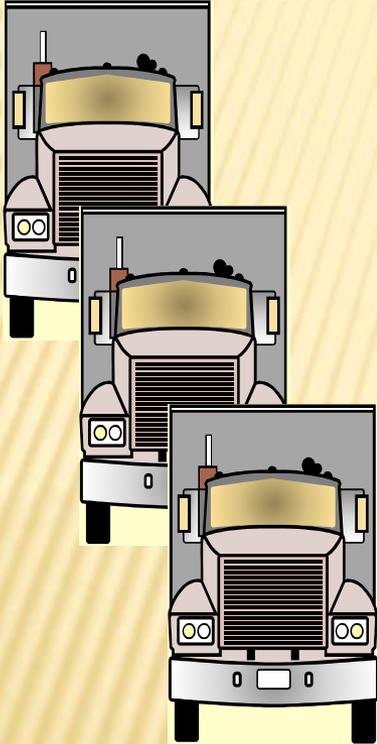


# Modeling and Assessing the Cost of Delays on an Heavily Trafficked Intercity Truck Corridor



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# Key Talking Points

## Project Motivation: Growing Highway Demand vs Highway Supply Imbalance

- ❖ Forecast Continued & Rapid Growth in National/ South-Eastern Truck Traffic

## Project Objectives:

- ❖ To develop and test a method that can be applied at the statewide, major corridor level for the purpose of deriving the monetary benefits of limiting within-corridor travel delays.

## Key Technical/Conceptual Challenges:

- ❖ How Do We Determine The Types and Volumes of Commodities Moving Over Our Highly Trafficked Highway Corridors, and
- ❖ How Does This Commodity Mix Affect Delay Costs? (and by implication, How Should We Measure the Benefits of Reducing or Eliminating Such Delays)?

## Example Corridor Study (Some Preliminary Results):

- ❖ I-85 Truck Freight Movements Through Georgia

## Freight Traffic Is Expected to Grow Significantly in Georgia and the South-Eastern U.S. over the next 4 decades

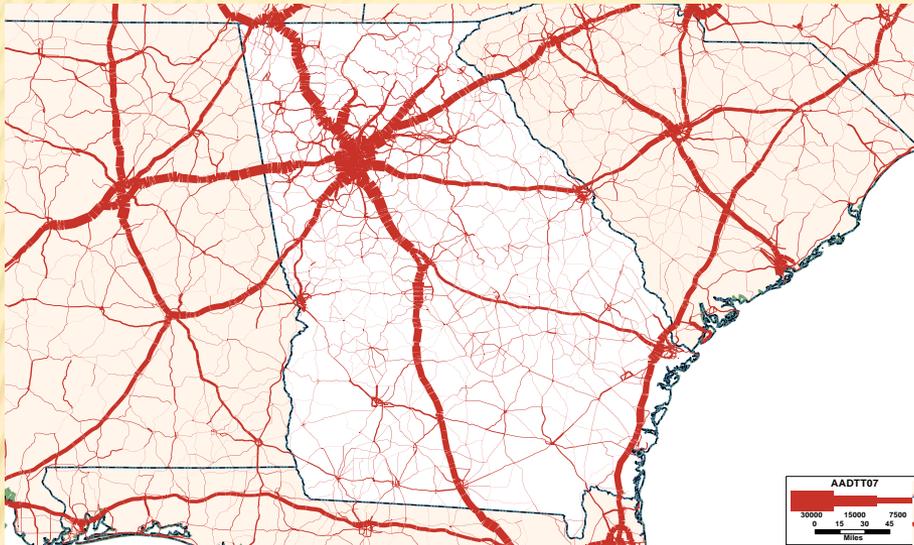
**Table ES.8 Freight and Economic Forecasts**

Source	Time Period	Tonnage Annual Growth Rate	Value Annual Growth Rate
GDOT Freight and Logistics Plan base forecast ( <i>TRANSEARCH Base Year Data w/FHWA FAF3 growth rates</i> )	2007-2050	1.5%	2.5%
Economy.com Georgia GDP	2007-2050	–	2.1%

**Table ES.9 Mode-Specific Forecasts**

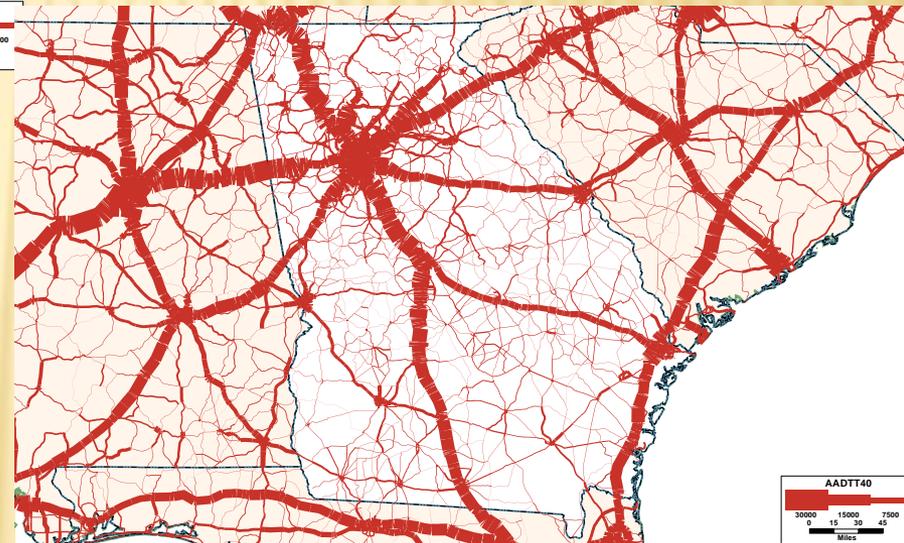
Mode / Source	Time Period	CAGR	Units
Port of Savannah Container Growth / GPA	2010-2050	4.5%	TEUs
Georgia Air Cargo / GDOT F&L Plan	2007-2050	3.1%	Tons
National Air Cargo / Federal Aviation Authority	2010-2030	5.0%	Revenue ton-miles
Georgia Truck / GDOT F&L Plan	2007-2050	1.5%	Tons
National Truck / American Trucking Assoc.	2009-2021	2.2%	Tons
Georgia Rail / GDOT F&L Plan	2007-2050	1.0%	Tons

