HOV / HOT Lane Modeling and Public Transport Research

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March 22, 2013
2013 Task Orders (** today's topics)**

- **T.O. 7** – Meetings and General Support
- **T.O. 8** – Traffic Assignment
  - 8.1 – HOT-lane Modeling **
  - 8.2 – HOV Modeling **
  - 8.3 – Speed Validation (submitted draft research memo)
  - Added – tech memo, meetings, and simple HOV model
- **T.O. 9** – Mode Choice and Transit Modeling
  - 9.1 – Network Preparation **
  - 9.2 – Path Building
  - Added – AEMS→ModeChoice example/documentation
HOV Modeling

- Motivation and Objective
  - Distinguish natural carpool travelers (joint travel) from those seeking travel time or cost saving (HOV choice)
  - HOV choice should be modeled in Mode Choice
    - Identify independent person and joint trips
    - For individual person trips, limit HOV option to interchanges with travel time or cost advantage
  - A simple HOV choice model was developed as an interim test for evaluation purposes
    - Calibrated to daily and peak period counts on I-95/I-395
    - Only AM peak HBW trips

March 22, 2013  Travel Forecasting Subcommittee 3
Proposed Changes

- **Current Process**
  - 5 Mode Choice models
    - SOV, HOV2, HOV3+, etc.
  - “Two-step”; 6 assignments
    - AM Non-HOV3+
    - AM HOV3+ Only
    - PM Non-HOV3+
    - PM HOV3+ Only
    - MD ALL
    - NT ALL

- **Proposed Process**
  - 5 Mode Choice* models
    - SOV, HOV2, HOV3+, etc.
  - HOV choice model
    - SOV*, HOV2*, HOV3+*
  - 4 assignments
    - AM ALL
    - PM ALL
    - MD ALL
    - NT ALL
Interim HOV Choice Process

Change Mode Choice control files to use SOV skims for HOV modes

If trips have HOV travel time savings, update auto trips
HOV Model Calibration

Compare estimated HOV traffic to counts

- Daily traffic counts from VDOT on the general purpose (GP) lanes and HOV lanes.
- The GP and HOV lane counts include SOV, HOV2 and HOV3+ vehicles since the HOV lanes are available to all travelers at some times of day.

# Background HOV Traffic

2010 daily background LOV and HOV3+ assigned volumes on I-95/I-395 general purpose lanes and HOV lanes compared to daily counts (AAWDT)

<table>
<thead>
<tr>
<th>Loc</th>
<th>GPL OBS</th>
<th>GPL EST</th>
<th>EST/OBS</th>
<th>HOVL OBS</th>
<th>HOVL EST</th>
<th>EST/OBS</th>
<th>OBS</th>
<th>EST</th>
<th>EST/OBS</th>
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</thead>
<tbody>
<tr>
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<td>87,000</td>
<td>80,210</td>
<td>92%</td>
<td>21,500</td>
<td>21,490</td>
<td>100%</td>
<td>108,500</td>
<td>101,700</td>
<td>94%</td>
</tr>
<tr>
<td>2</td>
<td>82,000</td>
<td>83,060</td>
<td>101%</td>
<td>19,500</td>
<td>19,710</td>
<td>101%</td>
<td>101,500</td>
<td>102,770</td>
<td>101%</td>
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<tr>
<td>3</td>
<td>76,500</td>
<td>72,800</td>
<td>95%</td>
<td>19,000</td>
<td>18,870</td>
<td>99%</td>
<td>95,500</td>
<td>91,670</td>
<td>96%</td>
</tr>
<tr>
<td>5</td>
<td>89,500</td>
<td>102,030</td>
<td>114%</td>
<td>16,000</td>
<td>17,190</td>
<td>107%</td>
<td>105,500</td>
<td>119,220</td>
<td>113%</td>
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<tr>
<td>6</td>
<td>82,000</td>
<td>81,850</td>
<td>100%</td>
<td>25,000</td>
<td>19,130</td>
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<td>107,000</td>
<td>100,980</td>
<td>94%</td>
</tr>
<tr>
<td>7</td>
<td>80,000</td>
<td>83,480</td>
<td>104%</td>
<td>22,000</td>
<td>17,500</td>
<td>80%</td>
<td>102,000</td>
<td>100,980</td>
<td>99%</td>
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<td>8</td>
<td>83,000</td>
<td>82,800</td>
<td>100%</td>
<td>21,000</td>
<td>16,620</td>
<td>79%</td>
<td>104,000</td>
<td>99,420</td>
<td>96%</td>
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<td>9</td>
<td>82,000</td>
<td>81,980</td>
<td>100%</td>
<td>14,500</td>
<td>15,120</td>
<td>104%</td>
<td>96,500</td>
<td>97,100</td>
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<td>10</td>
<td>77,000</td>
<td>69,380</td>
<td>90%</td>
<td>12,000</td>
<td>13,720</td>
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<td>83,100</td>
<td>93%</td>
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<td>11</td>
<td>68,500</td>
<td>75,900</td>
<td>111%</td>
<td>12,000</td>
<td>12,420</td>
<td>104%</td>
<td>80,500</td>
<td>88,320</td>
<td>110%</td>
</tr>
<tr>
<td>All</td>
<td>80,750</td>
<td>81,350</td>
<td>101%</td>
<td>18,250</td>
<td>17,180</td>
<td>94%</td>
<td>99,000</td>
<td>98,530</td>
<td>100%</td>
</tr>
</tbody>
</table>
Background AM Peak HOV Demand

