Forecasting
aka Travel Demand Modeling

S. Handy
TTP 220
4/20/16
Transportation planning and programming

Planning:
• Developing a vision
• Creating policies and strategies to support the vision
• Long-term horizon

Programming:
• Prioritizing proposed projects
• Matching projects with available funds
• Short-term horizon

Long-Range Plan (LRP)
Regional Transportation Plan (RTP)
Transportation Improvement Program (TIP)
Traditional Transportation Planning

Goals
Congestion Reduction

Measures
V/C Level-of-Service

Forecasts
Travel Demand Model
Will pending federal transportation rule double down on outdated view of congestion? 4/12/16

“USDOT is on the cusp of releasing crucial directions for how states and metro areas will have to measure traffic congestion. The new rule could push local communities to try in vain to build their way out of congestion, or mark a shift toward smarter approaches like shortening trip times, rewarding communities that provide more options or better accounting for other travel modes and telecommuting... how USDOT instructs states and metro areas to measure congestion will have huge impacts on communities of all sizes. \textit{Why? Because there’s a direct connection between how we decide to measure congestion and the resulting strategies for addressing it.}”

Problems with delay measures:
- Middle-of-the-night speeds used as basis for judging delay
- Rewards places with long commutes
- Focuses only on drivers
- Looks at vehicles moving in a corridor, not people

“Roadway delay, similar to what TTI measures, \textit{represents a flawed and unrealistic view on measuring congestion.}”
New Transportation Planning

Goals
- Congestion Reduction
- Environment
- Equity
- Accessibility

Measures
- V/C Level-of-Service
- Mode split
- ???

Forecasts
- Travel Demand Model
- ???
Travel Demand Forecasting Model
The 4-Step Model

• Pre-WWII: some data collection and analysis
• 1950s: Chicago Area Transportation Study (CATS) considered the first region model
• 1960s: Federal policy in required use of models and standardized 4-Step modeling practice
• 1970s and 1980s: Flourishing travel behavior research field promotes models based on individual behavior
• 1990s: Travel Model Improvement Program (TMIP) to develop and disseminate new methods
• 2000s: A few MPOs switch to next-generation models
• 2016: Many MPOs moving towards next-generation models but 4-Step still widely used!
The 4-Step Model

INPUTS?
- Land use data
- Network

4-STEPS?
- Trip Generation
- Trip Distribution
- Mode Split
- Assignment

OUTPUTS?
- Volumes
- LOS

Population, income, autos by zone
Employment by type by zone
Represented as nodes and links
Travel times from zone to zone

# trips from zones - Ps
# trips to zones - As
# trips between each pair of zones
% of trips between zones by each mode
driving trips assigned to routes
**Network – nodes and links (travel times)**

**TAZs – Traffic Analysis Zones (households, jobs)**

<table>
<thead>
<tr>
<th>Trip generation</th>
<th>20 Ps</th>
<th>10 As</th>
<th>12</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip distribution</td>
<td></td>
<td></td>
<td>3</td>
<td>+2</td>
</tr>
<tr>
<td>Mode split</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Route assignment</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

- # Ps and # As for each zone
- # trips between each zone pair
- # and % of trips by mode, overall and by zone pair
- Traffic volumes on each link
- Vehicle miles of travel
Four-Step Regional Travel Forecasting Model

1. Trip generation
2. Trip distribution
3. Mode choice
4. Trip assignment

Input:
- Land use data
- Highway and transit networks
- Zone-to-zone travel times, costs, etc.

Outputs:
- Highway and transit trips
- Traffic volumes

Flow:
- Congested traffic speeds
Modeling Process

• **Model Calibration** – for base year
  – Equations estimated for each of the 4-steps using demographic and economic data from existing sources and travel behavior data from travel diary survey

• **Model Validation** – for base year
  – Model outputs for base year compared to actual traffic counts

