Tennessee Statewide Model (TSM) V4

Model Overview

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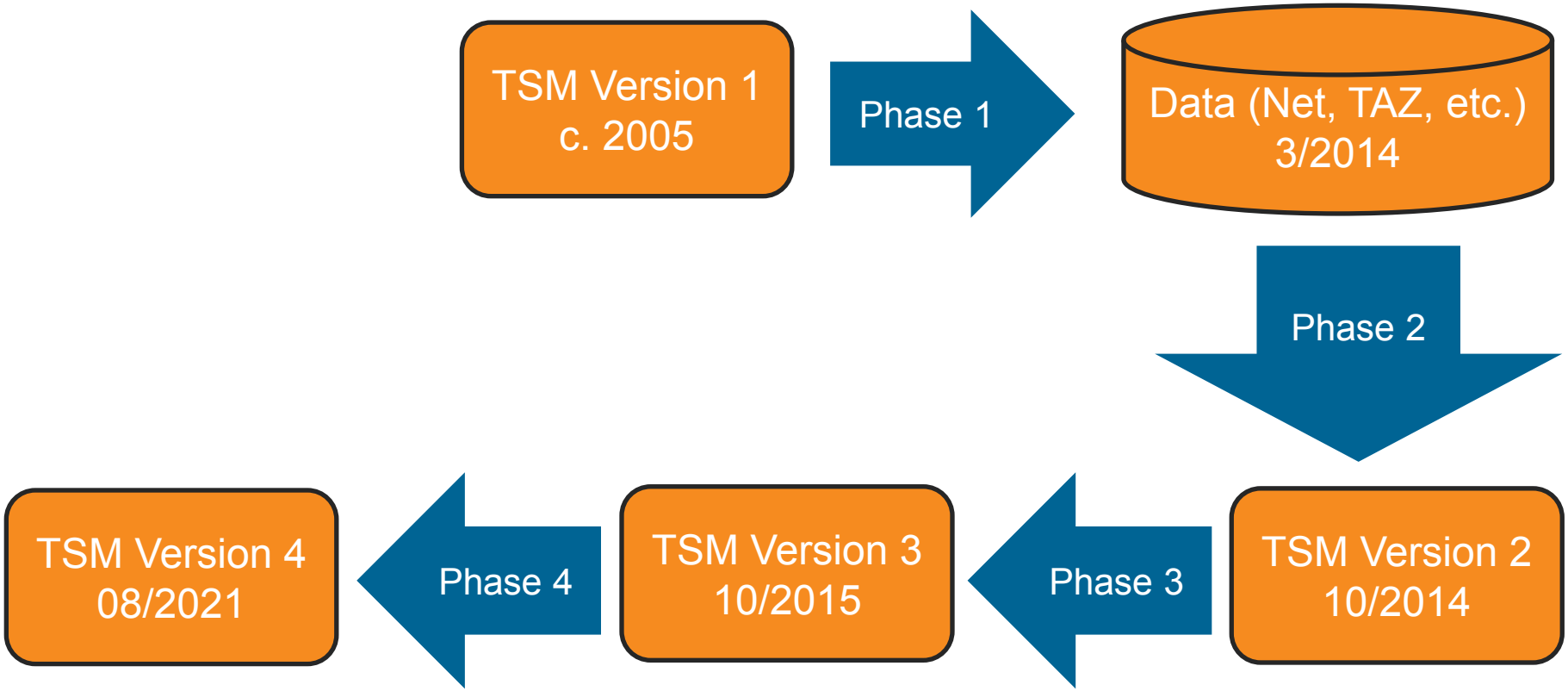
November 17, 2021

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)

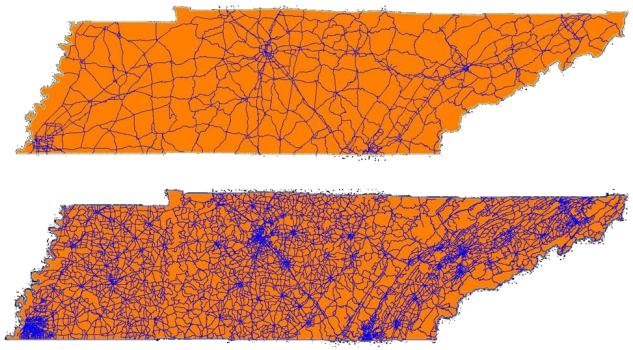
Tennessee Statewide Model (TSM) History

Phases and Versions



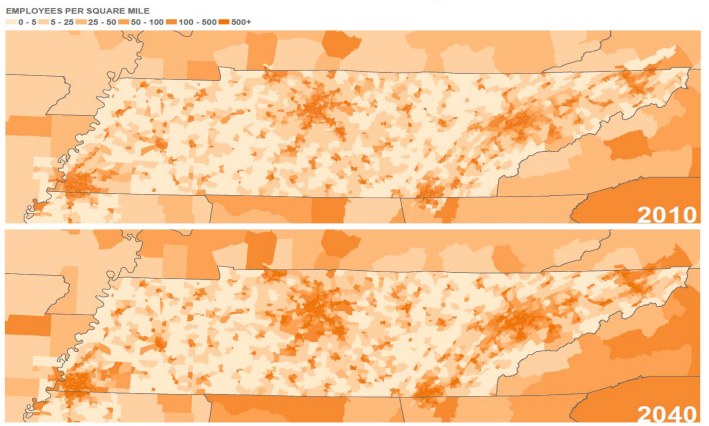
Phase 1: Data Development

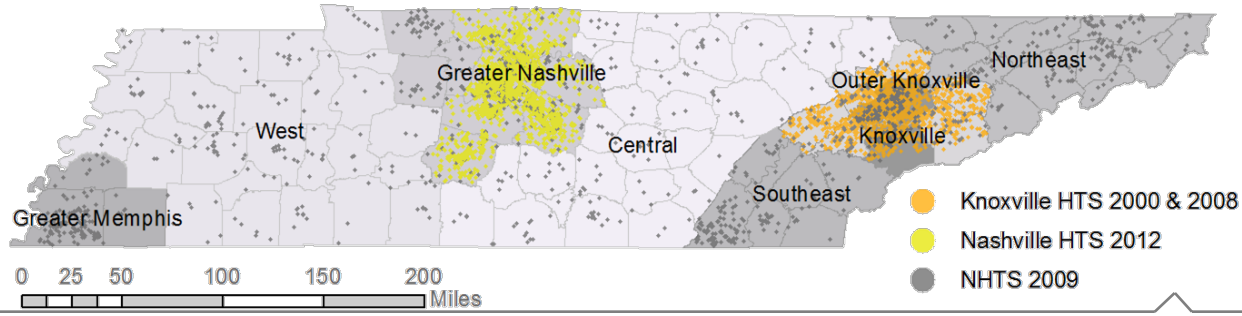
- New Network & Zone System
  - 3x network and zones
  - 2040 socioeconomic forecasts
- Truck GPS data from ATRI
  - Cleaned and expanded
- Combined TN HH Surveys
  - reweighted