2010 AM peak period background LOV and HOV3+ assigned volumes on I-395 at Glebe Road compared with AM peak period vehicle classification counts

<table>
<thead>
<tr>
<th></th>
<th>OBS</th>
<th>EST</th>
<th>EST/OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV</td>
<td>20,275</td>
<td>17,643</td>
<td>87%</td>
</tr>
<tr>
<td>HOV2</td>
<td>1,464</td>
<td>544</td>
<td>37%</td>
</tr>
<tr>
<td>HOV3+</td>
<td>6,266</td>
<td>3,167</td>
<td>51%</td>
</tr>
<tr>
<td>Total</td>
<td>28,005</td>
<td>21,354</td>
<td>76%</td>
</tr>
</tbody>
</table>

- AM Peak Period from 6 to 9 AM.
HOV3 Binary Choice Model

\[
\begin{align*}
\text{HOV3p'} &= (\text{SOV} + \text{HOV2} + \text{HOV3p}) \times \frac{\text{HOV3p} \times \exp(-\lambda \times (\Delta TT))}{(\text{SOV} + \text{HOV2}) + (\text{HOV3p} \times \exp(-\lambda \times (\Delta TT)))} \\
\text{SOV'} &= (\text{SOV} + \text{HOV2} + \text{HOV3p} - \text{HOV3p'}) \times \frac{\text{SOV}}{(\text{SOV} + \text{HOV2})} \\
\text{HOV2'} &= (\text{SOV} + \text{HOV2} + \text{HOV3p} - \text{HOV3p'}) \times \frac{\text{HOV2}}{(\text{SOV} + \text{HOV2})}
\end{align*}
\]

where:

- **SOV, HOV2 and HOV3p** are the background trips
- **HOV3p’** is the adjusted HOV3+ demand based in travel time benefit
- **\(\Delta TT\)** is the travel time benefit to using HOV lanes
- **\(\lambda\)** is the calibration parameter to shift LOV to HOV3+
  - Two sets of \(\lambda\) are calibrated – one \(\lambda_1\) for significant travel time benefits, and another \(\lambda_2\) for moderate travel time benefits
## HOV Model Impacts

