Urban Freight Travel Demand Modeling: Case Study of the FM Metropolitan Area

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Outline

- Introduction and Background
- Problem Statement
- Objectives
- Literature Review
- Case Study Description
- Data
- Methodology
- Conclusions
Introduction and Background

- Travel demand models forecast travel
- Freight movements neglected in travel demand models
  - Freight models lag significantly behind passenger models consequently
- Increased congestion, environmental, safety, security and federal regulations changing the picture
  - TEA-21 (1998)
  - SAFETEA-LU (2005)
Background and Trends

- Increased urban truck movement over past two decades (FHWA)
  - Truck VMT increased by 36% while passenger vehicle VMT increased by 25% (1993-2002)
  - Trend to continue, annual truck increase at 3%, passenger at 2%

- Increased movement not matched by Increased Transportation Supply
  - Total VMT Increased over 80% while lane-miles increased by 2%
Truck Impacts

- Important to economic growth and sustainability of for any region
- More than 10% of GDP in 2004 (USDOT RITA BTS 2006)
- Two thirds of value of goods moved and 60% tons moved in 2002 (US DOT FHWA 2006)
Truck Impacts

- Trucks have higher impacts on transportation system and societal cost
  - Highway costs
  - Cost to public agencies
  - Pollution
    - Air and Noise
  - Congestion
    - Reduces economic benefits derived from freight movement
    - Unexpected delays increase transportation costs by 50-250% (UDSOT FHWA 2001)
  - Crash
# Truck Impacts

<table>
<thead>
<tr>
<th>Vehicle Class/Highway Class</th>
<th>Pavement</th>
<th>Congestion</th>
<th>Crash</th>
<th>Air Pollution</th>
<th>Noise</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Autos/Rural Interstate</td>
<td>0</td>
<td>0.78</td>
<td>0.98</td>
<td>1.14</td>
<td>0.01</td>
<td>2.91</td>
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<td>Autos/Urban Interstate</td>
<td>0.1</td>
<td>7.7</td>
<td>1.19</td>
<td>1.33</td>
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<td>4.49</td>
<td>1.5</td>
<td>34.43</td>
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<td>5.6</td>
<td>3.27</td>
<td>0.47</td>
<td>3.85</td>
<td>0.11</td>
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<td>60 kip 4-axle S.U. Truck/Urban Interstate</td>
<td>18.1</td>
<td>32.64</td>
<td>0.86</td>
<td>4.49</td>
<td>1.68</td>
<td>57.77</td>
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<td>3.3</td>
<td>1.88</td>
<td>0.88</td>
<td>3.85</td>
<td>0.17</td>
<td>10.08</td>
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<td>60 kip 5-axle Comb/Urban Interstate</td>
<td>10.5</td>
<td>18.39</td>
<td>1.15</td>
<td>4.49</td>
<td>2.75</td>
<td>37.28</td>
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<td>80 kip 5-axle Comb/Rural Interstate</td>
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<td>2.23</td>
<td>0.88</td>
<td>3.85</td>
<td>0.19</td>
<td>19.85</td>
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<td>80 kip 5-axle Comb/Urban Interstate</td>
<td>40.9</td>
<td>20.06</td>
<td>1.15</td>
<td>4.49</td>
<td>3.04</td>
<td>69.6</td>
</tr>
</tbody>
</table>

Marginal Cost of illustrative vehicles to society (FHWA-2003)
Problem Statement

- Lack of Urban Freight Demand Models
  - Data deficiencies
  - Complexity of freight movements
  - Complexity of freight models

- Few practical freight forecasting models

- More significant in small and medium-sized MPOs
Implications of problem

- Models missing freight component could overestimate capacity
  - 1.5 cars per truck (HCM)

- Incapability to provide adequate info to decision makers
  - Justification for infrastructure improvement decisions
  - Analyses of policy and management strategies, such as pricing and multi-modal alternatives
Objectives of Study

- Conduct literature review of small urban areas
- Develop truck freight planning model
- Develop procedures to combine truck and passenger planning models
- Identify and recommend freight modeling data collection techniques
State-of-the-art in Freight Models

Two modeling platforms

- Commodity based
  - Uses commodity weight, size
    - Shipment attributes (size weight, density) influence shipping and logistics decisions
  - Limitations:
    - Data deficiencies at urban level
    - Conversion of commodity into truck tonnage
    - Empty Trips Typically unaccounted for
    - Truck movements for services unaccounted

- Applied at regional geographic levels
State-of-the-art in Freight Models

- **Trip-based**
  - Uses Trucks as unit of measurements
    - Typical unit of measure of travel demand
    - Trips generated is related to observable characteristic of commercial activity
    - Data available
    - Accounts for empty/service trips
  - Applied at urban level
Urban Planning Models

- **Baltimore**
  - Trip-based adaptable assignment

- **SCAG, Des Moines and Boston MPO**
  - Commodity-based

- **Limitations:**
  - No future year forecasts
  - Regional Models
  - House-keeping models
Case Study: Fargo-Moorhead