Original 2003 Model

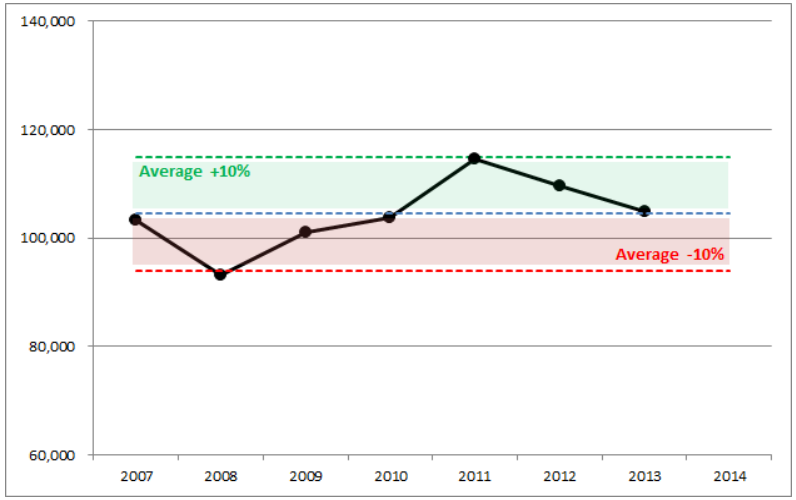
New Version 2 Model

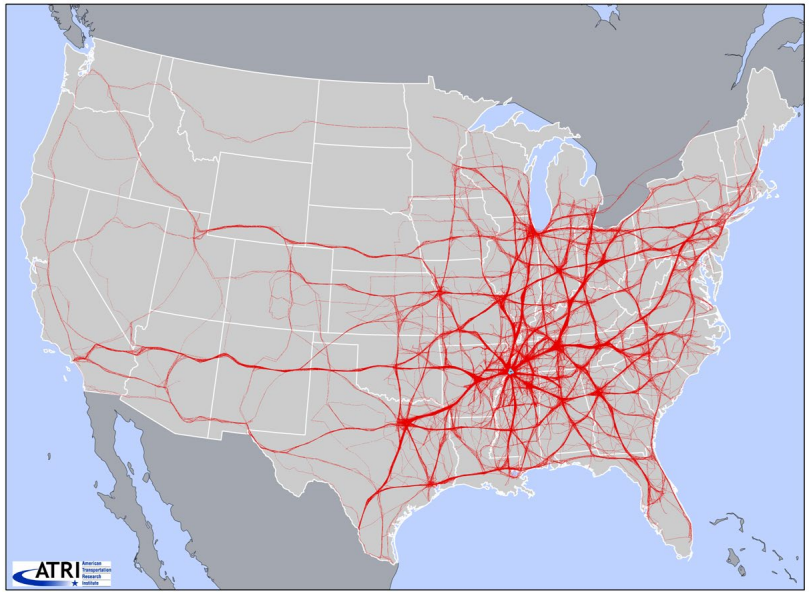




Phase 2: Interim Model

- Cleaned traffic counts
- Interim model
  - Simple three-step trip-based model
  - Data driven pivoting from ATRI & LEHD
- Post-processor

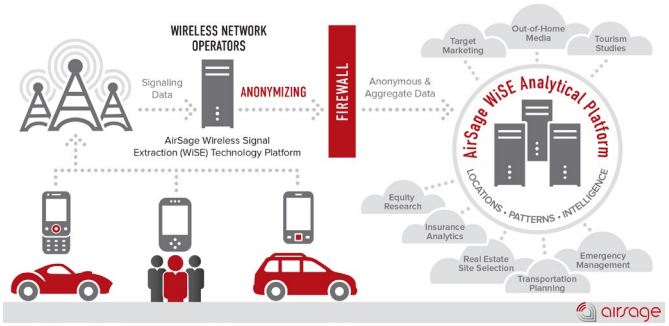


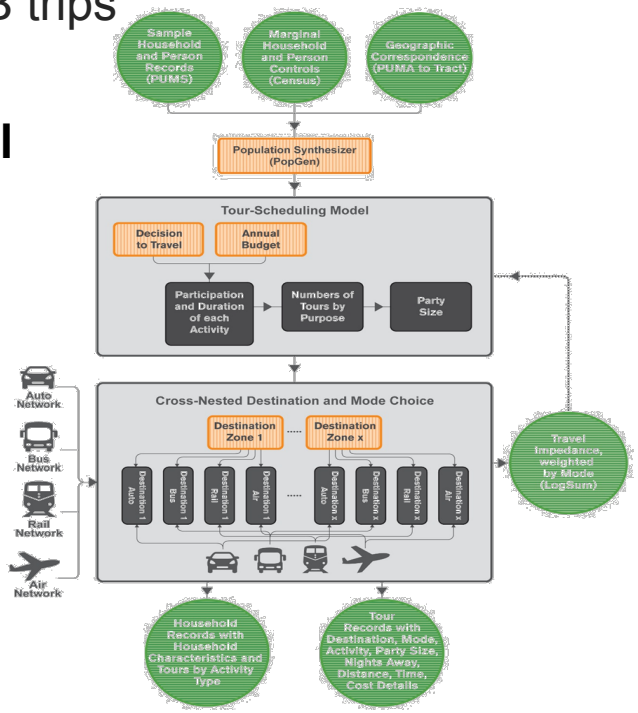


Phase 3: Freight and Long-Distance Modeling

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

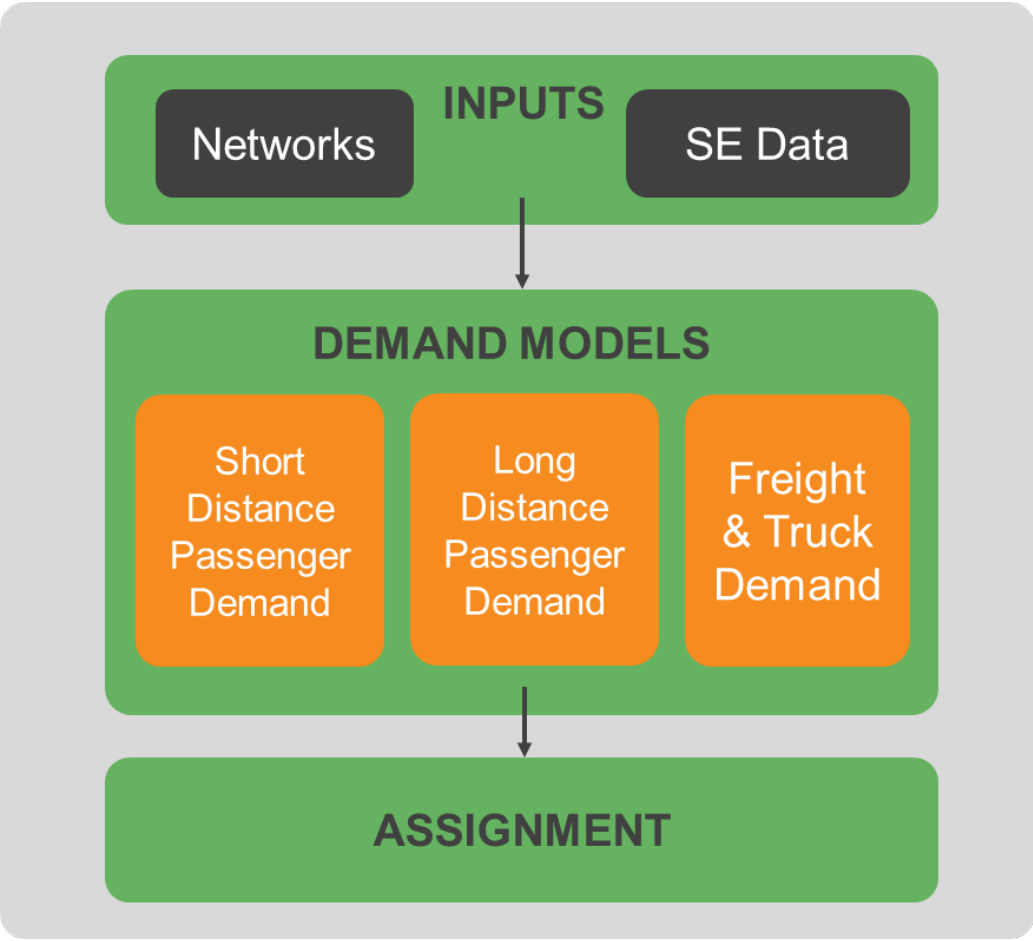
- a simple long-distance passenger model and visitor model
- Connected and autonomous vehicle (CAV) framework
- Option for travel time feedback loop
- Use of 2018 rMerge passive data

