

A Prototype NC Statewide Truck Network Model

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Research Project

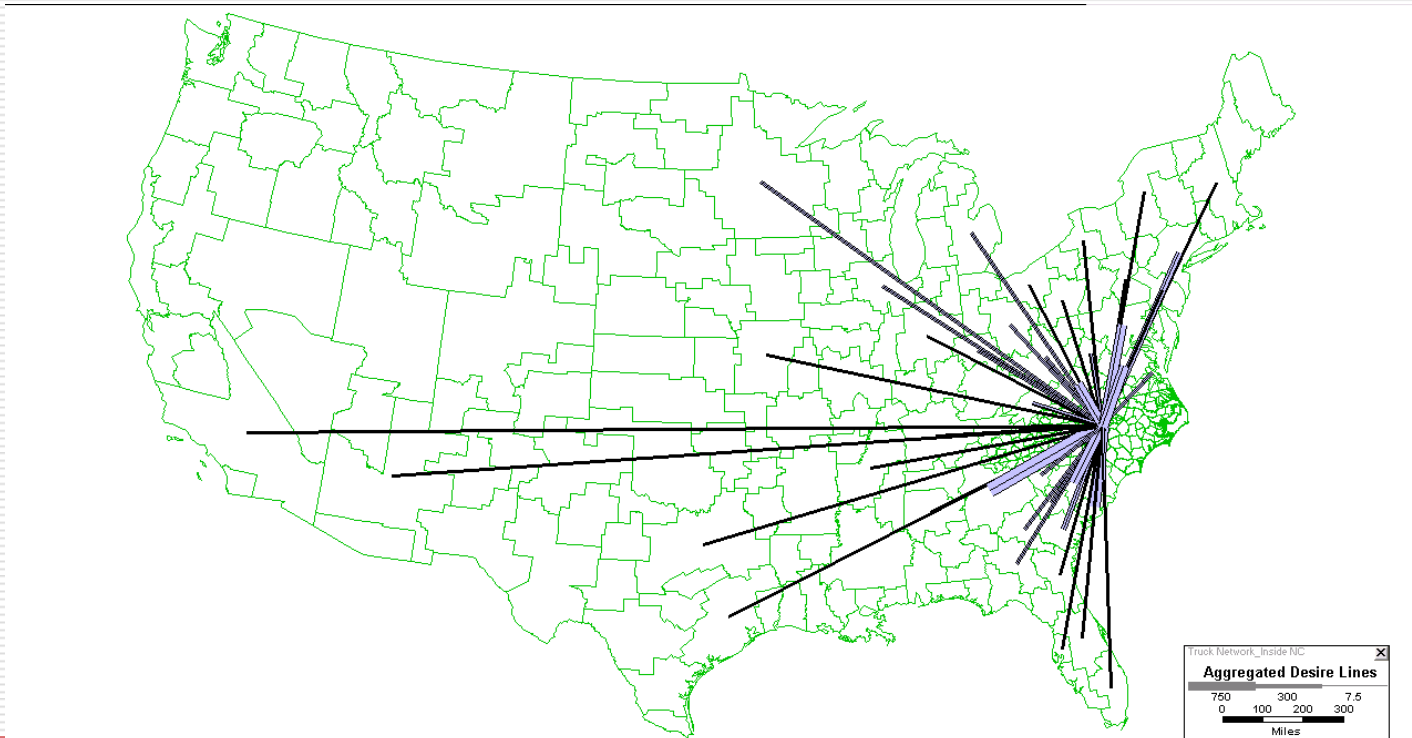
- Sponsored by NCDOT
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 - Project status:
 - Fine-tuning
 - Ending this June
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Model Overview

- A commodity- and trip-based model
 - Commodity-based: FAF² trips
 - Trip-based: Local trips (non-FAF trips)
 - Statewide
 - Traffic analysis zones:
 - 139 internal zones – basically county-based
 - 42 buffer zones – county-based
 - 176 external zones – basically serve FAF² trips
 - Highway network:
 - 13,425 miles of roadway inside NC
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Trip Components to Model

- Freight Analysis Framework² (FAF²) Trips
- Local Truck Trips (non-FAF trips)

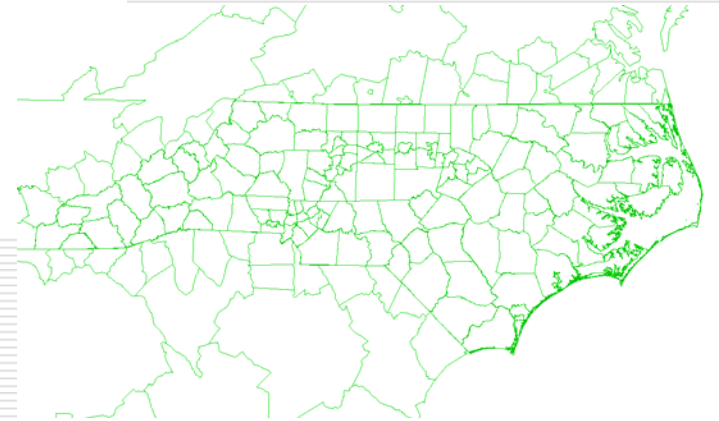
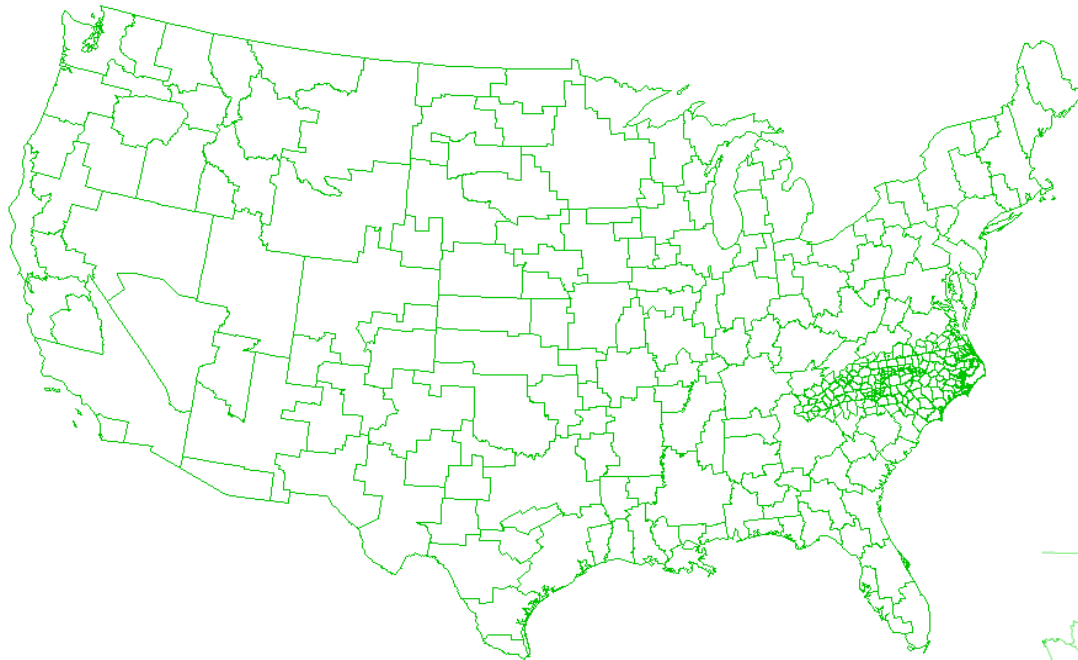


