Memorandum

To: Kimberly Kerr, Assistant Chief Administrative Officer
Cc: Natalie Porter, PE, TE
    Shawna Purvines
    Claudia Wade, PE

From: Michael Schmitt, AICP CTP, PTP

Re: Technical Memorandum #2: Model Sensitivity to El Dorado County Policies and Factors
    Technical Memorandum #7: Mode Choice
    El Dorado County Travel Demand Model Update

Date: November 27, 2012
       Revised August 26, 2013

The purpose of this memorandum is to present information related to the mode choice methodology and the application of procedures to increase the model's sensitivity to smart growth policies and mixed-use development (collectively called the “5Ds” - density, diversity, design, destination and distance) in the El Dorado County (EDC) Travel Demand Model (TDM). Mode choice and the 5D methodology in combination, determine the final number of trips that utilize each of the TDM’s identified travel modes. The resulting information directly feeds the assignment of transit and vehicular traffic on model networks which in turn influences the level of infrastructure needed to support the identified travel demand.

Given the interrelationship of the selected mode choice and 5D methodologies, it was determined that Technical Memorandum #2 and #7 would be combined to facilitate reader understanding and the review and discussion of their application.

1. Mode Choice Model

Mode choice refers to the method of transportation that a trip-maker utilizes (e.g. car, transit, bike, walk, etc.). Within the mode choice submodel, the likelihood that a particular travel mode is selected is based on several variables including household socio-economic profile, the location and availability of mode choices at the beginning and end of a trip, and select transportation costs.

The EDC TDM utilizes the mode choice submodel previously developed for SACOG’s SACMET model. This submodel has been refined several times prior to its most recent available description which is provided in the 2008 Model Update Report: SACMET 07. Based on a review of available documentation and a review of model scripts and procedures, the mode choice submodel was determined to be consistent with standard practices for regional model development, thus statistically valid and appropriate for application to the EDC TDM.

Specific socio-economic characteristics that the mode choice model considers include the number of persons, workers, automobiles owned and income. The submodel also takes into account the travel time and costs for each travel mode and the land use characteristics at the trip origin and destination zones. Person trips are assigned to one of seven travel modes:

- Drive alone
- HOV – 2 occupants
- HOV – 3 or more occupants
- Transit, walk access
- Transit, drive access (using park and rides)
- Walk
- Bicycle

The mode choice submodel relies on four distinct logit equations that measure the utility, or the user benefit of each travel mode with respect to the tradeoff between travel time and the costs associated with each travel mode. The logit equations are applied to the following person trip purposes:

- Home-based work trips (uses a nested logit equation that combines mode choice and destination choice)
- Home-based shop and home-based other trips
- Work-other and other-other trips
- Home-based school trips

The logit equations consider the following variables derived from the network skims that occur in the model workflow to determine a trip’s shortest path on the highway and transit networks:

- **In-vehicle travel time** for the drive alone, HOV2 and HOV3, transit walk access and transit drive access modes for Home-based work trip purposes; and drive alone and HOV2 and HOV3 modes for all other trip purposes.
- **Out of vehicle time** consisting of estimates of auto terminal time (walking to/from the vehicle and parking); walk time for transit walk access and transit drive access trips; transit wait times; transit transfer time; and bicycle travel time (in lieu of in/out of vehicle travel time).
- **Automobile operating cost** for the driving related modes; estimated at five cents per mile (in 1990 dollars).
- **Transit fares** for the different transit services operating in the region.
- **Automobile parking costs** that estimates the cost of daily, area wide parking costs for each zone; non-work parking is estimated at one half the cost of work related trips.

The mode choice submodel includes additional environmental variables that account for land use types and trip accessibility characteristics of the trip production and attraction zones, including:

- **Household density** measured as the number of households within a one-mile radius of the centroid in the production zone.
- **Employment density** measured as the number of employees within a one-mile radius of the centroid in the attraction zone.
- **Pedestrian Environmental Factor** consists of a scoring index that evaluates the continuity of streets, ease of crossing streets, sidewalks and topographic barriers.

