Tennessee Statewide Model (TSM) V4

Model Overview

Nagendra Dhakar, PhD

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Model Overview - Summary

- TN statewide model (TSM) history
- TSM version 4 framework
- Assignment validation
- Model development data
- Demand model components
- Assignment and feedback loop (optional)
- Connected and autonomous vehicle (CAV) model
- Questions and answers (Q&A)
Tennessee Statewide Model (TSM) History
Phase 1: Data Development

• New Network & Zone System
  – 3x network and zones
  – 2040 socioeconomic forecasts

• Truck GPS data from ATRI
  – Cleaned and expanded

• Combined TN HH Surveys
  – reweighted
Phase 2: Interim Model

- Cleaned traffic counts
- Interim model
  - Simple three-step trip-based model
  - Data driven pivoting from ATRI & LEHD
- Post-processor
Phase 3: Freight and Long-Distance Modeling

BUILD ON SUCCESSES AND CAPITALIZE ON OPPORTUNITIES

- **New Commodity Flow Freight Model**
  - To make ATRI-based trucks sensitive
- **Advanced trip-based model** to replace 3-step
  - Mode & Destination choice models, linked NHB trips
  - New AirSage+ATRI-based pivot point
- **Incorporate New National Long-Distance Model**
  - Calibrate to **AirSage**
  - Successful use in Chattanooga
  - Successful use for intercity corridors
Phase 4: TSM4

Additions

- a simple long-distance passenger model and visitor model
- Connected and autonomous vehicle (CAV) framework
- Option for travel time feedback loop
- Use of 2018 rMerge passive data

Updates

- Base year 2018 (SE, network)
- Future and interim year SE data forecasts to 2045
- 2018 truck ATRI data
- Peak periods to 3 periods TOD assignment
- Simplification of rJourney model
- Other model updates (usability, transit and walk variables, post-processor, and pivot methodology)
TSM4 Framework
TSM4 Framework

INPUTS

Networks
SE Data

DEMAND MODELS

Short Distance Passenger Demand
Long Distance Passenger Demand
Freight & Truck Demand

ASSIGNMENT

Runtime – 4.5 hours (with time-of-day assignment)

Machine - 24 physical cores and 256 GB RAM
TSM4 GUI
Assignment Validation
Validation Statistics – All Vehicles

- Model is performing well
- Require looking into big outliers
- Possible issue with traffic counts

**Figure 74: Modeled Volumes Versus Counts (All Vehicles)**
Validation Statistics - Trucks

- Model is performing well
- Require looking into big outliers
- Possible issue with traffic counts

FIGURE 75: MODELED TRUCK VOLUMES VERSUS TRUCK COUNTS
Model vs Targets – Volume Group

FIGURE 73: PIVOTTED MODEL ERROR VERSUS RMSE STANDARDS
Model Validation – Facility Class

- Freeways and arterials are doing well
- Lower facility class are performing relatively poor

<table>
<thead>
<tr>
<th>Class</th>
<th>Stations</th>
<th>Error (%)</th>
<th>MAPE (%)</th>
<th>RMSE (%)</th>
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<tr>
<td>Freeways</td>
<td>735</td>
<td>9.05</td>
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<td>Arterials</td>
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<td>Collectors</td>
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<td>-41.91</td>
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Validation - Comparison with Other SW Models

- Doing similar or better compared to most statewide models

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<th>Daily Volume Range</th>
<th>AL</th>
<th>AZ</th>
<th>FL</th>
<th>IN</th>
<th>OH</th>
<th>TX</th>
<th>UT</th>
<th>WI</th>
<th>TSM4</th>
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<td>&lt; 5,000</td>
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<td>61.0</td>
<td>57.5</td>
<td>22.3</td>
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<td>20,000 - 30,000</td>
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<td>45.0</td>
<td>19.3</td>
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<td>36.0</td>
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<td>14.8</td>
<td>24.0</td>
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<td>56.0</td>
<td>32.6</td>
<td>39.4</td>
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<td>90.0</td>
<td>49.0</td>
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Model Development Data
Data

