



What You Always Wanted to Know About the Tennessee Statewide Model Update, But Were Afraid to Ask

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Outline

Overview of the 25-Year Long Range Transportation Plan (Preston)

Phase 1 of the Statewide Model Update: Data Development (Vince)

Results of the MPO Survey (Preston and Vince)

Preview of Phase 2 of the Statewide Model Update (Vince)



Overview of the 25-Year Long Range Transportation Plan

Tennessee's 25-Year Long-Range Transportation Plan

The two main deliverables of this project:

- 25-Year Long-Range Transportation Policy Plan (*Policy Plan*)
- 10-Year Fiscally Constrained Strategic Investment Program

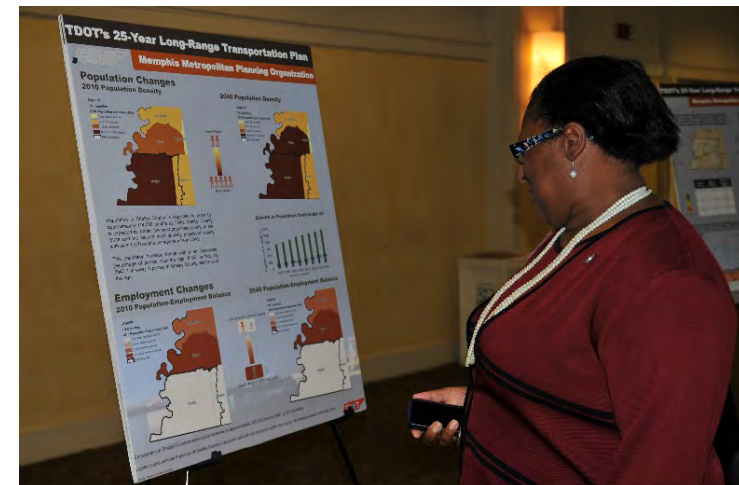
Other deliverables:

- An Updated Statewide Travel Demand Model
- An Updated Customer Satisfaction Survey
- A Financial & Revenue Forecasting Model



Tennessee's 25-Year Long-Range Transportation Plan

- Address Growing and Changing Demands
- Action-Orientated Policy Plan
- Include a 10-Year Strategic Investment Program
- Drive TDOT's 3-Year Transportation Program



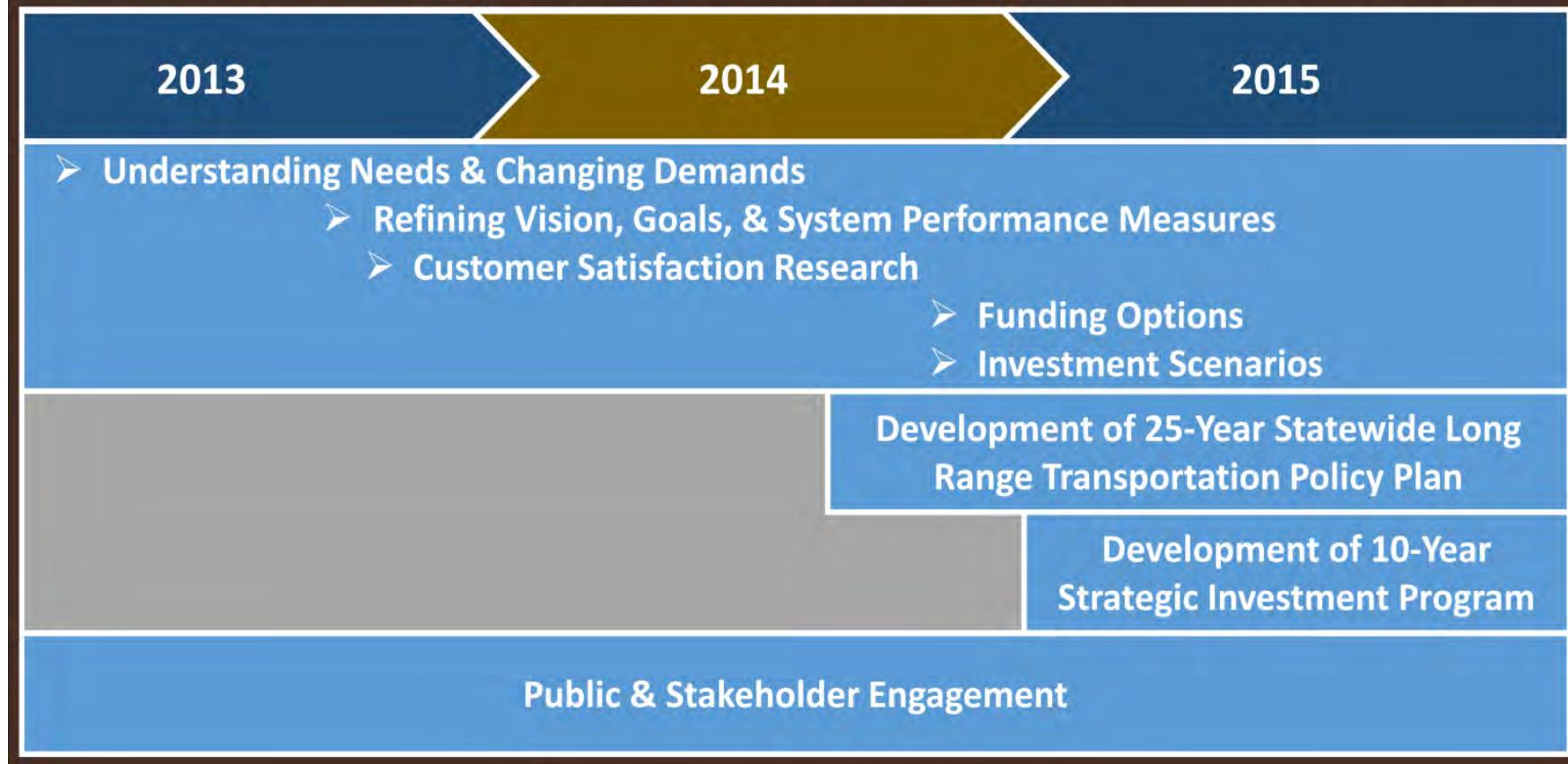
Policy Papers

- **Topical Areas**

- Demographic and Employment Changes & Trends: Population & Economic Conditions
- Travel Trends & System Performance
- Financial Revenues & Fiscal Outlook
- Safety, Security, & Transportation Resilience
- Freight Transportation: Movements & Infrastructure
- Mobility: Public Transportation, TDM, & Non-Motorized Modes
- Accessibility: Land Use Planning, Access Management, Complete Streets, and Health & Environment
- Coordination, Cooperation, & Consultation

Tennessee's 25-Year Long-Range Transportation Plan

Plan Development Process & Timeline



Continuous Public Outreach

- Project Website
- Online Survey
- Book-a-Planner



TDOT's 25-Year Long-Range Transportation Plan



General Project Overview:

The Tennessee Department of Transportation (TDOT) is creating a new long-term vision for transportation in Tennessee and public input is needed. This 25-Year Long-Range Transportation Plan provides the foundation for prioritizing transportation investments across the State. The updated plan will aid in accomplishing TDOT's mission to serve the public by providing the best multimodal transportation system in the Nation.

TDOT has a long history of planning for multimodal transportation needs within the State. TDOT's 25-Year Long-Range Transportation Plan is an important document for the Department and its many stakeholders as the Plan allows TDOT to make key long-term funding and policy decisions about transportation investments throughout Tennessee today and in the future.

A major outcome of this two-year comprehensive effort is a mid-term, 10-Year Strategic Investment Program. The intent of the 10-Year Strategic Investment Program is to capture the insights gained during the development of the 25-Year Long-Range Transportation Plan to concurrently develop a project program investment plan that is fiscally constrained that can be implemented over a 10-year horizon.



Over the course of the Plan process, an extensive [public involvement program](#) is in place to gather input from a variety of stakeholders, including the public, elected and appointed officials, and community groups located throughout the state.

Find Out More

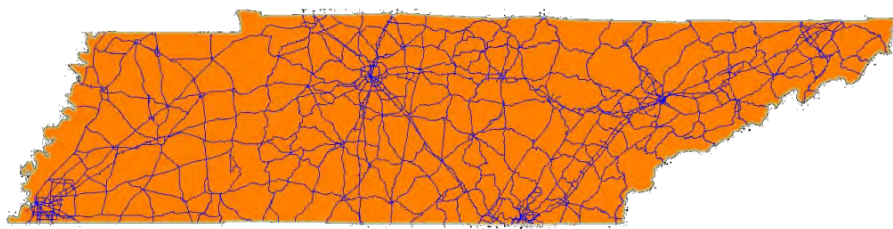
- [Online Survey](#)
- [Public Participation Plan](#)
- [Book a Planner](#)
- [Meeting Schedule](#)

www.tdot.state.tn.us/transportationplan



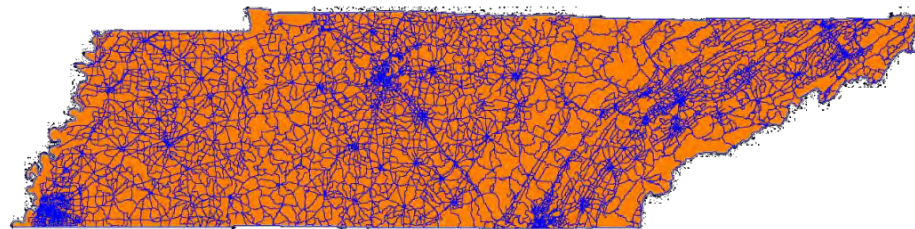
Phase 1 of the Statewide Model Update: Data Development

Statewide Model Update



Existing Statewide Model

- 2003 Base – 2030 Horizon
- Only Total Daily Traffic
- Limited Network Coverage
- Limited Sensitivity
 - Re-routing Only



New Statewide Model

- 2010 Base Year – 2040 Horizon Year
- Peak Hour and Daily Traffic
- Expanded Network Coverage
- New Sensitivity to:
 - Network changes
 - Induced demand
 - Alternative future land use scenarios
 - Population changes (aging, etc.)

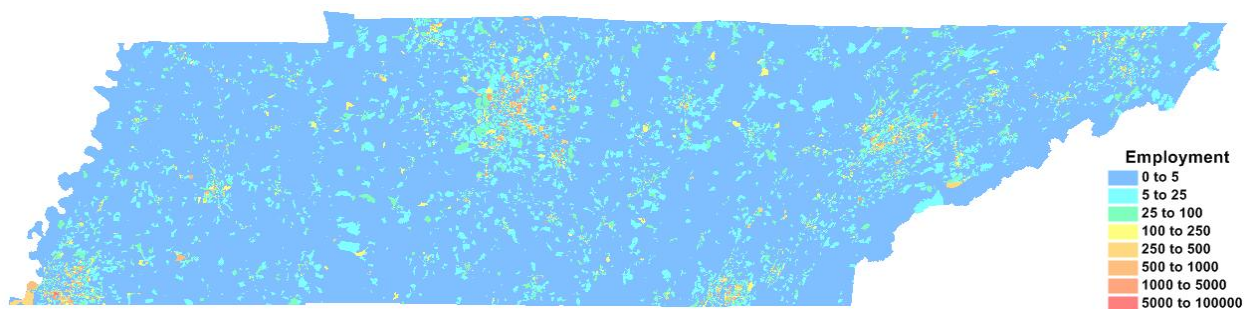
Statewide Model Update: Phases 1 & 2

Phase 1: Data Development (currently underway)

- New, Expanded Network
- New, More Detailed Zone System
- Obtain & Process Socioeconomic Data
- New Socioeconomic Forecasts
- Obtain & Process ATRI Truck GPS Data
- Combine NHTS & MPO Household Travel Survey Data

Phase 2: Model Development (2014)

- New Trip-based Model
- Time-of-Day Modeling (peak hour volumes)
- Destination Choice Models (greater accuracy)
- Possible Pivot-Point Structure (greater accuracy)
- Truck/Freight Modeling still being scoped
- Post-processing for Performance Measures (access to jobs, hospitals, etc.)