**II. Introduction to the 5D Process**

Traditional four step models are limited in their ability to account for adjustments to land use decisions and the built-environment – namely the pursuit of smart growth principles that feature greater mix-use development and accessibility to transit. These factors have been studied extensively and have been documented to have an effect on increasing the share of trips completed by transit, biking, and walking. Smart-growth strategies that integrate land use decisions and transportation is increasingly relevant for
regional planning agencies charged with carrying out the requirements of SB 375. This legislation includes the requirement that a Sustainable Communities Strategy (SCS) be prepared with the Regional Transportation Plan (RTP).

To improve the sensitivity of traditional TDMs to smart-growth strategies, many agencies have developed and incorporated methodologies into their forecasting processes. These methodologies vary greatly in terms of their development approach, sensitivity and selection of inputs, complexity of use, and integration into the model’s workflow. Methods range from a simple spreadsheet models applied as a traffic forecast “post-processor” to increasing orders of technical sophistication that might include state of the art activity-based models or sketch-planning tools such as i-Places or INDEX. A recent summary of select approaches is documented in the Caltrans report, *Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies* (July, 2007). This report provides guidelines to assist local agencies in improving the sensitivity of their models to smart-growth strategies. However, the report does not prescribe a specific solution that agencies should follow.

Though the tools for improving the sensitivity of TDMs to smart-growth strategies vary, many if not all make reference to the 5Ds as having an impact on travel behavior. The relationship between the 5Ds and their effect on trip-making is well documented and has been demonstrated in numerous studies, beginning with the research by Robert Cervero at the University of California, Berkeley. The following is a description of the 5D factors that influence trip-making:

- **Destination** refers to the accessibility to activity centers. Households located in low density developments often experience greater travel time to other destinations.
- **Distance** refers to the proximity to transit stations. Transit service situated near households or employment centers is more attractive to users.
- **Density** refers to the intensity of development. Areas with high concentrations of residences and jobs feature greater transit accessibility and walkability, resulting in less automobile travel.
- **Diversity** measures the balance of housing and jobs. It may also consider demographics inputs such as the number of available vehicles per household to determine if households are more or less likely to be transit-dependent.
- **Design** refers to the attractiveness of the built environment to pedestrians and cyclists. Areas that provide a safe environment for walking or biking enable and encourage more non-motorized trips.

### III. Application of the 5D Process

The 5Ds are integrated into the EDC TDM process as a refinement to the mode choice submodel. The vehicle trip tables from the mode choice model are adjusted based on the outcome of the 5D analysis. The result is a vehicle trip table that reflects a reduction in automobile trips based on the sensitivity of the zones in El Dorado County to smart-growth strategies according to the 5D factors.

The 5D process for the EDC TDM evaluates the smart-growth potential of each zone using a point system ranging between 0 and 10 for each 5D factor. **Exhibit 1** shows the scoring criteria for each of the 5Ds:
Exhibit 1 – Stratification of 5D Point System

<table>
<thead>
<tr>
<th>5D Factors</th>
<th>LOW (0 POINTS)</th>
<th>MEDIUM (5 POINTS)</th>
<th>HIGH (10 POINTS)</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSITY 1 (RESIDENTIAL)</td>
<td>&lt;4.00</td>
<td>&gt;=4.00 AND &lt;=12.00</td>
<td>&gt;12.00</td>
<td>Households/Acre</td>
</tr>
<tr>
<td>DENSITY 2 (EMPLOYMENT)</td>
<td>&lt;15.00</td>
<td></td>
<td>&gt;50.00</td>
<td>Employees/Acre</td>
</tr>
<tr>
<td>DESIGN</td>
<td>Low Walkability</td>
<td>Fair Walkability</td>
<td>Good Walkability</td>
<td>Pedestrian Environmental Factors (PEF)</td>
</tr>
<tr>
<td></td>
<td>PEF = 7.00 OR PEF = 8.00</td>
<td>PEF = 9.00</td>
<td>PEF = 10.00</td>
<td></td>
</tr>
<tr>
<td>DISTANCE</td>
<td>&gt; 1/2 MILE</td>
<td>&lt;= 1/2 AND &gt;= 1/4 MILES</td>
<td>&lt; 1/4 MILE</td>
<td>Miles to Transit Stop</td>
</tr>
<tr>
<td>DIVERSITY</td>
<td>&lt;=10,00</td>
<td>&lt;50,000 and &gt;10,00</td>
<td>&gt;=50,000</td>
<td>Median HH Income Classes</td>
</tr>
<tr>
<td>Class 5</td>
<td>Class 2, 3, 4</td>
<td></td>
<td>Class 1</td>
<td></td>
</tr>
<tr>
<td>DESTINATION</td>
<td>&lt;= 100</td>
<td>&gt;100 AND &lt; 500</td>
<td>&gt;= 500</td>
<td>Congested VHT per HH</td>
</tr>
</tbody>
</table>