• **Model Application** – for future years
  – Forecasts of all model inputs, e.g. population, income, employment, gas prices, etc.
  – Plans for future transportation network
<table>
<thead>
<tr>
<th>TIME OF</th>
<th>FASHION</th>
<th>GO TO</th>
<th>TIME AT</th>
<th>REASON FOR TRIP</th>
<th>TRIP</th>
<th>STREET ADDRESS</th>
<th>FROM ZONE</th>
<th>TOTAL TRIP GROUP</th>
<th>TRAVEL ELAPSED</th>
<th>TRAVEL INFORMATION BEFORE OR DURING TRIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00 AM</td>
<td>Home</td>
<td>Work</td>
<td>6:30 AM</td>
<td>Commute to Work</td>
<td>Car</td>
<td>Home Address</td>
<td>Zone A</td>
<td>Group 1</td>
<td>0.25 Hour</td>
<td>45 minutes.</td>
</tr>
<tr>
<td>7:00 AM</td>
<td>Home</td>
<td>School</td>
<td>7:30 AM</td>
<td>Commute to School</td>
<td>Walk</td>
<td>School Address</td>
<td>Zone B</td>
<td>Group 2</td>
<td>0.15 Hour</td>
<td>15 minutes.</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>School</td>
<td>Lunch</td>
<td>9:00 AM</td>
<td>Go to Lunch</td>
<td>Lunch</td>
<td>Lunch Area</td>
<td>Zone C</td>
<td>Group 3</td>
<td>0.25 Hour</td>
<td>45 minutes.</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>Lunch</td>
<td>Work</td>
<td>1:00 PM</td>
<td>Commute to Work</td>
<td>Car</td>
<td>Home Address</td>
<td>Zone D</td>
<td>Group 4</td>
<td>0.25 Hour</td>
<td>45 minutes.</td>
</tr>
<tr>
<td>6:00 PM</td>
<td>Home</td>
<td>Dinner</td>
<td>6:30 PM</td>
<td>Go to Dinner</td>
<td>Car</td>
<td>Home Address</td>
<td>Zone E</td>
<td>Group 5</td>
<td>0.25 Hour</td>
<td>45 minutes.</td>
</tr>
</tbody>
</table>

**Puget Sound Transportation Panel**

**2016 Travel Diary**

**Things to Remember:**
- Fill out the diary for the day indicated.
- For the diary, consider your day starting at 6 AM. For most people, when you wake up will be the start of your day.
- Record trips in sequence, including stops along the way and start times.
- If you switch transportation modes during the trip, please note each mode or one trip.
- The last trip of the day should be your home, where you were at 6 AM.
- If household members or other travelers are together, each should record their own trips.
Demands on models have changed!

- **Pre-ISTEA:** Capacity = f(volume, LOS)
- **Post-ISTEA:**
  - New kinds of projects and policies, e.g. biking
    - What variables are in the model?
  - New kinds of criteria, e.g. environmental justice
    - What outputs does the model produce?
  - Requirements for public involvement
    - How transparent is the model and its application?
  - Greater recognition of relationships with LU
    - How do models account for these relationships?
Question 1:
Variables in the Model
# Typical variables in the model

| Trip Generation          | Productions:  # households, average income, average autos owned, average household size, workers  
|                         | Attractions:  # employees by type of industry |
| Trip Distribution        | Zone-to-zone travel time – assumes peak hour by car  
|                         | Productions and attractions in each zone |
| Mode Split               | Zone-to-zone travel time by mode  
|                         | Zone-to-zone driving costs (gas price, parking cost, tolls)  
|                         | Zone-to-zone transit fares  
|                         | Average income, average autos owned |
| Route Assignment         | Zone-to-zone travel time by route – depending on volume |

**What if proposal is for bicycle and pedestrian infrastructure?**
If proposal is for bicycle and pedestrian infrastructure... we need a variable representing bicycle and pedestrian infrastructure in the model

Example: Portland’s Pedestrian Environment Factor (PEF)

<table>
<thead>
<tr>
<th>Ease of Street Crossing</th>
<th>width of key intersections, extent of signalization, and traffic volumes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk Continuity</td>
<td>presence (or absence) of a continuous sidewalk network.</td>
</tr>
<tr>
<td>Street Connectivity</td>
<td>numerous connections vs. cul-de-sacs, dead ends, long blocks, circular patterns</td>
</tr>
<tr>
<td>Topography</td>
<td>Steep slopes</td>
</tr>
</tbody>
</table>

Up to 3 points for each factor; 12 points = best for pedestrians

Model can now be used to test impact of change in PEF on mode split and traffic volumes
Question 2: Model Outputs
Baseline...
“Build”…

Traffic Congestion in 2025, with NTP Projects
peak weekday

Map 6

- Typical Urban Traffic or No Congestion
- Slow Traffic (heavy congestion)
- Prolonged Stop-and-Go Traffic (2+ hours)
- Extreme Congestion Points

