CAMBRIDGE SYSTEMATICS

California Statewide Travel Demand Model, Version 2.0

External Travel Model

final

report

prepared for

California Department of Transportation

prepared by

Cambridge Systematics, Inc.

and

HBA Specto, Inc.

May 2014

www.camsys.com

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date

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1.0 Introduction

The External Travel Model (ETM) is one of the five components of the California Statewide Travel Demand Model (CSTDM) Version 2.0. The ETM was designed to reflect vehicle trips entering or exiting California, along every state border, including the border with Mexico, and includes additional truck travel originating from the major California seaports.

The theoretical and mathematical basis of the model remained unchanged from the original version of the CSTDM (CSTDM09); details of the original ETM model development were provided in CSTDM09 documentation[1] and included in Appendix A. No additional calibration was conducted for this model, CSTDM Version 2.0, although external model volumes for Year 2010 are based on updated traffic counts collected between 2009 and 2011.

This document describes ETM vehicle trips for all external gateways. The integration of this model in the CSTDM model system is described in the documents "Model Overview" and "User Guide," which also contains more information on the operation of the model.

Overall, the ETM includes five vehicle classes (drive alone, shared ride two persons, shared ride three or more persons and trucks based on the FHWA vehicle classification scheme. There are two truck classes, labeled as medium duty (classes 6-7) and heavy duty (classes 8-13).

From these six classes of vehicles, the external model is divided into five segments according to short and long distance travel. Short distance autos and medium trucks are assigned to two short distance segments. Similarly, long distance autos and heavy trucks are assigned to two long distance segments. The fifth segment covers through trips (also called external-external trips).

Caltrans traffic counts collected between 2009 and 2011 were used for model validation. This report also examines the methodology for forecasting future year ETM volumes.

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[1] Source: Caltrans, http://www.dot.ca.gov/hq/tsip/otfa/cstdm/documents/tdm/CSTDM09_ETM_Final.pdf. Accessed April 20, 2014.

2.0 Overview

External travel into and out of California can be considered along several dimensions, including the direction, the vehicle used, and the border crossing that is used. In total, over 400,000 vehicles crossed the California State Line during a typical Year 2010 fall weekday. Although the total number of vehicles crossing the state line is a large number, external travel is small percentage of all trips.

2.1 Segmentation

In the ETM, the total set of external travel is divided into the following five segments by vehicle type and by purpose:

- **Passenger Vehicle Local.** Passenger vehicles being used to make short distance trips, crossing the California border but being based nearby. These vehicles are somewhat analogous to the travel covered in the Short Distance Personal Model. The two main concentrations for short distance external traffic are in the Tahoe Basin area and between San Diego and Tijuana.
- **Passenger Vehicle Long.** This category covers passenger vehicles used to make long distance trips, from more distant locations outside the state and/or to distant points within California. Long distance passenger vehicles are analogous to the Long Distance Personal Model. Examples can include travel from Oregon to San Francisco, or travel from Los Angeles to Las Vegas.
- **Medium Trucks.** Medium commercial vehicles are also called "Single Unit" vehicles; this is the same category as used in the Short Distance Commercial Vehicle Model and Long Distance Commercial Vehicle Model.
- **Heavy Trucks**. Heavy commercial vehicles are tractor-trailer units, and are the same categorization as used in the SDCVM and LDCVM.
- **External-External Travel**. External to External (E-E) vehicles are those traveling from one California external border station to another, without stopping in California. These are uncommon, particularly for personal travel, so the E-E vehicles used here represent only commercial freight hauling. Due to the long distances involved, only heavy commercial vehicles are assumed to make these movements.

2.2 EXTERNAL GATEWAYS

The ETM has 53 external gateways, located at every significant border crossing of California and at the major ports of Los Angeles, Long Beach, Oakland and Richmond; the gateways remain unchanged from CSTDM09.

External gateways were classified into six districts: one for crossings on the California/Oregon border, one on the northern part of the California/Nevada border (south to, and including, U.S. Highway 6 near Benton), one for the southern part of the California/Nevada border (starting at Cal 266 near Oasis), one for the California/Arizona border, one for the California/Mexico border, and one for the ports. The districts were defined to help determine where external vehicle trips will go to within California.

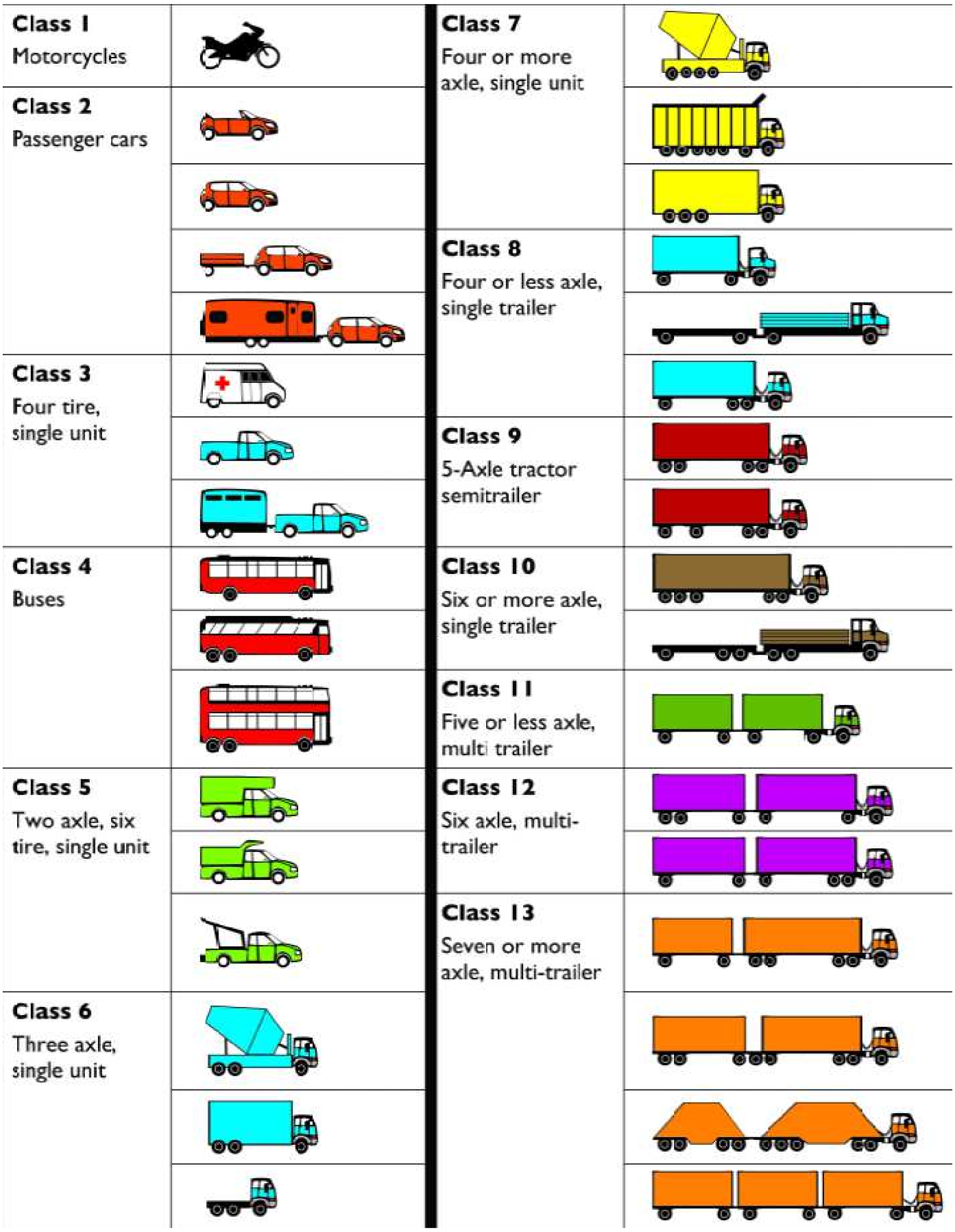
2.3 VEHICLE CLASSIFICATIONS

Six vehicle classifications are used, three for private vehicles and three for commercial trucks. These classifications are:

- Single Occupant Vehicles;
- Carpool Two Persons;
- Carpool Three or More Persons;
- Light Trucks (FHWA Classifications 3 and 5);
- Medium Trucks (FHWA Classifications 6-7); and
- Heavy Trucks (FHWA Classifications 8-13).

The truck classifications are part of the FHWA classification of 13 different vehicles types. Figure 2.1 shows the classification scheme.

Figure 2.1 FHWA Vehicle Classification System



Source: FHWA Traffic Monitoring Guide, 2013. Available on-line at: http://www.fhwa.dot.gov/policyinformation/tmguide/, accessed April 1, 2014.

3.0 2010 Model Inputs

Inputs to the ETM include external trip generation, time-of-day, direction of travel, segmentation, vehicle classification, and party size for each external station. Trip generation is defined by the traffic counts collected for each gateway. The traffic counts also provide time-of-day and travel direction. A limited set of vehicle classification counts were available, providing information on the split between autos and different truck types.

Segmentation, as described in Section 2.1, as well as party size were not available from traffic count data. As such, these variables have not been updated from CSTDM09.

3.1 Traffic Counts

Several data sources were consulted to achieve reasonable estimations of daily traffic at the external locations, as described below. Where possible, Caltrans vehicle counts were used. However, some additional data sources were also used when the count data was missing or suspect. In all, the following data sources were consulted:

Caltrans Vehicle Counts

Caltrans collects and maintains hourly traffic counts at various locations across the State. Count stations were identified at locations closest to identified screenline locations, and raw counts for each station for years 1999-2001 and 2009-2011 were extracted by Caltrans staff. CS staff processed the count data to remove counts on days not during average fall/spring weekdays and those that were more than one standard deviation away from the median, in an attempt to remove anomalies in the data.

Caltrans vehicle counts were the only available data source with information on traffic by time-of-day and could be queried to represent average fall/spring weekday traffic. However, some counts stations could be subject to faulty monitors or inconsistent data. Also, the count locations did not always match the identified locations and were several miles from the California border with significant changes in traffic volume between the count station and the actual border. In addition, truck counts were only available for a limited number of locations.

Caltrans Count Book

Caltrans Traffic Data Branch also maintains Annual Average Daily Traffic (AADT) volumes for many state highways at many locations. One main advantage of this data is that the historical data is available at all external crossing locations identified and represented in the ETM. However, this data source does not identify traffic volumes by direction or time-of-day and only represents AADT. Some locations may experience significantly different volumes during weekends, holidays, or summers, for example.

Caltrans Vehicle Classification Counts

Caltrans also provided vehicle classification counts, which provide hourly vehicles by vehicle type, for the purposes of estimated truck traffic at count locations. However, few counts were returned for the queried stations and the little data available was used for reasonableness checks at those locations.

Caltrans Truck Count Report

Caltrans maintains a Truck Count Report for annual average daily traffic at selected locations on state highways for trucks, classified by the number of axles. However, estimates may have been based on old data and was not considered reliable enough for validation purposes but was used for reasonableness checks.

ACCMA Truck Model

CS developed a truck revel demand model for the Alameda County Congestion Management Agency (ACCMA) in 2009. That effort included traffic counts for the three entrances to the Port of Oakland.

CSTDM09 Assumptions

In some cases, new traffic counts were not available. These were remote rural locations. For such cases, the same assumption used for CSTDM09 2008 traffic counts was used – an assumption of 100 total daily vehicles crossing the state line.

3.2 IMPLEMENTED METHODOLOGY

The data sources described were reviewed for reliability and suitability. No single data source contained all the information needed for every external station, so the Year 2010 traffic counts were determined from the best information of the available data. The hierarchy of data reliability and decision-making process to develop Year 2000 and Year 2010 daily vehicle trip assumptions at all external locations was conducted as follows for each individual gateway:

- Caltrans Vehicle Counts were compared to Caltrans Count Book and CSTDM09 assumptions for reasonableness. If the traffic volumes were within a reasonable range, Caltrans vehicle counts were used.
- In the absence of reasonable Caltrans Vehicle Counts, Caltrans Count Book AADT was used.

