Modeling Applications for Freight
Tennessee DOT Freight Planning

presented to
Tennessee Model Users Group

presented by
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Cambridge Systematics, Inc.

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Overview

- Recent Freight Modeling Applications
  - I-40/I-81 Corridor Truck Forecasting
  - Truck-Rail Diversion Model
  - Truck Climbing Lanes
  - Truck-Related Accidents

- Conceptual Applications for Other Freight Issues
  - Closure of intermodal rail station in E. Tennessee
  - New VW plant in Chattanooga
  - Freight Impact of Mississippi River Bridge

- Questions/Comments
I-40/I-81 Feasibility Study

Background

- **Strategic Investment Plan Corridor**
  - I-40 Mississippi River (Memphis) to I-81
  - I-81, I-40 to Virginia State Line (Bristol)

- **Cambridge Systematics – subconsultant to PB**
  - Freight Modeling and Planning
  - Travel Demand Forecasting
  - ITS Planning
Models that include I-40/I-81 corridor:

- MPO Models:
  - Memphis
  - Jackson
  - Nashville
  - Knoxville
  - Morristown
  - Kingsport
  - Bristol

- Statewide Models:
  - Passenger
  - Freight
I-40/I-81 Corridor Feasibility Study
Model Refinements and Adjustments

Base Year Models:
- Corrected network coding, where necessary

Year 2030 Models:
- Verified E+C/No Build networks, where necessary
- Adjusted external trips in MPO models to match SWM forecasts
- Work with smaller models discontinued:
  - Jackson – new model under development; external trips from SWM
  - Morristown – does not currently operate in batch mode
- Interpolated SE data, external trips, ODME trip tables:
  - 2011 and 2016 interpolated and adjusted per SWM at external zones
  - Available 2017 data sets used in place of 2016 for Memphis
I-40/I-81 Corridor Feasibility Study
Deficiency Analysis

GIS Mosaic of Statewide & MPO Model Results

Year 2030 - TN Statewide Model LOS based on V/C Ratios

Year 2030 - TN Statewide Model Total Truck Percentage

Note: SWM used for truck forecasts except in Memphis
I-40/I-81 Corridor Feasibility Study
Deficiency Analysis

Year 2011 - TN Statewide Model Total Truck Volumes

Year 2016 - TN Statewide Model Total Truck Volumes

Year 2030 - TN Statewide Model Total Truck Volumes
### Measures of Effectiveness – Preliminary Numbers

<table>
<thead>
<tr>
<th>Criteria</th>
<th>2011 E+C</th>
<th>2030 E+C</th>
<th>2030 Corr</th>
<th>2030 Road</th>
<th>2030 - 2011</th>
<th>Corr - E+C</th>
<th>Road - E+C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto hours of travel</td>
<td>369,229</td>
<td>609,930</td>
<td>557,570</td>
<td>570,501</td>
<td>240,701</td>
<td>-52,360</td>
<td>-39,429</td>
</tr>
<tr>
<td>Vehicle delay (mins.)</td>
<td>53</td>
<td>189</td>
<td>169</td>
<td>86</td>
<td>136</td>
<td>-20</td>
<td>-103</td>
</tr>
<tr>
<td>Truck hours of travel</td>
<td>127,362</td>
<td>280,256</td>
<td>248,354</td>
<td>253,094</td>
<td>152,894</td>
<td>-31,902</td>
<td>-27,162</td>
</tr>
<tr>
<td>Travel time in hours</td>
<td>10.6</td>
<td>12.6</td>
<td>12.2</td>
<td>10.8</td>
<td>1.9</td>
<td>-0.4</td>
<td>-1.7</td>
</tr>
<tr>
<td>Travel time in minutes</td>
<td>638</td>
<td>753</td>
<td>729</td>
<td>649</td>
<td>115</td>
<td>-24</td>
<td>-104</td>
</tr>
</tbody>
</table>

