices, the model distinguishes four levels of occupancy (1, 2, 3 and 4 persons per vehicle) and includes a pre-route toll/no toll binary choice. Although not shown Figure 6-1, the model includes a HOV/non-HOV path subnest for the shared-ride choices. This model and the toll choice model may be used in lieu of the assignment-based diversion models, at the user's request. Currently the region includes over 300 centerline miles of HOV lanes restricted to 2+ person carpools, one 10-mile facility restricted to 3+ person carpools, and several toll facilities including two HOT lane facilities nearing full implementation.

The Southern California region comprises a wide variety of transit markets, ranging from the traditional transit-captive local bus market to choice travelers on the long distance commuter rail market. By 2035, it is expected that high-speed rail service will connect the region's main airports as well as serve Union Station and other cities in the region as part of the San Francisco-to-San Diego statewide line. The principal provider of transit services in the region is LACTMA, which operates a variety of transit technologies and services—local, limited stop (rapid) and express buses, bus rapid transit on a dedicated guideway, and urban rail (underground, at-grade and elevated lines). Two transitways, the El Monte Busway and the Harbor (I-110) Freeway HOV lanes separate express buses from the general purpose freeway traffic. The Harbor HOV facility provides elevated stations for fast boarding and alighting.

Commuter rail service is provided by Metrolink, and to a lesser extent Amtrak. Metrolink trains provide frequent peak period service from North Los Angeles, San Bernardino and Riverside into Los Angeles and Orange counties. Nearly 60 other transit agencies provide local and/or regional express bus services in the 6-county region, ranging from large fleets such as the Orange County Transportation Agency, Foothill Transit and the City of Los Angeles, to small city-run fleets. The elemental transit choices in the mode choice model have been defined to represent this wide variety of transit services, recognizing that for several markets these modes provide a competitive choice. In consultation with FTA, eight transit choices were defined on the basis of level of service characteristics and un-included mode attributes.

Figure 6-1: SCAG Mode Choice Model Nest Structure



Relative to local bus, key features considered in the definition of the transit modes include:

- Express bus: limited stop and limited span of service operating partly in mixed-flow traffic
- Rapid bus: limited stops, more frequent service than express, distinctive branding; usually does not operate on freeways
- Transitway bus: limited stop service operating on semi-dedicated right of way (busway, HOV lanes)
- Bus Rapid Transit: limited stops, dedicated guideway, distinctive branding and vehicles
- Local (Urban) Rail: fixed-guideway transit (subways and light rail)
- Commuter Rail: fixed-guideway, long-distance rail, distinctive branding and vehicles, mostly commute market
- High Speed Rail: fixed-guideway, long-distance, distinctive branding and stops, commute and non-commute markets

Another feature of the SCAG mode choice model is the explicit modeling of station choice for all the rail modes. Station choice is modeled conditional on access mode. Rather than rely on the transit path builder to find the best combination of boarding and alighting stations, the mode choice model performs 'virtual' or 'on-the-fly' path building, explicitly trading off longer origin-to-station and/or station-to-destination paths with shorter station-to-station options (or vice-versa). For drive access, the model identifies the 10 best boarding stations and the 10 best alighting stations for a given OD pair, considering the entire transit path utility. Of these, the top four stations become the drive-to-rail choice set for the station choice nest. OD trips are therefore distributed among all possible paths formed by the four access stations and four egress stations on the basis of their likelihoods. For walk and bus access trips, up to five boarding/alighting station combinations are identified, and the best two become part of the rail choice set. This specification of twelve stations (across the four access modes) for the choice set is a result of balancing the desire to capture the variations in travel behavior with the need to keep the computation time to a reasonable level.

The transit access and egress modes allowed for each primary transit mode are listed in Table 6-1. The commuter rail drive egress mode is unique to Southern California, where people keep a 'station' car at some Metrolink stations to drive to their final destination. Drive egress is also allowed for high-speed rail, since pick-up/drop-off and taxi patronage at the attraction station is likely to occur.

Table 6-1: Transit Access and Egress Modes

Primary Transit Mode	Access Modes						Egress Modes		
	Walk	Drive	Bus	PnR	KnR		Walk	Drive	Bus
Bus Modes	X	X					X		
Bus Rapid Transit	X	X	X				X		
Urban Rail	X		X	X	X		X		X
Commuter Rail	X		X	X	X		X	X	X
High Speed Rail	X		X	X	X		X	X	X

Highway Path Building

A generalized cost function is used to build the highway travel time and cost matrices (skims). Up to eight different sets of skims are built for the mode choice model, one for each highway mode and time period combination. For each of these combinations, best path skims are built for the toll, no-toll and HOV paths, as appropriate.

$$GC_{ij} = Travel\ Time_{ij} + \left(AOC \times Distance_{ij} + Toll_{ij}\right)/VOT$$

The auto operating cost (AOC) is $0.19 per mile (in $1999), and the value of time (VOT) is $7 per hour.

Transit Path Building

Transit walk access paths are built using TransCAD's Pathfinder algorithm for each mode in the choice set. The model builds transit paths among an expanded set of transit origins and destinations, comprised of the TAZ centroids, rail stations and bus park-n-ride locations. The skims for the local bus and rapid bus modes are built in the usual zone-to-zone fashion. The skims for the express bus, transitway bus, BRT and the rail modes are built between zones and stations. The skim building process and method used to construct the entire path is described below, under Virtual Path Building.

A hierarchy of transit modes is assumed to identify the primary mode of a multimodal transit trip. At the bottom of the hierarchy is local bus; a local bus trip boards only local bus modes. At the top of the hierarchy is high-speed rail; a multimodal trip that includes at least one leg on high-speed rail modes is assumed to be a high-speed rail trip. The priority order of the transit modes and corresponding supporting modes are shown in Table 6-2.

Table 6-2: Primary and Support Transit Modes

Primary Transit Mode	Support Transit Mode(s)
Local Bus	None
Express Bus	Local, Rapid Bus
Rapid Bus	Local Bus
Transitway Bus	Local, Express, Rapid Bus
Bus Rapid Transit	Local, Rapid Bus, Express Bus
Local (Urban) Rail	Local, Express, Rapid, Transitway Bus and BRT
Commuter Rail	Local, Express, Rapid, Transitway Bus, BRT and Urban Rail
High Speed Rail	Local, Express, Rapid, Transitway Bus, BRT, Urban and Commuter Rail

For each primary mode, only the supporting modes are allowed when building its paths and skims. The path attributes and weights used to compute the generalized cost function are shown in Table 6-3. These weights are approximately consistent with the value of the HBW mode choice wait time and walk access time coefficients relative to the in-vehicle time coefficient. Travel time on the primary mode is always given a weight of 1.0, while travel time on the transit supporting modes is given a weight of 1.5. The exception is Rapid Bus; the local bus travel time is weighted only 1.1 when building Rapid Bus paths. All walk times (access, egress and transfer) are given a weight of 2.0, and similarly the wait time is weighted by 2.0.

Table 6-3: Transit Path Building Weights

Transit Mode	Run Time Factor		Wait Time Factor
	Primary Mode	Support Modes	
Walk access, egress, transfer	-	2.0	-
Local Bus	1.0	1.5	2.0
Rapid Bus	1.0	1.1	2.0
Express Bus, Transitway	1.0	1.5	2.0
BRT	1.0	1.5	2.0
Urban Rail	1.0	1.5	2.0
Commuter Rail	1.0	1.5	2.0
High-Speed Rail	1.0	1.5	2.0

Virtual Transit Path Building

The skims for the premium bus modes and for the rail modes are built to support the station choice nest of the mode choice model. For this reason, , the entire origin zone to destination zone path is broken into two or three parts-- zone to station, station to station, and station to zone for the rail modes, and zone to station and station to zone for the bus modes. Figure 6-2 shows a schematic of a rail skim core partitioned into these three parts, or trip legs. Paths and skims are built for each of these legs separately:

i. For the rail station-to-zone and zone-to-rail station legs, which represent the rail access and egress, the path is built by including only the transit supporting modes for each primary rail mode and the walk modes.

ii. For the rail station-to-station leg, which represents the primary mode line-haul component of the trip, the path is built including only the primary rail mode, and excluding all supporting and walk modes.

Figure 6-2: Rail Skim Core Schematic

		Destinations	
		Zones	Stations
Origins	Zones (1 thru 11,500)	(Unused)	Access leg All transit modes allowed except the primary rail mode
	Stations (11,501 thru 12,000)	Egress leg All transit modes allowed except the primary rail mode	Station-to-Station leg Only the primary rail mode is allowed

The mode choice model builds the entire zone-to-zone trip on the fly, by combining the different access, line haul and egress legs into candidate entire journeys such that the total weighted travel time is minimized for each origin and destination station pair.

The bus paths are built in a similar fashion, with the exception that the 'station-to-station' leg is not relevant, since the nature of these modes is such that there is no destination station.

BRT is a special case. Analysis of the on-board survey data revealed that many riders drive to a BRT station, ride the BRT system and transfer to an local rail line before reaching their final destination. As such, the sequence of elements is zone to station, station to station (BRT), station to station (local rail) and station to zone. Therefore, the virtual path consists of up to four legs, instead of just the three used for rail modes.

No drive access skims are required for the mode choice model. Drive access to all modes except local and rapid bus is handled by the mode choice virtual path builder. As indicated above, the locations where drive-to-transit trips access the bus or rail system are explicitly identified so that park-n-ride to zone skims are available to the mode choice model. The drive leg (zone to PNR/KNR location) is obtained from the drive-alone skims. For local and rapid bus, park-n-ride behavior is dominated by informal parking; that is, trips that access the bus system at locations other than formal park-n-ride lots. These trips are modeled using the walk access skims, with the walk access time replaced by an appropriate drive access time, given the distance.

Choice Availability

The availability of any given elemental choice is defined by the following rules:

- Drive alone: Available to all trips. For the toll option, a toll link must be in the path. For the HOV lane option, an HOV lane link must be in the path.
- Shared ride: Available to all trips. For the toll options, a toll link must be in the path.
- Walk: Available to trips up to 3 miles long.
- Bicycle: Available to trips up to 12 miles long.
- Transit: Available to all inter-zonal trips with non-zero primary mode in-vehicle time. In addition, commuter rail is available only to work trips.

Utility Specification

The general form of the utility function for the auto modes is:

$$
\begin{aligned}
Utility_m^{mkt} = {} & civt \times (in\ vehicle\ travel\ time) + covt \times (terminal\ time) + ccost^{mkt} \\
& \times \frac{(parking\ cost)}{2 \times occfac} ccost^{mkt} + \frac{(veh.\ operating\ cost \times distance)}{occfac} ccost^{mkt} \\
& + \frac{(toll\ cost)}{occfac}\ ccost^{mkt} + (HOT\ lane\ toll) \times \frac{distance}{occfac} + toll\ penalty_m + K_m
\end{aligned}
$$

Where:

occfac is the factor to discount travel costs among occupants of a carpool; typically this factor is smaller than the average vehicle occupancy. For the drive alone modes *occfac* is 1.0.

$toll\ penalty = min\{0.0,\ ctollintcpt + ctollslope * (toll\ distance)\}$, s a utility penalty applied to discourage very short trips from using the toll roads. The toll penalty decreases with distance and is zero for a trip that is 2.5 miles or longer.

K_m is the alternative-specific constant. The alternative-specific constant itself consists of several components. A common constant, for example, is applied to all the shared-ride modes, while a different constant value is applied to the shared ride 3+ modes. The constants are applied so that the model is not over-specified, and each constant value can be readily interpreted in terms of the un-included attributes it represents. The mode choice coefficients are shown in Table 6-4.

Table 6-4: Mode Choice Utility Coefficients

Coefficient	HBW	HBO	NHB
In-Vehicle Travel Time	-0.02500	-0.01321	-0.01620
Terminal Time	-0.05300	-0.02853	-0.03500
Transit Walk Time (< 20 min)	-0.05300	-0.02853	-0.03500
Transit Walk Time (> 20 min)	-0.06200	-0.03276	-0.03500
Walk Mode Time (< 20 min)	-0.05300	-0.02853	-0.03500
Walk Mode Time (> 20 min)	-0.07950	-0.04280	-0.03500
Drive Time	-0.02500	-0.01321	-0.01620
First Wait Time (<5 min)	-0.06875	-0.03638	-0.04460
First Wait Time (>5 min)	-0.06875	-0.03638	-0.04460
Second Wait Time	-0.06875	-0.03638	-0.04460
Cost – zero cars	-0.00276	-0.00517	
Cost – insufficient cars	-0.00130	-0.00284	
Cost – low income, sufficient cars	-0.00426	-0.00681	-0.00551
Cost – medium income, sufficient cars	-0.00142	-0.00227	
Cost – high income, sufficient cars	-0.00086	-0.00134	
Primary Mode Logsum	0.75	0.75	0.75
Sub Mode Logsum	0.60	0.60	0.60
Access Mode Logsum	0.60	0.60	0.60

The general form of the utility function for the walk access bus transit modes is:

$$Utility^{mkt} = civt \times (in\ vehicle\ travel\ time) + cfw_1 \times first\ wait\ 1 + cfw_2 \times first\ wait\ 2 + cxw \times transfer\ wait + cwalk_1 \times walk\ time\ 1 + cwalk_2 \times walk\ time\ 2 + ccost^{mkt} \times fare + K$$

The computation of first wait time assumes that travelers know the schedule and consequently do not arrive at random. Wait time is computed as follows:

$$Wait\ Time = \sum_{n=1}^{N} \frac{min[hdwy - 15(n-1), 15]}{n+1}$$

where

$$N = \begin{cases} hdwy/15, & mod(hdwy/15) = 0 \\ hdwy/15 + 1, & mod(hdwy/15) > 0 \end{cases}$$

Since the wait time calculation accounts for non-random arrivals, the same coefficient is used for all wait time components, instead of applying different coefficients to differentiate between real time wait and wait time inconvenience. The walk time component is split into the first mile (less than 20 minutes) and subsequent walk time. The transit alternative specific constant consists of the sum of several terms, some of which are mode-specific and some that are market-specific. A more detailed description of the transit constants is provided below.

The general form of the utility function for the drive access bus transit modes is similar to the walk access utility, with drive access time replacing walk access time, and the inclusion of vehicle operating cost, parking cost, and a term that discourages drive access paths when the distance from origin to PNR lot is longer than the distance from origin to final destination. The best drive access station is found by the virtual path builder by searching for the best combination of access time and station-to-destination utility among the stations that are within 15 miles of the production zone.

Similar terms as those used in the walk access bus transit utilities are used in the rail utility functions. Note however that the rail utility function consists of three components—zone to station, station to station, and station to zone—and therefore the terms that apply to each leg of the trip will vary, as appropriate. The station choice coefficients are shown in Table 6-5. These coefficients are based on model estimation work performed for Chicago. These coefficient values are expressed at the station choice level. In other words, they are not scaled by the appropriate LogSum coefficients for interpretation at the multinomial level. However, after scaling they closely match the multinomial values for in-vehicle time.

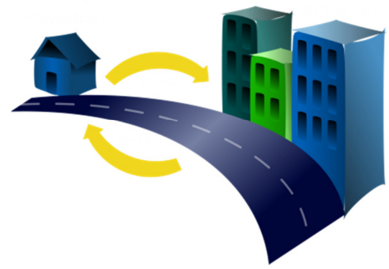
Table 6-5: Station Choice Utility Coefficients

Attribute	Coefficient					
	HBW		HBO		NHB	
	Value	Ratio wrt IVT	Value	Ratio wrt IVT	Value	Ratio wrt IVT
In-Vehicle Time	-0.16650	--	-0.09756	--	-0.11964	--
Drive Access Time	-0.41292	2.5	-0.24195	2.5	-0.25842	2.2
First Wait Time	-0.35298	2.1	-0.21073	2.2	-0.25842	2.2
Transfer Wait Time	-0.35798	2.2	-0.24195	2.5	-0.29073	2.4
Number of Transfers	-1.44400	8.7	-0.84584	8.7	-1.03761	8.7
Walk Time	-0.25974	1.6	-0.21073	2.2	-0.25842	2.2
Parking Capacity	0.00023	--	0.00023	--	0.00023	--
Drive Egress Time	-0.41292	--	-0.24195	--	-0.25842	--
In-Vehicle Time (CRail only)	-0.12488	--	-0.07317	--	-0.08973	--

Market Segmentation

The mode choice models were initially segmented by trip purpose, time period and four household income levels. This is the minimal level of segmentation required to expose trips to the correct transportation level of service and ensure that the model coefficients capture differences in travel behavior due to the type of trip and household wealth, in particular value of time. The final models are stratified by a combination of household income and car sufficiency, in order to better reflect the effect of transit-dependent users on mode and destination choice.

An important element of the market segmentation is the stratification of the alternative-specific constants (ASC). The specification of the ASCs responds to an understanding of the expected contribution of un-included attributes to the utility of each choice. Un-included attributes can be thought of as being a function of trip-maker characteristics, trip characteristics, or mode characteristics. The ASC can be considered as composed of two parts, one part that varies across demographic characteristics (for example, across household income groups or car ownership groups), and a second part that varies across mode and/or trip characteristics.



The transit constant is stratified by household income level, car sufficiency and trip distance, but not by primary transit mode. The stratification by household income and car sufficiency is recommended by FTA and responds to the higher likelihood of transit patronage among transit-dependent riders, all else equal. The stratification by trip distance is unique to the Southern California region and is based on analysis of the on-board survey data performed for LACMTA, as part of their model calibration and validation effort[1]. Specifically, three distinct transit markets were observed: a short distance market, primarily served by local and rapid bus and to a lesser extent local rail, a medium distance market served by local rail, express and transitway buses, and a long distance market served by commuter rail and a few express buses. The transit constant is therefore stratified into 5-mile distance ranges, and capped at 55 miles.

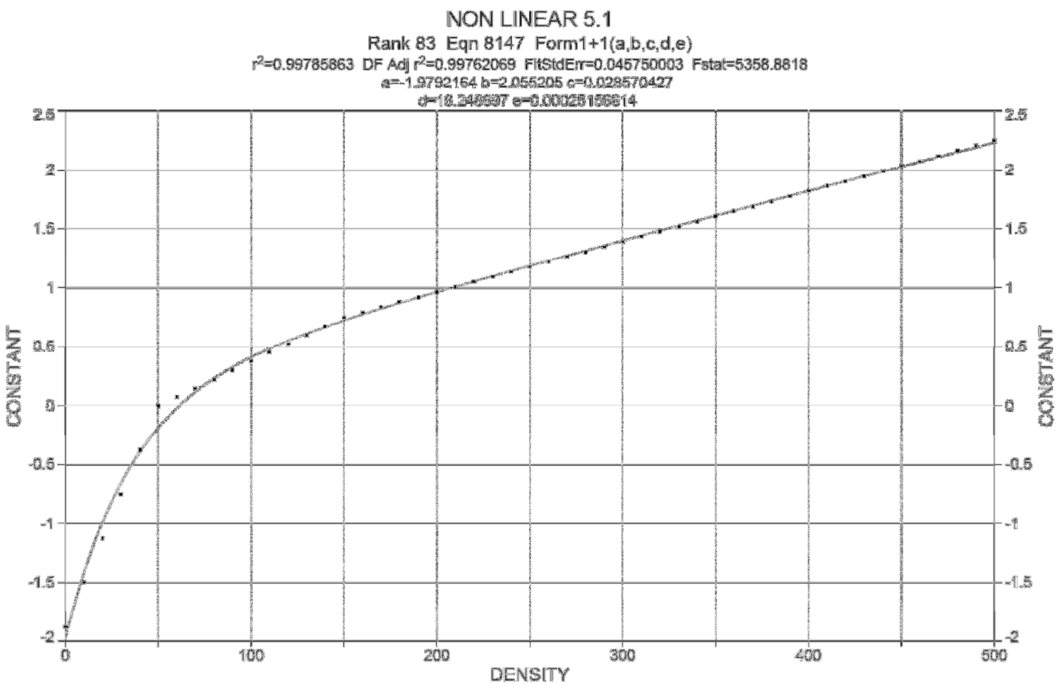
The primary transit mode constants are stratified by mode, but not by household income or car sufficiency. The rationale is that some un-included mode attributes are equally perceived by all riders, regardless of their income level. For example, the limited service span of express bus service is equally undesirable to all riders. The primary transit mode constants play a central role in an analysis of transit alternatives, because they contribute directly to the user benefits of each alternative mode as compared to the baseline alternative.

The transit constants also account for the effect of land use form. As part of the mode choice model calibration work performed for LACMTA, it was found that the level of service attributes and constants described above were insufficient to explain transit ridership in the more dense areas of the region. Functions of population and employment density were developed as part of this calibration work to further segment the transit constant. A sample urban form function is shown in Figure 6-3.

A CBD attraction constant that varies by mode was necessary to match observed HBW CBD transit attractions. A drive to transit constant (*KDTRN*), applied at the access mode level of the nest, captures the differences in the perception of drive and walk access across income and car sufficiency levels. An additional constant was needed to adequately match the proportion of commuter rail riders that park access commuter rail or local rail by bus (*KBCR* and *KBUR*, respectively).

[1] Los Angeles Mode Choice Model: Draft Calibration/Validation Report. Prepared for the Los Angeles Metropolitan Transit Authority, by Parsons Brinckerhoff. Los Angeles, CA: September 2010.

Figure 6-3: Density Component of the Transit Constant, HBWD Peak, Production End



Calibration Target Values

The mode choice calibration process consisted of adjusting the model constants to match observed transit travel patterns. These travel pattern summaries are called calibration target values; they are derived from the household travel survey and the on-board transit surveys, supplemented with ridership data. Calibration target values consist of various trip summaries, including:

- Number of trips by time period, trip purpose, mode and market segment (combined household survey and on-board surveys, expanded to validation year);
- On-board transit trip flows (for aggregate and district-level validation), by purpose, transit submode and time period;
- Trip length distribution (distance) by transit submode and market segment;
- Number of trips by access/egress mode (walk, bus, pnr, knr) by transit submode;
- Station-to-station trips, station boardings (total, by transit submode and by access mode); and
- Transfer rates or transfer trips, by transit submode and by access mode.

Each data source made a specific contribution to the development of the calibration target values: the household travel survey provided the share of auto and non-motorized trips across purposes, time periods and household income markets, while the on-board surveys provided the number of transit trips by mode, access submode, and household income. The total number of trips was obtained from the trip generation model forecasts, and the targets as derived from the survey data were scaled so that the number of transit trips remains constant. School bus trips were removed from the HBSC targets, since this mode is not part of the choice set.

The most recent regional household survey dates from 2001, conducted on the heels of the 2000 U.S. Census. A wealth of on-board surveys is available, most dating from the early 2000s and few more recent ones, as shown in Table 6-6. While these surveys comprise only 15 of the 60+ transit carriers in the region, they include all the major carriers, accounting for more than 90% of all regional local bus trips, nearly all of the express bus trips and all of the rail trips. The 2001 expansion factors developed as part of the LACMTA calibration work were adjusted to represent 2008 transit trips, using ridership data from the transit carriers (by mode and rail line, when available), National Transit Database (NTD) and the linked-to-unlinked trip ratios obtained from the survey data.