# Example Truck Traffic Growth Forecast for the South-Eastern Region\* -> Rapid Growth



**2007 Truck Flows**

**\* Ton-miles of truck freight are projected to increase by 67% and truck cargo value to increase by 93% between 2015 and 2040**



**2040 Truck Flows**

\* Includes AL,FL,GA,NC,SC and TN Source: Federal Highway Administration – Freight Analysis Framework (Version 3)

# Project Tasks

**Task 1: Defining a Study Corridor**



**Task 2: Generating a Suitably Disaggregated Matrix of Origin-Destination-Commodity-Truck Class (O-D-C-V) Flows based on Location Specific Economic Activity Data.**



**Task 3: Carrying out a Multi-Class, Origin-Based and Congestion Sensitive Assignment of Truck Trips to the Selected Corridor**

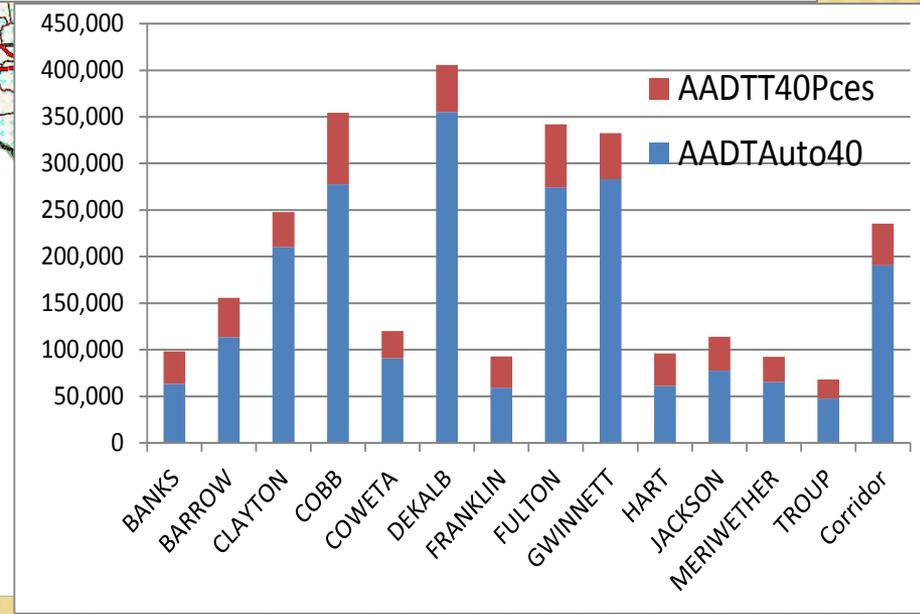
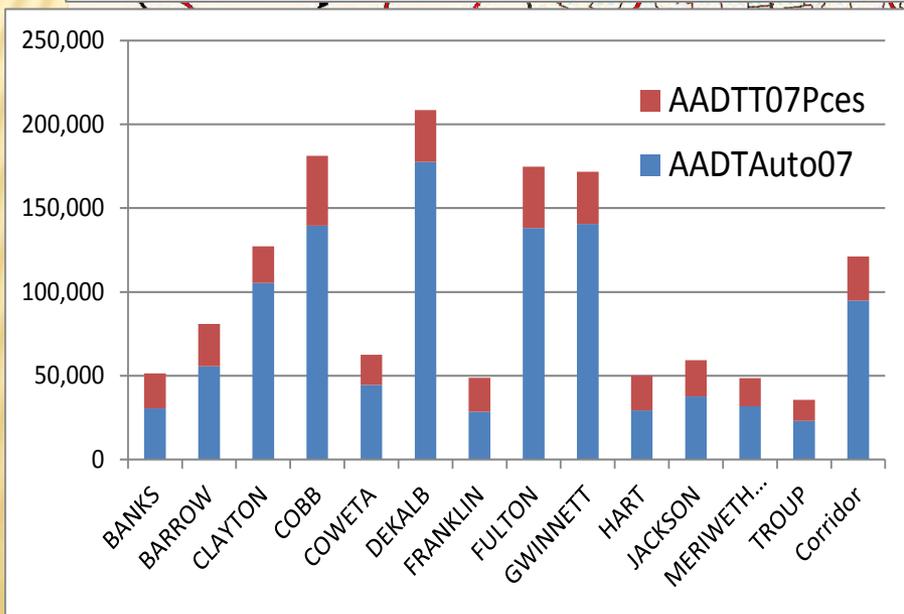
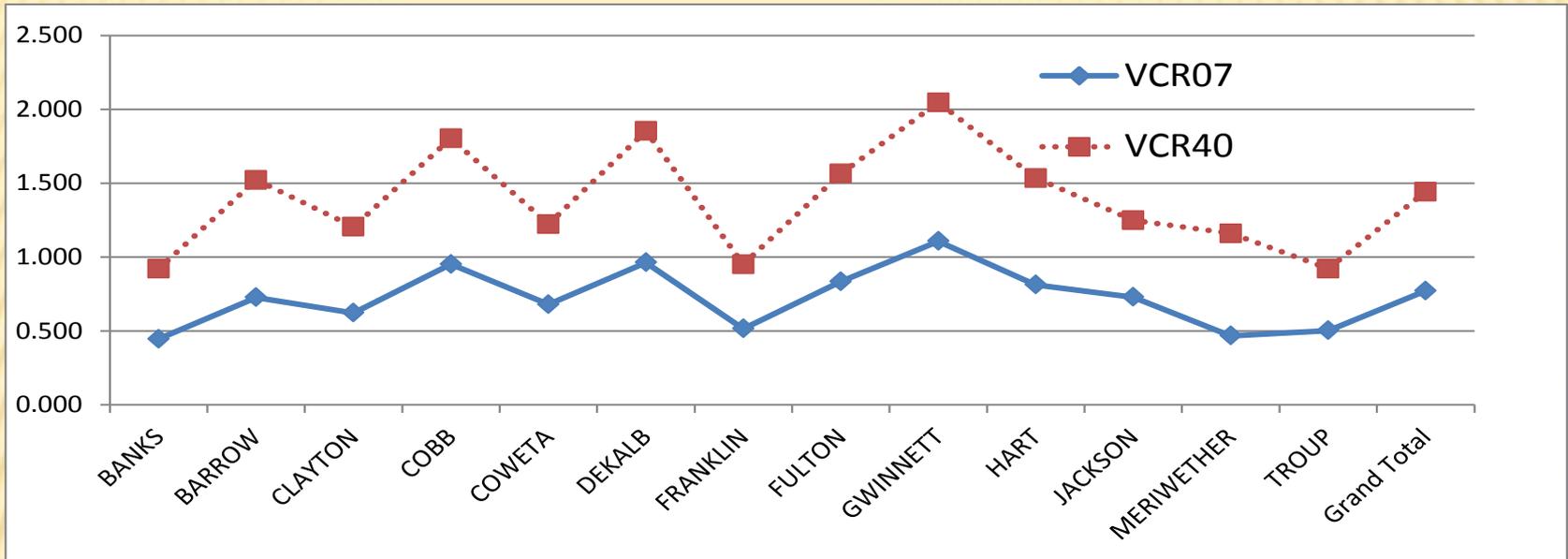