TAZ Structure

- Sub-county zones for Triangle, Triad, and Metrolina metropolitan areas
- County zones for other areas in NC and the buffer areas surrounding NC
- BEA zones for outside buffer areas
 - 179 BEA zones nationwide
 - 176 BEA zones in the model

* BEA: Bureau of Economic Analysis

TAZ Structure



Network Structure

- ❑ Based on National Highway Planning Network (NHPN) 2005
 - ❑ Interstate highways outside the buffer areas
 - ❑ Interstate highways plus US roads for the buffer areas
 - ❑ Everything in NHPN for inside NC
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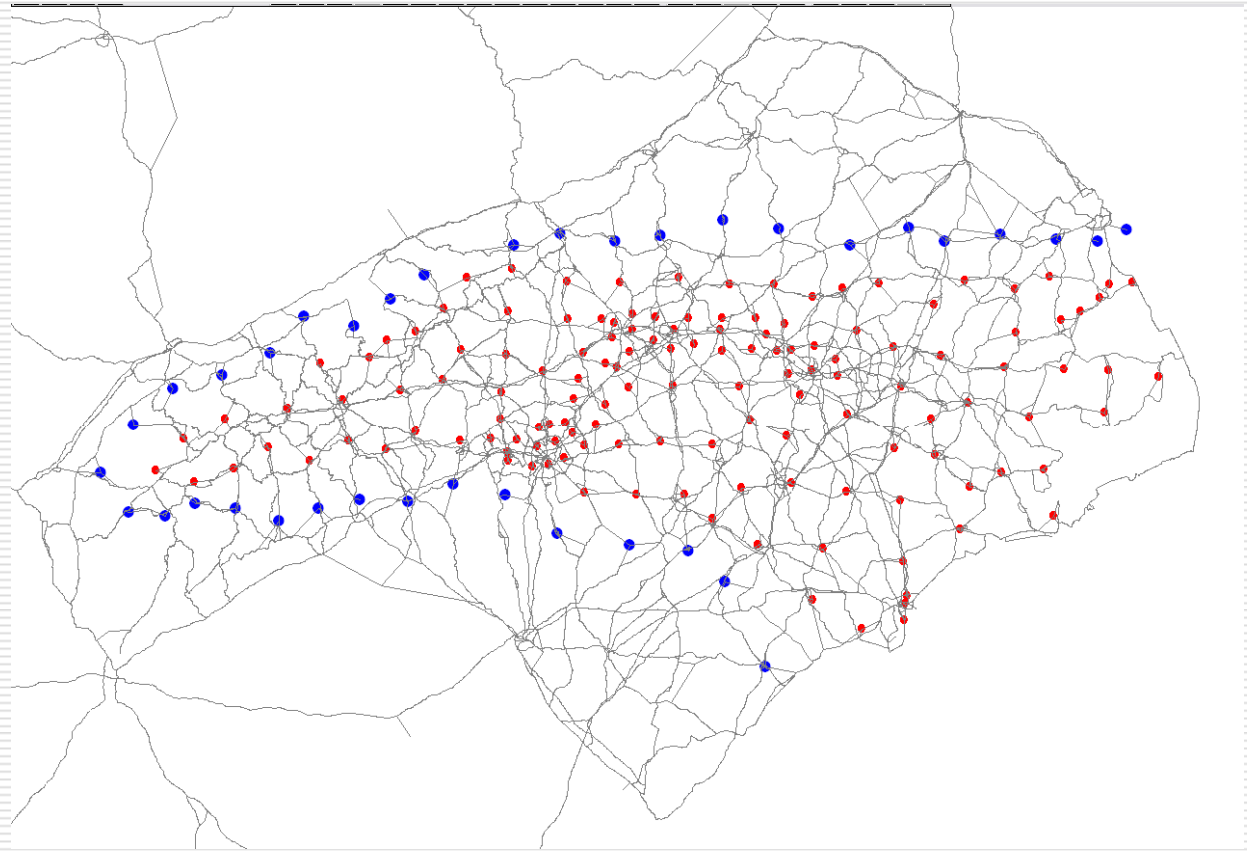
Network Structure



Handling Local Truck Trips

I-I trips

I-E trips



What We Have

- ❑ FHWA Freight Analysis Framework (FAF) Trip Matrix
 - ❑ Truck Traffic Count Data in NC
 - ❑ VIUS Data
 - ❑ Employment Data
 - ❑ NHPN & NC Universe Network
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What We Don't Have

- Primary survey data that can be used to derive:
 - Trip rates by employment type
 - Trip length distribution
 - Time-of-day parameters
 - Truck routing characteristics
 - Etc.
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FAF² Data

- 2002 Commodity Flow Survey (CFS)
 - Comprehensive nationwide freight movement data source, providing tonnage and value of commodities between destination pairs
 - The NAICS industries covered in the 2002 CFS

NAICS code	Description
212	Mining (Except Oil and Gas)
311	Food Manufacturing
312	Beverage and Tobacco Product Manufacturing
313	Textile Mills
314	Textile Product Mills
315	Apparel Manufacturing
316	Leather and Allied Product Manufacturing
321	Wood Product Manufacturing
322	Paper Manufacturing
323	Printing and Related Support Activities
324	Petroleum and Coal Products Manufacturing
325	Chemical Manufacturing
326	Plastics and Rubber Products Manufacturing
327	Nonmetallic Mineral Product Manufacturing
331	Primary Metal Manufacturing
332	Fabricated Metal Product Manufacturing
333	Machinery Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance, and Component Manufacturing
336	Transportation Equipment Manufacturing
337	Furniture and Related Product Manufacturing
339	Miscellaneous Manufacturing
421	Wholesale Trade, Durable Goods
422	Wholesale Trade, Nondurable Goods
4541	Electronic Shopping and Mail-Order Houses
49310	Warehousing and Storage
551114	Corporate, Subsidiary, and Regional Managing Offices