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

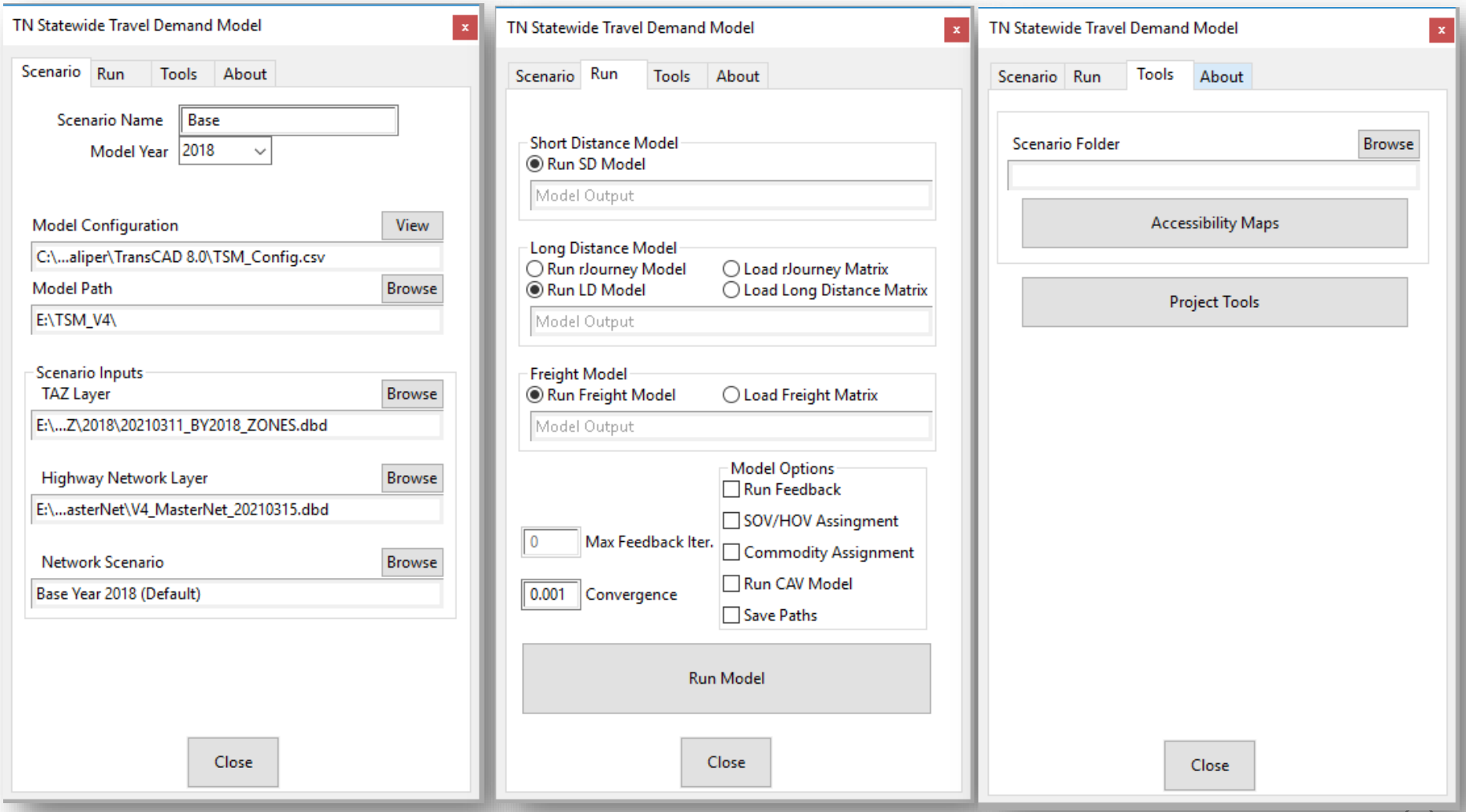
TSM4 Framework



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

Machine - 24 physical cores and 256 GB RAM

TSM4 GUI


TN Statewide Travel Demand Model
Scenario
Run
Tools
About
Scenario Name
Base
Model Year
2018
Model Configuration
View
C:\...aliper\TransCAD 8.0\TSM_Config.csv
Model Path
Browse
E:\TSM_V4\
Scenario Inputs
TAZ Layer
Browse
E:\...Z\2018\20210311_BY2018_ZONES.dbd
Highway Network Layer
Browse
E:\...asterNet\V4_MasterNet_20210315.dbd
Network Scenario
Browse
Base Year 2018 (Default)
Close
TN Statewide Travel Demand Model
Scenario
Run
Tools
About
Short Distance Model
Run SD Model
Model Output
Long Distance Model
Run rJourney Model
Load rJourney Matrix
Run LD Model
Load Long Distance Matrix
Model Output
Freight Model
Run Freight Model
Load Freight Matrix
Model Output
Model Options
Run Feedback
SOV/HOV Assingment
Commodity Assignment
Run CAV Model
Save Paths
0
Max Feedback Iter.
0.001
Convergence
Run Model
Close
TN Statewide Travel Demand Model
Scenario
Run
Tools
About
Scenario Folder
Browse
Accessibility Maps
Project Tools
Close

Assignment Validation

Validation Statistics – All Vehicles

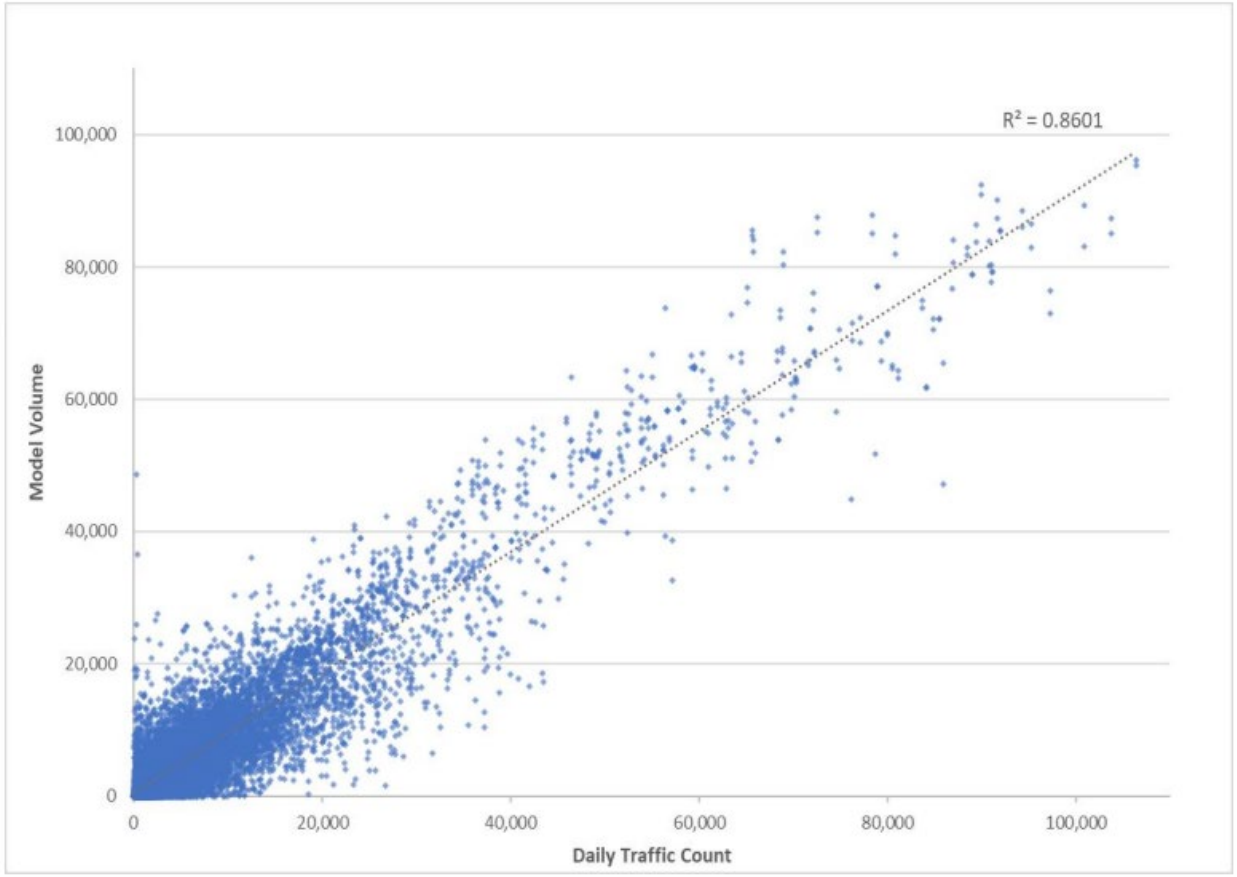


FIGURE 74: MODELED VOLUMES VERSUS COUNTS (ALL VEHICLES)

