A Prototype NC Statewide Truck Network Model

Presented by

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Research Project

☐ Sponsored by NCDOT

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Data

- **What We Have:**
  - FHWA Freight Analysis Framework (FAF2) Data - 2002
  - Truck Traffic Count Data in NC – 2006 & 2007
  - NC Vehicle Inventory and Use Survey (VIUS) Data - 2002
  - NC Employment Data- 2006
  - NHPN - 2005
  - NC Highway Attributes (e.g. functional class, posted speed, number of lanes, etc.)

Data (2)

- But we don't have primary survey data that can be used to derive:
  - Trip rates by employment type or NAICS sector
  - Trip length distribution
  - Truck routing characteristics
  - Time-of-day parameters
  - Etc.

Model Overview

- First statewide model for NC
- A commodity- and trip-based model
  - Commodity-based: FHWA FAF^2 trips
  - Trip-based: Local trips (non-FAF trips)
- Traffic analysis zones:
  - Internal zones (139) – basically county-based
  - Buffer zones (42) – county-based
  - external zones (176) – basically serve FAF^2 trips
- Highway network:
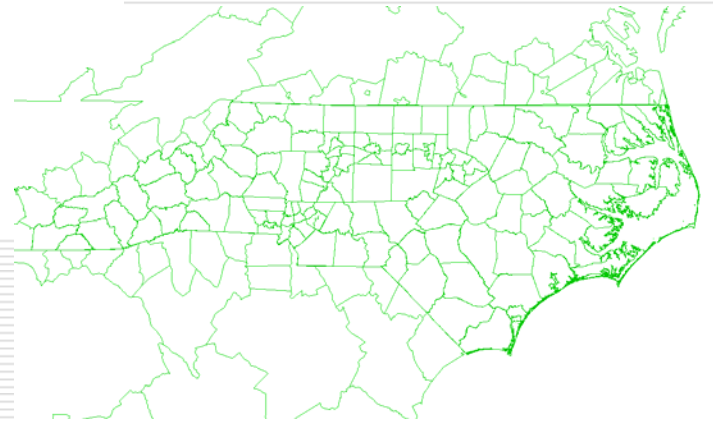 - NHPN
  - 11,053 miles of roadway in NC

TAZ Structure
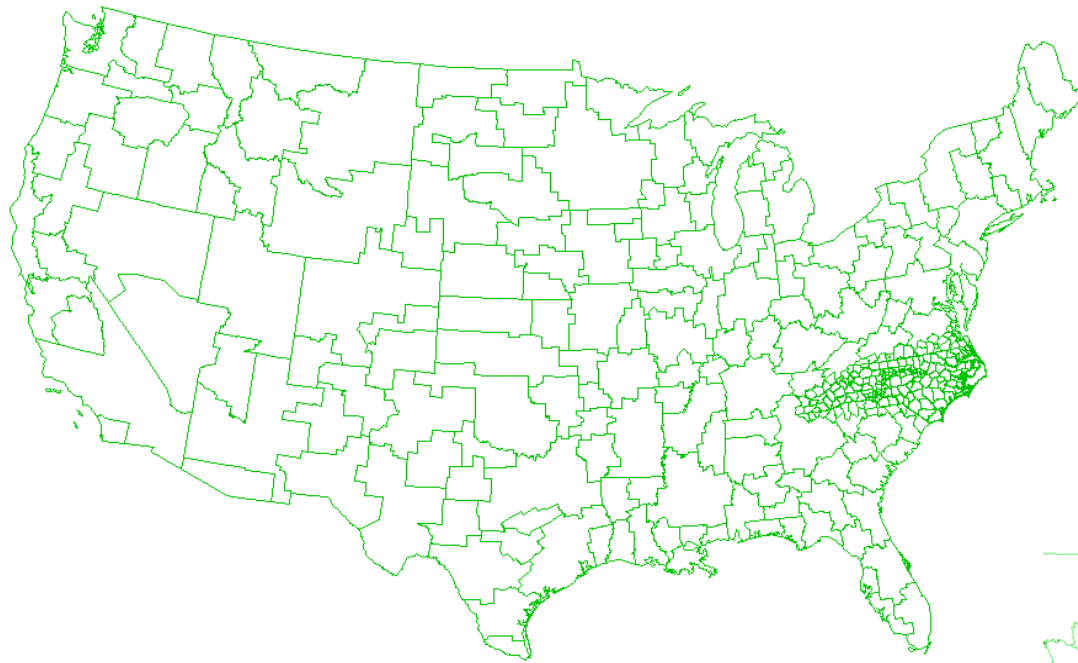
☐ Sub-county zones for Triangle, Triad, and Metrolina metropolitan areas

