Travel demand modeling at DRCOG

- Basics
- Unique aspects of Focus Model
- Input data
- Outputs, queries, and uses of the model
Travel demand modeling - basics

• Did you make a trip from your house this morning?

• Where did you go?

• What mode of travel did you use to get there?

• What driving path or transit route(s) did you take?

• 15 million “person trips” typical weekday!
  • 12.5 million in cars/trucks (9 million vehicle trips)
  • 2.0 million by pedestrian & bicycle
  • 0.5 million by transit and school bus
HOW IS FOCUS MODEL UNIQUE?
Focus includes an activity-based-trip model (ABM)

- Individual person and household characteristics modeled
  - Every person in the DRCOG region
  - Where people “choose” to work and go to school
  - How many “autos” a household has

- Tour-based
  - Full tour includes all travel between leaving from and returning home
  - A round trip tour may include intermediate stops

- Individual component travel choices
  - Time-of-day; Duration at destination; Intermediate stops
  - Mode of travel for tour (primary) and sub-trips (any mode)
What is a tour?
INPUT DATA
Model represented population (with RP&D Division land use team)

- **Households**
  - Housing unit location
  - Annual income
  - Number of persons

- **Individual persons**
  - Age & gender
  - Student status and “grade”
  - Worker status and occupation
  - Relationship with other household members
  - Added dormitory student residents
Socioeconomic data (with land use team and UrbanSim)

- **Housing unit points**
  - distance to transit

- **Employment establishment points**
  - industry sector
  - number of jobs

- **School points**
  - public or private, grade, K-8, high school or university
  - enrollment

- **Zone (TAZ) data**
  - points – households and employment establishments
  - centroid coordinates – start/end of assignment trips
Transportation analysis zones (2,832 TAZs)
Roadway network link data

- lanes
- fee-flow speed/time
- capacity – for final speed/time
- facility type
- operating cost / tolls
- TAZ centroid connectors
Transit network route information

- stop locations and dwell time
- frequency by time of day
- mode and service type
- fare (vary by person)
DECISIONS MODELED
Person decision/choice factors (utility functions)

- **Regular workplace location**
  - At home or outside the home?
  - What type (sector) of employment
  - Which TAZ?
- **Regular school location – by grade/age**
- **Daily activity pattern**
  - For which purposes will tours, trips or stops be made?
- **Number of tours by purpose**

Choice model components are calibrated to 2010 household travel survey results
US Census data – place of work by residence compare to Focus

- ACS – tallied by place of residence
  - How did you usually get to work last week?
  - Region values:
    - 82% in autos (74% drive alone; 8% carpool)
    - 4.5% transit
    - 5% walk/bicycle/other
    - 8.5% work at home
    - 0.001% by ferry

- CTPP – tallied by residence and workplace
  - 2010 down to TAZ (2,800)
  - 2020 down to block group (2,100)
Tour and trip decisions - weekday

- **Destinations**
  - Regular workplace/school or somewhere else for work/school travel? (or stay home)
  - Specific locations

- **Departure, arrival, and duration times**

- **Mode of travel**

- **ABM creates origin-destination (O-D) trip tables** (5 modes x 10 time periods)

- **Path or route of travel (assignment)**
  - By roadways (auto/truck)
  - By transit (bus/rail)
Mode of travel choices

Tour or Trip

- Auto
  - Drive Alone
  - Shared Ride 2
  - Shared Ride 3+

- Transit
  - Walk to Transit
  - Drive to Transit

- Non-Motorized
  - Walk
  - Bike

- School Bus

Trip Tables “Assigned” to routes/paths by time period of day.

Not “Assigned”
Mode of travel factors for personal trip mode choice

- **General**
  - Demographic: Income, household size, ages, auto availability
  - Auto operating cost, value of time, cost of transit, travel time, . . . .
  - Travel time by modes

- **Bicycle and pedestrian calculation factors (“utility functions”)**
  - Density of population & employment; Mixed use measure
  - Type of development activities (retail, entertainment, etc.)
  - Age, student status, other demographic, ..... 
  - Sidewalk + shared use path “density”
  - Bikeshare stations
  - Avg operating speeds: Pedestrian – 3 mph; Bicycle – 8 mph
    - Bicycle speed reflects legal cycling habits and terminal times at O & D

Note: Scooter trips are not calculated. Assumed to operate in either bicycle or pedestrian “mode.”
Bike stations and sidewalk/path density by TAZs
Assignment of auto/truck motor vehicle trips - roadway path factors

- TransCAD assigns trips for 10 time periods during weekday
- Departure, arrival, and duration at destination
- Mode: Drive Alone; Shared Ride 2; Shared Ride 3+
- Roadway travel times
  - operating speeds by time period;
  - terminal time at origin/destination ends of trip
- Path of travel (assignment)
  - by roadways between TAZs
Assignment of transit trips - route choice factors

