CSTDM09 – California Statewide Travel Demand Model

Model Development

External Travel Model

Final System Documentation: Technical Note

ULTRANS
Institute of Transportation Studies, UC Davis
Davis, California

HBA Specto Incorporated
Calgary, Alberta

May 2011

Table of Contents

Tables:

Figures:

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.

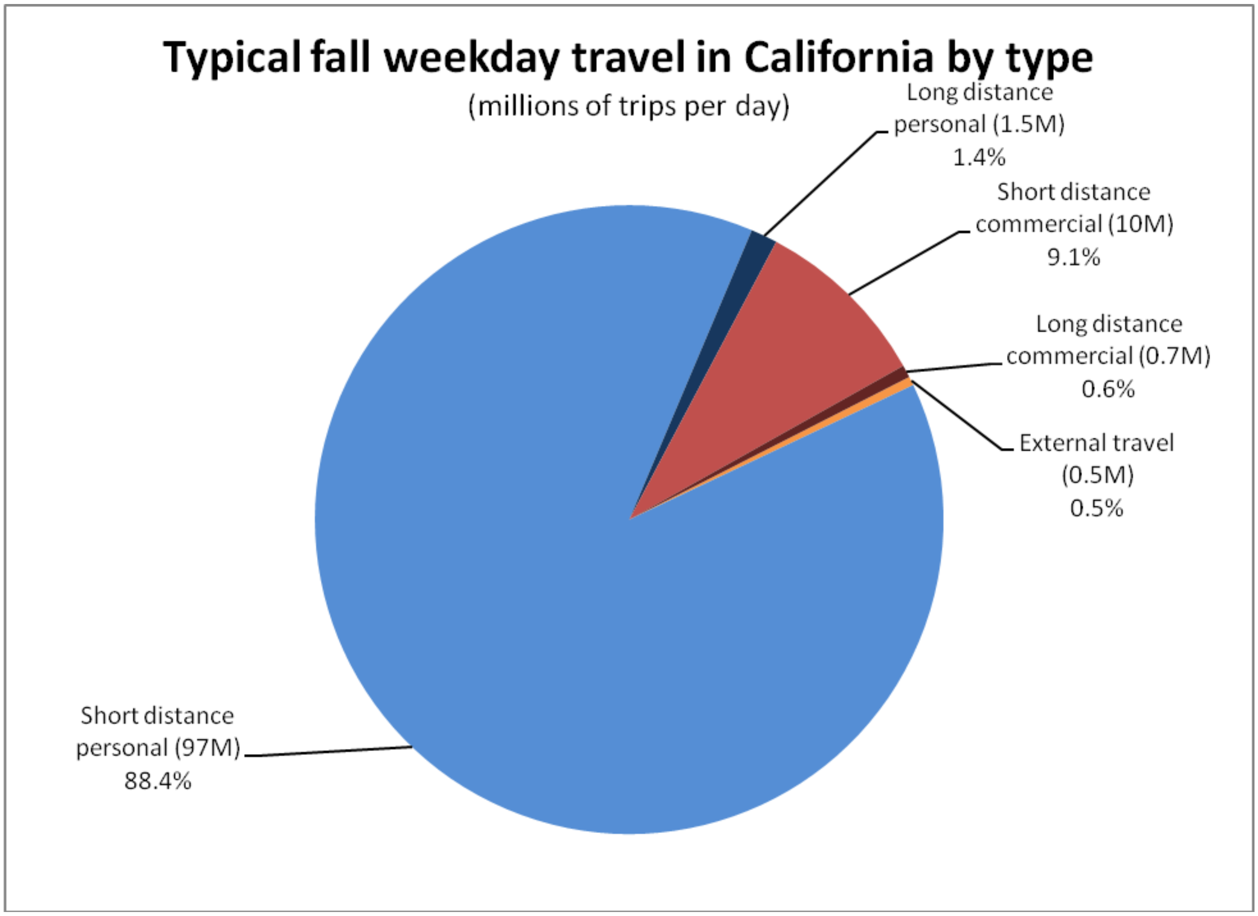


Figure 1: Breakdown of Travel in California

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.

