Innovative Models for Advanced Freight Analysis

presented to
Association of Metropolitan Planning Organizations

presented by
Cambridge Systematics, Inc.

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Acknowledgements

- Maricopa Association of Governments (MAG)
- Chicago Metropolitan Agency for Planning (CMAP)
Presentation Overview

- Freight Modeling
  - Objectives
  - Approaches

- Innovative Models
  - Supply Chain and Logistics
  - Truck Touring

- Application Examples
Freight Modeling Objectives

- **Traditional**
  - Long range transportation planning
  - Focus on truck (and maybe rail)
  - Traffic volumes
  - Air quality analysis

- **Emerging**
  - Regional freight planning
    - Freight performance measures
    - MAP-21
  - Multi-modal analysis
  - Economic impacts
The Evolution of Freight Models

Factor Auto Trips

Truck Trip Generation (QRFM)

O-D Matrix Estimation

Disaggregate Commodity Flows

Truck Touring Models

Supply Chain and Logistics Models
Recent Implementations

- Calgary (2005)
- Norway, Sweden (2007)
- Ohio (2007)
- CMAP (2011)
- Florida (present)
- MAG (2013)
Traditional Approach: Four-Step Model

- Level of analysis: Traffic Analysis Zones (TAZs)

TAZ 1:
- 1,000 Manufacturing jobs
- 1,500 Retail jobs
- 500 Other jobs
- 200 Residents

TAZ 2:
- 0 Manufacturing jobs
- 500 Retail jobs
- 500 Other jobs
- 5,000 Residents

100 Daily Trucks

- Assign trucks to daily network
Limitations of Traditional Approaches

- Focus on truck (and maybe rail)
- Aggregate level of detail
  - Limited behavioral understanding
- Limited analysis capabilities
  - Truck volumes
    - Identify highway bottlenecks
    - Toll studies
  - Emissions
Analysis Capabilities
Supply Chain and Logistics Model

Understand impacts of (for example):

» Changing macroeconomic factors
  – Fuel prices, labor costs

» Multi-modal network changes
  – Rail improvements (CREATE)
  – Intermodal connectors

» New logistics facilities
  – Intermodal facilities, airport, water port
  – Warehouses and distribution centers
Analysis Capabilities
Truck Touring Model

- Understand impacts of (for example):
  - Changing land use
  - Traffic conditions by time of day
  - Network changes
    - Detailed evaluation of tolls
    - Truck-only lanes
  - New logistics facilities
    - Intermodal facilities, airport, water port
    - Warehouses and distribution centers
Geographic Scale – Global

Legend
- State
- County
- Mesoscale Zones outside of CMAP (FAF3 Zones)
- Mesoscale Zones in CMAP Region
Generate Firm Population

- Agricultural Firms
- Construction Firms
- Foreign Firms

Firms

County Business Pattern (CBP) Data
Supplier Selection

- Identify potential suppliers
- Supply chain formation
  » Each buyer selects a supplier (based on FAME formulation)
Flow Estimation

- Estimate annual tons of goods traded

Selected Supplier: 50 tons to Purchasing Firm
Path Selection
Multi-Modal Path Options

Rail Carload

Water

Air

Rail-Truck Intermodal (IMX)
Path Selection
Detailed Transportation Logistics Decisions

Truck with Container

Truck
FTL: Full Truckload
LTL: Less-than-Truckload

Logistics Handling →
Transloading, Distribution
Path Selection Example
Overseas to the Chicago Area

Potential Paths

- Each supply chain selects a path
Prepare for Assignment

- Summarize shipments by:
  - Commodity type
  - Mode (truck, rail, air, water) and submode (TL, container, etc.)
  - Origin TAZ
  - Destination TAZ
  - Intermediate stops
    - Nodes (or TAZs) where logistics handling occurs

- Trip-based or tour-based assignment
EXAMPLE RESULTS
SUPPLY CHAIN MODEL
Example Results
Regional Mode Shares