Zone Size and Network Coverage

	Ohio	Iowa	Indiana	Tennessee v1	Tennessee v2
Population	11,500,000	3,100,000	6,500,000	6,500,000	6,500,000
Road Miles*	42,000	45,000	19,000	9,421	29,000
TAZ in state	3,660	1,866	4,690	1,222	3,500
Total TAZ	5,116	3,314	4,831	1,397	3,750
Pop / TAZ*	3,200	1,600	1,400	5,300	1,800
Acres / TAZ*	12.2	30.2	7.8	34.5	12.0
Miles / Acre	0.9	0.8	0.5	0.2	0.7
Pop / Miles	270	70	340	690	220
Miles / TAZ	11.5	24.1	4.1	7.7	8.3

*in state

- TAZ and network for new Tennessee model are current estimates
- New model probably will have **triple** the network and zones



Network Development

Defining the Network

How do we decide what to include in the network?

Old Model

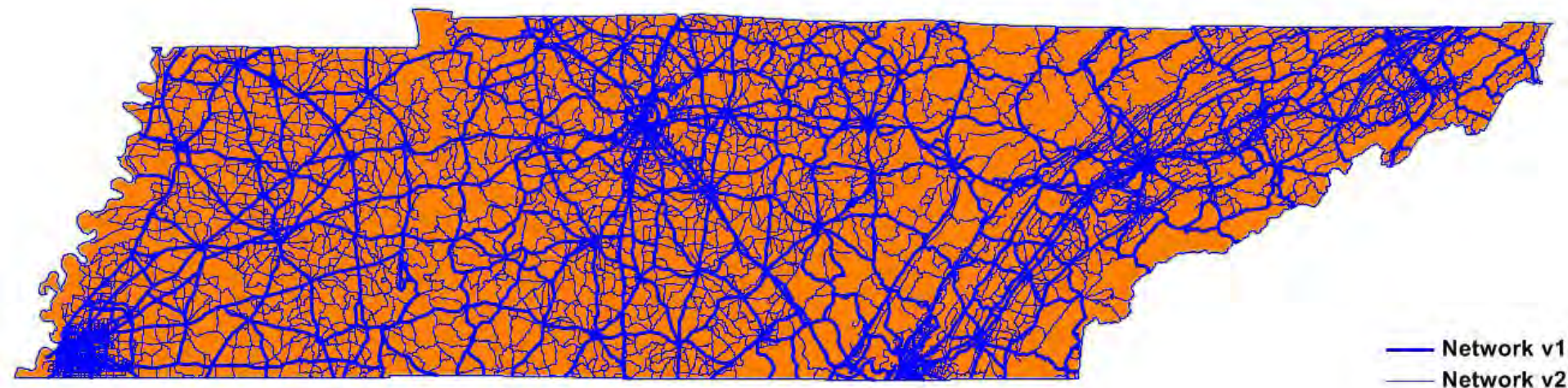
- Interstates & Principal Arterials

New Model

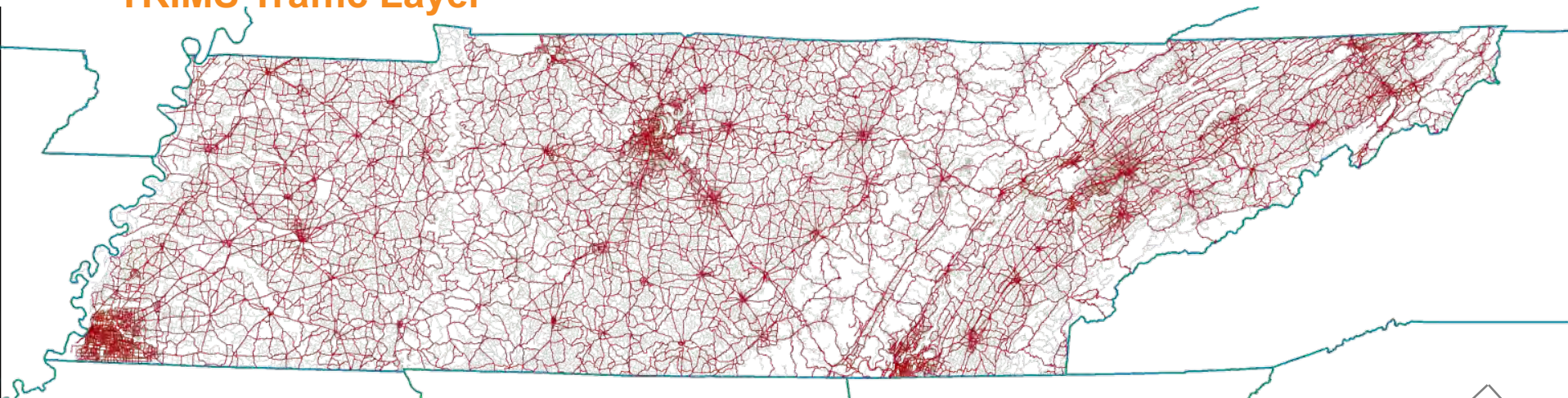
- Started with minimum criteria
 - Anything in the old model
 - Anything in the National Highway Planning Network (NHS, etc.)
 - All minor arterials
- Want network coverage one class lower than desired forecasts
- Began to look at TRIMS data, to consider volume thresholds, etc.
- Found the TRIMS Traffic layer (e.g., roads with TDOT traffic counts) has roughly the right level of network coverage
- Had to add ~100 links to minimum criteria
- May still remove a small number of roads to ensure good balance with TAZ

Defining the Network

New vs. Old Network



TRIMS Traffic Layer



Network Topology: Connectivity & Routing

Model Requirements

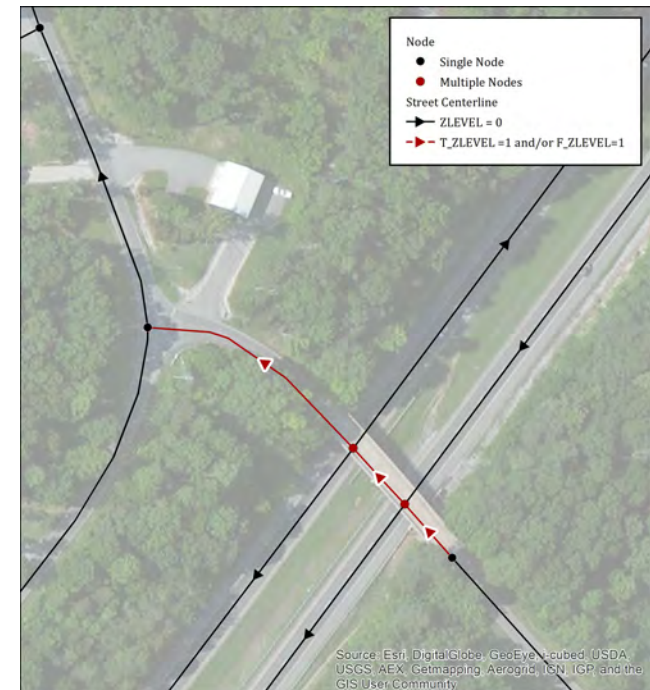
- Connected and routable network

Options

- Connect TRIMS GIS layers – Not enough time & budget
- TN OIR E99 layer – Not ready until 2014
- TeleAtlas network – Chosen

Issues

- How to connect with TRIMS
- TRIMS missing ramps
- Elevation (Z) data



Network Attributes

Chosen Attributes

- Design
 - Direction
 - Divided
 - Access Control
 - Lanes
 - Lane width
 - Shoulder width
 - Terrain
 - Speed Limit
- Administrative
 - Functional Class
 - Ownership
 - County
- Intersection
 - Control Type
- Traffic
 - AADT
 - Peak hour %
 - MU Truck %
 - SU Truck %

Attribute	Missing
Speed Limit	15.94%
Divided	0.01%
Lanes	0.03%
AADT	0.05%

Missing Attributes

- Most attributes substantially complete
- 90% of roads with missing speed are rural minor arterials
- Speed is missing on roughly half of this class
- No volume / geographic pattern – ok to impute

Network Development Process

Getting the TRIMS attributes on the routable TeleAtlas network...

- Develop a Least-Common-Denominator (LCD) TRIMS line layer network with a nodes anywhere a chosen attribute changes
- Get all the TRIMS attributes onto the single LCD layer
- Simplify and reduce the LCD representation above if possible
- Develop a common segmentation between LCD TRIMS and TeleAtlas
- Pass the TRIMS attributes over onto the newly segmented TeleAtlas layer
- Simplify the newly segmented TeleAtlas layer (remove unnecessary nodes)



TAZ Development

A Good Lookin' TAZ

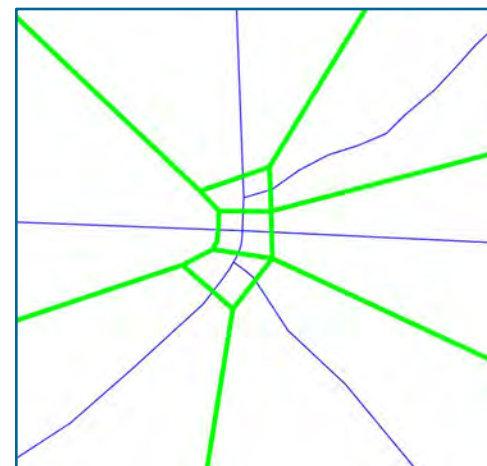
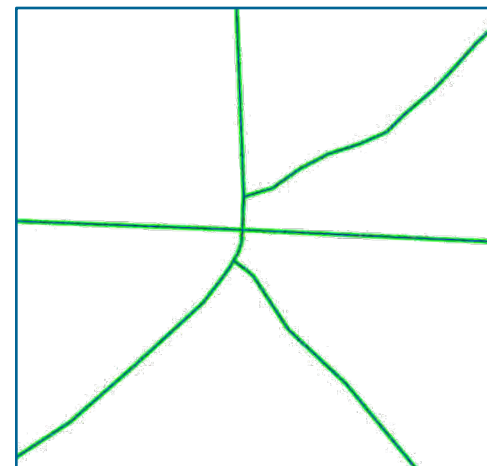
What should a TAZ look like? What makes for a good TAZ?

Traditionally

- Zone boundaries conform to the network
- And other boundaries, maybe
- And homogenous land use, maybe

Travel Sheds

- Zones as catchment areas around network
- Borrowed from hydrology
- First used for TAZ in NW 20+ years ago
- Increasingly common in statewide models
- Clearer relationship to the network, less ambiguity about loading points / centroid connectors
- Better able to represent distinct rural and small urban zones
- Take other boundaries more seriously



Building Blocks

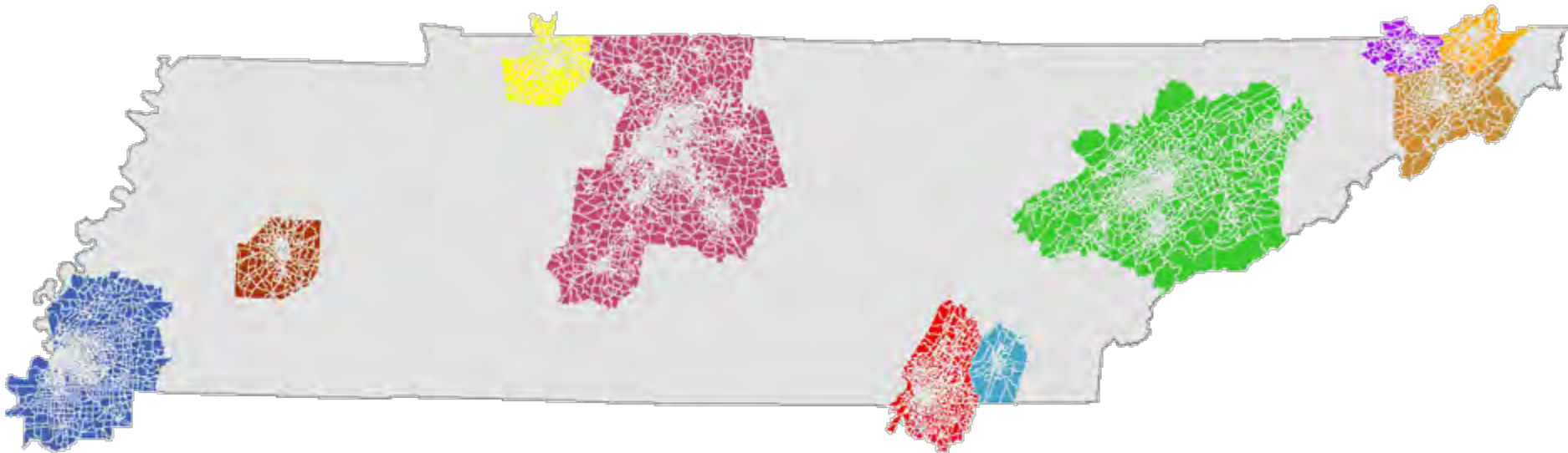
What are the statewide TAZ made of?