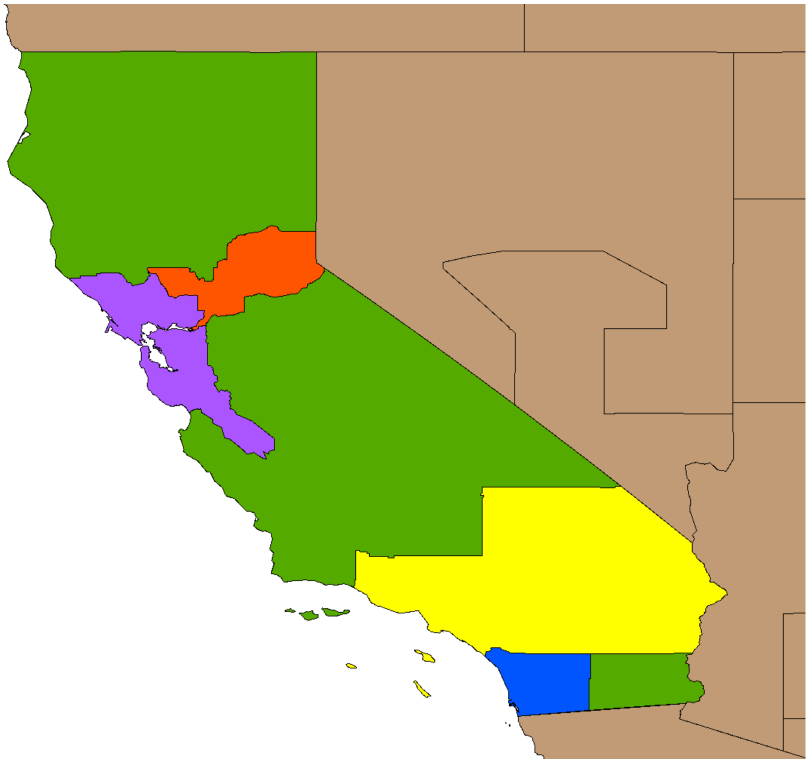


Figure 2: Freight Analysis Framework Districts in California

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.

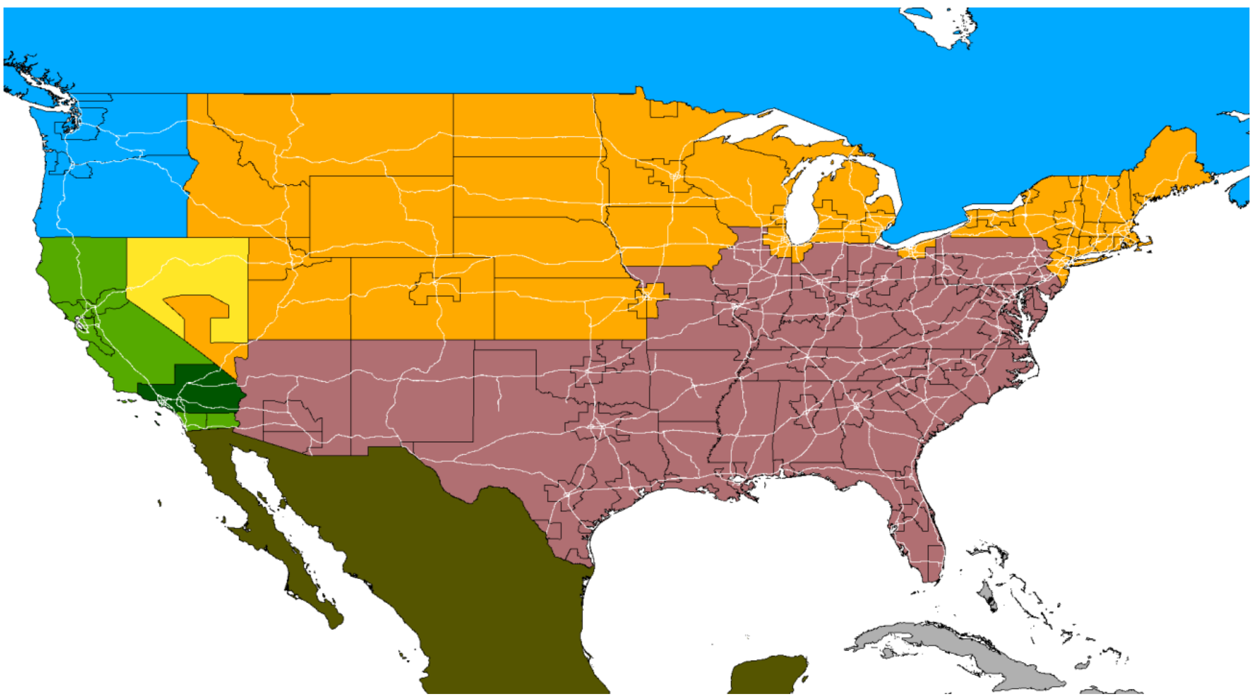


Figure 3: Freight Analysis Framework Crossing Districts

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.

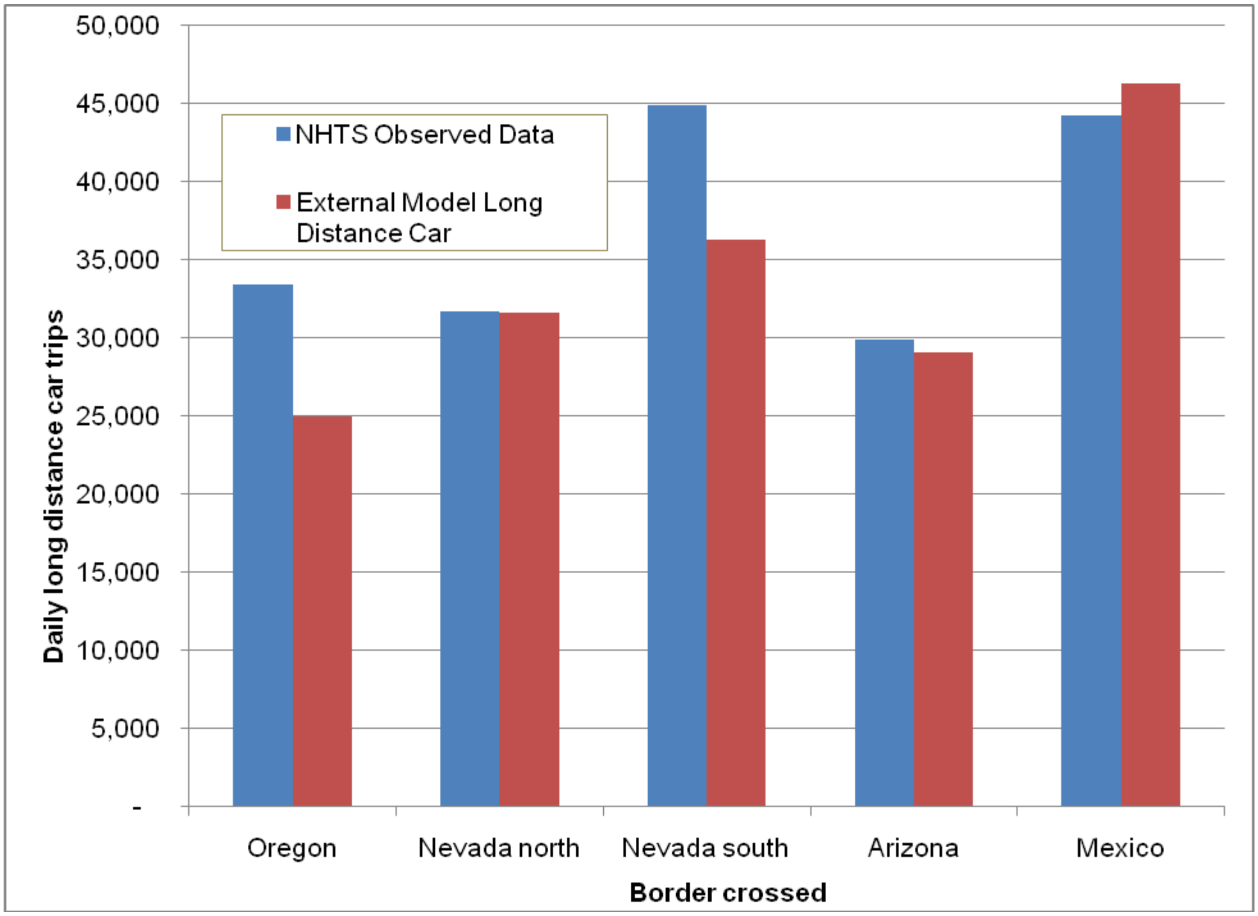


Figure 4: Model to Observed Match at Border Crossings

4.4 Party and Mode Choice

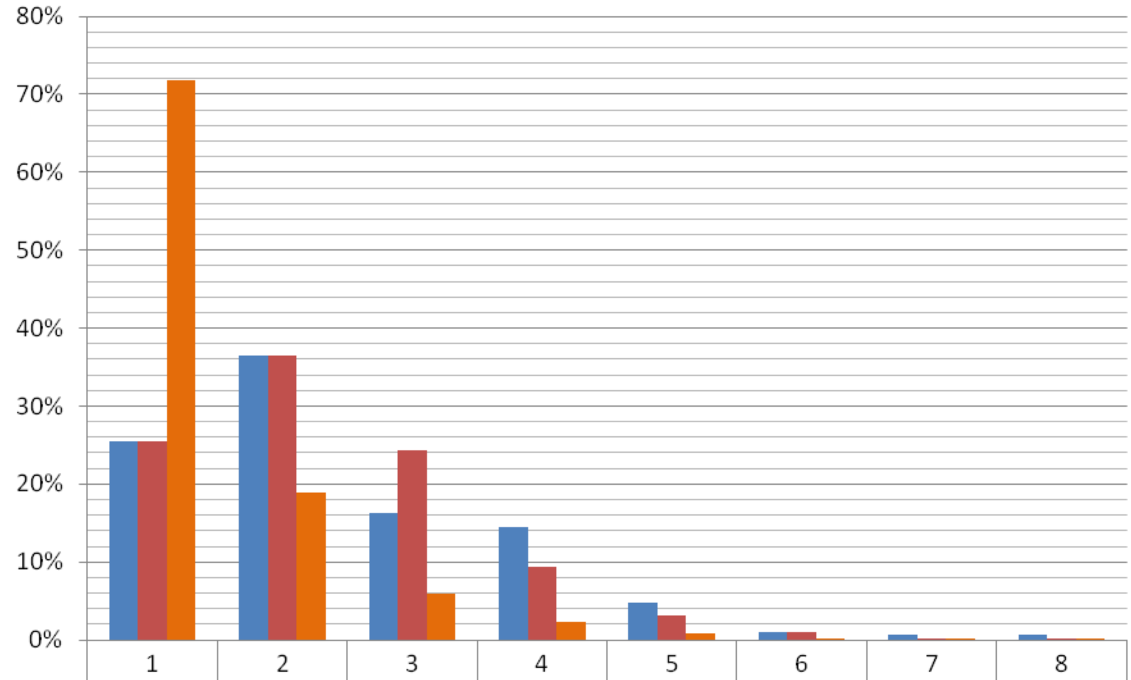
The choice of mode is mainly determined by the segment choice. As described earlier, E-E through flows are limited to freight and assumed to be heavy trucks. For the medium and heavy truck segments, the segment and mode are identical. The only possible mode choices are for the local and long distance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

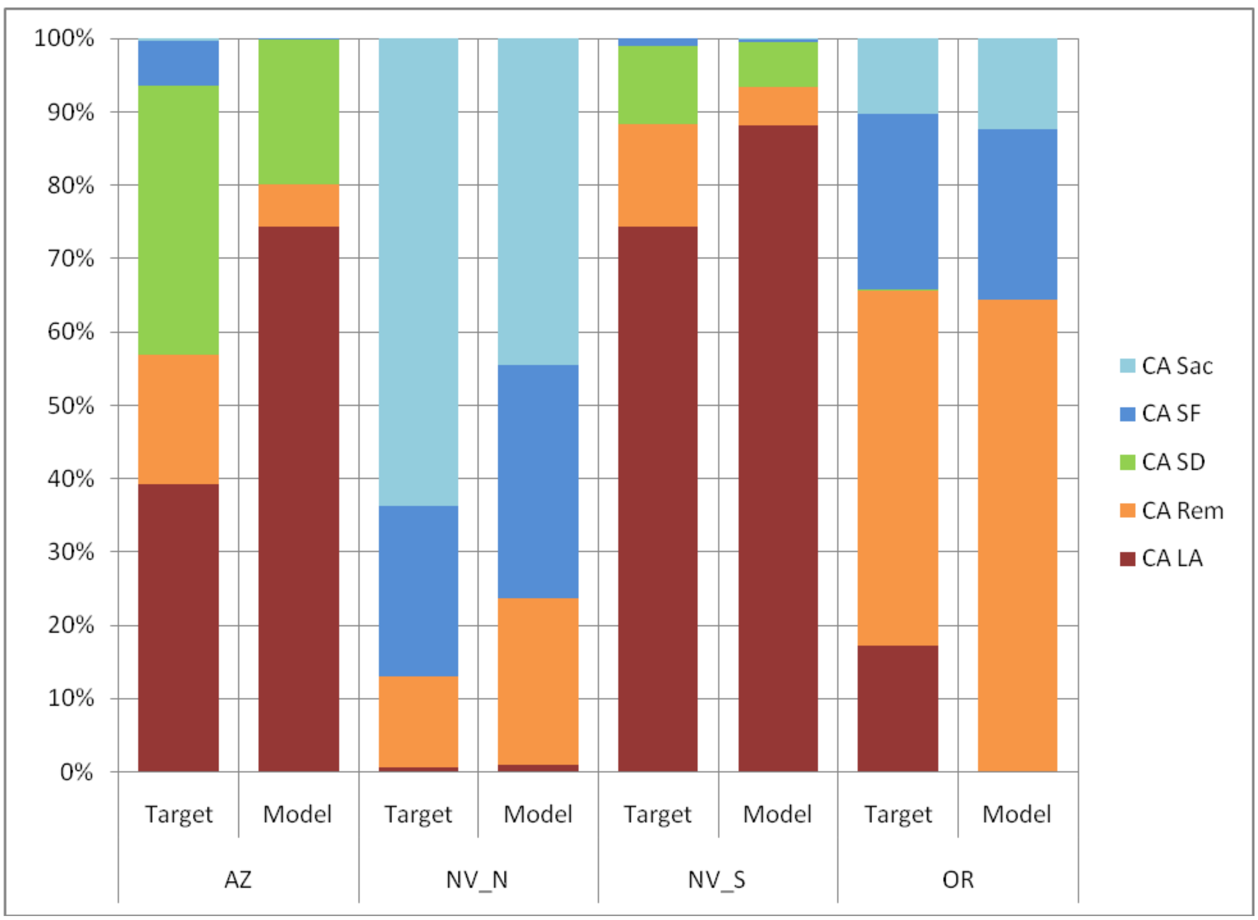


Figure 6: Long Distance Car Calibration Status

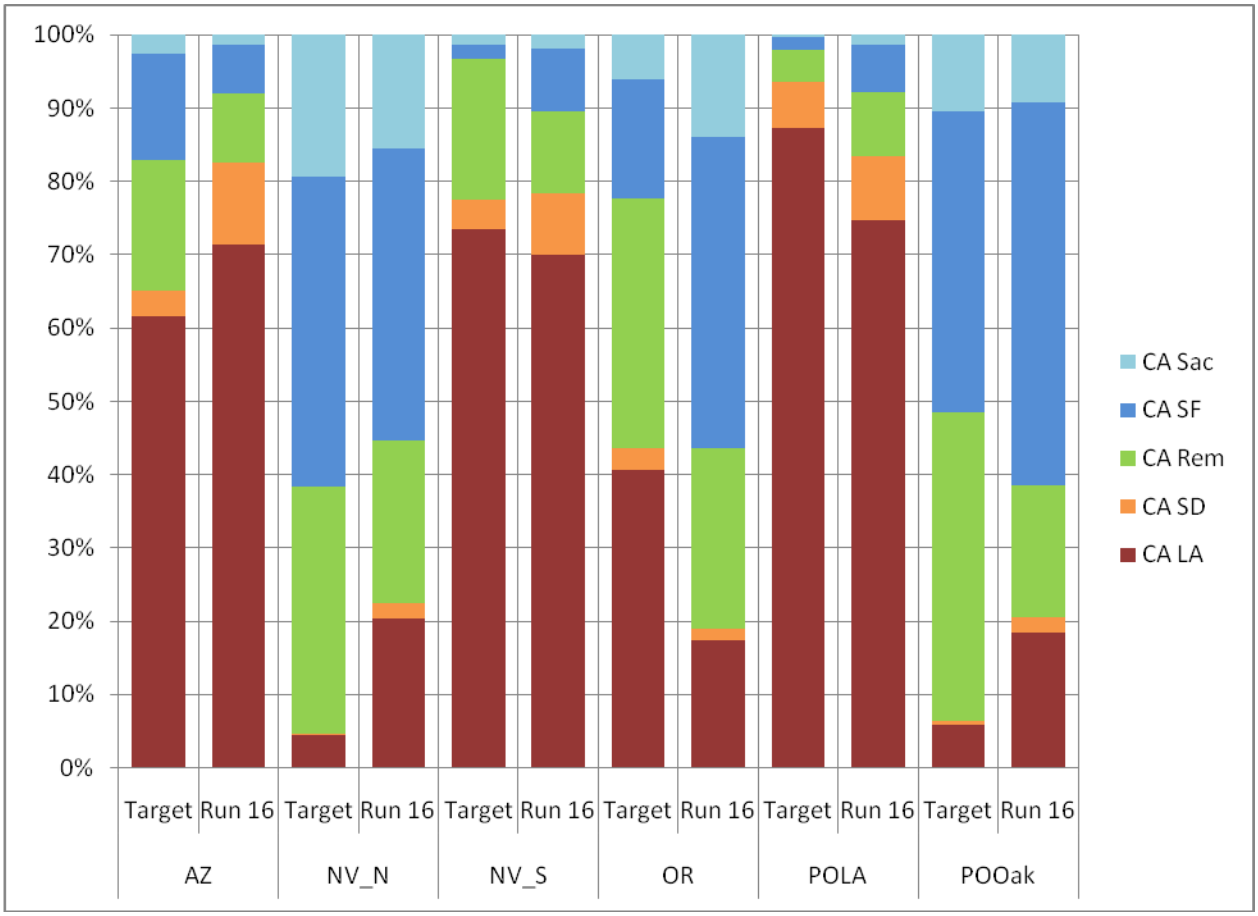


Figure 7: Heavy Truck Calibration Status

(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.

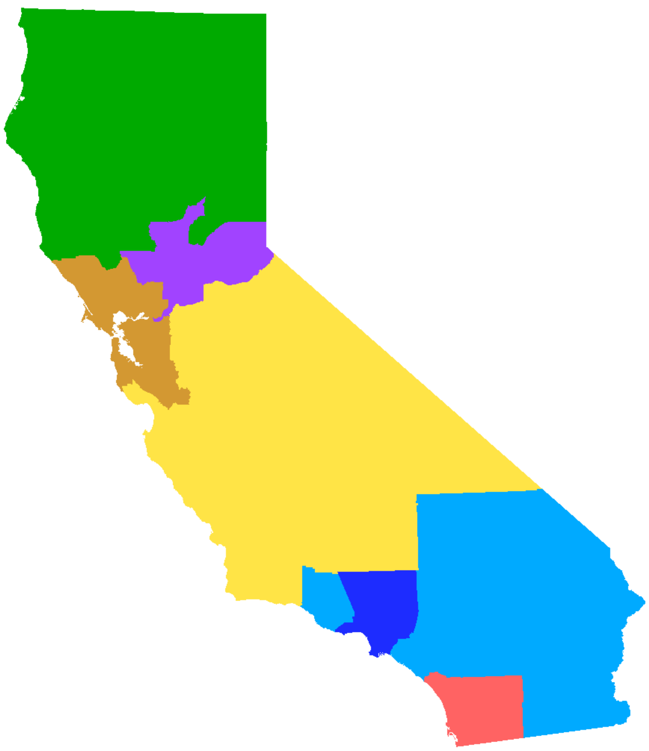


Figure 8: Seven Internal California Regions

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

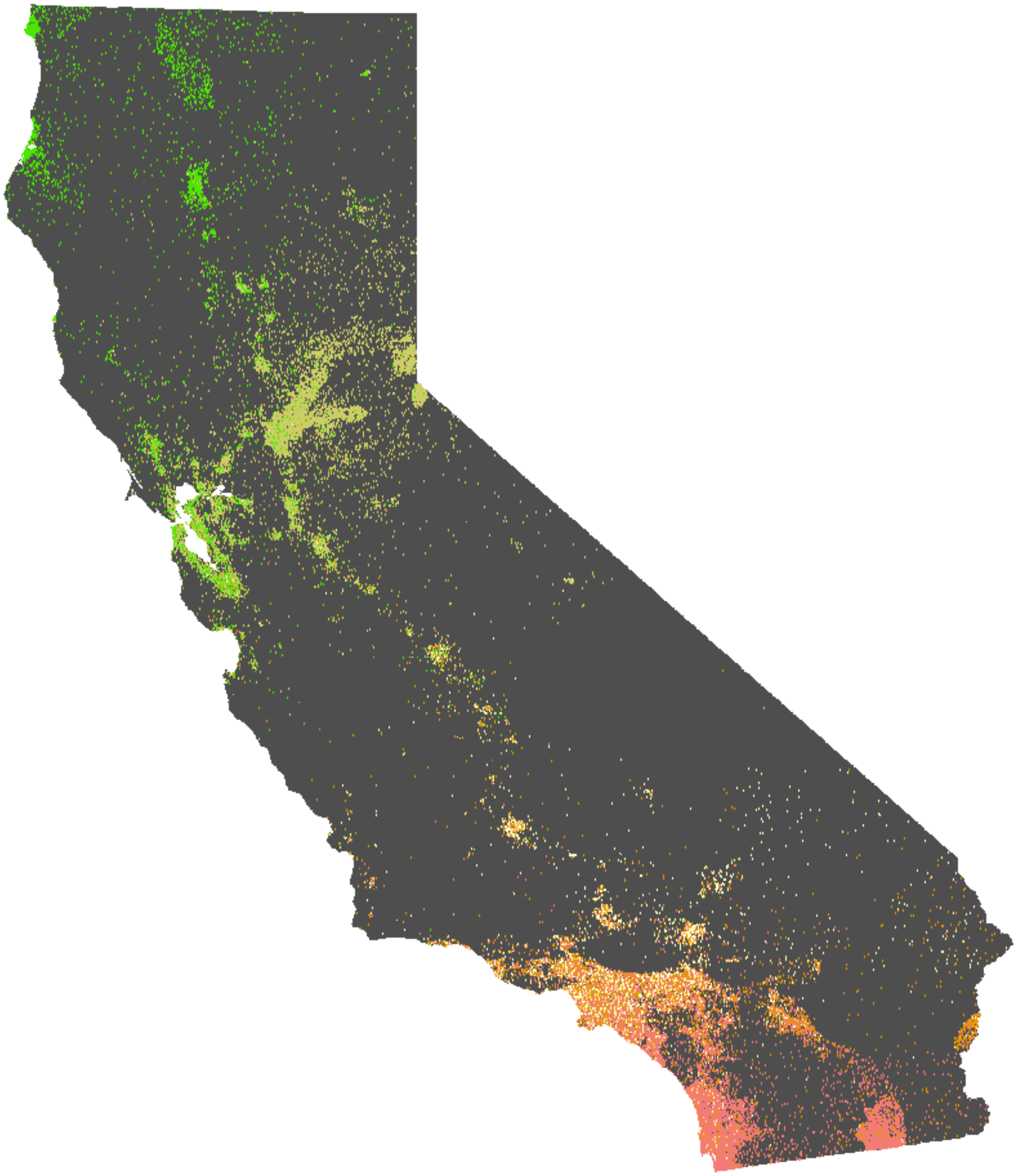


Figure 9: Example Distribution of External Travel (Land Borders)