For some of the surveyed bus routes no origin-destination data were collected. Also there are carriers that did not undertake surveys but have bus riders and routes in the travel forecasting networks. To compensate for the unavailable origin-destination data, daily trip data for those systems were obtained from the NTD, when available. The NTD data do not provide details about trip origins or destinations, trip purpose, access mode, or primary mode, therefore assumptions were made regarding the missing details and a "best assessment" was made of the trip origins and destinations. These trips were then added to the observed trip matrices by purpose and time period. These add-on trips represent approximately 65,000 trips, out of a total of approximately 1.4 million transit trips in 2008.

Table 6-6: On-Board Transit Surveys

Transit Agency	Sample Size
Alhambra	142
Carson	179
Cerritos	104
Commerce	131
Culver City	534
El Monte	100
Foothill-Transitway	952
LA DOT	451
Metro Bus	34,801
Metro Rail	15,452
Metro Orange Line (2006)	538
Metro Gold Line (2006)	2,880
Metro Rapid Bus (2006)	1,512
Metrolink (2002)	10,418
Metrolink (2008)	9,261
OCTA (2001)	11,753
OCTA (2010)	13,133
Pasadena	149
Santa Clarita	1,065
Santa Monica	2,454
Torrance	681

The on-board surveys listed in Table 6-6 collected household income information from the transit riders, but only the Metrolink surveys collected information about auto ownership. The lack of auto ownership data precluded the development of the detailed transit calibration targets listed above for the household income / car sufficiency stratified models. For this reason, a two-step process was employed to develop these calibration targets. First, a complete set of calibration targets was developed for a pure household income stratification. All the models were calibrated using these targets. Then, a set of targets was developed for the combined income and car sufficiency segmentation used by the final models. These targets were based largely on the 2001 post-census household survey, and were constructed such that in the aggregate they are consistent with the on-board survey targets. Due to the small number of transit observations captured by the household survey, the transit targets were stratified only by transit access mode, and not by primary transit line-haul mode. Tables 6-7 to 6-10 show the final calibration targets.

Table 6-7: HBW and HBO Mode Choice Calibration Targets, Peak Period

Household Segment	Mode	Trip Purpose					
		HBWD	HBWS	HBSh	HBSR	HBSP	HBO
No cars	Walk	10,248	6,554	53,106	23,946	115,695	37,359
	Bike	5,463	1,306	7,019	3,325	1,298	4,436
	Drive alone	3,400	4,598	2,530	2,406	5,963	3,767
	Shared ride 2	14,611	9,399	10,267	13,130	14,088	7,866
	Shared ride 3	6,088	8,203	4,838	4,346	23,173	2,314
	Shared ride 4+	3,653	5,656	3,327	2,240	19,470	3,663
	Walk to transit	72,898	-	17,968	11,552	-	36,978
	Kiss and ride	8,502	-	1,058	1,251	-	3,623
	Park and ride	1,212	-	-	-	-	-
	Total	**126,075**	**35,716**	**100,114**	**62,196**	**179,687**	**100,006**
Car competition	Walk	51,651	7,982	69,223	43,130	338,680	148,308
	Bike	5,971	1,322	4,445	7,798	1,931	11,989
	Drive alone	246,550	104,158	173,058	50,809	194,318	141,214
	Shared ride 2	123,682	31,475	72,370	112,438	271,491	223,758
	Shared ride 3	43,764	28,384	64,305	59,051	194,122	108,907
	Shared ride 4+	22,834	15,417	61,708	48,062	226,304	92,394
	Walk to transit	151,452	-	11,171	7,848	-	64,782
	Kiss and ride	5,629	-	413	561	-	1,836
	Park and ride	8,276	-	269	561	-	3,361
	Total	**659,808**	**188,737**	**456,962**	**330,258**	**1,226,845**	**796,549**
Income 0-25K	Walk	23,934	3,925	29,620	22,408	37,656	55,464
	Bike	2,853	699	1,444	925	368	5,921
	Drive alone	406,942	126,590	140,348	88,374	134,084	126,792
	Shared ride 2	47,379	17,680	38,986	44,480	184,121	98,115
	Shared ride 3	16,765	16,687	51,981	20,232	131,333	50,844
	Shared ride 4+	8,747	11,059	28,589	19,450	125,117	57,115
	Walk to transit	134,001	-	1,413	2,836	-	25,508
	Kiss and ride	4,443	-	82	199	-	797
	Park and ride	11,213	-	214	199	-	2,726
	Total	**656,276**	**176,639**	**292,678**	**199,104**	**612,678**	**423,282**
Income 25-50K	Walk	38,570	3,659	25,347	35,203	43,717	74,180
	Bike	4,168	422	685	1,622	404	8,064
	Drive alone	1,138,842	304,940	245,017	118,230	231,153	253,897
	Shared ride 2	89,331	30,808	38,020	104,546	288,130	179,958
	Shared ride 3	31,609	30,204	50,693	49,491	200,155	101,527
	Shared ride 4+	16,492	13,515	63,367	32,433	200,747	110,849
	Walk to transit	35,401	-	1,302	1,041	-	4,096
	Kiss and ride	2,540	-	38	41	-	70
	Park and ride	6,086	-	115	96	-	367
	Total	**1,363,039**	**383,548**	**424,584**	**342,703**	**964,306**	**733,008**
Income over 50K	Walk	42,276	8,791	18,185	42,109	44,887	122,464
	Bike	4,244	673	461	2,164	440	8,110
	Drive alone	2,918,200	892,298	527,834	211,532	473,235	632,911
	Shared ride 2	122,872	31,701	67,027	250,618	530,783	503,935
	Shared ride 3	24,574	52,073	100,540	117,688	386,091	303,909
	Shared ride 4+	6,144	23,249	125,675	82,258	345,542	222,206
	Walk to transit	18,222	-	516	304	-	1,673
	Kiss and ride	2,764	-	3	27	-	52
	Park and ride	28,734	-	23	70	-	617
	Total	**3,168,030**	**1,008,784**	**840,263**	**706,769**	**1,780,978**	**1,795,877**

Table 6-8: HBW and HBO Mode Choice Calibration Targets, Off-Peak Period

Household Segment	Mode	Trip Purpose					
		HBWD	HBWS	HBSh	HBSR	HBSP	HBO
No cars	Walk	5,893	4,373	82,377	47,747	62,333	36,756
	Bike	2,326	784	10,864	6,630	699	4,555
	Drive alone	1,448	2,761	3,733	4,797	3,213	3,157
	Shared ride 2	4,419	5,085	15,890	26,181	12,650	11,302
	Shared ride 3	2,946	4,557	7,489	8,665	10,404	4,987
	Shared ride 4+	1,473	3,882	5,150	4,467	7,518	5,262
	Walk to transit	34,773	-	20,889	11,298	-	52,740
	Kiss and ride	4,056	-	1,230	1,223	-	5,996
	Park and ride	578	-	-	-	-	-
	Total	**57,912**	**21,443**	**147,622**	**111,009**	**96,816**	**124,756**
Car competition	Walk	31,011	4,839	102,552	77,805	180,605	169,564
	Bike	3,585	801	6,585	14,067	3,025	15,231
	Drive alone	148,028	63,149	256,381	91,656	104,760	202,701
	Shared ride 2	74,258	19,083	107,214	202,833	182,958	295,383
	Shared ride 3	26,276	17,209	95,267	106,525	118,783	138,351
	Shared ride 4+	13,709	9,347	91,420	86,702	71,373	117,373
	Walk to transit	72,801	-	13,481	8,768	-	48,434
	Kiss and ride	3,309	-	499	627	-	1,469
	Park and ride	6,618	-	325	627	-	4,386
	Total	**379,596**	**114,428**	**673,724**	**589,611**	**661,504**	**992,891**
Income 0-25K	Walk	10,897	3,569	43,716	40,324	20,171	64,636
	Bike	1,233	424	2,132	1,664	330	6,908
	Drive alone	181,987	75,573	207,137	159,028	90,370	204,280
	Shared ride 2	21,169	10,718	57,538	80,042	103,246	126,767
	Shared ride 3	7,449	10,116	76,717	36,408	66,918	59,779
	Shared ride 4+	3,818	6,705	42,194	35,000	49,510	55,346
	Walk to transit	51,971	-	1,130	2,652	-	7,523
	Kiss and ride	1,018	-	85	213	-	786
	Park and ride	4,722	-	767	213	-	1,798
	Total	**284,263**	**107,105**	**431,416**	**355,545**	**330,546**	**527,823**
Income 25-50K	Walk	18,432	6,042	35,513	62,956	23,462	82,500
	Bike	2,004	326	2,888	2,901	322	10,065
	Drive alone	545,223	181,028	405,065	211,441	157,549	354,160
	Shared ride 2	42,716	18,683	62,318	186,968	161,535	226,521
	Shared ride 3	15,115	18,317	62,318	88,509	99,435	116,250
	Shared ride 4+	7,886	8,196	56,086	58,002	77,395	119,901
	Walk to transit	14,912	-	1,499	1,170	-	2,759
	Kiss and ride	175	-	38	92	-	334
	Park and ride	1,571	-	113	208	-	1,005
	Total	**648,032**	**232,592**	**625,838**	**612,247**	**519,698**	**913,495**
Income over 50K	Walk	22,178	15,633	24,691	76,485	19,568	125,300
	Bike	2,258	776	2,785	2,603	381	23,541
	Drive alone	1,532,862	530,548	802,467	377,876	318,934	880,998
	Shared ride 2	64,542	19,233	98,765	447,699	286,174	596,754
	Shared ride 3	12,908	31,594	148,148	210,234	187,347	356,097
	Shared ride 4+	3,227	14,106	160,493	146,943	146,911	253,440
	Walk to transit	9,329	-	1,059	529	-	1,414
	Kiss and ride	499	-	25	45	-	128
	Park and ride	6,181	-	74	123	-	437
	Total	**1,653,985**	**611,889**	**1,238,508**	**1,262,538**	**959,316**	**2,238,109**

Table 6-9: HBSC, HBCU and NHB Mode Choice Calibration Targets, Peak Period

Household Segment	Mode	Trip Purpose			
		HBSC	HBCU	WBO	OBO
All	Walk	889,863	43,174	71,513	471,901
	Bike	157,035	7,841	72,705	32,648
	Drive alone	111,328	201,529	1,561,008	2,315,953
	Shared ride 2	746,206	25,960	55,302	975,198
	Shared ride 3	649,432	8,971	117,782	1,062,786
	Shared ride 4+	618,179	12,606	74,352	1,361,955
	Walk to transit	20,980	68,943	43,358	27,533
	Kiss and ride	1,003	1,626	4,306	353
	Park and ride	974	4,804	2,375	1226
	School Bus	390,094	0	0	0
	Total	**3,585,093**	**375,455**	**2,002,701**	**6,249,554**

Table 6-10: HBSC, HBCU and NHB Mode Choice Calibration Targets, Off-Peak Period

Household Segment	Mode	Trip Purpose			
		HBSC	HBCU	WBO	OBO
All	Walk	403,825	36,458	135,680	545,463
	Bike	71,263	5,570	22,449	47,432
	Drive alone	59,171	171,872	1,317,194	3,870,404
	Shared ride 2	209,036	15,410	93,486	1,088,701
	Shared ride 3	176,191	10,917	72,151	1,188,226
	Shared ride 4+	161,886	7,278	62,443	1,216,102
	Walk to transit	10,138	58,181	31,518	27,419
	Kiss and ride	191	1,844	1,626	1,506
	Park and ride	756	1,434	2,194	1,628
	School Bus	175,653	0	0	0
	Total	**1,268,109**	**308,965**	**1,738,741**	**7,986,881**

Model Calibration and Validation

The calibration and validation of the mode choice model comprised an extensive, iterative effort that involved practically all model components, and in particular trip distribution, mode choice and transit path building. Mode-specific constants were first calibrated to match the household-based targets. The resulting relative values of these constants are examined for reasonableness, in particular the line-haul constants. Subsequently, the household stratified constants were recalibrated to the car sufficiency and income targets. The objective of the calibration is to determine the value of the alternative-specific constants. In addition, a set of coefficients were added to the transit utilities to reduce the number of premium mode trips that transfer to local bus at the destination end of the trip. The expected transfer frequency was established from the on-board survey data.

Table 6-11 shows the calibrated values of the transit line-haul constants, expressed as a constant and in equivalent minutes of in-vehicle time, relative to the local bus constant (the local bus constant is 0.0). Table 6-12 to Table 6-16 shows the estimated mode split and shares, compared to the target mode shares.

Table 6-11: Transit Line-Haul Constants (eq. in-vehicle time minutes)

Trip Purpose	Primary Transit Mode						
	Rapid Bus	Express Bus	Transitway Bus	BRT	Urban Rail	Commuter Rail	High Speed Rail *
HBWD PK	0.2980 (11.9)	-0.0899 (-3.6)	0.1623 (6.5)	0.1207 (4.8)	0.4125 (16.5)	1.2000 (48.0)	1.4400 (57.0)
HBWD OP	0.2000 (8.0)	-0.2601 (-10.4)	-0.2800 (-11.2)	0.1700 (6.8)	0.5500 (22.0)	0.6750 (27.0)	0.8100 (32.4)
HBCU	0.1213 (9.2)	-0.1500 (-11.3)	0.0750 (5.7)	0.0750 (5.7)	0.3115 (23.6)	0.3000 (22.7)	0.3600 (27.2)
HBSC	0.0641 (4.8)	-0.0793 (-6.0)	0.0396 3.0	0.0396 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)
HBSH	0.0641 (4.8)	-0.0793 (-6.0)	0.0396 (3.0)	0.0396 (3.0)	0.1608 (12.2)	0.1585 (12.0)	0.1900 (14.4)
HBSR	0.0641 (4.8)	-0.0793 (-6.0)	0.0396 (3.0)	0.0396 (3.0)	0.1608 (12.2)	0.1585 (12.0)	0.1900 (14.4)
HBO	0.0660 (5.0)	-0.0764 (-5.8)	0.1020 (7.7)	0.0700 (5.3)	0.1584 (12.0)	0.1056 (8.0)	0.1280 (12.1)
WBO	0.0810 (5.0)	-0.2430 (-15.0)	-0.1620 -10.0	0.1620 (10.0)	0.1944 (12.0)	0.4050 (25.0)	0.4860 (29.4)
OBO	0.0810 (5.0)	-0.2430 (-15.0)	0.0810 (5.0)	0.0162 (10.0)	0.1944 (12.0)	0.1292 (7.8)	0.1550 (9.6)

(*) The high speed rail constants were asserted at 20% premium over commuter rail.

Table 6-12: HBW Peak Period Mode Choice Calibration Results

Household Segment	Drive Alone	Shared Ride 2	Shared Ride 3	Shared Ride 4+	Transit	Non-Motorized	Total
Estimated Trips							
No Cars	6,436	19,082	10,511	6,357	61,598	15,081	119,065
Car Competition	384,408	172,769	77,986	39,914	212,830	67,786	955,693
Income 0-25K	452,318	53,133	24,093	11,801	137,357	21,821	700,523
Income 25-50K	1,329,269	109,542	52,587	24,622	36,809	38,924	1,591,753
Income over50K	3,889,850	167,995	95,974	40,994	32,850	53,578	4,281,241
Total	**6,062,281**	**522,521**	**261,151**	**123,688**	**481,444**	**197,190**	**7,648,275**
Estimated Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	5.4%	16.0%	8.8%	5.3%	51.7%	12.7%	100%
Car Competition	40.2%	18.1%	8.2%	4.2%	22.3%	7.1%	100%
Income 0-25K	64.6%	7.6%	3.4%	1.7%	19.6%	3.1%	100%
Income 25-50K	83.5%	6.9%	3.3%	1.5%	2.3%	2.4%	100%
Income over50K	90.9%	3.9%	2.2%	1.0%	0.8%	1.3%	100%
Total	**79.3%**	**6.8%**	**3.4%**	**1.6%**	**6.3%**	**2.6%**	**100%**
Target Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	4.9%	14.8%	8.7%	5.7%	51.4%	14.5%	100%
Car Competition	41.3%	18.3%	8.5%	4.5%	19.5%	7.9%	100%
Income 0-25K	64.1%	7.8%	4.0%	2.4%	18.0%	3.8%	100%
Income 25-50K	82.9%	6.9%	3.5%	1.7%	2.3%	2.7%	100%
Income over50K	91.2%	3.7%	1.8%	0.7%	1.2%	1.3%	100%
Total	**79.2%**	**6.7%**	**3.3%**	**1.6%**	**6.3%**	**2.9%**	**100%**

Table 6-13: HBW Off-Peak Period Mode Choice Calibration Results

Estimated Trips							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	3,818	8,008	5,850	3,723	31,165	9,946	62,510
Car Competition	218,389	94,139	43,147	22,302	85,186	40,667	503,830
Income 0-25K	248,761	28,339	12,920	6,231	58,929	14,137	369,317
Income 25-50K	699,898	57,115	28,511	13,213	16,332	24,883	839,952
Income over50K	2,044,067	85,819	53,850	23,545	15,956	42,307	2,265,544
Total	**3,214,933**	**273,420**	**144,278**	**69,014**	**207,568**	**131,940**	**4,041,153**
Estimated Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	6.1%	12.8%	9.4%	6.0%	49.9%	15.9%	100%
Car Competition	43.3%	18.7%	8.6%	4.4%	16.9%	8.1%	100%
Income 0-25K	67.4%	7.7%	3.5%	1.7%	16.0%	3.8%	100%
Income 25-50K	83.3%	6.8%	3.4%	1.6%	1.9%	3.0%	100%
Income over50K	90.2%	3.8%	2.4%	1.0%	0.7%	1.9%	100%
Total	**79.6%**	**6.8%**	**3.6%**	**1.7%**	**5.1%**	**3.3%**	**100%**
Target Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	5.0%	11.6%	9.0%	6.3%	51.5%	16.6%	100%
Car Competition	43.1%	18.8%	9.0%	4.8%	16.3%	8.1%	100%
Income 0-25K	66.2%	8.1%	4.3%	2.6%	14.6%	4.1%	100%
Income 25-50K	82.7%	7.0%	3.7%	1.8%	1.8%	3.0%	100%
Income over50K	91.1%	3.7%	2.0%	0.8%	0.7%	1.8%	100%
Total	**79.5%**	**6.7%**	**3.5%**	**1.7%**	**5.2%**	**3.3%**	**100%**

Table 6-14: HBNW Peak Period Mode Choice Calibration Results

Estimated Trips							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	15,310	48,718	37,951	30,746	71,907	236,057	440,689
Car Competition	628,584	740,835	460,548	459,052	83,491	608,030	2,980,540
Income 0-25K	489,882	357,064	243,427	211,404	33,705	131,754	1,467,236
Income 25-50K	862,325	618,512	394,213	400,358	7,037	170,869	2,453,314
Income over50K	1,918,520	1,463,468	996,027	912,176	3,636	226,991	5,520,818
Total	**3,914,621**	**3,228,597**	**2,132,166**	**2,013,736**	**199,776**	**1,373,701**	**12,862,597**
Estimated Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	3.5%	11.1%	8.6%	7.0%	16.3%	53.6%	100%
Car Competition	21.1%	24.9%	15.5%	15.4%	2.8%	20.4%	100%
Income 0-25K	33.4%	24.3%	16.6%	14.4%	2.3%	9.0%	100%
Income 25-50K	35.1%	25.2%	16.1%	16.3%	0.3%	7.0%	100%
Income over50K	34.8%	26.5%	18.0%	16.5%	0.1%	4.1%	100%
Total	**30.4%**	**25.1%**	**16.6%**	**15.7%**	**1.6%**	**10.7%**	**100%**
Target Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	3.3%	10.3%	7.8%	6.5%	16.4%	55.7%	100%
Car Competition	19.9%	24.2%	15.2%	15.2%	3.2%	22.3%	100%
Income 0-25K	32.0%	23.9%	16.7%	15.1%	2.2%	10.1%	100%
Income 25-50K	34.4%	24.8%	16.3%	16.5%	0.3%	7.7%	100%
Income over50K	36.0%	26.4%	17.7%	15.1%	0.1%	4.7%	100%
Total	**30.4%**	**24.7%**	**16.4%**	**15.1%**	**1.7%**	**11.8%**	**100%**

Table 6-15: HBNW Off-Peak Period Mode Choice Calibration Results

Estimated Trips							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	16,454	69,472	33,352	23,312	89,711	254,175	486,476
Car Competition	727,000	849,468	495,874	393,157	83,846	572,814	3,122,159
Income 0-25K	660,558	357,368	222,945	169,001	14,457	161,924	1,586,253
Income 25-50K	1,134,672	643,092	365,872	308,093	7,235	203,087	2,662,051
Income over50K	2,436,941	1,549,300	1,012,634	809,191	4,324	292,905	6,105,295
Total	**4,975,625**	**3,468,700**	**2,130,677**	**1,702,754**	**199,573**	**1,484,905**	**13,962,234**
Estimated Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	3.4%	14.3%	6.9%	4.8%	18.4%	52.2%	100%
Car Competition	23.3%	27.2%	15.9%	12.6%	2.7%	18.3%	100%
Income 0-25K	41.6%	22.5%	14.1%	10.7%	0.9%	10.2%	100%
Income 25-50K	42.6%	24.2%	13.7%	11.6%	0.3%	7.6%	100%
Income over50K	39.9%	25.4%	16.6%	13.3%	0.1%	4.8%	100%
Total	**35.6%**	**24.8%**	**15.3%**	**12.2%**	**1.4%**	**10.6%**	**100%**
Target Mode Shares							
Household Segment	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**Total**
No Cars	3.1%	13.7%	6.6%	4.7%	19.4%	52.5%	100%
Car Competition	22.5%	27.0%	15.7%	12.6%	2.7%	19.5%	100%
Income 0-25K	40.2%	22.3%	14.6%	11.1%	0.9%	10.9%	100%
Income 25-50K	42.2%	23.9%	13.7%	11.7%	0.3%	8.3%	100%
Income over50K	41.8%	25.1%	15.8%	12.4%	0.1%	4.8%	100%
Total	**36.1%**	**24.5%**	**14.9%**	**11.9%**	**1.5%**	**11.2%**	**100%**

Table 6-16: HBSC and NHB Mode Choice Calibration Results

Estimated Trips								
Trip Purpose	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**School Bus**	**Total**
HBSC Peak	310,650	783,594	665,272	637,679	110,062	1,064,511	387,078	**3,958,846**
HBSC Off-Peak	233,503	231,405	195,053	176,308	70,066	494,286	172,210	**1,572,831**
NHB Peak	3,903,685	1,040,681	1,174,759	1,449,330	76,353	566,261		**8,211,069**
NHB Off-Peak	5,564,455	1,208,325	1,187,947	1,143,606	60,000	685,626		**9,849,959**
Estimated Mode Shares								
Trip Purpose	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**School Bus**	**Total**
HBSC Peak	7.8%	19.8%	16.8%	16.1%	2.8%	26.9%	9.8%	100%
HBSC Off-Peak	14.8%	14.7%	12.4%	11.2%	4.5%	31.4%	10.9%	100%
NHB Peak	47.5%	12.7%	14.3%	17.7%	0.9%	6.9%	0.0%	100%
NHB Off-Peak	56.5%	12.3%	12.1%	11.6%	0.6%	7.0%	0.0%	100%
Target Mode Shares								
Trip Purpose	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3**	**Shared Ride 4+**	**Transit**	**Non-Motorized**	**School Bus**	**Total**
HBSC Peak	7.9%	19.4%	16.6%	15.9%	2.5%	27.7%	10.1%	100%
HBSC Off-Peak	14.7%	14.2%	11.9%	10.7%	4.6%	32.8%	11.1%	100%
NHB Peak	47.0%	12.5%	14.3%	17.4%	1.0%	7.9%	0.0%	100%
NHB Off-Peak	53.2%	12.2%	13.0%	13.2%	0.7%	7.7%	0.0%	100%