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

Validation Statistics - Trucks

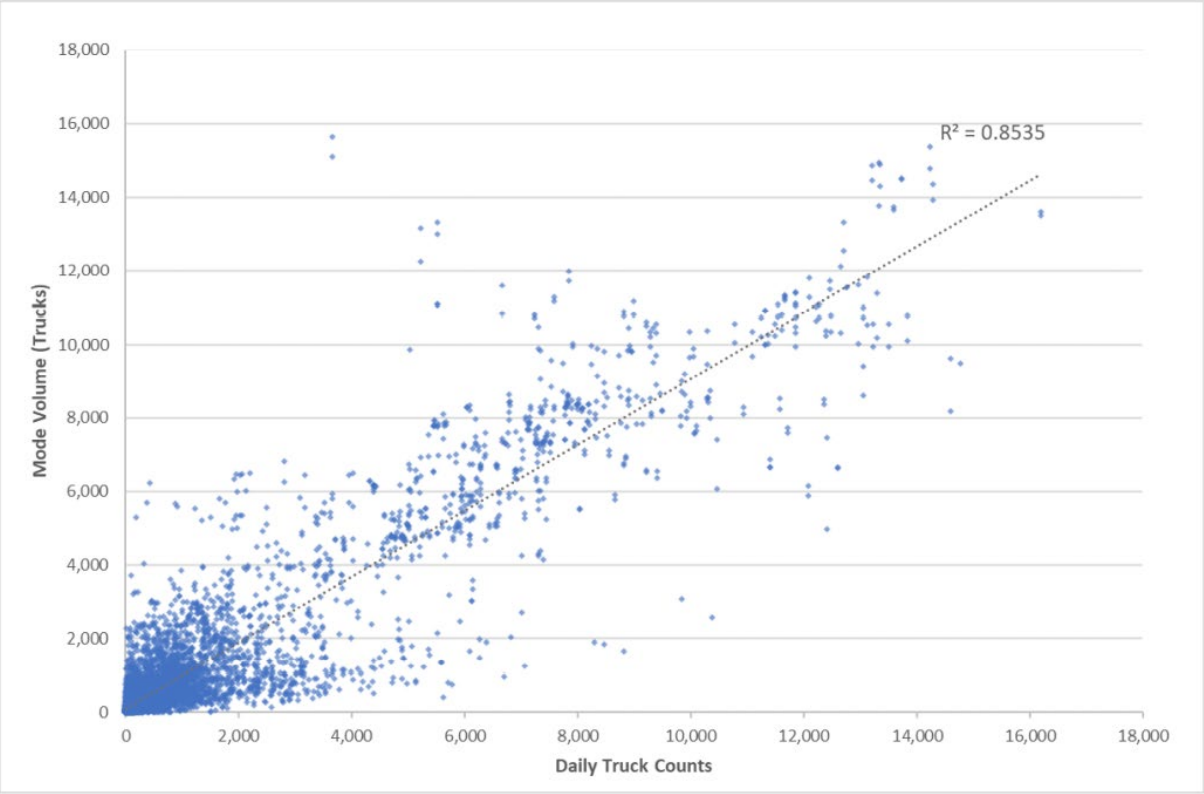


FIGURE 75: MODELED TRUCK VOLUMES VERSUS TRUCK COUNTS

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

Model vs Targets – Volume Group

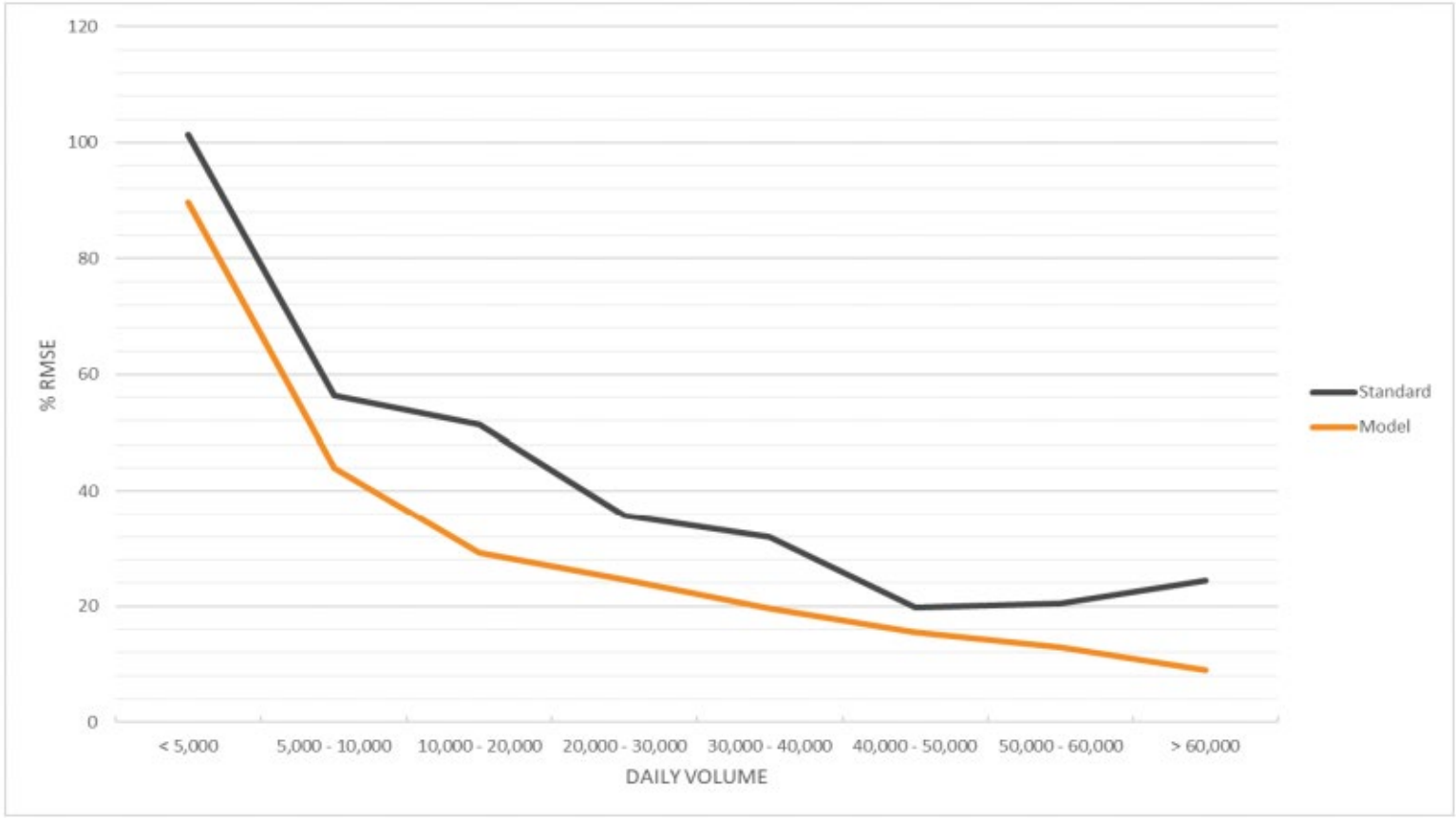


FIGURE 73: PIVOTED MODEL ERROR VERSUS RMSE STANDARDS

Model Validation – Facility Class

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

TABLE 97: PIVOTED MODEL ASSIGNMENT STATISTICS BY ROADWAY CLASS

Class	Stations	Error (%)	MAPE (%)	RMSE (%)
Freeways	735	9.05	15.76	14.68
Arterials	5,252	-3.03	42.11	38.05
Collectors	4,455	-13.49	67.62	86.77
Local	96	-41.91	98.89	124.53