☐ 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
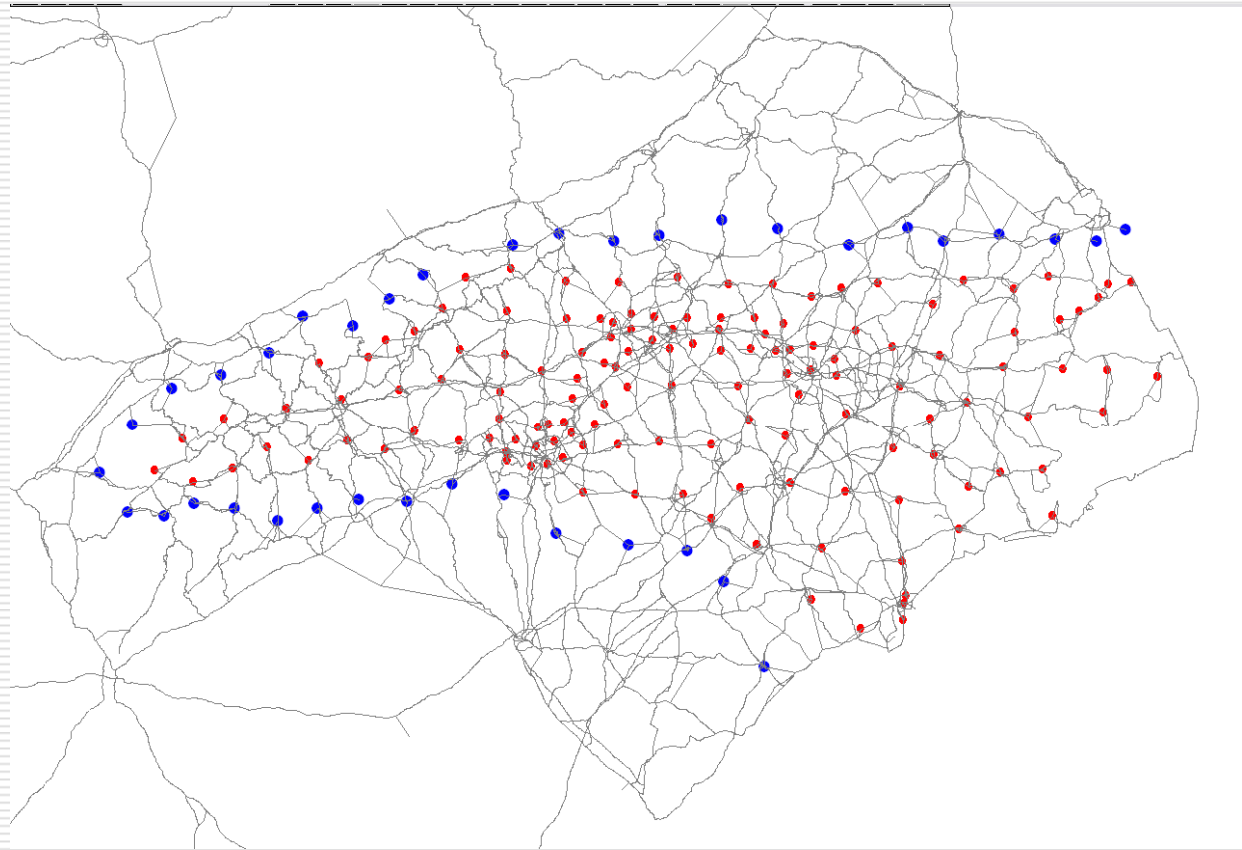- ☐ Everything in NHPN for inside NC

Network Structure

Handling Local Truck Trips

- ❑ I-I trips
- ❑ I-E trips

Freight Analysis Framework² (FAF²)