**Task 4: Estimating the Dollar Value of Recent and Future Year Truck Travel Time Savings (under different O-D disaggregation, different ton-to-truck conversions, different value of time assumptions)**



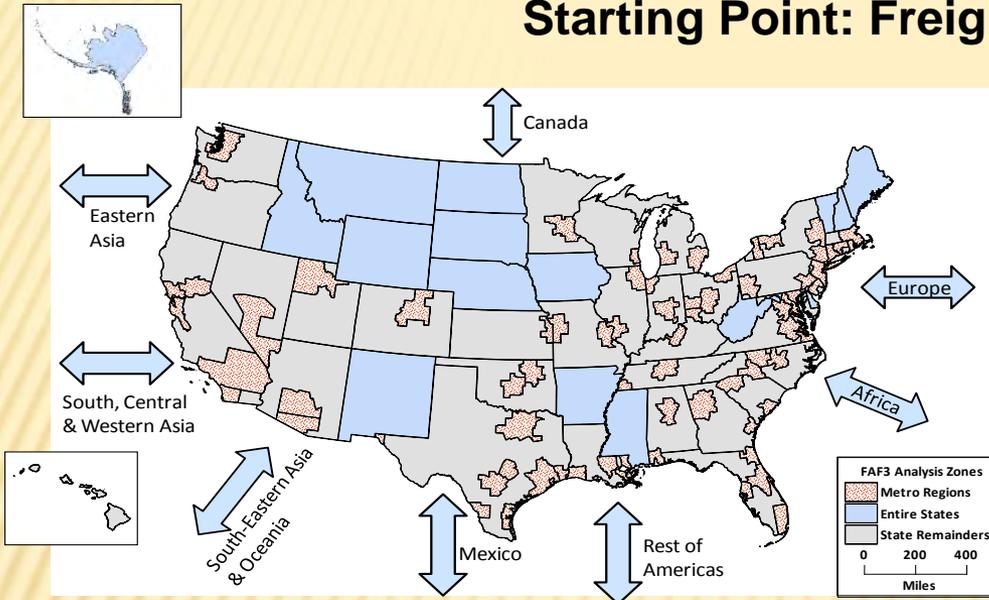
**Task 5: Writing the Draft and Final Project Reports**

# Task 1: Corridor Selection = I-85 /I-285 Through Georgia



# Task 2: Spatial & Commodity Disaggregation of O-D Flows

## Starting Point: Freight Analysis Framework (FAF3)



Spatial Resolution (based on 2007 U.S. Commodity Flow Survey regions):  
 123 domestic regions (74 metro/part metro area regions, 33 state remainders, and 16 entire state regions) + 8 foreign regions

Table 2.1 FAF3 2-Digit SCTG\* Commodity Classes

SCTG	Commodity	SCTG	Commodity	SCTG	Commodity
01	Live animals/fish	15	Coal	29	Printed products
02	Cereal grains	16	Crude petroleum	30	Textiles/leather
03	Other agricultural products.	17	Gasoline	31	Nonmetal mineral products
04	Animal feed	18	Fuel oils	32	Base metals
05	Meat/seafood	19	Natural gas and petroleum prods.	33	Articles-base metal
06	Milled grain prods.	20	Basic chemicals	34	Machinery
07	Other foodstuffs	21	Pharmaceuticals	35	Electronics
08	Alcoholic beverages	22	Fertilizers	36	Motorized vehicles
09	Tobacco prods.	23	Chemical prods.	37	Transport equipment
10	Building stone	24	Plastics/rubber	38	Precision instruments
11	Natural sands	25	Logs	39	Furniture
12	Gravel		Wood products	40	Misc. mfg. products.
13	Nonmetallic minerals	27	Newsprint/paper	41	Waste/scrap
14	Metallic ores		Paper articles	43	Mixed freight
				99	Commodity unknown

Commodity Class Detail (for O-D Flows):  
 43 2-Digit Standard Classification of Transported Goods (=SCTG) Codes, as developed for 2007 U.S. Commodity Flow Survey.