FAF² Data

□ FAF2 Zones

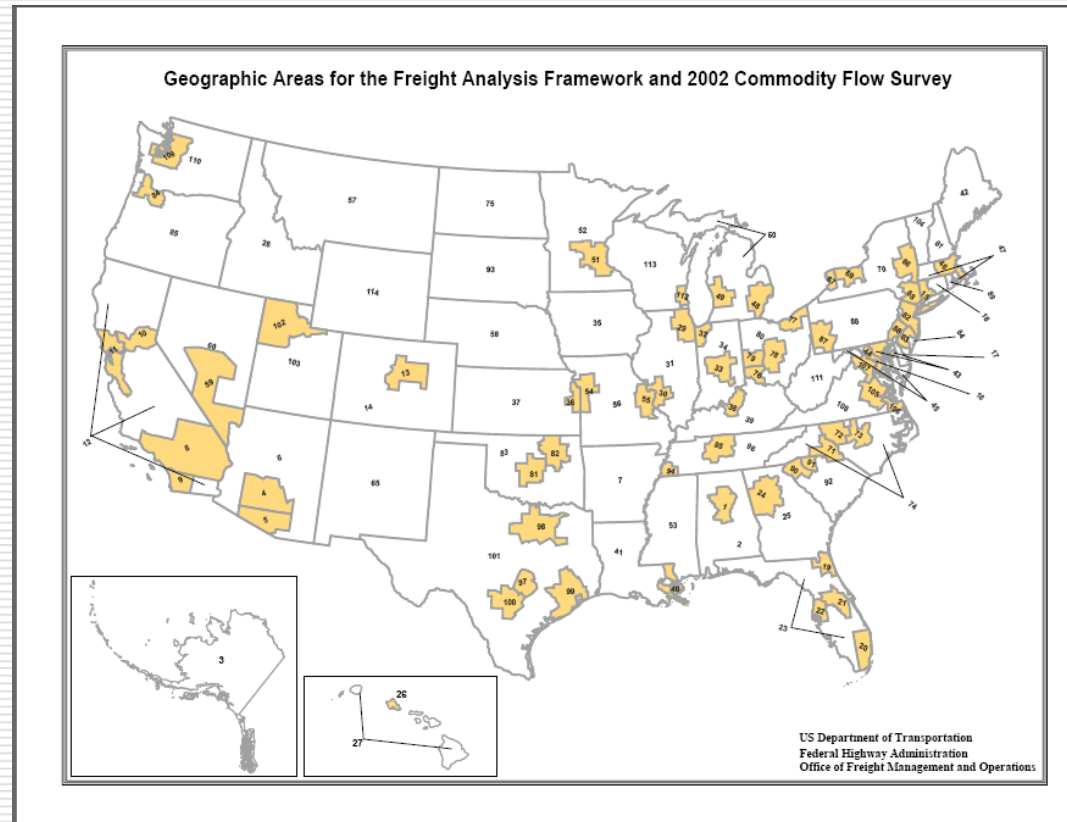
- 131 freight analysis zones
 - 114 CFS freight OD zones
 - 17 major ports & border crossings
- NC FAF zones
 - 71, 72, 73, and 74

□ FAF2 Network

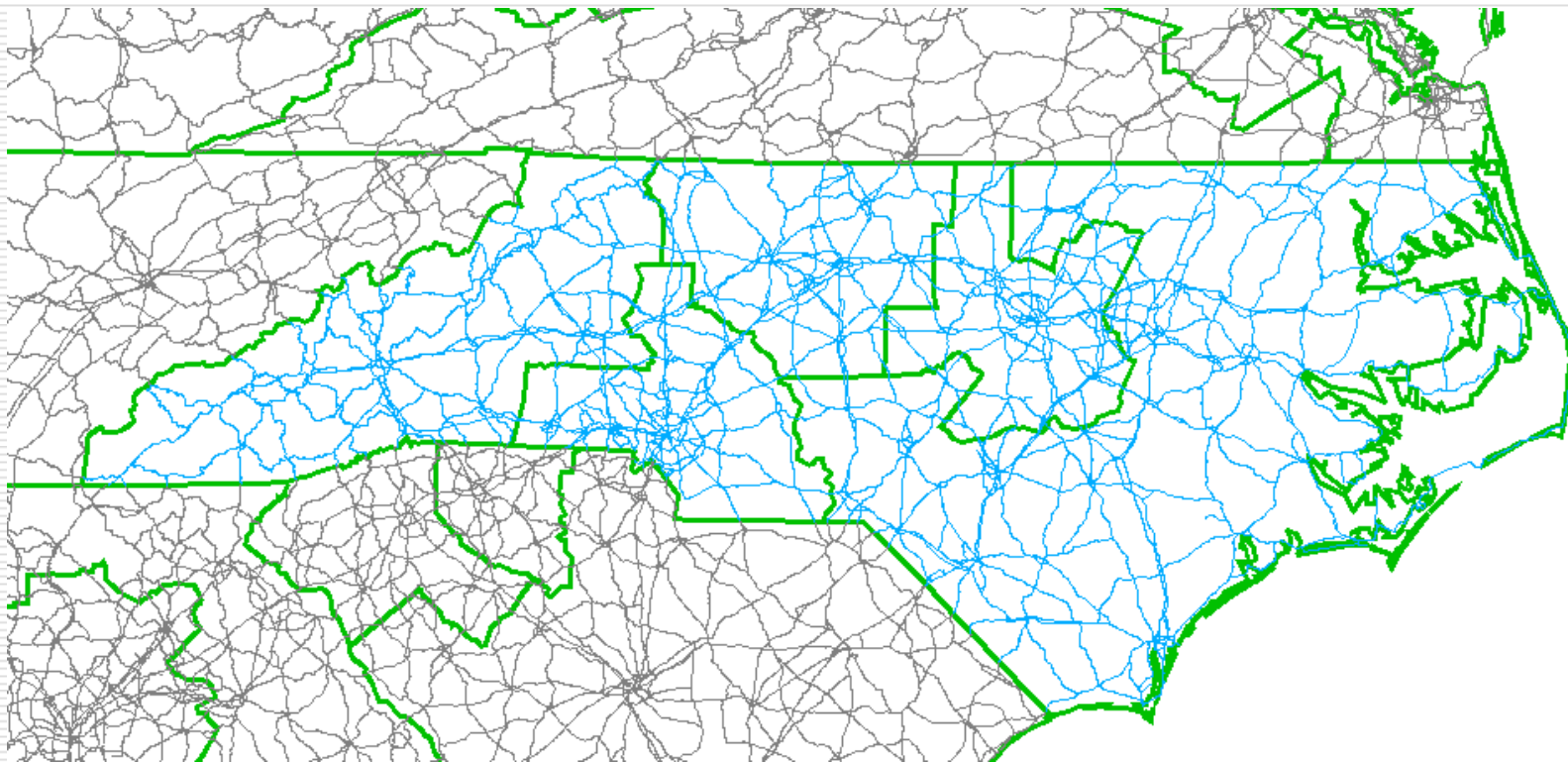
- NHPN version 2005.10
 - 450,000 miles of roadway nationwide
 - 11,053 miles NC statewide
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FAF² Zones - NC