- TransCAD transit assignment
- Travel Time
  - Walk to bus stop or station, drive to PnR, wait time, in-vehicle time, transfer time (penalty), final walk (or applicable mode) to destination
- Bus versus Rail
  - Rail and BRT attractiveness factors
- Drive access/PnR transit trips (driver, passenger, or drop-off)
  - Drive to the PnR lot not assigned in the model
  - Walk links from car to platform (larger lots, overpasses, etc.)
  - PnRs have no capacity
  - Fee for out-of-district residents
Other special vehicle trips – DIA, commercial vehicles, External

- Os and Ds calculated with gravity model in TransCAD
  - TAZ based (not individual persons)
- 1) DIA trips  (3% of VMT)
  - Work, drop-offs/pick-ups, long-term parking, rental cars, deliveries, etc.
- 2) Commercial vehicles (CVs)  (13% of VMT)
  - Light duty cars, trucks, vans & medium/heavy trucks
  - Services, package deliveries, freight shipments, food deliveries
- 3) External trips at border  (18% of VMT)
  - To, from, and through the DRCOG region  (28 roadways)
Sample O-D table: (auto, transit, walk, bicycle, CVs, external auto)

<table>
<thead>
<tr>
<th>&quot;From&quot; Origin TAZ #</th>
<th>&quot;To&quot; Destination TAZ #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6-2831</th>
<th>2832</th>
<th>Tot. Os</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>500</td>
<td>5</td>
<td>527</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>5</td>
<td>900</td>
<td>2</td>
<td>933</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>600</td>
<td>5</td>
<td>623</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>5</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>1,000</td>
<td>8</td>
<td>1,038</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>900</td>
<td>2</td>
<td>937</td>
</tr>
<tr>
<td>6-2831</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2832</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Os**: 528, 935, 621, 1,038, 936, 7,500, 630, 3,035, 15,223

**Intrazonal**

- Trip Tables for each travel mode and time period
OUTPUTS & QUERIES
DRCOG Plans and transportation activities use Focus Model used for all plans and activities.

**Metro Vision Plan**
Shared vision for the future

- 20-plus year “vision” transportation system
  - Metro Vision Regional Transportation Plan (RTP)

- 20-plus year affordable transportation system
  - Fiscally Constrained RTP

- Near-term program of funded projects
  - Transportation Improvement Program (TIP)

**Air Quality Conformity**

**NEPA – project development**
Trip outputs

- origins and destinations by TAZs (Intrazonal and Interzonal)
- trip purpose
- mode of travel
- Average/median trip length
- regional 2015 weekday values:

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>vehicle miles traveled (VMT)</td>
<td>77 million</td>
</tr>
<tr>
<td>person trips</td>
<td>14.5 million</td>
</tr>
<tr>
<td>vehicle trips</td>
<td>9 million</td>
</tr>
</tbody>
</table>
Focus output examples: tour purpose and primary mode

<table>
<thead>
<tr>
<th>Tour Purpose</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>1,670,155</td>
</tr>
<tr>
<td>School</td>
<td>901,746</td>
</tr>
<tr>
<td>Escort</td>
<td>718,650</td>
</tr>
<tr>
<td>Personal business</td>
<td>740,072</td>
</tr>
<tr>
<td>Shopping</td>
<td>717,832</td>
</tr>
<tr>
<td>Meal</td>
<td>308,277</td>
</tr>
<tr>
<td>Social recreation</td>
<td>752,710</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,809,442</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tour mode</th>
<th>Total</th>
<th>Mode share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike</td>
<td>42,278</td>
<td>0.73%</td>
</tr>
<tr>
<td>Drive alone</td>
<td>2,480,314</td>
<td>42.69%</td>
</tr>
<tr>
<td>Drive to transit</td>
<td>51,994</td>
<td>0.89%</td>
</tr>
<tr>
<td>School bus</td>
<td>119,654</td>
<td>2.06%</td>
</tr>
<tr>
<td>Shared ride 2</td>
<td>1,466,384</td>
<td>25.24%</td>
</tr>
<tr>
<td>Shared ride 3+</td>
<td>1,009,056</td>
<td>17.37%</td>
</tr>
<tr>
<td>Walk</td>
<td>481,525</td>
<td>8.29%</td>
</tr>
<tr>
<td>Walk to transit</td>
<td>158,236</td>
<td>2.72%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,809,442</strong></td>
<td></td>
</tr>
</tbody>
</table>

Trips = 14.5 million
A Tale of Two TAZs - 2015

Capital Hill/Cheeseman TAZ # 1503
- Pop. - 3,150, Jobs - 598
- Pop+Job density – 18,000/sq. mi.
- Avg./Median age – 38/31 (51% Age 18-34)
- Total Trip Os – 8,000
- Ped./Bicycle Trip Os – 2,800
- Transit Trip Os – 500
- Mot. Veh. Trip Os – 3,500
- CV Trip Os - 530