Validation - Comparison with Other SW Models

- Doing similar or better compared to most statewide models

Daily Volume Range	AL	AZ	FL	IN	OH	TX	UT	WI	TSM4
< 5,000	141.8	103.6	60.9	70.7	124.0	190.0	102.0	61.2	**89.6**
5,000 - 10,000	80.7	56.9	43.4	39.2	43.5	70.0	64.5	32.0	**44.0**
10,000 - 20,000	74.0	36.7	32.7	33.5	33.0	61.0	57.5	22.3	**29.2**
20,000 - 30,000	57.1	27.5	25.9	29.3	27.0	40.0	45.0	19.3	**24.6**
30,000 - 40,000	36.2		21.4	21.9	24.0		36.0	13.6	**19.6**
40,000 - 50,000			14.9	14.8	24.0				**15.5**
50,000 - 60,000									**12.9**
> 60,000									**8.9**
Total	82.2	56.0	32.6	39.4	47.7	90.0	49.0	39.2	**39.8**

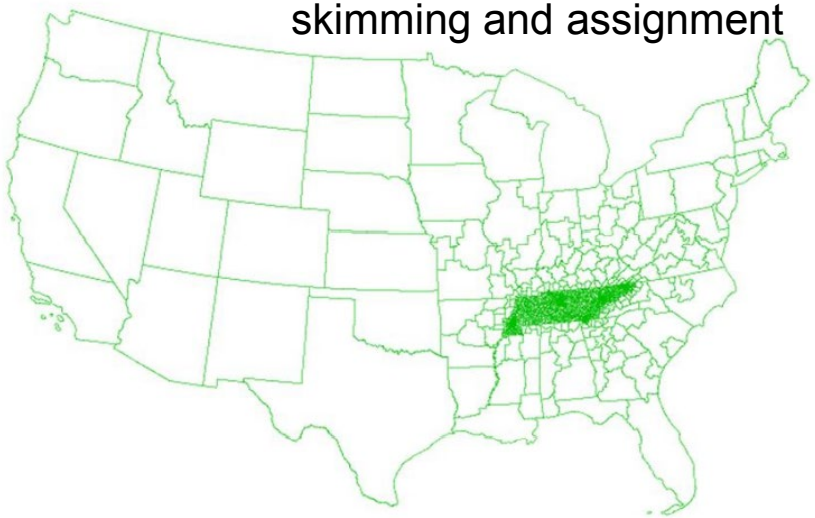
Model Development Data

Data

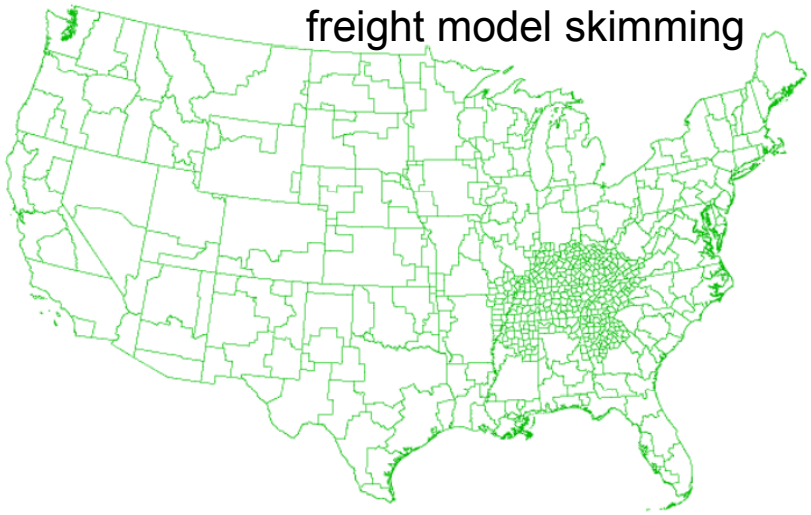
- Zone system
- Network
- Socio-economic (SE) data
- Household travel surveys
- LBS OD data (rMerge RSG)
- AirSage Cellular data
- LEHD LODES commute flow data
- Transearch commodity flow data
- ATRI truck GPS data
- Traffic count database (MS2)

Model Zones – Network Centroids

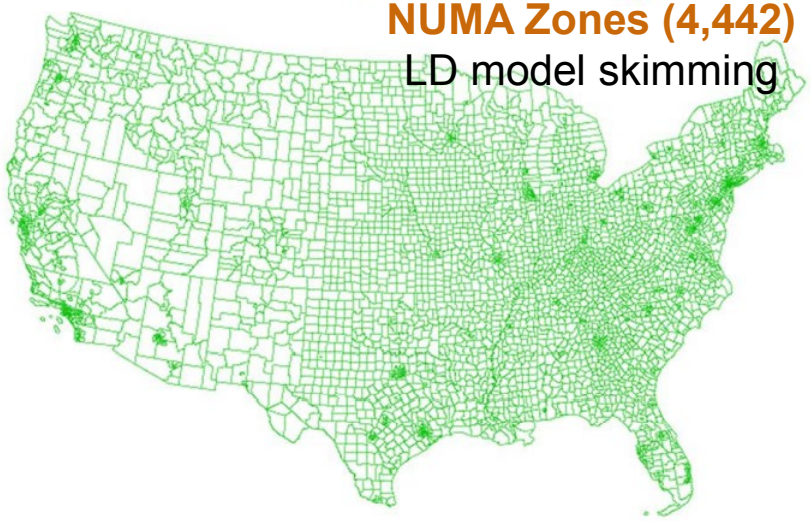
Assignment Zones (3,687)
skimming and assignment



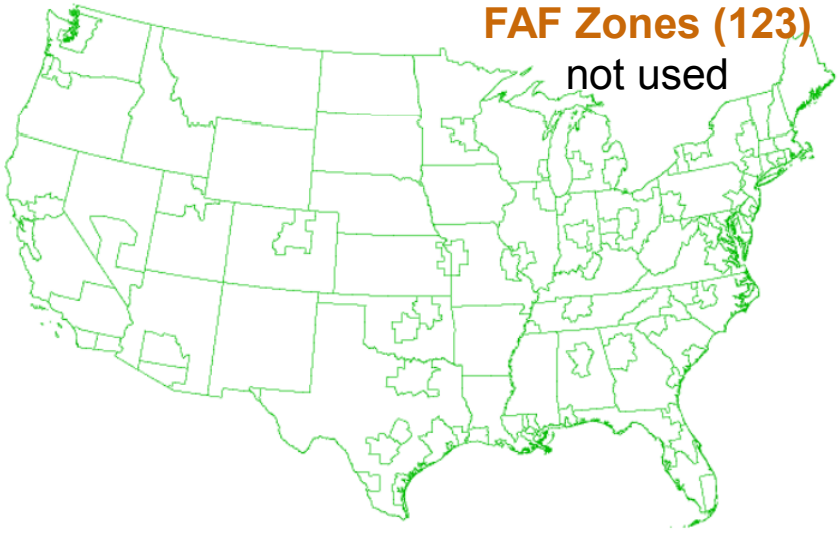
Transearch Zones (668)
freight model skimming



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)