- ❑ 71 Charlotte-Gastonia-Salisbury
- ❑ 72 Greensboro--Winston-Salem--High Point
- ❑ 73 Raleigh-Durham-Cary
- ❑ 74 Remainder of North Carolina



FAF² Network - NC



FAF² Disaggregation

- Disaggregate FAF² O-D to County Level
 - Disaggregate FAF zone totals (in tonnage) to county totals based upon county truck VMT
 - Use gravity model to distribute O's and D's based on FAF¹ observed truck trip length distribution (year 1998)
 - So county-to-county FAF² flows are estimated rather than observed
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Example of FAF² Zonal Total Disaggregation

CFIPS	FIPS	FAF Zone	Truck VMT/Day	Factor
01007	1	1	81,991	0.026
01009	1	1	129,757	0.040
01021	1	1	259,398	0.081
01043	1	1	366,189	0.114
01073	1	1	1,467,601	0.457
01115	1	1	312,747	0.097
01117	1	1	352,185	0.110
01127	1	1	242,103	0.075
04013	4	4	6,233,498	0.824
04021	4	4	1,335,447	0.176

FAF² Tons to Trucks

- Vehicle Inventory and Use Survey (VIUS) 2002
 - provides physical and operational characteristics of trucks
 - Primary source for developing commodity flow tonnage to truck trip conversion factors (payload factor)
 - Payload factors derived based on
 - Commodity type
 - Vehicle group
 - straight trucks
 - straight truck + trailer
 - tractor + single trailer
 - tractor + multiple (double and triple) trailer
 - Truck body type
 - automobile, livestock, bulk, flatbed, tank, van, reefer, logging, & other
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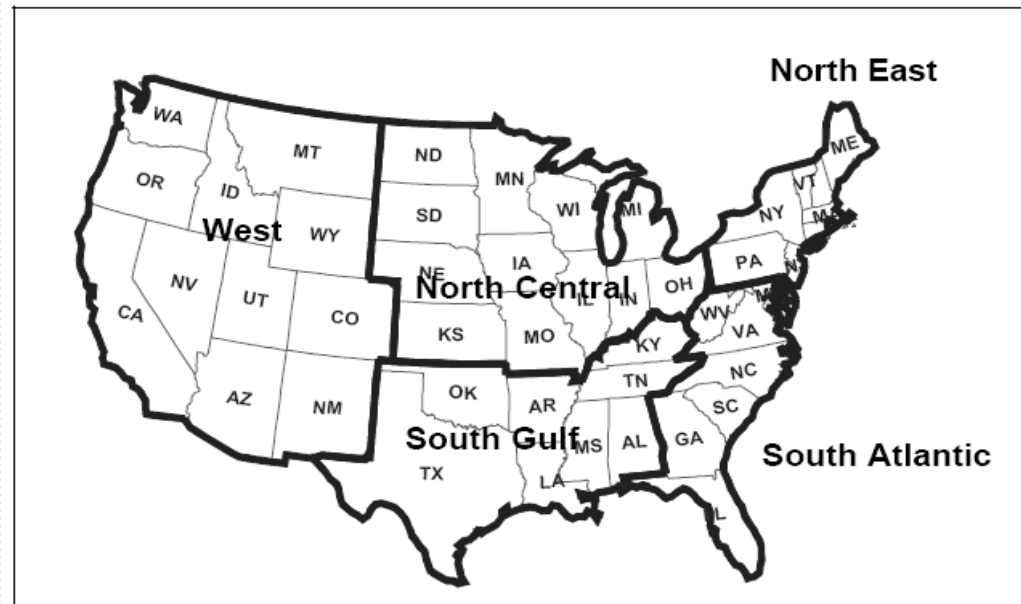
Average Payloads (tons): Example

Commodity Code	Body Type	Truck Type				
		Straight Trucks	Straight Truck +Trailer	Tractor +Trailer	Tractor +Double Trailer	Tractor + Triple Trailer
1	1-Automobile					
	2-Livestock			21.046	32.379	
	3-Bulk	9.750	9.458	23.529		
	4-Flatbed	7.283	9.071	20.704		
	5-Tank	12.531		23.431		
	6-Van	9.946	2.957	17.574		
	7-Reefer	12.531		21.441		
	8-Logging					
	9-Other		11.561			

