A Tour of ELToD4 Model

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What is ELToD4?

- ELToD4 stands for Express Lanes Time of Day Model version 4
- It is a Dynamic Traffic Assignment (DTA) model to forecast traffic and revenue for complex express lane networks in large metropolitan area
## Development Timeline

Developed by: AECOM and RSG for Florida’s Turnpike

<table>
<thead>
<tr>
<th>Year</th>
<th>ELToD1</th>
<th>ELToD2</th>
<th>ELToD3</th>
<th>ELToD4</th>
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<tbody>
<tr>
<td>2010</td>
<td>Excel</td>
<td>Cube</td>
<td>VB.net</td>
<td>C++</td>
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<td>2020</td>
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### Software
- Excel
- Cube
- VB.net
- C++

### Type
- Static
- Static
- DTA
- DTA

### Area
- Corridor
- Corridor
- Subarea
- Regional

### Resolution
- Hourly
- Hourly
- 15-min
- 15-min

In collaboration with:

- CITILABS
- WSP
- Parsons Brinckerhoff
- The Corradino Group
- HNTB
- CDM Smith
- Jacobs Engineering
Benefits of Using ELToD4 Model

Consistency in methodology and results
- Consultants
- Projects
- Over time

Savings in project time and budget

Easy quality control

Practice-ready for project needs

Open Source

Continuous support and improvement
Model Transferability

- ELToD4 is flexible and customizable to work with any existing regional models
  - Traditional four-step or ABM
  - Cube or TransCAD

**Build Model**
- Networks
- Trip table in 15-min interval

**Calibrate Base Year**
- Data collection
- Choice model parameters

**Applications**
- Summary spreadsheet
- Visual tools
Express Lanes Model Considerations

- Stakeholders
  - EL User
  - Government
  - Concessionaire
  - Lender/bond buyer
  - Rating agency

- Traffic and Revenue
  - Dynamic
  - Fixed time of day
  - Discount
  - Max traffic/revenue
  - Inflation

- Operation Hours
  - Peak hours only
  - Reversible lanes
  - Maintenance

- Toll Policy

- Vehicle Type Rule & Enforcement
  - HOV
  - Truck
  - Transit
  - EV

CAVs
Observed Traffic and Toll Rate

Source: Florida I-95 Phase 1 southbound 2017 average weekday
Time and Effort Requirement

Simulation and DTA Models

- Detailed Network Input
- Lengthy Run Time
- Inconsistent Result
- Queue spillback

- Simple Network Input
- Short Run Time
- Consistent Result
- Multi-resolution subarea queue

Regional DTA Model Spectrum

Analytical ↔ Simulation

ELToD4

Simulation

DTA Models

• Detailed Network Input
• Lengthy Run Time
• Inconsistent Result
• Queue spillback

• Simple Network Input
• Short Run Time
• Consistent Result
• Multi-resolution subarea queue

Time Resolution

1-sec
6-sec
1-min
15-min
Hours
Day

Micro Simulation

DTA Model

Static
Assignment
Express Lanes Choice

– Willingness to pay is measured by Value of Time (VOT) and Value of Reliability (VOR)
– VOT and VOR vary by person and trip

- Income
- Trip Purpose
- Toll Bias
- Personal Preference

Cost
- Toll

Benefit
- Time Savings
- More Reliable
- Less weaving
- No Heavy Trucks

Free General Use Lane
Distributed Value of Time (VOT)

VOT Distribution

Median
$13.92
Mean
$24.58

Trip VOT Distribution by Income

VOT1
VOT2
VOT3
VOT4
VOT5
Value of Reliability

- Value of Reliability (VOR) is the willingness to spend money to reduce the standard deviation of travel time

\[ \text{Reliability Ratio} = \frac{\text{VOR}}{\text{VOT}} \]

- Reliability values range from 0.5 to 2.5 in the SHRP2 Reliability Report
Binary Toll Choice Model

\[ P_{EL} = \frac{1}{1+e^{(Utility)}} \]

- Predict the probability of choosing two choices
- Produce “smooth” instead of “abrupt” responses to toll changes
Mixed Multinomial Logit Toll Choice Model