Mode Choice Model Results

Table 6-17: Year 2008 Mode Choice Summary Statistics (Home-Based Work)

Mode Choice	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	61,110	81.73%	5,298,702	81.65%	1,970,458	86.96%	984,686	88.15%	1,027,059	87.98%	503,008	87.96%	9,845,023	84.24%
Drive Alone	57,227	76.54%	4,994,240	76.96%	1,857,952	81.99%	926,088	82.90%	963,676	82.55%	477,823	83.56%	9,277,005	79.38%
2 Person Carpool	2,820	3.77%	213,648	3.29%	80,418	3.55%	40,136	3.59%	43,029	3.69%	17,723	3.10%	397,775	3.40%
3+ Person Carpool	1,063	1.42%	90,814	1.40%	32,088	1.42%	18,461	1.65%	20,354	1.74%	7,462	1.30%	170,243	1.46%
Auto Passenger Trips	5,487	7.34%	441,499	6.80%	160,927	7.10%	86,456	7.74%	94,104	8.06%	36,444	6.37%	824,918	7.06%
Vehicle Occupancy	1.09		1.08		1.08		1.09		1.09		1.07		1.08	
Transit Trips	1,256	1.68%	574,484	8.85%	72,089	3.18%	13,324	1.19%	14,311	1.23%	12,554	2.20%	688,018	5.89%
Non-Motorized Person Trips	6,918	9.25%	175,113	2.70%	62,540	2.76%	32,614	2.92%	31,910	2.73%	19,830	3.47%	328,926	2.81%
Total Person Trips	**74,771**	**100%**	**6,489,798**	**100%**	**2,266,014**	**100%**	**1,117,079**	**100%**	**1,167,384**	**100%**	**571,837**	**100%**	**11,686,884**	**100%**

Table 6-18: Year 2008 Mode Choice Summary Statistics (Home-Based Non-Work)

Mode Choice	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	100,499	48.63%	7,839,247	53.62%	2,562,611	55.57%	1,691,151	53.64%	1,617,829	53.85%	674,129	54.95%	14,485,467	54.01%
Drive Alone	64,384	31.16%	4,814,078	32.93%	1,573,577	34.12%	1,030,108	32.67%	985,021	32.79%	422,879	34.47%	8,890,047	33.14%
2 Person Carpool	22,613	10.94%	1,825,437	12.49%	592,553	12.85%	387,787	12.30%	371,325	12.36%	148,725	12.12%	3,348,440	12.48%
3+ Person Carpool	13,502	6.53%	1,199,733	8.21%	396,481	8.60%	273,256	8.67%	261,483	8.70%	102,526	8.36%	2,246,980	8.38%
Auto Passenger Trips	57,044	27.61%	4,885,675	33.42%	1,603,900	34.78%	1,084,798	34.41%	1,038,293	34.56%	410,258	33.44%	9,079,968	33.85%
Vehicle Occupancy	1.57		1.62		1.63		1.64		1.64		1.61		1.63	
Transit Trips	1,122	0.54%	328,361	2.25%	33,045	0.72%	15,789	0.50%	11,531	0.38%	8,488	0.69%	398,336	1.49%
Non-Motorized Person Trips	47,977	23.22%	1,566,503	10.71%	412,257	8.94%	360,892	11.45%	336,759	11.21%	134,005	10.92%	2,858,392	10.66%
Total Person Trips	**206,643**	**100%**	**14,619,785**	**100%**	**4,611,812**	**100%**	**3,152,630**	**100%**	**3,004,412**	**100%**	**1,226,880**	**100%**	**26,822,163**	**100%**

Does not include home-based school trips.

Table 6-19: Year 2008 Mode Choice Summary Statistics (Non-Home-Based)

Mode Choice	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	85,915	66.83%	6,689,059	66.51%	2,379,055	66.59%	1,151,882	64.65%	1,125,102	65.30%	521,420	65.51%	11,952,433	66.19%
Drive Alone	70,273	54.66%	5,324,546	52.94%	1,884,242	52.74%	896,258	50.30%	879,524	51.05%	413,126	51.90%	9,467,969	52.43%
2 Person Carpool	7,974	6.20%	629,682	6.26%	225,149	6.30%	109,016	6.12%	105,138	6.10%	47,366	5.95%	1,124,325	6.23%
3+ Person Carpool	7,667	5.96%	734,831	7.31%	269,664	7.55%	146,608	8.23%	140,440	8.15%	60,929	7.65%	1,360,139	7.53%
Auto Passenger Trips	28,238	21.97%	2,571,729	25.57%	937,828	26.25%	496,483	27.87%	476,302	27.64%	208,395	26.18%	4,718,975	26.13%
Vehicle Occupancy	1.33		1.38		1.39		1.43		1.42		1.40		1.39	
Transit Trips	111	0.09%	112,511	1.12%	14,643	0.41%	2,933	0.16%	2,394	0.14%	2,855	0.36%	135,447	0.75%
Non-Motorized Person Trips	14,292	11.12%	683,619	6.80%	240,935	6.74%	130,389	7.32%	119,154	6.92%	63,279	7.95%	1,251,669	6.93%
Total Person Trips	**128,556**	**100%**	**10,056,917**	**100%**	**3,572,462**	**100%**	**1,781,687**	**100%**	**1,722,952**	**100%**	**795,950**	**100%**	**18,058,524**	**100%**

Table 6-20: Year 2008 Mode Choice Summary Statistics (Home-Based School)

Mode Choice	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	14,262	25.73%	845,909	27.99%	258,626	29.48%	191,107	29.62%	203,802	30.31%	71,660	29.14%	1,585,366	28.73%
Drive Alone	4,682	8.45%	286,928	9.49%	95,880	10.93%	61,867	9.59%	69,381	10.32%	25,265	10.28%	544,003	9.86%
2 Person Carpool	4,711	8.50%	275,545	9.12%	80,002	9.12%	60,344	9.35%	64,038	9.52%	22,723	9.24%	507,363	9.19%
3+ Person Carpool	4,952	8.93%	288,380	9.54%	84,981	9.69%	70,782	10.97%	71,856	10.69%	24,231	9.85%	545,183	9.88%
Auto Passenger Trips	19,203	34.64%	1,122,721	37.15%	366,251	41.75%	299,838	46.46%	286,411	42.59%	100,690	40.95%	2,195,114	39.78%
Vehicle Occupancy	2.35		2.33		2.42		2.57		2.41		2.41		2.38	
Transit & School Bus Trips	941	1.70%	139,354	4.61%	19,034	2.17%	8,235	1.28%	5,922	0.88%	5,828	2.37%	179,315	3.25%
Non-Motorized Person Trips	21,028	37.93%	914,075	30.25%	233,374	26.60%	146,123	22.64%	176,283	26.22%	67,709	27.54%	1,558,592	28.24%
Total Person Trips	**55,434**	**100%**	**3,022,060**	**100%**	**877,286**	**100%**	**645,303**	**100%**	**672,417**	**100%**	**245,887**	**100%**	**5,518,386**	**100%**

Table 6-21: Year 2008 Mode Choice Summary Statistics (all trip purposes)

Peak Periods	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	136,713	54.09%	10,556,334	58.69%	3,681,004	61.96%	2,061,647	58.55%	2,049,432	58.98%	917,994	61.27%	19,403,124	59.38%
Drive Alone	99,720	39.45%	7,735,853	43.01%	2,740,881	46.13%	1,465,913	41.63%	1,461,163	42.05%	687,344	45.87%	14,190,872	43.43%
2 Person Carpool	20,918	8.28%	1,520,617	8.45%	504,005	8.48%	310,933	8.83%	307,829	8.86%	123,031	8.21%	2,787,333	8.53%
3+ Person Carpool	16,075	6.36%	1,299,865	7.23%	436,118	7.34%	284,802	8.09%	280,440	8.07%	107,620	7.18%	2,424,919	7.42%
Auto Passenger Trips	63,572	25.15%	4,921,254	27.36%	1,677,813	28.24%	1,082,697	30.75%	1,047,629	30.15%	412,756	27.55%	9,205,721	28.17%
Vehicle Occupancy	1.47		1.47		1.46		1.53		1.51		1.45		1.47	
Transit Trips	1,985	0.79%	717,594	3.99%	86,534	1.46%	22,357	0.63%	19,701	0.57%	17,497	1.17%	865,668	2.65%
Non-Motorized Person Trips	50,501	19.98%	1,792,581	9.97%	495,888	8.35%	354,408	10.07%	357,783	10.30%	150,072	10.02%	3,201,233	9.80%
Total Person Trips	252,771	100%	17,987,762	100%	5,941,239	100%	3,521,109	100%	3,474,545	100%	1,498,320	100%	32,675,746	100%
Off-Peak Periods	**Imperial**		**Los Angeles**		**Orange**		**Riverside**		**San Bernardino**		**Ventura**		**Total**	
Vehicle Trips	125,156	58.84%	10,121,527	62.46%	3,491,983	64.80%	1,959,063	61.65%	1,925,834	62.24%	852,783	63.51%	18,476,346	62.80%
Drive Alone	96,846	45.53%	7,683,939	47.41%	2,670,770	49.56%	1,448,409	45.58%	1,436,439	46.43%	651,749	48.54%	13,988,151	47.54%
2 Person Carpool	17,200	8.09%	1,423,695	8.79%	474,117	8.80%	286,350	9.01%	275,701	8.91%	113,506	8.45%	2,590,569	8.81%
3+ Person Carpool	11,110	5.22%	1,013,893	6.26%	347,096	6.44%	224,305	7.06%	213,693	6.91%	87,528	6.52%	1,897,626	6.45%
Auto Passenger Trips	46,401	21.81%	4,100,370	25.30%	1,391,093	25.82%	884,878	27.85%	847,482	27.39%	343,031	25.55%	7,613,254	25.88%
Vehicle Occupancy	1.37		1.41		1.40		1.45		1.44		1.40		1.41	
Transit Trips	1,446	0.68%	437,114	2.70%	52,278	0.97%	17,924	0.56%	14,457	0.47%	12,228	0.91%	535,447	1.82%
Non-Motorized Person Trips	39,714	18.67%	1,546,730	9.54%	453,218	8.41%	315,610	9.93%	306,322	9.90%	134,751	10.04%	2,796,345	9.50%
Total Person Trips	**212,717**	**100%**	**16,205,740**	**100%**	**5,388,572**	**100%**	**3,177,476**	**100%**	**3,094,094**	**100%**	**1,342,794**	**100%**	**29,421,393**	**100%**

Table 6-21: Year 2008 Mode Choice Summary Statistics (continued)

All Time Periods	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
Vehicle Trips	261,870	56.26%	20,677,861	60.47%	7,172,986	63.31%	4,020,711	60.02%	3,975,265	60.52%	1,770,778	62.33%	37,879,470	61.00%
Drive Alone	196,567	42.23%	15,419,791	45.10%	5,411,650	47.76%	2,914,321	43.51%	2,897,602	44.11%	1,339,093	47.13%	28,179,023	45.38%
2 Person Carpool	38,118	8.19%	2,944,312	8.61%	978,122	8.63%	597,283	8.92%	583,531	8.88%	236,537	8.33%	5,377,903	8.66%
3+ Person Carpool	27,185	5.84%	2,313,758	6.77%	783,214	6.91%	509,106	7.60%	494,133	7.52%	195,148	6.87%	4,322,545	6.96%
Auto Passenger Trips	109,973	23.63%	9,021,624	26.38%	3,068,906	27.09%	1,967,575	29.37%	1,895,111	28.85%	755,787	26.60%	16,818,976	27.08%
Vehicle Occupancy	1.42		1.44		1.43		1.49		1.48		1.43		1.44	
Transit Trips	3,431	0.74%	1,154,708	3.38%	138,812	1.23%	40,282	0.60%	34,157	0.52%	29,725	1.05%	1,401,115	2.26%
Non-Motorized Person Trips	90,215	19.38%	3,339,310	9.77%	949,106	8.38%	670,018	10.00%	664,105	10.11%	284,824	10.03%	5,997,578	9.66%
Total Person Trips	**465,488**	**100%**	**34,193,503**	**100%**	**11,329,810**	**100%**	**6,698,585**	**100%**	**6,568,639**	**100%**	**2,841,114**	**100%**	**62,097,139**	**100%**

Chapter 7 - Heavy Duty Truck Model

Contents

CHAPTER 7 – HEAVY DUTY TRUCK MODEL

Introduction

As part of the Regional Model Update, SCAG commissioned a team to develop improvements and enhancements to the Heavy Duty Truck (HDT) Model. This Chapter provides the technical approach used to implement various model improvements. A key element of this model development effort was the collection and analysis of HDT trip data. A report documenting this data collection effort is available from SCAG[2] This Chapter addresses the various elements of the Heavy Duty Truck Model, including internal and external HDT trips, Port HDT trips and Intermodal HDT trips.

HDT Model Structure

Figure 7-1 provides a flow chart of the overall structure of the HDT model. The model forecasts trips for three HDT weight classes: light-heavy (8,500 to 14,000 lbs. gross vehicle weight (GVW); medium-heavy (14,001 to 33,000 lbs. GVW); and heavy-heavy (>33,000 lbs. GVW). The key components of the new HDT Model are the following:

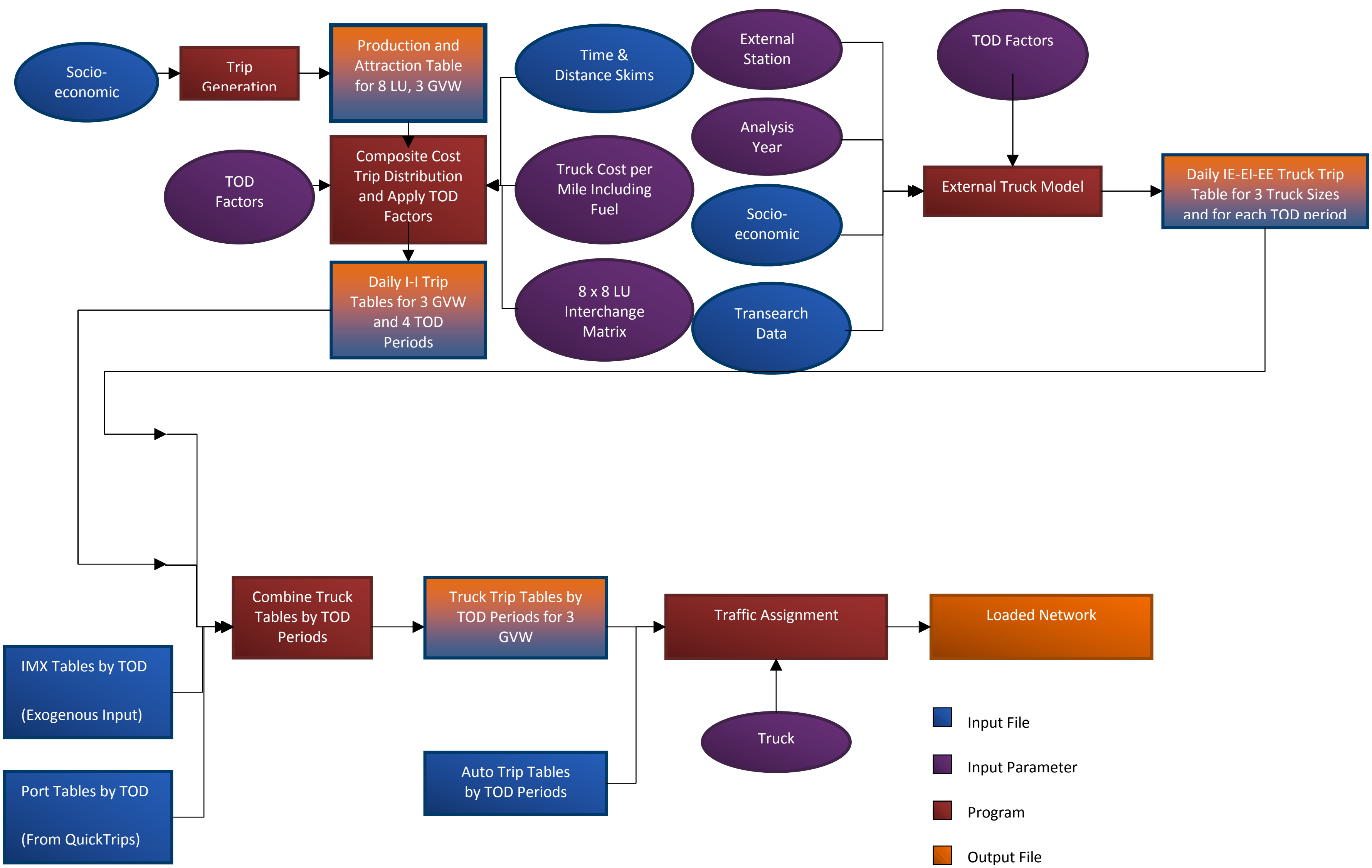
- ***External Trip Generation and Distribution Model.*** This component estimates the trip table for all interregional truck trips based on commodity flow patterns that link Southern California with the rest of the nation. The previous model used a commodity flow database obtained from outside sources, and included procedures for converting annual tonnage flows at the county level to daily truck trips at the TAZ level. The updated model replaces the older Caltrans Intermodal Transportation Management System (ITMS) commodity flow database with a new TRANSEARCH database from IHS/Global Insight. Adjustments were made to the TransCAD scripts that convert annual tonnage flows into daily truck trip tables. These modifications are a result of differences in data formats between TRANSEARCH and ITMS.

- ***Internal Trip Generation and Distribution Models.*** This component of the HDT Model estimates trip tables for intraregional trips. Trip generation is based on trip rates (number of trips per employee or household) for different land uses/industry sectors at the trip ends. This basic structure was retained, although all of the current trip rates were updated with new survey data. Other trip generation specifications (e.g., trip rates as a function of size of firm or more detailed industry/land use classifications) were reviewed, but it was determined that these specifications were not supported by currently available forecast data from SCAG.

  The trip distribution process was modified by developing a matrix of factors that indicate the trip interchange relationships among different land use types (i.e., what fraction of trips originating at a land use such as manufacturing sites go to warehouses vs. other manufacturing sites, etc.). The GPS survey data was used to develop a series of gravity models for each truck class. This offers some of the benefits of tour-based models by directing trips from zone to zone based on logical relationships amongst land use types without the extensive data requirements (typically difficult to collect from trip diary surveys) that are required to support development of a full tour-based model.

[2] Cambridge Systematics, Inc., *SCAG Task 4 Data Verification and Analysis – Final Report*, October 2010.

Figure 7-1: Final HDT Model Structure



- ***Special Generator Trip Generation and Distribution Models.*** These models include the port model and the intermodal rail model. All of the input parameters to the port trip generation model were updated to reflect current port capacity improvements and throughput forecasts. This model update also implements a procedure to incorporate secondary port truck trips. These are cargo trips from intermediate handling locations (container staging areas, transshipment sites, etc.) to final destinations. Additionally there are secondary (empty) movements of trucks associated with port truck trips, for purposes of truck repositioning. Both cargo and empty truck secondary trips are allocated to other destination in the regions using the gravity model distribution.

- ***Trip Assignment.*** The model incorporates a multiclass assignment combining the truck trip tables with the passenger trip tables. Prior to assignment, the truck trip tables are converted to PCEs. The PCE factors were adapted from the TRB Highway Capacity Manual[3], and are a function of the percent truck volume and length and steepness of grades. Five time periods are used to assign truck trips, consistent with the auto trip assignment. Updated time-of-day factors were developed using data from permanent classification count stations, weigh-in-motion (WIM), and vehicle classification counts.

Internal HDT Model

Internal HDT Trip Generation Model

The internal truck trip generation model is land use-based, where trip rates are multiplied by employment by industry sector to obtain internal truck trip productions and attractions. All the internal truck travel in the region is associated with eight broad but distinct land uses, namely, households, agriculture/mining/construction, retail, government, manufacturing, transportation/utility, wholesale, and other (service). The trip rates (i.e., truck trips per employee) for every land use were updated based on recent data collection efforts –establishment surveys and third-party truck GPS data.

Land Use and Socioeconomic Data

The socioeconomic data used by the Internal HDT Model is consistent with those data used by the passenger model, except that the employment data are stratified into more employment categories. The 22 two-digit NAICS categories of employment were mapped to 10 final categories to account for truck trip generation similarities. This employment category mapping is shown in Table 7-1. These stratified employment types, plus households, support eight land use purposes for the HDT trip generation models: Households, Agriculture/Mining/Construction, Retail, Governments, Manufacturing, Transportation and Utility, Wholesale, and Other (service).

[3] Highway Capacity Manual. Volume 2: Uninterrupted Flow. Transportation Research Board: Washington D.C., 2010.

Table 7-1: Aggregated Two-Digit NAICS Categories

	Two-Digit	Two-Digit Description		Aggregate Categories for Trip Generation Models
1	11	Agriculture, Forestry, Fishing, and Hunting	1	Agriculture, Forestry, Fishing, and Hunting
2	21	Mining	2	Mining
3	22	Utilities	3	Utilities
4	23	Construction	4	Construction
5	31	Manufacturing	5	Manufacturing
6	42	Wholesale Trade	6	Wholesale Trade
7	44	Retail Trade	7	Retail Trade
8	45	Retail Trade	7	Retail Trade
9	48	Transportation and Warehousing	8	Transportation and Warehousing
10	49	Transportation and Warehousing	8	Transportation and Warehousing
11	51	Information Services	9	FIRES
12	52	Finance and Insurance	9	FIRES
13	53	Real Estates, and Rental and Leasing	9	FIRES
14	54	Professional, Scientific, and Technical Services	9	FIRES
15	55	Management of Companies and Enterprises	9	FIRES
16	56	Administrative and Support, and Waste Management and Remediation Services	9	FIRES
17	61	Educational Services	10	EDU
18	62	Health Care, and Social Assistance	9	FIRES
19	71	Arts, Entertainment, and Recreation	9	FIRES
20	72	Accommodation, and Food Services	9	FIRES
21	81	Other Services (Except Public Administration)	9	FIRES
22	92	Public Administration	11	GOVT

Internal HDT Trip Rates

Trip rates derived from establishment surveys and GPS data for each truck type and land use are shown in Table 7-2.

Table 7-2: Internal HDT Trip Rates

Category	Light HDT Trip Rate	Medium HDT Trip Rate	Heavy HDT Trip Rate
Households	0.0147	0.0046	0.0072
Agriculture/Mining/Construction	0.0804	0.0778	0.0715
Retail	0.0663	0.0662	0.0703
Government	0.0296	0.0150	0.0148
Manufacturing	0.0613	0.0655	0.0924
Transportation/Utility/Warehousing	0.1583	0.1819	0.3206
Wholesale	0.0916	0.0968	0.1316
Other (Service)	0.0095	0.0111	0.0151

Table 7-3 shows the 2008 HDT trip generation estimates. As expected, households in the region generate a high number of trip ends. This is mostly due to the fact that land uses such as transportation and warehousing, utilities, service and retail deliver goods and provide services to residential neighborhoods. The largest HDT trip generator is the transportation and utility land use that includes trucks involved in power generation, water supply and sewage treatment, all kinds of transportation (trucking industry, taxi, and chartered services), and postal and courier services. The second highest generators of HDT trips are retail and manufacturing land uses, which account for a major share of employment in the region and serve the vast area and population of the six-county SCAG region.