Source: FHWA Peer Review Meeting, Washington, DC, 8/22/2006

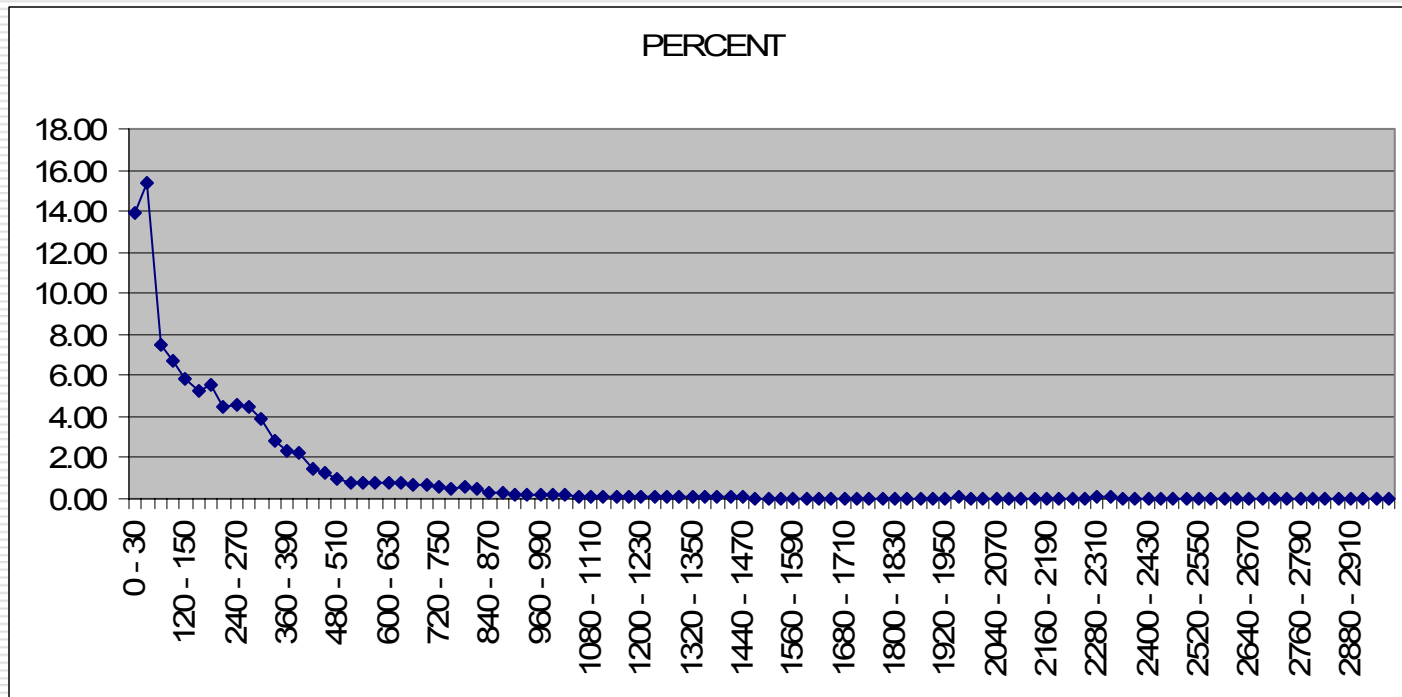
Regional Payload Factor

- ❑ Differences in State TSW regulations
- ❑ Reflected in truck configurations, body types, and populations
- ❑ 5 regions considered demonstrating regional variability



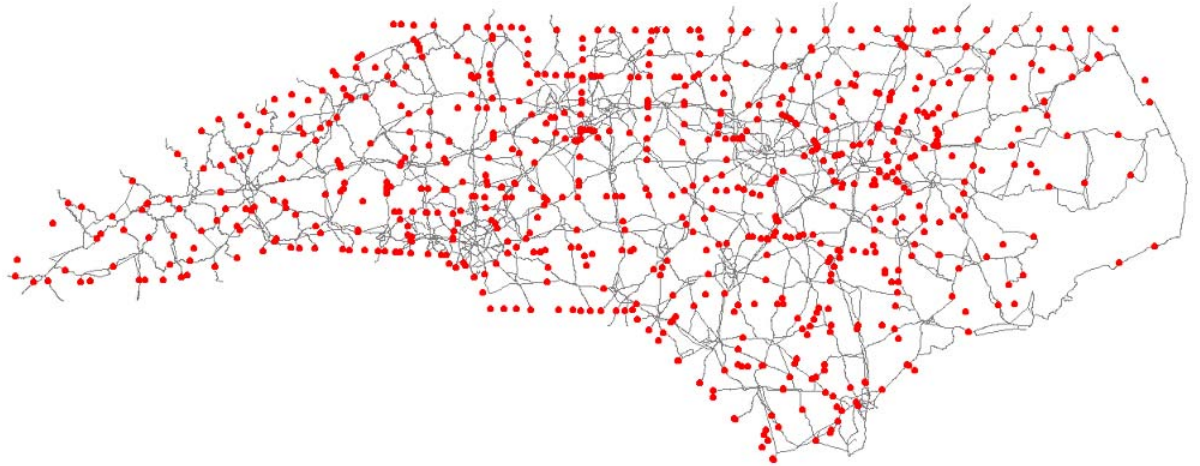
Trip Length Frequency Distribution of FAF² Truck Trips (in miles)

- ❑ Only include FAF2 truck trips from, to, and within NC
- ❑ Average trip length = 240 miles



Truck Traffic Count Data

- ❑ 724 locations in total
- ❑ 460 locations in the network
- ❑ Counts by vehicle type:
 - Motor Cycles
 - Autos
 - Trucks:
 - 2-axle 4-tire
 - single-unit: 2-, 3-, and 4-axle
 - single-trailer: 4-, 5-, and 6-axle
 - multi-trailer: 5-, 6-, and 7-axle



Employment Data

- ❑ North Carolina Employment and Security Commission (NCESC) employment data are used for estimating local truck trips
 - ❑ 260,711 employers in the records
 - ❑ 3,775,976 employees in NC in 2006
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Synthesized Speed Table

- Speed look-up table
 - Functional Class
 - Speed Limit
 - Two-lane or Multi-lanes
 - Terrain Type

Average Travel Speed		2 lanes speed limit (mph)										3 lanes or more speed limit (mph)							
Terrain Type	Functional Class	<=20	25	30	35	40	45	50	55	65	30	35	40	45	50	55	65	70	
1 (Flat)	1								59	62						60	69	73	
	2		30	33	37	42	46	50	56	59	36	40	45	49	54	59	65		
	6		27	31	36	41	45	47	53	58	35	39	44	48	53	58	62		
	7	24	26	30	35	40	44	46	51		34	38	43	48	52	57	60		
	8	21	23	27	34	36	40	41	45		30	33	39	42	47	50			
	9	20	22	24	29	33	36	38	40		27	31	35	38	42	46			
2 (Rolling)	1								58	61						60	68	72	
	2		28	31	35	40	45	49	54	59	33	38	44	48	53	58	63		
	6		26	29	34	39	44	47	49	58	32	38	43	46	50	55	61		
	7	22	25	28	33	38	42	46	48		31	36	41	45	49	54	59		
	8	20	22	26	31	34	39	42	44		28	32	36	40	44	49			
	9	20	22	24	28	32	35	37	40		25	29	31	36	40	43			
3 (Mountainous)	1								49	56						57	63	67	
	2		26	31	34	36	39	44	48	54	32	36	40	45	49	53	59		
	6		24	28	33	35	38	42	45	52	31	35	39	44	48	52	57		
	7	21	23	27	32	34	37	39	43		30	34	38	43	47	51	56		
	8	19	21	24	30	31	35	38	40		27	31	35	38	42	45			
	9	17	20	22	26	29	32	35	37		23	27	31	34	37	42			