- If Caltrans Count Book data were unavailable for a specific location, CSTDM09 values for 2008 and 2015 were interpolated to 2010 conditions. Generally, these locations were minor local roads with assumed traffic volumes of 100 vehicles per day.
- Counts used in the development of the ACCMA Truck Model were utilized for Port of Oakland traffic.

3.3 Year 2000 and 2010 External Gateway Daily Traffic Counts

Table 3-1 lists the traffic counts crossing each external station for Year 2000 and 2010 base years, along with the data source ultimately used. For most locations, traffic at external gateways show modest increases, and in some cases small reductions in traffic between 2000 and 2010.

An exception was found along the International border with Mexico where large drops in traffic were identified. A number of reasons have been speculated for this dramatic change in traffic, including the comparatively strong economy in 2000 and comparatively weaker economy in 2010, and the effects of increased border security since 2001.

Traffic counts at the actual International Border locations was generally not available, so traffic counts were typically counted upstream from the border. Significant efforts were taken to ensure that 2000 and 2010 gateway count station locations at the International Border were consistent. In addition, Caltrans District 11 staff were consulted for the reasonableness of the changes in traffic at the International Border. The conclusion of the project team was that the drops in traffic along the International Border, though striking, were reasonable.

Table 3-1 External Gateway Traffic Counts

External Zone	Location	Counts		Data Source
		Year 2000	Year 2010	
1	US 101 – N. Smith River	6,400	6,980	Caltrans Vehicle Counts
2	US 199 – N. Patrick Creek	2,700	3,100	Caltrans Count Book
3	Indian Creek Road	100	100	CSTDM09 Assumptions
4	I-5 – N. Hilt	12,590	12,570	Caltrans Vehicle Counts
5	US 97 – N. Dorris	3,830	3,940	Caltrans Vehicle Counts
6	Cal 139 – N. Tulelake	2,990	2,690	Caltrans Vehicle Counts
7	Cal 50 – S. Main (Ore)	100	100	CSTDM09 Assumptions
8	Muldoon Rd / Westside Rd	100	100	CSTDM09 Assumptions

External Zone	Location	Counts		Data Source
		Year 2000	Year 2010	
9	US 395 – N. New Pine Creek	870	850	Caltrans Vehicle Counts
10	Surprise Valley Road	100	100	CSTDM09 Assumptions
11	Cal 299 – E. Cedarville	210	180	Caltrans Count Book
12	Cal 81 – S. Eagleville	100	100	CSTDM09 Assumptions
13	Wendel Rd / Summers Rd E. Wendel / Herlong	100	100	CSTDM09 Assumptions
14	US 395 – N. Lemmon Valley (Nev)	8,750	8,140	Caltrans Vehicle Counts
15	15 miles N. of 80 / 89	100	100	CSTDM09 Assumptions
16	I-80 – W. Reno (Nev)	24,940	23,630	Caltrans Vehicle Counts
17	Cal 28 – E. Kings Beach	13,550	10,890	Caltrans Vehicle Counts
18	US 50 – N. South Lake Tahoe	26,080	24,690	Caltrans Vehicle Counts
19	Cal Cal 88 – N. Paynesville	2,920	3,820	Caltrans Vehicle Counts
20	US 395 – S. Topaz Lake (Nev)	3,470	3,570	Caltrans Vehicle Counts
21	State Highway 182 – N. Bridgeport	240	260	Caltrans Vehicle Counts
22	Cal 167 – E. Mono	80	90	Caltrans Vehicle Counts
23	US 6 – N. Benton	890	920	Caltrans Vehicle Counts
24	Cal 266 – N. Oasis	70	90	Caltrans Vehicle Counts
25	Cal 266 – E. Oasis	80	130	Caltrans Vehicle Counts
26	N Hwy (Cal 267) – Death Valley	100	100	CSTDM09 Assumptions
27	Daylight Pass Rd (Cal 374) – Death Valley	100	100	CSTDM09 Assumptions
28	Cal 127 – N. Death Valley Junction	670	620	Caltrans Vehicle Counts
29	Ash Meadows Rd – E. Death Valley Junction	100	100	CSTDM09 Assumptions
30	Cal 178 – W. Pahrump (Nev)	710	750	Caltrans Vehicle Counts
31	I-15 – N. Mountain Pass	35,000	39,500	Caltrans Count Book
32	Nipton Rd (Cal 164) – E. Nipton	100	100	CSTDM09 Assumptions
33	US 95 – N. Arrowhead Junction	2,800	3,300	Caltrans Count Book
34	US 95 – E. Laughlin	100	100	CSTDM09 Assumptions
35	I-40 – W. Topock (Nev)	11,520	11,930	Caltrans Vehicle Counts
36	Parker Dam (N. Parker)	100	100	CSTDM09 Assumptions
37	Cal 62 – Earp	4,500	6,000	Caltrans Count Book
38	Agnes Wilson Rd E. 95 (S. of Earp)	100	610	CSTDM09 Assumptions
39	I-10 – E. Blythe	19,760	22,970	Caltrans Vehicle Counts
40	E. Laguna Rd at Imperial Reservoir (Imperial Dam)	100	100	CSTDM09 Assumptions
41	S. 4th Ave – Yuma	100	100	CSTDM09 Assumptions

External Zone	Location	Counts		Data Source
		Year 2000	Year 2010	
42	Highway 186 – Mexican Border Yuma	5,180	7,950	Caltrans Vehicle Counts
43	Cal 111 – Calexico	40,220	26,580	Caltrans Vehicle Counts
44	Cal 188 – Tecate	5,470	5,660	Caltrans Vehicle Counts
45	I-5 – San Diego	109,000	74,000	Caltrans Count Book
46	I-8 – Yuma	13,080	14,810	Caltrans Vehicle Counts
47	Collina del Sol (Cal 905)– – San Diego	30,850	24,240	Caltrans Vehicle Counts
48	Cal 7 – Calexico	9,180	7,700	Caltrans Vehicle Counts
49	Long Beach (Port)	23,691	25,090	CSTDM09 Assumptions
50	Los Angeles (Port)	25,864	27,390	CSTDM09 Assumptions
51	Oakland (Port)	10,470	12,030	ACCMA Truck Model
52	Richmond (Port)	0	0	CSTDM09 Assumptions
53	Otay Mesa East (open 2016)	0	0	CSTDM09 Assumptions

External traffic either enters California (classified as external to internal travel or E-I), leaves California (classified as internal to external or I-E) or travel through California (external to external or E-E).

The E-E component uses a fixed proportion split from each external station to each other possible station. CS reviewed the E-E assumptions from CSTDM09 and made some adjustments based on planning knowledge of California travel. The E-E volumes cannot be verified with observable information at this time. However, no major changes in assumptions were made to E-E volumes. Tables 3.2 and 3.3 show daily E-E trips for Years 2000 and 2010, respectively.

Table 3-2 Year 2000 Daily External to External

Gateway		OR	NV			AZ			Mexico						Port		
		I-5	U.S. 395	I-80	I-15	I-40	I-10	I-8	SR 186	SR 111	SR 7	SR 188	SR 905	I-5	Long Beach	Los Ang.	Oak.
Oregon	I-5	0	260	20	20	20	390	30	20	30	30	20	70	50	100	110	100
Nevada	U.S. 395	250	0	30	10	20	10	30	20	40	20	30	30	40	0	0	0
	I-80	40	30	0	30	30	20	20	20	30	30	30	20	60	50	40	500
	I-15	20	20	20	0	20	10	20	30	30	20	10	50	60	290	300	70
Arizona	I-40	20	20	40	20	0	0	0	20	30	30	20	30	50	320	280	90
	I-10	350	20	30	20	0	0	0	40	60	50	60	40	130	90	180	90
	I-8	20	10	20	10	0	0	0	80	150	270	50	250	160	90	90	50
Mexico	SR 186	30	20	20	20	30	40	80	0	0	0	0	0	0	20	20	10
	SR 111	30	20	30	20	30	60	150	0	0	0	0	0	0	20	30	40
	SR 7	30	30	30	30	30	40	230	0	0	0	0	0	0	40	40	30
	SR 188	10	30	30	20	30	60	50	0	0	0	0	0	0	20	30	10
	SR 905	50	30	30	50	20	60	210	0	0	0	0	0	0	30	40	30
	I-5	60	20	50	60	50	120	190	0	0	0	0	0	0	220	270	70
Port	Long Beach	120	0	50	340	340	80	80	20	40	30	20	20	230	0	0	0
	Los Angeles	90	0	40	300	330	200	100	20	30	40	10	30	240	0	0	0
	Oakland	100	0	480	80	80	80	30	20	30	20	20	30	60	0	0	0

Table 3-3 Year 2010 Daily External to External

Gateway		OR	NV			AZ			Mexico						Port		
		I-5	U.S. 395	I-80	I-15	I-40	I-10	I-8	SR 186	SR 111	SR 7	SR 188	SR 905	I-5	Long Beach	Los Ang.	Oak.
Oregon	I-5	0	250	30	30	30	370	20	20	20	30	30	60	40	120	110	120
Nevada	U.S. 395	260	0	20	30	20	30	20	30	20	30	20	20	20	0	0	0
	I-80	20	20	0	30	30	30	30	30	30	20	20	30	50	60	60	510
	I-15	20	30	30	0	30	30	30	20	30	20	30	50	60	330	350	140
Arizona	I-40	20	30	30	20	0	0	0	30	20	30	20	20	70	330	380	100
	I-10	350	30	30	20	0	0	0	70	50	50	60	50	100	80	200	110
	I-8	20	20	30	30	0	0	0	90	130	270	50	190	150	100	80	60
Mexico	SR 186	20	30	20	20	30	50	100	0	0	0	0	0	0	20	20	20
	SR 111	20	40	10	20	30	50	120	0	0	0	0	0	0	20	30	20
	SR 7	30	20	20	20	30	50	250	0	0	0	0	0	0	20	30	20
	SR 188	20	20	20	20	20	50	50	0	0	0	0	0	0	20	20	20
	SR 905	60	30	20	50	30	40	170	0	0	0	0	0	0	40	20	20
	I-5	60	30	40	50	60	110	140	0	0	0	0	0	0	190	200	50
Port	Long Beach	110	0	40	350	340	110	80	40	30	20	30	20	180	0	0	0
	Los Angeles	90	0	60	350	330	190	100	20	30	30	30	20	190	0	0	0
	Oakland	100	0	480	100	110	90	50	30	20	30	30	20	70	0	0	0

4.0 Future Year Model Inputs

The total volumes that were included for the gateway crossings in the 53 active California gateways for future scenarios were generated applying growth factors to the 2010 data. The model treats all external crossing points as bidirectional locations, so any changes in future volume produce a balanced response in both directions.

The State of California was divided into 6 main areas of influence that affect the vehicle movements to/from the State, depending on the location of the gateways and road crossings:

- Oregon,
- Northern Nevada,
- Southern Nevada,
- Arizona,
- Mexico, and
- Seaports.

Growth rates for population in California for the years 2020 and 2035 were explicitly computed based on the official statistics and forecasts that were available. Forecasts for 2015 were obtained by interpolating the growth between 2010 and 2020; and for 2040 and 2050 by extrapolating the growth from 2020 to 2035. These growth rates were used to scale up the passenger vehicle trips in each one of the crossings in California.

Growth rates for commercial vehicle trips for the years 2020 and 2035 were explicitly computed for each one of the 6 main crossing areas reported above, using data for the expected growth in commodity flows and employment for each one of these 6 areas. Again, forecasts for 2015 were obtained by interpolating the growth between 2010 and 2020 and for 2040 and 2050 by extrapolating the growth from 2020 to 2035.