- Fargo, Moorhead, W Fargo, Dilworth
- Regional hub
  - Terminus, generator and bridge for freight
- Demographic Profile
  - 32% projected population growth
  - 40% projected household growth
- Economic profile, freight industries:
  - Agriculture, mining, manufacturing, wholesale, retail and warehousing
<table>
<thead>
<tr>
<th>NAICS Code</th>
<th>Sector</th>
<th>2004 Employment</th>
<th>% Total</th>
<th>2005 Employment</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Agriculture, Forestry, Fishing &amp; Hunting</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>21</td>
<td>Mining</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>31</td>
<td>Manufacturing</td>
<td>7,501</td>
<td>27%</td>
<td>7,957</td>
<td>28%</td>
</tr>
<tr>
<td>42</td>
<td>Wholesale Trade</td>
<td>6,048</td>
<td>22%</td>
<td>6,204</td>
<td>22%</td>
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<tr>
<td>44</td>
<td>Retail Trade</td>
<td>11,371</td>
<td>41%</td>
<td>11,687</td>
<td>41%</td>
</tr>
<tr>
<td>48</td>
<td>Transportation &amp; Warehousing</td>
<td>2,813</td>
<td>10%</td>
<td>2,834</td>
<td>10%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>27,733</td>
<td></td>
<td>28,682</td>
<td>***</td>
</tr>
</tbody>
</table>
## Largest Employers

<table>
<thead>
<tr>
<th>Largest Companies by Employment</th>
<th>Product/Service</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Crystal Sugar</td>
<td>Food Manufacturing</td>
<td>2,000</td>
</tr>
<tr>
<td>Case New Holland</td>
<td>Equipment Manufacturer</td>
<td>660</td>
</tr>
<tr>
<td>Phoenix International Corp</td>
<td>Electronics Manufacturer</td>
<td>558</td>
</tr>
<tr>
<td>Integrity Windows by Marvin</td>
<td>Window Production</td>
<td>549</td>
</tr>
<tr>
<td>HornBacher's Foods</td>
<td>Grocers</td>
<td>540</td>
</tr>
<tr>
<td>Swanson Health Products</td>
<td>Vitamin Distributor</td>
<td>537</td>
</tr>
<tr>
<td>Wal-Mart</td>
<td>Department Store</td>
<td>500</td>
</tr>
<tr>
<td>Food Services of America</td>
<td>Food Distributor</td>
<td>424</td>
</tr>
<tr>
<td>Cardinal IG Company</td>
<td>Window Glass Manufacturer</td>
<td>380</td>
</tr>
<tr>
<td>Fargo Assembly Company</td>
<td>Wiring Harness Manufacturer</td>
<td>350</td>
</tr>
<tr>
<td>Pepsi Cola</td>
<td>Wholesale Beverage Distributor</td>
<td>265</td>
</tr>
<tr>
<td>DMI Industries</td>
<td>Heavy Steel Manufacturer</td>
<td>250</td>
</tr>
</tbody>
</table>
FM freight transport supply

- Railway, air, pipeline
  - Limited freight generation in FM region

- Highway
  - 63% of total freight in state moved by trucks
  - Bisected by two interstates
  - Truck ADT > 14% on interstates
    - Forecasted to more than double in two decades
    - Freight will play increased importance in the region
Data Requirements

- Socioeconomic/land use data
  - Industrial classification/land use intensity
  - Population and household data
  - OD Data
  - Truck trip generation data per industrial group
- Network and FAZ data
  - Truck road system
  - Spatial FAZ data
  - Truck count data
Data Collection Efforts

- FMCOG facilitates data collection
  - Very short surveys to improve response rates
- Trip generation/OD survey of freight generating businesses in area
  - Mail in surveys with option of online/mail back response
  - Response rate at 55% currently
- OD survey for EE trips at truck stops
- Survey of MPOs with regards to current freight planning practices
Methodology

- Trip-Based modeling platform
  - Trip Generation
  - Trip Distribution
  - Trip Assignment
Methodology

Trip Generation

- Trip attraction and production
- Regression model
  \[ T = X\beta + \epsilon \]
  - Where, \( T \) is number of truck trips attracted or produced,
  - \( X \) is vector of independent variables (socioeconomic and land use intensity) for each industry
- Rates used to generate trip table for each Freight Analysis Zone
Trip Distribution

- Matches trips generated between OD pairs
- Gravity model for I-I and I-E trips

\[ T_{ij}^k = \theta_i O_i^k B_j D_j^k F_{ij} K_{ij} \]

- \( T_{ij} \) = number of truck trips of industrial group \( k \), between zones \( i \) an \( j \),
- \( O_i^k \) is the number of truck trips of industrial group \( k \), originating at zone \( i \),
- \( B_j \) ensures that the destination constraint is satisfied
- \( F_{ij} \) is friction factors (impedance measure) between zone \( i \) and \( j \)
- \( K \) is the K factors matrix which is an adjustment factor between zones \( i \) and \( j \) (OD matrix from survey).
- EE trips distributed based on OD survey
Methodology

- **Trip Assignment**
  - User equilibrium assignment method
  - Travel time, load restrictions main impedance measure
  - Output Truck AADT

- **Model Calibration and Validation**

- **Combine Truck and passenger models**

- **30 year forecast**
Conclusion

- Freight planning should be included in general planning process
- Methodology to develop truck freight planning model in progress
- Data Collection efforts ongoing and response rates so far good.
Questions?