VMT Module of SCAG Scenario Planning Model (SPM)

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New to SPM?

✍️ What is SPM?
A web-based land use sketch planning tool for data management, scenario development and modeling, built with open-source software and tools

✍️ Primary Objective
Support informed decision making by providing relative impact analysis of the issues and policy choices
Multi-Metric Analysis

- **Land Consumption**
  - Greenfield Land Consumed (acre)

- **Fiscal Impact**
  - Capital Infrastructure Cost ($) 
  - Operations & Maintenance Cost ($)

- **Water Use Module**
  - Indoor/Outdoor Water Use (gal)
  - Water Cost ($) 
  - Water-related Energy Use (kWh)
  - Water-related GHG Emissions (#s)

- **Energy Use Module**
  - Residential/Commercial Energy Use (kWh, thm)
  - Building-related Energy Cost ($)
  - Building-related GHG Emissions (#s)

- **Public Health Module**
  - Respirator Health Incidences and Cost ($) 
  - Obese Population (%) 
  - High Blood Pressure (%) 
  - Heart Disease (%) 
  - Type 2 Diabetes (%) 
  - Body Mass Index (BMI) Percentile

- **Land Conservation Module**
  - Above Ground Live Carbon Stocks (metric tons of C)
  - Below Ground Carbon Stocks (metric tons of C)
  - Watershed Integrity (acres)
  - Urban and Agricultural Water Demand (ac-ft)
  - Groundwater Recharge Potential (ac-ft/yr)
  - Water Resource Priority Areas (acres)
  - Habitat for Terrestrial Vertebrates (acres)
  - Species Movement Potential (acres)
  - Habitat Priority Areas (acres)
  - Agricultural Capacity (acres)
  - Agricultural Production Values ($) 

- **Transportation Module**
  - Vehicle Miles Traveled (VMT)
  - Trips by Mode/Type 
  - Transportation Costs ($)

- **Accessibility Module**
  - Number of destinations or opportunities one can reach within a specified amount of time or distance 
  - Travel time, in minutes, from an SPZ to the nearest Point Of Interest (POI)

*SPM Indicators for Scenario Analysis*
107,562 SPZs in SCAG

SPM’s primary geographic unit

Developed by grouping parcels of uniform or compatible land uses.
SPZ Land Use abstracted as “Place Type”
Some “Place Types”

**Mixed Office and R&D**

<table>
<thead>
<tr>
<th>Land Use Mix</th>
<th>Residential</th>
<th>Employment a</th>
<th>Mixed Use</th>
<th>Open Space/Civic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
<td>12%</td>
<td>0%</td>
<td>13%</td>
</tr>
</tbody>
</table>

**Built Environment**

- Intersections per mi²: 45
- Average Floors: 2–6
- Floors Range: 1–6
- Total Net FAR: 0.8

**Gross Density Range (per acre)**

- Household: 6–15
- Employee: 33

**Neighborhood Residential**

<table>
<thead>
<tr>
<th>Land Use Mix</th>
<th>Residential</th>
<th>Employment</th>
<th>Mixed Use</th>
<th>Multi-Family</th>
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<tbody>
<tr>
<td></td>
<td>60%</td>
<td>10%</td>
<td>7%</td>
<td>23%</td>
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</table>

**Built Environment**

- Intersections per mi²: 180
- Average Floors: 2
- Floors Range: 2–4
- Total Net FAR: 0.7

**Gross Density Range (per acre)**

- Household: 7–9
- Employee: 5

**Office/Industrial**

<table>
<thead>
<tr>
<th>Land Use Mix</th>
<th>Residential</th>
<th>Employment</th>
<th>Mixed Use</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>12%</td>
<td>82%</td>
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</tbody>
</table>

**Built Environment**

- Intersections per mi²: 40
- Average Floors: 1
- Floors Range: 1–4
- Total Net FAR: 0.3

**Gross Density Range (per acre)**

- Household: 0–5
- Employee: 21

**Neighborhood Low**

<table>
<thead>
<tr>
<th>Land Use Mix</th>
<th>Residential</th>
<th>Employment</th>
<th>Mixed Use</th>
</tr>
</thead>
<tbody>
<tr>
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<td>13%</td>
<td>57%</td>
</tr>
</tbody>
</table>

**Built Environment**

- Intersections per mi²: 250
- Average Floors: 2
- Floors Range: 2–4
- Total Net FAR: 0.3

**Gross Density Range (per acre)**

- Household: 4–5
- Employee: 2

**Description**

Mixed Office and R&D is characterized by a mix of employment buildings. Typical structures are 1-6 stories tall, surrounded by surface parking and some structured parking where appropriate.