These forecasts reflect an optimistic outlook for the growth in California import and export flows, consistent with projections prepared by the Ports on anticipate growth in international cargo. These forecasts for goods movement greatly exceed anticipated growth in California residents and California jobs.

The final growth factor to scale up the number of external trips at each crossing was computed by:

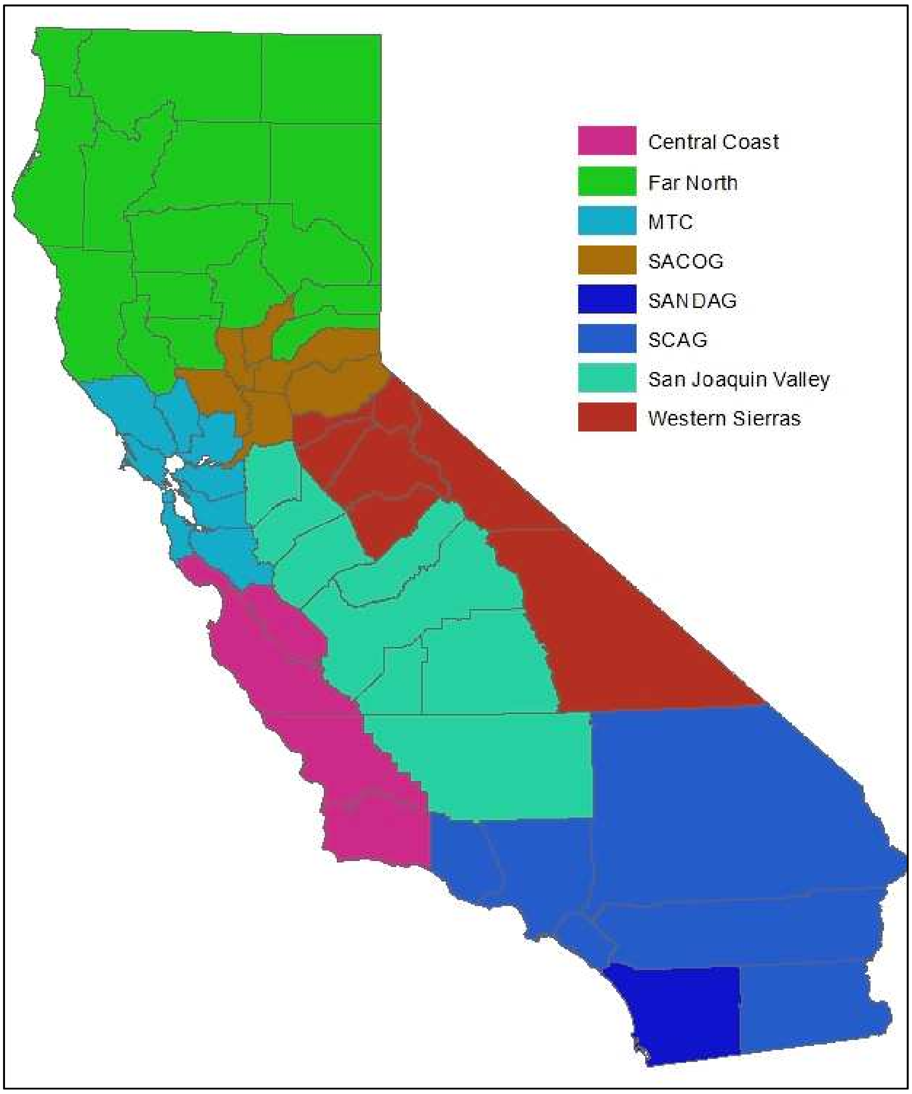
- Multiplying the proportion of the passenger trips at that specific crossing by the growth rate for passenger trips; and

- Summing it with the proportion of commercial vehicle trips at that crossing multiplied by the growth rate for commercial vehicle trips for that area.

5.0 External Trip Summaries

External trips to, from, and through California are summarized in a series of tables, shown below. These include base year 2010 distributions of persons and vehicles by vehicle class, by segmentation, and by border crossing group. External trips that have one trip end within California have been collapsed to eight California Regions. These regions are groups of counties, and include entire Metropolitan Planning Organizations (MPOs) or groups of MPOs and Regional Transportation Planning Agencies (RTPAs). The Sacramento Area Council of Governments (SACOG) Region includes the portions of Placer and El Dorado Counties that fall within the Tahoe Regional Planning Agency jurisdiction (TRPA). However, the TRPA areas within the State of Nevada are excluded from the following summaries. See Figure 5.1.

Figure 5.1 California Regions



5.1 Summary Statistics

Tables 5-1 through 5-2 summarize the travel by mode and by border crossing to each of seven internal regions, as shown in Figure 5.1, for the base Year 2010. Table 5-3 summarizes total vehicle crossing for base and future year forecasts.

Table 5-1 Distribution by Mode (Vehicle Trips) Year 2010

Region	SOV	HOV2	HOV3+	Medium Trucks	Heavy Trucks
Northern counties	12,640	12,370	11,010	720	1,780
SACOG area	1,140	770	510	50	120
AMBAG area	21,590	13,820	11,210	1,240	3,170
Central California	890	1,060	1,040	1,770	11,550
Los Angeles	10	20	20	180	1,410
Remainder of SCAG area	790	1,040	950	1,090	4,680
SANDAG area	36,200	34,130	31,090	14,810	56,180
Total	49,020	28,560	21,990	2,990	6,750

Table 5-2 Distribution by Border Crossed (Vehicle Trips) Year 2010

Region	Oregon	Nevada North	Nevada South	Arizona	Mexico	Ports
Northern counties	23,800	14,250	0	0	10	260
SACOG area	30	2,280	180	0	0	50
AMBAG area	1,350	48,480	30	30	10	1,210
Central California	2,580	5,530	120	150	50	7,710
Los Angeles	130	140	110	130	50	1,070
Remainder of SCAG area	650	3,050	1,330	720	170	2,810
SANDAG area	180	350	39,850	45,420	42,920	43,690
Total	10	30	1,190	5,810	98,450	3,630

Table 5-3 External Vehicle Trips by Gateway and Year

Ext. Zone	Location	Daily Traffic Volumes						
		2000	2010	2015	2020	2035	2040	2050
1	US 101 – N. Smith River	6,400	6,980	7,530	8,060	9,710	10,300	11,470
2	US 199 – N. Patrick Creek	2,700	3,100	3,390	3,670	4,520	4,820	5,410
3	Indian Creek Road	100	100	110	110	130	140	160
4	I-5 – N. Hilt	12,590	12,570	14,060	15,390	19,430	20,820	23,620
5	US 97 – N. Dorris	3,830	3,940	4,460	4,900	6,260	6,730	7,670
6	Cal 139 – N. Tulelake	2,990	2,690	2,950	3,190	3,930	4,190	4,710
7	Cal 50 – S. Main (Ore)	100	100	110	110	130	140	160
8	Muldoon Rd / Westside Rd	100	100	110	110	130	140	160
9	US 395 – N. New Pine Creek	870	850	920	980	1,190	1,260	1,410
10	Surprise Valley Road	100	100	110	110	140	140	160
11	Cal 299 – E. Cedarville	210	180	190	200	240	250	280
12	Cal 81 – S. Eagleville	100	100	110	110	140	140	160
13	Wendel Rd / Summers Rd	100	100	110	110	140	140	160
14	US 395 – N. Lemmon Valley (Nev)	8,750	8,140	8,700	9,310	11,200	11,870	13,210
15	15 miles N. of 80 / 89	100	100	110	110	140	140	160
16	I-80 – W. Reno (Nev)	24,940	23,630	26,040	28,320	35,290	37,730	42,590
17	Cal 28 – E. Kings Beach	13,550	10,890	11,620	12,350	14,640	15,470	17,110
18	US 50 – N. South Lake Tahoe	26,080	24,690	26,170	27,810	32,900	34,730	38,400
19	Cal Cal 88 – N. Paynesville	2,920	3,820	4,070	4,350	5,210	5,520	6,140
20	US 395 – S. Topaz Lake (Nev)	3,470	3,570	3,890	4,200	5,180	5,520	6,210
21	State Highway 182	240	260	280	300	370	390	430
22	Cal 167 – E. Mono	80	90	100	100	120	130	140
23	US 6 – N. Benton	890	920	1,030	1,120	1,420	1,520	1,730
24	Cal 266 – N. Oasis	70	90	100	100	120	130	140
25	Cal 266 – E. Oasis	80	130	140	150	180	190	210
26	N Hwy (Cal 267) – Death Valley	100	100	110	110	140	140	160
27	Daylight Pass Rd (Cal 374)	100	100	110	110	140	140	160
28	Cal 127 – N. Death Valley Junction	670	620	690	760	970	1,040	1,180
29	Ash Meadows Rd	100	100	110	120	140	150	160
30	Cal 178 – W. Pahrump (Nev)	710	750	810	870	1,050	1,110	1,240
31	I-15 – N. Mountain Pass	35,000	39,500	43,330	47,010	58,280	62,230	70,120
32	Nipton Rd (Cal 164) – E. Nipton	100	100	110	110	140	140	160
33	US 95 – N. Arrowhead Junction	2,800	3,300	3,580	3,860	4,710	5,010	5,610

Ext. Zone	Location	Daily Traffic Volumes						
		2000	2010	2015	2020	2035	2040	2050
34	US 95 – E. Laughlin	100	100	110	110	140	140	160
35	I-40 – W. Topock (Nev)	11,520	11,930	14,610	16,630	22,710	24,760	28,850
36	Parker Dam (N. Parker)	100	100	110	110	130	140	160
37	Cal 62 – Earp	4,500	6,000	6,630	7,200	8,930	9,530	10,740
38	Agnes Wilson Rd E. 95 (S. of Earp)	100	610	650	690	820	870	960
39	I-10 – E. Blythe	19,760	22,970	26,150	28,790	36,840	39,600	45,140
40	E. Laguna Rd (Imperial Dam)	100	100	110	110	130	140	160
41	S. 4th Ave – Yuma	100	100	110	110	130	140	160
42	Highway 186 – Mexican-Yuma	5,180	7,950	8,390	8,910	10,530	11,120	12,280
43	Cal 111 – Calexico	40,220	26,580	28,330	30,250	36,180	38,290	42,500
44	Cal 188 – Tecate	5,470	5,660	6,010	6,400	7,600	8,040	8,900
45	I-5 – San Diego	109,000	74,000	78,020	82,620	96,940	102,120	112,490
46	I-8 – Yuma	13,080	14,810	16,270	17,610	21,720	23,150	26,020
47	Collina del Sol (Cal 905)	30,850	24,240	25,640	27,260	32,290	34,090	37,690
48	Cal 7 – Calexico	9,180	7,700	8,220	8,800	10,570	11,190	12,440
49	Long Beach (Port)	23,691	25,090	30,280	34,410	46,780	50,910	59,160
50	Los Angeles (Port)	25,864	27,390	33,060	37,560	51,070	55,570	64,580
51	Oakland (Port)	10,470	12,030	14,520	16,500	22,430	24,410	28,360
53	Otay Mesa East (open 2016)	0	0	4,450	5,810	9,870	11,230	13,940

A. CSTDM09 ETM Documentation

CSTDM09 – California Statewide Travel Demand Model

Model Development

External Travel Model

Final System Documentation: Technical Note

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1. Introduction

This technical note describes the External Travel Model (ETM), which is one of the five components of the California Statewide Travel Demand Model (CSTDM09). The ETM is designed to reflect road vehicle trips entering or exiting California, along every state border, including the border with Mexico. It also includes additional travel originated from the three major seaports of California.