\* Standard Classification of Transported Goods

# Steps in Spatially Disaggregating Corridor-Based Commodity Flows, Truck Trips & Costs

Input-Output (Use & Make) Modeling of Commodity Flow and Industrial Activity Data\*

1. Develop Spatially Disaggregated (County/Sub-County) Commodity Productions & Attractions

2. Develop O-D-Commodity Flow Estimates

(Modified) FAF Highway Network

Pre-Load FAF3 Auto Traffic Volumes

GDOT/HPMS Truck Counts

3. Convert to O-D-Vehicle Trips (Including Empty Trips)

3a. Convert to Truck PCEs

Identify/Modify High Volume Corridor O-D-Vs

4. Flow Truck Trips Over Highway Network Using Multi-Vehicle Class Origin-Based User Equilibrium Assignment\*\*

Flow/Speed Validations

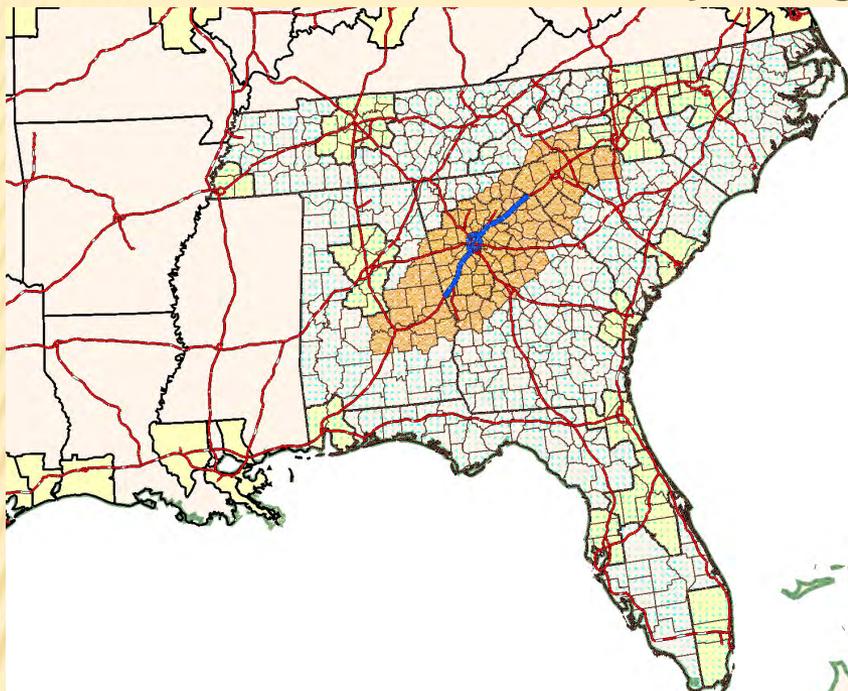
ATRI Speed Data

5. Compute O-D-V-(C) Trip Costs =  
Function (Money + Travel Time + Travel Time Unreliability)

\* Includes CFS, CBP/ZBP, BEA, EPA, DOE, USDA data sources

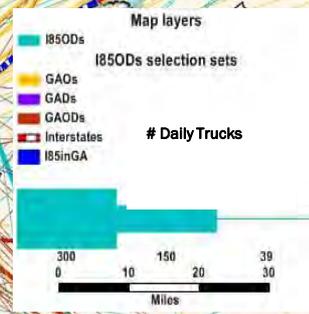
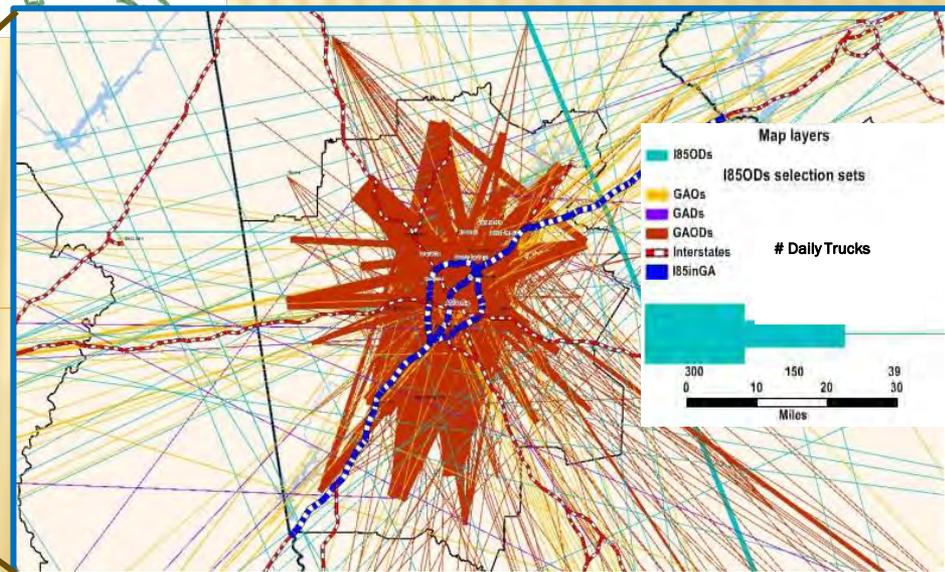
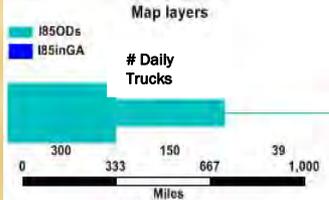
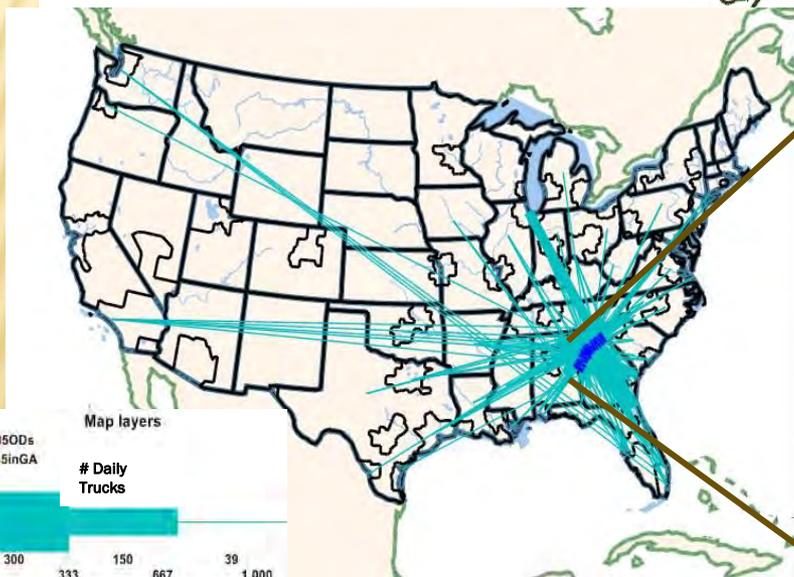
\*\*Using TransCAD's OUE Assignment Routine