Neighborhood Residential areas are traditional neighborhoods containing mostly single-family homes on small lots, interspersed with occasional retail spaces. Typical buildings are between 2 and 3 stories tall, with small yards and an active focus on the public realm, with a design that is to be supportive of transit service, walking, and bicycling.

Office/Industrial areas are moderate-density suburban office and industrial areas. Typical structures are 1-5 stories tall, surrounded by surface lots and truck loading bays.

Neighborhood Low contains a mix of single-family homes on small lots interspersed with some medium and larger lots. Neighborhood Low is a traditional neighborhood area designed to be supportive of walking and bicycling. Typical buildings are 1-3 stories tall, usually located within walking distance of a mixed-use neighborhood center.
Motivations and Objectives of SPM-TM

- Quantitative tool to predict VMT impact of detailed land use patterns.
- Used alongside SCAG Regional Travel Model (ABM)
  - ABM model represents behavioral detail and patterns of travel
  - SPM-TM respects ABM results for identical land use
  - Increases or decreased trips, trip distance, mode split based on detailed land use changes
- Based on SCAG data/analysis
- Compatible with other SCAG tools especially the ABM
Previous VMT Module

- Based on land use data from mixed use developments around the nation
- Development characteristics and accessibility
- Internal capture and walk/transit probabilities

<table>
<thead>
<tr>
<th>Region</th>
<th>MXDs</th>
</tr>
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<tbody>
<tr>
<td>Atlanta</td>
<td>24</td>
</tr>
<tr>
<td>Boston</td>
<td>59</td>
</tr>
<tr>
<td>Houston</td>
<td>34</td>
</tr>
<tr>
<td>Portland</td>
<td>53</td>
</tr>
<tr>
<td>Sacramento</td>
<td>25</td>
</tr>
<tr>
<td>Seattle</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>239</td>
</tr>
</tbody>
</table>

**Land Use (Grid Cell, ½ Mile Buffer)**
- Population, Employment
- Dwelling units by type
- Sq. ft. of non-residential use by category: office, retail, service, public

**Urban Form (Grid Cell, ½ Mi Buffer)**
- Intersection density
- Household size
- Auto ownership

**ITE Trip Generation Rates**
- Apply standard ITE Manual trip generation rates or equations to individual land uses
- Estimate maximum potential traffic generation (sum of individual uses)

**MXD Equations**
- Compute likelihoods of internal capture, off-site walk and transit
- Estimate traffic generation reduction for internalization, walk and transit use.

**External Traffic Generation Estimate**
- Apply reduction for internal, walk and transit to maximum potential traffic generation
- Estimate total daily external traffic generation for each grid cell

**Grid Cell Location, Context**
- Employment within 1 mile radius
- Jobs within 30 min by transit
SPM Travel Model Structure
TAZ level

Generation (number of trips) → Distance Bands → Mode Choice
Daily Trip Generation

- Home to Work (H2W)
- Work to Home (W2H)
- Home to Other (H2O)
- Other to Home (O2H)
- Non-Home Based (NHB)

Trip rate per person (H2W, W2H, H2O, O2H, NHB)
Trip rate per employee (NHB)
Daily Trip Generation: Explanatory Variables

- Household size
- Proportion multi-unit building
- Proportion of mixed-use land use type
- Parking cost
- Intersection density
- Bike lane density
- Density of zone
- Employment within one mile of zone (including intrazonal)
- Employment between 1 and 5 miles from zone
Distance Band and Mode Choice Model by Purpose

- For each purpose (H2W, W2H, H2O, O2H, NHB)
- Distance band choice:
  - Intra-TAZ, 0-1 miles, 1-5 miles, 5-20 miles, 20+ miles
- Mode choice:
  - Auto Driver, Auto Passenger, Transit, Walk and Bike

Discrete choice model (logit model)

<table>
<thead>
<tr>
<th>Distance Band</th>
<th>Auto Driver</th>
<th>Auto Passenger</th>
<th>Transit</th>
<th>Walk and Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>&lt; 1 mi</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>1 – 5 mi</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5-20 mi</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>20+ mi</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Distance Band and Mode Choice Model by Purpose: Explanatory Variables:

- Total employment in each distance band
- Proportion Mixed Land Use in home TAZ
- Parking Cost
- Transit stops per km²
- Distance to light rail or subway/metro
- Bike Lane density
Development and Estimation