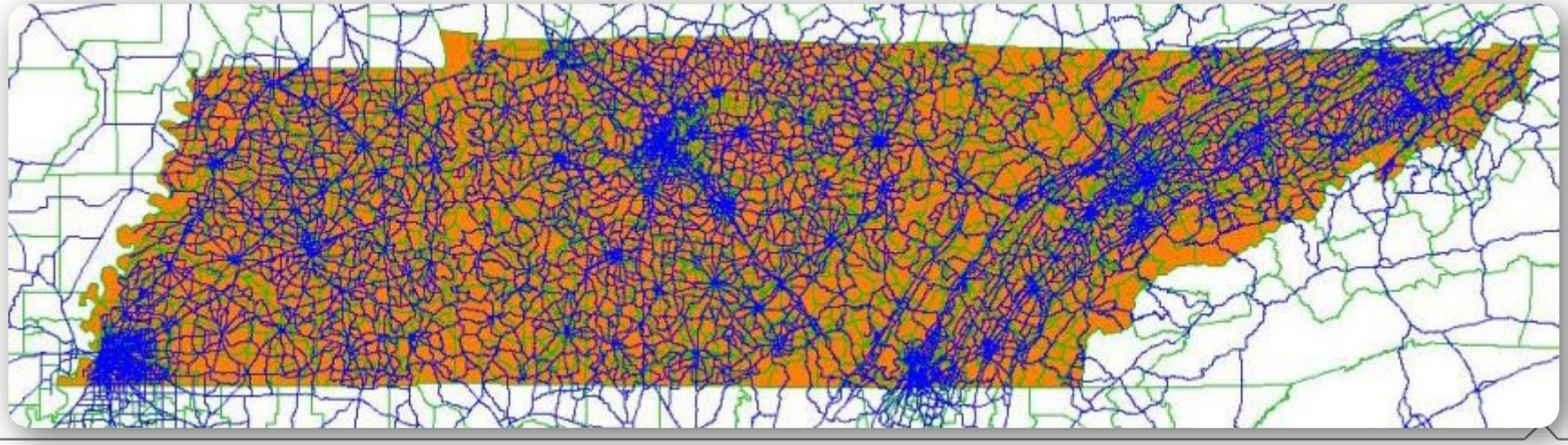
Model Year	2018	2025	2035	2045
Population	6,767,031	7,252,726	7,549,323	8,484,522
Household Population	6,625,204	7,102,861	7,396,100	8,317,388
Group Quarter Population	140,741	147,914	151,158	165,442
Households	2,568,000	2,748,533	2,857,245	2,933,717
Household Size	**2.63**	**2.79**	**2.89**	**2.88**
Household Income	**70,033**	**75,004**	**78,045**	**80,301**
Household Workers	**1.13**	**1.21**	**1.25**	**1.29**
Household Vehicles	**1.96**	**2.09**	**2.15**	**2.20**
Household with Seniors	718,142	763,067	787,848	804,315
University Enrollment	417,575	446,088	461,680	471,437
Employment	3,912,084	4,201,555	4,382,881	5,215,818

***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 86: LBS DATA STATISTICS

Metric	April 2019
Total Sightings	2,887,085,416
Total Devices	3,142,777
Resident Devices	469,900
Sample Rate	*6.8%*
Visitor Devices	616,049
Removed Devices	2,056,828
Clusters	13,503,003
Trips	58,240,979

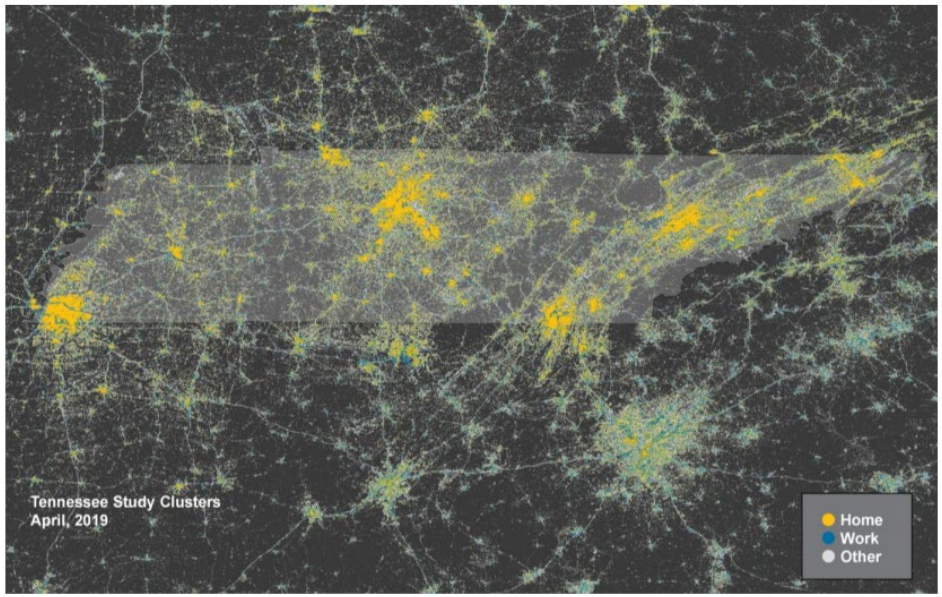
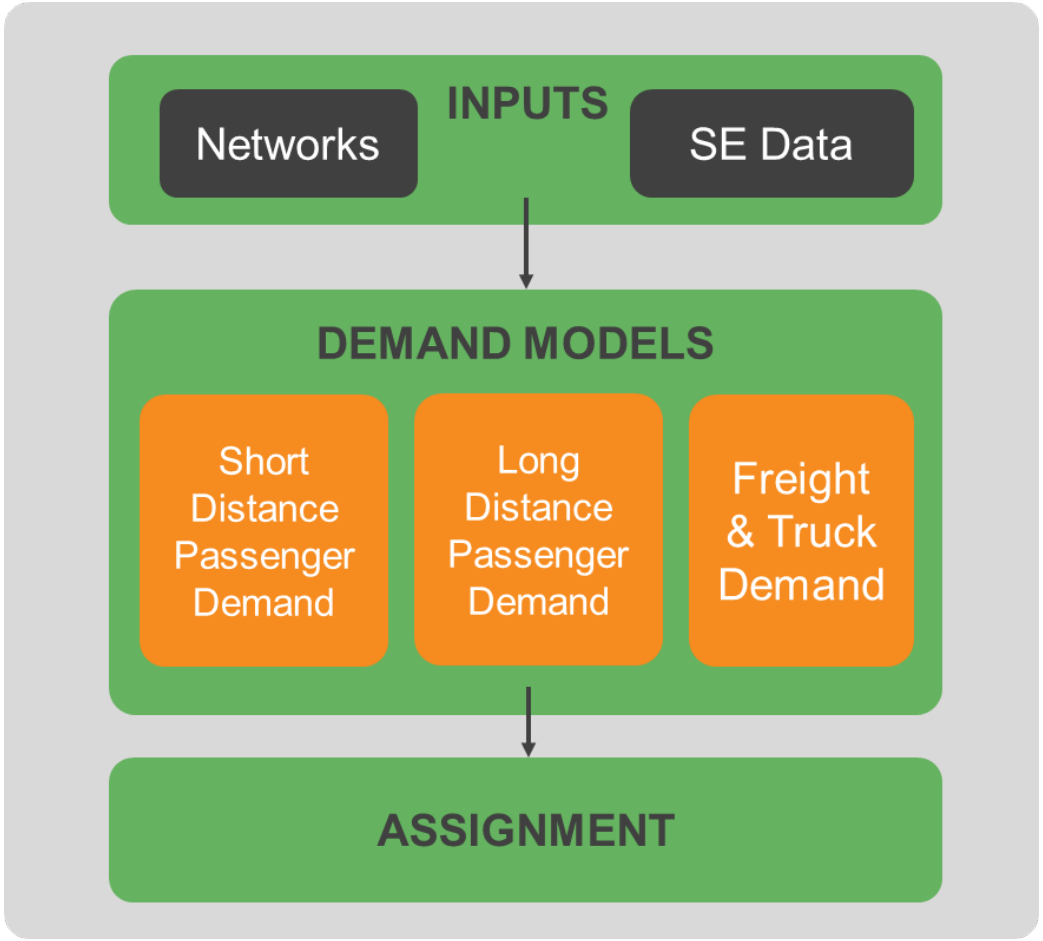