☐ **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

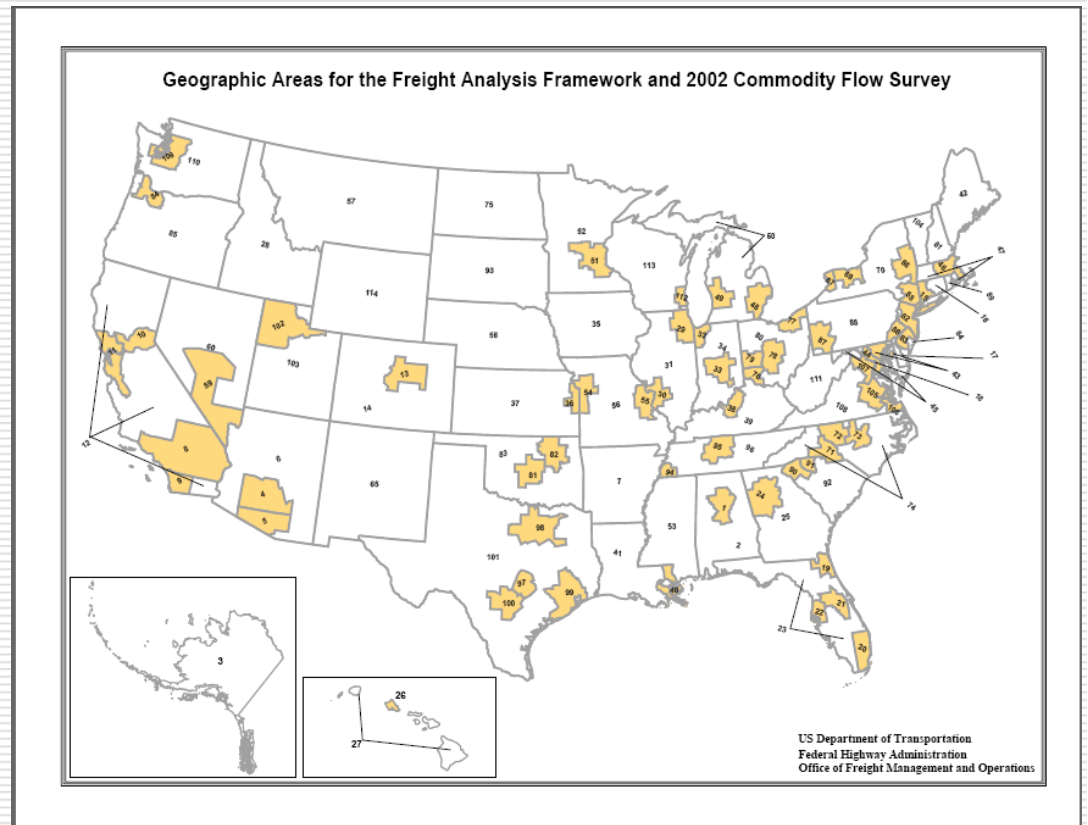| NAICS code	Description
212	Mining (Except Oil and Gas)
311	Food Manufacturing
312	Beverage and Tobacco Product Manufacturing
313	Textile Mills
314	Textile Product Mills
315	Apparel Manufacturing
316	Leather and Allied Product Manufacturing
321	Wood Product Manufacturing
322	Paper Manufacturing
323	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

FAF^2 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

FAF^2 Zones - NC

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

Geographic Areas for the Freight Analysis Framework and 2002 Commodity Flow Survey

US Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations

FAF^2 Disaggregation

- Disaggregate FAF^2 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 FAF^1 observed truck trip length distribution (year 1998)
  - So county-to-county FAF^2 flows are not truly observed

FAF^2 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
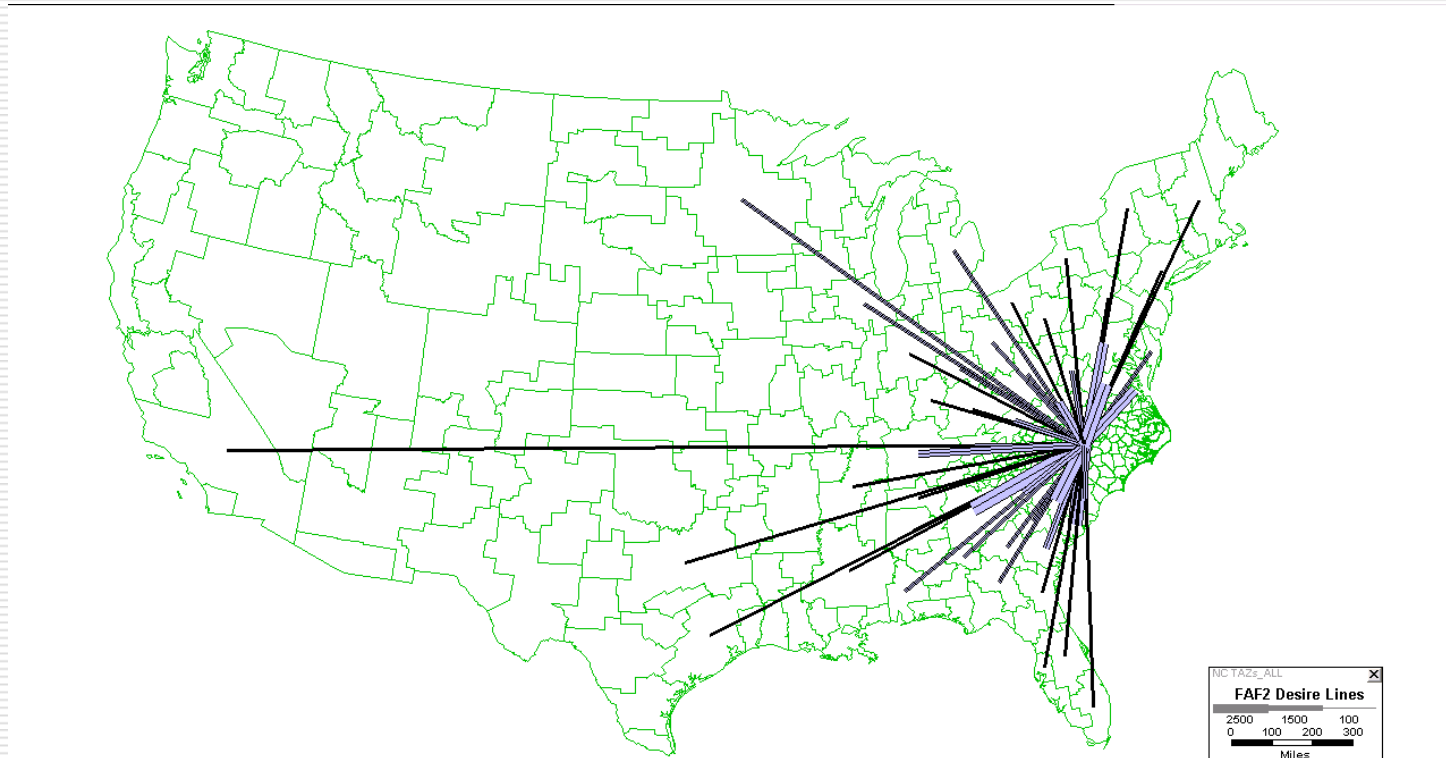
Regional Payload Factor