2010 AM peak period volumes on I-395 at Glebe Road based on the HOV model

<table>
<thead>
<tr>
<th></th>
<th>OBS</th>
<th>Background HOV</th>
<th>Adjusted HOV</th>
<th>Adjusted HOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV</td>
<td>20,275</td>
<td>17,643</td>
<td>15,152</td>
<td>14,493</td>
</tr>
<tr>
<td>HOV2</td>
<td>1,464</td>
<td>544</td>
<td>986</td>
<td>1,128</td>
</tr>
<tr>
<td>HOV3+</td>
<td>6,266</td>
<td>3,167</td>
<td>6,541</td>
<td>7,193</td>
</tr>
<tr>
<td>Total</td>
<td>28,005</td>
<td>21,354</td>
<td>22,679</td>
<td>22,814</td>
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</tbody>
</table>

**SOV**

<table>
<thead>
<tr>
<th></th>
<th>EST</th>
<th>EST/OBS</th>
<th>EST</th>
<th>EST/OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV</td>
<td>20,275</td>
<td>87%</td>
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<tr>
<td>HOV2</td>
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</tr>
<tr>
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<td>51%</td>
<td>3,167</td>
<td>51%</td>
</tr>
<tr>
<td>Total</td>
<td>28,005</td>
<td>76%</td>
<td>21,354</td>
<td>76%</td>
</tr>
</tbody>
</table>

**Adjusted HOV (λ1=0.15, λ2=0.10)**

<table>
<thead>
<tr>
<th></th>
<th>EST</th>
<th>EST/OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV</td>
<td>15,152</td>
<td>75%</td>
</tr>
<tr>
<td>HOV2</td>
<td>986</td>
<td>67%</td>
</tr>
<tr>
<td>HOV3+</td>
<td>6,541</td>
<td>104%</td>
</tr>
<tr>
<td>Total</td>
<td>22,679</td>
<td>81%</td>
</tr>
</tbody>
</table>

**Adjusted HOV (λ1=0.20, λ2=0.10)**

<table>
<thead>
<tr>
<th></th>
<th>EST</th>
<th>EST/OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV</td>
<td>14,493</td>
<td>71%</td>
</tr>
<tr>
<td>HOV2</td>
<td>1,128</td>
<td>77%</td>
</tr>
<tr>
<td>HOV3+</td>
<td>7,193</td>
<td>115%</td>
</tr>
<tr>
<td>Total</td>
<td>22,814</td>
<td>81%</td>
</tr>
</tbody>
</table>
Distribution of HOV Demand

2010 AM peak period Shirley Highway HOV3+ trip origins

Background HOV

Background + HOV Choice
# AM Peak Shirley Highway Assignment

2010 AM peak adjusted LOV and HOV3+ assigned volumes on I-95/I-395 general purpose and HOV lanes compared to current MWCOG volumes