Table 7-3: 2008 Internal HDT Trip Generation Estimates

Land Use	Light HDT Trip Ends	Medium HDT Trip Ends	Heavy HDT Trip Ends	Total Trip Ends	Percent of Total Trip Ends
Households	85,194	26,692	42,031	153,917	15%
Ag/Mining/Construction	39,080	37,833	34,784	111,698	11%
Retail	55,607	55,527	58,953	170,087	17%
Governments	7,339	3,733	3,670	14,742	1%
Manufacturing	46,715	49,902	70,471	167,087	17%
Transportation/Utility/ Warehousing	57,057	65,584	115,586	238,227	24%
Wholesale	36,468	38,549	52,395	127,412	13%
Other	2,937	3,422	4,664	11,023	1%
Total	**330,398**	**281,242**	**382,553**	**994,194**	

Internal HDT Trip Distribution Model

The trip distribution process was modified by developing a matrix of factors that indicate the trip interchange relationships among different land use types (i.e., what fraction of trips originating at a land use such as manufacturing sites go to warehouses vs. other manufacturing sites, etc.). The internal HDT trip distribution model uses a gravity formulation, stratified by land use type at both the production and the attraction end of the trip. This results in a total of 64 gravity models for each truck type (LHDT, MHDT and HHDT). After trip distribution, the 64 different trip matrices are combined into a single matrix for each truck type, so that only three matrices are passed on to time-of-day factoring and trip assignment.

Truck trips are distributed using composite cost impedances that accounts for time and distance-based monetary costs in addition to travel time. Based on a review of the literature, the appropriate distance-based costs for the SCAG model are identified in a report commissioned by the Minnesota DOT[4]. These costs account for fuel, tires, maintenance and repair, and depreciation.

The link composite cost is calculated as shown in the equation below. The corresponding unit costs are shown in Table 7-4.

Composite Cost = *Cost per hour * Congested time +*
*[Fuel Price / Fuel efficiency + Cost per mile (excluding fuel)] * Distance*

[4] Levinson, David Matthew, Corbett, Michael J. and Hashami, Maryam, *Operating Costs for Trucks*, (2005) http://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID1736159_code807532.pdf?abstractid=1736159&mirid=1.

Table 7-4: Composite Truck Unit Costs

Truck Type	Cost per Hour	Fuel Efficiency (MPG)	Cost per Mile (excluding fuel)	Fuel Price per Gallon
LHDT	$13.84	8.5	$0.14	$3.13 (a)
MHDT	$19.21	7.0	$0.23	$3.15 (b)
HHDT	$19.21	6.0	$0.26	$3.15 (b)

(a) Assumes a fleet mix of 60% gasoline and 50% diesel powered trucks.
(b) Average price of diesel fuel in California between 2006 and 2011.

The GPS survey of truck trips provided the data to calibrate the model friction factors. These data were used to build observed truck trip flow matrices, stratified by truck type (LHDT, MHDT and HHDT). The TransCAD gravity model calibration utility was used to calibrate the fraction factors that best matched the observed truck flow matrices, given the composite cost impedances and land-use based trip productions and attractions. Figures 7-2 to 7-4 show the trip length calibration, respectively for each truck class.

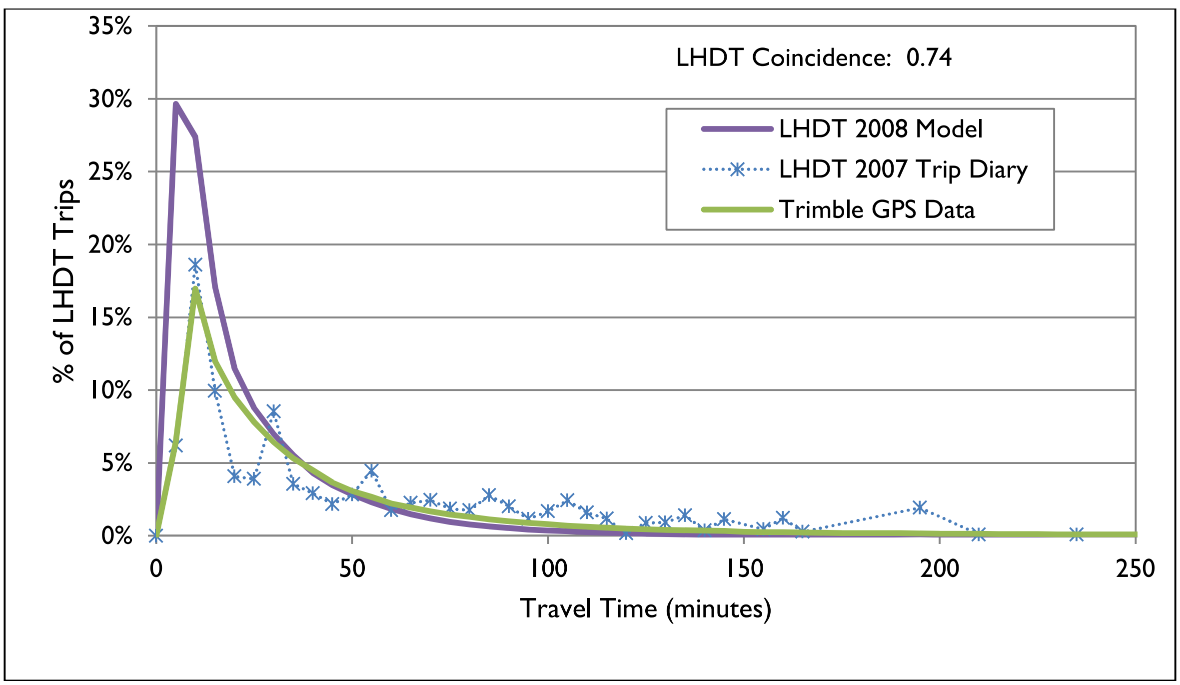


Figure 7-2 LHDT Internal Truck Trip Length Calibration

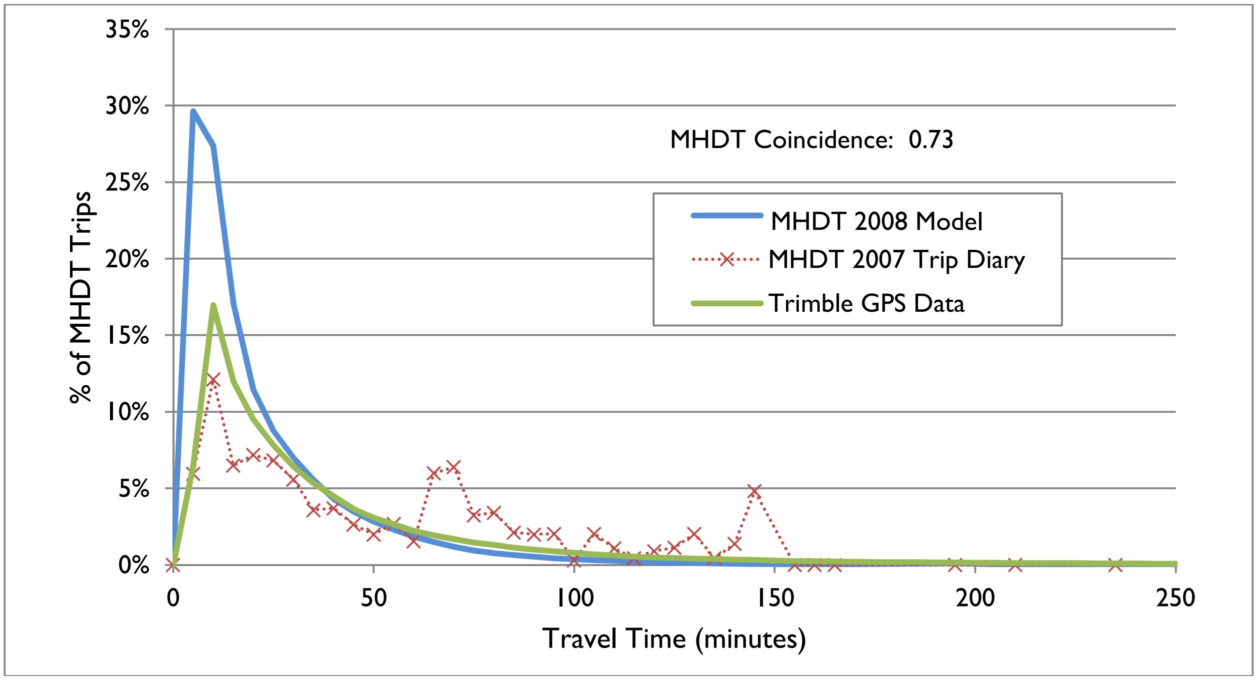


Figure 7-3 MHDT Internal Truck Trip Length Calibration

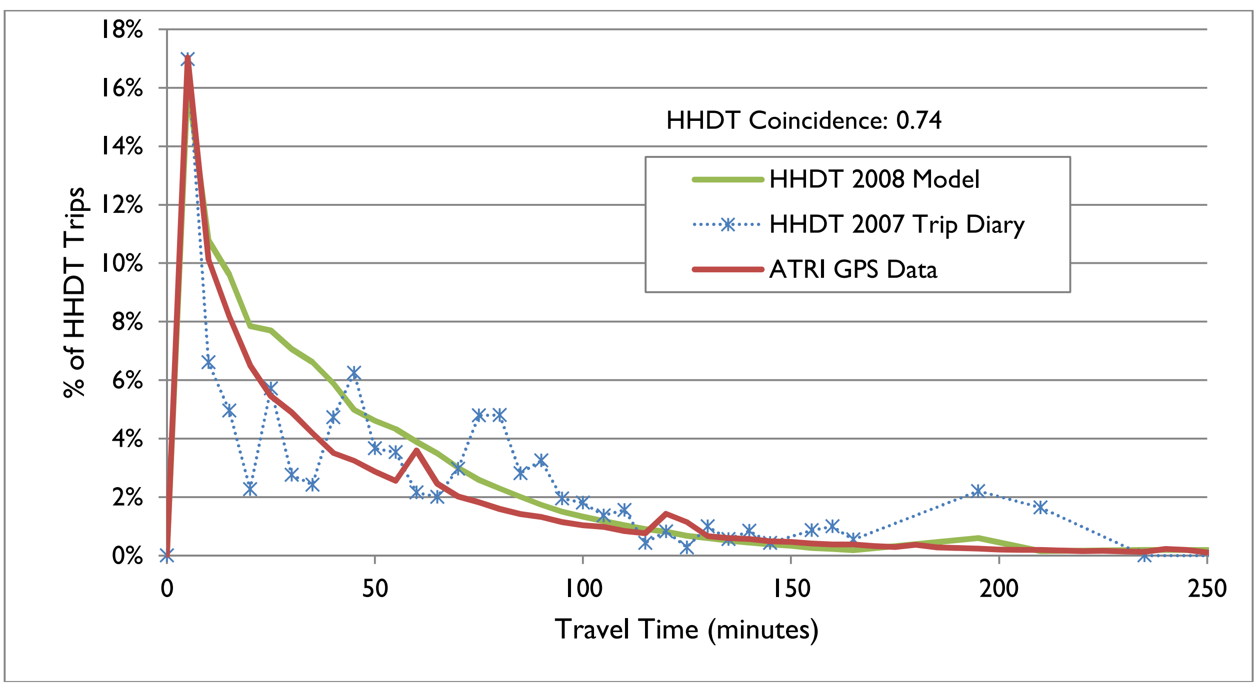


Figure 7-4 HHDT Internal Truck Trip Length Calibration

External HDT Model

The external HDT Model consists of internal-external & external-internal trips (IE/EI), and external-external truck trips (EE). The IE/EI HDT trips are generated and distributed using a combination of commodity flow data at the county level and 2-digit NAICS employment data for allocating county data to TAZs. Growth factors developed using the commodity flow data at a county level and external cordon are used to forecast future year external HDT trips from the base year trip flow matrices.

The external HDT Model is based on the 2007 TRANSEARCH commodity flow table. The TRANSEARCH data are provided as annual flows in tons and are converted to daily weekday flows using an annualization factor of 306 (6 days per week for 51 weeks) for all commodities. The flows are converted from tons to trucks using the payload factors shown in Table 7-5. These payload factors were developed using data from the 2002 Vehicle Inventory and Use Survey (VIUS).

The methodology that converts commodity flows to annual HDT trips at the TAZ level is described below for various direction, commodity and shipment type combinations.

Outbound Truck Load and Private Carrier Shipments

The external trip end of the outbound commodity flows are allocated to external cordon stations using survey data from the SCAG region. The internal trip end of the outbound commodity flows is disaggregated from counties to TAZs based on shares of employment in the manufacturing, agricultural, mining industries, or warehousing land use acreage, depending on the type of commodity.

Inbound Truck Load and Private Carrier Shipments

The external trip end of the inbound commodity flows are allocated to cordon stations as described above for outbound flows. To establish the internal TAZ trip end, flows of each commodity destined to warehouses are estimated using Reebie data, and then disaggregated to TAZs based on the share of warehousing land use acreage. The remaining non-warehouse destination flows are assumed to be destined directly to manufacturing facilities. To disaggregate these flows, the fraction of each commodity consumed by different industries is determined using an Input-Output table, and then disaggregated to TAZs based on shares of employment in the corresponding industry.

Less than Truck Load (TL) Shipments

SCAG inbound and outbound LTL shipments typically move through LTL terminals at the origin and destination so the same methodology is used for both directions. Also, since LTL shipments could carry any commodity, the approach is the same for all commodities. Truck load payload factors are used because payloads for LTL shipments cannot be determined (each LTL shipment carries many commodities with varying payloads). The external trip end of the LTL commodity flow is allocated to cordon stations as described above for truck load shipments. The internal trip end is disaggregated from county to TAZ based on the share of LTL trucking employment.

Table 7-5: External HDT Commodity Payload Factors

Commodity		Payload Factors (Tons per Truck)		
STCC	Description	LHDT	MHDT	HHDT
1	Farm Products	1	2	16
8	Forest Products	3	6	14
9	Fresh Fish or Other Marine Products	2	2	10
10	Metallic Ores	3	3	24
11	Coal	3	3	18
13	Crude Petroleum, Natural Gas, or Gasoline	3	6	15
14	Non-metallic Minerals	4	5	16
19	Ordinance or Accessories	2	5	14
20	Food or Kindred Products	3	4	15
21	Tobacco Products, excluding Insecticides	3	6	15
22	Textile Mill Products	1	4	11
23	Apparel or Other Finished Textile Products	5	6	9
24	Lumber or Wood Products, excluding Furniture	4	6	16
25	Furniture or Fixtures	2	3	9
26	Pulp, Paper, or Allied Products	2	7	13
27	Printed Matter	2	7	15
28	Chemicals or Allied Products	2	5	14
29	Petroleum or Coal Products	3	6	11
30	Rubber or Miscellaneous Plastics Products	3	5	12
31	Leather or Leather Products	3	6	13
32	Clay, Concrete, Glass, or Stone Products	3	7	14
33	Primary Metal Products	5	6	15
34	Fabricated Metal Products	5	5	11
35	Machinery, excluding Electrical	2	3	9
36	Electrical Machinery, Equipment, or Supplies	2	5	8
37	Transportation Equipment	2	7	11
38	Instruments, Photographic Goods, Optical Goods, Watches, or Clocks	2	4	10
39	Miscellaneous Products of Manufacturing	2	6	8
40	Waste or Scrap Materials	2	3	14
43	Mail	3	4	14
44	Freight Forwarder Traffic	3	1	7
45	Shipper Association or Similar Traffic	3	6	9
46	Freight All Kinds	3	5	12
47	Small Packages, LTC or LTL	3	6	10
48	Waste Hazardous Materials or Waste Hazardous Substances	3	6	15

External – External HDT Trips

The 2007 TRANSEARCH data identify EE truck freight flows passing through the SCAG region. To assign the cordon station to each EE trip end, a method similar to the one used for the external end of the IE/EI trips was used.

Empty Truck Trips

To account for all external truck trips in the SCAG region, empty truck are added to the loaded truck trips estimated from the commodity flows. Empty truck trip percentages at each external cordon location were generated from survey data. Assuming the empty truck fractions to be the same for all O-D pairs for an external cordon, empty truck trips are added to the loaded truck trips between SCAG TAZs and external TAZs.

Port HDT Model

Ports TAZ Development

The SCAG Tier 1 Zone System consists of 4,192 TAZs, including 40 TAZs that represent the Ports areas. The Port HDT Model was updated to use a more refined set of port TAZs, developed by the Port of Long Beach. This zone system, called Port TAM, includes a total of 85 Ports area TAZs, for a total of 4,251 Tier 1 TAZs. Table 7-6 below provides a summary breakdown of the 4,251 TAZ system.

Table 7-6: Port TAM 4,251 TAZ System

from Zone ID	To Zone ID	Zone Type	Total
1	4109	Internal zones	4,109
4110	4149	External zones	40
4150	4161	Airport zones	12
4162	4246	Port zones	85
4247	4251	Extra zones	5
Total Zones			**4,251**

Terminal Gate Surveys

Origin-destination (OD) truck surveys were conducted in early 2010 at the Ports of Los Angeles and Long Beach Marine Terminals. The marine terminals are distribution points where international cargo is loaded onto trucks and rail. The survey was conducted to obtain OD pattern information by truck type. Surveys were conducted at six Port of Long Beach terminals (ITS, PCT, LBCT, CUT, SSA, and HANJIN) and six Port of Los Angeles terminals (YTI, MAERSK, EVERGREEN, TRAPAC, YANG MING, and APL).

A total of 23,030 survey sheets were distributed and 3,559 were returned. From the returned surveys, 2,981 origin trips were fully completed and geo-coded, and another 2,593 destination trips were also fully completed and geo-coded for a total of 5,574 trips. Tables 7-7 and 7-8 present the survey sample origins and destinations by container type.

The marine terminal truck trips exhibited the following OD patterns:

- 12% traveled to the Ports areas & nearby locations
- 30% traveled to Gateway cities locations
- 20% traveled to off-dock yards
- 33% traveled to locations within the rest of the SCAG region
- Less than 5% traveled to out of state locations
- 98% of the off-dock intermodal yard traffic went to the four main intermodal yards (ICTF, Hobart, East LA, and LATC). Almost no traffic was recorded from yards at Industry and San Bernardino.

Table 7-7: Survey Sample Origins

Terminal	Bobtails	Chassis	Containers	Total
ITS	121	45	259	**425**
PCT	98	33	215	**346**
LBCT	165	14	282	**461**
CUT	94	45	151	**290**
SSA	75	26	73	**174**
HANJIN	142	13	198	**353**
YTI	9	3	21	**33**
MAERSK	107	31	80	**218**
EVERGREEN	59	21	104	**184**
TRAPAC	163	13	166	**342**
YANG MING	48	10	69	**127**
APL	13	1	14	**28**
Total	**1,094**	**255**	**1,632**	**2,981**

Table 7-8: Survey Sample Destinations

Terminal	Bobtails	Chassis	Containers	Total
ITS	116	22	246	**384**
PCT	77	22	173	**272**
LBCT	115	15	258	**388**
CUT	89	18	141	**248**
SSA	30	14	94	**138**
HANJIN	85	31	187	**303**
YTI	15	1	16	**32**
MAERSK	35	31	140	**206**
EVERGREEN	55	6	103	**164**
TRAPAC	86	14	213	**313**
YANG MING	23	10	81	**114**
APL	10	3	18	**31**
Total	**736**	**187**	**1670**	**2,593**

Port Truck Trip Generation

The port trip generation model was developed in 2008 based on a detailed port area zone system and specialized trip generation rates for autos and trucks by type (Bobtail, Chassis, and Containers). Port truck trip generation has two components: 1) container terminal truck trips, and 2) non-container terminal truck trips.

Container Terminal Truck Trip Generation

The container terminal truck trip generation model for the ports is referred to as the QuickTrip Model. QuickTrip was originally developed for the Ports of Los Angeles and Long Beach. The Model includes detailed input variables such as mode split (rail versus truck moves), time-of-day factoring, weekend moves, empty return factors, and other characteristics that affect the number of trucks entering and exiting through the terminal gates. The relevant input data for each container terminal include the following:

- Peak monthly Twenty-Foot Equivalent Units (TEU) throughput.
- TEU-to-lift conversion factor: factor determining the average number of TEUs associated with each lift at the terminal.
- TEU land-side throughput distributions: percent of TEU throughput associated with on-dock intermodal imports, on-dock intermodal exports, off-dock intermodal imports, off-dock intermodal exports, local imports, local exports, empties, and trans-shipments across the wharf.
- Number of operating days during the week.
- Percent of throughput moved during each terminal operating shift (for the day, second and hoot shifts).

QuickTrip produces the following truck trip outputs for each terminal:

- Monthly gate transactions
- Peak week truck trip volume
- Daily truck trips, and truck trips by each hour of the day by type of truck trip (bobtail, chassis, container, empty), and direction (arrival at and departure from the terminal)

QuickTrip can be used to generate base as well as future year truck trips by truck type and direction for each terminal, using the model inputs described earlier for each specific year. The inputs that are particularly expected to change for different years include the peak monthly TEU throughput, and the TEU land-side throughput distributions (based on expected increase in on-dock intermodal capacity at the port terminals in the future). Additionally, the model has the capability to analyze the impacts of other port truck trip reduction strategies such as virtual container yards and off-peak truck diversions, using specific inputs associated with these strategies.

The Model was enhanced to allow the user to assess whether the estimated capacity of each rail yard has been exceeded. If so, traffic is iteratively re-allocated to other yards that are not over capacity. The enhanced model also allows the user to choose different efficiency factors, such as "percent double cycle trucks," for different off-dock yards. In the original version, the user had to use the same variables for the entire off-dock market.

Non-Container Terminal Truck Trip Generation

Non-container terminal truck trip generation estimates were also developed for the Ports as part of the Port truck trip generation process. This includes trips to and from all of the other types of marine terminals (automobile terminals, dry bulk terminals, liquid bulk terminals and break-bulk terminals). In addition, there are many non-terminal land uses located throughout the ports (e.g., administrative offices, recreation, commercial, government buildings) that potentially generate truck traffic.

Existing non-container terminal truck trips were developed by conducting a series of driveway and midblock truck counts throughout the Ports. A number of specific terminals were counted at their driveways, while other terminals and miscellaneous land use activities were reflected via the use of downstream roadway truck counts. In some cases, a roadway truck count was used to represent the trip generation of a group of non-container terminals and other land uses.