- [ ] Differences in State TSW regulations
- [ ] Reflected in truck configurations, body types, and populations
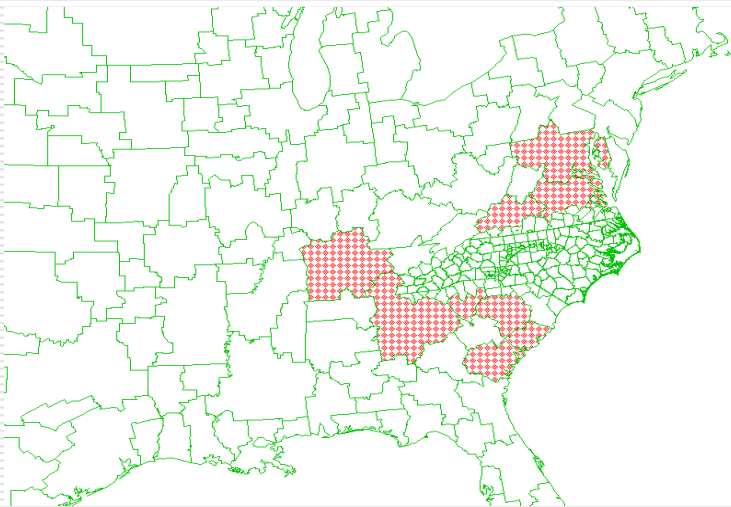- [ ] 5 regions considered demonstrating regional variability
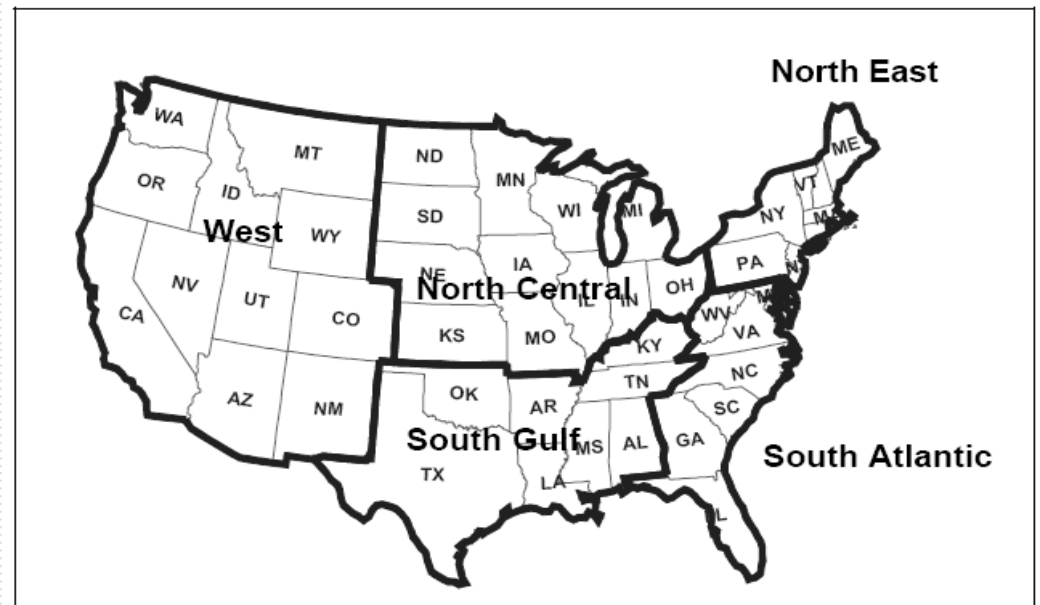
FAF² Trip Interchange Desire Lines