# Six-State South-Eastern County Disaggregations of O-D Flows (Preliminary)

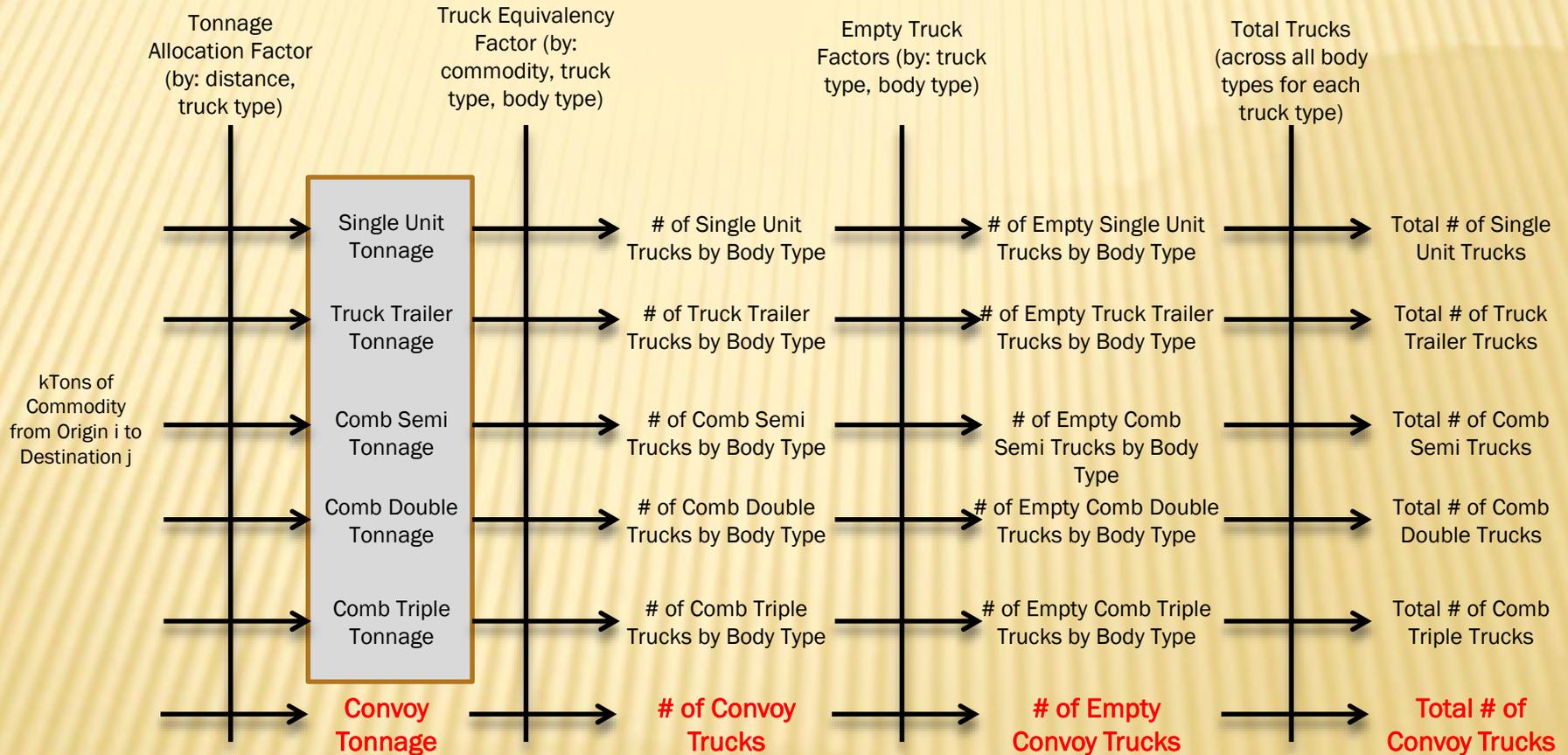


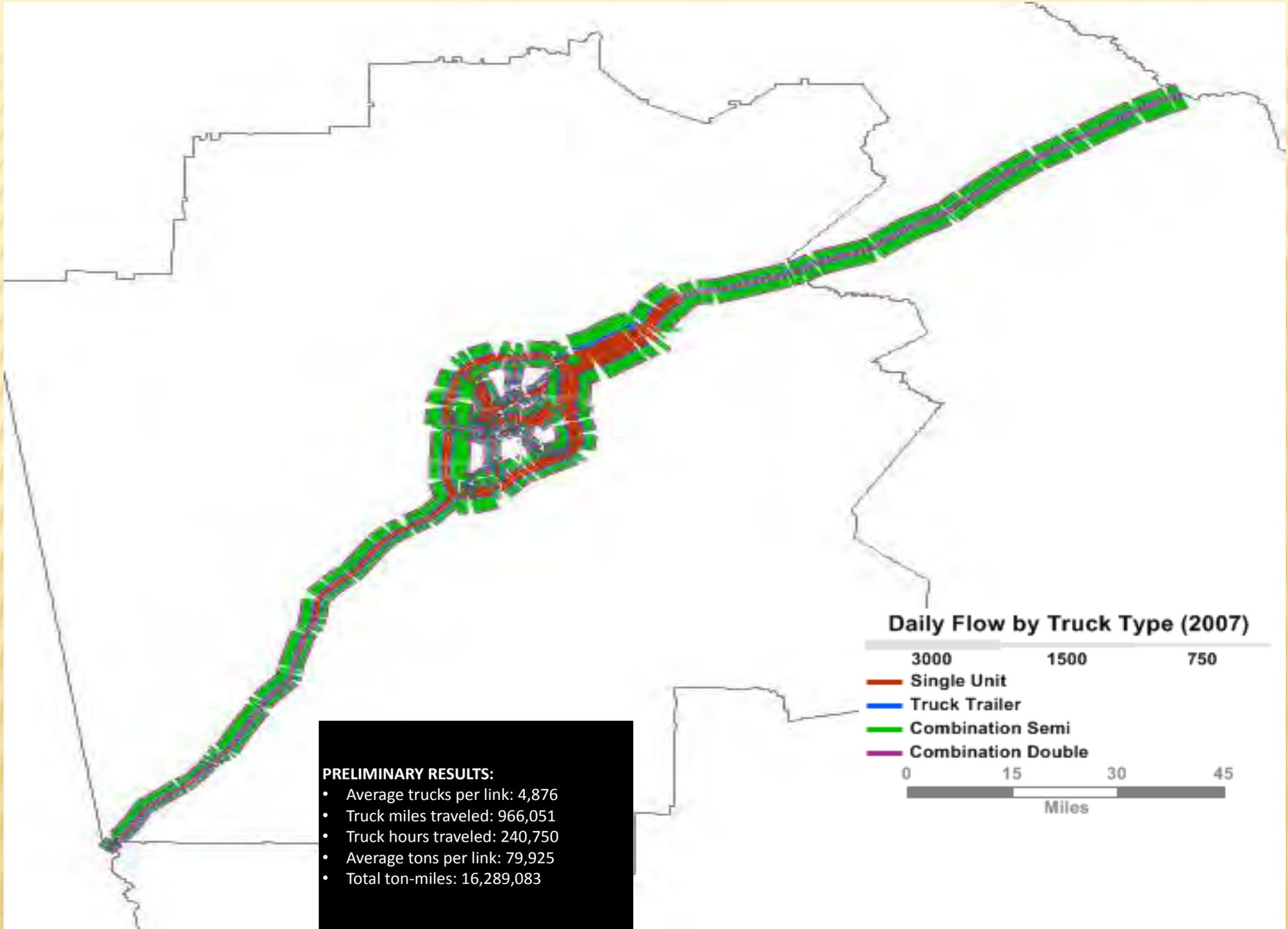
## Number Of O-D Flows Modeled

- External-External (EE) Flows  =  $102 \times 102$  O-D Flows
- Internal-External (I-E)  and  
External-Internal (E-I) Flows  =  $534 \times 102$  O-D Flows
- Internal-Internal (I-I) Flows  =  $534 \times 534$  O-D Flows