### Percentage of corridor at LOS D-F or Mountainous Terrain

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Memphis</th>
<th>Memphis to Jackson</th>
<th>Jackson</th>
<th>Jackson to Nashville</th>
<th>Nashville</th>
<th>Nashville to Knoxville</th>
<th>Knoxville</th>
<th>Knoxville to VA Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 Existing-plus-Committed</td>
<td>53%</td>
<td>0%</td>
<td>13%</td>
<td>85%</td>
<td>95%</td>
<td>100%</td>
<td>34%</td>
<td>40%</td>
</tr>
<tr>
<td>2030 Existing-plus-Committed</td>
<td>100%</td>
<td>60%</td>
<td>65%</td>
<td>98%</td>
<td>100%</td>
<td>100%</td>
<td>92%</td>
<td>96%</td>
</tr>
<tr>
<td>2030 Corridor Capacity</td>
<td>73%</td>
<td>TBD</td>
<td>TBD</td>
<td>98%</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>84%</td>
</tr>
<tr>
<td>2030 Roadway Capacity</td>
<td>67%</td>
<td>28%</td>
<td>93%</td>
<td>85%</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>72%</td>
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</tbody>
</table>
Truck-Rail Diversion Model

Background

- Initially developed for TDOT Long Range Transportation Plan
  - Developed as part of the TDOT Freight model
  - Assigns rail flows based on TRANSEARCH 2001 database and TransCAD rail network using length as impedance
  - Extensive national rail network imported for national studies

- Improved as part of I-40/I-81 Corridor Feasibility Study
  - Added price-elasticities by commodity group
  - Used to analyze Trans-TN Rail Corridor and NS Crescent Corridor
  - Used to analyze impact of improvements to highway network
Truck-Rail Diversion Model

Model Options Considered

“What if” analysis
  • How much truck-rail diversion needed to shift 5% of trucks

Intermodal Transportation and Inventory Cost (ITIC) Model
  • PC-based model developed by the FRA to estimate diversion generated by change in LOS or price

TDOT Freight Rail Model
Truck-Rail Diversion Model
Model Option Selected

- TDOT Freight Rail Model was selected for the following reasons
  - Ability to estimate diversion based on improvements likely to be proposed as part of I-40/I-81 study
  - Data consistency with previous TDOT freight rail analyses
  - ITIC model requires significant data inputs
  - “What if” analysis does not provide precise enough results

- Limitation of model
  - No capacity maximums on rail network
  - Capacity changes will need to be reality checked with RRs
Truck-Rail Diversion Model

Operation of Rail Model

- Run existing rail model under future year scenario
- Update future year scenario and re-run model
- Determine the distance difference between all O-D pairs in the existing and the updated rail models
- Estimate the change in cost associated with the distance difference
- Use cross-elasticities to estimate level of diversion from truck to rail
Truck-Rail Diversion Model Application

*Trans-TN Rail Corridor*

- **Build out rail network between Nashville and Knoxville**

Source: An Evaluation of the Tennessee Rail Plan’s Treatment of a Trans-Tennessee Rail Routing” by Center for Business and Economic Research University of Tennessee
Truck-Rail Diversion Model

Benefits of Trans-TN Rail Corridor

- Alternate route for through rail traffic
  - Supplement for NS’s current Knoxville-Memphis line

- Easy rail access for Nashville goods to the Mid-Atlantic and Northeast markets
  - CSX currently runs north-south through Nashville
  - Avoid circuitous Atlanta and Cincinnati routes
  - No NS service to Nashville

- Easy rail access for Knoxville goods to the northwest
Truck-Rail Diversion Model Application

Operation of Rail Model

- Run the existing model
  - Use TransCAD assignment script on the TDOT Rail network
  - Use the field “NEWLENGTH” as the impedance variable

- Calculate the distances of all origin-destination pairs for this model run
Truck-Rail Diversion Model Application

Update Future Year Model

- Add a rail link between Cookeville and Crossville to the rail network
- Use the FRA shapefile as a guide for link shape, length and placement
Truck-Rail Diversion Model Application

*Estimate New Distances*

- Calculate link lengths for new links in the updated rail network
- Re-run the rail model on the updated rail network
- Re-calculate the distances of all origin-destination pairs for this new assignment
Truck-Rail Diversion Model Application

Estimate Cost Savings

- Estimate the rail cost associated for each origin-destination pair with and without the new rail link
  - use TxDOT distance based formula

- Calculate the percent change in costs for each origin-destination pair with and without the new rail link
Truck-Rail Diversion Model Application

**Estimate Diversion**

- Use “cross-elasticities” to convert from change in rail costs to percent diversion from truck to rail in terms of tonnages