Urban

- Aggregations of MPO zones
- Mix of traditional and travel sheds

Rural / Small Town

- Aggregations of Census blocks? (Or overlay?)
- Less traditional, mostly travel sheds



Putting the Puzzle Pieces Together

How do you group MPO zones / Census blocks into SWM TAZ?

Clustering

- Groups nearby/similar blocks together
- Similarity / proximity can be defined
- Does not ensure contiguity (can have “islands”)
- Does not ensure compactness (can have “tentacles”)

Partitioning

- Takes clusters as input
- Ensures contiguous, compact, balanced zones

Matchmaking

So how do you cluster blocks? What does “nearby” or “similar” mean?

Distance Function

- Combines various measures of proximity and similarity into a single measure

$$\text{“Distance”} = TT + aD + bC + cP + dHX + eWX + fRR + gMX$$

TT: travel time (from TeleAtlas)

D: Simpson’s D dissimilarity statistic calculated from pop, ind emp, com emp

C: Different County (binary)

P: Different Census Designated Place (binary)

HX: Major (access controlled) highway crossings (# of)

WX: Major water crossings (# of)

RR: Railroad crossings (# of)

MX: Ridge line (Mountain) crossings (# of)

a, b, c, d, e, f, g: weights (minutes of penalty per unit of variable)

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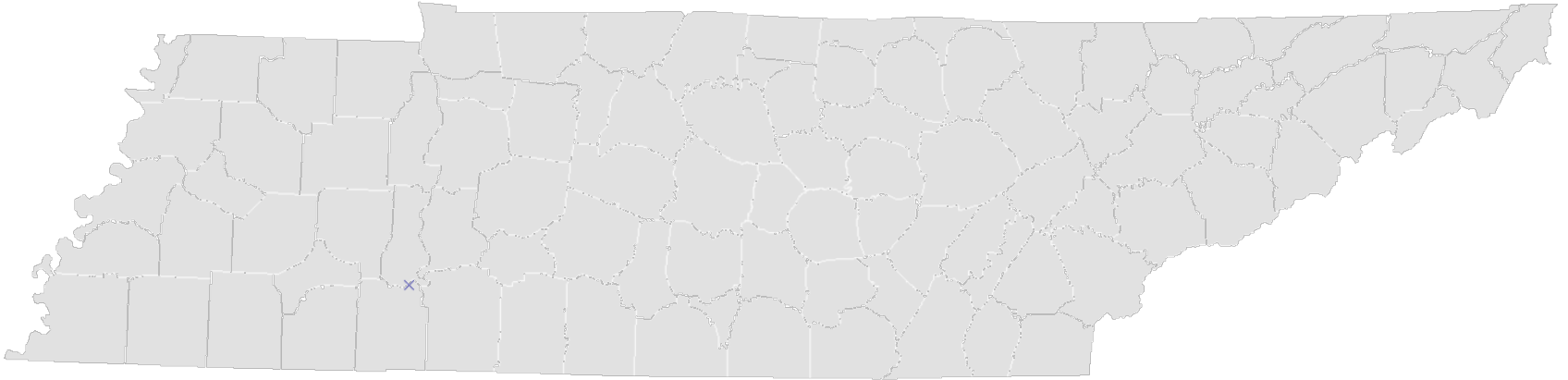
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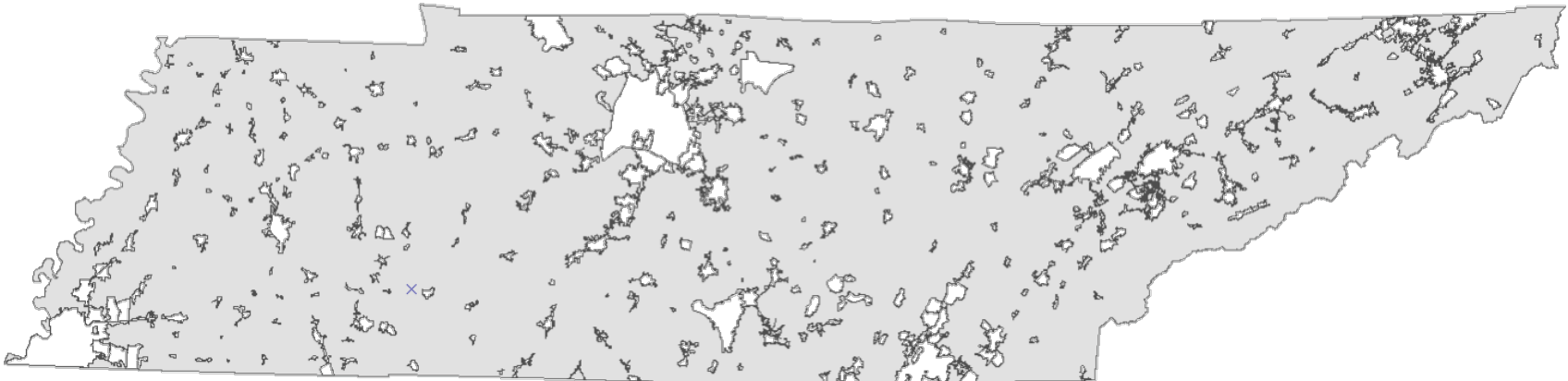
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Easy Criteria

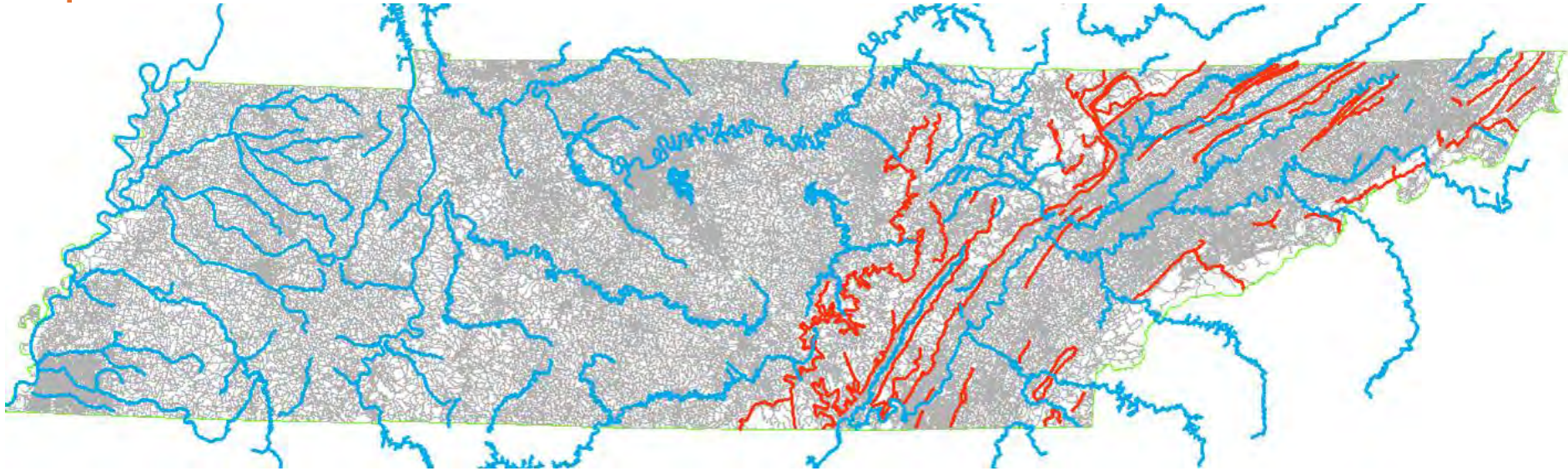
Counties



Places



Harder Criteria



Slopes, Ridgelines and Water Features

- Plenty of water layers, but how to define “major”
- No canned “ridgeline” layers
- Created ridgelines by processing DEMs
- Tried to define “internal” criteria
- Instead, used visual inspection against TeleAtlas, looking for network gaps
- Found slopes more a barrier than ridges in some areas

Diversity vs. Homogeneity

How do you measure “homogenous land use”?

Diversity or Dissimilarity Statistics

- Lieberman's (1969) D statistic
 - Measures the probability that two items drawn at random from two different samples will belong to the same category

$$d_{ij} = 1 - \sum_c [P_i(c)][P_j(c)]$$

- Defined on the interval [0,1]
- Two zones with all items of only one category have $d = 0$
- Two zones with no category with an item in both zones have $d = 1$
- For “land use” we simply take each household, commercial job and industrial job as an item



Socioeconomic Data Development

Demographics

Decennial Census

- Population, Households, Children, Seniors
- Block level data

American Communities Survey

- Workers, Vehicles, Income
- Block group level available
- Disaggregate to blocks proportionally to households

Employment Categories

Industry Categories

- Using standard 20 two digit NAICS categories for data development
- May combine categories later if not needed for the model

NAICS Code	Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing (31, 32, 33)
42	Wholesale Trade
44-45	Retail Trade (44 & 45)
48-49	Transportation and Warehousing (48 & 49)
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services, except Public Administration
92	Public Administration

Employment Data Sources

InfoGroup

- Purchased data for all Tennessee
- Individual business with lat, long locations
- Based on phone surveys, aggregated data

LEHD

- Freely available federal data
- Employment by NAICS category by Census block
- Based on administrative (tax) records, with some 'fuzziness' added to preserve privacy

BEA

- Freely available federal data
- Total employment by NAICS category at County level