Percentage of Tonnage by Mode

- Rail carload, 47.3%
- Truck, 43.0%
- Rail intermodal, 4.5%
- Water, 5.1%
- Air, 0.002%

Source: CMAP Mesoscale Model (2011) and Cambridge Systematics.
Example Results
Rail Volumes

Source: Cambridge Systematics
Example Results
Port Choice

- Greatest flow through Ports of LA/Long Beach
- Flows through other ports
  - Port of Portland
  - Pass through Panama Canal to Port of New Orleans
Example Results: Rail, Air, & Water Terminals
Number of Shipments

Source: CMAP Mesoscale Model (2011) and Cambridge Systematics.
TRUCK TOURING MODEL
OVERVIEW
GPS Data Overview

- Cost for one month of data – $10K
- GPS data used to supplement heavy truck trip diary surveys
- 3.5 million positional records from 22,000 trucks
- Close to 60,000 truck tours

Relatively Cheap
Heavy Trucks
Large Sample of Trucks
Commercial Vehicle GPS Data

GPS devices common in cell phones, autos, and trucks

Truck fleet operators subscribe to GPS services for operational and maintenance purposes

Entities (e.g., ATRI) collect and store historical GPS from operators (2004 to present)
Truck GPS Data from Phoenix
All Trucks in April 2011

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<tr>
<th>All Trucks</th>
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Truck GPS Data from Phoenix
One Truck in April 2011

ATRI GPS Truck ID 3570452
April 2011

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Truck GPS Data from Phoenix
TAZ of Trip Ends for One Truck on April 1, 2011

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Map showing industrial and landfill areas.
Truck Tour-Based Model Structure

- **Tour Generation**
  - Heavy truck tour rates by industry type
    - 1 stop
    - 2 stops
    - .......
    - 11 stops

- **Stop Generation**
  - 1 stop
  - 2 stops
  - .......
  - 11 stops

- **Tour Completion**
  - Yes – return to home base
  - No – does not return

- **Stop Purpose**
  - One of 10 stop types
    - Retail
    - Constr.
    - Farming
    - Resid.
    - Govt.
    - Warehs.
    - Transp.
    - Office
    - Industrial
    - Service

- **Stop Location**
  - One of 3,000 TAZs

- **Stop TOD Choice**
  - 1st Stop TOD (24 1-hr periods)
  - Next Stop TOD (24 1-hr periods)
Initial Findings
Distribution of Stop Purposes

<table>
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<tr>
<th>Stop Purposes</th>
<th>Percent of Stop Purposes</th>
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<tr>
<td>Ret</td>
<td>Model: 30%</td>
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<tr>
<td>Cns</td>
<td>Target: 10%</td>
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<tr>
<td>Frm</td>
<td>Model: 6%</td>
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<td>Gov</td>
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<td>War</td>
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<tr>
<td>Ind</td>
<td>Target: 30%</td>
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<tr>
<td>Srv</td>
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Model vs. Target
Initial Findings
Time of Day (First Stop)
Initial Findings
Time of Day (Subsequent Stops)
Applications

- Changes in land use
  - Evaluate changes in trip distribution pattern

- Evaluate time of day policies
  - Truck restrictions by time of day
  - Evaluate impact of congestion on time of day
Analysis Capabilities

- Analytical advantages
  - More detailed
  - More transparent and intuitive

- Greater ability to understand:
  - Mode shifts
  - Macroeconomic impacts
  - Land use impacts
  - Usage of logistics facilities
  - Impact of reliability
  - Time of day patterns
Impacts on Regional Commerce

- Understand impact of MPO decisions on regional economy
  - Economic measures
    - Efficiency
    - Productivity
    - Reliability
  - Competitive advantages of your transportation system
  - Use analysis to guide funding and policy
    - Highway congestion / routing of trips
    - Investment in intermodal terminals
    - Investments in key highways that serve intermodal terminals or truck distribution centers
THANK YOU!
Questions:

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