<table>
<thead>
<tr>
<th>Loc</th>
<th>GPL COG</th>
<th>GPL EST</th>
<th>EST/COG</th>
<th>HOVL COG</th>
<th>HOVL EST</th>
<th>EST/COG</th>
<th>COG</th>
<th>EST</th>
<th>EST/COG</th>
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<tr>
<td>1</td>
<td>17,300</td>
<td>17,310</td>
<td>100%</td>
<td>5,690</td>
<td>5,380</td>
<td>95%</td>
<td>22,990</td>
<td>22,690</td>
<td>99%</td>
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<tr>
<td>2</td>
<td>17,910</td>
<td>17,930</td>
<td>100%</td>
<td>5,250</td>
<td>4,910</td>
<td>94%</td>
<td>23,160</td>
<td>22,840</td>
<td>99%</td>
</tr>
<tr>
<td>3</td>
<td>16,500</td>
<td>16,430</td>
<td>100%</td>
<td>4,350</td>
<td>4,140</td>
<td>95%</td>
<td>20,850</td>
<td>20,570</td>
<td>99%</td>
</tr>
<tr>
<td>5</td>
<td>19,270</td>
<td>18,950</td>
<td>98%</td>
<td>4,060</td>
<td>3,890</td>
<td>96%</td>
<td>23,330</td>
<td>22,840</td>
<td>98%</td>
</tr>
<tr>
<td>6</td>
<td>17,260</td>
<td>17,110</td>
<td>99%</td>
<td>3,840</td>
<td>3,760</td>
<td>98%</td>
<td>21,100</td>
<td>20,870</td>
<td>99%</td>
</tr>
<tr>
<td>7</td>
<td>17,260</td>
<td>17,110</td>
<td>99%</td>
<td>3,840</td>
<td>3,760</td>
<td>98%</td>
<td>21,100</td>
<td>20,870</td>
<td>99%</td>
</tr>
<tr>
<td>8</td>
<td>18,900</td>
<td>18,480</td>
<td>98%</td>
<td>3,650</td>
<td>3,570</td>
<td>98%</td>
<td>22,550</td>
<td>22,050</td>
<td>98%</td>
</tr>
<tr>
<td>9</td>
<td>15,930</td>
<td>15,750</td>
<td>99%</td>
<td>3,260</td>
<td>3,220</td>
<td>99%</td>
<td>19,190</td>
<td>18,970</td>
<td>99%</td>
</tr>
<tr>
<td>10</td>
<td>14,980</td>
<td>14,650</td>
<td>98%</td>
<td>3,260</td>
<td>3,220</td>
<td>99%</td>
<td>18,240</td>
<td>17,870</td>
<td>98%</td>
</tr>
<tr>
<td>11</td>
<td>14,810</td>
<td>14,560</td>
<td>98%</td>
<td>1,760</td>
<td>1,810</td>
<td>103%</td>
<td>16,570</td>
<td>16,370</td>
<td>99%</td>
</tr>
<tr>
<td>All</td>
<td>17,010</td>
<td>16,830</td>
<td>99%</td>
<td>3,900</td>
<td>3,770</td>
<td>97%</td>
<td>20,910</td>
<td>20,590</td>
<td>98%</td>
</tr>
</tbody>
</table>
HOV Summary

- A simple HOV choice model was calibrated to achieve desired HOV volumes on HOV facilities
  - Low overall assignment for Shirley Highway prevents estimated HOV volumes from matching counts without estimated LOV volumes being off-target from counts
- Additional count detail required to better calibrate HOV choice model parameters
  - Difference between validation of peak period and daily HOV volumes to be considered in calibration
- HOV choice model is integrated into the overall model stream and with HOT lane modeling
HOT Lane Modeling Goals

- Enhance current highway assignment
  - Replace “two-step” with a full multi-class assignment
    - Utilize proposed HOV modeling
  - Include dynamic toll setting in the standard model
    - Determine HOT lane tolls as part of highway assignment
  - Streamline highway assignment
    - Utilize CUBE cluster efficiently (MDP & IDP)
    - Minimizing repetition of common code

- Improve overall highway assignment runtime
Current HOT Lane Model
Current HOT Lane Toll Setting

1. Trip Generation
   - Trip Distribution
   - Mode Choice
   - Assignment

2. Base Tolls
   - Trip Generation
   - Trip Distribution
   - Mode Choice
   - Assignment

3. Final Tolls
   - Toll Setting Process
   - Assignment

4. Trip Generation
   - Trip Distribution
   - Mode Choice
   - Assignment
Current Toll Groups

- 134 toll groups
- Two types:
  - Static (red)
  - Dynamic (green)
- Groups formed with contiguous links
- Each is adjusted independently
HOT Lane Modeling Changes

• **Current Process**
  - **Fixed Toll Model**
    - Two full model runs
    Total = ~40 hours
  - **Toll Setting Model**
    - Two full model runs
      (~40 hours)
    - Toll setting process
      (~30 hours+)
    - Final full model run
      (~20 hours)
    Total = 90 hours (~4 days)

• **Proposed Process**
  - **Fixed Toll Model**
    - Single full model run
    *Estimated ~1 day*
  - **Dynamic Toll Model**
    - Single full model run
      - “Progressive” gap
    *Estimated ~1+ days*
  - **Full Toll Setting Model**
    - Single full model run with enhanced toll-search
    *Estimated 2-5 days*
Proposed HOT Lane Model