Woods & Poole

- Purchased data including employment forecasts consistent with BEA

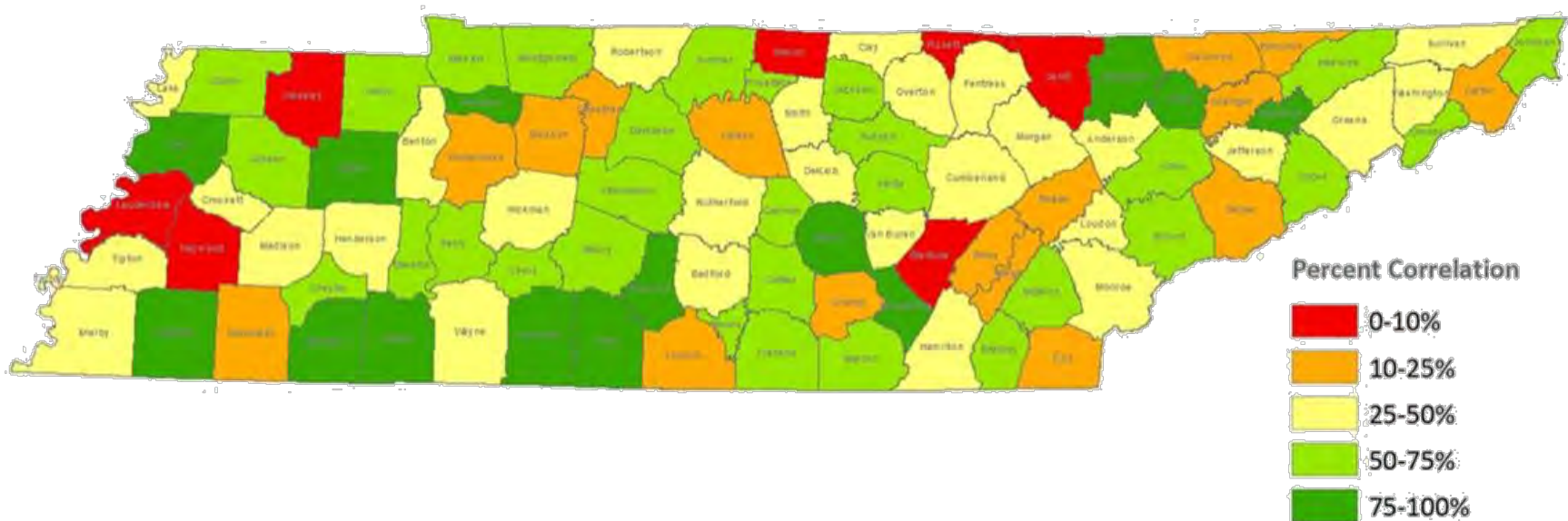
Using InfoGroup and LEHD Together

Cleaning

- Compare differences and correlations look for outliers

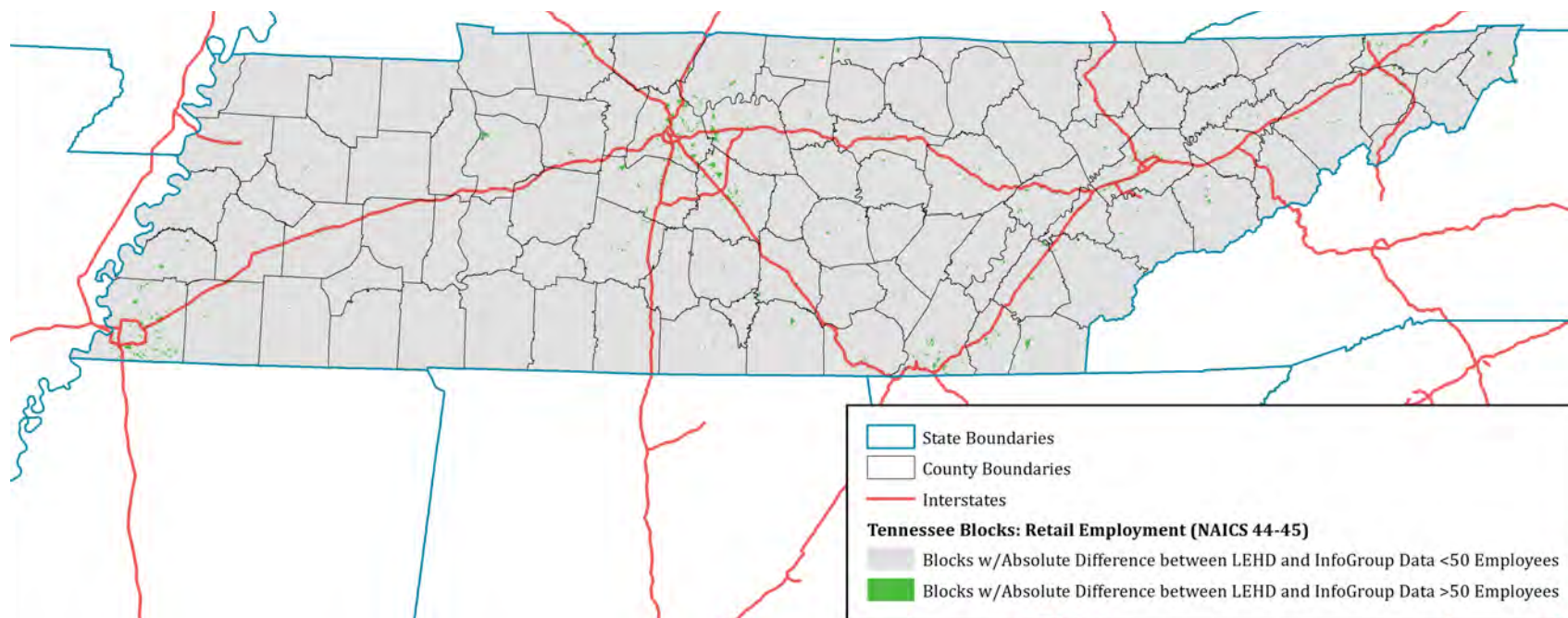
Combining

- Both InfoGroup and LEHD account for roughly 85% of BEA
- If they are independent, together they would account for 98% of BEA
- Research in Ohio suggests they are close to independent



Using InfoGroup and LEHD Together

Cleaning





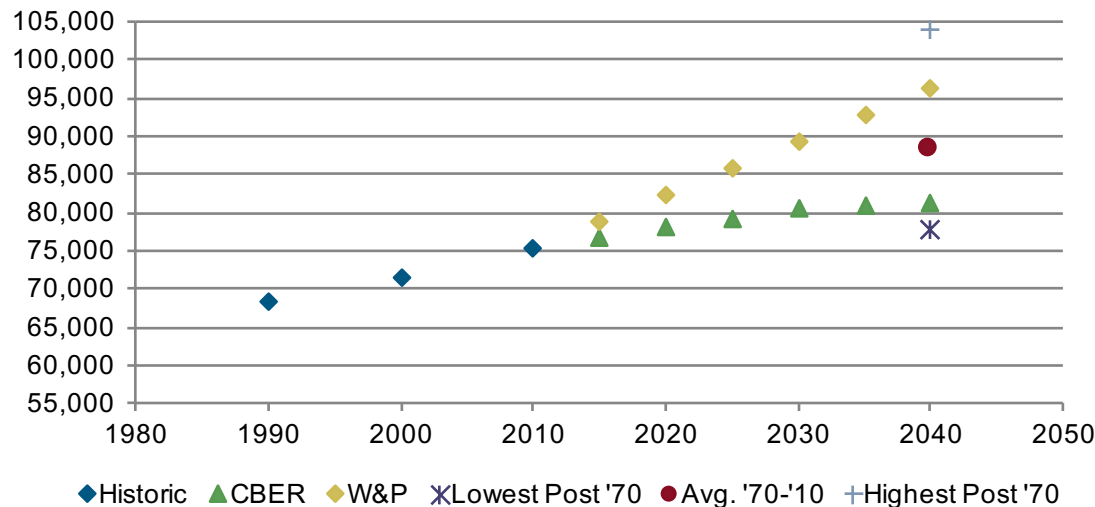
Socioeconomic Forecasts

County Control Totals

Sources of Forecasts

- UT's Center for Business and Economic Research (CBER) – population only
- Woods & Poole
- MPO forecasts
- Historic growth rates and trends

Anderson County Population Projections



Allocation to TAZ

MPO areas

- Use MPO growth allocations
- Absolute growth may not match exactly if control totals differ, but same pattern will be assumed

Non-MPO areas

- Allocate future growth near/where growth has occurred historically
 - Population: Census 2000 & 2010
 - Employment: LEHD 2002-2012



ATRI Truck GPS Data

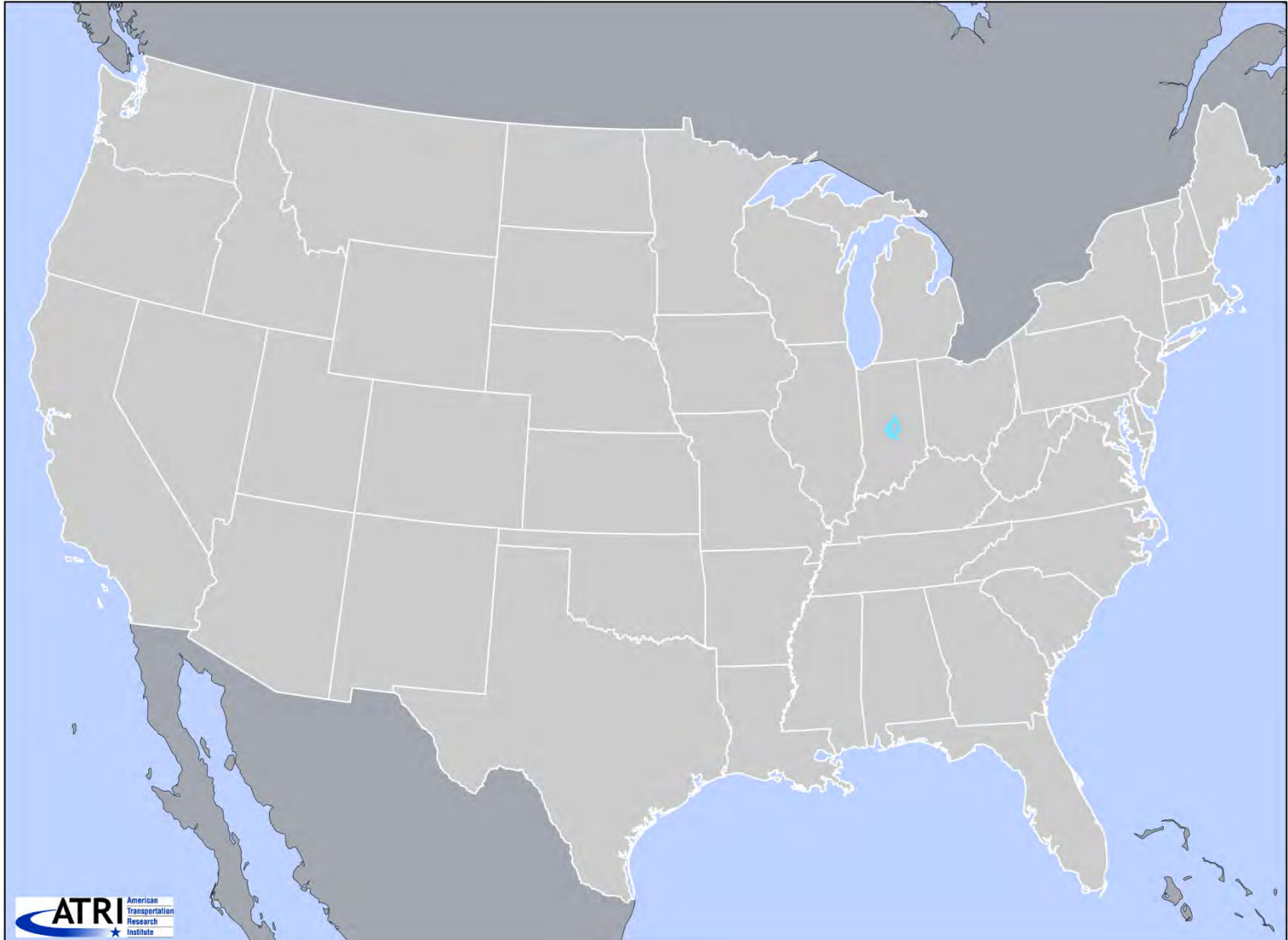
ATRI Truck GPS Data

What's ATRI?