Scale: the dashed divided highway

Area of region shown

[Map showing traffic congestion]
“No Build”…
### MTC’s Goals and Measures

<table>
<thead>
<tr>
<th>Goal</th>
<th>Measures of Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Number of injuries and fatalities at hot spots, pavement condition index, age of transit fleet, bridge retrofit</td>
</tr>
<tr>
<td>Reliability</td>
<td>Capacity added to system, LOS in congested corridors, progress on ramp meters and signal timing, transit connectivity projects, incident management strategies</td>
</tr>
<tr>
<td>Access</td>
<td>Amount of lifeline transit service provided, progress in programs for older adults, progress in community-based plans,</td>
</tr>
<tr>
<td>Livable Communities</td>
<td>Number of Transportation for Livable Communities projects, number of TOD and mixed-use projects with incentives</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Conformity analysis, progress on retrofitting buses, new controls for spare-the-air days, funding for bike/ped projects</td>
</tr>
<tr>
<td>Efficient Freight Travel</td>
<td>Identification of key freight projects, development of regional truck network on arterials, develop regional air cargo plan</td>
</tr>
</tbody>
</table>
Possibilities?

**Model Outputs**
- # Ps and # As for each zone
- # trips between each zone pair
- # and % of trips by mode, overall and by zone pair
- traffic volumes on each link
- vehicle miles of travel

**SACOG’s Goals**
- Quality of Life
- Access and mobility
- Air quality
- Travel choices
- Economic vitality
- Equity
- Transportation and land use
- Funding and revenue
- Health and safety
- Environmental sustainability
Example from MTC’s Equity Analysis for the Transportation 2035 Plan

Low-Income Jobs Accessible in 30 Minutes by Auto

Low-Income Jobs Accessible in 30 Minutes by Transit

Source: MTC estimates

### Regional Demographic, Travel and Air Quality Indicators

Bay Area Total in 2035 (future conditions, without Transportation 2035 Plan) and Percent Change From 2006

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>9.0 million</td>
<td>26%</td>
</tr>
<tr>
<td>Mean Household Income ($)</td>
<td>$133,000</td>
<td>29%</td>
</tr>
<tr>
<td>Employed Residents (workers)</td>
<td>5.0 million</td>
<td>53%</td>
</tr>
<tr>
<td>Employment (jobs)</td>
<td>5.2 million</td>
<td>50%</td>
</tr>
<tr>
<td>Workers from Outside Area</td>
<td>(231,000)</td>
<td>7%</td>
</tr>
<tr>
<td>Developed Land (acres)</td>
<td>(926,000)</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Travel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Daily Trips</td>
<td>29.1 million</td>
<td>37%</td>
</tr>
<tr>
<td>Daily Auto Trips</td>
<td>23.3 million</td>
<td>32%</td>
</tr>
<tr>
<td>Daily Transit Trips</td>
<td>(1.9 million linked trips)</td>
<td>75%</td>
</tr>
<tr>
<td>Daily Commercial Vehicle Trips</td>
<td>(4.7 million)</td>
<td>45%</td>
</tr>
<tr>
<td>Daily Non-Motorized Trips</td>
<td>(3.9 million)</td>
<td>41%</td>
</tr>
<tr>
<td>Daily Vehicle Miles of Travel</td>
<td>(1.923 million)</td>
<td>33%</td>
</tr>
<tr>
<td>Average Commute Duration</td>
<td>(24.3 minutes)</td>
<td>7%</td>
</tr>
<tr>
<td>Average Commute Distance</td>
<td>(11.1 miles)</td>
<td>-8%</td>
</tr>
<tr>
<td><strong>Air Quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse Particle (PM10) Emissions</td>
<td>(85 tons/day)</td>
<td>29%</td>
</tr>
<tr>
<td>Fine Particle (PM2.5) Emissions</td>
<td>(21 tons/day)</td>
<td>20%</td>
</tr>
<tr>
<td>CO2 Emissions</td>
<td>(77,000 tons/day)</td>
<td>-14%</td>
</tr>
</tbody>
</table>

Forecasted inputs: Population, Mean Household Income, Employed Residents, Employment, Workers from Outside Area, Developed Land.

Model outputs: Total Daily Trips, Daily Auto Trips, Daily Transit Trips, Daily Commercial Vehicle Trips, Daily Non-Motorized Trips, Daily Vehicle Miles of Travel, Average Commute Duration, Average Commute Distance.

Post-processing: Coarse Particle (PM10) Emissions, Fine Particle (PM2.5) Emissions, CO2 Emissions.