- FAF² Desire Lines from and to NC:

FAF2 – Top 10 BEA Zones for NC

BEA Zone	Major MSA(s)	Daily Trips* (2-way)
11	Atlanta-Sandy Springs-Gainesville, GA-AL	4616
38	Columbia-Newberry, SC	4233
30	Charleston - North Charleston, SC	4153
137	Richmond, VA	3620
173	Virginia Beach-Norfolk-Newport News, VA-NC	3105
138	Roanoke, VA	3042
174	Washington-Baltimore-Northern Virginia, DC-MD-VA-WV	2771
68	Greenville-Spartanburg-Anderson, SC	2472
116	Nashville-Davidson-Murfreesboro-Columbia, TN	1984
149	Savannah-Hinesville-Fort Stewart, GA	1912

* Note: factored to 2006 from 2002

Trip Length Frequency Distribution of FAF^2 Truck Trips (in miles)

❑ Only FAF2 truck trips from, to, and within NC included

❑ Average trip length = 250 miles

❑ Median trip length = 180 miles
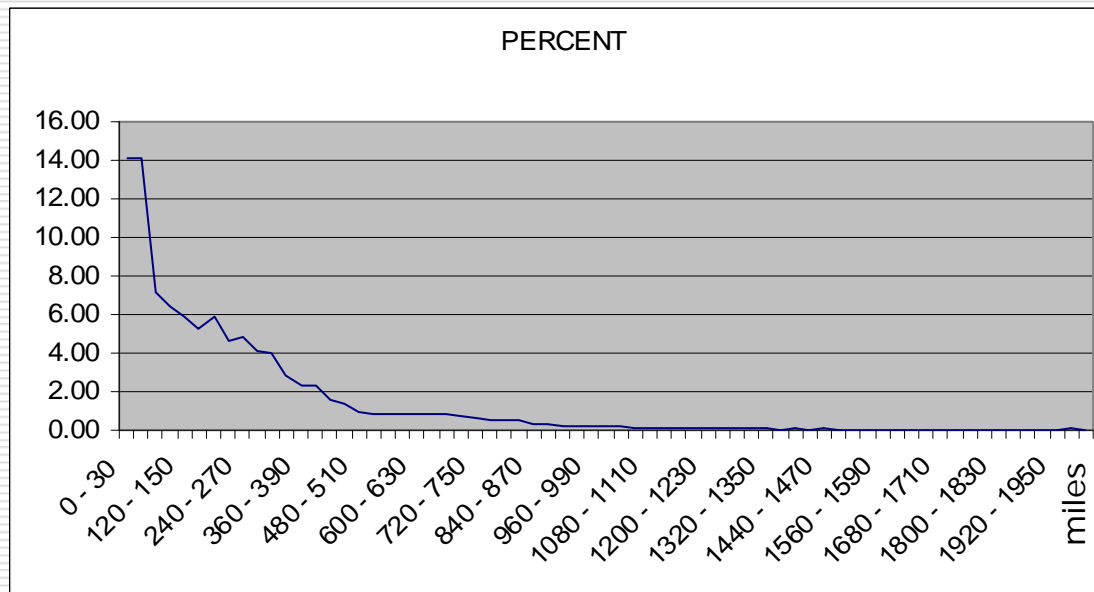
Employment Data

- 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

Truck Traffic Count Data

❑ 724 locations in total

❑460 locations in the network

❑ Counts by vehicle type:

- ➤ Motor Cycles
- ➤ Autos
- ➤ Small Trucks: 2-axle 4-tire (e.g. pick-ups)
- ➤ Trucks:
  - ➤ single-unit: 2-, 3-, and 4-axle
  - ➤ single-trailer: 4-, 5-, and 6-axle
  - ➤ multi-trailer: 5-, 6-, and 7-axle
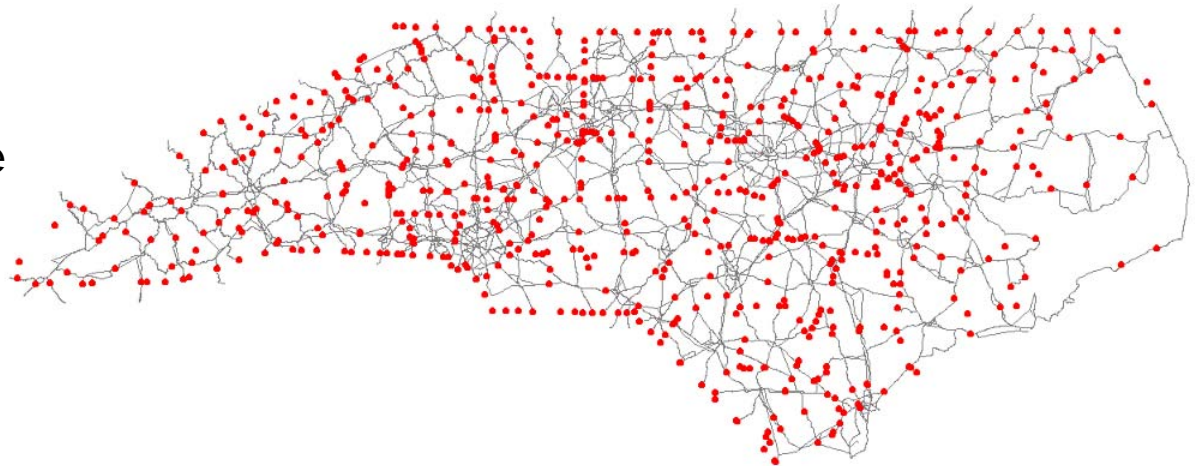
Synthesized Speed Table

☐ Average Travel Speed look-up table

- ■ Functional Class
- ■ Speed Limit
- ■ Two-lane or Multi-lanes
- ■ Terrain Type

| Average Travel Speed		2 lanes									3 lanes or more							
		speed limit (mph)									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	39	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		

Model Development and 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
- Multi-path Stochastic Assignment – Dial's Algorithm
- Calibrated truck trip rate = 0.124 trips/employee
- Local trips account for 85% of total truck trips; FAF[2] trips account for 15%

Trip Length Frequency Distribution of Local Truck Trips

❑ Average trip length = 38 miles

❑ Median trip length = 31 miles
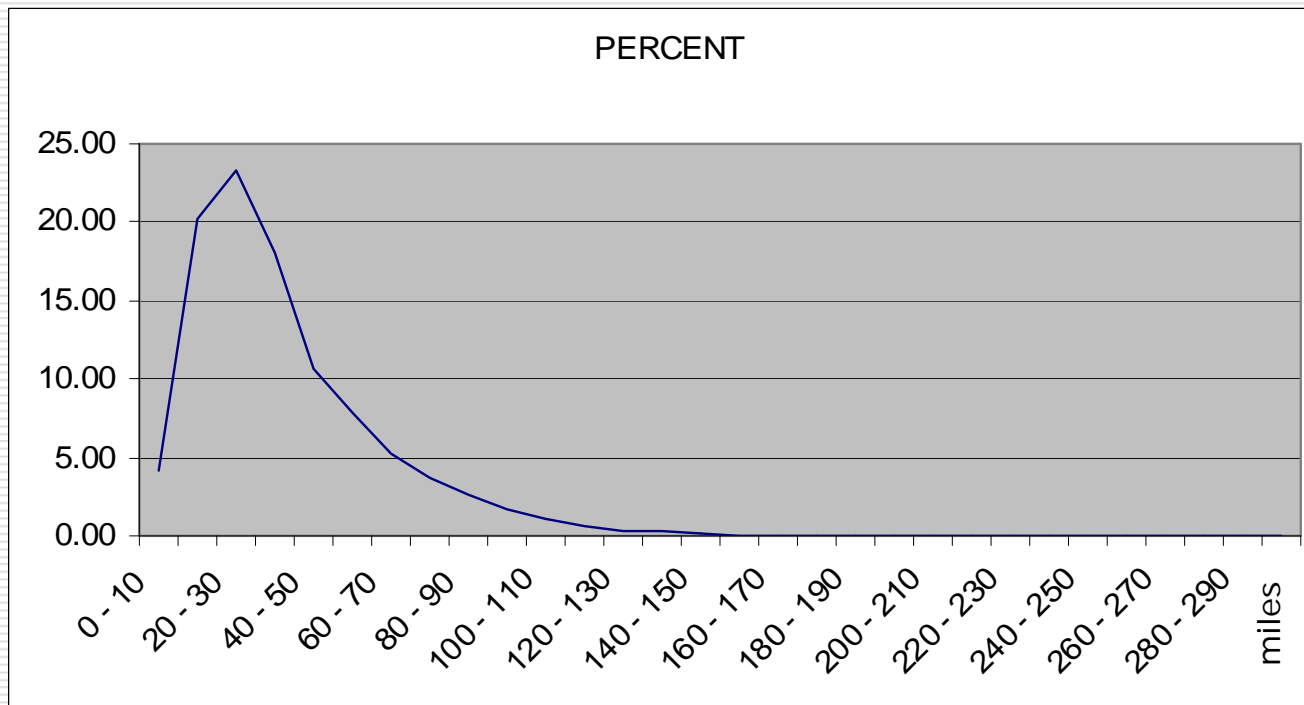
Performance Measures