American Transportation Research Institute (ATRI)

- non-profit funded by the trucking industry
- Receives over 4 Billion GPS truck positions annually from member organizations
- Cannot disclose the individual raw truck traces, but can provide processed data products which avoid disclosure
- Basis of FHWA's Freight Performance Measures Webtool
- Used for major corridor studies, I-95, I-70
- Incorporated in Indiana & Iowa's statewide models
- Now in the process of acquiring data for Tennessee

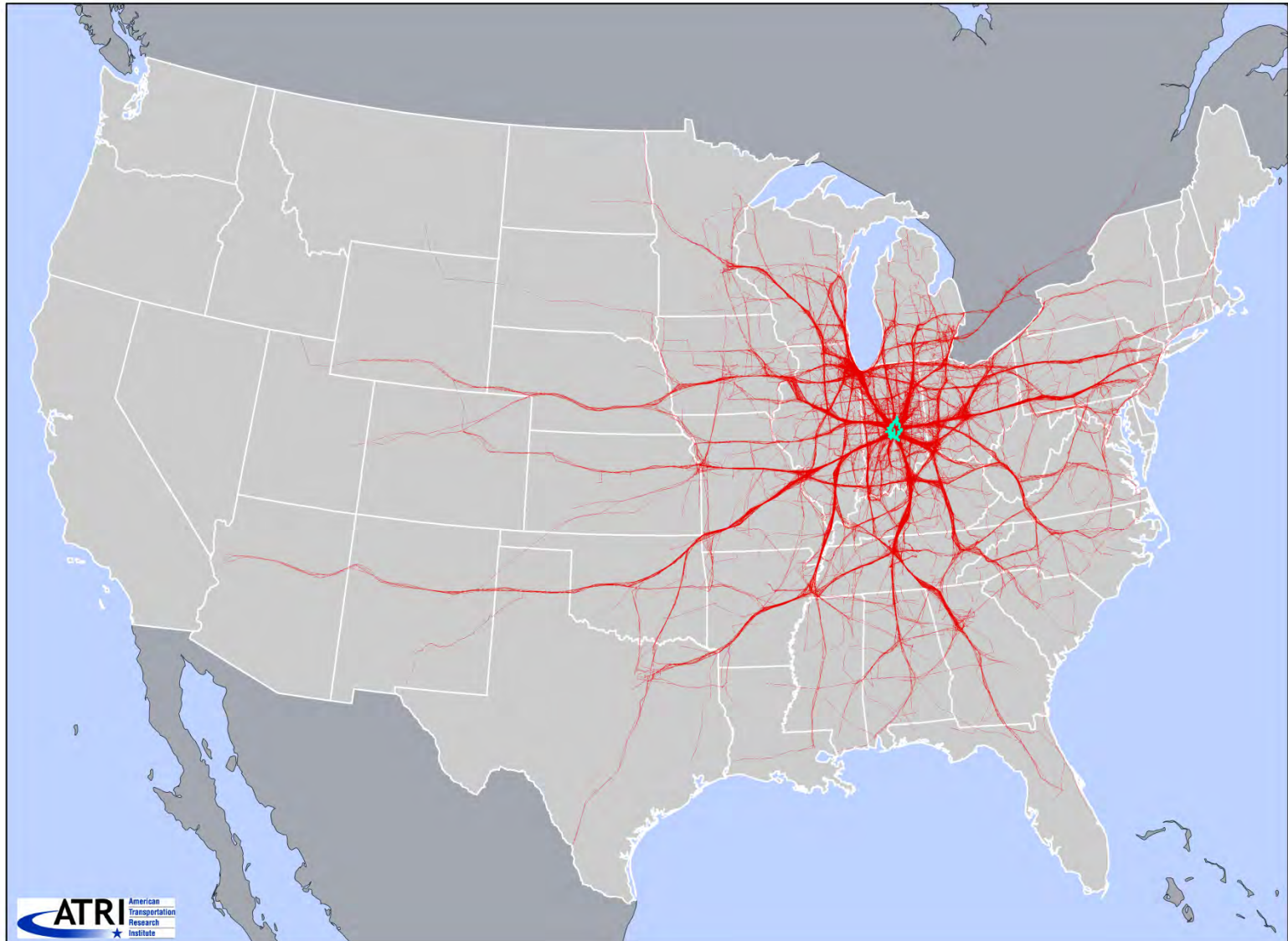
Indianapolis



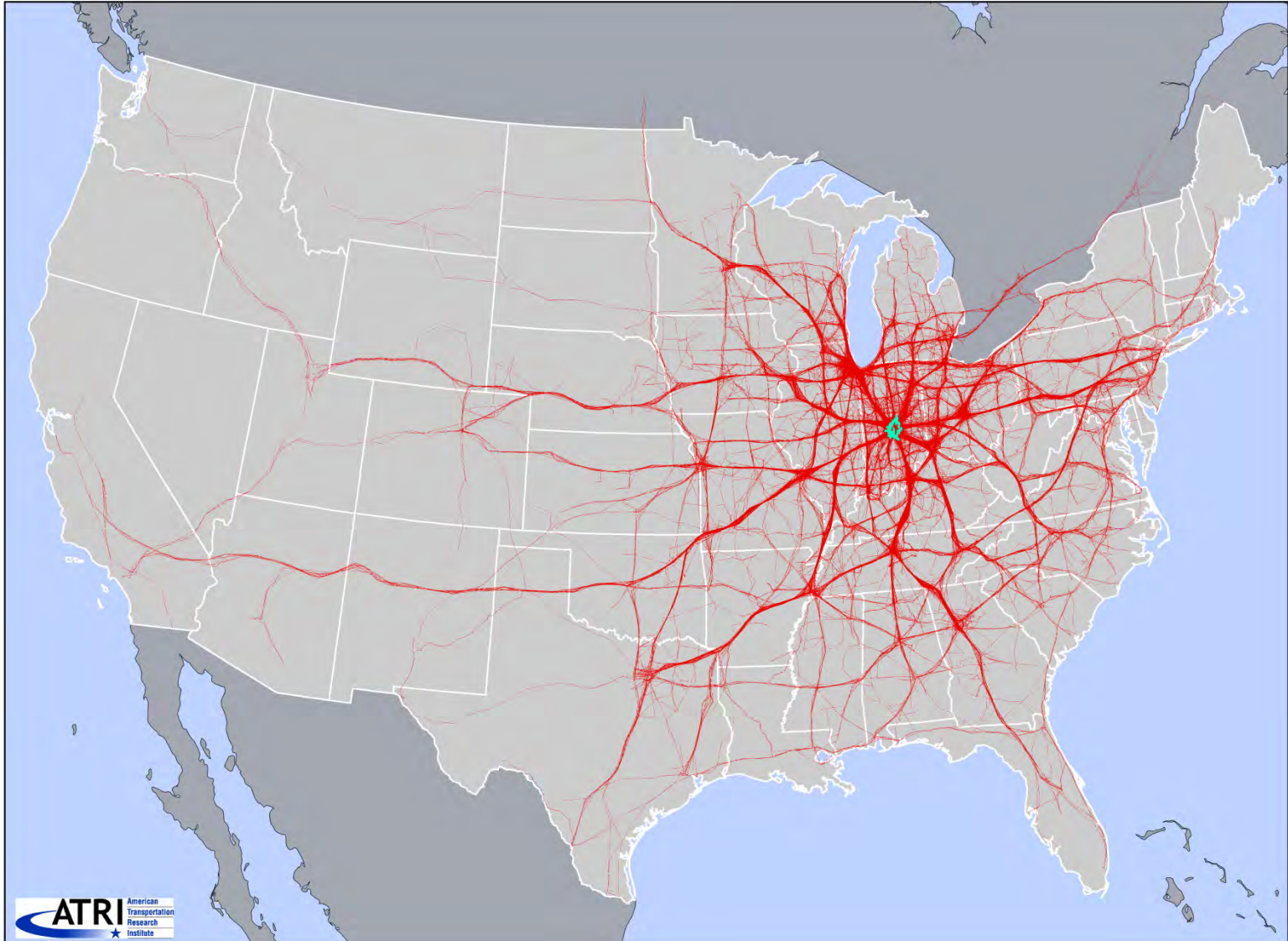
24 Hours



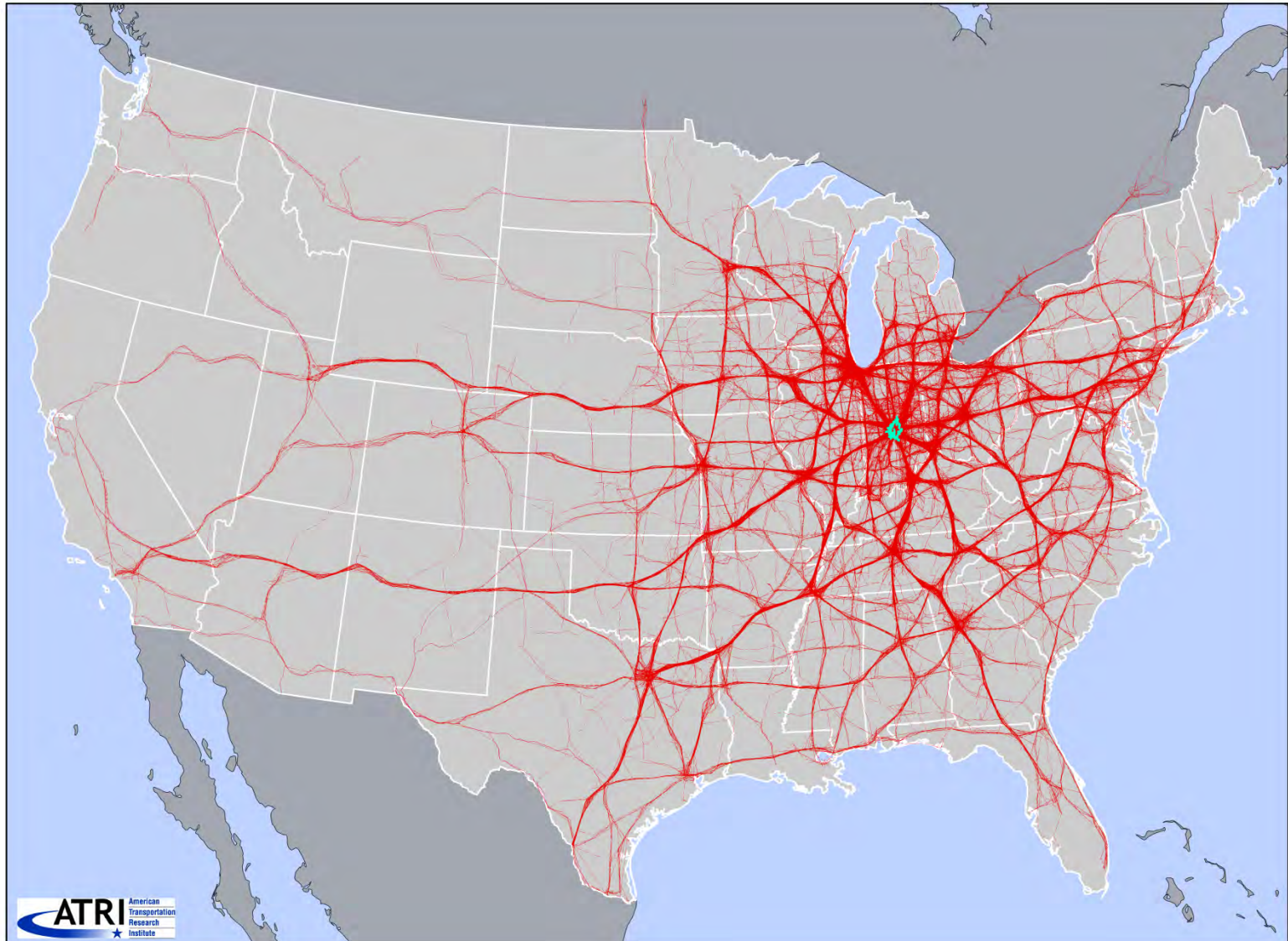
48 Hours



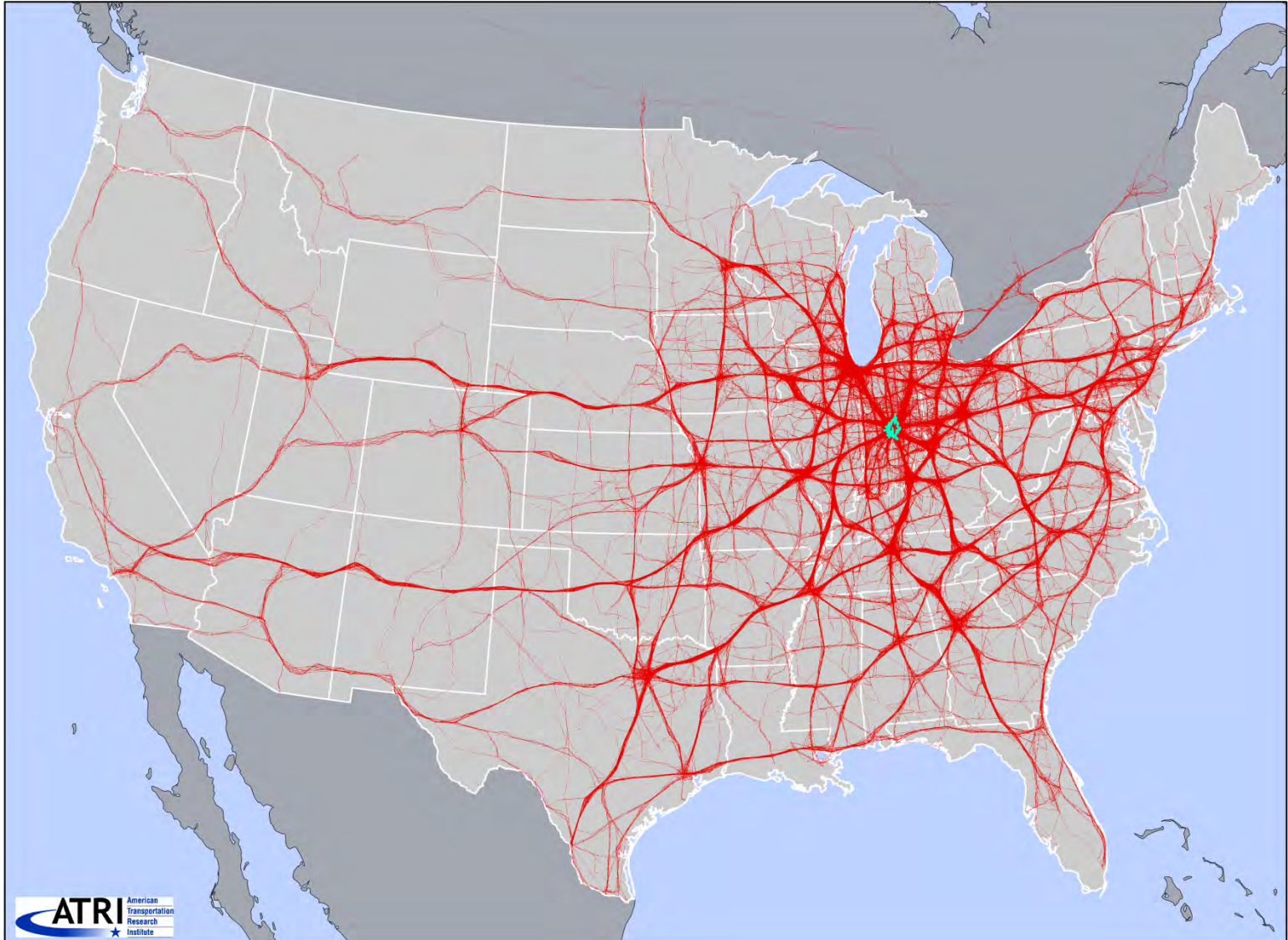
72 Hours



5 Days



7 Days



Indiana Experience

Data

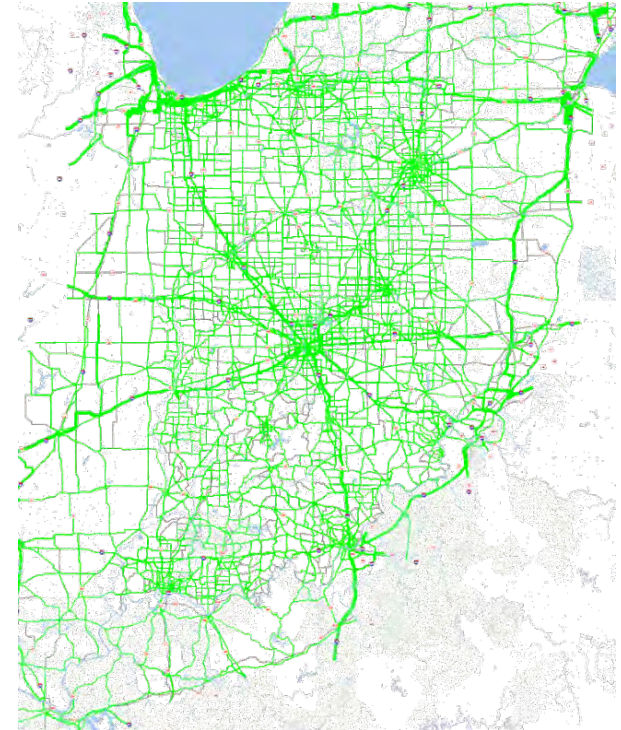
- Eight week sample
- 16 million records
- 305,000 trucks
- 2 million truck trips

Method

- Used existing commodity-flow based model to pivot off of expanded ATRI data

Results

Model	2006 Model	2010 Model
Observations	6,689	5,898
Avg. Count	1,379	1,264
RMSE	69.3%	60.6%
Avg Error	5.4%	-0.1%
MAPE	74%	42%



Data Processing

What constitutes a stop?

Anonymized GPS records converted to ODs

- Criteria based on speed and time
- Duration of a stop necessary to avoid counting traffic stops as destinations

from TAZ	to TAZ	distance	time	elapsed time	speed	status1	status2
10	101032	66.0	57.7	57.7	68.6	moving	moving
101032	101033	16.3	14.3	72.0	68.6	moving	moving
101033	101015	26.8	27.9	99.9	57.5	moving	moving
101015	101015	0.0	5.0	5.0	0.0	stopped	stopped
101015	101015	0.2	2.7	7.7	5.2	stopped	stopped
101015	101015	0.3	9.8	17.5	2.0	stopped	stopped
101015	101015	0.1	0.3	0.3	28.2	moving	<i>stopped?</i>
101015	2035	37.1	60.0	60.3	37.1	moving	moving
2035	18099	67.8	65.4	125.7	62.2	moving	moving
18099	27006	5.9	5.4	131.1	65.3	moving	moving
27006	18023	10.0	15.9	147.0	37.8	moving	moving
18023	18023	0.0	5.0	5.0	0.0	stopped	stopped



Trip	O	D
1	10	101015
2	101015	18023

Data Expansion

It's a big sample, but it's still a sample.

Simple Scaling

- Single uniform expansion factor
 - sample truck VMT to HPMS truck VMT