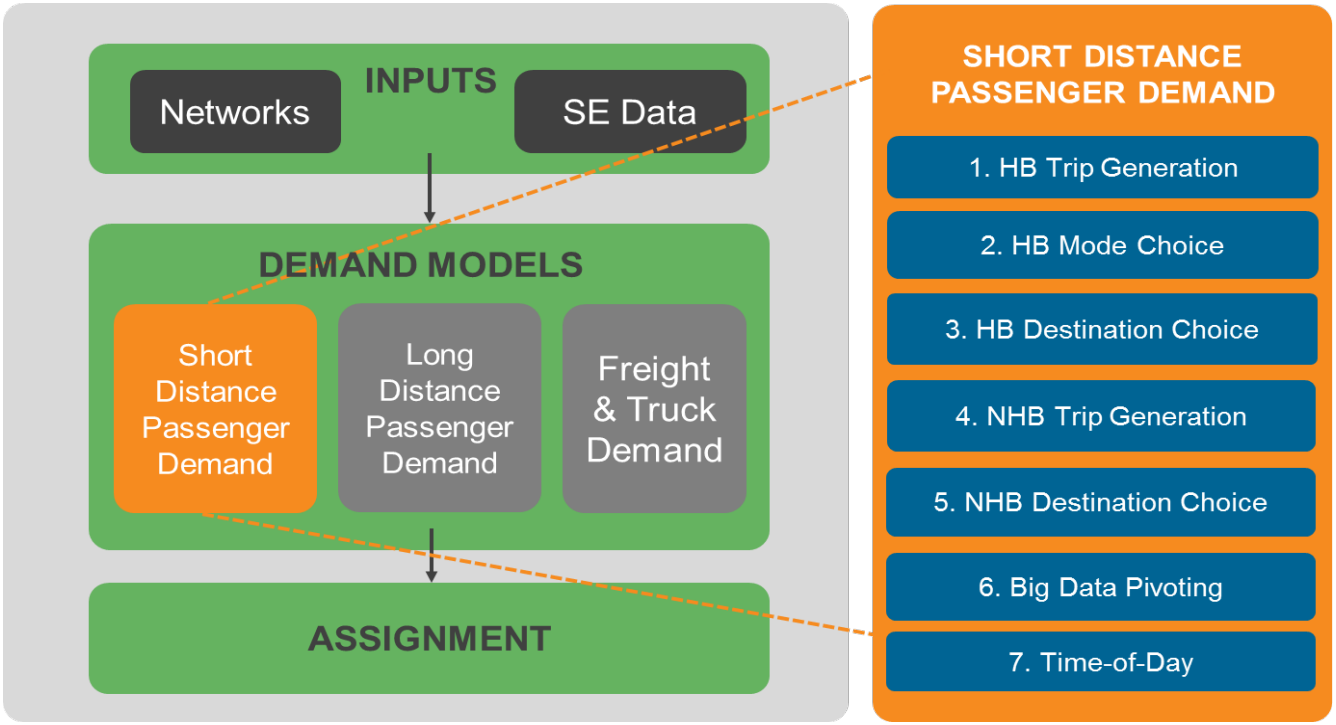
FIGURE 68: TSM4 LBS CLUSTERS – STATEWIDE VIEW

Demand Model Components

TSM4 Framework



Short Distance (SD) Demand Models



- Advanced trip-based model
  - NHB models are conditionally on HB models
  - Destination choice models & semi-aggregate discrete regression models

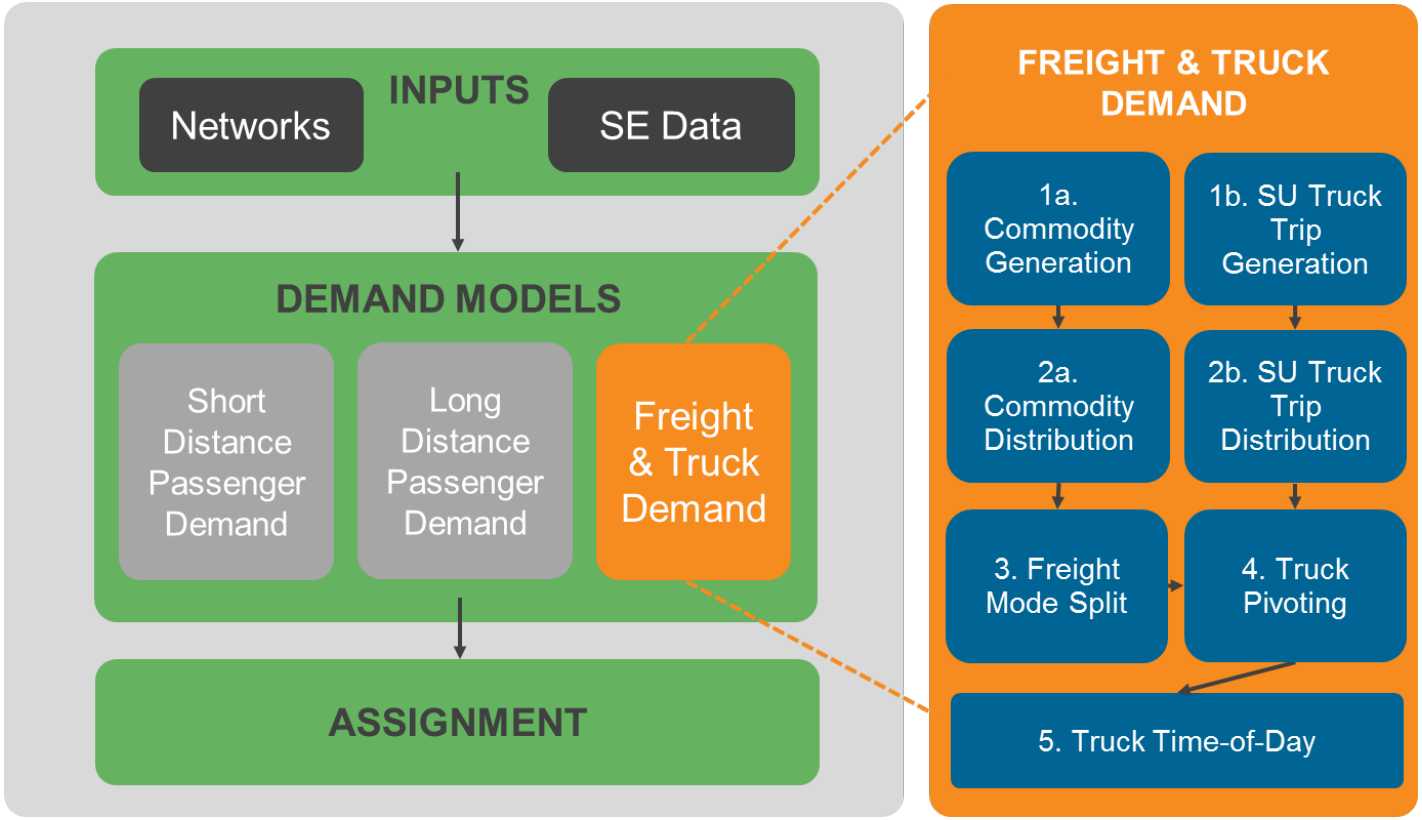
Long Distance (LD) Models

- 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



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

Skim Feedback

Demand Models

Feedback

DTAZ

OTAZ	1	2	3	4	5	6	7	8	9	10
1	1.94	3.40	5.38	6.03	6.54	7.61	8.77	8.09	3.55	5.73
2	3.81	1.89	3.68	4.26	5.25	7.78	8.54	7.87	5.64	7.87
3	4.82	3.41	2.12	3.51	5.04	6.69	7.28	5.96	5.26	7.72
4	6.69	4.02	3.11	2.18	3.47	5.36	5.87	5.46	6.00	8.42
5	8.98	5.52	5.19	4.03	2.33	5.59	7.00	7.57	9.37	10.62
6	8.44	7.15	5.86	5.81	4.58	2.55	3.78	6.50	8.85	10.31
7	12.40	9.30	7.53	6.88	7.15	5.02	4.24	8.20	11.16	11.78
8	11.44	7.69	5.35	5.58	6.95	7.35	7.74	4.65	8.91	10.08
9	5.53	6.35	6.35	8.98	10.13	10.34	11.07	10.55	4.25	5.90
10	7.85	7.84	9.24	11.81	13.80	12.38	13.14	13.68	6.82	3.28

