Factors and Methods Relating Land Use and Transportation Plans to VMT and CO₂

The Relationships
VMT Benefits of Compact Development

Vehicle travel 20% to 40% lower in dense, diverse, well-designed neighborhoods vs conventional suburbs

Region-wide neighborhood comparison: 2/3rd VMT reduction for central compact neighborhoods

Daily Vehicle Miles per Person vs. Residential Density

Source: Baltimore Metropolitan Council, 2001 Travel Survey
26% VMT reduction by 2050 in 62 study locations

Central location:
33% less vehicle travel
Studies of Site-Plan Variations

2% travel reduction due to site design

Atlantic Station – Successful Community

Lower VMT than Predicted
Modeling the Relationships

• Relationship between density and VMT consistent with statistical research
• Enhanced transit service impacts on VMT
• Induced travel and development from highway or passenger rail expansion
“D” Factors that Influence VMT

1. **Density** dwellings, jobs per acre
2. **Diversity** mix of housing, jobs, retail
3. **Design** connectivity, walkability
4. **Destinations** regional accessibility
5. **Distance to Transit** rail proximity
6. **Development Scale** pop, jobs
7. **Demographics** household size, income
8. **Demand Management** pricing, incentives

1. **Density** (jobs and dwellings per acre)

- Shortens trip lengths
- More walking/biking
- Supports quality transit
2. Diversity (mix of housing, jobs, retail)

- Links trips, shortens distances
- More walking/biking
- Allows shared parking

3. Design (connectivity, walkability)
4. Destinations (accessibility to activities)

Development at infill or close-in locations reduces vehicle trips and miles

Typical 4D Elasticities

<table>
<thead>
<tr>
<th></th>
<th>Vehicle Trips Per Capita</th>
<th>VMT per Capita</th>
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<tbody>
<tr>
<td>Density</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Diversity</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>Design</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>Destinations</td>
<td>17%</td>
<td>35%</td>
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</table>

Sources: National Syntheses, Twin Cities, Sacramento, Holtzclaw
D’s Help Refine Travel Model Sensitivity

<table>
<thead>
<tr>
<th>Reality</th>
<th>Model’s View</th>
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<tbody>
<tr>
<td>Circulation Network</td>
<td><img src="image1" alt="Circulation Network Reality" /> <img src="image2" alt="Circulation Network Model’s View" /></td>
</tr>
<tr>
<td>Walking Environment</td>
<td><img src="image3" alt="Walking Environment Reality" /> <img src="image4" alt="Walking Environment Model’s View" /></td>
</tr>
<tr>
<td>Density, Clustering</td>
<td><img src="image5" alt="Density Clustering Reality" /> <img src="image6" alt="Density Clustering Model’s View" /></td>
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</table>

Caltrans Recommendation on 4D’s

*Use D’s to compensate for any lack of sensitivity in travel models*

- 4D Model Enhancements
- PLACE’S
- INDEX

*Source: Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies, 2007*
4D Experience in California

- EPA and Caltrans Recommendations
- SACOG Blueprint
- SLOCOG Vision Plan
- San Joaquin Valley Growth Response
- Contra Costa Shaping our Future
- Fresno COG Blueprint
- SANDAG Smart Growth Trip Generation
- SJCOG Blueprint (under consideration)

5. Distance from Transit (transit service level)

Vehicle-miles traveled, compared with regional average:
- 42% reduction for households within ½ mile of rail transit
- 21% reduction for households between ½ and 1 rail mile
Generating Transit Ridership, Reducing VMT

- TOD Population
- TOD Employment
- Catchment Population
- Parking Supply
- Train Frequency
- Feeder Bus Frequency
- Walk Connections
- Bike Parking

Examples: BART, Caltrain, Sacramento LRT, Salt Lake LRT, Denver RTD

Direct Transit Ridership Models

Model 1 - Relationship Between PM Peak Boardings and 1/2 mile Non-Retail Employment, 1/2 mile Population, and Downtown SF Indicator, R²=.985
**TOD Impact on Transit Ridership**

- Station parking x 0.99
- Off-site parking x 0.69
- Peak buses x 60
- Bike parking x 2.5
- TOD population x 0.14
- Catchment pop. x 0.004

**Walk/Bike Access Share**

- TOD Population x 0.12
- TOD Employment x 0.14
- Bike Parking x 4.0
- Buses x -9.7
6+ Emerging Research

6. Development scale
7. Demographics
8. Demand management

Nationwide Survey of Mixed-Use Travel

240 MXD in Sacramento, Portland, Seattle, Boston, Atlanta, Houston

Gateway Oaks, Sacramento  River Place, Portland
Factors Correlated with Reduced Travel*

- Density of population and employment
- Diversity: jobs/housing relative to regional balance
- Diversity: balance of commercial, office, and public
- Design: intersections per square mile
- Destination Accessibility: jobs within 1 mile
- Destination Accessibility: jobs within a 30 min by transit
- Distance to Transit: rail station, bus stops within MXD

- Development Scale: MXD population and employment
- Demographics: household size, vehicle ownership

* Internal travel and walking, transit use, trip length

Validation: 15 Nationwide Validation Sites

- 3 Northern California
- 3 Southern California
- 6 Florida
- 3 in Texas, Georgia
Comparison of MXD Model to ITE Methods

### Preliminary

#### Errors in Estimates at 15 Locations

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<tr>
<th></th>
<th>ITE Rates</th>
<th>Internal</th>
<th>7D MXD Model</th>
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<tbody>
<tr>
<td>External Vehicle Trips</td>
<td>44%</td>
<td>31%</td>
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New Findings on Smart Growth Trip Generation

<table>
<thead>
<tr>
<th>Trip Discount</th>
<th>MXD</th>
<th>TOD</th>
<th>Infill</th>
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<tbody>
<tr>
<td>30%</td>
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<tr>
<td>44%</td>
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<tr>
<td>36%</td>
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Examples: San Diego, Seattle, Portland, Sacramento, Houston, Atlanta, Boston
Sources: EPA MXD, SANDAG SG TG, TCRP 128, Caltrans Urban Infill
### Effects of Supply-Side Strategies

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Highway Lane Miles</th>
<th>+0.55</th>
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<tbody>
<tr>
<td></td>
<td>Transit Revenue Miles</td>
<td>-0.06</td>
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<tr>
<td></td>
<td>Real Fuel Price</td>
<td>-0.17</td>
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Sources:

### Induced Travel: Trade-Off Evaluation

- **Possible benefits of adding roadway capacity:**
  - Improved flow stability and reduced CO2/VMT

- **Possible adverse consequences:**
  - Increased investment in auto-dependent corridors*
  - Induced auto trips, longer trips, mode shift to auto*
  - Increase in peak concentrations
  - Magnitude of effect depends on severity and duration of congestion, role of facility in regional multi-modal circulation

* *Investing in transit corridor may have opposite effects*
Network Management Strategies

**Congestion Mitigation**
- Signal coordination
- Ramp metering
- Incident management

**Flow Smoothing Techniques**
- Variable speed limit
- Intelligent speed adaptation

**Speed Management**
- Improved enforcement
- Speed limiters
- Active accelerator pedal

Source: Barth, Matthew; *ITS and the Environment, UC Riverside*, 2008

Factors with Quantifiable Effects on VMT, CO₂

**Land Use - Demand Side**
- Density
- Diversity
- Design
- Destination Accessibility
- Distance to Transit
- Development Scale
- Demographics
- Demand Management

**Transportation - Supply Side**
- Highway Lane Miles
- Transit Revenue Miles
- Induced Travel
- Pricing
- Network Management