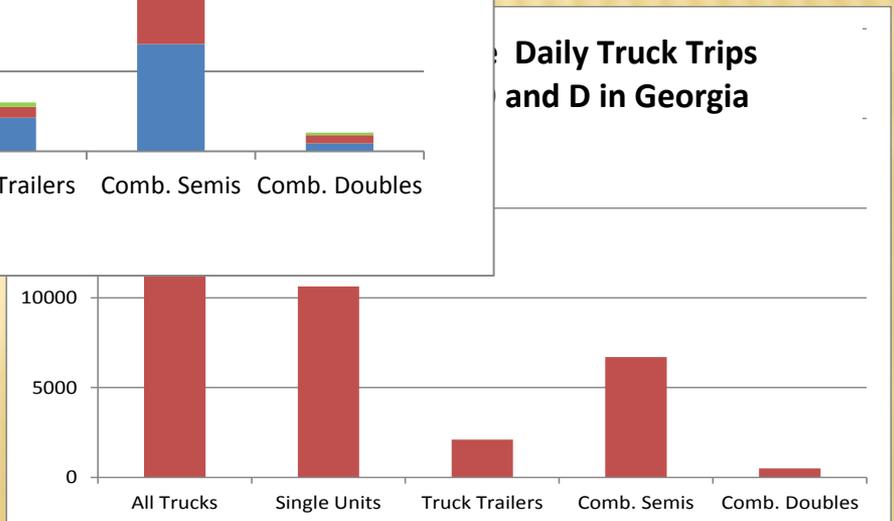
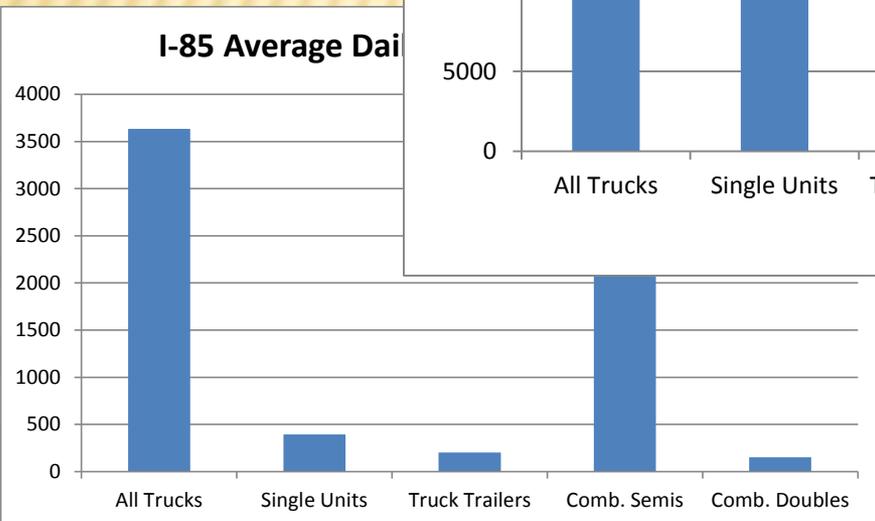
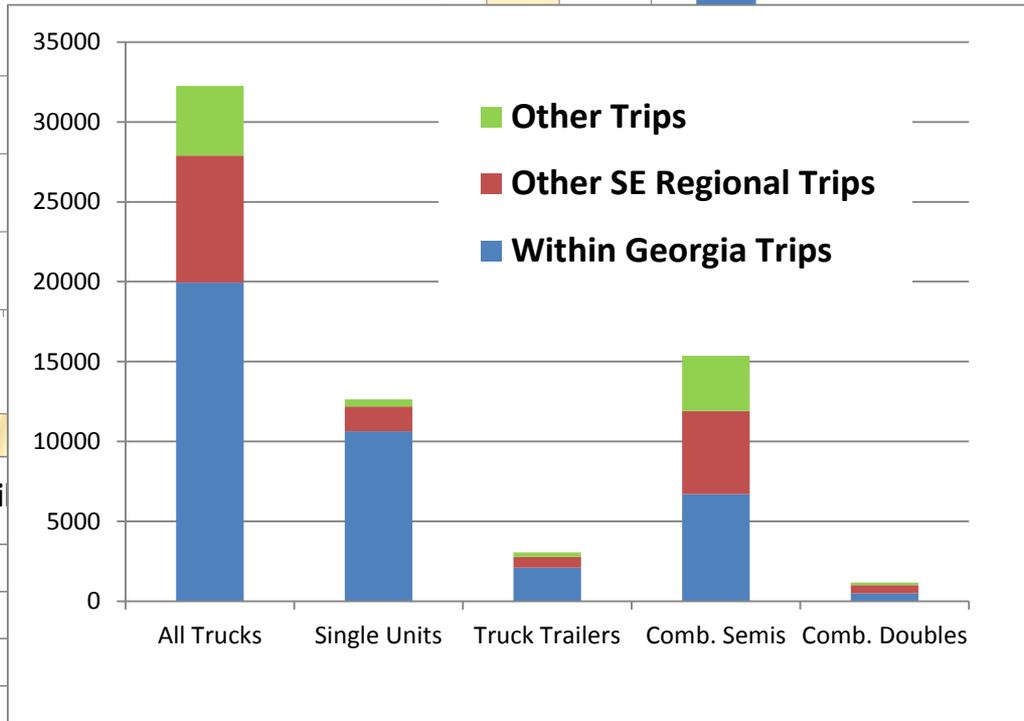