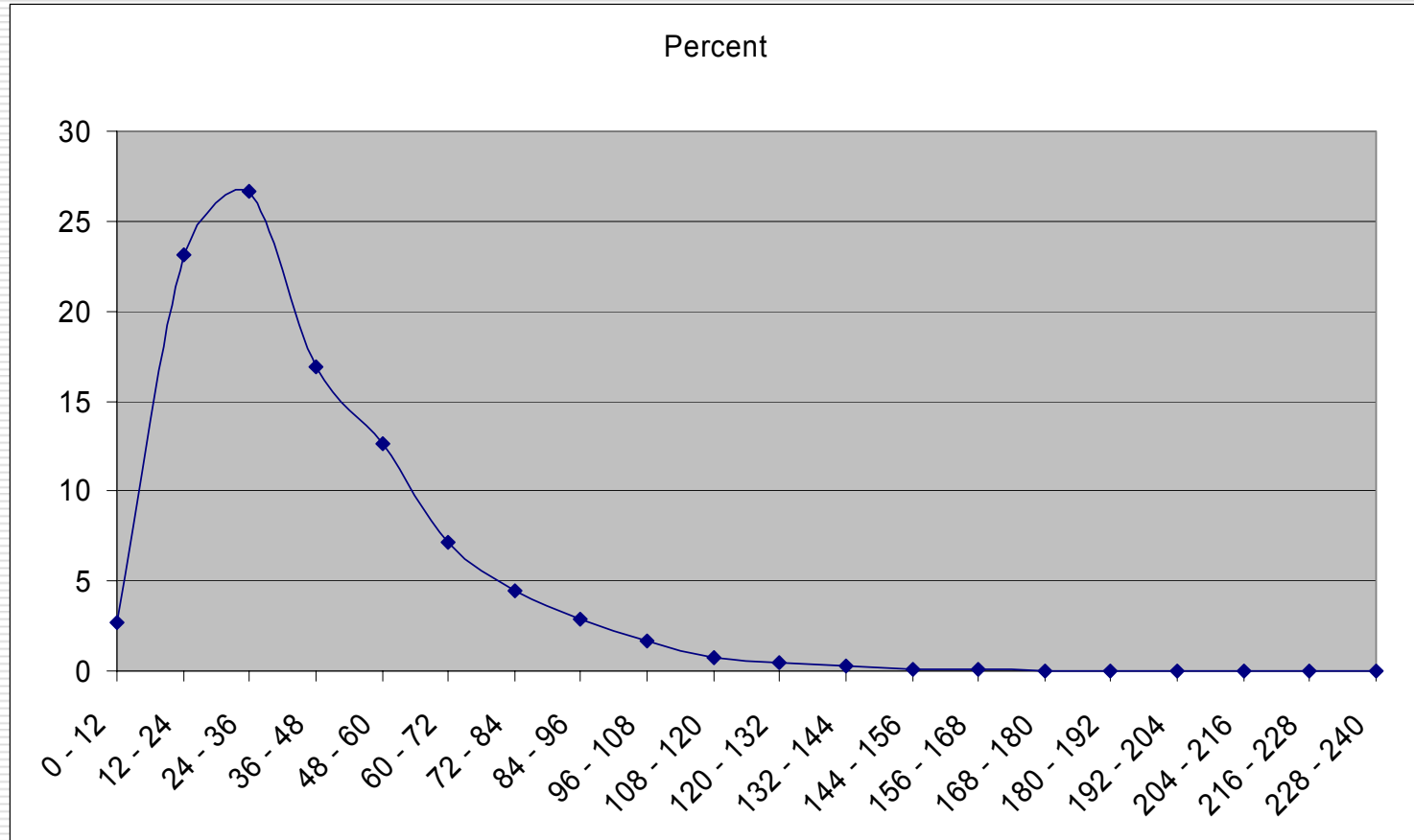
Adding Empty Truck Trips to FAF2

- 30% empty truck trips were assumed based on
 - Global Insight Recommendations
 - VIUS
 - Literature about empty truck percentage in other states
 - 30% of back-haul trips
 - Zonal origins and destinations are not balanced in original FAF2 trip matrix
 - Must make sure after adding empty trips zonal origins and destinations are balanced
 - A method has been developed by the team
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Model Calibration

- Iterating between trip rates adjustment and trip distribution parameters to find the best fit to:
 - Truck traffic counts; AND
 - VIUS trip length distribution
 - Gravity model with exponential function for trip distribution
 - Calibrated truck trip rate = 1.2 trips/employee
 - Local trips account for 83% of total truck trips
 - FAF² trips account for 17%, including empty truck trips.
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Trip Length Frequency Distribution of Local Truck Trips (in minutes)



VIUS vs. Modeled Range of Operation

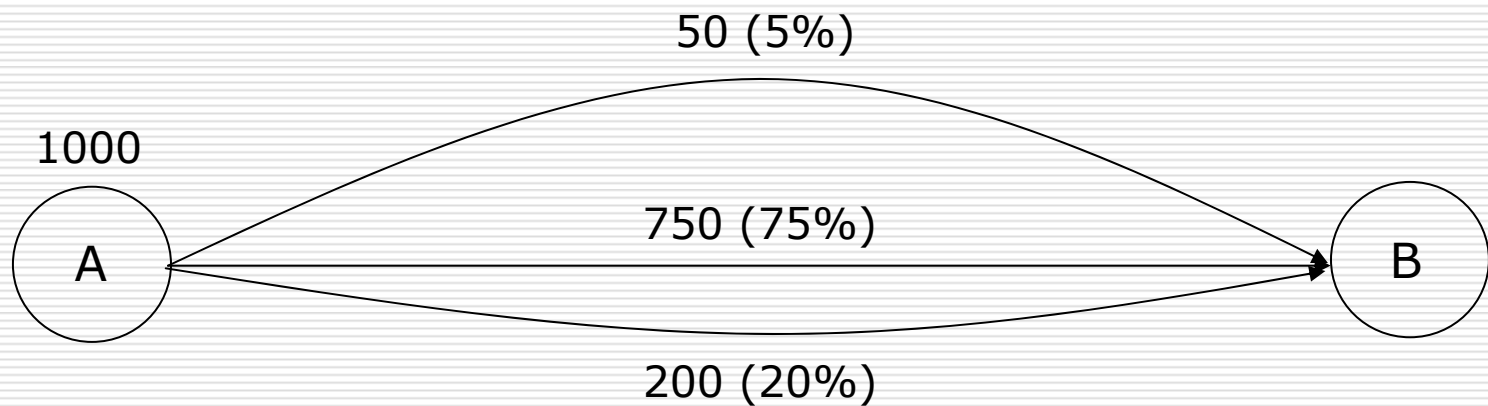
❑ FAF2 + Local Truck Trips

Range of Operation	VIUS	Model
50 miles or less	65.5%	69.3%
51 to 200 miles	25%	23.8%
201 miles or more	9.5%	6.9%

Traffic Assignment

- Multi-path Stochastic Assignment
 - Dial's algorithm
 - Demonstration with a simple example
 - Why not UE?
 - No passenger traffic modeled, which account for
 - 70 – 90% on interstate highways
 - 80 – 90% on rural arterials
 - 85 – 95% on other lower level roads
 - Don't want to apply growth factors to HPMS auto traffic volumes
-

Demonstration of Dial's Algorithm



How much assignment approach matters?