<table>
<thead>
<tr>
<th>Table 3. Market price elasticities of demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity group (CG)*</td>
</tr>
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<td>Region(^b)</td>
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<tr>
<td>I</td>
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<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>1. Truck—truck</td>
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<td>O</td>
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<td>S</td>
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<td>W</td>
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<td>2. Rail—rail</td>
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<td>3. Rail—truck</td>
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<td>4. Truck—rail</td>
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<td>SW</td>
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<td>M-P</td>
</tr>
</tbody>
</table>

Source: “Estimates of Mode Choice Probabilities and Market Elasticities of Demand” by Walid M. Adelwahab
Rail costs decrease for goods shipped by rail from Nashville to the mid-Atlantic and northeast.
Rail costs also decrease for goods shipped by rail from Knoxville to some states to the west.
Rail costs also decrease for goods shipped from North Carolina to some states in the west.
Rail costs decreased slightly from Washington State to North Carolina and some counties in Eastern Tennessee.
Truck-Rail Diversion Model

*Trans-TN Rail Corridor Alignment*

- Proposed east-west connection distance = 469 miles

- Current Knoxville-Memphis rail line distance = 446 miles
Truck-Rail Diversion Model

*Impact on Highway Flows*

- Calculate diversion of tonnages to truck trips diverted
- Remove diverted trucks from the truck trip table in the TransCAD truck model
- Assign new truck trip table to the highway network to determine the magnitude of the diversion for each highway link
Norfolk Southern plans several improvements to its Crescent Corridor Line
Truck-Rail Diversion Application

Crescent Corridor Description

- NS estimates over 1 million divertible truckloads in the corridor
- Plans forecast 28 new trains per day
- Highway competitive speeds for total travel time
- NS seeking public-private partnerships to improve the rail network
  - VDOT has committed $16 million
Conceptual Freight Applications

Applications
- Closure of intermodal rail yard in E. Tennessee
- New VW plant in Chattanooga
- Truck tolling in Memphis

Freight applications typically require a mix of
- Creative off-model analysis
- Model operations
- Post-processing
Conceptual Freight Applications

Highway Impact of Closure of Intermodal Yard

Option 1 - Ask intermodal rail yard operator for shipper information

Option 2 – In-House Estimate

- Conduct truck counts (or O-D surveys if possible) at rail yard
- Utilize Transearch commodity flow data to understand distribution of origins and destinations rail flows at the yard
- Utilize Transearch data to understand distribution of commodities at rail yard
- Convert tonnage data to truckload data
- Scale Transearch data to count data
- Adjust truck trip table based on count and O-D information
- Determine feedback impact on truck-rail mode share
Conceptual Freight Applications

New VW Plant in Chattanooga

- Option 1 - Ask VW about the amount of goods used, mode share for each commodity, and O-D patterns of each commodity

- Option 2 – In-House Estimate
  - Determine size of plant (150,000 cars in 2011)
  - Describe supply chain for plant based on similar types of facilities
  - Use Transearch data and BTS CFS data to determine mode share and O-D patterns of each commodity type
  - Update truck trip table based on changes estimated by the truck mode
  - Follow-up with counts in 2011 to confirm or adjust estimates
Truck-Rail Diversion Application

Relocation of Nashville Railyard

- **Option 1** – Ask railroad of the customer impacts of relocation

- **Option 2** – In-House Estimate
  - Update rail network in the TDOT Freight Rail Model
  - Re-run model for year of relocation
    - Shorter distances
    - Higher speeds
  - Convert tonnage diversion to truckloads
  - Update truck trip table to determine highway impacts
TDOT Freight Planning Tasks

- Scan of Freight Planning Activities
  - TDOT
  - MPOs, Surrounding State DOTs
  - Academic and Research Institutions
  - Economic and business development agencies

- Best Practices at State DOTs
  - Interviewed DOTs in Florida, Virginia, Maine, Kentucky, and Indiana
  - Lessons learned in regards to structure, funding and projects
Conclusions

- Freight models and analytical tools have been used successfully on recent TDOT studies

- Range of applicable options to utilize to analyze a broad set of freight issues

- Analysis often requires significant pre-processing and post-processing to develop actionable results