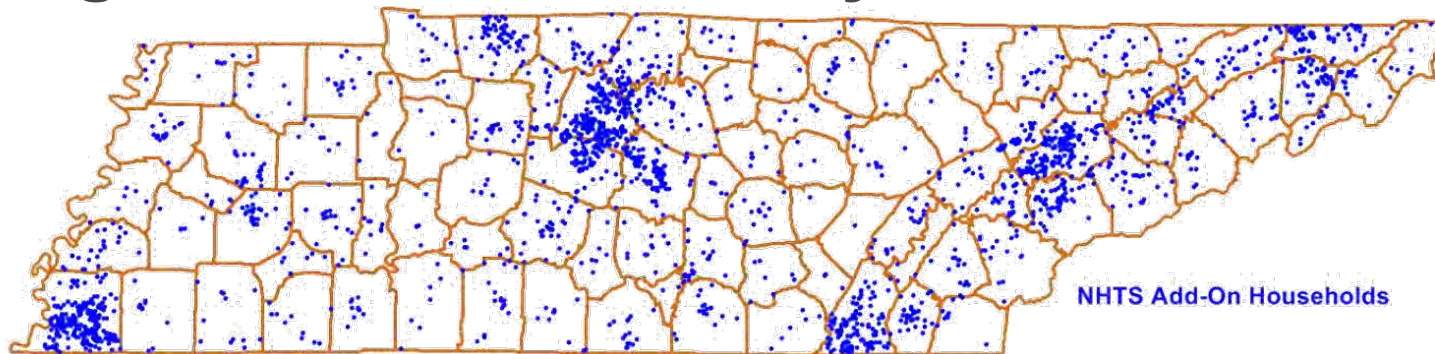
Complex Weighting

- Varying weights by
 - Region
 - Trip length
- Weights developed by analyzing results of ODME



Household Survey Data

Combining NHTS & MPO Surveys



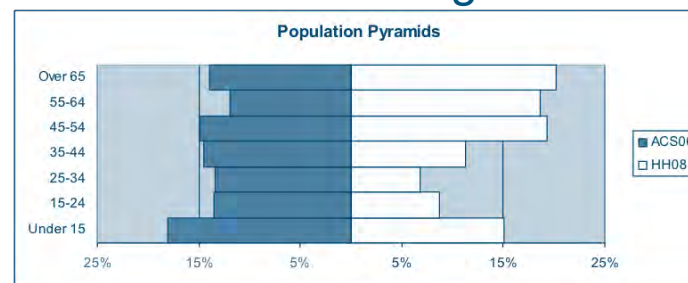
Datasets

- NHTS Add-On for Tennessee
 - Oversampled rural areas
- MPO surveys
 - Complete/complement NHTS
 - May not use all MPO surveys

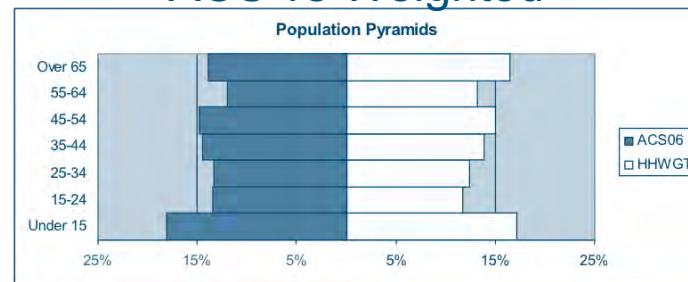
Re-weighting and combining

- Controls
 - Region
 - Household size by vehicles
 - Person age
- Iterative Proportional Fitting

ACS vs Unweighted



ACS vs Weighted

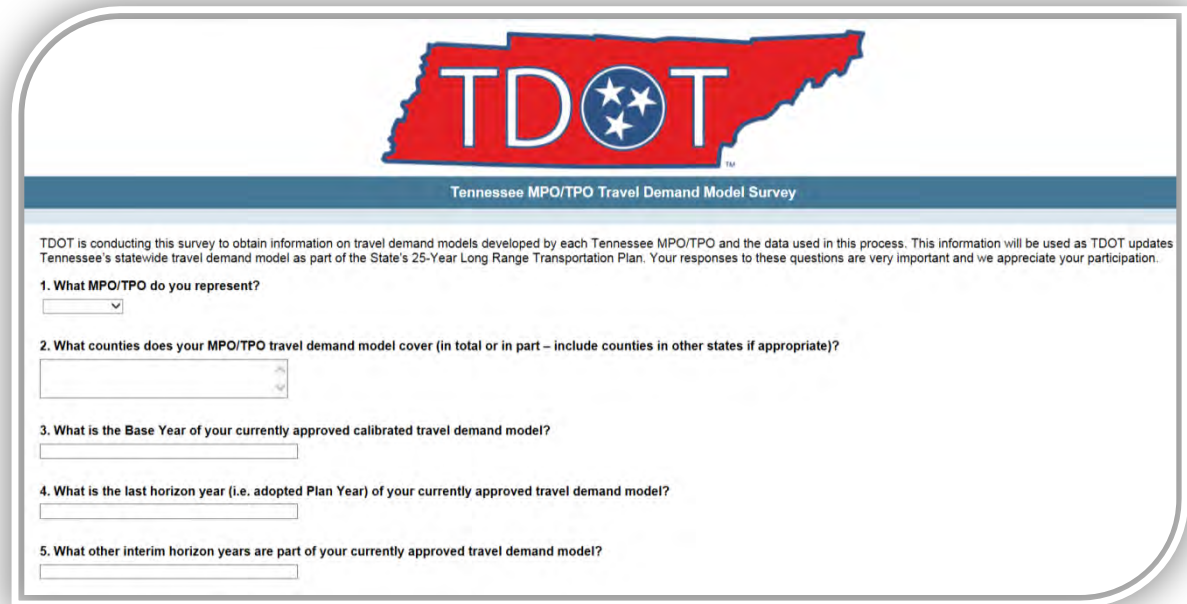




Results of the MPO Survey

TN MPO Travel Demand Model Survey

- Online Survey
- Conducted between Sept to Oct 2013
- 20 Questions
- Completed by all 11 TN MPOs



The screenshot shows the header of the survey form. At the top is the TDOT logo, which consists of a red outline of the state of Tennessee with the letters 'TDOT' in white and blue, and three white stars on a blue background. Below the logo is a blue horizontal bar with the text 'Tennessee MPO/TPO Travel Demand Model Survey' in white. Underneath this bar is a paragraph of text: 'TDOT is conducting this survey to obtain information on travel demand models developed by each Tennessee MPO/TPO and the data used in this process. This information will be used as TDOT updates Tennessee's statewide travel demand model as part of the State's 25-Year Long Range Transportation Plan. Your responses to these questions are very important and we appreciate your participation.' Below this text are five numbered questions, each followed by a text input field:

1. What MPO/TPO do you represent?
2. What counties does your MPO/TPO travel demand model cover (in total or in part – include counties in other states if appropriate)?
3. What is the Base Year of your currently approved calibrated travel demand model?
4. What is the last horizon year (i.e. adopted Plan Year) of your currently approved travel demand model?
5. What other interim horizon years are part of your currently approved travel demand model?