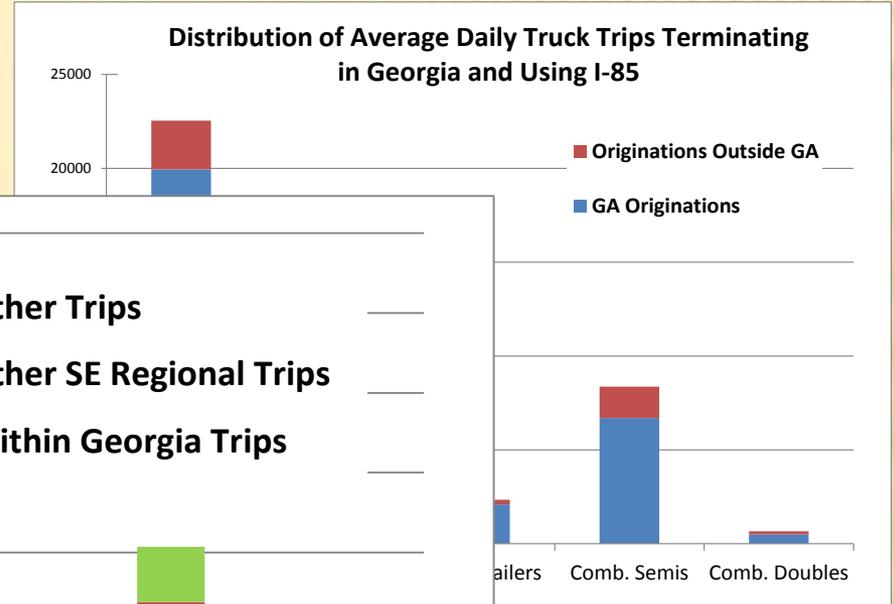
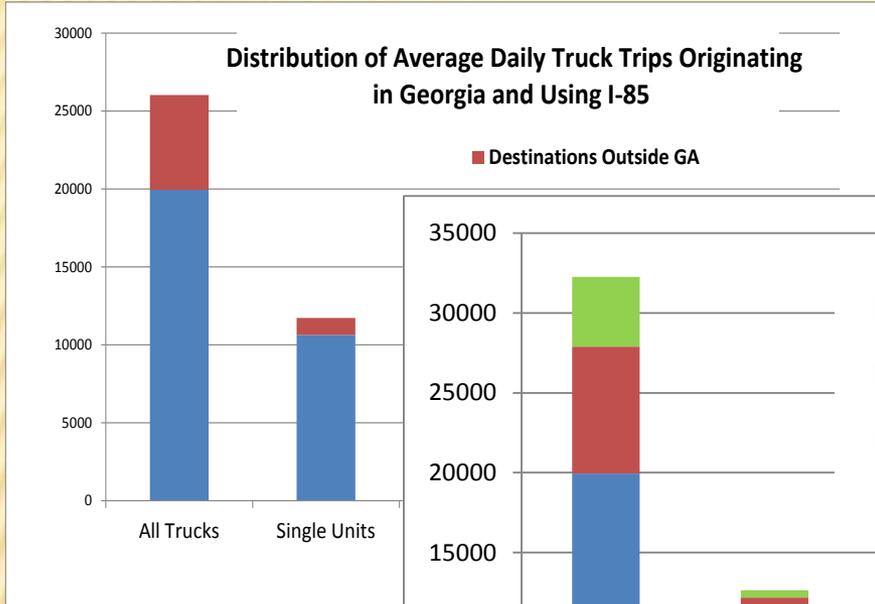