Sources: MTC; ABAG, Projections 2007

1. Home-based work vehicle trips
2. Home-based work vehicle driver miles
### Transportation 2035 Performance Objectives

#### Three Es

**Economy**

- Reduce per-capita delay by 20 percent from today by 2035
- Improve Maintenance
  - Maintain pavement condition index (PCI) of 75 or greater for local streets and roads
  - Distressed pavement condition lane-miles not to exceed 10 percent of total state highway system
- Achieve an average age for all transit asset types that is no more than 50 percent of their useful life
- Increase the average number of miles between service calls for transit service in the region to 8,000 miles

**Reduce Collisions/Fatalities**

- Reduce fatalities from motor vehicle collisions by 15 percent from today by 2035
- Reduce bicycle and pedestrian fatalities attributed to motor vehicle collisions by 25 percent (each) from 2000 by 2035
- Reduce bicycle and pedestrian injuries attributed to motor vehicle collisions by 25 percent (each) from 2000 by 2035

**Improve Regional Transportation Emergency Preparedness**

- Conduct regional transportation exercise that tests emergency response and coordination capabilities for special needs populations
- Improve the seismic safety of high-priority transportation facilities

**Increase the number of transportation agency employees trained in security/emergency awareness protocols**

**Reduce Vulnerability to Transportation Security Threats**

- Increase the number of transportation agency employees trained in security/emergency awareness protocols
- Enhance or install critical infrastructure detection equipment on high-priority transportation facilities

**Environment**

- Reduce daily per-capita vehicle miles traveled (VMT) by 10 percent from today by 2035
- Reduce Emissions
  - Reduce emissions of fine particulates (PM_{2.5}) by 10 percent from today by 2035
  - Reduce emissions of coarse particulates (PM_{10}) by 45 percent from today by 2035
  - Reduce carbon dioxide (CO_{2}) emissions to 40 percent below 1990 levels by 2035

**Equity**

- Decrease by 10 percent the combined share of low-income and lower-middle-income residents' household income consumed by transportation and housing

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*Other things hard to forecast – how do we know how well plan will do?*
from MTC’s Transportation 2035 Plan

Project 1: Annual Household Transportation Costs in 2035

<table>
<thead>
<tr>
<th>Income Level</th>
<th>Rural-Suburban</th>
<th>Dense Suburban</th>
<th>Urban Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Income</td>
<td>$5,000</td>
<td>$7,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>Moderately Low-Income</td>
<td>$10,000</td>
<td>$12,000</td>
<td>$13,000</td>
</tr>
<tr>
<td>All Households</td>
<td>$20,000</td>
<td>$22,000</td>
<td>$24,000</td>
</tr>
</tbody>
</table>

Source: MTC
Question 3: Transparency of Model Application
Perspectives on Use

• **Rational:** Model gives the answer
• **Political:** Model used to justify answer
• **Interactive:** Model used to foster public dialogues
Deception in Dallas
Strategic Misrepresentation in Rail Transit Promotion and Evaluation

John F. Kain

This article describes the misuse of land-use and ridership forecasts by Dallas Area Rapid Transit (DART). DART made extensive use of clearly unrealistic land use forecasts and optimistic ridership forecasts in its unsuccessful efforts to obtain voter approval for a 91-mile rail transit system. When alternative analyses indicated that the proposed $2.6-billion rail system would carry only slightly more riders than an unimproved bus system, DART tried to conceal the information. Subsequently, when a citizen's group obtained the release of these unfavorable findings, DART attempted to mislead voters about their significance and released cost-effectiveness analyses based on earlier, and clearly incorrect, ridership forecasts.

In 1983, the Dallas Area Rapid Transit District (DART) persuaded Dallas area voters to create a permanent regional transit authority and to impose a 1-percent sales tax to build and operate a 160-mile rail rapid transit system. DART spent the next five years and more than $75 million designing a rail system (Deloitte, Haskins, and Sells 1987). As planning proceeded, the system's planned size was steadily reduced.

In 1988, DART returned to the voters in its service area for authority to sell long term bonds to build a 92-mile light rail transit (LRT) system. While the referendum was concerned solely with the question of whether DART would be given authority to sell long term bonds, it was interpreted by supporters and opponents alike as a referendum on DART's competence and as a plebiscite on its rail plan. In a single issue election held on Saturday, June 25, 1988, Dallas area voters, worried about high unemployment, falling property values, bank closures, rising taxes, and sharp cuts in local government services, dealt DART and its supporters a crushing defeat as 59 percent of those voting rejected the proposed financing plan.

In campaigns to obtain voter support for its proposed rail system, the Dallas Area Rapid Transit District (DART) overstated the benefits and understated the costs of the proposed system and attempted, first, to conceal and then to misrepresent the results of unfavorable travel forecasts.