- Trip Length Distribution
- Screenlines & Cordon lines
- R-squared
- VMT comparison
- Scatter Plots
- %RMSE

VIUS vs. Modeled Range of Operation

❑ FAF2 + Local Truck Trips

Range of Operation	VIUS* (2002)	Model (2006)
50 miles or less	65.5%	68.8%
51 to 200 miles	25%	24.9%
201 miles or more	9.5%	6.3%

* Excluding 1) pickups, minivans, other light vans, and sport utilities; and

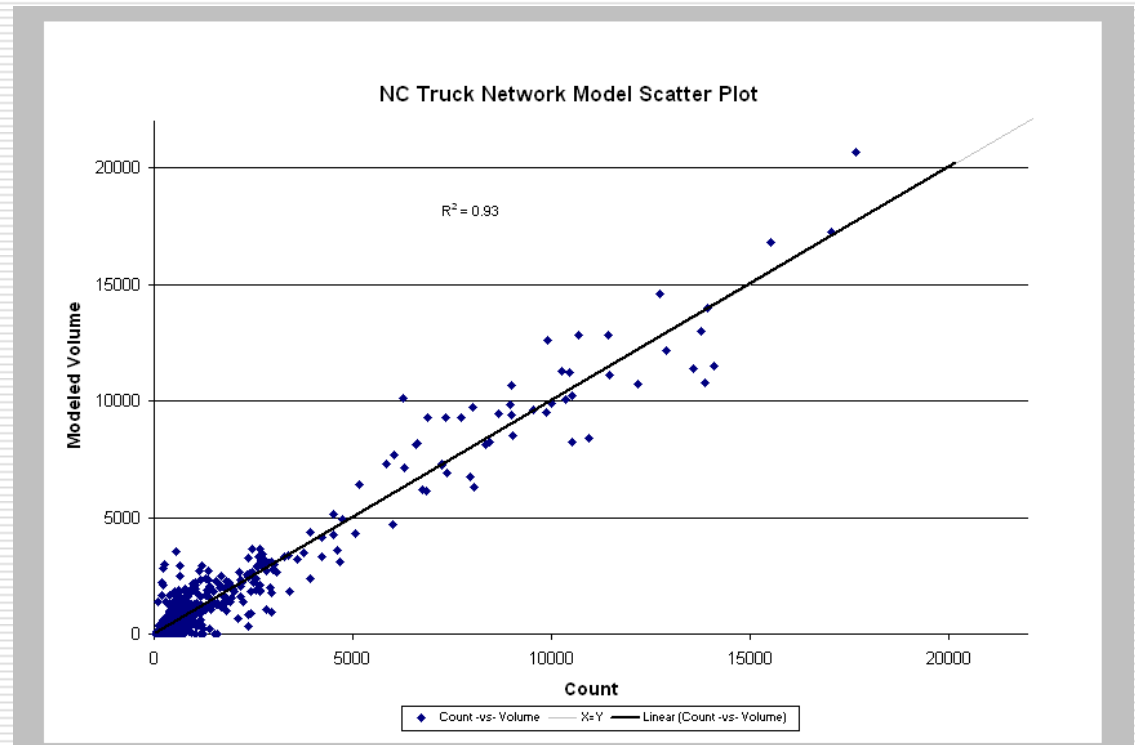2) Off-the-road, not reported, and not applicable

VMT & Volume Comparisons

NC Region	% VMT Deviation (modeled vs. observed)
Mountain	- 5.7%
Coastal	+ 11.5%
Central	+ 0.7%
Total	+ 1.9%

$R^2 = 0.93$

%RMSE = 40%

NC Truck Network Model Scatter Plot

VMT & Volume Comparisons (2)