- Load ABM Base Scenario data
  - Simulated trip list in 2016
  - Land use data by TAZ (population, residents, households, employees)
- Calculate "Observed" ABM VMT
  - Trip rates (5 per TAZ)
  - Mode choice and distance band choice (95 per TAZ)
  - Travel distance by band, segment, and mode (100 per TAZ)
- Smooth ABM Indicators
  - to remove microsimulation error, small number rate errors, and missing value errors
- Regression for trip generation
- Logit Choice model for mode and distance band
## Generation Parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Units</th>
<th>Home to Work</th>
<th>Work to Home</th>
<th>Home to Other</th>
<th>Other To Home</th>
<th>Non Home Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household Size</td>
<td>Residents per household</td>
<td>RES/HH</td>
<td>-0.02375</td>
<td>-0.00592</td>
<td>0.05024</td>
<td>0.03162</td>
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</tr>
<tr>
<td>Proportion Multi-Use</td>
<td>Proportion of Multi Unit buildings</td>
<td>proportion</td>
<td></td>
<td>-0.08553</td>
<td>-0.07188</td>
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<td></td>
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<tr>
<td>Proportion Mixed Use Land Use</td>
<td>Sum of proportion of &quot;mixed use&quot; land use type</td>
<td>proportion</td>
<td>0.01786</td>
<td>0.01464</td>
<td></td>
<td></td>
<td>0.36238</td>
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<tr>
<td>Land Use Density</td>
<td>(\sqrt{\text{residents} + \text{employment} / \text{area}})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.07485</td>
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<td>Short Term Parking Cost</td>
<td>One Hour short term parking cost</td>
<td>2011 $</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.08925</td>
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<tr>
<td>Intersection Density</td>
<td>Average intersection density</td>
<td>Intersections per sq.mi.</td>
<td>0.000005</td>
<td>-0.00004</td>
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<td></td>
<td></td>
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<tr>
<td>Bike Lane Density</td>
<td>Bike Lane Density</td>
<td>miles/acre</td>
<td>0.60086</td>
<td>0.46420</td>
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</tr>
<tr>
<td>Employment &lt; 1 mile</td>
<td>Employment within 1 mile of zone</td>
<td>jobs (’000)</td>
<td>0.000327</td>
<td>0.000161</td>
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<tr>
<td>Employment 1-5 Miles</td>
<td>Employment in the band between 1 and 5 miles from edge of zone</td>
<td>jobs (’000) number</td>
<td>0.000093</td>
<td>0.000045</td>
<td>0.96388</td>
<td>1.08042</td>
<td>0.86588</td>
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<td>Constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Trips per Resident for home-based trip purposes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Daily Trips per (Employment + 0.4 * Population) for Non Home Based</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
<td>Units</td>
<td>Applied To Mode Choice</td>
<td>Applied To Distance Choice</td>
<td>Trip Purpose</td>
<td>Non Home Based</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>------------------------</td>
<td>-----------------------------</td>
<td>--------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Employment In Zone</td>
<td>in (total employment) in zone</td>
<td>in [jobs]</td>
<td>Intra-Zonal</td>
<td>Intra-Zonal</td>
<td>Home to Work</td>
<td>0.19894</td>
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</tr>
<tr>
<td>Employment &lt; 1 mile</td>
<td>in (total employment) within 1 mile of zone</td>
<td>in [jobs]</td>
<td>0 - 1 miles</td>
<td>0 - 1 miles</td>
<td>Work to Home</td>
<td>0.44150</td>
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<tr>
<td>Employment 1-5 Miles</td>
<td>in (total employment) between 1 and 5 miles from zone</td>
<td>in [jobs]</td>
<td>1 - 5 miles</td>
<td>1 - 5 miles</td>
<td>Home to Other</td>
<td>0.24866</td>
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<tr>
<td>Employment 5-20 Miles</td>
<td>in (total employment) between 5 and 20 miles from zone</td>
<td>in [jobs]</td>
<td>5 - 20 miles</td>
<td>5 - 20 miles</td>
<td>Other To Home</td>
<td>0.5114</td>
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<td>Proportion Mixed Use Land Use</td>
<td>Sum of proportion of &quot;mixed use&quot; land use type</td>
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<td>Transit, Non-motorised</td>
<td>Transit, Non-motorised</td>
<td>Based</td>
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<td>Monthly Parking Cost</td>
<td>Monthly parking cost per day</td>
<td>2011 $</td>
<td>Auto Driver, Auto Passenger</td>
<td>Auto Driver, Auto Passenger</td>
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<td>0.04421</td>
<td></td>
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<td>Transit Stop Density</td>
<td>Density of transit stops per square km</td>
<td>stops/km^2</td>
<td>Transit</td>
<td>Transit</td>
<td></td>
<td>0.00003</td>
<td></td>
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<tr>
<td>Light Rail Accessibility</td>
<td>Is 1AZ greater than 1.500m from light rail / subway / metro?</td>
<td>1 (Yes) or 0 (No)</td>
<td>Transit</td>
<td>Transit</td>
<td></td>
<td>0.00003</td>
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<tr>
<td>Bike Lane Density</td>
<td>Bike Lane Density</td>
<td>miles/acre</td>
<td>Non-motorised</td>
<td>Non-motorised</td>
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<td>0.00004</td>
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<td>number</td>
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<td>Intra-Zonal</td>
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<td>Auto Passenger 0-1 mile Constant</td>
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<td>Auto Passenger</td>
<td>1 - 5 miles</td>
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<td>1 - 5 miles</td>
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<td>Transit 5-20 miles Constant</td>
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</tr>
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<td>Auto Driver</td>
<td>&gt; 20 miles</td>
<td>&gt; 20 miles</td>
<td></td>
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<td>Transit</td>
<td>&gt; 20 miles</td>
<td>&gt; 20 miles</td>
<td></td>
<td>0.00000</td>
<td></td>
</tr>
</tbody>
</table>
Offsets