- ❑ Of 460 counts, daily
 - ❑ v/c ratio ≥ 1 : 3 (**0.6%**)
 - ❑ $0.5 < \text{v/c ratio} < 1$: 25 (**5.4%**)
 - ❑ $0.1 < \text{v/c ratio} \leq 0.5$: 193 (**42%**)
 - ❑ v/c ratio ≤ 0.1 : 239 (**52%**)

- ❑ After applying 30% increase, daily
 - ❑ v/c ratio ≥ 1 : 9 (**2%**)
 - ❑ $0.5 < \text{v/c ratio} < 1$: 39 (**8.5%**)
 - ❑ $0.1 < \text{v/c ratio} \leq 0.5$: 216 (**47%**)
 - ❑ v/c ratio ≤ 0.1 : 196 (**42.5%**)

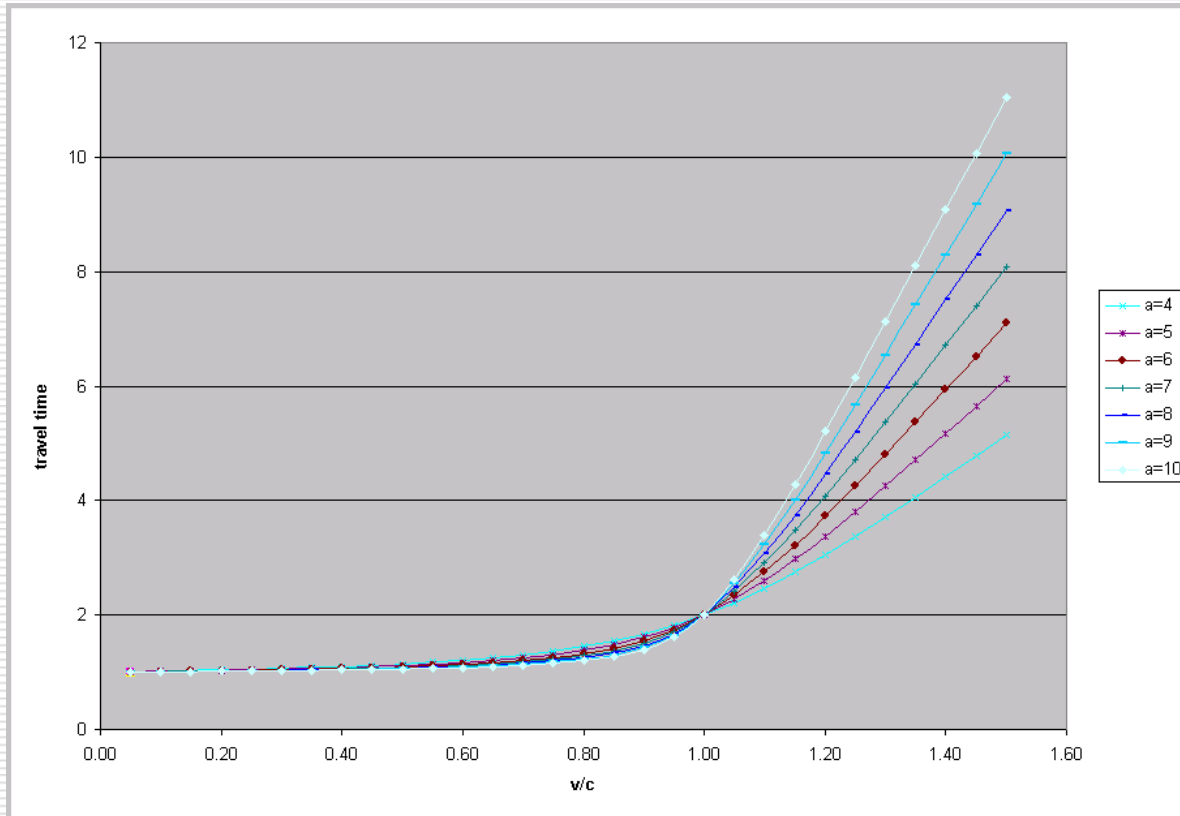
❖ TRM Daily (2005)

→ 5%

→ 31%

} 64%

How much assignment approach matters?