It is difficult, if not impossible, to identify those responsible for this misrepresentation or their motivations. DART has had three executive directors in its short life; the unpaid chairman of its board and several board members, who had strong commitments to rail, were actively involved in setting policy. In addition, many professionals at both DART and the North Central Texas Council of Governments (NCTCOG) tried to assess realistically the rail option. Indeed, the analyses presented in this article were possible only because a number of DART and NCTCOG professionals freely shared their knowledge and concerns with the author. DART's efforts to mislead the public, moreover, were abetted by a less-than-vigilant media that editorially supported the rail plan and were encouraged by community mores that discourage public debate on issues of this kind.

This article is an examination of issues related to the creation of DART, its controversial rail plan, the referendum seeking bonding authority, and in particular DART's persistent misuse of land-use and travel forecasts. While the article deals principally with efforts by one transit authority to convince area residents to provide funding for an extensive rail rapid transit system, the practices described here occur in virtually every metropolitan area (Gomez-Ibanez 1985; Gordon and Wilson 1985; Hamer 1976; Kain 1988a; Peat, Marwick, Main & Co. 1988; Pickrell 1989).

Travel Forecasting and Alternatives Analyses

Transportation planners throughout the world rely on a travel forecasting methodology developed in the United States of America, most notably by the U.S. Department of Transportation. This method, known as the "Trip Generation and Trip Distribution" model, involves a four-step process: trip generation, trip distribution, route choice, and mode choice. Each step is modeled separately, and the results of one step are fed into the next. The model is based on the assumption that travel patterns are predictable and that historical data can be used to forecast future travel. However, the model has been criticized for its oversimplification of complex travel behavior and for its failure to account for the influence of transportation planning decisions on travel patterns.
Assessing the Dallas Example

What do the preceding analyses of DART land use and travel forecasts indicate? They strongly suggest that, in the past at least, DART could not be trusted to provide voters and policymakers, or even its own board, with accurate and unbiased information about the ridership, benefits, and costs of its proposed rail systems and, more important, of alternatives to its extravagant rail plan.

The analyses call into question the techniques used by DART and its supporters to persuade Dallas voters first to provide DART with a dedicated source of tax revenues and then to approve the sale of long term bonds to build an extravagant rail transit system. The motivations, accountability, and integrity of the professionals and political leaders involved in selling rail transit to the region’s voters warrant close examination. While some advocates were clearly acting out of perceived self-interest, the unswerving and blind commitment of many others to rail is difficult to explain in these terms. I leave it to others, more skilled in bureaucratic and political analysis or psychology to provide an explanation. While the specific findings presented in this article are limited to Dallas, abuses similar to those described here are commonplace and occur in varying degrees in virtually every metropolitan area, both in the United States and overseas.
Early example of interactive use of models...

Making the Land Use, Transportation, Air Quality Connection (LUTRAQ)—Freeways or Communities: It's Your Choice

Adapted from a speech by
Keith Bartholomew,
Staff Attorney/LUTRAQ Project Director

See http://www.friends.org/resources/reports
<table>
<thead>
<tr>
<th></th>
<th>No Build</th>
<th>Highways Only</th>
<th>Highways/Parking Pricing</th>
<th>LUTRAQ</th>
<th>LUTRAQ/Congestion Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Use</strong></td>
<td>Existing plans</td>
<td>Existing plans</td>
<td>Existing plans</td>
<td>Transit-oriented development</td>
<td>Same as &quot;LUTRAQ&quot;</td>
</tr>
<tr>
<td><strong>Transit</strong></td>
<td>Westside LRT to 185th w/feeder buses</td>
<td>&quot;No Build&quot; + LRT to Hillsboro; express bus on Hwy 217</td>
<td>&quot;Highways Only&quot; + demand responsive transit</td>
<td>&quot;Highways/Parking Pricing&quot; + LRT on Hwy 217, Barbur Blvd &amp; Hwy 43; express bus to Forest Grove, Sherwood, Bethany &amp; Scholls Ferry</td>
<td>Same as &quot;LUTRAQ&quot;</td>
</tr>
<tr>
<td><strong>Roads</strong></td>
<td>Only fully funded projects</td>
<td>Western Bypass &amp; 48 other improvements</td>
<td>Same as &quot;Highways Only&quot;</td>
<td>Selected improvements; no Bypass</td>
<td>Same as &quot;LUTRAQ&quot;</td>
</tr>
<tr>
<td><strong>Walk/Bike Facilities</strong></td>
<td>Existing</td>
<td>Existing</td>
<td>Existing</td>
<td>Existing + improvements in transit oriented developments &amp; LRT corridors</td>
<td>Same as &quot;LUTRAQ&quot; + improvements in bus corridors</td>
</tr>
<tr>
<td><strong>Demand Management</strong></td>
<td>None</td>
<td>None</td>
<td>Parking charges/transit passes for workers</td>
<td>Same as &quot;Highways/Parking Pricing&quot;</td>
<td>Same as &quot;LUTRAQ&quot;</td>
</tr>
<tr>
<td><strong>Road Pricing</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Peak period charge of $0.15/mile for work trips</td>
</tr>
</tbody>
</table>
Figure 2-4: Vehicle Trips per Household