Port Trip Table Distribution

The zone to zone distribution of port truck trips is based on a fixed OD matrix. A detailed and comprehensive truck driver survey was undertaken by the ports at the marine container terminals. The survey was used to develop detailed origin-destination "trip tables" for use in the Port area travel demand model. The stated trip OD from every valid survey was correlated with the travel demand model TAZ system. The survey results were then used to develop port truck OD matrices by truck type for use in the model. Distribution patterns were developed separately for arrival trips and departure trips for each terminal. A total of 15 Port Truck Trip Tables were developed (5 time periods by 3 vehicle classes): AM, MD, PM, EV and NT time periods, and Bobtails, Chassis and Container truck trips. The time periods are consistent with those used by the passenger model. Empty container and loaded container truck types are combined into one truck type called container truck type.

For terminals with few or no observations (Pier C, YTI and APL) an average distribution of all surveyed records was used. Before creating survey frequency distribution vectors, survey sample trips were adjusted to exclude trips that have both OD within the same terminal.

Base Year Port Trip Tables Summary

Summaries of 2008 Port truck trips are shown in Tables 7-9 and 7-10.

Table 7-9: 2008 Port HDT Trips by Truck Type

Time Period	Bobtails	Chassis	Containers	Total
AM	1,339	415	1,858	3,612
MD	7,756	2,439	11,037	21,232
PM	3,669	1,159	5,248	10,076
EV	1,888	596	2,696	5,180
NT	2,832	895	4,045	7,772
Daily	**17,484**	**5,504**	**24,884**	**47,872**

Table 7-10: 2008 Port HDT Trips by Time Period and County

County	Time Period					
	AM	MD	PM	EV	NT	Total
Imperial						**0**
Los Angeles	3,276	19,752	9,430	4,846	7,269	**44,573**
Orange	108	475	206	106	159	**1,055**
Riverside	46	204	89	46	69	**455**
San Bernardino	153	675	295	153	230	**1,506**
Ventura	6	26	12	7	10	**62**
External Stations	23	100	44	23	34	**224**
Total	**3,612**	**21,233**	**10,076**	**5,182**	**7,772**	**47,875**
% of Daily Trips	**7.5%**	**44.4%**	**21.0%**	**10.8%**	**16.2%**	

Intermodal HDT Trips

Intermodal Trip Tables

Intermodal (IMX) trucks trips are heavy HDT movements generated at the six regional intermodal facilities in the SCAG region. These intermodal facilities are shown in Figure 7-5. The intermodal (IMX) trip tables were developed from the IMX surveys conducted for LACMTA in 2005[5]. These surveys collected the following data on truck movements at these facilities: total inbound and outbound trains by month, including origin, destination, and number of containers by type; weekly train schedule; number of "lifts" (loading/unloading rail cars) by month split by containers versus trailers; and gate transactions by day by type (inbound, outbound, loaded, empty and bobtail).

The data obtained from the six IMX terminals were used to put together matrices of annual shipment flows at the zip code level. Trips to or from the ports were excluded, as they will be modeled by the Port HDT Model. Four customer data matrices were developed: TL inbound, TL outbound, LTL inbound, and LTL outbound. A summary of these truck movements is shown in Table 7-11. These truck trips were all assumed to be HHDTs. The daily truck trips were developed assuming an annualization factor of 306. A summary of the IMX daily trip tables by terminal and county, as derived from the 2005 IMX surveys, is presented in Table 7-12.

[5] Cambridge Systematics, Inc. LACMTA Cube Cargo Model Development. 2005.

Figure 7-5: Intermodal Facilities in the SCAG Region

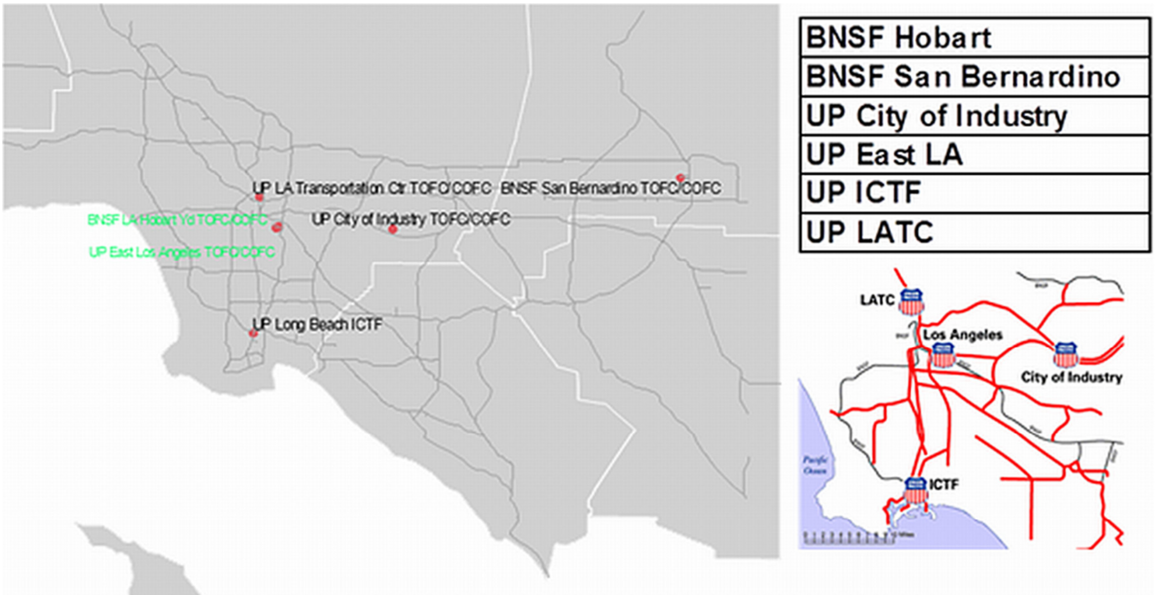


Table 7-11: 2005 Domestic IMX (Non-Port) Annual Truck Trips

Domestic	BNSF Hobart	BNSF San Bernardino	UP City of Industry	UP East LA	UP ICTF	UP LATC	Total
Inbound	444,204	433,333	93,789	96,757	2,463	21,812	1,092,357
TL/IMC	273,495	300,654	81,789	85,567	2,276	18,781	762,562
LTL	170,708	132,679	12,000	11,190	187	3,031	329,795
Outbound	445,011	458,677	78,431	69,837	662	21,353	1,073,970
TL/IMC	280,997	331,201	66,901	59,086	482	18,441	757,108
LTL	164,014	127,476	11,530	10,751	180	2,912	316,862
Total	889,214	892,009	172,220	166,594	3,125	43,165	2,166,327
TL/IMC	554,492	631,855	148,690	144,653	2,758	37,222	1,519,670
LTL	334,722	260,154	23,530	21,941	367	5,943	646,657

Table 7-12: 2008 Intermodal HHDT Trips by Terminal and County

IMX Terminal	IMX Terminal TAZ	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Grand Total	Share by Terminal
UP ICTF	1,360	0	9	1	1	1	0	**13**	**0%**
UP LATC	1,591	0	84	22	24	15	1	**147**	**2%**
BNSF Hobart	1,679	10	1,722	280	327	532	36	**2,905**	**40%**
UP East LA	1,702	2	322	110	78	73	4	**589**	**8%**
UP City of Industry	2,304	6	283	152	112	49	3	**606**	**8%**
BNSF San Bernardino	3,773	19	516	1,687	687	50	2	**2,961**	**41%**
Grand Total		**37**	**2,937**	**2,252**	**1,228**	**720**	**47**	**7,221**	
Share by County		**1%**	**41%**	**31%**	**17%**	**10%**	**1%**		

Secondary HDT Trips

The truck trip table calculated from the Port and IMX models comprises only the portion of the trip between those facilities and locations, primarily wholesale land uses, elsewhere in the SCAG region. These trips give rise to additional, "secondary" trips from these locations. That is, the first leg of this HDT trip chain is from Port or IMX to wholesale, while the second leg is from that wholesale land use to any internal TAZ in the six-county SCAG region.

These trips should be represented as wholesale land use truck trips in the internal HDT Model. The Port and IMX implied secondary truck production and attractions were added to the internal trucks prior to trip distribution. Table 7-13 presents a summary of the total wholesale HHDT trips in the region that are computed from three models – internal HDT, Port and IMX.

Table 7-13: 2008 Wholesale HDT Trips

Truck Type/PA	Internal HDT	Port Model HHDT	IMX HHDT Trips	Total Wholesale HHDT
LHDT Productions	35,129	n/a		
LHDT Attractions	35,129			
MHDT Productions	37,133			
MHDT Attractions	37,133			
HHDT Productions	50,470	12,885	3,405	66,760
HHDT Attractions	50,470	12,254	3,570	66,294

HDT Time-of-Day Factoring & Assignment

The HDT Model uses fixed time-of-day factors derived from observed truck counts. The HDT time of time periods are consistent with the passenger model periods, namely:

- AM Peak: 6:00 AM – 9:00 AM
- Mid-day: 9:00 AM - 3:00 PM
- PM Peak: 3:00 PM - 7:00 PM
- Evening: 7:00 PM – 9:00 PM
- Night: 9:00 PM – 6:00 AM

The HDT diurnal factors were derived from the 2007 Vehicle Travel Information System (VTRIS)[6] database. VTRIS is maintained by the FHWA Office of Highway Policy Information to track traffic trends, vehicle distributions and weight of vehicles to meet data needs specified in highway legislation. The VTRIS database contains truck classification counts spanning nearly half a year at many locations on SCAG interstate and state highways. The HDT time of day factors are shown in Table 7-14.

[6] http://www.fhwa.dot.gov/ohim/ohimvtis.cfm

Table 7-14: HDT Time-of-Day Factors

Time Period	Diurnal Factors		
	LHDT	MHDT	HHDT
AM Peak (6 AM - 9AM)	18.8%	18.0%	13.9%
Midday (9 AM-3PM)	42.9%	46.5%	35.3%
PM Peak (3 PM- 7PM)	20.3%	15.5%	16.7%
Evening (7 PM - 9 PM)	4.8%	3.5%	7.2%
Night (9 PM - 6AM)	13.2%	16.5%	26.9%

HDT trips are assigned simultaneously with the auto trips as part of a user equilibrium multiclass assignment. The assignment methodology is described in detail in Chapter 8 – Trip Assignment. Truck volumes are converted to PCEs following the procedures recommended in the 2010 Highway Capacity Manual. The PCE factors are a function of grade, length of the climb segment, and percent of truck volume, and vary by truck type (LHDT, MHDT and HHDT). These factors are shown in Table 7-15.

Table 7-15: HDT Passenger Car Equivalent Factors

Percent Trucks	Length of Grade in miles	Light -Heavy				Medium-Heavy				Heavy-Heavy			
		% Grade				% Grade				% Grade			
		< 2	2 - 4	4 - 6	> 6	< 2	2 - 4	4 - 6	> 6	< 2	2 - 4	4 - 6	> 6
0-5%	< 1	1.3	1.5	3.0	4.0	1.5	2.0	3.5	5.0	2.5	2.5	4.5	6.0
	1 - 2	1.3	2.5	4.0	5.0	1.5	3.5	5.0	6.5	2.5	5.0	7.5	12.5
	> 1	1.3	2.5	4.0	5.0	1.5	3.5	5.0	6.5	2.5	5.0	7.5	12.5
5-10%	< 1	1.3	1.5	2.5	3.0	1.5	2.0	3.0	4.0	2.5	2.5	4.5	5.5
	1 - 2	1.3	2.0	3.5	4.0	1.5	3.0	4.0	5.5	2.5	4.0	8.0	11.5
	> 1	1.3	2.0	3.5	4.0	1.5	3.0	4.0	5.5	2.5	4.0	8.0	11.5
>10%	< 1	1.3	1.5	2.0	2.5	1.5	2.0	2.5	3.0	2.5	2.5	4.0	4.0
	1 - 2	1.3	2.0	3.0	3.5	1.5	2.5	3.5	4.0	2.5	3.5	6.0	9.0
	> 1	1.3	2.0	3.0	3.5	1.5	2.5	3.5	4.0	2.5	3.5	6.0	9.0

CHAPTER 8 – TRIP ASSIGNMENT

Contents

CHAPTER 8 – TRIP ASSIGNMENT

Introduction

This Chapter describes the various trip assignment methodologies and 2008 validation results. Assignments used in the 2012 RTP model include a static, multiclass user equilibrium highway assignment to the highway network, and a multi-path (Pathfinder) transit assignment to the transit network. The multi-class highway assignment simultaneously loads the vehicle forecasted by the mode choice model, the internal-external and external-external vehicle trips, and the three classes of heavy duty trucks (light, medium and heavy). The OD trip tables loaded to the highway network includes the following vehicle classes:

- Drive Alone
- Shared Ride 2 No HOV
- Shared Ride 3+ No HOV
- Shared Ride 2 HOV
- Shared Ride 3+ HOV
- Light Trucks
- Medium Trucks
- Heavy Trucks

Highway assignment is the process of loading vehicles onto the appropriate highway facilities to produce traffic volumes, congested speeds, vehicle-miles traveled (VMT), and vehicle-hours traveled (VHT) estimates, for each of the five time periods. Link or segment assignments by time period are added to produce average daily traffic volumes for the model network.

Highway assignment validation is one of the crucial steps in the modeling process. The ability of the model to produce base year volume estimates within acceptable ranges of tolerance compared to actual ground counts is essential to validate the entire travel demand model. The screenline analysis for the 2008 validation year is presented in this Chapter. Also, key to highway assignment validation is the comparison of model estimated VMT to estimates from the Highway Performance Monitoring System (HPMS). An acceptable tolerance level is mandatory for regional air quality planning and conformity purposes. Specifics regarding the comparative analyses are summarized in this Chapter and assignment statistics for the SCAG region are also presented.

Time-of-Day Factors

In the highway assignment, vehicle trips for all trip purposes are assigned, or loaded, onto each of five time period highway networks. The five time periods are:

- AM Peak (AM) - 6:00 AM to 9:00 AM,
- Midday (MD) - 9:00 AM to 3:00 PM,
- PM Peak (PM) - 3:00 PM to 7:00 PM,
- Evening (EV) - 7:00 PM to 9:00 PM, and
- Night (NT) - 9:00 PM to 6:00 AM.

Prior to assignment, the mode choice output is converted from peak/off-peak production-attraction format to time-of-day OD format. The procedure used to accomplish this conversion is based on trips-in-motion diurnal factors.

Trips-in-motion diurnal factors were derived from the 2001 Post-Census Household Survey. These diurnal factors allocate the production-attraction trips by purpose to each of the five time periods. There are two sets of factors. The first set is applied at the end of trip generation to subdivide trips by purpose into "peak" and "off-peak" categories prior to the application of the trip distribution model. These factors are shown in Table 8-1. The second set is applied prior to trip assignment to allocate peak trips into the AM and PM peak periods by direction of travel, and off-peak trips into MD, EV and NT by direction of travel. These factors are displayed in Table 8-2. Once all of the factors are applied, OD trip tables by mode are summed for all trip purposes, combined with the internal-external, external-external and heavy duty truck trips, and then assigned by time period.

Table 8-1: Peaking Factors

Trip Purpose	Peak	Off-Peak
HBWD	0.6628	0.3372
HBWS	0.6224	0.3776
HBCU	0.5483	0.4517
HBSC	0.7390	0.2610
HBSH	0.4042	0.5958
HBSR	0.3574	0.6426
HBSP	0.6497	0.3503
HBO	0.4451	0.5549
WBO	0.5353	0.4647
OBO	0.4350	0.5651

Table 8-2: Time-of-Day Factors

Trip Purpose	Peak Period				Off Peak Period					
	AM		PM		MD		EV		NT	
	PA	AP	PA	AP	PA	AP	PA	AP	PA	AP
HBWD	45.0	1.4	3.4	50.3	27.5	18.2	1.5	15.2	24.3	13.6
HBWS_HBI	29.7	0.2	2.4	67.6	27.8	14.5	0.1	30.1	7.6	19.9
HBWS_IBW	33.4	1.4	3.4	61.8	34.0	45.7	0.7	8.8	7.4	3.4
HBCU	47.9	1.2	18.3	31.3	34.3	31.3	0.2	13.8	1.9	18.5
HBSC	68.8	0.0	1.0	30.2	8.7	82.0	0.8	4.5	1.3	2.6
HBSH	12.5	2.8	23.8	60.9	35.8	35.1	5.5	13.0	3.3	7.4
HBSR	16.8	2.2	37.9	43.0	27.7	15.0	5.4	17.7	5.3	28.9
HBSP	36.8	14.0	17.0	32.1	38.8	29.6	3.8	9.3	7.5	10.9
HBO	29.0	3.2	25.8	42.1	41.5	30.3	4.1	10.1	4.1	9.9
WBO	5.3	26.9	62.7	5.1	60.4	26.5	5.4	0.6	2.9	4.1
OBO	11.5	11.5	38.5	38.5	40.4	40.4	5.8	5.8	3.9	3.9

External Trips

External trips (cordon trips) are trips with one or both ends outside the modeling area. External trips for the light-and-medium duty vehicles are estimated independently from heavy-duty vehicles (trucks). The following provides a brief description of the methodology used to estimate light-and-medium duty (auto) vehicle external trips.

Traffic counts were obtained for each cordon location to estimate Year 2008 cordon volumes. Previous cordon survey results were then used to split total external trips into: 1) through trips - External-to-External (E-E), and 2) External-to-Internal (E-I) and Internal-to-External (I-E). The resulting through trip table (E-E) and the I-E/E-I trip table were combined with trip tables from previous steps to form final O-D vehicle trip tables for highway assignment.

Highway Assignment Procedures

Vehicle trip assignment is the process of loading vehicle trips onto the appropriate highway facilities. This process produces traffic volumes and resulting congested speeds on each road segment represented in the network for the five time periods. The 2012 RTP/SCS model assignments consist of a series of multi-class simultaneous equilibrium assignments for the eight classes of vehicles listed above, and for each of the five time periods. During the assignment process, trucks are converted to passenger-car equivalents (PCE) for each link based on the percentage of trucks, grade, link length and level of congestion. Transit vehicles are pre-loaded to the highway links.

To achieve travel time convergence between the highway assignment and the demand model, a five loop feedback procedure is used in the 2012 RTP model. The following describes the travel time feedback process:

- **Step 1**: Auto ownership, trip generation, trip distribution and mode choice are run using the speeds coded on the input highway networks. These coded speeds represent observed speeds, where available. The resulting trip tables for each vehicle class and time period are assigned to the highway networks, which yields the first pass loaded volumes and congested speeds.

- **Step 2**: These congested speeds are fed back into the demand model (auto ownership, trip generation, etc.) to produce a second set of congested speeds for the AM peak, PM peak, and midday periods. An averaging process is used to smooth the volume variation between the first and second pass assignments. These averaged speeds are again fed back to the demand model, and the process is repeated three more times for a total of five feedback loops.

- **Step 3**: During the final, 5th loop assignment, all highway assignments are performed: AM peak, Midday, PM peak, evening and night time.

The averaging process used to smooth volume variations across feedback loops is the method of successive averages, with a 1/n step, where n is the number of iterations. Convergence for each assignment process (as opposed to model-wide convergence) is achieved when the bi-conjugate user equilibrium assignment achieves a relative gap of 0.001or 200 iterations, whichever occurs first.

Volume-Delay Function

The volume delay function utilized for the traffic assignment portion of the Regional Model is the Bureau of Public Roads (BPR) function. The volume-delay function is used in assignment to simulate the relationship between traffic volume, congestion delay, and congested speeds. The equation of the function is as follows:

$$t_i \cdot \left[1 + \alpha_i \left(\frac{x_i}{C_i}\right)^{\beta_i}\right]$$

where:

t_i	=	Free flow travel time on link i
C_i	=	Capacity of link i
x_i	=	Flow on link i
α	=	Constant
β	=	Constant

If $\frac{x_i}{C_i}$ <= 1 then β is set to the specific value of 5.0. If $\frac{x_i}{C_i}$ > 1, then α and β are set to values that vary by link facility type, posted speed, and area type according to the values in Table 8-3.

Table 8-3: Volume-Delay Function Parameters

Facility Type	Posted Speed	Area Type	Alpha	Beta
Freeways and HOV	All	All	0.60	8.0
Expressways	<=45mph	1-5	0.60	5.0
Expressways	<=45mph	6-7	0.60	6.0
Expressways	>45mph	All	0.60	8.0
All Others	All	1-5	0.60	5.0
All Others	All	6-7	0.60	6.0

Freeway on-ramps (facility types 82 and 84) have a separate volume-delay function. The function is as follows:

$$\frac{L_i}{FFS_i} + \frac{\left[\frac{PLPHx_i}{120} * 5.0 * \left(1 + \frac{x_i}{C_i}\right)^8\right]}{60}$$

where:

L_i	=	Length on link i in miles
FFS_i	=	Free Flow Speed on link i in miles/hour
C_i	=	Capacity of link i
x_i	=	Flow on link i
$PLPHx_i$	=	Per-Lane-Per-Hour Flow on link i

HOV Diversion

A binomial diversion model is applied prior to highway assignment to split carpool trips between vehicles that use the HOV lanes and vehicles that remain on the general purpose flow lanes. The probability of choosing the HOV facility is given by the function below:

$$P(HOV) = \frac{b}{b + e^{at}}$$

Where t represents the travel time savings from using the HOV facility, $t = HOV\ time - GP\ time + access\ penalty$, and a and b are calibrating factors. The HOV access penalty measures the inconvenience of entering and exiting the lanes, given that many of them are buffer or barrier-separated with limited opportunities for access and egress. The access penalty is 5.0 minutes across all time periods. The calibrating factor a determines the steepness of the logistic curve, while b determines the likelihood of using the HOV lanes at zero travel time savings. To encourage carpool trips to stay on the HOV lanes, a factor of 1.1 is used on the mainline travel times. All the parameters of the HOV diversion function can be specified by time period, however, currently the same parameters are used for all time periods.

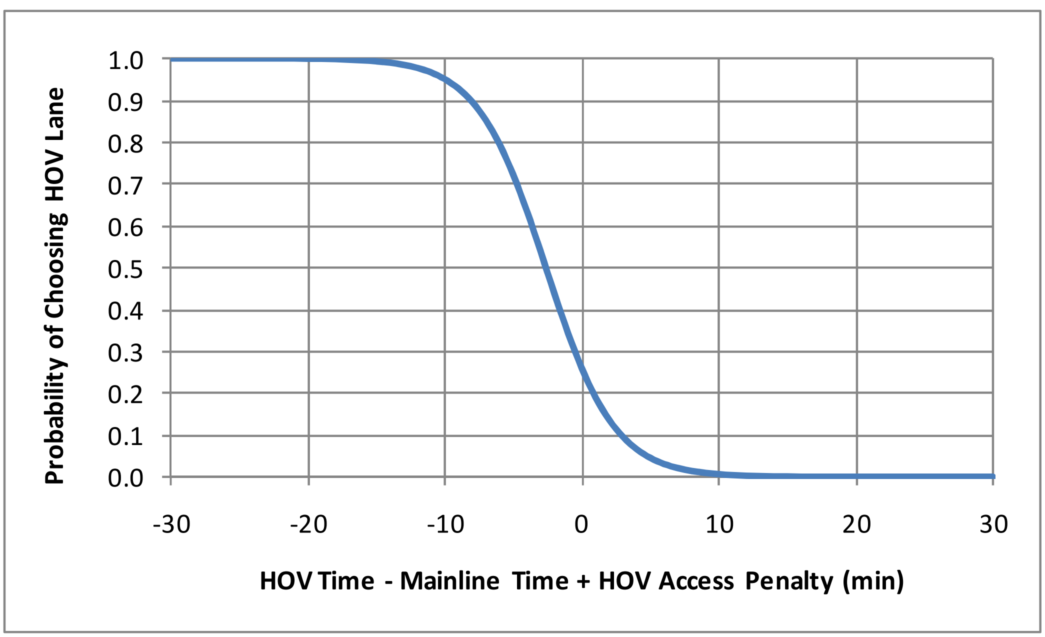


Figure 8-1: HOV Diversion Function

HPMS Factoring

After the entire model has converged, the estimated link volumes are factored prior to performing the emission calculations. Although the model achieves a good match to HPMS estimates without any factoring, as shown in the tables below, HPMS factoring is used to overcome the small remaining discrepancies and ensure consistency among the emission calculations and HPMS. The adjustment factors are calculated by comparing model VMT estimates to HPMS estimates by air basin, county and vehicle type (light vehicles and heavy duty trucks).

Highway Assignment Validation and Summary

This section describes how the 2012 RTP Regional Model's highway trip assignment module has been validated to observed conditions. It includes results for Heavy Duty Truck (HDT) and mixed-flow components of the trip assignment model. Figures 8-2 and 8-3 provide a visual representation of the SCAG regional screenlines.

Figure 8-2: Screenlines (Regional)

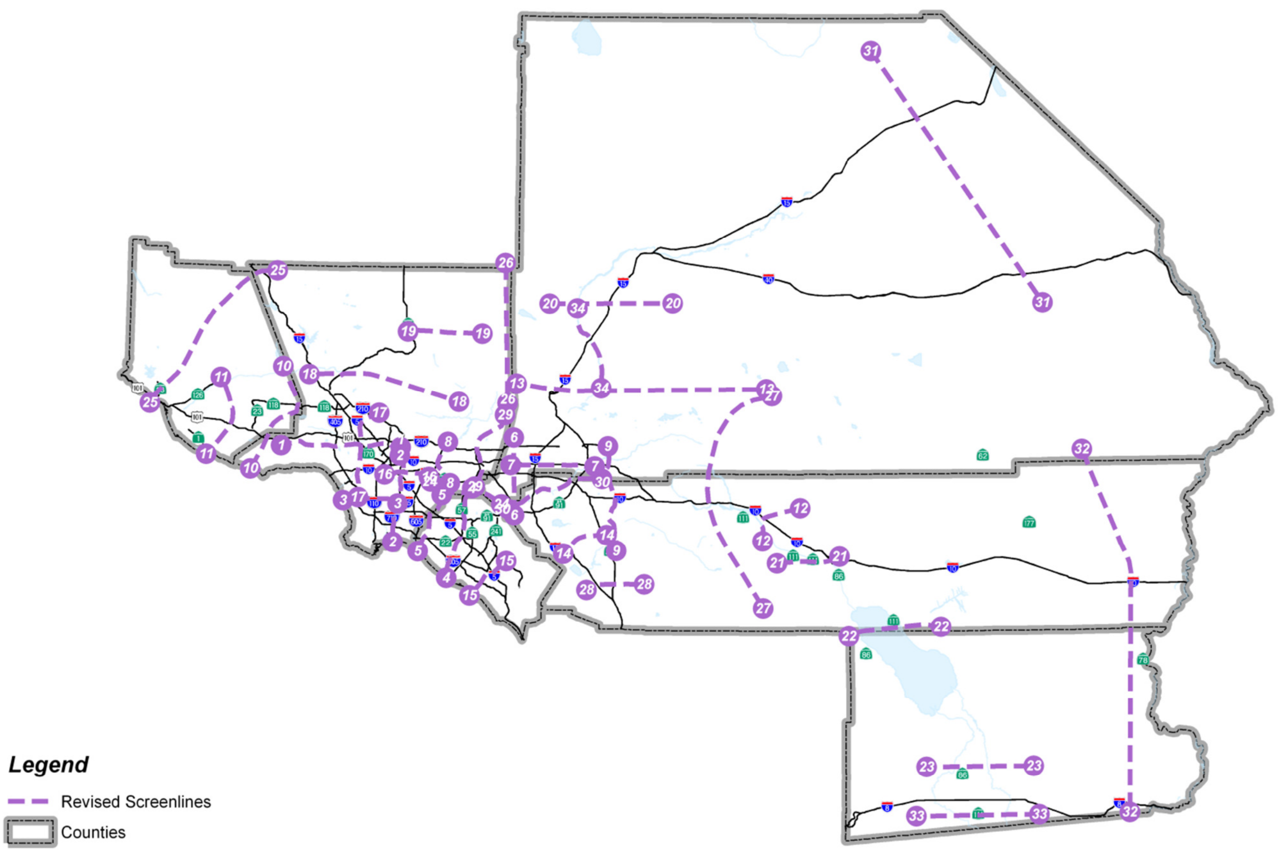
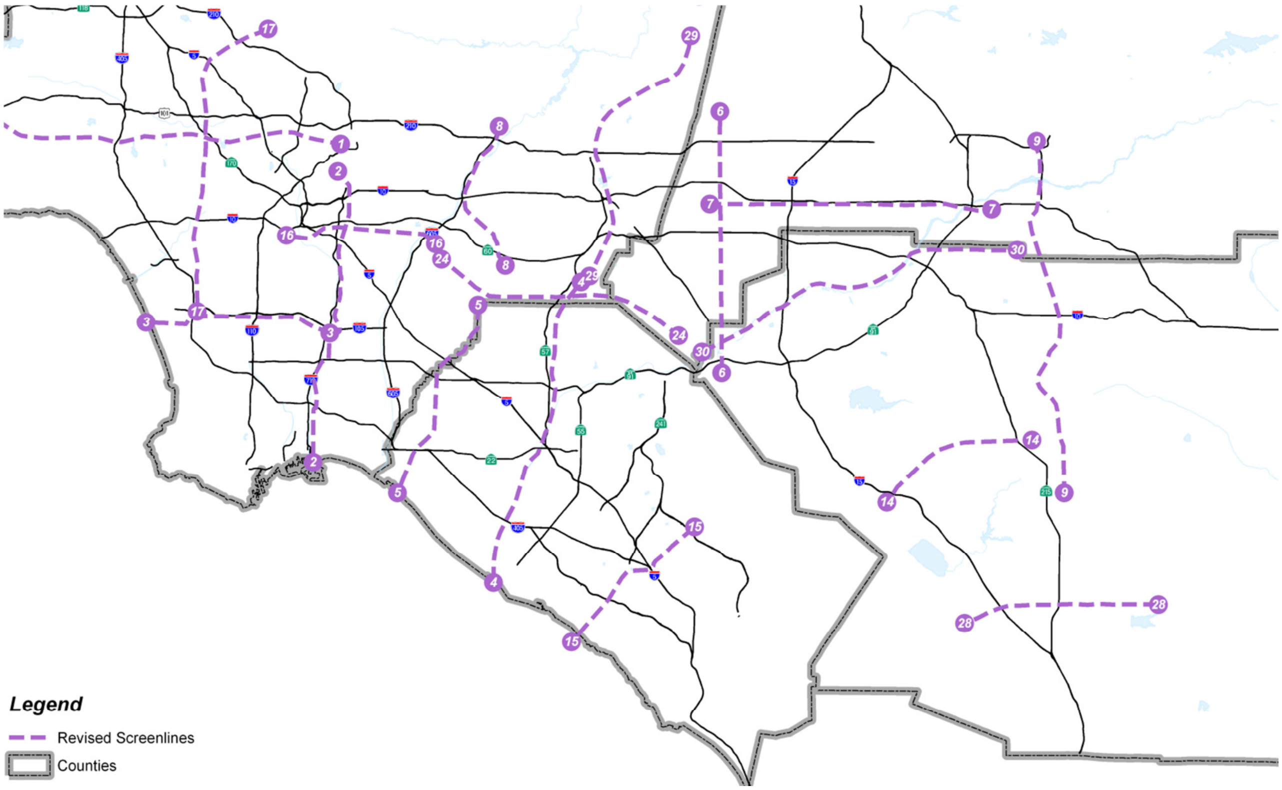


Figure 8-3: Screenlines (Detail)



Validation of the Mixed-Flow Trip Assignment Model

Tables 8-4 through 8-9 present an overview of the highway assignment statistics for each model time period and daily total. After the HPMS volume adjustment, the 2012 RTP model forecasts 415,643,000 VMT on an average weekday in 2008 within the model area for light and medium duty vehicles. In addition, the model forecasts 30,203,000 VMT for heavy-duty vehicles in the expanded model area. The total for all vehicle types combined is 445,846,000 VMT.

A comparison of 2008 model speeds to PeMS speed data is shown in Figures 8-5 to 8-8.

Table 8-4: Year 2008 Loaded Highway Network Summary

From Assignment						
Light and Medium Duty Vehicles	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	32.2	27.4	39.9	43.1	47.0	**33.7**
Vehicle Miles Traveled (`000)	82,357	132,106	112,783	26,110	37,791	**391,147**
Vehicle Hours Traveled (`000)	2,560	4,828	2,825	606	803	**11,623**
Vehicle Hours Delay (`000)	725	1,804	292	31	5	**2,857**
Heavy Duty Vehicles	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	40.3	35.5	50.4	55.7	58.8	**46.9**
Vehicle Miles Traveled (`000)	4,410	5,118	11,184	1,842	6,504	**29,059**
Vehicle Hours Traveled (`000)	109	144	222	33	111	**620**
Vehicle Hours Delay (`000)	30	51	26	2	1	**109**
All Vehicles Combined	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	32.5	27.6	40.7	43.7	48.5	**34.3**
Vehicle Miles Traveled (`000)	86,767	137,225	123,968	27,952	44,295	**420,206**
Vehicle Hours Traveled (`000)	2,669	4,972	3,048	639	914	**12,243**
Vehicle Hours Delay (`000)	755	1,855	318	33	6	**2,966**
After HPMS Adjustment						
Light and Medium Duty Vehicles	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	30.5	25.9	39.5	42.9	46.5	**32.4**
Vehicle Miles Traveled (`000)	87,512	140,330	119,887	27,735	40,180	**415,643**
Vehicle Hours Traveled (`000)	2,869	5,428	3,031	646	863	**12,838**
Vehicle Hours Delay (`000)	913	2,196	324	32	3	**3,468**
Heavy Duty Vehicles	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	38.0	33.5	49.7	55.2	58.3	**45.5**
Vehicle Miles Traveled (`000)	4,590	5,320	11,600	1,914	6,778	**30,203**
Vehicle Hours Traveled (`000)	121	159	233	35	116	**664**
Vehicle Hours Delay (`000)	39	63	32	2	3	**140**
All Vehicles Combined	**AM PEAK**	**PM PEAK**	**Midday**	**Evening**	**Night**	**Total**
Average Speed (mph)	30.8	26.1	40.3	43.6	47.9	**33.0**
Vehicle Miles Traveled (`000)	92,102	145,650	131,487	29,649	46,958	**445,846**
Vehicle Hours Traveled (`000)	2,990	5,587	3,265	681	980	**13,502**
Vehicle Hours Delay (`000)	952	2,260	356	34	5	**3,607**

Table 8-5: Year 2008 VMT Comparison by County and by Air Basin (in Thousands)

County		VC SCCAB		SCAB		MDAB		SSAB		Total		County Total
		Auto	Truck	Auto	Truck	Auto	Truck	Auto	Truck	Auto	Truck	
Imperial	Model							3,890	534	3,890	534	4,423
	HPMS							4,660	830	4,660	830	5,490
Los Angeles	Model			197,322	12,778	6,574	373			203,896	13,151	217,048
	HPMS			205,014	11,585	8,472	605			213,486	12,190	225,676
Orange	Model			71,189	3,512					71,189	3,512	74,700
	HPMS			73,933	3,400					73,933	3,400	77,333
Riverside	Model			39,276	2,719	1,324	693	8,006	1,236	48,606	4,648	53,254
	HPMS			40,546	3,436	1,469	621	9,471	1,667	51,486	5,724	57,210
San Bernardino	Model			31,213	2,440	16,380	3,369			47,594	5,809	53,403
	HPMS			35,615	3,307	17,936	3,806			53,550	7,113	60,663
Ventura	Model	15,973	1,405							15,973	1,405	17,378
	HPMS	18,698	953							18,698	953	19,651
Total	**Model**	**15,973**	**1,405**	**339,001**	**21,449**	**24,278**	**4,435**	**11,895**	**1,770**	**391,147**	**29,059**	**420,206**
	HPMS	**18,698**	**953**	**355,108**	**21,728**	**27,877**	**5,032**	**14,131**	**2,497**	**415,814**	**30,210**	**446,024**
	Ratio	**0.854**	**1.474**	**0.955**	**0.987**	**0.871**	**0.881**	**0.842**	**0.709**	**0.941**	**0.962**	**0.942**

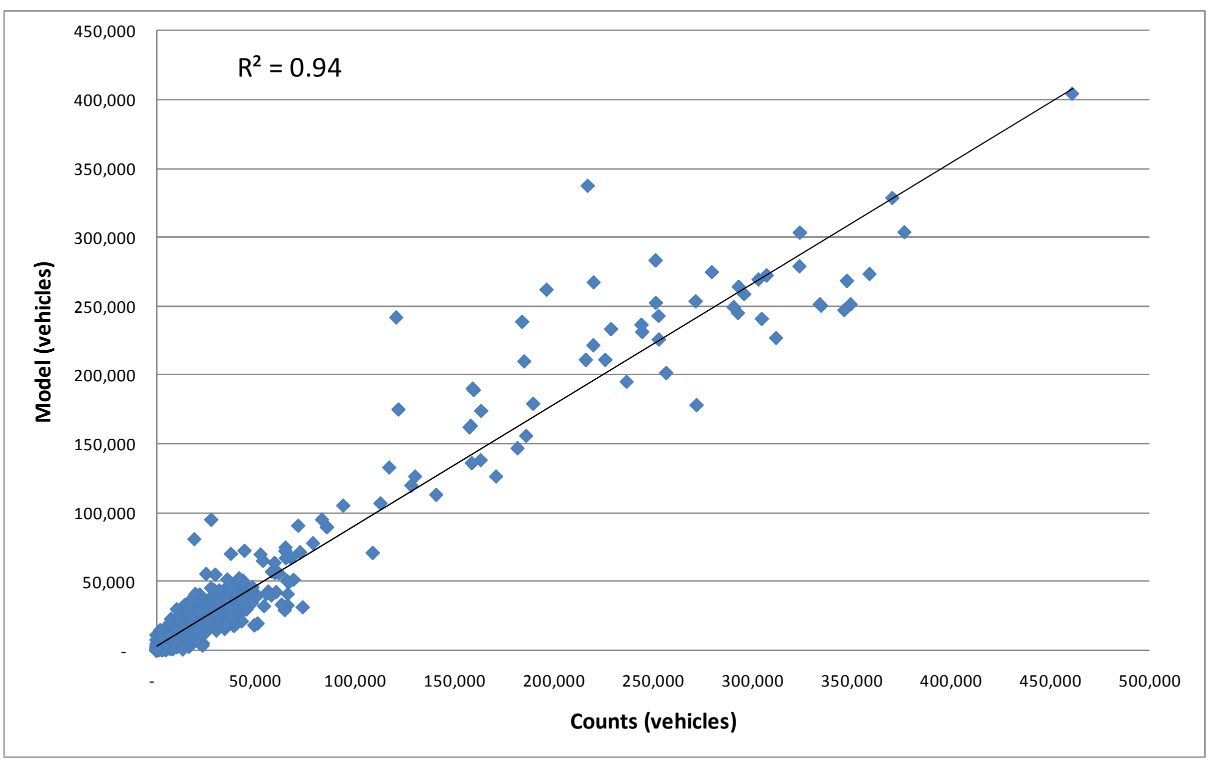


Figure 8-4: Year 2008 Screenline Location Volumes

Table 8-6: Year 2008 Screenline Comparison of Model Weekday ADT and Ground Counts

Screenline	Location	Direction	Light & Medium Duty Vehicles				Heavy Duty Vehicles				Total		
			Model	Count	Ratio	RMSE	Model	Count	Ratio	RMSE	Model	Count	Ratio
1	Los Angeles	EW	1,592,312	1,407,661	1.131	36.926	94,265	66,280	1.422	135.000	1,686,576	1,473,941	1.144
2	Los Angeles	NS	2,630,820	2,532,519	1.039	26.215	179,841	170,598	1.054	79.578	2,810,661	2,703,117	1.040
3	Los Angeles	EW	1,243,931	1,356,751	0.917	30.601	91,159	88,370	1.032	84.562	1,335,090	1,445,122	0.924
4	Orange	NS	2,038,499	2,010,020	1.014	54.251	104,775	115,392	0.908	91.141	2,143,274	2,125,412	1.008
5	Los Angeles/ Orange	NS	1,607,002	1,304,602	1.232	39.324	96,913	81,578	1.188	116.988	1,703,915	1,386,180	1.229
6	San Bernardino/ Riverside	NS	1,193,833	1,154,189	1.034	38.768	117,594	97,668	1.204	117.790	1,311,427	1,251,857	1.048
7	San Bernardino	EW	817,433	801,619	1.020	25.172	46,283	74,025	0.625	78.029	863,716	875,644	0.986
8	Los Angeles	NS	1,130,425	1,132,794	0.998	19.657	97,105	85,017	1.142	84.412	1,227,529	1,217,811	1.008
9	San Bernardino/ Riverside	NS	429,679	492,336	0.873	29.074	34,477	55,349	0.623	78.854	464,156	547,685	0.847
10	Ventura/ Los Angeles	NS	424,369	411,796	1.031	33.670	38,013	19,970	1.904	190.811	462,382	431,766	1.071
11	Ventura	NS	244,217	219,933	1.110	20.557	28,066	13,467	2.084	236.040	272,283	233,400	1.167
12	Riverside	NS	131,009	165,856	0.790	26.874	20,572	33,255	0.619	43.214	151,582	199,111	0.761
13	San Bernardino	EW	141,102	128,430	1.099	39.369	25,093	23,708	1.058	24.175	166,195	152,138	1.092
14	Riverside	EW	278,156	245,851	1.131	21.536	20,725	29,665	0.699	55.998	298,881	275,516	1.085
15	Orange	NS	629,310	607,404	1.036	46.595	39,950	21,979	1.818	162.810	669,260	629,383	1.063
16	Los Angeles	EW	1,402,943	1,189,196	1.180	31.442	104,747	92,891	1.128	64.730	1,507,690	1,282,088	1.176
17	Los Angeles	NS	2,398,150	2,298,925	1.043	35.935	126,980	127,587	0.995	85.760	2,525,131	2,426,512	1.041
18	Los Angeles	EW	389,474	450,493	0.865	31.514	33,997	36,150	0.940	35.398	423,471	486,644	0.870
19	Los Angeles	EW	158,452	232,355	0.682	75.702	8,627	16,151	0.534	95.779	167,078	248,506	0.672
20	San Bernardino	EW	69,543	83,794	0.830	31.123	18,183	22,785	0.798	23.620	87,727	106,579	0.823
21	Riverside	EW	139,976	155,882	0.898	28.214	17,184	28,782	0.597	56.567	157,160	184,665	0.851
22	Riverside/ Imperial	EW	11,827	13,309	0.889	12.685	2,652	4,352	0.609	40.600	14,479	17,661	0.820
23	Imperial	EW	42,275	41,022	1.031	94.077	2,935	5,724	0.513	58.380	45,211	46,746	0.967
24	Los Angeles/ San Bernardino	EW	522,102	330,543	1.580	70.207	23,491	27,200	0.864	32.578	545,593	357,743	1.525
25	Ventura/ Los Angeles	NS	150,611	158,458	0.950	14.901	28,558	26,986	1.058	39.184	179,169	185,445	0.966
26	Los Angeles	NS	23,943	19,174	1.249	28.502	3,642	2,171	1.677	73.104	27,585	21,345	1.292

Screenline	Location	Direction	Light & Medium Duty Vehicles				Heavy Duty Vehicles				Total		
			Model	Count	Ratio	RMSE	Model	Count	Ratio	RMSE	Model	Count	Ratio
27	San Bernardino/ Riverside	NS	82,686	90,442	0.914	21.751	22,290	21,220	1.050	10.446	104,976	111,662	0.940
28	Riverside	EW	239,708	239,228	1.002	27.662	15,749	20,970	0.751	40.437	255,457	260,198	0.982
29	Los Angeles	NS	900,691	871,282	1.034	30.095	91,482	90,562	1.010	42.441	992,174	961,844	1.032
30	Riverside	EW	781,238	655,638	1.192	31.721	49,059	64,145	0.765	39.433	830,297	719,783	1.154
31	San Bernardino	NS	39,689	41,964	0.946	6.792	14,960	15,153	0.987	22.380	54,650	57,117	0.957
32	San Bernardino/ Riverside/ Imperial	NS	25,612	31,358	0.817	32.719	15,101	13,474	1.121	26.069	40,713	44,832	0.908
33	Imperial	EW	47,974	49,150	0.976	74.570	1,233	5,684	0.217	152.809	49,208	54,834	0.897
34	San Bernardino	NS	103,237	121,726	0.848	15.814	17,344	19,714	0.880	62.698	120,580	141,440	0.853
Total			**22,062,228**	**21,045,700**	**1.05**	**38.97**	**1,633,047**	**1,618,021**	**1.01**	**85.20**	**23,695,275**	**22,663,721**	**1.05**

Table 8-7: Year 2008 Screenline Comparison of Model Weekday ADT and Ground Counts by Volume Group

	Volume Group By Facility	OBS	Daily Vehicle Volumes				Daily Vehicle Volumes				Daily Vehicle Volumes		
			LM				HDT				TOTAL		
			Model	Count	Ratio	RMSE	Model	Count	Ratio	RMSE	Model	Count	Ratio
1	0 - 4,999	118	493,340	393,897	1.25	146.42	16,732	23,981	0.70	129.10	510,073	417,878	1.22
2	5,000 - 24,999	250	3,892,077	3,720,869	1.05	49.83	150,862	261,309	0.58	73.97	4,042,939	3,982,177	1.02
3	25,000 - 49,999	122	3,850,230	3,682,133	1.05	35.98	139,577	238,827	0.58	68.57	3,989,807	3,920,960	1.02
4	50,000 - 99,999	38	1,225,942	1,444,490	0.85	33.80	159,907	173,275	0.92	44.12	1,385,849	1,617,766	0.86
5	100,000 - 199,999	44	2,827,925	2,693,574	1.05	25.86	309,227	262,566	1.18	58.28	3,137,152	2,956,140	1.06
6	200,000 or More	123	9,772,715	9,110,737	1.07	26.82	856,742	658,063	1.30	68.89	10,629,456	9,768,800	1.09
Total		**695**	**22,062,228**	**21,045,700**	**1.05**	**38.97**	**1,633,047**	**1,618,021**	**1.01**	**85.20**	**23,695,275**	**22,663,721**	**1.05**

Note: RMSE - root mean square error, OBS - number of roadway facility in the group.

Table 8-8: Year 2008 Screenline Comparison of Model Weekday ADT and Ground Counts by Facility Type

	Area Type	OBS	Light And Medium Duty Vehicles				Heavy-Duty Vehicles				TOTAL		
			Model	Count	Ratio	RMSE	Model	Count	Ratio	RMSE	Model	Count	Ratio
10	Freeway	154	12,614,951	12,079,101	1.04	25.70	1,355,661	1,092,596	1.24	54.48	13,970,612	13,171,697	1.06
20	HOV	53	870,900	729,818	1.19	38.66	-	-	-	-	870,900	729,818	1.19
30	Expressway/Parkway	12	187,551	181,552	1.03	29.79	14,739	19,242	0.77	35.10	202,290	200,794	1.01
40	Principal Arterial	184	5,180,140	4,872,997	1.06	41.46	170,255	316,567	0.54	75.26	5,350,396	5,189,564	1.03
50	Minor Arterial	194	2,796,200	2,722,576	1.03	47.86	80,979	153,878	0.53	90.85	2,877,179	2,876,454	1.00
60	Major Collector	87	386,095	435,115	0.89	81.23	10,858	33,826	0.32	123.97	396,953	468,941	0.85
70	Minor Collector	11	26,390	24,540	1.08	130.22	555	1,913	0.29	94.46	26,945	26,453	1.02
Total		**695**	**22,062,228**	**21,045,700**	**1.05**	**38.97**	**1,633,047**	**1,618,021**	**1.01**	**85.20**	**23,695,275**	**22,663,721**	**1.05**

Note: RMSE - root mean square error, OBS - number of roadway facility in the group.

Table 8-9: Year 2008 Screenline Comparison of Model Weekday ADT and Ground Counts by Area Type

	Area Type	OBS	Light And Medium Duty Vehicles				Heavy-Duty Vehicles				TOTAL		
			Model	Count	Ratio	RMSE	Model	Count	Ratio	RMSE	Model	Count	Ratio
1	Core	0	-	-	-	-	-	-	-	-	-	-	-
2	Central Business District	3	72,492	57,342	1.26	49.50	2,435	2,443	1.00	13.90	74,927	59,785	1.25
3	Urban Business District	127	5,309,505	5,030,736	1.06	40.40	341,747	310,051	1.10	99.31	5,651,252	5,340,787	1.06
4	Urban	249	8,718,335	8,450,588	1.03	36.17	619,025	590,202	1.05	73.49	9,337,360	9,040,790	1.03
5	Suburban	206	6,374,297	5,938,754	1.07	37.24	436,810	472,692	0.92	100.32	6,811,107	6,411,446	1.06
6	Rural	96	1,377,592	1,390,544	0.99	29.36	204,656	217,107	0.94	52.10	1,582,248	1,607,651	0.98
7	Mountain	14	210,008	177,737	1.18	65.71	28,375	25,526	1.11	39.88	238,383	203,262	1.17
Total		**695**	**22,062,228**	**21,045,700**	**1.05**	**38.97**	**1,633,047**	**1,618,021**	**1.01**	**85.20**	**23,695,275**	**22,663,721**	**1.05**

Note: RMSE - root mean square error, OBS - number of roadway facility in the group.

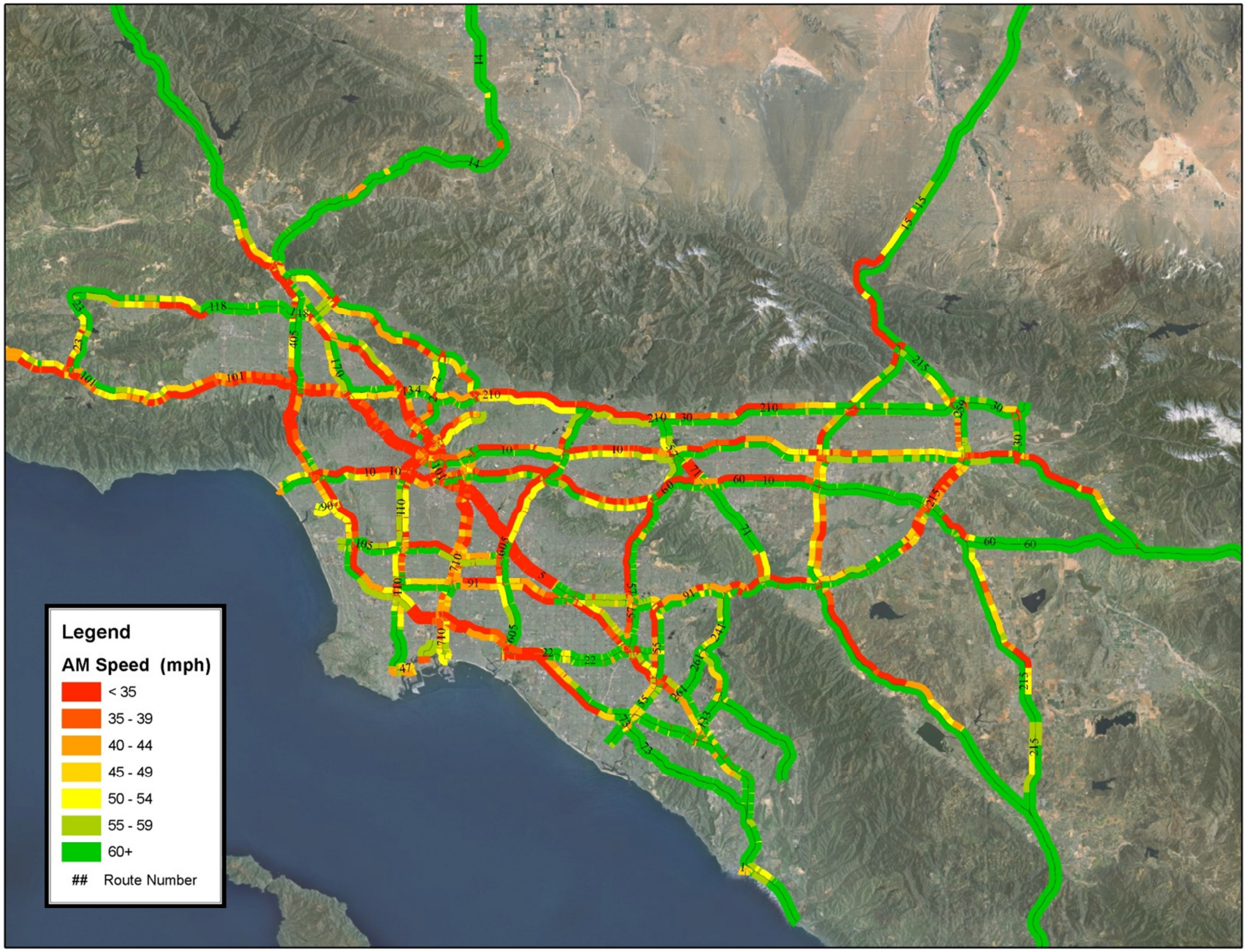


Figure 8-5: Year 2008 Model Estimated AM Peak Period Speeds

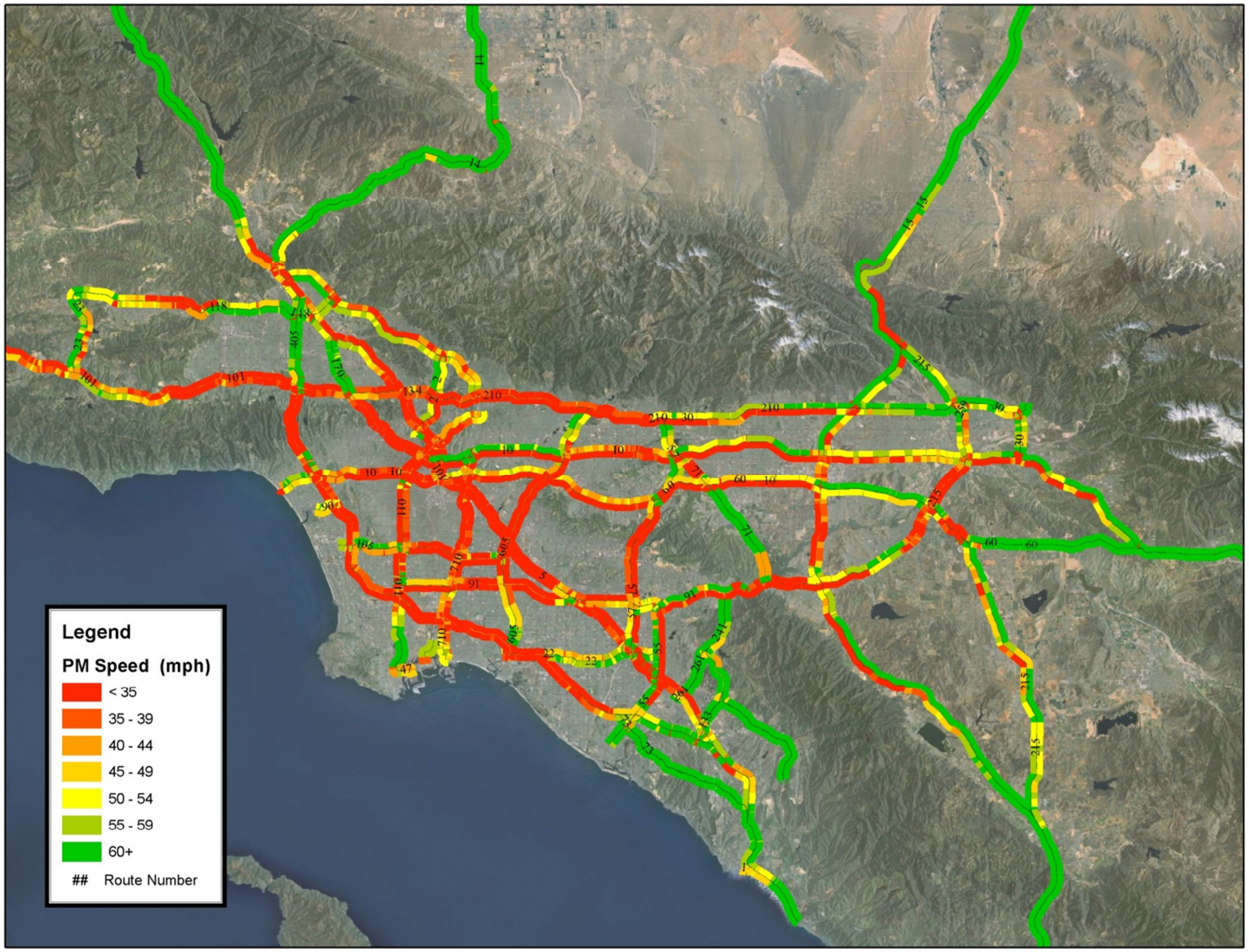


Figure 8-6: Year 2008 Model Estimated PM Peak Speeds

Figure 8-7: PeMS AM Peak Speeds

Figure 8-8: PeMS PM Peak Speeds

Transit Assignment Procedures

Transit trips estimated by the model choice model on the final feedback loop are aggregated across trip purposes to create linked transit trips for each primary line-haul mode, resulting in two transit trip tables: peak and off-peak linked trips. For drive access trips, only the portion from the park-n-ride location to the final attraction zone is included in the transit trip table. The rail trips are assigned in a manner consistent with the station choice estimates generated by the mode choice models. These trips are split into three parts:

- Production zone to boarding station (bus access trips only)
- Boarding station to alighting station (all trips)
- Alighting station to attraction zone (all trips)

The production zone to boarding station leg of walk access and drive access rail trips is not assigned to the transit network because it does not comprise any bus loadings.

The resulting peak and off-peak loaded transit network files are aggregated to create total daily loaded trips.

Transit Assignment Validation and Summary

The 2008 transit assignment loaded 2,743,100 unlinked passenger trips (boardings) on the transit network. Table 8-10 compares the model estimated daily transit boardings for the four predominant transit modes, to actual transit boarding statistics for 2008.

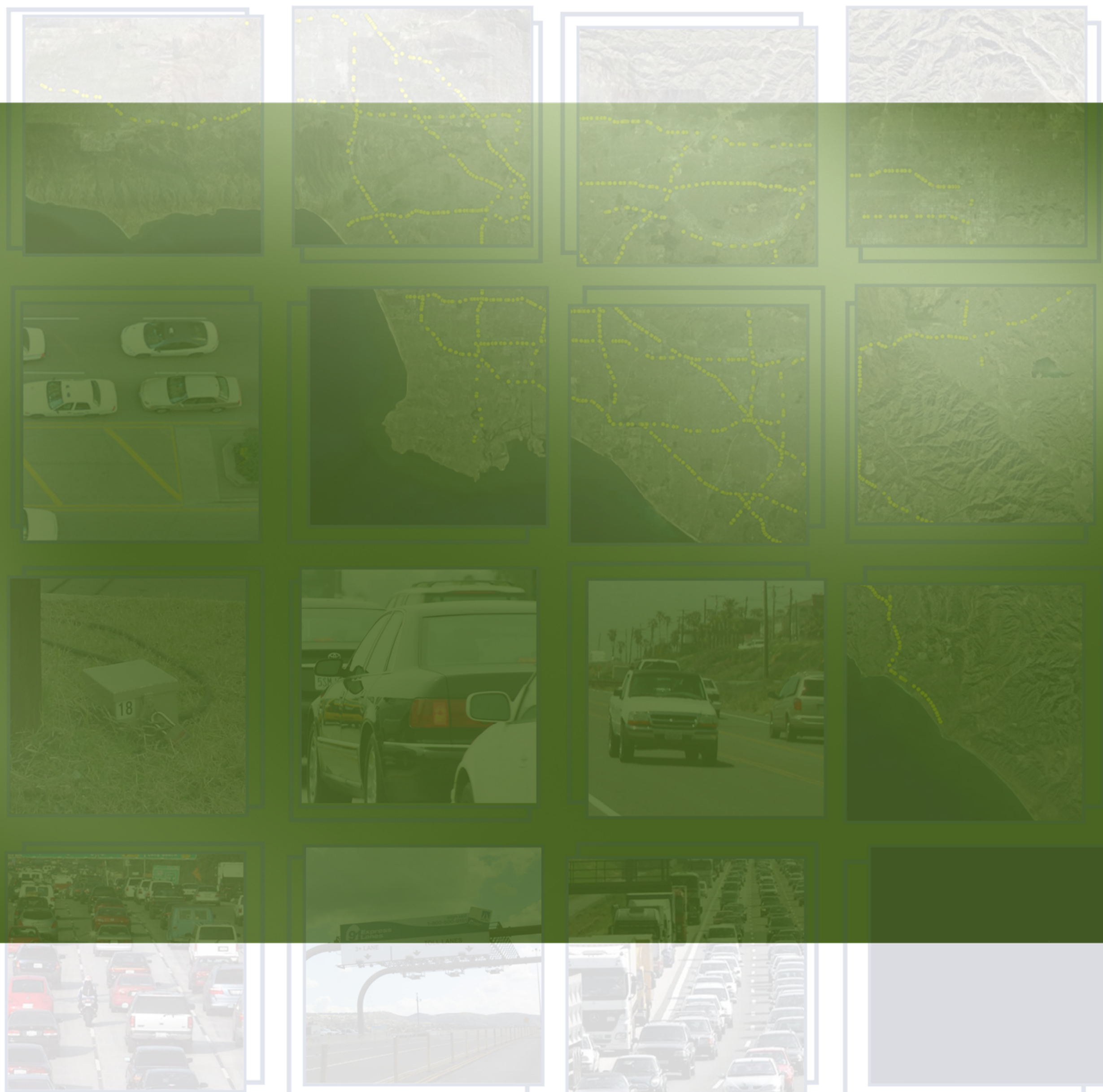
Table 8-10: Year 2008 Daily Transit Boardings - Model vs. Actual Counts

Transit Mode	Model Estimated Boardings	Actual Boardings	Ratio
Commuter Rail	44,600	48,400	**0.92**
Urban Rail	249,800	276,100	**0.90**
MTA Bus *	1,315,600	1,554,700	**0.85**
Other Transit **	1,133,100	899,900	**1.26**
Total Boardings	**2,743,100**	**2,779,100**	**0.99**

** MTA Bus: Local bus, Rapid bus, Express bus operated by LACMTA*
*** Other Transit: Local bus, Rapid bus, Express bus operated by other transit carriers in SCAG region*

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Appendix A: Highway Network Coding Conventions



Appendix A: Highway Network Coding Conventions

Facility Type

1 – Freeways

10 – Freeway

2 – HOV

20 – HOV 2
21 – HOV 3+
22 – HOV – HOV Connector

3 - Expressway/Parkway

30 – Undivided
31 – Divided, Interrupted
32 – Divided, Uninterrupted

4 - Principal Arterial

40 – Undivided
41 – Divided
42 – Continuous Left Turn

5 - Minor Arterial

50 – Undivided
51 – Divided
52 – Continuous Left Turn

6 – Major Collector

60 – Undivided
61 – Divided
62 – Continuous Left Turn

7 - Minor Collector

70 – Undivided
71 – Divided
72 – Continuous Left Turn
73 – Posted Speed 25
74 – Posted Speed 15

8 – Ramps

80 – Freeway to Freeway Connector
81 – Freeway to arterial
82 – Arterial to freeway
83 – Ramp Distributor
84 – Ramp from Arterial to HOV
85 – Ramp from HOV to Arterial
86 – Collector distributor
87 – Shared HOV Ramps to MF
89 – Truck only

9 – Trucks

90 – Truck only

100 – Centroid Connector - Tier 1

200 – Centroid Connector - Tier 2

Flag Fields

Main Lane – Through Freeway Lanes
Aux_Lane – Auxiliary Lane of Capacity Significance
Accel_Decel Lane - Other Freeway Lane

Truck Climbing Lanes Flag

0 – None
1 – 1 Truck Climbing Lane
2 – 2 Truck Climbing Lane
3 – 3 + Truck Climbing Lane

Toll Flag

0 – None
1 – Toll road
2 – HOT Road

Signals Flag

0 – None
1 – Signal and progression optimized streets
2 – Divided and signal optimized
3 – Continuous left-turn Lanes

HOV Operation Flag

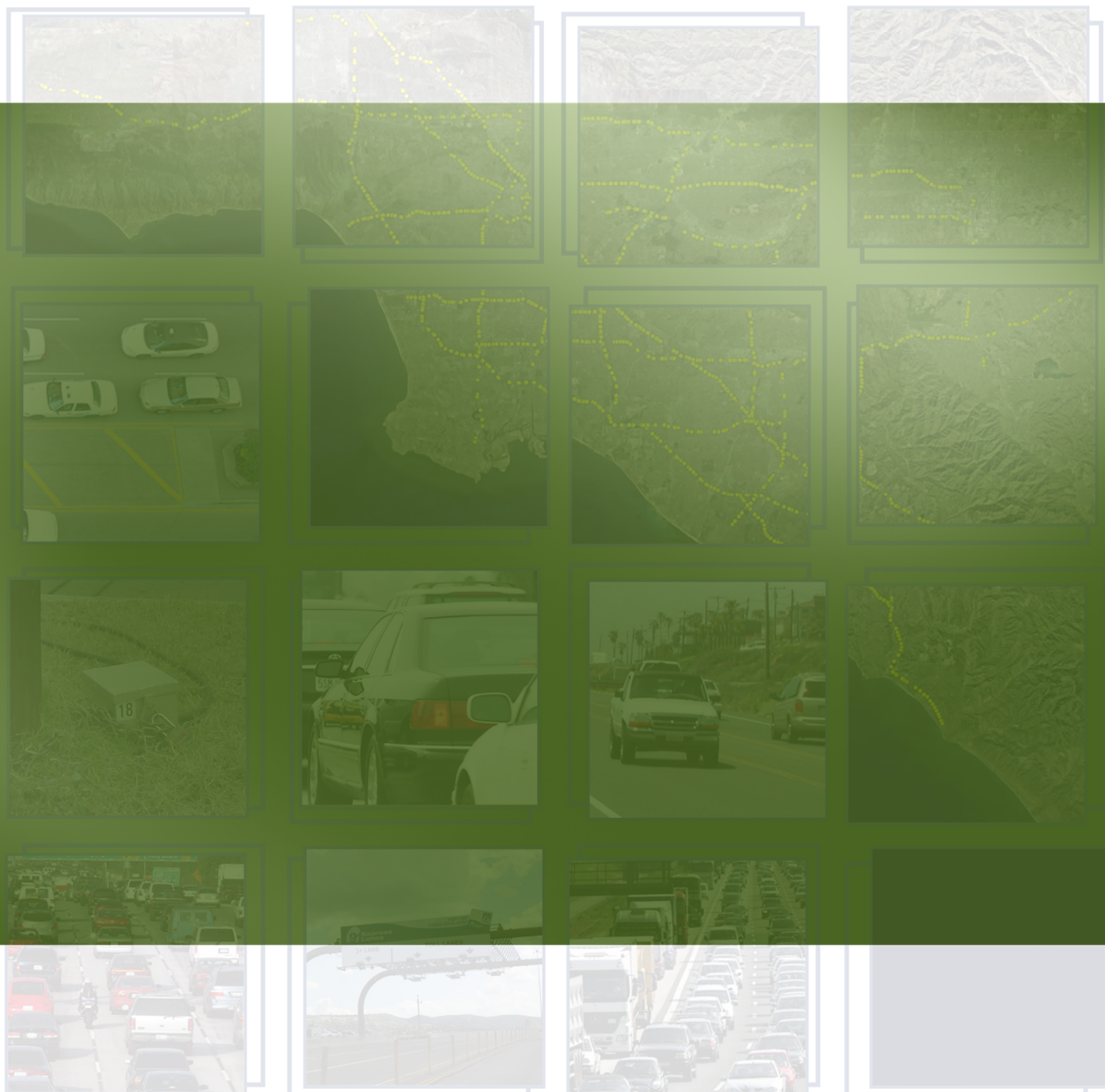
0 – Standard HOV
1 – HOV AM Peak Only
2 – HOV PM Peak Only
3 – HOV AM & PM Peak Only

Truck Prohibition Flag

0 - Truck Not Prohibited
1 - Trucks Prohibited

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B: AUTO OPERATING COSTS



Appendix B: Auto Operating Costs

Auto operating cost (in cents/mile) is a key parameter in the calculation of the marginal utility cost functions used in mode choice. In the current mode split model, auto operating cost is defined as an out-of-pocket expense consisting of fuel (primarily gasoline) cost and "other" costs. Other costs include repairs, maintenance, tires, and accessories.

The table below summarizes the Year 2008 auto operation cost calculation and gives the values of the intermediate parameters. The calculation of the fuel cost per mile requires the composite fuel economy for the fleet and an average motor fuel price. Historical U.S. fuel efficiency data from 1980 to 2008 collected and compiled by the U.S. DOT National Highway Safety Administration was used by SCAG staff to calculate the average miles per gallon. The average price of a gallon of motor vehicle fuel was calculated as the sum of the prices of each grade sold, weighted by its fractional share of the market. The average fuel cost, including all taxes, for 2008 was 362.7 cents per gallon, which equates to 267.74 cents per gallon in 1999 constant dollars. Thus the fuel costs for 2008 in terms of cents/mile can be derived from dividing fuel costs (267.74 cents/gallon) by average fuel efficiency (18.87 miles/gallon). As a result, the 14.2 cents-per-mile fuel costs (in 1999 cents) was estimated and used for the 2008 model validation.

AUTO OPERATING COST CALCULATION

Description	Value	Based on
2008 On-road miles/gallon	18.87	MPG for SCAG Region (SCAG Model)
Avg. Year 2008 cents/gallon	362.70	Price & volume sold by fuel grade
Converted to 1999_cents*/gallon	267.74	
Fuel Cost (1999_cents/mile)	14.2	Gallon/mile * cents/gallon
Other Costs (1999_cents/mile)	6.43	Repairs, maint., tires, accessories
Total Cost/Mile (1999 cents)	20.63	
Total Cost/Mile (1999 cents)	**20.63**	

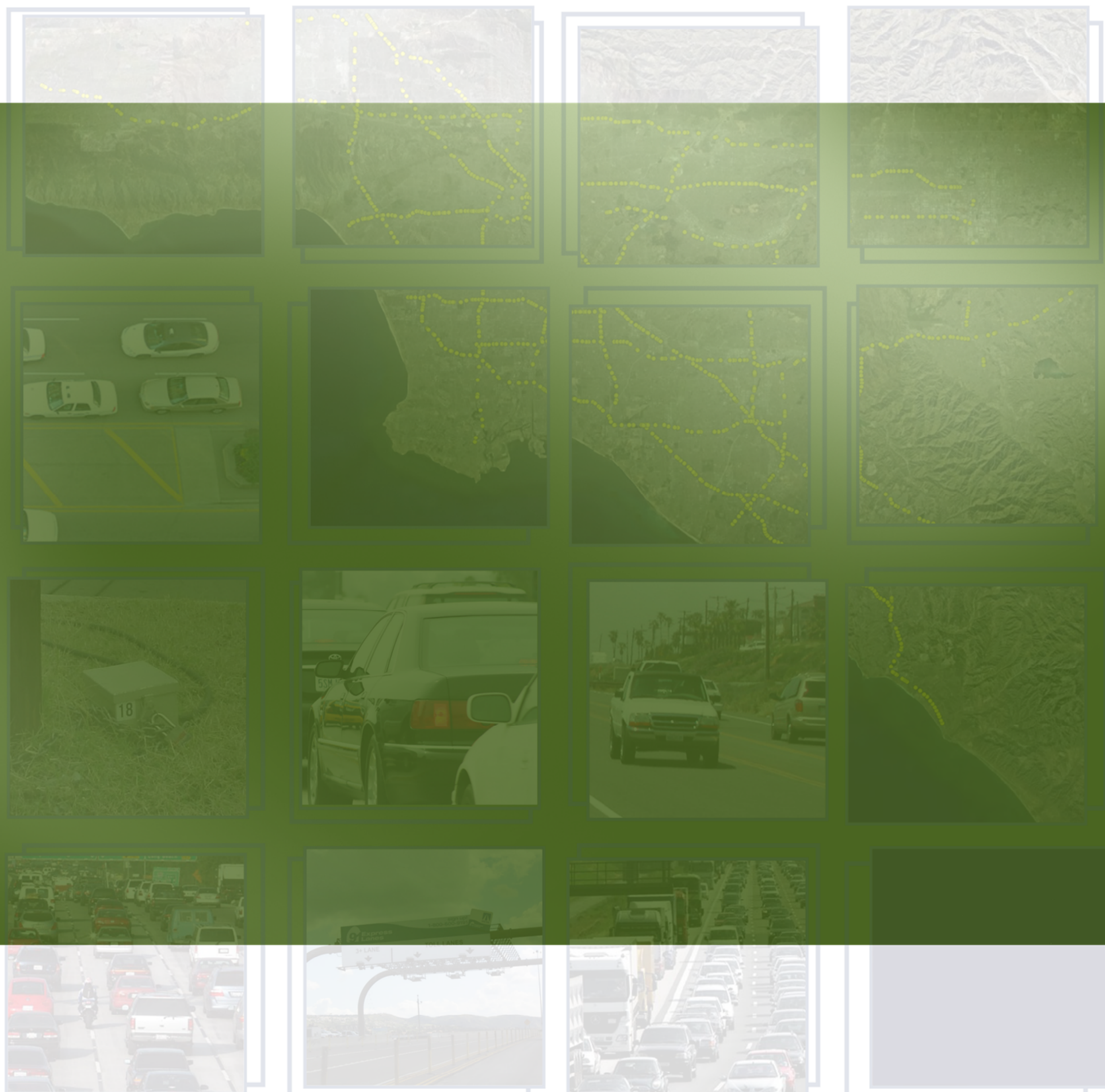
Note: *2008/1999 CPI = 225/166.1 = 1.35465

The Year 2008 Model Validation uses the value of 6.43 cents per mile (in 1999 dollars) for "other costs" as calculated by SCAG's Economic Analysis/Forecasting Section using data compiled by the General Services Administration and the National/Southern California AAA. Adding 6.43 cents per mile for "other" costs to the fuel costs per mile (14.2 cents/mile), yields a total auto operating cost of 20.63 cents per mile for 2008 in 1999 dollars.

THIS PAGE INTENTIONALLY LEFT BLANK

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Appendix C: SCAG Model Peer Review #4



APPENDIX C: SCAG MODEL PEER REVIEW #4

Background

The primary objective of the Peer Review Panel was to review SCAG's model development program, validation tests and results, expert panel discussions, and overall model enhancement effort for validity with regard to state of the practice so that the Model can be applied with sufficient reliability in the RTP, FTIP, and AQMP planning processes. The Panel was also asked to provide recommendations for future short-term and long-term model enhancements. Their major conclusions and recommendations are described in this Appendix.

SCAG's 2008 Regional Travel Model Peer Review Panel was comprised of nationally-recognized experts in the fields of travel demand modeling and data collection and analysis. The panel members are listed below:

Peer Review Panel Members

Name	Organization
Guy Rousseau (Chair)	Atlanta Regional Commission
Chaushie Chu, Ph.D.	Los Angeles County Metropolitan Transportation Authority (Metro)
Chris Forinash	Environmental Protection Agency (EPA)
David Levinson, Ph.D.	University of Minnesota
David Ory, Ph.D.	Metropolitan Transportation Commission (MTC)
Eric Pihl	Federal Highway Administration (FHWA)
Kara M. Kockelman, P.E., Ph.D.	University of Texas, Austin; Expert Panel – Congestion Pricing
Ken Cervenka	Federal Transit Administration (FTA)
Mark Bradley	Mark Bradley Research and Consulting

Recommendations and Findings

Overall Findings of the Peer Review Panel

The current SCAG travel demand model is an advanced 4-step model that meets and in many cases exceeds the state of the practice – with the exception of the lack of zero-vehicle ownership sensitivity in the destination and mode choice models. With this one change properly addressed, the model is suitable for use in preparing 2012 RTP, conformity analysis, and SCS.

Model Strengths

The Panel feels that the level of effort for the SCAG model is impressive and ambitious. SCAG should continue to manage and coordinate the overall model enhancement program and individual consultant work efforts. The Panel encourages SCAG to continue to explore and implement as practical activity-based modeling and land use forecasting models.

There are a number of new features in the model that in all cases meet and in many instances are an improvement over the typical state of the practice, including:

- the multi-level geographic zone structure, particularly the "Tier 2" zone system with over 11,000 zones,
- a truck model that includes all classes of commercial vehicles, as well as a special generator model for the Ports of L.A and Long Beach (San Pedro Bay ports),
- grade-based PCE adjustments for heavy-duty trucks,
- the modeling of secondary truck trips associated with transload facilities,
- an auto ownership model that includes a number of different land use and accessibility variables,
- origin zone income model,
- the use of destination choice models with logsums from mode choice, instead of gravity models,
- the use of a time-of-day choice model, instead of fixed factors,
- the congestion pricing model's ability to analyze user benefits with regard to delay and mobility performance perspectives,
- the use of a nested mode choice model with a large number of competing modes, and
  the use of advanced models for congestion pricing.

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Recommendations for Model Validation and 2012 RTP Process (Short-Term)

The major conclusions and recommendations of the Peer Review Panel for short-term consideration by SCAG are listed in this section. The recommendations described herein are intended for short-term implementation in the model prior to using the model for developing the 2012 RTP. In some cases, the recommendations do not require additional efforts on the part of the model development team.

- **Auto Ownership Sensitivity** – The Peer Review Panel suggests adding auto ownership sensitivity in the destination choice and mode choice models. Along with travel time and cost, auto availability is one of the most significant explanatory variables. For example, there may be zero-car households in higher income categories that are not captured by household income groups. Furthermore, there are single people and couples in high accessibility areas that choose to own less than one vehicle per driver. The California Transportation Commission's 2010 RTP Guidelines specifically mention auto availability per household as an important quantifiable variable for describing travel behavior. This could potentially be a significant issue in forecast years; and there may be significant cultural/immigrant differences that should be considered. In updating the model, the calibrated constant for zero-car household transit riders should be closely reviewed.

  Note: The 2001 onboard transit survey data does not include auto ownership information. The upcoming 2011 onboard survey being conducted by Metro will include this information.

  - *Response / Follow-Up – SCAG retained a consultant to address the Peer Review Panel's recommendation regarding auto ownership sensitivity. The final 2012 RTP Model is now stratified by car sufficiency and household income through the entire set of core demand models.*

- **Sensitivity Testing** – The Panel suggests doing sensitivity testing on a single-county version of the model, or something similar, since model run times limit opportunities for extensive testing. The sensitivities to longer travel by medium and high density areas should be reviewed.

  - *Response / Follow-Up – Model sensitivity tests were performed as part of the validation process. The Model displayed reasonable responses to changes made to the following variables:*
    1. *Fuel Pricing*
    2. *Auto Operating Costs*
    3. *Transit Capacity – Bus Frequency*
    4. *Transit Capacity – Rail Frequency*
    5. *Transit Capacity (bus, rail, BRT, etc. combined)*
    6. *Telecommute*
    7. *Freeway Capacity*
    8. *Income Distribution*

- **Traffic Count Averaging** – SCAG might consider averaging traffic counts over 3 or so years instead of using single year counts.

  - *Response / Follow-Up - The traffic counts on screenlines were closely reviewed against historical and current data on the specific link or adjoining links. This was done in an attempt to verify the quality of each screenline traffic count as well as to replicate 2008 conditions as closely as possible. If the desire is to replicate conditions before 2008 (i.e., before the economic* *downturn), this could be accomplished with geo-spatial (e.g., district, county, etc.) adjustment factors.*

- **Heavy-Duty Truck Model Validation** – The Panel suggests comparing model results and observed data grouped by percent of trucks on roadway links to look at the model results in a different way.
  - *Response / Follow-Up - The Traffic Assignment Chapter provides tables showing heavy-duty trucks grouped and summarized by several different criteria.*

- **Validation of Speeds/Travel Times** - SCAG should try to match observed travel times (speeds) on links as part of validation.
  - *Response / Follow-Up - SCAG agrees with this comment and will attempt to implement this in future model validations. SCAG is currently investigating technology based methods for building an accurate region-wide speed database for this purpose.*

- **Reporting** - Add basic demographic profiles including maps of the SCAG region to the Validation Report.
  - *Response / Follow-Up – Maps displaying the geographic distribution of the basic demographic variables are included in this Report.*

Recommendations for Model Enhancement Program (Long-Term)

The major conclusions and recommendations of the Peer Review Panel for longer-term consideration by the SCAG and consultant modeling team are listed in this section. The recommendations described herein are intended for exploration or implementation in the model after the 2008 model validation is final. These longer-term recommendations would be anticipated prior to using the model for developing the 2016 RTP. In some cases, the recommendations do not require additional efforts on the part of the model development team.

- Model Inputs and Assumptions
  - Consider the use of actual speeds as free-flow speeds in the model rather than artificially capping them at the speed limit.
  - Review the potential for better enforcement of speeds through technology in the future and how this may impact assumptions in the model. Or, consider using the model to test the impacts of policy scenarios such as more comprehensive speed enforcement.
  - Incorporate the most recent Census data (e.g., SF-1) into the model assumptions, recognizing that it will not be available for the 2012 RTP analysis.
  - SCAG may wish to explore the use of the US Census LEHD (Longitudinal Employer - Household Dynamics) data for validation. There are some concerns that the LEHD data does not contain realistic home to work data.

    Note #1: Longitudinal Employer-Household Dynamics (LEHD) is an innovative program within the U.S. Census Bureau. Modern statistical and computing techniques are used to combine federal and state administrative data on employers and employees with core Census Bureau censuses and surveys while protecting the confidentiality of people and firms that provide the data (Source: US Census LEHD website).

    Note #2: The Atlanta Regional Commission has worked with LEHD data and is available for consultation.
  - Area types and densities may not be the best variables for determining roadway attributes (e.g., capacities, speeds, etc.). SCAG may wish to explore the use of roadway widths and intersections per mile surrogate variables to augment this approach.
  - The model should include attributes that allow for the specific quantification of benefits from ramp metering.
  - Toll-choice models in both mode choice and assignment may increase model run times unnecessarily. SCAG may wish to consider turning off one of these processes to reduce run times.

- Trip-Based Model Enhancements

  - Consider reversing the order of destination / mode choice nesting when the 2011 onboard transit survey data is available so that the mode choice logsum coefficient in the destination / mode choice model does not need to be constrained, or allow the inclusive value coefficient to be the estimated value even if it is greater than 1 (one).

  - Conduct rigorous performance checks of model results once the 2011 onboard transit survey data is available. These may include trip-based and activity-based district-to-district transit rider flows by mode, market segment, and mode of access, etc.

  - Run the model with observed travel times and review results.

  - The SCAG model uses a 5-option multi-nomial logit choice model used for auto ownership. Some have argued that this is an ordered choice. SCAG may wish to explore the use of negative binomial or ordered probit models for auto ownership.

  - The workplace allocation component of the destination choice model has room for improvement according to some panel members based on calibration/validation results. SCAG should review its methodology and ensure that the upcoming activity-based modeling will address these issues.

  - Consider the use of stochastic user equilibrium in traffic assignment to reduce the effects of all travelers taking the shortest path. This may however increase model run times.

  - The SCAG model currently runs the time-of-day choice model runs after mode choice. Some panel members suggested that SCAG consider reviewing the processing order.

  - SCAG should consider improving the integration between the time-of-day model and the congestion pricing model components.

- Model Integration and Software Implementation

  - SCAG should invest in the appropriate computer technology (e.g., servers with sufficient storage and processing power and/or multiple computers to run separate model components) to meet the demands of their ambitious modeling needs in the future.

  - Identify which modeling steps are scalable and where additional computers could reduce model run times through parallel processing.

- Congestion Pricing

  - Stated Preference survey results should be studied and validated to the extent possible before using them in the model for future applications such as the 2016 RTP.

  - The trip suppression model component appears ad hoc and should be better integrated with the model.

- Societal equity is often a political concern for any type of road pricing. A process (similar to the FTA SUMMIT program) to identify benefits/dis-benefits for users as well as non-users resultant from road pricing alternatives would be a helpful tool to address the equity concerns that may be raised by elected officials and interest groups.

- Heavy-Duty Truck Model
  - Review the assumption that the trucks per employee stay constant over time. Possibly use historical trends and commodity flow information to augment this part of the truck forecast assumptions.
  - Review and possibly update the assumptions for forecasting transload facilities.
  - Compare model results using the grade-adjusted PCE factors against model results without the PCE adjustment.

- Activity-Based Modeling
  - Model results should be compared at the 2035 future scenario level and fully understood before using ABM for the 2016 RTP.
  - SCAG should investigate how well the ABM results are matching journey to work data.
  - Next steps in developing the ABM modeling should be considered in the context of the weaknesses of the trip based model. For example, the workplace location choice, mode/destination choice order, capacity representation, etc. should be revisited.
  - The Activity Based Model should be used where possible to conduct sensitivity tests to the SB 375 / SCS policies that aren't well-represented in the trip-based model.

- Land Use Forecasting
  - Consider utilizing the PECAS / Land Use model to inform the heavy duty truck model. It is well-suited for this task.

Acronyms

Acronym	Definition
AADT	Average Annual Daily Traffic
AB 32	California's Assembly Bill 32
ABM	Activity-Based Modeling
ACS	American Community Survey
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
AOC	Auto Operating Cost
AQMP	Air Quality Management Plan
ARB	California's Air Resources Board
ARC	Atlanta Regional Council
ARRA	American Recovery and Reinvestment Act of 2009
ASC	Alternative-Specific Constants
AT	Area Type
BLM	Bureau of Land Management
BRT	Bus Rapid Transit
CARB	California Air Resources Board
CASI	Computer-Assisted Self-Interview
CBD	Central Business District
CEMDAP	Comprehensive Econometric Micro-simulator of Daily Activity-travel Patterns
CIP	Capital Improvement Program
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO2	Carbon Dioxide
CSULB	Cal State Long Beach
CTPP	Census Transportation Planning Package

Acronym	Definition
DOF	California Department of Finance
DOT	Department of Transportation
DTA	Dynamic Traffic Assignment
EDD	California Employment Development Department
EMP	Employment
EPA	Environmental Protection Agency
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
FIRES	Finance/Insurance/Real Estate/Services
FT	Facility Type
FTA	Federal Transit Administration
FTIP	Federal Transportation Improvement Program
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HBCU	Home-Based College
HBNW	Home-Based Non-Work
HBO	Home-Based Other Trips
HBSC	Home-Based School
HBSH	Home-Based Shopping Trips
HBW	Home-Based Work
HBWD	Home-Based Work Direct
HBWS	Home-Based Work Strategic Trips
HCM	Highway Capacity Manual
HDT	Heavy Duty Truck
HH	Household Diversity

Acronym	Definition
HHDT	Heavy-Heavy Duty Trucks
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IE/EI	Internal-External
IMX	Intermodal
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation Systems
LACMTA	Los Angeles County Metropolitan Transportation Authority
LADOT	Los Angeles Department of Transportation
LHDT	Light-Heavy Duty Trucks
LOS	Levels of Service
LRTP	Long Range Transportation Plan
LS	Logsum
LTL	Less-Than-Truckload
LU-LU	Land Use-to-Land Use
MDCEV	Multiple Discrete-Continues Extreme Value
MHDT	Medium-Heavy Duty Trucks
MLA	Modern Language Association
MPO	Metropolitan Planning Organization
MPU	Minimum Planning Unit
MTC	Metropolitan Transportation Commission
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industrial Classification Standard
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NHB	Non-Home Based
NHTS	National Household Travel Survey

Acronym	Definition
NOX	Nitrogen Oxides
NRE	Non-Retail Employment
NTD	National Transit Database
OBO	Other-Based Other Trips
OCTA	Orange County Transportation Authority
OD	Origin-Destination
PA	Production-Attraction
PAM	Pricing Adjustment Module
PATH	Partnership for Advanced Technology on Highways
PCEs	Passenger Car Equivalents
PCPLPH	Passenger Car Per Lane Per Hour
PopGen	Population Generator
PSRC	Puget Sound Regional Council
PUMS	Public Use Microsample
RE	Retail Employment
RHTS	Regional Household Travel Survey
RMSE	Root Mean Squared Error
ROW	Right-of-Way
RPC	Regional Planning Grant
RSA	Regional Statistical Area
RSE	Retail/Service Employment
RTP	Regional Transportation Plan
SACOG	Sacramento Area Council of Governments
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity ACT - A Legacy for Users
SANBAG	San Bernardino Association of Governments
SASVAM	Small Area Secondary Variables Allocation Model
SB 375	California's Senate Bill 375
SCAG	Southern California Association of Governments

Acronym	Definition
SCS	Sustainable Communities Strategy
SIC	Standard Industrial Classification
SimAGENT	Simulator of Activities, Greenhouse Emissions, Networks, and Travel
SIP	State Implementation Plan
SP	Stated Preference
STCC	Standard Transportation Commodity Classification
TAC	Technical Advisory Committee
TAZ	Transportation Analysis Zone
TCA	Transportation Corridor Agency
TDM	Transportation Demand Management
TIP	Transportation Improvement Program
TL	Truckload
TSM	Transportation System Management
UPWP	Unified Planning Work Program
VDF	Volume-Delay Function
VHT	Vehicle-Hours Traveled
VMT	Vehicle Miles of Travel
VOC	Volatile Organic Compounds
VOT	Values of Time
VRH	Vehicle Revenue Hours
VRM	Vehicle Revenue Miles
WIM	Weigh In Motion

ACKNOWLEDGMENTS

SCAG Management

- Hasan Ikhrata, Executive Director
- Sharon Neely, Deputy Executive Director – Strategy, Policy and Public Affairs Group
- Debbie Dillon, Deputy Executive Director – Administration
- Joann Africa, Chief Counsel / Director of Legal Services
- Wayne Moore, Chief Financial Officer
- Rich Macias, Director of Transportation Planning
- Huasha Liu, Director of Land Use and Environmental Planning
- Sylvia Patsaouras, Director of Regional Services and Public Affairs (acting)
- Catherine Chavez, Chief Information Officer (acting)

SCAG Transportation and Air Quality Modeling Staff

- Jonathan Nadler (Manager)
- Guoxiong Huang (Chief Modeler)
- Mike Ainsworth
- Rongsheng Luo
- Hao Cheng
- Sreedhar Nambisan
- Mana Sangkapichai
- Sung Su Yoon
- Yongping Zhang
- Arnie Sherwood
- Teresa Wang
- Daji Yuan

SCAG New Model Development Staff

- Hsi-Hwa Hu – Activity-Based Model
- Sungbin Cho – Land Use Model

SCAG Data/GIS and Growth Forecasting Staff

- Frank Wen – Manager
- Simon Choi – Chief of Research and Forecasting
- Javier Aguilar
- Kimberly Clark
- Seong Hee Min
- Javier Minjares
- Sungho Ryu
- Jung H. Seo
- Ping Wang
- Ying Zhou

SCAG's Modeling Task Force and Participating Agencies

- California State Department of Transportation – Caltrans Districts 7, 8, 11, & 12
- SCAG Subregional Agencies
- California Air Resources Board
- South Coast Air Quality Management District
- Ventura Air Pollution Control District
- Mojave Desert Air Quality Management District
- Imperial County Air Pollution Control District
- Antelope Valley Air Pollution Control District
- Los Angeles County Metropolitan Transportation Authority
- Orange County Transportation Commission
- Riverside County Transportation Commission
- Riverside County
- San Bernardino Associated Governments
- Ventura County Transportation Commission
- Imperial County Transportation Commission
- Federal Highway Administration
- Federal Transit Administration
- Environmental Protection Agency

Consultant Team

- Caliper Corporation – TransCad Software Services and Model Development Support
- Cambridge Systematics – Heavy-Duty Truck Model Development and Model Calibration
- Dowling Associates – Speed Data Gathering and Speed Curve Development
- Jacobs Engineering – Regional Highway Inventory
- LSA Associates, Inc. – Traffic Count Development and Model Validation Support
- M.E. Consulting Services – Transit Level of Service Data Development
- Parsons Brinckerhoff – Model Enhancement, Model Calibration and Model Validation
- Sierra Research Inc. – Air Quality Modeling Enhancement and Support
- Wilbur Smith – Congestion Pricing Model Enhancements

*** *Special thanks to Jim Lam (Caliper) and Rosella Picado (Parsons Brinckerhoff) for their long hours and extra efforts to successfully complete the model enhancements and validation.*

Report Development and Editing

- Everett Bacon – LSA Associates, Inc.