Conical Volume-Delay Function

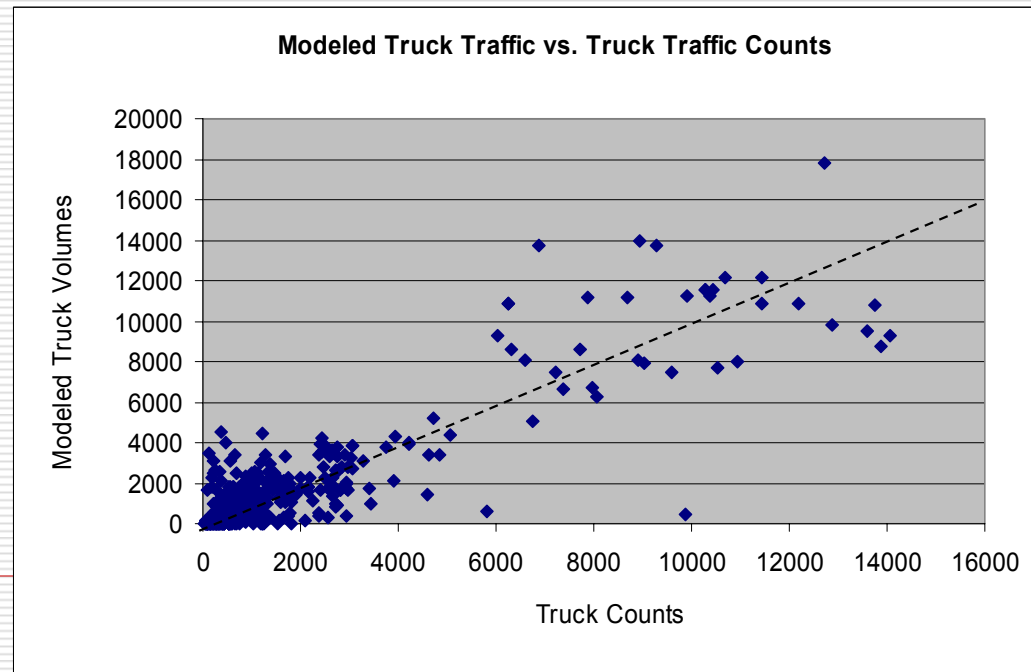
Performance Measures

- ❑ Screenlines & Cordon lines
 - ❑ R-squared
 - ❑ VMT comparison
 - ❑ Scatter Plots
 - ❑ Etc.
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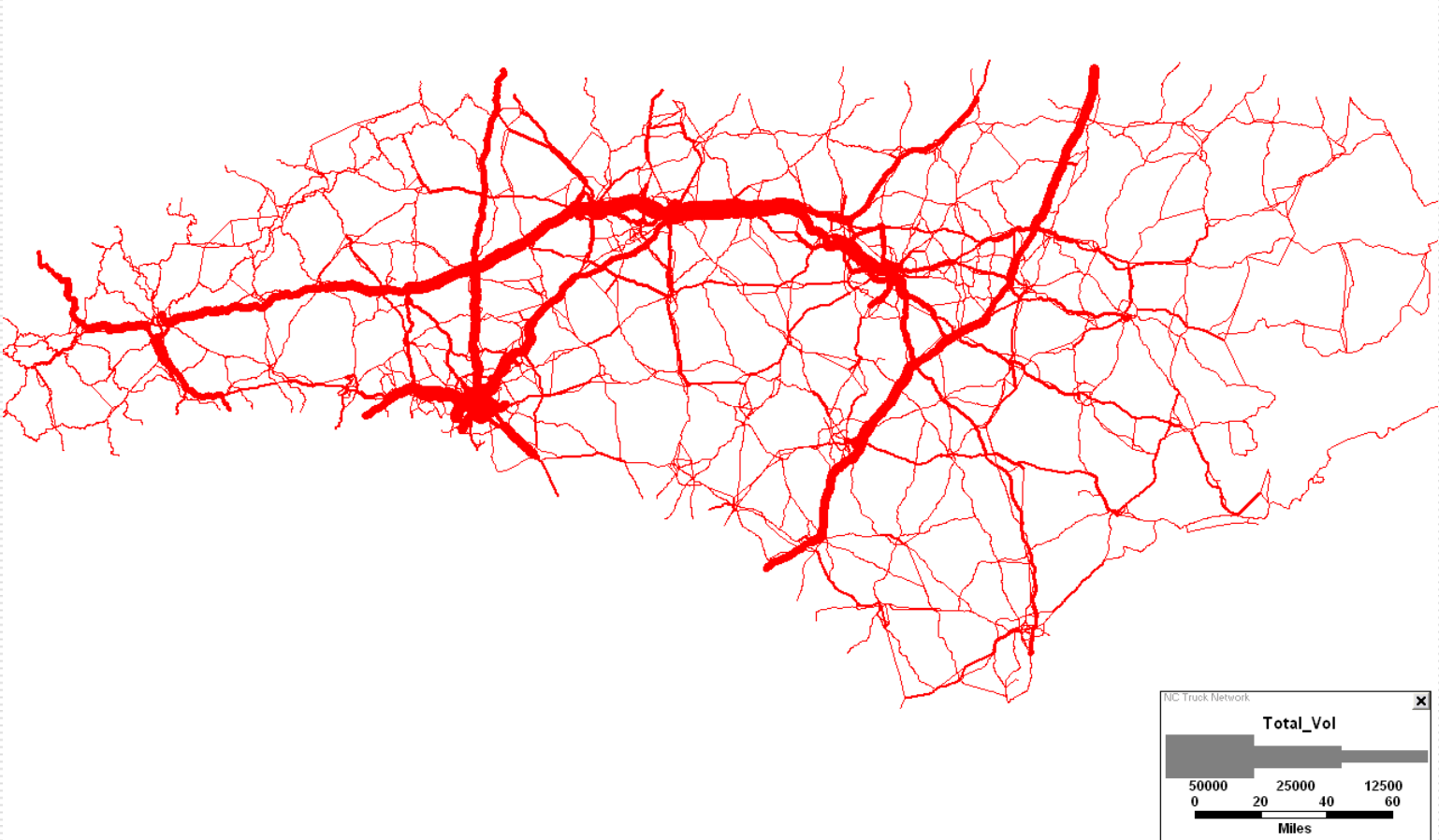
VMT & Volume Comparisons

NC Region	Truck Counts Based VMT	Model Estimated Truck VMT	% Deviation
Mountain	1,254,866	1,168,637	- 7%
Coastal	1,329,124	1,386,750	+ 4%
Central	1,967,652	2,113,502	+ 7%
Total	4,551,642	4,668,889	+ 2.5%

$R^2 = 0.8$



Modeled Truck Volumes on the Network



Work in Progress

- Trip matrix estimation based on ground counts
 - Approach 1: use the trip matrix developed from the gravity model as a seed matrix and estimated local truck trips based on counts
 - Approach 2: combine FAF2 matrix with the trip matrix developed from the gravity model, use the combined matrix as a seed matrix, and estimated all truck trips based on counts
 - Trying different weights on the seed matrix
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Use of the Model

- It is a statewide model with strengths in:
 - Intercity / inter-region travel forecasting
 - Rural area travel forecasting
 - I-E travel forecasting for a study area
 - E-E travel forecasting for a study area
 - More sophisticated urban models handle commercial vehicle travel for urban areas.
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Use of the Model

- Intercity corridor studies
 - Through traffic forecasting for MPO models
 - Other special applications:
 - NC truck profiles project
 - Commercial vehicle monitoring
 - Etc.
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Future Improvements

- Input-Output Modeling
 - Better reflecting the relationship between economy and freight
 - Multi-modal Freight Modeling
 - Highway, Rail, Air, and Water Modes
 - A Full-blown Statewide Model:
 - Passenger Trips
 - Long trips: business, tourism, & other long trips
 - Daily short trips: HBW, HBO, & NHB
 - Commercial vehicle trips
 - Freight
 - Service
 - Intercity & intra-city trips
 - Multi-modal
 - Time-of-day
-