Toll Share = \frac{1}{1+e(\text{Utility})}

where

\text{Utility} = -1 \times (\beta_{\text{Constant}} + \beta_{\text{Time}} \times \text{Time} + \beta_{\text{Toll}} \times \text{Toll} + \beta_{\text{Reliability}} \times \text{Reliability})

\text{Reliability} = \gamma_r \times (\text{Time}_{\text{Congested}} - \text{Time}_{\text{FreeFlow}}) \times (\text{Distance})^{-\eta_r}

VOT = \frac{60 \times \beta_{\text{Time}}}{\beta_{\text{Toll}}}

VOR = \frac{60 \times \beta_{\text{Reliability}}}{\beta_{\text{Toll}}}

Choice Model Toll Sensitivity

Time savings = 1 minute; Distance = 4 miles; Income = $85,000
Time Dependent Shortest Path (TDSP)

- Static Shortest Path uses average link travel time of a time period (several hours)
- TDSP uses the travel time when the vehicle is going through the link

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Link 1</th>
<th>Link 2</th>
<th>Link 3</th>
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<tbody>
<tr>
<td>7:00</td>
<td>10</td>
<td>11</td>
<td>10</td>
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<td>7:15</td>
<td>12</td>
<td>16</td>
<td>12</td>
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<tr>
<td>7:30</td>
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<td>15</td>
<td>20</td>
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<tr>
<td>Average</td>
<td>12</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

- Links 12 = 33 min
- Links 14 = 48 min
- Links 14 = 40 min
En-route Toll Choice Making

To simulate driver’s behavior:

- Other models assign all trips to one shortest time path
  - Toll converted to time penalty
- ELToD4 splits the trips at each decision node using an en-route toll choice model
  - Reflect heterogeneity in the population
  - Drivers only know the toll when they are at the entrances and exits
Toll Policy Curves

\[ \text{Toll} = \text{Min} + (\text{Max} - \text{Min}) \times (\text{VC Ratio} - \text{Offset})^{\text{Exp}} \]

- Adjust toll rate based on V/C Ratio at 15 minutes interval
- Flexible to be applied by facilities and time of day
- A toll policy example: Dynamic toll during peak hours and static toll rates during off-peak hours
Model Result Example

Express Lanes Volume

General Purpose Lanes Volume

Toll

Express Lanes Volume Share

Florida I-95 express lanes segment 1 Southbound
Connected and Autonomous Vehicle (CAV) Module

Socioeconomics Input

- High income family and urban areas will adopt CAVs first

Adoption Rate Variation by TAZ

Regional Penetration Rate

Legend

- <10%
- 10%-20%
- 20%-30%
- 30%-40%
- 40%-50%
- 50%-60%
- 60%-70%
- 70%-80%
- 80%-90%
- >90%
Capacity with CAVs
Example: CAV Model Outputs

Regional Penetration Rate 20%

Regional Penetration Rate 60%

Penetration Rate

< 10%

50%

> 90%
Question: What is the CAV impact to transactions comparing 2-lane and 4-lane express lanes network in 2045?

Variables Tested:
- Technology
  CAV headway reduction
- Regulation
  CAV preference on limited access road
- Driver behavior
  CAV has lower value of time

### TECHNOLOGY

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<tr>
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<th>2-lane</th>
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<tbody>
<tr>
<td>P80</td>
<td>-11.4%</td>
<td>-9.9%</td>
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<tr>
<td>P60</td>
<td>-8.7%</td>
<td>-8.3%</td>
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<tr>
<td>P40</td>
<td>-7.5%</td>
<td>-6.7%</td>
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<tr>
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### BEHAVIOR

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### REGULATION

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### COMBINED IMPACT

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P##: Assumed CAV regional penetration rate
Hybrid Simulation Module - Ongoing

- Integrate mesoscopic simulation into the regional model

Diagram:

1. Analytical Iterations
2. Subarea Path Log
3. Subarea Simulation
4. Update Subarea Time
5. Check Model Convergence
   - No
   - Yes
      - End
Any questions?
Contact us

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