- Zone system
- Network
- Socio-economic (SE) data
- Household travel surveys
- LBS OD data (rMerge RSG)
- AirSage Cellular data
- LEHD LODES commute flow data
- Transearch commodity flow data
- ATRI truck GPS data
- Traffic count database (MS2)
Model Zones – Network Centroids

Assignment Zones (3,687)
skimming and assignment

Transearch Zones (668)
freight model skimming

NUMA Zones (4,442)
LD model skimming

FAF Zones (123)
not used
Socio-Economic (SE) Data – Zone Layer

• SE data for 2018 (base year), 2025, 2035, and 2045 (horizon year)
  – Households, population, employment by 2-digit NAICS, densities, and accessibilities
  – College enrollment and total park area

• Two steps development process
  – County level control totals
  – TAZ suballocation

• Intermediate years (2025 and 2035)
SE Data - Demographics Data Sources

2014-18 ACS 5-year Estimates
• SE data at Census block
• For comparison and checks in 2018 base year model development

Center for Business and Economic Research (CBER)
• 2018-2070 County level population for TN only from University of TN
• Used for both 2018 and 2045 control totals

Woods & Poole (W&P)
• Purchased 2019 data including demographic variables
• Used for both 2018 and 2045 control totals

MPOs
• Total population estimate at MPO TAZ level
SE Data - Employment Data Sources

**Woods & Poole (W&P)**
- Purchased 2019 data including employment forecasts consistent with BEA
- Used for both 2018 and 2045 control totals

**Infogroup**
- Purchased 2018 data for all Tennessee
- Individual business with lat, long locations based on phone surveys, aggregated data

**Bureau of Economic Analysis (BEA)**
- Freely available federal data
- **Total** employment by NAICS category at County level

**MPOs**
- Total employment estimate at MPO TAZ level
- Not full two-digit NAICS breakouts
## SE Data - Control Totals (TN Statewide)

<table>
<thead>
<tr>
<th>Model Year</th>
<th>2018</th>
<th>2025</th>
<th>2035</th>
<th>2045</th>
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<tr>
<td>Population</td>
<td>6,767,031</td>
<td>7,252,726</td>
<td>7,549,323</td>
<td>8,484,522</td>
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<td>Household Population</td>
<td>6,625,204</td>
<td>7,102,861</td>
<td>7,396,100</td>
<td>8,317,388</td>
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<td>Group Quarter Population</td>
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<td>147,914</td>
<td>151,158</td>
<td>165,442</td>
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<td>Households</td>
<td>2,568,000</td>
<td>2,748,533</td>
<td>2,857,245</td>
<td>2,933,717</td>
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<td>Household Size</td>
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<td>2.89</td>
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<td>75,004</td>
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<td>80,301</td>
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<td>1.21</td>
<td>1.25</td>
<td>1.29</td>
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<tr>
<td>Household Vehicles</td>
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<td>2.09</td>
<td>2.15</td>
<td>2.20</td>
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<tr>
<td>Household with Seniors</td>
<td>718,142</td>
<td>763,067</td>
<td>787,848</td>
<td>804,315</td>
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<td>University Enrollment</td>
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<tr>
<td>Employment</td>
<td>3,912,084</td>
<td>4,201,555</td>
<td>4,382,881</td>
<td>5,215,818</td>
</tr>
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</table>

*Bold numbers are averages*
ATRI Truck GPS Dataset

ATRI DATA SAMPLE FOR TENNESSEE

- Four 2-week samples over 2018 (Q3 and Q4) and 2019 (Q1 and Q2) quarters
- 536,000 unique trucks with 4.95 million trips
- Sample rate of 10%
- Processed and expanded to weekday classification counts
rMerge OD Passive Data

- Location-based services (LBS) or smartphone application data – April 2019
- Data expansion
  - Demographics and employment data (Census)
  - Traffic counts