- No Build: 7.53
- Highways Only: 7.5
- Highways/Parking Pricing: 7.29
- LUTRAQ: 7.17
- LUTRAQ (TOD Only): 5.79
- LUTRAQ/Cong. Pricing: 7.07
- LUTRAQ/Cong. Pricing (TOD Only): 5.67

Legend:
- Solid black: Home to Work
- Light gray: Home to College
- White: Home to Other
- Gray: Non-Home/Work
- Dark gray: Home to School
- Medium gray: Non-Home/Non-Work
Figure 2-5: Vehicle Hours of Delay (P.M. Peak Hour)

- **No Build**: Total delay = 2930
  - Freeways = 1000
  - Principal/Major Arterials = 900
  - Minor/Other Arterials = 1030

- **Highways Only**: Total delay = 1670
  - Freeways = 500
  - Principal/Major Arterials = 570
  - Minor/Other Arterials = 500

- **Highways/Parking Pricing**: Total delay = 1210
  - Freeways = 370
  - Principal/Major Arterials = 300
  - Minor/Other Arterials = 540

- **LUTRAQ**: Total delay = 1370
  - Freeways = 400
  - Principal/Major Arterials = 370
  - Minor/Other Arterials = 600

- **LUTRAQ/Cong. Pricing**: Total delay = 1000
  - Freeways = 300
  - Principal/Major Arterials = 270
  - Minor/Other Arterials = 430
Table 2-10: Air Pollutant Emissions (kg/day)

<table>
<thead>
<tr>
<th></th>
<th>No Build</th>
<th>Highways Only</th>
<th>Highways/Parking Pricing</th>
<th>LUTRAQ</th>
<th>LUTRAQ/Congestion Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
</tr>
<tr>
<td>HC</td>
<td>9,988</td>
<td>9,965</td>
<td>-0.2%</td>
<td>9,626</td>
<td>-3.6%</td>
</tr>
<tr>
<td>NO\textsubscript{X}</td>
<td>14,104</td>
<td>15,054</td>
<td>6.7%</td>
<td>14,620</td>
<td>3.6%</td>
</tr>
<tr>
<td>CO</td>
<td>94,605</td>
<td>94,057</td>
<td>-0.6%</td>
<td>90,813</td>
<td>-4%</td>
</tr>
</tbody>
</table>

1. Compared to the No Build alternative.

Table 2-11: Greenhouse Gas Emissions (kg/day) & Energy Consumption (millions of BTUs)

<table>
<thead>
<tr>
<th></th>
<th>No Build</th>
<th>Highways Only</th>
<th>Highways/Parking Pricing</th>
<th>LUTRAQ</th>
<th>LUTRAQ/Congestion Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
<td>Difference</td>
</tr>
<tr>
<td>CH\textsubscript{4}</td>
<td>786</td>
<td>799</td>
<td>1.6%</td>
<td>783</td>
<td>-0.4%</td>
</tr>
<tr>
<td>N\textsubscript{2}O</td>
<td>526</td>
<td>534</td>
<td>1.6%</td>
<td>524</td>
<td>-0.4%</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>4,814,705</td>
<td>4,893,061</td>
<td>1.6%</td>
<td>4,795,466</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>35,089</td>
<td>35,660</td>
<td>1.6%</td>
<td>34,949</td>
<td>-0.4%</td>
</tr>
</tbody>
</table>

1. Compared to the No Build alternative.
Sketch planning tools used in community workshops...
There are three main components to the PLACE$^3$S method:
- Public participation
- Planning and design
- Measurement

“A key role for planners in the development of integrated policy is to make the complexity of the interactions intelligible to decision makers and their constituents so that decisions are better informed.”