TN MPO Travel Demand Model Survey Results

What counties does your travel demand model cover?

- MPO models cover 42 counties (29 in TN and 8 in other States)
- Other States include: Georgia, Kentucky, Virginia, & Mississippi
- MPO models range from 1 county to 10 counties in size



TN MPO Travel Demand Model Survey Results

What is the Base Year of your currently approved model?

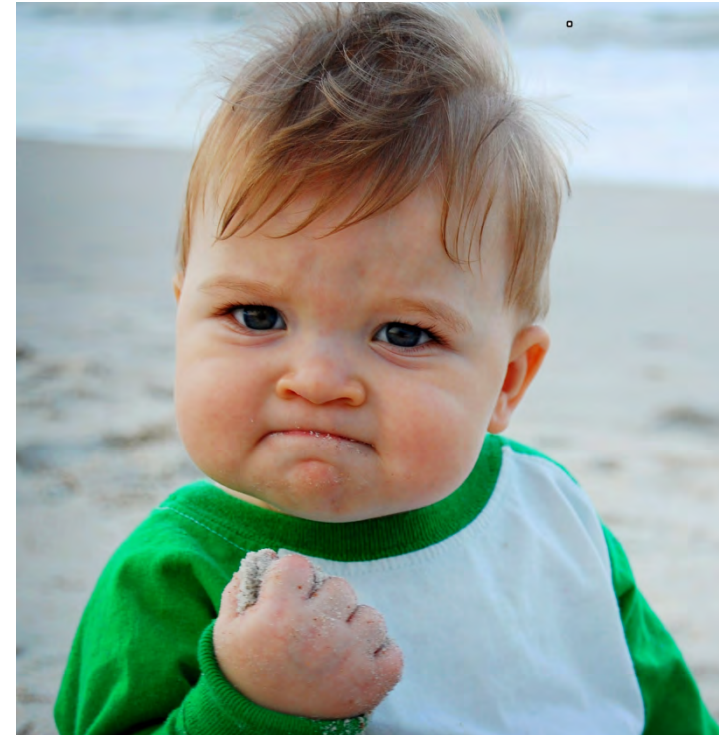
- Base Years range from 2004 to 2010
- Six models have a Base Year of 2010

What is the Last Horizon Year of your currently approved model?

- Future Years range from 2035 to 2040
- Future Year - 4 have 2035 - 7 have 2040

What other interim horizon years are part of your model?

- Most models have interim horizon years



TN MPO Travel Demand Model Survey Results

When are you looking to update your model?

- Four are currently updating their model (Bristol, Chattanooga, Nashville, & Memphis)
- Five in 2016

What will be the Base Year of the new model?

- Three are looking at 2010
- Others range from 2012 to 2017



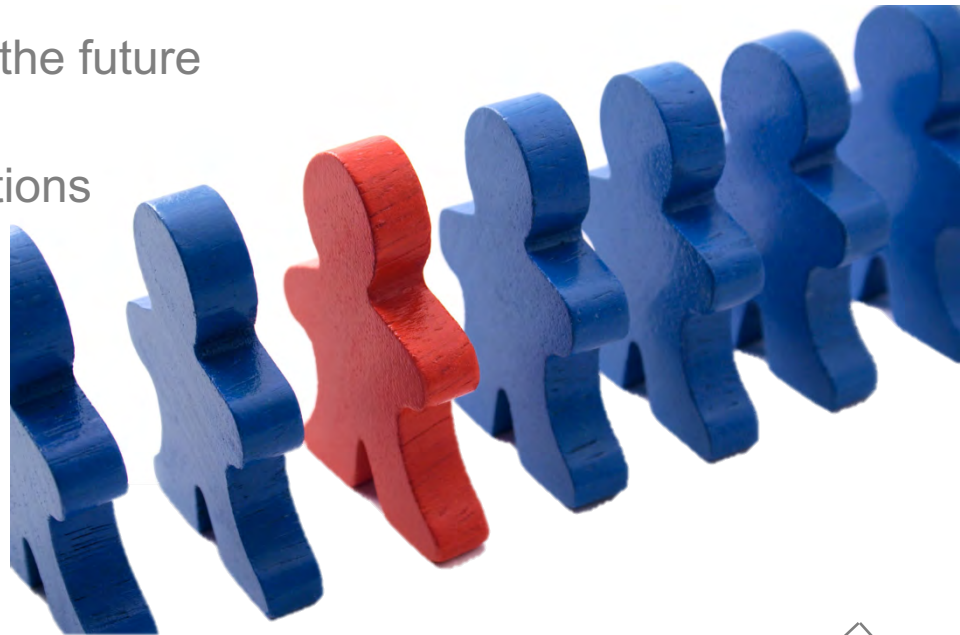
TN MPO Travel Demand Model Survey Results

What data was used for your Base Year POPULATION control totals?

- 2000 and 2010 US Census data most cited

What data was used for your Future Year POPULATION control total projections?

- 9 of the 11 used Woods & Poole for the future year population projections
- 4 referenced UT's population projections



TN MPO Travel Demand Model Survey Results

What data was used for your Base Year EMPLOYMENT control totals?

- 7 MPOs referenced Woods & Poole
- Other sources: InfoGroup, Dun & Bradstreet, Bureau of Labor Statistics

What data was used to allocate your Base Year EMPLOYMENT to the TAZ?

- 8 MPOs referenced using InfoGroup data

What data was used for your Future Year EMPLOYMENT control total projections?

- 9 MPOs referenced Woods & Poole data



TN MPO Travel Demand Model Survey Results

TDOT is considering several options for other data that could be available to MPOs; which of the following are you interested in:

Woods & Poole Economics (Economic & Demographic Data)

- 7 would Love to Have
- 4 would be Nice to Have

InfoGroup (Locational Employment Data)

- 8 would Love to Have
- 3 would be Nice to Have



TN MPO Travel Demand Model Survey Results

What type of freight data was used in your current travel demand model?

- 6 MPOs referenced TRANSEARCH data
- 4 MPOs referenced FAF Commodity Flow data

What freight data are you likely to use in the future?

- TRANSEARCH data: 2 Certain / 4 Likely / 5 Possibly
- ATRI Truck GPS data: 3 Certain / 1 Likely / 7 Possibly
- FAF data: 2 Certain / 3 Likely / 6 Possibly

TDOT is considering several options for freight data; which of the following are you most interested in: ?

- 9 MPOs used Woods & Poole for the future year population projections
- 4 MPOs referenced UT's population projections



TN MPO Travel Demand Model Survey Results

TDOT is considering several options for freight data; which of the following are you most interested in:

TRANSEARCH data

- 3 - 1st Choice, 5 - 2nd Choice, 3 - 3rd Choice

ATRI Truck GPS data

- 4 - 1st Choice, 5 - 2nd Choice, 2 - 3rd Choice

FHWA FAF data

- 4 - 1st Choice, 1 - 2nd Choice, 6 - 3rd Choice



TN MPO Travel Demand Model Survey Results

How best can TDOT and their consultant involve you in the update of the statewide travel demand model?

- Email
- TNMUG Meetings
- Periodic Conference Calls





Preview of Phase 2 of the Statewide Model Update

Phase 2: Model Development

Advanced Trip-based Passenger Model

- Advanced trip generation
- Destination choice models
- Peak hour models

Truck / Freight Model

- Still being scoped

Validation

Post-processing

- Traffic statistics
- Post-processing

Advanced Trip Generation

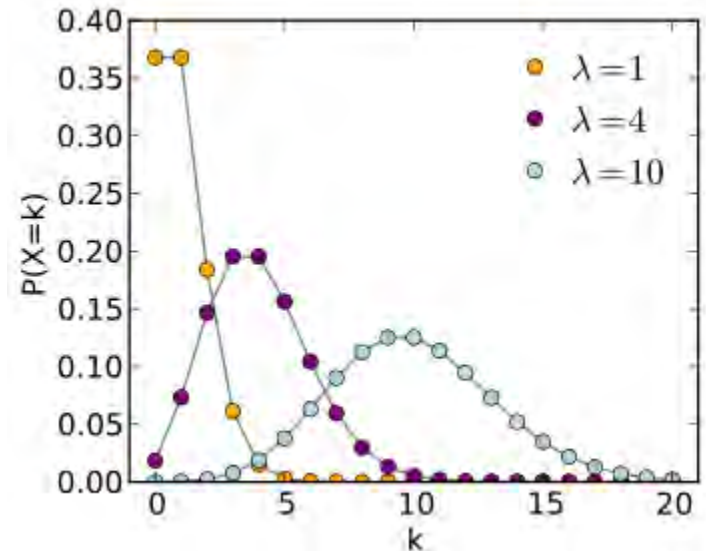
Non-linear Regression Models

- Allow multiple explanatory variables
 - Effect of area type /accessibility
 - Effect of seniors / children
- Capture both rational non-linearities
 - Diminishing returns to scale
 - Interaction effects

Poisson Distributed Household Variables

- Reduces aggregation as in cross-class
- But don't require stratification curves, etc.