* Fixed tolls or outputs from the toll setting process of the previous global iteration

* Two levels of toll setting convergence criteria and search methods
Toll Choice in Assignment

Value of Time by Vehicle Type, Time of Day, etc. → Toll Choice Probability Distribution

Vehicle Trip Types

Toll Choice

Pay-Toll Vehicles

No-Toll Vehicles

Traffic Assignment

Set Toll Rates

Toll/No-Toll Skims

Optimize Operating Policy

Optimize Operating Policy
Model Runtime Considerations

- **Compute-intensive due to iterative toll-setting**
  - Each highway assignment takes ~2 hours @ 0.001 gap
    - “Progressive” gap criteria can reduce runtime

- **The key factor in toll-setting efficiency:**
  - Minimize optimal-toll search loops
    - Limit number of loops
    - Use good starting “seed” tolls
    - Smart logic
    - Protect against infinite loops
    - Aggregate toll groups
      - Reduce combinations to evaluate
TRNBUILD to PT Conversion

• Background
  ▪ Evaluated issues in converting from TRNBUILD to PT
  ▪ Developed scripts to convert TRNBUILD routes to PT
  ▪ Tested PT procedures for generating access links

• Recent Progress
  ▪ MWCOG converted the TRNBUILD routes to PT
    • Added transit-only links to the highway network
  ▪ Implemented PT Generate processes to develop walk access, P&R access and K&R access links
  ▪ Compared PT generated paths with TRNBUILD paths
# Key Differences

<table>
<thead>
<tr>
<th>TRNBUILD</th>
<th>PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station nodes and links are part of a transit-only network</td>
<td>Station nodes and links are part of a single multi-modal network</td>
</tr>
<tr>
<td>Transit-only nodes and links (LINK, SUPPLINK, XY data) added during path-building</td>
<td>Transit-only nodes and links are part of the master network</td>
</tr>
<tr>
<td>Transit paths are a series of links between origin and destination zones</td>
<td>Transit paths are a set of legs between transit stops or between a transit stop and a zone centroid</td>
</tr>
<tr>
<td>Paths may include multiple non-transit links</td>
<td>No consecutive non-transit legs in a path</td>
</tr>
</tbody>
</table>
Path Differences

- **TRNBUILD**
  - Zone X to Node Y using Mode 16 link
  - Node Y to Node Z using Mode 13 link
  - Node Z to Station A using Mode 12 link
  - Station A to Station B using Route X
  - Station B to Station C using Mode 12 link…

- **PT**
  - Zone X to Station A using Non-Transit Leg E
    - walk path from X to A using “E” constraints
  - Station A to Station B using Route X
  - Station B to Station C using Non-Transit Leg F
    - Walk path from B to C using “F” constraints
Generating Non-Transit Legs

- PT Generate statement builds non-transit legs between zones and stops using “permitted” links
  - **Walk access legs**
    - Zone centroids to bus stops using links that permit walking
    - Zone centroids to stations…
    - Bus stops to stations…
    - Bus stops to bus stops…
  - **Kiss-n-Ride access legs**
    - Zone centroids to stations using auto links and travel times
  - **Park-n-Ride access legs**
    - Zone centroids to stations passing through a park-n-ride lot
Station Connection Options

- Need to connect Metrorail and commuter rail stations to the highway/transit network
  - Manual Coding
    - One-time task, ensure feasibility of connector links
  - Connect each station to the station centroid
    - Only one connection, may not be appropriate for walk access
  - Connect stations to nearest “N” nodes
    - Spatial analysis does not consider physical barriers
  - Recode existing access generation programs to output data in PT network format
    - Contrary to the “spirit” of PT
Next Steps

- **HOV model**
  - Document the results and propose additional data collections for calibration purposes

- **HOT lanes model**
  - Implement additional process performance tests
  - Propose a reduced number of toll groups

- **PT conversion**
  - Connect stations to the highway network
  - Develop scripts to generate “useful” non-transit leg modes (e.g., walk, PNR, KNR, bus-rail transfer, etc.)