- Trip rate corrections by TAZ
- Mode and distance corrections by TAZ
- Represent the ABM’s detailed insight into complex relationships
Cumulative effect of VMT Offsets

vmt_zone_show_offset
-80076 - -65516
-65516 - -50957
-50957 - -36398
-36398 - -21839
-21839 - -7280
-7280 - 7280
7280 - 21839
21839 - 36398
36398 - 50957
50957 - 65516
65516 - 711291
Impact of mode-distance offsets

Zone 22080100

Total Probability – all 5 trip types

SPM Estimation

ABM (SPM + Offset)
Impact of mode-distance offsets
Zone 20757100
<table>
<thead>
<tr>
<th>Alternative</th>
<th>H2O</th>
<th>H2W</th>
<th>NHB</th>
<th>O2H</th>
<th>W2H</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ad-0to1</td>
<td>329,054</td>
<td>22,046</td>
<td>492,939</td>
<td>235,057</td>
<td>17,532</td>
<td>1,096,628</td>
</tr>
<tr>
<td>ad-1to5</td>
<td>14,321,605</td>
<td>2,866,371</td>
<td>17,486,142</td>
<td>14,452,231</td>
<td>2,417,824</td>
<td>51,544,173</td>
</tr>
<tr>
<td>ad-5to20</td>
<td>41,101,744</td>
<td>23,201,838</td>
<td>51,319,474</td>
<td>50,149,440</td>
<td>18,262,209</td>
<td>184,034,705</td>
</tr>
<tr>
<td>ad-own</td>
<td>180,763</td>
<td>7,850</td>
<td>239,124</td>
<td>142,984</td>
<td>6,822</td>
<td>577,542</td>
</tr>
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<td>Grand Total</td>
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Implementation

- PostgreSQL Database
- Quick response to changes in land use variables
  - ~4 minutes to recalculate proximity/accessibility
  - ~3 minutes to calculate VMT details by TAZ
- Load new ABM inputs to account for overall system changes or infrastructure performance
- Overnight process to change zone system (TAZ or SPZ)
```
FROM vmt_with_md_and_gen_off
UPDATE set
  trip_generation_offsets.
```
• SPM database is a robust set of PostgreSQL databases
• Connected to a web-based tool called Urban Footprint
• Many other ways to interact with the SPM database
  • GIS
  • Web apps
  • 3rd party tools
  • Open Geospatial protocols
Summary of SPM VMT/Travel Model

- SPZ data used to calculate TAZ attributes
- TAZ attributes including accessibilities lead to trip generation rates by trip type
  - From statistical estimation of 2016 patterns in SCAG region
- ABM Offsets from a particular chosen ABM scenario add additional detail:
  - Regionwide variables, such as age demographics, industry mix
  - Zonal specific trip making, such as special generators or demographics
- Accessibility by distance band and TAZ attributes lead to mode choice and distance band choice
- ABM Offsets from chosen ABM scenario add additional detail:
  - Regionwide considerations, such as transit fares, auto operating cost, or auto ownership
  - Zonal specific mode choice and distance choice, such as nearby special amenities or transit level-of-service beyond stop proximity/density.
Conclusions

- VMT calculation fully consistent with / informed by / SCAG’s Regional Travel Model (ABM)
- Quick calculation of the VMT impacts of changes in land use patterns
- Supports the multi-disciplinary evaluation of policies, by putting VMT impacts alongside the other metrics in the multidisciplinary SPM
- Database infrastructure design supports application above/beyond the existing Urban Footprint web tool.