Poisson Distributions

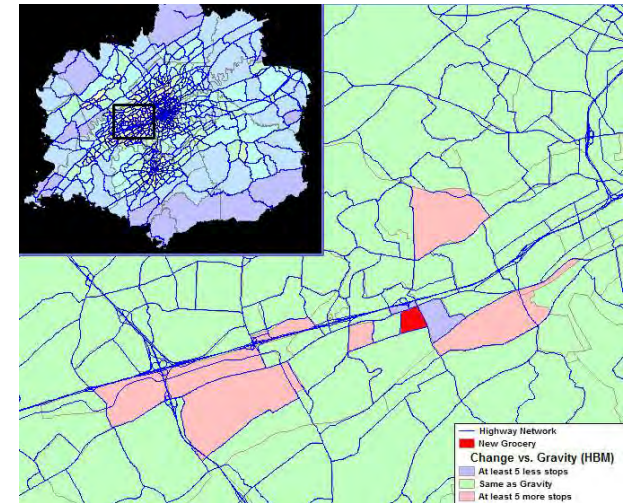


Source: Wikimedia Commons

Destination Choice Models

Account for More Factors

- Number of Attractions
- Travel Time / Impedance
- Effect of Residence Location on Willingness to Travel
- Psychological Boundaries
 - River Crossings
 - Ridgeline Crossings
 - Major Highway Crossings
 - State / County Line Crossings
- Walkability of Destination
- Mixture of Land Uses at Destination
- Convenience for Trip-Chaining
- Spatial Auto-correlation Effects



Trip Chaining in Knoxville



**Fewer, Longer Rural Trips
More, Shorter Urban Trips**

Peak Hour Models

Nested Logit Models

- Must account for duration of long trips
- Upper nest determines at least some portion of the trip occurs in the AM peak hour, PM peak hour or both
- Lower nest determines how much of the trip occurs in the peak hour
- Will consider differences in peak hour factors related to
 - area type / accessibility of origin and destination
 - trip length
 - region

Truck / Freight Model Options

Three Options

- ATRI-based Truck Models
- Commodity flow-based Freight Models
- Supply Chain Logistics & Truck Tour Simulation Models

Considerations

- Budget
- Schedule for Long Range Plan
- Availability of Required Data
- Ability to Evaluate Potential Projects

Truck Models

Model Structure

- Three step, like traditional passenger models
- Segmentation
 - by vehicle type
 - light commercial vehicles*
 - single unit trucks*
 - multi-unit trucks*
 - by trip type
 - commercial passenger trip*
 - service delivery trip*
 - freight delivery trip*



Can be developed based on ATRI data, pivot off of ATRI data

New truck-rail intermodal facilities can be handled by special diversion module

Inexpensive and quick to develop

Commodity Flow-based Models

Model Structure

- Commodities produced, consumed & exchanged
- Four step, like traditional passenger models
- Must be used together with truck models since only long-haul freight movements included

Other Modes

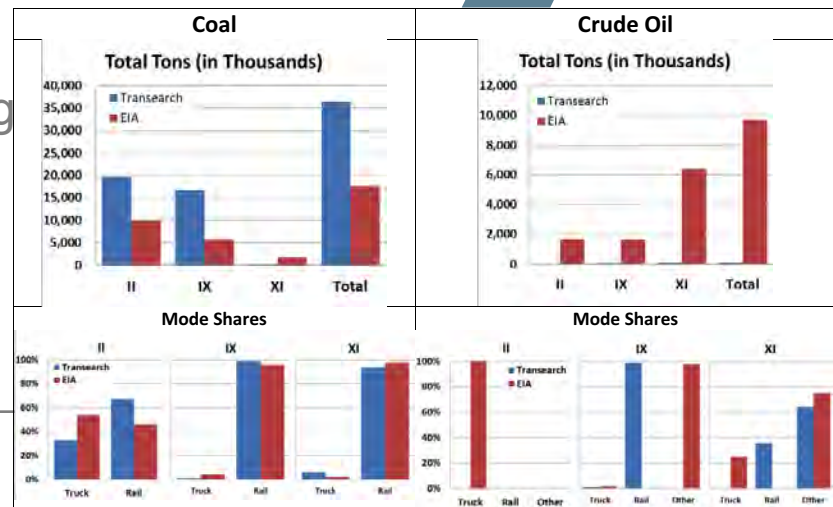
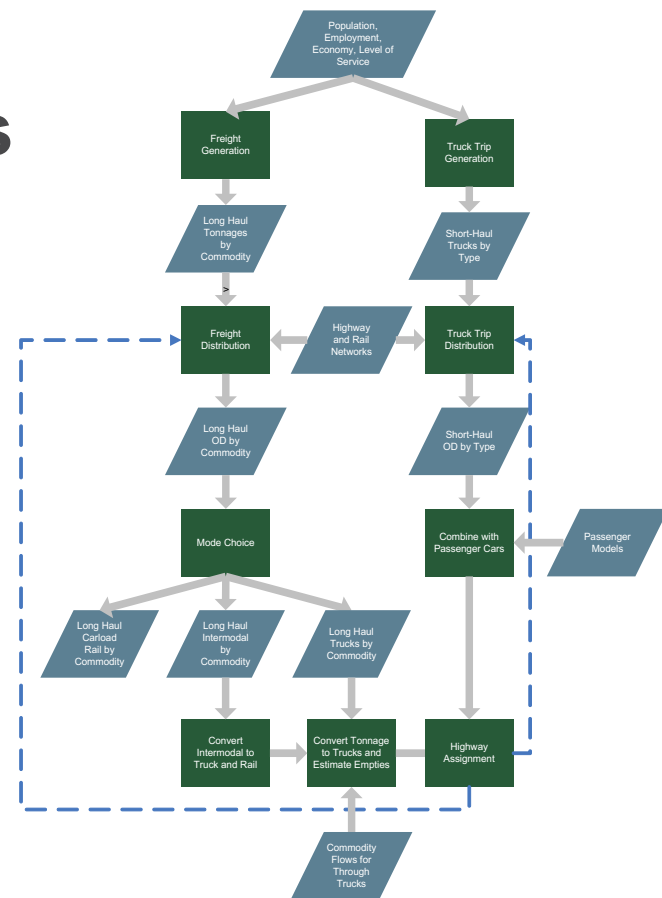
- Can provide information on freight movements by modes other than truck
- Limited ability to model freight mode shifts
- Rail assignment still experimental

Commodity Flow Data

- Transearch requires considerable cleaning
- FAF requires considerable disaggregation

Moderately Expensive to Develop

Moderately Time Consuming to Develop



Supply Chain Logistics & Truck Tour Simulation Models

Model Structure

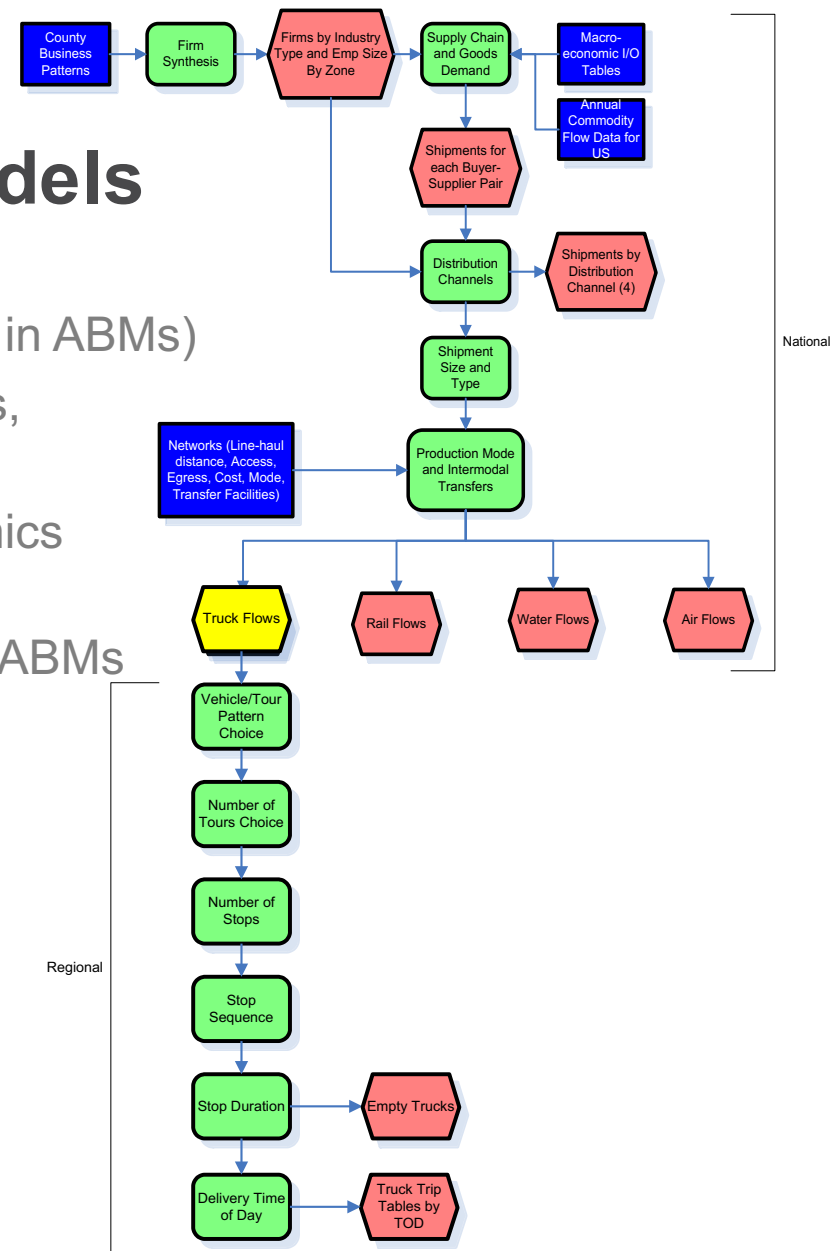
- Firm synthesis (like population synthesis in ABMs)
- Simulated negotiations between shippers, carriers, 3PLs
 - agent-based computational economics & game theory
- For truck mode, simulation of tours as in ABMs

Most Realistic Freight Mode Choices

Data Hungry

Expensive to Develop

Time Consuming to Develop



Validation

Demand Validation

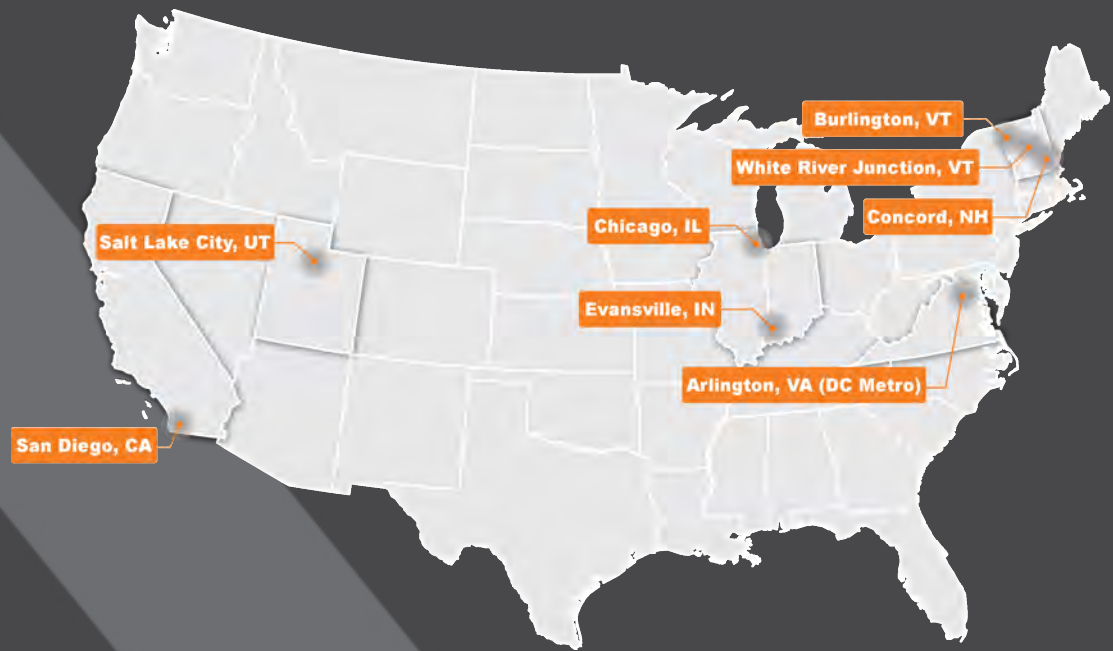
- Generation Rates
- Trip Lengths
- JTW Patterns

Assignment Validation

- Will produce similar statistics as for MPO models
- Different criteria for statewide models

%RMSE for Statewide Models from NCHRP 08-36-91

Volume Range		Average	Avg + 10%
1	5000	92.2	101.4
5000	10000	51.2	56.3
10000	20000	46.7	51.4
20000	30000	32.4	35.7
30000	40000	29.1	32.0
40000	50000	18.0	19.8
50000	60000	18.6	20.5
60000	+	22.2	24.4
Total		54.5	60.0



Contacts

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Palette (save me)

The palette must be saved by EACH computer using the template. Go to Design> Colors> Create new theme color. The default colors will be the RSG colors. Give it a name and SAVE. Otherwise, the first time you change colors you will lose the palette