Terry Moore and Paul Thorsnes, The Transportation/Land Use Connection

http://www.energy.ca.gov/places/EXECSUMM.PDF
Models and Professional Ethics

• Illusion of certainty
  – What is the confidence interval?
• Illusion of technical objectivity
  – What are the bases for assumptions?
• Cloak of complexity
  – What’s really going on in there?
MPO Assessment
Example 1 - MTC

Average Commute Distance in 2030

<table>
<thead>
<tr>
<th>County of Residence</th>
<th>Distance (miles)</th>
<th>Change from 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda</td>
<td>12.3</td>
<td>6%</td>
</tr>
<tr>
<td>Contra Costa</td>
<td>16.0</td>
<td>3%</td>
</tr>
<tr>
<td>Marin</td>
<td>11.4</td>
<td>-11%</td>
</tr>
<tr>
<td>Napa</td>
<td>16.1</td>
<td>39%</td>
</tr>
<tr>
<td>San Francisco</td>
<td>6.1</td>
<td>-15%</td>
</tr>
<tr>
<td>San Mateo</td>
<td>10.0</td>
<td>-6%</td>
</tr>
<tr>
<td>Santa Clara</td>
<td>9.5</td>
<td>-3%</td>
</tr>
<tr>
<td>Solano</td>
<td>22.9</td>
<td>26%</td>
</tr>
<tr>
<td>Sonoma</td>
<td>13.2</td>
<td>-12%</td>
</tr>
<tr>
<td><strong>Bay Area Average</strong></td>
<td><strong>11.9</strong></td>
<td><strong>3%</strong></td>
</tr>
</tbody>
</table>

Source: MTC travel forecasts
Example 2 - SACOG

• “Models can provide information about travel today, and forecast travel in the future, but do not make decisions.”

• “A model’s calculations will be no better than the vision and instructions it is given.”
Example 2 - SACOG

“The average person drives 22.9 miles per day now, which increases to 24.4 miles per day by 2025.”
Example 3 - PSRC

• “The regional travel demand model isn’t a crystal ball; it can’t predict the future.”

• “The model does provide technical information which helps to guide and support good decision-making.”

• Forecasts are “only one of the many pieces of information used in developing a regional plan.”
2010 Performance Data

**TABLE 8-5. Daily Vehicle Miles Traveled on the Arterial and Freeway Network**

<table>
<thead>
<tr>
<th>SUBAREA</th>
<th>1998 BASELINE</th>
<th></th>
<th>2010 CURRENT LAW REVENUE</th>
<th></th>
<th>2010 STRATEGY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAILY VMT</td>
<td>DAILY VMT PER CAPITA</td>
<td>DAILY VMT</td>
<td>DAILY VMT PER CAPITA</td>
<td>DAILY VMT</td>
<td>DAILY VMT PER CAPITA</td>
</tr>
<tr>
<td>Region</td>
<td>64,490,626</td>
<td>20.5</td>
<td>80,188,658</td>
<td>21.1</td>
<td>79,394,356</td>
<td>20.9</td>
</tr>
<tr>
<td>Northwest King County</td>
<td>11,958,359</td>
<td>19.7</td>
<td>13,605,074</td>
<td>19.9</td>
<td>13,377,546</td>
<td>19.6</td>
</tr>
<tr>
<td>East King County</td>
<td>10,542,720</td>
<td>22.0</td>
<td>13,264,330</td>
<td>24.1</td>
<td>13,497,226</td>
<td>24.5</td>
</tr>
<tr>
<td>South King County</td>
<td>14,567,719</td>
<td>25.1</td>
<td>17,751,789</td>
<td>25.5</td>
<td>17,344,633</td>
<td>24.9</td>
</tr>
<tr>
<td>King County</td>
<td>37,069,046</td>
<td>22.3</td>
<td>44,621,502</td>
<td>23.1</td>
<td>44,224,176</td>
<td>22.9</td>
</tr>
<tr>
<td>Kitsap County</td>
<td>3,193,155</td>
<td>13.9</td>
<td>4,500,761</td>
<td>15.6</td>
<td>4,095,874</td>
<td>14.2</td>
</tr>
<tr>
<td>Pierce County</td>
<td>12,602,705</td>
<td>18.3</td>
<td>16,333,723</td>
<td>19.5</td>
<td>15,995,417</td>
<td>19.1</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>11,624,002</td>
<td>20.5</td>
<td>14,730,381</td>
<td>19.8</td>
<td>15,070,111</td>
<td>20.2</td>
</tr>
</tbody>
</table>
## Example 4 – Met Council