# Task 2a. Conversion of Commodity Tons to Truck Trips

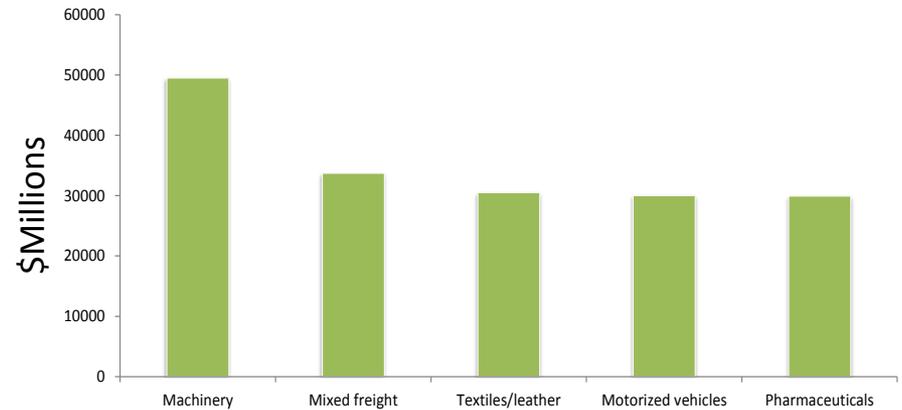
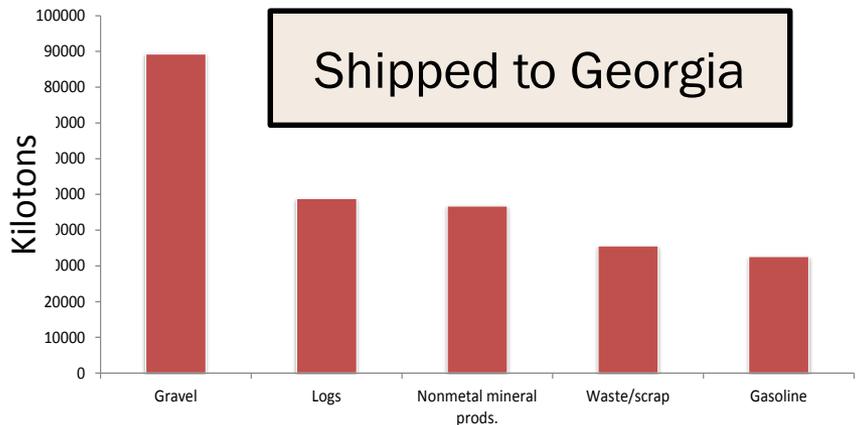
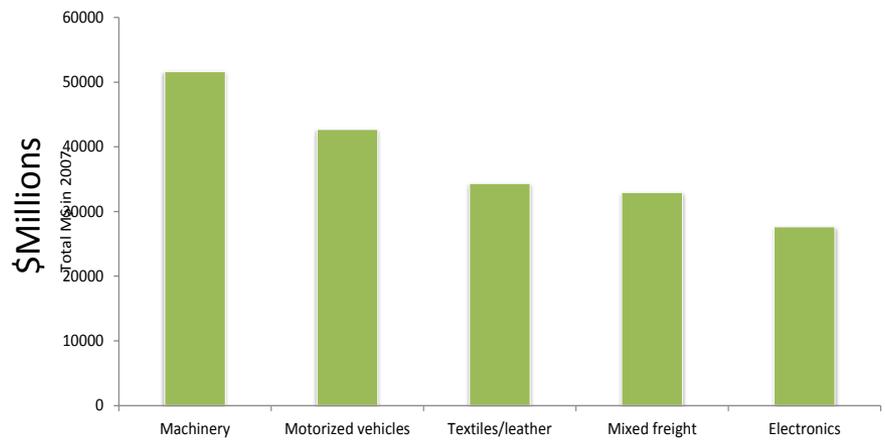




# Model Estimated Daily Truck Trips Volumes on I-85 (in 2007) by Truck Type (Preliminary)



# Model Estimated Top 5 Commodity Classes Moving On I-85 in 2007 by Weight (Ktons) and Value (\$Millions) (Preliminary)



## Task 4: Calculating The Costs of Trucking Delay

### Measurement Issues:

#### 1) What Are The Relevant Delay-Induced Costs?

a) *Direct Vehicle O&M Costs*: Labor, Fuel, Administrative, Maintenance, Insurance, etc. per mile or per hour costs)

b) *Other Travel Time-Based Costs*: Extra Unloading Costs, Extra In-Transit Inventory Holding Costs, Cargo Lost Value Costs, