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$\square$ (5) $\square$


# Documentation for the Eight San Joaquin Valley MPO Traffic Models to Meet the Requirements of SB 375 

## IMPORTANT NOTICE

The electronic documents included in the model files and documentation are the tools developed based on the data provided and the associated standard items for the Traffic Model Improvements for each of the Eight San Joaquin Valley MPO Traffic Models to meet the Requirements of SB 375 (SJV MIP) (Fehr \& Peers, November 2010). The data, analysis, and results presented herein have been prepared for the sole purpose of this project. The model scenarios were developed based on consultation with the San Joaquin Valley MPO staff. Post processing functions were based on the translation of the intent of the pre-MIP scripts to the MIP models and Fehr \& Peers may not agree with the method or assumptions.

We have relied on scenario data and other information provided to us by the San Joaquin Valley MPOS as well as data from publicly available information sources. The opinions presented as a result of our analysis cannot be taken as an endorsement or inducement for any financial transaction. Fehr \& Peers does not make any warranty, guarantee, certification or other representation with respect to the information contained herein if applied to any other project or for any other purpose without the prior written consent of Fehr \& Peers, which expressly denies any and all liability for damages or losses of any kind resulting from use of the information contained herein for any purposes other than this project. We do not accept any responsibility for damages, if any, that may result from decisions made or actions taken by any third parties based on its analysis. Any use that a third party makes of our analysis and opinions will be the sole responsibility of such third party.

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### 1.0 DEMOGRAPHIC AND LAND USE DATA

### 1.1 LAND USE CATEGORIES

## TABLE 1-1 LAND USE VARIABLES


tABLE 1-1 LAND USE VARIABLES

| Attribute | Description | Units |
| :---: | :---: | :---: |
| TECH | Professional, Scientific, and Technical Services (54) | Employees |
| MANAGEMENT | Management of Companies and Enterprises (55) | Employees |
| WASTE | Administrative/Support, Waste Management \& Remediation (56) | Employees |
| EDU | Educational Services (61) | Employees |
| HEALTH | Health Care and Social Assistance (62) | Employees |
| ARTS | Arts, Entertainment and Recreation (71) | Employees |
| ACCOM | Accommodation (721) | Employees |
| FOOD | Food Services (722) | Employees |
| OTHER | Other Services Except Public Administration (81) | Employees |
| PUBLIC | Public Administration (92) | Employees |
| ELEM | Elementary and middle school enrollment | Student Enrollment |
| HS | High school enrollment | Student Enrollment |
| COLLEGE | College enrollment | Student Enrollment |

## Notes:

See Tables 3.2-2 for residential development density categories.
See Tables 3.2-3 for unit type categories.
See Tables 3.2-4 for annual household income categories.
See Tables 3.2-5 for age of householder categories.
See Tables 3.2-6 for population distribution by age range categories.
See Tables 3.2-7 for household size categories.
Non-residential description contains NAICS sector number(s).

## TABLE 1-2 RESIDENTIAL DEVELOPMENT DENSITY

| Category | Name | Density Range (Gross) | Description |
| :---: | :---: | :---: | :---: |
| HDR | High <br> Density <br> Residential | >20 du/acre | Largely apartments and condominiums |
| MDR | Medium Density Residential | 10-20 du/acre | Duplexes, triplexes, zero-lot line development, or very dense single family dwellings (mostly older neighborhoods, or possibly New Urbanist, or neotraditional developments) |
| LDR | Low Density Residential | 10-2 du/acre | The common single family detached subdivision density range |
| EG | Exurban Growth | 2-1 du/acre | Large lot residential, generally found near the urban edge or in large lot subdivisions |
| RE | Rural <br> Estates | < 1 du/acre | Individual residential houses on large lots, frequently classified as agricultural. |

Source:

TABLE 1-3 RESIDENTIAL UNIT TYPES

| Category |  | Description |
| :--- | :--- | :--- |
| RU1 | 1, detached |  |
| RU2 | 1, attached |  |
| RU3 | 2 |  |
| RU4 | 3 or 4 |  |
| RU5 | 5 to 9 |  |
| RU6 | 10 to 19 |  |
| RU7 | 20 to 49 |  |
| RU8 | 50 or more |  |
| RU9 | Mobile home |  |
| RU10 | Boat, RV, van, etc. |  |

[^0]
## TABLE 1-4 AVERAGE HOUSEHOLD INCOME

| Category |  |
| :--- | :--- |
| INC1 | Less than $\$ 19,999$ |
| INC2 | $\$ 20,000$ to $\$ 39,999$ |
| INC3 | $\$ 40,000$ to $\$ 59,999$ |
| INC4 | $\$ 60,000$ to $\$ 99,999$ |
| INC5 | $\$ 100,000$ or more |

Source:

## TABLE 1-5 AGE OF HOUSEHOLDER

| Category |  |
| :--- | :--- |
| Age1524 | Householder 5 to 24 years |
| Age2564 | Householder 25 to 64 years |
| Age6574 | Householder 65 to 74 years |
| Age75 | Householder 75 years and over |

Source:

## TABLE 1-6 POPULATION BY AGE RANGE

| Category | Description |
| :--- | :--- |
| POP0005 | People under 5 years |
| POP0514 | People 5 to 14 years |
| POP1517 | People 15 to 17 years |
| POP1824 | People 18 to 24 years |
| POP2554 | People 25 to 54 years |
| POP5564 | People 55 to 64 years |
| POP6574 | People 65 to 74 years |
| POP75 | People 75 years and over |

Source:

## TABLE 1-7 HOUSEHOLD SIZE

| Category |  |
| :--- | :--- |
| HHSIZE1 | 1 person household |
| HHSIZE2 | 2 person household |
| HHSIZE3 | 3 person household |
| HHSIZE4 | 4 person household |
| HHSIZE5 | 5 or more person household |

Source:

| TABLE 1-8 POTENTIAL LAND USE CATEGORY AGGREGATION STRUCTURE |  |  |  |
| :--- | :--- | :--- | :--- |
| NAICS | SJV MIP Category | $\begin{array}{c}\text { CTPP } \\ \text { Aggregation }\end{array}$ | $\begin{array}{c}\text { CSTDM } \\ \text { Activity }\end{array}$ |
| 11 | Agriculture, Forestry, Fishing and Hunting | Ag_Mining | Primary and |
| Secondary |  |  |  |$\}$


| TABLE 1-8 POTENTIAL LAND USE CATEGORY AGGREGATION STRUCTURE |  |  |  |
| :--- | :--- | :--- | :--- |
| NAICS | CTPP <br> SJV MIP Category | CSTDM <br> Activity |  |
| 81 | Other Services (except Public Administration) | Other Service | Other Service |
| xx | Military employment, all industries | Armed Forces | Military |

Source:

### 2.0 ROAD NETWORKS

### 2.1 ROADWAY NETWORK ATTRIBUTES

## TABLE 2-1 STANDARD MASTER HIGHWAY NETWORK VARIABLES

| Attribute | Description |
| :--- | :--- |
| Nodes |  |
| X | X-coordinate of node in Nad 83 |
| Y | N-coordinate of node in Nad 83 |
| N | Traffic Analysis Zone Number |
| TAZ | Super district number used for aggregation |
| DISTRICT | Sphere of influence used to number TAZs alphabetically |
| SOI | Study location number used to record turning movements when non-zero |
| STYINT | County where node is located |
| COUNTY | Political jurisdiction where node is located |
| JURISDICTION | Community/district name |
| COMMUNITY |  |

## Links



## TABLE 2-1 STANDARD MASTER HIGHWAY NETWORK VARIABLES

| Attribute | Description |
| :--- | :--- |
| XXXX_AREATYP $^{1}$ | Area type by year ${ }^{2}$ |
| XXXX_LANES $^{1}$ | Number of directional through travel lanes by year ${ }^{2}$ |
| XXXX_AUX $^{1}$ | Auxiliary lane ( $0=$ no, $1=$ =yes) |
| XXXX_SPEED $^{1}$ | Free-flow speed in miles-per hour by year ${ }^{3}$ |
| XXXX_CAPCLASS $^{1}$ | Capacity class by year (derived from Terrain, Facility type, and Area Type) ${ }^{2}$ |
| XXXX_CAPACITY ${ }^{1}$ | Vehicle per hour (calculated based on Lanes and CapClass) ${ }^{4}$ |
| XXXX_USE ${ }^{1}$ | Identifies vehicle prohibitions by year ${ }^{5}$ |
| XXXX_TOLL ${ }^{1}$ | Code used for cost on toll facilities by year ${ }^{3}$ |
| AREATYP | Character to store scenario variable basin number for air quality |
| AIRBASIN | Transportation System Management |
| TSM | Environmental Justice designation (0 or 1) |
| EJ |  |

Notes:
XXXX represents BASE (calibration/validation year), IMP1 (status after first improvement), and IMP2 (status after second improvement). In addition to calibration/validation year which varies by MPO, required years to be covered by improvement are 05 , 20,35 , and 40.
See Tables 3.3-2 for details on CapClass by Terrain, Facility Type, and Area Type.
See Tables 3.3-3 for Speed ranges by Terrain, Facility Type, and Area Type.
See Tables 3.3-4 for details on Capacity by Terrain, Facility Type, and Area Type.
0 or 1 =facility open to all ("general purpose") ; $2=$ Carpool $2 ; 3=$ Carpool $3+; 4=$ Combination trucks prohibited; $5=$ Walk or bike only Source:

TABLE 2-2 CAPACITY CLASS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type |  | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| Flat |  |  |  |  |  |  |
|  | Freeway | 1 | 11 | 21 | 31 | 41 |
|  | Highway | 2 | 12 | 22 | 32 | 42 |
|  | Expressway | 3 | 13 | 23 | 33 | 43 |
|  | Arterial | 4 | 14 | 24 | 34 | 44 |
|  | Collector | 5 | 15 | 25 | 35 | 45 |
|  | Local | 6 | 16 | 26 | 36 | 46 |
|  | Ramp: FreewayFreeway | 7 | 17 | 27 | 37 | 47 |
|  | Ramp: Slip | 8 | 18 | 28 | 38 | 48 |
|  | Ramp: Loop | 9 | 19 | 29 | 39 | 49 |
|  | Connector: Dist. $\leq$ $0.25$ | 10 | N/A | N/A | N/A | N/A |
|  | $\begin{aligned} & \text { Connector: Dist. > } \\ & 0.25 \end{aligned}$ | 20 | N/A | N/A | N/A | N/A |
| Rolling |  |  |  |  |  |  |
| 1. | Freeway | 51 | 61 | 71 | 81 | 91 |
| 2. | Highway | 52 | 62 | 72 | 82 | 92 |
| 3. | Expressway | 53 | 63 | 73 | 83 | 93 |
| 4. | Arterial | 54 | 64 | 74 | 84 | 94 |
| 5. | Collector | 55 | 65 | 75 | 85 | 95 |
| 6. | Local | 56 | 66 | 76 | 86 | 96 |
|  | Ramp: FreewayFreeway | 57 | 67 | 77 | 87 | 97 |
| 8. | Ramp: Slip | 58 | 68 | 78 | 88 | 98 |
| 9. | Ramp: Loop | 59 | 69 | 79 | 89 | 99 |

TABLE 2-2 CAPACITY CLASS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| 10. Connector: Dist. $\leq$ 0.25 | 60 | N/A | N/A | N/A | N/A |
| 11. Connector: Dist. > 0.25 | 70 | N/A | N/A | N/A | N/A |
| Mountain |  |  |  |  |  |
| 1. Freeway | 101 | 111 | 121 | 131 | 141 |
| 2. Highway | 102 | 112 | 122 | 132 | 142 |
| 3. Expressway | 103 | 113 | 123 | 133 | 143 |
| 4. Arterial | 104 | 114 | 124 | 134 | 144 |
| 5. Collector | 105 | 115 | 125 | 135 | 145 |
| 6. Local | 106 | 116 | 126 | 136 | 146 |
| 7. Ramp: FreewayFreeway | 107 | 117 | 127 | 137 | 147 |
| 8. Ramp: Slip | 108 | 118 | 128 | 138 | 148 |
| 9. Ramp: Loop | 109 | 119 | 129 | 139 | 149 |
| 10. Connector: Dist. $\leq$ 0.25 | 110 | N/A | N/A | N/A | N/A |
| 11. Connector: Dist. > 0.25 | 120 | N/A | N/A | N/A | N/A |

Note: Area type based on Area Density using the following:
Area Density $=($ Total Population +2.5 * Total Employment $) /($ Residential Acres + Employment Acres $)$

1. Rural $<6.0$
2. Suburban $6.0-30.0$
3. Urban $30.0-55.0$
4. Fringe 55.0-100.0
5. $C B D>100.0$

Source:

TABLE 2-3 TYPICAL SPEED RANGES BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type |  | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| Flat |  |  |  |  |  |  |
| 1. | Freeway | 70 | 65-70 | 55-65 | 55-65 | 55-65 |
| 2. | Highway | 40-45 | 40-45 | 40-45 | 40-45 | 40-45 |
| 3. | Expressway | 55 | 45-55 | 45-55 | 45-55 | 40-45 |
| 4. | Arterial | 40-45 | 30-45 | 25-45 | 30-45 | 25-45 |
| 5. | Collector | 50 | 50 | 35-40 | 35-40 | 35-40 |
| 6. | Local | 25-40 | 25-40 | 25-40 | 25-40 | 25-40 |
| 7. | Ramp: FreewayFreeway | 50 | 50 | 50 | 50 | 50 |
| 8. | Ramp: Slip | 50 | 50 | 50 | 50 | 50 |
| 9. | Ramp: Loop | 45 | 45 | 45 | 45 | 45 |
|  | Connector: Dist. $\leq$ $0.25$ | 35 | 35 | 35 | 35 | 35 |
| 11. | Connector: Dist. > <br> 0.25 | 15 | 15 | 15 | 15 | 15 |
| Rolling |  |  |  |  |  |  |
| 1. | Freeway | 65-70 | 65-70 | 65-70 | 65-70 | 65-70 |
| 2. | Highway | 40-45 | 40-45 | 40-45 | 40-45 | 40-45 |
| 3. | Expressway | 50-65 | 50-65 | 50-65 | 50-65 | 50-65 |
| 4. | Arterial | 30-45 | 30-45 | 30-45 | 30-45 | 30-45 |
| 5. | Collector | 50 | 50 | 50 | 50 | 50 |
| 6. | Local | 50 | 50 | 50 | 50 | 50 |
| 7. | Ramp: FreewayFreeway | 50 | 50 | 50 | 50 | 50 |
| 8. | Ramp: Slip | 50 | 50 | 50 | 50 | 50 |
| 9. | Ramp: Loop | 45 | 45 | 45 | 45 | 45 |

TABLE 2-3 TYPICAL SPEED RANGES BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| 10. Connector: Dist. $\leq$ $0.25$ | 35 | 35 | 35 | 35 | 35 |
| 11. Connector: Dist. > 0.25 | 15 | 15 | 15 | 15 | 15 |
| Mountain |  |  |  |  |  |
| 1. Freeway | 65 | 65 | 65 | 65 | 65 |
| 2. Highway | 40-45 | 40-45 | 40-45 | 40-45 | 40-45 |
| 3. Expressway | 40-55 | 40-55 | 40-55 | 40-55 | 40-55 |
| 4. Arterial | 30-45 | 30-45 | 30-45 | 30-45 | 30-45 |
| 5. Collector | 25-40 | 25-40 | 25-40 | 25-40 | 25-40 |
| 6. Local | 25-40 | 25-40 | 25-40 | 25-40 | 25-40 |
| 7. Ramp: FreewayFreeway | 50 | 50 | 50 | 50 | 50 |
| 8. Ramp: Slip | 45 | 45 | 45 | 45 | 45 |
| 9. Ramp: Loop | 35 | 35 | 35 | 35 | 35 |
| 10. Connector: Dist. $\leq$ 0.25 | 15 | 15 | 15 | 15 | 15 |
| 11. Connector: Dist. > $0.25$ | 25 | 25 | 25 | 25 | 25 |

Note: Speed shown as miles per hour (MPH)
Source:

TABLE 2-4 DEFAULT CAPACITY BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| Flat |  |  |  |  |  |
| 1. Freeway | 2,000 | 2,000 | 1,800 | 1,750 | 1,750 |
| 2. Highway | 1,800 | 1,800 | 1,600 | 1,500 | 1,300 |
| 3. Expressway | 1,100 | 1,100 | 1,000 | 900 | 800 |
| 4. Arterial | 900 | 900 | 900 | 800 | 750 |
| 5. Collector | 700 | 700 | 800 | 800 | 700 |
| 6. Local | 600 | 600 | 700 | 700 | 600 |
| 7. Ramp: FreewayFreeway | 1,800 | 1,800 | 1,800 | 1,800 | 1,800 |
| 8. Ramp: Slip | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 |
| 9. Ramp: Loop | 1,250 | 1,250 | 1,250 | 1,250 | 1,250 |
| 10. Connector: Dist. $\leq$ 0.25 | N/A | N/A | N/A | N/A | N/A |
| 11. Connector: Dist. > 0.25 | N/A | N/A | N/A | N/A | N/A |
| Rolling |  |  |  |  |  |
| 1. Freeway | 1,800 | 1,800 | 1,620 | 1,580 | 1,580 |
| 2. Highway | 1,460 | 1,460 | 1,300 | 1,220 | 1,060 |
| 3. Expressway | 890 | 890 | 810 | 730 | 650 |
| 4. Arterial | 730 | 730 | 730 | 650 | 610 |
| 5. Collector | 570 | 570 | 650 | 650 | 570 |
| 6. Local | 550 | 550 | 640 | 640 | 550 |
| 7. Ramp: FreewayFreeway | 1,800 | 1,800 | 1,800 | 1,800 | 1,800 |
| 8. Ramp: Slip | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 |

TABLE 2-4 DEFAULT CAPACITY BY TERRAIN, FACILITY TYPE, AND AREA TYPE

| Facility Type | Area Type |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rural (R) | Suburban (SU) | Urban (U) | Fringe (F) | Central Business District (CBD) |
| 9. Ramp: Loop | 1,250 | 1,250 | 1,250 | 1,250 | 1,250 |
| 10. Connector: Dist. $\leq$ 0.25 | N/A | N/A | N/A | N/A | N/A |
| 11. Connector: Dist. > 0.25 | N/A | N/A | N/A | N/A | N/A |
| Mountain |  |  |  |  |  |
| 1. Freeway | 1,500 | 1,500 | 1,350 | 1,310 | 1,310 |
| 2. Highway | 790 | 790 | 700 | 660 | 570 |
| 3. Expressway | 480 | 480 | 440 | 390 | 350 |
| 4. Arterial | 390 | 390 | 390 | 350 | 330 |
| 5. Collector | 310 | 310 | 350 | 350 | 310 |
| 6. Local | 330 | 330 | 380 | 380 | 330 |
| 7. Ramp: FreewayFreeway | 1,800 | 1,800 | 1,800 | 1,800 | 1,800 |
| 8. Ramp: Slip | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 |
| 9. Ramp: Loop | 1,250 | 1,250 | 1,250 | 1,250 | 1,250 |
| 10. Connector: Dist. $\leq$ 0.25 | N/A | N/A | N/A | N/A | N/A |
| 11. Connector: Dist. > 0.25 | N/A | N/A | N/A | N/A | N/A |

[^1]
### 3.0 TRANSIT NETWORKS

### 3.1 TRANSIT LINE ATTRIBUTES

Table 3-1 Standard Transit Variables

| Attribute | Description |
| :--- | :--- |
| Transit Lines | Unique and concise string identifier for a transit line. |
| NAME | Unique common name for transit line. |
| LONGNAME | Integer indicating mode of the transit line. |
| MODE ${ }^{1}$ | Interval, in minutes, between two vehicles on a line. |
| HEADWAY | List of nodes that the transit line traverses. |
| NODE | Defines the transit and non-transit modes that the transit system uses |
| Transit System | Defines the operators in the transit system |
| MODE | Wait curve lookup for initial and transfer wait times at stop |
| OPERATOR | Vehicle types used by the transit line |
| WAITCRVDEF |  |
| VEHICLETYPE |  |

[^2]TABLE 3-2 TRANSIT MODE VARIABLES


### 4.0 TRIP GENERATION

### 4.1 TRIP GENERATION RATES

TABLE 4-1 DAILY PERSON TRIP GENERATION RATES

| Land Use | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Residential |  |  |  |  |  |  |  |  |
| RU 1 | 7.01 | 6.95 | 8.82 | 8.61 | 5.2 |  | 4.74 | 8.93 |
| RU 3 | 4.43 | 4.51 | 6.34 | 6.74 | 3.1 |  | 2.87 | 6.00 |
| RU 9 | 4.57 | 4.32 | 7.84 | 5.32 | 3.4 |  | 3.07 | 7.84 |

Non-Residential (CSTDM Activity Group Aggregations)

| Primary and Secondary | 1.79 | 2.28 | 2.13 | 2.12 | 1.45 | 1.30 | 2.11 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Wholesale | 4.76 | 5.77 | 8.11 | 8.11 | 4.34 | 3.91 | 9.79 |
| Transportation and Utilities | 2.43 | 3.20 | 3.21 | 3.97 | 2.10 | 1.89 | 3.21 |
| Retail | 10.38 | 13.53 | 27.65 | 27.65 | 19.72 | 17.75 | 27.65 |
| Office | 2.66 | 5.85 | 28.68 | 19.96 | 3.26 | 2.93 | 24.94 |
| Education and Health | 2.27 | 3.65 | 3.80 | 4.06 | 1.81 | 1.63 | 5.05 |
| Leisure and Hospitality | 20.17 | 15.67 | 41.90 | 50.74 | 22.93 | 20.64 | 47.83 |
| Other service | 4.79 | 7.12 | 27.58 | 27.58 | 14.54 | 13.09 | 30.72 |
| Student Enrollment |  |  |  |  |  |  |  |
| Elementary | 3.22 | 3.56 | 4.23 | 3.56 | 3.16 | 2.84 | 4.91 |
| High School | 4.25 | 4.72 | 5.60 | 4.72 | 4.16 | 3.74 | 4.72 |
| College | 4.14 | 5.97 | 5.69 | 5.41 | 4.66 | 4.19 | 5.41 |

### 4.2 CORDON OR "GATEWAY" TRIPS

TABLE 4-2 DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS

| Purpose | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Home- <br> Work | $\begin{gathered} 80,611 \\ (22,012) \end{gathered}$ | $\begin{gathered} 45,156 \\ (28,378) \end{gathered}$ | $\begin{gathered} 16,484 \\ (18,589) \end{gathered}$ | $\begin{gathered} 8,753 \\ (37,126) \end{gathered}$ | 12,879 (118,389) |  |  | 39,658 (24,303) |
| Home- <br> Shop | $\begin{gathered} 7,627 \\ (6,028) \end{gathered}$ | $\begin{gathered} 14,035 \\ (46,790) \end{gathered}$ | $\begin{gathered} 2,408 \\ (2,408) \end{gathered}$ | $\begin{gathered} 918 \\ (8,567) \end{gathered}$ | 7,881 (15,257) |  |  | 8,236 $(2,805)$ |
| Home-K12 | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |  |  | 0 (0) |
| HomeCollege | $\begin{gathered} 244 \\ (146) \end{gathered}$ | $\begin{gathered} 5,166 \\ (5,050) \end{gathered}$ | $\begin{gathered} 9 \\ (5,452) \end{gathered}$ | $\begin{gathered} 37 \\ (4,800) \end{gathered}$ | 74 (873) |  |  | 143 (96) |
| Home- <br> Other | $\begin{gathered} 33,038 \\ (19,808) \end{gathered}$ | $\begin{gathered} 71,870 \\ (21,489) \end{gathered}$ | $\begin{gathered} 7,060 \\ (7,060) \end{gathered}$ | $\begin{gathered} 5,036 \\ (25,869) \end{gathered}$ | 10,003 (118,082) |  |  | 19,375 (12,976) |
| Work- <br> Other | $\begin{gathered} 9,969 \\ (22,962) \end{gathered}$ | $\begin{gathered} 23,619 \\ (28,566) \end{gathered}$ | $\begin{gathered} 3,668 \\ (3,668) \end{gathered}$ | $\begin{gathered} 6,723 \\ (4,242) \end{gathered}$ | 12,076 (9,066) |  |  | 7,468 (10,951) |
| Other- <br> Other | $\begin{gathered} 33,699 \\ (150,53) \end{gathered}$ | $\begin{gathered} 76,924 \\ (110,549) \end{gathered}$ | $\begin{gathered} 3,225 \\ (7,145) \end{gathered}$ | $\begin{gathered} 6,800 \\ (12,623) \end{gathered}$ | 16,185 (21,406) |  |  | 13,324 (8,988) |
| Highway Commercial | $\begin{gathered} 3,560 \\ (3,560) \end{gathered}$ | $\begin{gathered} 2,969 \\ (2,969) \end{gathered}$ | $\begin{gathered} 1,072 \\ (1,072) \end{gathered}$ | $\begin{gathered} 1,653 \\ (1,653) \end{gathered}$ | 4,705 (4,705) |  |  | 2,156 (2,156) |
| TrucksSmall | $\begin{gathered} 1,406 \\ (1,407) \end{gathered}$ | $\begin{gathered} 1,153 \\ (1,158) \end{gathered}$ | $\begin{gathered} 434 \\ (543) \end{gathered}$ | $\begin{gathered} 491 \\ (568) \end{gathered}$ | 1,341 (1,485) |  |  | 887 (920) |
| TrucksMedium | $\begin{gathered} 709 \\ (699) \end{gathered}$ | $\begin{gathered} 741 \\ (715) \end{gathered}$ | $\begin{gathered} 201 \\ (262) \end{gathered}$ | $\begin{gathered} 271 \\ (331) \end{gathered}$ | 709 (753) |  |  | 509 (524) |
| TrucksHeavy | $\begin{gathered} 10,298 \\ (11,267) \end{gathered}$ | $\begin{gathered} 14,933 \\ (16,071) \end{gathered}$ | $\begin{gathered} 2,182 \\ (2,814) \end{gathered}$ | $\begin{gathered} 4,104 \\ (4,872) \end{gathered}$ | 15,104 (16,784) |  |  | 7,249 (7,786) |

Notes: Values shown as Production (Attraction)

### 4.3 SPECIAL GENERATORS

TABLE 4-3 SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS

| Purpose | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| HomeWork | 0 (0) | $\begin{gathered} 0 \\ (10,610) \end{gathered}$ | $\begin{gathered} 1,311 \\ (2,932) \end{gathered}$ | 0 (0) |  | 0 (0) |  | 0 (0) |
| HomeShop | 0 (0) | $\begin{gathered} 0 \\ (1,329) \end{gathered}$ | $\begin{gathered} 960 \\ (135) \end{gathered}$ | 0 (0) |  | 0 (0) |  | 0 (0) |
| Home-K12 | 0 (0) | 0 (0) | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |
| HomeCollege | 0 (0) | 0 (0) | 0 (0) | 0 (0) |  | 0 (0) |  | $0(22,545)$ |
| HomeOther | $\begin{gathered} 0 \\ (52,386) \end{gathered}$ | $\begin{gathered} 0 \\ (3,865) \end{gathered}$ | $\begin{gathered} 2,107 \\ (12,321) \end{gathered}$ | 0 (0) |  | 0 (0) |  | 0 (0) |
| Work- <br> Other | 0 (0) | $\begin{aligned} & 5,062 \\ & (606) \end{aligned}$ | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |
| Other- <br> Other | $\begin{gathered} 744 \\ (744) \end{gathered}$ | $\begin{gathered} 3,175 \\ (4,307) \end{gathered}$ | $\begin{gathered} 10,833 \\ (10,833) \end{gathered}$ | 0 (0) |  | 0 (0) |  | 0 (0) |
| Highway Commercial | 0 (0) | 0 (0) | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |
| TrucksSmall | 0 (0) | $\begin{gathered} 1,158 \\ (1,158) \end{gathered}$ | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |
| TrucksMedium | 0 (0) | $\begin{gathered} 994 \\ (994) \end{gathered}$ | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |
| TrucksHeavy | 0 (0) | $\begin{gathered} 487 \\ (487) \end{gathered}$ | 0 (0) | 0 (0) |  | 0 (0) |  | 0 (0) |

Notes: Values shown as Production (Attraction)

### 5.0 TRIP DISTRIBUTION

See Parameters Workbook for individual models

### 6.0 MODE CHOICE

See Parameters Workbook for individual models.

### 7.0 PEAK HOUR FACTORS

See Parameters Workbook for individual models.

### 8.0 STATIC MODEL VALIDATION

The summary tables below and in the appendices show the high level and detailed summary of each model by category and criteria. It should be noted that the household survey data being compared to is from 2001 and other data (land use, traffic and transit counts, etc) are for the base year of the model, so the model may perform better than the static validation shows since not all criteria can be met simultaneously. Category B and C MPOs are not required to meet all the same criteria as the Category D MPOs; in those cases the validation topic is labeled as Met / Not Required.

TABLE 8-1 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced ${ }^{1}$ | San Joaquin ${ }^{1}$ | Stanislaus ${ }^{1}$ | Tulare |
| Land Use | 0 | - | $\bigcirc$ | - |  | - |  | 0 |
| Trip Generation | $\bullet$ | - | - | - |  | $\bullet$ |  | © |
| Trip Distribution | - | $\bullet$ | $\bigcirc$ | - |  | $\bullet$ |  | $\bullet$ |
| Mode Choice | - | $\bullet$ | $\bullet$ | $\bullet$ | - | - | - | - |
| Traffic <br> Assignment | © | © | $\bigcirc$ | $\bullet$ | $\bigcirc$ | © | - | $\bigcirc$ |
| Transit <br> Assignment | $\bigcirc$ | $\bullet$ | N/A | N/A | $\bullet$ | $\bigcirc$ | $\bigcirc$ | N/A |

[^3]
### 8.1 LAND USE DATA VALIDATION

TABLE 8-2 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Residential |  |  |  |  |  |  |  |  |
| Household Population | $\bullet$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |  | $\bigcirc$ |  | $\bigcirc$ |
| Total <br> Households | $\bigcirc$ | $\bullet$ | $\bigcirc$ | $\bullet$ |  | - |  | - |
| Employment |  |  |  |  |  |  |  |  |
| Retail | $\bigcirc$ | $\bullet$ | $\bigcirc$ | $\bigcirc$ |  | $\bigcirc$ |  | $\bigcirc$ |
| Non-Retail | $\bullet$ | - | $\bigcirc$ | $\bigcirc$ |  | $\bullet$ |  | $\bullet$ |
| Total | $\bullet$ | $\bullet$ | $\bigcirc$ | $\bigcirc$ |  | - |  | - |

Notes:

- Met / Not Required
- = Partially Met

O Not Met

### 8.2 TRIP GENERATION VALIDATION

## TABLE 8-3 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

| County |  |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Validation <br> Topic | Fresno | Kern | Kings | Madera | Merced | San <br> Joaquin | Stanislaus | Tulare |

Trip Balancing by Purpose

| HBW | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | 0 | 0 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| HBS | $\bullet$ | 0 | $\bullet$ | $\bullet$ | $\bullet$ | 0 |
| HBO | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |
| NHB | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |
| Total | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |

Percentage of Trips by Purpose After Balancing


Notes:

|  | $=$ Met $/$ Not Required |
| ---: | :--- |
|  | $=$ Partially Met |
|  | $=$ Not Met |

### 8.3 TRIP DISTRIBUTION VALIDATION

TABLE 8-4 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION


## Average Travel Time



```
Notes:
- = Met / Not Required
O = Partially Met
O Not Met
```


### 8.4 MODE CHOICE VALIDATION

TABLE 8-5 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE


Notes:

- = Met / Not Required
- = Partially Met
- = Not Met


### 8.5 TRAFFIC ASSIGNMENT VALIDATION

TABLE 8-6 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Vehicle <br> Miles <br> Traveled | $\bullet$ | $\bullet$ |  | - | $\bigcirc$ | - | - | $\bigcirc$ |

All Vehicles - Traffic Counts

| Daily | 0 | 0 | 0 | 0 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| AM Period | 0 | 0 | 0 | 0 | 0 | 0 |


| Midday Period | - | © | $\bigcirc$ | $\bigcirc$ | - |  | - | $\bigcirc$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| PM Period | - | © | $\bigcirc$ | $\bigcirc$ | 0 | - |  | - |
| Nighttime Period | - | © | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |  | - |
| AM 1 Hour | - | © | - | $\bigcirc$ | $\bigcirc$ | © |  | $\bigcirc$ |
| PM 1 Hour | - | © | - | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |  | $\bigcirc$ |


| Daily | 0 | 0 |  | 0 | 0 | 0 | 0 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| AM Period | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| PM Period | 0 | 0 |  | 0 | 0 | 0 | 0 | 0 |
| AM 1 Hour | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| PM 1 Hour | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |

Distribution of Class by Time of Day - Truck Traffic Counts


Distribution of Time of Day by Class - Truck Traffic Counts
Medium -
AM Period

| Medium - <br> Midday <br> Period | - | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bullet$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Medium - <br> PM Period | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | - | $\bullet$ | $\bullet$ | $\bigcirc$ |




| Heavy - <br> Evening Period | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |

Notes:

- Met / Not Required
(1) = Partially Met

O $=$ Not Met

### 8.6 TRANSIT ASSIGNMENT VALIDATION

TABLE 8-7 SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT

|  | County |  |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Validation <br> Topic | Fresno | Kern | Kings | Madera | Merced | San <br> Joaquin | Stanislaus | Tulare |
| System <br> Ridership | O |  |  | N/A | N/A |  |  |  |

Notes:

- Met / Not Required
(1) = Partially Met

O Not Met

### 9.0 DYNAMIC MODEL VALIDATION

TABLE 9-1 SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Land Use | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bullet$ |
| Traffic <br> Assignment | © | © | - | © | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | © |
| Travel Cost | $\bigcirc$ | $\bigcirc$ | $\bullet$ | $\bullet$ | $\bullet$ | $\bigcirc$ | $\bigcirc$ | $\bullet$ |
| Induced Demand | $\bullet$ | $\bigcirc$ | $\bullet$ | $\bigcirc$ | $\bullet$ | $\bigcirc$ | $\bigcirc$ | $\bullet$ |

Notes:

- = Met / Not Required
- = Partially Met
- = Not Met

TABLE 9-2 SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Geographic Change | - | $\bullet$ | - | $\bullet$ | - | - | - | - |
| Placetype <br> Change | $\bullet$ | $\bullet$ | $\bullet$ | - | - | - | - | - |
| Total | $\bullet$ | $\bullet$ | - | $\bullet$ | $\bullet$ | - | - | - |

Notes:

|  | $=$ Met $/$ Not Required |
| ---: | :--- |
|  | $=$ Partially Met |
|  | $=$ Not Met |

TABLE 9-3 SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT


TABLE 9-4 SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Add Toll to Corridor | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |

Notes:

```
= Met / Not Required
O = Partially Met
O Not Met
```

TABLE 9-5 SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND

| Validation Topic | County |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fresno | Kern | Kings | Madera | Merced | San Joaquin | Stanislaus | Tulare |
| Interstate <br> Capacity <br> Change | $\bullet$ | $\bigcirc$ | $\bigcirc$ | $\bullet$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ | $\bigcirc$ |

Notes:

|  | $=$ Met $/$ Not Required |
| ---: | :--- |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## APPENDIX A: FRESNO MODEL VALIDATION DETAILS

Table A-1: Daily Person Trip Generation Rates - Fresno Table A-2-A: Daily Productions and Attractions at Gateways - Fresno
Table A-2-B: Special Generator Daily Productions and Attractions - Fresno
Table A-3: Summary of Model Performance - Static Validation - Fresno
Table A-4: Summary of Model Performance - Static Validation - Land Use - Fresno
Table A-5: Summary of Model Performance - Static Validation - Land Use - Detailed - Fresno
Table A-6: Summary of Model Performance - Static Validation - Trip Generation - Fresno
Table A-7: Summary of Model Performance - Static Validation - Trip Generation - PA Balance - Fresno
Table A-8: Summary of Model Performance - Static
Validation - Trip Generation - Trip Purpose Split - Fresno
Table A-9: Summary of Model Performance - Static
Validation - Trip Generation -Weekday Person Trips per Household - Fresno
Table A-10: Summary of Model Performance - Static Validation - Trip Generation -Vehicle Availability Fresno
Table A-11: Summary of Model Performance - Static Validation - Trip Distribution - Fresno
Table A-12: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (All Modes) Fresno
Table A-13: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (Driving Trips Only) - Fresno
Table A-14: Summary of Model Performance - Static Validation - Trip Distribution - Average Travel Time (in minutes) by Trip Purpose - Fresno
Table A-15: Summary of Model Performance - Static Validation - Mode Choice - Fresno

Table A-16: Summary of Model Performance - Static Validation - Mode Choice - Fresno
Table A-17-A: Summary of Model Performance - Static Validation - Traffic Assignment - Fresno
Table A-17-B: Summary of Model Performance - Static Validation - Traffic Assignment - VMT - Fresno
Table A-18: Summary of Model Performance - Static
Validation - Transit Assignment - Fresno
Table A-19: Summary of Model Performance - Static
Validation - Transit Assignment - Detailed - Fresno
Table A-20: Summary of Model Performance - Dynamic Validation - Fresno
Table A-21: Summary of Model Performance - Dynamic Validation - Land Use - Fresno
Table A-22: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Fresno
Table A-23: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add Lane - Fresno
Table A-24: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add/Delete Link Fresno
Table A-25: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Speed Change - Fresno Table A-26: Summary of Model Performance - Dynamic Validation - Travel Cost - Fresno
Table A-27: Summary of Model Performance - Dynamic Validation - Travel Cost (Add Toll Rates) - Fresno
Table A-28: Summary of Model Performance - Dynamic Validation - Induced Demand - Fresno
Table A-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity Change - Fresno


## TABLE A-1:

DAILY PERSON TRIP GENERATION RATES - FRESNO

| Land Use | Fresno |
| :---: | :---: |
| Residential |  |
| RU 1 | 7.01 |
| RU 3 | 4.43 |
| RU 9 | 4.57 |
| Non-Residential |  |
| Agriculture | 1.80 |
| Mining | 1.75 |
| Utilities | 1.74 |
| Construction | 1.75 |
| Manufacturing | 1.82 |
| Wholesale | 4.76 |
| Retail | 10.38 |
| Warehouse | 2.56 |
| Information | 2.42 |
| Financial and Insurance | 2.57 |
| Real Estate | 2.56 |
| Professional Services | 2.38 |
| Management Services | 1.97 |
| Administrative Services | 2.57 |
| Education | 0.00 |
| Health | 4.76 |
| Entertainment and Recreation | 7.51 |

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS | Bowman-Bradley | MCCOY-ROTH | CAC | Citilabs

| Accommodations | 7.34 |
| :---: | :---: |
| Food | 23.41 |
| Other Service | 4.79 |
| Public | 2.90 |
| Student Enrollment |  |
| Elementary | 3.22 |
| High School | 4.25 |
| College | 4.14 |

Notes:

TABLE A-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - FRESNO

| Purpose | Fresno |
| :---: | :---: |
| Home-Work | $80,611(22,012)$ |
| Home-Shop | $7,627(6,028)$ |
| Home-K12 | $0(0)$ |
| Home-College | $244(146)$ |
| Home-Other | $33,038(19,808)$ |
| Work-Other | $9,969(22,962)$ |
| Other-Other | $33,699(15,053)$ |
| Highway Commercial | $3,560(3,560)$ |
| Trucks-Small | $1,406(1,407)$ |
| Trucks-Medium | $709(699)$ |
| Trucks-Heavy | $10,298(11,267)$ |

Notes: Values shown as Production (Attraction)

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-Bradley | MCCOY-ROTH | CAC | Citilabs

TABLE A-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS - FRESNO

| Purpose | Fresno |
| :---: | :---: |
| Home-Work | $0(0)$ |
| Home-Shop | $0(0)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(0)$ |
| Work-Other | $0(52,386)$ |
| Other-Other | $0(0)$ |
| Trucks-Small | $0(0444)$ |
| Trucks-Medium | $0(0)$ |
| Trucks-Heavy | $0(0)$ |

Notes: Values shown as Production (Attraction)

## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)

TABLE A-3:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - FRESNO

|  | Validation Topic | Fresno |
| :---: | :---: | :---: |
|  | Land Use |  |
|  | Trip Generation |  |
|  | Trip Distribution |  |
|  | Mode Choice |  |
|  | Traffic Assignment |  |

TABLE A-4:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE - FRESNO

|  | Validation Topic | Fresno |
| :---: | :---: | :---: |
| Residential |  |  |
|  | Household Population |  |
| Total Households |  |  |
| Retail |  |  |
| Non-Retail |  |  |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE A-5:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - FRESNO

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Household <br> Population | $+/-3 \%$ | 927,055 | 912,071 | $-14,984$ | $-1.6 \%$ |
| Total <br> Households | $+/-3 \%$ | 288,215 | 308,047 | 19,832 | $6.9 \%$ |
| Employment |  |  |  |  |  |
| Retail | $+/-10 \%$ | 63,400 | 284,714 | 11,314 | $17.8 \%$ |
| Non-Retail | $+/-10 \%$ | 351,900 | 345,102 | $-17,398$ | $-6.0 \%$ |
| Total | $+/-10 \%$ |  |  |  | $-6,084$ |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE A-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| Trip Balancing by Purpose |  |
| HBW |  |
| HBS |  |
| HBO |  |
| NHB |  |
| Total |  |
| Percentage of Trips by Purpose After Balancing |  |

TABLE A-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - FRESNO

|  | Validation Topic | Fresno |
| :---: | :---: | :---: |
|  | HBO | - |
|  | NHB | - |
|  | Person Trips Per HH | - |
|  | Vehicle Availability | - |
| Notes: | = Met / Not Required <br> = Partially Met <br> = Not Met |  |

TABLE A-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - PA BALANCE - FRESNO

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | Difference | Percent <br> Difference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| HBW | $+/-10 \%$ | 472,643 | 463,761 | 1.02 | $-8,882$ | $-1.9 \%$ |
| HBS | $+/-10 \%$ | 274,269 | 268,473 | 1.02 | $-5,795$ | $-2.1 \%$ |
| HBO | $+/-10 \%$ | $1,009,579$ | 986,323 | 1.02 | $-23,256$ | $-2.3 \%$ |
| NHB | $+/-10 \%$ | 550,985 | 538,708 | 1.02 | $-12,277$ | $-2.2 \%$ |
| Total | $+/-10 \%$ | $2,307,475$ | $2,257,266$ | 1.02 | $-50,210$ | $-2.2 \%$ |

Notes:

TABLE A-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

- TRIP PURPOSE SPLIT - FRESNO

| Purpose | Total (All Modes) |  |
| :---: | :---: | :---: |
| HBW | CHTS | Model |
| HBO | $19.6 \%$ | $18.0 \%$ |
| NHB | $55.5 \%$ | $58.6 \%$ |
| Total (All Purposes) | $24.9 \%$ | $23.4 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey.

TABLE A-9:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - FRESNO

| CHTS | Model |
| :---: | :---: |
| 6.8 | 6.8 |

Notes: 2000-2001 California Statewide Household Travel Survey.

TABLE A-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - FRESNO

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 11.9\% | 11.8\% | 32.5\% | 29.6\% | 37.1\% | 37.7\% | 18.5\% | 20.8\% |

[^4]TABLE A-11:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | $\bullet$ |
| Internal-External / External-Internal | - |
| Passenger Auto Trips Only |  |
| Internal-Internal | $\bullet$ |
| Internal-External / External-Internal | $\bullet$ |
| Average Travel Time |  |
| HBW | $\bigcirc$ |
| HBO | $\bigcirc$ |
| NHB | $\bullet$ |
| Notes:  <br> $=$ Met $/$ Not Required <br>  $=$ Partially Met <br>  $=$ Not Met |  |

TABLE A-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - FRESNO

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 88.2\% | 96.4\% | 83.0\% | 85.6\% | 91.1\% | 99.5\% | 86.8\% | 98.4\% |
| IX / XI | 11.8\% | 3.6\% | 17.0\% | 14.4\% | 8.9\% | 0.5\% | 13.2\% | 1.6\% |

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips.

TABLE A-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - FRESNO

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | $86.8 \%$ | $96.1 \%$ | $82.5 \%$ | $84.9 \%$ | $90.3 \%$ | $99.5 \%$ | $85.9 \%$ | $98 \%$ |
| IX / XI | $13.2 \%$ | $3.9 \%$ | $17.5 \%$ | $15.1 \%$ | $9.7 \%$ | $0.5 \%$ | $14.1 \%$ | $1.8 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips.

TABLE A-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - FRESNO

## Trip Purpose

|  | HBW |  |  | NHB |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| CHTS | Model | CHTS | Model | CHTS | Model |
| 20.2 | 16.2 | 15.1 | 19.7 | 15.5 | 15.2 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE A-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - FRESNO

\begin{tabular}{|c|c|c|}
\hline \& Validation Topic \& Fresno <br>
\hline \& Drive Alone \& - <br>
\hline \& Shared Ride 2 \& - <br>
\hline \& Shared Ride 3+ \& - <br>
\hline \& Transit \& - <br>
\hline \& Walk \& - <br>
\hline \& Bike \& $\bigcirc$ <br>

\hline \begin{tabular}{l}
Notes: <br>
©

 \& 

$=$ Met / Not Required <br>
= Partially Met <br>
$=$ Not Met
\end{tabular} \& <br>

\hline
\end{tabular}

TABLE A-16:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - FRESNO

|  | Purpose |  |
| :---: | :---: | :---: |
|  | CHTS | Model |
| Drive Alone | $41.7 \%$ | $42.2 \%$ |


| Shared Ride 2 | $26.5 \%$ | $19.4 \%$ |
| :---: | :---: | :---: |
| Shared Ride 3+ | $24.3 \%$ | $29.4 \%$ |
| Transit | $1.1 \%$ | $1.5 \%$ |
| Walk | $5.8 \%$ | $5.5 \%$ |
| Bike | $0.6 \%$ | $2.0 \%$ |
| Total | $100 \%$ | $100 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE A-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - FRESNO

| Validation Topic | Fresno |  |
| :---: | :---: | :---: |
| Vehicle Miles Traveled | 0 |  |
| All Vehicles - Traffic Counts | 0 |  |
| Daily | 0 |  |
| Midday Period | 0 |  |
| PM Period | 0 |  |
| Nighttime Period | 0 |  |
| AM 1 Hour | 0 |  |
| PM 1 Hour | 0 |  |
| Facility Type - Traffic Counts |  | 0 |


| Daily | 0 |
| :---: | :---: |
| AM Period | 0 |
| PM Period | 0 |
| AM 1 Hour | 0 |

TABLE A-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| PM 1 Hour | - |
| Distribution of Class by Time of Day - Truck Traffic Counts |  |
| Medium - AM Period | - |
| Medium - Midday Period | - |
| Medium - PM Period | - |
| Medium - Evening Period | - |
| Heavy - AM Period | - |
| Heavy - Midday Period | - |
| Heavy - PM Period | - |
| Heavy - Evening Period | $\bullet$ |
| Distribution of Time of Day by Class - Truck Traffic Counts |  |
| Medium - AM Period | $\bigcirc$ |
| Medium - Midday Period | - |
| Medium - PM Period | $\bigcirc$ |
| Medium - Evening Period | - |
| Heavy - AM Period | $\bigcirc$ |
| Heavy - Midday Period | - |
| Heavy - PM Period | $\bigcirc$ |
| Heavy - Evening Period | - |

Notes:

- = Met / Not Required
- = Partially Met

O $=$ Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-Bradley | MCCOY-ROTH | CAC | CItilabs

## TABLE A-17-B:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT

- VMT - FRESNO

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $22,376,000$ | $22,607,331$ | $1 \%$ |

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Fresno County Model

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Model Validation by Facility Type Results
Fresno County Model


TABLE A-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - FRESNO
Validation Topic Fresno

System Ridership

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met

TABLE A-19:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT

- DETAILED - FRESNO

| Validation | Evaluation <br> Statistic | Criterion | Ridership | Model Ridership |
| :--- | :---: | :---: | :---: | :---: | Percentage

Notes: Observed Ridership includes Fresno Area Express (FAX) average weekday unlinked trips as reported in the National Transit Database 2008 Report Year.

## DYNAMIC VALIDATION

TABLE A-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| Land Use | 0 |
| Traffic Assignment | 0 |
| Travel Cost |  |
| Induced Demand |  |

Notes:

- Met / Not Required
(1) = Partially Met

○ $=$ Not Met

TABLE A-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| Geographic Change |  |
| Placetype Change |  |
| Total |  |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-BRADLEY | MCCOY-ROTH | CAC| CITILABS

| TestNumber | TestType | ZoneType | TAZ_Before | TDFVT_Before | MXDVT_Before | RawModelPT_Before | TAZ_After | TDFVT_After | MXXVT_After | RawModelPT_After | TDFVT_\%Delta | MXDVT_\%Delta |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 GeographyChange | Primary | 932 | 563 | 770 | 921 | 1799 | 73 | 116 | 145 | 87\% | 85\% |
|  | 1 GeographyChange | Primary | 1799 | 966 | 1,546 | 1,896 | 932 | 1,522 | 2,289 | 2,670 | 57\% | 48\% |
|  | 1 GeographyChange | Adjacent | 1793 | 8,323 | 11,440 | 12,498 | 1793 | 8,311 | - 11,427 | 12,488 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 1794 | 664 | 1,052 | 1,238 | 1794 | 662 | 1,050 | 1,238 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 1798 | 1,260 | 1,965 | 2,243 | 1798 | 1,259 | 1,964 | 2,242 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 1800 | 1,546 | 2,504 | 3,006 | 1800 | 1,542 | 2,498 | 3,005 | 0\% | 0\% |
| 1 | 1 GeographyChange | Adjacent | 1804 | 1,373 | 2,172 | 2,474 | 1804 | 1,370 | 2,169 | 2,473 | 0\% | - 0\% |
| 1 | 1 GeographyChange | Adjacent | 1805 | 3,204 | 5,079 | 5,842 | 1805 | 3,193 | 5,064 | 5,838 | 0\% | - 0\% |
| 1 | 1 GeographyChange | Adjacent | 2300 | -60 | 87 | 95 | 2300 | 60 | 87 | - 95 | 0\% | - $0 \%$ |
|  | 1 GeographyChange | Adjacent | 2305 | 2,409 | 3,599 | 3,839 | 2305 | 2,422 | 3,619 | 3,836 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 2313 | 14 | 19 | 20 | 2313 | 14 | 19 | 20 | 0\% | 0\% |
|  | 2 GeographyChange | Primary | 1724 | 145 | 213 | 263 | 2245 | 87 | 126 | 138 | 40\% | 41\% |
|  | 2 GeographyChange | Primary | 2245 | -74 | 101 | 111 | 1724 | 132 | 186 | 228 | 78\% | 84\% |
|  | 2 GeographyChange | Adjacent | 1722 | 942 | 1,462 | 1,714 | 1722 | 942 | 1,461 | 1,713 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1725 | -328 | 514 | 600 | 1725 | 328 | 513 | 600 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1727 | 1,085 | 1,707 | 2,018 | 1727 | 1,084 | 1,706 | 2,018 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1728 | 822 | 1,255 | 1,534 | 1728 | 821 | 1,254 | 1,534 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1729 | 1,516 | 2,381 | 2,831 | 1729 | 1,513 | 2,377 | 2,830 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1742 | 40 | 57 | 66 | 1742 | 40 | 57 | 66 | 0\% | - 0\% |
|  | 2 GeographyChange | Adjacent | 2202 | 735 | 1,163 | 1,246 | 2202 | 730 | 1,155 | 1,245 | 1\% | - ${ }^{1 \%}$ |
|  | 2 GeographyChange | Adjacent | 2243 | 12 | 18 | 20 | 2243 | 12 | 18 | 20 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 2244 | 21 | 28 | 30 | 2244 | 21 | 28 | 30 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 2246 | - 407 | 601 | 658 | 2246 | 406 | 599 | 658 | 0\% | 0\% |
|  | 3 GeographyChange | Primary | 1561 | 1 60 | 95 | 120 | 2582 | 75 | 120 | 130 | 25\% | 25\% |
|  | 3 GeographyChange | Primary | 2582 | 11 | 17 | 20 | 1561 | 4 | - 8 | 10 | 60\% | 54\% |
|  | 3 GeographyChange | Adjacent | 1541 | 312 | 513 | 600 | 1541 | 312 | 514 | 600 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 1542 | - 174 | 277 | 341 | 1542 | 174 | 277 | 340 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 1543 | 896 | 1,455 | 1,770 | 1543 | 896 | 1,455 | 1,769 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 2204 | 111 | 159 | 176 | 2204 | 112 | 159 | 176 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 2290 | 343 | 490 | 524 | 2290 | 345 | 492 | 523 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 2301 | - 218 | 298 | 321 | 2301 | 218 | 298 | 321 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 2303 | -987 | 1,574 | 1,633 | 2303 | 996 | 1,588 | 1,631 | 1\% | 1\% |
|  | 3 GeographyChange | Adjacent | 2316 | - 12 | 16 | 18 | 2316 | 12 | 16 | 18 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 2317 | 21 | 27 | 32 | 2317 | 21 | 27 | 32 | 0\% | 0\% |
|  | 4 GeographyChange | Primary | 1274 | 30 | 48 | 53 | 2828 | 169 | 250 | 271 | 458\% | 416\% |
|  | 4 GeographyChange | Primary | 2828 | 260 | 406 | 444 | 1274 | 123 | 201 | 226 | 53\% | 51\% |
|  | 4 GeographyChange | Adjacent | 1288 | , | - 1 | 1 | 1268 |  | 1 | 1 | 0\% | 0\% |
| 4 | 4 GeographyChange | Adjacent | 1273 | 32 | 53 | 56 | 1273 | 32 | 53 | 56 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 1280 |  | , | $\square$ | 1280 | $3^{3}$ | 4 | 4 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2667 | 2 | 3 | - $3^{3}$ | 2667 | 2 | 3 | - ${ }^{3}$ | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2824 | 212 | 324 | 362 | 2824 | 212 | 324 | 362 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2826 | 2,197 | 3,367 | 3,913 | 2826 | 2,197 | 3,366 | 3,912 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2830 | - 390 | 599 | 670 | 2830 | 390 | 599 | 670 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2831 | $1{ }^{676}$ | 1,042 | 1,161 | 2831 | 676 | 1,042 | 1,161 | 0\% | 0\% |
|  | 5 GeographyChange | Primary | 684 | 182 | 297 | 356 | 1636 | 194 | 319 | 356 | 7\% | 7\% |
|  | 5 GeographyChange | Primary | 1636 | - 684 | 1,121 | 1,252 | 684 | 653 | 1,045 | 1,251 | 5\% | 7\% |
|  | 5 GeographyChange | Adjacent | 644 | 1,270 | 1,999 | 2,379 | 644 | 1,271 | 1,999 | 2,378 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 683 | - 574 | 892 | 1,058 | 683 | 584 | 893 | 1,057 | 2\% | 0\% |
| 5 | 5 GeographyChange | Adjacent | 697 | 836 | 1,318 | 1,571 | 697 | 852 | 1,321 | 1,570 | 2\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1107 | 582 | 925 | 1,099 | 1107 | 583 | 926 | 1,099 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1631 | 396 | 641 | 706 | 1631 | 395 | 639 | 705 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1635 | 121 | 194 | 217 | 1635 | 121 | 194 | 216 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1642 | 1,539 | 2,470 | 2,780 | 1642 | 1,538 | 2,468 | 2,779 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1643 | 583 | 940 | 1,098 | 1643 | 582 | 940 | 1,098 | 0\% | - 0\% |
|  | 6 PlacetypeChange | Primary | 1312 | 450 | 720 | 777 | 1312 | 463 | 709 | 767 | 3\% | 2\% |
|  | 6 PlacetypeChange | Adjacent | 481 | - 53 | 84 | 90 | 481 | 53 | 84 | 90 | 0\% | 0\% |
|  | 6 PlacetypeChange | Adjacent | 520 | , | 0 | $\square 0$ | 520 | 0 | 0 | $\square$ | 99900\% | 99900\% |
|  | 6 PlacetypeChange | Adjacent | 538 | 8 | 14 | 16 | 538 | 9 | 14 | 16 | 0\% | 0\% |
|  | 6 PlacetypeChange | Adjacent | 1311 | 1212 | 343 | 370 | 1311 | 212 | 342 | 370 | 0\% | - 0\% |
|  | 6 PlacetypeChange | Adjacent | 1313 | 301 | 314 | 349 | 1313 | 201 | 314 | 349 | 0\% | - 0\% |
|  | 6 PlacetypeChange | Adjacent | 1314 | , | 0 | 0 | 1314 |  | 0 | 0 | 0\% | \% |
|  | PlacetypeChange | Primary | 2476 | 44 | 70 | 80 | 2476 | 385 | 635 | 746 | 781\% | 307\% |
|  | PlacetypeChange | Adjacent | 2143 | 195 | 312 | 354 | 2143 | 197 | 315 | 354 | 1\% | 1\% |
|  | PlacetypeChange | Adjacent | 2472 | 398 | 616 | 687 | 2472 | 400 | 618 | 686 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2475 | 86 | 137 | 154 | 2475 | 86 | 136 | 154 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2477 | 410 | 641 | 712 | 2477 | 410 | 642 | 712 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2478 | 89 | 139 | 156 | 2478 | 89 | 139 | 156 | 0\% | 0\% |
|  | 8 PlacetypeChange | Primary | 2250 |  | - | 0 | 2250 | 21 | 38 | 47 | 99900\% | 99900\% |
|  | 3 PlacetypeChange | Adjacent | 1690 | 191 | 305 | 358 | 1690 | 190 | 305 | 357 | 0\% | 0\% |
|  | 3 PlacetypeChange | Adjacent | 1702 | 2 | 11 | 12 | 1702 | $8^{8}$ | 11 | 12 | 0\% | 0\% |
|  | 3 PlacetypeChange | Adjacent | 2249 | 13 | 17 | 19 | 2249 | 13 | 17 | 19 | 0\% | 0\% |
|  | 3 PlacetypeChange | Adjacent | 2251 | 1 21 | 28 | 32 | 2251 | 21 | 28 | 32 | 0\% | 0\% |
|  | PlacetypeChange | Primary | 2409 | - 14 | 21 | 23 | 2409 | $8^{8}$ | 11 | 12 | 47\% | 47\% |
|  | PlacetypeChange | Adjacent | 2390 | - 96 | 150 | 164 | 2390 | 96 | 150 | 164 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2391 | 1 | 9 | -9 | 2391 | $6^{6}$ | - 9 | 9 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2392 | 11 | 17 | 19 | 2392 | 11 | 17 | 19 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2407 | - 328 | 538 | 570 | 2407 | 328 | 538 | 569 | 0\% | 0\% |
|  | 9 PlacetypeChange | Adjacent | 2410 | - 14 | 21 | 23 | 2410 | 14 | 21 | 23 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2414 | - 12 | 18 | 20 | 2414 | 12 | 18 | 20 | 0\% | 2\% |
|  | 9 PlacetypeChange | Adjacent | 2415 | -37 | 57 | 60 | 2415 | 37 | 57 | 60 | 0\% | 0\% |
| 10 | PlacetypeChange | Primary | 1942 | 45 | 64 | 78 | 1942 | 0 | , | - 0 | 100\% | 100\% |
| 10 | PlacetypeChange | Adjacent | 1923 | 32 | 50 | 61 | 1923 | 32 | 50 | 61 | 0\% | 0\% |
| 10 | PlacetypeChange | Adjacent | 1924 | 400 | 772 | 928 | 1924 | 499 | 771 | 928 | 0\% | 0\% |
| 10 | PlacetypeChange | Adjacent | 1926 | 48 | 73 | 85 | 1926 | 48 | 73 | 85 | 0\% | 0\% |
| 10 | PlacetypeChange | Adjacent | 2278 | - 23 | 38 | 46 | 2278 | 23 | 38 | 46 | 1\% | 1\% |
| 10 | PlacetypeChange | Adjacent | 2279 | 32 | 43 | 50 | 2279 | 32 | 43 | 50 | 0\% | 0\% |
| 11 | 1 PlacetypeChange | Primary | 331 | - 672 | 1,038 | 1,285 | 331 | 260 | 396 | 487 | 61\% | 62\% |
| 11 | 1 PlacetypeChange | Adjacent | 329 | 1,058 | 1,632 | 2,162 | 329 | 1,057 | 1,632 | 2,160 | 0\% | 0\% |
| 11 | 1 PlacetypeChange | Adjacent | 330 | - 690 | 1,085 | 1,336 | 330 | 691 | 1,087 | 1,336 | 0\% | - 0\% |
|  | 1 PlacetypeChange | Adjacent | 332 | 643 | 999 | 1,227 | 332 | 644 | 1,001 | 1,227 | 0\% | 0\% |
| 11 | 1 PlacetypeChange | Adjacent | 334 | 695 | 1,088 | 1,327 | 334 | 696 | 1,089 | 1,326 | 0\% | 0\% |
| 11 | 1 PlacetypeChange | Adjacent | 336 | 1,146 | 1,796 | 2,213 | 336 | 1,148 | 1,800 | 2,212 | 0\% | 0\% |
| 12 | 12 PlacetypeChange | Primary | 392 | 2 | 2 | - 2 | 392 | 831 | 1,326 | 1,543 | 51833\% | 79459\% |
| 12 | PlacetypeChange | Adjacent | 371 | 275 | 442 | 517 | 371 | 274 | 439 | 517 | 0\% | 1\% |
| 12 | PlacetypeChange | Adjacent | 374 | - 552 | 901 | 1,068 | 374 | 555 | 907 | 1,067 | 1\% | 1\% |
| 12 | PlacetypeChange | Adjacent | 391 | 180 | 289 | 331 | 391 | 179 | 287 | 331 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 2227 | 21 | 32 | 36 | 2227 | 21 | 32 | 36 | 0\% |  |

SJV MIP - Placetype Summary - Fresno


TABLE A-22:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| Add Lanes to a Link |  |
| Add/Remove Link |  |
| Change Link Speed |  |


| Notes: |  |
| ---: | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE A-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - FRESNO

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Street Across Screenline - W. Olive Avenue from N. Golden State Boulevard to N. Weber Avenue |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 3,875 | 3,078 | 0 | -1 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 3,375 | 3,794 | 0 | 0 |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 1,327 | 1,635 | 0 | 2 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 554 | 289 | 0 | 0 |
| Total | 9,132 | 8,795 | 0 | 1 |

## Notes:

Source:

## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

W. Olive Avenue from N. Golden State Boulevard to N. Weber Avenue was under capacity in the base scenario so the addition of lanes did not introduce any more volume to the subject link. The parallel facilities also were not affected. The model responded appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

TABLE A-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - FRESNO

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Added Link Across Screenline - Connecting N. West Avenue to N. Golden State Boulevard |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 3,874 | 3,079 | -1 | 1 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 3,378 | 3,817 | 3 | 23 |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 873 | 1,117 | -454 | -516 |
| Added Link | 543 | 623 | 543 | 623 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 511 | 193 | -43 | -96 |
| Total | 9,178 | 8,829 | 47 | 34 |
| Deleted Street Across Screenline - W. Mickinley Avenue from N. Golden State Boulevard to N. Weber Avenue |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 4,550 | 4,079 | 676 | 1,001 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 0 | 0 | -3,375 | $-3,794$ |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 2,103 | 2,214 | 776 | 581 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 622 | 339 | 68 | 49 |

TABLE A-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - FRESNO

|  | Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: |
|  |  | NB/EB | SB/WB | NB/EB | SB/WB |
| Total | 7,276 | 6,632 | $-1,855$ | $-2,163$ |  |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a similar magnitude decrease in volume and the screenline showed a slight increase. For the deleted link test, the parallel facilities showed an increase in volume but not to the magnitude of the subject link decrease. The screenline was showed a significant decrease in volume. The model responded appropriately for the added link test and less appropriately for the deleted link test.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/-10 mph on subject facility.

TABLE A-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - FRESNO

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increased Speed on Street Across Screenline - W. Olive Avenue from N. Golden State Boulevard to N. Weber Avenue |  |  |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 40 | 40 | 3,873 | 3,046 | -2 | -32 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 40 | 40 | 3,387 | 3,847 | 12 | 53 |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 35 | 45 | 1,518 | 1,661 | 191 | 28 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 30 | 30 | 516 | 286 | -38 | -4 |
| Total |  |  | 9,294 | 8,840 | 163 | 46 |
| Decreased Speed on Street Across Screenline - W. Olive Avenue from N. Golden State Boulevard to N. Weber Avenue |  |  |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 40 | 40 | 3,879 | 3,099 | 4 | 21 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 40 | 40 | 3,389 | 3,761 | 14 | -33 |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 35 | 25 | 1,184 | 1,561 | -143 | -72 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 30 | 30 | 591 | 301 | 37 | 12 |
| Total |  |  | 9,043 | 8,722 | -89 | -72 |

[^5]
## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the subject link showed an increase in volume. However, the parallel facilities did not show a decrease in volume similar to the magnitude of the increase on the subject link. For the decrease speed test, the subject link showed a decrease in volume. However, the parallel facilities did not show an increase in volume similar to the magnitude of the decrease on the subject link. The model did not respond appropriately.

TABLE A-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - FRESNO

| Validation Topic | Fresno |
| :---: | :---: |
| Add Toll to Corridor | $\bigcirc$ |

```
Notes:
    = Met / Not Required
O = Partially Met
O Not Met
```


## Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE A-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAVEL COST (ADD TOLL RATES) - FRESNO

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| State Route Corridor - SR 180 from S. Roeding Drive to N. Peach Avenue |  |  |  |  |
| W. Clinton Avenue - SR 99 to N. Weber Avenue | 3,885 | 3,949 | 11 | 871 |
| W. McKinley Avenue - N. Golden State Boulevard to N. Weber Avenue | 3,808 | 3,377 | 433 | -417 |
| W. Olive Avenue - N. Golden State Boulevard to N. Weber Avenue | 2,771 | 3,008 | 1,444 | 1,374 |
| W. Belmont Avenue - N. Golden State Boulevard to N. Weber Avenue | 2,026 | 2,312 | 1,471 | 2,022 |
| Total | 12,490 | 12,646 | 3,359 | 3,851 |
| Notes: |  |  |  |  |

Source:

## Notes:

Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities parallel to the subject corridor showed an increase in volumes. However, the model was too sensitive and all trips were shifted from the subject corridor due to tolling. The model did not respond appropriately.

TABLE A-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - FRESNO

| Validation Topic | Fresno |
| :---: | :---: | :---: |
| Interstate Capacity Change | $\bullet$ |

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met


## Reduce Roadway Capacity

Halve roadway capacity on a State Route within the County.

TABLE A-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - FRESNO

| Performance Measure | Base Scenario | Reduce Roadway <br> Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | $6,408.6$ | $6,315.8$ | $-1.45 \%$ |
| VMT | $17,765,837$ | $17,577,615$ | $-1.06 \%$ |
| Elasticity |  |  | 0.73 |

Notes:
Source:

Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature: Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed but the model was too sensitive to the effects. VMT decreased more than the literature elasticity suggests. The model partially responded appropriately.

## APPENDIX B: <br> KERN MODEL VALIDATION DETAILS

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Table B-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity Change - Kern


## TABLE B-1:

DAILY PERSON TRIP GENERATION RATES - KERN

| Land Use | Kern |
| :---: | :---: |
| Residential |  |
| RU 1 | 6.95 |
| RU 3 | 4.51 |
| RU 9 | 4.32 |
| Non-Residential |  |
| Agriculture | 2.36 |
| Mining | 2.35 |
| Utilities | 2.31 |
| Construction | 2.24 |
| Manufacturing | 2.20 |
| Wholesale | 5.77 |
| Retail | 13.53 |
| Warehouse | 3.38 |
| Information | 3.40 |
| Financial and Insurance | 3.66 |
| Real Estate | 3.66 |
| Professional Services | 3.40 |
| Management Services | 3.08 |
| Administrative Services | 3.67 |
| Education | 0.00 |
| Health | 6.19 |
| Entertainment and Recreation | 11.02 |


| Accommodations | 10.32 |
| :---: | :---: |
| Food | 41.52 |
| Other Service | 7.12 |
| Public | 8.96 |
| Student Enrollment |  |
| Elementary | 3.56 |
| High School | 4.72 |
| College | 5.97 |

Notes:

TABLE B-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - KERN

| Purpose | Kern |
| :---: | :---: |
| Home-Work | $45,156(28,378)$ |
| Home-Shop | $14,035(46,790)$ |
| Home-K12 | $0(0)$ |
| Home-College | $5,166(5,050)$ |
| Home-Other | $71,870(21,489)$ |
| Work-Other | $23,619(28,566)$ |
| Other-Other | $76,924(110,549)$ |
| Highway Commercial | $2,969(2,969)$ |
| Trucks-Small | $1,153(1,158)$ |
| Trucks-Medium | $741(715)$ |
| Trucks-Heavy | $14,933(16,071)$ |

Notes: Values shown as Production (Attraction)

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-BRADLEY | MCCOY-ROTH | CAC | CITILABS

TABLE B-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - KERN

| Purpose | Kern |
| :---: | :---: | :---: |
| Home-Work | $0(10,610)$ |
| Home-Shop | $0(1,329)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(0)$ |
| Work-Other | $0(3,865)$ |
| Other-Other | $5,062(606)$ |
| Highway Commercial | $3,175(4,307)$ |
| Trucks-Small | $0(0)$ |
| Trucks-Medium | $1,158(1,158)$ |
| Trucks-Heavy | $994(994)$ |

Notes: Values shown as Production (Attraction)

## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)

TABLE B-3:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - KERN

|  | Validation Topic | Kern |
| :---: | :---: | :---: |
|  | Land Use |  |
|  | Trip Generation |  |
|  | Trip Distribution |  |
|  | Mode Choice |  |
|  | Traffic Assignment |  |

TABLE B-4:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE - KERN

|  | Validation Topic | Kern |
| :---: | :---: | :---: |
| Residential |  |  |
|  | Household Population |  |
| Total Households |  |  |
| Retail |  |  |
| Non-Retail | Total |  |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE B-5:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - KERN

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Household <br> Population | $+/-3 \%$ | 815,023 | 766,869 | $-48,154$ | $-5.9 \%$ |
| Total <br> Households | $+/-3 \%$ | 249,386 | 254,179 | 4,793 | $1.9 \%$ |
| Employment |  |  |  |  |  |
| Retail | $+/-10 \%$ | 48,900 | 238,869 | $-1,031$ | $-2.1 \%$ |
| Non-Retail | $+/-10 \%$ | 287,600 | 248,680 | 9,980 | $4.2 \%$ |
| Total | $+/-10 \%$ | 296,549 | 8,949 | $3.1 \%$ |  |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE B-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Trip Balancing by Purpose |  |
| HBW |  |
| HBS |  |
| HBO | Total |
| HBW |  |
| Percentage of Trips by Purpose After Balancing |  |

TABLE B-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - KERN

\begin{tabular}{|c|c|c|}
\hline \& Validation Topic \& Kern <br>
\hline \& HBO \& $\bullet$ <br>
\hline \& NHB \& - <br>
\hline \& Person Trips Per HH \& - <br>
\hline \& Vehicle Availability \& $\bigcirc$ <br>

\hline \begin{tabular}{l}
Notes: <br>
O

 \& 

= Met / Not Required <br>
= Partially Met <br>
$=$ Not Met
\end{tabular} \& <br>

\hline
\end{tabular}

TABLE B-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

- PA BALANCE - KERN

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | Difference | Percent <br> Difference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| HBW | $+/-10 \%$ | 390,047 | 406,459 | 0.96 | 16,413 | $4.2 \%$ |
| HBS | $+/-10 \%$ | 236,998 | 264,152 | 0.90 | 27,154 | $11.5 \%$ |
| HBO | $+/-10 \%$ | 898,143 | 896,232 | 1.00 | $-1,912$ | $-0.2 \%$ |
| NHB | $+/-10 \%$ | 674,034 | 652,177 | 1.03 | $-21,857$ | $-3.2 \%$ |
| Total | $+/-10 \%$ | $2,199,222$ | $2,219,021$ | 0.99 | 19,798 | $0.9 \%$ |

Notes:

TABLE B-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

- TRIP PURPOSE SPLIT - KERN

|  | Total (All Modes) |  |  |
| :---: | :---: | :---: | :---: |
| Purpose | CHTS | Model |  |
| HBW | $19.0 \%$ | $17.8 \%$ |  |
| HBO | $50.6 \%$ | $55.5 \%$ |  |
| NHB | $30.4 \%$ | $26.7 \%$ |  |
| Total (All Purposes) | $100.0 \%$ | $100.0 \%$ |  |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

## TABLE B-9:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - KERN

| CHTS | Model |
| :---: | :---: |
| 7.1 | 7.3 |

[^6]TABLE B-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - KERN

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 8.8\% | 7.4\% | 33.9\% | 28.5\% | 37.0\% | 40.1\% | 20.3\% | 24.0\% |

Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

TABLE B-11:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - KERN

| Validation Topic | Kern |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | $\bullet$ |
| Internal-External / External-Internal | - |
| Passenger Auto Trips Only |  |
| Internal-Internal | $\bullet$ |
| Internal-External / External-Internal | - |
| Average Travel Time |  |
| HBW | $\bullet$ |
| HBO | $\bigcirc$ |
| NHB | $\bullet$ |
| = Met / Not Required <br> = Partially Met <br> = Not Met |  |

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-Bradley | MCCOY-ROTH | CAC | CItilabs

TABLE B-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - KERN

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 98\% | 83.1\% | 92\% | 92\% | 100\% | 87\% | 99\% |
| IX / XI | 11\% | 2\% | 16.9\% | 8\% | 8\% | 0\% | 13\% | 1\% |

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE B-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - KERN

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 98\% | 83.8\% | 92.1\% | 91.5\% | 99.5\% | 86.1\% | 99\% |
| IX / XI | 11\% | 2\% | 16.2\% | 7.9\% | 8.5\% | 0.5\% | 13.9\% | 0.8\% |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE B-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - KERN

|  |  | Trip Purpose |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | HBW |  | HBO |  | NHB |
| CHTS | Model | CHTS | Model | CHTS | Model |
| 20.2 | 19.6 | 15.1 | 20.4 | 15.5 | 14.0 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE B-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Drive Alone | $\bullet$ |
| Shared Ride 2 | $\bullet$ |
| Shared Ride 3+ | - |
| Transit | $\bigcirc$ |
| Walk | - |
| Bike | - |

## Notes:

$=$ Met / Not Required

- $\quad$ Partially Met

O $=$ Not Met

TABLE B-16:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - KERN

|  | Purpose | Model |
| :---: | :---: | :---: |
| Drive Alone | CHTS | $46.7 \%$ |
| Shared Ride 2 | $43.6 \%$ | $23.5 \%$ |
| Shared Ride 3+ | $28.4 \%$ | $20.5 \%$ |
| Transit | $22.4 \%$ | $2.6 \%$ |
| Walk | $1.0 \%$ | $5.5 \%$ |
| Bike | $4.3 \%$ | $1.0 \%$ |
| Total | $0.3 \%$ | $100 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

= Met / Not Required

TABLE B-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Vehicle Miles Traveled | - |
| All Vehicles - Traffic Counts |  |
| Daily | - |
| AM Period | © |
| Midday Period | © |
| PM Period | © |
| Nighttime Period | © |
| AM 1 Hour | - |
| PM 1 Hour | © |
| Facility Type - Traffic Counts |  |
| Daily | © |
| AM Period | © |
| PM Period | © |
| AM 1 Hour | - |
| PM 1 Hour | 0 |
| Distribution of Class by Time of Day - Truck Traffic Counts |  |
| Medium - AM Period | $\bigcirc$ |
| Medium - Midday Period | $\bigcirc$ |
| Medium - PM Period | - |
| Medium - Evening Period | $\bigcirc$ |

TABLE B-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Heavy - AM Period | $\bigcirc$ |
| Heavy - Midday Period | $\bigcirc$ |
| Heavy - PM Period | $\bullet$ |
| Heavy - Evening Period | $\bigcirc$ |
| Distribution of Time of Day by Class - Truck Traffic Counts |  |
| Medium - AM Period | $\bigcirc$ |
| Medium - Midday Period | $\bigcirc$ |
| Medium - PM Period | $\bigcirc$ |
| Medium - Evening Period | $\bigcirc$ |
| Heavy - AM Period | $\bigcirc$ |
| Heavy - Midday Period | $\bigcirc$ |
| Heavy - PM Period | $\bigcirc$ |
| Heavy - Evening Period | $\bigcirc$ |

TABLE B-17-B:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - KERN

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+-3 \%$ | $22,217,235$ | $22,753,795$ | $2.4 \%$ |

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Valdal
Kern County Model

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation by Facility Type Results


TABLE B-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - KERN

| Validation Topic | Kern |
| :---: | :---: |
| System Ridership |  |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE B-19:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - DETAILED - KERN

| Validation | Evaluation <br> Statistic | Criterion | Ridership | Model Ridership |
| :--- | :---: | :---: | :---: | :---: | Percentage | ( |
| :--- |
| Difference between <br> actual ridership to <br> model results for <br> entire system |

Notes: Observed Ridership includes Fresno Area Express (FAX) average weekday unlinked trips as reported in the National Transit Database 2008 Report Year.

## DYNAMIC VALIDATION

TABLE B-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Land Use | 0 |
| Traffic Assignment | 0 |
| Travel Cost | 0 |
| Induced Demand |  |

Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE B-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - KERN




TABLE B-22:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - KERN

| Validation Topic | Kern |
| :---: | :---: |
| Add Lanes to a Link |  |
| Add/Remove Link | $\bullet$ |
| Change Link Speed | $\bullet$ |


| Notes: |  |
| ---: | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE B-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - KERN

| Screenline Roadways | Peak Hour <br> Volume | Volume Change |  |  |
| :--- | :--- | :--- | :--- | :--- |
| Street Across Screenline - Calloway Drive from Brimhall Road to Stockdale Highway |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 3,817 | 4,062 | -1 | 5 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 3,173 | 2,364 | 6 | 0 |
| Coffee Road - Brimhall Road to Truxtun Avenue | 6,268 | 6,330 | 20 | -3 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 20,233 | 21,830 | -35 | -111 |
| Total | 33,490 | 34,586 | -10 | -109 |

[^7]
## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

Model showed a slight increase in volume on the subject link. However, Parallel facilities showed a decrease in volume much larger in magnitude than the subject link. The model did not respond appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

TABLE B-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - KERN

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Added Link Across Screenline - Connecting Mohawk Street across Kern River |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 3,837 | 4,001 | 19 | -55 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 2,932 | 2,298 | -235 | -67 |
| Coffee Road - Brimhall Road to Truxtun Avenue | 6,062 | 6,043 | -186 | -290 |
| Added Link | 910 | 822 | 910 | 822 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 19,877 | 21,550 | -390 | -392 |
| Total | 33,619 | 34,714 | 119 | 19 |
| Deleted Street Across Screenline - Calloway Drive from Brimhall Road to Stockdale Highway |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 4,913 | 4,688 | 1,095 | 632 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 0 | 0 | -3,167 | $-2,365$ |
| Coffee Road - Brimhall Road to Truxtun Avenue | 7,561 | 7,143 | 1,313 | 809 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 21,026 | 22,577 | 759 | 636 |

TABLE B-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - KERN

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
|  | 33,501 | 34,407 | 0 | -288 |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a similar magnitude decrease in volume and the screenline showed a slight increase. For the deleted link test, the parallel facilities showed a similar magnitude increase in volume and the screenline showed a slight decrease. The model responded appropriately.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/-10 mph on subject facility.

TABLE B-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - KERN

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increased Speed on Street Across Screenline - Coffee Road from Brimhall Road to Truxtun Avenue |  |  |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 35 | 35 | 3,819 | 4,048 | 1 | -8 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 45 | 45 | 3,062 | 2,324 | -105 | -41 |
| Coffee Road - Brimhall Road to Truxtun Avenue | 45 | 55 | 6,390 | 6,423 | 141 | 89 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 65 | 65 | 20,235 | 21,899 | -32 | -42 |
| Total |  |  | 33,506 | 34,694 | 5 | -1 |
| Decreased Speed on Street Across Screenline - Coffee Road from Brimhall Road to Truxtun Avenue |  |  |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 35 | 35 | 3,831 | 4,023 | 13 | -33 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 45 | 45 | 3,168 | 2,414 | 1 | 49 |
| Coffee Road - Brimhall Road to Truxtun Avenue | 45 | 35 | 6,176 | 6,249 | -73 | -85 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 65 | 65 | 20,277 | 21,863 | 10 | -79 |
| Total |  |  | 33,451 | 34,548 | -49 | -147 |

Notes:
Source:

## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the parallel facilities showed a similar magnitude decrease in volume. For the decreased speed test, the parallel facilities showed both increases and decreases in volume. The model responded appropriately for the increased speed test and less appropriately for the decreased speed test.

TABLE B-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - KERN

| Validation Topic | Kern |
| :--- | :--- |
| Add Toll to Corridor | O |


| Notes: |  |
| :--- | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE B-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - KERN

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| State Route Corridor - SR 99 from Houghton Road to SR 204 |  |  |  |  |
| Stockdale Highway - Jewetta Avenue to Buena Vista Road | 4,772 | 5,205 | 954 | 1,149 |
| Calloway Drive - Brimhall Road to Stockdale Highway | 5,862 | 5,535 | 2,696 | 3,170 |
| Coffee Road - Brimhall Road to Truxtun Avenue | 7,596 | 7,545 | 1,348 | 1,212 |
| SR 99 - Rosedale Highway to Truxtun Avenue | 4,154 | 5,184 | -16,113 | -16,758 |
| Total | 22,384 | 23,468 | -11,116 | -11,227 |

Notes:
Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities parallel to the subject corridor showed an increase in volumes. However, the model was too sensitive and all trips were shifted from the subject corridor due to tolling. The model did not respond appropriately.

TABLE B-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - KERN
Validation Topic $\quad$ Kern

Interstate Capacity Change

## Notes

|  | $=$ Met $/$ Not Required |
| ---: | :--- |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Reduce Roadway Capacity

Halve roadway capacity on a State Route within the County.

TABLE B-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - KERN

| Performance Measure | Base Scenario | Reduce Roadway <br> Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | $7,420.5$ | $7,235.1$ | $-2.50 \%$ |
| VMT | $27,503,520$ | $25,860,117$ | $-5.98 \%$ |
| Elasticity |  | 2.39 |  |

[^8]
## Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature. Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed but the model was too sensitive to the effects. VMT decreased more than the literature elasticity suggests. The model did not respond appropriately.

## APPENDIX C: <br> KINGS MODEL VALIDATION DETAILS (LAST UPDATED FEB. 29, 2012)

Table C-1: Daily Person Trip Generation Rates - Kings Table C-2-A: Daily Productions and Attractions at Gateways - Kings
Table C-2-B: Special Generator Daily Productions and Attractions - Kings
Table C-3: Summary of Model Performance - Static Validation - Kings
Table C-4: Summary of Model Performance - Static Validation - Land Use - Kings
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Table C-6: Summary of Model Performance - Static Validation - Trip Generation - Kings
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Table C-10: Summary of Model Performance - Static Validation - Trip Generation -Vehicle Availability - Kings
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Table C-15: Summary of Model Performance - Static Validation - Mode Choice - Kings

Table C-16: Summary of Model Performance - Static Validation - Mode Choice - Kings
Table C-17-A: Summary of Model Performance - Static Validation - Traffic Assignment - Kings
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Validation - Traffic Assignment - VMT - Kings
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Table C-20: Summary of Model Performance - Dynamic Validation - Kings
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Table C-27: Summary of Model Performance - Dynamic Validation - Travel Cost (Add Toll Rates) - Kings
Table C-28: Summary of Model Performance - Dynamic Validation - Induced Demand - Kings
Table C-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity Change - Kings


TABLE C-1:
DAILY PERSON TRIP GENERATION RATES - KINGS

| Land Use | Kings |
| :---: | :---: |
| Residential |  |
| RU 1 | 8.82 |
| RU 3 | 6.34 |
| RU 9 | 7.84 |
| Non-Residential |  |
| Agriculture | 2.07 |
| Mining | 2.05 |
| Utilities | 2.21 |
| Construction | 2.09 |
| Manufacturing | 2.17 |
| Wholesale | 8.11 |
| Retail | 27.65 |
| Warehouse | 4.20 |
| Information | 4.36 |
| Financial and Insurance | 4.37 |
| Real Estate | 4.34 |
| Professional Services | 4.37 |
| Management Services | 4.28 |
| Administrative Services | 4.37 |
| Education | 0.00 |
| Health | 5.96 |
| Entertainment and Recreation | 39.84 |

TABLE C-1:
DAILY PERSON TRIP GENERATION RATES - KINGS

|  | Land Use | Kings |
| :--- | :--- | :--- |
| Accommodations | 14.49 |  |
| Food | 71.37 |  |
| Other Service | 27.58 |  |
| Public | 33.05 |  |
| Student Enrollment | 4.23 |  |
| Elementary | 5.60 |  |
| High School | 5.69 |  |
| College |  |  |

Notes:

TABLE C-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - KINGS

| Purpose | Kings |
| :--- | :--- |
| Home-Work | $16,484(18,589)$ |
| Home-Shop | $2,408(2,408)$ |
| Home-K12 | $0(0)$ |
| Home-College | $9(5,452)$ |
| Home-Other | $7,060(7,060)$ |
| Work-Other | $3,668(3,668)$ |
| Other-Other | $3,225(7,145)$ |
| Highway Commercial | $1,072(1,072)$ |
| Trucks-Small | $434(543)$ |

TABLE C-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - KINGS

| Purpose |  |
| :--- | :--- |
|  | Kings |
| Trucks-Medium | $201(262)$ |
| Trucks-Heavy | $2,182(2,814)$ |

Notes: Values shown as Production (Attraction)

TABLE C-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - KINGS

| Purpose | Kings |
| :--- | :--- |
| Home-Work | $1,311(2,932)$ |
| Home-Shop | $960(135)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(0)$ |
| Home-Other | $2,107(12,321)$ |
| Work-Other | $0(0)$ |
| Other-Other | $10,833(10,833)$ |
| Highway Commercial | $0(0)$ |
| Trucks-Small | $0(0)$ |
| Trucks-Medium | $0(0)$ |
| Trucks-Heavy |  |

Notes: Values shown as Production (Attraction)

## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)

| TABLE C-3: <br> SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - KINGS |  |
| :---: | :---: |
|  |  |
| Validation Topic | Kings |
| Land Use | $\bigcirc$ |
| Trip Generation | 0 |
| Trip Distribution | $\bigcirc$ |
| Mode Choice | - |
| Traffic Assignment | $\bigcirc$ |
| Transit Assignment | N/A |
| Notes: $\begin{aligned} & =\text { Met } / \text { Not Required } \\ & =\text { Partially Met } \\ & =\text { Not Met } \end{aligned}$ |  |

TABLE C-4:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE - KINGS

| Validation Topic |  | Kings |
| :--- | :--- | :--- |
| Residential |  |  |
| Household Population |  |  |
| Total Households |  |  |
| Employment |  |  |
| Retail |  |  |
| Non-Retail |  |  |
| Total |  |  |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE C-5:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - KINGS

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Household <br> Population <br> +/- $3 \%$ | 153,531 | 123,554 | $-29,977$ | $-19.5 \%$ |  |
| Total <br> Households | $+/-3 \%$ | 39,766 | 37,509 | $-2,257$ | $-5.7 \%$ |
| Employment |  | 6,800 | 5,718 | $-1,082$ | $-15.9 \%$ |
| Retail | 37,500 | 29,343 | $-8,157$ | $-21.8 \%$ |  |
| Non-Retail | 44,300 | 35,061 | $-9,239$ | $-20.9 \%$ |  |
| Total |  |  |  |  |  |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE C-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - KINGS

| Validation Topic |  | Kings |
| :--- | :--- | :--- |
| Trip Balancing by Purpose |  |  |
| HBW |  |  |
| HBS |  |  |
| HBO |  |  |
| NHB |  |  |
| Total |  |  |
| Percentage of Trips by Purpose After Balancing |  |  |
| HBW |  |  |

TABLE C-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - KINGS

| Validation Topic | Kings |
| :---: | :---: |
| HBO | $\bullet$ |
| NHB | $\bigcirc$ |
| Person Trips Per HH | $\bigcirc$ |
| Vehicle Availability | - |
| Notes: |  |
| $=$ Met $/$ Not Required <br> $=$ Partially Met <br> $=$ Not Met |  |

TABLE C-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - PA BALANCE - KINGS

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | DifferencePercent <br> Difference |  |
| :--- | :--- | :--- | :---: | :---: | :---: | :--- |
| HBW | $+/-10 \%$ | 78,956 | 79,117 | 1.00 | 162 | $0.2 \%$ |
| HBS | $+/-10 \%$ | 43,768 | 43,649 | 1.00 | -119 | $-0.3 \%$ |
| HBO | $+/-10 \%$ | 174,271 | 170,757 | 1.02 | $-3,514$ | $-2.0 \%$ |
| NHB | $+/-10 \%$ | 179,102 | 168,028 | 1.07 | $-11,074$ | $-6.2 \%$ |

Notes:

TABLE C-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - TRIP PURPOSE SPLIT - KINGS

| Purpose |  | Total (All Modes) |  |
| :--- | :--- | :--- | :--- |
|  |  | CHTS |  |
| HBW | $15.0 \%$ |  | Model |
| HBO | $50.6 \%$ | $50.4 \%$ |  |
| NHB | $34.5 \%$ | $38.0 \%$ |  |
| Total (All Purposes) | $100.0 \%$ | $100.0 \%$ |  |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting. Transit excludes school bus trips.

TABLE C-9:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - KINGS

| CHTS | Model |  |
| :--- | :--- | :--- | :---: |
| 8.5 | 10.2 |  |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, made by households within the county, weighted by weekday, household-level weights ("HHWDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting.

TABLE C-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - KINGS

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 7.8\% | 5.7\% | 29.1\% | 28.5\% | 39.7\% | 40.9\% | 23.4\% | 24.9\% |

[^9]TABLE C-11-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - KINGS

| Validation Topic | Kings |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | $\bigcirc$ |
| Internal-External | $\bigcirc$ |
| External-Internal | $\bigcirc$ |
| Passenger Auto Trips Only |  |
| Internal-Internal | $\bigcirc$ |
| Internal-External | $\bigcirc$ |
| External-Internal | $\bigcirc$ |
| Vehicle Miles Traveled | $\bigcirc$ |
| Average Travel Time |  |
| HBW | - |
| HBO | $\bigcirc$ |
| NHB | $\bigcirc$ |
| Notes: <br> $=$ Met / Not Required <br> = Partially Met <br> = Not Met |  |

TABLE C-11-B:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - KINGS

| Evaluation Criterion | HPMS | Model |  |
| :--- | :---: | :---: | :---: |
| $+/-5 \%$ | $3,615,697$ | $4,154,117$ | $14.9 \%$ |

TABLE C-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - KINGS

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 61.5\% | 56.1\% | 70.8\% | 88.5\% | 69.8\% | 87.0\% | 61.5\% | 56.1\% |
| IX | 19.9\% | 23.5\% | 14.5\% | 7.3\% | 15.0\% | 6.5\% | 19.9\% | 23.5\% |
| XI | 18.6\% | 20.4\% | 14.7\% | 4.2\% | 15.1\% | 6.5\% | 18.6\% | 20.4\% |

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips. Trips are weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting.

TABLE C-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - KINGS

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 61.9\% | 55.1\% | 68.1\% | 87.5\% | 71.1\% | 86\% | 61.9\% | 55.1\% |
| IX | 19.4\% | 24.0\% | 15.6\% | 7.9\% | 15.0\% | 7\% | 19.4\% | 24.0\% |
| XI | 18.7\% | 20.9\% | 16.3\% | 4.6\% | 14.0\% | 7\% | 18.7\% | 20.9\% |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips. Trips are weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting.

TABLE C-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - KINGS

| Trip Purpose |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | HBW | HBO |  | NHB |  |
| CHTS | Model | CHTS | Model | CHTS | Model |
| 18.1 | 17.2 | 13.9 | 16.0 | 13.6 |  |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting.

TABLE C-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - KINGS

| Validation Topic | Kings |
| :---: | :---: |
| Drive Alone | - |
| Shared Ride 2 | $\bullet$ |
| Shared Ride 3+ | $\bullet$ |
| Transit | $\bigcirc$ |
| Walk | - |
| Bike | $\bullet$ |
| Notes: <br> $=$ Met / Not Required <br> = Partially Met <br> $=$ Not Met |  |

TABLE C-16:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - KINGS

|  | Purpose |  |
| :--- | :---: | :--- |
|  | CHTS | Model |
| Drive Alone | $42.4 \%$ |  |
| Shared Ride 2 | $26.3 \%$ | $40.8 \%$ |
| Shared Ride 3+ | $26.3 \%$ | $25.8 \%$ |
| Transit | $0.0 \%$ | $26.0 \%$ |
| Walk | $4.9 \%$ | $1.2 \%$ |
| Bike | $0.2 \%$ | $5.9 \%$ |
| Total | $42.4 \%$ | $0.3 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting. Transit excludes school bus trips.

TABLE C-17:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - KINGS

|  | Kings |
| :---: | :---: |
| All Vehicles |  |
| Daily | $\bigcirc$ |
| AM Period | $\bigcirc$ |
| Midday Period | $\bigcirc$ |
| PM Period | - |
| Nighttime Period | - |
| AM 1 Hour | $\bigcirc$ |
| PM 1 Hour | $\bigcirc$ |
| Trucks |  |
|  | GG ASSOCIATES \| RSG | CS | COY-ROTH | CAC | CItilabs |

TABLE C-17:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - KINGS

|  | Validation Topic | Kings |  |
| :---: | :---: | :---: | :---: |
| By Time |  | $\bigcirc$ |  |
| By Class |  | $\bigcirc$ |  |
| Notes: |  |  |  |
| $\bigcirc$ | = Met / Not Required |  |  |
| - | = Partially Met |  |  |
| $\bigcirc$ | = Not Met |  |  |

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Kings County Model


TABLE C-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - KINGS
Validation Topic $\quad$ Kings

System Ridership
Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE C-19:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT

- DETAILED - KINGS

| Validation <br> Statistic | Evaluation <br> Criterion | Ridership | Model Ridership | Percentage |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Difference between <br> actual ridership to <br> model results for <br> entire system | $+/-20 \%$ | N/A | N/A | N/A |

Notes: Observed Ridership includes Fresno Area Express (FAX) average weekday unlinked trips as reported in the National Transit Database 2008 Report Year.

## DYNAMIC VALIDATION

TABLE C-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - KINGS

| Validation Topic | Kings |
| :--- | :--- |
| Land Use |  |
| Traffic Assignment | 0 |
| Travel Cost | 0 |
| Induced Demand |  |

Notes:

- = Met / Not Required
- = Partially Met
- = Not Met

TABLE C-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - KINGS

| Validation Topic | Kings |
| :---: | :---: |
| Geographic Change | $\bullet$ |
| Placetype Change | $\bullet$ |
| Total | - |
| Notes: <br> $=$ Met / Not Required <br> = Partially Met <br> = Not Met |  |


| TestNumber | TestType | ZoneType | TAZ_Before | TDFVT_Before | MXDVT_Before | RawModelPT_Before | TAZ_After ${ }^{\text {T }}$ | TDFVT_After | MXDVT_After | RawModelPT_After | TDFVT_\%Delta | MXDVT_\%Delta |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 GeographyChange | Primary | 302 | 182 | 268 | 296 | 540 | 184 | 272 | 294 | 1\% | 1\% |
|  | 1 GeographyChange | Primary | 540 | 787 | 1,150 | 1,226 | 302 | 770 | 1,125 | 1,219 | 2\% | 2\% |
|  | 1 GeographyChange | Adjacent | 282 | 2 | 0 |  | 282 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 1 GeographyChange | Adjacent | 283 | 519 | 776 | 849 | 283 | 516 | 772 | 844 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 284 | 554 | 865 | 961 | 284 | 552 | 862 | 961 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 301 | 406 | 600 | 662 | 301 | 403 | 596 | 657 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 303 | 3 | 1 |  | 303 | 0 | 1 | - 1 | 0\% | - 0\% |
| 1 | 1 GeographyChange | Adjacent | 304 | 293 | 403 | 445 | 304 | 285 | 391 | 433 | 3\% | - 3\% |
|  | 1 GeographyChange | Adjacent | 305 | 22 | 33 | 37 | 305 | 22 | 33 | 37 | 1\% | - 0\% |
|  | 1 GeographyChange | Adjacent | 306 | , | , | 7 | 306 | 4 | - 6 | 7 | 1\% | 0\% |
|  | 1 GeographyChange | Adjacent | 492 | 1,478 | 2,159 | 2,321 | 492 | 1,480 | 2,158 | 2,306 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 536 | 1,016 | 1,477 | 1,552 | 536 | 1,011 | 1,468 | 1,543 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 539 | 425 | 622 | 661 | 539 | 421 | 616 | 654 | 1\% | 1\% |
|  | 2 GeographyChange | Primary | 275 | 78 | 114 | 123 | 596 | 79 | 115 | 122 | 1\% | 1\% |
|  | 2 GeographyChange | Primary | 596 | - 267 | 385 | 404 | 275 | 262 | 377 | 401 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 269 | 650 | 1,024 | 1,148 | 269 | 647 | 1,020 | 1,147 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 274 | 65 | 92 | 102 | 274 | 64 | 91 | 101 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 276 | 476 | 751 | 840 | 276 | 476 | 750 | 841 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 292 | 392 | 582 | 635 | 292 | 390 | 578 | 630 | 1\% | - 1\% |
|  | 2 GeographyChange | Adjacent | 295 | - 346 | 516 | 557 | 295 | 345 | 513 | 554 | 1\% | - 0\% |
|  | 2 GeographyChange | Adjacent | 311 | 225 | 330 | 355 | 311 | 223 | 328 | 352 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 345 | 109 | 162 | 175 | 345 | 109 | 161 | 174 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 576 | 1,360 | 1,973 | 2,062 | 576 | 1,354 | 1,964 | 2,049 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 577 | 831 | 1,262 | 1,364 | 577 | 828 | 1,258 | 1,363 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 595 | 138 | 200 | 207 | 595 | 137 | 199 | 206 | 0\% | 1\% |
|  | 2 GeographyChange | Adjacent | 597 | 126 | 182 | 190 | 597 | 126 | 181 | 189 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 651 | 1 | , |  | 651 | 0 | 1 | 1 | 0\% | 0\% |
|  | 2 GeographyChange | Adjacent | 1048 | 33 | 47 | 49 | 1048 | 33 | 47 | 48 | 0\% | 0\% |
|  | 3 GeographyChange | Primary | 433 | 142 | 203 | 230 | 804 | 140 | 202 | 222 | 1\% | 1\% |
|  | 3 GeographyChange | Primary | 804 | 821 | 1,181 | 1,306 | 433 | 785 | 1,118 | 1,262 | 4\% | 5\% |
|  | 3 GeographyChange | Adjacent | 430 | 298 | 416 | 470 | 430 | 291 | 404 | 454 | 2\% | 3\% |
|  | 3 GeographyChange | Adjacent | 431 | 249 | 346 | 391 | 431 | 245 | 338 | 380 | 2\% | 2\% |
|  | 3 GeographyChange | Adjacent | 432 | 10 | 13 | 15 | 432 | 10 | 13 | 14 | 1\% | 2\% |
|  | 3 GeographyChange | Adjacent | 434 | 59 | 85 | 96 | 434 | 57 | 82 | 93 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 435 | 332 | 477 | 540 | 435 | 322 | 462 | 522 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 436 | - 170 | 241 | 274 | 436 | 167 | 236 | 265 | 2\% | 2\% |
|  | 3 GeographyChange | Adjacent | 801 | 157 | 226 | 247 | 801 | 155 | 222 | 242 | 2\% | 2\% |
|  | 3 GeographyChange | Adjacent | 803 | 416 | 595 | 654 | 803 | 406 | 579 | 635 | 2\% | 3\% |
|  | 3 GeographyChange | Adjacent | 805 | 212 | 304 | 336 | 805 | 206 | 295 | 325 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 806 | 191 | 282 | 305 | 806 | 191 | 281 | 303 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 811 | 442 | 638 | 689 | 811 | 439 | 632 | 681 | 1\% | 1\% |
|  | 3 GeographyChange | Adjacent | 816 | 450 | 640 | 728 | 816 | 438 | 620 | 704 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 817 | 281 | 406 | 448 | 817 | 273 | 393 | 432 | 3\% | - 3\% |
|  | 4 GeographyChange | Primary | 181 | 8 | 9 | 9 | 1258 | 8 | 9 | 9 | 2\% | 1\% |
|  | 4 GeographyChange | Primary | 1258 |  | 1 | $\square$ | 181 | 1 | 1 | 1 | 3\% | 9\% |
|  | 4 GeographyChange | Adjacent | 178 | 8 | 0 | - 0 | 178 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 180 |  | 0 | - 0 | 180 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 182 | 105 | 156 | 170 | 182 | 105 | 155 | 169 | 1\% | 1\% |
|  | 4 GeographyChange | Adjacent | 183 | 210 | 310 | 336 | 183 | 209 | 308 | 334 | 1\% | 1\% |
|  | 4 GeographyChange | Adjacent | 184 | , | 0 | $\square$ | 184 | 0 | - | $\square$ | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 316 | , | 1 | $\square 1$ | 316 | 0 | 1 | 1 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 1256 | 29 | 42 | 45 | 1256 | 29 | 42 | 44 | 1\% | - ${ }^{1 \%}$ |
|  | 4 GeographyChange | Adjacent | 1259 | 28 | 40 | 43 | 1259 | 27 | 40 | 43 | 1\% | 0\% |
|  | 4 GeographyChange | Adjacent | 1312 | 3 | 3 | 3 | 1312 | 3 | 3 | - 3 | 2\% | 2\% |
|  | 5 GeographyChange | Primary | 660 |  | 12 | 12 | 1202 |  | 12 | 12 | 0\% | 0\% |
|  | 5 GeographyChange | Primary | 1202 | 2 | 0 | 0 | 660 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 656 | - 13 | 19 | 20 | 656 | 13 | 19 | 20 | 0\% | 1\% |
|  | 5 GeographyChange | Adjacent | 659 | 9, | 0 | $\square 0$ | 659 | 0 | - 0 | - 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 661 | 16 | 21 | 22 | 661 | 16 | 21 | 22 | $2 \%$ | 2\% |
|  | 5 GeographyChange | Adjacent | 941 | , | 0 | 0 | 941 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 1045 | 166 | 239 | 248 | 1045 | 164 | 237 | 246 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 1063 | 3 | 12 | 12 | 1063 | 8 | 12 | 12 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1199 |  | 0 | 0 | 1199 | 1 | 0 | 0 | 2\% | 0\% |
|  | 5 GeographyChange | Adjacent | 1200 |  | 0 | 0 | 1200 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 1201 | 0 | 0 | 0 | 1201 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 1203 | , | 0 | 0 | 1203 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 5 GeographyChange | Adjacent | 1204 | , | , | $\square 0$ | 1204 | , | 0 | 0 | 99900\% | 99900\% |
|  | 6 PlacetypeChange | Primary | 673 | 740 | 843 | 888 | 673 | 10,517 | 15,093 | 16,226 | 1321\% | 1690\% |
|  | 6 PlacetypeChange | Adjacent | 531 | 1 | 0 | $\square 0$ | 531 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 6 PlacetypeChange | Adjacent | 672 | 2 | 11 | 11 | 672 | 8 | 10 | 11 | 2\% | $2 \%$ |
|  | 6 PlacetypeChange | Adjacent | 1112 | 12 | 1 | $\square$ | 1112 | 1 | 1 | 1 | 3\% | 2\% |
|  | 6 PlacetypeChange | Adjacent | 1113 | 3 | 8 | $\square 9$ | 1113 | $\square$ | 8 | - 8 | 4\% | 5\% |
|  | PlacetypeChange | Primary | 561 | 1,335 | 1,915 | 2,126 | 561 | 755 | 1,095 | 1,218 | 43\% | 43\% |
|  | PlacetypeChange | Adjacent | 550 | , | 0 | $\square 0$ | 550 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 552 | 20 | 28 | 30 | 552 | 20 | 27 | 29 | 3\% | 3\% |
|  | PlacetypeChange | Adjacent | 560 | 2,291 | 3,291 | 3,674 | 560 | 2,219 | 3,179 | 3,546 | 3\% | 3\% |
|  | 7 PlacetypeChange | Adjacent | 562 |  | 0 | $\square 0$ | 562 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 563 | 213 | 308 | 343 | 563 | 212 | 306 | 341 | 0\% | 0\% |
|  | 3 PlacetypeChange | Primary | 761 | 1,202 | 1,748 | 1,884 | 761 | 1,330 | 2,030 | 2,114 | 11\% | 16\% |
|  | 3 PlacetypeChange | Adjacent | 762 | 255 | 364 | 389 | 762 | 252 | 359 | 386 | 1\% | 1\% |
|  | 8 PlacetypeChange | Adjacent | 763 | 108 | 153 | 164 | 763 | 107 | 151 | 163 | 1\% | 1\% |
|  | 3 PlacetypeChange | Adjacent | 764 | 88 | 131 | 136 | 764 | 85 | 126 | 132 | 3\% | 3\% |
|  | 3 PlacetypeChange | Adjacent | 1310 | - | 0 | $\square$ | 1310 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 9 PlacetypeChange | Primary | 1103 | 3 | , | $\square$ | 1103 | , | , | 0 | 100\% | 100\% |
|  | PlacetypeChange | Adjacent | 1102 | 295 | 443 | 458 | 1102 | 294 | 440 | 456 | 0\% | 1\% |
|  | 9 PlacetypeChange | Adjacent | 1105 |  | , | $\square \quad 4$ | 1105 | 3 | 4 | $\square$ | 1\% | 1\% |
|  | PlacetypeChange | Adjacent | 1195 | - 1 | 1 | $\square 1$ | 1195 | 1 | 1 | - 1 | 2\% | 1\% |
| 10 | PlacetypeChange | Primary | 897 | 546 | 797 | 852 | 897 | 60 | 83 | 91 | 89\% | 90\% |
| 10 | PlacetypeChange | Adjacent | 842 | 1,246 | 1,851 | 2,005 | 842 | 1,238 | 1,839 | 1,988 | 1\% | 1\% |
|  | PlacetypeChange | Adjacent | 844 | , | , | , | 844 | , | 0 | 0 | 99900\% | 99900\% |
| 10 | PlacetypeChange | Adjacent | 845 | 336 | 498 | 528 | 845 | 335 | 496 | 525 | 0\% | 0\% |
| 10 | PlacetypeChange | Adjacent | 894 | 1,087 | 1,553 | 1,683 | 894 | 1,070 | 1,528 | 1,651 | 2\% | 2\% |
|  | PlacetypeChange | Adjacent | 896 | - 563 | 872 | 937 | 896 | 563 | 873 | 937 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 898 | 484 | 711 | 741 | 898 | 482 | 708 | 736 | 0\% | 0\% |
|  | PlacetypeChange | Adjacent | 899 | 1,269 | 1,864 | 1,951 | 899 | 1,264 | 1,857 | 1,940 | 0\% | 0\% |
| 11 | 1 PlacetypeChange | Primary | 126 |  |  |  | 126 |  | 2 | 2 | 66\% | 50\% |
|  | PlacetypeChange | Adjacent | 106 | ( 1,130 | 1,712 | 1,833 | 106 | 1,144 | 1,737 | 1,828 | 1\% |  |

SJV MIP - Placetype Summary - Kings


TABLE C-22:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - KINGS

| Validation Topic |  |
| :--- | :--- |
| Add Lanes to a Link |  |
| Add/Remove Link |  |
| Change Link Speed |  |


| Notes: |  |
| :--- | :--- |
|  | $=$ Met / Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE C-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - KINGS

| Screenline Roadways | Peak Hour <br> Volume |  | Volume Change |  |
| :--- | :--- | :--- | :--- | :--- |
|  | NB/EB | SB/WB | NB/EB |  |
| SB/WB |  |  |  |  |
| Street Across Screenline - N. Douty Street from W. 6th Street to W. 5th Street |  |  |  |  |
| 12th Avenue - Mall Drive to Glendale Avenue | 1,660 | 2,010 | 0 | 0 |
| N. 11th Avenue - W. 6th Street to W. 5th Street | 2,482 | 2,563 | 0 | 0 |
| S. Phillips Street - W. 6th Street to W. 5th Street | 154 | 113 | 0 | 0 |
| S. Redington Street - W. 6th Street to W. 5th Street | 332 | 374 | 0 | 0 |
| N. Douty Street - W. 6th Street to W. 5th Street | 512 | 610 | 0 | 0 |
| S. Brown Street - W. 6th Street to W. 5th Street | 41 | 99 | 0 | 0 |
| N. 10th Street - W. 6th Street to W. 5th Street | 1,795 | 1,433 | 0 | 0 |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 108 | 173 | 0 | 0 |
| Total | 7,085 | 7,375 | 0 | 0 |

## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

N. Douty Street from W. 6th Street to W. 5th Street was under capacity in the base scenario so the addition of lanes did not introduce any more volume to the subject link. The parallel facilities also were not affected. The model responded appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

TABLE C-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - KINGS

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Added Link Across Screenline - Connecting N. White Street and S. White Street |  |  |  |  |
| 12th Avenue - Mall Drive to Glendale Avenue | 1,660 | 2,010 | 0 | 0 |
| N. 11th Avenue - W. 6th Street to W. 5th Street | 2,482 | 2,563 | 0 | 0 |
| S. Phillips Street - W. 6th Street to W. 5th Street | 154 | 113 | 0 | 0 |
| S. Redington Street - W. 6th Street to W. 5th Street | 332 | 374 | 0 | 0 |
| N. Douty Street - W. 6th Street to W. 5th Street | 512 | 610 | 0 | 0 |
| S. Brown Street - W. 6th Street to W. 5th Street | 39 | 80 | -2 | -19 |
| Added Link | 12 | 32 | 13 | 32 |
| N. 10th Street - W. 6th Street to W. 5th Street | 1,784 | 1,420 | -11 | -13 |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 108 | 173 | 0 | 0 |
| Total | 7,085 | 7,375 | 0 | 0 |

TABLE C-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD/DELETE LINK - KINGS

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :--- | :--- | :--- | :--- |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| 12th Avenue - Mall Drive to Glendale Avenue | 1,674 | 2,026 | 14 | 16 |
| N. 11th Avenue - W. 6th Street to W. 5th Street | 2,586 | 2,587 | 103 | 24 |
| S. Phillips Street - W. 6th Street to W. 5th Street | 156 | 115 | 3 | 2 |
| S. Redington Street - W. 6th Street to W. 5th Street | 352 | 374 | 19 | 0 |
| N. Douty Street - W. 6th Street to W. 5th Street | 1,318 | 746 | 805 | 136 |
| S. Brown Street - W. 6th Street to W. 5th Street | 459 | 1,042 | 417 | 943 |
| N. 10th Street - W. 6th Street to W. 5th Street | 0 | 0 | $-1,795$ | $-1,433$ |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 270 | 260 | 161 | 86 |
| Total | 6,814 | 7,149 | -271 | -226 |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a decrease in volume identical to the subject link increase. For the deleted link test, the parallel facilities showed a similar magnitude increase in volume and the screenline showed a slight decrease. The model responded appropriately.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/- 10 mph on subject facility.

TABLE C-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - KINGS

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increase Speed on Street Across Screenline - S. Phillips Street from W. 6th Street to W. 5th Street |  |  |  |  |  |  |
| 12th Avenue - Mall Drive to Glendale Avenue | 35 | 35 | 1,659 | 2,010 | -1 | 0 |
| N. 11th Avenue - W. 6th Street to W. 5th Street | 35 | 35 | 2,460 | 2,556 | -22 | -7 |
| S. Phillips Street - W. 6th Street to W. 5th Street | 30 | 40 | 183 | 275 | 29 | 162 |
| S. Redington Street - W. 6th Street to W. 5th Street | 30 | 30 | 332 | 373 | -1 | 0 |
| N. Douty Street - W. 6th Street to W. 5th Street | 30 | 30 | 509 | 458 | -3 | -152 |
| S. Brown Street - W. 6th Street to W. 5th Street | 30 | 30 | 39 | 97 | -2 | -2 |
| N. 10th Street - W. 6th Street to W. 5th Street | 45 | 45 | 1,795 | 1,433 | 0 | 0 |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 40 | 40 | 108 | 173 | 0 | 0 |
| Total |  |  | 7,086 | 7,375 | 1 | 0 |

Decrease Speed on Street Across Screenline - S. Phillips Street from W. 6th Street to W. 5th Street

| 12th Avenue - Mall Drive to Glendale <br> Avenue | 35 | 35 | 1,660 | 2,010 | 0 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| N. 11th Avenue - W. 6th Street to W. 5th <br> Street | 35 | 35 | 2,506 | 2,567 | 24 | 4 |
| S. Phillips Street - W. 6th Street to W. 5th <br> Street | 30 | 20 | 50 | 107 | -104 | -6 |
| S. Redington Street - W. 6th Street to W. <br> Sth Street | 30 | 30 | 405 | 375 | 73 | 1 |

TABLE C-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - KINGS

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| N. Douty Street - W. 6th Street to W. 5th Street | 30 | 30 | 520 | 611 | 7 | 1 |
| S. Brown Street - W. 6th Street to W. 5th Street | 30 | 30 | 41 | 99 | 0 | 0 |
| N. 10th Street - W. 6th Street to W. 5th Street | 45 | 45 | 1,795 | 1,433 | 0 | 0 |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 40 | 40 | 108 | 173 | 0 | 0 |
| Total |  |  | 7,085 | 7,374 | 0 | 0 |

Notes:
Source:

## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the parallel facilities showed a decrease in volume nearly identical to the subject link increase. For the deleted link test, the parallel facilities showed an increase in volume identical to the subject link decrease. The model responded appropriately.

TABLE C-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - KINGS
Validation Topic $\quad$ Kings

Add Toll to Corridor
Notes:

- = Met / Not Required
- = Partially Met
- Not Met


## Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE C-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - KINGS

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  | NB/EB | SB/WB | NB/EB | SB/W |
| State Route Corridor - SR 198 from 12th Avenue to S. 10th Avenue |  |  |  |  |
| 12th Avenue - Mall Drive to Glendale Avenue | 2,797 | 3,539 | 1,137 | 1,530 |
| N. 11th Avenue - W. 6th Street to W. 5th Street | 1,758 | 1,880 | -724 | -684 |
| S. Phillips Street - W. 6th Street to W. 5th Street | 139 | 110 | -15 | -3 |
| S. Redington Street - W. 6th Street to W. 5th Street | 19 | 53 | -314 | -321 |
| N. Douty Street - W. 6th Street to W. 5th Street | 296 | 315 | -216 | -295 |
| S. Brown Street - W. 6th Street to W. 5th Street | 44 | 48 | 3 | -51 |
| N. 10th Street - W. 6th Street to W. 5th Street | 1,192 | 907 | -602 | -526 |
| E. Lacey Boulevard - Jessie Avenue to 14th Avenue | 179 | 229 | 71 | 56 |
| Total | 6,425 | 7,081 | -660 | -294 |

Notes:
Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities perpendicular and within the extents of the subject corridor showed volume decreases. However, the model was too sensitive and all trips were shifted from the subject corridor due to tolling. The model did not respond appropriately.

TABLE C-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - KINGS
Validation Topic $\quad$ Kings

Interstate Capacity Change

| Notes: |  |
| ---: | :--- | :--- |
|  | $=$ Met / Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Reduce Roadway Capacity

Halve roadway capacity on a State Route within the County.

TABLE C-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - KINGS

| Performance Measure | Base Scenario | Reduce Roadway Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | 2,362.0 | 2,307.0 | -2.33\% |
| VMT | 3,460,845 | 3,458,119 | -0.08\% |
| Elasticity |  |  | 0.03 |

[^10]
## Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature: Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed but the model was not sensitive to the effects. VMT decreased less than the literature elasticity suggests. The model did not respond appropriately.

## APPENDIX D: <br> MADERA MODEL VALIDATION DETAILS

Table D-1: Daily Person Trip Generation Rates - Madera Table D-2-A: Daily Productions and Attractions at Gateways - Madera
Table D-2-B: Special Generator Daily Productions and Attractions - Madera
Table D-3: Summary of Model Performance - Static Validation - Madera
Table D-4: Summary of Model Performance - Static Validation - Land Use - Madera
Table D-5: Summary of Model Performance - Static Validation - Land Use - Detailed - Madera
Table D-6: Summary of Model Performance - Static Validation - Trip Generation - Madera
Table D-7: Summary of Model Performance - Static Validation - Trip Generation - PA Balance - Madera
Table D-8: Summary of Model Performance - Static Validation - Trip Generation - Trip Purpose Split Madera
Table D-9: Summary of Model Performance - Static Validation - Trip Generation -Weekday Person Trips per Household - Madera
Table D-10: Summary of Model Performance - Static Validation - Trip Generation -Vehicle Availability Madera
Table D-11: Summary of Model Performance - Static Validation - Trip Distribution - Madera
Table D-12: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (All Modes) Madera
Table D-13: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (Driving Trips Only) - Madera
Table D-14: Summary of Model Performance - Static Validation - Trip Distribution - Average Travel Time (in minutes) by Trip Purpose - Madera
Table D-15: Summary of Model Performance - Static Validation - Mode Choice - Madera

Table D-16: Summary of Model Performance - Static Validation - Mode Choice - Madera
Table D-17-A: Summary Of Model Performance - Static Validation - Traffic Assignment - Madera
Table D-17-B: Summary Of Model Performance - Static
Validation - Traffic Assignment - VMT - Madera
Table D-18: Summary of Model Performance - Static
Validation - Transit Assignment - Madera
Table D-19: Summary of Model Performance - Static
Validation - Transit Assignment - Detailed - Madera
Table D-20: Summary of Model Performance - Dynamic
Validation - Madera
Table D-21: Summary of Model Performance - Dynamic Validation - Land Use - Madera
Table D-22: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Madera
Table D-23: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add Lane - Madera
Table D-24: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add/Delete Link -
Madera
Table D-25: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Speed Change Madera
Table D-26: Summary of Model Performance - Dynamic Validation - Travel Cost - Madera
Table D-27: Summary of Model Performance - Dynamic Validation - Travel Cost (Add Toll Rates) - Madera
Table D-28: Summary of Model Performance - Dynamic Validation - Induced Demand - Madera
Table D-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity Change - Madera


TABLE D-1:
DAILY PERSON TRIP GENERATION RATES - MADERA

| Land Use | Madera |
| :---: | :---: |
| Residential |  |
| RU 1 | 8.61 |
| RU 3 | 6.74 |
| RU 9 | 5.32 |
| Non-Residential |  |
| Agriculture | 2.07 |
| Mining | 2.05 |
| Utilities | 2.21 |
| Construction | 2.09 |
| Manufacturing | 2.17 |
| Wholesale | 8.11 |
| Retail | 27.65 |
| Warehouse | 4.20 |
| Information | 4.36 |
| Financial and Insurance | 4.37 |
| Real Estate | 4.34 |
| Professional Services | 4.37 |
| Management Services | 4.28 |
| Administrative Services | 4.37 |
| Education | 0.00 |
| Health | 5.96 |
| Entertainment and Recreation | 39.84 |


| Accommodations | 14.49 |
| :---: | :---: |
| Food | 71.37 |
| Other Service | 27.58 |
| Public | 33.05 |
| Student Enrollment |  |
| Elementary | 3.56 |
| High School | 4.72 |
| College | 5.41 |

Notes:

## TABLE D-2-A:

DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - MADERA

| Purpose | Madera |
| :---: | :---: |
| Home-Work | $8,753(37,126)$ |
| Home-Shop | $918(8,567)$ |
| Home-K12 | $0(0)$ |
| Home-College | $37(4,800)$ |
| Home-Other | $5,036(25,869)$ |
| Work-Other | $6,723(4,242)$ |
| Other-Other | $6,800(12,623)$ |
| Highway Commercial | $1,653(1,653)$ |
| Trucks-Small | $491(568)$ |
| Trucks-Medium | $271(331)$ |
| Trucks-Heavy | $4,104(4,872)$ |

Notes: Values shown as Production (Attraction)

FEHR \& PEERS | DOWLING AsSOCIATES | RSG | CS |
BOWMAN-BRADLEY | MCCOY-ROTH | CAC | CITILABS

TABLE D-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - MADERA

| Purpose | Madera |
| :---: | :---: |
| Home-Work | $0(0)$ |
| Home-Shop | $0(0)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(0)$ |
| Work-Other | $0(0)$ |
| Highway Commercial | $0(0)$ |
| Trucks-Small | $0(0)$ |
| Trucks-Medium | $0(0)$ |
| Trucks-Heavy | $0(0)$ |

Notes: Values shown as Production (Attraction)

## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)



## TABLE D-5: <br> SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - MADERA

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Household <br> Population | $+/-3 \%$ | 150,254 | 130,643 | $-19,611$ | $-13.1 \%$ |
| Total <br> Households | $+/-3 \%$ | 44,345 | 43,317 | $-1,028$ | $-2.3 \%$ |
| Employment |  | 6,500 |  |  |  |
| Retail | 38,800 | 30,119 | 3,619 | $55.7 \%$ |  |
| Non-Retail | 45,300 | 40,172 | $-8,747$ | $-22.5 \%$ |  |
| Total |  |  |  | $-5,128$ | $-11.3 \%$ |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE D-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - MADERA

| Validation Topic | Madera |
| :---: | :---: | :---: |
| Trip Balancing by Purpose |  |
| HBW |  |
| HBS |  |
| HBO |  |
| Total |  |
| Percentage of Trips by Purpose After Balancing |  |
| HBW |  |

TABLE D-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| HBO | $\bigcirc$ |
| NHB | $\bigcirc$ |
| Person Trips Per HH | 0 |
| Vehicle Availability |  |

## Notes:

- = Met / Not Required
- = Partially Met
- = Not Met

TABLE D-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - PA BALANCE - MADERA

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | Difference | Percent <br> Difference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| HBW | $+/-10 \%$ | 295,789 | 297,166 | 1.00 | 1,377 | $0.5 \%$ |
| HBS | $+/-10 \%$ | 172,511 | 176,607 | 0.98 | 4,096 | $2.4 \%$ |
| HBO | $+/-10 \%$ | 662,104 | 667,182 | 0.99 | 5,078 | $0.8 \%$ |
| NHB | $+/-10 \%$ | 595,425 | 624,600 | 0.95 | 29,175 | $4.9 \%$ |
| Total | $+/-10 \%$ | $1,725,828$ | $1,765,555$ | 0.98 | 39,727 | $2.3 \%$ |

Notes:

TABLE D-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - TRIP PURPOSE SPLIT - MADERA

| Purpose | CHTS | Total (All Modes) |
| :---: | :---: | :---: |
| HBW | $13.6 \%$ | Model |
| HBO | $59.7 \%$ | $7.7 \%$ |
| NHB | $26.7 \%$ | $41.8 \%$ |
| Total (All Purposes) | $100.0 \%$ | $50.5 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey.

TABLE D-9:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - MADERA

| CHTS | Model |
| :---: | :---: | :---: |
| 7.9 | 12.5 |

Notes: 2000-2001 California Statewide Household Travel Survey.

TABLE D-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - MADERA

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 7.8\% | 10.7\% | 29.1\% | 25.5\% | 39.7\% | 39.8\% | 23.4\% | 23.9\% |

[^11]TABLE D-11:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | $\bullet$ |
| Internal-External/External-Internal | - |
| Passenger Auto Trips Only |  |
| Internal-Internal | $\bullet$ |
| Internal-External/External-Internal | - |
| Average Travel Time |  |
| HBW | $\bigcirc$ |
| HBO | $\bigcirc$ |
| NHB | $\bigcirc$ |
| Notes:  <br> $=$ Met $/$ Not Required <br>  $=$ Partially Met <br>  $=$ Not Met |  |

TABLE D-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - MADERA

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  |  | NHB |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | $82.8 \%$ | $90 \%$ | $48.6 \%$ | $52 \%$ | $81.7 \%$ | $94 \%$ | $68.6 \%$ | $97 \%$ |
| IX/XI | $17 \%$ | $10 \%$ | $51 \%$ | $48 \%$ | $18 \%$ | $6 \%$ | $31 \%$ | $3 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips.

TABLE D-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - MADERA

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 82.6\% | 89\% | 47.4\% | 51.4\% | 82.0\% | 93.9\% | 67.4\% | 96\% |
| IX/XI | 17\% | 11\% | 53\% | 48.6\% | 18\% | 6.1\% | 33\% | 3.6\% |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips.

TABLE D-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - MADERA

|  |  | Trip Purpose |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | HBW |  |  |  |
|  |  | HBO | NHB |  |
| CHTS | Model | CHTS | Model | CHTS |
| 23.1 | 3.8 | 13.8 | 3.0 | 10.1 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE D-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - MADERA

\begin{tabular}{|c|c|c|}
\hline \& Validation Topic \& Madera <br>
\hline \& Drive Alone \& $\bullet$ <br>
\hline \& Shared Ride 2 \& - <br>
\hline \& Shared Ride 3+ \& - <br>
\hline \& Transit \& - <br>
\hline \& Walk \& $\bigcirc$ <br>
\hline \& Bike \& - <br>

\hline \begin{tabular}{l}
Notes: <br>
©

 \& 

= Met / Not Required <br>
= Partially Met <br>
$=$ Not Met
\end{tabular} \& <br>

\hline
\end{tabular}

TABLE D-16:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - MADERA

|  | Purpose | Model |
| :---: | :---: | :---: |
| Drive Alone | CHTS | $37.40 \%$ |
| Shared Ride 2 | $40.40 \%$ | $32.70 \%$ |
| Shared Ride 3+ | $33.19 \%$ | $23.40 \%$ |
| Transit | $25.18 \%$ | $0.80 \%$ |
| Walk | $0.05 \%$ | $5.20 \%$ |
| Bike | $1.19 \%$ | $0.40 \%$ |
| Total | $0.00 \%$ | $100 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE D-17:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| Vehicle Miles Traveled | • |
| All Vehicles - Traffic Counts |  |
| Daily | 0 |
| Midday Period | 0 |
| PM Period | 0 |
| Nighttime Period | 0 |
| AM 1 Hour | 0 |

## TABLE D-17:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - MADERA

| Validation Topic |  |
| :--- | :--- |
| Facility Type - Traffic Counts |  |


| Daily | 0 |
| :---: | :---: |
| AM Period | 0 |
| PM Period | 0 |
| AM 1 Hour | 0 |
| PM 1 Hour | 0 |

Distribution of Class by Time of Day - Truck Traffic Counts
Medium - AM Period
Medium - Midday Period
Medium - PM Period
Medium - Evening Period
Heavy - AM Period
Heavy - Midday Period
Heavy - PM Period
Heavy - Evening Period
Distribution of Time of Day by Class - Truck Traffic Counts

| Medium - AM Period | 0 |
| :---: | :---: | :---: |
| Medium - Midday Period | 0 |
| Medium - PM Period | 0 |
| Medium - Evening Period | 0 |
| Heavy - AM Period | 0 |
| Heavy - Midday Period | 0 |

TABLE D-17:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| Heavy - PM Period | 0 |
| Heavy - Evening Period | 0 |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE D-17-B:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - MADERA

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $4,785,470$ | $4,685,002$ | $-2.1 \%$ |

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Madera County

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation by Facility Type Results

AM 3 Hour

PM 3 Hour


TABLE D-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| System Ridership | N/A |

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met

TABLE D-19:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - DETAILED - MADERA

| Validation <br> Statistic | Evaluation <br> Criterion | Ridership | Model Ridership | Percentage |
| :--- | :---: | :---: | :---: | :---: |
| Difference between <br> actual ridership to <br> model results for <br> entire system | $+/-20 \%$ | $\mathrm{~N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |

Notes: Observed Ridership includes Fresno Area Express (FAX) average weekday unlinked trips as reported in the National Transit Database 2008 Report Year.

## DYNAMIC VALIDATION

TABLE D-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| Land Use | 0 |
| Traffic Assignment | 0 |
| Travel Cost | 0 |
| Induced Demand |  |

Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE D-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - MADERA

| Validation Topic | Madera |
| :---: | :---: |
| Geographic Change |  |
| Placetype Change |  |
| Total | $\bullet$ |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-BRADLEY | MCCOY-ROTH | CAC| CITILABS

| TestNumber | TestType | ZoneType | \|TAZ_Before | TDFVT_Before | MXDVT_Before | RawModelPT_Before | TAZ_After | TDFVT_After | MXDVT_After | RawModelPT_After | TDFVT_\%Delta | MXDVT_\%Delta |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 GeographyChange | Primary | 246 | 377 | 552 | 595 | 794 | 285 | 413 | 452 | 25\% | 25\% |
|  | 1 GeographyChange | Primary | 794 | 55 | -77 | -87 | 246 | -58 | - 84 | 92 | 6\% | 0\% |
|  | 1 GeographyChange | Adjacent | 218 | 1,774 | 2,590 | 2,886 | 218 | 1,796 | 2,621 | 2,901 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 219 | 1,321 | 2,024 | 2,269 | 219 | 1,344 | 2,056 | 2,269 | 2\% | 2\% |
|  | 1 GeographyChange | Adjacent | 220 | 303 | 447 | 480 | 220 | 306 | 450 | 481 | 1\% | $1 \%$ |
|  | 1 GeographyChange | Adjacent | 245 | 927 | 1,352 | 1,458 | 245 | 936 | 1,363 | 1,462 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 248 | 2,111 | 3,618 | 4,168 | 248 | 2,197 | 3,753 | 4,152 | 4\% | - 4\% |
|  | 1 GeographyChange | Adjacent | 272 | 196 | 288 | 308 | 272 | 198 | 290 | 308 | 1\% | - 1\% |
|  | 1 GeographyChange | Adjacent | 329 | 3 | 4 | 6 | 329 | 3 | 4 | -6 | 3\% | \% |
|  | 1 GeographyChange | Adjacent | 765 | 1,482 | 1,959 | 2,314 | 765 | 1,486 | 1,963 | 2,319 | 0\% | - 0 |
|  | 1 GeographyChange | Adjacent | 786 | 178 | 231 | 274 | 786 | 180 | 233 | 277 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 793 | 2,498 | 3,303 | 4,013 | 793 | 2,508 | 3,315 | 4,027 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 795 | 3,522 | 4,727 | 5,721 | 795 | 3,562 | 4,775 | 5,769 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 801 | 2,517 | 3,357 | 4,043 | 801 | 2,531 | 3,375 | 4,062 | 1\% | 1\% |
|  | 1 GeographyChange | Adjacent | 805 | 1,328 | 1,785 | 2,072 | 805 | 1,333 | 1,791 | 2,078 | 0\% | - $0 \%$ |
|  | 2 GeographyChange | Primary | 213 | 779 | 1,131 | 1,306 | 410 | 557 | 776 | 82 | 29\% | 31\% |
|  | 2 GeographyChange | Primary | 410 | 9,713 | 13,068 | 14,581 | 213 | 3,567 | 4,865 | 5,551 | 63\% | 63\% |
|  | 2 GeographyChange | Adjacent | 203 | 834 | 1,188 | 1,382 | 203 | 851 | 1,209 | 1,393 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 204 | 3,341 | 4,858 | 5,520 | 204 | 3,392 | 4,928 | 5,568 | 2\% | 1\% |
|  | 2 GeographyChange | Adjacent | 212 | 1,422 | 2,059 | 2,379 | 212 | 1,447 | 2,090 | 2,390 | 2\% | - $2 \%$ |
|  | 2 GeographyChange | Adjacent | 214 | 2,232 | 3,199 | 3,614 | 214 | 2,276 | 3,253 | 3,640 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 232 | 2,016 | 2,942 | 3,390 | 232 | 2,042 | 2,978 | 3,417 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 234 | 2,793 | 4,102 | 4,702 | 234 | 2,833 | 4,157 | 4,729 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 407 | 0 | 0 | 0 | 407 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 408 | 0 | 0 | 0 | 408 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 409 | 0 | 0 | 0 | 409 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 411 | 0 | 0 | $\square$ | 411 | $\bigcirc$ | 0 | 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 415 | 0 | 0 | 0 | 415 | 0 | 0 | $\square$ | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 416 | 0 | 0 | 0 | 416 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 417 | 0 | 0 | $\square$ | 417 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Primary | 540 | 10 | 14 | 17 | 706 | 10 | 14 | 17 | 2\% | 2\% |
|  | 3 GeographyChange | Primary | 706 | 0 | - 0 | - 0 | 540 | 0 | - 0 | - 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 539 | 0 | 0 | 0 | 539 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 551 | 112 | 159 | 180 | 551 | 112 | 159 | 180 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 701 | 39 | 55 | 59 | 701 | 40 | 55 | 59 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 703 | 159 | 203 | 226 | 703 | 160 | 204 | 227 | 1\% | 0\% |
|  | 3 GeographyChange | Adjacent | 705 | 0 | 0 | 0 | 705 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 707 | 22 | 31 | 34 | 707 | 22 | 31 | 34 | 0\% | 0\% |
|  | 4 GeographyChange | Primary | 347 | 135 | 191 | 209 | 484 | 136 | 196 | 210 | 0\% | 3\% |
|  | 4 GeographyChange | Primary | 484 | 21 | 27 | 31 | 347 | 20 | 26 | 31 | 0\% | - 3\% |
|  | 4 GeographyChange | Adjacent | 340 | 1,611 | 2,194 | 2,491 | 340 | 1,615 | 2,198 | 2,497 | 0\% | - 0\% |
|  | 4 GeographyChange | Adjacent | 341 | 1,904 | 2,531 | 2,932 | 341 | 1,908 | 2,534 | 2,938 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 346 | 400 | 547 | 612 | 346 | 400 | 548 | 613 | 0\% | - 0\% |
|  | 4 GeographyChange | Adjacent | 482 | 0 | - 0 | - 0 | 482 | 0 | - 0 | - 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 483 | 0 | 0 | 0 | 483 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 485 | 0 | 0 | $\bigcirc$ | 485 | 0 | 0 | $\bigcirc$ | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 493 | 0 | 0 | 0 | 493 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 494 | 0 | 0 | 0 | 494 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 496 | 0 | 0 | 0 | 496 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 497 | 0 | 0 | 0 | 497 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 689 | 0 | 0 | - 0 | 689 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 690 | 188 | 264 | 286 | 690 | 189 | 264 | 287 | 0\% | - 0\% |
|  | 5 GeographyChange | Primary | 112 | 3 | - 4 | - 4 | 325 | 8 | 11 | - 11 | 185\% | 207\% |
|  | 5 GeographyChange | Primary | 325 | 1,372 | 2,019 | 2,146 | 112 | 0 | 0 | 0 | 100\% | 100\% |
|  | 5 GeographyChange | Adjacent | 109 | 2,503 | 3,750 | 4,308 | 109 | 2,516 | 3,769 | 4,329 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 110 | 115 | 172 | 183 | 110 | 115 | 172 | 183 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 111 | 30 | 44 | 48 | 111 | 30 | 44 | 49 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 113 | 1,774 | 2,781 | 3,176 | 113 | 1,773 | 2,776 | 3,178 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 116 | 1,845 | 2,713 | 3,083 | 116 | 1,858 | 2,734 | 3,101 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 117 | 405 | 579 | 642 | 117 | 409 | 584 | 647 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 118 | 127 | 170 | 184 | 118 | 128 | 171 | 186 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 120 | - 6 | - 9 | 10 | 120 | ${ }^{6}$ | 9 | 10 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 132 | 37 | 55 | 58 | 132 | 38 | 55 | 58 | 0\% | - $0 \%$ |
|  | 5 GeographyChange | Adjacent | 324 | 969 | 1,251 | 1,467 | 324 | 976 | 1,260 | 1,480 | 1\% | - 1\% |
|  | 5 GeographyChange | Adjacent | 572 | 43 | 58 | 63 | 572 | 44 | 58 | 63 | 0\% | - ${ }^{1 \%}$ |
|  | 5 GeographyChange | Adjacent | 573 | 461 | 609 | 686 | 573 | 462 | 611 | 688 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 574 | 35 | 45 | 50 | 574 | 36 | 45 | 50 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 575 | 9 | 10 | 12 | 575 | -9 | 10 | 12 | 2\% | 1\% |
|  | 6 PlacetypeChange | Primary | 773 | 3 | 4 |  | 773 | 0 | 0 | - 0 | 100\% | 00\% |
|  | 6 PlacetypeChange | Adjacent | 771 | 1,046 | 1,423 | 1,636 | 771 | 1,048 | 1,425 | 1,638 | 0\% | \% |
|  | 6 PlacetypeChange | Adjacent | 772 | 222 | 306 | 366 | 772 | 224 | 307 | 368 | 1\% | 1\% |
|  | 6 PlacetypeChange | Adjacent | 774 | 132 | 176 | 218 | 774 | 133 | 177 | 219 | 1\% | 1\% |
|  | 6 PlacetypeChange | Adjacent | 775 | 1,142 | 1,555 | 1,920 | 775 | 1,153 | 1,569 | 1,935 | 1\% | 1\% |
|  | 6 PlacetypeChange | Adjacent | 778 | 1,169 | 1,631 | 1,970 | 778 | 1,177 | 1,642 | 1,982 | 1\% | 1\% |
|  | 7 PlacetypeChange | Primary | 459 | 0 | 0 | 0 | 459 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 445 | 0 | 0 | 0 | 445 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 446 | 0 | 0 | 0 | 446 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 458 | 0 | 0 | 0 | 458 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 460 | 0 | 0 | 0 | 460 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 465 | 0 | 0 | - 0 | 465 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 7 PlacetypeChange | Adjacent | 466 | 0 | 0 | - 0 | 466 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 8 PlacetypeChange | Primary | 663 | 494 | 713 | 771 | 663 | 615 | 859 | 929 | 24\% | 21\% |
|  | 8 PlacetypeChange | Adjacent | 660 | 147 | 209 | 221 | 660 | 147 | 210 | 222 | 0\% | 0\% |
|  | 8 PlacetypeChange | Adjacent | 661 | 51 | 72 | 77 | 661 | 51 | 72 | 78 | 0\% | 0\% |
|  | 8 PlacetypeChange | Adjacent | 662 | 214 | 305 | 329 | 662 | 216 | 307 | 332 | 1\% | 1\% |
|  | 8 PlacetypeChange | Adjacent | 664 | 72 | 102 | 113 | 664 | 73 | 102 | 113 | 0\% | 0\% |
|  | 8 PlacetypeChange | Adjacent | 665 | 57 | 80 | - 86 | 665 | 57 | 80 | 86 | 0\% | - 0\% |
|  | 8 PlacetypeChange | Adjacent | 666 | 86 | 122 | 132 | 666 | 86 | 122 | 132 | 0\% | 0\% |
|  | 9 PlacetypeChange | Primary | 281 | 238 | 347 | 375 | 281 | 548 | 780 | 870 | 130\% | 125\% |
|  | 9 PlacetypeChange | Adjacent | 280 | 1,056 | 1,543 | 1,664 | 280 | 1,065 | 1,553 | 1,670 | 1\% | 1\% |
|  | 9 PlacetypeChange | Adjacent | 282 | 752 | 1,194 | 1,321 | 282 | 759 | 1,198 | 1,319 | 1\% | 0\% |
|  | 9 PlacetypeChange | Adjacent | 286 | 170 | 248 | 279 | 286 | 174 | 253 | 279 | 2\% | 2\% |
|  | 9 PlacetypeChange | Adjacent | 338 | 79 | 109 | 131 | 338 | 79 | 109 | 131 | 0\% | 0\% |
|  | 9 PlacetypeChange | Adjacent | 615 | 1 | 2 |  | 615 | 1 | 2 | 3 | 0\% | 0\% |
|  | PlacetypeChange | Primary | 309 | 164 | 230 | 252 | 309 | 505 | 698 | 821 | 207\% | 204\% |
|  | PlacetypeChange | Adjacent | 267 | 1,896 | 2,818 | 3,036 | 267 | 1,919 | 2,847 | 3,039 | 1\% | 1\% |
|  | PlacetypeChange | Adjacent | 268 | 2,384 | 3,550 | 3,923 | 268 | 2,421 | 3,599 | 3,927 | 2\% | 1\% |



TABLE D-22:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT MADERA

| Validation Topic | Madera |
| :---: | :---: |
| Add Lanes to a Link |  |
| Add/Remove Link | 0 |
| Change Link Speed |  |

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met


## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE D-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - MADERA

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Street Across Screenline - N. Lake Street from E. Cleveland Avenue to E. Central Avenue |  |  |  |  |
| Road 23 - W. Cleveland Avenue to Avenue 15 | 622 | 564 | -1 | 0 |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 447 | 570 | -2 | -2 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 760 | 982 | 0 | 0 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 9,901 | 6,399 | -12 | -15 |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 498 | 545 | 6 | 16 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 723 | 572 | -16 | 0 |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 1,745 | 1,045 | 40 | 1 |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 2,695 | 1,909 | -19 | -5 |

## Notes:

Source:

## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

Model showed a slight increase in volume on the subject link. Parallel facilities showed both slight increases and decreases in volume similar in magnitude to the subject link. The screenline showed a slight decrease. The model appeared to be overly sensitive and did not respond appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

## TABLE D-24:

SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD/DELETE LINK - MADERA

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Added Link Across Screenline - Connecting N. Westberry Boulevard |  |  |  |  |
| Road 23 - W. Cleveland Avenue to Avenue 15 | 533 | 425 | -90 | -140 |
| Added Link | 468 | 539 | 468 | 539 |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 174 | 293 | -275 | -279 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 682 | 884 | -78 | -98 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 9,930 | 6,409 | 17 | -5 |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 467 | 535 | -25 | 7 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 736 | 561 | -4 | -10 |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 1,695 | 1,040 | -9 | -4 |

TABLE D-24:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - MADERA

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 2,721 | 1,915 | 7 | 1 |
| Total | 17,407 | 12,602 | 11 | 11 |
| Delete Street Across Screenline - N. D Street from E. Cleveland Avenue to E. Central Avenue |  |  |  |  |
| Road 23 - W. Cleveland Avenue to Avenue 15 | 627 | 564 | 3 | 0 |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 449 | 571 | 0 | 0 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 766 | 987 | 5 | 5 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 10,011 | 6,503 | 98 | 90 |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 805 | 795 | 313 | 266 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 0 | 0 | -740 | -572 |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 1,997 | 1,255 | 293 | 211 |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 2,739 | 1,911 | 25 | -3 |
| Total | 17,393 | 12,588 | -3 | -3 |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a similar magnitude decrease in volume and the screenline showed a slight increase. For the deleted link test, the parallel facilities showed a similar magnitude increase in volume and the screenline showed a slight decrease. The model responded appropriately.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/- 10 mph on subject facility.

TABLE D-25:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - MADERA

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increase Speed on Street Across Screenline - N. Gateway Drive from W. Cleveland Avenue to W. Central Avenue |  |  |  |  |  |  |
| Road 23 - W. Cleveland Avenue to Avenue 15 | 50 | 50 | 620 | 564 | -4 | -1 |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 25 | 25 | 443 | 568 | -7 | -4 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 35 | 35 | 757 | 979 | -4 | -4 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 60 | 60 | 9,678 | 6,129 | -235 | -285 |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 35 | 45 | 834 | 854 | 342 | 325 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 35 | 35 | 648 | 561 | -92 | -11 |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 35 | 35 | 1,700 | 1,030 | -4 | -14 |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 35 | 35 | 2,704 | 1,893 | -10 | -21 |
| Total |  |  | 17,383 | 12,577 | -13 | -14 |

Decrease Speed on Street Across Screenline - N. Gateway Drive from W. Cleveland Avenue to W. Central Avenue

Road 23 - W. Cleveland Avenue to Avenue 15

50
50
623
564
0

TABLE D-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - MADERA

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 25 | 25 | 449 | 571 | 0 | 0 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 35 | 35 | 761 | 985 | 0 | 2 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 60 | 60 | 10,132 | 6,517 | 219 | 103 |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 35 | 25 | 231 | 371 | -260 | -158 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 35 | 35 | 768 | 604 | 29 | 32 |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 35 | 35 | 1,706 | 1,064 | 2 | 19 |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 35 | 35 | 2,724 | 1,914 | 10 | 0 |
| Total |  |  | 17,395 | 12,589 | -1 | -1 |

Notes:
Source:

## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the parallel facilities showed a decrease in volume similar in magnitude to the subject link increase. For the deleted link test, the parallel facilities showed an increase in volume similar in magnitude to the subject link decrease. The model responded appropriately.

TABLE D-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - MADERA

| Validation Topic | Madera |
| :--- | :--- |

Add Toll to Corridor

| Notes: |  |
| ---: | :--- | ---: |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE D-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - MADERA

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| State Route Corridor - SR 99 from Avenue 12 to Avenue 17 |  |  |  |  |
| Road 23 - W. Cleveland Avenue to Avenue 15 | 3,063 | 2,637 | 2,440 | 2,073 |
| N. Granada Drive - W. Cleveland Avenue to Riverview Drive | 781 | 670 | 332 | 99 |
| N. Schnoor Street - W. Cleveland Avenue to Riverview Drive | 1,803 | 1,345 | 1,043 | 363 |
| SR 99 - W. Cleveland Avenue to W. 4th Street | 0 | 0 | -9,913 | $-6,413$ |
| N. Gateway Drive - W. Cleveland Avenue to W. Central Avenue | 2,483 | 2,385 | 1,991 | 1,857 |
| N. D Street - E. Cleveland Avenue to E. Central Avenue | 1,603 | 1,034 | 863 | 463 |

TABLE D-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - MADERA

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| N. Lake Street - E. Cleveland Avenue to E. Central Avenue | 3,002 | 1,622 | 1,297 | 577 |
| Tozer Street - E. Cleveland Avenue to E. Yosemite Avenue | 4,354 | 2,708 | 1,640 | 794 |
| Total | 17,089 | 12,402 | -307 | -189 |

Notes:
Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities parallel to the subject corridor showed an increase in volumes. However, the model was too sensitive and all trips were shifted from the subject corridor due to tolling. The model did not respond appropriately.

TABLE D-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - MADERA
Validation Topic

| Interstate Capacity Change |
| :--- | :--- |
| Notes:  <br> $=$ Met / Not Required <br> $=$ Partially Met Met |
| Reduce Roadway Capacity |

Halve roadway capacity on a State Route within the County.

TABLE D-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - MADERA

| Performance Measure | Base Scenario | Reduce Roadway <br> Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | $1,612.1$ | $1,549.3$ | $-3.90 \%$ |
| VMT | $4,825,306$ | $4,789,609$ | $-0.75 \%$ |
| Elasticity |  |  | 0.19 |

## Notes:

Source:

## Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature: Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed and the elasticity observed is in line with published literature. The model responded appropriately.

## APPENDIX E:

## THREE-COUNTY MODEL VALIDATION DETAILS

Table E-1-A: Daily Person Trip Generation Rates - ThreeCounty - Merced
Table E-1-B: Daily Person Trip Generation Rates - ThreeCounty - San Joaquin/StanislausTable E-2-A: Daily
Productions and Attractions at Gateways - Three-County Table E-2-B: Special Generator Daily Productions and Attractions - Three-County
Table E-3: Summary of Model Performance - Static Validation - Three-County
Table E-4: Summary of Model Performance - Static Validation - Land Use - Three-County
Table E-5: Summary of Model Performance - Static
Validation - Land Use - Detailed - Three-County
Table E-6: Summary of Model Performance - Static Validation - Trip Generation - Three-County
Table E-7: Summary of Model Performance - Static
Validation - Trip Generation - PA Balance - ThreeCounty
Table E-8: Summary of Model Performance - Static
Validation - Trip Generation - Trip Purpose Split - ThreeCounty
Table E-9: Summary of Model Performance - Static
Validation - Trip Generation -Weekday Person Trips per Household - Three-County
Table E-10: Summary of Model Performance - Static Validation - Trip Generation -Vehicle Availability - ThreeCounty
Table E-11: Summary of Model Performance - Static Validation - Trip Distribution - Three-County
Table E-12: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (All Modes) -Three-County
Table E-13: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (Driving Trips Only) - Three-County
Table E-14: Summary of Model Performance - Static Validation - Trip Distribution - Average Travel Time (in minutes) by Trip Purpose - Three-County
Table E-15: Summary of Model Performance - Static Validation - Mode Choice - Three-County

Table E-16: Summary of Model Performance - Static Validation - Mode Choice - Three-County
Table E-17-A: Summary Of Model Performance - Static
Validation - Traffic Assignment - Three-County
Table E-17-B: Summary Of Model Performance - Static
Validation - Traffic Assignment -San Joaquin
Table E-17-C: Summary Of Model Performance - Static
Validation - Traffic Assignment - Stanislaus
Table E-17-D: Summary Of Model Performance - Static
Validation - Traffic Assignment - VMT - Three County
Table E-17-E: Summary Of Model Performance - Static
Validation - Traffic Assignment - VMT - Merced
Table E-17-F: Summary Of Model Performance - Static
Validation - Traffic Assignment - VMT - San Joaquin
Table E-17-G: Summary Of Model Performance - Static
Validation - Traffic Assignment - VMT - Stanislaus
Table E-18: Summary of Model Performance - Static
Validation - Transit Assignment - Three-County
Table E-19: Summary of Model Performance - Static
Validation - Transit Assignment - Detailed - Three-
County
Table E-20: Summary of Model Performance - Dynamic Validation - Three-County
Table E-21: Summary of Model Performance - Dynamic Validation - Land Use - Three-County
Table E-22: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Three-County
Table E-23: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add Lane - ThreeCounty
Table E-24: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add/Delete Link -Three-County
Table E-25: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Speed Change - ThreeCounty
Table E-26: Summary of Model Performance - Dynamic Validation - Travel Cost - Three-County
Table E-27: Summary of Model Performance - Dynamic Validation - Travel Cost (Add Toll Rates) - Three-County Table E-28: Summary of Model Performance - Dynamic Validation - Induced Demand - Three-County
Table E-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity
Change - Three-County

TABLE E-1-A:
DAILY PERSON TRIP GENERATION RATES - THREE-COUNTY - MERCED

| Land Use | Three-County - Merced |
| :---: | :---: |
| Residential |  |
| RU 1 | 5.27 |
| RU 3 | 3.18 |
| RU 9 | 3.41 |
| Non-Residential |  |
| Agriculture | 1.44 |
| Mining | 1.45 |
| Utilities | 1.50 |
| Construction | 1.40 |
| Manufacturing | 1.45 |
| Wholesale | 4.34 |
| Retail | 19.72 |
| Warehouse | 2.71 |
| Information | 2.90 |
| Financial and Insurance | 2.98 |
| Real Estate | 2.95 |
| Professional Services | 2.93 |
| Management Services | 2.86 |
| Administrative Services | 2.97 |
| Education | 0.00 |
| Health | 3.63 |
| Entertainment and Recreation | 22.15 |


| Land Use | Three-County - Merced |
| :---: | :---: |
| Accommodations | 8.71 |
| Food | 37.93 |
| Other Service | 14.54 |
| Public | 5.21 |
| Student Enrollment |  |
| Elementary | 3.16 |
| High School | 4.16 |
| College | 4.66 |

Notes:

TABLE E-1-B:
DAILY PERSON TRIP GENERATION RATES - THREE-COUNTY - SAN JOAQUIN/STANISLAUS

| Land Use | Three-County - San Joaquin/Stanislaus |
| :---: | :---: |
| Residential |  |
| RU 1 | 4.74 |
| RU 3 | 2.87 |
| RU 9 | 3.07 |
| Non-Residential |  |
| Agriculture | 1.29 |
| Mining | 1.30 |
| Utilities | 1.35 |
| Construction | 1.26 |
| Manufacturing | 1.30 |
| Wholesale | 3.91 |
| Retail | 17.75 |
| Warehouse | 2.44 |
| Information | 2.61 |
| Financial and Insurance | 2.68 |
| Real Estate | 2.66 |
| Professional Services | 2.64 |
| Management Services | 2.57 |
| Administrative Services | 2.67 |
| Education | 0.00 |
| Health | 3.26 |
| Entertainment and Recreation | 19.94 |

TABLE E-1-B:
DAILY PERSON TRIP GENERATION RATES - THREE-COUNTY - SAN JOAQUIN/STANISLAUS

| Land Use | Three-County - San Joaquin/Stanislaus |
| :---: | :---: | :---: |
| Accommodations | 7.84 |
| Food | 34.14 |
| Other Service | 13.09 |
| Public | 4.68 |
| Student Enrollment | 2.84 |
| Elementary | 3.74 |
| High School | 4.19 |
| College |  |

Notes:

TABLE E-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - THREE-COUNTY

| Purpose | Three-County |
| :---: | :---: |
| Home-Work | $12,879(118,389)$ |
| Home-Shop | $7,881(15,257)$ |
| Home-K12 | $0(0)$ |
| Home-College | $74(873)$ |
| Home-Other | $10,003(118,082)$ |
| Work-Other | $12,076(9,066)$ |
| Other-Other | $16,185(21,406)$ |
| Highway Commercial | $4,705(4,705)$ |
| Trucks-Small | $1,341(1,485)$ |

TABLE E-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - THREE-COUNTY

| Purpose | Three-County |
| :---: | :---: |
| Trucks-Medium | $709(753)$ |
| Trucks-Heavy | $15,104(16,784)$ |

Notes: Values shown as Production (Attraction)

TABLE E-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS - THREE-COUNTY

| Purpose | Three-County |
| :---: | :---: |
| Home-Work | $0(0)$ |
| Home-Shop | $0(0)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(0)$ |
| Work-Other | $0(0)$ |
| Other-Other | $0(0)$ |
| Trucks-Small | $0(0)$ |
| Trucks-Medium | $0(0)$ |
| Trucks-Heavy | $0(0)$ |

[^12]
## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)

TABLE E-3:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - THREE-COUNTY


TABLE E-4:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE - THREE-COUNTY

|  | Validation Topic | Three-County |
| :---: | :---: | :---: |
| Residential |  |  |
|  | Household Population |  |
| Total Households |  |  |
| Retail |  |  |
| Non-Retail |  |  |
| Total |  | 0 |

Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE E-5:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - THREE-COUNTY

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Household <br> Population | $+/-3 \%$ | $1,457,029$ | $1,384,445$ | $-72,584$ | $-5.0 \%$ |
| Total <br> Households | $+/-3 \%$ | 467,552 | 459,347 | $-8,205$ | $-1.8 \%$ |
| Employment |  |  |  |  |  |
| Retail | $+/-10 \%$ | 92,300 | 105,153 | 12,853 | $13.9 \%$ |
| Non-Retail | $+/-10 \%$ | 367,100 | 356,287 | $-10,813$ | $-2.9 \%$ |
| Total | $+/-10 \%$ | 459,400 | 461,439 | 2,039 | $0.4 \%$ |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE E-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - THREECOUNTY

| Validation Topic | Three-County |
| :---: | :---: |
| Trip Balancing by Purpose |  |
| HBW |  |
| HBS |  |
| NHB |  |
| Total |  |
| Percentage of Trips by Purpose After Balancing |  |

TABLE E-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - THREECOUNTY

| Validation Topic | Three-County |
| :---: | :---: | :---: |
| HBW |  |
| HBO |  |
| NHB |  |
| Person Trips Per HH |  |
| Vehicle Availability |  |

TABLE E-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - PA BALANCE - THREE-COUNTY

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | Difference | Percent <br> Difference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| HBW | $+/-10 \%$ | 554,171 | 627,385 | 0.88 | 73,214 | $13.2 \%$ |
| HBS | $+/-10 \%$ | 319,326 | 321,668 | 0.99 | 2,342 | $0.7 \%$ |
| HBO | $+/-10 \%$ | $1,233,997$ | $1,242,844$ | 0.99 | 8,847 | $0.7 \%$ |
| NHB | $+/-10 \%$ | 756,306 | 771,426 | 0.98 | 15,120 | $2.0 \%$ |
| Total | $+/-10 \%$ | $2,863,801$ | $2,963,323$ | 0.97 | 99,522 | $3.5 \%$ |

Notes:

TABLE E-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

- TRIP PURPOSE SPLIT - THREE-COUNTY

| Purpose | CHTS | Total (All Modes) |
| :---: | :---: | :---: |
| HBW | $16.5 \%$ | Model |
| HBO | $55.6 \%$ | $17.1 \%$ |
| NHB | $27.9 \%$ | $54.8 \%$ |
| Total (All Purposes) | $100.0 \%$ | $28.1 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Transit excludes school bus trips.

## TABLE E-9:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - THREE-COUNTY

| CHTS | Model |
| :---: | :---: |
| 6.2 | 5.6 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, made by households within the county, weighted by weekday, household-level weights ("HHWDWGT").

TABLE E-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - THREE-COUNTY

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 8.5\% | 10.8\% | 29.6\% | 27.7\% | 38.6\% | 39.0\% | 23.3\% | 22.6\% |

[^13]TABLE E-11:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - THREECOUNTY

| Validation Topic | Three-County |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | - |
| Internal-External / External-Internal | - |
| Passenger Auto Trips Only |  |
| Internal-Internal | - |
| Internal-External / External-Internal | $\bullet$ |
| Average Travel Time |  |
| HBW | $\bigcirc$ |
| HBO | $\bigcirc$ |
| NHB | - |
| Notes: $\begin{aligned} & =\text { Met } / \text { Not Required } \\ & =\text { Partially Met } \\ & =\text { Not Met } \end{aligned}$ |  |

Notes: Daily Vehicle Miles Traveled. Highway Performance Management System - 2008 California Public Road Data, Table 11.
TABLE E-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - THREE-COUNTY

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 91\% | 81.5\% | 81\% | 92.4\% | 92\% | 87.1\% | 98\% |
| IX / XI | 11\% | 9\% | 18\% | 19\% | 8\% | 8\% | 13\% | 2\% |

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-BRADLEY | MCCOY-ROTH | CAC | CITILABS

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE E-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - THREE-COUNTY

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 91\% | 82.2\% | 80.5\% | 91.0\% | 91.1\% | 87.4\% | 97\% |
| IX / XI | 11\% | 9\% | 18\% | 19.5\% | 9\% | 8.9\% | 13\% | 2.7\% |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE E-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - THREE-COUNTY

| Trip Purpose |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | HBW |  |  |  |  |
|  |  | HBO | NHB |  |  |
| CHTS | Model | CHTS | Model | CHTS | Model |
| 21.5 | 14.9 | 15.0 | 23.8 | 14.4 | 15.1 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE E-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - THREE-COUNTY

| Validation Topic | Merced | San Joaquin | Stanislaus |
| :---: | :---: | :---: | :---: |
| Drive Alone | 0 |  | 0 |
| Shared Ride 2 | 0 | 0 | 0 |
| Shared Ride 3+ | 0 | 0 | 0 |
| Transit | 0 | 0 | 0 |
| Walk | 0 | 0 | 0 |

## Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met


## TABLE E-16: <br> SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - THREE-COUNTY

|  | Purpose | Model |
| :---: | :---: | :---: |
| Crive Alone | $51.9 \%$ | $41.5 \%$ |
| Shared Ride 2 | $20.4 \%$ | $21.0 \%$ |
| Shared Ride 3+ | $23.7 \%$ | $28.9 \%$ |
| Transit | $0.5 \%$ | $1.1 \%$ |
| Walk | $3.2 \%$ | $5.8 \%$ |
| Bike | $0.2 \%$ | $1.8 \%$ |
| Total | $100 \%$ | $100 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Transit excludes school bus trips.

TABLE E-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT MERCED


Notes:
= Met / Not Required
= Partially Met
$=$ Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
Bowman-Bradley | MCCOY-ROTH | CAC | Citilabs

TABLE E-17-B:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - SAN JOAQUIN


Notes:
= Met / Not Required
= Partially Met
$=$ Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
Bowman-Bradley | MCCOY-ROTH | CAC | Citilabs

## TABLE E-17-C: <br> SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT STANISLAUS



Notes:
= Met / Not Required
= Partially Met
$=$ Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
Bowman-Bradley | MCCOY-ROTH | CAC | Citilabs
San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Three County Model - Merced

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation by Facility Type Results

AM 3 Hour

PM 3 Hour

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Three County Model - San Joaquin

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation by Facility Type Results

AM 3 Hour

PM 3 Hour

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Three County Model - Stanislaus

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) ume Model Validation by Facility Type Results
Three County Model - Stanislaus

AM 3 Hour

PM 3 Hour


TABLE E-17-D:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - THREE-COUNTY

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $35,106,798$ | $37,045,086$ | $5.5 \%$ |

TABLE E-17-E:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT

- VMT - MERCED

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $6,975,375$ | $8,748,983$ | $25.4 \%$ |

TABLE E-17-F:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - SAN JOAQUIN

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $17,257,156$ | $17,312,968$ | $0.3 \%$ |

TABLE E-17-G:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - VMT - STANISLAUS

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $10,874,267$ | $10,979,171$ | $1.0 \%$ |

TABLE E-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - THREECOUNTY

| Validation Topic | Merced | San Joaquin | Stanislaus |
| :---: | :---: | :---: | :---: |
| System Ridership |  | 0 |  |

## Notes:

= Met / Not Required
(1) = Partially Met
$\bigcirc \quad=$ Not Met

## TABLE E-19: <br> SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - DETAILED - THREE-COUNTY

| Validation | Evaluation <br> Criterion | Ridership | Model Ridership | Percentage |
| :--- | :---: | :---: | :---: | :---: |
| Statistic |  |  |  |  |
| Difference between <br> actual ridership to <br> model results for <br> entire system | $+/-20 \%$ | 21,908 | 27,181 | $19 \%$ |
| Notes: |  |  |  |  |

Notes:

## DYNAMIC VALIDATION

TABLE E-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - THREE-COUNTY

| Validation Topic | Merced | San Joaquin | Stanislaus |
| :---: | :---: | :---: | :---: |
| Land Use | 0 |  | 0 |
| Traffic Assignment | 0 | 0 | 0 |
| Travel Cost | 0 | 0 | 0 |
| Induced Demand |  | 0 | 0 |

Notes:

- = Met / Not Required
- = Partially Met
- = Not Met

TABLE E-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - THREE-COUNTY

| Validation Topic | Three-County |
| :---: | :---: |
| Geographic Change |  |
| Placetype Change | 0 |
| Total | 0 |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met

| TestNumber | TestType | ZoneType | TAZ_Before | TDFVT_Before | MXDVT_Before | RawModelPT_Before | TAZ_After | TDFVT_After | MXDVT_After | RawModelPT_After | TDFVT_\%Delta | MXDVT_\%Delta |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 GeographyChange | Primary | 2609 | 38 | 62 | 35 | 2662 | 24 | 39 | 22 | 38\% | 37\% |
|  | 1 GeographyChange | Primary | 2662 | 72 | 118 | 60 | 2609 | 60 | 98 | 52 | 17\% | 17\% |
|  | 1 GeographyChange | Adjacent | 2601 | 557 | 936 | 456 | 2601 | 549 | 924 | 450 | - $1 \%$ | 1\% |
| 1 | 1 GeographyChange | Adjacent | 2603 | 1,308 | 2,027 | 1,096 | 2603 | 1,246 | 1,939 | 1,042 | - 5\% | 4\% |
|  | 1 GeographyChange | Adjacent | 2607 | 184 | 303 | 156 | 2607 | 179 | 295 | 151 | 3\% | 3\% |
| 1 | 1 GeographyChange | Adjacent | 2608 | 453 | 756 | 372 | 2608 | 451 | 754 | 370 | 0\% | 0\% |
|  | 1 GeographyChange | Adjacent | 2610 | 962 | 1,735 | 752 | 2610 | 934 | 1,692 | 728 | 3\% | 2\% |
|  | 1 GeographyChange | Adjacent | 2663 | 161 | 267 | 133 | 2663 | 152 | 253 | 126 | 6\% | - 6 \% |
|  | 1 GeographyChange | Adjacent | 2664 | 989 | 1,682 | 846 | 2664 | 970 | 1,653 | 830 | 2\% | - ${ }^{2 \%}$ |
|  | 1 GeographyChange | Adjacent | 2666 | 1,259 | 2,183 | 1,011 | 2666 | 1,237 | 2,149 | 993 | - 2\% | 2\% |
|  | 1 GeographyChange | Adjacent | 2673 | 1,786 | 2,925 | 1,479 | 2673 | 1,765 | 2,892 | 1,461 | - $1 \%$ | 1\% |
|  | 1 GeographyChange | Adjacent | 2707 | 616 | 1,099 | 519 | 2707 | 587 | 1,052 | 496 | 5\% | 4\% |
|  | 1 GeographyChange | Adjacent | 2708 | 14 | 24 | 14 | 2708 | 2 | 4 | 2 | 85\% | 83\% |
|  | 1 GeographyChange | Adjacent | 2770 | 0 | 0 | 0 | 2770 | $\bigcirc$ | 0 | 0 | 99900\% | 99900\% |
|  | 1 GeographyChange | Adjacent | 3208 | 0 | 0 | 0 | 3208 | 0 | 0 | - 0 | 99900\% | 99900\% |
|  | 1 GeographyChange | Adjacent | 3249 | 0 | 0 | - 0 | 3249 | 0 | ${ }^{0}$ | - 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Primary | 1967 | 164 | 272 | 136 | 2192 | 154 | 254 | 140 | 6\% | $7 \%$ |
|  | 2 GeographyChange | Primary | 2192 | 2,610 | 4,280 | 2,352 | 1967 | 2,861 | 4,731 | 2,334 | - 10\% | 11\% |
|  | 2 GeographyChange | Adjacent | 1966 | 260 | 434 | 223 | 1966 | 263 | 439 | 224 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 1969 | 0 | - 0 | 0 | 1969 | 0 | - 0 | - 0 | 99900\% | 99900\% |
|  | 2 GeographyChange | Adjacent | 2000 | 2,746 | 4,521 | 2,272 | 2000 | 2,717 | 4,479 | 2,243 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 2001 | 6,035 | 10,290 | 4,896 | 2001 | 5,940 | 10,149 | 4,814 | - $2 \%$ | 1\% |
|  | 2 GeographyChange | Adjacent | 2146 | 2,517 | 4,318 | 2,367 | 2146 | 2,475 | 4,257 | 2,325 | 2\% | 1\% |
|  | 2 GeographyChange | Adjacent | 2157 | 5,518 | 9,509 | 5,061 | 2157 | 5,409 | 9,341 | 4,963 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 2158 | 3,435 | 5,697 | 3,198 | 2158 | 3,391 | 5,630 | 3,158 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 2185 | 3,940 | 6,636 | 3,749 | 2185 | 3,862 | 6,527 | 3,671 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 2189 | 1,221 | 2,049 | 1,073 | 2189 | 1,201 | 2,017 | 1,054 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 2191 | 3,950 | 6,892 | 3,846 | 2191 | 3,872 | 6,776 | 3,766 | 2\% | 2\% |
|  | 3 GeographyChange | Primary | 2714 | 3,832 | 6,477 | 3,083 | 4979 | 2,919 | 4,780 | 2,430 | 24\% | 26\% |
|  | 3 GeographyChange | Primary | 4979 | 71 | 119 | 63 | 2714 | 891 | 1,663 | 692 | 1155\% | 1294\% |
|  | 3 GeographyChange | Adjacent | 2615 | 292 | 481 | 244 | 2615 | 298 | 492 | 249 | 2\% | 2\% |
|  | 3 GeographyChange | Adjacent | 2616 | 974 | 1,732 | 770 | 2616 | 957 | 1,707 | 755 | 2\% | 1\% |
|  | 3 GeographyChange | Adjacent | 2719 | 1,230 | 1,949 | 1,056 | 2719 | 1,183 | 1,889 | 1,010 | 4\% | 3\% |
|  | 3 GeographyChange | Adjacent | 2753 | 581 | 1,044 | 482 | 2753 | 569 | 1,026 | 474 | 2\% | 2\% |
|  | 3 GeographyChange | Adjacent | 3082 | 0 | - 0 | 0 | 3082 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 3085 | 0 | 0 | 0 | 3085 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 3086 | 0 | 0 | 0 | 3086 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 3 GeographyChange | Adjacent | 4306 | 1,187 | 2,141 | 1,002 | 4306 | 1,146 | 2,077 | 970 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 4312 | 399 | 707 | 344 | 4312 | 362 | 646 | 312 | 9\% | 9\% |
|  | 3 GeographyChange | Adjacent | 4314 | 154 | 280 | 136 | 4314 | 132 | 244 | 115 | 14\% | 13\% |
|  | 3 GeographyChange | Adjacent | 4328 | 1,401 | 2,331 | 1,324 | 4328 | 1,401 | 2,330 | 1,303 | 0\% | 0\% |
|  | 3 GeographyChange | Adjacent | 4978 | 1,131 | 2,124 | 860 | 4978 | 1,121 | 2,125 | 848 | 1\% | 0\% |
|  | 3 GeographyChange | Adjacent | 4980 | 5,128 | 9,098 | 4,316 | 4980 | 4,993 | 8,885 | 4,215 | 3\% | 2\% |
|  | 3 GeographyChange | Adjacent | 4984 | 18 | 31 | 20 | 4984 | 6 | 11 | - 8 | 65\% | 63\% |
|  | 3 GeographyChange | Adjacent | 4987 | , | - 3 | $\square 6$ | 4987 | 0 | - 0 | - 1 | 96\% | 96\% |
|  | 4 GeographyChange | Primary | 2231 | 619 | 764 | 552 | 2468 | 577 | 720 | 522 | 7\% | 6\% |
|  | 4 GeographyChange | Primary | 2468 | 639 | 1,013 | 548 | 2231 | 618 | 982 | 527 | 3\% | 3\% |
|  | 4 GeographyChange | Adjacent | 1842 | 7,935 | 13,113 | 7,181 | 1842 | 7,764 | 12,852 | 7,053 | 2\% | 2\% |
|  | 4 GeographyChange | Adjacent | 1867 | , | 0 | 0 | 1867 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 2227 | 3,662 | 6,110 | 3,286 | 2227 | 3,651 | 6,092 | 3,273 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2228 | 0 | 0 |  | 2228 | 0 |  | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 2232 | 4,912 | 8,227 | 4,148 | 2232 | 4,899 | 8,207 | 4,133 | 0\% | 0\% |
|  | 4 GeographyChange | Adjacent | 2233 | 2,891 | 4,883 | 2,687 | 2233 | 2,817 | 4,785 | 2,614 | 3\% | 2\% |
|  | 4 GeographyChange | Adjacent | 2466 | 924 | 1,510 | 784 | 2466 | 907 | 1,486 | 770 | 2\% | 2\% |
|  | 4 GeographyChange | Adjacent | 2467 | 130 | 209 | 118 | 2467 | 123 | 198 | 112 | 6\% | 5\% |
|  | 4 GeographyChange | Adjacent | 2469 | 4,181 | 7,199 | 3,499 | 2469 | 4,031 | 6,974 | 3,386 | 4\% | 3\% |
|  | 4 GeographyChange | Adjacent | 2491 | 0 | 0 | $\square 0$ | 2491 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 2492 | 0 | - 0 | 0 | 2492 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 2494 | 0 | 0 | 0 | 2494 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | 4 GeographyChange | Adjacent | 2509 | 245 | 408 | 210 | 2509 | 225 | 376 | 193 | 8\% | 8\% |
|  | 5 GeographyChange | Primary | 2211 | 2,762 | 4,758 | 2,337 | 2539 | 2,513 | 4,283 | 2,044 | 9\% | 10\% |
|  | 5 GeographyChange | Primary | 2539 | 48 | 79 | 41 | 2211 | 398 | 742 | 311 | 730\% | 845\% |
|  | 5 GeographyChange | Adjacent | 2144 | 6,351 | 10,658 | 5,975 | 2144 | 6,195 | 10,439 | 5,823 | 2\% | 2\% |
|  | 5 GeographyChange | Adjacent | 2209 | 2,203 | 3,858 | 1,824 | 2209 | 2,182 | 3,826 | 1,805 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 2210 | 2,447 | 4,127 | 2,087 | 2210 | 2,430 | 4,100 | 2,071 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 2215 | 1,408 | 2,254 | 1,296 | 2215 | 1,409 | 2,262 | 1,294 | 0\% | 0\% |
|  | 5 GeographyChange | Adjacent | 2217 | 3,850 | 6,513 | 3,356 | 2217 | 3,796 | 6,428 | 3,311 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 2218 | 3,348 | 5,628 | 2,927 | 2218 | 3,307 | 5,562 | 2,891 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 2527 | 469 | 740 | 393 | 2527 | 446 | 705 | 373 | 5\% | 5\% |
|  | 5 GeographyChange | Adjacent | 2535 | 388 | 634 | 320 | 2535 | 391 | 639 | 322 | 1\% | 1\% |
|  | 5 GeographyChange | Adjacent | 2536 | 137 | 226 | 114 | 2536 | 141 | 233 | 117 | 3\% | 3\% |
|  | 5 GeographyChange | Adjacent | 2538 | 28 | 44 | 24 | 2538 | 18 | 28 | 16 | 36\% | 37\% |
|  | 6 PlacetypeChange | Primary | 2681 | 57 | 96 | 51 | 2681 | 21,049 | 37,146 | 18,450 | 36674\% | 38604\% |
|  | 6 PlacetypeChange | Adjacent | 2682 | 151 | 250 | 130 | 2682 | 150 | 248 | 129 | 1\% | 1\% |
|  | 6 PlacetypeChange | Adjacent | 2685 | 347 | 586 | 284 | 2685 | 344 | 581 | 281 | 1\% | 1\% |
|  | 6 PlacetypeChange | Adjacent | 2688 | 594 | 987 | 495 | 2688 | 575 | 959 | 479 | 3\% | 3\% |
|  | 6 PlacetypeChange | Adjacent | 2699 | 172 | 264 | 144 | 2699 | 153 | 235 | 128 | 11\% | 11\% |
|  | PlacetypeChange | Primary | 3156 | 0 | 0 | , | 3156 | , | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3094 | 0 | 0 | 0 | 3094 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3150 | 0 | 0 | , | 3150 | - | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3186 | 0 | - 0 | , | 3186 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3187 | 0 | - 0 | 0 | 3187 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3256 | 0 | 0 | 0 | 3256 |  | 0 | 0 | 99900\% | 99900\% |
|  | 3 PlacetypeChange | Primary | 1822 | 5,423 | 9,120 | 4,996 | 1822 | 30,597 | 55,685 | 27,960 | 464\% | 511\% |
|  | 3 PlacetypeChange | Adjacent | 1821 | 2,355 | 4,039 | 2,110 | 1821 | 2,338 | 4,013 | 2,106 | 1\% | 1\% |
|  | 3 PlacetypeChange | Adjacent | 1827 | 1,996 | 3,256 | 1,818 | 1827 | 1,956 | 3,190 | 1,790 | 2\% | 2\% |
|  | PlacetypeChange | Adjacent | 1828 | 11,394 | 19,830 | 10,309 | 1828 | 11,085 | 19,316 | 10,085 | 3\% | 3\% |
|  | 3 PlacetypeChange | Adjacent | 1843 | 4,986 | 8,554 | 4,179 | 1843 | 4,910 | 8,436 | 4,124 | 2\% | 1\% |
|  | 3 PlacetypeChange | Adjacent | 1847 | 2,211 | 3,706 | 2,020 | 1847 | 2,164 | 3,633 | 1,984 | 2\% | 2\% |
|  | 3 PlacetypeChange | Adjacent | 2729 | 58 | 84 | 54 | 2729 | 49 | 69 | 46 | 17\% | 18\% |
|  | PlacetypeChange | Primary | 2797 | 0 | 0 | $\square$ | 2797 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 2723 | 194 | 309 | 163 | 2723 | 190 | 303 | 159 | 2\% | 2\% |
|  | PlacetypeChange | Adjacent | 2795 | 0 | O | 0 | 2795 | - | - 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 3275 | 0 | - 0 | $\square 0$ | 3275 | 0 | - 0 | 0 | 99900\% | 99900\% |
| 10 | PlacetypeChange | Primary | 1860 | 0 | 0 | 0 | 1860 | 0 | 0 | 0 | 99900\% | 99900\% |
|  | PlacetypeChange | Adjacent | 1859 | 47 | 71 | 43 | 1859 | 34 | 50 | 32 | 27\% | 29\% |
|  | PlacetypeChange | Adjacent | 1861 | 0 | 0 | 0 | 1861 | 0 | 0 | 0 | 99900\% | 99900\% |

TABLE E-22:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - THREECOUNTY

| Validation Topic | Three-County |
| :---: | :---: |
| Add Lanes to a Link | 0 |
| Add/Remove Link |  |
| Change Link Speed |  |

## Notes:

- = Met / Not Required
- = Partially Met
- = Not Met


## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE E-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - THREE-COUNTY

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Street Across Screenline - Sunrise Avenue from E. Briggsmore Avenue to W. Granger Avenue |  |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | 1,202 | 772 | 53 | 6 |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 3,310 | 2,674 | 46 | 42 |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 2,820 | 1,556 | -46 | -33 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 4,912 | 4,597 | -6 | -64 |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 2,520 | 1,874 | 421 | 161 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,373 | 5,277 | -90 | -24 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 1,484 | 1,565 | -38 | 100 |
| Oakdale Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 6,359 | 4,694 | -9 | 178 |
| Roselle Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 2,698 | 2,037 | 195 | 116 |

TABLE E-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - THREE-COUNTY

| Screenline Roadways | Peak Hour <br> Volume |  | Volume Change |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Claus Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,847 | 4,636 | 159 | -117 |
| Total | 36,525 | 29,681 | 687 | 365 |

Notes:
Source:

## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

Model showed an increase in volume on the subject link. Parallel facilities showed both slight increases and decreases in volume. The screenline showed a substantial increase in volume. The model appeared to be overly sensitive and did not respond appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

TABLE E-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD/DELETE LINK - THREE-COUNTY

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Added Link Across Screenline - Connecting Sherwood Avenue north | and south of W. Briggsmore Avenue |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | NB/EB | SB/WB | NB/EB | SB/WB |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 1,159 | 772 | 10 | 6 |

TABLE E-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD/DELETE LINK - THREE-COUNTY

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 2,706 | 1,525 | -160 | -64 |
| Added Link | 1,069 | 882 | 1,069 | 882 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 4,387 | 4,266 | -530 | -395 |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 1,969 | 1,619 | -130 | -94 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,401 | 5,243 | -62 | -57 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 1,394 | 1,462 | -127 | -4 |
| Oakdale Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 6,494 | 4,595 | 126 | 78 |
| Roselle Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 2,529 | 1,935 | 26 | 14 |
| Claus Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,796 | 4,750 | 108 | -3 |
| Total | 36,118 | 29,577 | 280 | 261 |
| Delete Street Across Screenline - Tully Road from W. Briggsmore Avenue to W. Granger Avenue |  |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | 1,666 | 1,161 | 518 | 395 |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 0 | 0 | -3,264 | $-2,631$ |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 4,667 | 3,423 | 1,801 | 1,835 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 5,174 | 4,683 | 256 | 22 |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 2,167 | 1,809 | 69 | 95 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,611 | 5,405 | 147 | 105 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 1,561 | 1,539 | 40 | 74 |
| Oakdale Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 6,537 | 4,638 | 170 | 122 |
| Roselle Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 2,689 | 2,067 | 185 | 146 |
| Claus Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,773 | 4,738 | 86 | -16 |
| Total | 35,846 | 29,463 | 8 | 148 |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a similar magnitude decrease in volume and the screenline showed a slight increase. For the deleted link test, the parallel facilities showed a similar magnitude increase in volume and the screenline showed a slight increase. The model responded appropriately.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/- 10 mph on subject facility.

TABLE E-25:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - THREE-COUNTY

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increase Speed on Street Across Screenline - Tully Road from W. Briggsmore Avenue to W. Granger Avenue |  |  |  |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | 35 | 35 | 1,222 | 780 | 74 | 14 |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 35 | 45 | 3,652 | 3,507 | 388 | 875 |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 35 | 35 | 2,680 | 1,049 | -186 | -539 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 35 | 35 | 4,993 | 4,688 | 76 | 27 |

TABLE E-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - THREE-COUNTY

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 30 | 30 | 2,016 | 1,582 | -83 | -131 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 40 | 40 | 5,543 | 5,462 | 79 | 162 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 35 | 35 | 1,580 | 1,580 | 58 | 115 |
| Oakdale Road - E. Briggsmore Avenue to <br> E. Orangeburg Avenue | 45 | 45 | 6,486 | 4,694 | 118 | 178 |
| Roselle Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 35 | 35 | 2,435 | 1,985 | -68 | 63 |
| Claus Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 50 | 50 | 5,866 | 4,836 | 178 | 82 |
| Total |  |  | 36,474 | 30,162 | 635 | 846 |
| Decrease Speed on Street Across Screenline - Tully Road from W. Briggsmore Avenue to W. Granger Avenue |  |  |  |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | 35 | 35 | 1,273 | 987 | 125 | 221 |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 35 | 25 | 2,366 | 1,448 | -898 | -1,183 |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 35 | 35 | 3,661 | 2,501 | 795 | 912 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 35 | 35 | 5,043 | 4,682 | 125 | 21 |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 30 | 30 | 2,063 | 1,758 | -36 | 45 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 40 | 40 | 5,529 | 5,465 | 65 | 165 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 35 | 35 | 1,536 | 1,652 | 14 | 187 |

TABLE E-25:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT

- SPEED CHANGE - THREE-COUNTY

| Speed | Peak Hour <br> Volume | Volume Change |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |

Notes:
Source:

## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the parallel facilities showed both increases and decreases in volume. For the decreased speed test, the parallel facilities showed increases in volume greater than the magnitude decrease of the subject link. The model did not respond appropriately.

TABLE E-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - THREE-COUNTY
Validation Topic $\quad$ Three-County

Add Toll to Corridor

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met


## Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE E-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - THREE-COUNTY

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| State Route Corridor - SR 99 from E. Keyes Road to Main Street |  |  |  |  |
| Carver Road - W. Briggsmore Avenue to W. Orangeburg Avenue | 1,210 | 885 | 61 | 119 |
| Tully Road - W. Briggsmore Avenue to W. Granger Avenue | 3,862 | 3,156 | 598 | 525 |
| College Avenue - W. Briggsmore Avenue to W. Granger Avenue | 3,889 | 2,709 | 1,024 | 1,121 |
| McHenry Avenue - W. Briggsmore Avenue to W. Granger Avenue | 5,061 | 4,904 | 143 | 243 |
| Sunrise Avenue - E. Briggsmore Avenue to W. Granger Avenue | 2,157 | 1,840 | 58 | 126 |
| Coffee Road - E. Briggsmore Avenue to E. Orangeburg Avenue | 5,917 | 5,593 | 453 | 293 |
| Rose Avenue - E. Briggsmore Avenue to E. Orangeburg Avenue | 1,877 | 1,718 | 355 | 253 |

TABLE E-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAVEL COST (ADD TOLL RATES) - THREE-COUNTY

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Oakdale Road - E. Briggsmore Avenue to E. Orangeburg <br> Avenue | 6,736 | 4,761 | 368 | 245 |
| Roselle Avenue - E. Briggsmore Avenue to E. Orangeburg <br> Avenue | 3,106 | 2,396 | 603 | 475 |
| Claus Road - E. Briggsmore Avenue to E. Orangeburg <br> Avenue | 6,156 | 4,963 | 469 | 210 |
| Total | 39,970 | 32,925 | 4,132 | 3,609 |

Notes:
Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities parallel to the subject corridor showed an increase in volumes. However, the model was too sensitive and all trips were shifted from segments along the subject corridor due to tolling. The model did not respond appropriately.

TABLE E-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - THREE-
COUNTY

## Validation Topic

> Three-County

Interstate Capacity Change

| Notes: |  |
| :--- | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Reduce Roadway Capacity

Halve roadway capacity on a State Route within the County.

TABLE E-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - THREE-COUNTY

| Performance Measure | Base Scenario | Reduce Roadway <br> Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | 7,696 | 7,521 | $-2.28 \%$ |
| VMT | $26,250,820$ | $24,408,086$ | $-7.02 \%$ |
| Elasticity |  |  | 3.09 |

Notes:
Source:

## Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature: Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed but the model was too sensitive to the effects. VMT decreased more than the literature elasticity suggests. The model did not respond appropriately.

## APPENDIX F:

## TULARE MODEL VALIDATION DETAILS

Table F-1: Daily Person Trip Generation Rates - Tulare Table F-2-A: Daily Productions and Attractions at Gateways - Tulare
Table F-2-B: Special Generator Daily Productions and Attractions - Tulare
Table F-3: Summary of Model Performance - Static Validation - Tulare
Table F-4: Summary of Model Performance - Static Validation - Land Use - Tulare
Table F-5: Summary of Model Performance - Static
Validation - Land Use - Detailed - Tulare
Table F-6: Summary of Model Performance - Static Validation - Trip Generation - Tulare
Table F-7: Summary of Model Performance - Static Validation - Trip Generation - PA Balance - Tulare Table F-8: Summary of Model Performance - Static Validation - Trip Generation - Trip Purpose Split - Tulare Table F-9: Summary of Model Performance - Static Validation - Trip Generation -Weekday Person Trips per Household - Tulare
Table F-10: Summary of Model Performance - Static Validation - Trip Generation -Vehicle Availability - Tulare Table F-11: Summary of Model Performance - Static Validation - Trip Distribution - Tulare
Table F-12: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (All Modes) Tulare
Table F-13: Summary of Model Performance - Static Validation - Trip Distribution - By Purpose (Driving Trips Only) - Tulare
Table F-14: Summary of Model Performance - Static Validation - Trip Distribution - Average Travel Time (in minutes) by Trip Purpose - Tulare
Table F-15: Summary of Model Performance - Static Validation - Mode Choice - Tulare

Table F-16: Summary of Model Performance - Static Validation - Mode Choice - Tulare
Table F-17-A: Summary of Model Performance - Static Validation - Traffic Assignment - Tulare
Table F-17-B: Summary of Model Performance - Static Validation - Traffic Assignment - VMT - TulareTable F-
18: Summary of Model Performance - Static Validation Transit Assignment - Tulare
Table F-19: Summary of Model Performance - Static
Validation - Transit Assignment - Detailed - Tulare
Table F-20: Summary of Model Performance - Dynamic Validation - Tulare
Table F-21: Summary of Model Performance - Dynamic Validation - Land Use - Tulare
Table F-22: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Tulare
Table F-23: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add Lane - Tulare Table F-24: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Add/Delete Link Tulare
Table F-25: Summary of Model Performance - Dynamic Validation - Traffic Assignment - Speed Change - Tulare Table F-26: Summary of Model Performance - Dynamic Validation - Travel Cost - Tulare
Table F-27: Summary of Model Performance - Dynamic Validation - Travel Cost (Add Toll Rates) - Tulare Table F-28: Summary of Model Performance - Dynamic Validation - Induced Demand - Tulare
Table F-29: Summary of Model Performance - Dynamic Validation - Induced Demand - Interstate Capacity Change - Tulare


## TABLE F-1:

DAILY PERSON TRIP GENERATION RATES - TULARE

| Land Use | Tulare |
| :---: | :---: |
| Residential |  |
| RU 1 | 8.93 |
| RU 3 | 6.00 |
| RU 9 | 7.84 |
| Non-Residential |  |
| Agriculture | 2.07 |
| Mining | 2.05 |
| Utilities | 2.21 |
| Construction | 2.09 |
| Manufacturing | 2.17 |
| Wholesale | 9.79 |
| Retail | 27.65 |
| Warehouse | 4.20 |
| Information | 4.36 |
| Financial and Insurance | 4.37 |
| Real Estate | 4.34 |
| Professional Services | 4.37 |
| Management Services | 4.28 |
| Administrative Services | 4.37 |
| Education | 0.00 |
| Health | 6.48 |
| Entertainment and Recreation | 45.75 |

TABLE F-1:
DAILY PERSON TRIP GENERATION RATES - TULARE

| Land Use | Tulare |  |
| :---: | :---: | :---: |
| Accommodations | 17.19 |  |
| Food | 80.55 |  |
| Other Service | 30.72 |  |
| Public | 35.47 |  |
| Student Enrollment |  |  |
| Elementary | 3.56 |  |
| High School | 4.72 |  |
| College | 5.41 |  |

Notes:

TABLE F-2-A:
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - TULARE

| Purpose | Tulare |
| :---: | :---: |
| Home-Work | $39,658(24,303)$ |
| Home-Shop | $8,236(2,805)$ |
| Home-K12 | $0(0)$ |
| Home-College | $143(96)$ |
| Home-Other | $19,375(12,976)$ |
| Work-Other | $7,468(10,951)$ |
| Other-Other | $13,324(8,988)$ |
| Highway Commercial | $2,156(2,156)$ |
| Trucks-Small | $887(920)$ |

## TABLE F-2-A:

DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS - TULARE

| Purpose | Tulare |
| :---: | :---: |
| Trucks-Medium | $509(524)$ |
| Trucks-Heavy | $7,249(7,786)$ |

Notes: Values shown as Production (Attraction)

TABLE F-2-B:
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS - TULARE

| Purpose | Tulare |
| :---: | :---: |
| Home-Work | $0(0)$ |
| Home-Shop | $0(0)$ |
| Home-K12 | $0(0)$ |
| Home-College | $0(22,545)$ |
| Work-Other | $0(0)$ |
| Other-Other | $0(0)$ |
| Highway Commercial | $0(0)$ |
| Trucks-Small | $0(0)$ |
| Trucks-Medium | $0(0)$ |

## STATIC VALIDATION (SEE VALIDATION SPREADSHEETS FOR DETAIL)

TABLE F-3:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| Land Use | 0 |
| Trip Generation | - |
| Trip Distribution | - |
| Mode Choice | - |
| Traffic Assignment | $\bigcirc$ |
| Transit Assignment | N/A |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met


## TABLE F-4:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE - TULARE

|  | Validation Topic | Tulare |
| :---: | :---: | :---: |
| Residential |  |  |
|  | Household Population |  |
|  | Total Households |  |
| Employment | Retail |  |
| Non-Retail | Total |  |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met

TABLE F-5:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - LAND USE DETAILED - TULARE

| Validation <br> Statistic | Evaluation <br> Criterion | Reference* | Model | Difference | Percent <br> Difference |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Household <br> Population | $+/-3 \%$ | 433,038 | 406,419 | $-26,619$ | $-6.1 \%$ |
| Total <br> Households | $+/-3 \%$ | 128,938 | 125,846 | $-3,092$ | $-2.4 \%$ |
| Employment | $+/-10 \%$ | 24,500 | 17,867 | $-6,633$ | $-27.1 \%$ |
| Retail | 125,700 | 130,733 | 5,033 | $4.0 \%$ |  |
| Non-Retail | $+/-10 \%$ | 150,200 | 148,600 | $-1,600$ | $-1.1 \%$ |
| Total | $+/-10 \%$ |  |  |  |  |

*Population and household data are 2008 values from California Department of Finance's Table "E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010." Employment data are 2008 values from California Economic Development Department's Data Library: http://www.labormarketinfo.edd.ca.gov/?PAGEID=94. "Retail" category includes EDD's Retail Trade and Leisure \& Hospitality categories.

TABLE F-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - TULARE
Validation Topic $\quad$ Tulare

Trip Balancing by Purpose

| HBW |  |
| :---: | :---: | :---: |
| HBS |  |
| HBO |  |
| NHB |  |
| Total |  |
| Percentage of Trips by Purpose After Balancing |  |

TABLE F-6:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - TULARE

|  | Validation Topic | Tulare |
| :---: | :---: | :---: |
|  | HBO | $\bullet$ |
|  | NHB | $\bullet$ |
|  | Person Trips Per HH | $\bullet$ |
|  | Vehicle Availability | $\bigcirc$ |
|  | = Met / Not Required <br> $=$ Partially Met <br> $=$ Not Met |  |

TABLE F-7:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION - PA BALANCE - TULARE

| Trip Purpose | Evaluation <br> Criterion | Productions | Attractions | P/A Ratio | Difference | Percent <br> Difference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| HBW | $+/-10 \%$ | 260,636 | 303,285 | 0.86 | 42,649 | $16.4 \%$ |
| HBS | $+/-10 \%$ | 155,318 | 201,020 | 0.77 | 45,702 | $29.4 \%$ |
| HBO | $+/-10 \%$ | 589,580 | 656,323 | 0.90 | 66,742 | $11.3 \%$ |
| NHB | $+/-10 \%$ | 524,939 | 525,045 | 1.00 | 106 | $0.0 \%$ |
| Total | $+/-10 \%$ | $1,530,474$ | $1,685,673$ | 0.91 | 155,200 | $10.1 \%$ |

[^14]TABLE F-8
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION

- TRIP PURPOSE SPLIT - TULARE

| Purpose | Total (All Modes) |  |
| :---: | :---: | :---: |
| HBW | $12.5 \%$ | Model |
| HBO | $53.8 \%$ | $14.6 \%$ |
| NHB | $33.6 \%$ | $50.5 \%$ |
| Total (All Purposes) | $100.0 \%$ | $34.9 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Transit excludes school bus trips.

## TABLE F-9:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -WEEKDAY PERSON TRIPS PER HOUSEHOLD - TULARE

| CHTS | Model |
| :---: | :---: |
| 12.1 | 11.1 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, made by households within the county, weighted by weekday, household-level weights ("HHWDWGT").

TABLE F-10:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP GENERATION -VEHICLE AVAILABILITY - TULARE

| Vehicle Availability |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 |  | 1 |  | 2 |  | 3+ |  |
| CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| 12.8\% | 7.1\% | 29.2\% | 21.0\% | 32.9\% | 35.9\% | 25.1\% | 35.9\% |

[^15]TABLE F-11:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| All Modes |  |
| Internal-Internal | $\bullet$ |
| Internal-External / External-Internal | - |
| Passenger Auto Trips Only |  |
| Internal-Internal | - |
| Internal-External / External-Internal | $\bullet$ |
| Average Travel Time |  |
| HBW | $\bigcirc$ |
| HBO | - |
| NHB | - |
| Notes: <br> = Met / Not Required <br> = Partially Met <br> = Not Met |  |

TABLE F-12:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (ALL MODES) - TULARE

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip <br> Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 92\% | 83.1\% | 80\% | 92\% | 95\% | 87\% | 94\% |


| IX / XI | $17 \%$ | $8 \%$ | $19.7 \%$ | $20 \%$ | $7.4 \%$ | $5 \%$ | $10.7 \%$ | $6 \%$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE F-13:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - BY PURPOSE (DRIVING TRIPS ONLY) - TULARE

| Trip Purpose |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | HBW |  | HBO |  | NHB |  |
| Trip Type | CHTS | Model | CHTS | Model | CHTS | Model | CHTS | Model |
| II | 89\% | 92\% | 83.8\% | 80.0\% | 91.5\% | 94.7\% | 86.1\% | 94\% |
| IX / XI | 16\% | 8\% | 17.6\% | 20.0\% | 8.5\% | 5.3\% | 10.3\% | 6.2\% |

Notes: 2000-2001 California Statewide Household Travel Survey. Weekday, driving trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday driving trips. Trips are weighted by weekday, trip-level weights ("WDWGT").

TABLE F-14:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRIP DISTRIBUTION - AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE - TULARE

|  | Trip Purpose |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | HBW |  | HBO | NHB |  |
| CHTS | Model | CHTS | Model | CHTS | Model |
| 19.5 | 17.6 | 16.1 | 12.1 | 13.7 | 11.1 |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

TABLE F-15:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| Drive Alone | $\bigcirc$ |
| Shared Ride 2 | $\bigcirc$ |
| Shared Ride 3+ | 0 |
| Transit | $\bigcirc$ |
| Walk |  |
| Bike |  |

## Notes:

- = Met / Not Required
- = Partially Met
- Not Met

TABLE F-16:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - MODE CHOICE - TULARE

|  | Purpose | Model |
| :---: | :---: | :---: |
| Crive Alone | CHTS | $43.4 \%$ |
| Shared Ride 2 | $26.1 \%$ | $31.1 \%$ |
| Shared Ride 3+ | $26.0 \%$ | $15.1 \%$ |
| Transit | $43.3 \%$ | $1.0 \%$ |
| Walk | $0.7 \%$ | $8.0 \%$ |
| Bike | $3.2 \%$ | $1.4 \%$ |
| Total | $0.6 \%$ | $100.0 \%$ |

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Transit excludes school bus trips.

## TABLE F-17-A:

SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - TULARE

| Validation Topic | Tulare |  |
| :---: | :---: | :---: |
| Vehicle Miles Traveled | 0 |  |
| All Vehicles - Traffic Counts |  |  |
| Daily | 0 |  |
| AM Period | 0 |  |
| Midday Period | 0 |  |
| PM Period | 0 |  |
| Nighttime Period | 0 |  |
| AM 1 Hour |  | 0 |
| Facility Type - Traffic Counts |  | 0 |


| Daily |  |
| :--- | :---: |
| AM Period | 0 |
| PM Period | 0 |
| AM 1 Hour | 0 |
| PM 1 Hour | 0 |

Distribution of Class by Time of Day - Truck Traffic Counts

| Medium - AM Period |  |
| :---: | :---: |
| Medium - Midday Period | 0 |
| Medium - PM Period | 0 |
| Medium - Evening Period | 0 |
| Heavy - AM Period |  |

TABLE F-17-A:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT - TULARE

|  | Validation Topic | Tulare |
| :---: | :---: | :---: |
|  | Heavy - Midday Period | - |
|  | Heavy - PM Period | - |
|  | Heavy - Evening Period | - |
| Distribution of Time of Day by Class - Truck Traffic Counts |  |  |
|  | Medium - AM Period | $\bigcirc$ |
|  | Medium - Midday Period | - |
|  | Medium - PM Period | $\bigcirc$ |
|  | Medium - Evening Period | $\bigcirc$ |
|  | Heavy - AM Period | $\bigcirc$ |
|  | Heavy - Midday Period | $\bigcirc$ |
|  | Heavy - PM Period | $\bigcirc$ |
|  | Heavy - Evening Period | $\bigcirc$ |
| Notes:$\begin{aligned} & =\text { Met } / \text { Not Required } \\ & =\text { Partially Met } \\ & =\text { Not Met } \end{aligned}$ |  |  |

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation Results
Tulare County Model

San Joaquin Valley Model Improvement Project (San Joaquin Valley MIP) Two-Way Volume Model Validation by Facility Type Results

AM 3 Hour

PM 3 Hour


TABLE F-17-B:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRAFFIC ASSIGNMENT

- VMT - TULARE

| Evaluation Criterion | HPMS | Model | Deviation |
| :---: | :---: | :---: | :---: |
| $+/-3 \%$ | $9,964,748$ | $10,537,950$ | $5.8 \%$ |

TABLE F-18:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - TULARE

| Validation Topic | Tulare |
| :--- | :--- | :--- |
| System Ridership | N/A |


| Notes: |  |
| :--- | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

TABLE F-19:
SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION - TRANSIT ASSIGNMENT - DETAILED - TULARE

| Validation <br> Statistic | Evaluation <br> Criterion | Ridership | Model Ridership | Percentage |
| :--- | :---: | :---: | :---: | :---: |
| Difference between <br> actual ridership to <br> model results for <br> entire system | $+/-20 \%$ | N/A | N/A | N/A |

Notes:

## DYNAMIC VALIDATION

TABLE F-20:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| Land Use | 0 |
| Traffic Assignment | 0 |
| Travel Cost | 0 |
| Induced Demand |  |

Notes:

- = Met / Not Required
- = Partially Met
- $=$ Not Met

TABLE F-21:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - LAND USE - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| Geographic Change |  |
| Placetype Change |  |
| Total | 0 |

Notes:

- = Met / Not Required
- = Partially Met
- Not Met

FEHR \& PEERS | DOWLING ASSOCIATES | RSG | CS |
BOWMAN-Bradley | MCCOY-ROTH | CAC | CItilabs

| TestNumber | TestType | ZoneType | \|TAZ_Before | TDFVT_Before | MXXVV_Before | RawModelPT_Before | TAZ_After | TDFVT_After | MXDVT_After | RawModelPT_After | TDFVT_\%Delta | MXDVT_\%Delta |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 GeographyChange | Primary | 243 | 468 | 724 | 783 | 829 | 478 | 725 | 790 | 2\% | 0\% |
|  | 1 GeographyChange | Primary | 829 | 14 | 20 | 22 | 243 | 14 | 21 | 22 | 1\% | $3 \%$ |
|  | 1 GeographyChange | Adjacent | 246 | 565 | 927 | 1,021 | 246 | 616 | 1,001 | 1,092 | 9\% | - ${ }^{8 \%}$ |
|  | 1 GeographyChange | Adjacent | 248 | 1,058 | 1,706 | 1,873 | 248 | 1,120 | 1,797 | 1,958 | 6\% | - 5\% |
|  | 1 GeographyChange | Adjacent | 249 | 229 | 356 | 407 | 249 | 234 | 364 | 414 | 2\% | 2\% |
|  | 1 GeographyChange | Adjacent | 250 | 167 | 261 | 295 | 250 | 170 | 266 | 299 | 2\% | - $2 \%$ |
|  | 1 GeographyChange | Adjacent | 253 | 1,214 | 1,871 | 2,031 | 253 | 1,239 | 1,909 | 2,067 | 2\% | - 2\% |
|  | 1 GeographyChange | Adjacent | 776 | 258 | 378 | 410 | 776 | 265 | 388 | 415 | 3\% | - 3\% |
|  | 1 GeographyChange | Adjacent | 777 | 1,084 | 1,626 | 1,838 | 777 | 1,117 | 1,679 | 1,859 | 3\% | - 3\% |
|  | 1 GeographyChange | Adjacent | 778 | 2 | 3 | $\square$ | 778 | 2 | 3 | 3 | 17\% | 14\% |
|  | 1 GeographyChange | Adjacent | 779 | 10 | 15 | 16 | 779 | 10 | 15 | 16 | 3\% | 3\% |
|  | 1 GeographyChange | Adjacent | 2015 | 34 | 41 | 47 | 2015 | 30 | 43 | 45 | 13\% | 3\% |
|  | 2 GeographyChange | Primary | 524 | 38 | 44 | 49 | 1441 | 49 | 55 | 59 | 29\% | 26\% |
|  | 2 GeographyChange | Primary | 1441 | 2 | 2 | 2 | 524 | - 2 | 2 | 2 | 20\% | 24\% |
|  | 2 GeographyChange | Adjacent | 518 | 364 | 550 | 600 | 518 | 377 | 570 | 610 | 3\% | - $4 \%$ |
|  | 2 GeographyChange | Adjacent | 519 | 928 | 1,375 | 1,501 | 519 | 981 | 1,451 | 1,583 | 6\% | - 6 \% |
|  | 2 GeographyChange | Adjacent | 523 | 139 | 209 | 225 | 523 | 142 | 216 | 229 | 3\% | - 3\% |
|  | 2 GeographyChange | Adjacent | 525 | 560 | 844 | 935 | 525 | 581 | 877 | 95 | 4\% | 4\% |
|  | 2 GeographyChange | Adjacent | 530 | 602 | 920 | 1,001 | 530 | 619 | 947 | 1,012 | 3\% | - 3\% |
|  | 2 GeographyChange | Adjacent | 531 | 389 | 573 | 658 | 531 | 418 | 612 | 691 | 7\% | - $7 \%$ |
|  | 2 GeographyChange | Adjacent | 547 | 765 | 1,143 | 1,289 | 547 | 803 | 1,200 | 1,322 | 5\% | 5\% |
|  | 2 GeographyChange | Adjacent | 550 | 316 | 481 | 529 | 550 | 325 | 498 | 536 | 3\% | $4 \%$ |
|  | 2 GeographyChange | Adjacent | 551 | 858 | 1,341 | 1,477 | 551 | 943 | 1,463 | 1,573 | 10\% | 9\% |
|  | 2 GeographyChange | Adjacent | 1424 | 1,302 | 1,900 | 1,994 | 1424 | 1,315 | 1,919 | 2,014 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 1425 | 463 | 670 | 711 | 1425 | 467 | 676 | 718 | 1\% | 1\% |
|  | 2 GeographyChange | Adjacent | 1479 | 555 | 800 | 855 | 1479 | 582 | 836 | 893 | 5\% | 5\% |
|  | 2 GeographyChange | Adjacent | 1480 | 21 | 31 | 32 | 1480 | 22 | 32 | 33 | 2\% | 2\% |
|  | 2 GeographyChange | Adjacent | 1509 | 133 | 184 | 191 | 1509 | 146 | 200 | 207 | 10\% | $8 \%$ |
|  | 2 GeographyChange | Adjacent | 1691 | - 6 | 6 | $\square$ | 1691 | 4 | 5 | $\square$ | 37\% | 24\% |
|  | 3 GeographyChange | Primary | 831 | 503 | 733 | 844 | 1021 | 568 | 831 | 894 | 13\% | 13\% |
|  | 3 GeographyChange | Primary | 1021 | 1,299 | 1,907 | 2,071 | 831 | 1,310 | 1,906 | 2,192 | 1\% | 0\% |
|  | 3 GeographyChange | Adjacent | 765 | 1,409 | 2,032 | 2,361 | 765 | 1,497 | 2,146 | 2,455 | 6\% | 6\% |
|  | 3 GeographyChange | Adjacent | 767 | 246 | 340 | 393 | 767 | 273 | 373 | 426 | 11\% | 10\% |
|  | 3 GeographyChange | Adjacent | 769 | 1,264 | 1,809 | 2,099 | 769 | 1,367 | 1,941 | 2,242 | 8\% | 7\% |
|  | 3 GeographyChange | Adjacent | 789 | 2,226 | 3,319 | 3,836 | 789 | 2,397 | 3,553 | 4,042 | 8\% | 7\% |
|  | 3 GeographyChange | Adjacent | 790 | 1,195 | 1,783 | 2,040 | 790 | 1,229 | 1,836 | 2,066 | 3\% | 3\% |
|  | 3 GeographyChange | Adjacent | 832 | 158 | 229 | 279 | 832 | 169 | 245 | 296 | 7\% | 7\% |
|  | 3 GeographyChange | Adjacent | 1006 | 700 | 1,016 | 1,075 | 1006 | 710 | 1,029 | 1,089 | 1\% | 1\% |
|  | 3 GeographyChange | Adjacent | 1008 | 3 | 3 | - 3 | 1008 | 3 | 4 | 4 | 20\% | 18\% |
|  | 3 GeographyChange | Adjacent | 1020 | 303 | 432 | 477 | 1020 | 324 | 458 | 496 | 7\% | 6\% |
|  | 3 GeographyChange | Adjacent | 1022 | 5,307 | 7,732 | 8,564 | 1022 | 5,705 | 8,288 | 9,079 | 7\% | 7\% |
|  | 3 GeographyChange | Adjacent | 1023 | 3 | 4 | $\square$ | 1023 | 4 | 5 | $\square$ | 26\% | 24\% |
|  | 3 GeographyChange | Adjacent | 1138 | 2 | 3 | - 3 | 1138 | 3 | 3 | - 4 | 28\% | 26\% |
|  | 4 GeographyChange | Primary | 188 | 534 | 773 | 844 | 710 | 550 | 797 | 852 | 3\% | 3\% |
|  | 4 GeographyChange | Primary | 710 | 350 | 512 | 572 | 188 | 377 | 532 | 596 | 7\% | 4\% |
|  | 4 GeographyChange | Adjacent | 139 | 920 | 1,341 | 1,518 | 139 | 983 | 1,428 | 1,603 | 7\% | 6\% |
|  | 4 GeographyChange | Adjacent | 141 | 1,002 | 1,509 | 1,684 | 141 | 1,077 | 1,611 | 1,772 | 7\% | 7\% |
|  | 4 GeographyChange | Adjacent | 142 | 576 | 851 | 906 | 142 | 584 | 864 | 915 | 1\% | 1\% |
|  | 4 GeographyChange | Adjacent | 143 | 835 | 1,224 | 1,328 | 143 | 863 | 1,264 | 1,364 | 3\% | 3\% |
|  | 4 GeographyChange | Adjacent | 152 | 123 | 173 | 195 | 152 | 137 | 190 | 211 | 11\% | 10\% |
|  | 4 GeographyChange | Adjacent | 153 | 2,808 | 4,092 | 4,676 | 153 | 3,012 | 4,374 | 4,954 | 7\% | 7\% |
|  | 4 GeographyChange | Adjacent | 154 | 707 | 1,028 | 1,155 | 154 | 745 | 1,079 | 1,201 | 5\% | - 5\% |
|  | 4 GeographyChange | Adjacent | 155 | 164 | 242 | 270 | 155 | 170 | 250 | 277 | 4\% | - 4\% |
|  | 4 GeographyChange | Adjacent | 187 | 481 | 719 | 791 | 187 | 509 | 747 | 815 | 6\% | - $4 \%$ |
|  | 4 GeographyChange | Adjacent | 702 | 691 | 1,024 | 1,081 | 702 | 704 | 1,044 | 1,095 | 2\% | 2\% |
|  | 4 GeographyChange | Adjacent | 703 | 150 | 223 | 235 | 703 | 153 | 227 | 238 | 2\% | 2\% |
|  | 4 GeographyChange | Adjacent | 704 | 3 | 4 |  | 704 | - 3 | - 5 | - 5 | 13\% | 10\% |
|  | 4 GeographyChange | Adjacent | 708 | 1,901 | 2,827 | 3,083 | 708 | 1,992 | 2,956 | 3,198 | 5\% | 5\% |
|  | 4 GeographyChange | Adjacent | 709 | 810 | 1,191 | 1,292 | 709 | 827 | 1,218 | 1,307 | 2\% | 2\% |
|  | 4 GeographyChange | Adjacent | 711 | 425 | 696 | 804 | 711 | 485 | 784 | 861 | 14\% | 13\% |
|  | 4 GeographyChange | Adjacent | 712 | 597 | 915 | 1,024 | 712 | 651 | 992 | 1,084 | 9\% | 8\% |
|  | 4 GeographyChange | Adjacent | 713 | 592 | 879 | 971 | 713 | 609 | 904 | 980 | 3\% | - 3\% |
|  | 5 GeographyChange | Primary | 1311 | 1,504 | 2,191 | 2,471 | 1771 | 1,714 | 2,537 | 2,627 | 14\% | 16\% |
|  | 5 GeographyChange | Primary | 1771 | 600 | 906 | 959 | 1311 | 4,220 | 6,147 | 6,943 | 603\% | 579\% |
|  | 5 GeographyChange | Adjacent | 1304 | 647 | 901 | 1,126 | 1304 | 715 | 984 | 1,201 | 10\% | - $9 \%$ |
|  | 5 GeographyChange | Adjacent | 1305 | 198 | 271 | 333 | 1305 | 224 | 302 | 362 | 13\% | 12\% |
|  | 5 GeographyChange | Adjacent | 1306 | 1,398 | 2,000 | 2,267 | 1306 | 1,517 | 2,157 | 2,422 | 9\% | 8\% |
|  | 5 GeographyChange | Adjacent | 1310 | 377 | 520 | 642 | 1310 | 420 | 573 | 691 | 11\% | 10\% |
|  | 5 GeographyChange | Adjacent | 1312 | 846 | 1,199 | 1,358 | 1312 | 958 | 1,351 | 1,501 | 13\% | 13\% |
|  | 5 GeographyChange | Adjacent | 1315 | 306 | 429 | 484 | 1315 | 338 | 468 | 522 | 10\% |  |
|  | 5 GeographyChange | Adjacent | 1316 | 207 | 297 | 334 | 1316 | 225 | 320 | 357 | 9\% | 8\% |
|  | 5 GeographyChange | Adjacent | 1761 | 861 | 973 | 1,098 | 1761 | 642 | 834 | 849 | 25\% | 14\% |
|  | 5 GeographyChange | Adjacent | 1762 | 191 | 182 | 235 | 1762 | 112 | 129 | 133 | 41\% | 29\% |
|  | 5 GeographyChange | Adjacent | 1769 | 592 | 710 | 779 | 1769 | 453 | 593 | 610 | 23\% | 17\% |
|  | 5 GeographyChange | Adjacent | 1770 | 275 | 371 | 395 | 1770 | 229 | 322 | 332 | 17\% | 13\% |
|  | 6 PlacetypeChange | Primary | 830 | 443 | 655 | 693 | 830 | 1,166 | 1,705 | 1,838 | 163\% | 160\% |
|  | 6 PlacetypeChange | Adjacent | 782 | 1,236 | 1,928 | 2,161 | 782 | 1,340 | 2,083 | 2,253 | 8\% | 8\% |
|  | 6 PlactypeChange | Adjacent | 783 | 543 | 801 | 870 | 783 | 556 | 822 | 881 | 3\% | 3\% |
|  | 6 PlacetypeChange | Adjacent | 785 | 1,663 | 2,441 | 2,657 | 785 | 1,708 | 2,507 | 2,704 | 3\% | 3\% |
|  | 6 PlacetypeChange | Adjacent | 796 | 1 | 2 | 2 | 796 | 1 | 2 | - 2 | 15\% | 13\% |
|  | 6 PlacetypeChange | Adjacent | 1982 | 77 | 105 | 115 | 1982 | 77 | 111 | 116 | 0\% | 6\% |
|  | 7 PlacetypeChange | Primary | 680 | - 6 | 7 |  | 680 | 0 | - 0 | 0 | 100\% | 100\% |
|  | 7 PlacetypeChange | Adjacent | 678 | 2,232 | 3,486 | 3,634 | 678 | 2,299 | 3,582 | 3,734 | 3\% | 3\% |
|  | 7 PlacetypeChange | Adjacent | 679 | 0 | 1 | 324 | 679 | 0 | 1 | 353 | 25\% | 27\% |
|  | 7 PlacetypeChange | Adjacent | 683 | 41 | 54 | 56 | 683 | 47 | 61 | 63 | 14\% | 12\% |
|  | 7 PlacetypeChange | Adjacent | 1994 | 662 | 807 | 877 | 1994 | 536 | 737 | 756 | 19\% | - 9\% |
|  | 8 PlacetypeChange | Primary | 1096 | 149 | 219 | 233 | 1096 | 18,658 | 27,113 | 29,668 | 12385\% | 12296\% |
|  | 8 PlacetypeChange | Adjacent | 1095 | 7 | 8 | - 8 | 1095 | 8 | 9 | 10 | 21\% | 19\% |
|  | 8 PlacetypeChange | Adjacent | 1097 | 33 | 48 | 51 | 1097 | 34 | 49 | 52 | 3\% | 2\% |
|  | 8 PlacetypeChange | Adjacent | 1112 | 48 | 68 | 72 | 1112 | 51 | 71 | 77 | 6\% | 5\% |
|  | 8 PlactypeChange | Adjacent | 1896 | 634 | 845 | 908 | 1896 | 298 | 402 | 416 | 53\% | 52\% |
|  | 9 PlacetypeChange | Primary | 1481 | 103 | 150 | 162 | 1481 | 363 | 532 | 571 | 252\% | 256\% |
|  | 9 PlacetypeChange | Adjacent | 1234 | 2,346 | 3,477 | 3,681 | 1234 | 2,418 | 3,577 | 3,790 | 3\% | 3\% |
|  | 9 PlacetypeChange | Adjacent | 1235 | 106 | 154 | 161 | 1235 | 107 | 155 | 162 | 1\% | 1\% |
|  | 9 PlacetypeChange | Adjacent | 1237 | 1,670 | 2,527 | 2,698 | 1237 | 1,723 | 2,601 | 2,781 | 3\% | 3\% |
|  | 9 PlacetypeChange | Adjacent | 1266 | 1,826 | 2,643 | 2,867 | 1266 | 1,852 | 2,678 | 2,905 | 1\% | 1\% |
|  | 9 PlacetypeChange | Adjacent | 1267 | 1,073 | 1,509 | 1,633 | 1267 | 1,151 | 1,607 | 1,736 | 7\% | 7\% |

SJV MIP - Placetype Summary - Tulare


TABLE F-22:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - TULARE

| Validation Topic | Tulare |
| :---: | :---: |
| Add Lanes to a Link | 0 |
| Add/Remove Link | 0 |
| Change Link Speed | 0 |


| Notes: |  |
| ---: | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

## Add Lanes to a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected link.

TABLE F-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - TULARE

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Street Across Screenline - S. Court Street from W. Tulare Avenue to W. Walnut Avenue |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 1,174 | 1,249 | 0 | 0 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 30 | 38 | 0 | 0 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 2,516 | 2,419 | -3 | -3 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut Avenue | 575 | 682 | 0 | 0 |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 160 | 220 | 0 | 0 |
| Road 108 - W. Tulare Avenue to W. Walnut Avenue | 2,924 | 3,113 | -19 | 5 |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 807 | 811 | -8 | 0 |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 83 | 113 | 0 | 0 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 3,056 | 3,514 | 44 | -27 |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 538 | 949 | -1 | -23 |

TABLE F-23:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - ADD LANE - TULARE

| Screenline Roadways | Peak Hour <br> Volume |  | Volume Change |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 182 | 323 | -23 | -6 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 1,616 | 1,655 | 30 | 104 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 930 | 1,038 | -30 | -11 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 1,326 | 1,524 | 19 | 0 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 171 | 273 | 0 | 0 |
| Road 140 - E. Tulare Avenue to E. Walnut Avenue | 3,259 | 3,403 | -7 | -3 |
| Total | 19,347 | 21,326 | 2 | 37 |

Notes:
Source:

## Expectation

Model should show increased volume on subject links. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. Changes should be concentrated near the subject link.

## Model Response

Model showed an increase in volume on the subject link. Parallel facilities showed both slight increases and decreases in volume. The screenline showed a slight increase in volume. The model appeared to be overly sensitive and did not respond appropriately.

## Add/Delete a Link

Select a street across a constraint (railroad track, river, or freeway). Add lanes to selected links.

TABLE F-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - TULARE

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Added Link Across Screenline - Connecting S. Cotta Street between E. Tulare Avenue to E. Walnut Avenue |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 1,175 | 1,249 | 1 | 0 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 30 | 38 | 0 | 0 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 2,515 | 2,417 | -4 | -5 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut Avenue | 576 | 687 | 0 | 5 |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 160 | 215 | 0 | -5 |
| Road 108 - W. Tulare Avenue to W. Walnut Avenue | 2,946 | 3,110 | 3 | 2 |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 815 | 811 | 0 | 0 |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 83 | 113 | 0 | 0 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 3,010 | 3,526 | -2 | -15 |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 538 | 950 | 0 | -22 |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 205 | 324 | 0 | -6 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 1,564 | 1,471 | -22 | -80 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 877 | 1,050 | -82 | 2 |
| Added Link | 121 | 174 | 121 | 174 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 1,297 | 1,476 | -10 | -48 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 171 | 273 | 0 | 0 |
| Road 140-E. Tulare Avenue to E. Walnut Avenue | 3,264 | 3,406 | -2 | 0 |
| Total | 19,346 | 21,292 | 1 | 3 |
| Delete Street Across Screenline - SR 63 from W. Tulare Avenue to W. Walnut Avenue |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 1,191 | 1,304 | 17 | 55 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 28 | 34 | -1 | -3 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 2,510 | 2,488 | -10 | 67 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut Avenue | 585 | 698 | 9 | 16 |

TABLE F-24:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION

- TRAFFIC ASSIGNMENT - ADD/DELETE LINK - TULARE

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 169 | 299 | 9 | 78 |
| Road 108 - W. Tulare Avenue to W. Walnut Avenue | 3,333 | 3,131 | 390 | 23 |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 866 | 955 | 51 | 144 |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 820 | 1,165 | 737 | 1,052 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 0 | 0 | $-3,012$ | $-3,541$ |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 1,313 | 1,865 | 774 | 893 |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 544 | 839 | 339 | 509 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 1,679 | 1,699 | 93 | 148 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 999 | 1,122 | 39 | 74 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 1,351 | 1,526 | 44 | 2 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 170 | 276 | 0 | 2 |
| Road 140 - E. Tulare Avenue to E. Walnut Avenue | 3,385 | 3,486 | 119 | 80 |
| Total | 18,943 | 20,887 | -402 | -402 |

Notes:
Source:

## Expectation

For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease.

## Model Response

For the added link test, the parallel facilities showed a similar magnitude decrease in volume and the screenline showed a slight increase. For the deleted link test, the parallel facilities showed a similar
magnitude increase in volume and the screenline showed a slight decrease. The model responded appropriately.

## Change Link Speed

Select one street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. Increase and decrease posted speeds by +/- 10 mph on subject facility.

TABLE F-25:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - TULARE

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| Increase Speed on Street Across Screenline - Road 108 from W. Tulare Avenue to W. Walnut Avenue |  |  |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 45 | 45 | 1,204 | 1,288 | 30 | 39 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 28 | 33 | -2 | -5 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 45 | 45 | 2,409 | 2,266 | -110 | -155 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut Avenue | 40 | 40 | 586 | 702 | 11 | 20 |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 78 | 173 | -82 | -48 |
| Road 108 - W. Tulare Avenue to W. Walnut Avenue | 40 | 50 | 3,297 | 3,586 | 354 | 478 |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 606 | 727 | -209 | -85 |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 83 | 99 | 0 | -14 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 2,962 | 3,419 | -50 | -122 |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 539 | 974 | 1 | 2 |

TABLE F-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - TULARE

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 199 | 322 | -6 | -8 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 1,591 | 1,505 | 5 | -46 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 35 | 35 | 970 | 1,070 | 10 | 21 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 40 | 40 | 1,372 | 1,521 | 65 | -3 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 35 | 35 | 169 | 275 | -2 | 2 |
| Road 140 - E. Tulare Avenue to E. Walnut Avenue | 55 | 55 | 3,264 | 3,403 | -2 | -3 |
| Total |  |  | 19,357 | 21,363 | 12 | 73 |
| Decrease Speed on Street Across Screenline - Road 108 from W. Tulare Avenue to W. Walnut Avenue |  |  |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 45 | 45 | 1,183 | 1,286 | 9 | 36 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 30 | 38 | 0 | 0 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 45 | 45 | 2,543 | 2,508 | 23 | 87 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut Avenue | 40 | 40 | 572 | 709 | -3 | 26 |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 262 | 319 | 101 | 99 |
| Road 108-W. Tulare Avenue to W. Walnut Avenue | 40 | 30 | 2,598 | 2,599 | -345 | -509 |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 781 | 811 | -34 | 0 |

TABLE F-25:

## SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAFFIC ASSIGNMENT - SPEED CHANGE - TULARE

| Screenline Roadways | Speed |  | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Posted | Adjusted | NB/EB | SB/WB | NB/EB | SB/WB |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 90 | 261 | 7 | 148 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 3,137 | 3,523 | 125 | -18 |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 539 | 972 | 1 | 0 |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 30 | 30 | 210 | 333 | 6 | 4 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 35 | 35 | 1,605 | 1,587 | 19 | 36 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 35 | 35 | 970 | 1,037 | 10 | -11 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 40 | 40 | 1,311 | 1,522 | 5 | -2 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 35 | 35 | 172 | 276 | 1 | 2 |
| Road 140 - E. Tulare Avenue to E. Walnut Avenue | 55 | 55 | 3,283 | 3,409 | 17 | 3 |
| Total |  |  | 19,284 | 21,191 | -61 | -99 |

Notes:
Source:

## Expectation

As posted speed is increased, volume on selected link should increase and volume on adjacent screenline links should decrease. As posted speed is decreased, volume on selected link should decrease and volume on adjacent screenline links should increase. The influence area should be concentrated near the subject link.

## Model Response

For the increased speed test, the parallel facilities showed a similar magnitude decrease in volume. For the decreased speed test, the parallel facilities showed a similar magnitude increase volume. The model responded appropriately for the increased speed test and less appropriately for the decreased speed test.

TABLE F-26:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST - TULARE
Validation Topic $\quad$ Tulare

Add Toll to Corridor

| Notes: |  |
| ---: | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

Add Toll

Select a corridor of a State Route within the vicinity of a defined screenline. Add tolling to the subject corridor.

TABLE F-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - TULARE

| Screenline Roadways | Peak Hour Volume | Volume Change |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| State Route Corridor - SR 99 from Rd B to Elder Avenue |  |  |  |  |
| S. Shirk Road - SR 198 to W. Walnut Avenue | 852 | 2,754 | -322 | 1,505 |
| Roeben Road - W. Tulare Avenue to W. Walnut Avenue | 27 | 37 | -2 | 0 |
| S. Akers Street - W. Tulare Avenue to W. Walnut Avenue | 3,773 | 3,223 | 1,254 | 801 |
| S. Linwood Street - W. Tulare Avenue to W. Walnut <br> Avenue | 746 | 720 | 171 | 38 |
| Chinowth Street - W. Tulare Avenue to W. Walnut Avenue | 274 | 364 | 114 | 144 |
| Road 108 - W. Tulare Avenue to W. Walnut Avenue | 2,766 | 3,232 | -177 | 124 |

TABLE F-27:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - TRAVEL COST (ADD TOLL RATES) - TULARE

| Screenline Roadways | Peak Hour Volume |  | Volume Change |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NB/EB | SB/WB | NB/EB | SB/WB |
| S. County Center Drive - W. Tulare Avenue to W. Walnut Avenue | 933 | 834 | 117 | 23 |
| S. Woodland Street - W. Tulare Avenue to W. Walnut Avenue | 84 | 150 | 1 | 37 |
| SR 63 - W. Tulare Avenue to W. Walnut Avenue | 3,701 | 3,667 | 689 | 126 |
| S. Giddings Street - W. Tulare Avenue to W. Walnut Avenue | 596 | 1,049 | 57 | 78 |
| S. Conyer Street - W. Tulare Avenue to W. Walnut Avenue | 205 | 336 | 0 | 6 |
| S. Court Street - W. Tulare Avenue to W. Walnut Avenue | 1,617 | 1,457 | 31 | -94 |
| S. Santa Fe Avenue - E. Tulare Avenue to E. Walnut Avenue | 1,154 | 1,361 | 194 | 312 |
| S. Ben Maddox Way - E. Tulare Avenue to E. Walnut Avenue | 1,546 | 1,593 | 240 | 68 |
| S. Pinkham Street - E. Tulare Avenue to E. Walnut Avenue | 179 | 274 | 8 | 1 |
| Road 140 - E. Tulare Avenue to E. Walnut Avenue | 3,420 | 3,518 | 154 | 112 |
| Total | 21,874 | 24,569 | 2,529 | 3,279 |

Notes:
Source:

## Expectation

Screenline facilities parallel to the State Route should show an increase in volume. Facilities perpendicular to the State Route may show slight volume decreases. Screenline should show volume increase.

## Model Response

The screenline facilities parallel to the subject corridor showed an increase in volumes. However, the model was too sensitive and all trips were shifted from the subject corridor south of the screenline due to tolling. The model did not respond appropriately.

TABLE F-28:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND - TULARE

## Validation Topic

Interstate Capacity Change

| Notes: |  |
| :--- | :--- |
|  | $=$ Met $/$ Not Required |
|  | $=$ Partially Met |
|  | $=$ Not Met |

Reduce Roadway Capacity

Halve roadway capacity on a State Route within the County.

TABLE F-29:
SUMMARY OF MODEL PERFORMANCE - DYNAMIC VALIDATION - INDUCED DEMAND INTERSTATE CAPACITY CHANGE - TULARE

| Performance Measure | Base Scenario | Reduce Roadway <br> Capacity | \% Change |
| :---: | :---: | :---: | :---: |
| Lane Miles | 223.5 | 111.7 | $-50 \%$ |
| VMT | $12,862,940$ | $12,615,583$ | $-1.96 \%$ |
| Elasticity |  |  | 0.69 |

Notes:
Source:
Expectation

Percent change in VMT should increase as capacity is halved. Calculated short-term elasticity should compare to literature: Cervero short-term elasticity $=0.20-0.50$.

## Model Response

Percent change in VMT was observed but the model was too sensitive to the effects. VMT decreased more than the literature elasticity suggests. The model did not respond appropriately.

## APPENDIX G:

ORIGIN-DESTINATION STUDY


## Memorandum

TO: San Joaquin Valley Model Improvement Project<br>FROM: Ron West, Lawrence Liao, Sashank Musti and Sarahjoy Gallaher<br>DATE: December 19, 2011<br>RE: SJVMIP Summary of Travel Surveys

## Overview

This memorandum summarizes a series of observed data sources that can support model validation of the Three County Northern San Joaquin Valley Model. These data sources include new origin-destination surveys collected at rest stops near area gateways, traffic counts at area gateways, origins-destinations from cell phone records, and Year 2000 Census Transportation Planning Package (CTPP) reports on work trip interregional travel.

## Rest Stop Origin-Destination Surveys

Rest stop surveys were collected at fifteen study area locations. Surveys were collected at Caltrans rest stops, gas stations and convenience stores near key study area gateways to gauge origin and destinations at these key gateways. Locations were selected by StanCOG staff, and the surveys were collected in the field and summarized by the survey research firm of Corey, Canapary and Galanis. Surveys were collected in May and June of 2011

Full documentation of the survey design and results was prepared in a report, Central Valley Intercept Survey Documentation. This report included the survey questionnaire, detailed survey locations, interviewer instructions, and data dictionary. A companion full survey database with geocodes was also prepared and distributed to the project team. In addition, paper copies of the all completed surveys were provided to StanCOG staff.

Survey respondents were asked a short battery of questions, including trip origin and trip destination. Stops at the rest areas were not considered origins or destinations. A summary of the completed surveys is shown in Table 1. Locations were grouped into three groups:

- Caltrans rest stops
- Gas stations/convenience stores located outside of three county area
- Gas stations/convenience stores located inside of three county area

The individual rest stops were so grouped as each has unique traveler characteristics. Note that the Pilot Station on SR 99 in Madera was included in the third group because the traveler characteristics more closely matched that of the intra-regional locations than for locations outside the three county area.

Travel patterns were grouped into four categories:

- Intraregional trips that began and ended within the three-county area,
- Interregional trips that had one trip end in the three-county area and the other trip end outside the three county area,
- Through trips traveled through the three county area, but did not have an origin or destination within the Three County Area, and
- Local trips, defined as trip origins and destinations totally outside the Three County Area.

Caltrans rest stops response showed very high numbers of through trips, with comparatively few intraregional or interregional trips. Caltrans rest stops are designed for long-distance travelers and do not provide much of a local service function. Because so few rest stop travelers lived or were traveling to the three county area, it is difficult to relate results from these locations back to travel patterns at three county area gateways.

Two locations comprised the gas stations/convenience stores located outside of Three County Area - Livermore and Jamestown. Although these areas are outside the Three County Area, these locations were considered to be the closest and most convenient locations to represent interregional and through travel. However, at both of these locations, approximately $70 \%$ of all trips were local trips, i.e., were made totally within the Bay Area or within the Gold Country (respectively for the Vasco Road and Jamestown locations). Thus, the vast majority of surveys at these locations are not relevant to the three county model. The number of potentially relevant surveys was too small to be effectively used for model validation purposes.

The remaining six locations were rest stops within the three county area, including the abovementioned Madera location on SR 99. These surveys provided the most useful information for determining the split of interregional from through travel near area gateways.

However, a larger question exists whether persons stopping at rest stops are representative of all travelers crossing regional gateways. The study team did find that people were willing to respond to the surveys at rest stops. However, the budget available for the project did not allow for enough responses to be useful for model validation or estimation purposes. There is also a legitimate question as to whether the respondents at rest stops are typical of all travelers crossing Three County Area gateways.

This is the first time a survey of this type has been attempted for this area. Information now exists on the numbers of valid responses that may be expected over a given time period.

However, the results from this initial effort must be classified as inconclusive in terms of serving as a model validation database.
Table 1 - Summary of Rest Stop Origin-Destination Surveys by Location

| ID | Highway | County | Location | Establishment | At or Near | Percent of Surveyed Trips: |  |  |  | Total (Number) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | IntraRegional | InterRegional | Through Travel | Local |  |
| Caltrans Rest Stops |  |  |  |  |  |  |  |  |  |  |
| 6N | SR 99 | Stanislaus | Turlock | Caltrans Rest Stop | Near Merced County Line | 9\% | 22\% | 69\% | 0\% | 86 |
| 6S | SR 99 | Stanislaus | Turlock | Caltrans Rest Stop | Near Merced County Line | 10\% | 14\% | 75\% | 1\% | 91 |
| 8N | 1-5 | Merced | Merced County | Caltrans Rest Stop | Near Fresno County Line | 0\% | 9\% | 91\% | 0\% | 53 |
| 8S | 1-5 | Merced | Merced County | Caltrans Rest Stop | Near Fresno County Line | 1\% | 9\% | 90\% | 0\% | 86 |
| 11N | 1-5 | Stanislaus | Westly | Caltrans Rest Stop | Near 1-5/I-580 Split | 2\% | 23\% | 75\% | 0\% | 64 |
| 11S | 1-5 | Stanislaus | Westly | Caltrans Rest Stop | Near I-5/l-580 Split | 0\% | 7\% | 93\% | 0\% | 75 |
|  |  |  |  |  |  | 4\% | 14\% | 81\% | 0\% | 455 |
| Rest Stops Outside Three-County Region (I-580 and SR 49) |  |  |  |  |  |  |  |  |  |  |
| 1 | 1-580 | Alameda | Livermore | Quick Stop | Vasco Road | 1\% | 22\% | 7\% | 70\% | 198 |
| 10 | SR 49 | Tuolumne | Jamestown | Chevron |  | 1\% | 12\% | 19\% | 68\% | 75 |
|  |  |  |  |  |  | 1\% | 19\% | 10\% | 70\% | 273 |
| Other Rest Stops Within Three County Region (Non-Caltrans Rest Stops) |  |  |  |  |  |  |  |  |  |  |
| 2 | I-5 | San Joaquin | Lodi | Flying J | SR 12 | 22\% | 45\% | 30\% | 3\% | 130 |
| 3 | SR 99 | San Joaquin | Lodi | Econo Gas | Victor Road | 53\% | 42\% | 6\% | 0\% | 106 |
| 4 | SR 99 | San Joaquin | Ripon | Love's | West Colony Road | 49\% | 39\% | 13\% | 0\% | 134 |
| 5B | Schulte Rd | San Joaquin | Tracy | 7-Eleven | Near l-580 | 31\% | 49\% | 17\% | 3\% | 35 |
| 7 | SR 33 | Merced | Santa Nella | Pilot | Near SR 152 | 12\% | 31\% | 56\% | 1\% | 86 |
| 9 | SR 99 | Madera | Madera | Pilot | Avenue 18 1/2 | 2\% | 45\% | 18\% | 35\% | 62 |
|  |  |  |  |  |  | 31\% | 41\% | 23\% | 5\% | 553 |

## Imported and Exported Workers beyond the Three County Area

Year 2000 Census Transportation Planning Package (CTPP) Journey-to-Work information was compiled within the three county area to calculate the percentage of workers commuting to jobs outside the three county area (exported workers) and percent of jobs filled by workers who lived outside the Three County Area (imported workers).

These data provide another observed source of information regarding interregional commuting patterns, although the 2000 CTPP data is more than 10 years old and counts only work trips. Although only a component of total travel, work trips are a critically important aspect of travel across the Altamont and Pacheco Passes. And despite the fact the data is over ten years old, commute patterns between the Three County Area and the San Francisco Bay Area are thought to have been stable during this time period.

It is well understood that the Three County Area exports many workers outside its borders, particularly to the job-rich San Francisco Bay Area - a trend that has existed for well over 20 years. The 47 localities of the Three County Area include 44 incorporated cities and unincorporated Census Designated Places (CDPs are defined as having populations of at least 2,500 persons), and the remaining rural and smaller urbanized parts of each county. Only three communities - small CDPs in San Joaquin County - imported greater shares of workers than they export. See Table 2.

As one would expect, the Three County Area exports many more workers than are imported. The more urbanized communities along I-5, I-205 and I-580 export much higher percentages of workers, than do communities in Stanislaus and Merced Counties settled along SR 99, or are more rural/agriculturally based. For example, Manteca exported over $28 \%$ of its resident workers, while Modesto exported less than $9 \%$ of its resident workers.

Overall, Tracy, Los Banos and Lathrop exported the highest percentage of resident workers. These communities are also located closest to the key Bay Area gateways of SR 152 and I-580. Each of these communities exported at least $39 \%$ of its workers.

By comparison, Lodi, which has closest proximity to Sacramento County, and to SR 12/Eastern Contra Costa County only exported 12.6 of its resident workers. Eastern Contra Costa and Southern Sacramento Counties do not have major job centers that can attract Three County Area workers.

As noted above, these data represent only work trips. However, work-based travel is likely the key interregional trip purpose - particularly during weekdays. Traffic on I-580 across the Altamont Pass tends to be highest during weekday AM and PM commute periods. As such, the imported/exported workers database is a valuable validation dataset. However, it is recommended that updated ACS estimates from more recent time periods be used when those data records become available.
Table 2 - Imported/Exported Worker Percentages by Place


## County to County Travel Patterns by Time of Day from Cell Phone Records

A new and potentially valuable source of information was from cell phone records collected by a third party vendor called Air Sage. Air Sage processes locational and speed information from cell phone records (calculated by triangulating signal tower data). Air Sage has created a process to extract moment-by-moment data from cell phones to calculate vehicle speeds, and origin and destination trip data. Although the data manipulations are proprietary, there was enthusiasm for this information to provide detailed interregional trip volumes all Three County Area gateways.

After analysis of the data, we determined that cell phone records were actually not useable outside the Three County Area. The consulting team came to understand that the language of transportation professionals is substantially different than that employed by Air Sage, and the definitions of trip purposes were at variance from that used in travel demand modeling practice. As such, travel outside the three county area (external and through trips) were not captured from the cell phone records. [As a side bar, it is hoped that cell phone records could be more useful in the future to capture external travel, but a more comprehensive scope and understanding would first need to be fully developed.]

The project team did settle on using the cell phone data as a trip distribution validation database for trips within the Three County Area. As noted above, we were not able to separate out trip purposes due to the different definitions used in the travel modeling community respective to the definitions employed by Air Sage.

In addition, the total volumes of trips from the cell phone records were peculiar, so we settled on using percentages of total travel within the Three County Area as the best method for expressing travel patterns from the cell phone records. Although more limited in use than initially intended, the trip distribution database does represent a new observed database. Trip distribution travel patterns tend to be some of the least well understood areas of travel demand modeling, so the cell phone database does represent an important new set of information that is otherwise unavailable for model developers and model users.

The project team, however, was able to summarized time of day data. Some variation in travel patterns was evidenced by time of day, but overall, travel patterns seem generally stable - at least within the Three County Area - for each time period. These data clearly show there is no predominant commuting travel pattern within the three county area, in contrast to the large numbers of residents commuting to Bay Area jobs each weekday. See Table 3.

Overall, the cell phone data showed that between 88 and $90 \%$ of all Three County Area intraregional trips (depending on time of day) were made solely within one of the counties, while the remaining trips had an origin and destination in different counties. The conclusion from this information is that most travel within this region is made solely within each respective county. This conclusion makes sense as areas near the county boundaries are predominately rural; there are comparatively fewer opportunities for short distance, high volume trips that cross county boundaries.

Table 3 - County to County Travel Patterns by Time of Day from Cell Phone Records

| Origin | Destination | Morning | Mid-Day | Afternoon | Evening | Night | Grand <br> Total |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Merced | Merced | $12 \%$ | $10 \%$ | $12 \%$ | $13 \%$ | $13 \%$ | $12 \%$ |
| Merced | SanJoaquin | $0 \%$ | $1 \%$ | $0 \%$ | $0 \%$ | $1 \%$ | $0 \%$ |
| Merced | Stanislaus | $2 \%$ | $2 \%$ | $1 \%$ | $1 \%$ | $2 \%$ | $2 \%$ |
| SanJoaquin | Merced | $0 \%$ | $1 \%$ | $0 \%$ | $0 \%$ | $0 \%$ | $0 \%$ |
| SanJoaquin | SanJoaquin | $47 \%$ | $48 \%$ | $45 \%$ | $45 \%$ | $46 \%$ | $46 \%$ |
| SanJoaquin | Stanislaus | $4 \%$ | $4 \%$ | $4 \%$ | $3 \%$ | $3 \%$ | $4 \%$ |
| Stanislaus | Merced | $1 \%$ | $2 \%$ | $2 \%$ | $2 \%$ | $1 \%$ | $2 \%$ |
| Stanislaus | SanJoaquin | $3 \%$ | $4 \%$ | $3 \%$ | $3 \%$ | $5 \%$ | $4 \%$ |
| Stanislaus | Stanislaus | $29 \%$ | $29 \%$ | $32 \%$ | $33 \%$ | $30 \%$ | $30 \%$ |
| Total | Total | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ | $100 \%$ |
|  | $88 \%$ | $87 \%$ | $89 \%$ | $90 \%$ | $88 \%$ | $88 \%$ |  |
| Intra County | $12 \%$ | $13 \%$ | $11 \%$ | $10 \%$ | $12 \%$ | $12 \%$ |  |

Source: Air Sage, summarized by Cambridge Systematics.

## SJVMIP Traffic Counts

Traffic Counts were collected a key study area locations, focusing on Three County Area gateways. These counts were collected for weekday daily conditions, and include vehicle classifications. Summarized here are total passenger vehicles, total trucks, total vehicles (which include a limited number of unclassified vehicles and percent trucks for each survey location. See Tables 4 through 7.

Traffic counts represent a key validation data source for measuring traffic assignment performance. Data has been summarized for all time periods included in the Three County Model - single peak hours for AM and PM hours, and daily data divided by four time periods (three AM hours, seven midday hours, three PM hours and eleven night/evening hours.
Table 4-2011 Passenger Vehicle Traffic Counts by Time Period

| Location | AM 1 Hour | AM 3Hours | Midday | PM 1 Hour | PM 3 Hour | Evening | Daily |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Passenger Vehicles |  |  |  |  |  |  |  |
| I-205/Patterson Pass Road | 6,224 | 17,550 | 38,512 | 7,677 | 21,533 | 31,886 | 109,481 |
| I-5/Blewett Rd | 463 | 1,398 | 4,134 | 640 | 1,754 | 2,413 | 9,699 |
| 1-5/Eagle Field Rd | 696 | 2,129 | 11,201 | 1,811 | 5,417 | 7,431 | 26,178 |
| I-5/Grove | 2,057 | 5,699 | 12,851 | 2,567 | 7,299 | 6,769 | 32,618 |
| 1-5/Sullivan | 724 | 2,169 | 9,499 | 1,421 | 4,190 | 5,624 | 21,482 |
| \|-580/|-5 | 671 | 2,053 | 4,431 | 850 | 2,511 | 3,916 | 12,911 |
| 1-580/Patterson Pass | 1,394 | 4,246 | 8,235 | 1,923 | 5,371 | 7,207 | 25,059 |
| SR 4 and Tracy Blvd | 499 | 1,410 | 2,696 | 631 | 1,721 | 1,569 | 7,396 |
| Santa Fe/East Ave | 198 | 468 | 1,057 | 242 | 596 | 499 | 2,620 |
| SR 140/Cunningham | 208 | 514 | 1,778 | 288 | 812 | 564 | 3,668 |
| SR 108/Williams Rd | 426 | 1,154 | 3,982 | 651 | 1,807 | 1,698 | 8,641 |
| SR 12 and Cocrreia Rd | 580 | 1,876 | 4,153 | 888 | 2,417 | 2,569 | 11,015 |
| SR 120/Cambell Ave | 462 | 1,254 | 3,659 | 562 | 1,704 | 1,689 | 8,306 |
| SR 132/SR 33 | 500 | 1,571 | 2,630 | 837 | 2,331 | 2,502 | 9,034 |
| SR 132/Yosemite Road | 84 | 225 | 529 | 101 | 284 | 227 | 1,265 |
| SR 152/Santa Nella Road | 1,158 | 3,405 | 9,580 | 2,124 | 5,940 | 6,714 | 25,639 |
| SR 152/SR 59 | 399 | 1,139 | 3,642 | 649 | 1,879 | 2,116 | 8,776 |
| SR 33/ SR 140 | 456 | 1,139 | 3,014 | 549 | 1,504 | 1,379 | 7,036 |
| SR 33/Maze Blvd | 122 | 328 | 578 | 173 | 444 | 401 | 1,751 |
| SR 4/MILTON | 206 | 588 | 1,509 | 258 | 783 | 640 | 3,520 |
| SR 52 NB/SR 152 | 295 | 706 | 1,891 | 345 | 941 | 859 | 4,397 |
| SR 88/ SR 12 | 369 | 972 | 2,008 | 448 | 1,198 | 940 | 5,118 |
| SR 99/Golden State Blvd | 1,223 | 3,372 | 13,356 | 2,838 | 8,029 | 23,034 | 47,791 |
| SR 99/Hammet Road | 6,462 | 16,695 | 36,545 | 7,407 | 20,563 | 21,196 | 94,999 |
| SR 99/Liberty Road | 3,255 | 8,723 | 17,599 | 3,541 | 9,775 | 9,900 | 45,997 |
| SR 99/Miniturn | 1,506 | 4,250 | 12,129 | 2,168 | 6,188 | 7,066 | 29,633 |

Table 5-2011 Total Truck Traffic Counts by Time Period

| Location | AM 1 Hour | AM 3Hours | Midday | PM 1 Hour | PM 3 Hour | Evening | Daily |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Total Trucks |  |  |  |  |  |  |  |
| 1-205/Patterson Pass Road | 266 | 868 | 1,900 | 210 | 622 | 1,863 | 5,253 |
| I-5/Blewett Rd | 314 | 906 | 2,760 | 371 | 1,061 | 2,191 | 6,918 |
| 1-5/Eagle Field Rd | 309 | 1,000 | 2,641 | 474 | 1,387 | 3,595 | 8,623 |
| 1-5/Grove | 652 | 1,833 | 4,973 | 535 | 1,686 | 3,485 | 11,977 |
| 1-5/Sullivan | 349 | 1,032 | 2,796 | 385 | 1,139 | 3,274 | 8,241 |
| \|-580/|-5 | 447 | 1,305 | 3,209 | 482 | 1,451 | 2,897 | 8,862 |
| I-580/Patterson Pass | 337 | 1,032 | 2,731 | 222 | 675 | 2,218 | 6,656 |
| SR 4 and Tracy Blvd | 88 | 279 | 595 | 82 | 229 | 205 | 1,308 |
| Santa Fe/East Ave | 38 | 96 | 238 | 24 | 63 | 42 | 439 |
| SR 140/Cunningham | 29 | 81 | 251 | 26 | 82 | 62 | 476 |
| SR 108/Williams Rd | 133 | 353 | 966 | 126 | 330 | 325 | 1,974 |
| SR 12 and Cocrreia Rd | 275 | 853 | 2,022 | 226 | 669 | 900 | 4,444 |
| SR 120/Cambell Ave | 112 | 348 | 949 | 101 | 300 | 294 | 1,891 |
| SR 132/SR 33 | 166 | 439 | 1,067 | 127 | 402 | 642 | 2,550 |
| SR 132/Yosemite Road | 6 | 19 | 63 | 12 | 38 | 29 | 149 |
| SR 152/Santa Nella Road | 263 | 771 | 2,124 | 268 | 790 | 1,663 | 5,348 |
| SR 152/SR 59 | 159 | 503 | 1,310 | 148 | 487 | 1,031 | 3,331 |
| SR 33/ SR 140 | 90 | 245 | 594 | 81 | 213 | 209 | 1,261 |
| SR 33/Maze Blvd | 31 | 85 | 254 | 32 | 91 | 80 | 510 |
| SR 4/MILTON | 38 | 98 | 266 | 38 | 115 | 92 | 571 |
| SR 52 NB/SR 152 | 102 | 300 | 815 | 112 | 297 | 439 | 1,851 |
| SR 88/ SR 12 | 39 | 129 | 328 | 64 | 159 | 111 | 727 |
| SR 99/Golden State Blvd | 458 | 1,426 | 4,138 | 541 | 1,606 | 3,834 | 11,004 |
| SR 99/Hammet Road | 1,028 | 2,995 | 7,950 | 760 | 2,450 | 5,186 | 18,581 |
| SR 99/Liberty Road | 786 | 2,430 | 6,520 | 863 | 2,511 | 4,297 | 15,758 |
| SR 99/Miniturn | 451 | 1,348 | 3,865 | 488 | 1,451 | 3,134 | 9,798 |

Table 6-2011 Total Vehicle Traffic Counts by Time Period (Including Unclassified Vehicles)

| Location | AM 1 Hour | AM 3Hours | Midday | PM 1 Hour | PM 3 Hour | Evening | Daily |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Total Vehicles, Including Unclassified |  |  |  |  |  |  |  |
| 1-205/Patterson Pass Road | 6,623 | 18,539 | 40,544 | 8,014 | 22,286 | 33,880 | 114,863 |
| I-5/Blewett Rd | 898 | 2,424 | 7,016 | 1,133 | 2,937 | 4,720 | 16,737 |
| I-5/Eagle Field Rd | 1,005 | 3,129 | 13,842 | 2,285 | 6,804 | 11,026 | 34,801 |
| 1-5/Grove | 2,848 | 7,670 | 17,956 | 3,244 | 9,125 | 10,388 | 44,730 |
| I-5/Sullivan | 1,205 | 3,334 | 12,432 | 1,946 | 5,469 | 9,023 | 29,856 |
| \|-580/|-5 | 1,273 | 3,512 | 7,793 | 1,497 | 4,125 | 6,964 | 21,927 |
| I-580/Patterson Pass | 1,731 | 5,278 | 10,966 | 2,145 | 6,046 | 9,425 | 31,715 |
| SR 4 and Tracy Blvd | 694 | 1,796 | 3,396 | 819 | 2,058 | 1,883 | 8,811 |
| Santa Fe/East Ave | 352 | 681 | 1,409 | 385 | 778 | 660 | 3,176 |
| SR 140/Cunningham | 362 | 719 | 2,150 | 438 | 1,017 | 750 | 4,266 |
| SR 108/Williams Rd | 680 | 1,628 | 5,064 | 899 | 2,257 | 2,145 | 10,734 |
| SR 12 and Cocrreia Rd | 956 | 2,834 | 6,281 | 1,224 | 3,197 | 3,582 | 15,567 |
| SR 120/Cambell Ave | 689 | 1,716 | 4,717 | 775 | 2,117 | 2,101 | 10,309 |
| SR 132/SR 33 | 775 | 2,123 | 3,809 | 1,078 | 2,845 | 3,257 | 11,697 |
| SR 132/Yosemite Road | 190 | 344 | 687 | 213 | 419 | 353 | 1,511 |
| SR 152/Santa Nella Road | 1,421 | 4,176 | 11,704 | 2,392 | 6,730 | 8,377 | 30,987 |
| SR 152/SR 59 | 685 | 1,768 | 5,080 | 930 | 2,499 | 3,274 | 12,236 |
| SR 33/ SR 140 | 651 | 1,488 | 3,710 | 732 | 1,820 | 1,691 | 8,400 |
| SR 33/Maze Blvd | 270 | 533 | 946 | 321 | 650 | 598 | 2,377 |
| SR 4/MILTON | 375 | 817 | 1,904 | 428 | 1,028 | 865 | 4,222 |
| SR 52 NB/SR 152 | 515 | 1,121 | 2,821 | 569 | 1,353 | 1,413 | 6,363 |
| SR 88/ SR 12 | 527 | 1,220 | 2,453 | 630 | 1,476 | 1,170 | 5,963 |
| SR 99/Golden State Blvd | 1,818 | 4,935 | 17,631 | 3,519 | 9,775 | 27,008 | 58,934 |
| SR 99/Hammet Road | 7,631 | 19,832 | 44,633 | 8,310 | 23,155 | 26,525 | 113,721 |
| SR 99/Liberty Road | 4,180 | 11,291 | 24,252 | 4,546 | 12,426 | 14,332 | 61,891 |
| SR 99/Miniturn | 2,083 | 5,722 | 16,115 | 2,782 | 7,764 | 10,319 | 39,553 |

Table 7-2011 Percent Trucks from Traffic Counts by Time Period

| Location | AM 1 Hour | AM 3Hours | Midday | PM 1 Hour | PM 3 Hour | Evening | Daily |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Percent Trucks |  |  |  |  |  |  |  |
| I-205/Patterson Pass Road | 4\% | 5\% | 5\% | 3\% | 3\% | 5\% | 5\% |
| 1-5/Blewett Rd | 35\% | 37\% | 39\% | 33\% | 36\% | 46\% | 41\% |
| I-5/Eagle Field Rd | 31\% | 32\% | 19\% | 21\% | 20\% | 33\% | 25\% |
| 1-5/Grove | 23\% | 24\% | 28\% | 16\% | 18\% | 34\% | 27\% |
| 1-5/Sullivan | 29\% | 31\% | 22\% | 20\% | 21\% | 36\% | 28\% |
| 1-580/\|-5 | 35\% | 37\% | 41\% | 32\% | 35\% | 42\% | 40\% |
| I-580/Patterson Pass | 19\% | 20\% | 25\% | 10\% | 11\% | 24\% | 21\% |
| SR 4 and Tracy Blvd | 13\% | 16\% | 18\% | 10\% | 11\% | 11\% | 15\% |
| Santa Fe/East Ave | 11\% | 14\% | 17\% | 6\% | 8\% | 6\% | 14\% |
| SR 140/Cunningham | 8\% | 11\% | 12\% | 6\% | 8\% | 8\% | 11\% |
| SR 108/Williams Rd | 20\% | 22\% | 19\% | 14\% | 15\% | 15\% | 18\% |
| SR 12 and Cocrreia Rd | 29\% | 30\% | 32\% | 18\% | 21\% | 25\% | 29\% |
| SR 120/Cambell Ave | 16\% | 20\% | 20\% | 13\% | 14\% | 14\% | 18\% |
| SR 132/SR 33 | 21\% | 21\% | 28\% | 12\% | 14\% | 20\% | 22\% |
| SR 132/Yosemite Road | 3\% | 6\% | 9\% | 6\% | 9\% | 8\% | 10\% |
| SR 152/Santa Nella Road | 19\% | 18\% | 18\% | 11\% | 12\% | 20\% | 17\% |
| SR 152/SR 59 | 23\% | 28\% | 26\% | 16\% | 19\% | 31\% | 27\% |
| SR 33/ SR 140 | 14\% | 16\% | 16\% | 11\% | 12\% | 12\% | 15\% |
| SR 33/Maze Blvd | 11\% | 16\% | 27\% | 10\% | 14\% | 13\% | 21\% |
| SR 4/MILTON | 10\% | 12\% | 14\% | 9\% | 11\% | 11\% | 14\% |
| SR 52 NB/SR 152 | 20\% | 27\% | 29\% | 20\% | 22\% | 31\% | 29\% |
| SR 88/ SR 12 | 7\% | 11\% | 13\% | 10\% | 11\% | 9\% | 12\% |
| SR 99/Golden State Blvd | 25\% | 29\% | 23\% | 15\% | 16\% | 14\% | 19\% |
| SR 99/Hammet Road | 13\% | 15\% | 18\% | 9\% | 11\% | 20\% | 16\% |
| SR 99/Liberty Road | 19\% | 22\% | 27\% | 19\% | 20\% | 30\% | 25\% |
| SR 99/Miniturn | 22\% | 24\% | 24\% | 18\% | 19\% | 30\% | 25\% |

$$
\text { Appendix A - Rest Stop Survey Summaries by Location }
$$

A series of tables are shown for each rest stop survey location. To help visualize the data, locations were divided into a matrix of
counts of origins and destinations for the following sub-areas or regions:

Each grid in the matrix was color-coded to help identify which trips were interregional, intraregional, through the Three County Area or totally outside the Three County Area (labeled 'Local').
Table A-1 - Rest Stop Location 1 - Quick Stop Livermore

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced <br> County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 1 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 1 | 23 |
| Stanislaus County | 0 | 0 | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 7 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| San Francisco Bay Area | 6 | 10 | 0 | 0 | 2 | 139 | 2 | 0 | 1 | 160 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 |
| Total | 7 | 10 | 1 | 0 | 2 | 174 | 2 | 0 | 2 | 198 |


| Percent Intraregional | 2 | $1 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 44 | $22 \%$ |
| Through Trips | 13 | $7 \%$ |
| Local/Other Region | 139 | $70 \%$ |
|  | 198 | $100 \%$ |

Table A-2 - Rest Stop Location 2 - Flying J Travel Plaza Lodi

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 26 | 0 | 0 | 0 | 17 | 15 | 0 | 0 | 5 | 63 |
| Stanislaus County | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 |
| Merced County | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| AMBAG | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| Sacramento Region | 7 | 3 | 0 | 3 | 4 | 14 | 0 | 0 | 1 | 32 |
| San Francisco Bay Area | 4 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 8 | 14 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 3 |
| Other | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 5 | 8 |
| Total | 39 | 3 | 0 | 3 | 29 | 33 | 1 | 1 | 21 | 130 |


| Percent Intraregional | 28 | $22 \%$ |
| :--- | ---: | :---: |
| Percent Interregional | 59 | $45 \%$ |
| Through Trips | 39 | $30 \%$ |
| Local/Other Region | 4 | $3 \%$ |
|  | 130 | $100 \%$ |

Table A-3 - Rest Stop Location 3 -Econo Gas in Lodi

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San <br> Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 52 | 1 | 0 | 0 | 16 | 1 | 14 | 1 | 0 | 85 |
| Stanislaus County | 3 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 5 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| San Francisco Bay Area | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sierras | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 |
| South San Joaquin Valley | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Other | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 5 |
| Total | 65 | 1 | 0 | 0 | 20 | 1 | 15 | 1 | 3 | 106 |


| Percent Intraregional | 56 | $53 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 44 | $42 \%$ |
| Through Trips | 6 | $6 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 106 | $100 \%$ |

Table A-4 - Rest Stop Location 4 -Love's Travel Stop in Ripon

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 19 | 16 | 4 | 0 | 3 |  | 1 | 2 | 2 | 55 |
| Stanislaus County | 24 | 2 | 0 | 0 | 3 | 14 | 1 | 0 | 1 | 45 |
| Merced County | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 |
| AMBAG | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sacramento Region | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 5 |
| San Francisco Bay Area | 3 | 5 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 11 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South San Joaquin Valley | 1 | 0 | 1 | 0 | 4 | 1 | 0 | 0 | 1 | 8 |
| Other | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 7 |
| Total | 48 | 26 | 6 | 0 | 12 | 23 | 4 | 5 | 10 | 134 |


| Percent Intraregional | 65 | $49 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 52 | $39 \%$ |
| Through Trips | 17 | $13 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 134 | $\mathbf{1 0 0 \%}$ |

Table A-5 - Rest Stop Location 5B -7-11 Tracy

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San <br> Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 6 | 4 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 15 |
| Stanislaus County | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| San Francisco Bay Area | 7 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 15 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 4 |
| Total | 13 | 10 | 0 | 0 | 0 | 8 | 0 | 0 | 4 | 35 |


| Percent Intraregional | 11 | $31 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 17 | $49 \%$ |
| Through Trips | 6 | $17 \%$ |
| Local/Other Region | 1 | $3 \%$ |
|  | 35 | $\mathbf{1 0 0 \%}$ |

Table A-6 - Rest Stop Location 6S - SR 99 South Rest Stop (\#45), Turlock

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | - | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 8 |
| Stanislaus County | 0 | 1 |  | 0 | 0 | 0 | 0 | 0 | 3 | 8 |
| Merced County | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 8 | 30 |
| San Francisco Bay Area | 0 | 0 | 4 | 0 | 0 | 0 | 5 | 6 | 3 | 18 |
| Sierras | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 12 | 23 |
| Total | 0 | 1 | 12 | 0 | 2 | 0 | 5 | 43 | 28 | 91 |
|  |  |  |  |  |  |  |  |  |  |  |
| Percent Intraregional | 9 | 10\% |  |  |  |  |  |  |  |  |
| Percent Interregional | 13 | 14\% |  |  |  |  |  |  |  |  |
| Through Trips | 68 | 75\% |  |  |  |  |  |  |  |  |
| Local/Other Region | 1 | 1\% |  |  |  |  |  |  |  |  |
|  | 91 | 100\% |  |  |  |  |  |  |  |  |

Table A-7 - Rest Stop Location 6N - SR 99 South Rest Stop (\#44), Turlock

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Stanislaus County | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Merced County | 1 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sierras | 0 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 5 |
| South San Joaquin Valley | 8 | 3 | 0 | 0 | 15 | 11 | 2 | 0 | 13 | 52 |
| Other | 2 | 2 | 0 | 0 | 10 | 0 | 1 | 0 | 3 | 18 |
| Total | 11 | 12 | 2 | 0 | 27 | 14 | 3 | 0 | 17 | 86 |


| Percent Intraregional | 8 | $9 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 19 | $22 \%$ |
| Through Trips | 59 | $69 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 86 | $100 \%$ |

Table A-8 - Rest Stop Location 7 - Pilot Travel Center/Love's Travel Stop, Gustine

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| Stanislaus County | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 1 | 5 |
| Merced County | 1 | 0 | 7 | 4 | 2 | 4 | 0 | 0 | 4 | 22 |
| AMBAG | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 3 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| San Francisco Bay Area | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 6 | 9 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 2 | 8 |
| Other | 4 | 0 | 0 | 0 | 3 | 11 | 1 | 0 | 17 | 36 |
| Total | 5 | 1 | 12 | 6 | 6 | 22 | 1 | 1 | 32 | 86 |


| Percent Intraregional | 10 | $12 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 27 | $31 \%$ |
| Through Trips | 48 | $56 \%$ |
| Local/Other Region | 1 | $1 \%$ |
|  | 86 | $100 \%$ |

Table A-9 - Rest Stop Location 8S - I-5 North Rest Stop (\#10), Firebaugh

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region |  | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stanislaus County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sierras | 2 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 3 | 11 |
| South San Joaquin Valley | 0 | 0 | 2 | 0 | 5 | 16 | 0 | 0 | 12 | 35 |
| Other | 0 | 0 | 0 | 0 | 1 |  | 0 | 0 | 1 | 6 |
| Total | 2 | 0 | 3 | 0 | 6 | 26 | 0 | 0 | 16 | 53 |


| Percent Intraregional | 0 | $0 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 5 | $9 \%$ |
| Through Trips | 48 | $91 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 53 | $\mathbf{1 0 0 \%}$ |

Table A-10 - Rest Stop Location 8N - I-5 North Rest Stop (\#11), Firebaugh

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 |
| Stanislaus County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Merced County | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 11 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 45 | 48 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Other | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 12 | 16 |
| Total | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 8 | 74 | 86 |


| Percent Intraregional | 1 | $1 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 8 | $9 \%$ |
| Through Trips | 77 | $90 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 86 | $100 \%$ |

Table A-11 - Rest Stop Location 9 - Pilot Travel Center, Madera

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San <br> Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stanislaus County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Merced County | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 8 | 1 | 10 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| South San Joaquin Valley | 1 | 3 | 12 | 2 | 2 | 1 | 0 | 22 | 2 | 45 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 3 | 13 | 2 | 2 | 1 | 0 | 36 | 4 | 62 |


| Percent Intraregional | 1 | $2 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 28 | $45 \%$ |
| Through Trips | 11 | $18 \%$ |
| Local/Other Region | 22 | $35 \%$ |
|  | 62 | $100 \%$ |

Table A-12 - Rest Stop Location 10 - Chevron, Jamestown

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San <br> Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stanislaus County | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 4 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 3 |
| Sierras | 1 | 3 | 0 | 0 | 0 | 2 | 51 | 3 | 1 | 61 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 4 |
| Other | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 1 | 5 | 0 | 0 | 2 | 2 | 59 | 3 | 3 | 75 |


| Percent Intraregional | 1 | $1 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 9 | $12 \%$ |
| Through Trips | 14 | $19 \%$ |
| Local/Other Region | 51 | $68 \%$ |
|  | 75 | $\mathbf{1 0 0 \%}$ |

Table A-13 - Rest Stop Location 11N - I-5 North Rest Stop (\#12), Westley

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stanislaus County | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| AMBAG | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 2 | 7 |
| Sacramento Region | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South San Joaquin Valley | 1 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | 4 | 11 |
| Other | 4 | 0 | 0 | 0 | 6 | 16 | 0 | 0 | 14 | 40 |
| Total | 6 | 1 | 0 | 0 | 13 | 20 | 2 | 0 | 22 | 64 |


| Percent Intraregional | 1 | $2 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 15 | $23 \%$ |
| Through Trips | 48 | $75 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 64 | $100 \%$ |

Table A-14 - Rest Stop Location 11S - I-5 South Rest Stop (\#13), Westley

|  | Destination |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin | San Joaquin County | Stanislaus County | Merced County | AMBAG | Sacramento Region | San Francisco Bay Area | Sierras | So. San Joaquin Valley | Other | Total |
| San Joaquin County | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| Stanislaus County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Merced County | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMBAG | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Region | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 3 | 14 | 20 |
| San Francisco Bay Area | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 9 | 17 | 27 |
| Sierras | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| South San Joaquin Valley | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Other | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 20 | 24 |
| Total | 0 | 0 | 1 | 2 | 2 | 4 | 0 | 14 | 52 | 75 |


| Percent Intraregional | 0 | $0 \%$ |
| :--- | :---: | :---: |
| Percent Interregional | 5 | $7 \%$ |
| Through Trips | 70 | $93 \%$ |
| Local/Other Region | 0 | $0 \%$ |
|  | 75 | $\mathbf{1 0 0 \%}$ |

# APPENDIX H: <br> SUB-MODEL ESTIMATION, CALIBRATION, VALIDATION 



# DAYSIM Activity and Travel Schedule Simulator Technical Documentation 

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## Introduction and Model System Overview

## Introduction

This document presents the DaySim Activity and Travel Schedule Simulator, and provides technical details of each component model. DaySim builds on the prototype first developed by John Bowman while he was a student at MIT under the guidance of Moshe Ben-Akiva. Mark Bradley and John Bowman subsequently developed a full working model system for Portland Metro, and then again for Sacramento Area Council of Governments (SACOG), where it was first called DaySim. For SACOG, the component models of DaySim were estimated using data from the 1999 Sacramento Area Household Travel Survey, fielded by NuStats. This version of DaySim implements the structure and most of the model coefficients of the Sacramento version of DaySim, within a completely rewritten enhanced software program developed as a collaborative project with Resource Systems Group. In a few cases, coefficients are drawn from other studies. The model is calibrated for each region using survey and traffic data from the region.

DaySim is an integrated econometric microsimulation of personal activities and travel with a highly disaggregate treatment of the purpose, time of day and location dimensions of the modeled outcomes. Figure 1 shows the model system context within which DaySim functions. The Representative Population Generator creates a synthetic population, comprised of households drawn from the region's U.S. Census Public Use Microdata Sample (PUMS) and allocated to parcels. DaySim simulates longterm choices (work location, school location and auto ownership) for all members of the population, and creates a one-day activity and travel schedule for each person in the population, including a list of their tours and the trips on each tour. The DaySim components, implemented in a single custom software program, consist of a hierarchy of multinomial logit and nested logit models. The models within DaySim are connected by adherence to an assumed conditional hierarchy, and by the use of accessibility logsums.

The trips predicted by DaySim are aggregated and combined with predicted airport passenger trips, external trips and commercial vehicle trips into time- and mode-specific trip matrices. The network traffic assignment models load the trips onto the network. Traffic assignment is iteratively equilibrated with DaySim and the other demand models.

Figure 1: DaySim's Model System Context


## DaySim Overview

DaySim follows the day activity schedule approach developed by Bowman and Ben-Akiva (2001). Its features include the following:

- The model uses a microsimulation structure, predicting outcomes for each household and person in order to produce activity/trip records comparable to those from a household survey (Bradley, et al, 1999).
- The model works at four integrated levels-longer term person and household choices, single day-long activity pattern choices, tour-level choices, and trip-level choices
- The upper level models of longer term decisions and activity/tour generation are sensitive to network accessibility and a variety of land use variables.
- The model allows the specific work tour destination for the day to differ from the person's usual work location.
- The model uses seven different activity purposes for both tours and intermediate stops (work, school, escort, shop, personal business, meal, social/recreation).
- The model predicts locations down to the individual parcel level. Alternatively, it can also predict locations at a microzone level or TAZ level. In this document, use of the word parcel refers to a microzone when DaySim is implemented with microzone geography instead of parcel geography.
- The model predicts the time that each trip and activity starts and ends to the nearest 30 minutes, using an internally consistent scheduling structure that is also sensitive to differences in travel times across the day (Vovsha and Bradley, 2004).
- The model is highly integrated, including the use of mode choice logsums and approximate logsums in the upper level models, encapsulating differences across different modes, destinations, times of day, and types of person.

The latter four features are enhancements relative to its closest precursor, the CHAMP model currently in active use by the San Francisco County Transportation Authority (SFCTA). See Bradley, et al. (2001) and Jonnalagadda, et al. (2001) for details of the SFCTA model.

Figure 2 is a flow diagram showing the relationships among DaySim's component models, which are also listed in Table 1. The models themselves are numbered in the figure and table; subsequently in this document, parenthetical numerical references to models refer to these numbers. The hierarchy embodies assumptions about the relationships among simultaneous real world outcomes. In particular, outcomes from models higher in the hierarchy are treated as known in lower level models. It places at a higher level those outcomes that are thought to be higher priority to the decision maker. The model structure also embodies priority assumptions that are hidden in the hierarchy, namely the relative priority of outcomes on a given level of the hierarchy. The most notable of these are the relative priority of tours in a pattern, and the relative priority of stops on a tour. The formal hierarchical structure provides what has been referred to by Vovsha, Bradley and Bowman (2004) as downward vertical integrity.

Figure 2: DaySim Model Structure


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Table 1. Component Models of DaySim
$\left.\begin{array}{|l|l|l|l|}\hline \text { Model \# } & \text { Model Name } & \text { Level } & \text { What is predicted } \\ \hline 1.1 & \text { Synthetic Sample Generator } & \text { Household } & \begin{array}{l}\text { Household size and composition, household income, } \\ \text { person age, gender, employment status, student status }\end{array} \\ \hline 1.2 & \text { Usual Workplace Location } & \text { Worker } & \text { Workplace location zone and parcel } \\ \hline 1.3 & \text { Usual School Location } & \text { Student } & \text { School location zone and parcel } \\ \hline 1.4 & \text { Auto Availability } & \text { Household } & \begin{array}{l}\text { Number of vehicles available for use by drivers of the } \\ \text { household }\end{array} \\ \hline 2.1 & \text { Day Pattern } & \text { Person-day } & \begin{array}{l}0 \text { or 1+ tours for 7 activity purposes. } \\ \text { o or 1+ stops for 7 activity purposes }\end{array} \\ \hline 2.2 & \text { Exact Number of Tours } & \text { Person-day } & \text { For purposes with 1+ tours, 1, 2 or 3 tours. } \\ \hline 3.1 & \text { Tour Destination } & \text { (Sub)Tour } & \begin{array}{l}\text { Primary destination zone and parcel (models are } \\ \text { purpose-specific) }\end{array} \\ \hline 3.2 & \begin{array}{l}\text { Number and Purpose of Work- } \\ \text { Based Subtours }\end{array} & \text { Work Tour } & \begin{array}{l}\text { Number and purpose of any subtours made during a } \\ \text { work tour }\end{array} \\ \hline 3.3 & \text { Tour Mode } & \text { (Sub)Tour } & \begin{array}{l}\text { Main tour mode } \\ \text { (models are purpose-specific) }\end{array} \\ \hline 3.4 & \text { Tour Time of Day } & \text { (Sub)Tour } & \begin{array}{l}\text { The time period arriving and the time period leaving } \\ \text { tour destination } \\ \text { (models are purpose-specific) }\end{array} \\ \hline 4.1 & \begin{array}{l}\text { Generation and Purpose of } \\ \text { Intermediate Stop }\end{array} & \begin{array}{l}\text { Trip within } \\ \text { halftour }\end{array} & \begin{array}{l}\text { Whether another stop occurs on half-tour and, if so, } \\ \text { its purpose, conditional on day pattern }\end{array} \\ \hline 4.2 & \text { Intermediate Stop Location } & \text { Trip } & \begin{array}{l}\text { Destination zone and parcel of each intermediate } \\ \text { stop, conditional on tour origin, destination, and } \\ \text { previously modelled stops }\end{array} \\ \hline 4.3 & \text { Trip Mode } & \text { Trip } & \begin{array}{l}\text { Trip mode, conditional on main tour mode }\end{array} \\ \hline \text { Departure time within 30 minn. periods, conditional on } \\ \text { choices }\end{array}\right\}$

Just as important as downward integrity is the upward vertical integrity that is achieved by the use of composite accessibility variables to explain upper level outcomes. Done properly, this makes the upper level models sensitive to important attributes that are known only at the lower levels of the model, most notably travel times and costs. It also captures non-uniform cross-elasticities caused by shared unobserved attributes among groups of lower level alternatives sharing the same upper level outcome.

Upward vertical integration is a very important aspect of model integration. Without it, the model system will not effectively capture sensitivity to travel conditions. However, when there are very many alternatives (millions in the case of the entire day activity schedule model), the most preferred measure of accessibility, the expected utility logsum, requires an infeasibly large amount of computation. So, for DaySim approaches have been developed to capture the most important accessibility effects with a feasible amount of computation. One approach involves using logsums that approximate the expected utility logsum. They are calculated in the same basic way, by summing the exponentiated utilities of multiple alternatives. However, the amount of computation is reduced, either by ignoring some differences among decisionmakers, or by calculating utility for a carefully chosen subset or aggregation of the available alternatives. The approximate logsum is pre-calculated and used by several of the model components, and can be re-used for many persons. Two kinds of approximate logsums are used, an approximate tour mode/destination choice logsum and an approximate intermediate stop location choice logsum. The approximate tour mode-destination choice logsum is used in situations where information is needed about accessibility to activity opportunities in all surrounding locations by all available transport modes at all times of day. The approximate intermediate stop location choice logsum is used in the activity pattern models, where accessibility for making intermediate stops affects whether the pattern will include intermediate stops on tours, and how many.

The other simplifying approach involves simulating a conditional outcome. For example, in the tour destination choice model, where time-of-day is not yet known, a mode choice logsum is calculated based on an assumed time of day, where the assumed time of day is determined by a probabilityweighted Monte Carlo draw. In this way, the distribution of potential times of day is captured across the population rather than for each person, and the destination choice is sensitive to time-of-day changes in travel level of service.

## Long term choice models

## Work location (1.2) and School location (1.3)

These are essentially destination choice models, but they determine the longer term choice of usual work and school locations (parcel within TAZ). These, along with residence location, tend to structure a person's spatial activity patterns. The choice is primarily a function of travel accessibility across all modes and land use characteristics in and surrounding each possible TAZ and parcel. Key segmentation variables include income for workers and age group for students. In the model sequence, work location conditions the school location for most workers, but for university and young driving age students, school location conditions work location.

Auto availability (1.4)
This model is applied at the household level, and determines the number of vehicles available to the household drivers. Key variables are the numbers of working adults, non-working adults, students of driving age, children below driving age, income, auto and non-auto accessibilities to work and school locations, and more general pedestrian, transit and auto accessibility to retail and service locations.

## Day level models

Day pattern (2.1) and exact number of tours (2.2)
This model is a variation on the Bowman and Ben-Akiva approach, jointly predicting the number of home-based tours a person undertakes during a day for seven purposes, and the occurrence of additional stops during the day for the same seven purposes. The seven purposes are work, school, escort, personal business, shopping, meal and social/recreational. The pattern choice is a function of many types of household and person characteristics, as well as land use and accessibility at the residence and, if relevant, the usual work location. The main pattern model (2.1) predicts the occurrence of tours ( 0 or $1+$ ) and extra stops ( 0 or $1+$ ) for each purpose, and a simpler conditional model (2.2) predicts the exact number of tours for each purpose.

## Tour level models

Within each tour, three main models are used, to simulate the tour's destination, main mode used for the tour, and the beginning and ending period of the tour's primary activity. For work tours, the number of work-based subtours is also modeled, after destination choice, and before timing and travel mode.

## Destination choice (3.1)

Similar to the work and school location models, these models determine the primary destination TAZ and parcel for home-based tours and work-based subtours. For the primary tour destination, the logsum from the mode choice model across all modes is used as the main level of service variable.

The universal choice set of destinations is very large, including all parcels within the metropolitan area. In any given situation, some of the parcels will be infeasible, either because the location cannot be reached in the available time, or because the desired activity cannot be accomplished there. Also, for the sake of computational feasibility, the huge size of the choice set makes it necessary to sample alternatives when applying the destination choice models. A sampling procedure deals with both of these issues. The available alternatives are sampled in a way that allows the probability of being drawn into the sample to be calculated for each drawn alternative. Statistical procedures are then used during model estimation and application to allow the sample to represent the entire set of available alternatives without biasing the results.

The chosen sampling procedure is called two-stage importance sampling with replacement. In the first stage, a TAZ is drawn with a known probability approximately equal to its chance of containing the chosen destination. Then, a parcel is drawn within that TAZ with a known probability approximately
equal to its chance of being the chosen parcel within the TAZ. The two main criteria used in the design of the procedure are statistical soundness and computational efficiency.

Number and purpose of work-based sub-tours (3.2)
For this model, the work tour destination is known, so variables measuring the number and accessibility of activity opportunities near the work site are expected to influence the number of workbased tours.

## Tour mode (3.3)

The tour mode choice model determines the main mode for each tour (a small percentage of tours are multi-modal), with the alternatives being drive to transit, walk to transit, school bus, car shared ride 3+, car shared ride 2, car drive alone, bike and walk.

Tour time of day (3.4)
The dependent variables of this choice model are a pair of 30 minute time periods representing the times that the person arrives at and departs from the tour primary activity location. It therefore provides an approximation of both time-of-day and activity duration. Since entire tours, including stop outcomes are modeled one at a time, first for work and school tours and then for other tours, the periods away from home for each tour become unavailable for subsequently modeled tours. The time period of a work-based subtour is constrained to be within the time period of its parent tour.

## Trip/stop level models

Although the presence of extra (intermediate) stops in the day pattern is determined in the pattern model, the exact number of stops for each purpose is a result of the stop level models. Within each tour, the stops are modeled one-by-one, first for stops before the tour destination, and then for stops after the tour destination. This is an iterative model structure, very similar to the one used in Model 3.2 for the number and purpose of work-based subtours.

Stops before the tour destination are modeled in reverse temporal sequence. First the possible participation in a stop is modeled simultaneously with the stop's purpose (4.1). If the stop occurs, then its location (4.2), and then its trip mode (4.3), and finally the 10 -minute time period of the arrival at the tour destination (4.4) are modeled. These results also determine the time period in which the trip from the stop location begins, since the trip mode and travel level of service are known. If a stop occurs, then the possible participation and purpose of a prior stop are modeled, along with details of location, trip mode and timing. This continues, constructing the trip chain from the tour primary destination to the tour origin in reverse chronological sequence until the model predicts no more stops (at which point, the "final" trip between the "last" stop and the tour origin is modeled). The reason for modeling in reverse chronological sequence for the first half tour is the hypothesis that people aim to arrive at the primary destination at a particular time, and adjust their tour departure time so as to enable completion of the desired intermediate stops. After the trip chain for the first half-tour is modeled, the trip chain for the second half-tour back to the tour origin is similarly modeled, but this time in regular chronological order.

Intermediate stop generation and purpose (4.1)
Throughout the construction of the trip chains, the making of intermediate stops by purpose is accounted for, so that as stop purposes called for by the pattern model are accomplished, the likelihood of additional stops decreases.

Intermediate stop location (4.2)
For intermediate stop locations, the main mode used for the tour is already known, so the choice is primarily a tradeoff between the additional deviation and impedance of making another stop by that mode versus the accessibility to additional land use opportunities in alternative zones and parcels.

As with tour destinations, a sampling procedure is required for the stop location models. The exact procedure is different, however, because the sampling problem is more complex. An intermediate stop essentially requires making a detour along a path between two known locations, and intermediate stops tend to occur near one of the two known locations. The sampling procedure therefore draws and combines two subsamples, one surrounding each of these two locations.

Trip mode (4.3)
The trip-level mode is conditional on the predicted tour mode, but now uses a specific OD pair and a time anchor, and also the trip mode for the adjacent, previously modeled trip in the chain. The trip mode alternatives are the same as the tour modes, but exclude drive-to-transit.

Stop/trip time of day (4.4)
For intermediate stop locations, this model predicts either the departure time (for stops on the $2^{\text {nd }}$ half tour) or the arrival time (for stops on the $1^{\text {st }}$ half tour). The use of travel time variables in this model and model 3.4 allows us to capture peak spreading effects for car tours and trips.

## Model Variables

Table 2 provides a summary of most of the explanatory variables used in the models. Details are provided in subsequent sections.

Table 2a. Overview of DaySim variables (part 1)

| ( $\mathrm{P}=$ predicted, $\mathrm{X}=$ explanatory) |  |  |  |  |  |  |  |  | Tour time of day choice | Stop frequency and purpose |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Household characteristics |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Household size | X |  | X | X | X |  |  | X |  | X |  | X |  |
| Household number of workers | X |  |  | X | X |  |  | X |  |  |  |  |  |
| Household income | X | X | X | X | X |  | X | X | X | X | X | X |  |
| Household includes children |  |  |  | X | X |  | X | X |  | X | X | X |  |
| Household includes people age 65+ | X |  |  | X | X |  | X | X | X | X |  |  |  |
| Household is non-family household |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Household number of driving age people |  |  |  | X | X | X | X | X |  |  |  | X |  |
| Household has no cars |  |  |  | P |  | X | X | X |  |  |  | X |  |
| Household has fewer cars than workers |  |  |  | P |  |  |  | X |  |  |  |  |  |
| Household has fewer cars than adults |  |  |  | P | X | X | X | X |  |  |  | X |  |
| Housing unit type | X |  |  |  |  |  |  |  |  |  |  |  |  |
| Person characteristics |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Full time worker |  | X |  | X | X |  | X | X | X | X |  |  |  |
| Part time worker |  | X |  | X | X |  | X | X | X | X |  |  |  |
| Non-working adult |  |  |  |  | X |  | X | X | X | X |  | X |  |
| University student |  | X | X | X | X |  | X |  | X |  |  |  | X |
| Driving age child |  | X | X | X | X |  | X | X | X | X | X | X | X |
| Child age 5-15 |  |  | X |  | X |  | X | X | X | X |  | X | X |
| Child age under 5 |  |  | X | X | X |  | X | X | X | X |  |  | X |
| Age is 65 or older |  |  |  | X | X |  | X | X | X | X |  |  |  |
| Age is 51-65 |  |  |  |  | X |  |  | X |  |  |  |  |  |
| Age is 26-35 |  |  |  |  | X |  |  |  |  |  |  | X |  |
| Age is 18-25 |  |  |  |  | X |  |  |  |  |  |  | X |  |
| Gender |  | X |  |  | X |  |  | X |  | X | X | X |  |
| Usual workplace is home |  | P |  |  | X |  |  |  |  |  |  |  |  |
| Parcel-level land use variables |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Service employment (density) |  | X | X | X |  | X | X |  |  |  | $x$ |  |  |
| Educational employment (density) |  | X | X |  |  |  | X |  |  |  | X |  |  |
| Government employment (density) |  | X | X |  |  |  | X |  |  |  | X |  |  |
| Office employment (density) |  | X | X |  |  |  | X |  |  |  | X |  |  |
| Retail employment (density) |  | X |  | X |  | X | X |  |  |  | X |  |  |
| Restaurant employment (density) |  | X |  | X |  | X | X |  |  |  | X |  |  |
| Medical employment (density) |  | X |  | X |  | X | X |  |  |  | X |  |  |
| Industrial employment (density) |  | X |  |  |  |  | X |  |  |  | X |  |  |
| Total employment density |  | X |  |  |  |  | X |  |  |  | X |  |  |
| Household density |  | X | X |  |  |  | X |  |  |  | X |  |  |
| University student enrollment (density) |  | X | X |  |  |  | X |  |  |  | X |  |  |
| K-12 student enrollment (density) |  | X | X |  |  | X | X |  |  |  | X |  |  |
| Mixed use balance |  | X |  |  | X |  | X | X |  |  | X | X |  |

Table 2b. Overview of DaySim variables (part 2)


## DaySim Software and Hardware

The DaySim software component is programmed in C\# ${ }^{1}$, Visual Studio ${ }^{2}$, and the Microsoft .Net platform ${ }^{3}$, and will run on 64 -bit Windows systems. DaySim is modular, and it was written using Dependency Injection ${ }^{4}$, which allows major components of the application to be customized and changed depending on the needs of the client. Dependency Injection is managed using an Inversion of Control framework called NInject ${ }^{5}$. DaySim starts by performing calculations common to the models being simulated. It then runs a component called the Choice Model Runner which is responsible for flow control of the overall simulation. The choice model runner cycles through every household and its members and executes the appropriate models. Due the use of Parallel LINQ ${ }^{6}$, the model runner is capable of utilizing all available hardware resources on the host computer.

A simulation consists a series of models that are customized based on the needs of a specific user region. The DaySim code includes a "core" module that includes code common to all DaySim users, as well as a "client" module where all user-specific customizations are specified and maintained. The client module contains the specification of data inputs, as well as outputs. The outputs of a DaySim simulation can be exported for further manipulation or evaluation in many different formats.

DaySim has a series of features that enhance speed, flexibility, and consistency: use of multi-threaded code to optimize run time on multi-core systems or networks; optimization of memory and data handling depending on the hardware; flexibility in how network skim matrices are handled. Also, a unique feature of DaySim is that for each choice model, the exact same code is used to set up the model for estimation and application. This feature helps to avoid programming errors, and makes it easier to update models in the future.

DaySim is "open source" software distributed under the GNU General Public License, V. 3.0 ${ }^{7}$. The primary requirements of this license are that any modified version of the software, if distributed to other parties, must be distributed under the same GNU General Public License, and that the source code must be distributed along with the program.

The optimal hardware configuration for DaySim depends on factors such as the number of zones and parcels (or microzones), as well as the number of modes (and submodes), variables and time periods used for network impedance variables. The latest Fresno DaySim implementation, which incorporates 4 time period skims, uses about 8GB of memory, and on a 4 core machine with fast clock speed runs in just about 1 hour for the full base year population. A similarly configured implementation for the three northern San Joaquin Valley counties requires nearly 16GB memory and runs in just under 2 hours

[^16](with the longer run time due primarily to the larger population in the 3 county region) . DaySim performance improves with up to 24 GB RAM, faster clock speeds, and up to eight or more dedicated cores.

## Day Pattern (2.1)

This model is a variation on the Bowman and Ben-Akiva approach, jointly predicting the number of home-based tours a person undertakes during a day for seven purposes, and the occurrence of additional stops during the day for the same seven purposes. The seven purposes are work, school, escort, personal business, shopping, meal and social/recreational. The pattern choice is a function of many types of household and person characteristics, as well as land use and accessibility at the residence and, if relevant, the usual work location. The main pattern model (2.1) predicts the occurrence of tours ( 0 or $1+$ ) and extra stops ( 0 or $1+$ ) for each purpose, and a simpler conditional model (2.2) predicts the exact number of tours for each purpose.

If the main pattern model were to include every combination of the 14 binary choice variables, there would be $2 \wedge 14$, or 16,384 alternatives. Based on an examination of the data, however, it is feasible to include only combinations that meet the following criteria:

- There can be no intermediate stop purpose with $1+$ stops unless there is at least 1 tour purpose with $1+$ tours.
- The maximum number of tour purposes with $1+$ tours is 3 .
- The maximum number of stop purposes with $1+$ stops is 4 .
- The maximum number of tour purposes + stop purposes with $1+$ is 5 .
- There can be no intermediate Work stops or School stops unless there are $1+$ Work tours and/or 1+ School tours.
- The pattern cannot include both intermediate Work stops and School stops (if one is 1+, the other must be 0 ).

Following these rules, the number of alternatives in the model is reduced to 2,080, while approximately $99 \%$ of the observed patterns in the household survey data are accommodated.

The "base alternative" in the model is the "stay at home" alternative where all 14 dependent variables are 0 (no tours or stops are made).

The main utility component for each purpose-specific tour or stop alternative is a vector of personspecific and household-specific characteristics and accessibility measures.. No set of variables used in the vector can cover the entire sample, so each characteristic used must have a base group. For the estimation, the following "base" characteristics are assumed to have coefficient 0 , with the other person- and household-specific variables estimated relative to these:

- Person type : Full-time worker
- Age group : 36-50
- Gender/role : Male adult with no children under age 16
- HH composition: Family household with 2+ adults and 2+ workers.
- HH income : \$45-75K/year

For all alternatives other than the base (stay at home) alternative, which has utility 0 , the utility consists of the following components:

```
U = sum over p(Ip.BPp)
    + BT(NT)
    + BS(NS)
    + C(NT,NS)
    + sum over p,q (Tp.Tq.BXpq)
    + sum over p,q (Sp.Sq.BYpq)
    + sum over p,q (Tp.Sq.BZpq)
```

Where:

- $\quad \mathrm{p}$ and q are indices that range from 1 to 7 for the 7 tour/stop purposes
- Ip is 1 if there are EITHER $1+$ tours or $1+$ stops for purpose $p$, otherwise 0
- Tp is 1 if there are $1+$ tours for purpose $p$, otherwise 0
- NT is the sum of Tp across the 7 purposes $(1<=\mathrm{NT}<=3)$
- Sp is 1 if there are $1+$ stops for purpose $p$, otherwise 0
- NS is the sum of Sp across the 7 purposes ( $0<=\mathrm{NS}<=4$ )

The estimated coefficients are:

- BPp a purpose-specific array of coefficients related to making 1+ tours/stops for a specific purpose p , including a constant.
- BT an array of coefficients related to making more tours, not including a constant (the effect of each variable is proportional to the log of the number of tours)
- BS an array of coefficients related to making more stops, not including a constant (the effect of each variable is proportional to the log of the number of stops)
- C(NT,NS) a set of constants related to making tours for exactly NT different purposes and stops for exactly NS different purposes.
- BX a matrix of coefficients for making tours for BOTH of a given pair of tour purposes. Only a half-matrix is estimated, with the diagonal constrained to 0 .
- BY a matrix of coefficients for making stops for BOTH of a given pair of stop purposes. Only a half-matrix is estimated, with the diagonal constrained to 0 .
- BZ a matrix of coefficients for making a stop of a given purpose in combination with a tour of a given purpose. Here, a nearly full matrix can be estimated, as all stop purposes and tour purposes can occur together in the same pattern.

The model was estimated, on 8755 person-day observations, and the estimation results are shown in Tables 3 to 6 . The model fit statistics are shown below. The overall rho-squared with respect to constants of 0.136 seems very good considering that a model with 2080 alternatives would have 2079 alternative-specific constants!

| Observations | 8755 |
| :--- | :---: |
| Final log likelihood | 33234.3 |
| Rho-squared(0) | 0.503 |
| Rho-sqiared(constants) | 0.136 |

The main findings that can be seen in Tables $\mathbf{3}$ to $\mathbf{6}$ are:

- Many household and person variables have significant effects on the likelihood of participating in different types of activities in the day, and on whether those activities tend to be made on separate tours or as stops on complex tours.
- The significant variables include employment status, student status, age group, income group, car availability, work at home dummy, gender, presence of children in different age groups, presence of other adults in the household, and family/non-family status.
- For workers and students, the accessibility (mode choice logsum) of the usual work and school locations is positively related to the likelihood of traveling to that activity on a given day.
- For workers, the accessibility to retail and service locations on the way to and from work is positively related to the likelihood of making intermediate stops for various purposes.
DAYSIM Activity and Travel Simulator
Technical Documentation
Table 3: Day Pattern Model Estimation Results (part 1)

| Par\# | Purpose-specific variables (BP) | Work | $X=1$ | School | $X=2$ | Escort | $X=3$ | Per.Bus | $X=4$ | Shop | $X=5$ | Meal | $X=6$ | Soc+Rec | $X=7$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat |
| X00 | Constant-Tour | 0.5127 | 3.2 | -4.256 | -20.4 | -4.077 | -16.2 | -2.575 | -18.4 | -2.998 | -20.9 | -3.671 | -20.8 | -2.389 | -24.1 |
| X01 | Constant-Stop | 1.19 | 1.9 | -4.623 | -6.8 | -1.354 | -3.3 | -0.1647 | -0.5 | -0.4863 | -1.4 | -0.6483 | -1.8 | -0.4726 | -1.5 |
|  | Person Type |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X02 | Part-time worker | -0.784 | -7.1 | -1.448 | -2.0 |  |  |  |  | 0.2415 | 2.2 | -0.2599 | -2.0 |  |  |
| X03 | Retired | -5.769 | -23.0 | -3.364 | -3.3 | -0.4971 | -3.9 | 0.5196 | 5.2 | 0.3059 | 3.3 |  |  |  |  |
| X04 | Other non-worker | -4.465 | -26.6 | -0.3849 | -1.1 |  |  | 0.2516 | 2.4 | 0.4258 | 4.2 |  |  |  |  |
| X05 | University student | -2.305 | -14.7 | 1.903 | 9.6 |  |  |  |  |  |  |  |  |  |  |
| X06 | Student age 16+ | -3.136 | -13.5 | 3.897 | 16.7 |  |  | -0.3791 | -1.9 | -0.5627 | -2.7 | -0.5137 | -2.2 |  |  |
| X07 | Student age 5-15 | -20 |  | 4.309 | 20.7 |  |  | -0.5406 | -3.7 | -0.6673 | -4.6 | -0.9138 | -5.0 | 0.3234 | 3.0 |
| X08 | Child age 0-4 | -20 |  | 1.896 | 8.1 | 0.8636 | 5.5 | -0.5059 | -3.1 |  |  | -0.2058 | -1.1 | 0.5279 | 3.9 |
|  | Adult age group |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X21 | Age 18-25 |  |  | 0.8488 | 4.5 | -0.7015 | -4.8 | -0.425 | -3.5 | -0.3178 | -2.7 |  |  |  |  |
| X22 | Age 26-35 |  |  | 0.3781 | 1.6 | -0.2772 | -2.4 | -0.2817 | -2.6 | -0.2606 | -2.5 |  |  |  |  |
| X23 | Age 51-65 |  |  | -0.9501 | -3.3 | -0.254 | -2.7 | 0.1504 | 2.0 | 0.1142 | 1.6 |  |  | -0.2656 | -3.5 |
|  | Adult gender/chidren |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X19 | Male / age 0-4 |  |  |  |  | 0.4954 | 2.9 |  |  | -0.3869 | -2.3 |  |  |  |  |
| X20 | Male / age 5-15 |  |  |  |  | 1.206 | 10.6 | -0.4442 | -4.0 |  |  | -0.4927 | -3.8 | -0.5121 | -4.0 |
| X16 | Female / none | 0.1629 | 2.1 |  |  |  |  |  |  | 0.1847 | 3.1 | -0.1314 | -1.8 |  |  |
| X17 | Female / age 0-4 | -0.2411 | -1.5 | -1.124 | -2.8 | 1.35 | 9.0 | -0.3885 | -2.5 |  |  |  |  |  |  |
| X18 | Female / age 5-15 |  |  |  |  | 1.803 | 17.6 | -0.2761 | -2.6 |  |  | -0.6791 | -5.2 | -0.5295 | -4.5 |
|  | Household composition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X13 | Only adult in HH |  |  |  |  | 0.3452 | 2.9 | 0.1119 | 1.4 | 0.2982 | 3.7 |  |  | 0.112 | 1.2 |
| X14 | Only worker in HH |  |  |  |  | -0.4844 | -4.4 |  |  |  |  |  |  |  |  |
| X15 | Non-family $2+$ person HH |  |  |  |  |  |  |  |  |  |  | 0.1582 | 0.9 |  |  |
|  | Household income |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X09 | Income 0-25K | -0.2439 | -2.1 | 0.4402 | 3.1 | -0.2769 | -2.6 | -0.1314 | -1.6 | -0.1888 | -2.3 | -0.1706 | -1.7 | -0.4891 | -5.3 |
| X10 | Income 25-45K | -0.1311 | -1.3 | 0.4486 | 3.5 | -0.1683 | -2.0 |  |  |  |  | -0.121 | -1.4 | -0.25 | -3.2 |
| X11 | Income over 75K | 0.1311 | 1.6 |  |  |  |  | 0.1658 | 2.8 | 0.1091 | 1.8 |  |  | 0.06062 | 0.9 |
|  | Other |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X12 | Cars per adult in HH | 0.4733 | 2.9 |  |  |  |  | 0.4717 | 4.0 | 0.578 | 4.7 | 0.4213 | 2.8 | 0.1336 | 1.4 |
| X24 | Work at home | -2.542 | -16.5 |  |  |  |  |  |  |  |  |  |  | -0.6038 | -3.3 |
| X25 | Home mixed use density |  |  |  |  |  |  |  |  | 0.1560 | 2.1 |  |  |  |  |
| X26 | Home intersection density |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| X27 | Home-work/school accessibiiity | 0.1976 | 3.6 | 1.395 | 18.0 |  |  |  |  |  |  |  |  |  |  |
| X27 | Home aggregate accessibility |  |  |  |  | 0.04319 | 1.8 |  |  |  |  |  |  |  |  |
| X28 | Home-work stop accessibility |  |  | 0.1115 | 4.2 | 0.01077 | 1.1 | 0.01169 | 1.4 |  |  | 0.01333 | 1.4 |  |  |

Table 4: Day Pattern Model Estimation Results (part 2)

| Par \# | Additional constants (C[NT,NS]) | Coeff | T-stat |
| :--- | :--- | :---: | :---: |
| $\mathbf{1 3 1 1}$ | 1 tour purpose + 1 stop purpose | -2.145 | -6.9 |
| $\mathbf{1 3 1 2}$ | 1 tour purpose + 2 stop purposes | -3.313 | -6.1 |
| $\mathbf{1 3 1 3}$ | 1 tour purpose + 3+stop purposes | -3.649 | -5.1 |
| $\mathbf{1 3 2 1}$ | 2 tour purposes + 1 stop purpose | -1.965 | -6.2 |
| $\mathbf{1 3 2 2}$ | 2 tour purposes + 2 stop purposes | -3.018 | -5.5 |
| $\mathbf{1 3 2 3}$ | 2 tour purposes + 3 stop purposes | -3.393 | -4.7 |
| $\mathbf{1 3 3 1}$ | 3 tour purposes + 1 stop purpose | -1.66 | -4.6 |
| $\mathbf{1 3 3 2}$ | 3 tour purposes + 2 stop purposes | -2.809 | -4.7 |

Table 5: Day Pattern Model Estimation Results (part 3)

| Par \# | Frequency-specific variables | LN( Tour purposes) | $X=8$ | LN(Stop purposes) | $X=9$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Coeff | T-stat | Coeff ( $\mathrm{X}=9$ ) | T-stat |
|  | Person Type |  |  |  |  |
| X02 | Part-time worker | 1.081 | 7.4 |  |  |
| X03 | Retired | 0.5032 | 3.2 |  |  |
| X04 | Other non-worker | 0.5956 | 3.8 | 0.2279 | 1.8 |
| X05 | University student | 0.7088 | 3.6 |  |  |
| X06 | Student age 16+ | 1.106 | 4.6 | 1.058 | 4.2 |
| X07 | Student age 5-15 | 0.5472 | 2.7 | 0.6778 | 3.6 |
| X08 | Child age 0-4 |  |  |  |  |
|  | Adult age group |  |  |  |  |
| X21 | Age 18-25 | 0.48 | 3.1 |  |  |
| X22 | Age 26-35 |  |  |  |  |
| X23 | Age 51-65 | -0.07682 | -0.7 |  |  |
|  | Adult gender/chidren |  |  |  |  |
| X19 | Male / age 0-4 | -0.34 | -1.5 |  |  |
| X20 | Male / age 5-15 | 0.7031 | 4.5 |  |  |
| X16 | Female / none | -0.2158 | -2.3 |  |  |
| X17 | Female / age 0-4 | -0.7844 | -3.8 |  |  |
| X18 | Female / age 5-15 | 0.8024 | 5.4 |  |  |
|  | Household composition |  |  |  |  |
| X13 | Only adult in HH |  |  |  |  |
| X14 | Only worker in HH |  |  |  |  |
| X15 | Non-family $2+$ person HH |  |  |  |  |
|  | Household income |  |  |  |  |
| X09 | Income 0-25K |  |  |  |  |
| X10 | Income 25-45K |  |  |  |  |
| X11 | Income over 75K |  |  |  |  |
|  | Other |  |  |  |  |
| X12 | Cars per adult in HH |  |  |  |  |
| X24 | Work at home | 1.011 | 5.1 | 0.4993 | 2.6 |
| X25 | Home mixed use density |  |  |  |  |
| X26 | Home intersection density | 0.001968 | 2.1 |  |  |
| X27 | Home-work/school accessibiiity |  |  |  |  |
| X27 | Home aggregate accessibility | 0.0437 | 2.5 |  |  |
| X28 | Home-work stop accessibility |  |  |  |  |

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Table 6: Day Pattern Model Estimation Results (part 4)

| Par \# | Purpose combination variables | Tour+Tour | $Y=11$ | Stop+Stop | $Y=12$ | Tour+Stop | $Y=10$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat |
| Y11 | Work + Work |  |  |  |  | -1.469 | -2.7 |
| Y12 | Work + School | -1.454 | -6.8 |  |  | 0.2223 | 0.4 |
| Y13 | Work + Escort | -0.7426 | -5.1 | -1.028 | -5.4 | 0.5514 | 4.2 |
| Y14 | Work + Per.Bus | -1.22 | -9.6 | -0.2313 | -1.5 | -0.1685 | -1.4 |
| Y15 | Work + Shop | -1.025 | -8.2 | -0.3903 | -2.4 | 0.04718 | 0.4 |
| Y16 | Work + Meal | -0.2655 | -1.8 | -0.3467 | -2.1 | 0.1761 | 1.3 |
| Y17 | Work + Soc/Rec | -0.4903 | -4.0 | -0.8318 | -3.9 |  |  |
| Y21 | School + Work |  |  |  |  | -0.4215 | -0.9 |
| Y22 | School + School |  |  |  |  | 2.625 | 4.7 |
| Y23 | School + Escort | -1.01 | -5.3 | -0.8321 | -2.7 | 0.5689 | 4.0 |
| Y24 | School + Per.Bus | -0.9665 | -5.9 | -0.3223 | -1.1 | -0.3841 | -2.7 |
| Y25 | School + Shop | -0.8558 | -5.1 | -1.203 | -3.3 | -0.3848 | -2.6 |
| Y26 | School + Meal | -0.4355 | -2.0 | -0.0102 | 0.0 | -0.4487 | -2.6 |
| Y27 | School + Soc/Rec | -0.5298 | -3.6 | -0.05269 | -0.2 |  |  |
| Y33 | Escort + Escort |  |  |  |  | 2.312 | 8.9 |
| Y34 | Escort + Per.Bus | 0.5593 | 4.2 | -0.5243 | -4.1 | -0.1566 | -1.2 |
| Y35 | Escort + Shop | 0.33 | 2.4 | -0.5016 | -3.9 | -0.3028 | -2.3 |
| Y36 | Escort + Meal | -0.04151 | -0.2 | -0.1916 | -1.4 | -0.1474 | -1.0 |
| Y37 | Escort + Soc/Rec | 0.4668 | 3.3 | -0.2277 | -1.6 |  |  |
| Y43 | Per.Bus + Escort |  |  |  |  | 0.3288 | 2.9 |
| Y44 | Per Bus + Per Bus |  |  |  |  | 0.9089 | 5.6 |
| Y45 | Per Bus + Shop | -0.2195 | -1.9 | -0.03368 | -0.3 | 0.254 | 2.5 |
| Y46 | Per Bus + Meal | 0.3488 | 2.3 | -0.3466 | -2.8 | 0.4017 | 3.5 |
| Y47 | Per Bus + Soc/Rec | -0.01914 | -0.2 | -0.4352 | -3.3 |  |  |
| Y53 | Shop + Escort |  |  |  |  | 0.179 | 1.5 |
| Y54 | Shop + Per Bus |  |  |  |  | 0.3853 | 3.8 |
| Y55 | Shop + Shop |  |  |  |  | 1.392 | 8.5 |
| Y56 | Shop + Meal | -0.116 | -0.7 | -0.3225 | -2.6 | 0.06504 | 0.5 |
| Y57 | Shop + Soc/Rec | 0.00233 | 0.0 | -0.4836 | -3.6 |  |  |
| Y63 | Meal + Escort |  |  |  |  | 0.4539 | 2.9 |
| Y64 | Meal + Per Bus |  |  |  |  | -0.2992 | -2.0 |
| Y65 | Meal + Shop |  |  |  |  | -0.1665 | -1.1 |
| Y66 | Meal + Meal |  |  |  |  | 0.36 | 1.7 |
| Y73 | Soc/Rec + Escort |  |  |  |  | 0.09108 | 0.8 |
| Y74 | Soc/Rec + Per Bus |  |  |  |  | -0.182 | -1.7 |
| Y75 | Soc/Rec + Shop |  |  |  |  | -0.04755 | -0.4 |
| Y76 | Soc/Rec + Meal |  |  |  |  | 0.4006 | 3.5 |

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|  | Work | \% | School | \% | Escort |  | Per.Bus. |  | Shop |  | Meal |  | Soc+Rec |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Observations | 3142 |  | 1462 |  | 600 |  | 1446 |  | 1307 |  | 399 |  | 1080 |  |
| 1 tour | 1390 | 95.1\% | 398 | 66.3\% | 1193 | 82.5\% | 1176 | 90.0\% | 383 | 96.0\% | 1009 | 93.4\% | 1390 | 95.1\% |
| 2 tours | 66 | 4.5\% | 159 | 26.5\% | 221 | 15.3\% | 120 | 9.2\% | 16 | 4.0\% | 67 | 6.2\% | 66 | 4.5\% |
| 3+ tours | 6 | 0.4\% | 43 | 7.2\% | 32 | 2.2\% | 11 | 0.8\% | 0 | 0.0\% | 4 | 0.4\% | 6 | 0.4\% |

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| Par\# |  | Work | $P=1$ | School | $P=2$ | Escort | $P=3$ | Per.Bus. | $P=4$ | Shop | $P=5$ | Meal | $P=6$ | Soc+Rec | $P=7$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Observations | 3142 |  | 1462 |  | 600 |  | 1446 |  | 1307 |  | 399 |  | 1080 |  |
|  | Final log likelihood | -820.7 |  | -281.8 |  | -442.7 |  | -725.2 |  | -411.4 |  | -47.5 |  | -251.9 |  |
|  | Rho-squared(0) | 0.762 |  | 0.825 |  | 0.328 |  | 0.544 |  | 0.713 |  | 0.892 |  | 0.788 |  |
|  | Rho-sqiared(constants) | 0.114 |  | 0.084 |  | 0.093 |  | 0.054 |  | 0.112 |  | 0.292 |  | 0.092 |  |
|  | Person//HH variables ( $X$ ) | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat |
|  | Person Type |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P01 | Full-time worker | 0.3705 | 1.8 |  |  |  |  |  |  | 0.5642 | 2.2 | -10 | * |  |  |
| P02 | Part-time worker |  |  | -10 | * |  |  |  |  |  |  | -10 | * |  |  |
| P03 | Retired |  |  | -10 | * |  |  |  |  |  |  |  |  |  |  |
| P04 | Other non-worker |  |  |  |  | 0.828 | 3.3 |  |  |  |  |  |  |  |  |
| P05 | University student |  |  | 0.94 | 2.7 |  |  |  |  |  |  | -10 | * |  |  |
| P06 | Student age 16+ |  |  | 0.479 | 1.3 |  |  | 0.7187 | 1.2 |  |  | -10 | * |  |  |
| P07 | Student age 5-15 |  |  |  |  |  |  | -0.9342 | -1.6 | -0.6396 | -0.8 | -10 | * |  |  |
| P08 | Child age 0-4 |  |  | -10 | * |  |  |  |  |  |  | -10 | * | -10 | * |
|  | Adult age group |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P21 | Age 18-25 | -0.4828 | -1.6 |  |  | -1.102 | -1.6 |  |  |  |  |  |  | 0.7688 | 1.8 |
| P22 | Age 26-35 | -0.415 | -1.9 |  |  | -0.6103 | -1.9 |  |  | -1.661 | -2.2 |  |  | 0.6217 | 1.1 |
| P23 | Age 51-65 |  |  |  |  | -0.4292 | -1.6 |  |  |  |  |  |  | 0.7787 | 2.7 |
|  | Adult gender/chidren |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P19 | Male / age 0-4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P20 | Male / age 5-15 |  |  |  |  | 0.6455 | 2.1 |  |  | 1.105 | 2.8 |  |  |  |  |
| P16 | Female / none | -0.302 | -1.9 |  |  |  |  | 0.3141 | 2.1 |  |  |  |  |  |  |
| P17 | Female / age 0-4 | -0.5121 | -1.2 |  |  |  |  | 0.5371 | 1.3 |  |  |  |  | -0.8909 | -0.8 |
| P18 | Female / age 5-15 |  |  |  |  | 0.8719 | 3.6 |  |  | 0.5436 | 1.7 |  |  | -1.006 | -1.3 |
|  | Household composition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P13 | Only adult in HH |  |  |  |  |  |  | 0.3596 | 1.8 | 0.5404 | 2.3 | -1.428 | -1.7 | 0.7188 | 2.2 |
| P14 | Only worker in HH |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P15 | Non-family $2+$ person HH |  |  |  |  | -5 | * |  |  |  |  |  |  |  |  |
|  | Household income |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P09 | Income 0-25K | 0.863 | 3.4 | 0.9686 | 3.2 | 0.8219 | 3.0 | -0.4943 | -2.3 |  |  | 1.651 | 2.8 |  |  |
| P10 | Income 25-45K |  |  |  |  | 0.4439 | 1.8 |  |  |  |  |  |  |  |  |
| P11 | Income over 75K |  |  |  |  |  |  |  |  | 0.3538 | 1.5 |  |  |  |  |
|  | Other |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P12 | Cars per adult in HH |  |  | 0.7023 | 1.4 |  |  |  |  |  |  |  |  |  |  |
| P24 | Work at home | 1.036 | 3.0 |  |  | 0.925 | 2.8 |  |  | 0.4937 | 1.3 |  |  |  |  |
|  | Logsum variables (L) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P27 | Accssibility logsum-2 tours | 1.66 | 10.4 | 0.3914 | 1.5 | 0.1476 | 2.1 | 0.0349 | 0.6 | 0.5011 | 3.9 |  |  |  |  |
| P29 | Accssibility logsum- 3 tours | 2.917 | 4.5 | 1.185 | 1.7 | 0.2124 | 2.0 | 0.0584 | 0.4 | 0.9517 | 1.9 |  |  |  |  |

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| Par\# |  | Work | $P=1$ | School | $P=2$ | Escort | $P=3$ | Per.Bus. | $P=4$ | Shop | $P=5$ | Meal | $P=6$ | Soc+Rec | $P=7$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Pattern outcomes ( $Y$ ) | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat | Coeff | T-stat |
| P31 | Other tours in day Work tours (\#) |  |  |  |  | -0.4197 | -2.1 | -0.7577 | -3.7 | -2.443 | -5.2 | -10 | * | -1.465 | -3.4 |
| P32 | School tours (\#)** | -0.6543 | -1.2 |  |  | -1.675 | -3.3 | -1.104 | -2.1 |  |  | -10 | * |  |  |
| P33 | Escort tours (\#)** | 0.6317 | 2.5 |  |  |  |  | -0.266 | -1.6 |  |  | -10 | * | 0.6477 | 2.3 |
| P34 | Per.bus tours (\#) |  |  |  |  |  |  |  |  | -0.2152 | -1.1 |  |  |  |  |
| P35 | Shop tours (0/1+) |  |  |  |  |  |  | -0.5737 | -2.9 |  |  |  |  |  |  |
|  | Other stops in day |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P41 | Work stops (0.1+) | 0.6464 | 3.5 |  |  |  |  |  |  |  |  |  |  |  |  |
| P42 | School stops (0.1+) |  |  | 0.7152 | 1.4 |  |  |  |  |  |  |  |  |  |  |
| P43 | Escort stops (0.1+) |  |  |  |  |  |  |  |  | 0.7218 | 2.7 |  |  |  |  |
| P44 | Per.bus stops (0.1+) | 0.5487 | 3.5 |  |  |  |  | 0.7424 | 5.1 | 0.3099 | 1.5 |  |  |  |  |
| P45 | Shop stops (0.1+) |  |  |  |  |  |  |  |  | 0.3513 | 1.7 |  |  |  |  |
| P46 | Meal stops (0.1+) | -0.3543 | -1.7 |  |  |  |  |  |  |  |  |  |  | 0.5485 | 1.8 |
| P47 | Soc/rec stops (0.1+) |  |  |  |  |  |  |  |  | 0.328 | 1.2 |  |  | 0.4922 | 1.6 |
|  | Constants (C) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P52 | 2 Tours | -3.264 | -14.1 | -4.515 | -8.1 | -2.802 | -4.0 | -2.165 | -2.9 | -7.469 | -6.1 | -2.416 | -6.9 | -3.034 | -13.9 |
| P53 | $3+$ Tours | -6.72 | -12.8 | -7.928 | -6.8 | -4.704 | -4.6 | -4.379 | -2.5 | -14.18 | -2.9 | -20 | * | -5.852 | -11.0 |

## Exact Number of Tours (2.2)

A much simpler model specification was used to estimate models of the exact number of tours for any given purpose, conditional on making $1+$ tours for that purpose. It is similar in structure to the stop generation and purpose model (4.1) described later.

The specification for this model is:
$\mathrm{U}(1$ tour $)=0$
$\mathrm{U}(2$ tours $)=\mathrm{C} 2+\mathrm{BL} 2 . \mathrm{L}+\mathrm{BX} . \mathrm{X}+\mathrm{BY} . \mathrm{Y}$
$\mathrm{U}(3$ tours $)=\mathrm{C} 3+$ BL3.L + BX. $\mathrm{X}+$ BY. Y
Where:

- C2 and C3 are estimated alternative-specific constants for 2 and 3 tours, respectively
- L is an accessibility logsum for the purpose
- BL2 and BL3 are estimated accessibility logsum coefficients for 2 and 3 tours, respectively
- X is a vector of person and household characteristics.
- Y is a vector of outcomes from the main pattern model (2.1) and the outcomes for higher priority purposes from this model (2.2)
- BX and BY are vectors of estimated coefficients

Table 7 shows the distribution of the estimation data in terms of those making 1, 2 or $3+$ tours for each purpose. For all purposes except for Escort and Personal Business, the number making $3+$ tours is less than $1 \%$. (For all purposes, the percent making 4 tours was negligible, which is why the model is capped at 3 tours.). Because there are so few people making 3 tours for a purpose, it was decided not to use different $X$ and $Y$ vectors for the 2 and 3 tour alternatives. So, the only alternative-specific coefficients or variables for the 3 tour alternative is the constant (C3) and the accessibility logsum coefficient (BL3).

The estimation results are shown in Tables 8 and $\mathbf{9}$. An interesting result is that, compared to the main day pattern model, the person and household variables have less influence, but the accessibility variables have relatively more influence. This result indicates that the small percentage of people who make multiple tours for any given purpose during a day tend to be those people who live in areas that best accommodate those tours. Other people will be more likely to participate in fewer activities and/or chain their activities into fewer home-based tours.

## Number and Purpose of Work-Based Subtours (3.2)

For each home-based Work tour predicted by Models 2.1 and 2.2, this model predicts the exact number and primary purpose of Work-based subtours that originate from that tour. This model uses a stop/repeat structure, with 8 possible alternatives: 1 (more) subtour for any of 7 different activity purposes, or No (more) subtours, here called the 'quit' alternative. When the model is applied the choice is repeated until the purpose of the third subtour or the quit alternative is chosen, whichever comes first. Three subtours is the limit because that is the maximum number observed in the estimation data set.

For this model, the following activity schedule outcomes are known:

- number and purpose of all home based tours (from models 2.1 and 2.2)
- whether or not there are any stops and/or work-based subtours in the day pattern (but not whether they are intermediate stops or subtours) (from model 2.1). For cases where model 2.1 determines that there are no stops or work-based subtours, then the work-based subtour model is not needed.
- if there are stops and/or subtours, what purposes are included (from model 2.1)

For estimation purposes, the set of observed outcomes includes:

- all observed work-based subtours (in which case the outcome is one more subtour of the observed purpose).
- a record for each work tour where another subtour could have been chosen, but wasn't, representing the 'quit' outcome. This includes:
- one additional record for each work tour with at least one observed work-based subtour
- one record for each work tour where no work-based subtour was taken, as long as there was at least one intermediate stop predicted in the pattern model. If there were no intermediate stops and no observed work-based tours, then the outcome of pattern model 2.1 has already determined that there are no work-based subtours.

With choice cases defined this way, the Sacramento survey data provides 2524 cases, with the following distribution of observed choices:

| Choice | Frequency | Percent |
| :--- | ---: | ---: |
| Quit | 1937 | 76.7 |
| Work | 136 | 5.4 |
| Education | 5 | 0.2 |
| Escort | 17 | 0.7 |
| Personal Business | 113 | 4.5 |
| Shop | 79 | 3.1 |
| Meal | 209 | 8.3 |
| Social/recreation | 28 | 1.1 |
| Total | 2524 | 100 |

In a given choice case, a subtour purpose is available only if the pattern indicates that at least one intermediate stop or work-based subtour occurs for that purpose. In addition, education subtours are considered unavailable unless the person reported being a student. As a result, every choice case in the estimation data has a restricted choice set. The following table shows the number of cases grouped by the number of non-quit alternatives available for the choice:

| Number of non-quit <br> purposes available | Frequency <br> in <br> estimation <br> data | Percent |
| :--- | :--- | :--- |
| 1 | 1255 | 49.7 |
| 2 | 783 | 31.0 |
| 3 | 387 | 15.3 |
| 4 | 82 | 3.2 |
| 5 | 17 | 0.7 |
| Total | 2524 | 100 |

Model estimation yielded the following summary results:

| Summary statistics |  |
| :--- | ---: |
| Number observed choices | 2524 |
| Number of estimated parameters | 16 |
| Log likelihood w coeffs=0 | -2429.0 |
| Final Log likelihood | -530.9 |
| Rho squared | 0.781 |
| Adjusted rho squared | 0.775 |

Table 10 shows the details of the estimation results. Parameters 1 through 7 are the alternative specific constants for the purpose alternatives, capturing the tendency to take a tour of a given purpose, given all the other factors affecting choice, with the quit alternative serving as the base case.
Parameters 9 through 14 are factors affecting the tendency to quit, and parameter 15 is one factor affecting the tendency to make an escort subtour. The results indicate that a subtour is less likely if it would be the second subtour of the tour (8), if the pattern has multiple home-based tours (9), and especially multiple home-based work tours (10). Subtours are seldom taken from work locations other than the usual workplace (11), and workers in households with auto limitations take less subtours $(12,13)$. Subtours of any purpose are more likely if there is a lot of commercial employment within a quarter mile of the work location (14), and an escort subtour is more likely if there is a lot of grade school enrollment within a quarter mile of the work location.
Finally, the model specification is nested logit, with the non-quit alternatives grouped together in a nest separate from the quit alternative. The nesting parameter (16) of 0.749 yields a model in which cross-elasticities among the available purposes is greater than the cross-elasticities with the quit alternative. That is, when attractiveness of a purpose changes, there is a tendency to substitute with other purposes rather than substitute with not having a subtour.

Table 10: Number and Purpose of Work-Based Subtours Estimation Results

| Parm <br> ID | Description of utility term | Coefficient <br> Estimate | Std <br> Error | T stat |
| ---: | :--- | ---: | ---: | ---: |
| 1 | Work subtour constant | 0.969 | 0.5 | 1.8 |
| 2 | education subtour constant | 0.140 | 0.9 | 0.2 |
| 3 | escort subtour constant | -2.137 | 0.6 | -3.4 |
| 4 | personal business subtour constant | 0.074 | 0.5 | 0.1 |
| 5 | shop subtour constant | -0.181 | 0.5 | -0.3 |
| 6 | meal subtour constant | 0.582 | 0.5 | 1.1 |
| 7 | social/recreation subtour constant | -0.258 | 0.6 | -0.5 |
| 8 | Quit--second or third subtour | 1.116 | 0.5 | 2.3 |
| 9 | Quit---Nat log of no. of HB tours | 2.102 | 0.7 | 3.1 |
| 10 | Quit--Pattern has 2+ HB work tours | 1.502 | 0.6 | 2.5 |
| 11 | Quit--Work location is not usual workplace | 8.766 | 2.2 | 4.1 |
| 12 | Quit--HH has no car | 1.216 | 2.2 | 0.6 |
| 13 | Quit--HH has less cars than drivers | 0.904 | 0.5 | 1.7 |
| 14 | Quit--Nat. log of (1+commercial employment) <br> within a qtr mile of work location | -0.794 | 0.2 | -4.0 |
| 15 | Escort subtour--Nat. log of (1+ grade school |  |  |  |
| enrollment within a qtr mile of work location) |  |  |  |  |

## Generation and Purpose of Intermediate Stop (4.1)

For each tour, once its destination, timing and mode have been determined, the exact number of stops and their purposes is modeled for the halftours leading to and from the tour destination. For each potential stop, the model predicts whether it occurs or not and, if so, its purpose. This repeats, stop by stop, until the quit alternative is predicted or 5 stops have been made. The five stop limit arises because no halftours in the estimation data have more than five intermediate stops. In model application, for the last modeled tour, the model is constrained to accomplish all intermediate stop activity purposes prescribed by the activity pattern model that have not yet been accomplished on other tours.

The set of observed outcomes for model estimation includes

- all observed intermediate stops
- an additional record for each halftour on which one or more stops occurred
- a record for each halftour on which no stops occurred, unless the pattern model (2.1) determined that the pattern has no intermediate stops or work-based subtours.

The resulting data include 20297 observed choices.
The results of model estimation are shown in Table 11. Many factors affect the choices. Some summary observations can be made:

- The outcomes of this model are strongly conditioned by the outcome of the day activity pattern model, including the presence and purpose of tours and stops.
- Known characteristics of the tour and halftour strongly affect the stop choices, including tour purpose and mode; and type, timing and time available for the halftour
- Outcomes of this model for higher priority tours have significant effects. For example, once a stop purpose has been taken, the likelihood of another stop for that purpose drops considerably.
- Person type and presence of children affect the likelihood and purpose of intermediate stops.
- Accessibility has a small but measurable effect. For auto-based modes, accessibility is measured by the aggregate intermediate stop logsum. For non-auto-based modes, stop tendency depends on street network connectivity and commercial employment density.

Table 11: Number and Purpose of Intermediate Stops Estimation Results

| Parm <br> ID | Utility variable <br> stop <br> alternative |  | Estim. <br> Error | Tat <br> stat |
| :---: | :--- | :--- | ---: | ---: | ---: |
| Quit tendencies by trip and halftour |  |  |  |  |
| 1 trip 2 on halftour 1 | quit | 0.480 | 0.07 | 6.6 |
| 2 trip 3 on halftour 1 | quit | 0.478 | 0.10 | 4.6 |
| 3 trip 4 on halftour 1 | quit | 0.392 | 0.15 | 2.6 |
| 4 trip 5 on halftour 1 | quit | 1.050 | 0.26 | 4.1 |
| 5 trip 2 on halftour 2 | quit | 0.727 | 0.07 | 11.0 |
| 6 trip 3 on halftour 2 | quit | 0.920 | 0.09 | 10.0 |
| 7 trip 4 on halftour 2 | quit | 0.640 | 0.13 | 4.9 |
| 8 trip 5 on halftour 2 | quit | 0.812 | 0.18 | 4.4 |
| Quit tendencies by halftour type |  |  |  |  |

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| Parm ID | Utility variable | Intermediate stop alternative | Estim. | $\begin{array}{r} \text { Std } \\ \text { Error } \end{array}$ | T stat |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 9 | HB tour with subtours | quit | 0.298 | 0.08 | 3.9 |
| 10 | secondary tour | quit | -0.147 | 0.06 | -2.6 |
| 11 | work-based tour | quit | 0.747 | 0.10 | 7.3 |
| 12 | before work or school | quit | 0.297 | 0.08 | 3.7 |
| 17 | transit with walk access tour mode | quit | -0.747 | 0.20 | -3.7 |
|  | Effect of accessibility on quit tendency |  |  |  |  |
| 13 | Intermediate stop aggregate logsum, tour mode is auto | quit | -0.074 | 0.01 | -5.3 |
| 14 | Intermediate stop aggregate logsum, tour mode is transit w auto access | quit | -0.184 | 0.02 | -7.4 |
| 15 | Intermediate stop aggregate logsum, tour mode is school bus | quit | -0.203 | 0.02 | -8.3 |
| 16 | \{Connectivity ratio: (\# 3 and 4 link nodes)/(\# 1,3,4-link nodes) within a qtr mile ${ }^{*}\{N a t$. log of ( $1+$ commercial employment) within a quarter mile of tour destination\}, tour mode is transit with walk access, wlk or bike | quit | -0.089 | 0.03 | -3.0 |
|  | Stop purpose tendencies by tour purpose |  |  |  |  |
| 33 | work or education tour | work | -3.648 | 0.31 | -11.7 |
| 34 | work or education tour | education | 2.011 | 0.77 | 2.6 |
| 35 | work or education tour | escort | -3.215 | 0.25 | -12.8 |
| 36 | work or education tour | pers. business | -0.733 | 0.20 | -3.6 |
| 37 | work or education tour | shop | -0.910 | 0.19 | -4.7 |
| 38 | work tour | meal | -0.757 | 0.26 | -2.9 |
| 39 | work or education tour | social/ rec | -0.844 | 0.24 | -3.6 |
| 40 | education tour | quit | 0.468 | 0.07 | 6.4 |
| 46 | education tour | meal | -0.270 | 0.32 | -0.8 |
| 47 | escort tour | work | -30.000 |  |  |
| 48 | escort tour | education | -30.000 |  |  |
| 49 | escort tour | escort | -4.816 | 0.27 | -17.6 |
| 50 | escort tour | pers. business | -2.220 | 0.26 | -8.4 |
| 51 | escort tour | shop | -2.145 | 0.26 | -8.4 |
| 52 | escort tour | meal | -1.460 | 0.36 | -4.1 |
| 53 | escort tour | social/ rec | -1.318 | 0.33 | -4.0 |
| 54 | personal business tour | work | -4.173 | 0.39 | -10.6 |
| 55 | personal business tour | education | 1.316 | 1.10 | 1.2 |
| 56 | personal business tour | escort | -3.467 | 0.26 | -13.5 |
| 57 | personal business tour | pers. business | -0.970 | 0.21 | -4.6 |
| 58 | personal business tour | shop | -1.061 | 0.20 | -5.4 |
| 59 | personal business tour | meal | -0.920 | 0.29 | -3.2 |
| 60 | personal business tour | social/ rec | -1.223 | 0.26 | -4.7 |
| 61 | shop tour | work | -5.375 | 0.61 | -8.8 |
| 62 | shop tour | education | 0.659 | 1.04 | 0.6 |
| 63 | shop tour | escort | -3.807 | 0.26 | -14.4 |
| 64 | shop tour | pers. business | -1.005 | 0.21 | -4.8 |
| 65 | shop tour | shop | -0.507 | 0.20 | -2.6 |
| 66 | shop tour | meal | -0.418 | 0.30 | -1.4 |
| 67 | shop tour | social/ rec | -0.817 | 0.26 | -3.2 |
| 68 | meal tour | work | -6.297 | 1.05 | -6.0 |
| 69 | meal tour | education | -30.000 |  |  |
| 70 | meal tour | escort | -4.067 | 0.29 | -13.9 |
| 71 | meal tour | pers. business | -1.681 | 0.29 | -5.7 |
| 72 | meal tour | shop | -1.662 | 0.30 | -5.6 |

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| Parm ID | Utility variable | Intermediate stop alternative | Estim. | $\begin{array}{r} \text { Std } \\ \text { Error } \end{array}$ | $\begin{array}{r} \mathrm{T} \\ \text { stat } \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 73 | meal tour | meal | -3.229 | 0.66 | -4.9 |
| 74 | meal tour | social/ rec | -0.973 | 0.30 | -3.2 |
| 75 | social/ recreation tour | work | -6.274 | 1.05 | -6.0 |
| 76 | social/ recreation tour | education | 2.638 | 1.00 | 2.6 |
| 77 | social/ recreation tour | escort | -3.900 | 0.27 | -14.5 |
| 78 | social/ recreation tour | pers. business | -1.569 | 0.23 | -6.7 |
| 79 | social/ recreation tour | shop | -1.168 | 0.22 | -5.4 |
| 80 | social/ recreation tour | meal | -0.538 | 0.31 | -1.7 |
| 81 | social/ recreation tour | social/ rec | -0.757 | 0.25 | -3.0 |
|  | Stop purpose tendencies by halftour |  |  |  |  |
| 82 | halftour 1 | work | 0.384 | 0.17 | 2.3 |
| 83 | halftour 1 | education | -0.089 | 0.37 | -0.2 |
| 84 | halftour 1 | escort | -0.347 | 0.09 | -3.8 |
| 85 | halftour 1 | pers. business | -0.425 | 0.08 | -5.3 |
| 86 | halftour 1 | shop | -1.116 | 0.08 | -13.7 |
| 87 | halftour 1 | meal | -1.059 | 0.12 | -8.8 |
| 88 | halftour 1 | social/ rec | -0.779 | 0.12 | -6.6 |
|  | Affect of prior stops upon stop tendency for the same purpose |  |  |  |  |
| 89 | no. of intermed. work stops already chosen in this pattern | work | -0.019 | 0.08 | -0.3 |
| 90 | no. of intermed. educ stops already chosen in this pattern | education | -4.826 | 0.57 | -8.4 |
| 91 | no. of intermed. esco stops already chosen in this pattern | escort | -0.534 | 0.06 | -8.5 |
| 92 | no. of intermed. perb stops already chosen in this pattern | pers. business | -0.608 | 0.06 | -10.6 |
| 93 | no. of intermed. shop stops already chosen in this pattern | shop | -0.721 | 0.06 | -11.7 |
| 94 | no. of intermed. meal stops already chosen in this pattern | meal | -4.606 | 0.31 | -14.8 |
| 95 | no. of intermed. socr stops already chosen in this pattern | social/ rec | -1.925 | 0.13 | -14.5 |
| 96 | no. of intermed. work stops already chosen in prior halftours | work | -0.591 | 0.17 | -3.5 |
| 97 | no. of intermed. educ stops already chosen in prior halftours | education | 1.841 | 0.64 | 2.9 |
| 98 | no. of intermed. esco stops already chosen in prior halftours | escort | -0.514 | 0.11 | -4.7 |
| 99 | no. of intermed. perb stops already chosen in prior halftours | pers. business | -1.128 | 0.10 | -11.6 |
| 100 | no. of intermed. shop stops already chosen in prior halftours | shop | -1.121 | 0.10 | -10.9 |
| 101 | no. of intermed. meal stops already chosen in prior halftours | meal | 1.162 | 0.34 | 3.4 |
| 102 | no. of intermed. socr stops already chosen in prior halftours | social/ rec | -0.732 | 0.19 | -3.9 |
|  | Affect of remaining tours in pattern upon stop tendency, by stop purpose |  |  |  |  |
| 103 | HB tours remaining to model, including this one | work | -0.248 | 0.08 | -3.1 |
| 104 | HB tours remaining to model, including this one | education | -0.988 | 0.25 | -3.9 |
| 105 | HB tours remaining to model, including this one | escort | -0.332 | 0.04 | -8.5 |
| 106 | HB tours remaining to model, including this one | pers. business | -0.630 | 0.04 | -14.1 |
| 107 | HB tours remaining to model, including this one | shop | -0.603 | 0.05 | -12.7 |
| 108 | HB tours remaining to model, including this one | meal | -0.666 | 0.07 | -9.1 |
| 109 | HB tours remaining to model, including this one | social/ rec | -0.778 | 0.07 | -10.5 |
|  | Affect of available time upon stop tendency, by stop purpose |  |  |  |  |
| 110 | hours available for stops on halftour | work | 0.168 | 0.02 | 9.5 |
| 111 | hours available for stops on halftour | education | 0.039 | 0.05 | 0.8 |
| 112 | hours available for stops on halftour | escort | 0.057 | 0.01 | 5.9 |
| 113 | hours available for stops on halftour | pers. business | 0.060 | 0.01 | 6.7 |
| 114 | hours available for stops on halftour | shop | 0.078 | 0.01 | 8.4 |
| 115 | hours available for stops on halftour | meal | 0.080 | 0.01 | 5.7 |
| 116 | hours available for stops on halftour | social/ rec | 0.090 | 0.01 | 6.6 |

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| Parm ID | Utility variable | Intermediate stop alternative | Estim. | $\begin{array}{r} \text { Std } \\ \text { Error } \end{array}$ | $\begin{array}{r} \mathrm{T} \\ \text { stat } \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Affect of hour in which primary activity begins (halftour 1) or ends (halftour 2) upon stop tendency, by stop purpose; 5PM-7PM is base |  |  |  |  |
| 131 | 9AM-5PM | work | 1.139 | 0.15 | 7.5 |
| 138 | 7PM-9AM | education | -2.535 | 0.48 | -5.3 |
| 146 | 7AM-9AM | escort | 0.689 | 0.11 | 6.4 |
| 147 | 9AM-5PM | escort | 0.505 | 0.08 | 6.1 |
| 154 | 7PM-9AM | pers. business | -0.693 | 0.12 | -5.6 |
| 155 | 9AM-5PM | pers. business | 0.422 | 0.10 | 4.3 |
| 162 | 9PM-9AM | shop | -0.609 | 0.12 | -5.1 |
| 164 | 11AM-5PM | shop | 0.184 | 0.07 | 2.7 |
| 170 | 11PM-9AM | meal | -0.699 | 0.20 | -3.4 |
| 171 | 11AM-3PM | meal | 0.861 | 0.11 | 7.8 |
| 172 | 7PM-9PM | meal | 0.739 | 0.19 | 4.0 |
| 173 | 11PM-9AM | social/ rec | -0.702 | 0.18 | -4.0 |
| 174 | 11AM-5PM | social/ rec | 0.318 | 0.10 | 3.1 |


|  | Affect of person characteristics and tour mode upon stop tendency, by stop purpose |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 175 | adult male | work | 0.463 | 0.13 | 3.5 |
| 181 | adult female with children in HH | escort | 0.288 | 0.07 | 4.2 |
| 183 | car shared ride 2 | escort | 2.119 | 0.14 | 15.0 |
| 184 | car shared ride 3+ | escort | 2.750 | 0.14 | 19.3 |
| 195 | one-person household | pers. business | 0.155 | 0.09 | 1.8 |
| 196 | car shared ride 2 | pers. business | 0.198 | 0.07 | 2.7 |
| 197 | car shared ride 3+ | pers. business | 0.402 | 0.09 | 4.5 |
| 207 | adult female with children in HH | shop | 0.212 | 0.08 | 2.5 |
| 209 | car shared ride 2 | shop | 0.439 | 0.07 | 6.2 |
| 210 | car shared ride 3+ | shop | 0.426 | 0.09 | 4.6 |
| 221 | one-person household | meal | 0.348 | 0.15 | 2.3 |
| 222 | car shared ride 2 | meal | 0.420 | 0.12 | 3.4 |
| 223 | car shared ride 3+ | meal | 0.746 | 0.15 | 5.1 |
| 226 | part-time worker, retired or driving age child | meal | -0.299 | 0.13 | -2.3 |
| 228 | non-working adult or child age 0-15 | meal | -0.479 | 0.14 | -3.5 |
| 235 | car shared ride 2 | social/ rec | 0.291 | 0.11 | 2.6 |
| 236 | car shared ride 3+ | social/ rec | 0.546 | 0.12 | 4.7 |
|  | Stop purpose tendency for first modeled stop on halftour |  |  |  |  |
| 237 | first modeled trip on halftour | education | -2.134 | 0.35 | -6.2 |
| 238 | first modeled trip on halftour | escort | 0.414 | 0.09 | 4.4 |
| 239 | first modeled trip on halftour | meal | -0.350 | 0.12 | -2.9 |
|  |  |  |  |  |  |
|  | Summary statistics |  |  |  |  |
|  | Number observed choices | 20297 |  |  |  |
|  | Number of estimated parameters | 126 |  |  |  |
|  | Log likelihood w coeffs=0 | -20505.9 |  |  |  |
|  | Final Log likelihood | -13530.9 |  |  |  |
|  | Rho squared | 0.340 |  |  |  |
|  | Adjusted rho squared | 0.334 |  |  |  |

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## Usual Work Location (1.2), Usual School Location (1.3) and Tour Destination (3.1)

The dependent variable in the usual location and tour destination models is the parcel address where the activity takes place. Because of the large number of locations in the universal set of location choice alternatives, it is necessary to both estimate and apply the location choice models using a sample of alternatives. The sampling of alternatives is done using two-stage importance sampling with replacement; first a TAZ is drawn according to a probability determined by its size and impedance, and then a parcel is drawn within the TAZ, with a size-based probability.

Some differences among the models come from the assumed model hierarchy in Figure 2. For the usual work and school location models, auto ownership is assumed to be unknown, based on the assumption that auto ownership is mainly conditioned by work and school locations of household members, rather than the other way around. For the tour destinations, auto ownership levels are treated as given, and affect location choice. For university and grade school students who also work, the usual school location is known when usual work location is modeled; for other workers who also go to school, the work location is known when usual school location is modeled. For the tour destination models, all usual locations are known.

There are additional structural differences among these models. For the two usual location models (work and school), the home location is treated as a special location, because it occurs with greater frequency than any given non-home location, and size and impedance are not meaningful attributes. As a result, both of these models take the nested logit form, with all nonhome locations nested together under the conditioning choice between home and non-home. In the estimation data, all workers have a usual work location and all students have a usual school location, so the model does not have an alternative called "no usual location".

Because a large majority of work tours go to the usual work location, the work tour destination model has this as a special alternative. Therefore, the model is nested, with all locations other than the usual location nested together under the conditioning binary choice between usual and non-usual. (Nearly all observed school tours go to the usual school location. Therefore, there is no school tour destination choice model.)

Since there are no modeled usual locations for activities other than work and school, the destination choice model of all remaining purposes is simply a multinomial logit model.

The structure of the models is shown in Figure 3.

Figure 3: Structure of the usual location and tour destination models


Locations


Destinations

Non-work/ nonschool Tour


Destinations

The usual work location model was estimated using all survey person records of employed persons, with the reported usual work location as the dependent variable. Similarly, the school location model uses all survey person records of students, with the reported usual school location as dependent variable. Some persons are both employed and student, so they provide observed outcomes for both models. In the estimation data, all workers have a usual work location and all students have a usual school location (counter to our expectation that some workers would not have a usual location), so the model does not have an alternative called "no usual location".

Since most work tours go to the usual location, there are relatively few data records to provide good parameter estimates of the factors affecting choice among the "non-usual" alternatives. Therefore, the work destination choice model was estimated with a combined data set including all work tour records and also all person records of persons with a non-home usual location. The standard method of combining data from multiple sources was used. This includes the estimation of separate scale of the two data sets and, since ALOGIT was used for estimation, the specification of dummy nodes to accommodate the scale differences. For most utility variables, it was assumed that the effect is the same in the two data sets, but some distinct parameters were estimated for work tours, such as the attractiveness of the usual location, and the effects of distance and street connectivity.

Nearly all school tours go to the usual school location. Therefore, there is no school tour destination choice model. When students with a non-home usual location have a school tour, it is always assigned to the usual location. School tours are excluded from the day pattern choice set of students having home as the usual school location.

## Utility function

The utility function of each regular location alternative includes a regular utility component and a size function component.

Utility component. The utility component consists of the sum of several utility terms. Each utility term consists of an estimated coefficient multiplied by an alternative attribute and a tour characteristic. The tour characteristic is a dummy ( $0 / 1$ ) variable that says to which subset of tours the coefficient applies. The alternative attribute is either a scalar value or a dummy variable that is nonzero only for the applicable subset of alternatives. Each utility term measures one aspect of a parcel's attractiveness for a given trip.

Size function component. The size function also measures attractiveness of a parcel for a given trip. However, in this case the attractiveness depends on the parcel's size, that is, its capacity for accommodating the stop's activity purpose. The size function consists of several utility-like terms that are combined in the utility function in a form that corresponds with utility theory for aggregate alternatives. Although parcels are quite small, they must still be considered as aggregate alternatives because they have widely differing capacities for accommodating activities. For example, one residential parcel might include a large apartment building and another might have a single-family dwelling; the apartment building has a much larger capacity for accommodating activities that occur in homes. A size function is used instead of a single size variable because the defined activity purposes and size attributes do not have a simple one-to-one correspondence. Rather, several attributes can indicate capacity for accommodating a given purpose. For example, personal business could be conducted at many types of places, such as restaurants, stores or office buildings. The estimated coefficients give different weights to different size variables for a given purpose, and a scale parameter captures correlation among elemental activity opportunities within parcel.

Equation 1 shows the form of the utility function, with size function included as the portion after the ' + ' sign:

$$
\begin{equation*}
V_{i n}=\sum_{k=1}^{K^{v}} \beta_{k} x_{i n k} z_{n k}+\mu^{\prime} \ln \sum_{k=K^{v}+1}^{K^{v}+K^{s}} \exp \left(\beta_{k}\right) x_{i n k} z_{n k} \tag{1}
\end{equation*}
$$

where:
$V_{i n}$ is the systematic utility of parcel alternative $i$ for tour $n$,
$K^{v}$ is the number of utility parameters,
$K^{s}$ is the number of size parameters,
$\beta_{k}, k=1,2, \ldots, K^{v}+K^{s}$ are the utility and size parameters,
$x_{\text {ink }}$ is an attribute of parcel alternative $i$ for tour $n$,
$Z_{n k}$ is a characteristic of tour $n$,
$\mu^{\prime}$ is a scale parameter measuring correlation among elemental activity opportunities within parcels (1—no correlation, 0+--high correlation)

Table 12 provides an overview of the variables (alternative attributes and person/tour characteristics) used in the utility and size functions to explain choice in the models. The lefthand column lists the alternative attributes for the binary choice (special vs. regular alternative) as well as for the conditional MNL choice among regular parcel alternatives. To the right is a column for each of the four models, and in each model's column are the characteristics associated with each of the applicable attributes.

Table 12-Utility function variables in the location choice models

| Attributes | Usual work location | Work tour destination | Usual school location | Non-work tour destination |
| :---: | :---: | :---: | :---: | :---: |
| Binary choice | Home vs other | Usual vs other | Home vs other | not applicable |
| Constants | by person type* | Byperson type* <br> tour type |  |  |
| Disaggregte logsum among regular locations | Yes | Yes | yes |  |
| Conditional MNL choice among regular locations |  |  |  |  |
| Disaggregate mode choice logsum to destination | Yes | Yes | Yes | Yes |
| Piecewise linear driving distance function | For fulltime workers |  | For children under age 16 | By Purpose <br>  Priority <br>  Pattern type |
| Natural log of driving distance | For other then fulltime workers by person type* income | By person type* <br> tour type | For persons age 16+ by person type* | By tour type <br> income <br>  person type* <br>  time available |
| Distance from usual work location |  | Yes | for not student aged |  |
| Distance from usual school location | for student aged | for student aged |  | Yes |
| Aggregate mode-dest logsum at destination | By person type | By person type | By person type | By purpose |
| Parking and employment mix | For daily parking in parcel and in TAZ | for daily parking in parcel and TAZ |  | For hourly parking in parcel and TAZ by car availability |
| Ratio of neighborhood nodes with 3 or 4 entering links | Yes | By car availability |  | By car availability |
| employment, enrollment and households by category: | byperson type <br> income | By person type <br> Income | by person type | by purpose (and by 'kids in household' for escort tours) |
| --Zonal density | --yes | --yes | --yes | --yes |
| --Parcel size | --yes | --yes | --yes | --yes |
| Person type categories in the models | full-time worker part-time worker not full- or part-time | full-time worker part-time worker not full- or part-time | child under 5 child 5 to 15 child 16+ university student not student aged | full-time worker part-time worker retired adult other adult university student child 16+ child 5 to 15 child under 5 |

## Model estimation results

Tables 13 through 16 show the estimated parameters for all four of the models. Within each table, the parameters appear in the same order as the variables listed in Table 12.

Table 13-_Usual Work Location Estimation Results

| Row | $\begin{aligned} & \hline \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person Type | HH Inc (annual) | Est. | Std. error | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | Sampling adjustment factor for estimation |  |  | 1.000 |  |  |
| 2 | 192 | Home location | constant |  | -1.6240 | 7.225 | -0.2 |
| 3 | 193 | Home location | PT worker |  | 7.0933 | 3.569 | 2.0 |
| 4 | 194 | Home location | child or univ. stud. |  | -11.5700 | 5.508 | -2.1 |
| 5 | 195 | Home location | female |  | -2.7963 | 1.369 | -2.0 |
| 6 | 998 | Dest choice logsum (in home vs other choice) |  |  | 0.1496 | 0.065 | 2.3 |
| 7 | 2 | Mode choice logsum | FT worker |  | 1.0000 |  |  |
| 8 | 4 | Mode choice logsum | PT worker |  | 1.0000 |  |  |
| 9 | 5 | Mode choice logsum | not FT/PT worker |  | 1.0000 |  |  |

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| Row | $\begin{aligned} & \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person Type | $\begin{aligned} & \text { HH Inc } \\ & \text { (annual) } \end{aligned}$ | Est. | $\begin{aligned} & \text { Std. } \\ & \text { error } \end{aligned}$ | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10 | 18 | One-way drive dist--0-3.5 mi (10s of mi) | FT worker |  | -4.0525 | 0.332 | -12.2 |
| 11 | 27 | One-way drive dist--3.5-10 mi (10s of mi) | FT worker |  | -0.1416 | 0.114 | -1.2 |
| 12 | 28 | One-way drive dist--10+ mi (10s of mi) | FT worker |  | -0.5787 | 0.040 | -14.3 |
| 13 | 20 | Nat $\log (1+$ one-way drive dist (10s of mi)) | PT worker |  | -2.8608 | 0.195 | -14.7 |
| 14 | 21 | Nat log ( $1+$ one-way drive dist (10s of mi) | not FT/PT worker |  | -3.3753 | 0.329 | -10.3 |
| 15 | 22 | Nat log ( $1+$ one-way drive dist (10s of mi)) |  | <\$15K | -0.3740 | 0.289 | -1.3 |
| 16 | 23 | Nat $\log (1+$ one-way drive dist (10s of mi) |  | \$50-75K | 0.3497 | 0.114 | 3.1 |
| 17 | 24 | Nat $\log (1+$ one-way drive dist ( 10 s of mi) $)$ |  | \$75-100K | 0.4282 | 0.152 | 2.8 |
| 18 | 29 | Nat $\log (1+$ one-way drive dist (10s of mi) | female |  | -0.4861 | 0.104 | -4.7 |
| 19 | 35 | Nat $\log$ ( $1+$ one-way drive dist from school (10s of mi)) | child or univ. stud. |  | -1.7998 | 0.335 | -5.4 |
| 20 | 37 | Aggr. mode-dest logsum at dest | FT worker |  | 0.1081 | 0.035 | 3.1 |
| 21 | 38 | Aggr. mode-dest logsum at dest | PT worker |  | 0.0362 | 0.092 | 0.4 |
| 22 | 39 | Aggr. mode-dest logsum at dest | not FT/PT worker |  | 0.0657 | 0.133 | 0.5 |
| 23 | 52 | Mix of daily parking \& empl. in parcel: ln(1+prkg*empl/(prkg+empl)) |  |  | 0.1989 | 0.023 | 8.8 |
| 24 | 54 | Mix of daily parking \& (empl+stud) in TAZ: In(1+prkgdens*(empldens+studdens)/ (prkgdens+empldens+studdens)), (dens in units/Msqft) |  |  | 0.1231 | 0.011 | 10.9 |
| 25 | 56 | Street connectivity: (\# 3 \& 4 link nodes)/(\# 1,3,4link nodes) within a qtr mile |  |  | 0.7375 | 0.121 | 6.1 |
| 26 | 69 | dens of service empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | <\$50K | -0.0525 | 0.019 | -2.7 |
| 27 | 70 | dens of households in TAZ <br> ( $\left.\ln \left[1+\mathrm{HH}^{*} 100 / \mathrm{Msqft}\right]\right)$ | FT worker | <\$50K | -0.0782 | 0.012 | -6.4 |
| 28 | 71 | dens of educ empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | >\$50K | -0.0270 | 0.009 | -3.1 |
| 29 | 72 | dens of gov empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | >\$50K | 0.0268 | 0.008 | 3.6 |
| 30 | 73 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | >\$50K | 0.1275 | 0.023 | 5.6 |
| 31 | 74 | dens of service empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | >\$50K | -0.0861 | 0.023 | -3.7 |
| 32 | 75 | dens of households in TAZ <br> ( $\left.\ln \left[1+\mathrm{HH}^{*} 100 / \mathrm{Msqft}\right]\right)$ | FT worker | >\$50K | -0.0711 | 0.009 | -7.8 |
| 33 | 83 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | PT worker | >\$50K | 0.1243 | 0.072 | 1.7 |
| 34 | 84 | dens of service empl in TAZ ( In[1+emp\|*100/Msqft]) | PT worker | >\$50K | -0.1452 | 0.075 | -1.9 |
| 35 | 90 | dens of households in TAZ ( $\left.\ln \left[1+\mathrm{HH}^{\star} 100 / \mathrm{Msqft}\right]\right)$ | not FT/PT worker | reported | -0.0990 | 0.028 | -3.6 |
| 36 | 91 | dens of educ empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ |  | unreported | 0.0124 | 0.025 | 0.5 |
| 37 | 92 | dens of gov empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ |  | unreported | 0.0024 | 0.019 | 0.1 |
| 38 | 93 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ |  | unreported | 0.1711 | 0.059 | 2.9 |
| 39 | 94 | dens of service empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ |  | unreported | -0.1163 | 0.062 | -1.9 |
| 40 | 95 | dens of households in TAZ $\left(\ln \left[1+\mathrm{HH}^{*} 100 / \mathrm{Msqft}\right]\right)$ |  | unreported | -0.0564 | 0.025 | -2.2 |
| 41 | 999 | Size function scale |  |  | 0.4963 | 0.012 | 43.0 |
| 42 | 101 | size: service empl. in parcel | FT worker | <\$50K | -0.9521 | 0.316 | -3.0 |
| 43 | 102 | size: education empl. in parcel | FT worker | <\$50K | -1.0527 | 0.408 | -2.6 |
| 44 | 103 | size: restaurant empl. in parcel | FT worker | <\$50K | -1.5551 | 0.427 | -3.6 |
| 45 | 104 | size: gov empl. in parcel | FT worker | <\$50K | 0.0000 |  |  |
| 46 | 105 | size: office empl. in parcel | FT worker | <\$50K | -0.8820 | 0.311 | -2.8 |
| 47 | 106 | size: other empl. in parcel | FT worker | <\$50K | -1.5311 | 0.670 | -2.3 |
| 48 | 107 | size: retail empl. in parcel | FT worker | <\$50K | -1.1755 | 0.349 | -3.4 |
| 49 | 108 | size: medical empl. in parcel | FT worker | <\$50K | -0.3607 | 0.380 | -1.0 |
| 50 | 109 | size: industrial empl. in parcel | FT worker | <\$50K | -1.2685 | 0.320 | -4.0 |
| 51 | 111 | size: \# households in parcel | FT worker | <\$50K | -10.9767 | 0.607 | -18.1 |
| 52 | 114 | size: service empl. in parcel | FT worker | >\$50K | -1.2946 | 0.232 | -5.6 |
| 53 | 115 | size: education empl. in parcel | FT worker | >\$50K | -0.3744 | 0.251 | -1.5 |
| 54 | 116 | size: restaurant empl. in parcel | FT worker | >\$50K | -2.7613 | 0.341 | -8.1 |

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Table 14-Work Tour Destination Estimation Results

| Row | $\begin{aligned} & \hline \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person/Tour Characteristics |  | Est. | Std. error | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | Sampling adjustment factor for estimation |  |  | 1.0000 |  |  |
| 2 | 2 | Usual location | constant |  | 57.1879 | 4.476 | 12.8 |
| 3 | 3 | Usual location | PT worker |  | -7.7853 | 3.121 | -2.5 |
| 4 | 4 | Usual location | child or univ. stud. |  | -8.7800 | 4.540 | -1.9 |
| 5 | 12 | Usual location | pattern has 2+ work tours | primary tour | -11.4371 | 3.259 | -3.5 |
| 6 | 13 | Usual location | pattern has intermediate work stop(s) |  | -14.2930 | 2.676 | -5.3 |
| 7 | 16 | Usual location |  | secondary tour | -18.2026 | 3.031 | -6.0 |
| 8 | 994 | Dest choice logsum (in usual location vs other choice) |  |  | 0.0750 |  |  |
| 9 | 17 | Mode choice logsum | FT worker | usual location | 1.0000 |  |  |
| 10 | 18 | Mode choice logsum | FT worker | tour dest. | 1.0000 |  |  |
| 11 | 19 | Mode choice logsum | PT worker |  | 1.0000 |  |  |
| 12 | 20 | Mode choice logsum | not FT/PT worker |  | 1.0000 |  |  |
| 13 | 21 | Nat log (1 + one-way drive dist (10s of mi)) | FT worker | usual location | -1.5039 | 0.054 | -27.9 |
| 14 | 22 | Nat log ( $1+$ one-way drive dist (10s of mi)) | FT worker | tour dest. | -0.8291 | 0.298 | -2.8 |
| 15 | 23 | Nat log (1 + one-way drive dist (10s of mi)) | PT worker |  | -3.0011 | 0.164 | -18.3 |
| 16 | 24 | Nat log (1 + one-way drive dist (10s of mi)) | not FT/PT worker |  | -3.5019 | 0.310 | -11.3 |
| 17 | 35 | Nat log (1 + one-way drive dist (10s of mi)) |  | secondary tour | -2.3438 | 0.664 | -3.5 |
| 18 | 37 | Nat log (1 + one-way drive dist from work (10s of mi)) |  | tour dest. | -0.2761 | 0.276 | -1.0 |
| 19 | 38 | Nat log (1 + one-way drive dist from school (10s of mi)) | child or univ. stud. |  | -1.8451 | 0.327 | -5.7 |
| 20 | 39 | Aggr. mode-dest logsum at dest | FT worker |  | 0.0867 | 0.034 | 2.5 |
| 21 | 41 | Aggr. mode-dest logsum at dest | not FT/PT worker |  | 0.0386 | 0.133 | 0.3 |
| 22 | 52 | Mix of daily parking \& empl. in parcel: In(1+prkg*empl/(prkg+empl)) |  |  | 0.1974 | 0.022 | 8.8 |
| 23 | 54 | Mix of daily parking \& (empl+stud) in TAZ: In(1+prkgdens*(empldens+studdens)/ (prkgdens+empldens+studdens)), (dens in units/Msqft) |  |  | 0.1259 | 0.011 | 11.5 |
| 24 | 56 | Street connectivity: (\# 3 \& 4 link nodes)/(\# 1,3,4-link nodes) within a qtr mile |  | usual location | 0.7782 | 0.119 | 6.5 |
| 25 | 57 | Street connectivity: (\# 3 \& 4 link nodes)/(\# 1,3,4-link nodes) within a qtr mile | HH has 0 cars or less than drivers | tour dest. | 2.3027 | 1.472 | 1.6 |
| 26 | 68 | dens of service empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | HH inc <\$50K | -0.0484 | 0.019 | -2.5 |
| 27 | 69 | dens of households in TAZ ( $\ln [1+\mathrm{HH} * 100 / \mathrm{Msqft}]$ ) | FT worker | HH inc <\$50K | -0.0680 | 0.012 | -5.6 |
| 28 | 70 | dens of educ empl in TAZ ( $\ln [1+e m p l * 100 / \mathrm{Msqft}])$ | FT worker | HH inc >\$50K | -0.0231 | 0.009 | -2.7 |
| 29 | 71 | dens of gov empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | HH inc > $\$ 50 \mathrm{~K}$ | 0.0281 | 0.007 | 3.8 |
| 30 | 72 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 /$ Msqft] $)$ | FT worker | HH inc >\$50K | 0.1244 | 0.022 | 5.5 |
| 31 | 73 | dens of service empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | FT worker | HH inc > $\$ 50 \mathrm{~K}$ | -0.0889 | 0.023 | -3.9 |
| 32 | 74 | dens of households in TAZ ( $\ln [1+\mathrm{HH}$ * $100 / \mathrm{Msqft}]$ ) | FT worker | HH inc > $\$ 50 \mathrm{~K}$ | -0.0725 | 0.009 | -8.1 |
| 33 | 82 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | PT worker | HH inc >\$50K | 0.1372 | 0.070 | 2.0 |

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| 34 | 83 | dens of service empl in TAZ ( $\ln [1+e m p l * 100 / M s q f t])$ | PT worker | HH inc > ${ }^{\text {S }}$ 50K | -0.1410 | 0.073 | -1.9 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 35 | 89 | dens of households in TAZ ( $\left.\ln \left[1+H H^{*} 100 / M s q f t\right]\right)$ | not FT/PT worker | HH inc reported | -0.0970 | 0.028 | -3.5 |
| 36 | 92 | dens of office empl in TAZ ( $\ln [1+e m p l * 100 / M s q f t])$ |  | HH inc unreported | 0.1861 | 0.054 | 3.4 |
| 37 | 93 | dens of service empl in TAZ ( $\ln [1+e m p l * 100 / M s q f t])$ |  | HH inc unreported | -0.1343 | 0.058 | -2.3 |
| 38 | 94 | dens of households in TAZ ( $\ln [1+\mathrm{HH} * 100 / \mathrm{Msqft}]$ ) |  | HH inc unreported | -0.0424 | 0.024 | -1.8 |
| 39 | 999 | Size function scale |  |  | 0.4950 | 0.011 | 43.5 |
| 40 | 100 | size: service empl. in parcel | FT worker | HH inc <\$50K | -0.7498 | 0.312 | -2.4 |
| 41 | 101 | size: education empl. in parcel | FT worker | HH inc < \$50K | -0.8826 | 0.402 | -2.2 |
| 42 | 102 | size: restaurant empl. in parcel | FT worker | HH inc $<\$ 50 \mathrm{~K}$ | -1.4107 | 0.426 | -3.3 |
| 43 | 103 | size: gov empl. in parcel | FT worker | HH inc <\$50K | 0.0000 |  |  |
| 44 | 104 | size: office empl. in parcel | FT worker | HH inc $<\$ 50 \mathrm{~K}$ | -0.6592 | 0.307 | -2.2 |
| 45 | 105 | size: other empl. in parcel | FT worker | HH inc <\$50K | -1.3898 | 0.667 | -2.1 |
| 46 | 106 | size: retail empl. in parcel | FT worker | HH inc <\$50K | -0.9463 | 0.345 | -2.7 |
| 47 | 107 | size: medical empl. in parcel | FT worker | HH inc <\$50K | -0.2649 | 0.379 | -0.7 |
| 48 | 108 | size: industrial empl. in parcel | FT worker | HH inc <\$50K | -1.0914 | 0.317 | -3.4 |
| 49 | 110 | size: \# households in parcel | FT worker | HH inc $<\$ 50 \mathrm{~K}$ | -10.8318 | 0.602 | -18.0 |
| 50 | 113 | size: service empl. in parcel | FT worker | HH inc > \$50K | -1.3080 | 0.226 | -5.8 |
| 51 | 114 | size: education empl. in parcel | FT worker | HH inc > ${ }^{\text {S }}$ 50K | -0.4178 | 0.244 | -1.7 |
| 52 | 115 | size: restaurant empl. in parcel | FT worker | HH inc > ${ }^{\text {S }}$ 50K | -2.7440 | 0.332 | -8.3 |
| 53 | 116 | size: gov empl. in parcel | FT worker | HH inc $>$ \$50K | 0.0000 |  |  |
| 54 | 117 | size: office empl. in parcel | FT worker | HH inc $>$ \$50K | -0.9488 | 0.211 | -4.5 |
| 55 | 118 | size: other empl. in parcel | FT worker | HH inc $>$ \$50K | -0.6469 | 0.334 | -1.9 |
| 56 | 119 | size: retail empl. in parcel | FT worker | HH inc $>$ \$50K | -2.1131 | 0.273 | -7.7 |
| 57 | 120 | size: medical empl. in parcel | FT worker | HH inc $>\$ 50 \mathrm{~K}$ | -0.8517 | 0.261 | -3.3 |
| 58 | 121 | size: industrial empl. in parcel | FT worker | HH inc $>$ \$50K | -2.0475 | 0.246 | -8.3 |
| 59 | 123 | size: \# households in parcel | FT worker | HH inc > ${ }^{\text {d }}$ 50K | -11.6581 | 0.532 | -21.9 |
| 60 | 124 | size: University enrollment in parcel | FT worker | HH inc $>\$ 50 \mathrm{~K}$ | -3.2596 | 1.211 | -2.7 |
| 61 | 126 | size: service empl. in parcel | PT worker | HH inc <\$50K | -0.6245 | 0.597 | -1.0 |
| 62 | 127 | size: education empl. in parcel | PT worker | HH inc <\$50K | 0.0000 |  |  |
| 63 | 128 | size: restaurant empl. in parcel | PT worker | HH inc <\$50K | -1.1490 | 0.839 | -1.4 |
| 64 | 129 | size: gov empl. in parcel | PT worker | HH inc <\$50K | -0.7867 | 0.959 | -0.8 |
| 65 | 130 | size: office empl. in parcel | PT worker | HH inc <\$50K | -0.5929 | 0.577 | -1.0 |
| 66 | 131 | size: other empl. in parcel | PT worker | HH inc < $\$ 50 \mathrm{~K}$ | -1.9033 | 1.992 | -1.0 |
| 67 | 132 | size: retail empl. in parcel | PT worker | HH inc <\$50K | -0.8655 | 0.682 | -1.3 |
| 68 | 133 | size: medical empl. in parcel | PT worker | HH inc <\$50K | -2.7120 | 1.359 | -2.0 |
| 69 | 134 | size: industrial empl. in parcel | PT worker | HH inc <\$50K | -2.0559 | 0.707 | -2.9 |
| 70 | 136 | size: \# households in parcel | PT worker | HH inc <\$50K | -11.3527 | 1.182 | -9.6 |
| 71 | 139 | size: service empl. in parcel | PT worker | HH inc >\$50K | -0.6517 | 0.791 | -0.8 |
| 72 | 140 | size: education empl. in parcel | PT worker | HH inc $>$ \$50K | 0.8319 | 0.998 | 0.8 |
| 73 | 141 | size: restaurant empl. in parcel | PT worker | HH inc $>$ \$50K | -2.0638 | 1.157 | -1.8 |
| 74 | 142 | size: gov empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | 0.3718 | 0.971 | 0.4 |
| 75 | 143 | size: office empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | 0.1608 | 0.734 | 0.2 |
| 76 | 144 | size: other empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | -1.0027 | 1.446 | -0.7 |
| 77 | 145 | size: retail empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | -0.6300 | 0.838 | -0.8 |
| 78 | 146 | size: medical empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | 0.3197 | 0.855 | 0.4 |
| 79 | 147 | size: industrial empl. in parcel | PT worker | HH inc $>\$ 50 \mathrm{~K}$ | -1.7929 | 0.864 | -2.1 |
| 80 | 149 | size: \# households in parcel | PT worker | HH inc $>$ \$50K | -12.5391 | 1.636 | -7.7 |
| 81 | 151 | size: K-12 enrollment in parcel | PT worker | HH inc > ${ }^{\text {S }}$ 50K | 0.0000 |  |  |
| 82 | 152 | size: service empl. in parcel | not FT/PT worker | HH inc reported | -1.7889 | 0.573 | -3.1 |
| 83 | 153 | size: education empl. in parcel | not FT/PT worker | HH inc reported | -1.7642 | 0.751 | -2.3 |
| 84 | 154 | size: restaurant empl. in parcel | not FT/PT worker | HH inc reported | 0.0000 |  |  |
| 85 | 155 | size: gov empl. in parcel | not FT/PT worker | HH inc reported | -0.7816 | 0.822 | -1.0 |
| 86 | 156 | size: office empl. in parcel | not FT/PT worker | HH inc reported | -0.2222 | 0.476 | -0.5 |

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| 87 | 157 | size: other empl. in parcel | not FT/PT worker | HH inc reported | -1.3686 | 1.227 | -1.1 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 88 | 158 | size: retail empl. in parcel | not FT/PT worker | HH inc reported | -0.9169 | 0.580 | -1.6 |
| 89 | 159 | size: medical empl. in parcel | not FT/PT worker | HH inc reported | -2.2593 | 0.955 | -2.4 |
| 90 | 160 | size: industrial empl. in parcel | not FT/PT worker | HH inc reported | -3.2709 | 0.743 | -4.4 |
| 91 | 162 | size: \# households in parcel | not FT/PT worker | HH inc reported | -11.1263 | 0.980 | -11.4 |
| 92 | 163 | size: University enrollment in parcel | not FT/PT worker | HH inc reported | -1.5327 | 2.161 | -0.7 |
| 93 | 174 | size: total empl. in parcel |  | HH inc unreported | 0.8463 | 1.275 | 0.7 |
| 94 | 175 | size: \# households in parcel |  | HH inc unreported | -8.4416 | 1.479 | -5.7 |
| 95 | 176 | size: University enrollment in parcel |  | HH inc unreported | 0.0000 |  |  |
| 96 | 177 | size: K-12 enrollment in parcel |  | HH inc unreported | -0.3387 | 1.524 | -0.2 |
| 97 | 188 | size: \# households in parcel |  | tour dest. | -5.6565 | 0.516 | -11.0 |
| 98 | 992 | Scale of usual location data |  |  | 1.1702 | 0.106 | 11.1 |
| 99 | 993 | Scale of tour data |  |  | 1.0000 |  |  |
| Summary statistics |  |  |  |  |  |  |  |
| Number observed choices 6538 |  |  |  |  |  |  |  |
| Number of estimated parameters 86 |  |  |  |  |  |  |  |
| Log likelihood w coeffs=0 -29957.4 |  |  |  |  |  |  |  |
| Final Log likelihood |  |  |  |  | -15527.5 |  |  |
| Rho squared |  |  |  |  | 0.482 |  |  |
| Adjusted rho squared |  |  |  |  | 0.479 |  |  |

Table 15—School Location Estimation Results

| Row | $\begin{aligned} & \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person Characteristic | Est. | Std. error | $\begin{array}{r} \mathrm{T}- \\ \text { stat } \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | Sampling adjustment factor for estimation |  | 1.0000 |  |  |
| 2 | 95 | Home location | constant | -80.5728 | 65.388 | -1.2 |
| 3 | 96 | Home location | adult not univ. stud. | 22.4107 | 11.362 | 2.0 |
| 4 | 102 | Home location | HH size | 7.3239 | 5.451 | 1.3 |
| 5 | 998 | Dest choice logsum (in home vs other choice) |  | 0.0675 | 0.047 | 1.4 |
| 6 | 2 | Mode choice logsum | child age <5 | 1.0000 |  |  |
| 7 | 3 | Mode choice logsum | child age 5-15 | 1.0000 |  |  |
| 8 | 4 | Mode choice logsum | driving age stud. | 1.0000 |  |  |
| 9 | 5 | Mode choice logsum | univ. stud. | 1.0000 |  |  |
| 10 | 6 | Mode choice logsum | adult not univ. stud. | 1.0000 |  |  |
| 11 | 7 | One-way drive dist--0-1 mi (10s of mi) | child age <5 | -22.7384 | 5.052 | -4.5 |
| 12 | 8 | One-way drive dist--1-5 mi (10s of mi) | child age <5 | -4.1532 | 0.795 | -5.2 |
| 13 | 9 | One-way drive dist--5+ mi (10s of mi) | child age <5 | -1.6212 | 0.249 | -6.5 |
| 14 | 10 | One-way drive dist--0-1 mi (10s of mi) | child age 5-15 | -16.2979 | 1.577 | -10.3 |
| 15 | 11 | One-way drive dist--1-5 mi (10s of mi) | child age 5-15 | -8.0099 | 0.307 | -26.1 |
| 16 | 12 | One-way drive dist--5+ mi (10s of mi) | child age 5-15 | -2.2769 | 0.154 | -14.8 |
| 17 | 13 | Nat log (1 + one-way drive dist (10s of mi)) | driving age stud. | -6.1357 | 0.299 | -20.5 |
| 18 | 14 | Nat log ( 1 + one-way drive dist (10s of mi) | univ. stud. | -2.9403 | 0.188 | -15.6 |
| 19 | 15 | Nat log (1 + one-way drive dist (10s of mi) | adult not univ. stud. | -1.7008 | 0.235 | -7.2 |
| 20 | 16 | Nat log (1 + one-way drive dist from work (10s of mi)) | adult not univ. stud. | -1.4594 | 0.254 | -5.8 |
| 21 | 17 | Aggr. mode-dest logsum at dest | child age <5 | 0.2850 | 0.159 | 1.8 |
| 22 | 18 | Aggr. mode-dest logsum at dest | child age 5-15 | 0.1009 | 0.085 | 1.2 |
| 23 | 19 | Aggr. mode-dest logsum at dest | driving age stud. | 0.1085 | 0.161 | 0.7 |
| 24 | 20 | Aggr. mode-dest logsum at dest | univ. stud. | 1.3147 | 0.115 | 11.4 |
| 25 | 21 | Aggr. mode-dest logsum at dest | adult not univ. stud. | 1.0434 | 0.127 | 8.2 |
| 26 | 53 | dens of educ empl in TAZ <br> ( $\ln [1+$ empl*100/Msqft]) | child age 5-15 | 0.0884 | 0.019 | 4.7 |
| 27 | 56 | dens of service empl in TAZ ( $\ln [1+$ empl*100/Msqft]) | child age 5-15 | -0.0952 | 0.025 | -3.8 |
| 28 | 71 | dens of educ empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | driving age stud. | 0.0895 | 0.033 | 2.7 |
| 29 | 91 | dens of gov empl in TAZ ( In[1+empl*100/Msqft]) | adult or univ. stud. | 0.0628 | 0.015 | 4.2 |
| 30 | 92 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | adult or univ. stud. | 0.0793 | 0.038 | 2.1 |
| 31 | 93 | dens of service empl in TAZ ( In[1+empl*100/Msqft]) | adult or univ. stud. | -0.2318 | 0.040 | -5.8 |
| 32 | 94 | dens of households in TAZ ( $\left.\ln \left[1+\mathrm{HH}^{\star} 100 / \mathrm{Msqft}\right]\right)$ | adult or univ. stud. | -0.1620 | 0.016 | -9.8 |
| 33 | 999 | Size function scale |  | 0.2395 | 0.004 | 62.1 |
| 34 | 22 | size: education empl. in parcel | child age <5 | -6.4212 | 2.178 | -2.9 |
| 35 | 28 | size: service empl. in parcel | child age <5 | -8.0189 | 1.212 | -6.6 |
| 36 | 32 | size: \# households in parcel | child age <5 | -18.3839 | 0.997 | -18.4 |
| 37 | 34 | size: K-12 enrollment in parcel | child age <5 | 0.0000 |  |  |
| 38 | 40 | size: education empl. in parcel | child age 5-15 | -9.0152 | 0.740 | -12.2 |
| 39 | 46 | size: service empl. in parcel | child age 5-15 | -22.4509 | 1.546 | -14.5 |
| 40 | 50 | size: \# households in parcel | child age 5-15 | -23.4589 | 0.553 | -42.4 |
| 41 | 52 | size: K-12 enrollment in parcel | child age 5-15 | 0.0000 |  |  |
| 42 | 58 | size: education empl. in parcel | driving age stud. | -8.5263 | 1.391 | -6.1 |
| 43 | 64 | size: service empl. in parcel | driving age stud. | -18.6746 | 1.854 | -10.1 |
| 44 | 68 | size: \# households in parcel | driving age stud. | -21.0771 | 0.695 | -30.3 |
| 45 | 70 | size: K-12 enrollment in parcel | driving age stud. | 0.0000 |  |  |

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Table 16-Non-work/Non-school Tour Destination Estimation Results

| Row | $\begin{aligned} & \hline \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person/Tour Char | acteristics | Est. | $\begin{aligned} & \text { Std. } \\ & \text { error } \end{aligned}$ | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | Sampling adjustment factor for estimation |  |  | 1.0000 |  |  |
| 2 | 2 | Mode choice logsum |  |  | 1.0000 |  |  |
| 3 | 3 | One-way drive dist--0-1 mi (10s of mi) | escort |  | -10.3465 | 2.251 | -4.6 |
| 4 | 4 | One-way drive dist--1-3.5 mi (10s of mi) | escort |  | -3.5546 | 0.554 | -6.4 |
| 5 | 5 | One-way drive dist--3.5-10 mi (10s of mi) | escort |  | -2.4826 | 0.271 | -9.2 |
| 6 | 7 | One-way drive dist--0-1 mi (10s of mi) | personal business |  | -13.4222 | 1.973 | -6.8 |
| 7 | 8 | One-way drive dist-1-3.5 mi (10s of mi) | personal business |  | -4.1386 | 0.439 | -9.4 |
| 8 | 9 | One-way drive dist--3.5-10 mi (10s of mi) | personal business |  | -2.1585 | 0.185 | -11.6 |
| 9 | 10 | One-way drive dist--10+ mi (10s of mi) | personal business |  | -0.7635 | 0.090 | -8.5 |
| 10 | 11 | One-way drive dist--0-1 mi (10s of mi) | shopping |  | -9.6628 | 2.168 | -4.5 |
| 11 | 12 | One-way drive dist--1-3.5 mi (10s of mi) | shopping |  | -7.1718 | 0.466 | -15.4 |
| 12 | 13 | One-way drive dist--3.5-10 mi (10s of mi) | shopping |  | -2.6892 | 0.215 | -12.5 |
| 13 | 14 | One-way drive dist--10+ mi (10s of mi) | shopping |  | -0.8238 | 0.110 | -7.5 |
| 14 | 15 | One-way drive dist--0-1 mi (10s of mi) | meal |  | -15.6510 | 2.741 | -5.7 |
| 15 | 16 | One-way drive dist--1-3.5 mi (10s of mi) | meal |  | -6.4441 | 0.723 | -8.9 |
| 16 | 17 | One-way drive dist--3.5-10 mi (10s of mi) | meal |  | -1.9888 | 0.317 | -6.3 |
| 17 | 18 | One-way drive dist--10+ mi (10s of mi) | meal |  | -1.1556 | 0.218 | -5.3 |
| 18 | 19 | One-way drive dist--0-1 mi (10s of mi) | social/recreation |  | -16.1538 | 2.471 | -6.5 |
| 19 | 20 | One-way drive dist--1-3.5 mi (10s of mi) | social/recreation |  | -3.4164 | 0.586 | -5.8 |
| 20 | 21 | One-way drive dist--3.5-10 mi (10s of mi) | social/recreation |  | -2.0259 | 0.234 | -8.6 |
| 21 | 22 | One-way drive dist--10+ mi (10s of mi) | social/recreation |  | -0.4468 | 0.104 | -4.3 |
| 22 | 23 | One-way drive dist--0-1 mi (10s of mi) | secondary tour | work/school pattern | 3.2248 | 2.107 | 1.5 |
| 23 | 24 | One-way drive dist--1-5 mi (10s of mi) | secondary tour | work/school pattern | -1.1027 | 0.320 | -3.4 |
| 24 | 25 | One-way drive dist--5-10 mi (10s of mi) | secondary tour | work/school pattern | 0.0240 | 0.289 | 0.1 |
| 25 | 26 | One-way drive dist--10+ mi (10s of mi) | secondary tour | work/school pattern | -0.4439 | 0.127 | -3.5 |
| 26 | 27 | One-way drive dist--0-1 mi (10s of mi) | secondary tour | not work/school pattern | -3.7189 | 2.064 | -1.8 |
| 27 | 28 | One-way drive dist--1-5 mi (10s of mi) | secondary tour | not work/school pattern | -0.8124 | 0.307 | -2.6 |
| 28 | 29 | One-way drive dist--5-10 mi (10s of mi) | secondary tour | not work/school pattern | -0.3132 | 0.278 | -1.1 |
| 29 | 30 | One-way drive dist--10+ mi (10s of mi) | secondary tour | not work/school pattern | -0.3648 | 0.118 | -3.1 |
| 30 | 31 | Nat log (1 + one-way drive dist (10s of mi)) | work based tour |  | -1.2039 | 0.281 | -4.3 |
| 31 | 32 | Nat $\log (1+$ one-way drive dist (10s of mi) $)$ |  | HH inc<\$15K | 0.5535 | 0.213 | 2.6 |
| 32 | 33 | Nat log ( $1+$ one-way drive dist (10s of mi)) |  | HH inc unreported | 0.4300 | 0.171 | 2.5 |
| 33 | 34 | Nat $\log (1+$ one-way drive dist (10s of mi) |  | nonworker age 65+ | -0.4296 | 0.132 | -3.3 |
| 34 | 35 | Nat $\log (1+$ one-way drive dist ( 10 s of mi) $)$ |  | univ. stud. | 0.3536 | 0.269 | 1.3 |
| 35 | 36 | Nat $\log (1+$ one-way drive dist ( 10 s of mi) $)$ |  | child age 5-15 | -0.8487 | 0.254 | -3.3 |
| 36 | 37 | Nat $\log (1+$ one-way drive dist (10s of mi) |  | child age <5 | -0.9308 | 0.272 | -3.4 |
| 37 | 38 | Nat $\log (1+$ one-way drive dist (10s of mi)) | home based tour | inverse of (hours avail. in 18 hour day)/(remaining HB tours, including this one) | -2.3372 | 1.122 | -2.1 |
| 38 | 40 | Nat log (1 + one-way drive dist from school (10s of mi)) | home based tour |  | -0.5644 | 0.184 | -3.1 |
| 39 | 41 | Aggr. mode-dest logsum at dest | escort |  | 0.1648 | 0.083 | 2.0 |
| 40 | 42 | Aggr. mode-dest logsum at dest | personal business |  | 0.0206 | 0.052 | 0.4 |
| 41 | 43 | Aggr. mode-dest logsum at dest | shopping |  | 0.1892 | 0.060 | 3.1 |
| 42 | 56 | Mix of hourly parking \& commercial empl in parcel: $\ln (1+$ prkg*empl/(prkg+empl)) |  | Less cars than drivers | 0.2506 | 0.060 | 4.2 |
| 43 | 57 | Mix of hourly parking \& commercial empl in parcel: $\ln \left(1+\right.$ prkg $^{*}$ empl/(prkg+empl) $)$ |  | 1+ cars per driver | 0.1561 | 0.043 | 3.7 |
| 44 | 58 | Mix of hourly parking \& commercial empl.in TAZ: In(1+ prkgdens*empldens/ (prkgdens+empldens)), (dens in units/Msqft) |  | Less cars than drivers | 0.0607 | 0.024 | 2.5 |
| 45 | 59 | Mix of hourly parking \& commercial empl.in TAZ: In(1+ prkgdens*empldens/ (prkgdens+empldens)), (dens in units/Msqft) |  | 1+ cars per driver | 0.0479 | 0.015 | 3.3 |

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| Row | $\begin{aligned} & \hline \text { Parm } \\ & \text { ID } \end{aligned}$ | Alternative Attribute | Person/Tour Characteristics | Est. | Std. error | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 46 | 60 | Street connectivity: (\# 3 \& 4 link nodes)/(\# 1,3,4-link nodes) within a qtr mile | HH has no car | 0.7290 | 1.029 | 0.7 |
| 47 | 62 | Street connectivity: (\# 3 \& 4 link nodes)/(\# 1,3,4-link nodes) within a qtr mile | 1+ cars per driver | 0.2101 | 0.118 | 1.8 |
| 48 | 64 | dens of gov empl in TAZ ( $\ln [1+e m p l * 100 / \mathrm{Msqft}])$ | escort, HH w/o kids | 0.0570 | 0.021 | 2.8 |
| 49 | 67 | dens of households in TAZ ( $\left.\ln \left[1+H H^{*} 100 / \mathrm{Msqft}\right]\right)$ | escort, HH w/o kids | -0.1676 | 0.036 | -4.7 |
| 50 | 68 | dens of univ enroll. in TAZ ( $\ln [1+$ students*100/Msqft]) | escort, HH w/o kids | 0.1113 | 0.047 | 2.4 |
| 51 | 74 | dens of households in TAZ ( $\ln [1+\mathrm{HH} * 100 / \mathrm{Msqft}])$ | escort, HH w kids | -0.2159 | 0.028 | -7.8 |
| 52 | 75 | dens of K-12 enroll. in TAZ ( $\ln [1+$ students*100/Msqft]) | escort, HH w kids | 0.0926 | 0.014 | 6.5 |
| 53 | 76 | dens of educ empl in TAZ ( $\ln [1+e m p l * 100 / M s q f t])$ | personal business | 0.0218 | 0.010 | 2.2 |
| 54 | 78 | dens of office empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | personal business | 0.0674 | 0.026 | 2.6 |
| 55 | 79 | dens of service empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | personal business | -0.1216 | 0.025 | -4.8 |
| 56 | 80 | dens of medical empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | personal business | 0.0618 | 0.012 | 5.3 |
| 57 | 81 | dens of households in TAZ ( $\ln [1+\mathrm{HH} * 100 / \mathrm{Msqft}])$ | personal business | -0.0790 | 0.012 | -6.3 |
| 58 | 82 | dens of univ enroll. in TAZ ( $\ln [1+$ students*100/Msqft]) | personal business | 0.0739 | 0.025 | 3.0 |
| 59 | 83 | dens of educ empl in TAZ ( $\ln [1+e m p I * 100 / \mathrm{Msqft}])$ | shopping | -0.0513 | 0.009 | -5.6 |
| 60 | 86 | dens of retail empl in TAZ ( $\ln [1+e m p l * 100 / \mathrm{Msqft}])$ | shopping | -0.0821 | 0.015 | -5.4 |
| 61 | 98 | dens of office empl in TAZ <br> ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | social/recreation | 0.0636 | 0.029 | 2.2 |
| 62 | 99 | dens of service empl in TAZ ( $\ln [1+e m p \mid * 100 / \mathrm{Msqft}])$ | social/recreation | -0.0662 | 0.030 | -2.2 |
| 63 | 100 | dens of households in TAZ $\left(\ln \left[1+\mathrm{HH}^{*} 100 / \mathrm{Msqft}\right]\right)$ | social/recreation | -0.1166 | 0.016 | -7.1 |
| 64 | 999 | Size function scale |  | 0.5114 | 0.011 | 45.6 |
| 65 | 101 | size: education empl. in parcel | escort, HH w/o kids | -0.9176 | 0.763 | -1.2 |
| 66 | 102 | size: restaurant empl. in parcel | escort, HH w/o kids | -5.6366 | 2.038 | -2.8 |
| 67 | 103 | size: gov empl. in parcel | escort, HH w/o kids | -3.0659 | 1.230 | -2.5 |
| 68 | 104 | size: office empl. in parcel | escort, HH w/o kids | -2.3159 | 0.626 | -3.7 |
| 69 | 105 | size: other empl. in parcel | escort, HH w/o kids | -2.9968 | 1.963 | -1.5 |
| 70 | 106 | size: retail empl. in parcel | escort, HH w/o kids | -3.1226 | 0.838 | -3.7 |
| 71 | 107 | size: service empl. in parcel | escort, HH w/o kids | -1.1827 | 0.510 | -2.3 |
| 72 | 108 | size: medical empl. in parcel | escort, HH w/o kids | -1.7080 | 0.733 | -2.3 |
| 73 | 109 | size: industrial empl. in parcel | escort, HH w/o kids | -6.0840 | 1.396 | -4.4 |
| 74 | 111 | size: \# households in parcel | escort, HH w/o kids | -5.6072 | 0.502 | -11.2 |
| 75 | 113 | size: K-12 enrollment in parcel | escort, HH w/o kids | 0.0000 |  |  |
| 76 | 114 | size: education empl. in parcel | escort, HH w kids | -2.7619 | 0.491 | -5.6 |
| 77 | 116 | size: gov empl. in parcel | escort, HH w kids | -4.1676 | 1.046 | -4.0 |
| 78 | 117 | size: office empl. in parcel | escort, HH w kids | -5.5261 | 0.693 | -8.0 |
| 79 | 118 | size: other empl. in parcel | escort, HH w kids | -2.5723 | 0.693 | -3.7 |
| 80 | 119 | size: retail empl. in parcel | escort, HH w kids | -4.6152 | 0.525 | -8.8 |
| 81 | 120 | size: service empl. in parcel | escort, HH w kids | -3.3857 | 0.358 | -9.4 |
| 82 | 121 | size: medical empl. in parcel | escort, HH w kids | -5.3776 | 1.020 | -5.3 |
| 83 | 122 | size: industrial empl. in parcel | escort, HH w kids | -6.8507 | 0.881 | -7.8 |
| 84 | 124 | size: \# households in parcel | escort, HH w kids | -6.7705 | 0.341 | -19.9 |
| 85 | 126 | size: K-12 enrollment in parcel | escort, HH w kids | 0.0000 |  |  |
| 86 | 127 | size: education empl. in parcel | personal business | -2.6366 | 0.352 | -7.5 |
| 87 | 128 | size: restaurant empl. in parcel | personal business | -4.3771 | 0.527 | -8.3 |
| 88 | 129 | size: gov empl. in parcel | personal business | -2.4465 | 0.365 | -6.7 |
| 89 | 130 | size: office empl. in parcel | personal business | -2.2034 | 0.217 | -10.1 |

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| Row | $\begin{gathered} \hline \text { Parm } \\ \text { ID } \end{gathered}$ | Alternative Attribute | Person/Tour Characteristics | Est. | Std. error | T-stat |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 90 | 132 | size: retail empl. in parcel | personal business | -2.7544 | 0.285 | -9.7 |
| 91 | 133 | size: service empl. in parcel | personal business | -1.2135 | 0.195 | -6.2 |
| 92 | 134 | size: medical empl. in parcel | personal business | 0.0000 |  |  |
| 93 | 135 | size: industrial empl. in parcel | personal business | -5.4169 | 0.405 | -13.4 |
| 94 | 137 | size: \# households in parcel | personal business | -6.5677 | 0.270 | -24.3 |
| 95 | 139 | size: K-12 enrollment in parcel | personal business | -4.2720 | 0.491 | -8.7 |
| 96 | 141 | size: restaurant empl. in parcel | shopping | -3.8967 | 0.381 | -10.2 |
| 97 | 143 | size: office empl. in parcel | shopping | -7.4857 | 0.384 | -19.5 |
| 98 | 145 | size: retail empl. in parcel | shopping | 0.0000 |  |  |
| 99 | 146 | size: service empl. in parcel | shopping | -4.7453 | 0.217 | -21.9 |
| 100 | 154 | size: restaurant empl. in parcel | meal | 0.0000 |  |  |
| 101 | 156 | size: office empl. in parcel | meal | -8.2240 | 0.904 | -9.1 |
| 102 | 162 | size: total empl. in parcel | meal | -8.2056 | 0.343 | -23.9 |
| 103 | 163 | size: \# households in parcel | meal | -11.1591 | 0.385 | -29.0 |
| 104 | 166 | size: education empl. in parcel | social/recreation | -3.0254 | 0.602 | -5.0 |
| 105 | 167 | size: restaurant empl. in parcel | social/recreation | -2.0484 | 0.552 | -3.7 |
| 106 | 168 | size: gov empl. in parcel | social/recreation | -4.2847 | 1.052 | -4.1 |
| 107 | 169 | size: office empl. in parcel | social/recreation | -3.7599 | 0.419 | -9.0 |
| 108 | 170 | size: other empl. in parcel | social/recreation | -4.6129 | 1.381 | -3.3 |
| 109 | 171 | size: retail empl. in parcel | social/recreation | -3.8140 | 0.527 | -7.2 |
| 110 | 172 | size: service empl. in parcel | social/recreation | 0.0000 |  |  |
| 111 | 173 | size: medical empl. in parcel | social/recreation | -1.4894 | 0.373 | -4.0 |
| 112 | 176 | size: \# households in parcel | social/recreation | -4.6660 | 0.218 | -21.5 |
| 113 | 177 | size: University enrollment in parcel | social/recreation | -2.5902 | 1.269 | -2.0 |
| 114 | 178 | size: K-12 enrollment in parcel | social/recreation | -3.4295 | 0.634 | -5.4 |
| Summary statistics |  |  |  |  |  |  |
|  |  | Number observed choices |  | 5772 |  |  |
|  |  | Number of estimated parameters |  | 106 |  |  |
|  |  | Log likelihood w coeffs=0 |  | -26382.2 |  |  |
|  |  | Final Log likelihood |  | -21818.1 |  |  |
|  |  | Rho squared |  | 0.173 |  |  |
|  |  | Adjusted rho squared |  | 0.169 |  |  |

In the binary choice between the special alternative and all other possible locations, an alternative specific constant captures the basic tendency to choose one or the other, and dummy variables capture significant differences in this effect among various population segments. The logsum variable from the regular alternatives captures the effect of level of service on this basic choice. In all three cases the parameter is larger than zero, but quite small; that is, the tendency to choose home as the usual location, or to choose the usual location for the work tour, is barely effected by level of service. In the case of the work tour choice, at parameter values close to zero the likelihood function is very flat, so it is difficult to accurately estimate its exact size. Therefore, it is constrained to a specific small value.

Two important variables in all four models are the disaggregate mode choice logsum and network distance. The logsum represents the expected maximum utility from the tour mode choice, and captures the effect of transportation system level of service on the location choice. Distance effects, independent of the level of service, are also present to varying degrees depending on the type of tour being modeled. Since the logsum variable and distance are highly correlated it was difficult in estimation to separately identify the magnitude of their parameters. Therefore, the logsum parameters are constrained to the value one, representing the simple assumption of a multinomial logit form for the joint choice of mode and destination. In nearly
all cases, sensitivity to distance declines as distance increases; in some cases this is captured through a logarithmic form of distance. In other cases, where there is plenty of data to support a larger number of estimated parameters, a piecewise linear form is used to more accurately capture this nonlinear effect.

In most cases the models include an aggregate mode-destination logsum variable at the destination. A positive effect is interpreted as the location's attractiveness for making subtours and intermediate stops on tours to this location. A mix of parking and employment, at both the zone and parcel level, as well as street connectivity in the neighborhood, attract workers and tours for non-work purposes. Also, as in the case of intermediate stops, parcel size variables and TAZ-level density variables affect location choice.

An important test of the model estimation results involves applying the model to the sample used for estimation, and comparing its predictions to observed choices for various subsets of the sample, defined by population characteristics. This test was used during model estimation to identify poorly predicted population segments so that variables could be added or changed to improve the prediction. Appendix 3 shows the application results for nearly final versions of the models.

An important aspect of the destination choice models, determined by the model structure and parameter estimates, is their sensitivity to travel time and cost. In order to test this, the models were applied on the estimation data set under the base conditions assumed for estimation, and then again with travel times increased by $10 \%$. Table 17 shows the average one-way tour distance predicted by the model for various population subsets under the base conditions, and the elasticity of distance with respect to travel time. The first column shows that aggregate elasticity for usual work locations is -.0 .22 . That is, if travel time increases by $10 \%$, then predicted work location distance decreases, on average, by $2.2 \%$. The elasticity of the work tour location choice is quite small, in fact nearly zero. This is because the vast majority of work tours go to the usual work location, and the elasticity would come only from distance sensitivity on the small percent of tours to other locations, and any small shift to or from the usual location arising from the change in travel time. Elasticity for the school location choice is -0.14 , smaller than for work location, and elasticity for other purposes is greater, at -0.29 . Elasticities for some of the population segments differ considerably from the aggregate elasticities.

Table 17: Elasticity of distance with respect to travel time

|  | Average predicted distance (1-way miles, base conditions) |  |  |  | Elasticity of distance with respect to travel time |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Population Segment | Usual work | Work tour | Usual school | Other tour | Usual work | Work tour | Usual school | Other tour |
| Total | 9.4 | 11.9 | 5.0 | 5.1 | -0.22 | -0.01 | -0.14 | -0.29 |
| Purpose |  |  |  |  |  |  |  |  |
| Escort |  |  |  | 3.9 |  |  |  | -0.61 |
| personal business |  |  |  | 5.7 |  |  |  | -0.25 |
| Shop |  |  |  | 4.7 |  |  |  | -0.21 |
| Meal |  |  |  | 4.5 |  |  |  | -0.20 |
| social/recreation |  |  |  | 6.1 |  |  |  | -0.30 |
| Person Type |  |  |  |  |  |  |  |  |
| FT worker | 10.2 | 12.3 | 9.4 | 4.7 | -0.23 | -0.01 | -0.12 | -0.27 |
| PT worker | 6.3 | 10.1 |  | 5.0 | -0.24 | -0.01 |  | -0.34 |
| Retired |  |  |  | 5.3 |  |  |  | -0.24 |
| Non-worker |  |  |  | 5.7 |  |  |  | -0.32 |
| University student | 5.2 | 7.9 | 8.2 | 5.4 | -0.17 | -0.01 | -0.17 | -0.32 |
| Drive student | 5.2 | 6.2 | 3.9 | 5.1 | -0.13 | 0.00 | -0.08 | -0.26 |
| Student age 5-15 |  |  | 3.0 | 4.7 |  |  | -0.10 | -0.26 |
| Under age 5 |  |  | 5.1 | 4.7 |  |  | -0.16 | -0.30 |
| HH Income |  |  |  |  |  |  |  |  |
| <15 K | 6.5 | 10.2 | 4.8 | 4.9 | -0.23 | -0.01 | -0.19 | -0.28 |
| 15-50K | 8.4 | 11.4 | 4.7 | 5.0 | -0.23 | -0.01 | -0.13 | -0.28 |
| 50-75K | 10.2 | 12.7 | 5.2 | 5.0 | -0.23 | -0.01 | -0.12 | -0.28 |
| 75-100K | 10.6 | 12.4 | 5.5 | 5.4 | -0.22 | -0.01 | -0.11 | -0.30 |
| 100K+ | 9.7 | 11.4 | 4.9 | 5.4 | -0.21 | -0.01 | -0.12 | -0.28 |
| HH Size |  |  |  |  |  |  |  |  |
| 1 | 7.9 | 11.9 | 6.7 | 4.3 | -0.21 | -0.01 | -0.15 | -0.21 |
| 2 | 9.6 | 11.8 | 6.7 | 5.4 | -0.22 | -0.01 | -0.15 | -0.24 |
| 3 | 9.5 | 12.4 | 5.6 | 5.3 | -0.22 | -0.01 | -0.13 | -0.30 |
| 4 | 9.8 | 12.6 | 4.6 | 5.2 | -0.22 | -0.02 | -0.13 | -0.33 |
| 5 | 9.9 | 10.8 | 4.2 | 5.1 | -0.22 | -0.01 | -0.14 | -0.35 |
| 6 | 9.5 | 9.6 | 3.2 | 4.3 | -0.20 | -0.01 | -0.13 | -0.35 |
| Gender |  |  |  |  |  |  |  |  |
| Male | 10.0 | 12.2 | 4.8 | 5.1 | -0.22 | -0.01 | -0.13 | -0.27 |
| Female | 8.8 | 11.6 | 5.2 | 5.1 | -0.22 | -0.01 | -0.13 | -0.29 |
| Tour priority |  |  |  |  |  |  |  |  |
| Primary |  | 12.3 |  | 6.0 |  | -0.01 |  | -0.30 |
| Secondary |  | 7.6 |  | 4.8 |  | -0.03 |  | -0.27 |
| Workbased |  |  |  | 3.4 |  |  |  | -0.21 |
| Auto Ownership |  |  |  |  |  |  |  |  |
| 0 autos |  | 8.4 |  | 2.9 |  | -0.01 |  | -0.21 |
| < 1 per driver |  | 10.4 |  | 5.0 |  | -0.01 |  | -0.30 |
| 1+ per driver |  | 12.3 |  | 5.2 |  | -0.02 |  | -0.29 |

## Intermediate Stop Location (4.2)

Intermediate stops include all stops on the way to and from the primary destination of a tour, but do not include the primary destination itself.

## Basic features of the intermediate stop model

At the time that a particular stop's location is modeled, information about the tour (origin, destination, time arriving and departing the primary destination, and tour mode are known, and can be used to explain the location choice. The number of stops in each half-tour and their purposes are known. Additionally, details about any stops nearer to the primary destination are also known, including the location, trip mode, and the time of departure toward the tour destination (or arrival from the tour destination on the second half-tour).

However, at the time a stop's destination is modeled, several things are NOT known. These include the trip mode for the trip between this stop and the stop nearer to the tour destination, and the departure and arrival times of that trip, which will be modeled immediately after this stop's location. The arrival time from the stop nearer to the tour origin (or departure time to that stop on second half-tour) is also not known because it will be modeled along with stop location and trip mode for the next stop closer to the tour origin.

As a result of this modeling approach, two known locations serve as anchor points for calculating travel impedance. These are the stop location immediately toward the tour destination (the tour destination itself for the first stop in a half-tour), which we call the stop origin, and the tour origin.

As with the usual and tour location models, the dependent variable is the parcel, the model uses sampling of alternatives, and each alternative's utility function consists of the sum of several utility terms and one size function.

## Trip characteristic variables

The following trip characteristics are used in the utility function, interacting with attributes so that the effect of attributes depends on the characteristics of the trip. They are all $0 / 1$ indicator variables, with 1 corresponding to the identified trip type. In many cases, the variable $z_{n k}$ above represents the interaction of two or more of the characteristics from this list. For example, in one case $z_{n k}$ equals one only for shopping stops with auto tour mode.

## Stop purpose

## Tour mode

## Tour and trip characteristics

Work-based tour
School tour
Nonwork tour
Shop tour
Stop before work or school
Not first stop from tour destination

## Person type and household characteristics

Person type: child under age 16, driving age child, university student
Female adult
HH with children
HH without children
HH income under \$50K
HH income over \$100K
HH income unreported (used in estimation only)
The most important characteristics are the tour mode and the stop purpose. The tour mode restricts the modes available for the stop, and this affects the availability and impedance of stop locations. The availability and attractiveness of stop locations depend heavily on the stop
purpose. Tour characteristics also affect willingness to travel for the stop, and the tendency to stop near the stop or tour origin. The above characteristics tend to overshadow the effect of personal and household characteristics in this model.

## Alternative attributes and estimation results

The following alternative attributes are used in the utility function.
Alternative sampling adjustment term (-lnq). This term is technically not a utility term, but rather it weights the alternative by the number of alternatives it represents as a result of the alternative sampling procedure.

## Impedance variables

The impedance variables calculated for the intermediate stop model are based on the notion that the perceived impedance of an intermediate stop is a function of the time and cost along the path from the last prior known stop location to the intermediate stop location, and on to the first subsequent known stop location. It is assumed that the traveler forms their tour from the primary tour destination back toward the tour origin. For the first half-tour, this is in reverse chronological order. The reason for this is the hypothesis that people aim to arrive at the primary destination at a particular time, and choose their intermediate stop attributes so as to enable completion of the desired intermediate stops and still arrive at the primary destination on time. These assumptions affect the assumption of what is known when the intermediate stop choice is modeled. The known time and space anchors, used for measuring impedance, are the location and departure time from the stop nearer to the primary destination (or arrival time for second half-tour), and the location of the tour origin. Additionally, assumptions are made about the trip mode for each leg of the journey to and from the intermediate stop location, based on the known tour mode, the half-tour, and the proximity and connectivity of the stop location to the stop origin and tour origin.

Generalized time (100 minute units), generalized time squared and generalized time cubed. The main impedance variable is generalized time. It combines all travel cost and time components according to the following assumptions:

Table 18: Assumptions used in calculation of generalized time

| 1 | walk speed | 2 | 3 mph |
| :--- | :--- | :--- | :--- |
| 3 | bike speed | 4 | 8 mph |
| 5 | school bus travel time as multiple of SOV time | 6 | 3 |
| 7 | perceived auto operating cost | 8 <br> mile |  |
| 9 | distance under which walk LOS is assumed | 10 | .25 mile |
| 11 | value of transit in-vehicle time, as multiple of value of auto IVT | 12 | 1.0 |
| 13 | value of walk time, as multiple of value of auto IVT | 14 | 1.5 |
| 15 | value of bike time, as multiple of value of auto IVT | 16 | 1.5 |
| 17 | value of wait time, as multiple of value of auto IVT | 18 | 2.0 |
| 19 | value of one transit boarding, in terms of auto IVT | 20 | 7 minutes |
| 21 | value of traveler time, trips with HH income under \$15K/year | 22 | $\$ 5 / \mathrm{hr}$ |
| 23 | value of traveler time, trips with HH income under \$15-50K/year | 24 | $\$ 10 / \mathrm{hr}$ |


| 25 | value of traveler time, trips with HH income under \$50-75K/year | 26 | $\$ 15 / \mathrm{hr}$ |
| :--- | :--- | :--- | :--- |
| 27 | value of traveler time, trips with HH income under \$75- | \$25/hr |  |
| $100 \mathrm{~K} /$ year |  |  |  |

Generalized time is used, instead of various separately estimated time and cost coefficients, because the intermediate stop data is not robust enough to support good estimates of the relative values. Higher values of time were considered, and increasing them improved the model fit substantially, indicating that travelers are perhaps more time-sensitive for intermediate stops than for other travel. However, the lower values were retained because of FTA expectations. Higher values of walk, bike and wait time were also considered because of FTA expectations, but in this case the lower values were retained because of better model fit.

Generalized time is calculated by first calculating generalized time for the entire journey from the stop origin, through the stop location, and on to the tour origin, using the above assumptions and information about the known details of the tour and stop. It is then reduced by a distancebased factor to approximate the generalized time for only the detour to the stop location. Thus it might more appropriately be called generalized detour time.

Generalized detour time is further modified by discounting it according to the distance between the stop origin and the tour origin. The discount increases linearly from zero to $30 \%$ for distances between 0 and 30 miles, and remains at $30 \%$ for distances over 30 miles. This enables a single estimated coefficient to capture distance-based discounting. The discounting is based on the hypothesis that people are more willing to make longer detours for intermediate stops on long tours than they are on short tours. The hypothesis was tested by estimating the model with various discounting assumptions. Model fit improved with discounting and the best fit was with the assumptions of $30 \%$ and 30 miles.

Further mention of generalized time refers to discounted generalized detour time as described here.

Figure 4 shows the effects of generalized time on stop location utility.

Figure 4: Effect of generalized time on stop location utility


Detour distance (miles) cubed. The generalized time variables and coefficients, as defined, and the imposed availability restrictions, don't adequately account for the tendency to avoid long intermediate stops, and the result is excessively large estimated sensitivity to generalized time. Therefore, distance cubed is included as a variable. The effect of distance on utility is shown in Figure 5. With it, the model fit improves and the elasticities come down to reasonable levels.

Figure 5: Effect of detour distance on stop location utility


Travel time as a fraction of the available time window. This variable captures the tendency to choose nearby activity locations if there are tight time constraints on the stop. Figure 6 shows the utility effect.

Figure 6: Effect of time pressure on stop location utility


Proximity to stop origin (prxs), proximity to tour origin (prxo), (units of 1/(10 min): 1=10 $\mathrm{min}, .1=100 \mathrm{~min}$ ). Prxs is inverse travel time between stop destination and stop origin. It captures the tendency to stop near the stop origin. Analogously, prxo captures the tendency to stop near the tour origin. Figure 7 shows proximity effects.

Figure 7: Effect of proximity to stop and tour origin on stop location utility


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Estimation results for the impedance variables. Table 21 provides the estimation results for all the coefficients in the intermediate stop model. Parameters 2-26 are the generalized time parameters, including the square and cubic components. Figure 4 above graphs the resulting effect of generalized time for various trip purposes. In all cases, the curve is s-shaped, with sensitivity to generalized time gradually diminishing up to a certain point, and then it increases again. Sensitivity is lower for work and school purposes, and higher for shopping, meals, and escorting (HH with kids).

The distance cubed parameter (30) captures the tendency to distance-limit stops.
Parameter 60 captures a tendency for shorter trips when they are constrained by a short time window.

Parameters 35-59 capture the tendency for trips of various types to occur near the stop origin (35-46) or tour origin (48-59). For example, parameter 48 indicates that trips have a tendency to occur near the tour origin, but parameters 53 and 54 reduce that effect for stops on bike and walk tours.

## Connectivity and parking variables

Walk and transit both unavailable for 1 or both legs ( $0 / 1$ indicator variables). A value of 1 indicates that the stop location is accessible by neither walk nor transit from either the stop origin or the tour origin, or both. These reduce the utility of stop locations when the tour mode is transit.

Intersection density. Number of network nodes with 1, 3 or 4 links within a quarter mile of parcel centroid. This reduces utility of stop locations when the tour mode is auto. One interpretation of this effect is that neighborhoods with very dense networks cause enough trouble for drivers that they are more inclined to go elsewhere for making intermediate stops.

Paid parking density. Natural log of (1+ amount of paid parking within a quarter mile of parcel centroid). This reduces utility of stop locations when the tour mode is auto. A similar interpretation as for intersection density is that auto drivers tend to avoid paying for parking for intermediate stops.

## Parcel size and neighborhood variables

In the intermediate stop location model, the attractiveness of a parcel as a potential stop location depends on the employment, housing and school enrollment on the parcel, as measured by the size function. In addition, employment, housing and school enrollment in the neighborhood of the parcel affect its attractiveness. The types of employment that attract or repel a stop depend heavily on the stop's purpose. Tables 19 and 20 show the size and neighborhood effects purpose by purpose. For each purpose, one variable serves as the base size variable, and the effect of other size variables in the size function is measured relative to the base variable. The neighborhood effects enter the utility function as regular utility terms.

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Table 19: Size and neighborhood effects (part 1)

| Stop Type <br> Size/neighborhood attribute | size effect relative to base | Neighborhood effect (coefficient) |
| :---: | :---: | :---: |
| Escort, HH with kids |  |  |
| total employment | 0.1541 |  |
| K-12 enrollment | 1.0000 | 0.053186 |
| \# households | tiny |  |
| indust.+agr+res.+constr employment |  | -0.183888 |
|  |  |  |
| Escort, HH with no kids |  |  |
| total employment | 0.0876 | insignif |
| K-12 enrollment | 0.1463 | insignif |
| University enrollment | 1.0000 |  |
| \# households | tiny |  |
|  |  |  |
| Meal |  |  |
| restaurant employment | 1.0000 |  |
| retail employment | tiny | 0.092026 |
| service employment | tiny |  |
| total employment | tiny |  |
| \# households | tiny |  |
| gov+office+educ employment |  | insignif |
|  |  |  |
| Personal Business |  |  |
| restaurant employment | 0.0004 | 0.115185 |
| indust.+agr+res.+constr employment | 0.0009 |  |
| medical employment | 1.0000 | -0.086049 |
| gov+office+educ employment | 0.6598 |  |
| retail employment | 0.0074 | 0.136901 |
| service employment | 0.0135 |  |
| \# households | tiny |  |
| K-12 enrollment |  | -0.014661 |
|  |  |  |

Table 20: Size and neighborhood effects (part 2)

| Stop Type <br> Size/neighborhood attribute | size effect relative to base | Neighborhood effect (coefficient) |
| :---: | :---: | :---: |
| School (under age 16) |  |  |
| gov+office+educ employment | 0.1270 |  |
| total employment | 0.0409 |  |
| K-12 enrollment | 1.0000 |  |
| School (driving age) |  |  |
| gov+office+educ employment | 0.1444 |  |
| K-12 enrollment | 1.0000 |  |
| \# households | 0.0010 |  |
|  |  |  |
| University |  |  |
| gov+office+educ employment | 0.0008 |  |
| total employment | tiny |  |
| University enrollment | 1.0000 |  |
|  |  |  |
| Shop |  |  |
| retail employment | 1.0000 | 0.213171 |
| service employment | tiny |  |
| total employment | tiny |  |
| \# households | tiny |  |
|  |  |  |
| Social and Recreational |  |  |
| restaurant employment | 1.0000 | 0.049346 |
| medical employment | 0.2800 |  |
| retail employment | 0.2938 |  |
| service employment | 0.3997 | 0.048528 |
| total employment | 0.5473 | 0.075875 |
| parcels in open space GIS layer w/in qtr mi | 0.0192 |  |
| K-12 enrollment | 0.6231 | -0.042176 |
| university enrollment | 0.4503 |  |
| \# households | 0.0017 | -0.114319 |
| indust.+agr+res.+constr employment |  | -0.188370 |
|  |  |  |
| Work |  |  |
| gov+office+educ employment | 1.0000 |  |
| service employment | 0.2461 |  |
| total employment | 0.2025 | 0.189605 |
| K-12 enrollment |  | insignif |
| \# households | tiny |  |

Tables 21 through 23 provide the detailed estimation results for the intermediate stop location model. This model was estimated using the Puget Sound Regional Council 2006 household survey.
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## Table 21: Intermediate stop location model estimation results: Utility terms

| Parm ID | Alternative attribute | Stop Characteristics | Other stop characteristics | Est. | $\begin{array}{r} \text { Std } \\ \text { error } \end{array}$ | T stat | Unit value in generalized minutes (at 5th incremental min. of pbus stop on 30 mile auto tour) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Alt sampling adjustment term (-Inq) | generic |  | 1.000000 | 0.000 |  |  |
| 2 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min .) | generic |  | -12.210615 | 0.253 | -48.19 | 127.67 |
| 6 | gen. time ${ }^{*}\left(1-.3^{*} \min (1,(\right.$ stopO-to-tourO mi.)/30)) ( $1=100 \mathrm{~min}$.) | work or school stop |  | 1.084987 | 0.178 | 6.08 | -11.34 |
| 7 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min .) | escort stop, HH no kids |  | 0.319872 | 0.339 | 0.94 | -3.34 |
| 8 | gen. time*(1-.3* $\mathrm{min}(1$, (stopO-to-tourO mi.)/30)) ( $1=100 \mathrm{~min}$.) | escort stop, HH w kids |  | -0.934446 | 0.216 | -4.32 | 9.77 |
| 9 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min .) | shop stop (purp 5) |  | -2.087624 | 0.179 | -11.69 | 21.83 |
| 11 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min.$)$ | meal stop (purp 6) |  | -1.302000 | 0.212 | -6.14 | 13.61 |
| 12 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min .) | social rec stop |  | 0.694263 | 0.149 | 4.66 | -7.26 |
| 15 | gen. time*(1-.3* $\mathrm{min}(1,($ stopO-to-tourO mi.)/30)) (1 = 100 min .) | HH inc <=50K per yr |  | 0.411669 | 0.129 | 3.20 | -4.30 |
| 16 | gen. time*(1-.3* $\min (1,($ stopO-to-tourO mi.)/30)) (1 = 100 min .) | HH inc >100K per yr |  | -0.322059 | 0.142 | -2.27 | 3.37 |
| 17 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min.$)$ | HH income unreported |  | -0.240443 | 0.180 | -1.34 | 2.51 |
| 20 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min.$)$ | nonwork tour |  | -0.641611 | 0.118 | -5.44 | 6.71 |
| 21 | gen. time*(1-.3*min(1,(stopO-to-tourO mi.)/30)) (1 = 100 min .) | female adult, HH w kids |  | -0.741453 | 0.145 | -5.10 | 7.75 |
| 22 | gen. time squared | generic |  | 8.307406 | 0.476 | 17.47 | -86.86 |
| 26 | gen. time cubed | generic |  | -2.097096 | 0.218 | -9.62 | 21.93 |
| 30 | Detour XY distance (miles) cubed | generic |  | -7.890959 | 1.610 | -4.90 | 82.51 |
| 35 | proxim. to stop O (10=1min, 1=10 min, .1=100min) | generic |  | 0.165368 | 0.011 | 14.43 | -1.73 |
| 37 | proxim. to stop O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | escort stop, HH no kids |  | -0.043241 | 0.059 | -0.74 | 0.45 |
| 42 | proxim. to stop O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | walk tour |  | -0.094615 | 0.039 | -2.44 | 0.99 |
| 43 | proxim. to stop O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | not 1st stop from tour dest |  | 0.106521 | 0.015 | 7.34 | -1.11 |
| 46 | proxim. to stop O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | shop stop on shop tour |  | -0.125932 | 0.027 | -4.59 | 1.32 |
| 48 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | generic |  | 0.301302 | 0.024 | 12.35 | -3.15 |
| 49 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | escort stop, HH no kids |  | 0.277654 | 0.073 | 3.82 | -2.90 |
| 50 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | escort stop, HH w kids |  | 0.223309 | 0.046 | 4.88 | -2.33 |
| 51 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | auto 2+ tour |  | -0.105049 | 0.033 | -3.20 | 1.10 |
| 52 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | non-auto tour |  | -0.140057 | 0.053 | -2.62 | 1.46 |
| 53 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | bike tour |  | -0.178901 | 0.110 | -1.63 | 1.87 |
| 54 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | walk tour |  | -0.245503 | 0.084 | -2.91 | 2.57 |
| 55 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | work-based tour |  | -0.237372 | 0.096 | -2.48 | 2.48 |
| 56 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min})$ | school tour |  | 0.066888 | 0.052 | 1.28 | -0.70 |
| 58 | proxim. to tour O ( $10=1 \mathrm{~min}, 1=10 \mathrm{~min}, .1=100 \mathrm{~min}$ ) | escort stop on school tour |  | -0.122469 | 0.085 | -1.45 | 1.28 |
| 59 | proxim. to tour O (10=1min, 1=10 $\mathrm{min}, .1=100 \mathrm{~min}$ ) | stop before W or S |  | 0.245931 | 0.033 | 7.39 | -2.57 |
| 60 | (trav time as fraction of avail. time window)^3 (unit free ratio) | generic |  | -2.072210 | 0.357 | -5.80 | 21.67 |
| 61 | walk and transit both unavailable for 1 leg | trans. W access tour |  | 0.000000 | 999.000 | 0.00 | 0.00 |
| 62 | walk and transit both unavailable for both legs | trans. W access tour |  | -0.556920 | 0.136 | -4.09 | 5.82 |

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| Parm ID | Alternative attribute | Stop Characteristics | Other stop characteristics | Est. | $\begin{array}{r} \text { Std } \\ \text { error } \end{array}$ | T stat | Unit value in generalized minutes (at 5th incremental min. of pbus stop on 30 mile auto tour) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 64 | \# 1,3\&4-link street nodes w/in qtr mi | auto tour |  | -0.007963 | 0.001 | -11.43 | 0.08 |
| 71 | In (1+pkg within qtr mi) | auto tour |  | -0.053669 | 0.005 | -9.82 | 0.56 |
| 73 | $\ln (1+$ indust.+agr+res.+constr employment) w/in qtr mi) | escort stop, HH w kids |  | -0.183888 | 0.014 | -13.57 | 1.92 |
| 76 | $\ln$ (1+K-12 enrollment w/in qtr mi) | escort stop, HH w kids |  | 0.053186 | 0.011 | 4.90 | -0.56 |
| 79 | $\ln$ (1+total employment w/in qtr mi) | escort stop, HH no kids |  | 0.027081 | 0.027 | 1.02 | -0.28 |
| 80 | $\ln (1+\mathrm{K}-12$ enrollment w/in qtr mi) | escort stop, HH no kids |  | -0.024873 | 0.021 | -1.17 | 0.26 |
| 85 | $\ln (1+$ gov+office+educ employment) w/in qtr mi) | meal stop (purp 6) |  | -0.012651 | 0.018 | -0.70 | 0.13 |
| 86 | In(1+retail employment w/in qtr mi) | meal stop (purp 6) |  | 0.092026 | 0.017 | 5.43 | -0.96 |
| 92 | $\ln (1+$ medical employment w/in qtr mi) | pers business stop (purp 4) |  | -0.086049 | 0.010 | -8.30 | 0.90 |
| 97 | $\ln (1+\mathrm{K}-12$ enrollment w/in qtr mi) | pers business stop (purp 4) |  | -0.014661 | 0.007 | -1.96 | 0.15 |
| 101 | In (1+restaurant employment w/in qtr mi) | pers business stop (purp 4) |  | 0.115185 | 0.013 | 9.08 | -1.20 |
| 104 | In(1+retail employment w/in qtr mi) | pers business stop (purp 4) |  | 0.136901 | 0.013 | 10.67 | -1.43 |
| 131 | $\operatorname{In}(1+$ retail employment w/in qtr mi) | shop stop (purp 5) |  | 0.213171 | 0.013 | 16.53 | -2.23 |
| 137 | In (1+restaurant employment w/in qtr mi) | social rec stop |  | 0.049346 | 0.017 | 2.91 | -0.52 |
| 138 | $\ln (1+$ indust.+agr+res.+constr employment) w/in qtr mi) | social rec stop |  | -0.188370 | 0.017 | -11.12 | 1.97 |
| 140 | $\ln (1+$ service employment w/in qtr mi) | social rec stop |  | 0.048528 | 0.023 | 2.08 | -0.51 |
| 141 | In(1+total employment w/in qtr mi) | social rec stop |  | 0.075875 | 0.026 | 2.95 | -0.79 |
| 142 | $\ln (1+\mathrm{K}-12$ enrollment w/in qtr mi) | social rec stop |  | -0.042176 | 0.012 | -3.56 | 0.44 |
| 145 | $\ln$ (1+\# households w/in qtr mi) | social rec stop |  | -0.114319 | 0.015 | -7.47 | 1.20 |
| 150 | $\ln (1+$ total employment w/in qtr mi) | work stop (purp 1) |  | 0.189605 | 0.021 | 8.88 | -1.98 |
| 151 | $\ln (1+\mathrm{K}-12$ enrollment w/in qtr mi) | work stop (purp 1) |  | 0.009698 | 0.014 | 0.70 | -0.10 |
| 155 | $\ln (1+\mathrm{K}-12$ enrollment w/in qtr mi) | meal, pers. bus., shop or social | school age youth | 0.063139 | 0.014 | 4.49 | -0.66 |
| 157 | $\ln (1+$ University enrollment w/in qtr mi) | meal, pers. bus., shop or social | university student | 0.042707 | 0.041 | 1.05 | -0.45 |

Effect in size
function relative to

| $\begin{aligned} & \text { N} \\ & \text { N } \\ & \text { in } \\ & \text { H } \end{aligned}$ | $\begin{aligned} & \dot{\infty} \\ & \underset{i}{i} \\ & \underset{\sim}{2} \end{aligned}$ |  |  | $\begin{array}{\|l} \hline \infty \\ \infty \\ \dot{0} \\ \underset{\sim}{N} \\ \end{array}$ | $\begin{array}{\|c\|} \hline \underset{y}{c} \\ \dot{m} \\ 1 \end{array}$ | $\begin{array}{\|c\|} \hline 0 \\ \underset{1}{\sim} \\ \underset{1}{2} \\ \hline \end{array}$ |  | $\begin{array}{\|c} \hline m \\ 0 \\ 0 \\ \vdots \\ 1 \end{array}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $$ | $\begin{array}{\|l\|} \hline 0 \\ 0 \\ 0 \\ 0 \\ \hline \end{array}$ | $\begin{array}{\|l} \hline \stackrel{\circ}{\circ} \\ \hline \dot{\circ} \\ \hline \end{array}$ | $\begin{gathered} \stackrel{n}{N} \\ \stackrel{\sim}{0} \end{gathered}$ | $\begin{array}{\|l\|} \hline \infty \\ \underset{\wedge}{+} \\ \dot{0} \end{array}$ | $\begin{array}{\|c\|} \hline m \\ \underset{\sim}{n} \\ \dot{o} \end{array}$ | $\left.\begin{array}{\|c} - \\ \infty \\ 0 \\ 0 \end{array} \right\rvert\,$ | $\begin{array}{\|l\|} \hline \stackrel{\circ}{\circ} \\ 0 \\ \hline- \end{array}$ | $$ | $\begin{aligned} & \hline \stackrel{\circ}{\circ} \\ & \hline \stackrel{\rightharpoonup}{\circ} \\ & \hline \end{aligned}$ |


| $\begin{aligned} & \dot{0} \\ & \text { 留 } \end{aligned}$ |  | $\begin{aligned} & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{array}{\|c\|} \hline \underset{\sim}{N} \\ \tilde{N} \\ \underset{\infty}{\infty} \\ \underset{\sim}{i} \end{array}$ |  |  | $\begin{aligned} & \hat{\imath} \\ & e \\ & \tilde{N} \\ & \tilde{N} \\ & \underset{\sim}{i} \end{aligned}$ | $\begin{aligned} & \hline \stackrel{\circ}{\circ} \\ & \stackrel{\rightharpoonup}{\circ} \\ & 0 \\ & \stackrel{\rightharpoonup}{\circ} \\ & \dot{\circ} \end{aligned}$ | $\begin{array}{\|l} 0 \\ 0 \\ 0 \\ N \\ \hat{N} \\ 0 \\ 0 \\ \vdots \\ 1 \end{array}$ | $\begin{array}{\|l} \hline \stackrel{\circ}{\circ} \\ \stackrel{\circ}{\circ} \\ \stackrel{\circ}{\circ} \\ \vdots \\ \hline 0 \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |

Table 22: Intermediate stop location model estimation results: Size function terms

|  |  |  |
| :--- | :--- | :--- |
| Parm ID | Alternative attribute | Stop Characteristics |
| 300 | Size Function Scale | generic |
| 301 | size: K-12 enrollment in parcel | escort, HH w kids (K-12 enr. base) |
| 303 | size: total employment in parcel | escort, HH w kids (K-12 enr. base) |
| 304 | size: \# households in parcel | escort, HH w kids (K-12 enr. base) |
| 305 | size: total employment in parcel | escort, HH no kids (Univ. enr. base) |
| 306 | size: K-12 enrollment in parcel | escort, HH no kids (Univ. enr. base) |
| 308 | size: University enrollment in parcel | escort, HH no kids (Univ. enr. base) |
| 309 | size: \# households in parcel | escort, HH no kids (Univ. enr. base) |
| 310 | size: restaurant employment in parcel | meal (rest. emp base) |

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| Parm ID | Alternative attribute | Stop Characteristics | Other stop characteristics | Est. | $\begin{array}{r} \text { Std } \\ \text { error } \end{array}$ | T stat | Effect in size function relative to base |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 311 | size: retail employment in parcel | meal (rest. emp base) |  | -14.218457 | 0.985 | -14.43 | 0.000 |
| 312 | size: service employment in parcel | meal (rest. emp base) |  | -17.121939 | 2.735 | -6.26 | 0.000 |
| 313 | size: total employment in parcel | meal (rest. emp base) |  | -17.517461 | 0.983 | -17.82 | 0.000 |
| 317 | size: \# households in parcel | meal (rest. emp base) |  | -17.242905 | 0.921 | -18.72 | 0.000 |
| 327 | size: restaurant employment in parcel | pers bus. (gov+ofc+educ emp base) |  | -7.827708 | 0.515 | -15.19 | 0.000 |
| 328 | size: (indust.+agr+res.+constr employment) in parcel | pers bus. (gov+ofc+educ emp base) |  | -7.047558 | 0.310 | -22.74 | 0.001 |
| 329 | size: medical employment in parcel | pers bus. (gov+ofc+educ emp base) |  | 0.000000 | 0.000 |  | 1.000 |
| 330 | size: (gov+office+educ employment) in parcel | pers bus. (gov+ofc+educ emp base) |  | -0.415887 | 0.120 | -3.45 | 0.660 |
| 331 | size: retail employment in parcel | pers bus. (gov+ofc+educ emp base) |  | -4.905346 | 0.303 | -16.21 | 0.007 |
| 332 | size: service employment in parcel | pers bus. (gov+ofc+educ emp base) |  | -4.305081 | 0.251 | -17.12 | 0.013 |
| 336 | size: \# households in parcel | pers bus. (gov+ofc+educ emp base) |  | -17.375633 | 0.519 | -33.45 | 0.000 |
| 347 | size: (gov+office+educ employment) in parcel | school under age 16 (K-12 enr. base) |  | -2.063178 | 1.132 | -1.82 | 0.127 |
| 348 | size: total employment in parcel | school under age 16 (K-12 enr. base) |  | -3.196699 | 1.036 | -3.09 | 0.041 |
| 349 | size: K-12 enrollment in parcel | school under age 16 (K-12 enr. base) |  | 0.000000 | 0.000 |  | 1.000 |
| 352 | size: (gov+office+educ employment) in parcel | school, driving age student (K-12 enr. base) |  | -1.935215 | 1.471 | -1.32 | 0.144 |
| 354 | size: K-12 enrollment in parcel | school, driving age student (K-12 enr. base) |  | 0.000000 | 0.000 |  | 1.000 |
| 356 | size: \# households in parcel | school, driving age student (K-12 enr. base) |  | -6.902051 | 2.828 | -2.44 | 0.001 |
| 357 | size: (gov+office+educ employment) in parcel | university (univ enr. base) |  | -7.104093 | 0.944 | -7.52 | 0.001 |
| 358 | size: total employment in parcel | university (univ enr. base) |  | -13.656305 | 2.112 | -6.47 | 0.000 |
| 359 | size: University enrollment in parcel | university (univ enr. base) |  | 0.000000 | 0.000 |  | 1.000 |
| 362 | size: retail employment in parcel | shop (retail emp base) |  | 0.000000 | 0.000 |  | 1.000 |
| 363 | size: service employment in parcel | shop (retail emp base) |  | -9.478390 | 0.579 | -16.37 | 0.000 |
| 364 | size: total employment in parcel | shop (retail emp base) |  | -10.015493 | 0.223 | -44.93 | 0.000 |
| 368 | size: \# households in parcel | shop (retail emp base) |  | -18.634522 | 1.457 | -12.79 | 0.000 |
| 369 | size: restaurant employment in parcel | social rec (svc. emp base) |  | -0.584471 | 0.299 | -1.96 | 0.557 |
| 370 | size: medical employment in parcel | social rec (svc. emp base) |  | -2.550026 | 0.477 | -5.35 | 0.078 |
| 371 | size: retail employment in parcel | social rec (svc. emp base) |  | -3.167902 | 0.694 | -4.57 | 0.042 |
| 372 | size: service employment in parcel | social rec (svc. emp base) |  | 0.000000 | 0.000 |  | 1.000 |
| 373 | size: total employment in parcel | social rec (svc. emp base) |  | -2.891155 | 0.234 | -12.35 | 0.056 |
| 374 | In(1+\# parcels in open space GIS layer w/in qtr mi) | social rec (svc. emp base) |  | -3.952280 | 0.250 | -15.81 | 0.019 |
| 375 | size: K-12 enrollment in parcel | social rec (svc. emp base) |  | -0.473037 | 0.347 | -1.36 | 0.623 |
| 376 | size: University enrollment in parcel | social rec (svc. emp base) |  | -0.797845 | 0.682 | -1.17 | 0.450 |
| 377 | size: \# households in parcel | social rec (svc. emp base) |  | -6.397282 | 0.245 | -26.16 | 0.002 |
| 379 | size: (gov+office+educ employment) in parcel | work (gov+ofc+educ emp. base) |  | 0.000000 | 0.000 |  | 1.000 |
| 381 | size: service employment in parcel | work (gov+ofc+educ emp. base) |  | -1.401843 | 0.459 | -3.05 | 0.246 |
| 382 | size: total employment in parcel | work (gov+ofc+educ emp. base) |  | -1.596878 | 0.221 | -7.23 | 0.203 |
| 386 | size: \# households in parcel | work (gov+ofc+educ emp. base) |  | -11.510201 | 1.359 | -8.47 | 0.000 |
|  |  |  |  |  |  |  |  |
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Table 23: Intermediate stop location model estimation results: Summary statistics


## Tour Mode Choice Models (3.3)

Table 24 shows the number of tours in the estimation data set by tour purpose and mode. There are seven home-based tour purposes (work, school, escort, personal business, shopping, meal, and social/recreation) plus one work-based purpose. There are also eight modes, although some of them are only available for specific purposes. They are listed below along with the availability rules, the same priority order as used to determine the main mode of a multi-mode tour:
(1) DT- Drive to Transit: Available only in the Home-based Work model, for tours with a valid drive to transit path in both the outbound and return observed tour
(2) WT- Walk to Transit: Available in all models except for Home-based Escort, for tours with a valid walk to transit path in both the outbound and return observed tour periods.
(3) SB: School Bus: Available only in the Home-based School model, for all tours.
(4) S3- Shared Ride 3+: Available in all models, for all tours.
(5) S2- Shared Ride 2: Available in all models, for all tours.
(6) DA- Drive Alone: Available in all models except for Home-based Escort, for tours made by persons age 16+ in car-owning households.
(7) BI- Bike: Available in all models except for Home-based Escort, for all tours with round trip road distance of 30 miles or less.
(8) WK- Walk: Available in all models, for all tours with round trip road distance of 10 miles or less.

Table 25 shows the observations in terms of percentages of the estimation sample within tour purpose. Transit has less than $1 \%$ mode share and Bicycle has less than $2 \%$ mode share for all purposes except Work and School.

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Table 24: Tour Mode Choice Estimation Data - Mode Choice and Availability - \# of Observations

| Mode | Code | Home-Based Work |  | Home-Based School |  | Home-Based Escort | Work-Based |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Chosen | Available | Chosen | Available | Chosen | Available | Chosen | Available |
| Drive to Transit | DT | 30 | 1539 |  |  |  |  |  |  |
| Walk to Transit | WT | 68 | 1720 | 55 | 868 |  |  | 362 |  |
| Shared Ride 3+ | S3 | 208 | 3063 | 540 | 1484 | 388 | 877 | 49 | 573 |
| Shared Ride 2 | S2 | 480 | 3063 | 295 | 1484 | 443 | 877 | 100 | 573 |
| Drive Alone | DA | 2172 | 3035 | 188 | 504 |  |  | 321 | 570 |
| Bike | BI | 58 | 2530 | 80 | 1429 |  | 415 | 6 | 545 |
| Walk | WK | 47 | 1221 | 157 | 1191 | 46 | 715 | 428 |  |
| School Bus | SB |  |  | 169 | 1484 |  | 877 | 573 | 573 |
| TOTAL |  | 3063 | 3063 | 1484 | 1484 | 877 | 877 |  |  |


| Mode | Code | HB Pers. Business |  | Home-Based Shop |  | Home-Based Meal | HB Social/Recreat. |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Chosen | Available | Chosen | Available | Chosen | Available | Chosen | Available |
| Walk to Transit | WT | 14 | 1031 | 4 | 926 | 3 | 252 | 3 | 649 |
| Shared Ride 3+ | S3 | 256 | 1643 | 184 | 1382 | 127 | 398 | 270 | 1103 |
| Shared Ride 2 | S2 | 511 | 1643 | 473 | 1382 | 166 | 398 | 344 | 1103 |
| Drive Alone | DA | 801 | 1472 | 655 | 1244 | 81 | 361 | 389 | 881 |
| Bike | BI | 18 | 1539 | 15 | 1301 | 2 | 378 | 17 | 1017 |
| Walk | WK | 43 | 1040 | 51 | 1035 | 19 | 252 | 80 | 719 |
| TOTAL |  | 1643 | 1643 | 1382 | 1382 | 398 | 398 | 1103 | 1103 |

Table 25: Tour Mode Choice Estimation Data - Mode Choice and Availability - \% of Observations

| Mode | Code | Home-Based Work |  | Home-Based School |  | Home-Based Escort | Work-Based |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Chosen | Available | Chosen | Available | Chosen | Available | Chosen | Available |
| Drive to Transit | DT | $1.0 \%$ | $50.2 \%$ |  |  |  |  |  |  |
| Walk to Transit | WT | $2.2 \%$ | $56.2 \%$ | $3.7 \%$ | $58.5 \%$ |  |  |  |  |
| Shared Ride 3+ | S3 | $6.8 \%$ | $100.0 \%$ | $36.4 \%$ | $100.0 \%$ | $44.2 \%$ | $100.0 \%$ | $8.6 \%$ | $100.0 \%$ |
| Shared Ride 2 | S2 | $15.7 \%$ | $100.0 \%$ | $19.9 \%$ | $100.0 \%$ | $50.5 \%$ | $100.0 \%$ | $17.5 \%$ | $100.0 \%$ |
| Drive Alone | DA | $70.9 \%$ | $99.1 \%$ | $12.7 \%$ | $34.0 \%$ |  |  | $56.0 \%$ | $99.5 \%$ |
| Bike | BI | $1.9 \%$ | $82.6 \%$ | $5.4 \%$ | $96.3 \%$ |  |  | $1.0 \%$ | $95.1 \%$ |
| Walk | WK | $1.5 \%$ | $39.9 \%$ | $10.6 \%$ | $80.3 \%$ | $5.2 \%$ | $81.5 \%$ | $16.6 \%$ | $74.7 \%$ |
| School Bus | SB |  |  | $11.4 \%$ | $100.0 \%$ |  |  |  |  |


| Mode | Code | HB Pers. Business |  | Home-Based Shop |  | Home-Based Meal | HB Social/Recreat. |  |  |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Chosen | Available | Chosen | Available | Chosen | Available | Chosen | Available |
| Walk to Transit | WT | $0.9 \%$ | $62.8 \%$ | $0.3 \%$ | $67.0 \%$ | $0.8 \%$ | $63.3 \%$ | $0.3 \%$ | $58.8 \%$ |
| Shared Ride 3+ | S3 | $15.6 \%$ | $100.0 \%$ | $13.3 \%$ | $100.0 \%$ | $31.9 \%$ | $100.0 \%$ | $24.5 \%$ | $100.0 \%$ |
| Shared Ride 2 | S2 | $31.1 \%$ | $100.0 \%$ | $34.2 \%$ | $100.0 \%$ | $41.7 \%$ | $100.0 \%$ | $31.2 \%$ | $100.0 \%$ |
| Drive Alone | DA | $48.8 \%$ | $89.6 \%$ | $47.4 \%$ | $90.0 \%$ | $20.4 \%$ | $90.7 \%$ | $35.3 \%$ | $79.9 \%$ |
| Bike | BI | $1.1 \%$ | $93.7 \%$ | $1.1 \%$ | $94.1 \%$ | $0.5 \%$ | $95.0 \%$ | $1.5 \%$ | $92.2 \%$ |
| Walk | WK | $2.6 \%$ | $63.3 \%$ | $3.7 \%$ | $74.9 \%$ | $4.8 \%$ | $63.3 \%$ | $7.3 \%$ | $65.2 \%$ |

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In order to get enough transit and bicycle tours to provide reasonable estimates, the home-based non-mandatory purposes of shopping, personal business, meal and social/recreation were grouped in a single model, but using purpose-specific dummy variables to allow for different mode shares for different purposes. So, there are five different tour mode choice models, with results shown in Tables $\mathbf{2 6}$ to $\mathbf{3 0}$ below. Some comments on the results follow:

Level of service variables: In general, it was possible to obtain significant coefficients for out-of-vehicle times, but not for travel costs or in-vehicle times. This is a typical result for RP data sets, particularly when there are few transit observations. As a result, many of the coefficients for cost and in-vehicle time were constrained at values that met the following criteria: (1) the invehicle time coefficients meet FTA guidelines, (2) the imputed values of time are reasonable and meet FTA guidelines, and (3) the values were kept as close as possible to what the initial estimation indicated.
(Note: We had thought of using the transit on-board survey data in combination with the household survey data, but recent experience in other cities has shown that this still does not often give significant LOS coefficients, and can introduce error into the models because onboard survey data tends to contain a large amount of coding error and incomplete data relative to household survey data. Furthermore, the on-board survey data does not contain sufficient information about the tour that the trip is part of, which makes it problematic to use in tour-based model estimation.)

The resulting values of time and out-of-vehicle/in-vehicle time ratios are shown in the following table:

Model
Vehicle

| Home-Based Work | $\$ 11.20$ | 2.95 | 2.50 |
| :--- | :--- | :--- | :--- |
| Home-Based School | $\$ 6.00$ | 2.20 | 2.20 |
| Home-Based Escort | $\$ 7.50$ | 3.00 | N/A |
| Home-Based Other | $\$ 7.50$ | 2.72 | 2.72 |
| Work-Based | $\$ 7.50$ | 2.84 | 2.84 |

The number of transfers was not found to be significant in any of the models, however transfer wait time is included in the out-of-vehicle time coefficients.

Other LOS-related variables are included in the Home-Based Work model. Having an LRT stop as the closest stop to home significantly increases the probability of choosing Walk to Transit. Also, the higher the percentage of time in a Drive to Transit path that is spent in the car rather than on transit, the lower the probability of choosing it. This is a result often found in other

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cities as well, which serves to discourage park-and-ride choices that include long drives followed by short transit rides.

Land use variables: Two land use variables came out as significant in many of the models, increasing the probability of walk, bike and transit.

Mixed use density: This is defined as the geometric average of retail and service employment (RS) and households (HH) within a half mile of the origin or destination parcel, in units of thousands of persons $(=0.001 * R S * H H /(R S+H H))$. This value is highest when jobs and households are both high and balanced. High values near the tour origin tend to encourage walking and biking, while high values near the tour destination more often encourage transit use.

Intersection density: This is defined as the number of 4-way intersections plus one half the number of 3-way intersections within a half mile of the origin or destination parcel. Higher values tend to encourage walking for School and Escort tours, where safety for children is an issue, and also to encourage walking, biking and transit for Home-Based Other tours.

Pattern-specific variables: In terms of the activity pattern, the variable that influences mode choice the most is whether or not there are intermediate stops along the tour. With our model design, we do not predict the exact number and purpose of stops on a tour until AFTER tour mode choice is predicted, so we do not know the exact stops on the tour. From the pattern model, however, we do know how many tours are made during the day, as well as for which purposes stops and tours are made. So, if the tour is the only one made during the person-day (which is true in the majority of cases), then we do know when we apply the mode choice models whether or not there are stops on the tour for each purpose. Two variables are used in the models to reflect this type of knowledge:

Escort stop dummy divided by the number of tours in the day: The higher this variable, the higher the chance that there is an escort stop on the tour (the maximum value is 1.0). This variable significantly increases the chance of choosing Shared Ride and decreases the chance of choosing Drive Alone, as one would expect. The effect is strongest for Work tours, but also found for School and HBOther tours.

Number of other stop purposes divided by the number of tours in the day: This variable is analogous to the one for escort stops, but adds together all other stop purposes. The higher this variables, the higher the chance of choosing both Shared Ride and Drive Alone, as the automobile is more conducive to making multi-stop tours. The effects are not as strong as those found for escort stops, however.

Other variables: The other variables in the model are those that are related to the household and the person, and many are those typically found in mode choice models:

Car availability: There are three separate variables:

- HH has no cars
- HH has cars but fewer cars than drivers,
- HH has cars but fewer cars than workers

All of these variables have significant effects in most of the models.
Income: The income effects are not very strong, but there are a few effects discouraging car use for lower income households.

Gender: The only gender effect is one that is often found - that males are more likely to go by bicycle than females.

Age: As one would expect, the strongest age effects are in the School model, with students of various age groups preferring different modes. For the other purposes, there is less chance of choosing Bike (and sometimes Walk) for those over age 50,

Household size: There are strong effects that reduce the chance of Shared Ride 3+ in 1-person or 2-person households and reduce the chance of Shared Ride 2 in 1-person households, reflecting the fact that most "carpools" are intra-household, even for Work tours. There are also effects by age group, with the number of children under 5 and age 5-15 increasing the probability of Shared Ride for Work and Other tours, and the number of children age 16-17 and non-working adults decreasing the probability of Shared Ride. Household size is the strongest variable in the Escort tour model, with both Shared Ride 3+ and Walk becoming more likely relative to Shared Ride $2+$ as the number of young children increases.

Mode to work: It is a typical finding that the most important single variable determining mode choice for work-based tours is the mode used to get to work, with people tending to use that same mode for their work-based tours.

Sub-purposes: In the HBOther model, the results show that, relative to Personal Business tours...

- Shopping tours are more likely to go by Shared Ride and less likely to go by Transit.
- Meal tours are more likely to go by Shared Ride, Transit and Walk.
- Social/recreation tours are more likely to go by Shared Ride, Bike and Walk.

Nesting: A number of different nesting structures were tested. In particular, three nests that combined:
(1) Drive to Transit with Walk to Transit
(2) Shared Ride 2 with Shared Ride 3+
(3) Bike with Walk
were tested with separate coefficients, and all coefficients were less than 1.0 but not significantly different from each other. Because ALOGIT gives more stable results with fewer different nesting parameters (due to the need to define dummy nests for each parameter), it was decided to estimate a single nesting parameter that would apply to all 3 nests (as well as to the 2 additional "nests" that only have one alternative each: Drive Alone, and School Bus). Note that the Transit nest only has a single alternative - Walk to Transit - in all models except for Work.

The estimated logsum parameters are 0.51 for Work, 0.86 for School, and 0.73 for Other. For Work-Based tours, it was not possible to obtain a stable estimate, so a constrained value of 0.75 (similar to HBOther) was used.

No nesting was used for the Escort model, as it contains only 3 alternatives and is a very simple model.

## Application

The application of the models in Tables 26 to 30 was programmed, and the code was used for 3 purposes:

- To test the application of the models against the observed shares in the estimation data.
- To calculate mode choice logsums to be used in other models in the system.
- To be implemented in the final model system.

The tables contain the parameter numbers as used in the application code and coefficients file.

Table 26: Home-Based Work Tour Mode Choice Model

| Par \# | Modes | Variable | Coefficient | T-Stat |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Level of Service |  |  |
| 1 | DA,S2,S3,DT,WT | Cost (\$) | -0.161 | -4.9 |
| 2 | DA,S2,S3,DT,WT | In-vehicle time (min) | -0.030 | Const |
| 3 | DT,WT | Wait time (min) | -0.075 | Const |
| 7 | DT,WT,BI,WK | Walk and bike time (min) | -0.089 | -7.3 |
|  |  | Mode-specific |  |  |
| 10 | DT | Constant | -4.089 | -3.2 |
| 11 | DT | No cars in HH | -2.000 | Const |
| 13 | DT | HH fewer cars than workers | -1.563 | -2.2 |
| 18 | DT | Drive time/total in-vehicle time | -3.393 | -1.6 |
| 20 | WT | Constant | -4.195 | -3.7 |
| 8 | WT | LRT walk access | 3.552 | 2.3 |
| 168 | WT,DT | Mixed use density at destination | 0.018 | 3.8 |
| 30 | S3 | Constant | -3.772 | -5.2 |
| 38 | S3 | One person HH | -3.624 | -5.1 |
| 39 | S3 | Two person HH | -1.729 | -6.5 |
| 40 | S2 | Constant | -3.143 | -4.4 |
| 48 | S2 | One person HH | -3.145 | -4.8 |
| 31 | S2,S3 | HH \# children under age 5 | 0.744 | 2.6 |
| 32 | S2,S3 | HH \# children age 5-15 | 0.546 | 3.6 |
| 34 | S2,S3 | HH \# non-working adults 18+ | -0.287 | -1.3 |
| 35 | S2,S3 | Log of auto distance (miles) | -0.376 | -3.5 |
| 41 | S2,S3 | No cars in HH | -5.246 | -3.6 |
| 42 | S2,S3 | HH fewer cars than drivers | 1.024 | 3.0 |
| 133 | S2,S3 | Escort stop purpose / \# tours in day | 6.643 | 5.3 |
| 134 | S2,S3 | Other stop purposes / \# tours in day | 0.709 | 2.3 |
| 50 | DA | Constant | 1.512 | 2.4 |
| 53 | DA | HH fewer cars than workers | -1.304 | -3.7 |
| 54 | DA | HH income under \$25K | -1.174 | -3.0 |
| 131 | DA | Escort stop purpose / \# tours in day | -4.232 | -3.9 |
| 132 | DA | Other stop purposes / \# tours in day | 0.342 | 1.3 |
| 60 | BI | Constant | -5.407 | -6.2 |
| 61 | BI | Male | 1.822 | 2.9 |
| 63 | BI | Age over 50 | -1.369 | -2.4 |
| 64 | BI | Davis zones | 4.957 | 6.6 |
| 67 | BI | Mixed use density at origin | 0.019 | 3.0 |
| 71 | WK | Male | -1.487 | -2.4 |
| 77 | WK | Mixed use density at origin | 0.013 | 2.1 |
| 99 | All | Mode nesting parameter | 0.510 | 7.6 |

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Table 27: Home-Based School Tour Mode Choice Model

| Par \# | Modes | Variable | Coefficient | T-Stat |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Level of Service |  |  |
| 1 | DA,S2,S3,WT | Cost (\$) | -0.150 | Const |
| 2 | DA,S2,S3,WT | In-vehicle time (min) | -0.015 | Const |
| 3 | WT,BI,WK | Out-of-vehicle time (min) | -0.033 | -6.9 |
|  |  | Mode-specific |  |  |
| 10 | SB | Constant | -1.294 | -3.5 |
| 17 | SB | Child under age 5 | -0.612 | -0.5 |
| 18 | SB | Adult age 18+ | -3.011 | -2.4 |
| 20 | WT | Constant | -2.331 | -3.4 |
| 21 | WT | No cars in HH | 1.113 | 1.9 |
| 22 | WT | HH fewer cars than drivers | 0.716 | 1.8 |
| 27 | WT | Child under age 5 | -5.000 | Const |
| 28 | WT | Adult age 18+ | 1.993 | 4.0 |
| 29 | WT | Child age 16-17 | 1.566 | 3.0 |
| 167 | WT | Mixed use density at origin | 0.013 | 2.3 |
| 168 | WT | Mixed use density at destination | 0.007 | 1.4 |
| 30 | S3 | Constant | 0.345 | 1.0 |
| 37 | S3 | One or two person HH | -1.412 | -4.8 |
| 40 | S2 | Constant | -0.311 | -0.9 |
| 38 | S2 | One person HH | -1.768 | -1.6 |
| 41 | S2,S3 | No cars in HH | -2.803 | -3.2 |
| 44 | S2,S3 | HH income under \$25K | -0.675 | -2.5 |
| 45 | S2,S3 | HH income \$25-50K | -0.520 | -2.6 |
| 47 | S2,S3 | Child under age 5 | 1.646 | 2.6 |
| 133 | S2,S3 | Escort stop purpose / \# tours in day | 2.762 | 4.3 |
| 134 | S2,S3 | Other stop purposes / \# tours in day | 0.433 | 2.5 |
| 50 | DA | Constant | 2.287 | 4.6 |
| 52 | DA | HH fewer cars than drivers | -1.111 | -3.7 |
| 54 | DA | HH income under \$ 25 K | -1.409 | -3.3 |
| 56 | DA | HH income over \$75K | 0.583 | 1.8 |
| 59 | DA | Child age 16-17 | -2.245 | -5.7 |
| 131 | DA | Escort stop purpose / \# tours in day | -1.575 | -1.5 |
| 132 | DA | Other stop purposes / \# tours in day | 0.464 | 1.8 |
| 60 | BI | Constant | -2.873 | -6.8 |
| 61 | BI | Male | 0.564 | 1.8 |
| 64 | BI | Davis zones | 3.739 | 9.0 |
| 69 | BI | Adult age 18+ | 0.760 | 1.9 |
| 75 | WK | Intersection density at origin | 0.009 | 2.3 |
| 99 | All | Mode nesting parameter | 0.865 | 7.7 |

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Table 28: Home-Based Escort Tour Mode Choice Model

| Par \# | Modes | Variable | Coefficient | T-Stat |
| :--- | :--- | :--- | :---: | :---: |
|  |  | Level of Service |  |  |
| 7 | S2,S3,WK | Cost (\$) | -0.400 | Const |
| 7 | S2,S3,WK | In-vehicle time (min) | -0.050 | Const |
| 7 | S2,S3,WK | Out-of-vehicle time (min) | -0.150 | -5.8 |
|  |  | Mode-specific |  |  |
| 40 | S2 | Constant | 0.267 | 0.4 |
| 30 | S3 | Constant | -0.629 | -0.8 |
| 31 | S3 | HH \# children under age 5 | 0.915 | 5.8 |
| 32 | S3 | HH \# children age 5-15 | 0.469 | 7.1 |
| 33 | S3 | HH \# children age 16-17 | -0.372 | -2.8 |
| 41 | S2,S3 | No cars in HH | -5.914 | -3.4 |
| 73 |  | WK | Age over 50 | -0.703 |
| 76 | WK | Intersection density at destination | 0.020 | -1.0 |
| 81 | WK | HH \# children under age 5 | 0.9 |  |
| 82 | WK | HH \# children age 5-15 | 0.437 | 2.7 |
| 83 | WK | HH \# children age 16-17 | -1.626 | -2.9 |

Table 29: Work-Based Tour Mode Choice Model

| Par \# | Modes | Variable | Coefficient | T-Stat |
| :--- | :--- | :--- | :---: | :---: |
|  |  | Level of Service |  |  |
| 1 | DA,S2,S3,WT | Cost (\$) | -0.200 | Const |
| 2 | DA,S2,S3,WT | In-vehicle time (min) |  |  |
| Out-of-vehicle time (min) | -0.025 | Const <br> 3 | WT,BI,WK | -0.071 |
|  | Mode-specific |  |  |  |
| 20 | WT | Constant | -3.436 | -3.4 |
| 30 | S3 | Constant | -4.748 | -3.4 |
| 40 | S2 | Constant | -3.978 | -2.8 |
| 88 | S2,S3 | Drive alone to work | 2.720 | 2.1 |
| 89 | S2,S3 | Shared ride to work | 3.222 | 2.4 |
| 50 | DA | Constant | -4.595 | -2.5 |
| 54 | DA | HH income under \$25K | -0.827 | -1.3 |
| 55 | DA | DH income \$25-50K | -0.428 | -1.3 |
| 58 | DA | Shared ride to work | 5.502 | 3.1 |
| 59 | DA | Constant | 4.368 | 2.5 |
| 60 | BI | Male | -12.436 | -6.0 |
| 61 | BI | Davis zones | 2.032 | 1.2 |
| 64 | BI | Bike to work | 10.299 | 6.3 |
| 69 | BI | Mixed use density at origin | 10.000 | Const |
| 77 | WK | Walk to work | 0.015 | 4.8 |
| 79 | WK | Mode nesting parameter | 7.000 | Const |
| 99 | All |  | 0.750 | Const |

Table 30: Home-Based Other Tour Mode Choice Model

| Par \# | Modes | Variable | Coefficient | T-Stat |
| :--- | :--- | :--- | :---: | :---: |
|  |  | Level of Service | -0.200 | Const |
| 1 | DA,S2,S3,WT | Cost (\$) | -0.025 | Const |
| 2 | DA,S2,S3,WT | In-vehicle time (min) | -0.068 | -8.9 |
| 7 | WT,BI,WK | Out-of-vehicle time (min) |  |  |
|  |  | Mode-specific | -4.660 | -4.3 |
| 20 | WT | Constant | 3.594 | 3.9 |
| 21 | WT | No cars in HH | 0.008 | 1.3 |
| 165 | WT | Intersection density at origin | 0.014 | 2.5 |
| 168 | WT | Mixed use density at destination | -1.928 | -2.1 |
| 171 | WT | Shopping tour | 2.000 | 2.0 |
| 172 | WT | Meal tour | -0.643 | -1.7 |
| 30 | S3 | Constant | -4.149 | -9.8 |
| 38 | S3 | One person HH | -1.779 | -16.8 |
| 39 | S3 | Two person HH | -0.650 | -1.7 |
| 40 | S2 | Constant | -2.454 | -6.8 |
| 48 | S2 | One person HH | 0.657 | 3.7 |
| 31 | S2,S3 | HH \# children under age 5 children age 5-15 | 0.127 | 1.7 |
| 32 | S2,S3 | HH \# non-working adults 18+ | 0.244 | 3.8 |
| 34 | S2,S3 | Log of auto distance (miles) | 0.317 | 4.5 |
| 35 | S2,S3 | No cars in HH | -1.323 | -2.4 |
| 41 | S2,S3 | HH fewer cars than workers | 0.439 | 2.5 |
| 43 | S2,S3 | Escort stop purpose / \# tours in day | 1.742 | 3.1 |
| 133 | S2,S3 | Other stop purposes / \# tours in day | 0.514 | 2.6 |
| 134 | S2,S3 | Shopping tour | 0.243 | 2.0 |
| 174 | S2,S3 | Meal tour | 2.329 | 7.0 |
| 175 | S2,S3 | Social/recreation tour | 0.580 | 3.9 |
| 176 | S2,S3 | Constant | 1.590 | 3.7 |
| 50 | DA | HH fewer cars than drivers | -0.432 | -2.7 |
| 52 | DA | Escort stop purpose / \# tours in day | -1.020 | -1.8 |
| 131 | DA | Other stop purposes / \# tours in day | 0.294 | 1.5 |
| 132 | DA | Constant | -4.085 | -7.1 |
| 60 | BI | Male | 0.911 | 2.7 |
| 61 | BI | Age over 50 | -0.619 | -1.7 |
| 63 | BI | Davis zones | 2.845 | 5.6 |
| 64 | BI | Intersection density at origin | 0.011 | 1.9 |
| 65 | BI | Mixed use density at origin | 0.011 | 2.0 |
| 67 | BI | Social/recreation tour | 0.881 | 2.2 |
| 182 | BI | Age over 50 | -0.471 | -1.9 |
| 73 | WK | Davis zones | 1.367 | 3.4 |
| 74 | WK | Intersection density at origin | 0.012 | 4.1 |
| 75 | WK | Meal tour | 1.390 | 3.2 |
| 178 | WK | Social/recreation tour | 1.349 | 4.5 |
| 179 | WK | Mode nesting parameter | 0.730 | 8.6 |
| 99 | All |  |  |  |
|  |  |  |  |  |

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## Trip Mode Choice Model (4.3)

Table 31 below shows the distribution in the household survey data of valid trip-level mode choice records versus the mode for the tour. According to the hierarchy used to assign the main mode, only a subset of modes may be parts of certain tours. At the extreme end, all 1127 trips that are part of walk tours are walk trips.

Table 31: Tour Mode (columns) vs. Trip Mode (rows)

| Tour mode / <br> Trip mode | drive-transitwalk | walk-transitwalk | school bus | shared ride 3+ | shared ride 2 |  | bike | walk | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| drive-transit-walk | 47 |  |  |  |  |  |  |  | 47 |
| walk-transit-drive | 23 |  |  |  |  |  |  |  | 23 |
| walk-transit-walk | 9 | 282 |  |  |  |  |  |  | 291 |
| school bus | 2 | 3 | 293 |  |  |  |  |  | 298 |
| car-shared ride 3+ | 7 | 17 | 62 | 4,024 |  |  |  |  | 4,110 |
| car-shared ride 2 | 20 | 37 | 62 | 1,085 | 5,895 |  |  |  | 7,099 |
| car-drive alone | 15 | 13 | 9 | 719 | 1,852 | 11,478 |  |  | 14,086 |
| Bike |  | 8 |  | 7 | 12 | 8 | 437 |  | 472 |
| Walk | 11 | 58 | 23 | 116 | 113 | 64 | 22 | 1,127 | 1,534 |
| Total | 134 | 418 | 449 | 5,951 | 7,872 | 11,550 | 459 | 1,127 | 27,960 |

As shown in Table 32, almost 85\% of all trips have the same tour mode and trip mode. The purpose of the trip level mode choice model is to explain the other $15 \%$. The table also shows that the large majority of those remaining trips are either shared ride 2 trips in shared ride 3+ tours, or else drive alone trips in shared ride tours. So, it is up to the trip level mode choice model to explain which trips in shared ride tours are shared ride and which are drive alone. There are also 205 trips ( $0.7 \%$ ) that are shared ride trips in transit or (mainly) school bus tours. A further 407 trips are walk trips on non-walk tours (1.5\%). This leaves only $0.3 \%$ of trips in all other combinations.

Table 32: Summary of tour/trip mode combination types

|  | Frequency | Percent |
| :--- | ---: | ---: |
| Tour mode and trip mode are the same | 23,606 | 84.4 |
| Tour and trip modes are different, but both by car | 3,656 | 13.1 |
| Shared ride trip on a transit/school bus tour | 205 | 0.7 |
| Walk trip on a non-walk tour | 407 | 1.5 |
| All other combinations | 86 | 0.3 |
| Total | 27,960 | 100 |

For model estimation, trips were excluded for the same for a number of reasons:

- Walk trips on walk tours were excluded because only one alternative is available
- Trips were excluded when they were the last chronological trip in the tour, and no previous trip in the tour had used the main tour mode. In those cases, by definition, the last trip must be the main tour mode. (This was 423 cases, or about 1.5\%)
- Various other trips were dropped when the chosen mode was not available in the networks.

The remaining cases for estimation is 25,080. Model statistics are shown in Table 33.
Table 33: Model Statistics

| Alternative | Chosen | Unchosen | Available | Unavailable |  |
| :--- | ---: | ---: | ---: | ---: | :---: |
| drive-transit-walk | 50 | 34 | 84 | 24,996 |  |
| walk-transit-walk | 249 | 188 | 437 | 24,643 |  |
| school bus | 261 | 261 | 522 | 24,558 |  |
| car-shared ride 3+ | 3,964 | 2,685 | 6,649 | 18,431 |  |
| car-shared ride 2 | 6,900 | 7,418 | 14,318 | 10,762 |  |
| car-drive alone | 12,826 | 8,199 | 21,025 | 4,055 |  |
| Bike | 434 | 23,898 | 24,332 | 748 |  |
| Walk | 396 | 16,991 | 17,387 | 7,693 |  |
| Final log likelihood | -9017.6 |  |  |  |  |
| Rho-squared (0) | 0.6943 |  |  |  |  |
| Rho-squared (constants) |  |  |  |  |  |

Table 34 shows the estimated coefficients for the model. A key variable was the generalized cost of the trip. To calculate the generalized cost, the all time and cost variables were multiplied by the estimated coefficients for the appropriate tour level mode choice model (Tables 26 to 30 above), assuming that the value of time is the same for all trips along the same tour. For this assumption to hold, the estimated coefficient on the generalized cost variable should be near 1.0, and the estimated result is 1.069 , not significantly different from 1 . Most of the other modespecific variables in Table 34 are variables that were also significant in at least one of the tour level models (Tables 26 to 30), and they show similar effects here.

The model also includes three new types of variables that are specific to the trip-level data. A large proportion of the mixed drive alone (DA)/shared ride (SR) tours are tours that contain at least one escort (pick up/drop off) stop. The first set of variables (par \# 161-170) attempt to explain which trips are shared ride by looking at both the origin purpose and destination purpose, as well as the time of day. Not surprisingly, trips to work in the morning after dropping someone off and from work in the afternoon before picking someone up are rarely shared ride trips. The opposite side of these are the positive SR coefficients for trips from home to drop off in the AM and trips from pick up to home in the PM. Trips from an escort stop back home in the AM, and to an escort stop in the midday tend not to be shared ride.

Table 34: Trip mode choice model coefficients

| Par <br> $\#$ | Variable | Coefficient | T- |
| :---: | :--- | :---: | :---: |
| statistic |  |  |  |
| 1 | Generalized cost (using coef from tour mode choice) | 1.069 | 17.2 |
| 10 | DT- constant | 0.365 | 0.8 |
| 12 | DT- cars < household drivers | -1.054 | -2.0 |
| 20 | WT - constant | 0.060 | 0.2 |
| 22 | WT- cars < household drivers | -0.845 | -3.1 |
| 30 | S3- constant | 1.574 | 6.9 |
| 36 | S3- One person household | -0.215 | -8.5 |
| 37 | S3- Two person household | 0.095 | 2.7 |
| 40 | S2- Constant | -1.180 | -6.4 |
| 38 | S2- One person household | -0.362 | -4.1 |
| 32 | SR- Household members age 5-15 | -0.931 | -8.5 |
| 34 | SR- Household non-working adults | 1.032 | 4.9 |
| 41 | SR- No cars in household | -1.094 | -3.6 |
| 149 | SR- work tour | -1.250 | -15.4 |
| 150 | SR - school tour | -0.974 | -6.6 |
| 152 | SR - escort tour | -0.951 | -9.0 |
| 153 | SR - shopping tour | 0.276 | 3.0 |
| 154 | SR - meal tour | 0.833 | 4.8 |
| 155 | SR - social/rec tour | 0.151 | 1.4 |
| 50 | DA- constant | 1.514 | 7.7 |
| 52 | DA- cars < household drivers | -0.275 | -4.7 |
| 54 | DA- household income <\$25000 | -0.521 | -5.4 |
| 55 | DA- household income \$25-45000 | -0.128 | -1.8 |
| 59 | DA - age 16-17 | -0.955 | -4.6 |
| 60 | BI- constant | -1.870 | -4.8 |
| 61 | BI- male | 1.065 | 4.0 |
| 62 | BI - age under 35 | 0.611 | 2.0 |
| 64 | BI - Davis origin/destination | 2.122 | 7.1 |
| 65 | BI - origin intersection density | 0.006 | 2.5 |
| 147 | BI - work-based tour | -1.771 | -1.8 |
| 72 | WK - age under 35 | 0.647 | 3.9 |
| 75 | WK - origin intersection density | 0.002 | 1.9 |
| 78 | WK - destination mixed use density | 0.006 | 4.1 |
| 141 | WK - work tour | 0.463 | 2.9 |
| 142 | WK - school tour | 0.863 | 4.5 |
| 161 | SR - escort to work trip / am peak period | -1.860 | -9.5 |
| 162 | SR - work to escort trip / pm peak period | -1.768 | -8.4 |
| 163 | SR - home to escort trip / am peak period | 1.883 | 11.8 |
| 164 | SR - home to escort trip / midday period | -1.771 | -11.8 |
| 165 | SR - home to escort trip / pm peak period | -0.167 | -0.7 |
| 166 | SR - home to escort trip / evening period | -1.522 | -7.0 |
| 167 | SR - escort to home trip / am peak period | -2.771 | -14.6 |
| 168 | SR - escort to home trip / midday period | -0.105 | -0.6 |
| 169 | SR - escort to home trip / pm peak period | 1.634 | 7.3 |
| 170 | SR - escort to home trip / evening period | -0.975 | -5.3 |
|  |  |  |  |

Table 34: Trip mode choice model coefficients (continued)

| Par <br> $\#$ | Variable | Coefficient | T- <br> statistic |
| :---: | :--- | :---: | :---: |
| 100 | All - Same as tour mode | 2.183 | 11.7 |
| 102 | All- same as tour mode - only outbound trip | 0.788 | 10.8 |
| 103 | All- same as tour mode - only return trip | 0.677 | 9.1 |
| 104 | All- same as tour mode - first of 2+ outbound trips | -0.159 | -1.9 |
| 105 | All- same as tour mode - first of 2+ return trips | 0.041 | 0.5 |
| 106 | All- same as tour mode - last of 2+ outbound trips | 0.102 | 1.1 |
| 107 | All- same as tour mode - last of 2+ return trips | -0.110 | -1.3 |
| 112 | SB - DT tour | -2.104 | -2.0 |
| 113 | SB - WT tour | -3.326 | -4.3 |
| 114 | S3 - DT tour | -1.596 | -3.6 |
| 115 | S3 - WT tour | -2.559 | -6.4 |
| 116 | S3 - SB tour | 0.884 | 2.7 |
| 118 | S2 - WT tour | -1.325 | -3.8 |
| 119 | S2 - SB tour | 1.392 | 4.3 |
| 120 | S2 - S3 tour | 1.666 | 7.2 |
| 121 | DA - DT tour | -1.723 | -4.7 |
| 122 | DA - WT tour | -3.253 | -7.5 |
| 124 | DA - S3 tour | 0.537 | 2.1 |
| 125 | DA - S2 tour | 0.557 | 2.3 |
| 127 | BI - WT tour | -2.004 | -4.2 |
| 129 | BI - S3 tour | -2.246 | -4.9 |
| 130 | BI - S2 tour | -1.910 | -5.0 |
| 131 | BI - DA tour | -2.579 | -4.5 |

Parameters 100-107 are mainly positive coefficients for the likelihood that the trip mode is the same as the tour mode, regardless of mode. This is particularly true when the half tour only has one trip (no intermediate stops). In cases where the half tour has $2+$ trips, the mode for the first outbound trip and last return trip are the least likely to be the same as the tour mode, although these effects are not strong.

Finally, parameters 112-131 apply to specific trip mode/tour mode combinations, all relative to the "base" trip mode of walk. The general pattern in these coefficients is:

- Relative to the walk mode, school bus (SB), shared ride (S3,S2) and drive alone (DA) are not likely as part of transit tours (DT,WT)
- Relative to the walk mode, shared ride $(\mathrm{S} 2, \mathrm{~S} 3)$ are more likely as part of school bus (SB) tours.
- The strongest positive switching is for S2 on S3 tours.
- Relative to the walk mode, drive alone (DA) is more likely on shared ride (S2, S3) tours.
- Relative to the walk mode, bike (BI) is not likely to be a part of any tours that are not bike-only tours.


## Auto Availability Model (1.4)

The auto availability model occurs within the Long Term Choice portion of the model system, occurring at model step 1.4, as highlighted in Figure 2. In this structure, it is assumed that the household's auto availability decision is made with full knowledge of all household members' usual work and school locations.

Throughout this document, the terms auto, vehicle and car are used interchangeably. They all refer to vehicles as defined and counted in the household survey used for model estimation. Auto availability refers to the number of vehicles owned, leased, or otherwise available for use by the household. Any person aged 16 or over is called a driver.

Table 35 shows the distribution of available autos by number of drivers among the households in the survey data used for model estimation. The number of autos is strongly correlated with the number of drivers.

Table 35a: Frequency of households in estimation sample tabulated by number of household autos available and number of drivers in household

|  |  | Number of household autos available |  |  |  |  |  |  |  |  |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |  |
|  | 1 | 131 | 771 | 146 | 49 | 7 | 1 | 2 |  |  |  | 1107 |
| Number of | 2 | 34 | 364 | 1315 | 339 | 78 | 34 | 7 | 2 | 3 | 4 | 2180 |
| drivers in | 3 | 5 | 44 | 161 | 195 | 56 | 18 | 3 | 1 | 2 |  | 485 |
| household | 4 | 1 | 13 | 24 | 40 | 36 | 17 | 3 | 1 |  |  | 135 |
|  | 5 |  | 1 | 11 | 1 | 6 | 5 | 1 | 1 |  |  | 26 |
|  | 6 |  | 1 |  | 1 | 1 | 2 | 1 |  |  |  | 6 |
|  | 7 |  |  |  |  | 1 |  |  | 1 |  |  | 2 |
|  | 8 |  |  |  |  |  |  | 1 |  |  |  | 1 |
|  | tal | 171 | 1194 | 1657 | 625 | 185 | 77 | 18 | 6 | 5 | 4 | 3942 |

Table 35b: Percentage of households in estimation sample tabulated by number of household autos available and number of drivers in household

|  |  | Number of household autos available |  |  |  |  |  |  |  |  |  | $\frac{\text { Total }}{28.1 \%}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |  |
|  | 1 | 3.3\% | 19.6\% | 3.7\% | 1.2\% | .2\% | .0\% | .1\% |  |  |  |  |
| Number of | 2 | .9\% | 9.2\% | 33.4\% | 8.6\% | 2.0\% | .9\% | .2\% | .1\% | .1\% | .1\% | 55.3\% |
| drivers in | 3 | .1\% | 1.1\% | 4.1\% | 4.9\% | 1.4\% | .5\% | .1\% | .0\% | .1\% |  | 12.3\% |
| household | 4 | .0\% | .3\% | .6\% | 1.0\% | .9\% | .4\% | .1\% | .0\% |  |  | 3.4\% |
|  | 5 |  | .0\% | . $3 \%$ | .0\% | .2\% | .1\% | .0\% | .0\% |  |  | .7\% |
|  | 6 |  | .0\% |  | .0\% | .0\% | .1\% | .0\% |  |  |  | .2\% |
|  | 7 |  |  |  |  | .0\% |  |  | .0\% |  |  | .1\% |
|  | 8 |  |  |  |  |  |  | .0\% |  |  |  | .0\% |
|  | tal | 4.3\% | 30.3\% | 42.0\% | 15.9\% | 4.7\% | 2.0\% | .5\% | .2\% | .1\% | .1\% | 100\% |

The model is structured as a multinomial logit (MNL) with five available alternatives: $0,1,2,3$, and $4+$. The 4+ aggregate category is used because very few of the 3942 households in the sample have five or more autos, and all but 12 of those have less than five drivers, so households with $4+$ autos almost never have competition for autos within the household.

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Table 36 shows the results of model estimation, and a description of the model variables follows with a summary of the estimation results.

Table 36: Household Auto Availability Model

|  | No car |  |  | 1 car |  |  | 2 cars |  |  | 3 cars |  |  | 4 cars |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Description | ID | Coeff | T stat | ID | Coeff | T stat | ID | Coeff | T stat | ID | Coeff | T stat | ID | Coeff | T stat |
| 1 driver in HH | 1 | -5.819 | -5.6 |  |  |  | 2 | -1.575 | -10.1 | 3 | -2.676 | -12.9 | 4 | -4.031 | -10.4 |
| 2 drivers in HH | 5 | -6.830 | -6.5 | 6 | -1.772 | -9.3 |  |  |  | 7 | -1.375 | -11.8 | 8 | -2.100 | -9.3 |
| 3 drivers in HH | 9 | -6.680 | -5.7 | 10 | -1.486 | -5.3 | 11 | -0.280 | -1.3 |  |  |  | 12 | -0.477 | -1.9 |
| 4+ drivers in HH | 13 | -8.086 | -5.3 | 14 | -1.997 | -4.6 | 15 | -1.024 | -3.0 | 16 | -0.969 | -2.8 |  |  |  |
| Cars per driver--nonfamily households | 17 | -0.469 | -1.8 | 17 | -0.469 | -1.8 | 17 | -0.469 | -1.8 | 17 | -0.469 | -1.8 | 17 | -0.469 | -1.8 |
| Dummy-at least as many cars as workers | 18 | 0.578 | 4.9 | 18 | 0.578 | 4.9 | 18 | 0.578 | 4.9 | 18 | 0.578 | 4.9 | 18 | 0.578 | 4.9 |
| part-time workers per driver | 19 |  |  | 20 |  |  |  |  |  | 21 | -0.325 | -1.2 | 22 | -0.382 | -0.9 |
| retired adults per driver | 23 |  |  | 24 | 0.281 | 2.4 |  |  |  | 25 | -0.338 | -2.1 | 26 | -0.560 | -2.2 |
| university students per driver | 27 |  |  | 28 | 0.795 | 3.0 |  |  |  | 29 | 0.682 | 2.1 | 30 |  |  |
| driving age children per driver | 31 | 2.281 | 1.9 | 32 | 1.234 | 2.1 |  |  |  | 33 | -0.742 | -1.4 | 34 | -2.830 | -3.8 |
| home-based workers and students per driver | 35 | 1.000 | 2.7 | 36 | 0.570 | 3.2 |  |  |  | 37 |  |  | 38 | -0.211 | -0.8 |
| children under 5 per driver | 39 | -0.630 | -0.9 | 40 |  |  |  |  |  | 41 | -0.475 | -1.6 | 42 | -1.717 | -2.8 |
| Dummy--HH income under \$15,000 per year | 43 | 2.217 | 8.7 | 44 | 0.547 | 3.0 |  |  |  | 45 | -0.609 | -1.9 | 46 | -1.218 | -2.2 |
| Dummy--HH income \$50-75,000 per year | 47 | -1.419 | -3.5 | 48 | -1.138 | -9.0 |  |  |  | 49 | 0.178 | 1.4 | 50 | 0.198 | 1.1 |
| Dummy--HH income above \$75,000 per year | 51 | -1.600 |  | 52 | -1.231 | -6.6 |  |  |  | 53 | 0.310 | 2.2 | 54 | 0.435 | 2.2 |
| Dummy--HH income not reported | 55 | -0.081 | -0.2 | 56 | -0.577 | -3.6 |  |  |  | 57 | 0.168 | 0.9 | 58 | -0.371 | -1.2 |


|  | No car |  |  | Less cars than drivers |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Accessibility: Difference between logsums with full HH car availability and no HH car availability <br> --Mode choice logsum to work--fulltime workers | 59 | -0.242 | -3.3 | 60 | -0.068 | -3.1 |
| --Mode choice logsum to work-other workers | 61 | -0.279 | -1.9 | 61 | -0.077 | -2.0 |
| --Mode choice logsum to school--students age 16+ | 63 |  |  | 64 | -0.094 | -1.9 |
| --Driver's non-work mode-dest logsum | 67 | -0.250 | -1.7 | 68 |  |  |
| Amount (mi) by which distance to nearest transit stop is less than $1 / 2$ mile (capped at .25) | 70 | 11.141 | 2.6 | 72 | 1.126 | 1.5 |
| Amount (mi) by which distance to nearest transit stop is less than $1 / 4$ mile | 69 | 5.244 | 3.3 | 71 | 1.338 | 1.7 |
| Avg daily parking price (\$) within $1 / 2$ mile of home | 73 | 0.104 | 3.5 | 74 | 0.051 | 1.2 |
| Natural log of commercial employment (food, retail, serevice, medical) within $1 / 2 \mathrm{mi}$ of home | 75 | 0.210 | 3.8 | 76 | 0.138 | 5.0 |
| Summary statistics |  |  |  |  |  |  |
| Number observed choices |  | 3942 |  |  |  |  |
| Number of estimated parameters |  | 64 |  |  |  |  |
| Log likelihood w coeffs=0 |  | -6344 |  |  |  |  |
| Final Log likelihood |  | -3884 |  |  |  |  |
| Rho squared |  | 0.388 |  |  |  |  |
| Adjusted rho squared |  | 0.378 |  |  |  |  |

Number of drivers in household. Rows 1-4 are alternative-specific constants by number of drivers. They capture much of the strong correlation between number of drivers and number of autos.

Cars per driver (for nonfamilies). The negative coefficient for this variable indicates that nonfamily households tend to have less cars per driver than do families.

Cars greater than or equal to number of workers. This captures the tendency to have at least one car for every worker in the household.

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Persons per driver by person type. Rows 7-12 capture variations in car ownership rates depending on the type of persons in the household. For example, row 10 indicates that households are less likely to have a car for every high school driver than for other drivers in the household, and row 11 indicates that the same is true for workers who usually work at home.

Income categories. Rows 13-15 are alternative-specific dummy variables for income categories that capture a strong correlation between income and car ownership.

Accessibility to work and school. The variables in rows 17-19 are derived from mode choice logsums for workers and students in the household, traveling to their usual work and school locations. Row 17, for fulltime workers, is explained here, and rows 18 and 19 are analogous for other workers and students, respectively. The mode choice logsum for the work tour is calculated for each fulltime worker assuming the household has a car for every driver, and again assuming the household has no cars. The variable used in model estimation is the difference between these two logsums. Two separate coefficients are estimated, one associated with the 0 car alternative, and the other associated with all alternatives where drivers in the household must compete for cars. Both coefficients are negative, with the 0 car coefficient being larger in magnitude. The effect in the model is as follows: The difference variable is always positive, and when accessibility by car is much greater than by other modes, the difference variable is larger. When the difference is larger, the household is less likely to tolerate competition for cars among drivers, and even less likely to live without a car at all.

Accessibility of nonwork activities. This variable in row 20 is calculated and used like the work and school accessibility variables, with the following differences. Only one variable is used for the entire household, instead of one per driver. It is derived from non-work modedestination logsums, so it represents accessibility in the neighborhood surrounding the residence for non-work activities. The pre-calculated aggregate mode-destination logsums for adults (with and without car available) are used for this purpose. Here, the effect is only statistically significant for the 0 car alternative. Inaccessibility by non-auto modes for nonwork activities slightly increases the tendency to have at least one car, but doesn't increase the tendency to have at least one car per driver.

Accessibility to nearest transit stop. Rows 21 and 22 capture increased tendency to live with less or no cars when the nearest transit stop is within a half mile. Row 21 captures this for distances less than $1 / 2$ mile, with an increasing effect as the distance drops to $1 / 4$ mile. Row 22 captures additional effect for distances less than $11 / 4$ mile, with the effect also increasing as distance drops to 0 .

Parking prices in neighborhood. Row 23 captures lower vehicle ownership rates among people living in neighborhoods where it costs money to park during the day, with ownership rates dropping as the price increases.

Commercial employment in the neighborhood. Similarly, row 24 captures correlation between vehicle ownership rates and commercial employment in the neighborhood, with ownership rates declining as commercial employment increases. The hypothesis is that people are more likely to live with less cars if they can get to commercial activities without one.

## Model application with estimation data

An appendix provides statistical results from applying the models on the estimation data, showing how well the model predicts the observed outcomes in the estimation data set. Table 37 extracts from the appendix the modeled average auto ownership for various subsets of the sample households, and compares it to modeled auto ownership under four simple prediction scenarios. The results indicate that the model is sensitive to the policy scenarios, but the elasticity is very small. The most sensitive population segment by far is the lowest income group, and after that the elasticity is greater for households with one person, one driver, or no worker, than for other households.

Table 37: Modeled average car ownership and elasticity for four scenarios

|  | $\begin{aligned} & \text { Base } \\ & \text { case } \end{aligned}$ | Increase auto time by 10\% |  | Reduce walk distance to transit by 10\% |  | Increase auto cost by 10\% |  | All other changes, plus reduce transit times and costs by 10\% |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Subset of households | Avg \# cars | $\begin{aligned} & \text { avg } \\ & \text { \# cars } \end{aligned}$ | elast. | $\begin{gathered} \text { avg } \\ \# \text { cars } \end{gathered}$ | elast. | $\begin{gathered} \text { avg } \\ \# \text { cars } \end{gathered}$ | elast. | $\begin{gathered} \text { avg } \\ \text { \# cars } \end{gathered}$ | elast. |
| Aggregate | 1.962 | 1.961 | -0.01 | 1.958 | -0.02 | 1.961 | -0.01 | 1.953 | -0.05 |
| No kids | 1.857 | 1.856 | -0.01 | 1.853 | -0.02 | 1.857 | 0.00 | 1.849 | -0.04 |
| With kids | 2.272 | 2.271 | 0.00 | 2.268 | -0.02 | 2.271 | 0.00 | 2.263 | -0.04 |
| HH size 1 | 1.127 | 1.126 | -0.01 | 1.123 | -0.04 | 1.127 | 0.00 | 1.117 | -0.09 |
| HH size 2 | 2.062 | 2.061 | 0.00 | 2.057 | -0.02 | 2.061 | 0.00 | 2.055 | -0.03 |
| HH size 3 | 2.432 | 2.431 | 0.00 | 2.428 | -0.02 | 2.431 | 0.00 | 2.423 | -0.04 |
| HH size 4 | 2.568 | 2.567 | 0.00 | 2.563 | -0.02 | 2.567 | 0.00 | 2.558 | -0.04 |
| HH size 5 | 2.514 | 2.514 | 0.00 | 2.510 | -0.02 | 2.514 | 0.00 | 2.506 | -0.03 |
| no worker | 1.491 | 1.489 | -0.01 | 1.484 | -0.05 | 1.490 | -0.01 | 1.480 | -0.07 |
| 1 worker | 1.758 | 1.757 | -0.01 | 1.754 | -0.02 | 1.757 | -0.01 | 1.750 | -0.05 |
| 2 workers | 2.389 | 2.388 | 0.00 | 2.386 | -0.01 | 2.388 | 0.00 | 2.383 | -0.03 |
| 3 workers | 3.123 | 3.121 | -0.01 | 3.116 | -0.02 | 3.122 | 0.00 | 3.108 | -0.05 |
| 4 workers | 3.805 | 3.803 | -0.01 | 3.797 | -0.02 | 3.803 | -0.01 | 3.784 | -0.06 |
| no student | 1.807 | 1.806 | -0.01 | 1.803 | -0.02 | 1.807 | 0.00 | 1.799 | -0.04 |
| 1 student | 2.188 | 2.187 | 0.00 | 2.184 | -0.02 | 2.188 | 0.00 | 2.179 | -0.04 |
| 2 students | 2.352 | 2.351 | 0.00 | 2.348 | -0.02 | 2.351 | 0.00 | 2.342 | -0.04 |
| 3 students | 2.405 | 2.404 | 0.00 | 2.400 | -0.02 | 2.404 | 0.00 | 2.395 | -0.04 |
| no fulltime worker | 1.526 | 1.524 | -0.01 | 1.520 | -0.04 | 1.525 | -0.01 | 1.516 | -0.07 |
| 1 fulltime worker | 1.939 | 1.938 | -0.01 | 1.935 | -0.02 | 1.939 | 0.00 | 1.931 | -0.04 |
| 2 fulltime workers | 2.496 | 2.495 | 0.00 | 2.493 | -0.01 | 2.495 | 0.00 | 2.489 | -0.03 |
| 3 fulltime workers | 3.372 | 3.371 | 0.00 | 3.366 | -0.02 | 3.371 | 0.00 | 3.358 | -0.04 |
| HH income < \$15K | 1.043 | 1.039 | -0.04 | 1.033 | -0.10 | 1.041 | -0.02 | 1.022 | -0.20 |
| HH Income \$15-50K | 1.724 | 1.723 | -0.01 | 1.720 | -0.02 | 1.724 | 0.00 | 1.716 | -0.05 |
| HH Income \$50-75K | 2.306 | 2.305 | 0.00 | 2.303 | -0.01 | 2.305 | 0.00 | 2.300 | -0.03 |
| HH Income \$75-100K | 2.552 | 2.552 | 0.00 | 2.550 | -0.01 | 2.552 | 0.00 | 2.547 | -0.02 |
| HH Income >\$100K | 2.509 | 2.508 | 0.00 | 2.506 | -0.01 | 2.508 | 0.00 | 2.504 | -0.02 |
| 1 driver | 1.134 | 1.133 | -0.01 | 1.130 | -0.04 | 1.134 | 0.00 | 1.125 | -0.08 |
| 2 drivers | 2.109 | 2.108 | 0.00 | 2.105 | -0.02 | 2.108 | 0.00 | 2.103 | -0.03 |
| 3 drivers | 2.716 | 2.715 | 0.00 | 2.710 | -0.02 | 2.716 | 0.00 | 2.703 | -0.05 |
| 4 drivers | 3.321 | 3.320 | 0.00 | 3.312 | -0.03 | 3.320 | 0.00 | 3.301 | -0.06 |

## Time of Day Models: Tour (3.4) and Intermediate Stop/Trip (4.4)

## Model Specification

DaySim employs a method of modeling time of day developed by Vovsha and Bradley (2004). The time of day models explicitly model the 30 minute time periods of arrival and departure at all activity locations, and hence for all trips between those locations. It thereby also provides an approximate duration of the activity at each activity location. The model uses 48 half-hour periods in the day-3:00-3:29 AM, 3:30-3:59 AM, ..., 2:30 AM-2:59 AM. Given the way that the activity diary data was collected, no tour begins before 3:00 AM or ends after 2:59 AM.

DaySim includes two types of time-of-day models:
Tour primary destination arrival and departure time: For each home-based or work-based tour, the model predicts the time that the person arrives at the tour primary destination, and the time that the person leaves that destination to begin the return half-tour. The tour model includes as alternatives every possible combination of the 48 alternatives, or $48 \times 49 / 2=1,716$ possible alternatives. The model is applied after the tour primary destination and main mode have already been predicted.

Intermediate stop arrival or departure time: For each intermediate stop made on any tour, this model predicts either the time that the person arrives at the stop location (on the first half tour), or else the time that the person departs from the stop location (on the second half tour). On the second (return) half tour, we know the time that the person departs from the tour primary destination, and, because the model is applied after the stop location and trip mode have been predicted, we also know the travel time from the primary destination to the first intermediate stop. As a result, we know the arrival time at the first intermediate stop, so the model only needs to predict the departure time from among a maximum of 48 alternatives (the same 30 minute periods that are used in the tour models). This procedure is repeated for each intermediate stop on the half tour. On the first (outbound) half tour, the stops are simulated in reverse order from the primary destination back to the tour origin, so we know the departure time from each stop and only need to predict the arrival time.

## Estimation Data

Table 38 below shows the number of tours and intermediate stops in the survey data by purpose. These observations were used to estimate 5 separate models:

1. Home-based work tours
2. Home-based school tours
3. Home-based other tours (escort, shopping, personal bus., meal, and social/recreation)
4. Work-based subtours
5. All intermediate stops

Table 38: Sample Sizes

| Purpose | Work | School | Escort | Shop | Pers. <br> Bus | Meal | Soc- <br> Recr | Work- <br> Based | TOTAL |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Tours | 3,532 | 1,562 | 958 | 1,862 | 1,569 | 457 | 1,235 | 695 | 11,870 |
| Intermediate <br> Stops | 522 | 116 | 1,997 | 2,145 | 2,117 | 880 | 974 | NA | 8,751 |

Figure 8 shows the distribution of observed arrival times at the tour primary destination by tour purpose. School has the highest peak at 8 AM. Work and escort also have a peak at around 8 AM, and escort has another peak at around 2-3 PM, presumably picking up kids at school. Meal activities have the largest peak at dinner time, with a smaller peak at lunch time. Most workbased tours begin near lunch time, while social/recreation activities tend to begin in the evening. Shopping and personal business activities are spread fairly evenly across the day.

Figure 9 shows the distribution of departure times from tour primary activities. Note that for all purposes except work and school, Figures $\mathbf{8}$ and $\mathbf{9}$ are very similar, indicating that those activities tend to be of shorter duration with similar start and end times. This is confirmed by Figure 10 which shows duration of stay at the tour destination. Most escort (pick up/drop off) activities have duration 0 , meaning that they begin and end in the same $1 / 2$ hour period. The most common duration for school is roughly 7 hours, and for work is 9 hours.

Figure 11 shows the duration distribution for intermediate stops by activity purpose at the stop. In general, intermediate stops are of shorter duration than activities at primary destinations. This is partly by definition, since the rule for determining primary destination uses both activity purpose and duration. In general, work-related stops have the longest duration.

A related question is whether the duration of intermediate stops is a function of the tour purpose and direction. Figure 12 shows that there is not much variation in the duration distribution by tour type/direction. The largest difference is for work tours, with intermediate stops on the way home from work tending to have longer duration than stops on the way to work.

Figure 8


Figure 9


Figure 10


Figure 11


Figure 12


## Estimation Results

The estimation results are shown in Tables 39-43, and the model fit statistics in Table 44. Below is a brief description of the key results, listed by variable type:

## Constants

Each alternative in the models is characterized by three separate dimensions: arrival time, departure time, and duration of stay. Any one of these is defined by the other two-for example, the departure time equals the arrival time plus the duration of stay. In all of the models, we use 10 period-specific constants for each of the three dimensions (parameters 11-40). One of the 10 constants is constrained to 0 , and the other 9 are estimated relative to the constrained one. It would be possible to estimate many more constants (the tour models have 1716 alternatives, so could support 1715 constants), but it is best to use constants only for the key periods, and let the rest of the variables explain the time periods as much as possible.

In the intermediate stop model, the departure time is fixed for stops on the outbound half tour, so those observations only contribute to the constants for arrival time and duration, and the arrival time is fixed for stops on the return half tour, so those observations only contribute to the constants for departure time and duration.

For work and school tours, which are generally the highest priority tour of the day and thus have the entire day available for scheduling, the constants are generally negative, because the coefficients for the most commonly chosen times are constrained to 0 . For other tours and workbased subtours, the set of available alternatives is generally much more restricted because other
tours and trips have already been scheduled and those limit the available time window. As a result, the constants for those models do not follow a clear pattern, because the (non-) availability of alternatives is doing much of the "job" that the constants would do otherwise. The same is true for the intermediate stop models, which tend to have the most restricted time windows.

## Person type variables

People with different roles in the household may tend to schedule their activities differently. This is captured in the models mainly through the role of shift variables. These are dummy variables interacted with the arrival time and the duration of the alternative. If the arrival shift variable is negative, it means that activities tend to made earlier, and if is positive, it means that activities tend to be made later. If the duration shift variable is negative, it means that activities tend to be shorter, and if it positive, activities tend to be longer. No departure shift variable is estimated because the departure shift is simply the sum of the arrival shift and the duration shift (e.g. if the arrival shift is an hour earlier and the duration shift is an hour longer, the departure shift is 0 ). For that reason, if either the arrival or duration shift is significant, both variables have been retained in the model. (This is not true for the intermediate stop model, where in most cases only the duration shift is relevant.)

Findings for the person type variables are:

- Work: Part-time workers, university students, K-12 students age 16+, and other adults tend to all begin work later than full-time workers. Part-time workers and other adults also tend to work for the shortest duration. A dummy variable was added to capture the fact that full time workers rarely have work duration of less than 9 hours.
- School: Relative to the base group, K-12 students age 5-15, K-12 students age 16+ tend to arrive at school earlier and stay longer. All other person types tend to arrive at school later. University students stay at school for a somewhat shorter duration, while preschool children stay for a longer duration-presumably for as long as their parents stay at work.
- Other tours: University and K-12 students tend to begin their non-mandatory tours somewhat later in the day, while retired persons age 65+ tend to begin their nonmandatory tours earlier in the day, even after taking into account previously scheduled tours. Non-working adults, both over and under age 65, tend to make shorter nonmandatory tours.
- Work-based subtours: Part-time workers make subtours of slightly longer duration, although this coefficient may be offsetting availability effects (part-time workers have a shorter available time window).
- Intermediate stops: University students and children tend to make longer duration stops than adults do.

Income variables
Income-related variables were only significant for work tours. The findings are:

- Low income workers tend to work slightly shorter duration, while high income workers tend to work somewhat longer duration.
- High income workers are less likely to have extreme hours: they are less likely to arrive at work before 6 AM or depart after 10 PM.

Purpose variables:
Other than the work and school tour models, several activity purposes were combined in the models. Thus, activity purpose variables are very important for determining scheduling:

- Other tours: Relative to personal-business activities, people tend to arrive earlier for escort activities and later for shopping, meal and social/recreation activities. Escort and shopping activities also tend to be much shorter in duration, while social/recreation activities are much longer.
- In addition to the shift variables, some dummy variables are also significant: Escort and shopping activities are likely to last less than an hour, and shopping and meal activities are likely to last 1-2 hours. Shopping activities are unlikely to begin before 7 AM or end after 9 PM. Meal activities are also unlikely to end after 9 PM. Escort activities are relatively likely to end after 9 PM.
- Work-based subtours: Relative to work-related activities on subtours, escort, meal and shopping activities tend to start later and be of shorter duration. Social/recreation activities also tend to start later, while personal business activities are also of shorter duration.
- Intermediate stops: Compared to work-related activities, stops for escort, shopping, meal, and personal business activities all tend to be of shorter duration. Escort, shopping, social/recreation and personal business stops also tend to be somewhat later in the day. These results are very similar to those in the work-based subtour model.


## Presence of stops and subtours

Activities may be scheduled differently depending on the complexity of the tour and how many stops need to be scheduled. The tour time of day models are applied before the exact number and purpose of stops for a tour are determined. So, all we know at this stage is the number of purposes for which 1+ intermediate stops must be made, as well as the number of tours to be made.

- Work tours: The more purposes for which intermediate stops must be made, the shorter the duration at the primary destination. This effect is stronger when the work tour is the only tour of the day, in which case all stops must be part of that work tour. When the person makes $1+$ escort stops in the day, the work activity tends to be both earlier and longer, presumably staying at work longer to coordinate schedules with a passenger. (The escort stop is not always part of the work tour, but it is in most cases.) The more workbased subtours that are part of the tour, the longer the total duration of the work activity (including the subtour). There is also a slight shift to later arrival times for tours with subtours, indicating that those people tend to depart later from work.
- School tours: The results are generally the same as for work tours, except that the influence of escort stops on duration is not as large.
- Other tours: These same variables for other non-mandatory tours have much less significant effects, with only the positive effect of escort stops on activity duration significant. Even if the tour is the only tour of the day, the duration of stay at the primary destination is not affected by the number of intermediate stops.
- Intermediate stops: Compared to stops made on the outbound half of a non-work tour, stops made on the return half of a non-work tour or on either half of a work-based
subtour tend to be shorter. On the other hand, stops made as part of work tours tend to last longer.

Position of the tour in simulation priority order: Due to the rules for ordering tours by purpose and duration, there are some systematic effects on scheduling related to the simulation order:

- Work tours: If there are $2+$ work tours made during the day, the lower priority one(s) tend to happen later and last longer than would be expected based on the available time window alone. In such cases, all work tours are more likely to last less than 8 hours, particularly the lower priority one(s). If the work tour is complimented by one or more tours of different purposes, then it is somewhat less likely to last less than 8 hours. (This effect probably offsets schedule pressure effects described below.)
- Other tours: If there are $2+$ tours in the day for the same purpose, the highest priority one tends to be of longer duration, and the lower priority one(s) tend to be both shorter and earlier, compared to cases with just 1 tour. If there are $2+$ tours in the day for different purposes, the lower priority one(s) tend to be both shorter and earlier than otherwise, and also tend to be of less than 4 hours duration. These latter effects are in addition to the availability effects of "shrinking" the available time window by the time spent in the higher priority tour(s).

Periods partially used
In the simulation, it is possible to arrive at the primary destination if another tour ended in that period, and possible to leave a primary destination if another tour began in that period. Such cases should be less likely, however, because part of the period is already "used up". These variables have negative and significant coefficients in all 5 models.

## Schedule pressure effects

For each time period, six variables are used to calculate time pressure effects:

1. Duration of the adjacent empty window before period starts
2. Duration of the maximum consecutive empty window before the period starts
3. Total duration of all empty windows in the day before the period starts
4. Duration of the adjacent empty window after the period ends
5. Duration of the maximum consecutive empty window after the period ends
6. Total duration of all empty windows in the day after the period ends

These variables, along with the remaining number of tours to be scheduled in the day after scheduling the current tour, are used to calculate several other variables:

- Work tours: The overall scheduling pressure is given by the number of tours remaining to be scheduled divided by the total empty window that would remain if an alternative is chosen. The negative effect indicates that people are less likely to choose schedule alternatives that would leave them with much time to schedule and little time to schedule it in. A similar variable is the number of tours remaining divided by the maximum consecutive time window. This is also negative, meaning that people with more tours to schedule will tend to try to leave a large consecutive block of time rather than two or more smaller blocks. In other words, they will tend to "crowd" the work tour and any
other tours together rather than spacing them evenly across the day. As an offsetting effect, they will tend to avoid leaving small blocks of time immediately before the work activity.
- School tours: The estimated effects are very similar to those found for work tours.
- Other tours: Again, the effects are similar to those found for work and school tours. The main difference is that the overall time pressure effect is stronger, but the other effects are weaker, and there is evidence that people will try to space tours more evenly in the day.
- Work-based subtours: People try to leave consecutive windows both before and after the tour, meaning a tendency to "center" the subtour during the duration of the work activity.
- Intermediate stops: Stops will tend to be shorter when there are more tours to be scheduled in the day, and also when there more stops to scheduled on the half tour.

Travel time
The travel time for the period is based on the network travel times for the 4 periods of the day AM peak, midday, PM peak, and off-peak. The variable is applied for both the outbound half tour (tour origin to tour destination) and the return half (tour destination to tour origin). For auto, the time is just the in-vehicle time, while transit time is in-vehicle time plus first wait time, transfer time, and drive access time. Walk access/egress time is not included, as that does not vary by time period. These variables are not applied for walk, bike or school bus tours.

- Work tours: For both auto and transit tours, both outbound and return half tours, the travel time coefficient is marginally significant at about -0.04 to -0.05 . (One coefficient was constrained to have a value similar to the unconstrained ones.) If there is no network transit path in the period, that has a significant negative effect for transit tours (equivalent to about 70 minutes travel time). Note that not every trip in a transit tour has to be by transit, so it would be possible for somebody making a transit tour to arrive or depart work during a period when transit is not available.
- School tours: No significant travel time effects were found for school tours.
- Other tours: Large and significant negative travel time effects were found for auto tours, but not for transit tours. (There are relatively few transit tours for these purposes.) There were no transit tours observed to begin or end in periods when transit was not available, so this coefficient was constrained to -5.0.
- Work-based subtours: No significant travel time effects were found for subtours.
- Intermediate stops: The results are very similar to those for non-mandatory tours, with significant effects for auto time and for transit path not available.


## Auto congestion effects

There may also be effects for time shifts within the AM peak and PM periods. For this purpose, the variable used was the extra time spent on links where the congested time is over $20 \%$ higher than the free flow time. (Include formula here). This extra congested time was converted to shift variables by multiplying by the time difference between the period and the "peak of the peak":

1. AM shift earlier: If the period is 6 AM to 8 AM , multiply by ( 8 AM - time)
2. AM shift later: If the period is 8 AM to 10 AM , multiply by (time -8 AM )
3. PM shift earlier: If the period is 3 PM to 5 PM , multiply by ( 5 PM - time)
4. PM shift later: If the period is 5 PM to 7 PM, multiply by (time -5 PM )

With this formulation, the more positive the coefficient and the larger the congested time, the more that the peak demand is spread away from the peak of the peak.

- Work tours: For both AM and PM, the tendency is to move the work activity earlier as the time in very congested conditions increases. Note that a number of "time missing" variables are also included. These are included so that non-auto tours or auto tours with missing geocodes do not bias the estimates, as they would if they were treated as auto tours with 0 congestion. Behaviorally, these coefficients are not of interest.
- School tours and work-based subtours: No significant congestion effects were estimated.
- Other tours: The PM peak was found to shift both earlier and later with high congestion. No effects were found for the AM peak, where there are fewer such tours.
- Intermediate stops: Small positive effects were found for the AM peak shifting both earlier and later and the PM peak shifting earlier. Although these effects are not significant, they are of the correct sign, so were retained.

Table 39: Home-based Work Tour Arrival and Departure Time Model

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 11 | Arrival 0300 - 0559 constant | -2.1958 | -13.1 |
| 12 | Arrival 0600 - 0659 constant | -0.6919 | -6.6 |
| 13 | Arrival 0700 - 0759 constant | -0.1168 | -1.7 |
| 14 | Arrival 0800 - 0859 constant | 0.0000 | Constr. |
| 15 | Arrival 0900 - 0959 constant | -0.9072 | -11.5 |
| 16 | Arrival 1000 - 1259 constant | -1.7580 | -13.1 |
| 17 | Arrival 1300 - 1559 constant | -1.8168 | -7.9 |
| 18 | Arrival 1600 -1859 constant | -2.4870 | -7.5 |
| 19 | Arrival 1900 - 2159 constant | -3.8442 | -7.7 |
| 20 | Arrival 2200 - 0259 constant | -5.1755 | -6.3 |
| 21 | Depart 0300 - 0659 constant | -0.8102 | -1.8 |
| 22 | Depart 0700 - 0959 constant | -0.9947 | -3.6 |
| 23 | Depart 1000 - 1259 constant | -0.1798 | -1.1 |
| 24 | Depart 1300 - 1559 constant | -0.0962 | -1.3 |
| 25 | Depart 1600 - 1659 constant | 0.0000 | Constr. |
| 26 | Depart 1700 - 1759 constant | 0.0029 | 0.0 |
| 27 | Depart 1800 - 1859 constant | -0.8363 | -8.1 |
| 28 | Depart 1900 - 2059 constant | -2.2834 | -15.0 |
| 29 | Depart 2100 - 2359 constant | -2.7267 | -12.5 |
| 30 | Depart 2400 - 0259 constant | -4.5953 | -13.2 |
| 31 | Duration 0 - 259 constant | -0.4520 | -1.5 |
| 32 | Duration 300 - 459 constant | 0.1503 | 0.6 |
| 33 | Duration 500 - 659 constant | 0.1030 | 0.5 |
| 34 | Duration 700 - 859 constant | 0.4339 | 2.8 |
| 35 | Duration 900 - 959 constant | 0.0000 | Constr. |
| 36 | Duration 1000 - 1059 constant | -0.4829 | -7.2 |
| 37 | Duration 1100 - 1159 constant | -1.3272 | -11.8 |
| 38 | Duration 1200 - 1359 constant | -2.3789 | -14.1 |
| 39 | Duration 1400 - 1759 constant | -4.5120 | -14.2 |
| 40 | Duration 1800 - 2359 constant | -7.0030 | -8.2 |
| 41 | Part-time worker-Arrival shift | 0.0307 | 2.8 |
| 42 | Part-time worker-Duration shift | -0.0442 | -2.9 |
| 45 | Uinversity student -Arrival shift | 0.0927 | 5.3 |
| 46 | University student-Duration shift | 0.0224 | 0.9 |
| 49 | K12 student 16+ -Arrival shift | 0.1889 | 7.3 |
| 50 | K12 student 16+ -Duration shift | -0.0190 | -0.5 |
| 43 | Other non-worker -Arrival shift | 0.0559 | 2.3 |
| 44 | Other non-worker -Duration shift | -0.1011 | -3.0 |
| 71 | Full-time worker - Duration < 900 | -1.3676 | -8.6 |
| 51 | Income <\$15K - Arrival shift | 0.0155 | 1.3 |
| 52 | Income <\$15K - Duration shift | -0.0307 | -2.1 |
| 53 | Income >\$75K - Arrival shift | 0.0097 | 0.9 |
| 54 | Income >\$75K - Duration shift | 0.0259 | 2.5 |
| 72 | Income <\$75K - Arrival before 0600 | -0.3683 | -3.0 |
| 73 | Income >\$75K - Depart after 2200 | -0.8499 | -3.4 |
|  |  |  |  |

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Table 39: Home-based Work Tour Arrival and Departure Time Model (continued)

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :---: | :---: | :---: |
| 61 | \# stop purposes/only tour - Arrival shift | -0.0048 | -0.8 |
| 62 | \# stop purposes/only tour - Duration shift | -0.0759 | -12.5 |
| 63 | \# stop purposes/mult. tours - Arrival shift | 0.0084 | 1.7 |
| 64 | \# stop purposes/mult. tours - Duration shift | -0.0506 | -8.2 |
| 67 | Escort stops in day - Arrival shift | -0.0269 | -2.6 |
| 68 | Escort stops in day - Duration shift | 0.0430 | 3.7 |
| 69 | \# subtours in tour - Arrival shift | 0.0171 | 1.8 |
| 70 | \# subtours in tour - Duration shift | 0.1487 | 14.3 |
| 57 | Lower of 2+ work tours - Arrival shift | 0.0597 | 2.2 |
| 58 | Lower of 2+ work tours - Duration shift | 0.1964 | 4.3 |
| 81 | Higher of 2+ work tours- Duration<800 | 1.9103 | 8.7 |
| 82 | Lower of 2+ work tours- Duration<800 | 5.0000 | Constr. |
| 83 | Higher of 2+ different tours- Duration<800 | -0.4524 | -3.8 |
| 91 | Arrival period partially used | -1.5832 | -4.0 |
| 92 | Departure period partially used | -1.5249 | -2.5 |
| 93 | Empty window remaining before-1st tour | -0.1084 | -3.9 |
| 94 | Empty window remaining after - 1st tour | -0.2046 | -7.5 |
| 95 | Empty window remaining before- 2nd+ tour | 0.0962 | 1.9 |
| 96 | Empty window remaining after - 2nd+ tour | 0.0946 | 2.5 |
| 97 | Remaining tours/total remaining window | -77.5309 | -6.1 |
| 98 | Remaining tours/maximum remaining window | -20.7164 | -5.0 |
| 99 | Remaining tours/adjacent window before | -0.8229 | -3.1 |
| 100 | Remaining tours/adjacent window after | -0.0679 | -0.3 |
| 85 | Auto travel time (min) - outbound period | -0.0526 | -1.7 |
| 86 | Auto travel time (min) - return period | -0.0400 | Constr. |
| 87 | Transit travel time (min) - outbound period | -0.0410 | -1.7 |
| 88 | Transit travel time (min) - return period | -0.0433 | -1.9 |
| 89 | No transit path in period | -2.8379 | -1.9 |
| 101 | Auto AM congested time - shift earlier | 0.0323 | 5.5 |
| 103 | Auto PM congested time - shift earlier | 0.0347 | 5.2 |
| 105 | Auto AM time missing - shift earlier | 0.1380 | 1.3 |
| 106 | Auto AM time missing - shift later | -0.1187 | -1.0 |
| 107 | Auto PM time missing - shift earlier | 0.1672 | 1.7 |
| 108 | Auto PM time missing - shift later | -0.3751 | -3.3 |

Table 40: Home-based School Tour Arrival and Departure Time Model

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :---: | :---: | :---: |
| 11 | Arrival 0300-0559 constant | -10.0000 | Constr |
| 12 | Arrival 0600-0659 constant | -3.1769 | -15.4 |
| 13 | Arrival 0700-0759 constant | -0.1488 | -2.0 |
| 14 | Arrival 0800-0859 constant | 0.0000 | Constr |
| 15 | Arrival 0900-0959 constant | -1.2758 | -10.9 |
| 16 | Arrival 1000-1259 constant | -2.3804 | -12.9 |
| 17 | Arrival 1300-1559 constant | -3.1937 | -9.4 |
| 18 | Arrival 1600-1859 constant | -2.3961 | -5.2 |
| 19 | Arrival 1900-2159 constant | -4.0757 | -6.2 |
| 20 | Arrival 2200-0259 constant | -10.0000 | Constr |
| 21 | Depart 0300-0659 constant | -10.0000 | Constr |
| 22 | Depart 0700-0959 constant | -0.9307 | -2.3 |
| 23 | Depart 1000-1259 constant | 0.9092 | 4.2 |
| 24 | Depart 1300-1559 constant | 1.7734 | 14.1 |
| 25 | Depart 1600-1659 constant | 0.0000 | Constr |
| 26 | Depart 1700-1759 constant | -0.1961 | -1.3 |
| 27 | Depart 1800-1859 constant | -1.3392 | -6.2 |
| 28 | Depart 1900-2059 constant | -1.9347 | -7.6 |
| 29 | Depart 2100-2359 constant | -2.7719 | -8.1 |
| 30 | Depart 2400-0259 constant | -10.0000 | Constr |
| 31 | Duration 0-259 constant | -2.2150 | -5.9 |
| 32 | Duration 300-459 constant | -1.2738 | -4.4 |
| 33 | Duration 500-659 constant | -1.0923 | -5.2 |
| 34 | Duration 700-859 constant | -0.0272 | -0.2 |
| 35 | Duration 900-959 constant | 0.0000 | Constr |
| 36 | Duration 1000-1059 constant | 0.3146 | 1.8 |
| 37 | Duration 1100-1159 constant | -0.5924 | -1.9 |
| 38 | Duration 1200-1359 constant | -2.3843 | -4.2 |
| 39 | Duration 1400-1759 constant | -2.7444 | -3.8 |
| 40 | Duration 1800-2359 constant | -10.0000 | Constr |
| 41 | Part-time worker-Arrival shift | 0.1900 | 3.4 |
| 42 | Part-time worker-Duration shift | -0.0236 | -0.3 |
| 139 | Full-time worker-Arrival shift | 0.2606 | 8.5 |
| 140 | Full-time worker-Duration shift | 0.0974 | 2.7 |
| 47 | Non-worker 65+-Arrival shift | 0.1900 | 3.4 |
| 48 | Non-worker 65+-Duration shift | -0.0236 | -0.3 |
| 43 | Other non-worker -Arrival shift | 0.1900 | 3.4 |
| 44 | Other non-worker -Duration shift | -0.0236 | -0.3 |
| 45 | Uinversity student -Arrival shift | 0.1728 | 8.4 |
| 46 | University student-Duration shift | -0.0380 | -1.9 |
| 49 | K12 student 16+-Arrival shift | -0.0701 | -2.1 |
| 50 | K12 student 16+-Duration shift | 0.0741 | 3.6 |
| 143 | Child age 0-4-Arrival shift | 0.0920 | 2.2 |
| 144 | Child age 0-4 -Duration shift | 0.1670 | 5.8 |

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Table 40: Home-based School Tour Arrival and Departure Time Model (continued)

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 61 | \# stop purposes/only tour - Arrival shift | -0.0101 | -0.7 |
| 62 | \# stop purposes/only tour - Duration shift | -0.0510 | -4.3 |
| 65 | \# stop purposes/mult. tour - Arrival shift | -0.0262 | -2.0 |
| 66 | \# stop purposes/mult. tour - Duration shift | -0.0661 | -5.3 |
| 67 | Escort stops in day - Arrival shift | -0.0342 | -1.4 |
| 68 | Escort stops in day - Duration shift | 0.0750 | 3.4 |
| 91 | Arrival period partially used | -1.8658 | -3.1 |
| 92 | Departure period partially used | -2.7304 | -2.6 |
| 93 | Empty window remaining before- 1st tour | -0.0230 | -0.8 |
| 94 | Empty window remaining after - 1st tour | -0.0641 | -2.7 |
| 95 | Empty window remaining before- 2nd+ tour | 0.0965 | 2.4 |
| 96 | Empty window remaining after - 2nd+ tour | 0.0607 | 2.0 |
| 97 | Remaining tours/total remaining window | -78.6755 | -5.6 |
| 99 | Remaining tours/adjacent window before | -2.0269 | -2.1 |
| 100 | Remaining tours/adjacent window after | -1.59 | constant74 |

Table 41: Home-based Other Tour Arrival and Departure Time Model

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :---: | :---: | :---: |
| 11 | Arrival 0300-0559 constant | -4.1869 | -17.1 |
| 12 | Arrival 0600-0659 constant | -1.9909 | -13.1 |
| 13 | Arrival 0700-0759 constant | -0.7600 | -8.9 |
| 14 | Arrival 0800-0859 constant | 0.0000 | Constr |
| 15 | Arrival 0900-0959 constant | -0.0294 | -0.4 |
| 16 | Arrival 1000-1259 constant | 0.2904 | 3.1 |
| 17 | Arrival 1300-1559 constant | 0.5652 | 4.1 |
| 18 | Arrival 1600-1859 constant | 1.0069 | 5.6 |
| 19 | Arrival 1900-2159 constant | 0.6179 | 2.8 |
| 20 | Arrival 2200-0259 constant | -1.1000 | -3.6 |
| 21 | Depart 0300-0659 constant | -0.2679 | -0.9 |
| 22 | Depart 0700-0959 constant | 0.0319 | 0.2 |
| 23 | Depart 1000-1259 constant | 0.1363 | 1.1 |
| 24 | Depart 1300-1559 constant | 0.2635 | 3.5 |
| 25 | Depart 1600-1659 constant | 0.0000 | Constr |
| 26 | Depart 1700-1759 constant | -0.3129 | -4.0 |
| 27 | Depart 1800-1859 constant | -0.5627 | -6.1 |
| 28 | Depart 1900-2059 constant | -0.4799 | -4.5 |
| 29 | Depart 2100-2359 constant | -0.7410 | -4.8 |
| 30 | Depart 2400-0259 constant | -2.2996 | -9.2 |
| 31 | Duration 0-59 constant | -0.8314 | -8.7 |
| 32 | Duration 100-159 constant | -0.1588 | -2.5 |
| 33 | Duration 200-259 constant | 0.0000 | Constr |
| 34 | Duration 300-459 constant | -0.4028 | -5.5 |
| 35 | Duration 500-659 constant | -0.8494 | -5.3 |
| 36 | Duration 700-859 constant | -0.8150 | -3.2 |
| 37 | Duration 900-1159 constant | -0.7825 | -2.2 |
| 38 | Duration 1200-1359 constant | -2.7541 | -3.2 |
| 39 | Duration 1400-1759 constant | -1.6635 | -2.2 |
| 40 | Duration 1800-2359 constant | -10.0000 | Constr |
| 41 | Part-time worker-Arrival shift | -0.0085 | -1.2 |
| 42 | Part-time worker-Duration shift | -0.0140 | -0.6 |
| 43 | Other non-worker -Arrival shift | -0.0049 | -0.9 |
| 44 | Other non-worker-Duration shift | -0.0344 | -2.2 |
| 45 | Uinversity student -Arrival shift | 0.0239 | 2.4 |
| 46 | University student-Duration shift | 0.0201 | 0.8 |
| 47 | Non-worker 65+ -Arrival shift | -0.0261 | -4.9 |
| 48 | Non-worker 65+ -Duration shift | -0.0467 | -3.3 |
| 49 | K12 student 16+-Arrival shift | 0.0325 | 2.2 |
| 50 | K12 student 16+-Duration shift | 0.0509 | 1.6 |
| 141 | Child age 5-15-Arrival shift | 0.0123 | 1.4 |
| 142 | Child age 5-15-Duration shift | 0.0165 | 0.9 |
| 143 | Child age 0-4-Arrival shift | -0.0115 | -1.2 |
| 144 | Child age 0-4 -Duration shift | 0.0154 | 0.7 |

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Table 41: Home-based Other Tour Arrival and Departure Time Model (continued)

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 145 | Escort tour - Arrival shift | -0.0271 | -3.8 |
| 146 | Escort tour - Duration shift | -0.4407 | -8.7 |
| 147 | Shopping tour - Arrival shift | 0.0245 | 4.4 |
| 148 | Shopping tour - Duration shift | -0.1175 | -3.5 |
| 149 | Meal tour - Arrival shift | 0.0872 | 8.9 |
| 150 | Meal tour - Duration shift | 0.0530 | 1.6 |
| 151 | Social/recreation tour - Arrival shift | 0.0353 | 6.1 |
| 152 | Social/recreation tour - Duration shift | 0.1839 | 13.3 |
| 169 | Escort tour - Duration 0 - 59 constant | 1.3779 | 9.8 |
| 170 | Shopping tour - Duration 0 -59 constant | 1.3456 | 7.4 |
| 171 | Meal tour - Duration 0 -59 constant | -0.5644 | -2.6 |
| 173 | Shopping tour - Duration 100 - 159 constant | 1.2175 | 8.8 |
| 174 | Meal tour - Duration 100 -159 constant | 0.3127 | 2.1 |
| 176 | Shopping tour - Arrival before 0700 | -1.6702 | -3.9 |
| 177 | Meal tour - Arrival before 0700 | 0.6782 | 1.6 |
| 178 | Escort tour - Depart after 2100 | 0.5536 | 3.0 |
| 179 | Shopping tour - Depart after 2100 | -0.9987 | -6.2 |
| 180 | Meal tour - Depart after 2100 | -0.6477 | -3.8 |
| 55 | Higher of 2+ same tours - Arrival shift | 0.0077 | 0.6 |
| 56 | Higher of 2+ same tours - Duration shift | 0.1535 | 3.6 |
| 57 | Lower of 2+ same tours - Arrival shift | -0.0689 | -4.5 |
| 58 | Lower of 2+ same tours - Duration shift | -0.5021 | -9.0 |
| 155 | Higher of 2+ diff. tours - Arrival shift | -0.0027 | -0.2 |
| 156 | Higher of 2+ diff. tours - Duration shift | 0.1213 | 2.1 |
| 157 | Lower of 2+ diff. tours - Arrival shift | -0.0594 | -4.5 |
| 158 | Lower of 2+ diff. tours - Duration shift | -0.1947 | -7.1 |
| 84 | Lower of 2+ different tours- Duration<400 | 0.4969 | 3.9 |
| 59 | Only tour of the day - Arrival shift | -0.0207 | -1.2 |
| 60 | Only tour of the day - Duration shift | 0.0636 | 1.2 |
| 61 | \# stop purposes/only tour - Arrival shift | 0.0034 | 0.9 |
| 62 | \# stop purposes/only tour - Duration shift | -0.0068 | -0.9 |
| 63 | \# stop purposes/mult. tour - Arrival shift | 0.0039 | 1.9 |
| 64 | \# stop purposes/mult. tour - Duration shift | -0.0083 | -1.2 |
| 67 | Escort stops in day - Arrival shift | -0.0010 | -0.2 |
| 68 | Escort stops in day - Duration shift | 0.0562 | 3.7 |
| 91 | Arrival period partially used | -1.2923 | -13.4 |
| 92 | Departure period partially used | -5.8166 | -5.0 |
| 93 | Empty window remaining before- 1st tour | 0.1674 | 2.8 |
| 94 | Empty window remaining after - 1st tour | 0.2213 | 3.8 |
| 95 | Empty window remaining before- 2nd+ tour | 0.0006 | 0.1 |
| 96 | Empty window remaining after - 2nd+ tour | 0.0220 | 4.1 |
| 97 | Remaining tours/total remaining window | -131.4534 | -6.1 |
| 98 | Remaining tours/maximum remaining window | -2.7639 | -1.1 |
| 99 | Remaining tours/adjacent window before | -0.2774 | -3.1 |
| 100 | Remaining tours/adjacent window after | -0.1569 | -1.5 |
|  |  |  |  |

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Table 41: Home-based Other Tour Arrival and Departure Time Model (continued)

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 85 | Auto travel time $(\mathrm{min})$ - outbound period | -0.1675 | -5.0 |
| 86 | Auto travel time $(\mathrm{min})$ - return period | -0.1210 | -3.5 |
| 89 | No transit path in period | -5.0000 | Constr |
| 103 | Auto PM congested time - shift earlier | 0.0435 | 4.1 |
| 104 | Auto PM congested time - shift later | 0.0301 | 2.5 |
| 105 | Auto AM time missing - shift earlier | -0.0686 | -0.6 |
| 106 | Auto AM time missing - shift later | 0.0345 | 0.4 |
| 107 | Auto PM time missing - shift earlier | 0.0390 | 0.5 |
| 108 | Auto PM time missing - shift later | 0.0971 | 1.2 |

Table 42: Work-based Sub-tour Arrival and Departure Time Model

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :---: | :---: | :---: |
| 11 | Arrival 0300-0559 constant | -0.4519 | -0.2 |
| 12 | Arrival 0600-0659 constant | -5.0000 | Constr |
| 13 | Arrival 0700-0759 constant | -0.2749 | -0.7 |
| 14 | Arrival 0800-0859 constant | 0.0000 | Constr |
| 15 | Arrival 0900-0959 constant | -0.4405 | -1.8 |
| 16 | Arrival 1000-1259 constant | -0.1867 | -0.7 |
| 17 | Arrival 1300-1559 constant | -1.6032 | -4.4 |
| 18 | Arrival 1600-1859 constant | -2.6232 | -4.7 |
| 19 | Arrival 1900-2159 constant | -4.4149 | -5.2 |
| 20 | Arrival 2200-0259 constant | -10.0000 | Constr |
| 21 | Depart 0300-0659 constant | 2.5150 | 0.9 |
| 22 | Depart 0700-0959 constant | 0.0470 | 0.1 |
| 23 | Depart 1000-1259 constant | 0.5978 | 2.0 |
| 24 | Depart 1300-1559 constant | 0.6220 | 2.7 |
| 25 | Depart 1600-1659 constant | 0.0000 | Constr |
| 26 | Depart 1700-1759 constant | 0.0969 | 0.3 |
| 27 | Depart 1800-1859 constant | 0.1199 | 0.2 |
| 28 | Depart 1900-2059 constant | 1.0428 | 2.0 |
| 29 | Depart 2100-2359 constant | 2.1327 | 3.0 |
| 30 | Depart 2400-0259 constant | -10.0000 | Constr |
| 31 | Duration 0-59 constant | 0.3405 | 1.4 |
| 32 | Duration 100-159 constant | 0.7208 | 4.1 |
| 33 | Duration 200-259 constant | 0.0000 | Constr |
| 34 | Duration 300-459 constant | -0.2508 | -1.0 |
| 35 | Duration 500-659 constant | -0.5567 | -1.1 |
| 36 | Duration 700-859 constant | 0.4981 | 0.7 |
| 37 | Duration 900-1159 constant | 0.0520 | 0.0 |
| 38 | Duration 1200-1359 constant | -10.0000 | Constr |
| 39 | Duration 1400-1759 constant | -10.0000 | Constr |
| 40 | Duration 1800-2359 constant | -10.0000 | Constr |
| 41 | Part-time worker-Arrival shift | 0.0026 | 0.1 |
| 42 | Part-time worker-Duration shift | 0.1281 | 1.6 |
| 145 | Escort subtour - Arrival shift | 0.1819 | 3.1 |
| 146 | Escort subtour - Duration shift | -1.9103 | -3.4 |
| 147 | Shopping subtour - Arrival shift | 0.0581 | 1.8 |
| 148 | Shopping subtour - Duration shift | -0.8893 | -7.1 |
| 149 | Meal subtour - Arrival shift | 0.0473 | 1.8 |
| 150 | Meal subtour - Duration shift | -0.3517 | -6.6 |
| 151 | Social/recreation subtour - Arrival shift | 0.1500 | 2.9 |
| 152 | Social/recreation subtour - Duration shift | -0.0377 | -0.5 |
| 153 | Personal business subtour - Arrival shift | 0.0162 | 0.5 |
| 154 | Personal business subtour - Duration shift | -0.2996 | -4.9 |
| 91 | Arrival period partially used | -5.0000 | Constr |
| 92 | Departure period partially used | -2.0366 | -3.5 |
| 93 | Empty window remaining before | 0.1606 | 2.9 |
| 94 | Empty window remaining after | 0.0665 | 1.3 |

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Table 43: Intermediate Stop Arrival or Departure Time Model

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 11 | Arrival 0300 - 0559 constant | -2.6105 | -8.1 |
| 12 | Arrival 0600 - 0659 constant | -1.3833 | -7.0 |
| 13 | Arrival 0700 - 0759 constant | -0.2411 | -1.9 |
| 14 | Arrival 0800 - 0859 constant | 0.0000 | Constr |
| 15 | Arrival 0900 - 0959 constant | 0.2108 | 1.7 |
| 16 | Arrival 1000 - 1259 constant | 0.1696 | 1.0 |
| 17 | Arrival 1300-1559 constant | 0.0331 | 0.1 |
| 18 | Arrival 1600 -1859 constant | 0.2444 | 0.8 |
| 19 | Arrival 1900-2159 constant | -0.5341 | -1.3 |
| 20 | Arrival 2200 - 0259 constant | 0.5407 | 0.4 |
| 21 | Depart 0300 - 0659 constant | 0.9533 | 1.0 |
| 22 | Depart 0700 - 0959 constant | -0.6163 | -2.3 |
| 23 | Depart 1000 - 1259 constant | -0.2667 | -1.8 |
| 24 | Depart 1300 - 1559 constant | -0.1694 | -2.0 |
| 25 | Depart 1600 - 1659 constant | 0.0000 | Constr |
| 26 | Depart 1700 - 1759 constant | 0.0819 | 0.9 |
| 27 | Depart 1800 - 1859 constant | -0.2144 | -1.7 |
| 28 | Depart 1900 - 2059 constant | -0.3800 | -2.3 |
| 29 | Depart 2100 - 2359 constant | -0.6197 | -2.6 |
| 30 | Depart 2400 - 0259 constant | -1.1813 | -3.0 |
| 31 | Duration 0 - 59 constant | 1.3863 | 14.0 |
| 32 | Duration 100 - 159 constant | 0.8280 | 11.0 |
| 33 | Duration 200 - 259 constant | 0.0000 | Constr |
| 34 | Duration 300 - 459 constant | -0.7698 | -6.9 |
| 35 | Duration 500 - 659 constant | -2.4074 | -10.1 |
| 36 | Duration 700 - 859 constant | -4.3928 | -8.8 |
| 37 | Duration 900 - 1159 constant | -5.0901 | -7.7 |
| 38 | Duration 1200 - 1359 constant | -10.0000 | Constr |
| 39 | Duration 1400 - 1759 constant | -10.0000 | Constr |
| 40 | Duration 1800 - 2359 constant | -10.0000 | Constr |
| 46 | University student-Duration shift | 0.1407 | 4.6 |
| 50 | K12 student 16+ -Duration shift | 0.2022 | 6.3 |
| 52 | Child age 5-15 -Duration shift | 0.2147 | 8.4 |
| 54 | Child age 0-4 -Duration shift | 0.1067 | 2.7 |
| 145 | Escort stop - Arrival shift | 0.1862 | 4.1 |
| 146 | Escort stop - Duration shift | -1.3598 | -29.4 |
| 147 | Shopping stop - Arrival shift | 0.0867 | 2.8 |
| 148 | Shopping stop - Duration shift | -0.6900 | -21.8 |
| 149 | Meal stop - Arrival shift | 0.0169 | 0.7 |
| 150 | Meal stop - Duration shift | -0.1512 | -6.0 |
| 151 | Social/recreation stop - Arrival shift | 0.0678 | 3.1 |
| 152 | Social/recreation stop - Duration shift | -0.0021 | -0.1 |
| 153 | Personal business stop - Arrival shift | 0.1178 | 4.7 |
| 154 | Personal business stop - Duration shift | -0.5103 | -19.6 |
| 155 | School stop - Arrival shift | 0.0466 | 1.3 |
| 156 | School stop - Duration shift | 0.0391 | 1.0 |
|  |  |  |  |

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Table 43: Intermediate Stop Arrival or Departure Time Model (continued)

| Coef \# | Variable description | Estimate | T-stat |
| :---: | :--- | :---: | :---: |
| 132 | Work tour outbound - Duration shift | 0.1342 | 4.5 |
| 134 | Work tour return - Duration shift | 0.0815 | 2.5 |
| 136 | Non-work tour return - Duration shift | -0.1363 | -3.7 |
| 138 | Work-based subtour - Duration shift | -0.2404 | -3.7 |
| 91 | Arrival period partially used | -0.5719 | -5.1 |
| 92 | Departure period partially used | -2.0076 | -3.4 |
| 97 | Remaining tours/total remaining window | -2.4493 | -2.4 |
| 99 | Remaining stops on half tour/adjacent window | -1.6976 | -4.3 |
| 86 | Auto travel time (min) in period | -0.0533 | -1.2 |
| 88 | Transit travel time (min) in period | -0.1143 | -2.3 |
| 89 | No transit path in period | -5.0000 | Constr |
| 101 | Auto AM congested time - shift earlier | 0.0282 | 1.2 |
| 102 | Auto AM congested time - shift later | 0.0146 | 0.9 |
| 103 | Auto PM congested time - shift earlier | 0.0077 | 0.5 |
| 105 | Auto AM time missing - shift earlier | 0.0021 | 0.0 |
| 106 | Auto AM time missing - shift later | 0.3041 | 1.6 |
| 107 | Auto PM time missing - shift earlier | -0.0757 | -0.5 |
| 108 | Auto PM time missing - shift later | 0.0208 | 0.1 |

Table 44: Additional Model Estimation Statistics

|  | Home- <br> based <br> Work <br> Tours | Home- <br> based <br> School <br> Tours | Home- <br> based <br> Other <br> Tours | Work- <br> based <br> Sub- <br> tours | Inter- <br> mediate <br> Stops |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Model | 3,532 | 1,561 | 6,062 | 682 | 8,508 |
| \# Observations | $-18,785.9$ | $-7,142.7$ | $-29,569.4$ | -2817.5 | $-10,531.6$ |
| Final log(likelihood) | -10.343 | 0.239 | 0.162 | 0.550 |  |
| Rho-squared (0) | 0.239 | 0.343 |  |  |  |

## Accessibility Logsums

## Introduction

A frequent critique of some trip-based models is that, for some aspects of travel choice that are sensitive to travel impedance, the travel demand models are NOT sensitive to travel impedance. This often includes trip generation and time-of-day aspects, and if the model is not properly equilibrated with the traffic assignment model, then it also includes trip distribution and mode choice. A second criticism, heard less often but still important, is that sometimes the techniques used to make the models sensitive to impedance are flawed, yielding inaccurate sensitivity to impedance. For example, if a destination choice or trip distribution model uses auto travel time and ignores transit time, then it is sensitive to auto impedance, but completely insensitive to
transit impedance. It is even possible to construct composite accessibility measures that are sensitive in the wrong direction: improve transit service and transit mode share predictions fall. One argument in favor of properly constructed nested logit models has been that their logsum variable captures impedance effects at the upper level of a nested model in a way that takes into consideration all lower level alternatives and avoids counter-intuitive effects (Ben-Akiva and Lerman, 1985).

A similar critique can be made for models' sensitivity to spatial attributes, such as the distribution of employment, housing and other activity opportunities. Although proper sensitivity to these does not necessarily require equilibration with a traffic assignment model, since these attributes depend on land development processes, it still requires integration of the model components. For example, although a person or household's trip generation rates may depend significantly on the distribution of activity opportunities, model sensitivity to activity opportunities may be limited to the trip distribution or destination choice model. It is possible to use ad hoc measures, such as the density of activity opportunities of certain types within certain distances, to capture sensitivity of trip generation to activity opportunities. Here again, however, it is easy to make the models inappropriately sensitive in ways that bias predictions, and the use of logsum measures have been highly regarded as perhaps the best available means of capturing composite effects that cannot be measured directly in a model.

In recent years, activity-based models have been widely praised as being behaviorally more realistic than traditional trip-based models. They are supposed to achieve this by modeling aspects of choice that trip-based models ignore, by integrating the choices made by an individual over the course of a day, and in some cases, by integrating choices made by members of the same household. To the authors' knowledge, all current practical activity-based models with a behavioral foundation, including those under development, model the many aspects of choice by breaking the outcome into a conditional model hierarchy or a chain of models. Models lower in the hierarchy (or later in the chain) take as given the outcomes higher in the hierarchy. This achieves what has been referred to by Vovsha, Bradley and Bowman (2004) as downward vertical integrity. Done properly, it assures that lower level models adhere to constraints imposed at higher levels, and makes the lower level models indirectly sensitive to all variables that directly affect the upper level outcomes.

Just as important as downward vertical integrity is upward vertical integrity (In this paper we ignore the likely problems caused by choosing an inferior hierarchy or forcing a network of interrelated choice aspects into a hierarchy or chain). Upward vertical integrity comes from making the upper level models appropriately sensitive to variables that affect the upper level outcome, but can't be measured directly because they differ among the undetermined lower level model outcomes. In formal nested logit hierarchies the upward integrity comes from the logsum, the composite measure of expected utility across the lower level alternatives.

One of the key contributions made by Bowman (1995) when he first developed a hierarchical model system representing a person's entire day, was his demonstration that the model of a person's choice of overarching day activity pattern can be made sensitive to transportation level of service, via logsum variables based on nested logit concepts. By doing that he also gave evidence that the choice of day activity pattern is indeed sensitive to transportation level of
service. In other words, he demonstrated the need for upward vertical integrity and a way to achieve it.

Unfortunately, the strength of the logsum variable as a composite measure rests in a feature that makes it computationally expensive, and essentially infeasible with very large and detailed hierarchical model systems: it requires the calculation of utility for every single alternative in the hierarchy below the level being modeled. In order to model the highest level outcome, utilities of all alternatives in the entire hierarchy must be computed.

## Upward vertical integration in DaySim

DaySim uses two techniques in an effort to achieve accurate upward vertical integrity, in cases where using true disaggregate logsums is computationally too expensive. The basic idea of the first technique is to avoid the use of a logsum when applying an upper level model by treating as given a conditional outcome that is not known, and would otherwise require the calculation of a logsum from all possible conditional outcomes. The assumed conditional outcome is selected by a Monte Carlo draw using approximate probabilities for the conditional outcome. Rather than making every simulated outcome sensitive to variability in the conditional outcome, sensitivity is achieved across the population through the variability of outcome in the Monte Carlo draws. This technique is used to include time-of-day sensitivity in the tour destination choice models, along with tour mode choice logsums. In this way, the destination choice models are sensitive to variations in transport level of service and spatial attributes across all possible combinations of time-of-day and mode, with the affects approximately weighted by the joint time-of-day and mode choice probabilities.

The basic idea of the second technique is to calculate an approximate, or aggregate, logsum. It is calculated in the same basic way as a true logsum, by calculating the utility of multiple alternatives, and then taking expectation across the alternatives by calculating the log of the sum of the exponentiated utilities. However, the amount of computation is reduced, either by ignoring some differences among decisionmakers, or by calculating utility for a carefully chosen subset or aggregation of the available alternatives. The approximate logsum is pre-calculated and used by several of the model components, and can be re-used for many persons. The categories of decisionmakers and the aggregation of alternatives are chosen so that in all choice cases an approximate logsum is available that closely approximates the true logsum. In essence, this is a sophisticated ad hoc measure that is intended to achieve most of the realism of the true logsum at a small fraction of the cost. Two kinds of approximate logsums are used, an approximate tour mode-destination choice logsum and an approximate intermediate stop location choice logsum.

The approximate tour mode-destination choice logsum is used in situations where information is needed about accessibility to activity opportunities in all surrounding locations by all available transport modes at all times of day. Because of the large amount of computation required for calculating a true logsum for all feasible combinations in these three dimensions, an approximate logsum is used with several simplifications. First, it ignores socio-demographic characteristics, except for car availability. Second, it uses aggregate distance bands for transit walk access. Third, sometimes it uses a logsum for a composite or most likely purpose instead of calculating it across a full set of specific purposes. Finally, instead of basing the logsum on the exact available
time window of the choice situation, and calculating it across all of the available time period combinations within the window, it uses a particular available time window size and time period combination. With these simplifications, it is possible to pre-calculate a relatively small number of logsums for each TAZ, and use them when needed at any point in the simulation of any person's day activity schedule.

The approximate intermediate stop location choice logsum is used in the activity pattern models, where accessibility for making intermediate stops affects whether the pattern will include intermediate stops on tours, and how many. Four logsums are calculated for each OD zone pair, distinguished by tour mode (transit or auto) and time of day (peak or offpeak). Each logsum is calculated across all possible intermediate stop zones, each stop's utility is a function of travel time and zonal attractiveness, and zonal attractiveness is a function of employment and school enrollment, taken from an estimated purpose-non-specific location choice model.

Table 45 lists the DaySim models in numerical order from top to bottom of the conditional hierarchy. For each model it identifies how travel impedance and spatial attributes affect the model, including the use of direct measures, true mode choice logsums, simulated conditional outcomes, and aggregate logsums.

Table 45: Impedance and spatial attribute effects in the DaySim model hierarchy

|  | Model | Direct measures of travel impedance | Direct measures of spatial attributes | Tour mode choice logsum | Simulated conditional outcomes | Aggregate tour modedestination choice logsum | Aggregate intermediate stop location choice logsum |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.2 | Usual Work Location | Distance. Distance from school. | Employment, enrollment, households. <br> Parking \& employment mix. <br> Grid connectivity. | Yes. |  | At destination. |  |
| 1.3 | School Location | Distance. | Employment, enrollment, households. | Yes. |  | At destination. |  |
| 1.4 | HH Auto Availability | Distance to transit stop. | Parking price near home. Commercial employment near home. | To work. To school. |  | At home. |  |
| 2.1 | Day Activity Pattern |  | Mixed use density near home. <br> Intersection density near home. | For work \& school. |  | At home. | Yes. |
| 2.2 | Number of Tours (by purpose) |  |  | For work and school tours. |  | At home. |  |
| 3.1 | Tour Destination | Distance. Distance from work. Distance from school. | Employment, enrollment, households. <br> Parking \& employment mix Grid connectivity. | Yes. | Primary activity periods | At destination. |  |
| 3.2 | Number \& purpose of work-based tours |  | Commercial employment near work. <br> School enrollment near work. |  |  |  |  |
| 3.3 | Tour Mode | All impedance variables | Parking costs. Transit accessibility. Mixed use density. |  |  |  |  |
| 3.4 | Tour Primary Activity Timing (begin and end time periods) | Travel times | Mixed use density |  |  |  |  |
| 4.1 | Number \& Purpose of Intermediate Stops |  | Grid connectivity X commercial employment at tour dest. |  |  |  | For autobased tour modes. |
| 4.2 | Stop Location | Generalized time. Distance. <br> Distance from tour origin. <br> Distance from tour destin. | Employment, enrollment, households. <br> Parking \& employment mix. |  |  |  |  |
| 4.3 | Trip Mode | All impedance variables | Parking costs. Transit accessibiity. |  |  |  |  |
| 4.4 | Trip Departure Time | Travel times |  |  |  |  |  |

## Details of Implementation

Aggregate accessibility logsums are used for several upper level models in the system, as shown in the next to last column in Table 45. The form is that of mode-destination choice logsums to indicate the accessibility of various zones for non-mandatory activity purposes. To make it feasible to use such measures, they are pre-calculated for a limited number of segments. Those segments are each combination of:

Non-mandatory tour purpose:
(1) Home-based personal business
(2) Home-based shopping
(3) Home-based meal
(4) Home-based social/recreation
(5) Home-based escort
(6) All home-based purposes combined
(7) Work-based

Car availability segment:
(1) Child age under 16
(2) Adult in HH with no cars
(3) Adult in HH with cars, but fewer cars than drivers
(4) Adult in HH with $1+$ cars per driver

Transit accessibility:
(1) Origin is within $1 / 4$ mile of transit stop
(2) Origin is more than $1 / 4$ mile from transit stop, but walk to transit is available
(3) Walk to transit not available

In total, this makes $7 * 4 * 3=84$ combinations for each origin zone.
So, the simplified mode and destination choice models include only those variables that are defined by those segments. Other simplifications include:

- Only TAZ-based information is used, and no parcel-based land use information.
- Drive to transit, school bus and bike are all omitted, and shared ride is a single mode. This leaves 4 modes: WT - Walk to Transit, SR - Shared Ride 2+, DA - Drive Alone, and WK - Walk.

The resulting estimates for mode choice are shown in Table 46.
The application of these models has been programmed, and incorporated into a DaySim routine that calculates mode/destination choice logsums from every possible origin zone for each of the 84 segment combinations. This application code for precalculating the accessibility logsums essentially applies two steps of a 4-step zonal aggregate travel demand model system:

- Loop on origin zones
- Loop on 84 tour purpose/car availability/transit accessibility segments
- Loop on destinations zones and calculate mode choice utilities, mode choice logsums, destination choice utilities and accessibility logsum
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|  |  | $\begin{gathered} \text { All Home- } \\ \text { Based } \\ \hline \end{gathered}$ |  | WorkBased |  | $\begin{gathered} \mathrm{HB} \\ \text { Escort } \end{gathered}$ |  | $\begin{gathered} \mathrm{HB} \\ \text { Pers.Bus } \\ \hline \end{gathered}$ |  | $\begin{gathered} \hline \text { HB } \\ \text { Shop } \\ \hline \end{gathered}$ |  | $\begin{gathered} \hline \mathrm{HB} \\ \text { Meal } \\ \hline \end{gathered}$ |  | $\begin{gathered} \text { HB } \\ \text { SocRec } \\ \hline \end{gathered}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Mode | Variable | Coefficient | T-stat | Coefficient | $\begin{aligned} & \text { T- } \\ & \text { stat } \end{aligned}$ | Coefficient | T-stat | Coefficient | T-stat | Coefficient | T-stat | Coefficient | Tstat | Coefficient | $\begin{gathered} \text { T- } \\ \text { stat } \end{gathered}$ |
| DA, SR, WT | Cost (\$) | -0.1826 | -7.2 | -0.2008 | -4.6 | -0.12 | * | -0.2361 | -5.2 | -0.4386 | -6.8 | -0.1215 | -1.1 | -0.3194 | -5.4 |
| DA, SR, WT | In-vehicle time (min) | -0.025 | * | -0.025 | * | -0.04 | * | -0.02 | * | -0.025 | * | -0.03 | * | -0.025 | * |
| WT, WK | Out-of-vehicle time (min) | -0.07227 | -17.5 | -0.08339 | -9.4 | -0.1296 | -7.2 | -0.05341 | -8.4 | -0.0757 | -9.1 | -0.09441 | -4.8 | -0.06894 | -9.6 |
| DA | Constant | -0.5821 | -4.5 | -1.358 | -5.9 | -5.619 | -10.5 | 0.4807 | 1.8 | 0.03664 | 0.1 | -1.793 | -3.2 | -0.7357 | -3.1 |
| DA | HH fewer cars than drivers | -0.3404 | -3.2 | -0.5896 | -3.3 | 0.3267 | 1.1 | -0.3777 | -1.7 | -0.3622 | -1.7 | -0.4127 | -1.0 | -0.9187 | -3.7 |
| SR | Constant | -0.4841 | -3.6 | -2.396 | -9.6 | -1.073 | -2.8 | -0.03517 | -0.1 | -0.4242 | -1.5 | -0.685 | -1.2 | -1.047 | -4.2 |
| SR | Child under age 16 | 0.2458 | 1.9 | 1.033 | 3.7 | 1.822 | 4.0 | 1.194 | 2.7 | 0.3822 | 1.3 | -1.72 | -2.8 | 0.2101 | 1.0 |
| SR | No cars in HH | -2.518 | -9.4 | -1.782 | -3.5 | -5.265 | -4.9 | -1.73 | -3.9 | -2.187 | -5.0 | -2.472 | -2.2 | -1.933 | -2.8 |
| SR | HH fewer cars than drivers | -0.1648 | -1.5 | -0.1185 | -0.7 | 0.4327 | 1.6 | -0.1929 | -0.9 | -0.3522 | -1.7 | -0.4882 | -1.2 | -0.4833 | -2.0 |
| WT | Constant | -3.911 | -9.7 | -4.792 | -5.6 | -3.447 | -2.7 | -2.712 | -4.6 | -3.0 | * | -4.013 | -2.9 | -3.589 | -4.2 |
| WT | Child under age 16 | -1.0 | * | 0.0 | * | -1.0 | * | -1.0 | * | -1 | * | -1 | * | -1.0 | * |
| WT | No cars in HH | 2.722 | 7.3 | 2.048 | 2.9 | 1.0 | * | 3.117 | 5.1 | 1.91 | 3.1 | 2.663 | 2.4 | 2.485 | 2.5 |
| WT | HH fewer cars than drivers | 0.7025 | 2.0 | 1.226 | 2.4 | 0.004716 | 0.0 | -0.1959 | -0.4 | 1.049 | 2.0 | 1.798 | 1.4 | -0.2369 | -0.3 |
| WT | Walk at origin>0. 25 miles | -1.958 | -1.6 | -1.268 | -0.8 | -2.0 | * | -2.0 | * | -2 | * | -2.0 | * | -2.0 | * |
|  | *=constrained |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

A second routine also calculates intermediate stop logsums for car tours. As shown in the last column in Table 45, these measures are used in the pattern models (2.1 and 4.1) to make intermediate stops more likely between zone pairs where useful stop locations can be conveniently reached. This routine takes longer to run than the first one described above, because it uses 3 nested zone loops:

- Loop on time periods (peak, off-peak)
- Loop on origin zones
- Loop on destination zones
- Loop on all intermediate stop zones and calculate intermediate stop location choice logsum using the formula below

Logsum is the log of the sum over all zones of : Size * $\exp (-2 *$ extra time / 6.0 minutes)
Where Size is a weighted function of various attraction variables (the size variable function estimated for the composite non-mandatory tour purpose in the aggregate destination choice model), and Extra time is the auto travel time from the origin zone to the stop zone plus the auto travel time from the stop zone to the destination zone, minus the direct auto travel time from the origin zone to the destination zone (i.e. the detour time required to make the stop on the way from the origin to the destination).

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## Appendix 1—Usual and tour destination choice model application on estimation data

This appendix provides statistical results from applying the models on the estimation data. It is divided into four sections, with a separate section for each of the four models. In each section, each table is in two parts. The first part compares the observed and predicted distribution of travel time for various subsets of the tours (see column headings) under the base conditions used for model estimation. The comparison is made by identifying the number of tours (observed and predicted) falling into each of several travel time bands (see row headings in the left hand column), where travel time is the one-way mid-day travel time by automobile. The estimated standard deviation of the observed choices is also provided, and the number of stars for a prediction indicates the number of standard deviations by which the predicted deviates from the observed.

The second part of each table reports the predicted average value of ten tour attributes for each tour category. These attributes are:

```
ddist one-way auto travel distance (10ths of miles)
dtime round-trip auto travel time (minutes)
emped medical employment at destination parcel
empsvc service employment at destination parcel
empret retail employment at destination parcel
emprest restaurant employment at destination parcel
empofc office employment at destination parcel
houses households at destination parcel
studk12 grade school enrollment at destination parcel
studuniv university enrollment at destination parcel
```

This section of the non-work table especially informative because it shows how effective the model is at matching trips of specific purposes with parcels that have appropriate levels of employment or enrollment of specific types.

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## Appendix 1.1—Usual work location model application

Table for perstype


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Table for inc6

|  | $<15 \mathrm{~K}$ | $\begin{aligned} & \text { \|15- } \\ & 150 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \mid 50- \\ & \mid 75 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \text { \| 75- } \\ & 1100 \mathrm{~K} \end{aligned}$ | $\|100 \mathrm{~K}+\|$ | $\begin{aligned} & \text { \| re- } \\ & \text { \| fuse } \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 5.0 | 47.0 | 98.0 | 44.0 | 32.0 | 11.0 | 237.0 |
| SD. Chsn | 2.2 | 7.7 | 10.0 | 6.8 | 5.4 | 3.6 | 15.8 |
| $25+\mathrm{mi}$ |  | *+ | + | + | - | + |  |
| No. Pred | 4.9 | 60.1 | 101.5 | 46.5 | 29.7 | 13.2 | 255.8 |
| No. Chsn | 29.0 | 309.0 | 432.0 | 198.0 | 136.0 | 82.01 | 1186.0 |
| SD. Chsn | 5.2 | 17.0 | 20.7 | 13.5 | 11.1 | 8.7 | 33.5 |
| $10-25 \mathrm{mi}$ | - | - | + | - | *- | - |  |
| No. Pred | 28.3 | 293.8 | 436.6 | 185.4 | 124.6 | 77.81 | 1146.4 |
| No. Chsn | 51.0 | 440.0 | 476.0 | 175.0 | 117.0 | 94.01 | 1353.0 |
| SD. Chsn | 7.4 | 20.9 | 21.6 | 13.7 | 11.8 | 10.1 | 37.3 |
| $3-10 \mathrm{mi}$ | + | + | + | *+ | **+ | *+ | *+ |
| No. Pred | 55.6 | 448.2 | 479.9 | 192.1 | 143.8 | 105.31 | 1424.9 |
| No. Chsn | 57.0 | 251.0 | 225.0 | 101.0 | 89.0 | 73.0 | 796.0 |
| SD. Chsn | 7.2 | 15.3 | 14.5 | 9.3 | 8.7 | 7.8 | 26.8 |
| 0-3 mi | - | - | - | *- | *- | *- | *- |
| No. Pred \| | 55.6 | 246.7 | 221.5 | 90.4 | 79.4 | 63.3 | 756.8 |
| No. Chsn | 14.0 | 92.0 | 101.0 | 34.0 | 31.0 | 18.0 | 290.0 |
| SD. Chsn | 3.2 | 9.0 | 9.2 | 5.9 | 5.0 | 4.1 | 15.9 |
| home | - | - | - | + | - | + | - |
| No. Pred \| | 11.6 | 90.3 | 92.5 | 37.7 | 27.5 | 18.5 | 278.0 |
| No. Chsn | 156. | 1139.01 | 1332.0 | 552.0 | 405.0 | 278.03 | 3862.0 |
| Total |  |  |  |  |  |  |  |
| No. Pred | 156.01 | 1139.01 | 1332.0 | 552.0 | 405.0 | 278.03 | 3862.0 |
| ddist | 64.6 | 84.4 | 102.0 | 105.9 | 97.0 | 86.2 | 94.2 |
| dtime | 20.5 | 25.5 | 29.8 | 31.1 | 29.0 | 26.1 | 28.0 |
| empmed | 15.9 | 13.7 | 14.3 | 14.2 | 14.1 | 11.6 | 13.9 |
| empsvc | 10.2 | 11.0 | 11.2 | 11.7 | 11.4 | 12.8 | 11.3 |
| empret | 9.2 | 10.1 | 8.4 | 8.3 | 8.9 | 10.0 | 9.1 |
| emprest | 3.6 | 3.8 | 3.4 | 3.3 | 3.6 | 4.6 | 3.6 |
| empofc | 20.3 | 18.4 | 23.3 | 24.4 | 25.7 | 23.4 | 22.2 |
| houses | 2.3 | 1.9 | 1.8 | 1.9 | 1.9 | 1.8 | 1.9 |
| studk12 | 11.6 | 13.3 | 20.8 | 22.3 | 21.3 | 28.7 | 19.0 |
| studuniv | 9.3 | 24.3 | 36.2 | 26.6 | 38.5 | 85.8 | 34.1 |
| INFORMATION | 571: root-Mean-Square-Error is |  |  |  |  | 8.277 |  |
| INFORMATION | 572: number |  | of **stars** in ta |  |  | able is 13 |  |

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Table for hhsize

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | $\text { \| } 10$ | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 13.0 | 103.0 | 55.0 | 51.0 | 11.0 | 4.0 | . 0 | . 0 | . 0 | . 0 | 237.0 |
| SD. Chsn | 4.1 | 10.0 | 7.6 | 7.3 | 3.9 | 2.4 | 1.2 | 1.0 | . 3 | . 3 | 15.8 |
| 25+ mi | + | - | + | + | * | + | * | *+ |  |  | * |
| No. Pred | 17.0 | 101.8 | 59.0 | 54.0 | 15.2 | 5.7 | 1.7 | 1.1 | . 1 |  | 255.8 |
| No. Chsn | 117.0 | 449.0 | 281.0 | 226.0 | 72.0 | 28.0 | 5.0 | 5.0 | 3.0 |  | 186.0 |
| SD. Chsn | 10.1 | 20.6 | 15.9 | 14.9 | 8.4 | 5.7 | 2.5 | 2.5 | 1.3 | . 9 | 33.5 |
| 10-25 mi | *- | - | *- | - | + | + | + | + | - | + | *- |
| No. Pred | 104.6 | 435.5 | 259.5 | 225.7 | 72.6 | 33.3 | 6.3 | 6.4 | 1.8 |  | 1146.4 |
| No. Chsn | 157.0 | 496.0 | 302.0 | 250.0 | 81.0 | 40.0 | 8.0 | 11.0 | 4.0 | 4.01 | 353.0 |
| SD. Chsn | 12.6 | 22.9 | 17.7 | 16.2 | 8.8 | 5.9 | 2.8 | 2.8 | 1.9 | 1.7 | 37.3 |
| $3-10 \mathrm{mi}$ | + | *+ | *+ | *+ | - | - | - | * | - | - | * |
| No. Pred | 161.4 | 535.0 | 320.7 | 270.7 | 78.9 | 35.4 | 7.8 | 8.1 | 3.5 | 3.21 | 424.9 |
| No. Chsn | 99.0 | 286.0 | 176.0 | 159.0 | 46.0 | 22.0 | 5.0 | 2.0 | . 0 | 1.0 | 796.0 |
| SD. Chsn | 9.8 | 16.3 | 12.9 | 11.3 | 6.0 | 4.0 | 2.0 | 1.7 | 1.0 | . 8 | 26.8 |
| 0-3 mi | + | - | - | ** | *- | *- | - | + | *+ | - | *- |
| No. Pred | 101.7 | 280.4 | 174.9 | 134.6 | 38.7 | 17.2 | 4.3 | 3.3 | 1.1 | . 7 | 756.8 |
| No. Chsn | 30.0 | 125.0 | 61.0 | 52.0 | 11.0 | 5.0 | 4.0 | 2.0 | . 0 | . 0 | 290.0 |
| SD. Chsn | 5.3 | 9.8 | 7.4 | 6.9 | 3.8 | 2.6 | 1.3 | 1.0 | . 6 | . 5 | 15.9 |
| home | + | *- |  | + | *+ | + | *- | - | + | + | - |
| No. Pred | 31.3 | 106.3 | 60.9 | 53.0 | 15.6 | 7.4 | 1.9 | 1.1 | . 5 | . 2 | 278.0 |
| No. Chsn | 416.01 | 459.0 | 875.0 | 738.0 | 221.0 | 99.0 | 22.0 | 20.0 | 7.0 | 5.03 | 3862.0 |
| Total |  |  |  |  |  |  |  |  |  |  |  |
| No. Pred | 416.01 | 459.0 | 875.0 | 738.0 | 221.0 | 99.0 | 22.0 | 20.0 | 7.0 | 5.03 | 3862.0 |
| ddist | 79.4 | 95.5 | 94.8 | 97.9 | 99.0 | 95.4 | 92.5 | 94.9 | 75.7 | 71.1 | 94.2 |
| dtime | 24.2 | 28.3 | 28.2 | 29.0 | 29.1 | 28.4 | 27.8 | 28.1 | 22.9 | 22.5 | 28.0 |
| empmed | 16.4 | 14.1 | 13.4 | 12.9 | 13.9 | 14.2 | 11.6 | 10.4 | 16.9 | 8.8 | 13.9 |
| empsvc | 12.6 | 11.2 | 11.0 | 11.1 | 11.1 | 12.2 | 10.0 | 9.7 | 7.2 | 8.7 | 11.3 |
| empret | 9.1 | 8.9 | 8.7 | 9.4 | 9.9 | 10.0 | 11.2 | 12.9 | 6.3 | 12.0 | 9.1 |
| emprest | 3.7 | 3.5 | 3.6 | 3.7 | 3.9 | 3.9 | 6.6 | 3.9 | 3.0 | 4.6 | 3.6 |
| empofc | 22.4 | 22.5 | 22.3 | 21.4 | 21.9 | 21.4 | 17.9 | 23.1 | 30.3 | 19.0 | 22.2 |
| houses | 1.8 | 1.8 | 1.9 | 1.9 | 2.0 | 2.2 | 2.9 | 2.3 | 1.0 | 2.7 | 1.9 |
| studk12 | 15.9 | 18.9 | 19.0 | 21.4 | 18.0 | 22.6 | 18.0 | 11.9 | 20.6 | 7.5 | 19.0 |
| studuniv | 18.4 | 31.7 | 43.0 | 33.7 | 53.3 | 24.8 | 16.4 | . 0 | . 3 | 109.4 | 34.1 |

INFORMATION 571: root-Mean-Square-Error is 4.756

INFORMATION 572: number of **stars** in table is 21

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Table for gend

|  | \| Male | | $\begin{array}{l\|l} \mid F e- & \mid \\ \|m a l e ~\| \end{array}$ |  |  |  |  |  | $\begin{aligned} & \text { \| re- } \\ & \text { \| fuse } \end{aligned}$ |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 154.0 | 83.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 237.0 |
| SD. Chsn | \| 12.4 | 9.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 3 | 15.8 |
| $25+\mathrm{mi}$ | + | *+ |  |  |  |  |  |  |  | * |
| No. Pred | \| 156.6 | 99.2 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 1 | 255.8 |
| No. Chsn | 660.0 | 525.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.01 | 186.0 |
| SD. Chsn | \| 25.2 | 22.1 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 7 | 33.5 |
| $10-25 \mathrm{mi}$ | I | *- |  |  |  |  |  |  | - | *- |
| No. Pred | \| 648.3 | 497.6 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 146.4 |
| No. Chsn | 686.0 | 667.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 01 | 353.0 |
| SD. Chsn | 26.6 | 26.1 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 4 | 37.3 |
| $3-10 \mathrm{mi}$ | ) *+ | *+ |  |  |  |  |  |  | + | *+ |
| No. Pred | \| 726.1 | 698.6 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 21 | 424.9 |
| No. Chsn | 381.0 | 415.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 796.0 |
| SD. Chsn | 18.5 | 19.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 4 | 26.8 |
| 0-3 mi | *- | - |  |  |  |  |  |  | + | *- |
| No. Pred | \| 357.0 | 399.7 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 2 | 756.8 |
| No. Chsn | 166.0 | 124.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 290.0 |
| SD. Chsn | \| 12.0 | 10.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 3 | 15.9 |
| home | 1 - |  |  |  |  |  |  |  |  | - |
| No. Pred | \| 159.0 | 118.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 1 | 278.0 |
| No. Chsn | 12047.01 | 1814.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.03 | 862.0 |
| Total |  |  |  |  |  |  |  |  |  |  |
| No. Pred | 12047.01 | 1814.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.03 | 3862.0 |
| ddist | 100.1 | 87.5 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 133.3 | 94.2 |
| dtime | 29.4 | 26.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 37.8 | 28.0 |
| empmed | 13.8 | 14.1 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 14.1 | 13.9 |
| empsvc | 11.5 | 11.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 9.4 | 11.3 |
| empret | 9.0 | 9.2 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 8.7 | 9.1 |
| emprest | 3.6 | 3.7 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.7 | 3.6 |
| empofc | \| 22.4 | 21.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 20.9 | 22.2 |
| houses | \| 1.9 | 1.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 8 | 1.9 |
| studk12 | \| 17.0 | 21.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 16.1 | 19.0 |
| studuniv | 32.6 | 35.7 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 34.1 |

INFORMATION 571: root-Mean-Square-Error is 18.499
INFORMATION 572: number of **stars** in table is 9

## Appendix 1.2—Work tour destination model application

|  | $\begin{aligned} & \text { prim } \\ & \text { usual } \end{aligned}$ |  | Total |
| :---: | :---: | :---: | :---: |
| No. Chsn | 265.0 | 5.0 | 270.0 |
| SD. Chsn | 3.0 | . 9 | 3.2 |
| usu 25+ mi | + |  | + |
| No. Pred | 265.3 | 5.1 | 270.3 |
| No. Chsn | 1085.0 | 60.0 | 145.0 |
| SD. Chsn | 6.1 | 2.8 | 6.7 |
| usu 10-25m | - | *- |  |
| No. Pred | 1083.3 | 55.51 | 138.8 |
| No. Chsn | 923.0 | 65.0 | 988.0 |
| SD. Chsn | 5.6 | 3.0 | 6.4 |
| usu 3-10mi | * | + | - |
| No. Pred | 915.7 | 66.8 | 982.5 |
| No. Chsn | 367.0 | 67.0 | 434.0 |
| SD. Chsn | 3.6 | 3.0 | 4.7 |
| usu 0-3 mi | **+ | + | ** + |
| No. Pred | 375.8 | 69.7 | 445.5 |
| No. Chsn | 7.0 | . 0 | 7.0 |
| SD. Chsn | 3.5 | . 7 | 3.5 |
| tour $25+\mathrm{mi}$ | * | + | * |
| No. Pred | 12.2 | . 4 | 12.6 |
| No. Chsn | 38.0 | 5.0 | 43.0 |
| SD. Chsn | 5.4 | 2.1 | 5.8 |
| tour 10-25m\| | *- | - | *- |
| No. Pred | 28.9 | 4.4 | 33.4 |
| No. Chsn | 28.0 | 14.0 | 42.0 |
| SD. Chsn | 6.2 | 3.9 | 7.3 |
| tour 3-10mi\| | * | + | * |
| No. Pred | 38.2 | 15.2 | 53.4 |
| No. Chsn | 23.0 | 14.0 | 37.0 |
| SD. Chsn | 4.1 | 3.6 | 5.4 |
| tour 0-3 mil | *- | - | *- |
| No. Pred \| | 16.7 | 12.9 | 29.6 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

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```
Table for tcat
    ..(continued)
-------------------------------
-------------------------------
ddist | 123.0 75.5 119.3
dtime | 35.1 23.1 34.2
empmed | 18.1 4.2 17.1
empsvc | 13.2 7.3 12.8
empret | 8.4 7.9 8.4
emprest | 3.0 1.3 2.9
empofc | 27.0 19.8 26.4
houses | 2.1 1.7 2.1
studk12 | 22.3 28.6 22.7
studuniv | 87.5 7.0 81.3
INFORMATION 571: root-Mean-Square-Error is 6.643
INFORMATION 572: number of **stars** in table is 14
```

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Table for perstype

|  | FT <br> workr | \| PT workr| | red | n <br> rkr | $\begin{aligned} & \text { Univ \| } \\ & \text { Stud } \end{aligned}$ | $\begin{aligned} & \mid \text { Driv \| } \\ & \text { \| Stud \| } \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 1249.0 | 17.0 | . 0 | . 0 | 3.0 | 1.0 | 270.0 |
| SD. Chsn | 13.0 | 1.0 | . 0 | . 0 | . 4 | . 3 | 3.2 |
| usu 25+ mi | $1+$ |  |  |  | - | - | + |
| No. Pred | \| 249.7 | 17.0 | . 0 | . 0 | 2.8 | . 9 | 270.3 |
| No. Chsn | 11017.0 | 98.0 | . 0 | 2.0 | 26.0 | 2.011 | 145.0 |
| SD. Chsn | 16.0 | 2.5 | . 0 | . 2 | 1.5 | . 3 | 6.7 |
| usu 10-25m |  | *- |  |  | + |  | - |
| No. Pred | 11013.3 | 95.1 | . 0 | 1.9 | 26.5 | 1.911 | 138.8 |
| No. Chsn | 1848.0 | 102.0 | . 0 | . 0 | 29.0 | 9.0 | 988.0 |
| SD. Chsn | 15.7 | 2.4 | . 0 | . 0 | 1.2 | . 7 | 6.4 |
| usu 3-10mi | , | - |  |  | * | - | - |
| No. Pred | \| 844.9 | 101.8 | . 0 | . 0 | 27.4 | 8.5 | 982.5 |
| No. Chsn | 1351.0 | 48.0 | . 0 | 1.0 | 21.0 | 13.0 | 434.0 |
| SD. Chsn | 14.0 | 2.0 | . 0 | . 2 | 1.3 | . 9 | 4.7 |
| usu 0-3 mi | ) *+ | *+ |  |  | * | + | **+ |
| No. Pred | \| 357.3 | 51.2 | . 0 | . 9 | 22.9 | 13.1 | 445.5 |
| No. Chsn | 6.0 | 1.0 | . 0 | . 0 | . 0 | . 0 | 7.0 |
| SD. Chsn \| | 3.5 | . 7 | . 0 | . 0 | . 3 | . 2 | 3.5 |
| tour 25+mi | 1 *+ | - |  |  | + |  | *+ |
| No. Pred | 112.0 | . 4 | . 0 | . 0 | . 1 | . 0 | 12.6 |
| No. Chsn | 38.0 | 4.0 | . 0 | . 0 | 1.0 | . 0 | 43.0 |
| SD. Chsn | 5.5 | 1.6 | . 0 | . 2 | . 9 | . 4 | 5.8 |
| tour 10-25m\| | 1 | - |  |  | - | + | *- |
| No. Pred | 129.9 | 2.5 | . 0 | . 0 | . 8 | . 1 | 33.4 |
| No. Chsn | 37.0 | 5.0 | . 0 | . 0 | . 0 | . 0 | 42.0 |
| SD. Chsn | 16.4 | 2.9 | . 0 | . 2 | 1.6 | . 7 | 7.3 |
| tour 3-10mil | $1+$ | *+ |  |  | *+ | + | *+ |
| No. Pred | 141.5 | 8.6 | . 0 | . 1 | 2.6 | . 6 | 53.4 |
| No. Chsn | 21.0 | 9.0 | . 0 | . 0 | 6.0 | 1.0 | 37.0 |
| SD. Chsn | 14.3 | 2.7 | . 0 | . 2 | 1.7 | . 9 | 5.4 |
| tour 0-3 mil | \| | - |  |  | * | - | *- |
| No. Pred \| | 18.4 | 7.4 | . 0 | . 0 | 3.0 | . 8 | 29.6 |
| No. Chsn | 12567.0 | 284.0 | . 0 | 3.0 | 86.0 | 26.02 | 2966.0 |
| Total |  |  |  |  |  |  |  |
| No. Pred | 12567.0 | 284.0 | . 0 | 3.0 | 86.0 | 26.02 | 2966.0 |

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```
Table for perstype
    ..(continued)
```



```
\begin{tabular}{l|rrrrrrr} 
ddist & 123.3 & 100.6 & .0 & 102.9 & 79.4 & 61.8 & 119.3 \\
dtime & 35.1 & 30.1 & .0 & 33.9 & 24.0 & 19.5 & 34.2 \\
empmed & 18.1 & 13.0 & .0 & .1 & 3.6 & 1.5 & 17.1 \\
empsvc & 13.4 & 10.0 & .0 & 2.4 & 5.3 & 6.2 & 12.8 \\
empret & 8.0 & 11.3 & .0 & 9.8 & 10.5 & 5.6 & 8.4 \\
emprest & 2.6 & 4.6 & .0 & 12.5 & 4.1 & 9.7 & 2.9 \\
empofc & 27.6 & 17.4 & .0 & .3 & 27.4 & 3.3 & 26.4 \\
houses & 2.1 & 1.3 & .0 & .0 & 3.8 & 2.1 & 2.1 \\
studk12 & 20.1 & 54.6 & .0 & .2 & 2.7 & .8 & 22.7 \\
studuniv & 70.9 & 204.9 & .0 & 1.6 & 9.5 & 3.9 & 81.3
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 2.121
INFORMATION 572: number of **stars** in table is 16
```

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|  | $\begin{aligned} & \text { no } \\ & \text { car } \end{aligned}$ | $\begin{aligned} & \mid<1 \text { per\| } \\ & \mid \text { driv\| } \end{aligned}$ | $\begin{array}{r} 1+\text { per } \\ \text { driv } \end{array}$ | Total |
| :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 1.0 | 35.0 | 234.0 | 270.0 |
| SD. Chsn | . 2 | 1.1 | 3.0 | 3.2 |
| usu 25+ mi \| |  | * | + | + |
| No. Pred | 1.0 | 33.8 | 235.6 | 270.3 |
| No. Chsn \| | 8.0 | 193.0 | 944.01 | 145.0 |
| SD. Chsn \| | . 5 | 2.9 | 6.0 | 6.7 |
| usu 10-25m \| | - | - | - | - |
| No. Pred \| | 7.7 | 192.0 | 939.01 | 138.8 |
| No. Chsn | 17.0 | 209.0 | 762.0 | 988.0 |
| SD. Chsn \| | . 6 | 2.8 | 5.7 | 6.4 |
| usu 3-10mi \| | - | - | - | - |
| No. Pred \| | 16.6 | 206.2 | 759.7 | 982.5 |
| No. Chsn | 5.0 | 90.0 | 339.0 | 434.0 |
| SD. Chsn \| | . 4 | 2.1 | 4.2 | 4.7 |
| usu 0-3 mi \| | - | + | **+ | ** |
| No. Pred \| | 4.9 | 91.3 | 349.3 | 445.5 |
| No. Chsn | . 0 | . 0 | 7.0 | 7.0 |
| SD. Chsn | . 2 | 1.4 | 3.2 | 3.5 |
| tour 25+mi \| |  | *+ | *+ |  |
| No. Pred | . 0 | 1.9 | 10.6 | 12.6 |
| No. Chsn | . 0 | 6.0 | 37.0 | 43.0 |
| SD. Chsn \| | . 3 | 2.4 | 5.3 | 5.8 |
| tour 10-25m\| |  | - | *- | *- |
| No. Pred \| | . 1 | 5.6 | 27.7 | 33.4 |
| No. Chsn I | . 0 | 9.0 | 33.0 | 42.0 |
| SD. Chsn \| | . 6 | 3.2 | 6.5 | 7.3 |
| tour 3-10mi\| | + | + | * + | * |
| No. Pred \| | . 3 | 10.3 | 42.8 | 53.4 |
| No. Chsn I | . 0 | 5.0 | 32.0 | 37.0 |
| SD. Chsn \| | . 6 | 2.4 | 4.8 | 5.4 |
| tour 0-3 mil | + | + | *- | * |
| No. Pred \| | . 4 | 5.8 | 23.4 | 29.6 |
| No. Chsn | 31.0 | 547.02 | 388.02 | 966.0 |
| Total |  |  |  |  |
| No. Pred \| | 31.0 | 547.02 | 388.02 | 966.0 |

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```
Table for asuf
    ..(continued)
------------------------------------
--------------------------------------
ddist | 83.7 104.0 123.3 119.3
dtime | 25.1 30.7 35.1 34.2
empmed | 9.6 25.8 15.1 17.1
empsvc | 7.6 13.2 12.7 12.8
empret | 9.1 9.4 8.1 8.4
emprest | 3.7 3.3 2.8 2.9
empofc | 45.5 21.6 27.3 26.4
houses | .9 1.5 2.3 2.1
studk12 | 21.1 23.3 22.6 22.7
studuniv | .8 3.2 100.2 81.3
INFORMATION 571: root-Mean-Square-Error is . 848
INFORMATION 572: number of **stars** in table is 14
```

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Table for inc6

|  | $<15 \mathrm{~K}$ | $\begin{aligned} & \text { \| } 15- \\ & 150 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & 150- \\ & 175 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & 175- \\ & 1100 \mathrm{~K} \end{aligned}$ | $\text { \| } 100 \mathrm{~K}+$ | re- <br> fuse | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 8.0 | 68.0 | 103.0 | 47.0 | 29.0 | 15.0 | 270.0 |
| SD. Chsn \| | . 5 | 1.6 | 1.9 | 1.2 | 1.2 | . 6 | 3.2 |
| usu 25+ mi \| | - | + |  | + | - | - | + |
| No. Pred \| | 7.7 | 69.3 | 103.0 | 47.4 | 28.4 | 14.6 | 270.3 |
| No. Chsn \| | 32.0 | 308.0 | 416.0 | 170.0 | 113.0 | 106.01 | 145.0 |
| SD. Chsn \| | 1.3 | 3.5 | 4.0 | 2.5 | 2.2 | 2.1 | 6.7 |
| usu 10-25m \| | *- | - | + | - | *- | - | - |
| No. Pred \| | 30.2 | 305.2 | 419.2 | 169.3 | 110.6 | 104.31 | 38.8 |
| No. Chsn | 34.0 | 312.0 | 317.0 | 150.0 | 109.0 | 66.0 | 988.0 |
| SD. Chsn \| | 1.1 | 3.6 | 3.5 | 2.4 | 2.2 | 1.8 | 6.4 |
| usu 3-10mi \| | + | - | + | - | - | * | - |
| No. Pred \| | 34.7 | 310.8 | 317.3 | 147.9 | 108.8 | 63.1 | 982.5 |
| No. Chsn | 19.0 | 131.0 | 131.0 | 54.0 | 60.0 | 39.0 | 434.0 |
| SD. Chsn I | 1.2 | 2.5 | 2.7 | 1.6 | 1.5 | 1.6 | 4.7 |
| usu 0-3 mi \| | * | - | + | **+ | + | **+ | * + |
| No. Pred \| | 21.3 | 130.1 | 132.4 | 57.3 | 60.5 | 43.8 | 445.5 |
| No. Chsn | 1.0 | 1.0 | 4.0 | 1.0 | . 0 | . 0 | 7.0 |
| SD. Chsn \| | . 6 | 1.8 | 2.2 | 1.3 | 1.2 | . 9 | 3.5 |
| tour 25+mi \| |  | *+ | + | + | * | + | *+ |
| No. Pred | . 4 | 3.4 | 4.7 | 1.8 | 1.6 | . 8 | 12.6 |
| No. Chsn | . 0 | 12.0 | 16.0 | 4.0 | 5.0 | 6.0 | 43.0 |
| SD. Chsn \| | 1.0 | 3.0 | 3.4 | 2.2 | 2.1 | 1.7 | 5.8 |
| tour 10-25m\| | + | - | *- | + | - | *- | *- |
| No. Pred | . 9 | 9.0 | 11.4 | 4.8 | 4.3 | 2.9 | 33.4 |
| No. Chsn | 1.0 | 11.0 | 21.0 | 5.0 | 2.0 | 2.0 | 42.0 |
| SD. Chsn \| | 1.4 | 4.0 | 4.2 | 2.7 | 2.4 | 2.3 | 7.3 |
| tour 3-10mil | + | *+ | - | + | *+ | *+ | *+ |
| No. Pred \| | 2.0 | 15.7 | 17.4 | 7.1 | 5.9 | 5.3 | 53.4 |
| No. Chsn | 4.0 | 9.0 | 7.0 | 8.0 | 5.0 | 4.0 | 37.0 |
| SD. Chsn \| | 1.4 | 2.9 | 3.1 | 1.8 | 1.7 | 1.8 | 5.4 |
| tour 0-3 mil | *- | - | + | **- | *- | - | *- |
| No. Pred \| | 1.9 | 8.5 | 9.7 | 3.4 | 2.9 | 3.2 | 29.6 |
| No. Chsn \| | 99.0 | 852.01 | 1015.0 | 439.0 | 323.0 | 238.02 | 966.0 |
| Total |  |  |  |  |  |  |  |
| No. Pred \| | 99.0 | 852.01 | 1015.0 | 439.0 | 323.0 | 238.02 | 966.0 |

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```
Table for inc6
    ..(continued)
---------------------------------------------------------------
------------------------------------------------------------
ddist | 101.9 114.3 126.8 124.2 114.1 110.3 119.3
dtime | 29.4 33.0 35.9 35.5 33.3 32.2 34.2
empmed | 1.2 15.0 20.9 21.0 15.5 9.0 17.1
empsvc | 6.1 13.7 12.8 7. 7.8 17.4 15.1 12.8
empret | 6.9 12.5 7 7.7 5.3 6. 6.3 5.7 8.4
emprest | 2.0 4.0 2.3 2.5 3.2 2.6 2.9
empofc | 18.5 18.7 24.6 26.4 52.2 30.2 26.4
houses | . . | 2.2 2.4 2.7 2.7 1.6 . | 2.1
studk12 | 3.3 14.0 19.6 39.7 29.7 34.8 22.7
studuniv | 1.8 70.7 30.1 68.4 186.8 250.8 81.3
INFORMATION 571: root-Mean-Square-Error is 1.883
INFORMATION 572: number of **stars** in table is 26
```

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Table for hhsize

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| \| |  |  |  |  |  |  |  |  |  |  |
| No. Chsn \| | 22.0 | 106.0 | 66.0 | 63.0 | 10.0 | 3.0 | . 0 | . 0 | . 0 | . 0270.0 |
| SD. Chsn | . 9 | 2.0 | 1.5 | 1.5 | . 6 | . 3 | . 0 | . 0 | . 0 | . 03.2 |
| usu 25+ mi | * + | + | - | - | - |  |  |  |  | + |
| No. Pred | 23.2 | 107.4 | 65.6 | 61.5 | 9.7 | 2.9 | . 0 | . 0 | . 0 | . 0270.3 |
| No. Chsn | 143.0 | 427.0 | 260.0 | 224.0 | 53.0 | 28.0 | 2.0 | 3.0 | 3.0 | 2.01145 .0 |
| SD. Chsn | 2.5 | 4.0 | 3.2 | 3.0 | 1.3 | 1.0 | . 2 | . 3 | . 3 | . 46.7 |
| usu 10-25m | - | - | - | - | ***+ | * |  |  |  | - - |
| No. Pred | 141.4 | 423.9 | 257.9 | 221.0 | 58.1 | 26.9 | 2.0 | 2.9 | 2.9 | 1.81138 .8 |
| No. Chsn | 108.0 | 370.0 | 223.0 | 184.0 | 61.0 | 21.0 | 7.0 | 9.0 | 3.0 | 2.0988 .0 |
| SD. Chsn | 2.1 | 3.9 | 3.1 | 2.7 | 1.6 | . 8 | . 5 | . 6 | . 2 | . 36.4 |
| usu 3-10mi \| | * + | * | - | + | - | - | - | - |  | - |
| No. Pred | 110.4 | 365.4 | 221.0 | 184.9 | 60.2 | 20.4 | 6.7 | 8.6 | 2.9 | 1.9982 .5 |
| No. Chsn I | 32.0 | 193.0 | 88.0 | 78.0 | 22.0 | 15.0 | 3.0 | 2.0 | . 0 | 1.0434 .0 |
| SD. Chsn | 1.3 | 3.1 | 2.0 | 2.1 | 1.3 | . 7 | . 4 | . 5 | . 0 | . 24.7 |
| usu 0-3 mi \| | * + | + | **+ | + | + | + | - | * |  | ** + |
| No. Pred | 33.8 | 194.5 | 92.5 | 79.5 | 23.2 | 15.4 | 2.8 | 2.8 | . 0 | 1.0445 .5 |
| No. Chsn | 2.0 | 3.0 | . 0 | 1.0 | 1.0 | . 0 | . 0 | . 0 | . 0 | . $0 \quad 7.0$ |
| SD. Chsn | 1.1 | 2.3 | 1.7 | 1.5 | . 9 | . 5 | . 1 | . 2 | . 1 | . 03.5 |
| tour $25+\mathrm{mi}$ | - | + | * | + | - | + |  |  |  | * |
| No. Pred | 1.1 | 5.2 | 2.9 | 2.3 | . 8 | . 2 | . 0 | . 0 | . 0 | . 012.6 |
| No. Chsn | 5.0 | 14.0 | 9.0 | 10.0 | 5.0 | . 0 | . 0 | . 0 | . 0 | . 043.0 |
| SD. Chsn I | 2.0 | 3.6 | 2.7 | 2.6 | 1.3 | . 8 | . 3 | . 4 | . 2 | . 35.8 |
| tour 10-25m\| | - | - | - | * | ** | + |  | + |  | * |
| No. Pred \| | 3.8 | 12.7 | 7.4 | 6.7 | 1.8 | . 7 | . 1 | . 1 | . 0 | . 133.4 |
| No. Chsn | 5.0 | 14.0 | 11.0 | 6.0 | 6.0 | . 0 | . 0 | . 0 | . 0 | . 042.0 |
| SD. Chsn \| | 2.4 | 4.5 | 3.5 | 3.2 | 1.7 | 1.0 | . 6 | . 6 | . 2 | . 47.3 |
| tour 3-10mil | + | * + | + | * | *- | * + | $+$ | + |  | + *+ |
| No. Pred \| | 6.0 | 20.2 | 12.1 | 10.3 | 2.9 | 1.1 | . 3 | . 3 | . 0 | .1 53.4 |
| No. Chsn | 6.0 | 13.0 | 9.0 | 7.0 | . 0 | 1.0 | . 0 | 1.0 | . 0 | . 037.0 |
| SD. Chsn \| | 1.8 | 3.3 | 2.6 | 2.6 | 1.2 | . 6 | . 3 | . 5 | . 1 | . 25.4 |
| tour 0-3 mil | * | - | - | - | * | - | $+$ | * |  | * |
| No. Pred \| | 3.3 | 10.7 | 6.6 | 6.6 | 1.5 | . 4 | . 1 | . 3 | . 0 | . 129.6 |
| No. Chsn \| | 323.0 | 140.0 | 666.0 | 573.0 | 158.0 | 68.0 | 12.0 | 15.0 | 6.0 | 5.02966 .0 |
| Total |  |  |  |  |  |  |  |  |  |  |
| No. Pred \| | 323.0 | 140.0 | 666.0 | 573.0 | 158.0 | 68.0 | 12.0 | 15.0 | 6.0 | 5.02966 .0 |

DAYSIM Activity and Travel Simulator
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```
Table for hhsize
    ..(continued)
```



```
\begin{tabular}{l|r|rrrrrrrrrrr} 
- \\
ddist & 119.1 & 117.6 & 123.7 & 126.3 & 108.1 & 95.7 & 72.2 & 68.4 & 95.4 & 102.7 & 119.3 \\
dtime & 34.1 & 33.7 & 35.2 & 36.1 & 32.0 & 29.6 & 23.7 & 21.7 & 28.7 & 26.9 & 34.2 \\
empmed & 19.4 & 15.7 & 23.1 & 17.1 & 4.0 & 6.5 & 4.8 & 4.6 & 15.0 & .2 & 17.1 \\
empsvc & 13.9 & 12.6 & 9.7 & 12.9 & 24.8 & 11.5 & 4.5 & 3.0 & 53.2 & 10.6 & 12.8 \\
empret & 9.7 & 7.8 & 10.6 & 5.8 & 11.3 & 2.7 & 14.4 & 21.2 & 1.6 & 1.1 & 8.4 \\
emprest & 2.8 & 3.1 & 3.0 & 2.5 & 3.4 & 3.3 & 1.0 & 2.7 & 1.5 & 5.9 & 2.9 \\
empofc & 26.1 & 29.8 & 23.6 & 29.1 & 13.9 & 16.4 & 3.7 & 2.9 & 15.1 & 1.2 & 26.4 \\
houses & 2.2 & 1.9 & 2.9 & 1.1 & 3.4 & 2.2 & .2 & 7.3 & 5.9 & .1 & 2.1 \\
studk12 & 9.2 & 33.6 & 11.6 & 26.4 & 13.6 & 16.8 & .2 & .8 & .0 & .0 & 22.7 \\
studuniv & 185.2 & 1.6 & 134.6 & 104.2 & 188.1 & 4.6 & .3 & 2.9 & .9 & .0 & 81.3
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 1.521
INFORMATION 572: number of **stars** in table is 28
```

DAYSIM Activity and Travel Simulator
Technical Documentation

|  | Male | $\begin{aligned} & \text { \| Fe- } \\ & \text { \| male } \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: |
| No. Chsn | 151.0 | 119.0 | 270.0 |
| SD. Chsn | 2.4 | 2.1 | 3.2 |
| usu 25+ mi | + | + | + |
| No. Pred | 151.1 | 119.2 | 270.3 |
| No. Chsn | 610.0 | 535.01 | 145.0 |
| SD. Chsn | 4.9 | 4.6 | 6.7 |
| usu 10-25m | - | - | - |
| No. Pred | 607.5 | 531.31 | 138.8 |
| No. Chsn \| | 512.0 | 476.0 | 988.0 |
| SD. Chsn | 4.8 | 4.2 | 6.4 |
| usu 3-10mi | + | * | - |
| No. Pred | 513.7 | 468.8 | 982.5 |
| No. Chsn \| | 222.0 | 212.0 | 434.0 |
| SD. Chsn | 3.2 | 3.5 | 4.7 |
| usu 0-3 mi |  | ***+ | ** |
| No. Pred | 220.5 | 225.0 | 445.5 |
| No. Chsn | 5.0 | 2.0 | 7.0 |
| SD. Chsn | 2.7 | 2.2 | 3.5 |
| tour 25+mi | + | * | * |
| No. Pred | 7.6 | 5.0 | 12.6 |
| No. Chsn | 22.0 | 21.0 | 43.0 |
| SD. Chsn | 4.3 | 3.9 | 5.8 |
| tour 10-25m\| | - | *- | *- |
| No. Pred | 18.5 | 14.9 | 33.4 |
| No. Chsn | 28.0 | 14.0 | 42.0 |
| SD. Chsn | 5.3 | 5.0 | 7.3 |
| tour 3-10mil |  | **+ | *+ |
| No. Pred | 28.0 | 25.4 | 53.4 |
| No. Chsn | 11.0 | 26.0 | 37.0 |
| SD. Chsn \| | 3.7 | 3.9 | 5.4 |
| tour 0-3 mil | + | ** | * |
| No. Pred \| | 14.2 | 15.5 | 29.6 |
| No. Chsn \| | 1561.01 | 1405.02 | 2966.0 |
| Total |  |  |  |
| No. Pred \| | 1561.01 | 1405.02 | 2966.0 |

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```
Table for gend
    ..(continued)
-------------------------------
-------------------------------
ddist | 122.4 115.8 119.3
dtime | 34.9 33.4 34.2
empmed | 12.2 22.4 17.1
empsvc | 12.7 12.8 12.8
empret | 8.0 8.8 8.4
emprest | 2.6 3.3 2.9
empofc | 25.0 28.0 26.4
houses | 1.7 2.6 2.1
studk12 | 17.4 28.7 22.7
studuniv | 58.7 106.4 81.3
INFORMATION 571: root-Mean-Square-Error is 2.295
INFORMATION 572: number of **stars** in table is 16
```


## Appendix 1.3-School location model application

Table for perstype

|  | $\begin{aligned} & \text { FT } \\ & \text { workr } \end{aligned}$ | $\begin{aligned} & \mid P T \\ & \mid \text { workr\| } \end{aligned}$ | $\begin{aligned} & \|R e-\quad\| \mid \\ & \mid \text { tired\| } \end{aligned}$ | \| Non workr | \|Univ |Stud | $\begin{aligned} & \text { \| Driv } \\ & \text { \| Stud } \end{aligned}$ | $\begin{aligned} & \text { \| Stud } \\ & \text { \| } 5-15 \end{aligned}$ | $\begin{aligned} & \mid \text { Under } \mid \\ & \mid 5 \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 46.0 | . 0 | . 0 | 1.0 | 60.0 | 9.0 | 18.0 | 12.0 | 146.0 |
| SD. Chsn | 6.6 | . 0 | . 8 | 1.1 | 7.6 | 2.7 | 4.6 | 2.8 | 11.8 |
| $15+\mathrm{mi}$ | + |  | + | + | + | - | + | *- | + |
| No. Pred | 49.7 | . 0 | . 7 | 1.8 | 66.1 | 7.4 | 21.6 | 8.2 | 155.6 |
| No. Chsn | 106.0 | . 0 | . 0 | 6.0 | 109.0 | 49.0 | 141.0 | 33.0 | 444.0 |
| SD. Chsn | 9.6 | . 0 | . 4 | 1.9 | 9.9 | 7.9 | 12.4 | 6.2 | 21.2 |
| 5-15 mi | - |  | + | *- | + | *+ | *+ | *+ | * |
| No. Pred | 105.8 | . 0 | . 2 | 4.0 | 111.3 | 63.8 | 155.1 | 40.4 | 480.7 |
| No. Chsn | 21.0 | . 0 | . 0 | . 0 | 23.0 | 22.0 | 47.0 | 10.0 | 123.0 |
| SD. Chsn | 4.0 | . 0 | . 1 | 1.0 | 4.6 | 4.8 | 7.1 | 3.1 | 11.0 |
| $4-5 \mathrm{mi}$ | - |  |  | *+ | + | + | + | - | + |
| No. Pred | 18.5 | . 0 | . 0 | 1.1 | 23.9 | 23.7 | 51.3 | 9.8 | 128.3 |
| No. Chsn | 28.0 | . 0 | . 0 | . 0 | 35.0 | 46.0 | 89.0 | 17.0 | 215.0 |
| SD. Chsn | 4.4 | . 0 | . 1 | . 5 | 5.4 | 5.8 | 9.5 | 3.4 | 13.6 |
| $3-4 \mathrm{mi}$ | *- |  |  | + | + | *- | + | - | *- |
| No. Pred | 22.9 | . 0 | . 0 | . 2 | 37.2 | 34.9 | 93.6 | 12.4 | 201.2 |
| No. Chsn | 21.0 | . 0 | . 0 | . 0 | 33.0 | 42.0 | 146.0 | 11.0 | 253.0 |
| SD. Chsn | 4.4 | . 0 | . 0 | . 7 | 5.4 | 6.4 | 11.6 | 3.7 | 15.5 |
| $2-3 \mathrm{mi}$ | + |  |  | *+ | *+ | + | - | *+ | + |
| No. Pred | 23.6 | . 0 | . 0 | . 7 | 39.0 | 43.3 | 141.7 | 14.8 | 263.2 |
| No. Chsn | 20.0 | . 0 | 1.0 | 2.0 | 73.0 | 68.0 | 229.0 | 16.0 | 409.0 |
| SD. Chsn | 4.1 | . 0 | . 1 | . 6 | 6.0 | 6.7 | 14.3 | 4.0 | 17.9 |
| $1-2 \mathrm{mi}$ | + |  |  | **- | *** | **- | - | + | ** |
| No. Pred | 21.0 | . 0 | . 0 | . 4 | 51.9 | 48.5 | 222.7 | 17.3 | 361.7 |
| No. Chsn | 12.0 | . 0 | . 0 | . 0 | 29.0 | 38.0 | 365.0 | 32.0 | 476.0 |
| SD. Chsn | 3.2 | . 0 | . 2 | . 5 | 4.8 | 7.0 | 17.2 | 5.0 | 20.1 |
| $0-1 \mathrm{mi}$ | + |  |  | + | + | **+ | *- | - | + |
| No. Pred | 13.0 | . 0 | . 0 | . 3 | 33.7 | 53.4 | 346.4 | 29.4 | 476.2 |
| No. Chsn | 7.0 | . 0 | . 0 | . 0 | 3.0 | 6.0 | 24.0 | 3.0 | 43.0 |
| SD. Chsn | 2.5 | . 0 | . 1 | . 5 | 1.4 | 2.2 | 5.0 | 1.3 | 6.3 |
| home | - |  |  | + | - | - | + | - | - |
| No. Pred | 6.6 | . 0 | . 0 | . 3 | 1.8 | 5.1 | 26.7 | 1.8 | 42.2 |
| No. Chsn | 261.0 | . 0 | 1.0 | 9.0 | 365.0 | 280.01 | 1059.0 | 134.02 | 2109.0 |
| Total |  |  |  |  |  |  |  |  |  |
| No. Pred | 261.0 | . 0 | 1.0 | 9.0 | 365.0 | 280.01 | 1059.0 | 134.02 | 2109.0 |

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```
Table for perstype
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline & \[
\begin{aligned}
& \text { | FT } \\
& \text { | workr }
\end{aligned}
\] & & \[
\begin{aligned}
& \mid \text { Re- | } \\
& \text { r|tired| }
\end{aligned}
\] & | Non | & Univ Stud & \[
\begin{aligned}
& \text { I Driv } \\
& \text { | Stud }
\end{aligned}
\] & \[
\begin{aligned}
& \text { IStud } \\
& 15-15
\end{aligned}
\] & \[
\begin{aligned}
& \mid \text { Under } \mid \\
& \mid 5
\end{aligned}
\] & Total \\
\hline ddist & 93.7 & . 0 & 205.8 & 84.1 & 82.1 & 39.3 & 29.5 & 51.3 & 49.6 \\
\hline dtime & | 28.2 & . 0 & - 48.2 & 27.6 & 25.1 & 14.3 & 11.1 & 17.3 & 16.6 \\
\hline empmed & 5.5 & . 0 & - . 5 & 5.9 & 8.8 & . 8 & . 8 & 1.8 & 2.8 \\
\hline empsvc & 3.4 & . 0 & - 2.9 & 3.2 & 3.5 & 1.4 & 1.2 & 3.6 & 2.1 \\
\hline empret & 2.2 & . 0 & 1.3 & 2.5 & 2.0 & . 3 & . 2 & 1.1 & . 8 \\
\hline emprest & 2.0 & . 0 & - . 2 & 3.4 & 1.7 & . 2 & . 1 & . 7 & . 7 \\
\hline empofc & 17.6 & . 0 & - 4.4 & 10.5 & 8.7 & 1.6 & 1.7 & 2.5 & 3.7 \\
\hline houses & 1.8 & . 0 & - . 4 & . 6 & . 7 & 1.3 & 1.4 & 1.7 & 1.2 \\
\hline studk12 & | 51.2 & . 0 & 157.2 & 50.4 & 44.2 & 266.6 & 353.4 & 118.8 & 234.7 \\
\hline studuniv & | 5714.1 & & 5228.86 & 6520.87 & 909.1 & 3.3 & 3.7 & 3.62 & 108.8 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 3.175
INFORMATION 572: number of **stars** in table is 29
```

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Table for inc6

|  | <15K | $\begin{aligned} & \text { \|15- } \\ & 150 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & 150- \\ & 175 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \text { \| 75- } \\ & 1100 \mathrm{~K} \end{aligned}$ | \| 100K+ | $\begin{array}{l\|l} \text { \|re- } & \mid \\ \text { \|fuse } \end{array}$ | \| Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 9.0 | 37.0 | 47.0 | 28.0 | 17.0 | 8.0 | 146.0 |
| SD. Chsn | 3.7 | 6.4 | 6.8 | 4.5 | 3.5 | 2.4 | 11.8 |
| $15+\mathrm{mi}$ | **+ | *+ | + | *- | *- | - | + |
| No. Pred | 16.5 | 46.0 | 52.4 | 21.7 | 13.1 | 5.9 | 155.6 |
| No. Chsn | 21.0 | 132.0 | 140.0 | 60.0 | 57.0 | 34.0 | 444.0 |
| SD. Chsn | 5.3 | 11.7 | 12.3 | 7.7 | 6.7 | 5.3 | 21.2 |
| 5-15 mi | *+ | *+ | *+ | + | *- | - | + |
| No. Pred | 30.2 | 148.2 | 161.9 | 63.6 | 46.8 | 30.1 | 480.7 |
| No. Chsn | 6.0 | 43.0 | 45.0 | 13.0 | 10.0 | 6.0 | 123.0 |
| SD. Chsn | 2.8 | 6.1 | 6.4 | 3.8 | 3.5 | 2.8 | 11.0 |
| 4-5 mi | + | - | - | + | + | + | + |
| No. Pred | 8.7 | 39.1 | 44.1 | 15.0 | 13.1 | 8.5 | 128.3 |
| No. Chsn | 19.0 | 81.0 | 65.0 | 27.0 | 15.0 | 8.0 | 215.0 |
| SD. Chsn | 3.7 | 7.8 | 7.7 | 4.8 | 4.0 | 3.2 | 13.6 |
| $3-4 \mathrm{mi}$ | - | *- | - | - | + | *+ | *- |
| No. Pred | 16.0 | 67.8 | 64.2 | 25.0 | 16.9 | 11.3 | 201.2 |
| No. Chsn | 18.0 | 101.0 | 67.0 | 24.0 | 22.0 | 21.0 | 253.0 |
| SD. Chsn | 4.3 | 9.2 | 8.2 | 5.5 | 4.8 | 3.9 | 15.5 |
| 2-3 mi | + | - | + | *+ | + | - | + |
| No. Pred | 21.8 | 92.9 | 72.7 | 33.6 | 25.0 | 17.2 | 263.2 |
| No. Chsn | 61.0 | 132.0 | 117.0 | 38.0 | 43.0 | 18.0 | 409.0 |
| SD. Chsn | 5.6 | 10.4 | 9.6 | 6.1 | 5.6 | 4.3 | 17.9 |
| 1-2 mi | ***- | - | *- | + | *- | + | **- |
| No. Pred | 40.8 | 122.3 | 102.9 | 40.9 | 34.1 | 20.8 | 361.7 |
| No. Chsn | 46.0 | 145.0 | 182.0 | 48.0 | 34.0 | 21.0 | 476.0 |
| SD. Chsn | 5.8 | 11.5 | 11.7 | 6.3 | 6.4 | 4.5 | 20.1 |
| 0-1 mi | - | *+ | **- | - | **+ | + | + |
| No. Pred | 41.6 | 159.0 | 158.5 | 45.9 | 47.6 | 23.6 | 476.2 |
| No. Chsn | . 0 | 19.0 | 6.0 | 13.0 | 2.0 | 3.0 | 43.0 |
| SD. Chsn | 2.0 | 3.8 | 3.5 | 2.3 | 1.8 | 1.3 | 6.3 |
| home | **+ | *- | *+ | ***- | + | - | - |
| No. Pred | 4.4 | 14.8 | 12.4 | 5.3 | 3.4 | 1.8 | 42.2 |
| No. Chsn | 180.0 | 690.0 | 669.0 | 251.0 | 200.0 | 119.02 | 2109.0 |
| Total |  |  |  |  |  |  |  |
| No. Pred | 180.0 | 690.0 | 669.0 | 251.0 | 200.0 | 119.02 | 2109.0 |

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```
Table for inc6
    ..(continued)
```



```
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline ddist & | & 48.1 & 46.7 & 52.0 & 54.6 & 48.5 & 46.1 & 49.6 \\
\hline dtime & | & 16.0 & 15.7 & 17.1 & 18.4 & 16.6 & 15.8 & 16.6 \\
\hline empmed & | & 6.4 & 3.1 & 2.0 & 2.7 & 1.7 & 2.8 & 2.8 \\
\hline empsvc & | & 2.3 & 2.2 & 1.9 & 1.8 & 1.8 & 2.8 & 2.1 \\
\hline empret & । & 1.0 & . 8 & . 8 & . 7 & . 9 & 1.4 & . 8 \\
\hline emprest & | & . 9 & . 8 & . 5 & . 6 & . 6 & 1.0 & . 7 \\
\hline empofc & | & 6.0 & 4.2 & 3.0 & 2.8 & 2.8 & 5.0 & 3.7 \\
\hline houses & & . 8 & 1.4 & 1.0 & 1.1 & 1.2 & 1.6 & 1.2 \\
\hline studk12 & & 173.4 & 229.7 & 251.3 & 238.0 & 258.9 & 215.8 & 234.7 \\
\hline studuniv & & 513.72 & 271.71 & 738.61 & 684.21 & 002.32 & 362.82 & 108.8 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 7.634
INFORMATION 572: number of **stars** in table is 33
```

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Table for hhsize

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | $\text { \| } 10$ | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 9.0 | 23.0 | 45.0 | 43.0 | 22.0 | 4.0 | . 0 | . 0 | . 0 | . 0 | 146.0 |
| SD. Chsn | 3.0 | 5.3 | 6.2 | 6.1 | 4.0 | 2.3 | 1.9 | 1.2 | . 4 | . 2 | 11.8 |
| $15+\mathrm{mi}$ | + | *+ | - | - | *- | + | **+ | *+ | $+$ |  | $+$ |
| No. Pred | 10.0 | 33.1 | 43.3 | 40.6 | 17.4 | 5.3 | 4.2 | 1.5 | . 1 |  | 155.6 |
| No. Chsn | 26.0 | 77.0 | 117.0 | 150.0 | 47.0 | 18.0 | 6.0 | 2.0 | 1.0 | . 0 | 444.0 |
| SD. Chsn | 4.7 | 8.1 | 10.6 | 12.2 | 7.6 | 4.9 | 3.0 | 2.8 | 1.0 | 1.0 | 21.2 |
| $5-15 \mathrm{mi}$ | - | - | + | + | *+ | *+ | *+ | **+ |  | *+ | * |
| No. Pred | 24.2 | 71.4 | 121.7 | 158.9 | 60.6 | 24.2 | 9.3 | 8.5 | . 9 | 1.0 | 480.7 |
| No. Chsn | 3.0 | 27.0 | 29.0 | 37.0 | 16.0 | 9.0 | 1.0 | 1.0 | . 0 | . 0 | 123.0 |
| SD. Chsn | 2.2 | 3.7 | 5.5 | 6.4 | 4.3 | 2.8 | 1.8 | 1.2 | . 2 | . 6 | 11.0 |
| 4-5 mi | *+ | *** | + | + | + | - | * | + |  | + | + |
| No. Pred | 5.7 | 14.5 | 32.0 | 42.8 | 20.0 | 7.8 | 3.6 | 1.4 | . 0 | . 3 | 128.3 |
| No. Chsn | 12.0 | 24.0 | 50.0 | 80.0 | 24.0 | 6.0 | 17.0 | 1.0 | 1.0 | . 0 | 215.0 |
| SD. Chsn | 2.8 | 4.6 | 6.5 | 8.1 | 4.8 | 3.5 | 2.6 | 2.0 | . 6 | . 7 | 13.6 |
| 3-4 mi | - | + | - | *- |  | *+ | *** | *+ | - | + | *- |
| No. Pred | 10.2 | 24.7 | 47.0 | 69.4 | 24.0 | 12.7 | 7.7 | 4.7 | . 4 | . 5 | 201.2 |
| No. Chsn | 9.0 | 29.0 | 54.0 | 89.0 | 34.0 | 20.0 | 4.0 | 14.0 | . 0 | . 0 | 253.0 |
| SD. Chsn | 2.7 | 4.9 | 7.2 | 9.2 | 6.6 | 4.4 | 2.1 | 2.0 | . 8 | . 5 | 15.5 |
| $2-3 \mathrm{mi}$ | + | - | + | + | *+ | + | + | ** | + | + | + |
| No. Pred | 9.9 | 28.2 | 57.0 | 91.1 | 46.0 | 21.4 | 4.6 | 4.2 | . 6 | . 3 | 263.2 |
| No. Chsn | 14.0 | 40.0 | 106.0 | 123.0 | 73.0 | 40.0 | 6.0 | 2.0 | . 0 | 5.0 | 409.0 |
| SD. Chsn | 3.0 | 5.6 | 8.3 | 10.9 | 7.1 | 4.8 | 3.1 | 2.3 | . 3 | 1.2 | 17.9 |
| 1-2 mi | - | - | ***- | + | **- | ***- | *+ | *+ | + | **- | ** |
| No. Pred | 12.2 | 38.1 | 78.5 | 132.0 | 57.3 | 24.8 | 10.7 | 6.4 | . 1 | 1.6 | 361.7 |
| No. Chsn | 8.0 | 23.0 | 83.0 | 175.0 | 93.0 | 62.0 | 16.0 | 10.0 | 4.0 | 2.0 | 476.0 |
| SD. Chsn | 2.3 | 5.3 | 9.3 | 11.8 | 8.3 | 7.2 | 3.1 | 2.7 | 1.6 | 1.2 | 20.1 |
| 0-1 mi | + | **+ | **+ | - | *- | - | *- | - | - | - | + |
| No. Pred | 8.4 | 35.4 | 103.9 | 163.3 | 80.0 | 60.1 | 12.3 | 8.3 | 2.8 | 1.7 | 476.2 |
| No. Chsn | . 0 | 4.0 | 4.0 | 12.0 | 4.0 | 4.0 | 6.0 | 9.0 | . 0 | . 0 | 43.0 |
| SD. Chsn | . 6 | 1.3 | 2.1 | 3.3 | 2.8 | 2.5 | 1.8 | 1.9 | . 9 | 1.1 | 6.3 |
| home | + | *- | + | - | *+ | *+ | * | **- | *+ | *+ | - |
| No. Pred | . 3 | 1.7 | 4.6 | 11.0 | 7.9 | 6.6 | 3.5 | 4.0 | . 9 | 1.6 | 42.2 |
| No. Chsn | 81.0 | 247.0 | 488.0 | 709.0 | 313.0 | 163.0 | 56.0 | 39.0 | 6.0 | 7.02 | 2109.0 |
| Total |  |  |  |  |  |  |  |  |  |  |  |
| No. Pred | 81.0 | 247.0 | 488.0 | 709.0 | 313.0 | 163.0 | 56.0 | 39.0 | 6.0 | 7.02 | 2109.0 |

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```
Table for hhsize
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline & & 1 & \[
2
\] & & 4 & 5 & 6 & 7 & 8 & & \[
\mid 10
\] & Total \\
\hline ddist & & 67.3 & 67.3 & 55.6 & 46.3 & 41.8 & 31.6 & 42.3 & 41.9 & 26.3 & 22.8 & 49.6 \\
\hline dtime & | & 21.5 & 21.4 & 18.2 & 15.7 & 14.4 & 11.6 & 14.3 & 14.5 & 9.1 & 8.0 & 16.6 \\
\hline empmed & I & 8.9 & 6.1 & 3.1 & 1.8 & 1.5 & 2.1 & 1.4 & 1.2 & . 4 & . 1 & 2.8 \\
\hline empsvc & | & 3.4 & 3.2 & 2.5 & 1.9 & 1.4 & 1.1 & 1.8 & 1.1 & 4.5 & . 5 & 2.1 \\
\hline empret & | & 1.8 & 1.9 & 1.0 & . 6 & . 5 & . 4 & . 3 & . 5 & . 9 & . 0 & . 8 \\
\hline emprest & I & 1.7 & 1.7 & . 9 & . 4 & . 3 & . 2 & . 2 & . 3 & . 0 & . 0 & . 7 \\
\hline empofc & I & 14.0 & 6.4 & 3.9 & 2.6 & 2.2 & 2.5 & 1.9 & 1.6 & 12.4 & 1.0 & 3.7 \\
\hline houses & | & . 8 & 1.1 & 1.1 & 1.2 & 1.2 & 1.7 & . 9 & 1.3 & . 6 & . 6 & 1.2 \\
\hline studk12 & & 29.5 & 118.0 & 220.0 & 266.5 & 280.2 & 316.4 & 254.3 & 261.9 & 244.6 & 280.0 & 234.7 \\
\hline studuniv & & 7665.14 & 998.92 & 374.81 & 223.3 & 965.1 & 741.92 & 001.8 & 780.1 & 2.4 & . 32 & 108.8 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 4.600
INFORMATION 572: number of **stars** in table is 56
```

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Table for gend

|  | Male | $\begin{array}{l\|} \|\mathrm{Fe}-\quad\| \\ \mid \text { male } \end{array}$ |  |  |  |  |  | $\begin{aligned} & \text { \|re- \| } \\ & \text { \|fuse } \end{aligned}$ |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 63.0 | 83.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 146.0 |
| SD. Chsn | 7.9 | 8.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 3 | 11.8 |
| $15+\mathrm{mi}$ | + | + |  |  |  |  |  |  |  | + |
| No. Pred | 68.2 | 87.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 155.6 |
| No. Chsn | 207.0 | 235.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.0 | 444.0 |
| SD. Chsn | \| 14.6 | 15.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.4 | 21.2 |
| $5-15 \mathrm{mi}$ | \| *+ | *+ |  |  |  |  |  |  | - | *+ |
| No. Pred | \| 227.7 | 251.1 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.9 | 480.7 |
| No. Chsn | 60.0 | 62.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.0 | 123.0 |
| SD. Chsn | \| 7.5 | 7.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 8 | 11.0 |
| $4-5 \mathrm{mi}$ | $1+$ | + |  |  |  |  |  |  | - | + |
| No. Pred | \| 60.1 | 67.5 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 7 | 128.3 |
| No. Chsn | \| 111.0 | 104.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 215.0 |
| SD. Chsn | \| 9.7 | 9.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.0 | 13.6 |
| 3-4 mi | I | - |  |  |  |  |  |  | *+ | *- |
| No. Pred | \| 102.8 | 97.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.1 | 201.2 |
| No. Chsn | \| 124.0 | 125.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 4.0 | 253.0 |
| SD. Chsn | \| 11.0 | 10.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.3 | 15.5 |
| 2-3 mi | ) + | + |  |  |  |  |  |  | * | + |
| No. Pred | \| 133.4 | 128.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.7 | 263.2 |
| No. Chsn | 200.0 | 205.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 4.0 | 409.0 |
| SD. Chsn | \| 12.5 | 12.6 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.8 | 17.9 |
| $1-2 \mathrm{mi}$ | \| **- | *- |  |  |  |  |  |  | - | ** |
| No. Pred | \| 175.0 | 183.4 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.3 | 361.7 |
| No. Chsn | 245.0 | 228.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.0 | 476.0 |
| SD. Chsn | \| 14.3 | 13.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.0 | 20.1 |
| $0-1 \mathrm{mi}$ | I | + |  |  |  |  |  |  | + | + |
| No. Pred | \| 242.5 | 228.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 4.8 | 476.2 |
| No. Chsn | 20.0 | 23.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 43.0 |
| SD. Chsn | \| 4.4 | 4.5 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 6 | 6.3 |
| home | $1+$ | - |  |  |  |  |  |  | + | - |
| No. Pred | \| 20.3 | 21.5 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 4 | 42.2 |
| No. Chsn | 11030.01 | 1065.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 14.02 | 109.0 |
| Total |  |  |  |  |  |  |  |  |  |  |
| No. Pred | \| 1030.01 | 1065.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 14.02 | 109.0 |

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```
Table for gend
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline & & Male & \[
\begin{aligned}
& \mid \mathrm{Fe}- \\
& \mid \mathrm{male}
\end{aligned}
\] & & & & & & \multicolumn{3}{|r|}{lre- | Total
Ifuse |} \\
\hline ddist & | & 47.5 & 51.9 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 25.2 & 49.6 \\
\hline dtime & | & 16.0 & 17.2 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 9.9 & 16.6 \\
\hline empmed & | & 2.4 & 3.3 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 1.2 & 2.8 \\
\hline empsvc & | & 1.9 & 2.2 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 1.1 & 2.1 \\
\hline empret & | & . 8 & . 9 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & . 4 & . 8 \\
\hline emprest & | & . 6 & . 7 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & . 2 & . 7 \\
\hline empofc & | & 3.2 & 4.2 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 4.7 & 3.7 \\
\hline houses & | & 1.2 & 1.1 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & . 9 & 1.2 \\
\hline studk12 & & 241.7 & 226.6 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & 332.0 & 234.7 \\
\hline studuniv & & 975.12 & 2265.8 & . 0 & . 0 & . 0 & . 0 & . 0 & . 0 & . 22 & 108.8 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 9.619
INFORMATION 572: number of **stars** in table is 11
```


## Appendix 1.4-Non-work/non-school tour destination model application

|  | prim \| <br> usual\| |  | \|Work | Total |based| |  |
| :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 50.0 | 37.0 | 6.0 | 93.0 |
| SD. Chsn | 7.8 | 6.6 | 1.2 | 10.3 |
| $25+\mathrm{mi}$ | *+ | *+ | ***- | *+ |
| No. Pred | 62.1 | 44.5 | 1.5 | 108.1 |
| No. Chsn | 322.0 | 335.0 | 21.0 | 678.0 |
| SD. Chsn | 17.3 | 18.1 | 5.6 | 25.6 |
| $10-25 \mathrm{mil}$ | *- | - | *+ | - |
| No. Pred | 303.0 | 330.9 | 31.7 | 665.6 |
| No. Chsn | 486.0 | 532.0 | 59.01 | 077.0 |
| SD. Chsn | - 22.0 | 24.6 | 8.0 | 33.9 |
| $5-10 \mathrm{mi}$ | + | ***+ | + | **+ |
| No. Pred | \| 491.1 | 615.9 | 65.01 | 171.9 |
| No. Chsn | 354.0 | 603.0 | 64.01 | 021.0 |
| SD. Chsn | 20.0 | 23.1 | 7.5 | 31.4 |
| $3-5 \mathrm{mi}$ | **+ | **- | - | - |
| No. Pred | \| 411.2 | 548.3 | 58.01 | 017.6 |
| No. Chsn | 1264.0 | 424.0 | 47.0 | 735.0 |
| SD. Chsn | 16.2 | 20.2 | 6.6 | 26.7 |
| $2-3 \mathrm{mi}$ | $1+$ |  | - | + |
| No. Pred | \| 274.9 | 426.0 | 44.9 | 745.8 |
| No. Chsn | \| 166.0 | 288.0 | 32.0 | 486.0 |
| SD. Chsn | \| 12.5 | 16.3 | 5.7 | 21.4 |
| $1.5-2 \mathrm{mi}$ | + | - | + | - |
| No. Pred | \| 166.6 | 281.3 | 34.2 | 482.0 |
| No. Chsn \| | \| 198.0 | 302.0 | 47.0 | 547.0 |
| SD. Chsn | 12.7 | 16.8 | 6.8 | 22.1 |
| $1-1.5 \mathrm{mi}$ | *- | + | + | - |
| No. Pred | \| 174.1 | 302.2 | 48.8 | 525.0 |
| No. Chsn \| | \| 219.0 | 349.0 | 74.0 | 642.0 |
| SD. Chsn | \| 12.9 | 17.7 | 8.2 | 23.4 |
| $0.5-1 \mathrm{mi}$ | \| **- |  | + | *- |
| No. Pred | \| 183.7 | 349.9 | 75.3 | 608.9 |
| No. Chsn \| | \| 121.0 | 281.0 | 91.0 | 493.0 |
| SD. Chsn । | \| 9.7 | 14.4 | 8.2 | 19.2 |
| $0-0.5 \mathrm{mi}$ | - - | **- | *- | ** |
| No. Pred | \| 113.3 | 252.2 | 81.6 | 447.1 |
| No. Chsn | 12180.03 | 3151.0 | 441.05 | 5772.0 |
| Total <br> No. Pred | 12180.03 | 3151.0 | 441.05 | 5772.0 |

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```
Table for tcat
    ..(continued)
--------------------------------------
-----------------------------------------
ddist | 59.9 47.6 33.7 51.2
dtime | 19.7 16.4 12.2 17.3
empmed | 16.0 11.2 12.3 13.1
empsvc | 9.6 9.4 17.8 10.1
empret | 17.5 18.2 23.4 18.3
emprest | 5.0 5.9 26.8 7.2
empofc | 11.5 9.4 27.5 11.6
houses | 1.5 1.7 1.7 1.6
studk12 | 45.0 43.8 13.3 42.0
studuniv | 22.1 18.0 5.5 18.6
INFORMATION 571: root-Mean-Square-Error is 25.824
INFORMATION 572: number of **stars** in table is 26
```

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Table for purp


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```
Table for purp
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline & Work & |Scho & \[
\mid \text { Esco }
\] & | Pers |Busi & | Shop | & |Meal | & \[
\begin{aligned}
& \text { | Soc } \\
& \text { | Rec }
\end{aligned}
\] & Total \\
\hline ddist & . 0 & . 0 & 39.3 & 56.5 & 47.2 & 45.3 & 61.0 & 51.2 \\
\hline dtime & . 0 & . 0 & 14.0 & 18.9 & 16.2 & 15.6 & 19.9 & 17.3 \\
\hline empmed & . 0 & . 0 & 5.3 & 31.5 & 3.8 & 2.9 & 8.3 & 13.1 \\
\hline empsvc & . 0 & . 0 & 5.4 & 9.6 & 13.3 & 9.4 & 10.8 & 10.1 \\
\hline empret & . 0 & . 0 & 4.2 & 6.7 & 51.2 & 18.5 & 4.7 & 18.3 \\
\hline emprest & . 0 & . 0 & . 9 & 2.7 & 9.2 & 33.4 & 2.2 & 7.2 \\
\hline empofc & . 0 & . 0 & 5.5 & 15.1 & 11.8 & 18.1 & 7.1 & 11.6 \\
\hline houses & . 0 & . 0 & 1.5 & 2.0 & . 7 & 1.2 & 2.5 & 1.6 \\
\hline studk12 & . 0 & . 0 & 223.5 & 18.2 & . 8 & 2.0 & 9.5 & 42.0 \\
\hline studuniv & . 0 & . 0 & 40.1 & 22.6 & 2.5 & 1.6 & 25.6 & 18.6 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 12.155
INFORMATION 572: number of **stars** in table is 32
```

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Table for perstype

|  | workr | PT workr | \| Re- <br> \|tired | \| Non | | $\begin{aligned} & \text { Univ \| } \\ & \text { Stud } \end{aligned}$ | $\begin{aligned} & \text { \| Driv } \\ & \text { \| Stud } \end{aligned}$ | $\begin{array}{ll} \mid \text { Stud } & \mid \\ \mid 5-15 & \mid \end{array}$ | \| Under  <br> $\mid 5$ Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 27.0 | 4.0 | 18.0 | 34.0 | 3.0 | 3.0 | 4.0 | . 093.0 |
| SD. Chsn | 5.2 | 2.8 | 5.4 | 5.3 | 2.2 | 1.4 | 2.2 | 1.710 .3 |
| $25+\mathrm{mi}$ | + | *+ | **+ | - | + | - | + | *+ |
| No. Pred | 27.4 | 7.8 | 29.3 | 28.8 | 5.0 | 2.0 | 4.8 | 3.0108 .1 |
| No. Chsn | 218.0 | 50.0 | 170.0 | 136.0 | 27.0 | 11.0 | 35.0 | 31.0678 .0 |
| SD. Chsn । | 13.9 | 6.8 | 12.9 | 12.2 | 5.1 | 4.1 | 6.3 | 4.725 .6 |
| $10-25 \mathrm{mil}$ | *- | - | - | *+ | - | *+ | + | *- - |
| No. Pred \| | 194.3 | 46.9 | 168.8 | 149.8 | 26.6 | 17.2 | 39.4 | 22.5665 .6 |
| No. Chsn | 296.0 | 74.0 | 325.0 | 223.0 | 36.0 | 30.0 | 58.0 | 35.01077 .0 |
| SD. Chsn | 18.3 | 9.3 | 17.9 | 15.3 | 5.7 | 5.3 | 8.3 | 6.533 .9 |
| $5-10 \mathrm{mi}$ \| | **+ | *+ | + | *+ | - | - | *+ | *+ **+ |
| No. Pred | 340.3 | 88.3 | 327.4 | 239.4 | 33.2 | 29.0 | 70.9 | 43.41171 .9 |
| No. Chsn | 296.0 | 79.0 | 258.0 | 206.0 | 28.0 | 30.0 | 82.0 | 42.01021 .0 |
| SD. Chsn | 17.0 | 8.8 | 16.2 | 14.3 | 5.7 | 4.7 | 7.8 | 6.231 .4 |
| $3-5 \mathrm{mi}$ | + | + | + | + | + | *- | ** | - - |
| No. Pred | 297.5 | 79.3 | 271.5 | 211.2 | 33.0 | 23.0 | 62.4 | 39.61017 .6 |
| No. Chsn | 221.0 | 53.0 | 204.0 | 141.0 | 29.0 | 23.0 | 52.0 | 12.0735 .0 |
| SD. Chsn । | 14.7 | 7.3 | 13.6 | 12.0 | 4.9 | 4.2 | 6.9 | 5.126 .7 |
| $2-3 \mathrm{mi}$ | + | + | - | + | - | - | - | **+ + |
| No. Pred | 225.3 | 55.8 | 193.7 | 150.6 | 24.7 | 18.8 | 49.6 | 27.2745 .8 |
| No. Chsn | 141.0 | 36.0 | 113.0 | 101.0 | 24.0 | 9.0 | 33.0 | 29.0486 .0 |
| SD. Chsn | 12.1 | 6.0 | 10.8 | 9.1 | 4.1 | 3.3 | 5.6 | 4.221 .4 |
| $1.5-2 \mathrm{mi}$ \| | *+ | + | *+ | *- | *- | + | + | ** |
| No. Pred | 153.6 | 37.2 | 123.9 | 86.7 | 17.4 | 11.2 | 33.7 | 18.3482 .0 |
| No. Chsn | 178.0 | 40.0 | 154.0 | 90.0 | 13.0 | 15.0 | 35.0 | 22.0547 .0 |
| SD. Chsn | 12.8 | 6.3 | 10.7 | 9.5 | 4.1 | 3.5 | 5.6 | 4.622 .1 |
| $1-1.5 \mathrm{mi}$ \| | - | + | **- | + | *+ | - | - | + |
| No. Pred | 175.3 | 42.8 | 123.4 | 96.0 | 17.6 | 13.1 | 33.9 | 22.9525 .0 |
| No. Chsn | 230.0 | 59.0 | 151.0 | 108.0 | 22.0 | 6.0 | 34.0 | 32.0642 .0 |
| SD. Chsn । | 13.9 | 6.5 | 11.3 | 9.4 | 4.5 | 3.7 | 6.1 | 5.023 .4 |
| $0.5-1 \mathrm{mi}$ | *- | *- | - | *- | + | **+ | *+ | - *- |
| No. Pred \| | 213.5 | 46.8 | 143.0 | 97.5 | 22.6 | 15.3 | 42.5 | 27.7608 .9 |
| No. Chsn | 199.0 | 44.0 | 71.0 | 91.0 | 16.0 | 12.0 | 39.0 | 21.0493 .0 |
| SD. Chsn | 12.2 | 5.4 | 8.3 | 7.6 | 3.9 | 2.8 | 5.2 | 3.919 .2 |
| $0-0.5 \mathrm{mi}$ \| | *- | *- | *+ | **- | + | - | - | * |
| No. Pred | 178.7 | 34.2 | 83.1 | 69.9 | 17.8 | 9.3 | 34.6 | 19.3447 .1 |
| No. ChsnTotal | 11806.0 | 439.01464 .01130 .0 |  |  | 198.0 | 139.0 | 372.0 | 224.05772 .0 |
|  | \| 1806.0 | 439.01 | $1464.01130 .0$ |  | 198.0 | $139.0$ |  |  |
| No. Pred \| |  |  |  |  | 372.0 |  | 224.05772 .0 |

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```
Table for perstype
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline & FT workr & \begin{tabular}{l}
| PT \\
|workr
\end{tabular} & \[
\begin{aligned}
& |R e-\quad| \\
& \mid \text { |tired| }
\end{aligned}
\] & | Non |workr & \[
\begin{aligned}
& \text { IUniv } \\
& \text { IStud }
\end{aligned}
\] & \[
\begin{aligned}
& \text { | Driv } \\
& \text { IStud }
\end{aligned}
\] & \[
\begin{aligned}
& \text { IStud } \\
& \text { | } 5-15
\end{aligned}
\] & \[
\begin{aligned}
& \text { | Under } \mid \\
& \mid 5
\end{aligned}
\] & Total \\
\hline ddist & 47.3 & 49.8 & 53.4 & 57.1 & 53.8 & 50.9 & 46.5 & 46.5 & 51.2 \\
\hline dtime & 16.2 & 16.9 & 18.0 & 18.9 & 17.8 & 17.3 & 16.1 & 15.9 & 17.3 \\
\hline empmed & 11.7 & 10.8 & 17.6 & 12.3 & 13.8 & 11.9 & 9.3 & 9.7 & 13.1 \\
\hline empsvc & 11.9 & 9.2 & 10.0 & 8.9 & 9.6 & 8.9 & 8.2 & 8.8 & 10.1 \\
\hline empret & 19.4 & 16.7 & 17.7 & 18.4 & 30.2 & 15.4 & 14.6 & 14.3 & 18.3 \\
\hline emprest & 10.7 & 6.3 & 6.0 & 4.9 & 7.5 & 6.1 & 4.2 & 4.3 & 7.2 \\
\hline empofc & 14.5 & 10.5 & 11.2 & 10.2 & 10.0 & 10.5 & 7.7 & 9.0 & 11.6 \\
\hline houses & 1.6 & 1.5 & 1.7 & 1.5 & 1.7 & 1.5 & 1.7 & 1.6 & 1.6 \\
\hline studk12 & 42.3 & 63.1 & 15.7 & 62.8 & 34.6 & 28.5 & 43.7 & 76.3 & 42.0 \\
\hline studuniv & 15.2 & 17.4 & 23.2 & 23.0 & 19.8 & 4.3 & 16.0 & 8.3 & 18.6 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 8.445
INFORMATION 572: number of **stars** in table is 45
```

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|  | $\begin{aligned} & \text { no } \\ & \text { car } \end{aligned}$ | $\begin{aligned} & \text { \|<1per\| } \\ & \text { \| driv\| } \end{aligned}$ | $\begin{aligned} & \mid 1+\text { per\| } \\ & \mid \text { driv\| } \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 0 | 15.0 | 78.0 | 93.0 |
| SD. Chsn | . 8 | 4.6 | 9.2 | 10.3 |
| $25+\mathrm{mi}$ | + | *+ | + | + |
| No. Pred | . 8 | 21.3 | 86.0 | 108.1 |
| No. Chsn | 4.0 | 138.0 | 536.0 | 678.0 |
| SD. Chsn \| | 2.0 | 11.7 | 22.7 | 25.6 |
| 10-25 mil | + |  | - | - |
| No. Pred | 4.2 | 138.1 | 523.3 | 665.6 |
| No. Chsn | 19.0 | 227.0 | 831.01 | 077.0 |
| SD. Chsn | 2.9 | 16.2 | 29.6 | 33.9 |
| $5-10 \mathrm{mi}$ | ***- | **+ | **+ | **+ |
| No. Pred | 8.6 | 268.3 | 895.01 | 171.9 |
| No. Chsn | 8.0 | 239.0 | 774.01 | 021.0 |
| SD. Chsn | 3.3 | 15.2 | 27.3 | 31.4 |
| $3-5 \mathrm{mi}$ | + | - | - | - |
| No. Pred | 11.1 | 237.8 | 768.71 | 017.6 |
| No. Chsn | 8.0 | 171.0 | 556.0 | 735.0 |
| SD. Chsn | 3.0 | 12.8 | 23.3 | 26.7 |
| $2-3 \mathrm{mi}$ | + | - | + | + |
| No. Pred | 8.9 | 170.8 | 566.1 | 745.8 |
| No. Chsn | 5.0 | 125.0 | 356.0 | 486.0 |
| SD. Chsn | 2.9 | 10.0 | 18.6 | 21.4 |
| $1.5-2 \mathrm{mi}$ | *+ | *- | + | - |
| No. Pred | 8.9 | 105.5 | 367.6 | 482.0 |
| No. Chsn | 13.0 | 134.0 | 400.0 | 547.0 |
| SD. Chsn | 3.3 | 10.4 | 19.2 | 22.1 |
| $1-1.5 \mathrm{mi}$ | - | *- | - | - |
| No. Pred | 11.3 | 115.3 | 398.4 | 525.0 |
| No. Chsn | 22.0 | 112.0 | 508.0 | 642.0 |
| SD. Chsn | 4.3 | 10.8 | 20.3 | 23.4 |
| $0.5-1 \mathrm{mi}$ | - | *+ | ** |  |
| No. Pred | 20.7 | 128.5 | 459.7 | 608.9 |
| No. Chsn | 13.0 | 120.0 | 360.0 | 493.0 |
| SD. Chsn | 3.7 | 8.9 | 16.6 | 19.2 |
| $0-0.5 \mathrm{mi}$ | *+ | **- | *- | ** |
| No. Pred | 17.5 | 95.4 | 334.2 | 447.1 |
| No. Chsn | 92.01281 .04399 .05772 .0 |  |  |  |
| Total |  |  |  |  |
| No. Pred \| | 92.01281 .04399 .05772 .0 |  |  |  |

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```
Table for asuf
    ..(continued)
-----------------------------------------
        | no |<1per|1+per| Total
    | car | driv| driv|
```



```
ddist | 28.6 50.2 52.0 51.2
dtime | 10.8 17.0 17.5 17.3
empmed | 20.3 13.6 12.8 13.1
empsvc | 16.3 10.7 9.8 10.1
empret | 22.3 17.2 18.6 18.3
emprest | 8.1 6.2 7.4 7.2
empofc | 17.4 12.0 11.4 11.6
houses | 1.7 1.6 1.6 1.6
studk12 | 5.4 54.8 39.0 42.0
studuniv | llllll
INFORMATION 571: root-Mean-Square-Error is 8.458
INFORMATION 572: number of **stars** in table is 24
```

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Table for inc6


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```
Table for inc6
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline & | & <15K & \[
\begin{aligned}
& \mid 15- \\
& 150 \mathrm{~K}
\end{aligned}
\] & \[
\begin{aligned}
& 150- \\
& 175 \mathrm{~K}
\end{aligned}
\] & \[
\begin{aligned}
& 175- \\
& 1100 \mathrm{~K}
\end{aligned}
\] & \[
|100 \mathrm{~K}+|
\] & \begin{tabular}{l}
|re- \\
|fuse
\end{tabular} & Total \\
\hline ddist & | & 49.2 & 50.1 & 49.6 & 54.2 & 53.5 & 56.5 & 51.2 \\
\hline dtime & | & 16.7 & 17.0 & 16.7 & 18.4 & 18.0 & 18.8 & 17.3 \\
\hline empmed & I & 15.1 & 14.2 & 12.8 & 12.1 & 10.4 & 12.3 & 13.1 \\
\hline empsvc & | & 9.7 & 9.6 & 10.1 & 10.2 & 11.5 & 10.9 & 10.1 \\
\hline empret & | & 17.7 & 17.7 & 17.4 & 19.9 & 23.2 & 18.3 & 18.3 \\
\hline emprest & | & 5.9 & 5.8 & 7.4 & 8.4 & 10.3 & 8.4 & 7.2 \\
\hline empofc & | & 9.9 & 11.0 & 11.2 & 12.3 & 15.1 & 12.4 & 11.6 \\
\hline houses & | & 1.5 & 1.7 & 1.6 & 1.6 & 1.6 & 1.7 & 1.6 \\
\hline studk12 & & 46.1 & 41.0 & 48.3 & 37.1 & 44.4 & 25.2 & 42.0 \\
\hline studuniv & | & 11.2 & 22.9 & 17.9 & 12.5 & 16.9 & 17.5 & 18.6 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 10.482
INFORMATION 572: number of **stars** in table is 33
```

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Table for hhsize

|  | 1 | 12 | 3 | 4 | 5 | 6 | 7 | 8 |  |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn | 13.0 | 42.0 | 12.0 | 19.0 | 6.0 | 1.0 | . 0 | . 0 | . 0 | . 0 | 93.0 |
| SD. Chsn I | 2.8 | 6.8 | 4.3 | 4.8 | 2.7 | 1.6 | . 9 | . 9 | . 2 | 4 | 10.3 |
| $25+\mathrm{mi}$ | * | + | *+ | + | + | + | + | + |  | + | *+ |
| No. Pred | 7.9 | 46.3 | 18.8 | 23.3 | 7.5 | 2.5 | . 8 | . 8 | . 0 | . 1 | 108.1 |
| No. Chsn | 81.0 | 297.0 | 98.0 | 138.0 | 35.0 | 23.0 | . 0 | 5.0 | . 0 | 1.0 | 678.0 |
| SD. Chsn I | 7.9 | 16.5 | 10.5 | 11.6 | 6.7 | 4.5 | 2.6 | 2.3 | . 7 | 1.0 | 25.6 |
| $10-25 \mathrm{mil}$ | **- | *- | * | - | *+ | - | **+ | + | $+$ |  | - |
| No. Pred \| | 63.1 | 276.1 | 110.7 | 136.8 | 45.1 | 20.2 | 6.7 | 5.4 | . 5 | 1.0 | 665.6 |
| No. Chsn \| | 118.0 | 486.0 | 176.0 | 187.0 | 61.0 | 24.0 | 15.0 | 7.0 | 3.0 |  | 077.0 |
| SD. Chsn I | 11.3 | 21.8 | 13.9 | 15.0 | 8.6 | 5.8 | 3.7 | 2.6 | 1.4 | 1.6 | 33.9 |
| $5-10 \mathrm{mi}$ \| | + | - | *+ | **+ | *+ | *+ | - |  | - |  | **+ |
| No. Pred \| | 129.0 | 485.0 | 196.5 | 227.7 | 74.7 | 33.7 | 13.5 | 7.0 | 2.0 | 2.71 | 171.9 |
| No. Chsn \| | 120.0 | 357.0 | 184.0 | 201.0 | 91.0 | 35.0 | 22.0 | 10.0 | . 0 | 1.01 | 021.0 |
| SD. Chsn I | 10.7 | 19.8 | 12.8 | 14.0 | 8.3 | 5.3 | 3.8 | 2.3 | 1.0 | 1.1 | 31.4 |
| $3-5 \mathrm{mi}$ \| | - | **+ | - | + | **- | *- | * | **- | *+ | + | - |
| No. Pred | 118.5 | 405.9 | 168.0 | 201.9 | 71.4 | 29.2 | 15.1 | 5.2 | 1.0 | 1.31 | 017.6 |
| No. Chsn | 81.0 | 289.0 | 119.0 | 154.0 | 57.0 | 27.0 | 1.0 | 5.0 | 2.0 | . 0 | 735.0 |
| SD. Chsn । | 9.4 | 16.7 | 10.5 | 12.3 | 6.8 | 5.1 | 2.5 | 2.5 | . 7 | . 7 | 26.7 |
| $2-3 \mathrm{mi}$ \| | *+ | + | - | + | *- | - | **+ | + | *- | + | + |
| No. Pred \| | 92.9 | 291.9 | 113.4 | 158.7 | 48.4 | 26.5 | 6.3 | 6.6 | . 6 |  | 745.8 |
| No. Chsn | 56.0 | 181.0 | 68.0 | 109.0 | 39.0 | 15.0 | 10.0 | 8.0 | . 0 |  | 486.0 |
| SD. Chsn I | 7.8 | 13.3 | 8.3 | 9.7 | 5.4 | 4.1 | 2.1 | 1.9 | . 5 | . 5 | 21.4 |
| $1.5-2 \mathrm{mi}$ \| | *+ | + | + | *- | *- | + | **- | * | + | + | - |
| No. Pred \| | 64.2 | 188.0 | 73.6 | 98.9 | 31.0 | 17.7 | 4.5 | 3.7 | . 3 | . 2 | 482.0 |
| No. Chsn | 78.0 | 214.0 | 80.0 | 116.0 | 29.0 | 26.0 | 1.0 | 1.0 | . 0 | 2.0 | 547.0 |
| SD. Chsn I | 8.2 | 13.4 | 9.0 | 9.9 | 5.9 | 4.7 | 1.9 | 1.8 | . 6 | . 9 | 22.1 |
| $1-1.5 \mathrm{mi}$ \| | - | *- | + | *- | *+ | - | *+ | *+ | + | *- | - |
| No. Pred | 72.3 | 193.1 | 86.8 | 103.8 | 37.2 | 23.3 | 3.7 | 3.6 | . 4 | . 9 | 525.0 |
| No. Chsn | 99.0 | 236.0 | 106.0 | 121.0 | 40.0 | 22.0 | 12.0 | 4.0 | . 0 | 2.0 | 642.0 |
| SD. Chsn । | 9.1 | 14.0 | 9.5 | 10.2 | 6.1 | 5.4 | 2.5 | 1.9 | . 5 | . 6 | 23.4 |
| $0.5-1 \mathrm{mi}$ \| | - |  | - |  | + | *+ | ** | + | + | **- | *- |
| No. Pred I | 93.5 | 217.9 | 99.9 | 114.0 | 40.5 | 31.5 | 6.8 | 4.1 | . 3 | . 4 | 608.9 |
| No. Chsn | 69.0 | 154.0 | 93.0 | 110.0 | 29.0 | 31.0 | 5.0 | 1.0 | . 0 | 1.0 | 493.0 |
| SD. Chsn | 7.7 | 11.3 | 7.6 | 8.7 | 5.0 | 3.9 | 2.3 | 1.7 | . 0 | . 0 | 19.2 |
| $0-0.5 \mathrm{mi}$ \| | + |  | ***- | **- | + | **- | *+ | **+ |  | ***- | **- |
| No. Pred I | 73.6 | 151.8 | 68.2 | 89.9 | 31.2 | 19.3 | 8.5 | 4.5 | . 0 | . 0 | 447.1 |
| No. Chsn | 715.02 | 2256.0 | 936.01 | 1155.0 | 387.0 | 204.0 | 66.0 | 41.0 | 5.0 | 7.05 | 772.0 |
| Total \| |  |  |  |  |  |  |  |  |  |  |  |
| No. Pred I | 715.02 | 2256.0 | 936.01 | 1155.0 | 387.0 | 204.0 | 66.0 | 41.0 | 5.0 | 7.05 | 772.0 |

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```
Table for hhsize
    ..(continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline & 1 & 2 & & 4 & & 6 & 7 & & & & Total \\
\hline ddist & 42.9 & 53.7 & 52.5 & 51.8 & 51.4 & 43.3 & 47.4 & 50.6 & 55.2 & 62.0 & 51.2 \\
\hline dtime & 15.1 & 18.0 & 17.7 & 17.4 & 17.2 & 14.9 & 15.9 & 17.0 & 17.9 & 20.8 & 17.3 \\
\hline empmed & 17.2 & 15.2 & 12.6 & 9.7 & 7.9 & 9.3 & 8.4 & 6.4 & 14.1 & 8.5 & 13.1 \\
\hline empsvc & 13.1 & 10.4 & 9.7 & 9.3 & 8.6 & 7.7 & 6.3 & 6.6 & 6.9 & 8.2 & 10.1 \\
\hline empret & 22.4 & 19.5 & 15.8 & 16.9 & 14.6 & 21.4 & 6.9 & 20.3 & 12.8 & 19.0 & 18.3 \\
\hline emprest & 8.9 & 7.7 & 6.8 & 7.4 & 4.8 & 3.1 & 2.1 & 3.7 & 1.8 & 4.1 & 7.2 \\
\hline empofc & 14.3 & 12.2 & 11.4 & 10.6 & 9.4 & 8.2 & 8.0 & 8.5 & 8.8 & 10.6 & 11.6 \\
\hline houses & 1.8 & 1.6 & 1.6 & 1.5 & 1.7 & 1.5 & 1.3 & 1.1 & 1.6 & 1.4 & 1.6 \\
\hline studk12 & 10.8 & 17.3 & 48.0 & 68.2 & 96.0 & 108.4 & 123.2 & 91.5 & 64.1 & 38.2 & 42.0 \\
\hline studuniv & 14.4 & 23.2 & 16.9 & 15.5 & 13.3 & 10.7 & 47.4 & 11.7 & 6.4 & 22.1 & 18.6 \\
\hline
\end{tabular}
INFORMATION 571: root-Mean-Square-Error is 6.053
INFORMATION 572: number of **stars** in table is 68
```

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Table for gend

|  | Male | \| Fe - <br> \|male |  |  |  |  |  | $\begin{array}{l\|} \text { \|re- \| } \\ \text { \|fuse \| } \end{array}$ |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| No. Chsn । | 52.0 | 41.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 93.0 |
| SD. Chsn । | 6.8 | 7.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 3 | 10.3 |
| $25+\mathrm{mi}$ \| | - | **+ |  |  |  |  |  |  |  | *+ |
| No. Pred । | 46.2 | 61.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 108.1 |
| No. Chsn \| | 329.0 | 348.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.0 | 678.0 |
| SD. Chsn । | 17.3 | 18.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.1 | 25.6 |
| $10-25 \mathrm{mil}$ | *- | + |  |  |  |  |  |  | + | - |
| No. Pred \| | 303.5 | 360.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.2 | 665.6 |
| No. Chsn \| | 494.0 | 581.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.01 | 077.0 |
| SD. Chsn I | 22.8 | 25.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.9 | 33.9 |
| $5-10 \mathrm{mi}$ \| | *+ | **+ |  |  |  |  |  |  |  | **+ |
| No. Pred \| | 531.3 | 636.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.81 | 171.9 |
| No. Chsn I | 434.0 | 584.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.01 | 021.0 |
| SD. Chsn । | 21.0 | 23.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.0 | 31.4 |
| $3-5 \mathrm{mi}$ \| | *+ | *- |  |  |  |  |  |  | + | - |
| No. Pred I | 456.2 | 557.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 4.11 | 017.6 |
| No. Chsn I | 339.0 | 386.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 10.0 | 735.0 |
| SD. Chsn । | 17.8 | 19.8 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.9 | 26.7 |
| $2-3 \mathrm{mi}$ \| | - | *+ |  |  |  |  |  |  | ***- | + |
| No. Pred \| | 332.5 | 409.6 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.7 | 745.8 |
| No. Chsn । | 215.0 | 271.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 486.0 |
| SD. Chsn । | 14.2 | 15.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.7 | 21.4 |
| $1.5-2 \mathrm{mi}$ \| | - | - |  |  |  |  |  |  | *+ | - |
| No. Pred । | 212.9 | 266.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.1 | 482.0 |
| No. Chsn \| | 231.0 | 312.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 4.0 | 547.0 |
| SD. Chsn \| | 14.9 | 16.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.6 | 22.1 |
| $1-1.5 \mathrm{mi}$ \| | + | *- |  |  |  |  |  |  | - | - |
| No. Pred \| | 236.4 | 285.9 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.8 | 525.0 |
| No. Chsn \| | 285.0 | 357.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 |  | 642.0 |
| SD. Chsn । | 15.9 | 17.2 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.6 | 23.4 |
| $0.5-1 \mathrm{mi}$ \| | - | *- |  |  |  |  |  |  | *+ | *- |
| No. Pred \| | 279.8 | 326.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 2.8 | 608.9 |
| No. Chsn I | 219.0 | 271.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 3.0 | 493.0 |
| SD. Chsn I | 12.8 | 14.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.1 | 19.2 |
| $0-0.5 \mathrm{mi}$ \| | *- | *- |  |  |  |  |  |  | *- | ** |
| No. Pred \| | 199.3 | 246.3 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 1.5 | 447.1 |
| No. Chsn I | 2598.03 | 3151.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 23.05 | 772.0 |
| Total \| |  |  |  |  |  |  |  |  |  |  |
| No. Pred \| | 2598.03 | 3151.0 | . 0 | . 0 | . 0 | . 0 | . 0 | . 0 | 23.05 | 772.0 |

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```
Table for gend
    ..(continued)
```



```
INFORMATION 571: root-Mean-Square-Error is 21.474
INFORMATION 572: number of **stars** in table is 25
```


## Appendix 2—Auto availability model application on estimation data

This appendix provides statistical results from applying the models on the estimation data. Each table is in two parts. The first part reports the observed (No. chsn) and predicted (No. Pred) distributions of household auto availability for various subsets of the households (see column headings) under the base conditions used for model estimation. The estimated standard deviation of the observed choices (SD. Chsn) is also provided; it indicates the variation that would likely be observed (in No. chsn) if the estimation sample were redrawn repeatedly. If there are few stars, then the discrepancies between observed and predicted are small compared to the uncertainty in the sample itself.

The second part of each table reports the predicted average value of household auto availability for each subset of households.

```
Table for aKids (Presence of children)
    ---------------------------------
        | no |with | Total
        | kids |kids |
-----------+-------------------
    No. Chsn | 153.0 18.0 171.0
    SD. Chsn | 10.4 3.8 11.0
No Car | - +
    No. Pred | 152.7 18.3 171.0
-----------+-------------------
    No. Chsn |1008.0 186.01194.0
    SD. Chsn | 20.5 10.1 22.9
1 Car | + -
    No. Pred |1014.4 179.61194.0
-----------+-------------------
    No. Chsn |1187.0 470.01657.0
    SD. Chsn | 23.3 14.2 27.3
2 Cars | - +
    No. Pred |1181.8 475.21657.0
-----------+-------------------
    No. Chsn | 413.0 212.0 625.0
    SD. Chsn | 17.7 12.2 21.6
3 Cars | - +
    No. Pred | 407.2 217.8 625.0
-_----------+--------------------
    No. Chsn | 186.0 109.0 295.0
    SD. Chsn | 12.3 8.7 15.1
4+ Cars | + -
    No. Pred | 190.8 104.2 295.0
-----------+-------------------
    No. Chsn |2947.0 995.03942.0
Total |
    No. Pred |2947.0 995.03942.0
--------------------------------
-
avg#carsx100|185.7 227.2 196.2
-----------------------------------
INFORMATION 571: root-Mean-Square-Error is 4.607
INFORMATION 572: number of **stars** in table is 0
```

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Table for aHHsize (Household Size)


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Table for aHHwork (number of workers in HH)


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Table for aHHstud (number of students in HH)


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Table for aHHFTW (number of fulltime workers in HH)


```
avg#carsx100|152.6 193.9 249.6 337.2 367.7 338.5 196.2
```


INFORMATION 571: root-Mean-Square-Error is 4.338
INFORMATION 572: number of **stars** in table is 11

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```
Table for ainc6 (Household income categories)
\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline & \[
<15 \mathrm{~K}
\] & \[
\begin{aligned}
& \text { | } 15- \\
& 150 \mathrm{~K}
\end{aligned}
\] & \[
\begin{aligned}
& 150- \\
& 175 \mathrm{~K}
\end{aligned}
\] & \[
\begin{aligned}
& \text { I 75- } \\
& 1100 \mathrm{~K}
\end{aligned}
\] & \[
|100 \mathrm{~K}+|
\] & |fuse & Total \\
\hline No. Chsn & 92.0 & 55.0 & 8.0 & . 0 & . 0 & 16.0 & 171.0 \\
\hline SD. Chsn & 7.3 & 6.8 & 2.7 & . 9 & . 9 & 3.6 & 11.0 \\
\hline No Car & & - & & + & + & & \\
\hline No. Pred & 92.0 & 53.4 & 8.0 & . 8 & . 8 & 16.0 & 171.0 \\
\hline No. Chsn & 181.0 & 662.0 & 176.0 & 31.0 & 22.0 & 122.01 & 194.0 \\
\hline SD. Chsn & 8.7 & 15.9 & 10.1 & 4.5 & 4.0 & 7.5 & 22.9 \\
\hline 1 Car & & & & - & + & & \\
\hline No. Pred & 181.0 & 662.0 & 176.0 & 28.9 & 24.1 & 122.01 & 194.0 \\
\hline No. Chsn & 65.0 & 554.0 & 556.0 & 175.0 & 144.0 & 163.01 & 657.0 \\
\hline SD. Chsn & 6.4 & 16.6 & -15.0 & 8.5 & 7.6 & 8.6 & 27.3 \\
\hline 2 Cars & & + & & + & - & & \\
\hline No. Pred & 65.0 & 555.6 & 556.0 & 175.8 & 141.6 & 163.01 & 657.0 \\
\hline No. Chsn & 14.0 & 167.0 & 229.0 & 90.0 & 65.0 & 60.0 & 625.0 \\
\hline SD. Chsn & 3.5 & 11.6 & -12.9 & 7.8 & 6.8 & 6.7 & 21.6 \\
\hline 3 Cars & & & & - & + & & \\
\hline No. Pred & 14.0 & 167.0 & 229.0 & 89.1 & 65.9 & 60.0 & 625.0 \\
\hline No. Chsn & 4.0 & 72.0 & 114.0 & 50.0 & 39.0 & 16.0 & 295.0 \\
\hline SD. Chsn & 1.9 & 7.8 & 9.3 & 6.1 & 5.2 & 3.7 & 15.1 \\
\hline 4+ Cars & & & & + & - & & \\
\hline No. Pred & 4.0 & 72.0 & 114.0 & 51.4 & 37.6 & 16.0 & 295.0 \\
\hline No. Chsn & 356.01 & 1510.01 & 1083.0 & 346.0 & 270.0 & 377.03 & 942.0 \\
\hline Total & & & & & & & \\
\hline No. Pred & 356.01 & 1510.01 & 1083.0 & 346.0 & 270.0 & 377.03 & 942.0 \\
\hline
\end{tabular}
```

```
avg#carsx100|104.3 172.4 230.6 255.2 250.9 186.0 196.2
```

avg\#carsx100|104.3 172.4 230.6 255.2 250.9 186.0 196.2
------------------------------------------------------------
INFORMATION 571: root-Mean-Square-Error is 1.228
INFORMATION 572: number of **stars** in table is 0

```

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Table for adriveage (number of driving age persons in HH )


RESOURCE SYSTEMS GROUP, INC.

\section*{San Joaquin Valley Model Improvement Program Freight Forecasting Models}


Resource Systems Group, Inc.
41 North Rio Grande Street, Suite 106
Salt Lake City, UT 84101
8017364100

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\subsection*{1.0 Introduction}

San Joaquin Valley (SJV) is the primary oil production region in the state of California. It is also one of the largest producers of agricultural and food products in the world (1). It serves as the warehousing center for most of the goods on transit to the rest of the United States. These factors lead to a continuous increase in population and employment in the SJV , as well as the demand for freight transportation.

Growth in population and truck volumes on roadways in the valley has increased congestion, crashes and emissions. To address these issues, a valley-wide goods movement study was carried out by the eight Regional Transportation Planning Agencies (RTPAs) in the valley and California Department of Transportation (Caltrans) in 2008, which included:
- Phase I - The level of goods movement by commodity was quantified,
- Phase II - A truck model was developed, and
- Phase III - The truck model was updated and used to support county modeling activities.

Subsequently, a Model Improvement Plan (MIP) - this model development effort - has been commissioned to update the valley-wide truck model that was originally developed in 2008 with a base year of 2000 and a primary forecast year of 2030. The updated model developed for the MIP has a base year of 2007. The following sections elaborate on the objectives and details of the MIP model update process.

\subsection*{1.1 Phase III San Joaquin Goods Movement Model}

The Phase III San Joaquin Valley Goods Movement Model was the starting point for the MIP Goods Movement Model. In general, Phase III of the study enhanced the model with updated input data, updated model components and improved truck model validation (1). The objectives were to update the model to:
- Inherently calculate emissions from heavy trucks.
- Accurately estimate traffic in major activity centers in order to analyze congestion impacts on major truck routes.
- Accurately analyze land use conflicts between truck intensive land uses and residential or commercial developments.
- Predict truck flows by truck class to analyze access to activity centers for heavy trucks.
- Develop a truck model maintenance plan for each of the eight valley RTPAs and Caltrans.

The truck model was designed to generate truck volumes based on average daily traffic. The truck model output reports truck volumes based on truck classes that the CARB (California Air Resources Board) defines as medium heavy-duty and heavy-heavy duty for regulatory purposes (more than 14,000 pounds gross vehicle weight rating). Medium-heavy duty trucks (MHDT) have a gross vehicle weight rating (GVWR) between 14,001 and 33,000 pounds. Heavy-heavy duty trucks (HHDT) have a GVWR of 33,001 pounds or more. A multiclass equilibrium assignment was performed and validated by comparing model truck volume outputs to truck counts in the Caltrans report titled, Annual Average Daily Truck Traffic on the California State Highway System.

\subsection*{1.2 Objectives of the MIP Valley-wide Goods Movement Models}

The basic goal of the MIP is to provide each of the eight RTPAs with a travel model that can meet the requirements for the 2013 Regional Transportation Plan (RTP), while still providing all of the functions performed by the current travel model including air quality conformity analysis. The basic model improvements are expected to provide most but not all of the required model sensitivities. An additional goal
of the basic model improvements was to standardize model inputs and processes among the eight RTPA models. Standardization will enhance the ability of the RTPAs to share data and resources, and will also make it easier to develop multi-county models, if needed, for certain studies. The objectives of the MIP are:
- Land use and demographics - Develop specifications for land use and building type classifications. Draft demographic and employment data specifications.
- Four-step model improvements - Develop revised trip generation rates for each RTPA. Develop updated trip distribution including additional trip purposes and consideration of multimodal times and costs. Update mode choice sensitivity for each RTPA. Modify trip assignment scripts to account for five vehicle classifications: dive alone, drive alone toll, shared ride 2 , shared ride \(3+\) and truck.
- Estimation, calibration, validation and evaluation of basic model improvements - Ensure that the models are producing accurate forecasts.
- Goods movement modeling improvements - Develop a valley-wide and county level goods movement models.

The goods movement modeling improvements are the focus of this report:
- Update commodity flow data from the Intermodal Transportation Management System (ITMS) to the Freight Analysis Framework version 3 (FAF3) for year 2007.
- Update economic flow data from a national source adjusted to California, to an 8-county San Joaquin Valley-specific source.
- Update agriculture flow data from the agriculture crop reports for each county.
- Revise the methods used for short haul commercial vehicles (identified as non-ITMS truck trips in the previous model) to include non-freight vehicles and to add a light truck trip classification.

The valley-wide goods movement model was validated with truck counts available from Caltrans to ensure that the demand was valid, but the focus of validation in the MIP is on the county level models, since there was significantly more truck counts available at the county level. The valley-wide goods movement model was used to provide long haul goods movements for each county model, supplemented with short haul commercial vehicles developed separately for each county.

\subsection*{1.3 Objectives of the County Goods Movement Models}

Each of the county models developed as part of the San Joaquin Valley Model Improvement Program were updated to include a new freight forecasting component. These were developed to incorporate the truck movements from the valley-wide goods movement model for each county in combination with short haul trucks calibrated to truck counts in each county. The objectives of these models were to improve upon both the long haul and short haul estimates of goods movements in each county. By calibrating the short haul movements separately for each county, we can recognize the unique aspects of truck movements in each county.

\subsection*{2.0 Data Sources}

\subsection*{2.1 Network Data}

No changes were made to the roadway networks from the previous model. The 2000 network was used for the 2007 scenario and the 2030 network was used for 2040 scenario. The focus of the valleywide goods movement model was on predicting demand for the county models, so adjustments to the supply side was not a significant factor.

\subsection*{2.2 Socioeconomic Data}

Due to a lack of readily available current socioeconomic data for the valley-wide modeling zone structure, 2007 and 2040 socioeconomic data inputs were developed by assuming straight-line growth and interpolating and extrapolating from the previously developed data. Table 1 below summarizes the resulting regional totals by year.

Table 1: Regional Socioeconomic Totals by Year
\begin{tabular}{|c|c|c|c|c|}
\hline & \multicolumn{4}{|c|}{Year} \\
\hline Socioeconomic Data & 2000 & 2007 & 2030 & 2040 \\
\hline Agriculture & 139,865 & 164,807 & 245,581 & 280,261 \\
\hline Mining & 4,641 & 5,823 & 9,700 & 11,388 \\
\hline Construction & 72,927 & 83,709 & 118,548 & 133,490 \\
\hline Mfg. Products & 70,234 & 81,077 & 116,056 & 131,010 \\
\hline Mfg. Equipment & 51,246 & 58,913 & 83,491 & 93,969 \\
\hline Transportation & 139,263 & 160,707 & 231,167 & 261,802 \\
\hline Wholesale & 66,989 & 75,850 & 104,546 & 116,875 \\
\hline Retail & 183,366 & 216,795 & 323,610 & 368,879 \\
\hline Finance & 362,099 & 429,882 & 650,428 & 746,714 \\
\hline Education/ Government & 147,214 & 176,823 & 272,853 & 314,851 \\
\hline Total Employment & 1,237,844 & 1,454,387 & 2,155,980 & 2,459,239 \\
\hline Households & 1,076,600 & 1,267,631 & 1,891,192 & 2,160,019 \\
\hline
\end{tabular}

\subsection*{2.3 Commodity Flow Data}

Commodity flow data for long haul were primarily obtained from the Federal Highway Administration (FHWA) Freight Analysis Framework version 3 (FAF3) statistics. The FAF3 database contains both tonnage and value data for 2007, 2015, and in five year increments to 2040 . There are 131 FAF3 zones: 123 domestic and 8 foreign. Outbound and inbound flows to each zone are provided for different commodities. There are 43 commodity types, classified according to the Standard Classification of Transported Goods (SCTG) codes. The mode of transportation for each commodity is also provided.

FAF3 was the only source of data for all commodity types except agriculture. Analysis showed that FAF3 underestimated agriculture flows. Therefore, additional data was obtained from the annual agricultural reports of the respective county departments of agriculture. The following section describes how FAF3 and county agricultural data were processed for use in developing the freight model.

\subsection*{2.4 Input/Output Data}

Input/Output (I/O) data contains information on how various industries interact with each other at a very detailed level of economic production and consumption. The data comprise of tables that show the flow of goods and commodities in and out of industries in terms of values of transactions made by them. The tables are also known as "make" and "use" tables referring to production and consumption values. There are different versions of I/O data available. Data for the current project were obtained from the IMPLAN (IMpact analysis for PLANning) software system created by MIG Inc (1). These data were provided by the University of California at Davis and covered the 8-county San Joaquin Valley for the year 2000. The data capture dollar values of the all business transactions made by businesses in the San Joaquin Valley (SJV) region.

Six tables were primarily used to construct the economic flow data for freight modeling:
- Local industry make (goods and services),
- Industry use of locally produced commodities,
- Industry foreign exports by commodity,
- Industry domestic exports by commodity,
- Industry foreign imports by commodity, and
- Industry domestic imports by commodity

Each of the above mentioned tables has transaction values in dollars by industry and commodity. The industries and commodities use the same classification and there were 528 categories or sectors in the classification scheme. A more recent classification has 440 sectors which are based on the 2007 NAICS.

\subsection*{2.5 Agriculture Data}

Since FAF commodity flows under-represented the flow of agricultural products and these are a major portion of the flows in and out of the SJV region, it was decided to augment the agricultural flows using local data. Additional agricultural data were obtained from the county annual agricultural crop reports of all the eight counties in SJV (2-9). The reports contained in them quantities and values (in dollars) of agricultural produce by commodity.

\subsection*{3.0 Long Haul Goods Movement}

\subsection*{3.1 FAF3 Data Processing}

The data required were both outbound and inbound flows for the 8 counties within the San Joaquin Valley (SJV) and 12 external regions for 2007 and 2040. The 8 counties are: Fresno, Kern, King, Madera, Merced, San Joaquin, Stanislaus and Tulare. However, FAF3 data is not provided for each county, it is aggregated into zones. The eight SJV counties are in FAF3 zone 69. This zone has 34 counties in total. Therefore, it was necessary to disaggregate the zone 69 flows to county flows. The methodology developed by Ruan and Lin (10) was utilized to disaggregate both outbound and inbound flows. The complete traffic analysis zone structure is provided in Figure 1.

Figure 1. FAF3 Traffic Analysis Zones


Source: http://cta.ornl.gov/cta/One_Pagers/FAF3.pdf

\subsection*{3.1.1 Disaggregating Outbound Flows for SJV counties}

Outbound tonnages were disaggregated based on proportional weighting (10). The proportional weightings were developed using annual payroll data obtained from County Business Patterns (CBP) statistics for 2008, developed by the United States Census Bureau (11). Commodities are classified in CBP following the North America Industry Classification System (NAICS). Therefore, it was necessary to first relate the NAICS commodities to SCTG commodities. Then the percentage share of each of the 34 counties in zone 69 was calculated for each SCTG commodity using the annual payroll information. Finally, zone 69 commodity outbound flow totals were allocated proportionally to counties based on the percent shares from the previous step. Tables 2 and 3 presents the outbound commodity flows from SJV counties following the allocation procedure for 2007 and 2040, respectively.

Table 2. 2007 Outbound Commodity Flows from SJV Counties (Annual Tonnage) by Employment
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline County & Ag & MfgEquip & MfgProd & Mining & Whlsale & Total \\
\hline Fresno & \(14,580,941\) & \(1,428,988\) & \(8,520,785\) & \(2,311,208\) & \(5,309,385\) & \(32,151,307\) \\
\hline Kern & \(8,540,037\) & 803,788 & \(4,846,764\) & \(50,252,908\) & \(3,552,349\) & \(67,995,846\) \\
\hline King & \(2,470,125\) & 222,861 & \(1,319,668\) & 200,086 & 628,243 & \(4,840,983\) \\
\hline Madera & \(2,552,727\) & 227,245 & \(1,348,081\) & 227,876 & 664,310 & \(5,020,238\) \\
\hline Merced & \(4,689,841\) & 453,518 & \(2,616,117\) & 660,486 & \(1,400,667\) & \(9,820,629\) \\
\hline San & \(13,137,206\) & \(1,374,341\) & \(7,647,191\) & \(2,035,056\) & \(6,158,670\) & \(30,352,464\) \\
\hline Joaquin & 2, & & & & & \\
\hline Stanislaus & \(5,791,719\) & 565,988 & \(2,804,346\) & 743,130 & \(2,178,816\) & \(12,083,999\) \\
\hline Tulare & \(7,041,665\) & 697,829 & \(3,964,016\) & 787,425 & \(2,756,928\) & \(15,247,864\) \\
\hline
\end{tabular}

Table 3. 2040 Outbound Commodity Flows from SJV Counties (Annual Tonnage) by Employment
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline County & Ag & MfgEquip & MfgProd & Mining & Whlsale & Total \\
\hline Fresno & \(36,833,824\) & \(3,147,270\) & \(11,851,091\) & \(3,607,976\) & \(8,925,230\) & \(64,365,390\) \\
\hline Kern & \(21,164,870\) & \(1,776,473\) & \(6,781,443\) & \(85,147,435\) & \(6,566,785\) & \(121,437,006\) \\
\hline King & \(6,169,996\) & 488,656 & \(1,811,499\) & 288,406 & 845,614 & \(9,604,171\) \\
\hline Madera & \(6,347,714\) & 498,491 & \(1,848,810\) & 334,785 & 924,131 & \(9,953,931\) \\
\hline Merced & \(11,871,724\) & 996,546 & \(3,597,041\) & \(1,018,957\) & \(2,121,251\) & \(19,605,519\) \\
\hline \begin{tabular}{c} 
San
\end{tabular} & Joaquin & \(33,351,182\) & \(3,042,012\) & \(10,585,313\) & \(3,165,165\) & \(11,757,872\)
\end{tabular}

\subsection*{3.1.2 Disaggregating Inbound Flows for SJV counties}

Inbound flows were disaggregated using simultaneous models which utilized the outbound flows as the inputs (10). These models were developed based on the assumption that, high outbound flow rates are associated with large inbound flow rates or high employment rates in the related industries, i.e., there are no inbound flows if there are no outbound flows or employments in the respective industries. The simultaneous models are presented in Table 1 of Ruan and Lin's research paper (10).
For some commodities, there were differences between zone 69 totals from the county inbound flow estimates and the reported inbound totals. These differences were disaggregated into the counties within zone 69 using the proportional weightings used in generating the outbound flows. This ensured that the total zone inbound flows were completely disaggregated into counties. Tables 3 and 4 summarize the results of this allocation process for 2007 and 2040, respectively.

Table 4. 2007 Inbound Commodity Flows to SJV Counties (Annual Tonnage) by Employment
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline County & Ag & MfgEquip & MfgProd & Mining & Whlsale & Total \\
\hline Fresno & \(14,389,946\) & \(1,968,147\) & \(10,092,262\) & \(3,261,246\) & \(4,126,302\) & \(33,837,902\) \\
\hline Kern & \(8,187,089\) & \(1,341,445\) & \(5,978,893\) & \(56,454,056\) & \(2,659,250\) & \(74,620,733\) \\
\hline King & \(2,437,623\) & 207,447 & \(1,258,688\) & 320,061 & 519,060 & \(4,742,880\) \\
\hline Madera & \(2,419,101\) & 219,594 & \(1,328,043\) & 349,962 & 548,149 & \(4,864,848\) \\
\hline Merced & \(4,700,235\) & 420,629 & \(2,551,193\) & 938,497 & \(1,130,821\) & \(9,741,375\) \\
\hline San & \(12,882,310\) & \(1,686,291\) & \(7,913,649\) & \(2,867,403\) & \(4,537,732\) & \(29,887,385\) \\
\hline Joaquin & 2, & & & & \\
\hline Stanislaus & \(5,595,756\) & 713,677 & \(2,801,188\) & \(1,611,786\) & \(1,383,919\) & \(12,106,327\) \\
\hline Tulare & \(6,965,034\) & 791,204 & \(4,162,986\) & \(1,186,320\) & \(2,070,381\) & \(15,175,925\) \\
\hline
\end{tabular}

Table 5. 2040 Inbound Commodity Flows to SJV Counties (Annual Tonnage) by Employment
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline County & Ag & MfgEquip & MfgProd & Mining & Whlsale & Total \\
\hline Fresno & 28,300,754 & 3,407,549 & 14,108,386 & 3,878,004 & 7,365,233 & 57,059,927 \\
\hline Kern & 16,219,467 & 2,167,730 & 8,284,565 & 76,394,447 & 5,000,512 & 108,066,721 \\
\hline King & 4,778,408 & 422,228 & 1,835,973 & 350,115 & 840,743 & 8,227,466 \\
\hline Madera & 4,808,273 & 442,971 & 1,923,108 & 390,353 & 897,335 & 8,462,041 \\
\hline Merced & 9,186,829 & 861,386 & 3,718,775 & 1,102,944 & 1,910,994 & 16,780,927 \\
\hline San Joaquin & 25,449,918 & 3,105,382 & 11,359,492 & 3,399,048 & 8,678,726 & 51,992,566 \\
\hline Stanislaus & 26,984,934 & 2,739,195 & 11,318,252 & 3,730,010 & 5,792,910 & 50,565,300 \\
\hline Tulare & 13,675,009 & 1,500,878 & 5,965,710 & 1,353,988 & 3,828,590 & 26,324,175 \\
\hline
\end{tabular}

\subsection*{3.1.3 Generating Flows for External Regions}

FAF3 data were also processed for 12 external regions (gateways) which represented the remainder of California and the rest of the USA. FAF3 has 4 other zones in California, in addition to zone 69, which contains SJV. Each of these 4 zones basically forms an external region for the San Joaquin Valley. But, some of these 4 external regions have additional counties which are in zone 69. Recall that zone 69 has 34 counties and only 8 are in SJV. The remaining 24 counties are the additional counties that fall under the 4 external regions in California. The rest of the external regions are the gateways from the rest of the USA. Flows from each of the 12 external regions to and from SJV were generated as follows:
1. Using the data developed in Section 3.1.1, computed the proportion of annual payroll in SJV as a percentage of the total payroll for zone 69, for each SCTG commodity.
2. Processed the total flows to and from each of the other 4 FAF3 zones in California in relation to zone 69.
3. Computed the basic flows to and from SJV for the 4 external regions within California by multiplying the proportions developed in Step 1 with the flows generated in Step 2. For the regions that have additional counties in zone 69, added the flows generated in Sections 3.1.1 and 3.1.2.
4. Processed the total flows to and from the rest of the USA in relation to zone 69, for each SCTG commodity.
5. Computed the flows to and from the rest of USA relative to SJV, by multiplying the flows generated in Step 4 by the proportions developed in Step 1.
6. Using the flows generated in Step5, calculated the shipments for each of the 8 remaining external regions. The split between the 8 regions was determined using truck count data obtained from the 2000 SJV travel demand model.

The results of this process are provided in Table 6 for 2007 and 2040.

Table 6. External Commodity Flows to and from SJV Counties (Annual Tonnage) by Employment
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline Ag & MfgEquip & MfgProd & Mining & Whlsale & Total \\
\hline \begin{tabular}{c} 
2007 \\
Originating in \\
SJC Counties
\end{tabular} & \(38,450,740\) & \(5,336,342\) & \(23,551,766\) & \(32,728,521\) & \(9,716,316\) & \(109,783,686\) \\
\hline \begin{tabular}{c} 
2007 Destined \\
for SJV \\
Counties
\end{tabular} & \(39,741,008\) & \(3,895,647\) & \(20,321,443\) & \(23,082,151\) & \(14,600,896\) & \(101,641,145\) \\
\hline \begin{tabular}{c} 
2040 \\
Originating in \\
SJC Counties
\end{tabular} & \(67,192,250\) & \(9,903,676\) & \(36,166,818\) & \(43,135,271\) & \(19,474,975\) & \(175,872,990\) \\
\hline \begin{tabular}{c} 
2040 Destined \\
for SJV \\
Counties
\end{tabular} & \(90,364,074\) & \(8,934,441\) & \(29,372,307\) & \(47,326,334\) & \(23,446,917\) & \(199,444,072\) \\
\hline
\end{tabular}

\subsection*{3.2 Supplemental Agriculture Movements}

Since preliminary analysis showed that FAF3 agriculture data were underestimated, supplemental data were obtained from county annual agricultural reports for each of the 8 SJV counties and added to the FAF3 data. The reports were downloaded from the respective county departments of agriculture and contained the quantities and values in dollars of each commodity produced in each county. The quantities were not always found to be reported in units of weight (for example - bales for cotton, cords for firewood). Instead of converting quantities into a single unit of weight for various commodities, it was decided that dollar values be used. Steps for augmenting FAF data with supplemental agriculture movements are as follow:
1. Commodities in all the county agricultural reports were mapped to SCTG commodity codes.
2. Aggregate production values for each SCTG commodity by county were calculated.
3. Tonnage/value ratios by commodity were computed using FAF3 data and were used to convert values of supplemental agricultural produce to tonnages.
4. The supplemental agricultural production tonnages by county were then added to the production flows calculated from FAF3 data.
5. Attraction values for county agricultural data were computed using production/attraction value ratios from FAF3.
6. The attraction values were then converted into tonnages using the tonnage/value ratios from FAF3 data and added to respective attraction flows from FAF3.

The results of this analysis are presented in Table 7. These productions and attractions represent the aggregate production and attraction values and tonnages from the USDA data.

Table 7: Agriculture Value and Tonnage for the San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline \multirow[b]{2}{*}{Description} & \multirow[b]{2}{*}{SCTG} & \multicolumn{3}{|c|}{Productions} & \multicolumn{3}{|c|}{Attractions} \\
\hline & & & nual Value (\$) & Annual & & nual Value (\$) & Annual \\
\hline Live animals/fish & 1 & \$ & 3,214,925,611 & 1,048,941 & \$ & 5,174,597,437 & 1,688,328 \\
\hline Cereal grains & 2 & \$ & 916,857,000 & 6,313,489 & \$ & 1,108,330,420 & 7,631,978 \\
\hline Other ag. prods. & 3 & \$ & 12,531,260,100 & 12,814,589 & \$ & 4,737,239,546 & 4,844,348 \\
\hline Animal feed & 4 & \$ & 2,660,841,250 & 4,401,074 & \$ & 2,558,827,663 & 4,232,342 \\
\hline Meat/seafood & 5 & \$ & 2,542,000 & 964 & \$ & 2,321,565 & 880 \\
\hline Other foodstuffs & 7 & \$ & 5,916,161,000 & 5,567,211 & \$ & 4,719,744,175 & 4,441,362 \\
\hline Fertilizers & 22 & \$ & 17,990,000 & 64,586 & \$ & 40,616,680 & 145,817 \\
\hline Logs & 25 & \$ & 9,006,000 & 25,239 & \$ & 4,869,712 & 13,647 \\
\hline Misc. mfg. prods. & 40 & \$ & 455,061,800 & 87,296 & \$ & 1,048,649,705 & 201,167 \\
\hline Total & & \$ & 25,724,644,761 & 30,323,389 & \$ & 19,395,196,904 & 23,199,868 \\
\hline
\end{tabular}

\subsection*{3.3 Economic Flows}

The goods movement model needs information on economic flows with respect to commodities and industries in the region. It uses consumption shares of all the industries by commodity to calculate inbound trips for each county by the consuming industry. The IMPLAN I/O data tables were processed to obtain these shares. Since the economic flows were used as shares, the year 2000 data were not factored to 2007. First, NAICS07 classification was mapped to the 10 industry/ commodity groups used in the goods movement model (Table 8).

Table 8: Correspondence between Model Industry Groups and NAICS 2007
\begin{tabular}{|l|c|}
\hline \multicolumn{1}{|c|}{ Model Industry/Commodity } & NAICS 2007 \\
\hline Ag/Farm/Fish & 11 \\
\hline Mining & 21 \\
\hline Construction & 23 \\
\hline Manufactured Products & \(31-325\) \\
\hline Manufactured Equipment & \(326-33\) \\
\hline Transportation/Communication/Utilities & \(22,48,492,493,51\) \\
\hline Wholesale & 42 \\
\hline Retail Trade & \(44-45\) \\
\hline Finance, Insurance, Real Estate, Service & \(52-56,62,71,72,81\) \\
\hline Education/Govt & \(491,61,92\) \\
\hline
\end{tabular}

The primary task then was to map IMPLAN sectors (528 of them) to NAICS07 industry codes. Correspondence between NAICS07 and a more recent IMPLAN industry classification consisting of 440 sectors was available. Between IMPLAN 528 and IMPLAN 440 classification schemes, there also existed another classification scheme consisting of 509 sectors. IMPLAN 528 to IMPLAN 509 and IMPLAN 509 to IMPLAN 440 correspondences were available. Therefore, the steps for mapping IMPLAN 528 sectors to the 10 model industry/commodity groups were as follow:
1. IMPLAN 440 - NAICS07 and IMPLAN 440 - IMPLAN 509 correspondences were merged to create a correspondence between IMPLAN 509 and NAICS07. If one category for IMPLAN 509 corresponded to more than one category of NAICS07, the IMPLAN 509 category with the maximum "split" value was retained. IMPLAN 440 - IMPLAN 509 correspondence was one-to-many and the split value represented the proportions of all IMPLAN 509 sectors that corresponded to a particular IMPLAN 440 sector.
2. IMPLAN 509 - NAICS07 and IMPLAN 509 - IMPLAN 528 correspondences were merged next. IMPLAN 509 - IMPLAN 528 correspondence had no split value to inform the creation of IMPLAN 528 - NAICS 07 correspondence. Hence, annual payroll information for the State of California from the Census County Business Pattern data was used to break a tie. An IMPLAN 528 sector was put in a NAICS07 category that had the highest annual payroll.
IMPLAN (528) sectors were mapped to NAICS07 categories in each of the six IMPLAN I/O tables. Since the industries and commodities in IMPLAN follow the same classification scheme, both of them were mapped to NAICS07. The tables were further mapped to the 10 industry/commodity categories in the model using the correspondence in Table 8. Each of the tables was aggregated to the model industry/commodity classification level. Local use share tables by commodity were prepared by taking an outer product of the proportions of values in the local-use table (by commodity) with values in the local-make table (by industry). This way, the total value of commodities produced is preserved. Domestic/foreign import and export share tables were created by calculating the proportion of values by industry/commodity in the respective aggregated tables. Economic flow table for region (consumption shares of industries by commodity) was created by combining the values of three tables - local-use, domestic import, and foreign import (Table 9).

Table 9: IMPLAN Economic Flows by Commodity and Industry
\begin{tabular}{|l|c|l|c|c|c|c|c|c|c|c|c|}
\hline Comm & Total & Ag & Const & EduGov & Fin & MfgEqp & MfgProd & Min & Ret & Trans & Whlsal \\
\hline Total & 9.71 & 0.81 & 1.45 & 0.03 & 1.94 & 0.53 & 2.79 & 0.27 & 0.24 & 1.40 & 0.25 \\
\hline Ag & 1.00 & 0.15 & 0.01 & 0.00 & 0.01 & 0.00 & 0.84 & 0.00 & 0.00 & 0.00 & 0.00 \\
\hline Const & 0.79 & 0.10 & 0.01 & 0.01 & 0.28 & 0.02 & 0.09 & 0.01 & 0.03 & 0.21 & 0.01 \\
\hline EduGov & 1.00 & 0.00 & 0.04 & 0.00 & 0.66 & 0.02 & 0.05 & 0.00 & 0.08 & 0.06 & 0.08 \\
\hline Fin & 0.94 & 0.05 & 0.08 & 0.00 & 0.45 & 0.03 & 0.12 & 0.02 & 0.06 & 0.08 & 0.05 \\
\hline MfgEqp & 1.00 & 0.06 & 0.19 & 0.00 & 0.12 & 0.33 & 0.20 & 0.01 & 0.01 & 0.07 & 0.01 \\
\hline MfgPro & 1.00 & 0.18 & 0.12 & 0.00 & 0.13 & 0.01 & 0.45 & 0.01 & 0.01 & 0.07 & 0.02 \\
\hline d & & & & & & & & & & & \\
\hline Min & 1.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.35 & 0.17 & 0.00 & 0.48 & 0.00 \\
\hline Ret & 0.99 & 0.00 & 0.81 & 0.00 & 0.05 & 0.00 & 0.06 & 0.01 & 0.02 & 0.03 & 0.01 \\
\hline Trans & 1.00 & 0.07 & 0.06 & 0.01 & 0.14 & 0.03 & 0.25 & 0.03 & 0.02 & 0.36 & 0.03 \\
\hline Whlsal & 1.00 & 0.20 & 0.14 & 0.00 & 0.10 & 0.08 & 0.39 & 0.01 & 0.00 & 0.04 & 0.03 \\
\hline
\end{tabular}

\subsection*{3.4 Truck Flows}

Daily truck flows are developed from the annual tonnages using the same methodology employed in the previous model. Annual tonnages are converted to daily tonnages by dividing by 250. Daily tonnages are converted to daily trucks by dividing by a payload factor that is determined by the commodity type, whether the truck is a medium or heavy truck, and whether the trip is intra-county or inter-county. Because the FAF and additional agriculture data do not distinguish between tonnages by heavy or medium trucks, a ratio was developed from the original model data and applied to all other years. Table 10 shows the payload factors and medium-to-heavy vehicle ratios by commodity for intra- and inter-county trips.

Table 10: Heavy and Medium Truck Payload Factors
\begin{tabular}{|l|c|c|c|c|c|c|c|}
\hline Commodity & \multicolumn{3}{|c|}{\begin{tabular}{c} 
Intra-County
\end{tabular}} \\
\hline & \begin{tabular}{c} 
Medium \\
Payload Factor
\end{tabular} & \begin{tabular}{c} 
Heavy Payload \\
Factor
\end{tabular} & \begin{tabular}{c} 
Medium-to- \\
Heavy Ratio
\end{tabular} & \begin{tabular}{c} 
Medium \\
Payload Factor
\end{tabular} & \begin{tabular}{c} 
Heavy Payload \\
Factor
\end{tabular} & \begin{tabular}{c} 
Medium-to- \\
Heavy Ratio
\end{tabular} \\
\hline Agriculture & 4.57 & 13.96 & 0.32 & 10.38 & 19.85 & 0.13 \\
\hline Mfg. Equip. & 2.46 & 7.30 & 0.47 & 7.45 & 14.74 & 0.14 \\
\hline Mfg. Prod. & 4.12 & 12.76 & 0.29 & 10.09 & 16.82 & 0.06 \\
\hline Mining & 8.87 & 20.21 & 0.21 & 9.32 & 11.04 & 0.08 \\
\hline Wholesale & 5.03 & 13.18 & 0.39 & 9.09 & 14.53 & 0.11 \\
\hline
\end{tabular}

\subsection*{4.0 Short Haul Commercial Vehicles}

\subsection*{4.1 FHWA Commercial Vehicle Research}

Data required for short haul commercial vehicle travel were obtained from prior research on commercial vehicles by FHWA (12). Estimation of commercial vehicle travel by service vehicle types and truck types was done using per capita fleet sizes, vehicle trip rates, and per trip vehicle miles traveled (VMT) rates collected from a number of commercial vehicle surveys around the country (Table 11 and Table 12).
For the current model, trips per vehicle and VMT per trip used were the average values of those from all the surveys in Table 12. For per capita fleet sizes, median values were used considering the variation found in surveys from different regions. In cases where the median values were found to be much different from the values in San Francisco survey, the values from San Francisco survey were used. The final rates used for the model along with truck type splits are shown in Table 13.

Table 11: Commercial Vehicle Fleet Sizes per 1000 persons
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline & \(\unlhd\) & 苞 & \# &  &  &  & \(\dot{D}\)
\(\stackrel{\rightharpoonup}{0}\)
0 &  &  &  &  & \[
\begin{aligned}
& 0 \\
& 0.0 \\
& \frac{0}{n} \\
& \ddot{U} \\
& 0.4
\end{aligned}
\] & W \\
\hline School Bus & 0.3 & 0.4 & 0.2 & 0.8 & 0.2 & 0.2 & 0.3 & 0.2 & 0.7 & & 1.5 & 2.7 & \\
\hline Fixed Shuttle & 0.2 & 0.7 & & & & 0.1 & & 0.2 & & 0.3 & & & \\
\hline Private Transport & 0.2 & 0.3 & 0.3 & 0.5 & 0.3 & 0.9 & 0.4 & 0.3 & 0.2 & 0.9 & 0.3 & & 0.3 \\
\hline Paratransit & 0.1 & 0.0 & 0.0 & 0.0 & 0.1 & 0.2 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.0 \\
\hline Rental Cars & 7.1 & 22.3 & & & 4.6 & & & & 7.1 & & & & \\
\hline Package, Product and Mail & 0.0 & 0.1 & 2.0 & 2.5 & 0.0 & 1.7 & 4.7 & 1.6 & 0.0 & 2.9 & 12.6 & 12.6 & 12.6 \\
\hline Urban Freight, Warehouse & 5.6 & 5.6 & 10.8 & 22.3 & 3.2 & & 14.9 & & 7.6 & & 33.6 & 33.6 & 33.6 \\
\hline Construction & 2.9 & 5.6 & 1.4 & 2.8 & 2.6 & & 4.2 & & 6.3 & & 3.6 & 3.6 & 3.6 \\
\hline Safety & 0.9 & 1.3 & 0.9 & & 1.3 & & & & 5.1 & & & & \\
\hline Utility & 1.6 & 1.9 & 0.4 & 0.5 & 1.0 & & 2.5 & & 3.7 & & 0.9 & 0.9 & 0.9 \\
\hline Public Service & 6.7 & 9.5 & & & 4.9 & & & & 26.3 & & & & \\
\hline Business/Personal Services & 26.0 & 37.9 & 4.1 & 8.2 & 19.0 & & 6.3 & & 31.6 & & & & \\
\hline
\end{tabular}

Table 12: Commercial Vehicle Trip Rates and VMT


Table 13: Final Commercial Vehicle Trip Model Parameters
\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{} & \multirow[t]{2}{*}{Vehicle Type} & \multirow[t]{2}{*}{Vehicles/ 1000 persons} & \multirow[t]{2}{*}{Trips/ Vehicle} & \multirow[t]{2}{*}{\[
\begin{aligned}
& \text { VMT/ } \\
& \text { Trip }
\end{aligned}
\]} & \multicolumn{3}{|c|}{Truck Type} \\
\hline & & & & & Light & Medium & Heavy \\
\hline \multirow[t]{3}{*}{Moving People} & School Bus & 0.35 & 1.35 & 15.83 & 20\% & 80\% & 0\% \\
\hline & Shuttle Service & 0.45 & 3.67 & 21.70 & 90\% & 10\% & 0\% \\
\hline & Private Transport & 0.25 & 2.97 & 27.19 & 90\% & 10\% & 0\% \\
\hline \multirow[t]{3}{*}{Goods} & Package/Product/Mail & 0.1 & 3.95 & 39.00 & 95\% & 3\% & 2\% \\
\hline & Urban Freight & 5.6 & 4.44 & 61.21 & 67\% & 8\% & 25\% \\
\hline & Construction & 4.25 & 3.33 & 44.24 & 50\% & 15\% & 35\% \\
\hline \multirow[t]{3}{*}{Services} & Safety & 1.3 & 5.62 & 36.44 & 49\% & 24\% & 27\% \\
\hline & Utility Vehicles & 1.75 & 1.98 & 22.33 & 73\% & 27\% & 0\% \\
\hline & Business/Personal Services & 28.8 & 2.95 & 51.61 & 83\% & 17\% & 0\% \\
\hline
\end{tabular}

\subsection*{4.2 Truck Flows}

A spreadsheet analysis was created to derive estimates of commercial vehicle trips and involved the following steps:
1. For each county, fleet size by vehicle type and truck type was estimated using per capita fleet rates and 2008 county population numbers from Census.
2. The number of short haul commercial vehicle trips were then estimated using the trip rates per vehicle and fleet sizes calculated in step 1.
3. Trip rates for use in the model were estimated by dividing the total number of short haul commercial trips by the total population, total employment, or both, depending on the attraction variable
4. Finally, for model validation purposes, VMT estimates were obtained by multiplying the VMT rates per trip and the number of trips estimated in step 2.

Table 14 shows the estimated commercial vehicle short haul trip rates by vehicle type and the attractors variables used to distribute these trips in the model.

Table 14: Short Haul Commercial Vehicle Trips Rates
\begin{tabular}{|l|c|c|c|l|}
\hline \multicolumn{1}{|c|}{ Type } & \multicolumn{3}{|c|}{ Trip Rates } & \multicolumn{2}{c}{ Attraction variables } \\
\hline & Light & Medium & Heavy & \\
\hline School Bus & 0.00029 & 0.00116 & 0 & Households \\
\hline Shuttle Service & 0.00212 & 0.00024 & 0 & Households + Employment \\
\hline Private Transport & 0.00178 & 0.00020 & 0 & Employment \\
\hline Package/Product/Mail & 0.00054 & 0.00002 & 0.00001 & Households + Employment \\
\hline Urban Freight & 0.15392 & 0.01695 & 0.05581 & \begin{tabular}{l} 
Households + Employment \\
(Proportionate to Employment Type)
\end{tabular} \\
\hline Construction & 0.01011 & 0.00303 & 0.00707 & Households + Employment \\
\hline Safety & 0.00511 & 0.00250 & 0.00281 & Households + Employment \\
\hline Utility Vehicles & 0.00774 & 0.00286 & 0 & Households \\
\hline \begin{tabular}{l} 
Business/Personal \\
Services
\end{tabular} & 0.10074 & 0.02063 & 0 & Households + Employment \\
\hline
\end{tabular}

\subsection*{5.0 Valley-Wide Model Validation}

The eight-county freight model was validated based on link volumes, VMT, and average trip lengths. Due to the relatively small quantity of 2008 traffic data, observed 2008 truck volumes were estimated by inflating the 2000 count data used for the previous model (491 locations). The adjustment factors were based on the population growth from 2000 to 2007. The target VMT values for medium and heavy trucks were developed by adjusting the model VMT output based on the overall link volumes percent error. The target average trip lengths were obtained from the commercial vehicle research conducted by FHWA (12).

A comparison was made between the number of 2007 truck trips generated by the previous model and the updated model, which is shown in Table 15. The long haul trips were developed from different sources; the majority of the long haul movements can be traced back to the Commodity Flow Survey and so are not substantially different. The short haul trips were developed using a different source and adjusted to match the available counts. The majority of the differences are in the short haul movements, where there are more medium truck trips and fewer heavy truck trips.

Table 15: Truck Trips by Truck Type and Length of Haul for 2007
\begin{tabular}{|l|c|c|c|c|c|c|c|c|c|}
\hline & \multicolumn{2}{|c|}{ Phase III Model } & \multicolumn{3}{c|}{ MIP Model } & \multicolumn{3}{c|}{ Percent Difference } \\
\hline & Medium & Heavy & Total & Medium & Heavy & Total & Medium & Heavy & Total \\
\hline \begin{tabular}{l} 
Short \\
Haul
\end{tabular} & 69,059 & 118,057 & 187,116 & 51,027 & 44,302 & 95,330 & \(-26 \%\) & \(-62 \%\) & \(-49 \%\) \\
\hline Long Haul & 23,953 & 87,812 & 111,765 & 24,734 & 78,564 & 103,298 & \(3 \%\) & \(-11 \%\) & \(-8 \%\) \\
\hline Total & \(\mathbf{9 3 , 0 1 2}\) & 205,869 & 298,881 & \(\mathbf{7 5 , 7 6 1}\) & \(\mathbf{1 2 2 , 8 6 7}\) & \(\mathbf{1 9 8 , 6 2 8}\) & \(\mathbf{- 1 9 \%}\) & \(\mathbf{- 4 0 \%}\) & \(\mathbf{- 3 4 \%}\) \\
\hline
\end{tabular}

Table 16 compares the 2007 average trip length for all truck trips with the previous model results. The overall 2007 modeled average truck trip length of 65 miles is the same as the target value. The trip lengths in the MIP model are longer than in the previous model, based on the higher target value derived from the FHWA research. The truck trips are fewer, so the combination of these produces VMT that is very close to the original model.

Table 16: Truck Trip Lengths (miles) and VMT by Truck Type and Length of Haul for 2007
\begin{tabular}{|l|r|r|r|r|r|c|c|c|c|c|}
\hline & \multicolumn{2}{|c|}{ Phase III Model } & \multicolumn{3}{c|}{ MIP Model } & \multicolumn{3}{|c|}{ Percent Difference } \\
\hline & Medium & Heavy & \multicolumn{1}{c|}{ Total } & Medium & Heavy & Total & Medium & Heavy & Total \\
\hline Short Haul & 11.0 & 14.6 & 13.3 & 13.1 & 13.4 & 13.2 & \(19 \%\) & \(-8 \%\) & \(0 \%\) \\
\hline Long Haul & 66.5 & 120.0 & 108.5 & 66.0 & 143.3 & 124.8 & \(-1 \%\) & \(19 \%\) & \(15 \%\) \\
\hline Total & \(\mathbf{2 5 . 3}\) & \(\mathbf{5 9 . 6}\) & \(\mathbf{4 8 . 9}\) & 30.4 & 96.5 & 71.3 & \(20 \%\) & \(62 \%\) & \(46 \%\) \\
\hline \begin{tabular}{l} 
Vehicle \\
Miles
\end{tabular} & & & & & & & & & \\
\hline \begin{tabular}{l} 
Traveled \\
(1000s)
\end{tabular} & 2,315 & 12,259 & 14,574 & 2,283 & 11,870 & 14,153 & \(-1 \%\) & \(-3 \%\) & \(-3 \%\) \\
\hline
\end{tabular}

Table 18 show the link level validation by facility type and by county, respectively. Overall, the model volumes are slightly higher than the counts, but these will be adjusted accordingly for each county model. The over-estimation of trucks on freeways will also be adjusted for each county model, based on much more detailed networks and volume-delay functions. Given the estimated counts available for this effort, and the additional counts that will be available for each county, we will be making additional validation adjustments for each county truck model.

Table 17: Link Level Validation by Facility Type for 2007
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline & \multicolumn{2}{|l|}{Estimated Counts} & \multicolumn{2}{|l|}{Model Volumes} & \multicolumn{2}{|l|}{Percent Difference} & \multicolumn{2}{|c|}{Difference} \\
\hline Link Class & Medium & Heavy & Medium & Heavy & Medium & Heavy & Medium & Heavy \\
\hline Freeways & 69,930 & 572,448 & 93,098 & 652,509 & 33\% & 14\% & 23,168 & 80,061 \\
\hline Expressways & 16,962 & 60,812 & 12,051 & 35,347 & -29\% & -42\% & -4,911 & -25,465 \\
\hline Arterials & 29,542 & 66,127 & 26,712 & 38,248 & -10\% & -42\% & -2,830 & -27,879 \\
\hline Local Roads & 6,248 & 9,425 & 4,522 & 4,700 & -28\% & -50\% & -1,726 & -4,725 \\
\hline Grand Total & 122,682 & 708,812 & 136,383 & 730,803 & 11\% & 3\% & 13,701 & 21,991 \\
\hline
\end{tabular}

Table 18: Link Level Validation by County for 2007
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline & \multicolumn{2}{|l|}{Estimated Counts} & \multicolumn{2}{|l|}{Model Volumes} & \multicolumn{2}{|l|}{Percent Difference} & \multicolumn{2}{|l|}{Difference} \\
\hline County & Medium & Heavy & Medium & Heavy & Medium & Heavy & Medium & Heavy \\
\hline Fresno & 21,973 & 111,144 & 21,528 & 105,219 & -2\% & -5\% & -445 & -5,925 \\
\hline Kern & 40,149 & 139,554 & 40,646 & 114,161 & 1\% & -18\% & 497 & -25,393 \\
\hline Kings & 3,392 & 15,564 & 2,772 & 19,083 & -18\% & 23\% & -620 & 3,519 \\
\hline Madera & 4,982 & 37,266 & 4,854 & 38,887 & -3\% & 4\% & -128 & 1,621 \\
\hline Merced & 5,630 & 53,098 & 8,500 & 75,281 & 51\% & 42\% & 2,870 & 22,183 \\
\hline San Joaquin & 29,332 & 231,270 & 40,361 & 248,043 & 38\% & 7\% & 11,029 & 16,773 \\
\hline Stanislaus & 6,112 & 50,174 & 7,911 & 59,684 & 29\% & 19\% & 1,799 & 9,510 \\
\hline Tulare & 8,454 & 49,554 & 6,524 & 42,465 & -23\% & -14\% & -1,930 & -7,089 \\
\hline Grand Total & 120,024 & 687,624 & 133,096 & 702,822 & 11\% & 2\% & 13,072 & 15,198 \\
\hline
\end{tabular}

\subsection*{6.0 County Goods Movement Models}

The county goods movement models were developed initially to emulate the valley-wide goods movement model. But several counties (Kern, Fresno, Tulare, and 3-county) had more recent vehicle classification counts that could be used for calibration in their respective county models. This allowed for an adjustment of the short haul model parameters to better match county vehicle classification counts. The vehicle classification counts were obtained and coded by the lead firm from the consultant team for each county.

The Kings and Madera County models used parameters for vehicle trip rates and diurnal factors from the Tulare County model, since they are more similar in terms of population. The friction factors are the same in all the models. Friction factors for all truck trip types (light, medium and heavy) are defined by the equation:

Where: Time is the congested travel time from the origin to the destination
\[
\begin{aligned}
& A=100,000 \\
& B=-0.07 \\
& C=-0.5
\end{aligned}
\]

The diurnal factors are the same for all trips (internal and external). Truck trip assignment volume-delay equations are also the same for all models. These parameters reduce the truck speeds on freeways by \(15 \%\) due to the fact that trucks travel slower than passenger cars.

Model parameters and calibration results for the county models are described in the following sections. Calibration results involve several reasonableness checks, which are reported for all county models, and comparisons of observed and estimated truck volumes for the 4 models where vehicle classification counts were available (Kern, Fresno, Tulare, and 3-county).

\subsection*{6.1 Fresno County}

Short haul commercial vehicle trip rates include three categories of trips: moving people, moving freight and providing services. These represent commercial vehicles used for these purposes. In some cases, the light truck trip category also includes passenger cars (taxis, rental cars, business services, etc.) but since this category is combined with passenger cars for analysis, it is not necessary to track these vehicles separately. Kern County short haul commercial vehicle trip rates are provided in Table 19 for light, medium and heavy vehicles. Diurnal factors for trucks were derived from truck counts for each county. Fresno County diurnal factors are provided in Table 20.

Calibration of the Fresno County goods movement model involves comparing vehicle classification counts to model volumes by truck type. Vehicle classification counts provide medium and heavy duty truck volumes, but light truck volumes are not separable from passenger cars so these truck volumes are calibrated based on reasonableness checks with the medium and heavy trucks. Table 19 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 2. This demonstrates that all the light trucks have short trip lengths; most of the medium trucks are relatively short, but some are external trips and are quite long; and most of the heavy trucks are external and quite long, although some are of midrange length. The through trips are quite long and exceed the \(8 \%\) distribution shown on this graph and reach up to \(40 \%\) for trips at 180 minutes and up to \(20 \%\) for trips at 170 minutes. These trip length frequency distributions are reasonable for Fresno County.

Table 19: Fresno County Short Haul Commercial Vehicle Trips Rates
\begin{tabular}{|c|c|c|c|c|}
\hline Type & Light & Medium & Heavy & Attraction variables \\
\hline \multirow[t]{2}{*}{Moving People (Bus, Shuttle, Taxi, Rental)} & 0.00750 & 0.00510 & 0 & Households \\
\hline & 0.01210 & 0.00158 & 0 & Employment \\
\hline Package/Product/Mail & 0.00167 & 0.00008 & 0.00001 & Households + Employment \\
\hline \multirow{5}{*}{Urban Freight} & 0.03551 & 0.00719 & 0.00345 & Households \\
\hline & 0.12571 & 0.01835 & 0.00592 & Retail Employment \\
\hline & 0.15714 & 0.02099 & 0.01583 & Agriculture, Mining, Construction Employment \\
\hline & 0.13278 & 0.01758 & 0.00945 & Manufacturing, Transportation, Wholesale Employment \\
\hline & 0.06186 & 0.00490 & 0.00081 & Finance, Government, Education Employment \\
\hline Construction & 0.03041 & 0.01070 & 0.00394 & Households, Total Employment, Construction Employment \\
\hline \multirow[t]{2}{*}{Providing Services (Business, Utility, Safety)} & 0.35243 & 0.09483 & 0.00161 & Households \\
\hline & 0.32839 & 0.08440 & 0.00161 & Employment \\
\hline
\end{tabular}

Table 20: Fresno County Diurnal Factors for Trucks
\begin{tabular}{|c|c|c|c|}
\hline Time of Day & Light & Medium & Heavy \\
\hline AM Peak (6-9am) & 0.0374 & 0.0427 & 0.0369 \\
\hline Midday (9am-4pm) & 0.0214 & 0.0255 & 0.0238 \\
\hline PM Peak (4-7pm) & 0.0505 & 0.043 & 0.0359 \\
\hline Evening/Night (7pm-6am) & 0.0079 & 0.0059 & 0.0105 \\
\hline
\end{tabular}

Table 21. Fresno County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 313,418 & 88,747 & 46,209 & 448,373 \\
\hline Time (min) & 16.2 & 24.0 & 122.0 & 28.7 \\
\hline Distance (mile) & 9.8 & 17.8 & 121.5 & 22.9 \\
\hline
\end{tabular}


Validation of the Fresno County truck trips was performed across three dimensions: truck type, facility type, and time period. Truck types include medium and heavy truck trips only because the vehicle classification counts are not able to distinguish light trucks from passenger cars. Facility types are limited to freeways and arterials, given the limited number of truck count locations. In Fresno County, there are 14 freeway truck count locations and 40 arterial truck count locations. Figure 3 demonstrates that the medium and heavy trucks by time of day estimated from the model are reasonable compared to observed counts. Figure 4 presents a close comparison of the distribution of trucks by facility type.

Figure 3. Fresno County Validation of Trucks by Truck Type and Time of Day


Figure 4. Fresno County Distribution of Medium and Heavy Trucks by Facility Type


\subsection*{6.2 Kern County}

Short haul commercial vehicle trip rates for Kern County are provided in Table 22 for light, medium and heavy vehicles. The medium duty vehicle trip rates are higher in Kern County than in Fresno County; the light and heavy duty vehicle trip rates are the same as they were for Fresno County. Diurnal factors for trucks were derived from truck counts for each county. Kern County diurnal factors are provided in Table 23.

Calibration of the Kern County goods movement model involves comparing vehicle classification counts to model volumes by truck type. Vehicle classification counts provide medium and heavy duty truck volumes, but light truck volumes are not separable from passenger cars so these truck volumes are calibrated based on reasonableness checks with the medium and heavy trucks. Table 24 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 5. This demonstrates that all the light trucks have short trip lengths; most of the medium trucks are relatively short, but some are external trips and are quite long; and most of the heavy trucks are external and quite long, although some are of midrange length. The through trips are quite long and exceed the \(8 \%\) distribution shown on this graph and reach up to \(60 \%\) for trips at 180 minutes. These trip length frequency distributions are reasonable for Kern County.

Validation of the Kern County truck trips was performed across three dimensions: truck type, facility type, and time period. Truck types include medium and heavy truck trips only because the vehicle classification counts are not able to distinguish light trucks from passenger cars. Facility types are limited to freeways and arterials, given the limited number of truck count locations. In Kern County, there are 11 freeway truck count locations and 22 arterial truck count locations. Figure 6 demonstrates that the medium and heavy trucks by time of day estimated from the model are reasonable compared to observed counts. Figure 7 presents a close comparison of the distribution of trucks by facility type.

Table 22: Kern County Short Haul Commercial Vehicle Trips Rates
\begin{tabular}{|c|c|c|c|c|}
\hline Type & Light & Medium & Heavy & Attraction variables \\
\hline \multirow[t]{2}{*}{Moving People (Bus, Shuttle, Taxi, Rental)} & 0.00750 & 0.00963 & 0 & Households \\
\hline & 0.01210 & 0.00298 & 0 & Employment \\
\hline Package/Product/Mail & 0.00167 & 0.00015 & 0.00001 & Households + Employment \\
\hline \multirow{5}{*}{Urban Freight} & 0.03551 & 0.01357 & 0.00345 & Households \\
\hline & 0.12571 & 0.03463 & 0.00592 & Retail Employment \\
\hline & 0.15714 & 0.03961 & 0.01583 & Agriculture, Mining, Construction Employment \\
\hline & 0.13278 & 0.03318 & 0.00945 & Manufacturing, Transportation, Wholesale Employment \\
\hline & 0.06186 & 0.00925 & 0.00081 & Finance, Government, Education Employment \\
\hline Construction & 0.03041 & 0.02020 & 0.00394 & Households, Total Employment, Construction Employment \\
\hline \multirow[t]{2}{*}{Providing Services (Business, Utility, Safety)} & 0.35243 & 0.17895 & 0.00161 & Households \\
\hline & 0.32839 & 0.15928 & 0.00161 & Employment \\
\hline
\end{tabular}

Note: Vehicle trip rates in italics are the same as the Fresno County Model.

Table 23: Kern County Diurnal Factors for Trucks
\begin{tabular}{|l|l|l|l|}
\hline \multicolumn{1}{|c|}{ Time of Day } & Light & Medium & Heavy \\
\hline AM Peak (6-9am) & 0.0192 & 0.0406 & 0.0289 \\
\hline Midday (9am-4pm) & 0.0266 & 0.0230 & 0.0198 \\
\hline PM Peak (4-7pm) & 0.0391 & 0.0386 & 0.0363 \\
\hline Evening/Night (7pm-6am) & 0.0126 & 0.0092 & 0.0151 \\
\hline
\end{tabular}

Table 24. Kern County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 246,899 & 132,933 & 42,384 & 422,216 \\
\hline Time (min) & 16.9 & 23.4 & 136.2 & 30.9 \\
\hline Distance (mile) & 9.5 & 15.2 & 124.0 & 22.8 \\
\hline
\end{tabular}

Figure 5. Kern County Travel Time Distribution by Truck Type


Figure 6. Kern County Validation of Trucks by Truck Type and Time of Day


Figure 7. Kern County Distribution of Medium and Heavy Trucks by Facility Type


\subsection*{6.3 Kings County}

Short haul commercial vehicle trip rates for Kings County were adopted from Tulare County and are the same for all categories. The medium duty vehicle trip rates are lower than in Kern County but higher than in Fresno County; the heavy duty vehicle trip rates are higher than in either Kern or Fresno Counties; the light duty vehicle trip rates are the same in all the counties. The diurnal factors are the same for Kings County as they were in Tulare County. Since there were few truck counts in Kings County, these were set to match Tulare County.

Calibration of the Kings County goods movement model involves reasonableness checks on truck trips and trip lengths for light, medium and heavy trucks. Table 25 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Table 25. Kings County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 31,679 & 16,974 & 20,717 & 69,369 \\
\hline Time (min) & 12.6 & 15.9 & 30.2 & 18.7 \\
\hline Distance (mile) & 7.0 & 11.1 & 30.9 & 15.1 \\
\hline
\end{tabular}

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 8. This demonstrates that all the light trucks have short trip lengths; most of the medium trucks are relatively short, but some are external trips and are around 30-35 minutes long; and most of the heavy trucks are external and longer. The through trips are around 30-35 minutes and exceed the \(12 \%\) distribution shown on this graph and reach up to \(70 \%\) of trips at this length. These trip length frequency distributions are reasonable for Kings County.

Figure 8. Kings County Travel Time Distribution by Truck Type


Specific validation of the Kings County truck volumes was not performed further because there were not sufficient vehicle classification counts to warrant a more specific validation test.

\subsection*{6.4 Madera County}

Short haul commercial vehicle trip rates for Madera County were adopted from Tulare County and are the same for all categories. The medium duty vehicle trip rates are lower than in Kern County but higher than in Fresno County; the heavy duty vehicle trip rates are higher than in either Kern or Fresno Counties; the light duty vehicle trip rates are the same in all the counties. The diurnal factors are the same for Madera County as they were in Tulare County. Since there were few truck counts in Madera County, these were set to match Tulare County.
Calibration of the Madera County goods movement model involves reasonableness checks on truck trips and trip lengths for light, medium and heavy trucks. Table 26 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Table 26. Madera County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 31,679 & 16,974 & 20,717 & 69,369 \\
\hline Time (min) & 12.6 & 15.9 & 30.2 & 18.7 \\
\hline Distance (mile) & 7.0 & 11.1 & 30.9 & 15.1 \\
\hline
\end{tabular}

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 9. This demonstrates that all the light trucks have short trip lengths; most of the medium trucks are relatively short, but some are external trips and are around 30-35 minutes long; and most of the heavy trucks are external and longer. The through trips are around 30-35 minutes and exceed the 8\% distribution shown on this graph and reach up to \(35 \%\) of trips at this length. These trip length frequency distributions are reasonable for Madera County.

Figure 9. Madera County Travel Time Distribution by Truck Type


Specific validation of the Madera County truck volumes was not performed further because there were not sufficient vehicle classification counts to warrant a more specific validation test.

\subsection*{6.5 Merced, San Joaquin and Stanislaus Counties}

Short haul commercial vehicle trip rates for Three County are provided in Table 27 for light, medium and heavy vehicles. The medium duty vehicle trip rates are lower than Kern and Fresno Counties; the heavy duty vehicle trip rates are slightly higher than in either Fresno County; the light duty vehicle trip rates are the same in all the counties.

Table 27: Three County Short Haul Commercial Vehicle Trips Rates
\begin{tabular}{|c|c|c|c|c|}
\hline Type & Light & Medium & Heavy & Attraction variables \\
\hline \multirow[t]{2}{*}{Moving People (Bus, Shuttle, Taxi, Rental)} & 0.00750 & 0.00443 & 0 & Households \\
\hline & 0.01210 & 0.00137 & 0 & Employment \\
\hline Package/Product/Mail & 0.00167 & 0.00007 & 0.00001 & Households + Employment \\
\hline \multirow{5}{*}{Urban Freight} & 0.03551 & 0.00624 & 0.00391 & Households \\
\hline & 0.12571 & 0.01591 & 0.00671 & Retail Employment \\
\hline & 0.15714 & 0.0182 & 0.01794 & Agriculture, Mining, Construction Employment \\
\hline & 0.13278 & 0.01525 & 0.01071 & Manufacturing, Transportation, Wholesale Employment \\
\hline & 0.06186 & 0.00425 & 0.00092 & Finance, Government, Education Employment \\
\hline Construction & 0.03041 & 0.00928 & 0.00446 & Households, Total Employment, Construction Employment \\
\hline \multirow[t]{2}{*}{Providing Services (Business, Utility, Safety)} & 0.35243 & 0.08223 & 0.00182 & Households \\
\hline & 0.32839 & 0.07319 & 0.00182 & Employment \\
\hline
\end{tabular}

Note: Vehicle trip rates in italics are the same in all the county models.

The friction factors are the same in all the counties. Diurnal factors for trucks were derived from truck counts for each county. Three County diurnal factors are provided in Table 28.

Table 28: Three County Diurnal Factors for Trucks
\begin{tabular}{|l|l|l|l|}
\hline \multicolumn{1}{|c|}{ Time of Day } & Light & Medium & Heavy \\
\hline AM Peak (6-9am) & 0.1538 & 0.2080 & 0.1624 \\
\hline Midday (9am-4pm) & 0.4262 & 0.4133 & 0.3943 \\
\hline
\end{tabular}
\begin{tabular}{|l|l|l|l|}
\hline PM Peak (4-7pm) & 0.2239 & 0.2095 & 0.1894 \\
\hline Evening/Night (7pm-6am) & 0.1960 & 0.1693 & 0.2539 \\
\hline
\end{tabular}

Truck trip assignment volume-delay equations for trucks have been adjusted to reduce the truck speeds on freeways by \(15 \%\) due to the fact that trucks travel slower than passenger cars.

Calibration of the Three County goods movement model involves comparing vehicle classification counts to model volumes by truck type. Vehicle classification counts provide medium and heavy duty truck volumes, but light truck volumes are not separable from passenger cars so these truck volumes are calibrated based on reasonableness checks with the medium and heavy trucks. Table 29 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Table 29. Three County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 3,845 & 2,307 & 1,022 & 7,174 \\
\hline Time (min) & 13.9 & 15.4 & 41.6 & 18.3 \\
\hline Distance (mile) & 13.4 & 14.9 & 41.1 & 17.8 \\
\hline
\end{tabular}

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 10. Light and medium trucks have shorter trip lengths while many heavy trucks fall in the midrange length. These trip length frequency distributions are reasonable for the Three County area.

Figure 10. Three County Travel Time Distribution by Truck Type


Validation of the Three County truck trips was performed across three dimensions: truck type, facility type, and time period. Truck types include medium and heavy truck trips only because the vehicle classification
counts are not able to distinguish light trucks from passenger cars. Facility types are limited to freeways and arterials, given the limited number of truck count locations. In Three County, there are 43 freeway truck count locations and 206 arterial truck count locations.

Figure 11 shows the medium and heavy trucks by time of day estimated from the model compared to observed counts. Figure 12 presents a comparison of the distribution of trucks by facility type, with model forecasting higher trips than counts on freeways and lower on arterials

Figure 11. Three County Validation of Trucks by Truck Type and Time of Day


Figure 12. Three County Distribution of Medium and Heavy Trucks by Facility Type


\subsection*{6.6 Tulare County}

Short haul commercial vehicle trip rates for Tulare County are provided in Table 27 for light, medium and heavy vehicles. The medium duty vehicle trip rates are lower than in Kern County but higher than in Fresno County; the heavy duty vehicle trip rates are higher than in either Kern or Fresno Counties; the light duty vehicle trip rates are the same in all the counties. Kings and Madera County short haul vehicle trip rates were adopted from Tulare County and are the same for all categories.

Table 30: Tulare County Short Haul Commercial Vehicle Trips Rates
\begin{tabular}{|c|c|c|c|c|}
\hline Type & Light & Medium & Heavy & Attraction variables \\
\hline \multirow[t]{2}{*}{Moving People (Bus, Shuttle, Taxi, Rental)} & 0.00750 & 0.00770 & 0 & Households \\
\hline & 0.01210 & 0.00238 & 0 & Employment \\
\hline Package/Product/Mail & 0.00167 & 0.00012 & 0.00001 & Households + Employment \\
\hline \multirow{5}{*}{Urban Freight} & 0.03551 & 0.01085 & 0.00323 & Households \\
\hline & 0.12571 & 0.02769 & 0.00554 & Retail Employment \\
\hline & 0.15714 & 0.03167 & 0.01482 & Agriculture, Mining, Construction Employment \\
\hline & 0.13278 & 0.02653 & 0.00885 & Manufacturing, Transportation, Wholesale Employment \\
\hline & 0.06186 & 0.00740 & 0.00076 & Finance, Government, Education Employment \\
\hline Construction & 0.03041 & 0.01615 & 0.00369 & Households, Total Employment, Construction Employment \\
\hline \multirow[t]{2}{*}{Providing Services (Business, Utility, Safety)} & 0.35243 & 0.14309 & 0.00151 & Households \\
\hline & 0.32839 & 0.12736 & 0.00151 & Employment \\
\hline
\end{tabular}

Note: Vehicle trip rates in italics are the same in all the county models.

The friction factors are the same in all the counties. Diurnal factors for trucks were derived from truck counts for each county. Tulare County diurnal factors are provided in Table 28.

Table 31: Tulare County Diurnal Factors for Trucks
\begin{tabular}{|l|l|l|l|}
\hline \multicolumn{1}{|c|}{ Time of Day } & Light & Medium & Heavy \\
\hline AM Peak (6-9am) & 0.0250 & 0.0408 & 0.0345 \\
\hline Midday (9am-4pm) & 0.0169 & 0.0252 & 0.0239 \\
\hline PM Peak (4-7pm) & 0.0578 & 0.0414 & 0.0367 \\
\hline Evening/Night (7pm-6am) & 0.0121 & 0.0007 & 0.0108 \\
\hline
\end{tabular}

Similar to Fresno County, truck trip assignment volume-delay equations for trucks have been adjusted to reduce the truck speeds on freeways by 15\% due to the fact that trucks travel slower than passenger cars.
Calibration of the Tulare County goods movement model involves comparing vehicle classification counts to model volumes by truck type. Vehicle classification counts provide medium and heavy duty truck volumes, but light truck volumes are not separable from passenger cars so these truck volumes are calibrated based on reasonableness checks with the medium and heavy trucks. Table 29 provides a summary of the truck trips and trip lengths (time and distance) for light, medium and heavy truck trips.

Table 32. Tulare County Truck Trips and Lengths by Type
\begin{tabular}{|c|c|c|c|c|}
\hline & Light & Medium & Heavy & Total \\
\hline Total Trips & 127,228 & 51,526 & 20,287 & 199,042 \\
\hline Time (min) & 16.2 & 18.8 & 65.4 & 21.9 \\
\hline Distance (mile) & 9.5 & 12.6 & 65.8 & 16.0 \\
\hline
\end{tabular}

Another reasonableness check is the trip length distribution of trucks by type presented in Figure 10. This demonstrates that all the light and medium trucks have short trip lengths; and most of the heavy trucks are external and quite long, although some are of midrange length. The through trips are quite long and exceed the \(8 \%\) distribution shown on this graph and reach up to \(30 \%\) for trips at 100 minutes. These trip length frequency distributions are reasonable for Tulare County.

Figure 13. Tulare County Travel Time Distribution by Truck Type


Validation of the Tulare County truck trips was performed across three dimensions: truck type, facility type, and time period. Truck types include medium and heavy truck trips only because the vehicle classification counts are not able to distinguish light trucks from passenger cars. Facility types are limited to freeways and arterials, given the limited number of truck count locations. In Tulare County, there are 12 freeway truck count locations and 92 arterial truck count locations. Figure 11 demonstrates that the medium and heavy trucks by time of day estimated from the model are reasonable compared to observed counts. Figure 12 presents a reasonable comparison of the distribution of trucks by facility type, with freeways slightly higher than counts and arterials slightly lower than counts.

Figure 14. Tulare County Validation of Trucks by Truck Type and Time of Day


Figure 15. Tulare County Distribution of Medium and Heavy Trucks by Facility Type


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San Joaquin Valley Model Improvement Program Vehicle Availability Models
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\subsection*{1.0 Introduction}

San Joaquin Valley Model Improvement Program (MIP) has 6 county models representing 8 counties in the valley. 5 of the 6 county models have a vehicle availability model component, which is documented in this report. Vehicle availability models estimate the number of vehicles that are available in a household. These used to be termed auto ownership models, but the definitions were expanded to include any vehicles (motorcycles, light trucks, vans, etc.) available to the household (including leased or company-owned vehicles) because the vehicle type and ownership do not affect the travel behavior associated with these households.

The vehicle availability model was originally estimated from National Household Travel Survey (NHTS) survey data for the 8 San Joaquin Valley counties and then calibrated using American Community Survey (ACS) data from the Census for each county model:
- Fresno County
- Kern County
- Kings County
- Madera County
- Tulare County

The remaining county model which does not have a vehicle availability model is for Merced, San Joaquin, and Stanislaus Counties and is called the 3-County Model. Fehr \& Peers decided not to develop a vehicle availability component for this model due to schedule constraints.
This report presents the data used in model estimation and calibration, as well as the parameters estimated for the initial and final models, and the calibration results.

\subsection*{2.1 Household Survey Data}

The 2009 National Household Travel Survey (NHTS) was used to estimate vehicle availability models for the San Joaquin Valley region. Table 1 presents a count of the households by county and vehicle availability in the San Joaquin Valley. Tables 2 through 9 present the percent of vehicles owned by the 1,647 SJ Valley households in the 2009 NHTS sample, crossed with a number of variables that were tested in the aggregate vehicle availability models:
- County
- Household size
- Number of adults in household
- Number of working adults in household
- Age category of head of household
- Housing type
- Own/rent home
- Land use/accessibility (area type)
- Household income group

The data shows definite patterns in auto ownership along all of these dimensions, although not all effects necessarily remain significant when all of them are included.

Table 1. Vehicles per Household by County in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[b]{2}{*}{County} & & \multicolumn{4}{|l|}{Vehicles per Household} & \multirow[t]{2}{*}{Total} \\
\hline & No
cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline FRESNO & 18 & 119 & 143 & 63 & 38 & 381 \\
\hline KERN & 11 & 91 & 120 & 59 & 28 & 309 \\
\hline KINGS & 2 & 14 & 24 & 16 & 7 & 63 \\
\hline MADERA & 0 & 13 & 26 & 13 & 12 & 64 \\
\hline MERCED & 6 & 27 & 31 & 16 & 10 & 90 \\
\hline SAN JOAQUIN & 21 & 65 & 135 & 59 & 26 & 306 \\
\hline STANISLAUS & 9 & 77 & 98 & 52 & 25 & 261 \\
\hline TULARE & 7 & 41 & 63 & 34 & 28 & 173 \\
\hline Total & 74 & 447 & 640 & 312 & 174 & 1647 \\
\hline
\end{tabular}

Table 2. Percent of Vehicles per Household by County in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[b]{2}{*}{County} & \multicolumn{5}{|c|}{Vehicles per Household} & \multirow[t]{2}{*}{Total} \\
\hline & \[
\begin{gathered}
\text { No } \\
\text { cars }
\end{gathered}
\] & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline FRESNO & 4.7\% & 31.2\% & 37.5\% & 16.5\% & 10.0\% & 100.0\% \\
\hline KERN & 3.6\% & 29.4\% & 38.8\% & 19.1\% & 9.1\% & 100.0\% \\
\hline KINGS & 3.2\% & 22.2\% & 38.1\% & 25.4\% & 11.1\% & 100.0\% \\
\hline MADERA & & 20.3\% & 40.6\% & 20.3\% & 18.8\% & 100.0\% \\
\hline MERCED & 6.7\% & 30.0\% & 34.4\% & 17.8\% & 11.1\% & 100.0\% \\
\hline SAN JOAQUIN & 6.9\% & 21.2\% & 44.1\% & 19.3\% & 8.5\% & 100.0\% \\
\hline STANISLAUS & 3.4\% & 29.5\% & 37.5\% & 19.9\% & 9.6\% & 100.0\% \\
\hline TULARE & 4.0\% & 23.7\% & 36.4\% & 19.7\% & 16.2\% & 100.0\% \\
\hline Total & 4.5\% & 27.1\% & 38.9\% & 18.9\% & 10.6\% & 100.0\% \\
\hline
\end{tabular}

Table 3. Percent of Vehicles per Household by Household Size in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Household members} & \multicolumn{5}{|c|}{Vehicles per Household} & \multirow[t]{2}{*}{Total} \\
\hline & No cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline 1 & 12.7\% & 70.6\% & 12.4\% & 3.9\% & .3\% & 100.0\% \\
\hline 2 & 3.2\% & 18.7\% & 50.5\% & 17.5\% & 10.0\% & 100.0\% \\
\hline 3 & 1.7\% & 12.7\% & 37.1\% & 35.4\% & 13.1\% & 100.0\% \\
\hline 4 & .9\% & 14.7\% & 43.1\% & 20.9\% & 20.4\% & 100.0\% \\
\hline 5 & 2.7\% & 11.7\% & 43.2\% & 27.9\% & 14.4\% & 100.0\% \\
\hline 6 & 1.8\% & 16.1\% & 35.7\% & 30.4\% & 16.1\% & 100.0\% \\
\hline 7 & & 18.8\% & 56.3\% & 12.5\% & 12.5\% & 100.0\% \\
\hline 8 & & 11.1\% & 22.2\% & 44.4\% & 22.2\% & 100.0\% \\
\hline 9 & & & & 33.3\% & 66.7\% & 100.0\% \\
\hline 11 & & 33.3\% & 33.3\% & & 33.3\% & 100.0\% \\
\hline Total & 4.5\% & 27.1\% & 38.9\% & 18.9\% & 10.6\% & 100.0\% \\
\hline
\end{tabular}

Table 4. Percent of Vehicles per Household by Adult Household Members in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Household members at least 18 years old} & \multicolumn{5}{|c|}{Vehicles per Household} & Total \\
\hline & No cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline 1 & 12.8\% & 69.3\% & 13.6\% & 4.1\% & . \(3 \%\) & 100.0\% \\
\hline 2 & 2.4\% & 16.6\% & 52.9\% & 18.5\% & 9.6\% & 100.0\% \\
\hline 3 & 1.0\% & 8.3\% & 21.9\% & 45.3\% & 23.4\% & 100.0\% \\
\hline 4 & 1.5\% & 10.6\% & 21.2\% & 30.3\% & 36.4\% & 100.0\% \\
\hline 5 & & 18.2\% & 18.2\% & 18.2\% & 45.5\% & 100.0\% \\
\hline 6 & & & & 100.0\% & & 100.0\% \\
\hline 7 & & & & 33.3\% & 66.7\% & 100.0\% \\
\hline Total & 4.5\% & 27.1\% & 38.9\% & 18.9\% & 10.6\% & 100.0\% \\
\hline
\end{tabular}

Table 5. Percent of Vehicles per Household by Age of Head of Household in 2009 NHTS for San Joaquin Valley
\begin{tabular}{lccccccc} 
Age of Head of & & \multicolumn{4}{c}{ Vehicles per Household } & & Total \\
Household & No cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline Head Age 18-29 & \(1.6 \%\) & \(26.0 \%\) & \(37.0 \%\) & \(22.8 \%\) & \(12.6 \%\) & \(100.0 \%\) \\
Head Age 30-49 & \(2.1 \%\) & \(17.1 \%\) & \(46.4 \%\) & \(23.3 \%\) & \(11.1 \%\) & \(100.0 \%\) \\
Head Age 50-69 & \(4.5 \%\) & \(24.2 \%\) & \(36.8 \%\) & \(21.3 \%\) & \(13.2 \%\) & \(100.0 \%\) \\
Head Age 70+ & \(8.3 \%\) & \(44.8 \%\) & \(34.7 \%\) & \(8.0 \%\) & \(4.3 \%\) & \(100.0 \%\) \\
Total & \(4.5 \%\) & \(27.1 \%\) & \(38.9 \%\) & \(18.9 \%\) & \(10.6 \%\) & \(100.0 \%\) \\
\hline
\end{tabular}

Table 6. Percent of Vehicles per Household by Housing Unit Type in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Housing Unit Type} & \multirow[b]{2}{*}{No cars} & \multicolumn{3}{|l|}{Vehicles per Household} & \multirow[b]{2}{*}{4+ cars} & \multirow[t]{2}{*}{Total} \\
\hline & & 1 car & 2 cars & 3 cars & & \\
\hline Refused & & & 50.0\% & 50.0\% & & 100.0\% \\
\hline Detached & 2.1\% & 22.9\% & 42.5\% & 20.8\% & 11.8\% & 100.0\% \\
\hline \multicolumn{7}{|l|}{Single} \\
\hline Duplex & 7.4\% & 35.8\% & 29.6\% & 18.5\% & 8.6\% & 100.0\% \\
\hline Rowhouse/ & 23.4\% & 54.0\% & 16.1\% & 4.8\% & 1.6\% & 100.0\% \\
\hline \multicolumn{7}{|l|}{Townhouse} \\
\hline Apartment/ & 12.6\% & 48.3\% & 23.0\% & 9.2\% & 6.9\% & 100.0\% \\
\hline \multicolumn{7}{|l|}{Condo} \\
\hline Other & & & & 100.0\% & & 100.0\% \\
\hline Total & 4.5\% & 27.1\% & 38.9\% & 18.9\% & 10.6\% & 100.0\% \\
\hline
\end{tabular}

Table 7. Percent of Vehicles per Household by Housing Unit Ownership in 2009 NHTS for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Housing Unit Type} & \multicolumn{5}{|c|}{Vehicles per Household} & \multirow[t]{2}{*}{Total} \\
\hline & No cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline Own & 2.0\% & 23.1\% & 41.8\% & 20.9\% & 12.1\% & 100.0\% \\
\hline Rent & 15.1\% & 44.2\% & 26.3\% & 10.6\% & 3.8\% & 100.0\% \\
\hline Total & 4.5\% & 27.1\% & 38.9\% & 18.9\% & 10.6\% & 100.0\% \\
\hline
\end{tabular}

Table 8. Percent of Vehicles per Household by Area Type in 2009 NHTS for San Joaquin Valley
\begin{tabular}{lcccccc} 
Area Type & & \multicolumn{4}{c}{ Vehicles per Household } & \\
& No cars & 1 car & 2 cars & 3 cars & 4+ cars & \\
\hline Second City & \(5.9 \%\) & \(29.6 \%\) & \(38.5 \%\) & \(17.7 \%\) & \(8.2 \%\) & \(100.0 \%\) \\
Suburban & \(2.4 \%\) & \(25.1 \%\) & \(42.8 \%\) & \(20.3 \%\) & \(9.5 \%\) & \(100.0 \%\) \\
Town/rural & \(1.8 \%\) & \(23.7 \%\) & \(37.5 \%\) & \(20.6 \%\) & \(16.4 \%\) & \(100.0 \%\) \\
Urban & \(10.7 \%\) & \(32.1 \%\) & \(34.9 \%\) & \(15.8 \%\) & \(6.5 \%\) & \(100.0 \%\) \\
Total & \(4.5 \%\) & \(27.1 \%\) & \(38.9 \%\) & \(18.9 \%\) & \(10.6 \%\) & \(100.0 \%\) \\
\hline
\end{tabular}

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\subsection*{2.2 American Community Survey 5-year Data}

Data from the American Community Survey (ACS) \({ }^{1}\) portion of the Census were used to establish calibration targets for each county. The ACS is an ongoing survey that provides data every year -- giving communities the current information they need to plan investments and services. These are population and housing characteristics based on data collected from January 1, 2006 to December 31, 2010.

Data for individual counties are provided in the calibration tables in Section 4. These are presented by comparing the ACS 5-year data to the results of the vehicle availability model calibrations to see how well the models fit these data.

\footnotetext{
\({ }^{1}\) http://www.census.gov/acs/www/data documentation/data main/
}

\subsection*{3.0 Valley-wide Model Estimation}

\subsection*{3.1 Initial Model}

The results of an initial multinomial logit choice model on the NHTS households are presented in Table 10. There are 5 alternatives in the model- \(0,1,2,3\), or \(4+\) vehicles. The alternatives are presented in the table columns, and the independent variables are in the rows. The most significant positive coefficients are in green, and the most significant negative coefficients in yellow. The non-significant coefficients were dropped from the final specification. Some discussion about the results of these models is summarized below:
- The main segmentation variable is the number of adults, which is used in place of alternative-specific constants. For each segment, the base alternative is set as number of cars=number of adults, so all constants relative to that one are expected to be negative, which is the case.
- The second most important segmentation variable is income. Here it is specified roughly as quintiles, with the \(60-100 \mathrm{~K}\) group used as the base segment (and the 2 -car alternative used as the base alternative for this and the rest of the variables). The effects are very strong with logical order for the lowest three income groups. The 'over 100 K ' segment is not very different from the base \(60-100 \mathrm{~K}\) segment. The "nuisance" parameters for missing income show that those with missing income data tend to act like one of the lower income groups in this case. (The missing income parameters are not be used in model application, but are included in order to keep those observations in the sample without biasing the results.)
- Some additional possible household type segments were tested. Households with one or more children are less likely to own 0 cars or 1 car. Household where all adults work are much less likely to have 0 cars and more likely to have \(4+\) cars. Households where the head is age 65+ are more likely to have one car and less likely to have more than two. Households where the head is under age 35 are not significantly different from the base age segment (head age 35-64). Of these, the age 65+ segmentation seems most important to include.
- Renters and apartment/condo/townhouse dwellers are much more likely to own 0 or 1 cars. These two variables are likely to be highly correlated, so it may not be necessary to segment by both of them - if owner/renter were dropped, the apartment/condo segment would capture much of the effect. Also, if they are both dropped, an area type variable and the income and household size variables might pick up some of this effect. (If we segment by dwelling type, we need to determine which segmentation best captures the distinction in the land use data, and also determine how we will provide joint distributions by dwelling type AND household type in the base year and forecast year input.)
- The classification by the Claritas PRIZM block-group level area type code shows a strong difference for rural areas (towards higher car ownership), but no significant differences between the other three area types. These variables with replaced with more detailed accessibility variables based on zonal attractions and impedance data in the final specifications.
- When all of the effects above are accounted for, there are virtually no significant county-specific effects related to constants for seven counties relative to Fresno (specified as the base county).
Table 10. Initial Vehicle Availability Model Results for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{\begin{tabular}{l}
Alternative \\
Times chosen
\end{tabular}} & & \multicolumn{2}{|l|}{0 cars} & \multicolumn{2}{|l|}{1 car} & \multicolumn{2}{|l|}{2 cars} & \multicolumn{2}{|l|}{3 cars} & \multicolumn{2}{|l|}{4+ cars} \\
\hline & & 74 & 4.5\% & 447 & 27.1\% & 640 & 38.9\% & 312 & 18.9\% & 174 & 10.6\% \\
\hline Segment & \% of sample & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat \\
\hline \multicolumn{12}{|l|}{HOUSEHOLD SIZE} \\
\hline One adult in HH & 22.3\% & -3.39 & -3.6 & & & -0.53 & -1.3 & -1.61 & -3.2 & -4.36 & -3.9 \\
\hline Two adults in HH & 61.1\% & -5.94 & -6.2 & -2.26 & -6.2 & & & -0.96 & -3.3 & -1.65 & -4.3 \\
\hline Three adults in HH & 11.7\% & -7.25 & -5.7 & -3.10 & -6.1 & -0.93 & -2.8 & & & -0.46 & -1.2 \\
\hline Four+ adults in HH & 4.9\% & -7.33 & -4.9 & -3.36 & -5.1 & -1.36 & -2.8 & -0.71 & -1.5 & & \\
\hline \multicolumn{12}{|l|}{HOUSEHOLD INCOME} \\
\hline HH income under 20 K & 18.7\% & 3.79 & 4.8 & 1.98 & 6.3 & & & -0.63 & -2.0 & -1.52 & -3.2 \\
\hline HH income 20-40 K & 22.7\% & 1.39 & 1.7 & 1.16 & 4.0 & & & -0.61 & -2.6 & -1.25 & -3.9 \\
\hline HH income 40-60 K & 16.8\% & & & 0.69 & 2.2 & & & -0.28 & -1.2 & -0.66 & -2.3 \\
\hline HH income 60-100 K & 19.4\% & & & & & & & & & & \\
\hline HH income over 100 K & 15.5\% & & & -0.25 & -0.6 & & & 0.01 & 0.1 & 0.10 & 0.4 \\
\hline HH income missing & 6.9\% & 3.45 & 4.1 & 1.31 & 3.5 & & & 0.02 & 0.1 & -0.85 & -1.6 \\
\hline \multicolumn{12}{|l|}{OTHER DEMOGRAPHICS} \\
\hline One+ children in HH & 30.0\% & -1.08 & -2.2 & -0.28 & -1.3 & & & -0.11 & -0.6 & -0.02 & -0.1 \\
\hline All HH adults workers & 25.6\% & -1.91 & -2.6 & -0.15 & -0.6 & & & 0.08 & 0.4 & 0.54 & 2.5 \\
\hline Head of HH age <35 & 10.9\% & -1.25 & -1.7 & 0.21 & 0.8 & & & -0.18 & -0.7 & -0.49 & -1.5 \\
\hline Head of HH age 65+ & 32.7\% & 0.24 & 0.7 & 0.60 & 3.0 & & & -0.45 & -2.3 & -0.31 & -1.1 \\
\hline
\end{tabular}

\footnotetext{
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bowman-bradley | MCCOY-Roth | CAC | Citilabs
}
Table 10. Initial Vehicle Availability Model Results for San Joaquin Valley (continued)
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline \multicolumn{2}{|l|}{Alternative} & \multicolumn{2}{|l|}{0 cars} & 1 car & \multicolumn{3}{|l|}{2 cars} & 3 cars & \multicolumn{3}{|l|}{4+ cars} \\
\hline \multicolumn{2}{|l|}{Times chosen} & 74 & 4.5\% & 447 & 27.1\% & 640 & 38.9\% & 312 & 18.9\% & 174 & 10.6\% \\
\hline Segment & \(\%\) of sample & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat \\
\hline \multicolumn{12}{|l|}{HOUSING TYPE} \\
\hline Renter & 18.9\% & 2.06 & 5.3 & 0.99 & 4.4 & & & -0.17 & -0.7 & -0.60 & -1.6 \\
\hline Apartment/condo & 12.8\% & 1.42 & 3.8 & 0.73 & 2.9 & & & -0.05 & -0.2 & 0.46 & 1.0 \\
\hline \multicolumn{12}{|l|}{AREA TYPE} \\
\hline Urban & 13.1\% & 0.73 & 1.4 & 0.08 & 0.3 & & & 0.30 & 1.0 & 0.12 & 0.3 \\
\hline Second city & 33.8\% & & & & & & & & & & \\
\hline Suburban area & 25.7\% & -0.58 & -1.2 & -0.04 & -0.2 & & & 0.14 & 0.7 & -0.02 & -0.1 \\
\hline Rural area & 27.4\% & -0.90 & -1.8 & -0.06 & -0.3 & & & 0.39 & 2.0 & 0.90 & 3.6 \\
\hline \multicolumn{12}{|l|}{COUNTY} \\
\hline Fresno & 23.1\% & & & & & & & & & & \\
\hline Kern & 18.8\% & -0.47 & -0.8 & -0.34 & -1.3 & & & 0.10 & 0.4 & -0.29 & -0.9 \\
\hline Stanislaus & 15.9\% & -0.34 & -0.5 & -0.17 & -0.6 & & & 0.21 & 0.8 & -0.05 & -0.1 \\
\hline San Joaquin & 18.6\% & 0.21 & 0.5 & -0.80 & -3.2 & & & -0.12 & -0.5 & -0.46 & -1.5 \\
\hline Merced & 5.5\% & 0.65 & 0.9 & -0.14 & -0.3 & & & 0.23 & 0.6 & 0.29 & 0.6 \\
\hline Tulare & 10.5\% & 0.80 & 1.2 & -0.11 & -0.3 & & & 0.23 & 0.8 & 0.38 & 1.1 \\
\hline Kings & 3.8\% & -0.82 & -0.8 & -1.30 & -2.7 & & & 0.48 & 1.2 & 0.08 & 0.2 \\
\hline Madera & 3.9\% & 0.00 & & -0.43 & -1.0 & & & 0.20 & 0.5 & 0.42 & 0.9 \\
\hline
\end{tabular}
- The model was developed in stages, adding a new type of segmentation at each stage. The improvement in log-likelihood compared to a constants-only model (in terms of rho-squared) for each addition was:
- Number of adults in HH an additional 15.5\%
- Income
an additional \(6.0 \%\)
- Other HH demographics
an additional 3.1\%
- Dwelling and area type
an additional 2.7\%
- County-specific dummies
an additional 0.8\%
- \(\quad>\) Total rho-squared (with respective to constants) of \(28.0 \%\)

Goodness of fit statistics from this initial model was:
- Observations

1647
- Final log-likelihood -1674.8
- Rho-squared(0) 0.368
- Rho-squared(const) 0.280

\subsection*{3.2 Final Model}

The final vehicle availability models were reduced to the most significant variables and limited to those that were available in the county trip-based modeling systems. The final model specifications are provided in Table 11. The variables in this model are:
- Household size
- Housing type
- Accessibility
- Household income

Household size was used instead of number of adults in the household because these data were developed and used in the county trip-based modeling systems. Household income and housing type were retained as a significant variable in the models. Accessibility was significant for households with no vehicles and was included in place of the prior area type proxy from the survey. Accessibility is calculated as a logsum value from the mode choice model.

County-specific dummies were dropped as they were largely insignificant. Age, workers, and children in households were dropped because they were primarily insignificant and these variables were not readily available in the trip-based modeling systems.

Goodness of fit statistics from the final model are:
- Observations 1646
- Final log-likelihood -1832.9
- Rho-squared(0) 0.308
- Rho-squared(const) 0.212

These statistics are reasonable for a logit choice vehicle availability model.
Table 11. Final Vehicle Availability Model for San Joaquin Valley
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline Alternative & & \multicolumn{2}{|l|}{0 cars} & \multicolumn{2}{|l|}{1 car} & \multicolumn{2}{|l|}{2 cars} & \multicolumn{2}{|l|}{3 cars} & \multicolumn{2}{|l|}{4+ cars} \\
\hline Times chosen & & 74 & 4.5\% & 447 & 27.1\% & 640 & 38.9\% & 311 & 18.9\% & 174 & 10.6\% \\
\hline Segment & \% of sample & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat & Coeff. & T-stat \\
\hline \multicolumn{12}{|l|}{HOUSEHOLD SIZE} \\
\hline One person in HH & 20.1\% & -8.268 & -4.3 & 0.44 & 1.6 & & & -0.94 & -2.9 & -3.22 & -3.2 \\
\hline Two people in HH & 41.2\% & -10.85 & -5.7 & -2.20 & -8.9 & & & -0.88 & -6.7 & -1.17 & -7.7 \\
\hline Three people in HH & 13.9\% & -11.10 & -5.6 & -2.26 & -7.2 & & & 0.13 & 0.8 & -0.64 & -2.8 \\
\hline Four+ people in HH & 24.9\% & -11.70 & -6.0 & -2.45 & -8.9 & & & -0.33 & -2.2 & -0.36 & -2.2 \\
\hline \multicolumn{12}{|l|}{HOUSEHOLD INCOME} \\
\hline HH income under 20 K & 18.7\% & 4.65 & 6.2 & 2.33 & 8.2 & & & -0.56 & -2.1 & -1.47 & -3.5 \\
\hline HH income 20-40 K & 22.6\% & 1.97 & 2.4 & 1.41 & 5.3 & & & -0.52 & -2.7 & -1.13 & -4.3 \\
\hline HH income 40-60 K & 16.8\% & & & 0.76 & 2.6 & & & -0.21 & -1.1 & -0.58 & -2.4 \\
\hline HH income 60-100 K & 19.4\% & & & & & & & & & & \\
\hline HH income over 100 K & 15.6\% & -2.00 & cons & -0.43 & -1.2 & & & & & & \\
\hline HH income missing & 6.9\% & 3.65 & 4.5 & 1.40 & 4.0 & & & -0.02 & -0.1 & -1.04 & -2.1 \\
\hline \multicolumn{12}{|l|}{HOUSING TYPE} \\
\hline Apartment/condo/etc & 12.8\% & 1.95 & 6.2 & 0.98 & 4.6 & & & & & & \\
\hline \multicolumn{12}{|l|}{ACCESSIBILITY} \\
\hline 0-veh. accessibility & 12.8\% & 0.440 & 3.0 & & & & & & & & \\
\hline
\end{tabular}

\subsection*{4.0 County Model Calibrations}

Calibration for each county model involved adjusted alternative specific constants for each household segment:
- 0-vehicle households
- 1-vehicle households
- 2-vehicle households
- 3-vehicle households
- 4 or more vehicle households

Each variable in the vehicle availability models requires a "base" alternative that is set to zero. For the alternative specific constants, the base alternative is the 4 or more vehicle households, which is set to zero. Subsequent calibrations of each county model are reported in the following sections, along with the final calibrated alternative specific constants.

\subsection*{4.1 Fresno County}

Calibration for the Fresno County model involved adjusted alternative specific constants for each household segment from zero to the best fit:
- 0-vehicle households 5.748949
- 1-vehicle households 1.337767
- 2-vehicle households 0.710481
- 3-vehicle households 0.03094
- 4 or more vehicle households 0

In addition to the alternative specific constants, 0 -vehicle accessibility for Fresno County was adjusted from a coefficient of 0.44 to a coefficient of 0.05 . This adjustment was necessary to avoid a larger alternative specific constant for 0 -vehicle households and may be caused by the small sample size of 0 -vehicle households in the NHTS survey in combination with the under-representation of this segment in the NHTS for Fresno County. This change indicates that accessibility in 0-vehicle households has less impact on vehicle availability in Fresno than in the San Joaquin Valley as a region.

The results of the calibration are provided in Table 12 by household size and income groups compared to the calibration targets provided by the ACS 5-year data. The results show that all groups are within \(+/-3 \%\) difference and most categories are within \(+/-1 \%\) difference. Figure 1 shows a reasonable comparison of the estimated and observed households by vehicle availability categories.

Table 12. Fresno County Vehicle Availability Model Calibration Results


Figure 1. Fresno County Estimated and Observed Vehicles per Household


\subsection*{4.2 Kern County}

Calibration for Kern County model involved adjusted alternative specific constants for each household segment from zero to the best fit:
- 0-vehicle households
6.388096
- 1-vehicle households
0.979657
- 2-vehicle households 0.613712
- 3-vehicle households 0.195301
- 4 or more vehicle households 0

In addition to the alternative specific constants, 0 -vehicle accessibility for Kern County was adjusted from a coefficient of 0.44 to a coefficient of 0.05 . This adjustment was necessary to avoid a larger alternative specific constant for 0 -vehicle households and may be caused by the small sample size of 0 -vehicle households in the NHTS survey in combination with the under-representation of this segment in the NHTS for Kern County.
This change indicates that accessibility in 0 -vehicle households has less impact on vehicle availability in Kern than in the San Joaquin Valley as a region.

The results of the calibration are provided in Table 13 by household size and income groups compared to the calibration targets provided by the ACS 5-year data. The results show that all groups are within \(+/-4 \%\) difference and most categories are within \(+/-1 \%\) difference. Two of the low income group targets (for 0vehicle and 1-vehicle households) were over-estimating households in this category by \(4 \%\), which caused the total low income group target to be over-estimated by a larger margin. This was not a significant factor for any other category, nor for the overall 0 -vehicle and 1 -vehicle household estimates. Figure 2 shows a reasonable comparison of the estimated and observed households by vehicle availability categories.

Table 13. Kern County Vehicle Availability Model Calibration Results
\begin{tabular}{lccccccccccccc} 
\\
& Total & VEH0 & VEH 1 & VEH2 & VEH3 & VEH4 & Total & VEH0 & VEH1 & VEH2 & VEH3 & VEH4 \\
All & \(100 \%\) & \(7.7 \%\) & \(28.6 \%\) & \(39.6 \%\) & \(16.9 \%\) & \(7.2 \%\) & \(100 \%\) & \(7.4 \%\) & \(30.9 \%\) & \(37.7 \%\) & \(16.6 \%\) & \(7.3 \%\) \\
Household Size & & & & & & & & & \\
\hline HH1 & \(21 \%\) & \(4 \%\) & \(14 \%\) & \(2 \%\) & \(1 \%\) & \(0 \%\) & \(20 \%\) & \(3 \%\) & \(13 \%\) & \(3 \%\) & \(1 \%\) & \(0 \%\) \\
HH2 & \(29 \%\) & \(2 \%\) & \(6 \%\) & \(15 \%\) & \(4 \%\) & \(2 \%\) & \(28 \%\) & \(1 \%\) & \(7 \%\) & \(14 \%\) & \(4 \%\) & \(1 \%\) \\
HH3 & \(16 \%\) & \(1 \%\) & \(3 \%\) & \(7 \%\) & \(4 \%\) & \(1 \%\) & \(16 \%\) & \(1 \%\) & \(4 \%\) & \(6 \%\) & \(4 \%\) & \(1 \%\) \\
HH4 & \(34 \%\) & \(1 \%\) & \(6 \%\) & \(15 \%\) & \(8 \%\) & \(4 \%\) & \(36 \%\) & \(2 \%\) & \(7 \%\) & \(14 \%\) & \(8 \%\) & \(5 \%\) \\
Household Income Groups & & & & & & & & & \\
Inc1 & \(20 \%\) & \(6 \%\) & \(9 \%\) & \(3 \%\) & \(1 \%\) & \(0 \%\) & \(10 \%\) & \(2 \%\) & \(5 \%\) & \(2 \%\) & \(0 \%\) & \(0 \%\) \\
Inc2 & \(22 \%\) & \(1 \%\) & \(9 \%\) & \(8 \%\) & \(3 \%\) & \(1 \%\) & \(24 \%\) & \(2 \%\) & \(10 \%\) & \(9 \%\) & \(3 \%\) & \(1 \%\) \\
Inc3 & \(17 \%\) & \(0 \%\) & \(5 \%\) & \(8 \%\) & \(3 \%\) & \(1 \%\) & \(19 \%\) & \(1 \%\) & \(6 \%\) & \(8 \%\) & \(3 \%\) & \(1 \%\) \\
Inc4 & \(23 \%\) & \(0 \%\) & \(3 \%\) & \(11 \%\) & \(5 \%\) & \(3 \%\) & \(30 \%\) & \(0 \%\) & \(5 \%\) & \(14 \%\) & \(7 \%\) & \(3 \%\) \\
Inc5 & \(18 \%\) & \(0 \%\) & \(2 \%\) & \(10 \%\) & \(4 \%\) & \(2 \%\) & \(18 \%\) & \(0 \%\) & \(2 \%\) & \(8 \%\) & \(5 \%\) & \(3 \%\)
\end{tabular}

Figure 2. Kern County Estimated and Observed Vehicles per Household


\subsection*{4.3 Kings County}

Calibration for Kings County model involved adjusted alternative specific constants for each household segment from zero to the best fit:
- 0-vehicle households 0.975465
- 1 -vehicle households 0.630665
- 2-vehicle households 0.445234
- 3-vehicle households -0.06932
- 4 or more vehicle households 0

The results of the calibration are provided in Table 14 by household size and income groups compared to the calibration targets provided by the ACS \(5-y e a r ~ d a t a . ~ T h e ~ r e s u l t s ~ s h o w ~ t h a t ~ a l l ~ g r o u p s ~ a r e ~ w i t h i n ~+/-3 \% ~\) difference and most categories are within \(+/-1 \%\) difference. Figure 3 shows a reasonable comparison of the estimated and observed households by vehicle availability categories.

Table 14. Kings County Vehicle Availability Model Calibration Results
\begin{tabular}{|ccccccccccccc}
\hline \multicolumn{11}{c|}{ Model } & & \\
& Total & VEH0 & VEH 1 & VEH2 & VEH3 & VEH4 & Total & VEH0 & VEH1 & VEH2 & VEH3 & VEH4 \\
\hline All & \(100 \%\) & \(6.0 \%\) & \(28.1 \%\) & \(40.9 \%\) & \(17.1 \%\) & \(7.9 \%\) & \(100 \%\) & \(6.5 \%\) & \(29.3 \%\) & \(40.1 \%\) & \(16.6 \%\) & \(7.6 \%\) \\
\hline Household Size & & & & & & & & & & \\
\hline HH1 & \(21 \%\) & \(3 \%\) & \(14 \%\) & \(3 \%\) & \(1 \%\) & \(0 \%\) & \(18 \%\) & \(3 \%\) & \(12 \%\) & \(3 \%\) & \(1 \%\) & \(0 \%\) \\
HH2 & \(25 \%\) & \(1 \%\) & \(5 \%\) & \(14 \%\) & \(3 \%\) & \(2 \%\) & \(26 \%\) & \(2 \%\) & \(7 \%\) & \(13 \%\) & \(4 \%\) & \(1 \%\) \\
HH3 & \(17 \%\) & \(1 \%\) & \(3 \%\) & \(8 \%\) & \(4 \%\) & \(2 \%\) & \(16 \%\) & \(1 \%\) & \(3 \%\) & \(8 \%\) & \(3 \%\) & \(2 \%\) \\
HH4 & \(37 \%\) & \(1 \%\) & \(6 \%\) & \(16 \%\) & \(10 \%\) & \(4 \%\) & \(40 \%\) & \(2 \%\) & \(8 \%\) & \(16 \%\) & \(9 \%\) & \(5 \%\) \\
\hline Household Income Groups & & & & & & & & & \\
\hline Inc1 & \(21 \%\) & \(5 \%\) & \(10 \%\) & \(4 \%\) & \(1 \%\) & \(0 \%\) & \(16 \%\) & \(4 \%\) & \(9 \%\) & \(3 \%\) & \(0 \%\) & \(0 \%\) \\
Inc2 & \(26 \%\) & \(1 \%\) & \(10 \%\) & \(11 \%\) & \(4 \%\) & \(1 \%\) & \(25 \%\) & \(2 \%\) & \(12 \%\) & \(9 \%\) & \(2 \%\) & \(0 \%\) \\
Inc3 & \(19 \%\) & \(0 \%\) & \(5 \%\) & \(9 \%\) & \(4 \%\) & \(1 \%\) & \(18 \%\) & \(0 \%\) & \(6 \%\) & \(9 \%\) & \(2 \%\) & \(1 \%\) \\
Inc4 & \(19 \%\) & \(0 \%\) & \(3 \%\) & \(9 \%\) & \(5 \%\) & \(3 \%\) & \(25 \%\) & \(0 \%\) & \(3 \%\) & \(12 \%\) & \(6 \%\) & \(3 \%\) \\
Inc5 & \(14 \%\) & \(0 \%\) & \(1 \%\) & \(8 \%\) & \(4 \%\) & \(2 \%\) & \(17 \%\) & \(0 \%\) & \(1 \%\) & \(7 \%\) & \(5 \%\) & \(4 \%\) \\
\hline
\end{tabular}

Figure 3. Kings County Estimated and Observed Vehicles per Household


\subsection*{4.4 Madera County}

Calibration for Madera County model involved adjusted alternative specific constants for each household segment from zero to the best fit:
- 0-vehicle households 0.975465
- 1-vehicle households 0.630665
- 2-vehicle households 0.445234
- 3-vehicle households -0.06932
- 4 or more vehicle households 0

The results of the calibration are provided in Table 15 by household size and income groups compared to the calibration targets provided by the ACS 5-year data. The results show that all groups are within \(+/-9 \%\) difference and most categories are within \(+/-3 \%\) difference. This is a larger difference by household size and income group than was found in any other county. This does not reflect on the calibration results of the vehicle availability models, since the total households in each group shows a large difference, but does identify a potential problem with the underlying socioeconomic data for Madera County. Figure 4 shows a reasonable comparison of the estimated and observed households by vehicle availability categories.

Table 15. Madera County Vehicle Availability Model Calibration Results
\begin{tabular}{lccccccccccccc} 
& \multicolumn{4}{c}{ Model } & \\
\hline & Total & VEH0 & VEH 1 & VEH2 & VEH3 & VEH4 & Total & VEH0 & VEH1 & VEH2 & VEH3 & VEH4 \\
All & \(100 \%\) & \(6 \%\) & \(29 \%\) & \(38 \%\) & \(17 \%\) & \(10 \%\) & \(100 \%\) & \(6 \%\) & \(28 \%\) & \(39 \%\) & \(18 \%\) & \(10 \%\) \\
Household Size & & & & & & & & & & & \\
\hline HH1 & \(32 \%\) & \(5 \%\) & \(21 \%\) & \(5 \%\) & \(1 \%\) & \(0 \%\) & \(19 \%\) & \(2 \%\) & \(12 \%\) & \(3 \%\) & \(1 \%\) & \(0 \%\) \\
HH2 & \(19 \%\) & \(0 \%\) & \(2 \%\) & \(11 \%\) & \(3 \%\) & \(2 \%\) & \(30 \%\) & \(1 \%\) & \(5 \%\) & \(16 \%\) & \(6 \%\) & \(2 \%\) \\
HH3 & \(18 \%\) & \(1 \%\) & \(3 \%\) & \(8 \%\) & \(4 \%\) & \(2 \%\) & \(16 \%\) & \(1 \%\) & \(4 \%\) & \(6 \%\) & \(4 \%\) & \(2 \%\) \\
HH4 & \(31 \%\) & \(0 \%\) & \(3 \%\) & \(14 \%\) & \(9 \%\) & \(5 \%\) & \(36 \%\) & \(2 \%\) & \(7 \%\) & \(14 \%\) & \(7 \%\) & \(6 \%\) \\
Household Income Groups & & & & & & & & & & \\
Inc1 & \(32 \%\) & \(5 \%\) & \(17 \%\) & \(7 \%\) & \(3 \%\) & \(1 \%\) & \(17 \%\) & \(3 \%\) & \(9 \%\) & \(4 \%\) & \(1 \%\) & \(0 \%\) \\
Inc2 & \(22 \%\) & \(0 \%\) & \(6 \%\) & \(10 \%\) & \(4 \%\) & \(2 \%\) & \(26 \%\) & \(1 \%\) & \(11 \%\) & \(9 \%\) & \(3 \%\) & \(2 \%\) \\
Inc3 & \(16 \%\) & \(0 \%\) & \(4 \%\) & \(7 \%\) & \(3 \%\) & \(2 \%\) & \(21 \%\) & \(1 \%\) & \(5 \%\) & \(9 \%\) & \(4 \%\) & \(2 \%\) \\
Inc4 & \(17 \%\) & \(0 \%\) & \(2 \%\) & \(8 \%\) & \(4 \%\) & \(3 \%\) & \(21 \%\) & \(1 \%\) & \(3 \%\) & \(10 \%\) & \(4 \%\) & \(2 \%\) \\
Inc5 & \(13 \%\) & \(0 \%\) & \(1 \%\) & \(6 \%\) & \(3 \%\) & \(3 \%\) & \(16 \%\) & \(0 \%\) & \(1 \%\) & \(6 \%\) & \(5 \%\) & \(3 \%\) \\
\hline
\end{tabular}


\subsection*{4.5 Tulare County}

Calibration for Tulare County model involved adjusted alternative specific constants for each household segment from zero to the best fit:
- 0-vehicle households -2.80134
- 1-vehicle households 1.039561
- 2 -vehicle households 0.584999
- 3-vehicle households -0.07702
- 4 or more vehicle households 0

In addition to the alternative specific constants, 0 -vehicle accessibility for Tulare County was adjusted from a coefficient of 0.44 to a coefficient of 0.05 . This adjustment was again necessary to avoid a larger alternative specific constant for 0-vehicle households and may be caused by the small sample size of 0-vehicle households in the NHTS survey in combination with the under-representation of this segment in the NHTS for Tulare County. This change indicates that accessibility in 0 -vehicle households has less impact on vehicle availability in Tulare than in the San Joaquin Valley as a region.

The results of the calibration are provided in Table 16 by household size and income groups compared to the calibration targets provided by the ACS 5-year data. The results show that all groups are within \(+/-2 \%\) difference and most categories are within \(+/-1 \%\) difference. Figure 5 shows a reasonable comparison of the estimated and observed households by vehicle availability categories.

Table 16. Tulare County Vehicle Availability Model Calibration Results
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline & \multicolumn{6}{|c|}{Model} & \multicolumn{6}{|c|}{ACS 5-year} \\
\hline & Total & VEHO & VEH 1 & VEH2 & VEH3 & VEH4 & Total & VEH0 & VEH1 & VEH2 & VEH3 & VEH4 \\
\hline All & 100\% & 6.6\% & 29.6\% & 40.5\% & 16.0\% & 7.4\% & 100\% & 7.2\% & 30.8\% & 39.5\% & 15.4\% & 7.1\% \\
\hline \multicolumn{13}{|l|}{Household Size} \\
\hline HH1 & 18\% & 3.2\% & 13.1\% & 1.9\% & 0.3\% & 0.0\% & 17.4\% & 2.9\% & 11.3\% & 2.4\% & 0.6\% & 0.1\% \\
\hline HH2 & 26\% & 1.4\% & 5.9\% & 14.1\% & 2.6\% & 1.8\% & 26.9\% & 1.3\% & 6.5\% & 14.2\% & 3.8\% & 1.1\% \\
\hline HH3 & 17\% & 0.9\% & 3.7\% & 7.6\% & 3.6\% & 1.5\% & 16.4\% & 1.0\% & 4.2\% & 6.6\% & 3.6\% & 1.0\% \\
\hline HH4 & 38\% & 1.1\% & 6.8\% & 16.8\% & 9.5\% & 4.2\% & 39.3\% & 2.0\% & 8.8\% & 16.3\% & 7.4\% & 4.9\% \\
\hline \multicolumn{13}{|l|}{Household Income Groups} \\
\hline Inc1 & 21\% & 5.1\% & 10.4\% & 3.8\% & 1.1\% & 0.3\% & 16.9\% & 3.3\% & 8.4\% & 4.0\% & 0.9\% & 0.2\% \\
\hline Inc2 & 24\% & 1.0\% & 9.8\% & 9.5\% & 3.0\% & 0.9\% & 24.8\% & 1.4\% & 10.6\% & 9.5\% & 2.4\% & 0.9\% \\
\hline Inc3 & 19\% & 0.2\% & 5.3\% & 8.6\% & 3.4\% & 1.3\% & 18.1\% & 0.6\% & 5.2\% & 8.3\% & 3.0\% & 1.0\% \\
\hline Inc4 & 21\% & 0.2\% & 3.0\% & 10.5\% & 4.9\% & 2.8\% & 26.0\% & 0.4\% & 4.0\% & 12.2\% & 6.3\% & 3.0\% \\
\hline Inc5 & 15\% & 0.0\% & 1.2\% & 8.0\% & 3.6\% & 2.1\% & 14.4\% & 0.1\% & 1.2\% & 6.3\% & 4.2\% & 2.5\% \\
\hline
\end{tabular}

Figure 5. Tulare County Estimated and Observed Vehicles per Household


\title{
San Joaquin Valley Model Improvement Program Activity-based Models
}

Resource Systems Group, Inc.
Mark Bradley
John Bowman


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\subsection*{1.0 Introduction}

The San Joaquin Valley Model Improvement Program (MIP) included development of activity-based models for Fresno County and the 3-County (San Joaquin, Merced and Stanislaus) region.

This report includes a description of the data items required as input to the activity-based model system being implemented for Fresno Council of Governments and the 3-County region. One of the distinguishing features of the Fresno model is that it uses parcels the basic spatial unit for referencing socioeconomic data such as households and population. One of the innovative features of the 3-County model is that it uses "microzones" as the basic spatial unit for referencing socioeconomic data such as households and population. The microzones essentially represent a Census block-level geographic resolution. An advantage of using this high level of spatial detail (parcels or microzones) is that it intrinsically provides more consistent sensitivity to urban form variables throughout all components of the model system than "post-processing" model outputs to estimate this sensitivity. The additional detail offered by parcels provides more precision and accuracy than a microzone level. However, use of parcels requires that model users establish methods for developing these spatially detailed data not only for the model calibration/validation base year, but also for all model forecast years. It should also be noted that although the parcel-level is used for maintaining socioeconomic and related data, TAZ-level geography is used for developing estimates of network- based travel times and costs (i.e. "skims").

An advantage of using the microzone-based approach is that it significantly reduces the data preparation and maintenance burden on model users with only minor compromises in model sensitivity. Instead of requiring agencies to maintain and update detailed parcel-level databases, this approach requires only TAZ-level controls of key employment and socioeconomic attributes and block-level household and employment information derived from publically available, free data sources. However, use of microzones still requires that model users establish methods for developing the TAZ-level inputs, as well as establish practices for either holding the microzone-level distributions constant or for updating as necessary not only for the model calibration/validation base year, but also for all model forecast years. It should also be noted that although the microzone-level is used for maintaining socioeconomic and related data, TAZ-level geography is used for developing estimates of network- based travel times and costs (i.e. "skims"). The following sections describe the specific DaySim input files, contents, and tools and processes for creating these inputs.

This report presents the data used in application and the calibration results for individual model components. The data used in application includes descriptions of the specific DaySim input files, contents, and tools and processes for creating these inputs.

\subsection*{2.0 DATA}

There are some data inputs that are similar for the Fresno County model and the 3-County model and others that are related to the spatial level of detail that are different between these models. The different spatial detail data are described initially and then data that are similar are discussed together.

\subsection*{2.1 Fresno County Parcel Data}

A key aspect of the use of parcel-level geography is that DaySim uses some parcel-level information directly (such as an estimated number of jobs on each parcel) but also uses derived parcel-level information (such as the number of jobs within \(1 / 4\) mile of each parcel). In order to make it easier for model users to develop all the parcel-level inputs to DaySim, a software tool has been developed which calculates all the derived parcel-level measures using basic parcel socioeconomic and geographic information and which then outputs a file in the format required for input to the DaySim application. The output of this ParcelBuffer process (which is the direct input to DaySim) is first described. Subsequently, the inputs to this "ParcelBuffer" tool are described and issues associated with these inputs are identified and discussed.
Use of parcels clearly allow a far more detailed, spatially disaggregate description of the land use in a region than use of TAZs_and as a result provides greater sensitivity to fine-grained urban form and accessibility attributes, particularly with respect to transportation and land use. However, use of these detailed measures results in the need to develop and manage larger quantities of data.
The parcel data input file is a space-delimited ASCII text format file (.dat) with one row of data per parcel. Table 1 shows the fields contained in the parcel data input file. The file begins with several fields that identify the parcel, and describe the physical location and size of the parcel, and then contains fields that describe the quantity of housing, school enrollment, and employment on the parcel and within a quarter mile and a half mile of the parcel. In addition, the parcel file contains information about urban form and the transportation system on and close to the parcel, including the proximity to transit stops and the price and supply of parking.

Table 1: Parcel data input file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline parcelid & Parcel ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft_p & Area - square feet \\
\hline taz_p & TAZ number \\
\hline lutype_p & land use type \\
\hline hh_p & households on parcel \\
\hline stugrd_p & grade school enrollment on parcel \\
\hline stuhgh_p & high school enrollment on parcel \\
\hline stuuni_p & university enrollment on parcel \\
\hline empedu_p & educational employment on parcel \\
\hline empfoo_p & food employment on parcel \\
\hline empgov_p & government employment on parcel \\
\hline empind_p & industrial employment on parcel \\
\hline
\end{tabular}

Table 1: Parcel data input file format (continued)
\begin{tabular}{|c|c|}
\hline FIELD & DESCRIPTION \\
\hline empmed_p & medical employment on parcel \\
\hline empofc_p & office employment on parcel \\
\hline empret_p & retail employment on parcel \\
\hline empsvc_p & service employment on parcel \\
\hline empoth_p & other employment on parcel \\
\hline emptot_p & total employment on parcel \\
\hline parkdy_p & offstreet daily parking on parcel \\
\hline parkhr_p & offstreet hourly parking on parcel \\
\hline ppricdyp & offstreet daily parking price \\
\hline pprichrp & offstreet hourly parking price \\
\hline hh_1 & households within buffer 1 \\
\hline stugrd_1 & grade school enrollment within buffer 1 \\
\hline stuhgh_1 & high school enrollment within buffer 1 \\
\hline stuuni_1 & university enrollment within buffer 1 \\
\hline empedu_1 & educational employment within buffer 1 \\
\hline empfoo_1 & food employment within buffer 1 \\
\hline empgov_1 & government employment within buffer 1 \\
\hline empind_1 & industrial employment within buffer 1 \\
\hline empmed_1 & medical employment within buffer 1 \\
\hline empofc_1 & office employment within buffer 1 \\
\hline empret_1 & retail employment within buffer 1 \\
\hline empsvc_1 & service employment within buffer 1 \\
\hline empoth_1 & other employment within buffer 1 \\
\hline emptot_1 & total employment within buffer 1 \\
\hline parkdy_1 & offstreet daily parking within buffer 1 \\
\hline parkhr_1 & offstreet hourly parking within buffer 1 \\
\hline ppricdy1 & average offstreet daily parking price within buffer 1 \\
\hline pprichr1 & average offstreet hourly parking price within buffer 1 \\
\hline nodes1_1 & number of single link street nodes (dead ends) within buffer 1 \\
\hline nodes3_1 & number of three-link street nodes (T-intersections) within buffer 1 \\
\hline nodes4_1 & number of 4+ link street nodes (traditional 4-way +) within buffer 1 \\
\hline tstops_1 & number of transit stops within buffer 1 \\
\hline nparks_1 & number of open space parks within buffer 1 \\
\hline
\end{tabular}

Table 1: Parcel data input file format (continued)
\begin{tabular}{|c|c|}
\hline FIELD & DESCRIPTION \\
\hline aparks_1 & open space area in square feet within buffer 1 \\
\hline hh_2 & households within buffer 2 \\
\hline stugrd_2 & grade school enrollment within buffer 2 \\
\hline stuhgh_2 & high school enrollment within buffer 2 \\
\hline stuuni_2 & university enrollment within buffer 2 \\
\hline empedu_2 & educational employment within buffer 2 \\
\hline empfoo_2 & food employment within buffer 2 \\
\hline empgov_2 & government employment within buffer 2 \\
\hline empind_2 & industrial employment within buffer 2 \\
\hline empmed_2 & medical employment within buffer 2 \\
\hline empofc_2 & office employment within buffer 2 \\
\hline empret_2 & retail employment within buffer 2 \\
\hline empsvc_2 & service employment within buffer 2 \\
\hline empoth_2 & other employment within buffer 2 \\
\hline emptot_2 & total employment within buffer 2 \\
\hline parkdy_2 & offstreet daily parking within buffer 2 \\
\hline parkhr_2 & offstreet hourly parking within buffer 2 \\
\hline ppricdy2 & average offstreet daily parking price within buffer 2 \\
\hline pprichr2 & average offstreet hourly parking price within buffer 2 \\
\hline nodes1_2 & number of single link street nodes (dead ends) within buffer 2 \\
\hline nodes3_2 & number of three-link street nodes (T-intersections) within buffer 2 \\
\hline nodes4_2 & number of 4+ link street nodes (traditional 4-way +) within buffer 2 \\
\hline tstops_2 & number of transit stops within buffer 2 \\
\hline nparks_2 & number of open space parks within buffer 2 \\
\hline aparks_2 & open space area in square feet within buffer 2 \\
\hline dist_lbus & distance to nearest local bus stop from parcel \\
\hline dist_ebus & distance to nearest express bus stop from parcel \\
\hline dist_crt & distance to nearest commuter rail stop from parcel \\
\hline dist_fry & distance to nearest ferry stop from parcel \\
\hline dist_Irt & distance to nearest light rail stop from parcel \\
\hline dist_park & distance to nearest park from parcel \\
\hline
\end{tabular}

As previously described, in order to create this detailed parcel file, including all buffer measures, urban form measures, and transit access measures, and automated software tool has been developed. This tool requires a set of established inputs, including:
- Parcel_Base file
- Intersection file
- Transit stop file
- Open space file

The contents of each of these required inputs are described below.

\subsection*{2.1.1 Parcel_Base}

The parcel_base file is the primary file used to maintain socioeconomic information. This file contains information on the geographic location of the file, corresponding aggregate geographies, households, enrollment by grade, employment by sector and parking. The parcel_base file can either be a DBF format file, or a space- or tab-delimited ASCII text format file. Table 2 summarizes the contents of this file.

\section*{Households}

Parcel-level information on households is used to allocate the synthetic population down to individual parcels, and to influence destination choices. These data are available in the model area from parcel-level databases maintained in each county for tax assessment purposes, potentially refined or enhanced with additional data sources such as the Census. It should be noted that the parcel level inputs that populate the parcel_base file described were prepared by other members of the Fresno Model Improvement Project team, and this critical data preparation process is described in other project documentation.

\section*{Employment}

Parcel-level information on the total number of jobs by employment type on each individual parcel is one of the most essential model inputs. In DaySim, the number of workers attracted to each employment site is calibrated to the number of jobs at that site. Detailed information on employment by type was developed for the Fresno region by MIP project team members. The detailed employment database developed to support the Fresno MIP effort includes point/location level data on the number of employees at that location by employment sector. This location level database was developed by combining multiple year InfoUSA data business location datasets, and adjusting to match more aggregate controls derived from the Fresno MIP tripbased model inputs. The business/employment locations were then associated with individual parcels, as the parcel is the fundamental spatial unit used in the model system. It should again be noted that the business location database was prepared by other members of the Fresno Model Improvement Project team, and this critical data preparation process is described in other project documentation.

The employment sectors used in the DaySim activity-based model system are somewhat more aggregate than those developed to support the trip-based model implementation. Thus, after associating the business locations with individual parcels, it is necessary to collapse the twenty one detailed trip-based model employment sectors to a more aggregate scheme that uses nine employment categories. Table 3 summarizes the correspondence between the original employment sectors developed for the MIP, and the more aggregate employment sectors used in the activity-based model system.

Table 2. Parcel_base file format
\begin{tabular}{|c|c|}
\hline FIELD & DESCRIPTION \\
\hline parcelid & Parcel ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft_p & parcel area - square feet \\
\hline taz_p & corresponding TAZ number \\
\hline block_p & corresponding census block number \\
\hline hh_p & households on parcel \\
\hline stugrd_p & grade school enrollment on parcel \\
\hline stuhgh_p & high school enrollment on parcel \\
\hline stuuni_p & university enrollment on parcel \\
\hline empedu_p & educational employment on parcel \\
\hline empfoo_p & food employment on parcel \\
\hline empgov_p & government employment on parcel \\
\hline empind_p & industrial employment on parcel \\
\hline empmed_p & medical employment on parcel \\
\hline empofc_p & office employment on parcel \\
\hline empret_p & retail employment on parcel \\
\hline empsvc_p & service employment on parcel \\
\hline empoth_p & other employment on parcel \\
\hline emptot_p & total employment on parcel \\
\hline parkdy_p & offstreet daily parking on parcel \\
\hline parkhr_p & offstreet hourly parking on parcel \\
\hline ppricdyp & offstreet daily parking price \\
\hline pprichrp & offstreet hourly parking price \\
\hline
\end{tabular}

Table 3. MIP Employment Sector - DaySim Employment Sector Correspondence
\begin{tabular}{|c|c|c|c|}
\hline MIP SECTOR & MIP DESCRIPTION & NAICS CODE & DAYSIM SECTOR \\
\hline AGRICULTUR & Agriculture, Forestry, Fishing and Hunting & 11 & EMPOTH \\
\hline MINING & Mining, Quarrying, and Oil and Gas Extraction & 21 & EMPIND \\
\hline UTILITIES & Utilities & 22 & EMPIND \\
\hline CONSTRUCTN & Construction & 23 & EMPOTH \\
\hline MANUFACTUR & Manufacturing & 31-33 & EMPIND \\
\hline WHOLESALE & Wholesale Trade & 42 & EMPIND \\
\hline RETAIL & Retail Trade & 44-45 & EMPRET \\
\hline WAREHOUSE & Transportation and Warehousing & 48, 492, 493 & EMPIND \\
\hline INFORMATN & Information & 51 & EMPOFC \\
\hline FINAN_INSR & Finance and Insurance & 52 & EMPOFC \\
\hline REALESTATE & Real Estate and Rental and Leasing & 53 & EMPOFC \\
\hline SVC_PROF & Professional, Scientific, and Technical Services & 54 & EMPOFC \\
\hline SVC_MNGMNT & Management of Companies and Enterprises & 55 & EMPOFC \\
\hline SVC_ADMIN & Administrative and Support and Waste Management and Remediation Services & 56 & EMPOFC \\
\hline EDUCATION & Educational Services (Schools, Junior Colleges, Colleges, Universities, Professional Schools & 6111-6113 & EMPEDU \\
\hline HEALTH & Health Care and Social Assistance & 62 & EMPMED \\
\hline ENT_REC & Arts, Entertainment, and Recreation & 71 & EMPSVC \\
\hline ACCOMODTNS & Accommodation & 721 & EMPFOO \\
\hline FOOD & Food Services & 722 & EMPFOO \\
\hline SVC_OTHER & Other Services (except Public Administration) & 81 & EMPSVC \\
\hline PUBLIC & Public Administration & 92 & EMPGOV \\
\hline
\end{tabular}

\section*{Enrollment}

Like workers, the number of students that are attracted to each school location is calibrated to the enrollment by grade-level at that school location. As a result, parcel-level information on school enrollment is necessary. DaySim distinguishes school enrollment into three enrollment sectors:
- Grade school enrollment (K-8)
- High school enrollment (9-12)
- University enrollment (post-secondary)

In Fresno, the enrollment by sector was derived from disaggregate school enrollment data provided by the California Department of Education. This data included information on enrollment by grade for all schools in the county. The school locations were geocoded and associated with parcels. Using land use information and air photos, the project team ensured that schools were being places in their correct locations. Future year school enrollment assumptions may be adjusted either by scaling the enrollment at the existing school
locations consistently or by identifying new parcels as locations for schools. In either case, the amount of the scaled or additional enrollment should be consistent with the expected change in population by age, which can be derived from the trip-based model inputs.

\section*{Parking}

Off-street parking location and pricing information is used in the activity-based models system to influence mode and other choices. Note that this parking information is focused on publically accessible off-street locations and does not consider private off-street parking locations (such as those available only to workers in an office building), nor does it consider on-street parking locations. In Fresno, approximately ten publically available off street parking structures or lots were identified and associated with individual parcels. Future year parking locations and costs can be easily added to the model system by simply updating the parcel_base file to identify parking capacity and costs for individual parcels. Where data is unavailable or unknown, the parking attributes should be set to 0 .

\section*{Quality Control}

Given the number and diversity of data items in the parcel_file, it is important to ensure that when edits, changes or updates are made to this file, that the values coded as logically consistent with what the model expects. A preliminary but not exhaustive list of QA/QC checks might include:
- Ensuring that there are no negative values in any of the fields
- Ensuring that sum of employment sectors equals total employment
- Checks against land use type
- Checks of households and employment against trip-based model inputs

\subsection*{2.1.2 Intersections}

A unique parcel-level measure of urban form that DaySim incorporates is the number of intersections or nodes of different types within \(1 / 4\) mile and \(1 / 2\) mile buffers. These intersection types include dead-ends (1 link), T-intersections (3-links), and tradition intersections (4+ links), and help characterize the pattern of urban development. The intersection file used as input to the ParcelBuffer tool is currently a DBF format file. Table 4 summarizes the contents of this file.

Table 4. Intersection file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Intersection ID number \\
\hline links & Number of links associated with node \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline
\end{tabular}

A largely automated process has been developed to calculate these urban form measures for Fresno based on detailed GIS street centerline files. This is more detailed than the modeled network, which does not include all streets. This GIS process first analyses the GIS street centerline file to locate nodes and assign an intersection type code to them based on the number of links joined to the node. The process then creates buffer areas around each parcel and then counts the number of intersections of each type that fall within the buffers. The process is described in Appendix A of this document.

\subsection*{2.1.3 Transit Stops}

In place of using TAZ-level information on access times to transit, DaySim also incorporates detailed parcellevel information on the distance to transit by transit sub-mode. In the case of Fresno, a single mode is included (e.g. local bus), although additional modes can be included, provided that they are consistent with the mode definitions used in the mode choice models. The transit stop file used as input to the ParcelBuffer tool is currently a DBF format file. Table 5 summarizes the contents of this file.

Table 5. Transit stop file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Transit stop ID number \\
\hline mode & Transit sub-mode code \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline
\end{tabular}

The primary source for bus stop info was a shape file of transit stop locations downloaded from the fresno.gov website. This site provides detailed GIS information on the specific locations of all bus stops located in the more urbanized areas of the county. In addition to the bus tops located in urban areas of the county, it is also necessary to incorporate bus stop locations for rural transit routes into the model. Lindsey Monge, Assistant Regional Planner with the Fresno Council of Governments provided shape files of Fresno County's rural transit stops and routes, which she developed in 2009. Not all the rural county transit routes have established stop locations, however. Some rural transit routes are "demand responsive." That is, transit vehicles travel along fixed routes, but stop anywhere along the route where they are flagged by a passenger for pickup or drop-off. Because these routes don't have established stop locations, it is necessary to convert the transit route alignments into a set of "potential" or "synthesized" stop locations by placing points along the route alignment at fixed intervals. For this effort, these stops were placed ever 500 feet. If additional demand responsive transit routes are expected in future year networks, it will be necessary to update these "synthesized" stop locations along expect demand responsive route alignments.

When developing or updating forecast year or project alternative networks, careful consideration should be given to the location of individual bus stops. As described, the current bus stop locations coded in the model are based on detailed information prepared by the local transit agency. This fine-grained information is used by DaySim to develop parcel-level estimates of access time to transit. Ideally, forecast year transit networks would include a similar level of detail. Forecast year travel model transit network do include information on stop locations as part of the network coding. However, these stop locations are constrained by the coarser resolution of the travel model roadway networks, and thus may tend to make transit access times appear longer by excluding stops that are not on major roads included in the roadway network. Model users should be ensure that the future year transit stop location file used as input to the parcel preparation contains information consistent with expected future year alignments and stop spacing assumptions.

\subsection*{2.1.4 Open Space}

A unique feature of DaySim is that it incorporates measures of access to publically accessible open space. Although open space is clearly an attractor of travel for recreational, social and other purposes, typically open space is not included in travel models because the traditional "size" measures used as input to travel models, such as employment and population, are not good indicators of the attractiveness of open space (i.e. a popular park will often have no employment and no population). The open space measures incorporated into DaySim capture the proximity of each parcel to the nearest open space, and the amount of open space within different
access bands from the parcel. The open space file used as input to the ParcelBuffer tool is currently a DBF format file. Table 6 summarizes the contents of this file.

Table 6. Open space file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Transit stop ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft & Open space grid cell size in sq ft \\
\hline
\end{tabular}

The individual records in the open space file are based on converting a shape file of regional, publically accessibility open spaces into a smaller set of open space grid cells. A detailed description of the process for creating these open space grid cells is outlined in Appendix B.

\subsection*{2.2 3-County Microzone Data}

A key aspect of the use of microzone-level geography is that DaySim uses some microzone-level information directly (such as an estimated number of jobs in each microzone) but also uses derived microzone-level information (such as the number of jobs within \(1 / 4\) mile of each microzone). In order to make it easier for model users to develop all the microzone-level inputs to DaySim, two new software tools have been developed. The first tool creates the microzone-level attributes based on the input TAZ- and block-level information, while the second tool calculates all the derived microzone-level measures using socioeconomic and geographic information and which then outputs a file in the format required for input to the DaySim application.

The following sections describe the inputs to and application of these two tools. First, the output from the MicrozoneDistribution process is described, followed by detailed documentation of the inputs to this tool and associated data issues. Second, the output of the ParcelBuffer process (which is the direct input to DaySim) is described. Subsequently, the inputs to this "ParcelBuffer" tool are described and issues associated with these inputs are identified and discussed.

\subsection*{2.2.1 Microzone Distribution Tool}

\section*{TAZ File}

The TAZ file used as input to the microzone distribution tool contains information control totals of employment by sector, households and enrollment, which are disaggregated down to the microzone level. This TAZ-level information is derived directly the TAZ-level information used as input the 3-County tripbased model system (Table 7).

Table 7. TAZ file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline TAZ & taz number \\
\hline XCOORD & X coordinate of taz centroid - state plane feet \\
\hline YCOORD & Y coordinate of taz centroid - state plane feet \\
\hline SQFT & taz area - square feet \\
\hline HH & households in taz \\
\hline STUGRD & grade school enrollment in taz \\
\hline STUHGH & high school enrollment in taz \\
\hline STUUNI & university enrollment in taz \\
\hline EMPEDU & education employment in taz \\
\hline EMPFOOD & food employment in taz \\
\hline EMPGOV & government employment in taz \\
\hline EMPIND & industrial employment in taz \\
\hline EMPMED & medical employment in taz \\
\hline EMPOFC & office employment in taz \\
\hline EMPRET & retail employment in taz \\
\hline EMPSVC & service employment in taz \\
\hline EMPOTH & other employment in taz \\
\hline EMPTOT & total employment in taz \\
\hline
\end{tabular}

The only significant difference between the trip-based model TAZ input and the microzone distribution tool input is that the employment by sector information has been aggregated from the 21 detailed sectors used in the trip-based model to the core 9 sectors used in the DaySim activity-based model. Thus, it is necessary to collapse the detailed trip-based model employment sectors to the more aggregate scheme that uses nine employment categories. Table 8 summarizes the correspondence between the original employment sectors developed for the MIP, and the more aggregate employment sectors used in the activity-based model system.

Table 8. MIP Employment Sector - DaySim Employment Sector Correspondence
\begin{tabular}{|c|c|c|c|}
\hline MIP SECTOR & MIP DESCRIPTION & NAICS CODE & DAYSIM SECTOR \\
\hline AGRICULTUR & Agriculture, Forestry, Fishing and Hunting & 11 & EMPOTH \\
\hline MINING & Mining, Quarrying, and Oil and Gas Extraction & 21 & EMPIND \\
\hline UTILITIES & Utilities & 22 & EMPIND \\
\hline CONSTRUCTN & Construction & 23 & EMPOTH \\
\hline MANUFACTUR & Manufacturing & 31-33 & EMPIND \\
\hline WHOLESALE & Wholesale Trade & 42 & EMPIND \\
\hline RETAIL & Retail Trade & 44-45 & EMPRET \\
\hline WAREHOUSE & Transportation and Warehousing & 48, 492, 493 & EMPIND \\
\hline INFORMATN & Information & 51 & EMPOFC \\
\hline FINAN_INSR & Finance and Insurance & 52 & EMPOFC \\
\hline REALESTATE & Real Estate and Rental and Leasing & 53 & EMPOFC \\
\hline SVC_PROF & Professional, Scientific, and Technical Services & 54 & EMPOFC \\
\hline SVC_MNGMNT & Management of Companies and Enterprises & 55 & EMPOFC \\
\hline SVC_ADMIN & Administrative and Support and Waste Management and Remediation Services & 56 & EMPOFC \\
\hline EDUCATION & Educational Services (Schools, Junior Colleges, Colleges, Universities, Professional Schools & 6111-6113 & EMPEDU \\
\hline HEALTH & Health Care and Social Assistance & 62 & EMPMED \\
\hline ENT_REC & Arts, Entertainment, and Recreation & 71 & EMPSVC \\
\hline ACCOMODTNS & Accommodation & 721 & EMPFOO \\
\hline FOOD & Food Services & 722 & EMPFOO \\
\hline SVC_OTHER & Other Services (except Public Administration) & 81 & EMPSVC \\
\hline PUBLIC & Public Administration & 92 & EMPGOV \\
\hline
\end{tabular}

\section*{Block File}

The block file used as input to the microzone distribution tool contains key information describing employment by sector and households, which are used to inform the disaggregation of the TAZ-level controls. There are two primary sources for this block-level information: the US Census Bureau's American Community Survey, and the US Census Bureau's Local Employment Dynamics database. Table 9 summarizes the contents of the block file.

Table 9. Block file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline ID & Block id number \\
\hline XCOORD & X coordinate of block centroid - state plane feet \\
\hline YCOORD & Y coordinate of block centroid - state plane feet \\
\hline SQFT & block area - square feet \\
\hline HH & households in block \\
\hline STUGRD & grade school enrollment in block \\
\hline STUHGH & high school enrollment in block \\
\hline STUUNI & university enrollment in block \\
\hline EMPEDU & education employment in block \\
\hline EMPFOOD & food employment in block \\
\hline EMPGOV & government employment in block \\
\hline EMPIND & industrial employment in block \\
\hline EMPMED & medical employment in block \\
\hline EMPOFC & office employment in block \\
\hline EMPRET & retail employment in block \\
\hline EMPSVC & service employment in block \\
\hline EMPOTH & other employment in block \\
\hline EMPTOT & total employment in block \\
\hline
\end{tabular}

\section*{Households}

Block-level information on households is used to allocate the TAZ-level controls of households and population down to the microzone level. This block level information on households was derived from the 2005-2009 American Community Survey.

\section*{Employment}

Block-level information on the total number of jobs by employment sector is one of the most essential, as well as challenging model inputs, and has typically been an obstacle to developing more spatially detailed model system (except in those regions that have parcel-level employment data). For the 3-County model development project, a new time series employment data source was exploited. The Local Employment Dynamics (LED) dataset provides previously unavailable details about employment by sector at small spatial resolutions by integrating existing data from state-supplied administrative records on workers and employers with existing censuses, surveys, and other administrative records. These employment data are available using NAICS codes, at various combinations of sector and spatial detail. For this effort, 2-digit NAICS information was used at the census block level. Table 3 illustrates the correspondence between the 2 -digit NAICS codes and the DaySim employment sectors.

A key aspect to the use of the LED data is that the actual employment totals by sector from LED are not used directly, but rather these totals are used to disaggregate the TAZ-level controls of employment by sector prepared by agency staff. The underlying LED data can be manipulated or "overridden" by agency staff in
order to ensure that the location of employment by sector is reasonable. Table 10 shows the correspondence between the 2-digit NAICS codes present the LED data set and the employment sectors used in the DaySim model system.

Table 10. LED/NAICS - DaySim Employment Sector Correspondence
\begin{tabular}{|l|l|}
\hline DAYSIM SECTOR & LED/NAICS CODE \\
\hline Industrial (EMPIND) & \(22,31-33,42,48-49\) \\
\hline Retail Trade (EMPRET) & \(44-45\) \\
\hline Office (EMPOFC) & \(51-56\) \\
\hline Educational Services (EMPEDU) & 61 \\
\hline Health / Medical (EMPMED) & 62 \\
\hline Government (EMPGOV) & 92 \\
\hline Food (EMPFOO) & 72 \\
\hline Services (EMPSVC) & 71,81 \\
\hline Other (EMPOTH) & \(11,21,23\) \\
\hline
\end{tabular}

\section*{TAZ-Block Intersect FIle}

The TAZ-block intersect file is the source for the microzone geography (Table 11). This geography is created by intersecting the Census block geography with the TAZ geography. In order to then develop the microzonelevel household and employment totals, it is necessary to have information associating each microzone with the TAZ and block with which it is located. The combination of TAZ controls, block distributions, and area are then used to develop microzone-level control totals. Note that when developing microzones, users may specify a minimum size threshold, so that small and/or "sliver" spatial units resulting from the geographic intersection are not considered as microzones.

Table 11. TAZ-Block file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline ID & Intersect id number \\
\hline XCOORD & X coordinate of intersect centroid - state plane feet \\
\hline YCOORD & Y coordinate of intersect centroid - state plane feet \\
\hline AREA & intersect area - square feet \\
\hline TAZID & TAZ in which intersect is located \\
\hline BLOCKID & Block in which intersect is located \\
\hline
\end{tabular}

\section*{School File}

School location-level information on enrollment is necessary to order to ensure that the proper number of students are being attracted to each school location. Unlike employment and households, for which we must rely on block-level and TAZ-level information in order to derive microzone-level totals for these attributes, the distribution tool uses school specific information to associate enrollment with microzones. This enrollment data was based on disaggregate school enrollment data provided by the California Department of

Education. This data included information on enrollment by grade for all schools in the 3-county region. The school locations were geocoded and visually inspected using land use information and air photos to ensure that schools were being placed in their correct locations. DaySim distinguishes school enrollment into three enrollment sectors:
- Grade school enrollment (K-8)
- High school enrollment (9-12)
- University enrollment (post-secondary)

Future year school enrollment assumptions may be adjusted either by scaling the enrollment at the existing school locations consistently or by identifying new parcels as locations for schools. In either case, the amount of the scaled or additional enrollment should be consistent with the expected change in population by age, which can be derived from the trip-based model inputs. Table 12 shows the content of the school file.

Table 12. School file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline TAZ & taz number \\
\hline XCOORD & X coordinate of taz centroid - state plane feet \\
\hline YCOORD & Y coordinate of taz centroid - state plane feet \\
\hline STUGRD & grade school enrollment of school \\
\hline STUHGH & high school enrollment of school \\
\hline STUUNI & university enrollment of school \\
\hline PRIVATE & private school indicator \\
\hline BLOCKID & block location of school \\
\hline TAZID & Taz location of school \\
\hline INTERSECTID & Intersect location of school \\
\hline
\end{tabular}

\subsection*{2.2.2 Parcel Buffer Tool}

A distinguishing feature of the 3-County implementation of DaySim is that it uses microzones as one of the fundamental spatial units. The microzone data input file contains input data at the microzone level of detail. Use of microzones clearly allow a far more detailed, spatially disaggregate description of the land use in a region than TAZ-based models and as a result provides greater sensitivity to fine-grained urban form and accessibility attributes, particularly with respect to transportation and land use. However, use of these detailed measures results in the need to develop and manage larger quantities of data.

The microzone data input file is a space-delimited ASCII text format file (.dat) with one row of data per microzone/parcel. Table 13 shows the fields contained in the microzone/parcel data input file. The file begins with several fields that identify the microzone, and describe the physical location and size of the microzone, and then contains fields that describe the quantity of housing, school enrollment, and employment on the microzone and within a quarter mile and a half mile of the microzone. In addition, the microzone file contains information about urban form and the transportation system on and close to the microzone, including the proximity to transit stops and the price and supply of parking.

Table 13. Microzone data input file format
\begin{tabular}{|c|c|}
\hline FIELD & DESCRIPTION \\
\hline id & Microzone ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft_p & Area - square feet \\
\hline taz_p & TAZ number \\
\hline lutype_p & land use type \\
\hline hh_p & households in microzone \\
\hline stugrd_p & grade school enrollment in microzone \\
\hline stuhgh_p & high school enrollment in microzone \\
\hline stuuni_p & university enrollment in microzone \\
\hline empedu_p & educational employment in microzone \\
\hline empfoo_p & food employment in microzone \\
\hline empgov_p & government employment in microzone \\
\hline empind_p & industrial employment in microzone \\
\hline empmed_p & medical employment in microzone \\
\hline empofc_p & office employment in microzone \\
\hline empret_p & retail employment in microzone \\
\hline empsvc_p & service employment in microzone \\
\hline empoth_p & other employment in microzone \\
\hline emptot_p & total employment in microzone \\
\hline parkdy_p & offstreet daily parking in microzone \\
\hline parkhr_p & offstreet hourly parking in microzone \\
\hline ppricdyp & offstreet daily parking price \\
\hline pprichrp & offstreet hourly parking price \\
\hline hh_1 & households within buffer 1 \\
\hline stugrd_1 & grade school enrollment within buffer 1 \\
\hline stuhgh_1 & high school enrollment within buffer 1 \\
\hline stuuni_1 & university enrollment within buffer 1 \\
\hline empedu_1 & educational employment within buffer 1 \\
\hline empfoo_1 & food employment within buffer 1 \\
\hline empgov_1 & government employment within buffer 1 \\
\hline empind_1 & industrial employment within buffer 1 \\
\hline empmed_1 & medical employment within buffer 1 \\
\hline
\end{tabular}

Table 13. Microzone data input file format (continued)
\begin{tabular}{|c|c|}
\hline FIELD & DESCRIPTION \\
\hline empofc_1 & office employment within buffer 1 \\
\hline empret_1 & retail employment within buffer 1 \\
\hline empsvc_1 & service employment within buffer 1 \\
\hline empoth_1 & other employment within buffer 1 \\
\hline emptot_1 & total employment within buffer 1 \\
\hline parkdy_1 & offstreet daily parking within buffer 1 \\
\hline parkhr_1 & offstreet hourly parking within buffer 1 \\
\hline ppricdy1 & average offstreet daily parking price within buffer 1 \\
\hline pprichr1 & average offstreet hourly parking price within buffer 1 \\
\hline nodes1_1 & number of single link street nodes (dead ends) within buffer 1 \\
\hline nodes3_1 & number of three-link street nodes (T-intersections) within buffer 1 \\
\hline nodes4_1 & number of 4+ link street nodes (traditional 4-way +) within buffer 1 \\
\hline tstops_1 & number of transit stops within buffer 1 \\
\hline nparks_1 & number of open space parks within buffer 1 \\
\hline aparks_1 & open space area in swuaresquare feet within buffer 1 \\
\hline hh_2 & households within buffer 2 \\
\hline stugrd_2 & grade school enrollment within buffer 2 \\
\hline stuhgh_2 & high school enrollment within buffer 2 \\
\hline stuuni_2 & university enrollment within buffer 2 \\
\hline empedu_2 & educational employment within buffer 2 \\
\hline empfoo_2 & food employment within buffer 2 \\
\hline empgov_2 & government employment within buffer 2 \\
\hline empind_2 & industrial employment within buffer 2 \\
\hline empmed_2 & medical employment within buffer 2 \\
\hline empofc_2 & office employment within buffer 2 \\
\hline empret_2 & retail employment within buffer 2 \\
\hline empsvc_2 & service employment within buffer 2 \\
\hline empoth_2 & other employment within buffer 2 \\
\hline emptot_2 & total employment within buffer 2 \\
\hline parkdy_2 & offstreet daily parking within buffer 2 \\
\hline parkhr_2 & offstreet hourly parking within buffer 2 \\
\hline ppricdy2 & average offstreet daily parking price within buffer 2 \\
\hline
\end{tabular}

Table 13. Microzone data input file format (continued)
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline pprichr2 & average offstreet hourly parking price within buffer 2 \\
\hline nodes1_2 & number of single link street nodes (dead ends) within buffer 2 \\
\hline nodes3_2 & number of three-link street nodes (T-intersections) within buffer 2 \\
\hline nodes4_2 & number of 4+ link street nodes (traditional 4-way +) within buffer 2 \\
\hline tstops_2 & number of transit stops within buffer 2 \\
\hline nparks_2 & number of open space parks within buffer 2 \\
\hline aparks_2 & open space area in swuaresquare feet within buffer 2 \\
\hline dist_lbus & distance to nearest local bus stop from microzone \\
\hline dist_ebus & distance to nearest express bus stop from microzone \\
\hline dist_crt & distance to nearest commuter rail stop from microzone \\
\hline dist_fry & distance to nearest ferry stop from microzone \\
\hline dist_Irt & distance to nearest light rail stop from microzone \\
\hline dist_park & distance to nearest park from microzone \\
\hline
\end{tabular}

As previously described, in order to create this detailed microzone file, including all buffer measures, urban form measures, and transit access measures, and automated software tool has been developed. This tool requires a set of established inputs, including:
- Microzone_Base file (generated by the microzone distribution tool described in the previous section)
- Intersection file
- Transit stop file
- Open space file

The contents of each of these required inputs is described below.

\section*{Microzone_Base}

The microzone_base file is the primary file used to maintain socioeconomic information. This file contains information on the geographic location of microzones, corresponding aggregate geographies, households, enrollment by grade, employment by sector and parking. The microzone_base file can either be a DBF format file, or a space- or tab-delimited ASCII text format file. Table 14 summarizes the contents of this file.

Table 14. Microzone_base file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline microzoneid & Microzone ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft_p & microzone area - square feet \\
\hline taz_p & corresponding TAZ number \\
\hline block_p & corresponding census block number \\
\hline hh_p & households in microzone \\
\hline stugrd_p & grade school enrollment in microzone \\
\hline stuhgh_p & high school enrollment in microzone \\
\hline stuuni_p & university enrollment in microzone \\
\hline empedu_p & educational employment in microzone \\
\hline empfoo_p & food employment in microzone \\
\hline empgov_p & government employment in microzone \\
\hline empind_p & industrial employment in microzone \\
\hline empmed_p & medical employment in microzone \\
\hline empofc_p & office employment in microzone \\
\hline empret_p & retail employment in microzone \\
\hline empsvc_p & service employment in microzone \\
\hline empoth_p & other employment in microzone \\
\hline emptot_p & total employment in microzone \\
\hline parkdy_p & offstreet daily parking in microzone \\
\hline parkhr_p & offstreet hourly parking in microzone \\
\hline ppricdyp & offstreet daily parking price \\
\hline pprichrp & offstreet hourly parking price \\
\hline & em \\
\hline & em \\
\hline
\end{tabular}

The development of the household, employment, and enrollment attributes are described in the prior section on microzone distribution tool.

\section*{Parking}

Offstreet parking location and pricing information is used in the activity-based models system to influence mode and other choices. Note that this parking information is focused on publically accessibility off-street locations and does not consider private off-street parking locations (such as those available only to workers in an office building), nor does it consider on-street parking location. Future year parking locations and costs can be easily added to the model system by simply updating the microzone_base file to identify parking
capacity and costs for individual microzones. Where data is unavailable or unknown, the parking attributes should be set to 0 .

\section*{Quality Control}

Given the number and diversity of data items in the microzone_file, it is important to ensure that when edits, changes or updates are made to this file, that the values coded are logically consistent with what the model expects. A preliminary but not exhaustive list of QA/QC checks might include:
- Ensuring that there are no negative values in any of the fields
- Ensuring that sum of employment sectors equals total employment
- Checks against land use type
- Checks of households and employment against trip-based model inputs

\section*{Intersections}

A unique microzone-level measure of urban form that DaySim incorporates is the number of intersections or nodes of different types within \(1 / 4\) mile and \(1 / 2\) mile buffers. These intersection types include, dead-ends (1 link), T-intersections (3-links), and tradition intersections (4+ links), and help characterize the pattern of urban development. The intersection file used as input to the MicrozoneBuffer is currently a DBF format file. Table 15 summarizes the contents of this file.

Table 15. Intersection file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Intersection ID number \\
\hline links & Number of links associated with node \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline
\end{tabular}

A largely automated process has been developed to calculate these urban form measures for the 3-County model based on detailed GIS street centerline files. This is more detailed than the modeled network, which does not include all streets. This GIS process first analyses the GIS street centerline file to locate nodes and assign an intersection type code to them based on the number of links joined to the node. The process then creates buffer areas around each microzone and then counts the number of intersections of each type that fall within the buffers. The process is described in Appendix A of this document.

\section*{Transit Stops}

In addition to using zone-level information on access times to transit, DaySim also incorporates detailed microzone-level information on the distance to transit by transit sub-mode. A single mode is included (local bus), although additional modes can be included, provided that they are consistent with the mode definitions used in the mode choice models. The transit stop file used as input to the MicrozoneBuffer is currently a DBF format file. Table 16 summarizes the contents of this file.

Table 16. Transit stop file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Transit stop ID number \\
\hline mode & Transit submode code \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline
\end{tabular}

The primary source for bus stop location information for the 3-county area was publically-available Google Transit Feed data. Detailed GIS information on the specific locations of all bus stops located in the 3-county were generated using these data. When developing or updating forecast year or project alternative networks, careful consideration should be given to the location of individual bus stops. As described, the current bus stop locations coded in the model are based on detailed information derived from the Google Transit Feed which was originally prepared by the local transit agency. This fine-grained information is used by DaySim to develop microzone-level estimates of access time to transit. Ideally, forecast year transit networks would include a similar level of detail. Forecast year travel model transit network do include information on stop locations as part of the network coding. However, these stop locations are constrained by the coarser travel model roadway networks, and thus may tend to make transit access times appear longer by not including stops that are on major roads included in the roadway network. Model users should be sure that the future year transit stop location file used as input to the microzone preparation contains information consistent with expected future year alignments and stop spacing assumptions.

\section*{Open Space}

A unique feature of DaySim is that it incorporates measures of access to publically accessible open space. Although open space is clearly an attractor of travel for recreational, social and other purposes, typically open space is not included in travel models because the traditional "size" measures used as input to travel models, such as employment and population, are not good indicators of the attractiveness of open space (i.e. a popular park will often have no employment and no population). The open space measures incorporated into DaySim capture the proximity of each microzone to the nearest open space, and the amount of open space within different access bands from the microzone. The open space file used as input to the MicrozoneBuffer is currently a DBF format file. Table 17 summarizes the contents of this file.

Table 17. Open space file format
\begin{tabular}{|l|l|}
\hline FIELD & DESCRIPTION \\
\hline id & Transit stop ID number \\
\hline xcoord_p & X coordinate - state plane feet \\
\hline ycoord_p & Y coordinate - state plane feet \\
\hline sqft & Open space grid cell size in sq ft \\
\hline
\end{tabular}

The individual records in the open space file are based on converting a shape file of regional, publically accessibility open spaces into a smaller set of open space grid cells. A detailed description of the process for creating these open space grid cells is outlined in Appendix B.

\subsection*{2.3 Synthetic Population}

Prior to applying the DaySim model, it is necessary to first develop a "synthetic population" of regional residents. This synthetic population comes in the form of lists of regional resident households and regional resident persons that is based on observed or forecasted distributions of socioeconomic attributes and created by sampling detailed Census microdata. This list functions as the basis for all subsequent choicemaking simulated in the model system. All base year 2008 data required to develop the synthetic population using the DaySim population generation component are available from the Census (American Community Survey Public Use Microdata Sample (PUMS) and Decennial PUMS), and from Fresno trip-based model inputs. The Fresno and 3-County synthetic sample populations are each comprised of two segments: permanent households and population and group quarters population. These segments were established to reflect the differences in travel patterns associated with these sub-populations. The synthetic population files used as input to the DaySim are currently space-delimited ASCII text file format. Table 18 summarizes the contents of the household file, while Table 19 summarizes the contents of the person file.

Table 18. Synthetic Population Household File Format
\begin{tabular}{|l|l|}
\hline Variable & Definition \\
\hline HHNO & Household id \\
\hline HHSIZE & Household size \\
\hline HHVEHS & Vehicles available \\
\hline HHWKRS & Household workers \\
\hline HHFTW & HH full time workers (type 1) \\
\hline HHPTW & HH part time workers (type 2) \\
\hline HHRET & HH retired adults (type 3) \\
\hline HHOAD & HH other adults (type 4) \\
\hline HHUNI & HH college students (type 5) \\
\hline HHHSC & HH high school students (type 6) \\
\hline HH515 & HH kids age 5-15 (type 7) \\
\hline HHCU5 & HH kids age 0-4 (type 8) \\
\hline
\end{tabular}

Table 18. Synthetic Population Household File Format (continued)
\begin{tabular}{|l|l|}
\hline Variable & Definition \\
\hline HHINCOME & Household income (\$) \\
\hline HOWNRENT & Household own or rent \\
\hline HRESTYPE & Household residence type \\
\hline HHPARCEL & Residence parcel id \\
\hline HHEXPFAC & HH expansion factor \\
\hline SAMPTYPE & Sample type \\
\hline
\end{tabular}

Table 19. Synthetic Population Person File Format
\begin{tabular}{|c|c|}
\hline Variable & Definition \\
\hline HHNO & hh id \\
\hline PNO & person seq no on file \\
\hline PPTYP & person type \\
\hline PAGEY & age in years \\
\hline PGEND & gender \\
\hline PWTYP & worker type \\
\hline PWPCL & usual work parcel id \\
\hline PSTYP & student type \\
\hline PSPCL & usual school parcel id \\
\hline PUWMODE & usual mode to work \\
\hline PUWARRP & Usual arrival period to work \\
\hline PUWDEPP & Usual depart period from work \\
\hline PTPASS & transit pass holder \\
\hline PPAIDPRK & paid parking at workplace \\
\hline PDIARY & Person used paper diary \\
\hline PPROXY & proxy response \\
\hline PSEXPFAC & Person expansion factor \\
\hline
\end{tabular}

\subsection*{2.4 Internal-External Worker Fractions}

Although the modeling area is defined in such a way as to capture as much "internal" travel by regional residents as possible (that is, travel with both origins and destinations with the modeling area), a certain portion of observed regional travel involves either regional residents travelling to destinations outside the modeling area or people who are not regional residents travelling to destinations within the modeling area. As in a traditional trip-based travel demand model system, these travel markets are typically incorporated into the model through the use of internal-external trip tables, which may be either fixed or dynamic.

A distinguishing feature of the DaySim activity-based model system is that, due to the spatial and behavioral detail embedded in the model, it is sensitive to how this internal-external travel affects the choices made by regional residents. A particular focus of this detail is on ensuring that the right numbers of workers are "outcommuting" to employment locations outside the modeling area, and that the right number of regional jobs is being consumed by non-residents "in-commuting" to the region. At present, this is accomplished by using a file that contains TAZ-based shares of workers who are in-commuting and out-commuting, which is provided as an external input to the DaySim model system. The shares can either be held fixed, or may be updated by deriving updates shares from the trip-based model outputs. Table 20 summarizes the contents of this internal-external worker fraction table.

Table 20. Internal-External Worker Fraction File Format
\begin{tabular}{|l|l|}
\hline Variable & Definition \\
\hline TAZ & taz id \\
\hline IXSHARE & share of workers who commute to jobs outside the region \\
\hline XISHARE & share of taz-level jobs consumed by workers from outside the region \\
\hline
\end{tabular}

\subsection*{2.5 Impedance Roster}

A key set of inputs to any travel demand forecasting model system are the files that contain the scenario, mode, user-class, and time period-specific measures of network impedance. Most often, the structure of these detailed network impedance measure inputs is "fixed" in the model system, and difficult to update to change without significant revisions to the model system code and scripting. DaySim, however, provides tremendous flexibility for users to define these impedance attributes without necessitating changes to the core DaySim model code. For example, a user may want to increase the number of time periods used in the model system to better reflect changes in network impedance by detailed time-of-day. In order to implement such an enhancement, a user would first revise the Cube-based network-processing and associated scripts in order to generate the desired number of skims by time period, but would only need to revise the DaySim impedance roster to make DaySim sensitive to this additional detail. Table 21 summarizes the contents of the impedance roster.

Table 21. Impedance Roster File Format
\begin{tabular}{|l|l|}
\hline Variable & Definition \\
\hline \#VARIABLE & type of measure (i.e. distance, fare, ivtime) \\
\hline MODE & mode to which to apply \\
\hline PATH-TYPE & type of path to which to apply (i.e. local bus) \\
\hline VOT-GROUP & value-of-time class to which to apply \\
\hline START-MINUTE & starting minute (3am =0) \\
\hline END-MINUTE & ending minute (3am = 0) \\
\hline LENGTH & to identify sub-ranges \\
\hline FILE-TYPE & file format type (Cube matrix, text file) \\
\hline NAME & Impedance file name \\
\hline FIELD & Impedance file field index or matrix core \\
\hline TRANSPOSE & transpose indicator \\
\hline BLEND-VAR & specify measure used to blend \\
\hline BLEND-PATH & specify paths used to blend \\
\hline FACTOR & factor indicator \\
\hline SCALING & scale indicator \\
\hline
\end{tabular}

\subsection*{2.6 Taz Index File}

The TAZ index file enables users to flexibly define non-continuous zones numbering systems, and to identify the availability of external and other zones as destination chocies, without impacting DaySim performance. Table 22 summarizes the contents of the TAZ index file.

Table 22. TAZ Index File Format
\begin{tabular}{|l|l|}
\hline Variable & Definition \\
\hline TAZ & zone number \\
\hline ZONE_ORDINAL & continuous taz numbering scheme \\
\hline DEST_ELIGIBLE & destination choice availability indicator \\
\hline EXTERNAL & external station indicator \\
\hline
\end{tabular}

\subsection*{3.0 Model Calibration and Validation}

The model calibration for the activity-based models is the process to compare observed travel behavior values for a specific model component to estimated values and adjust the alternative specific constants for a better fit to the observed data. This process also involves verifying that each model component produces reasonable travel behavior across dimensions other than those controlled by the alternative specific constants. Calibration results are documented in a series of spreadsheet tables.

Model validation for the activity-based models is the same process it is for the trip-based models, where the observed traffic counts are compared to model estimated volumes across a number of dimensions. Validation results are also provided in a spreadsheet.

\subsection*{3.1 Calibration Results}

\subsection*{3.1.1 Mobility Choice Models}

The first models in DaySim are the mobility choice models. These include work and school location models and vehicle availability models. Work and school location models identify the "usual" work and school locations similar to a distribution model that identifies the work and school locations, but these may differ from the actual work and school location for a travel day if a person is attending a business meeting outside their office or attending a class outside their school.

Work and school location models are calibrated using the National Household Travel Survey (NHTS) data for 2009. In addition, work locations are calibrated using the Census Transportation Planning Package (CTPP) for 2008 provided by the American Community Survey (ACS) for the 3 year span between 2006 and 2008. In the Fresno model, there are 4 areas summarized as counties: Fresno and Clovis Counties and other incorporated and unincorporated areas in the Fresno Council of Government regions. For the 3-County model, there are 3 counties included: Merced, San Joaquin and Stanislaus. Observed distances and travel times were obtained from the AM peak assignment of single occupant vehicles attached to the household survey. The Census does not report trip lengths by person type, so these summaries are only made with the NHTS.

Work location models are provided in the file WrkLocation.xlsm and are summarized as follows:
- Trip length (minutes) frequency distributions, an example of which is provided in Figure 1
- Trip distance (miles) frequency distributions
- Average trip length (minutes) and trip distance (miles) by person type (full-time worker, part-time worker and not a worker)
- County to county worker flows (based on residence and work locations)
- Work-at-home summaries by county and person type (full-time worker, part-time worker and not a worker)

School locations models are provided in the file SclLocation.xlsm and are summarized as follows:
- Trip length (minutes) frequency distributions
- Trip distance (miles) frequency distributions
- Average trip length (minutes) and trip distance (miles) by person type (children ages 5 to 15, students 16 and older, and university and adult students)
- County to county worker flows (based on residence and work locations)
- School-at-home summaries by county and person type (children ages 5 to 15, students 16 and older, and university and adult students)

Figure 1. Example of Trip Length Frequency Distribution for Work Locations in Fresno


Vehicle availability models are calibrated using the NHTS and the ACS 2006-2008 data. These data are documented in the Vehicle Availability Model report developed for the trip-based models. Vehicle availability models are provided in the file VehAvailability.xlsm and are summarized across three dimensions:
- Vehicles per household by County
- Vehicles per household by household income group
- Vehicles per household by number of potential drivers in a household (1,2,3, or 4 or more)

For these summaries, the following household income groups apply:
- Household income less than \$15,000
- Household income \$15,000-\$50,000
- Household income \$50,000-75,000
- Household income more than \$75,000

\subsection*{3.1.2 Day Level Models}

Day level models include models to predict the number of tours and stops by purpose across the day for each person. Summaries of the day pattern models are provided in the file DayPattern.xlsm. There are 8 tour and trip purposes: work, school, escort, personal business, shop, meal, social/recreation, and work-based. There are 8 person types included in these summaries: full time worker, part time worker, retired persons, nonworker, university student, student age 16 and over, student age 5-15, and persons under 5 . These summaries include the following tables:
- Summary tables of population by county and person type, and tours and trips by person type
- Percent of tours ( \(0,1,2,3\) or more) made by each person type
- Percent of tour and stop combinations ( \(0,1,2,3\) or more tours and \(0,1,2,3\) or more stops for 13 combinations) made by person type
- Percent of tour and stop combinations ( 0,1 or more tours and 0,1 or more stops for 4 combinations) made by purpose and person type
- Exact number of tours (1,2,3 or more) by purpose and person type if tours are made
- Exact number of tours (1, 2, 3 or more) by purpose and person type
- Exact number of work-based sub-tours ( \(0,1,2,3\) or more) for full time workers and other persons by purpose
- Tours by number of stops ( \(0,1,2,3,4,5,6\) or more) and purpose
- Tours by purpose and person type; tours by purpose and household income group; tours by purpose and auto sufficiency; tours by purpose and county;
- Stops by purpose and person type; stops by purpose and household income group; stops by purpose and auto sufficiency; stops by purpose and county;
- Trips by purpose and person type; trips by purpose and household income group; trips by purpose and auto sufficiency; trips by purpose and county;
For these summaries, auto sufficiency represents the ratio of potential drivers in the household to vehicles available:
- Fewer vehicles than drivers
- Same number of vehicles and drivers
- More vehicles than drivers

\subsection*{3.1.3 Tour Level Models}

Tour level models include destination choice, mode choice and time of day models for each of the non-work and school purposes:
- Escort - to pick up or drop off a passenger
- Personal Business - including activities for medical, banking, etc.
- Shop - to shop for clothes, food, etc.
- Meal - to dine at a restaurant or pick up take-out
- Social/Recreation - to visit friends or go to a park, etc.
- Work-Based - a tour that begins and ends at work, like going out to lunch

These are calibrated using NHTS data. The tour destination model reports are provided separately for each purpose and include the following summaries:
- Trip length (minutes) frequency distributions
- Trip distance (miles) frequency distributions
- Average trip length (minutes) and trip distance (miles)
- County to county flows (based on residence and destination locations)

These are contained in the files for each purpose: TourDestination_Escort.xlsm, TourDestination_PerBus.xlsm, TourDestination_Shop.xlsm, TourDestination_Meal.xlsm, TourDestination_SocRec.xlsm, and TourDestination_WrkBased.xlsm.

Tour mode choice summaries are provided in the file TourMode.xlsm and include summaries for all purposes:
- Summary tables of work tour modes by purpose
- Work tours by mode for 0-vehicle households and 1 or more vehicle households
- School tours by mode for 0-vehicle households and 1 or more vehicle households
- Escort tours by mode for 0-vehicle households and 1 or more vehicle households
- Personal business tours by mode for 0-vehicle households and 1 or more vehicle households
- Shop tours by mode for 0-vehicle households and 1 or more vehicle households
- Meal tours by mode for 0-vehicle households and 1 or more vehicle households
- Social-recreation tours by mode for 0-vehicle households and 1 or more vehicle households
- Work-based sub-tours by mode and work tour mode

Tour modes include the following 8 modes:
- Drive Alone (auto)
- Shared Ride with 2 persons (auto)
- Shared Ride 3 or more persons (auto)
- Drive to transit
- Walk to transit
- Bike
- Walk
- School bus

Tour time of day model summaries are provided in TourTOD.xlsm. These summaries include the following tables:
- Tour arrival time (half-hour time periods) by aggregate purpose (work, school, other, and workbased), an example of this type of frequency distribution is provided in Figure 2
- Tour departure time (half-hour time periods) by aggregate purpose (work, school, other, and workbased)
- Tour durations (half-hour time periods) by aggregate purpose (work, school, other, and work-based)
- Work tour arrival times (half-hour time periods) by person type (8)
- School tour arrival times (half-hour time periods) by person type (8)
- Other tour arrival times (half-hour time periods) by person type (8)
- Work-based tour arrival times (half-hour time periods) by person type (8)


\subsection*{3.1.4 Trip Models}

Calibration of the trip level models include mode choice and time of day models for each purposes. These are calibrated using NHTS data. Trip mode choice summaries are provided in the file TripMode.xlsm and include summaries for all purposes:
- Trips by tour and trip mode for all purposes
- Trips by tour and trip mode for work purposes
- Trips by tour and trip mode for school purposes
- Trips by tour and trip mode for escort purposes
- Trips by tour and trip mode for personal business purposes
- Trips by tour and trip mode for shop purposes
- Trips by tour and trip mode for meal purposes
- Trips by tour and trip mode for social-recreation purposes
- Trips by tour and trip mode for work-based purposes

Trip modes include the following 13 modes:
- Drive Alone (auto)
- Shared Ride with 2 persons (auto) - Driver
- Shared Ride with 2 persons (auto) - Passenger
- Shared Ride 3 or more persons (auto) - Driver
- Shared Ride 3 or more persons (auto) - Passenger
- Transit - local bus
- Transit - light rail
- Transit - premium bus
- Transit - commuter rail
- Transit - ferry
- Bike
- Walk
- School bus

Tour time of day model summaries are provided in TripTOD.xlsm. These summaries include the following tables:
- Tour arrival time (half-hour time periods) by purpose (work, school, escort, personal business, shop, meal, and social-recreation) for stops on the outbound half-tour
- Tour departure time (half-hour time periods) by purpose (work, school, escort, personal business, shop, meal, and social-recreation) for stops on the return half-tour
- Tour durations (half-hour time periods) by purpose (work, school, escort, personal business, shop, meal, and social-recreation) for stops on the both half-tours

\subsection*{3.2 Validation Results}

Model validation follows the same process as for the trip-based model, since these results are all derived from the highway assignment. Validation on the transit assignment could be completed in the future. Highway assignment validation results are provided in the following spreadsheets: Frenso_ABM_Validation_2012-0224.xlsm and 3County_ABM_Validation_2012-02-24.xlsm. These spreadsheets contain the following summaries of the highway assignment"
- One-way volume model validation results, including daily and time period (AM peak, midday, PM peak, off-peak periods and AM and PM peak hours) summaries, volume group and facility type summaries and charts of estimated and observed daily volumes
- Two-way volume model validation results, including daily and time period (AM peak, midday, PM peak, off-peak periods and AM and PM peak hours) summaries, volume group and facility type summaries and charts of estimated and observed daily volumes
- Base model volumes with link attributes and volumes by vehicle type and time period
- Count data with link attributes and volumes by vehicle type and time period
- Daily assignment summaries by link comparing estimated and observed volumes
- AM peak 3-hour assignment summaries by link comparing estimated and observed volumes
- Midday assignment summaries by link comparing estimated and observed volumes
- PM peak 4-hour assignment summaries by link comparing estimated and observed volumes
- Evening assignment summaries by link comparing estimated and observed volumes
- AM peak 1-hour assignment summaries by link comparing estimated and observed volumes
- PM peak 1-hour assignment summaries by link comparing estimated and observed volumes
- Distributions of volumes by vehicle class and time of day
- Daily screenline summaries of observed and estimated volumes
- AM peak 3-hour screenline summaries of observed and estimated volumes
- Midday screenline summaries of observed and estimated volumes
- PM peak 4-hour screenline summaries of observed and estimated volumes
- Evening screenline summaries of observed and estimated volumes
- AM peak 1-hour screenline summaries of observed and estimated volumes
- PM peak 1-hour screenline summaries of observed and estimated volumes Validation of both the Fresno and 3County activity-based models is ongoing.

\section*{Appendix A. Creating the Intersection File}

This appendix focuses on creating point representations of real world street intersections. This is done by using Centerline data to calculate where streets intersect and how many streets intersect at each intersection.

\section*{Requirements}
- Tools: "NodesTool" Toolbox
- Data: A single Polyline shapefile (or geodatabase feature class) representing centerline Street Data covering the extent of the region in question. This data should be clipped to the extent of the region in question (apply a half mile buffer to the region extent to limit data suppression). The shapefile should not contain any overlapping attributes.

\section*{Steps}

Add the centerline street data (here forward called "centerline") to a new ArcMAP project
\(Q A / Q C:\) Has a default projection been determined for the Data Prep work? If not, determine a default projection that will be used for the remaining data prep work. Once a default projection has been determined, check to make sure that the "centerline" data is properly projected (Right click on "centerline" file in the Table of Contents of the open ArcMAP project -> Select Properties -> navigate to the source tab -> look in the "Data Source" pane for the "Projected Coordinate system")
\(Q A / Q C:\) Run the "Intersect" (Analysis) tool from the ArcToolbox (*Note, perform a search within the ArcToolbox if you can't find the Intersect tool). The Input Features should be the single "centerline" data and the Output Feature Class should be called "Test" and should be generated in the location of your choosing. Add the "Test" data to the open ArcMAP project once it has been generated. If the "centerline" data is clean, the "Test" file will be empty. If the "Test" file is empty, continue to the next step, if the "Test" file is NOT empty, the "centerline" data contains overlapping features. Remove all overlapping features before continuing to the next step.

Open the attribute table for "centerline" (make sure that no records are selected)
Add a field called "X_Start" make sure the field type is Double
Repeat step 2 creating the following fields "X_End", "Y_Start", "Y_End" (all fields should be double)
Still in the attribute table, right click on the "X_Start" heading and select "Calculate Geometry" disregard any pop-up windows about being outside of an edit session. The "Property" you are calculating is " X Coordinate of Line Start", select the option to "Use coordinate system of the data source". The dialog box should look similar to the image to the right. Once it does, press ok.


Repeat step 4 to fill the additional 3 fields that you created. Match the "Property" to the column heading.

When all 4 fields are filled, export the table to a location of your choosing, when a dialog box asks you whether you would like to add the table to the display, hit OK (this table will be referred to as "New Table").
In the table of contents, right click on "New Table" and select the "Display \(x, y\) data" option (see the image to the right). Note* If for some reason you can't see the new table in the table of contents select the "Source" Tab in the Table of Contents.


A dialog box will pop-up, use the "X_Start" field from your table as the X field and "Y_Start" as the Y field. Click the "Edit" button to select the correct coordinate system, the "Spatial Reference Properties" dialog box will open. Click the "Import" button. This will allow you to point to the original Centerline Shapefile (in whose coordinate system the X and Y fields were calculated). Hit "Ok" in the "Spatial Reference" Dialog Box, then hit "Ok" again in the "Display X,Y, Data" dialog box. A new point event layer should appear in your dataview. Note* Event layers aren't permanent, that is why we follow the next step


Right click on the new point event layer and go to "Data" \(\rightarrow\) "Export Data". Choose an appropriate name and location for this shapefile (this shapefile will be referred to as "Line Start Points". Make sure to add this layer to your display. Lastly, remove the "Event Layer" created in the previous step.

Repeat the previous two steps using "X_End" and "Y_End". Export the data to a new shapefile (which will be referred to as "Line End Points"). Add this shapefile ("Line End Points") to the display as well.

\section*{Adding the "NodesTool" to your ArcToolbox}

An ArcTool was created to process the data created in the previous steps.
Open the ArcToolbox
Right Click the "ArcToolbox" folder at the top of the directory and select "Add Toolbox"
Locate the "NodesTool" Toolbox on your machine and select "Ok"

\section*{Creating the "Intersection" Shapefile PartII}


Double click on the "NodesTool" Toolbox
Double click on the "IntersectionTool" Model - A dialog box similar to the one below should appear:


Enter the data as follows:
- "Line Start/Line End Points" - "Line End Points" shapefile and "Line Start Points" shapefile
- "Centerline Data" - The "Centerline" shapefile
- "Intersections Output" - location of output containing the "Intersection" data

Once you have entered in the information, select OK. Once the tool has finished running, the intersection location data will have been created. The new shapefile will have an attribute with a Field name of "INTS" - this new field denotes the number of streets intersecting at that location.

\section*{Appendix B: Creating The Open Space}

This appendix focuses on creating point representations of real world open space areas. This is done by finding and processing open source spatial representations of "Protected Areas".

\section*{Requirements}
- Data: -A single Polygon shapefile (or geodatabase feature class) representing the extent of the region in question (apply a half mile buffer to the region extent to limit data suppression) THIS SHAPEFILE/FEATURE CLASS MUST BE IN THE DEFAULT PROJECTION.
- Projection: -By this point it is mandatory that a Default Projection has been decided upon for all DAYSIM data prep work.

\section*{Downloading and Installing ET Geowizards}

Continue to the next section if the current version of "ET Geowizards" is installed on the work computer.
1. Locate the "ET Geowizards" installer (which can be found at the following Web address: http://www.ianko.com/ *Note: Makes sure that correct installer is downloaded for the specific computer and the specific version of ArcGIS being run on that computer.

Install the software by following the instructions that accompany the installer file.
Open a new project in ArcMap
Click the "Customize" dropdown menu at the top of the ArcMap window \(\rightarrow\) hover over "Toolbars" \(\rightarrow\) Select "ET Geowizards" in the adjacent dropdown menu (see graphic to the right). Feel free to doc the "ET Geowizards toolbar".


If "ET Geowizards" does not appear in the aforementioned dropdown menu, please recheck that the installer ran correctly. If it did install correctly, navigate to the bottom of the list of "Toolbars" and select "Customize" \(\rightarrow\) a new window will appear which should look like the graphic to the right. Click on the "Add from file...." Button, and navigate to the *.dll file created by the Geowizards installer.


\section*{Finding Open source Representations of Protected Areas}

Continue to the next section if adequate spatial representations (in polygon format) of the region's open space areas have already been obtained.

Protected areas are locations which receive protection because of their recognized natural, ecological and/or cultural benefits. The USGS, as well as some state government agencies, actively monitor and inventory these areas. Spatial representations of California's "Protected Areas" can be found here: \(\underline{\text { http://www.calands.org/ }}\). For spatial representations of "Protected Areas" at a national level, follow this link: http://gapanalysis.usgs.gov/data/padus-data/*Note, the following steps use the California data, additional notes will supply directions for using the national data.
1. Navigate to the "CPAD: California Protected Areas Database" website using the link above. Download the most recently updated geospatial data. *Suggestion: download the data in *gdb format. *Note: if using the national database, navigate to the second web address provided and download the equivalent data.
2. Cn~ the data has completed downloading, open a new project in ArcMap and use the "Add Data" button to add the shapefile (or feature class) named in the following convention "*_Holdings" (this data will be referred to as "_Holdings").
3. Right click on the "_Holdings" file in the "Table of Contents" and select properties.
4. Navigate to the "Definition Query" tab.
5. In the box under "Definition Query:" write in the following expression:
"ACCESS" = 'OA' OR "ACCESS" = 'Open Access'

*Note: Users of the "national" database will have to determine their own qualifications for the equivalent of California's "Open Access" space
Add the shapefile/feature class representing the region's extent (forward referred to in the documentation as Extent").

\section*{Adding the "OpenspaceTool" to ArcToolbox}

An ArcTool was created to process the data created in the previous steps.
Open the ArcToolbox
Right Click the "ArcToolbox" folder at the top of the directory and select "Add Toolbox"
Locate the "ParksTool" Toolbox on the computer and select "Ok"
*Note: If problems arise with the "OpenspaceTool" Model consult the below image to
 understand the processes that make up the tool's operation.


The tool first Selects the data by attribute to subset the "Open Space" data from the larger umbrella of "Protected Areas" (it is up to the user to decide what "attribute" in the database designates a feature as "Open Space", for the California Data we suggest the "ACCESS" field where attributes are either 'OA' or 'Open Access'); The tool then clips the subset to the extent of the region in question; Then, the tool projects the data into the proper projection (reminder: all data should be prepared in a common projection); Last, the output is dissolved into one feature, this output constitutes all the "Open Space" in the region in question.
*Note: If problems arise with the "Grid1" Model consult the below image to understand the processes that make up the tool's operation.


The tool merely selects data from the input grid and creates 4 new shapefiles/feature classes.
*Note: If problems arise with the "Grid2" Model consult the below image to understand the processes that make up the tool's operation.


Based on user inputs the tool runs intersects the "Open Space" data with each of the 4 distinct sub-regions; once the data has been intersected, the 4 sub-regions are merged together.

\section*{Refining the "Protected Areas" data into "Open Space" Representations}

The following steps will use the protected areas data, "OpenspaceTool", and Geowizards Toolbar to refine and separate the data into sections.

Open the "OpenspaceTool" Model in the "ParksTool", a window like the one below should appear.


Submit the form with the following inputs:
-Input Protected Areas:
-Open Space Selection Expression (optional):
-Region Extent
-Output Coordinate System
-Geographic Transformation
-Output Open Space Dataset or Feature Class

\section*{-"_HOLDINGS" feature class}
- "ACCESS" = 'OA' OR "ACCESS" = 'Open Access'
-"Extent" feature class
-Default Projection for Project
-Leave blank unless asked to fill
- Name/Location of Open space feature class
(forward referred to in the documentation as "
Extent Open Space")

Click "OK".
*Note: if an error occurs run the "Select Tool" \(\rightarrow\) "Clip Tool" \(\rightarrow\) "Project Tool" and "Dissolve Tool" to get the same results

Make sure the new feature class, "Extent OpenSpace", is added to the ArcMap display. Remove all other data in the table of contents. This new feature class represents all the "Open Space" in the region in question.

\section*{Refining "Open Space" data to create a DAYSIM Input File}

The following steps:
1. Divide the region into a grid with \(250^{\prime}\) by \(250^{\prime}\) grid cells;
2. Intersect the open space data, that has already been created, with the new grid;
3. Converts the intersected "Open Space" data into centroid points that contain area data.

While ET Geowizards is a useful tool, there are many limitations to the tasks that the software can run. Many of the following steps concern getting around these limitations to create data that is as fine as possible. Feel free to attempt condensing the following steps into a single step (this may be possible for smaller, and/or less irregularly shaped, regions.

Open the "ParksExtent" excel workbook.
*Note: the excel document will be used to calculate some values to guide the production of the grid.
Return to ArcMap and Click the "ET Geowizards" Toolbar \(\varlimsup^{\underline{\underline{G G W}}}\)
Navigate to the "Basic" Tab \(\rightarrow\) Double Click on the "Vector Grid" tool. A window similar to the one below will appear.


For object \#1 "Select source for the initial GRID extent" use the "Extent OpenSpace" feature class.
For object \#2 "Specify output feature class or shapefile" use a name and location of users choice (here forward referred to as "Extent_Grid") \(\rightarrow\) Click on the "Next>" button.

For \#3 "Select output coordinate system", click the "Select Output coordinate system" button and ensure that the coordinate system matches the default coordinate system for the project. If it does not, change the projection to match the default projection for the project.
For object \#4 "Select GRID type" select the option for "Polygon". Click on the "Next>" button. The window should now look like this:


Object \#5 "Grid extents" will need to be updated. The excel workbook generates the required values based on the region specific data. Copy the "X Min", "X Max", "Y Min", and "Y Max" values into the appropriate cells in the excel workbook. The work book generates new "X Max" and "Y Max" values, copy and paste the new values into their appropriate places in Object \#5.

For Object \#6 "Cell Size", fill in the "X" and "Y" dimensions based on the values in the excel workbook. Click the "Finish" button.

Once the Geowizards processes have finished running, make sure that the new feature class, "Extent Grid," is added to the display. The region should have been split into 4 different regions: two north and two south.
*Note: Given the limitation of the Geowizards software, the entire region can rarely ever be converted to a \(250^{\prime}\) by \(250^{\prime}\) Grid in one step. One can make an attempt at creating the 250' by \(250^{\prime}\) Grid in one step, but should not be surprised if/when the software fails.
Double click on the "Grid1" Model within the "ParksTool" Toolbox. A window similar to the one to the right will open.
*Note, the "Grid1" Tool separates the "Extent Grid" into 4 separate files. The defaults identify Geowizards conventions to separate the region into SE, SW, NE, and NW regions. If this tool fails to run, the step can be replicated by manually selecting each region, and exporting the selected data to shapefile.


Submit the form with the following inputs:
\begin{tabular}{|c|c|}
\hline -Input Grid & - "Extent_Grid" feature class \\
\hline - South-West Selection Expression (optional) & - "ET_ID" = 0 \\
\hline -Output South-West Grid Feature class & - Name/Location of choosing (forward referred to as "Extent_Grid_SW") \\
\hline - South-East Selection Expression (optional) & - "ET_ID" = 1 \\
\hline -Output South-East Grid Feature class & - Name/Location of choosing (forward referred to as "Extent_Grid_SE") \\
\hline - North-West Selection Expression (optional) & - "ET_ID" = 2 \\
\hline -Output North-West Grid Feature class & - Name/Location of choosing (forward referred to as "Extent_Grid_NW") \\
\hline - North-East Selection Expression (optional) & - "ET_ID" = 3 \\
\hline -Output North-East Grid Feature class & - Name/Location of choosing (forward referred to as "Extent_Grid_NE") \\
\hline \multicolumn{2}{|l|}{The following steps will subdivide each of the 4 regions created by step \#19 into 250 foot grid cells. Re-open the "ET Geowizards" form and navigate to the "Vector Grid" tool. Submit the form once for each region using the following inputs (* represents each of the four subdivisions):} \\
\hline \#1 "Select source for the initial GRID extent" & - once each for all "Extent_Grid_*" \\
\hline \#2 "Specify output feature class or shapefile" & - Name/Location of users choosing \\
\hline & (forward referred to as "Extent_Grid_*_250") \\
\hline \#3 "Select output coordinate system" & - Check that it matches the default projection for which all data is being prepared \\
\hline \#4 "Select GRID type" & - Polygon \\
\hline \#5 "Grid extents" & - Use default \\
\hline \#6 "Cell Size" & - both X and Y should \(=250\) \\
\hline
\end{tabular}

Once generated, make sure all the "Extent_Grid_*_250" shapefiles are present in the ArcMAP display.
Double click the "Grid2" model within the "ParksTool" Toolbar. A window should appear matching the image below.


Fill in the appropriate fields with the following data:
"Open Space"

\section*{"South-East Extent Grid"}
"South-West Extent Grid"
"North-East Extent Grid"
"North-West Extent Grid"
"Output Open Space Grid Split"
- "Extent Open Space" feature class
-"Extent_Grid_SE_250" feature class
-"Extent_Grid_SW_250" feature class
-"Extent_Grid_NE_250" feature class
-"Extent_Grid_NW_250" feature class
- Name/Location of choosing
(forward referred to as "Extent Open Space 250")
Click the "OK" button once all fields have been properly filled. Make sure the feature class generated through this tool, "Extent Open Space 250", is added to the display.

Navigate to the "Delete Field" Tool in the ArcToolbox ("Data Management Tools" \(\rightarrow\) "Fields" \(\rightarrow\) "Delete Field"). A form like the image below should open.


The "Input Table is the "Extent Open Space 250" feature class. Check the box next to all the fields present in the "Drop Field" box. Click Ok.

Open the "Extent Open Space 250" feature class 's attribute table to check that all fields ("ID", "FID", "Name", etc.) have been removed. *Note: some fields are structurally mandatory and cannot be removed.
In the Attribute Table menu select \(\stackrel{\circ}{\circ} \boldsymbol{B}\) - and click on the option to "Add Field". The "Name" will be "SQ_FOOT" and the "Type" will be Long Integer.

Repeat this step and add fields "XCOORD" (Long) and "YCOORD" (Long)
Right click on the "SQ_FOOT" column heading and click the option to "Calculate Geometry..." The "property to be calculated" is "Area"; The Coordinate System choice is "Use coordinate system of the data source" and the Units should be "Square Feet US [sq ft]". Click "OK"

Right click on the "XCOORD" column heading and click the option to "Calculate Geometry..." The "property to be calculated" is "X Coordinate of Centroid"; The Coordinate System choice is "Use coordinate system of the data source" and the Units should be "Feet US [sq ft]". Click "OK"

Right click on the "YCOORD" column heading and click the option to "Calculate Geometry..." The
 "property to be calculated" is "Y Coordinate of Centroid"; The Coordinate System choice is "Use coordinate system of the data source" and the Units should be "Feet US [sq ft]". Click "OK".

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\section*{MEMORANDUM}

Date: February 17, 2012
To: SJ Valley MIP MPOs
From: SJ Valley MIP Consultant Team

\section*{Subject: Answers to Frequently Asked Post-MIP Questions}

This memo answers frequently asked questions relating to the recommendations and next steps for the San Joaquin Valley (SJV) models after the completion of the Model Improvement Project (MIP).

\section*{What land use and other assumptions were made and how do the assumptions influence the results?}

The MPOs provided the consultant team the pre-MIP RTP data and the consultant team disaggregated the land use into the refined zone systems and land use categories for base and future years. As part of separate projects or done by MPO staff, the base years were updated to reflect more recent data. The TAZ splits and disaggregated land use details for the validation year were reviewed and approved by MPO staff.

Future year pre-MIP data were split into the zone system and detailed land use categories based on the existing data. MPO staff reviewed or refined the data for geographic or categorization of development. If school data were updated, they were linked to the population of the region and remained in the same geographic location.

As land use changed in the model, the splits by geography, category, socio-economic detail, and developed area remained constant unless MPO staff refined the data. In aggregate, the residential units and employees match the pre-MIP models. However, with more refined travel characteristics the difference in the detailed categories has an influence on the model in terms of trip generation, split of trip purpose, and other similar travel characteristics. Similarly, the household size, age distribution of the population, and other socio-economic factors influence the travel of residential trips and schools. These factors and the geographic location between the original and refined zone system should be refined in the future to capture the nature of the development as intended. If the "Ds" are implemented, developed acres should also be refined. The age of population and student enrolment have an influence on the VMT associated with school travel and currently school enrolment adjusts in the same geographic area, potentially increasing VMT.

\section*{What areas should be a focus when updating the trip model?}

When updating the travel model base year or creating a new scenario, there are numerous important points that you must consider. The section below outlines some of the data types and issues you will need to consider. These issues span the range of sources for appropriate data, appropriate methods for use in preparing the data for the travel model, and quality review and consistency checks you when developing data.

\section*{Sources of data: Existing and Forcast}
- U.S. Census:
- 2010 Census, Summary File 1
- American Community Survey (1, 3, 5 year summaries)
- This is the replacement for most data previously in the Census Long Form.
- Note concerns about the margins of errors particularly at smaller geographies. According to Ed Christopher, U.S. Census Bureau, ACS data for block groups is intended for aggregation not standalone use.
- Longitudinal Employer Housing Dynamics (On The Map)
- Block level employment estimates, that are synthesized from ES202 filings.
- Does not include Federal employees, self-employed, or others not covered by state unemployment insurance.
- Does a poor job with large employers, suffering from central office issues (wherein most or all employment is assigned to a main office, at the expense of branch locations).
- State of California:
- California Employment Development Department
- County level employment estimates, both unemployment insurance based and estimated for full inclusion, by industry. There are some redactions or data aggregation to meet privacy protection requirements.
- California Department of Finance:
- Population and housing estimates by city and county
- Historic growth rates
- Population projections (last updated 2007)
- California Department of Transportation:
- California County-Level Economic Forecast 2010-2035 by the Office of Transportation Economics, Division of Transportation Planning (2010)
- California Department of Education:
- School enrollment, public and private
- Local Government:
- Parcel Data
- Land use codes, assessed values, and ownership information
- Caution should be used as there are many inconsistencies and missing/incorrect codes.
- Commissioned forecasts
- Commercial Data Sources:
- Employment, from InfoUSA, Dunn \& Bradstreet, etc.
- Undercounts of institutional employment (government, hospitals, schools)
- Available by street addresses by detailed industry code
- Forecasts:
- REMI
- Moody's

\section*{Quality of data in base and future:}
- Face Validity: Apply data in test cases or summarize data for a non-technical audience. Face validity asks only one question; "does the data or output seem reasonable?" The size and range of values is a primary consideration here. Many common errors are discovered by "eyeballing" or trying to explain data or output derived from data.
- Content Validity: This takes Face Validity a step further and asks whether your data is consistent with other sources of similar data. Are the ranges of values comparable? Are the distributions of values consistent?
- Statistical Validity: This applies to sampled or otherwise derived data and is a complex technical topic. .. When working with sample data, it is good practice to identify significant outliers or extreme values, and identifying whether such values are reasonable.They may represent real values, they may represent data errors or they may represent sampling or other process errors.
- Predictive validity: The most commonlycommonly discussed form of validity is predictive validity. This involves the prediction of a known validation year from a base year. It is a good test of a system but it is dependent on the previous tests as well since one could get the right result for the wrong reason if data did not meet other quality measures.
- Reliability: Increasingly we have more than one method for the measurement of a variable (e.g. VMT forecast). Reliability asks if independent measurements achieve comparable results. There may be many reasons for dissimilar results. Dissimilarity itself does not constitute unreliability but does need to be explained when it occurs. It can be a clue that data need examination.

Data Processing: Class disaggregation by existing proportions. This is a family of techniques that can be used to split an aggregate total into disaggregate counts, based on existing totals.
- When a category is forecast, or is developed from a dataset without the level of class detail used in the model, it can be split into subclasses using the ratios found within the current conditions.
- This will frequently be done in either GIS making use of field calculation tools or within a database or spreadsheet. This process makes the assumption that the current ratios will hold in the future (or scenario).
- Example: a forecast provides office employment, but the model's classification system uses multiple categories that nest within office (such as finance and insurance, real-estate, professional and scientific, management, etc). The ratios of existing employment by subclass can be calculated for each TAZ and then applied to the forecast total for office employment to generate a TAZ specific disaggregation.
- Class disaggregation by moving proportions. A minor modification of the above technique to adjust shares in a logical manner.
- A forecast category can be disaggregated by a systemantically modified version of the current shares.
- Example: Households are forecast, but households by age of householder are needed. A separate dataset indicates a systematic shift in the shares with aging households. The shares can be adjusted by moving portions of the shares to older age brackets. Note this requires careful checking to make sure that the counts do not gain or lose population on reaggregation.

Consistency of data: residential categories, population totals and age ranges, enrolment, faculty employment, etc
- The classification systems used within the model were designed to allow both flexibility for use as well as maintaining consistency with census data products. The classes defined within the models can be aggregated to produce close analogs to those used in prior versions of the travel demand models.
- The residential categories are drawn directly from the data available in the American Community Survey and are almost identical to those that were provided in the 2000 Long Form and 2010 Summary File 1.
- Examples of necessary checks to ensure internal consistency:
- Are the population, housing unit, and residential cross-classifications internally consistent? i.e. do the population totals for each TAZ match the total population generated by multiplying housing unit types by housing unit sizes?
- Are school faculty employment numbers appropriate given the school enrollment and are the school enrollments appropriate given the local age profile.

Developed area: residential, employment, enrolment values with developed acres by residential and employment
- Unlike prior models, the developed area must be specified for each TAZ. The models support using independent residential and employment developed areas.
- This developed area can come from either a visioning model, or from a manual estimation, but should be consistent with the local character.
- If the developed area is not increased when increasing the population, employment, or housing unit counts, you are assuming that the density is increasing
- To assume that the density will remain constant, the developed area can be increased by the same proportion as the population/employment growth. If this is done, you must review the developed area against the total area of the TAZ to ensure consistency.
- If a visioning tool is used, it will, with only a very few exceptions, be able to provide these developed acres.

Data assumptions in current models: developed area, school enrolment and sites, etc
- The current developed areas are based on the Farmland Mapping and Monitoring Program's 2008 data. It includes the type "D" (urban and built up with more than 6 structures per 10 acres), RR (rural residential), and sAC (semi-agricultural and commercial) categories. For more information, see:
- http://www.conservation.ca.gov/dlrp/fmmp/Pages/Index.aspx
- School enrollments were developed from California Department of Education school enrollment data, and geocoded to TAZ.

\section*{What data/processes are needed for ABM inputs beyond the trip model?}

The activity-based model simulates travel for persons and households in a region at disaggregate level, but this is developed from a combination of both aggregate and disaggregate data. In the case of Fresno, parcel data represents the disaggregate representation of both households and employment in the region and persons to live in
these households and work in these jobs are synthesized as part of the process. In the case of the 3-county model, Census blocks are used as microzones to represent households and employment in the region. In both cases, the disaggregate nature of these data provide more spatial detail for networks and travel times from one place to another. We have prepared data preparation processes to facilitate data preparation for the activity-based models. Data required for the activity-based models are as follows:
- TAZ and Census block (from Census ACS or LEHD) or parcel file with households and employment by type
- Student enrollment by parcel or block from the California Department of Education
- Offstreet parking supply and pricing from local sources
- Intersections within \(1 / 4\) and \(1 / 2\) mile buffers generated from GIS street centerline files
- Transit stop locations from local sources
- Open space in square feet
- Internal-external worker fractions to represent resident out-commuting and nonresident in-commuting

These data are processed to produce a synthetic population of regional residents, an impedance roster of network skims by time period and mode, and an index file of traffic analysis zones to identify internal and external zones.

\section*{What are Visioning Tools and how can they be used with the model?}

\section*{Visioning Tools}

Land use and visioning models play a significant role in specifying future land use data for travel demand models. These models fall into two primary classifications: predictive and design. A predictive land use model utilizes input from the users and disaggregates projections for future population and employment totals onto the landscape in an automated fashion based on the model's algorithms. A design model places the responsibility squarely into the "designer's" hands. The designer places the type of land use they want at the location they want it. Both types of models then compute the likely impacts of the land use patterns which they depict. Most of the models described here fall into the design class. Two predictive models, UPlan model and CommunityVIZ are also described in this section. The Cube Land predictive model will be covered in a separate section of this memo.

Design models, also called scenario planning tools, are intended to serve as a communication tool between land use and transportation planners, elected officials, and all other stakeholders. The land use planner can create a land use scenario and evaluate it in a framework that measures the effect on any number of variables ranging from trip generation to community
health. In essence, these models summarize what the professional literature says are the likely effects of land use configurations on variables of interest and apply those estimates to particular scenario configurations in order to estimate effects. Each hypothetical land use combination (scenario) will represent one case in the literature more than others and it will be ascribed the effect the literature held for the case most like it. The assumptions here are that the literature used is agreed to have validity and that the user designed scenario fits the cases from which the impacts in the literature are derived. .

An appendix to this memo provides a comparison between the capabilities of the visioning (design) tools mentioned here.

\section*{iPLACE \({ }^{3}\) S}
iPLACE \({ }^{3}\) S is an internet based design model or scenario tool. Like many of the scenario tools it uses a "place type" system that defines particular mixes of building structures and land uses in a zone. Each place type has an inventory of effects on a wide range of variables. The size of the geographic zone of a place type can range from small to large and its effects change in scale with its size. The results of a scenario sum the effects of all the place types in the scenario on all the variables of interest.
iPLACE \({ }^{3}\) S was used very successfully by the Sacramento Area Council of Governments during their regional blueprint and subsequent MTPs and has also been used by San Luis Obispo COG. iPLACE \({ }^{3}\) S has a wide variety of extensions to it that support performance measures relating to the return on investment from redevelopment, energy, water, urban service consumption, health and active living, and travel behavior. With suitable licensing for iCitilabs products, a direct linkage of \(\mathrm{PPLACE}^{3} \mathrm{~S}\) to a CitilabsCitilabs based travel demand model is possible.

At present, \(\mathrm{iPLACE}^{3} \mathrm{~S}\) is a proprietary system with a single hosting company. Its long term conversion to an open source business model is under consideration but this and future cost structures for services are uncertain at this time.

\section*{Envision Tomorrow}

The core of Envision Tomorrow (ET), developed by Fregonese Associates, is a place type painting system that allows a rapid assignment of place types to parcels. "Place Types" are functionally equivalent to those found in iPLACE \({ }^{3}\) S. \(\mathrm{ET}^{\prime}\) s place types are comprised to two levels of data. The lowest level is a building template that outlines buildings based on their square footage, uses and costs. These buildings are associated into community types which are the primary medium for assigning land uses and studying performance effects on a wide variety of variables similar
to those found in \(\mathrm{PPLACE}^{3} \mathrm{~S}\). For example a downtown commercial community type might have a mixture of mid and high rise commercial buildings with some retail and that mix would have a specific impact on travel demand, energy water use, health and so forth, consistent with the values for this place type in the literature and the size of the area covered by this type.

ET is being used by FresnoCOG for its development and testing of SCS scenarios and has been adapted by SCAG into a quick-response sustainability evaluation tool.

ET is the recent recipient of a Federal grant from the Housing and Urban Development Department. This grant is funding the transfer of Envision Tomorrow into Envision Tomorrow Plus (ET+). ET+ will be an open source toolkit with extensions similar to iPLACE \({ }^{3}\) S for the calculation of performance measures covering a wide range of topical areas. Unlike iPLACE \({ }^{3}\), ET and ET+ are not internet applications. They are extensions to ESRI's ArcGIS and have an evolving framework to support "plug-ins" that will extend its capabilities further. Once open source conversion is complete subscriptions to ESRI's software will be unnecessary

As part of the ET+ conversion, several extensions to ET are funded. One of these is a "Ds" processor that may be functionally similar to the tools being produced for UPlan and iPLACE \({ }^{3}\) S under the Statewide Tools for MPOs in the "parallel studies" section of this document.

\section*{Urban Footprint/RapidFire}

Urban Footprint is being developed by Calthorpe Associates under the Vision California Program of the California High Speed Rail Authority. Similar to ET+ and iPLACE \({ }^{3}\) S, Urban Footprint uses a place type system to represent the local mix of buildings and land uses at a parcel or small polygon level geography. Similar to UPlan, iPLACE \({ }^{3}\) S and ET+ it has a Ds processor slated for completion. Like iPLACE \({ }^{3}\) S, Urban Footprint is an internet based solution allowing shared access and very rapid processing for real time meeting use. Like ET+ it is written entirely using open source software and so it requires no ongoing software subscriptions fees for any software. Because the tool is still under development, its final specifications aren't available for review at this time, but previews of the tool are very promising.

RapidFire is a spreadsheet based tool also produced by Calthorpe Associates under the Vision California Program. It preceded the development of Urban Footprint and served as a platform for testing many of the functions that entered Urban Footprint, but remains a tool in its own right. It has been used by SCAG for scenario evaluation and by numerous advocacy groups as a scenario testing and outreach tool.

\section*{UPlan}

UPlan is a predictive model. It uses a simple disaggregation method to assign a set of land use classifications to the landscape based on the region's General Plans, or hypothetical growth plans, growth exclusion zones and discouragement areas, and a locally defined set of factors that represent attractions to growth in various land use categories at particular locations. UPlan tends to be run with fairly aggregate land uses. In order to accommodate travel models with complex demand generation categories, expansion techniques incorporating more diverse land use categories often need to be used UPlan, along with iPlace3s is the current target of a project that will create a new extension to create rapid feedback measures of VMT based on the developed environment, a Ds extension.

UPlan is familiar to the San Joaquin Valley, having been used extensively in the region for the San Joaquin Valley Blueprint. During this exercise, funded by the California Department of Transportation, all eight counties in the San Joaquin Valley prepared policy scenarios, implemented in UPlan to produce an outline for future growth. These scenarios strove to achieve several primary goals, the protection of the region's agricultural economy, conservation of natural resources, reduction in vehicle miles traveled, and the preservation of the region's distinctive communities.

\section*{CommunityViz}

CommunityViz is a commercially available extension to ArcGIS. CommunityViz provides land use painting support very similar to ET. It also provides both built in performance measure support for economic, environmental, social, and visual measures as well as a framework for creating new performance measures. CommunityViz's use of land use depends on the implementation but can resemble the place types systems used in other tools

CommunityViz does have an extension that provides land use prediction support. The underlying methods of this predictive system resemble UPlan, using similar inputs and algorithms.

\section*{Other Tools}

There are several other visioningvisioning tools, many of which are developing interfaces one of the platforms listed above:
- INDEX by Criterion Planners, is an ArcGIS extension with land use painting capabilities and more than 90 built in performance measures. It is available either as a standard install or can be customized under contract.
- Sonoran Institute Growth Model (SIGM), is a calibratable predictive model that allocates new housing units, or possibly employment locations to geographies, potentially TAZs, based on past behavior. The model is based on the Random Forest statistical methods, and is a likely contributor to the ET+ suite of tools.
- What If? A product of What If? Inc. This is a standalone GIS application, with a range of capabilities similar to CommunityViz (though not built as an ArcGIS extension). What If? Includes a site suitability analysis module which informs a future land allocation system similar to the methods used by UPlan and CommunityViz.
- MetroQuest is not primarily a tool developer, but instead is a provider of communication and visualization services. In the past MetroQuest has provided direct performance measure calculation, but the company is choosing to focus on the communication and outreach component of its profile.
- GreenSTEP_is a sketch planning model developed by the Oregon Department of Transportation to analyze various strategies for reducing statewide and metropolitan area greenhouse gas emissions from transportation. The model produces a wide variety of performance measures related to mode choice (pedestrian, bicycle, transit), costs related to mode choice, road tax revenues as well as emissions.

\section*{Developed Area}

Almost all of these tools can provide developed area measures either natively or with the use of GIS by a modestly skilled user. In many cases, the most time consuming portion of the process will be the necessary discussion that will define what outputs from the model are to be considered developed. Because most of these tools produce an output that can vary along several measures including the basic place type or land use as well as a measure of intensity of use, some agreement must be reached on what constitutes developed area. The definition applied in the existing analysis includes the bulk of urban developed space from the Farmland Mapping and Monitoring Program (FMMP) (California Department of Conservation) at one unit per 1.5 acres or approximately six structures per ten acres. Some additional data from the FMMP was provided identifying semi-agricultural and commercial, and explicitly identified rural residential locations for inclusion in built space. The 1.5 acres per structure threshold, in addition to its use by the FMMP, seems to match a natural threshold for what we perceive as developed.

\section*{"Cross-walking" land use from visioning categories to TDF catagories}

In any case some techniques will probably be necessary to translate or expand the output of any land use model to match the input needed to run a travel demand model. This translation can come in many forms. The most common is the development of a demographic profile from the land use model that is consistent with the input expectations of the travel model being used. At
present most of the land use modeling does not have as many demographic classes as the travel models utilize and so some method is needed to expand the classifications available from the land use model.

A commonly used method will be a disaggregation of the model output into the needed classifications. This should be considered a family of techniques, not a single method. For descriptive purposes we will outline the simplest method, and very briefly describe a more complex method.

Most of the disggregations used within the San Joaquin Valley will be simple disaggregations of an existing total which we will call the "parent class" into finer classifications called "children." A set of existing or assumed distributions will be used to set proportions of children within their parent class. For example if we have a parent class that includes all office workers, and children that include real estate, financial, and others. Let's assume we know the total of the parent class members from a land use model that estimates the total demand for office space based on the total number of future office workers and a formula for the amount of building space needed for each office worker. Let's further assume that we have some base year data for the proportion of office workers that are in each of three different kinds of office employment. We can then apply that proportion to the total of all office workers in the model. We could also do this with hypothetical future distributions of the types of office employment that will occur in the growth area. We could also distribute the proportion of these children office employment classes differently in different travel analysis zones (TAZs) if we had a hypothesis, or simply a desire to test, such differential distribution.

\section*{What is needed to implement the Cube Land model in its current state?}

The current implementation of Cube Land is calibrated with local skim data and national or valleywide pricing information. The SE Detail file is sufficient to start using the model as is, after the data are aggregated into the appropriate files for use in Cube Land. See training videos for instructions on using the data from the SE Detail file to create summaries for Cube Land.

\section*{What are MPOs around the state doing to account for recession induced demographic forecast changes?}

\section*{Large MPO}

\section*{SACOG \({ }^{1}\)}

The Sacramento Area Council of Governments (SACOG) commissioned a new set of job, population and housing projections that was prepared by Stephen Levy of the Center for Continuing Study of the California Economy (CCSCE) and Viviane Doche-Boulos of DB Consulting. These projections covered the entirety of the six county SACOG region (Sacramento, Placer, El Dorado, Yolo, Sutter and Yuba Counties) and did not contain any subregional projections. The responsibility for sub-regionalization of these growth projections resided with SACOG staff.

The demographic projection team of Levy and Doche-Boulos identified a set of factors that they forecast will govern the SACOG region's growth.
- Factors that predate the recession:
- California no longer significantly outpaces the nation in job growth
- Housing prices and construction had begun to decline prior to the beginning of the recession
- State budget challenges also predated the recession.
- Factors that were not affected by the recession:
- Baby boomers are transitioning from family formation and wage earning into retirement.
- Population growth will be largely in Hispanic and Asian populations both through immigration and births.
- Factors that were affected by the recession
- Foreign immigration has slowed.
- The region is slowly recovering from the worst recession since the Great Depression. The housing market correction and state budget challenges will influence job and income levels within the state government, the region's largest economic base sector.

The methodology for developing SACOG's regional projections stems from a method that uses standard population growth measures for a population evolving in place over time with some initial assumptions about domestic and foreign immigration rates. This population estimate was

\footnotetext{
\({ }^{1}\) "Draft Final Regional Projections Report Oct 12 2010.doc" Provided by Bruce Griesenbeck, Principal Transportation Analyst
}
then used to derive a labor force estimate which was then compared to a regional labor demand estimate. The regional labor demand estimate was derived in the following manner; first, the U.S. outlook for jobs was estimated by CCSCE. Second, California's share of the national jobs was projected. Finally, SACOG's regional share of those jobs was projected. The labor force projections derived from the demographic forecast were then compared to the labor force demanded by the jobs projections and the domestic migration rates in the demographic forecast were adjusted so that the labor force forecast matched the labor demand projection. The final population projection contained an enumeration by five year age group of sex and ethnic group for Hispanic, non-Hispanic White, Non-Hispanic Black, and Non-Hispanic Asian and others. Household projections were arrived at through using household formation rates by age and ethnic group as applied to the population projection.

Because of the time period during which the analysis was conducted (Early 2010), a great deal of uncertainty remained regarding the pace of economic recovery. The national projections were adjusted to reflect a small decrease in immigration rates and population growth, a small increase in the long-term equilibrium unemployment rate and a small decrease in labor force participation rates. The regional effect was that modest downwards effects are forecast to 2020 with smaller effects possible to 2035. Additionally, the regional forecast was influenced by a lower expectation of growth in state government jobs and reduced construction as the existing vacant inventory of residential and commercial space is exhausted.

SANDAG \({ }^{2}\)
The San Diego Association of Governments uses a set of four integrated models for demographic and land use forecasting. The Demographic and Economic Forecasting Model (DEFM) provides region wide demographic and economic forecasts. These forecasts are then used by the Urban Development Module (UDM), Population Age, Sex and Ethnicity Forecast (PASEF), and Interregional Commute Model (IRCM). Land use and transportation policies provide additional control to the UDM, PASEF, IRCM and the linkages to the travel demand model (Figure 1). The sizable military component of the San Diego economy and population is treated as an exogenous input to the majority of the model components.

Figure 1: Overview graphic of SANDAG's modeling framework.

\footnotetext{
\({ }^{2}\) http://www.sandag.org/index.asp?subclassid=118\&fuseaction=home.subclasshome
}


The DEFM is a linked econometric and demographic model for projecting the regions annual economy and demographics. The economic component of DEFM links historical changes in the region's economy to historical changes in the national economy through a set of linked economic functions governing fifty industries. It calculates resulting employment estimates, personal income and living costs and is sensitive to housing supply estimates and projections of public finance and facilities development (Figure 2). The demographic component of DEFM uses a cohort-survival model to forecast age, sex and ethnicity. The demographic component makes assumptions about domestic and foreign immigration based on historical figures and the difference between an available interregional workforce (the region proper plus the area defined in the interregional commute model) and labor demand forecast by the econometric model.

Figure 2: Economic linkages within the econometric component of DEFM


The Interregional Commute Model accounts for workers that have employment in the region but reside outside of the county. Workers are assigned living space in one of five regions; in San Diego County, Orange County, southwest Riverside County, Imperial County, or Tijuana/Northern Baja California (Mexico). The result is a count of housing units built in the region or in each of the surrounding areas to accommodate the labor force.

The Urban Development Model (UDM) allocates employment, population, housing, and income from the DEFM to sub-regional geographies in five year increments. This model operates by first allocating regional employment, and then allocating residential activity based on the prior employment allocation. The PASEF module produces detailed demographic disaggregation at a neighborhood level. Military and college populations are addressed independently of the remainder of the county population. For that remainder, population projections are disaggregated from larger regions to smaller (county/region \(\rightarrow\) SRA \(\rightarrow\) census tracts \(\rightarrow\) MGRA) with the larger areas providing control totals to the smaller geographies. This disaggregation is a two-step process with the first being the assignment of sex and ethnic population totals based on SRA level historical trends. Then age is forecast by 5 year age classes.

The modeling frame work is reviewed and advised by a wide range of professionals drawn from the region's jurisdiction and containing experts drawn from the fields of demographics and economics representing both the public and private sectors, forming a regionwide Forecast Technical Advisory Working Group. This group has the responsibility of reviewing the model structure, inputs, assumptions and evaluating the model outputs.

\section*{Rural MPOs}

\section*{Butte County Association of Governments (BCAG) \({ }^{3}\)}

BCAG produced a set of population forecasts (low, medium, and high growth) for population, housing and employment in 2010. These forecasts represent the first attempt by BCAG to account for the effects of the economic downturn in their forecasts. Population, housing, and employment forecasts were prepared for each five-year period between 2010 and 2035 for each scenario.

The methodology adopted by BCAG involved the use of California Department of Finance (DOF) and Employment Development Department (EDD) projections for the county as a baseline population, housing and employment projection for the county.

The most recent DOF forecast was set as the "high" growth line for housing with a compound annual growth rate of \(1.8 \%\). Local land use planning staff provided input on their jurisdiction's growth plans generating a \(1.6 \%\) annual growth rate as the medium forecast. This process also generated baseline shares of growth for each jurisdiction. A 1.4\% growth rate was then selected as the low based on the \(0.2 \%\) difference between the high and medium.

The population was assigned by applying jurisdiction specific persons per household to the high, medium and low household projections.

Employment forecasts were generated based on a figure for jobs per housing unit calculated based on the 2009 EDD county level. The 2009 EDD data generated 0.74 jobs per housing unit. Historic employment information produced 0.78 jobs per housing unit. An average of the two ( 0.76 jobs per housing unit) was also calculated. These were then applied so that 0.74 rate was applied for the years 2010-2015, 0.76 is applied for 2015-2020, and a return to the historic rate of 0.78 for 2020 and beyond.

\section*{Shasta County Regional Transportation Planning Agency \({ }^{4}\)}

Demographic and Land use forecasts for Shasta County were updated in 2011 based on California County-Level Economic Forecast 2010-2035 5 by the Office of Transportation

\footnotetext{
3 "Growth_Forecasts_2010-2035.pdf" Provided by Brian Lasagna, Senior Planner, Butte County Association of Governments

4 "111010 memo Shasta forecasts.pdf" Provided by Dan Wayne, Senior Planner, Shasta County Regional Transportation Planning Agency
\({ }^{5}\) http://www.dot.ca.gov/hq/tpp/offices/eab/socio economic.html
}

Economics, Division of Transportation Planning, California Department of Transportation. This document provides a post-economic downturn projection that is not provided by the 2007 California Department of Finance Forecasts.

The population forecast is based on the 2010 census plus the Caltrans Economic Forecast growth rate applied to each preceding year's population total. For example the 2015 population is equal to the compounding growth generated by applying the annual growth rate of \(0.67 \%\) to the 2010 population to generate the 2011 population, and then the same rate applied to the 2011 population to generate the 2012.

Housing estimates start with the 2010 U.S. Census household count. The estimates for each five year period are created through applying the growth rates from the Caltrans Economic Forecast in the same manner as for population.

Employment projection come from a base of the 2010 California Employment Development Department estimates of employment, adjusted by a factor (8\%) to account for part-time workers, self-employed, and other uncounted workers). This base is then increased by the growth rates from the Caltrans Economic Forecast using the same method as population and housing.

Because there was a net decrease in employment for Shasta County between the earlier 2004 land use inventory and the 2010 base year, Occupancy rates were adjusted downward by industry. These occupancy rates are projected to increase back to historic levels by 2030.

Jurisdictional estimates were prepared as shares of the total based on recent independent economic forecasting (City of Redding), or an older study from 2005 for the remainder.

\section*{How do parallel studies provide information for SJV models?}
- Statewide projects
- Vision California - is developing future planning scenarios for the San Joaquin Valley and most of the rest of California to represent growth conditions with and without the presence of California High Speed Rail. It is applying a consistent statewide land use representation consisting of about 30 place types applied at a level of detail captured in 5 -acre grid cells throughout the state. The study will apply sketch planning models to forecast future regional and statewide vehicle trips and VMT and about ten other indicators of environmental and economic impact. While local land use data and forecasts are preferred for official business it is very helpful to have unofficial scenarios that assist the public and decision makers in understanding the relative differences between generalized planning
patterns along a wide range of variables. The Vision California scenarios may be used as guidance to MPOs in formulating their own long range growth concepts.
- The California Statewide Travel Demand Model was designed to capture the interactions of land use plans all across the State as they affect interregional travel. The model operates at a scale coarser than the SJV-wide model and far coarser than local models. Its value is in placing local and regional travel in the context of total statewide activity. Understanding the origin and destination of long distance trips outside of a region can certainly help with planning for methods to reduce VMT and to capture more economic activity within a region.
- The PECAS model, a zonal economic model of California, will provide detailed forecasts of economic activity for a wide variety of industries and households in the San Joaquin Valley. 95 of the models 526 zones are in the San Joaquin Valley. The model will depict how the SJV zones compete with all of California for economic activity, job growth, land development and a wide variety of variables. This will provide another source of information on economic growth, job growth and population growth the decision makers and the public in the San Joaquin Valley. At present the model is \(60 \%\) complete but funding has been temporarily suspended due to the State's fiscal crisis. The PECAS model was originally slated for completion in December of 2012. There is now no certain date for completion of this valuable model.
- Statewide Planning Tools for MPOs - Caltrans is sponsoring a study to develop planning tools to capture the effects of different land use planning strategies in MPO models throughout the state. The effects of 4D land use variables are being quantified through analysis of National Household Travel Survey data for all of the state's medium and smaller MPOs, and the 4D effects are being installed in post-processors intended for use with regional travel models and in land use planning and visualization tools iPLACE \({ }^{3}\) S and UPLAN. Demonstration projects will be included in the study that will implement the tools in two of the eight Valley counties.
- Regional Projects
- The San Joaquin Valley Wide Model (SJVWM) being developed by ULTRANS at the University of California to accomplish two major goals. The first is to provide a consistent approach to forecasting interregional trips across all 8 of the MPOs in the San Joaquin Valley. With multiple models using multiple methodologies to forecast local travel in each MPO there are bound to be differences in conclusions about interregional trips across any boundary in the Valley. The SJVWM can be used as a single consistent source of these forecasts. The second goal is to improve understanding of the relationship of long distance trips leaving the SJV,
coming into the SJV or passing through the SJV. The SJVWM will connect to the CSTDM in a way that will create more precision regarding the origin and destination of these long distance trips. This information will hopefully aid in the development of economic, land use and transportation policies and investments that favor the capture of more economic activity within the SJV.
- Table of project, contact, current status, portions of SJV model that can be updated
\begin{tabular}{|c|c|c|}
\hline Valley Modeling \\
Milestone & \(\begin{array}{c}\text { Source Data or Study } \\
\text { (Date Available) }\end{array}\) & \multicolumn{1}{c|}{\(\begin{array}{c}\text { Update Activities }\end{array}\)} \\
\hline & \(\begin{array}{c}\text { Caltrans Statewide Planning } \\
\text { Tools for MPOs (model post } \\
\text { processors to account for } \\
\text { regionally-specific land use } \\
\text { sensitivities }\end{array}\) & \(\begin{array}{c}\text { Integrate new post-process tools } \\
\text { (May/June 2012) }\end{array}\) \\
\hline with VMIP models for all 8 MPOs (six \\
beyond the two Caltrans \\
demonstrations)
\end{tabular}\(\}\)
\begin{tabular}{|c|c|c|}
\hline & CSTDM Forecasts
(2012/2013) & Incorporate updated interregional travel forecasts into VMIP models for RTP forecasting \\
\hline 20_Conformity Analysis & \begin{tabular}{l}
2010 Census \\
2009 National Household Travel Survey
\end{tabular} & Recalibrate VMIP Models \\
\hline \multirow{2}{*}{2016/ 2017 SCS Development} & California Statewide Travel Survey & \begin{tabular}{l}
Recalibrate VMIP Models \\
Recalibrate SJVWM
\end{tabular} \\
\hline & Update interregional GPS travel survey & Recalibrate VMIP Models \\
\hline 2017/ 2018 RTP & & \\
\hline
\end{tabular}

\section*{What policies can be tested with the trip model?}
- Roadway network changes, including HOV/HOT lanes, and truck-only and transit-only lanes and facilities
- Transit network and service frequency enhancement
- Areawide jobs-housing ratio policies
- Land use density, diversity and access factors
- Changes in density of residential and non-residential land uses
- Changes in land use mix (diversity)
- Note: the trip models are most sensitive to density and diversity changes when these cover several TAZs, i.e., the area covered by a General Plan or a larger Specific Plan
- Local access changes that can be adequately represented by model network changes (including centroid connectors)
- Pricing Policies
- VMT charges (costs applied to all links)
- Road tolls (cost applied to select links)
- Parking charges (costs applied to select zones)
- School location

\section*{What additional policies can be tested with the ABM?}

Activity-based models provide sensitivity to more aspects of travel behavior than trip-based model and they also provide more precision about policies that trip-based models can test. Some examples of additional policies that can be tested with the ABM include:
- Travel demand management strategies, such as telecommuting (work-at-home) policies, flexible work schedules, and ridesharing programs. An example of a flexible work schedule program in Burlington, Vermont shows that the ABM produces fewer, and earlier, work trips and more non-work trips in the morning and evening.

Difference in Trips by Time of Day

- Environmental strategies to reduce greenhouse gas and other emissions. Trip chaining provides better data on starts and stops for emissions analysis, disaggregate data provides more accurate estimates of emissions, and compact urban form and transit oriented development policies can be better represented in ABM. Emissions can be reported based on the household producing the emissions in addition to the location where the emissions occur (on a link) so that policies for reducing household travel can be evaluated. An example of greenhouse gas emissions by residence parcel from Sacramento demonstrates suburban and rural areas with the highest generations of emissions.

- Parking strategies. Parking is directly represented in the ABM and can influence choices to avoid downtown destinations or park at transit stops if parking policies change. Parking supply and cost will influence travel demand in a broader way as well.
- Capacity improvements. Adding capacity to the highway or transit system can induce demand because of better travel opportunities. This is represented in several ways in the ABM as changes in vehicle ownership and changes in accessibilities affect work and school locations and daily activity patterns.

There are also improvements in accuracy for policies that affect an individual's travel behavior:
- Pricing policies. ABMs evaluate time and cost tradeoffs individually that people make to consider whether to pay a toll and these tradeoffs affect their choice of route, time of travel, mode, destination, vehicle occupancy, parking, work and school location, and vehicle ownership. Individual time and cost tradeoffs can vary by income, trip purpose, and other factors.
- Land use and transit strategies. The additional detail with either parcels or microzones allows for a more detailed evaluation of the impacts of changes in land use or transit. Small changes in transit stop locations or land use density can have impacts on travel demand that are difficult to capture in a zone-based model.
-
What policies can be tested with the quick-response tool (QRT)?
- Land use density, diversity and access factors at the
- Changes in density of residential and non-residential land uses
- Changes in land use mix (diversity)
- Intensification of the local pedestrian network (measures as the number of intersections per acre)
- Transit service improvements, as reflected in the amount of employment accessible within 30 minutes of a TAZ
- Local Jobs/Housing balance, as reflected in employment within one mile of a TAZ
- Note: the QRT is most sensitive to density and diversity changes when these affect one or at most a few TAZs, i.e., the area covered by a typical development project or a smaller Specific Plan
- Transportation Systems Management (TSM)
- User identifies a TSM strategy's effects on speed is for affected roadway segments; QRT summarizes VMT by speed and estimates GHG reduction
- Travel Demand Management (TDM)
- QRT can model the Valley Air District Rule 9410 compliance (this rule tasks large employers with attaining a goal of no more than one car driven to a work site for every 1.3 employees at that site
- Other demand management programs whose effectiveness can be expressed in terms of a percentage reductions in a class of vehicle trips (e.g. home-based work trips or non-home-based trips).

\section*{How can the demand management reductions be quantified for the QRT?}
- Local data e.g., from employer surveys is ideal.
- CAPCOA has compiled information on the effectiveness of many demand management projects in a 2010 resource document Quantifying Greenhouse Gas Reduction Measures: http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf
- In quantifying TDM reductions from other studies, consider the following:
- Thoroughness of the study - e.g. does is account for exogenous factors like changing fuel costs?
- Is it from a similar area in terms of employment type, land use and transportation modes available?
- Generally, local and recent studies are the most applicable

\section*{How can tansportation system management projects be quantified?}
- Collect local data on relevant projects, ideally actual before and after data
- For example, before and after studies of operational improvements that result in ssmoothing of traffic speeds and flow on on an arterial.
- If actual before and after studies are not available, data from environmental studies for the TSM project or a similar TSM project may be used
- Apply this data using the QRT to estimate GHG for VMT on affected facilities

\section*{How can the QRT be applied for regional quantification?}
- Quantify reduction for given location, as described immediately above
- Identify similar locations, apply reductions
- This is especially appropriate for a mandated reduction for all employers in a class (e.g. 100+ employees; all public employers; all schools; etc.

\section*{How can the OD survey be expanded, updated, or applied to other SJV MPOs?}

The survey data can be obtained for any area for any time in the past. As noted in the OD survey memo, future classification of travel patterns to include IX/XI and XX is desired. The standard descriptions have since been clarified with the data vendor and future studies will not have a classification issue.

How can external gateways, routes, or adjacent MPOs be included in the future?

Expanding the geographic coverage of counts, surveys, and cell phone data collection to include multiple areas. As the area expands, intra-study area counts may be desired to have screenlines within the study area collected.

\section*{What is the current status of EMFAC relating to conformity and SB 375?}
\begin{tabular}{|l|l|l|l|}
\hline Work Element & Anticipated Schedule & \begin{tabular}{l} 
Anticipated \\
Transportation Model
\end{tabular} & \begin{tabular}{l} 
Anticipated Emissions \\
Model
\end{tabular} \\
\hline 2013 FTIP Update & \(1^{\text {st }}-2^{\text {nd }}\) quarter 2012 & Current (NOT MIP) & EMFAC 2007 \\
\hline \begin{tabular}{l}
2012 SB-375 Target \\
Update
\end{tabular} & \(1^{\text {st }}-3^{\text {rd }}\) quarter 2012 & MIP & To be determined \\
\hline 2012 SIP Updates & \(1^{\text {st }}-3^{\text {rd }}\) quarter 2012 & MIP & EMFAC 2011 \\
\hline
\end{tabular}
\begin{tabular}{|l|l|l|l|}
\hline \begin{tabular}{l} 
2013 \\
Amendment
\end{tabular} & FSTIP & \(1^{\text {st }}\) quarter 2013 & To be determined
\end{tabular} EMFAC 2011 \(\quad\)\begin{tabular}{|l|l|l|}
\hline 2014 RTP & 2013 & MIP \\
\hline
\end{tabular}

NOTE: The interagency consultation for the 2013 FTIP and conformity analysis began in February 2012. The MIP models are anticipated to be delivered March 2, 2012. It is important to note that it is anticipated that the MIP models will continue to be refined after receipt, including potential updates to underlying data e.g., population and land use) and continued improvement to model validation/calibration. While the goal is to use the MIP models for planning purposes in 2012 (e.g., SB-375 Target Update and 2012 SIP Updates), it is anticipated that the MIP models will be approved by the MPOs for transportation conformity purposes in conjunction with the 2014 RTP.

\section*{Where is the Smart Growth Sensativity (aka "Ds") adjustment applied in the travel model and how do we know it is a valid method?}

The "Ds" are applied after daily mode choice just before diurnal factoring, and apply to vehicle trips only. Currently the models show enough sensitivity so additional adjustments are not needed, but the mechanism is in place to enhance further if needed. See Memo Comparing ARB to MXD 4.0 elasticities on validity of the method.

\section*{Capabilities of Regional Visioning and Scenario Planning Design Tools for Evaluating Interactions between Land Use and Transportation}

Tools
- CommunityViz \(\quad\) Envision Tomorrow
• Urban Footprint \(\quad \bullet\) Rapid Fire - MetroQuest

\section*{Data Needs, Capabilities and Metrics Produced}
\begin{tabular}{|c|c|c|c|}
\hline & \begin{tabular}{l}
Macro \\
Regional
\end{tabular} & \begin{tabular}{l}
Meso \\
Sub-regional /corridor
\end{tabular} & \begin{tabular}{l}
Micro \\
Neighborhood /community
\end{tabular} \\
\hline \multicolumn{4}{|l|}{Land Use Representation} \\
\hline - Place-types & - ० ०००७ & - - ०००७ & - ० - ० - \\
\hline - Parcel Based & - - - - - & - - - - - & - ○○○• \\
\hline - Grid-Cell Based & - - - - & - - ०० & - - - - \\
\hline - Census Block & - - - - & - - - & - - - - \\
\hline - Traffic Analysis Zone & - - - & - - - - & - - - \\
\hline \multicolumn{4}{|l|}{Major Transport Net Representation} \\
\hline - Internal major multi-modal network & - - & - - & - - \\
\hline - Shares data with network model & - ० - ० - & - ० - ० - & - - - ० - \\
\hline - Only local connectivity and transit stations & - - & - - & - - ७ - \\
\hline \multicolumn{4}{|l|}{Relationships Addressed} \\
\hline - Built Environment \(\rightarrow\) Demand &  & - ○○७ゃ७ & - ○○○○ \\
\hline - Demand Management \(\rightarrow\) Demand & - - & - - & - - \\
\hline - Demand + Supply \(\rightarrow\) Congestion & \(\bullet\) - & - & - \\
\hline - Feedback/ Induced Growth & \(\bullet\) & \(\bullet\) & -- \\
\hline - Feedback/ Induced Travel & \(\bullet\) & - & -- \\
\hline Capabilities of Planning Tools for Evaluating Interactions between Land Use and Transportation (continued) & \begin{tabular}{l}
Macro \\
Regional
\end{tabular} & \begin{tabular}{l}
Meso \\
Sub-regional /corridor
\end{tabular} & \begin{tabular}{l}
Micro \\
Neighborhood /community
\end{tabular} \\
\hline Metrics Produced & & & \\
\hline
\end{tabular}
\begin{tabular}{|c|c|c|c|}
\hline - Daily Vehicle Trips and VMT & - ० - - & - ०००० & - ००० \\
\hline - Daily Transit Trips or Share & - ०७ - & - ० - - & - ०००० \\
\hline - Vehicles by Purpose, Peak Periods & - & - - - & - - - \\
\hline - VHT, VHD, Emissions, Energy & - ० - - & - ००७७ & - ००० \\
\hline - Traveler Cost & - - & - - - & - - \\
\hline - Development Cost & - ० - - & - ० ० - & - ० - - \\
\hline - Transportation System/ Service Cost & \(\bullet\) & \(\bullet\) & \(\bullet\) \\
\hline - Location Efficiency & - - - & - - - & - - - \\
\hline - Economy, Property Values, Jobs & - ०७७ & - ००० & - ०० - \\
\hline - Environment and Equity & - ० - - & - ० - - & - ०० - \\
\hline - Livability, Community Character & - ००० & - ० - - & - - - \\
\hline - Building Energy Use and Emissions & - - & - - & \(\bullet\) \\
\hline - Building Water Use and Emissions & - - & - - & \(\bullet\) \\
\hline - Public Health Impacts and Costs & - & - - & \(\bullet\) \\
\hline - Local Infrastructure Costs (Capital, O\&M) & - & - & - \\
\hline - Local/jurisdictional revenues & - - & - - & \(\bullet\) \\
\hline - Land Consumption & - - & - - & \(\bullet\) \\
\hline - Fiscal Impact & \(\bullet\) & \(\bullet\) & - \\
\hline - Resource Usage and Waste Generation & \(\bullet\) & \(\bullet\) & \(\bullet\) \\
\hline - Housing Affordability & \(\bullet\) & \(\bullet\) & - \\
\hline
\end{tabular}

APPENDIX J:
STATIC VALIDATION GUIDANCE

TABLE J-1:
DRAFT SUMMARY OF MOLEL
\begin{tabular}{|c|c|c|c|c|c|}
\hline Model Component & Validation Statistic & Evaluation Criterion & Source & Notes, further guidance \({ }^{1}\) & Documentation \\
\hline \multicolumn{6}{|l|}{Static Validation} \\
\hline \multirow[t]{2}{*}{Transit Assignment} & \begin{tabular}{l}
1. \\
Difference between actual ridership to model results for entire system
\end{tabular} & +/-20\% & 2010 RTP Guidelines Daily & Source of actual daily ridership: http://www.ntdprogram.gov/ntdprogram/archives.htm (National transit database for base year, typically 2008) 2010 RTP Guidelines specify difference between actual ridership to model results for a given year by route group (i.e., Local Bus, Express Bus, etc.). However, National transit database only specifies transit ridership for entire system. Valley Transit operators do not use consistent route groups. & Table \\
\hline & \begin{tabular}{l}
2. \\
\% of Links within \\
Caltrans Deviation \\
Allowance
\end{tabular} & At Least 75\% & \begin{tabular}{l}
2010 RTP Guidelines \\
Travel Forecasting Guidelines, Caltrans, 1992
\end{tabular} & Source of traffic data: Vehicle count database for each County for comparison Daily, non directional & Table, Figure of location and deviation color (valid, +1, +2, -1, 2). Graph (model validation scatter plot). \\
\hline \multirow[t]{3}{*}{Traffic Assignment} & \begin{tabular}{l}
3. \\
\% of Screenlines within Caltrans Deviation Allowance
\end{tabular} & 100\% & \begin{tabular}{l}
2010 RTP Guidelines \\
Travel Forecasting Guidelines, Caltrans, 1992
\end{tabular} & Daily, non directional & Table \\
\hline & 4. Correlation Coefficient & At Least 0.88 & 3.2010 RTP Guidelines Travel Forecasting Guidelines, Caltrans, 1992 & Daily, non directional & Table \\
\hline & \begin{tabular}{l}
5. \\
Percent Root Mean Squared Error (RMSE) (model-wide)
\end{tabular} & Below 40\% & 2010 RTP Guidelines & Daily, non directional & Table \\
\hline
\end{tabular}
TABLE J-1:
\begin{tabular}{|c|c|c|c|c|c|}
\hline \multicolumn{6}{|l|}{\begin{tabular}{l}
TABLE J-1: \\
DRAFT SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION
\end{tabular}} \\
\hline Model & Validation Statistic & Evaluation Criterion & Source & Notes, further guidance \({ }^{1}\) & Documentation \\
\hline & \begin{tabular}{l}
6. \\
Percent Root Mean Squared Error (RMSE) (functional classification)
\end{tabular} & Below 40\% & & \begin{tabular}{l}
No specific criteria available Daily, non directional Functional Class: \\
Freeway \\
Highway \\
Expressway \\
Arterial \\
Collector
\end{tabular} & Table \\
\hline & \begin{tabular}{l}
7. \\
Percent Root Mean Squared Error (RMSE) (volume range)
\end{tabular} & \[
\begin{aligned}
& 0-4,999-<116 \% \\
& 5,000 \text { to } 9,999- \\
& <43 \% \\
& 10,000 \text { to } 19,999- \\
& <28 \% \\
& 20,000 \text { to } 39,999-< \\
& 25 \% \\
& 40,000 \text { to } 59,000-< \\
& 30 \% \\
& 60,000 \text { to } 89,999-<- \\
& 19 \%
\end{aligned}
\] & Harvey, G., et al. A Manual of Regional Transportation Modeling Practice for Air Quality Analysis for the Natural Association of Regional Councils, Washington, D.C. July 1993 & Is there a minimum number of counts in a volume range or functional class range that we want to consider? & Table \\
\hline & \begin{tabular}{l}
8. \\
Model Volume to Count Ratio (model-wide)
\end{tabular} & General relationship (i.e., high or low) between model volumes and counts & 2010 RTP Guidelines & \begin{tabular}{l}
Daily, non directional Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee. FHWA - identifies that model volumes should be within 5-10\% of observed traffic volumes on the highway network. \\
This is the range reference in TMIP, Model Validation and Reasonableness Checking Manual, 1997 for screenlines
\end{tabular} & Table \\
\hline & \begin{tabular}{l}
9. \\
Model Volume to Count Ratio (roadway functional classification)
\end{tabular} & Freeway - +/- \(7 \%\)
Major Arterial -
\(10 \%\)
Minor Arterial -
15\%
Collector - 25\% & TMIP, Model Validation and Reasonableness Checking Manual, 1997 & \begin{tabular}{l}
Daily, non directional \\
Percent difference targets for daily traffic volumes by facility type.
\end{tabular} & Table \\
\hline & \begin{tabular}{l}
XX. \\
Distribution of Class by Time of Day
\end{tabular} & Comparison to collected count data & & Total vehicles trips stratified by class and time of day. & Table \\
\hline
\end{tabular}
TABLE J-1:
DRAFT SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION
\begin{tabular}{|c|c|c|c|c|c|}
\hline Model & Validation Statistic & Evaluation Criterion & Source & Notes, further guidance \({ }^{1}\) & Documentation \\
\hline & \begin{tabular}{l}
\(X X\). \\
.Distribution of Time of Day by Class
\end{tabular} & Comparison to collected count data & & Total vehicles trips stratified by time of day and class. & Table \\
\hline & \begin{tabular}{l}
10. \\
Model Volume to Count Ratio (volume range)
\end{tabular} & \[
\begin{aligned}
& <1,000<60 \% \\
& 1,000-2,500 \\
& <47 \% \\
& 2,500-5,000- \\
& <36 \% \\
& 5,000-10,000- \\
& <29 \% \\
& 10,000-25,000- \\
& <25 \% \\
& 25,000-50,000- \\
& <22 \% \\
& >50,000-<21 \%
\end{aligned}
\] & TMIP, Model Validation and Reasonableness Checking Manual, 1997 & Percent difference targets for daily traffic volumes for individual links. & Table \\
\hline \multicolumn{6}{|l|}{Reasonableness Checks} \\
\hline Highway and Transit Networks & \begin{tabular}{l}
11. \\
General roadway network and transit line coding
\end{tabular} & Reasonableness Check & TDF Model & Centerline & \\
\hline Trip Generation & \begin{tabular}{l}
12. \\
PA Balance
\end{tabular} & +/- 10\% by purpose and overall & TDF Model & after including IX/XI trips & Table or bar chart comparing balance before and after adjustment \\
\hline Trip Distribution & \begin{tabular}{l}
13. \\
Zonal Trip Distribution
\end{tabular} & & TDF Model & Select link assignment for gateways, TAZ near gateway, and TAZ central to model network. & Network bandwidth plots. \\
\hline Vehicle Availability & 14. & & \begin{tabular}{l}
2010 ACS (Surveys from 2006-2010) \\
and \\
CAHHTS \\
http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001 Stw TravelSurveyWkdayRpt.pdf
\end{tabular} & \begin{tabular}{l}
County level comparison \\
Compare percent of households (single and multiple) with \(0,1,2,3+\) autos \\
CAHHTS includes survey data for Fresno, Kern, Merced, San Joaquin, Stanislaus, and Tulare counties. (Table 4, Pages 26-30)
\end{tabular} & \\
\hline
\end{tabular}
dTABLE J-1:
\begin{tabular}{|c|c|c|c|c|c|}
\hline Model & Validation Statistic & Evaluation Criterion & Source & Notes, further guidance \({ }^{1}\) & Documentation \\
\hline Feedback Loop & 15. & & & Convergence & \\
\hline \multicolumn{6}{|l|}{Comparisons} \\
\hline \multirow[t]{3}{*}{Land Use} & \begin{tabular}{l}
16. \\
Total Population
\end{tabular} & Within 3\% (based on RHNA criteria) & Census & by income group & Bar chart comparing model to census data. \\
\hline & \begin{tabular}{l}
17. \\
Total Households
\end{tabular} & Ideally within \(3 \%\) (RHNA criteria) & \begin{tabular}{l}
Census \\
or \\
Department of Finance
\end{tabular} & RHNA allocations are not anticipated until mid 2013 & Bar chart comparing model to census data. \\
\hline & \begin{tabular}{l}
18. \\
Total Employment
\end{tabular} & Note & Department of Finance & Check reasonableness of retail jobs per household and non-retail jobs per household. Job mix? & Bar chart comparing model to census data. \\
\hline \multirow[t]{2}{*}{Trip Generation} & \begin{tabular}{l}
19. \\
Person trip rates
\end{tabular} & & CAHHTS, ITE & Convert person trip rates to ITE rates using Ave Veh Occ by purpose & Table \\
\hline & \begin{tabular}{l}
20. \\
Average Trip Length by Purpose
\end{tabular} & & CAHHTS & 3-County model also has OD survey & Table \\
\hline \multirow[t]{2}{*}{Trip Distribution} & \begin{tabular}{l}
21. \\
Trip Length Frequency Distribution by Purpose
\end{tabular} & & CAHHTS & 3 -County model also has OD survey & Graph for each purpose \\
\hline & \begin{tabular}{l}
22. \\
Vehicle class
\end{tabular} & & Count data & Percent by class for each period Percent by time period for each class & Table \\
\hline Trip Assignment & 23. VMT & +/-5\% & \begin{tabular}{l}
HPMS \\
http://www.dot.ca.gov/hq/tsip/hpms/hpmslibrary
\end{tabular} & Compare countywide daily VMT estimate from HPMS (Table 10, Page 80) Reasonableness of comparison should be based on how the model compares to HMPS estimates. In general, The model should be VMT forecasts should be lower than the HPMS estimate, since HPMS VMT is estimated for local streets that are not in the model networks. & Table \\
\hline
\end{tabular}
TABLE J-1:
dRAFT SUMMARY OF MODEL PERFORMANCE - STATIC VALIDATION
\begin{tabular}{|c|c|c|c|c|c|}
\hline Model & Validation Statistic & Evaluation Criterion & Source & Notes, further guidance \({ }^{1}\) & Documentation \\
\hline & \begin{tabular}{l}
24. \\
Travel Speed by Functional Classification
\end{tabular} & & Existing Data & Compare by functional classification based on observed data. For all classifications, summarize average speed, minimum, and maximum. If observed data is not available, compare relative congested speed by functional class. & Table \\
\hline & \begin{tabular}{l}
25. \\
Average Travel Time by Trip Purpose
\end{tabular} & & CAHHTS & \begin{tabular}{l}
Daily \\
CAHHTS provide travel time for HBW trips and total trips. http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurvey s/Final2001 StwTravelSurveyWkdayRpt.pdf
\end{tabular} & Table \\
\hline Mode Split & \begin{tabular}{l}
26. \\
Mode split by purpose
\end{tabular} & & CAHHTS & Daily & Pie chart \\
\hline
\end{tabular}

APPENDIX K:
DYNAMIC VALIDATION GUIDANCE

TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE

Intent of rural vs. urban core is to test model sensitivity to destination proximity (p.55, point 2a)
TABLE K-1:

TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline
\end{tabular}

\footnotetext{
> Select two locations in a major
urban center. One location
> urban center. One location
should be a major street ac
> should be a major street across
a constraint (railroad track, river,
> or freeway). The other location
> should be a minor street.
> similar magnitude decrease in Graph comparing volume change for screenline facilities. volume. Screenline should show Network screen capture showing volume change using. Use
> \(\begin{array}{ll}\text { slight increase. } & \text { bandwidth to illustrate magnitude of change and color to } \\ \text { The influence area should be } & \text { distinguish increase or decrease. }\end{array}\) The influence area should be distinguish increase or decrease.
greater for the major street
> greater for the major street
compared to the minor street. In
> both cases, changes should be
> concentrated near the subject
link.
> Peak hour analysis
> Full model run (no peak period,
> off-peak period, or transit
assignment)
> off-peak period, or transit
assignment)
}
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Model Component} & \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline Assignment (2) & 4. Add/delete a Link & \begin{tabular}{l}
Select two locations in a major urban center. One location should be a major street across a constraint (railroad track, river, or freeway). The other location should be a minor street. For add-link test, expect increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. \\
For delete-link test, expect decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight decrease. \\
The influence area should be greater for the major street compared to the minor street. In both cases, changes should be concentrated near the subject link. \\
Peak hour analysis \\
Full model run(no peak period, off-peak period, or transit assignment)
\end{tabular} & Graph comparing volume change for screenline facilities. Network screen capture showing volume change using. Use bandwidth to illustrate magnitude of change and color to distinguish increase or decrease. & & X & \\
\hline
\end{tabular}
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|}
\hline & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline Expectation & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline
\end{tabular}

\footnotetext{
Select one location in a major
urban center, a major street
urban center, a major street
across a constraint (railroad
track, river, or freeway) that has
a defined screenline developed
\(\begin{aligned} & \text { with subject link and adjacent } \\ & \text { roadways. }\end{aligned}\)
\(\begin{aligned} & \text { Table comparing the following for the selected screenline for } \\ & \text { speed increase and speed decrease: }\end{aligned}\)
Increase and decrease posted Increase and decrease posted \(\quad\) Roadway
speeds by \(+/-10 \mathrm{mph}\) on
subject facility. As posted sp
is decreased, volume on selected - Posted speed
link should decrease and volume - Adjusted speed
on adjacent screenline links
should increase. As posted - Volume change
on adjacent screenline links
should increase. As posted
speed is increased, volume
speed is increased, volume on
selected link should increase and
\(\begin{array}{ll}\text { selected link should increase and } & \text { Network screen capture showing volume change using. Use } \\ \text { volume on adjacent screenline } & \text { bandwidth to illustrate magnitude of change and color to }\end{array}\)
links should decrease.
The influence area shou
The influence area should be distinguish increase or decrease. May need to post volume change
concentrated near the subject depending on the magnitude of change.
link.
Peak hour analysis
Full model run(no peak period,
off-peak period, or transit
assignment)
}
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline 6. Change Link Capacities & \begin{tabular}{l}
Select one location in a major urban center, a major street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. \\
Capacity added, increased volume on subject link. Parallel facility should show similar magnitude decrease in volume. Screenline should show slight volume increase. \\
Where capacity removed, decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight volume decrease. \\
The influence area should be concentrated near the subject link. \\
Peak hour analysis Full model run
\end{tabular} & Graph comparing volume change for screenline facilities. Network screen capture showing volume change using. Use bandwidth to illustrate magnitude of change and color to distinguish increase or decrease. & & X & \\
\hline
\end{tabular}
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & \begin{tabular}{l}
Recommended \\
by CTC 2010 RTP \\
Guidelines \({ }^{1}\)
\end{tabular} & Desirable Optional \\
\hline
\end{tabular}

\section*{㢄}

\begin{tabular}{ll} 
Table comparing & Although RTP \\
ridership before & Guidelines \\
mention \\
and after headway & \begin{tabular}{l} 
changing transit \\
changes.
\end{tabular} \\
\begin{tabular}{l} 
Bar charts
\end{tabular} & \begin{tabular}{l} 
speed, changes \\
co headways are
\end{tabular} \\
comparing same & a more feasible \\
information. & \begin{tabular}{l} 
policy change
\end{tabular}
\end{tabular}
FEHR \& Peers | DOWling AsSOCIATES | RSG | CS |
BOWman-Bradley | MCCOY-Roth | CAC | Citilabs
Increase/Decrease Transit
Headway
should respond in the range of elasticity form identified in the

Full model run(no auto assignment except within feedback loop)
Doubling and halving system-
wide fares. System-wide
wide fares. System-wide
ridership should
increase/decrease
elasticity from Table comparing daily system ridership before and after fare
change.
Table comparing daily system ridership before and after fare
change.
provides an absolute elasticity
range of -0.14 to -0.35 .
assignment except within
feedback loop)
feedback loop)
Doubling and halving system-
modeled ridership should
respond in the range of elasticity
form identified in the Traveler's
Response Handbook, which
provides an absolute elasticit
range of 0.3 to 1.0 .
Full model run(no auto
assignment except within
feedback loop)
7.
Increase/Decrease Transit
Fares
Transit Network (1)

9.
Transit Network
Transit Network (2)
Transit Network (3)
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Model Component} & \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline Travel Cost & 10. Increase/Decrease Toll Rates & \begin{tabular}{l}
1) Increase tolls model-wide Vehicle trips should decrease systemwide (other modes increase). \\
2) Select one location in a major urban center, a major street across a constraint (railroad track, river, or freeway) that has a defined screenline developed with subject link and adjacent roadways. \\
Toll decreased, decreased volume on subject link. Parallel facility should show similar magnitude increase in volume. Screenline should show slight volume decrease. \\
The influence area should be concentrated near the subject link. \\
Peak hour analysis \\
Full model run (no peak period, off-peak period, or transit assignment)
\end{tabular} & Graph comparing volume change for screenline facilities. Network screen capture showing volume change using. Use bandwidth to illustrate magnitude of change and color to distinguish increase or decrease. & & X & \\
\hline
\end{tabular}

For sub-area test, provide network screen capture showing volume
change using. Use bandwidth to illustrate magnitude of change
change using. Use bandwidth to illustrate magnitude of change
and color to distinguish increase or decrease. Provide table with
the following information:
\[
\begin{aligned}
& \text { - Percent change in lane miles } \\
& \text { - VMT } \\
& \text { - Percent change in VMT } \\
& \text { - Calculated elasticity } \\
& \text { - Published elasticity } \\
& \text { - Average trip distance by purpose }
\end{aligned}
\]

\section*{TABLE K-1: \\ SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE} Double and halve roadway
capacity and double number of
lanes in a major urban center. Percent change in VMT should decrease as capacity is halved
and increase as capacity and
number of travel lanes are
Calculate short-term elasticity
Cervero short-term elasticity =
0.20-0.50.
AM peak period
PM peak period
\(\begin{array}{ll}\text { Induced/Suppresse } & 11 . \\ \text { d Demand Tests } & \text { Double/Halve Roadway }\end{array}\)
d Demand Tests Capacity of Model Subarea
TABLE K-1:
summary guide to tests of dynamic model performance
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Model Component} & \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline Auto Availability and Auto Trip Variables & \begin{tabular}{l}
12. \\
Double Auto Operating Cost, Parking Cost, and Transit Frequency.
\end{tabular} & \begin{tabular}{l}
For a major urban center, double auto operating cost, parking cost, and transit frequency. Summarize change in vehicle trips, transit person trips, and walk/bike person trips. Increased auto operating and parking cost should result in lower vehicle ownership and trips. Transit, walk, and bike person trips should increase. Increased transit frequency should result in decreased vehicle availability and vehicle trips. Transit person trips and walk and bike person trips should increase. \\
Compare to literature, SACOG and Travelers Response Handbook. Observed elasticities vary; -0.2 is an approximate midpoint value (i.e., a \(20 \%\) reduction in vehicle trips/vmt vmt for a doubling in auto operating costs.
\end{tabular} & \begin{tabular}{l}
Provide a table that summarizes the following information for each test: \\
- Vehicle Availability/HH \\
- Vehicle trips \\
- Transit person trips \\
- Walk/bike person trips \\
- Difference \\
- Percent change from base model \\
Vehicle trips should be compared measured elasticity to literature.(0.2)
\end{tabular} & \begin{tabular}{l}
Sources: \\
http://onlinepubs.tr \\
b.org/onlinepubs/tc \\
rp/tcrp rpt 95c14.p \\
df \\
http://www.arb.ca.g \\
ov/cc/sb375/policie \\
s/pricing/roadpricin \\
g brief.pdf \\
http://www.arb.ca.g \\
ov/cc/sb375/policie \\
s/pricing/parkingpri \\
cing brief.pdf \\
Westside Mobility \\
Plan Model \\
Development \\
Report (Fehr \& \\
Peers); includes \\
summary of SACOC
\end{tabular} & X & \\
\hline
\end{tabular}
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE

First potential
solution for
unexpected results
from this and all D- \(\quad\) XX
tests below: check
centroid connector
length/impedance.
For a major urban center, doubl
each land use category to maintain the existing balance of land use so that the diversity is
not changed.
The models veh
The models vehicle trip elasticity
to a \(100 \%\) increase in density
should be about -0.04 .
и!
Density (4Ds)
TABLE K-1:
SUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Model Component} & \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline Diversity & \begin{tabular}{l}
14. \\
Optimizing Land Use Mix (Diversity) of a Single Area
\end{tabular} & \begin{tabular}{l}
Create a location that has a diversity score of 1.0 and modify the employment to create a diversity score of 0.5 . Diversity is calculated using the following formula: \\
Change in Diversity \(=\) Percent Change in \(\left\{1-\left[A B S\left(b^{*}\right.\right.\right.\) population \\
employment)/(b*population+em ployment)]\} \\
Where: \(A B S=\) absolute value; \(b=\) regional employment/regional population \\
For the select area of a major urban center, develop a test model that retains the regional average mix while maintaining the density level in the area to isolate the model's sensitivity to diversity. \\
A sensitive model should internalize a greater percentage of trips compared to an area that does not have a diverse land use mix. \\
Based on the 4D elasticity values, a 100 percent increase in overall diversity should result in a 6 percent reduction in vehicle trips (a -0.06 elasticity. Daily
\end{tabular} & \begin{tabular}{l}
Provide a table that summarizes the following information for the base model and test model: \\
- Vehicle trips \\
- Population \\
- Households \\
- Jobs \\
- Employment-to-population ratio \\
- Internal trips \\
- External trips \\
- Internal trips as a percent of total trips \\
Change if internal and external trips (test model - base model)
\end{tabular} & First Potential Solution - check centroid connector length/impedance. & X & \\
\hline
\end{tabular}
TABLE K-1:
sUMMARY GUIDE TO TESTS OF DYNAMIC MODEL PERFORMANCE
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{2}{*}{Model Component} & \multirow[t]{2}{*}{Test} & \multirow[t]{2}{*}{Expectation} & \multirow[t]{2}{*}{Output} & \multirow[t]{2}{*}{Notes, further guidance} & \multicolumn{2}{|l|}{Priority} \\
\hline & & & & & Recommended by CTC 2010 RTP Guidelines \({ }^{1}\) & Desirable Optional \\
\hline Urban Design/Walk & & Models presumed to be insensitive & & Will be modeled via BMP tool; adjusted trip table assigned by model & & \\
\hline Travel Demand Management & & Models presumed to be insensitive to most employmentsite TDM & & Will be modeled via BMP tool; adjusted trip table assigned by model (workrelated trips only) & & \\
\hline
\end{tabular}

APPENDIX T:
QUICK-RESPONSE TOOL


\title{
FehrłPeers
}

\section*{TECHNICAL MEMORANDUM}

Date: February 2, 2012
To: SJ Valley MIP Team
From: Richard Lee
Subject: D-Variable VMT Elasticities based on ARB Research and Comparison to Implied VMT Elasticities for MXD 4.0

WC10-2778-6

\section*{ARB RESEARCH ON D-VARIABLE VMT ELASTICITIES}

California Air Resources Board (ARB) staff have engaged researchers at UC Irvine (led by Dr. Marlon Boarnet) and UC Davis (led by Dr. Susan Handy) to identify the impacts on vehicle use and greenhouse gas emissions of key transportation and land use policies based on the scientific literature. ARB intends that these research results should help inform development of and potential improvements to the models and tools used by MPOs in the Valley and elsewhere for SB 375 implementation.

The outcomes of this research are summarized in this memo and more fully described in a series of policy and technical briefs that may found here:

\section*{http://arb.ca.gov/cc/sb375/policies/policies.htm}

For the Valley MIP models, model results for each D variable in each test zone will be calculated as an elasticity and compared to the range of elasticities found by the ARB-sponsored research.

Summary elasticity values for comparison to San Joaquin Valley MPO model results are shown in Table 1.

Table 1. Summary of ARB VMT Elasticities
\begin{tabular}{|l|c|c|c|c|}
\hline \multicolumn{1}{|c|}{ Variable } & \multicolumn{3}{|c|}{ Elasticities } & \multirow{2}{*}{ Notes and Caveats } \\
\cline { 2 - 3 } & Low & High & Average & \\
\hline \begin{tabular}{l} 
Residential \\
Density
\end{tabular} & 0.04 & 0.12 & 0.08 & \begin{tabular}{c} 
Literature largely focused on \\
urban areas
\end{tabular} \\
\hline \begin{tabular}{l} 
Land-use mix \\
(Entropy)measure)
\end{tabular} & 0.02 & 0.11 & 0.065 & \begin{tabular}{c} 
Self-selection effect may \\
overstate elasticities
\end{tabular} \\
\hline \begin{tabular}{l} 
Design Network \\
Connectivity
\end{tabular} & 0.06 & 0.12 & 0.09 & \begin{tabular}{c} 
Studies focus on residential \\
areas;
\end{tabular} \\
\hline \begin{tabular}{l} 
Regional \\
Accessibility
\end{tabular} & 0.13 & 0.25 & 0.19 & \begin{tabular}{c} 
Accessibility to Jobs (gravity \\
measure)
\end{tabular} \\
\hline \begin{tabular}{l} 
Distance to Transit \\
(job accessibility)
\end{tabular} & na & na & 0.05 & \begin{tabular}{c} 
Studies focused on metropolitan \\
areas only
\end{tabular} \\
\hline Soure ARB, 2011; Fhannn \\
\hline
\end{tabular}

Source: ARB, 2011; Fehr \& Peers

\section*{COMPARISON WITH MXD 4.0}

\section*{VMT Bridge}

The MXD 4.0 - the chosen tool for accounting for the effect of vehicular travel changes in response to local land use changes - estimates only percent reductions in VT and depends on external data for VMT estimates. The ARB research focuses solely on Vehicle Miles Traveled (VMT) as an outcome variable. Thus there is a need for a "bridge" multiplier between VT and VMT.

Prior summaries of national research suggest that the elasticities for vehicle trips and D variables track with VMT elasticities, but are generally slightly lower, as shown in Table 2. Table 2 also shows the midpoint multiplier

Table 2. Comparison of Range of Vehicle Trip and VMT Elasticities from Prior Studies
\begin{tabular}{|c|c|c|c|}
\hline Variable & Vehicle Trips & VMT & \begin{tabular}{c} 
Implied midpoint \\
VT \(\rightarrow\) VMT \\
Multiplier
\end{tabular} \\
\hline Density (Residential) & \(3 \%\) to \(12 \%\) & \(1 \%\) to \(17 \%\) & 1.2 \\
\hline Diversity (Mixed Use) & \(1 \%\) to \(11 \%\) & \(1 \%\) to \(13 \%\) & 1.15 \\
\hline Design (Network Connectivity) & \(2 \%\) to \(5 \%\) & \(2 \%\) to \(13 \%\) & 2.15 \\
\hline Destination Accessibility & \(5 \%\) to \(41 \%\) & \(20 \%\) to \(71 \%\) & 2.0 \\
\hline
\end{tabular}

Sources: Ewing/Cervero 2010, National Syntheses, Sacramento, Holtzclaw

\section*{Calculation of Individual Elasticities for MXD 4.0}

The MXD multi-tier regression model simultaneously considers the impact of the D-variables. To estimate the sensitivity of the MXD to individual D-variables, inputs corresponding to individual D variables were systematically increased by \(100 \%\) for a sample mixed use development (the Uptown Center in San Diego). The resulting change in VT corresponds to the MXD estimate of elasticity for that variable. The multiplier shown in Table 2 were then applied to the VT elasticities to estimate VMT elasticities

Results of this analysis are shown in Table 3. Table 3 also indicates that in most cases, MXD elasticities are within the lower end of the range of VMT elasticities summarized for ARB. For two D variables, Destinations and Distance to Transit, the MXD elasticities are lower than the low end of the ARB elasticity range. For these variables the MXD may be deemed overly conservative.

Table 3

\section*{MXD VERSION 4.0: Sensitivity to D Variables Comparison ARB VMT Elasticity Ranges}
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline D-Variable & Input Change & \[
\begin{aligned}
& \text { \%- } \\
& \text { chg }
\end{aligned}
\] & Net New Veh. Trips & \begin{tabular}{l}
VT \\
Reduction \\
(Uptown site)
\end{tabular} & Est. VMT reduction & \begin{tabular}{l}
ARB VMT \\
Elasticity Range
\end{tabular} \\
\hline Residential Density & \(295 \rightarrow 590\) condos & 100\% & 1,377 & -3\% & -4\% & -4-12\% \\
\hline Commercial Density & \(133 \rightarrow 267\) ksf & 100\% & 15,246 & 0\% & & NA \\
\hline Diversity 1 \& 2 & \(295 \rightarrow 800\) condos & \[
\begin{gathered}
\sim 100 \\
\%
\end{gathered}
\] & 2,413 & -4\% & -5\% & -2-11\% \\
\hline Design & \begin{tabular}{l}
\[
181 \rightarrow 362
\] \\
intersections/sq mi
\end{tabular} & 100\% & -451 & -2\% & -4\% & -6-12\% \\
\hline Destinations/ Design & \begin{tabular}{l}
\[
15,722 \rightarrow 31,444
\] \\
Jobs w/in 1 mile
\end{tabular} & 100\% & -532 & -3\% & -6\% & -13-25\% \\
\hline Distance to Transit & \[
\begin{gathered}
271,368 \rightarrow \\
542,736 \\
\text { Jobs w/in } 30 \mathrm{~m} \\
\text { transit }
\end{gathered}
\] & 100\% & -114 & -1\% & \[
\begin{aligned}
& -2 \% \\
& \text { est. }
\end{aligned}
\] & -5\% \\
\hline
\end{tabular}

Notes on Validation results for Uptown Center:
MXD prediction is one percent lower than actual (June 2009) counts
Note: on de facto single project trip gen rates:
Adding 295 condos yields 1,377 Net new vehicle trip ~ rate of 4.7/du
(SANDAG unadjusted daily trip gen. rate for condo is 8.0)

\title{
TRAFFIC CONGESTION AND Greenhouse Gases
}


URFace transportation in the United States is a
LARGE source of greenhouse gas emissions, and therefore a large contributor to global climate change. Roughly a third of America's carbon dioxide \(\left(\mathrm{CO}_{2}\right)\) emissions come from moving people or goods, and 80 percent of these emissions are from cars and trucks. To reduce \(\mathrm{CO}_{2}\) emissions from the transportation sector, policy makers are primarily pushing for more efficient vehicles, alternative fuels, and reducing vehicle miles traveled (VMT). Those who promote vehicle improvements have focused on building lighter and smaller vehicles (while main-
 taining safety), improving powertrain efficiency, and introducing alternative technologies such as hybrid and fuel cell vehicles. Alternative fuel possibilities include many low-carbon options such as biofuels and synthetic fuels.

Policy makers have placed less attention on reducing \(\mathrm{CO}_{2}\) emissions by reducing traffic congestion. As traffic congestion increases, so too do fuel consumption and \(\mathrm{CO}_{2}\) emissions. Therefore, congestion mitigation programs should reduce \(\mathrm{CO}_{2}\) emissions. The key question is how big of an emissions reduction we can get by reducing congestion. This question is difficult to answer, because \(\mathrm{CO}_{2}\) emissions, and the fuel consumption that causes them, are very sensitive to several factors. These factors include individual driving behavior,

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vehicle and roadway types, and traffic conditions. Because of these factors, a table that estimates \(\mathrm{CO}_{2}\) emissions based only on a single variable, such as trip distance, cannot provide an accurate estimate. Rather, a comprehensive methodology that takes advantage of the latest vehicle activity measurements and detailed vehicle emission factors can create a more accurate emissions inventory for different types of vehicles and different levels of traffic congestion. With this methodology, we can accurately estimate how congestion mitigation programs will reduce \(\mathrm{CO}_{2}\) emissions.

\section*{Driving Patterns and Emissions}

A typical driving trip consists of idling, accelerating, cruising, and decelerating. The proportion of a trip spent in these different stages will depend on the driver's behavior (e.g., aggressive vs. mild driving habits), the roadway type (e.g., freeway vs. arterial), and the level of traffic congestion. We can graphically display these factors through a vehicle velocity profile, a chart that shows speed over time (see Figure 1). The amount of \(\mathrm{CO}_{2}\) that is emitted during the trip will differ based on these different factors. Given a specific velocity profile and detailed information on the vehicle, we can estimate the \(\mathrm{CO}_{2}\) emissions using a vehicle emissions model. Researchers at the University of California, Riverside (UCR) have developed these emissions models for different vehicle types. We have collected a large amount of data both in the laboratory and on the road in real-world traffic (see Figure 2). These well-validated models provide the foundation for estimating the \(\mathrm{CO}_{2}\) emissions under different driving conditions with a wide variety of vehicles.

\section*{FIGURE 1}

Typical vehicle velocity patterns for different roadway types and conditions


FIGURE 2
Vehicle emissions testing using a) a laboratory dynamometer, and b) an on-board portable emissions measurement system



\section*{Measuring Vehicle Activity}

Travel survey projects carried out around the world have measured typical driving patterns for particular areas. These vehicle activity datasets usually consist of velocity profiles from a sampling of vehicles, typically collected from Global Positioning System (GPS) dataloggers. These dataloggers (see Figure 3) measure a vehicle's position and velocity on a second-by-second basis. The Southern California Association of Governments (SCAG), for example, conducted a post-census travel survey in 2001 that consisted of 467 representative households with 626 vehicles, where over 28,000 miles of data were collected. UCR researchers have taken this data set, along with several others, and have amassed a large vehicle activity database that represents typical driving patterns.

This large vehicle activity database allows us to directly apply individual representative trip patterns to the comprehensive emissions model and then determine the emission values for each trip. As an example, if we take a large number of car trip patterns in Los Angeles and apply it to an emissions model for a modern passenger car, we can develop a histogram of the \(\mathrm{CO}_{2}\) emissions for each trip in the database. This histogram is shown in Figure 4, which shows that most trips produce about 330 grams per mile (g/mi) of \(\mathrm{CO}_{2}\) emissions, corresponding to approximately 26 miles per gallon of fuel economy. Other trips, however, produced far less or far more \(\mathrm{CO}_{2}\) emissions per mile, depending on the specific driving pattern. This variation comes from the driver's behavior, the roadway type, and the level of traffic congestion. Further, other vehicle types will have quite different \(\mathrm{CO}_{2}\) emissions depending on their weight, power, and other vehicle factors.

\section*{Speed-Based Emission Factors}

Emission factors are commonly associated with average speed, and researchers often use average speed as a traffic performance measure. It is possible to create these speedbased emission factors (in terms of grams per mile) by simply taking the accumulated vehicle activity database and running each individual trip through the emission models. What results is a single emissions value associated with the average speed of the trip. We can
\(\mathrm{CO}_{2}\) emissions histogram for a representative database of trips in Southern California


FIGURE 5
Emission-speed plot of individual trips or trip segments


split the trip into smaller segments representing the time spent on freeways, major surface streets, and residential streets. We can then associate an emissions value with the average speed of that particular trip segment.

If we now take those emission values and plot them against their different average speeds, we get a "U"-shaped pattern as shown in Figure 5. We can then fit a line to this pattern, resulting in a typical emissions-speed curve. The concept of the emissions-speed curve can serve as the foundation for relating emissions to vehicle activity. In fact, a large family of curves can now be established for different roadway types, and even different levels of congestion, given that these factors can be determined and included in the vehicle activity database. Furthermore, we can also establish separate families of emissions-speed curves for different vehicle types by adjusting the emission models. We can even establish an emissions-speed curve for the vehicle fleet composition typically found on the road.

This family of emissions-speed curves illustrates several key ideas. Very low average speeds generally represent stop-and-go driving, and vehicles do not travel far. Therefore, the emission rates per mile are quite high. (When a car's engine is running but it is not moving, its emission rate per mile reaches infinity.) Conversely, when vehicles travel at much higher speeds, they demand very high engine loads, which require more fuel, and which therefore lead to high \(\mathrm{CO}_{2}\) emission rates. As a result, this emissions-speed curve has a distinctive parabolic shape, with high emission rates on both ends and low emission rates at moderate speeds of around 40 to 60 mph .

\section*{Potential Emissions Reductions}

The upper line in Figure 6 shows a representative emissions-speed curve for typical traffic. We can use this curve to examine how different traffic management techniques can affect vehicle emissions such as \(\mathrm{CO}_{2}\). The lower line represents the approximate lower bound of \(\mathrm{CO}_{2}\) emissions for vehicles traveling at a constant steady-state speed.

Several important results can be derived from Figure 6:
- If congestion reduces the average vehicle speed below 45 mph (for a freeway scenario), \(\mathrm{CO}_{2}\) emissions increase. Vehicles spend more time on the road, which results in higher \(\mathrm{CO}_{2}\) emissions. Therefore, in this scenario, congestion mitigation programs will directly reduce \(\mathrm{CO}_{2}\) emissions.
- If moderate congestion brings average speeds down from a free-flow speed over 70 mph to a slower speed of 45 to 55 mph , this moderate congestion can reduce \(\mathrm{CO}_{2}\) emissions. If congestion mitigation raises average traffic speed to above about 65 miles per hour, it can increase \(\mathrm{CO}_{2}\) emissions. And, of course, speeds above 65 or 70 also make the roadway more dangerous.
- Smoothing the stop-and-go pattern of traffic so that cars move at a relatively constant speed will reduce \(\mathrm{CO}_{2}\) emissions.

Figure 6 also illustrates three primary traffic operational improvement techniques that can directly lower \(\mathrm{CO}_{2}\) emissions. Congestion mitigation increases average traffic speeds from slower, heavily-congested speeds; examples of congestion mitigation include ramp metering, incident-management programs, and congestion pricing. Speed management reduces excessively high speeds to safer speeds; examples of this approach include direct enforcement by police and Intelligent Speed Adaptation (ISA) where top speeds are capped

Possible use of traffic operation strategies in reducing on-road \(\mathrm{CO}_{2}\) emissions

based on specific traffic conditions. Traffic smoothing reduces the number and intensity of accelerations and decelerations; examples include variable speed limits, dynamic ISA, and congestion pricing.

\section*{Coupling Emissions-Speed Curves to Traffic Performance Data}

Estimating emissions as a function of speed allows us to use the resulting emissionsspeed curves directly with traffic performance measurements. For example, if loop sensors in a roadway can measure traffic volume and average speed, we can use these parameters in conjunction with the emissions-speed curve to estimate overall traffic-related emissions for that location. The process is relatively simple: the average traffic speed for a link is used to index the emissions-speed curves that correspond to the vehicle fleet mix on that roadway. By weighting the emission values by the vehicle fleet mix and then multiplying by the total volume of traffic, we can estimate the total emissions for that roadway link. If the emissions for all the links are then combined, we can estimate an overall traffic-related emissions inventory for the region.

To illustrate this estimation, we have examined the Los Angeles freeway network. The LA freeway system has a rich set of embedded loop sensors that measure traffic parameters (speed, density, and volume) throughout the network. We used the loop-sensor data to generate emissions-speed curves for the average fleet mix of the region. We then used these emissions-speed curves together with the traffic performance measures to estimate realtime \(\mathrm{CO}_{2}\) emissions along individual freeway segments.

Vehicle Speed Histograms and \(\mathrm{CO}_{2}\) Reductions
Our next research goal was to estimate current levels of congestion and then estimate how much different congestion management programs could reduce \(\mathrm{CO}_{2}\) emissions. To illustrate this, we first develop vehicle-speed histograms for particular locations and timeframes using data from the traffic performance measurement system. For example, in Figure 7 we have examined the average traffic conditions on a downtown LA segment of Interstate 110 northbound between 4 p.m. and 5 p.m., for the month of March 2007. We then created a histogram of average traffic speed, showing the vehicle miles traveled (VMT) in each speed bin. Due to congested conditions, a significant portion of the traffic was moving in the 20 to 30 mph range. For these conditions, we can calculate that the congested traffic for this one-hour time period on this segment of freeway emits approximately 166 metric tons of \(\mathrm{CO}_{2}\).

Congestion mitigation programs that increase the overall traffic speed should reduce these \(\mathrm{CO}_{2}\) emissions. As shown in Figure 7, if we improve the overall average traffic speed by approximately 20 mph , the speed histogram would change, resulting in a reduction of 21 metric tons of \(\mathrm{CO}_{2}\), a 12 percent drop. We can then apply this methodology for additional roadway segments in the network.

FIGURE 7
Potential \(\mathrm{CO}_{2}\) emissions savings through congestion mitigation on Interstate-110 in downtown Los Angeles. The curved line indicates incremental improvements from 35 to 55 mph .



\section*{Conclusion}

There are many reasons to fight traffic congestion. Congestion wastes time and money, and it increases the risks of accidents and localized pollutants like particulate matter. But potentially the most serious, if also the least immediate, consequence of traffic congestion is increased emissions of greenhouse gases.

Although many people understand that driving contributes to greenhouse gas emissions, the measurement of this phenomenon has been surprisingly crude, often associating carbon emissions only with trip distance, without accounting for how carbon emissions change with vehicle speed.

In our research, we have developed a more finely grained way to measure the relationship between driving and carbon emissions, and this allows us to develop better estimates of how congestion-management techniques can help fight global warming. Specifically, we have estimated how three improvements in managing traffic operations can reduce \(\mathrm{CO}_{2}\) emissions:
- Congestion mitigation strategies that reduce severe congestion and increase traffic speeds (e.g. ramp metering, incident management, and congestion pricing);
- Speed management strategies that bring down excessive speeds to more moderate speeds of approximately 55 mph (e.g. enforcement and ISA); and
- Traffic smoothing strategies that reduce the number and intensity of acceleration and deceleration events (e.g. variable speed limits and ISA).

Using typical conditions on Southern California freeways as an example, our research has shown that each of the three traffic-management strategies above could reduce \(\mathrm{CO}_{2}\) emissions by 7 to 12 percent. All three strategies in combination could reduce \(\mathrm{CO}_{2}\) emissions by approximately 30 percent.

FURTHER READING

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[^0]:    Source:

[^1]:    Note: Capacity shown as vehicles per hour per lane (VPHPL)

[^2]:    Notes:
    Source:

[^3]:    Notes:
    $=$ Met $/$ Not Required
    = Partially Met
    = Not Met

[^4]:    Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

[^5]:    Notes:
    Source:

[^6]:    Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, made by households within the county, weighted by weekday, household-level weights ("HHWDWGT").

[^7]:    Notes:
    Source:

[^8]:    Notes:
    Source:

[^9]:    Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

[^10]:    Notes:
    Source:

[^11]:    Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

[^12]:    Notes: Values shown as Production (Attraction)

[^13]:    Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

[^14]:    Notes:

[^15]:    Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

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