**TABLE 66: LBS DATA STATISTICS**

<table>
<thead>
<tr>
<th>Metric</th>
<th>April 2019</th>
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<tbody>
<tr>
<td>Total Sightings</td>
<td>2,887,085,416</td>
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<tr>
<td>Total Devices</td>
<td>3,142,777</td>
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<tr>
<td>Resident Devices</td>
<td>469,900</td>
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<tr>
<td><strong>Sample Rate</strong></td>
<td><strong>6.8%</strong></td>
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<tr>
<td>Visitor Devices</td>
<td>616,049</td>
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<tr>
<td>Removed Devices</td>
<td>2,056,828</td>
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<tr>
<td>Clusters</td>
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<tr>
<td>Trips</td>
<td>58,240,979</td>
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</table>
Demand Model Components
TSM4 Framework

INPUTS

Networks

SE Data

DEMAND MODELS

Short Distance Passenger Demand

Long Distance Passenger Demand

Freight & Truck Demand

ASSIGNMENT
Short Distance (SD) Demand Models

- Advanced trip-based model
  - NHB models are conditionally on HB models
  - Destination choice models & semi-aggregate discrete regression models
Long Distance (LD) Models

• Passenger trips over 50 miles
• TN residents, non-residents, and visitors
• Two long-distance models
  – New LD and visitor model (TSM4) – default configuration
  – FHWA national LD model ‘rJourney’ (TSM3)
New Long-Distance and Visitor Model - Summary

- Used LBS smartphone data
  - Resident\non-resident – one trip end within 50miles of home
  - Visitor – both trip ends are far (>50miles) from home
- Visitor model
  - Visitor trips can be shorter (SD) and longer (LD) than 50miles
  - Visitor model trips based on the long-distance model
- Both models output vehicle trips so no mode choice model required
Freight and Truck Demand Model

**Inputs**
- Networks
- SE Data

**Demand Models**
- Short Distance Passenger Demand
- Long Distance Passenger Demand
- Freight & Truck Demand

**Assignment**

**Freight & Truck Demand**
- 1a. Commodity Generation
- 1b. SU Truck Trip Generation
- 2a. Commodity Distribution
- 2b. SU Truck Trip Distribution
- 3. Freight Mode Split
- 4. Truck Pivoting
- 5. Truck Time-of-Day
Assignment and Feedback Loop (Optional)
Assignment

- Multi-class user equilibrium for three time periods (AM, PM, and OP)
- Tri-Conjugate Frank-Wolfe (TCFW)
- Relative gap of 0.0001
- Two options
  - SOV and HOV assignment
  - Commodity assignment
### Create Trip Tables by Time Period and User Class

<table>
<thead>
<tr>
<th>OTAZ</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<td>179</td>
<td>742</td>
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<td>436</td>
<td>171</td>
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### Create Skims by Time Period and Mode

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### Skim Feedback

- **Demand Models**
- **Feedback**
- **Create Trip Tables by Time Period and User Class**
- **Create Skims by Time Period and Mode**
- **Network Assignment**
Feedback Loop

• Re-running demand models with assignment congested travel times
• Method of Successive Average (MSA) – feedback volume and time
• Base year model reached convergence after 3 iterations
• RMSE increased by 5.5%
Connected and Autonomous Vehicles (CAV)
How can trip-based models be USEFUL in planning for CAVs?

**Scenario Planning**
- Structured way for organizations to think about the future using a limited number of scenarios (e.g., best case, worst case, most likely, etc.)

**Exploratory Modeling Analysis (EMA)**
- Simultaneously vary input assumptions across a wide range of future scenarios along key dimensions of uncertainty
- Explore potential outcomes, find critical input assumptions, and identify future policy directions likely to be robust in the face of “deep uncertainty”
Framework

• Optional within the TSM4 model
• By default, not active
  – Activate in user interface
  – CAV parameters are in “cavparams.dbf”
Deadheading / ZOVs

• Types of ZOV trips
  – Private CAVs
    • for car sharing among household members (1)
    • to avoid paid parking
      – by parking at home (2)
      – by parking elsewhere (3)
      – by circulating instead of parking (4)
  – Shared CAVs
    • for passenger pick-up/drop-off (5)
    • to/from depots (6)
      (for re-charging / demand response)
Assignment

• Multi-class equilibrium
• Five assignment classes
  – ZOV
  – Auto CAV
  – Auto Conventional
  – SUT
  – MUT
• Dedicated CAV-only facilities/lanes with higher capacities or speeds
Questions?