This document describes the theoretical and mathematical basis of the model, with the description of the equations and proportions used. The integration of this model in the CSTDM model system is described in the documents “Model Overview” and “User Guide”, which also contains more information on the operation of the model..

2. Nature of external travel

External travel into and out of California can be considered along several dimensions, including the direction, the vehicle used, and the border crossing that is used. In total, approximately 500,000 vehicles enter or exit California on a typical fall weekday. This can be compared to the approximately 97 million short distance personal trips (under 100 miles). Figure 1 shows the breakdown between the five model components of the CSTDM09, revealing the external travel as the smallest of the components; roughly 0.4% of the total number of trips. It must be noted, however, that external travel contains a large number of long distance trips, producing a higher share of VMT. External travel is focused on a small number of facilities, and is partially comprised of heavier commercial vehicles; about 23% of trips are by medium or heavy trucks.

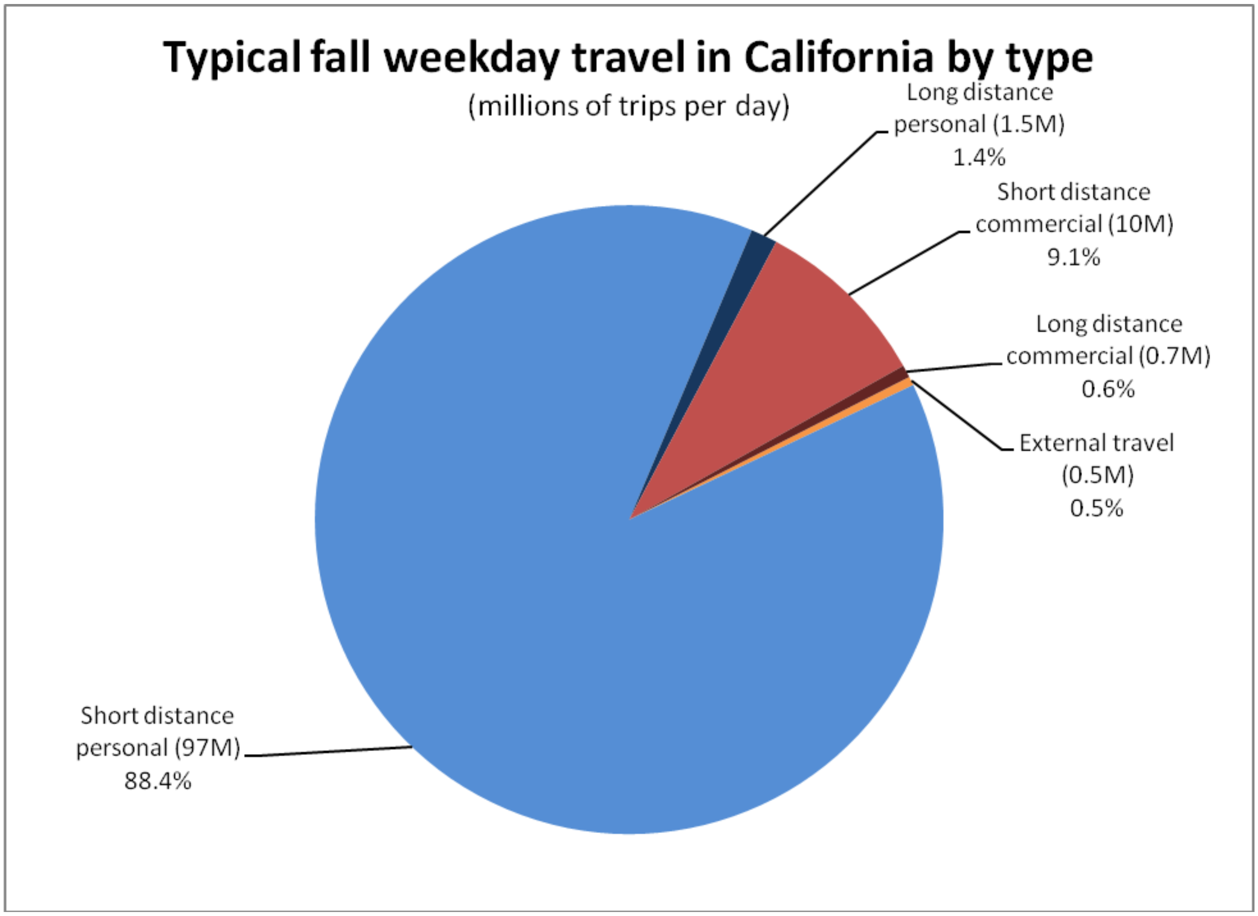


Figure 1: Breakdown of Travel in California

2.1 Segmentation

In the ETM, the total set of external travel is divided into five segments, by vehicle type and by purpose. These are:

- **Car Local**: Passenger vehicles being used to make short distance trips, crossing the California border but being based nearby. These vehicles are somewhat analogous to the travel covered in the Short Distance Personal Model. The two main concentrations of this kind of traffic are in the Tahoe Basin area and between San Diego and Tijuana.
- **Car Long**: Passenger vehicles being used to make long distance trips, from more distant locations outside the state and/or to distant points within California. These vehicles are analogous to the Long Distance Personal Model. Examples

might include travel from Oregon to San Francisco or Sacramento, or travel from Los Angeles to Las Vegas or Phoenix. These vehicles include both persons driving for business purposes, as well as pleasure travel – the latter is the most common.

- **Medium**: Medium commercial vehicles are also called “Single Unit” vehicles; this is the same category as used in the Short Distance Commercial Vehicle Model and Long Distance Commercial Vehicle Model.
- **Heavy**: Heavy commercial vehicles are tractor-trailer units, and are the same categorization as used in the SDCVM and LDCVM.
- **E-E**: External to External (E-E) vehicles are those travelling from one California external border station to another, without stopping in California. These are uncommon, particularly for personal travel, so the E-E vehicles used here represent only commercial freight hauling. Due to the long distances involved, it is assumed that loads will be aggregated for efficiency, and that therefore only heavy commercial vehicles will be used for these movements.

2.2 External Stations

The ETM has 51 external stations, located at every significant border crossing of California and at the major ports of Los Angeles, Long Beach, Oakland and Richmond. The 48 road crossings are the same as used in the previous (Dowling Associates) statewide model.

The external stations were classified into six districts: one for crossings on the California/Oregon border, one on the northern part of the California/Nevada border (south to, and including, US Highway 6 near Benton), one for the southern part of the California/Nevada border (starting at State Highway 266 near Oasis), one for the California/Arizona border, one for the California/Mexico border, and one for the ports. These external districts were used for both model preparation and calibration.

3. Model Design

The ETM is a disaggregate microsimulation model, using exogenous inputs for generation, a logit model for destination choice, and observed shares for the remainder of the aspects of the model. The output of the ETM is a list of trips, in the same format as the other lists of trips produced by the other components of the CSTDM09 system. Each row in the output file represents a trip, with the various properties (vehicle mode, origin TAZ, destination TAZ, time period, etc). The only difference between the outputs of the ETM and other portions of the CSTDM09 system is that the ETM produces trips for which one or both of the origin and destination TAZ are at external stations, where the remainder of the CSTDM09 produces travel that starts and ends at internal zones.

3.1 Generation

Trips are generated at each external station individually. The total number of external vehicle crossings is required as a model input. By definition, an external model deals with the world outside the CSTDM09, so the external crossings are an exogenous input.

Each external station takes a single volume, which represents 24 hour typical fall bidirectional volume. The current values are the 2007 AADT.

The microsimulation iterates through each external station, and for each external station starts by using the volume as the number of individual movements to produce. Each individual crossing is then assigned the detailed properties, such as the vehicle type, in the next steps.

3.2 Direction Choice

Each trip is assigned a direction, either inbound to California (external to internal, or E-I), outbound from California (internal to external, or I-E) or through California without stopping (external to external, or E-E). This is calculated based on a probability supplied to the model. In most cases, the probability is 50% I-E, 50% E-I and 0% E-E. Major freeway facilities have a nonzero E-E proportion; it is assumed that vehicles travelling across California will use the high speed freeways rather than small local roads to do so. In these cases, the I-E and E-I should be equal, to create a balanced flow of vehicles into and out of California. (If the flow was 51% I-E and 49% E-I, in about seven years there would be no more motorized vehicles in California.)

E-E flows are automatically assumed to be equally bidirectional; for instance, in 2008, 3.4% of the crossings are E-E at external station 39, I-10, which crosses the California-Arizona border at Blythe. For this station, 1.7% of the total trips will be E-E entering California at Blythe, and 1.7% will be exiting California. This produces an automatic balancing effect; if the flows at this crossing are expected to double (say, due to rapid growth in the Phoenix area), then there will be a 50% increase in each direction.

3.3 Segment, Party Size, and Mode Choice

There are, as described in section 2.1 above, five segments. The E-E flows are one of them, so the segment choice is implicit in a flow being an E-E flow. The other four segments, Car Long, Car Local, Medium and Heavy, are selected using observed probabilities for each choice.

Because the output of the ETM is intended to be in the same format as the other models, the ETM needs to produce person trips, rather than vehicle trips. When the chosen mode is Medium or Heavy, one vehicle trip is the same as one person trip. However, Car Local and Car Long segments can have more than one person in the vehicle; thus they may produce more than one person trip, as they may be different modes: Single Occupant Vehicle (SOV), High Occupancy Vehicle with two people (HOV2) or High Occupancy Vehicle with 3 or more people (HOV3).

For crossings assigned to the Car Local and Car Long segments, an additional choice model selects a party size from one to eight people, based on observed probabilities. If the party size is one, then the mode becomes SOV; if the party size is two, then the mode becomes HOV2; otherwise, the mode is HOV3. The trip will be written out once for each person in the party; a two person party will produce two rows in the output record, in the same way that each person in a household in the Short Distance Personal Travel Model (SDPTM) produces travel records for all of their trips, even if they may be travelling together.

3.4 Destination Choice

The destination choice model is a logit choice function; the model takes the form:

$U_j = w \times \ln(A_j) + c \times cost_{ij}$

Where:

- U_j is the utility of choosing zone j as a destination
- w is a weighting factor applied to the attractiveness of zone j
- A_j is the attractiveness of zone j
- c is the scale factor for the cost of travel
- $cost_{ij}$ is the cost of travel from i to j

The cost is taken as the network travel distance to the prospective destination zone, in miles. The attractiveness is a zonal measure of the "size" of the zone; how much activity is in the zone that may serve to attract travelers, and is dependent on the market segment, with cars being attracted to population and employment, particularly retail employment, and trucks being attracted to employment alone, in particular to transportation and wholesale employment.

With the utilities for each of the possible destination zones calculated, the probability of selecting a given zone j is: $P_j = e^{Uj} / \sum e^{U}$

These probabilities are then used to select a specific zone.

3.5 Time of Day

The time of day is determined based on observed probabilities; these are specified for each crossing and reflect all travel in each direction by all vehicle types.

4. Model Development

4.1 Generation

The external trip generation is exogenously defined. The 2007 observed AADT count totals are currently used. This can be scaled for future years as appropriate. The model treats all external crossing points as bidirectional locations, so any changes in future volume produce a balanced response in both directions.

4.2 Freight Analysis Framework Districts

To produce external to external volumes (and for a number of the other development and calibration aspects of this model), the 2002 Freight Analysis Framework (FAF) data was used. FAF reports five areas for California; the Los Angeles area (including the Inland Empire of Riverside and San Bernardino counties), the San Francisco Bay area, the Sacramento area, San Diego county and the rest of the state. These are shown in Figure 2 below.

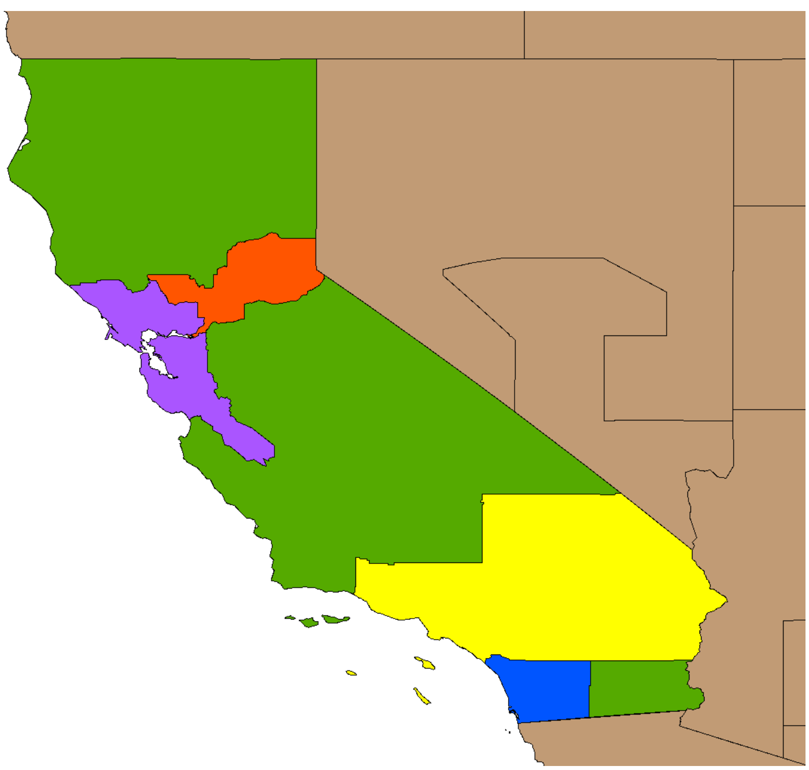


Figure 2: Freight Analysis Framework Districts in California

For a number of purposes, the remainder of the US was classified based on the external border that would most likely be crossed to access it (as based on Google Maps); this varies by California origin. These are called FAF Crossing Districts in this report. For instance, travel between Denver and Los Angeles would be made by I-15 crossing at the southern Nevada border, but travel between Denver and San Francisco would take I-80 and cross the northern part of the Nevada border. Figure 3 below shows FAF geography grouped into crossings from Los Angeles (shown in dark green); blue represents areas accessed by crossing the Oregon border, yellow represents areas accessed by crossing the northern Nevada border, orange southern Nevada, purple Arizona and brown Mexico.

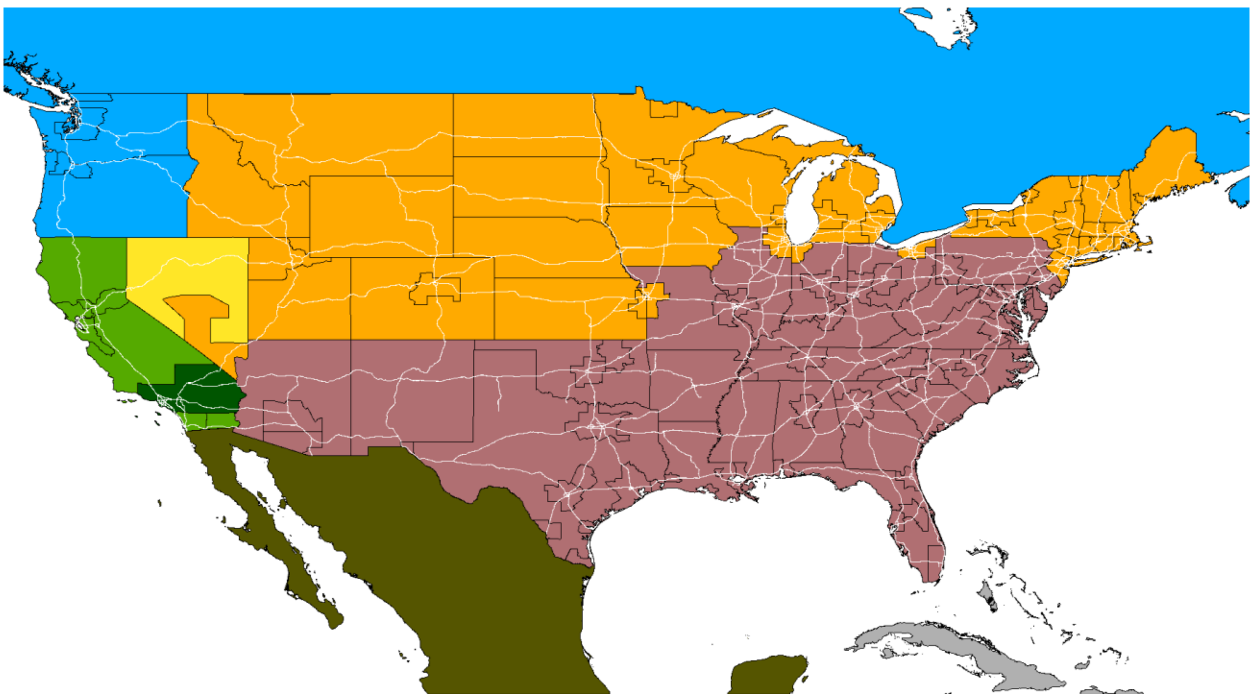


Figure 3: Freight Analysis Framework Crossing Districts

4.3 External – External Volumes

External to external (E-E) movements are those travelling through California, without stopping. While these could be commercial or personal travel, a preliminary investigation revealed that these comprised around 1.2% of personal external trips, but closer to 8.7% of commercial external trips. For this reason, it was decided to only include external to external movements of commercial vehicles. Because of the long distances involved, all E-E movements were assumed to use heavy commercial vehicles, due to their greater efficiency.

These E-E movements can be classified in three groups;

- Vehicles entering California from Mexico, bound for the remainder of the United States,
- Vehicles carrying goods between the major ports in California and the remainder of the United States, and
- Through movements of domestic shipments, which in the case of California are between the Northwest states of Washington and Oregon and the Southwest states of Nevada and Arizona.

These three segments generally correspond to three different FAF tables; the flows from Mexico correspond to the FAF land border crossing table, the flows from the ports corresponds to the FAF water border crossing table, and the Northwest/Southwest through flows corresponds to the FAF domestic flow table.

For the flows from Mexico, the FAF land border table was used to produce a split of crossings by combined bidirectional truck tonnage, from the CA-San Diego and CA-Remainder FAF areas to the aggregated FAF Crossing Districts as described in section 4-2. In this case, CA-Remainder is clearly Imperial County, so the FAF Crossing District was developed based on this. External stations along the Mexican border had the heavy vehicle flows split by these proportions, which are described in Table 1 below.

Table 1: Proportion of Truck Tons of Freight Entering California from Mexico, by FAF Crossing District

FAF Crossing District	Imperial	San Diego
Internal to California	86.1%	91.8%
Oregon border	0.8%	1.0%
Nevada northern border	0.0%	0.0%
Nevada southern border	0.2%	1.3%
Arizona border	12.9%	5.9%

For the flows from the ports, the FAF water border table was used. Again, a split by combined bidirectional truck tonnage was developed, with the CA-Los Angeles and CA-San Diego areas assigned to the ports of Los Angeles and Long Beach, and the other areas assigned to the port of Oakland, and the FAF Crossing Districts based on these locations. These ports had the heavy vehicle flows split by these proportions, which are described in the table below.

Table 2: Proportion of Truck Tons of Freight Entering California at Ports, by FAF Crossing District

State exit	Oakland	Los Angeles / Long Beach
Internal	88.9%	87.9%
Oregon border	1.6%	1.0%
Nevada northern border	4.9%	0.0%
Nevada southern border	0.8%	4.0%
Arizona border I-40	1.5%	4.4%
Arizona border I-10	2.4%	2.6%

For the Northwest / Southwest through flows from Washington or Oregon to Arizona or Nevada, the FAF domestic table of truck tonnage for the areas in these four states was combined with the import/export tables from the land border port of Blaine, Washington and the seaport activity at Seattle and Portland. Each of the possible pairs of FAF areas was investigated using Google maps to determine the most likely path. The "remainder of state" areas were assumed to be going to the largest cities in those remainders (Spokane WA, Eugene OR, Reno NV and Flagstaff AZ). For some of these cases, the route suggested didn't enter California, often taking US-93 through eastern Nevada; in these cases, the E-E flow is clearly not involved in California travel and was not included. In all cases where the flow passed through California, Interstate 5 was the crossing point used for the Oregon border. The routes used for the Nevada/Arizona border crossings are summarized in Table 3 below.

Table 3: Routes Used for the Nevada/Arizona Border Crossings

	Seattle	Blaine WA	Rest of WA	Portland	Rest of OR
Las Vegas					I-15
Rest of NV	US 395	US 395		US 395	US 395
Phoenix	I-10	I-10		I-10	I-10
Tucson	I-10	I-10		I-10	I-10
Rest of AZ				I-40	I-40

With the appropriate external station pairs established for these Northwest to Southwest crossings, the total volumes (which are in annual kilotons of freight) were converted into daily truck crossings. Because FAF reports total tonnage by truck for the Mexican border and for the port entries, and because there are observed counts at these areas, a conversion factor from annual kilotons to daily heavy vehicles could be developed. For Mexico, this was 0.353, and for the ports, this was 0.377. These values are fairly consistent, and the average, 0.365, was used to convert the annual kiloton of freight flows for these NW/SW through movements into vehicle trips.

The E-E component uses a fixed proportion split from each external station to each other possible station. Because of the long distances involved in travel through California, it is reasonable to assume that only major highways will be used. The external gates with assigned E-E flows are the ports and all six Mexican border crossings, as well as the interstate highways. Additionally, US 395 at Cold Springs, NV was used for the specific case of flows from the Pacific Northwest to the "Rest of

Nevada" FAF area, which was assumed to be Reno. Table 4 below shows overall base year external to external daily trips.

Table 4: Overall Base Year External to External Daily Trips

Daily trips		OR	NV			AZ			Mexico						Port		
		I-5	US 395	I-80	I-15	I-40	I-10	I-8	SR 186	SR 111	SR 7	SR 188	SR 905	I-5	LB	LA	Oak
OR	I-5	0	225	0	20	10	340	0	5	5	5	5	10	5	85	95	40
NV	US 395	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	I-80	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	110
	I-15	20	0	0	0	0	0	0	5	5	5	5	10	5	340	370	20
AZ	I-40	10	0	0	0	0	0	0	0	0	0	0	0	0	370	405	35
	I-10	340	0	0	0	0	0	0	0	0	0	0	0	0	220	240	55
	I-8	0	0	0	0	0	0	0	15	25	55	10	40	25	0	0	0
Mex	SR 186	5	0	5	5	0	0	15	0	0	0	0	0	0	0	0	0
	SR 111	5	0	5	5	0	0	25	0	0	0	0	0	0	0	0	0
	SR 7	5	0	5	5	0	0	55	0	0	0	0	0	0	0	0	0
	SR 188	5	0	5	5	0	0	10	0	0	0	0	0	0	0	0	0
	SR 905	10	0	5	10	0	0	40	0	0	0	0	0	0	0	0	0
	I-5	5	0	5	5	0	0	25	0	0	0	0	0	0	0	0	0
Port	Long Beach	85	0	5	340	370	220	0	0	0	0	0	0	0	0	0	0
	Los Angeles	95	0	5	370	405	240	0	0	0	0	0	0	0	0	0	0
	Oakland	40	0	110	20	35	55	0	0	0	0	0	0	0	0	0	0

4.3 Segment Choice

The ETM comprises five segments; the external to external flows have been described in section 4.2. The remaining four segments are heavy trucks, medium trucks, long distance car and local car. Observed count data from the Caltrans website for 32 of the 51 locations contains the observed split of trucks versus cars, and also the observed split of 4+ axle trucks within this, which is consistent with the heavy truck / medium truck classification. For the remaining 17 low volume road locations, the averages from the five available counts with the lowest volumes were used, rounded to the nearest 5%.

For the ports, available studies from the ports of Los Angeles and Long Beach suggested a PCE of 1.68, consistent with a 30%/70% medium/heavy vehicle proportions (assuming medium PCE of 1.0 and heavy of 2.0). This was checked with an aerial imagery based classification count of the Pier T containerized shipping facility of the Port of Long Beach. Port traffic, for the purposes of imports and exports to California is assumed to be done entirely by trucks; the car traffic of the ports should come primarily from the workers, which will be represented in the Short Distance Personal Travel model.

With the heavy / medium / light (car) vehicle split defined, the remaining task for segment choice is to split the car volumes into local and long distance. The 2001 National Household Travel Survey (NHTS) was analyzed to identify long distance auto trips into California; the long trip (over 100 mi) database included trip origin and destination MSAs, which were assigned to border crossings in the same way as the FAF division described in section 4.2. These expanded person trips were adjusted to reflect vehicle trips (through occupancy) and to represent October weekday crossings. This produced a set of expected long distance auto crossings for each of the five border segments.

Interstate highways, as the major long haul routes, were assumed to be 5% local and 95% long distance, with the exception of I-5 on the Mexico border. The two sites of major local commutes, the San Diego/Tijuana area and the Lake Tahoe area were assumed to be mostly local traffic; 90% local on I-5 and SR 905 in San Diego, 90% local on SR 28 on the north shore of Lake Tahoe, and 95% local on US 50 passing right through the South Lake Tahoe / Stateline urban area. The remaining facilities had local/long distance proportions adjusted to roughly match the NHTS data, which resulted in 10% local traffic along the Oregon, southern Nevada and Arizona borders, with 60% local along the northern Nevada border and 40% along the Mexico border. The match to observed data is shown in the figure below.

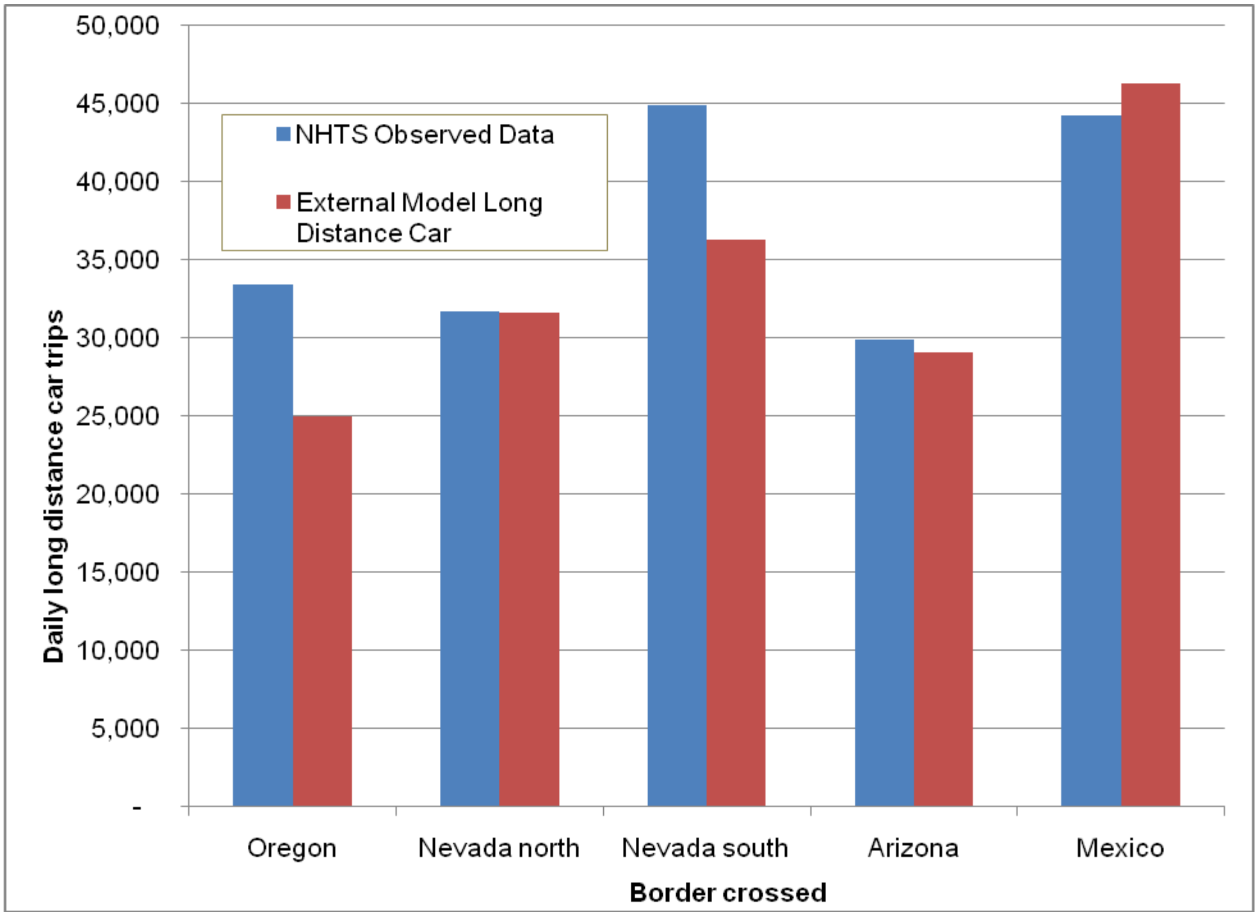


Figure 4: Model to Observed Match at Border Crossings

4.4 Party and Mode Choice

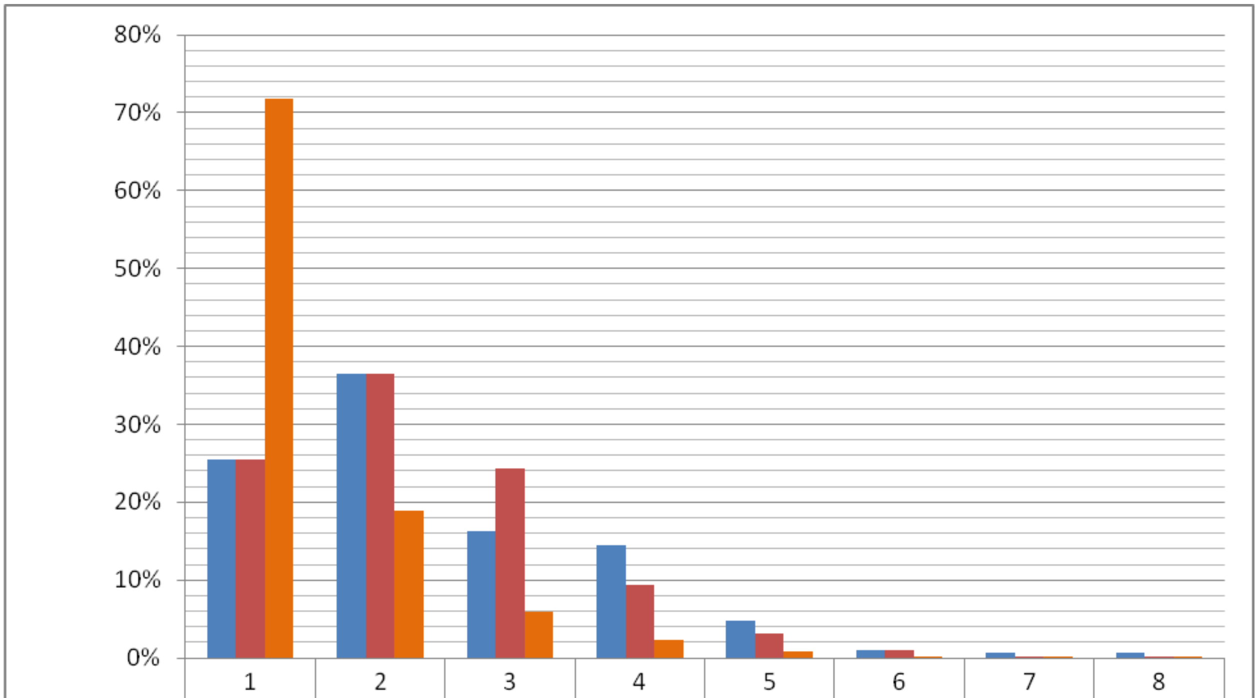
The choice of mode is mainly determined by the segment choice. As described earlier, E-E through flows are limited to freight and assumed to be heavy trucks. For the medium and heavy truck segments, the segment and mode are identical. The only possible mode choices are for the local and long distance car segments.

The CSTDM09 model system is designed to operate using person trips rather than vehicle trips, so the two car segments need to be converted into person trips from vehicle trips.

The first step in assigning a mode is choosing a party size. The party size is the number of persons travelling in the vehicle, and was limited to the range of 1 to 8 persons. (There were very few observations for parties of 6 or more, so the limit of 8 is reasonable.)

For Car Local trips, the split uses the observed data from the combined Travel Behavior Datasets, which are also used in the estimation of the Short Distance Personal Travel Model. This split is roughly 70% SOV, 20% HOV 2 person, with the remaining 10% in HOV 3+, with party sizes from 3 to 8 persons. This is consistent with 'typical' daily in-city travel, and with the Car Local segment.

For Car Long distance trips, the base split between SOV, HOV2 and HOV3+ (the three passenger auto modes represented in the CSTDM09 system) was determined using observed data from the 2001 NHTS. However, the party size distribution for HOV3+ for the NHTS is very different from the observed short distance party sizes seen in the combined Travel Behavior Datasets and thus the Short Distance Personal Travel Model (SDPTM). To avoid having HOV3+ person trips with two different conversion rates to vehicle trips, the HOV3+ party sizes were adjusted to match the distribution seen in the SDPTM. (The NHTS reported a roughly 40%/40%/20% split of 3, 4 and 5+ person party sizes, where the SDPTM datasets have a 65%/25%/10% split.) These party sizes are summarized in the figure below.



	1	2	3	4	5	6	7	8
NHTS	25.4%	36.5%	16.4%	14.5%	4.8%	1.0%	0.7%	0.7%
Car Long	25.4%	36.5%	24.3%	9.4%	3.1%	1.0%	0.2%	0.1%
Car Local	71.9%	18.9%	5.9%	2.3%	0.8%	0.2%	0.1%	0.0%

Travelling party size

Figure 5: Party Size

Once a party size is determined, the mode is also known. The only remaining step is to write out a suitable number of person trips to the output trip list. If the chosen party size is 5, for instance, then 5 records of HOV3+ person travel will be created (as seen in the chart above, the probability of this occurring is 3.1% for long distance car trips, and 0.8% for short).

4.5 Destination Choice

The destination choice model is a logit choice function; the model takes the form:

$U_j = w \times \ln(A_j) + c \times cost_{ij}$

Where:

- U_j is the utility of choosing zone j as a destination

- w is a weighting factor applied to the attractiveness of zone j
- A_j is the attractiveness of zone j
- c is the scale factor for the cost of travel
- $cost_{ij}$ is the cost of travel from i to j

The cost is taken as the network travel distance to the prospective destination zone, in miles. Because of the long distances involved and the relatively small changes in distance by time of day or by mode, for the sake of simplicity, the freeflow HOV3 distance is used across all segments. The attractiveness is determined based on a function that weights the aspects of a zone that may attract travel. These underlying functions were derived based on studies done at the boundary of Calgary for the car based travel, and at the boundary of Edmonton for commercial vehicles. This underlying behavior is seen as transferrable -- especially as attractiveness is a relative measure for comparing different zones -- with calibration done to match the observed data available for California.

For both kinds of auto travel, the function used is:

Attractiveness = population

+ 2.0 × total employment

+ 4.0 × retail employment

This provides a roughly even balance between the attractiveness of residential and employment areas (as the number of persons is roughly double the number of jobs in California), with additional attractiveness to areas of high retail employment, which include shopping districts, tourist attractions and airports.

For medium commercial vehicles, the function used is:

Attractiveness = Industrial Employment

+ 2.433 × Wholesale Employment

+ 0.635 × Retail Employment

+ 0.140 × Service Employment

+ 2.197 × Transport Employment

For heavy commercial vehicles, the function used is:

Attractiveness = Industrial Employment

+ 1.255 × Wholesale Employment

+ 0.085 × Retail Employment

+ 0.078 × Service Employment

+ 3.331 × Transport Employment

It can be seen that medium and heavy commercial vehicles are attracted to employment, especially wholesale and transport employment. Heavy industrial areas, especially transport and warehouse hubs, would be expected to attract a lot of external commercial vehicle travel.

For each segment, a value of *w*, the attractiveness weight factor, and *c*, the travel cost factor need to be determined. For local car trips, with no other data sources available, these factors were based on model estimations of vehicles crossing the Calgary cordon (about 30 mi from the city). For long distance car trips, the NHTS data was used to establish a set of targets, and the values of *c* and *w* were established by calibration through multiple model runs.

For heavy commercial vehicles, the same calibration procedure was used, with FAF data to establish targets. Medium commercial vehicles were established as having the same *w* as heavy commercial vehicles, but with the parameter *c* established relative to the heavy commercial vehicle sensitivity using the models estimated on Edmonton data. These initial parameters were updated with doubled cost (c) as model validation revealed external trips were travelling much farther than expected and producing high volumes versus observed data. These final adjusted parameters are summarized in the

Table 5 below, followed by two figures illustrating the initial calibration fit versus the targets.

Table 5: Final Adjusted Parameters

Parameter	CarLocal	CarLong	Medium	Heavy
C	-0.06452	-0.03280	-0.01312	-0.00984
W	0.6589	0.6675	0.7327	0.7327

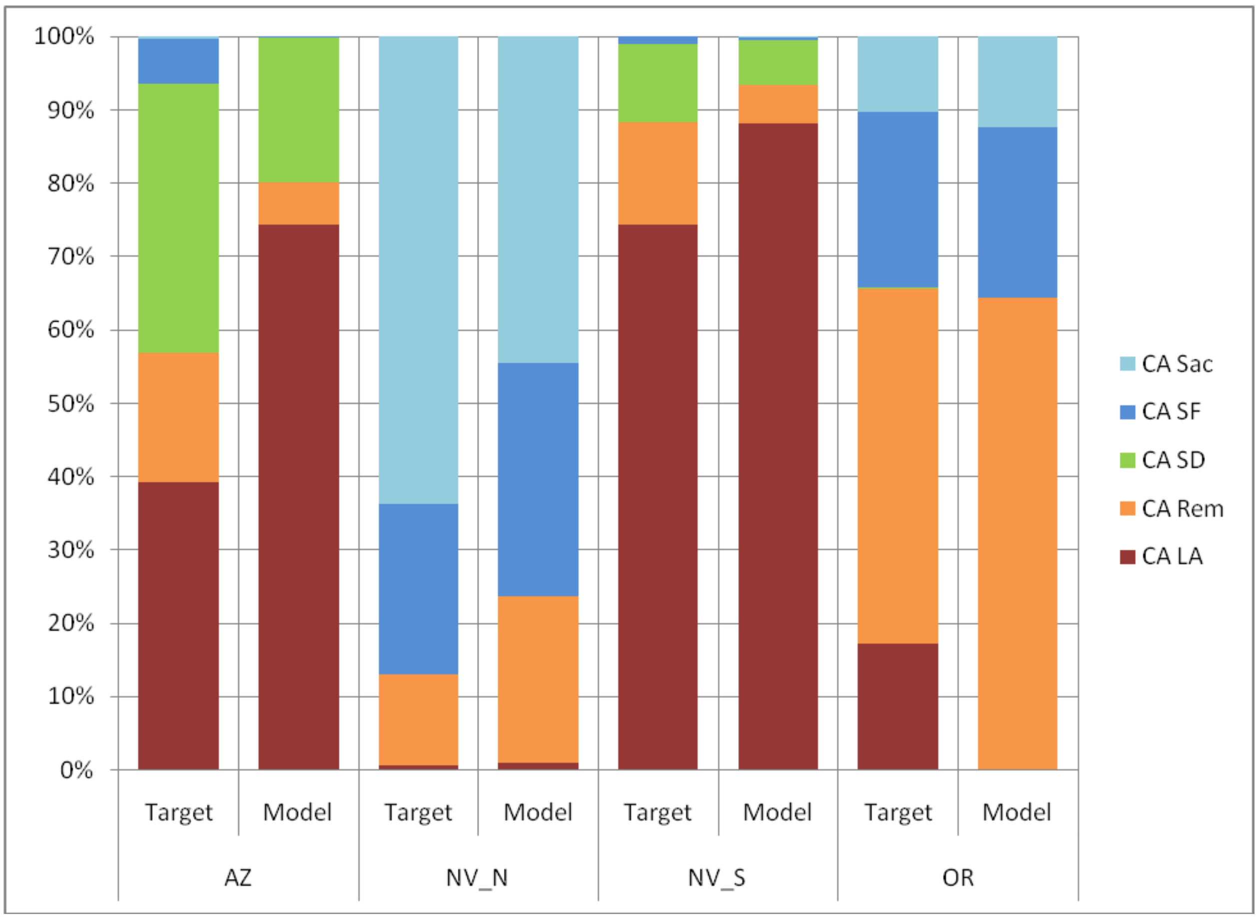


Figure 6: Long Distance Car Calibration Status

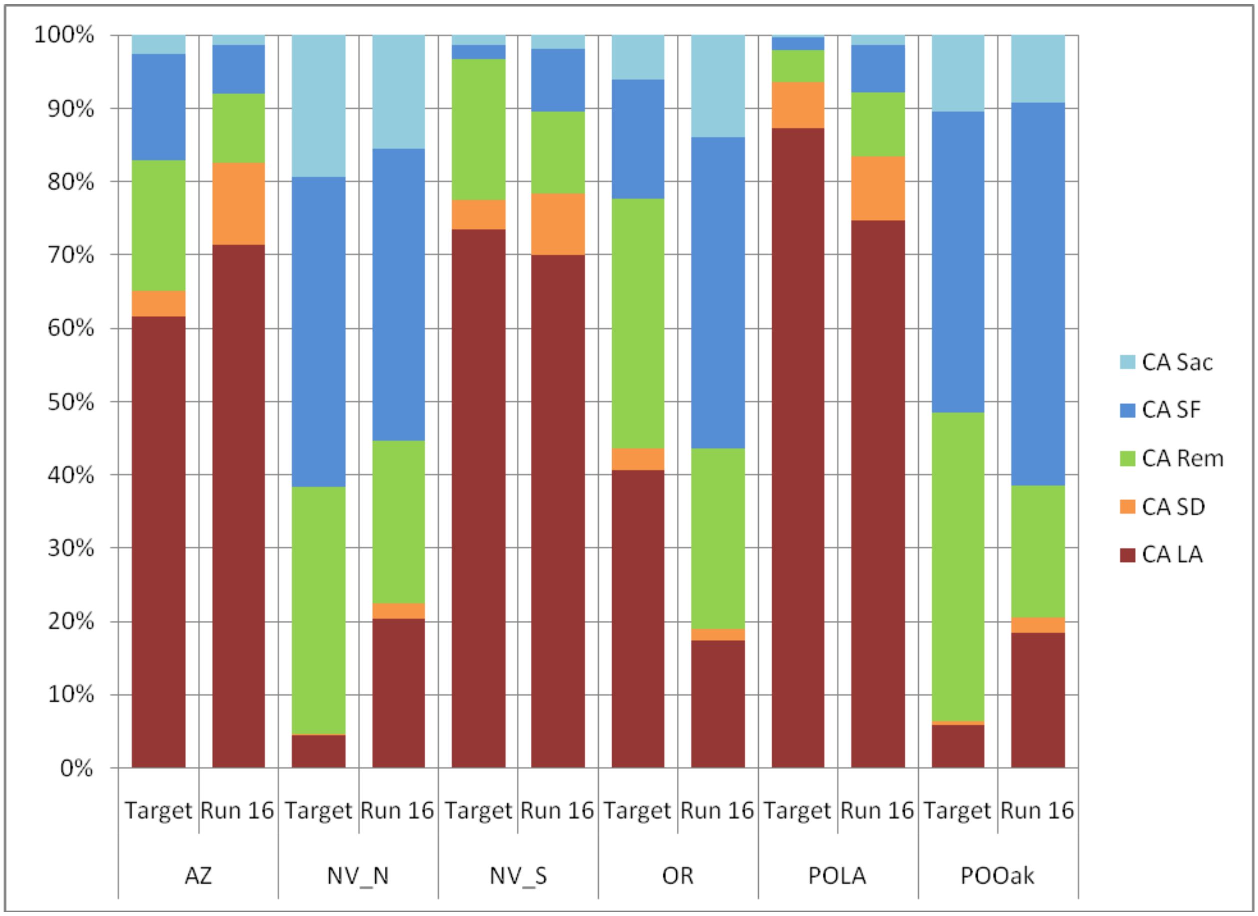


Figure 7: Heavy Truck Calibration Status

(note: POLA = Ports Of both Los Angeles and Long Beach)

With the utilities for each of the possible destination zones calculated, the probability of selecting a given zone j is: $P_j = e^{Uj} / \sum e^{U}$. For each external crossing, a full set of probabilities is calculated, and each trip is assigned a destination zone based on the probability matrix for the appropriate segment.

Note that the direction choice as described in section 3.2 is also considered here; in half of the cases (excluding E-E through movements), the direction will be E-I (external to internal) and the model described above will select an internal destination; in the other half of the cases (internal to external, or I-E), the model actually selects the origin. The functional forms and parameters are the same in both cases, and the E-I travel distance is used.

4.6 Time of Day

The time of day of travel currently uses observed proportions of time split. The border crossings use the observed time splits from counts provided by Caltrans. Where count data was not available, which was usually at low-volume locations, typical values observed on other stations were used. The ports use data derived from vehicle counts from of the Ports of Los Angeles and Long Beach. All counts are directional, with different splits supported for I-E and E-I travel, with E-E travel using the average of the two. (This is necessary in situations like the I-5 South border crossing, where a large traffic flow into San Diego in the morning and into Tijuana in the evening exists.) Some example splits are shown in the table below.

Table 6: Time of Day Splits by Crossing Type

Crossing	Offpeak Early (3-6 AM)	AM Peak (6-10 AM)	Midday (10 AM - 3 PM)	PM Peak (3 - 7 PM)	Offpeak Late (7 PM - 3 AM)
Ports	3.0%	21.8%	46.4%	26.3%	2.5%
All Other	3.0%	30.0%	30.0%	30.0%	7.0%

5. Preliminary Results

5.1. Status

The External Travel Model (ETM) is operational with the functions and parameters described in this technical note. The software, written in Python, uses standard network "skim" and zonal property files for the travel distances and attractors, and has a specific ".csv" format external input file specifying most of the values described above. The model generates approximately 870,000 trips (noting that for the two car segments, these are person trips).

5.2. Summary Statistics

The following three tables (7 to 9) summarize the travel by segment, by mode and by border crossing to each of seven internal regions, as shown in Figure 8, with the northern counties shown in green, SACOG in purple, AMBAG in brown, Central California in yellow, SCAG in blue (Los Angeles in darker blue) and SANDAG in pink. Note that this includes the origin zone regardless of whether it is the origin of an I-E trip or the destination of an E-I trip. These results are for the calibrated model, before the cost increase in the validation process.