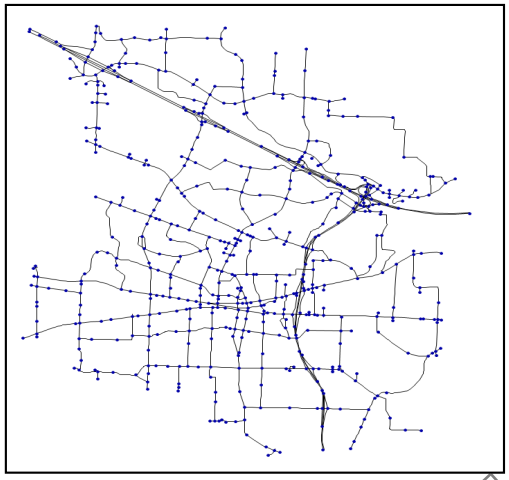
Create Skims by Time Period and Mode

Create Trip Tables by Time Period and User Class

DTAZ

OTAZ	1	2	3	4	5	6	7	8	9	10
1	901	1027	179	742	1562	436	171	174	246	102
2	172	568	107	454	820	143	63	64	43	17
3	592	1673	825	2734	4161	965	455	570	231	87
4	234	1001	440	3018	5006	1081	523	488	132	50
5	79	442	162	1208	5140	720	260	176	31	17
6	126	345	173	900	3343	2525	977	331	50	26
7	71	356	209	1329	3023	2397	1761	396	48	33
8	60	370	261	1242	1977	688	346	771	62	35
9	1370	1890	622	1349	2297	850	382	370	935	459
10	1323	2394	497	1091	1409	894	397	271	838	2203

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”

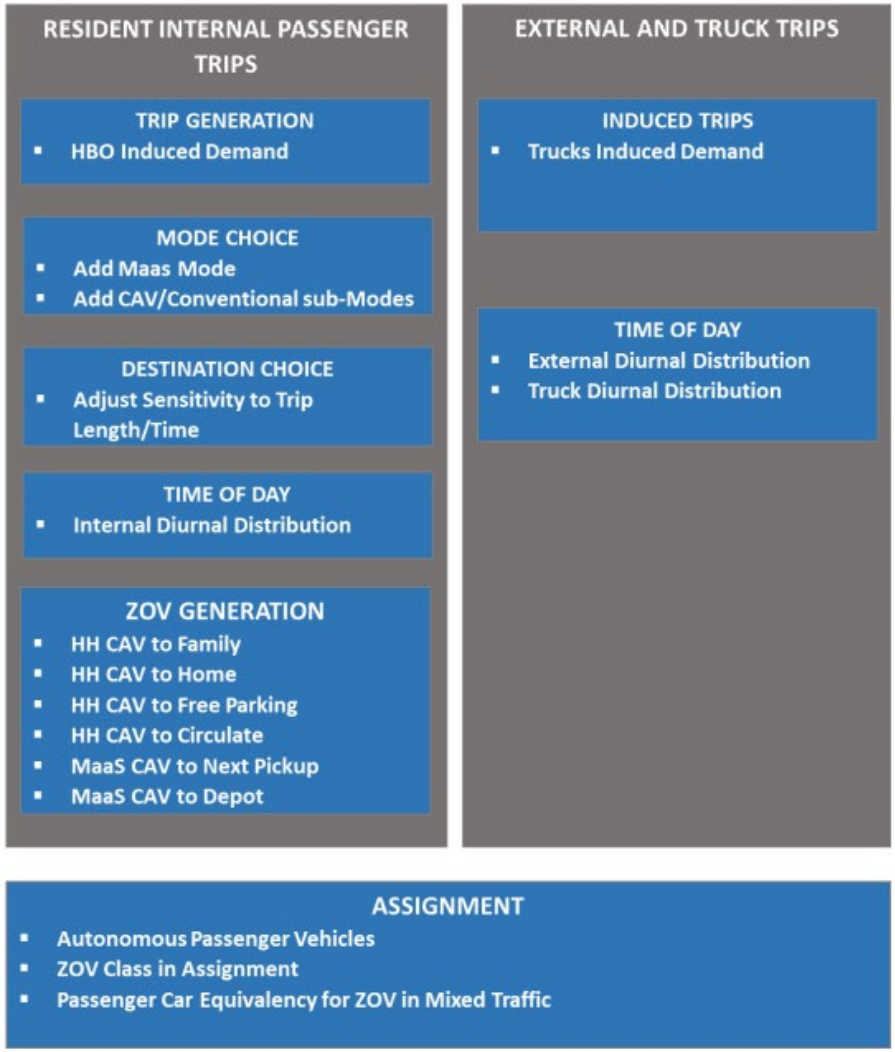


FIGURE 44: THE CAV MODELING FRAMEWORK

Deadheading / ZOVs

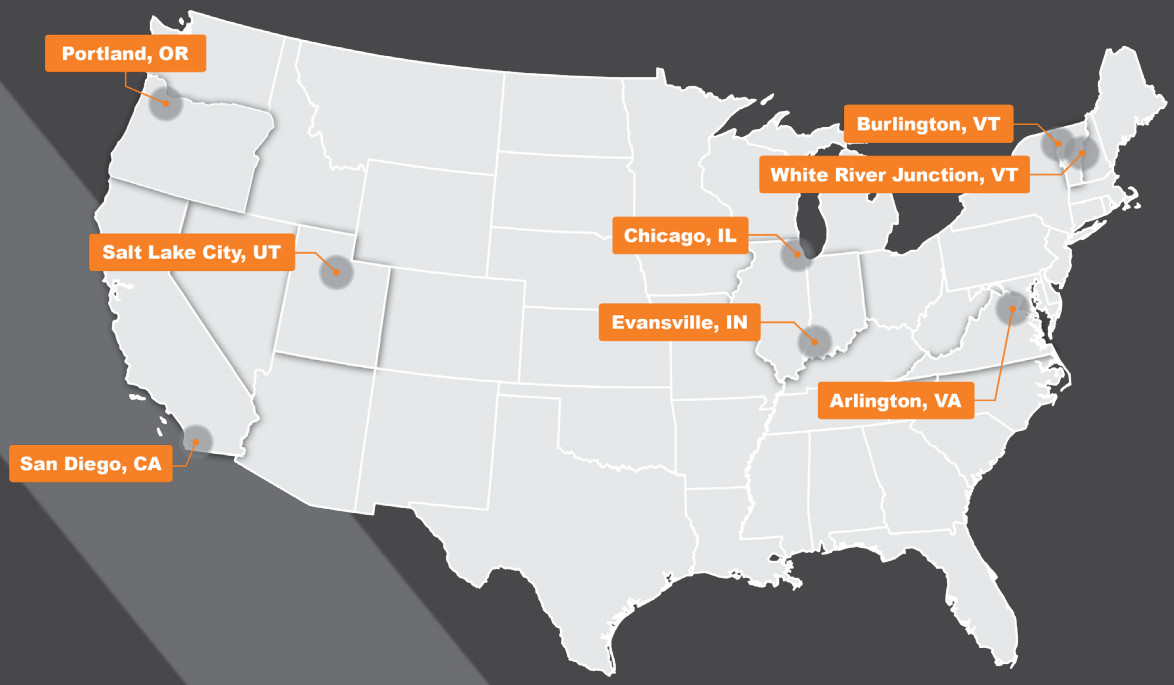
- Types of ZOV trips
  - Private CAVs
    - for car sharing among household members (1)
    - to avoid paid parking
      - by parking at home (2)
      - by parking elsewhere (3)
      - by circulating instead of parking (4)
  - Shared CAVs
    - for passenger pick-up/drop-off (5)
    - to/from depots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

Source: driverlesstransportation.com

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?



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