Population and Employment Density:
Residential and employment density factors are calculated using GIS by dividing the household and employee totals for each zone by the zone acreage. The following illustrates the distinctions in the levels of densities and the corresponding points associated with the scoring:

<table>
<thead>
<tr>
<th>0 points</th>
<th>5 points</th>
<th>10 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4 households per acre; Less than 15 employees per acre</td>
<td>Between 4 and 12 households units per acre</td>
<td>Greater than 12 households per acre; Greater than 50 employees per acre</td>
</tr>
</tbody>
</table>

Design:
The Pedestrian Environment Factor (PEF) is a composite measure developed by SACOG staff used to score the walkability of each zone and used as an input in the SACMET mode choice submodel. Specifically, SACOG staff used topographic maps, aerials and local knowledge to rate the following characteristics of each zone on a scale of 1 (poor) to 3 (good): continuity of streets and walkways; ease of crossing streets; provision of sidewalks; and topographic barriers. The PEF for the EDC TDM zones are determined by doing an overlay on the SACMET zones in GIS.
The PEF can be related to the Pedestrian Performance Measure (PPM) analysis of pedestrian level of service (LOS). The PPM is one of two approaches to assigning a LOS grade to the pedestrian environment – the other being the Multi-Modal Level of Service (MMLOS) which is the standard described in the 2010 edition of the Highway Capacity Manual (HCM 2010). The MMLOS methodology uses scoring criteria based on a quantitative analysis of pedestrian flow, density and facility size. Compared to the MMLOS, the PPM approach uses a point system more similar to the PEF system used by SACOG to evaluate the quality of pedestrian infrastructure.

Exhibit 2 shows how the PEF could translate to a PPM LOS grade. The table could provide guidance in scoring the pedestrian environment for future modeling scenarios while maintaining compatibility with the PEF rating required by the TDM.

### Exhibit 2 – Pedestrian LOS Rating

<table>
<thead>
<tr>
<th>PEF Rating</th>
<th>Pedestrian Performance Measure</th>
<th>PPM Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEF = 10</td>
<td>LOS A</td>
<td>These roadways are highly pedestrian oriented and will tend to attract pedestrian trips. The roadways will be characterized by ample sidewalk space, pedestrian-friendly intersection designs, low-speed or low-volume motor-vehicle traffic, and plentiful amenities (e.g., shade, benches, and so forth). The roadway and sidewalk features will be designed at human scale for maximum pedestrian comfort.</td>
</tr>
<tr>
<td>PEF = 9 or PEF = 10</td>
<td>LOS B</td>
<td>These roadways provide many pedestrian safety and comfort features that can attract pedestrian trips. These roadways will have many of the characteristics of an LOS A pedestrian facility, but there may be somewhat fewer amenities or pedestrian-friendly design elements. Pedestrians can anticipate a low to moderate level of interaction with motor vehicles.</td>
</tr>
<tr>
<td>PEF = 9</td>
<td>LOS C</td>
<td>These roadways are adequate for pedestrian use, but may not</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PEF Rating</th>
<th>Pedestrian Performance Measure</th>
<th>PPM Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>necessarily attract pedestrian trips. These roadways will provide a standard sidewalk, but will likely have some deficiencies in maintenance or intersection design, may be located on roadways with high-speed, high-volume motor-vehicle traffic, or may provide a sidewalk on one side of the street only. Pedestrians can anticipate moderate interaction with motor vehicles on these roadways.</td>
</tr>
<tr>
<td>PEF = 7 or PEF = 8</td>
<td>LOS D</td>
<td>These roadways are adequate for pedestrian use, but will not attract pedestrian trips. These roadways will have more frequent deficiencies in pedestrian safety and comfort features and are more likely to violate ADA requirements for width and clearance. Gaps in the sidewalk system may occur within this roadway corridor. Intersection crossings are likely to be more frequent and more difficult. Pedestrians can anticipate moderate to high levels of interaction with motor vehicles.</td>
</tr>
<tr>
<td>PEF = 7 or PEF = 8</td>
<td>LOS E</td>
<td>These roadways are inadequate for pedestrian use. These roadways may or may not provide a pedestrian facility. Even where a sidewalk is provided these roadways will not meet ADA requirements and will have frequent deficiencies in sidewalk width, clearance, continuity, and intersection design. Roadways in this category that do not provide a pedestrian facility may be characterized as urban fringe, rural section roadways with moderate motor-vehicle traffic. Pedestrians can anticipate a high level of interaction with motor vehicles.</td>
</tr>
<tr>
<td>PEF &lt; 6</td>
<td>LOS F</td>
<td>These roadways are inadequate for pedestrian use. These roadways do not provide any continuous pedestrian facilities and are characterized by high levels of motor-vehicle use and automobile-oriented development. These roadways are designed primarily for high-volume motor-vehicle traffic with frequent turning conflicts and high speeds.</td>
</tr>
</tbody>
</table>

**Distance:**
The walking distance to park-and-ride facilities in El Dorado County is measured using half mile and quarter mile buffers in GIS. Zones are assigned a score of 5 to 10 points if it is within at least a half mile of the park-and-ride facility.

**Diversity:**
The diversity factor is based on the income stratification from the SACMET household cross-classification data. The household cross-classification data classifies income in one of five classes, each representing median household income in $10,000 increments up to $50,000.

**Destination:**
The destination factor is determined using calculated congested vehicle hours traveled (VHT) for household trips; this factor is applied in conjunction with the distance factor so that points are credited for destination only if a transit station is within a minimum of a half mile of that zone.

The points for each 5D factor are aggregated on a TAZ basis to arrive at a composite score. The look-up table in Exhibit 3 is used to determine the automobile trip reduction factor for each TAZ. This factor is
applied on a TAZ basis to the vehicle trip table prior to assignment. The table below shows the composite score criteria and the resulting trip reductions:

**Exhibit 3 – 5D Automobile Trip Reduction Factors**

<table>
<thead>
<tr>
<th>5D COMPOSITE SCORE</th>
<th>TRIP REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;= 50</td>
<td>30%</td>
</tr>
<tr>
<td>&lt;50 AND &gt;=40</td>
<td>20%</td>
</tr>
<tr>
<td>&lt;40 AND &gt;=30</td>
<td>10%</td>
</tr>
<tr>
<td>&lt;30 AND &gt;=10</td>
<td>2%</td>
</tr>
<tr>
<td>&lt;10 AND &gt;=5</td>
<td>1%</td>
</tr>
<tr>
<td>&lt;5</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Exhibit 3 to Exhibit 7* shows the scoring by zone for each 5D factor. *Exhibit 8* shows the total composite score and *Exhibit 9* shows the vehicle trip reduction applied as a result of the composite score according to the look up table in Exhibit 2.
Exhibit 3 – 5D Scoring for Density
Exhibit 4 – 5D Scoring for Design
Exhibit 5 – 5D Scoring for Distance
Exhibit 6 – 5D Scoring for Diversity
Exhibit 7 – 5D Scoring for Destination
Exhibit 8 – 5D Composite Score
Exhibit 9 – 5D Vehicle Trip Reduction