Littleton/Centennial TAZ # 2190
- Pop. - 3,190, Jobs - 500
- Pop+Job density – 5,000/sq. mi.
- Avg./Median age – 42/44 (13% Age 18-34)
- Total Trip Os – 8,000
- Ped./Bicycle Trip Os - 570
- Transit Trip Os – 180
- Mot. Veh. Trip Os – 5,000
- CV Trip Os - 651
“Highway” assignment outputs

- link daily traffic volumes (x)
- person/vehicle miles traveled (P/VMT)
- vehicle and person hours of delay
- who uses specific roads?
  - “select link” analyses

(x) - Example traffic volumes (pass by one point):
  - I-25: 300,000 vehicles (= 420,000 people)
  - Colorado Blvd.: 60,000 vehicles (= 84,000 people)
  - 17th St.: 10,000 vehicles (includes ~300 buses) (= 20,000 people)
Traffic volume (ADT) validation – “observed” counts vs. model

• **Examples (1,000s/day):**
  - Bryant St.: traffic count 7k; model 3k 😞
  - I-25 nb: traffic count 129k; model 140k 😊
  - Alameda Ave.: traffic count 34k; model 34k 😘

(Average occupancy = 1.4 persons)
Select Link analysis – on-ramp from Vasquez/Steele to I-70
River Mile Development Proposal Analysis – TAZ split 2040

DRCOG 2040 RTP

<table>
<thead>
<tr>
<th>Zone</th>
<th>HHs</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1818</td>
<td>0</td>
<td>991</td>
</tr>
</tbody>
</table>

River Mile Analysis – additional growth

<table>
<thead>
<tr>
<th>Zone</th>
<th>HHs</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1818</td>
<td>7,654</td>
<td>37,819</td>
</tr>
<tr>
<td>1305</td>
<td>1,260</td>
<td>2,190</td>
</tr>
</tbody>
</table>
River Mile - Network Changes

- New street network connection to south
- 7th Ave Extension
- New Ped Bridge

Routes: 1, 20, 43, 6

- Freeway
- Principal Arterial
- Minor Arterial
- Collector
- Centroid Connector
Select TAZ Analysis – vehicle trips to and from

Traffic Changes:
- Diversion
- Regional Growth
- Induced
- Latent
Transit assignment outputs

<table>
<thead>
<tr>
<th>Boardings</th>
<th>Modeled 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free shuttles</td>
<td>49,100</td>
</tr>
<tr>
<td>Local bus</td>
<td>149,000</td>
</tr>
<tr>
<td>Limited bus</td>
<td>35,100</td>
</tr>
<tr>
<td>Express bus</td>
<td>9,300</td>
</tr>
<tr>
<td>Regional bus</td>
<td>12,300</td>
</tr>
<tr>
<td>SkyRide bus</td>
<td>7,500</td>
</tr>
<tr>
<td>Rail</td>
<td>98,500</td>
</tr>
<tr>
<td>Total</td>
<td>361,000</td>
</tr>
</tbody>
</table>

Daily value estimates:

- Station and PnR Boardings
  - DUS-14,000; Englewood-2,500; Lamar-400

- Route-by-route comparisons
  - Ridership (boardings), along entire route
    - Colfax 15/15L – 22,000
    - 0/0L – 9,000
    - W-Line – 12,500
    - P (Parker) - 500

- “Volume” of riders per day, at one point
  - Colfax Ave. E/of Grant – 8,000
  - Broadway S/of Littleton Blvd – 700
  - W-Line E/of JeffCo Ctr. – 2,350
  - Parker Road S/of Main St - 60
Example queries / “what ifs”

- How much will traffic volume, transit ridership, or bicycle & pedestrian travel modes change due to:
  - regional population & employment growth (e.g. through 2040)?
  - Specific proposed large-scale development
  - a new (or closed down!) road or transit line?
  - change in auto operating and fuel costs?
  - change in roadway capacity or mobility services – new technology?

- What are the travel characteristics of zero-car households?
Example queries / “what ifs” (continued)

• What modes of travel are used to get to/from workplaces or TAZs?
• What roadway paths or transit routes are used to get from A to B
• What if transit fares double? What if free?
• How will operating speeds and VMT affect “mobile source pollutant emissions?”
  • Air quality conformity
  • Emission inventories for nonattainment area Ozone Plans (SIPs)
• .................
DO NOT use direct model outputs to predict:

- Precise mode shares on individual roadway segments
- Bicyclists or pedestrians using a specific facility
- Exact intersection turning movements in the future
  - Model predicts levels of change for the future
- Socioeconomic changes in TAZ HH incomes over time
  - Model synthesizes these attributes for use within the model, but they are not “predictions”
- Other overly precise data outputs – “how many transit riders on Main Street are heading to the new brewpub?” – NO!
Terminology pitfalls

- Transit trips vs. boardings/ridership vs. riders (persons) vs. volume
- Tour vs. trip
- Commute trips vs. work trip vs. all trips
- “In and around” a TAZ vs. to and from a TAZ
- Modeled vs. surveyed (sample) vs. counted (observed)
- Average (mean) vs. median
- VMT in a TAZ or community by residents vs. by all roadway travelers

Any questions?