Toll Modeling in Context of Regional Travel Demand Model

presented to
NC Model Users Group
October 24, 2007
Overview

• Toll Modeling in General
• Toll model application in NC Models
• TransCAD application
Tolls Influence

- Trip Distribution
  - Destination Choice

- Mode Choice
  - SOV, HOV or Toll Path
  - Alternative Competitive Mode

- Trip Assignment
  - Alternative Path Finding
Cost Factor in Path Finding

- Highway operating cost
- Transit Fare
- Vehicle Occupancy >1
- Toll Cost
Toll Choice Factors

- Socio-Economic Characteristics of trip makers in combination with travel costs
Toll Choice Factors - Income

Effect of Income and Toll Cost on Time

- Income in $:
  - $25,000
  - $50,000
  - $75,000
  - $100,000

- Time in Minutes:
  - 5.00
  - 10.00
  - 15.00
  - 20.00
  - 25.00
  - 30.00
  - 35.00

- Toll Cost: 25c

Graph showing the effect of income and toll cost on travel time.
Toll Choice Factors - Income

Effect of Income and Toll Cost on Time

- 25c Toll
- 50c Toll

Time in Minutes

Income in $

- $25,000
- $50,000
- $75,000
- $100,000

$25,000 $50,000 $75,000 $100,000
Toll Choice Factors - Income

Effect of Income and Toll Cost on Time

- 25c Toll
- 50c Toll
- $1 Toll
- $2 Toll

Time in Minutes

Income in $

- $25,000
- $50,000
- $75,000
- $100,000

Income

- $25,000
- $50,000
- $75,000
- $100,000

Time

- 35.00
- 30.00
- 25.00
- 20.00
- 15.00
- 10.00
- 5.00
- 0.00
Toll Choice Factors

- Trip Purpose

### Value of $1.00 Toll in Minutes by Trip Purpose

<table>
<thead>
<tr>
<th>Income in $</th>
<th>HBO</th>
<th>NHB</th>
<th>HBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25,000</td>
<td>16.64</td>
<td>9.98</td>
<td>7.13</td>
</tr>
<tr>
<td>$50,000</td>
<td>8.32</td>
<td>4.99</td>
<td>3.57</td>
</tr>
<tr>
<td>$75,000</td>
<td>5.55</td>
<td>3.33</td>
<td>2.38</td>
</tr>
<tr>
<td>$100,000</td>
<td>4.16</td>
<td>2.50</td>
<td>1.78</td>
</tr>
</tbody>
</table>
Toll Choice Factors

• Time of Day
  - AM and PM Peak
  - Off Peak

• Method of Toll Collection
  - Cash
  - Electronic Toll Collection

• Vehicle Type
  Car, Trucks

• Vehicle Occupancy
  SOV, HOV
Toll Choice Factors

- Trip length for toll users

Travel Time by Trip Length

- Free Flow TT for 10 mile
- Congested TT for 10 mile
- Free Flow TT for 20 mile
- Congested TT for 20 mile

<table>
<thead>
<tr>
<th>Time in Minutes</th>
<th>No Toll</th>
<th>With Toll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Flow TT for 10 mile</td>
<td>10.00</td>
<td>18.32</td>
</tr>
<tr>
<td>Congested TT for 10 mile</td>
<td>17.14</td>
<td>19.23</td>
</tr>
<tr>
<td>Free Flow TT for 20 mile</td>
<td>20.00</td>
<td>28.32</td>
</tr>
<tr>
<td>Congested TT for 20 mile</td>
<td>34.29</td>
<td>30.14</td>
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</tbody>
</table>
Toll Models

- Mode Choice
- Highway Assignment
  - Route Choice Sub-Model
- Highway Assignment
  - Equivalent Time Penalties
Assignment Toll Models

Generalized assignment procedure
- uses travel time and costs by time of day

Feedback loop through mode choice
- uses successive averaging of travel times
Path-Finding

If no toll, then 1, 2, 3 is best path

With toll on 2-3, must convert $ and time to equivalent units

Best path might now be 1-4-6-3
Example: Wilmington

• 4-step model
  – Survey for Trip Generation, Distribution
  – Borrowed Mode Choice
• Developed, calibrated without tolls
Example: Wilmington

Used BPR as VDF

\[ t = t_f \left[ 1 + \alpha \left( \frac{v}{c} \right)^\beta \right] \]

⇒ How to incorporate toll without recalibration?
Example: Wilmington

- Use generalized cost VDF

\[ c_i(x) = k_i + \delta \cdot L_i + \varphi \cdot t_f \left[ 1 + \alpha \left( \frac{v}{c} \right)^\beta \right] \]

- \( k \): fixed cost \( \Rightarrow \) toll
- \( \delta \): operating cost (per mi) \( \Rightarrow \) 0
- \( \varphi \): value of time \( \Rightarrow \) ??

\( \rightarrow \) Use locally determined value
Example: Wilmington
MMA

- With MMA (more advanced) toll functionality built-in

BUT

- Must make sure VOT was correctly calibrated at outset

- Be aware of different cost function:

\[
gc_{OD}^m = \sum_{i \in A_{OD}^m} \left\{ VOT^m \cdot VDF \left( t_a, c_a, \sum_m PCE_m x_a, \ldots \right) + FT_a^m \right\} + \sum_{m \in M_{OD}^m} MT_i^m
\]
Hypothetical Toll for TRM