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Households</th>
<th>Employment</th>
<th>VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2,288,721</td>
<td>875,504</td>
<td>1,273,000</td>
<td>48,922,671</td>
</tr>
<tr>
<td>2000</td>
<td>2,642,062</td>
<td>1,021,459</td>
<td>1,600,348</td>
<td>57,195,148</td>
</tr>
<tr>
<td>2010</td>
<td>3,005,270</td>
<td>1,197,580</td>
<td>1,805,700</td>
<td>66,630,512</td>
</tr>
<tr>
<td>2020</td>
<td>3,334,160</td>
<td>1,361,870</td>
<td>1,978,000</td>
<td>74,014,160</td>
</tr>
<tr>
<td>2030</td>
<td>3,607,660</td>
<td>1,491,630</td>
<td>2,126,000</td>
<td>86,168,310</td>
</tr>
<tr>
<td>Models</td>
<td>Technical objectivity</td>
<td>Certainty</td>
<td>Black box</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------</td>
<td>----------------------------</td>
<td>-------------------------------</td>
<td></td>
</tr>
<tr>
<td>MTC</td>
<td>Does not discuss</td>
<td>No confidence intervals</td>
<td>Details on website</td>
<td></td>
</tr>
<tr>
<td>SACOG</td>
<td>Good caveats</td>
<td>No confidence intervals</td>
<td>Description in plan</td>
<td></td>
</tr>
<tr>
<td>PSRC</td>
<td>Good caveats</td>
<td>No confidence intervals</td>
<td>Description in plan</td>
<td></td>
</tr>
<tr>
<td>Met Council</td>
<td>Does not discuss</td>
<td>No confidence intervals</td>
<td>No information provided</td>
<td></td>
</tr>
</tbody>
</table>
Models Summary

• MPOs struggling (or should be) with how best to use forecasts in the planning process

• Options for reconciling models with public involvement requirements:
  – Sketch models in public workshops... *e.g. SACOG*
  – Activity-based models... *more in a minute*
    • New measures?
    • More intuitive?
What I think happens...

• Goals that have performance measures that can be forecast using TDMs get the most weight in the process.

• Goals that have performance measures that cannot be forecast using TDMs are unlikely to be forecast and thus get less weight in the process.

• Goals without performance measures get the least weight in the planning process.
In other words...

• Congestion relief may still be driving the planning process, despite the adoption of new goals, simply because of the entrenched use of TDMs to forecast system performance.
That means we need to...

- Develop performance measures for all goals and find ways to forecast these measures using TDM or other means.
- Find ways to give equal weight to goals with and without forecast-able performance measures.
“Good models are a necessary but not sufficient condition for good decision making”
Question 4: Transportation and Land Use are Inextricably Linked
What’s wrong with this picture?
Land use data \rightarrow \text{Network} \\
\text{Trip Generation} \rightarrow \text{Trip Distribution} \rightarrow \text{Mode Split} \rightarrow \text{Assignment} \\
\downarrow \\
\text{Volumes LOS}
Sierra Club vs. ILDOT 1997
Interstate Highway 355 Extension

• “Specifically, plaintiffs point out that defendants relied on a single population forecast and that the forecast was used to analyze the build and no-build scenarios.”

• “Plaintiff’s argument is persuasive. Highways create demand for travel and expansion by their very existence.”

Video: http://wn.com/I-355
“However, the final impact statement in this case relies on the implausible assumption that the same level of transportation needs will exist whether or not the tollroad is constructed. In particular, the final impact statement contains a socioeconomic forecast that assumes the construction of a highway such as the tollroad and then applies that forecast to both the build and no-build alternatives”
Sierra Club vs. ILDOT 1997
Interstate Highway 355 Extension

• “The result is a forecast of future needs that only the proposed tollroad can satisfy. As a result, the final impact statement creates a self-fulfilling prophecy that makes a reasoned analysis of how different alternatives satisfy future needs impossible.”

ILDOT redid forecasts and construction proceeded in 2004
Integrated Transportation-Land Use Modeling (ITLUM)

http://tmip.fhwa.dot.gov/clearinghouse/tmip_newsletter/spring05_issue22/images/integrated_model.jpg
Integrated Transportation-Land Use Modeling (ITLUM)
Other Improvements

• Activity-based models
• Micro-simulation models

Issues...
- More sensitivity to new kinds of projects and policies BUT...
- They are data intensive and thus costly to develop
- Are they really more accurate?
- Does the increased complexity make them harder to understand?
- Or does the more intuitive structure make them easier to understand?
“Most metropolitan planning agencies recognize travel demand modeling as a major component of transport planning. Yet... there remain a large number of jurisdictions... that adopt outdated models or do not rely on modeling to support decision-making.”

- Lack of resources for large-scale modeling efforts
- General disbelief in the usefulness of models for decision making

New goals but “...modelling tools that can assess the impacts of proposed policies on these goals have lagged behind.”
Next Up

- Air Quality Conformity
- Work on framework for MPO analysis!