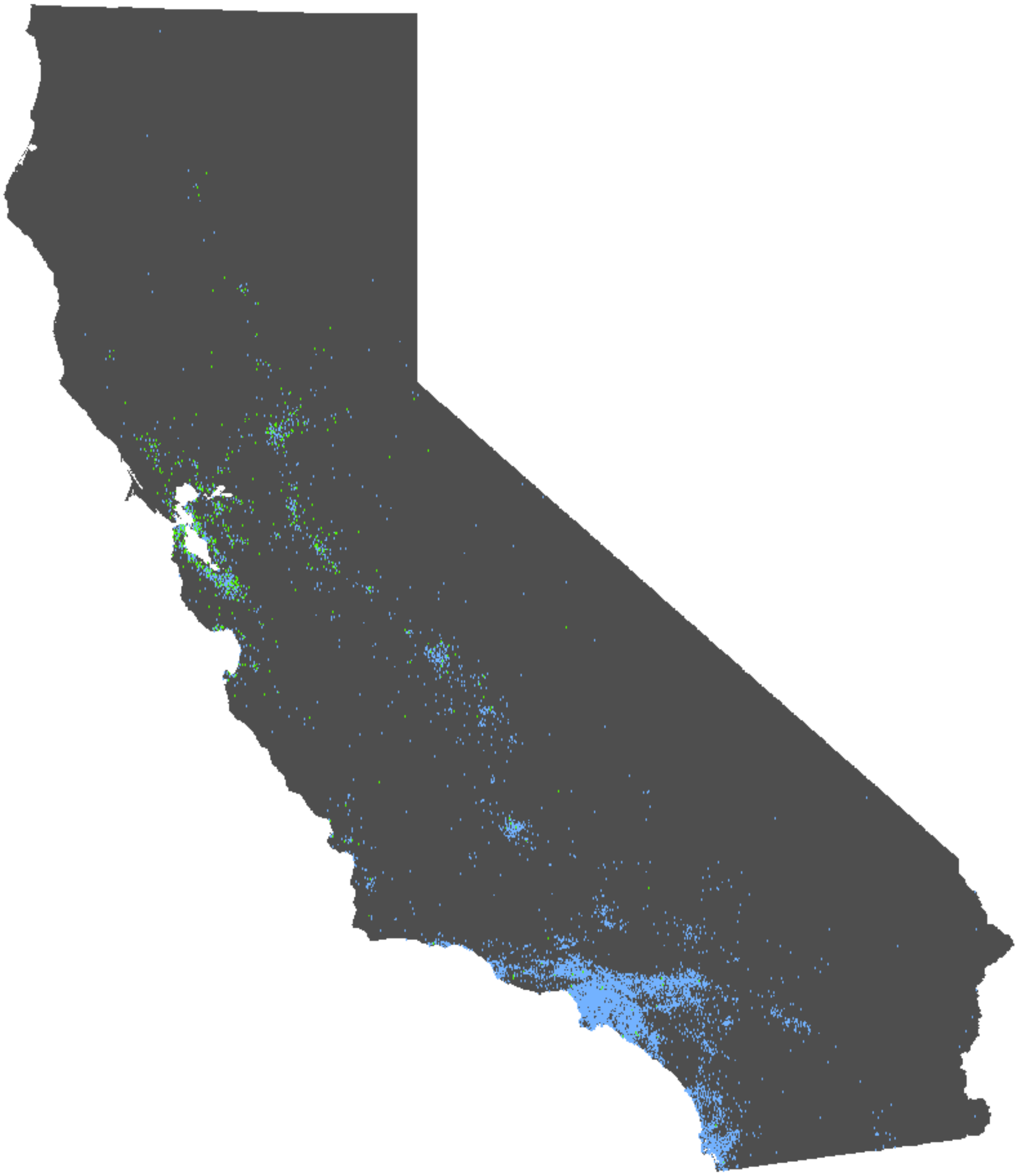


Figure 10: Example Distribution of External Travel (Ports)