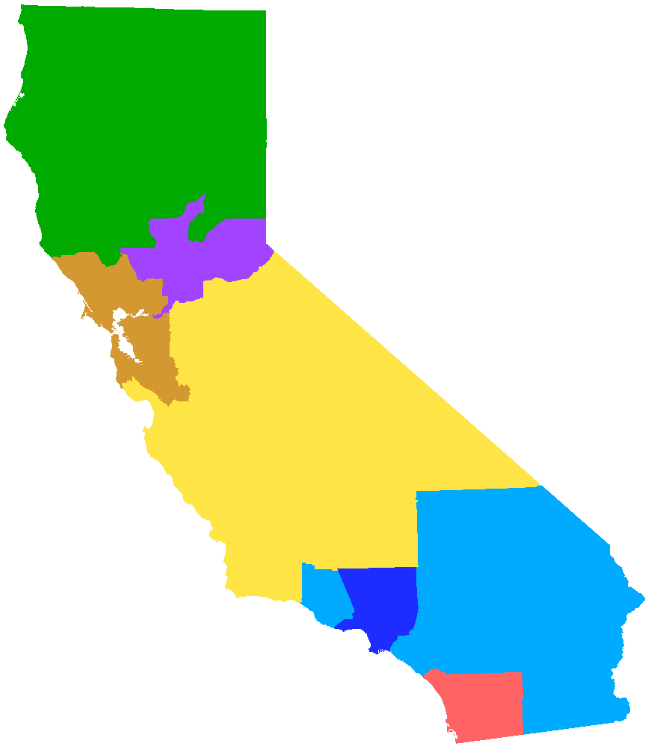


Figure 8: Seven Internal California Regions

Table 7: Distribution by Mode (Person Trips)

	SOV	HOV2	HOV3+	Medium	Heavy
Northern counties	9,400	16,400	28,300	800	1,000
SACOG area	26,400	29,800	43,600	1,600	2,700
AMBAG area	7,200	14,000	24,200	4,400	10,100
Central California	4,800	8,400	14,200	3,200	9,000
Los Angeles	16,500	33,600	60,100	12,200	24,100
Remainder of SCAG area	34,400	53,600	87,700	8,700	17,500
SANDAG area	71,900	73,100	100,300	3,600	6,300
Total	170,600	228,900	358,400	34,500	70,700

Table 8: Distribution by Segment (Vehicle Trips)

	Car Local	Car Long	Medium	Heavy
Northern counties	8,200	17,200	800	1,000
SACOG area	36,500	17,000	1,600	2,700
AMBAG area	5,200	15,700	4,400	10,100
Central California	4,700	8,200	3,200	9,000
Los Angeles	10,800	39,300	12,200	24,100
Remainder of SCAG area	36,500	49,100	8,700	17,500
SANDAG area	106,900	29,500	3,600	6,300
Total	208,800	176,000	34,500	70,700

Table 9: Distribution by Border Crossed (Person Trips)

	Oregon	Nevada North	Nevada South	Arizona	Mexico	Ports
Northern counties	37,200	18,000	0	100	0	400
SACOG area	9,000	92,900	300	400	100	1,400
AMBAG area	15,500	35,000	1,000	1,700	500	6,200
Central California	3,800	19,500	5,400	3,600	1,500	5,900
Los Angeles	800	1,500	41,000	37,500	44,400	21,300
Remainder of SCAG area	500	1,000	41,200	55,000	90,300	13,900
SANDAG area	100	200	5,900	22,300	222,100	4,500
Total	66,900	168,100	94,800	120,600	358,900	53,600

5.2. Graphical output

The Figures 9 and 10 show the trips produced in a run of the model; one dot represents an internal trip end. The colors representing the border crossed can be seen in Table 10.

Table 10: Colors Representing the Border Crossing

Figure	Border	Color
1	Oregon	Green
1	Nevada	Yellow
1	Arizona	Orange
1	Mexico	Pink
2	Port of Oakland	Teal
2	Ports of Los Angeles & Long Beach	Blue

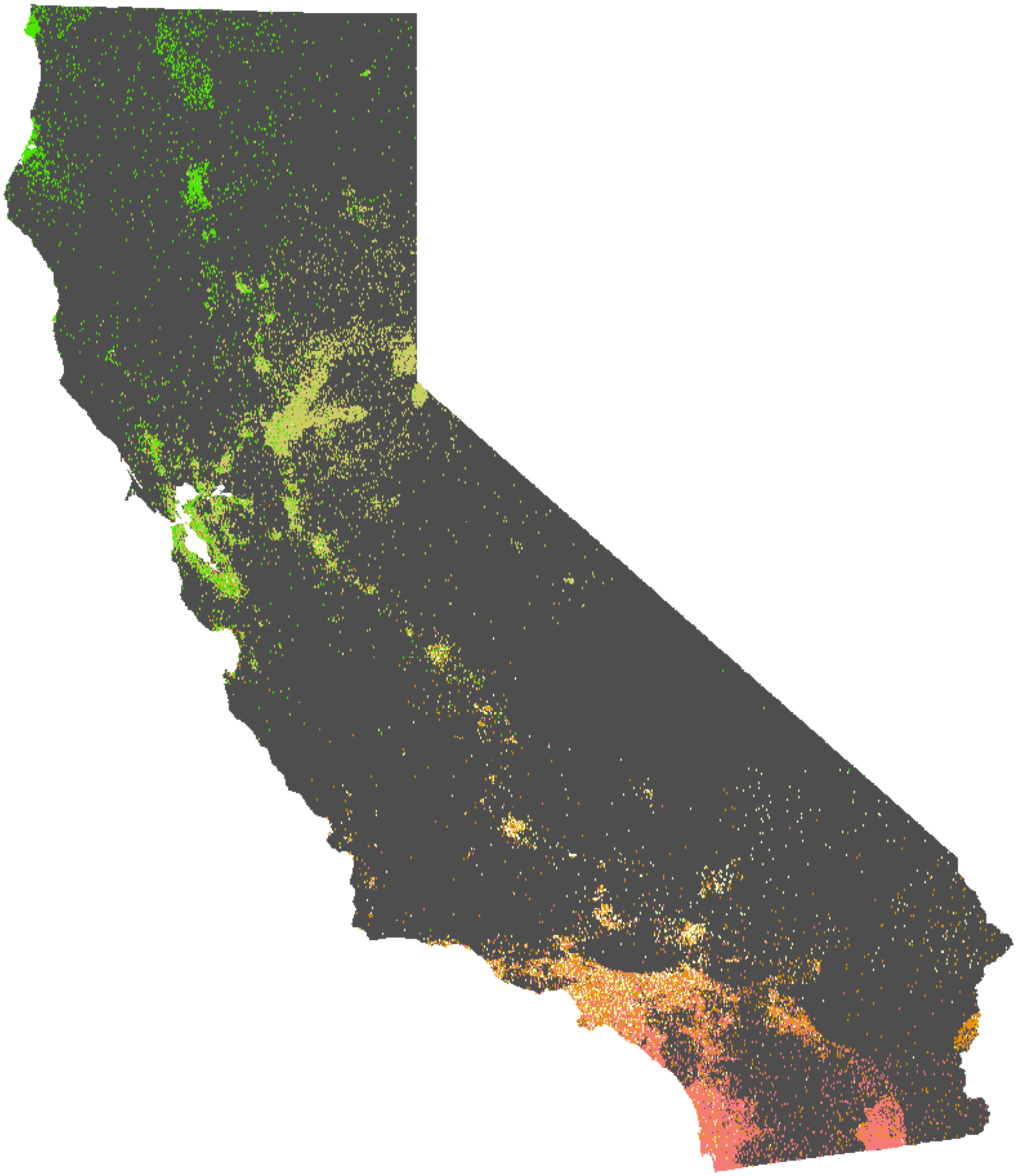


Figure 9: Example Distribution of External Travel (Land Borders)

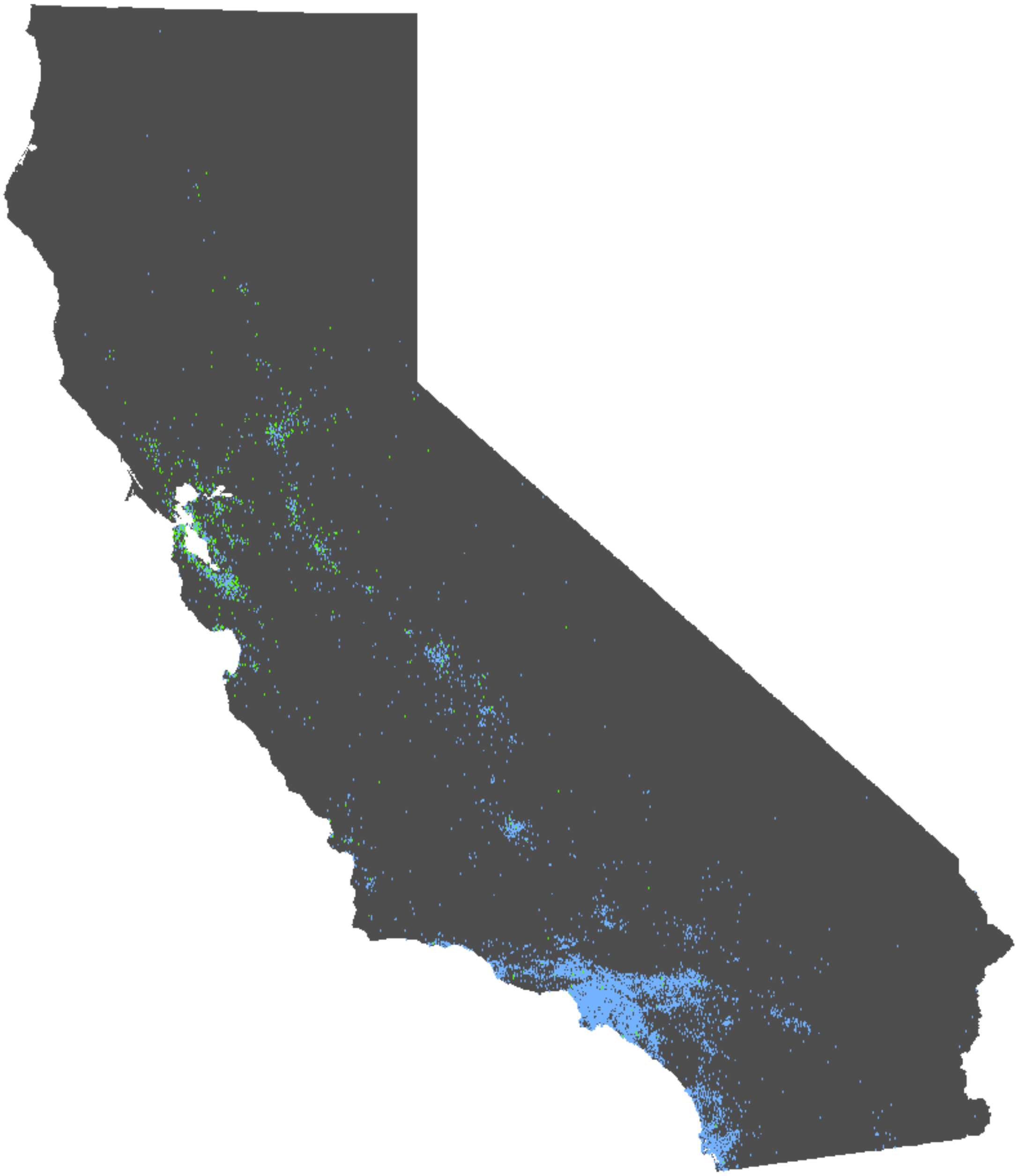


Figure 10: Example Distribution of External Travel (Ports)