Screenlines / Cordon Lines	Count	Modeled	% Deviation	% MDD*
1 - between Costal and Central	23045	26571	15%	+/- 28%
2 - between Central and Mountain	17355	19195	11%	+/- 30%
3 - surrounding Triangle	44832	43993	-2%	+/- 21%
4 - surrounding Triad	49268	45333	-8%	+/- 20%
5 - surrounding Charlotte	52829	56545	7%	+/- 19%
6 - surrounding Wilmington	11266	10378	-8%	+/- 35%
7 - surrounding Ashville	33201	30769	-7%	+/- 25%

* MDD: FHWA-recommended maximum desirable deviation (MDD)

Modeled Truck Volumes on the Network
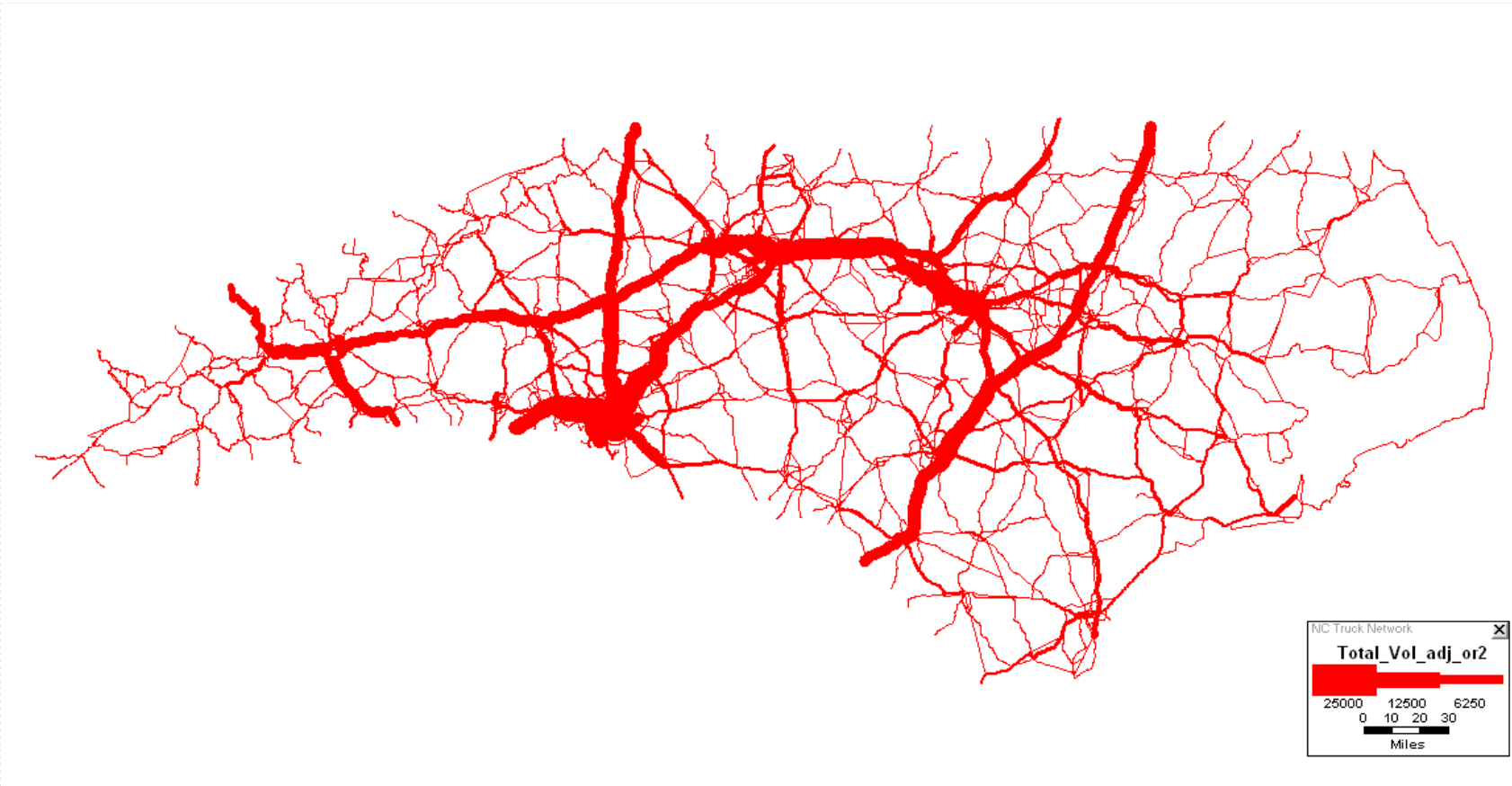
Use of the Model

- It is a statewide model with strengths in:
    - Intercity / inter-region travel forecasting
    - Intercity corridor studies
    - Rural area travel forecasting
    - I-E/through travel forecasting for a study area (e.g. MPO)
    - Vehicle diversion study
    - Alternative land use strategy testing

Potential 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

Thank You!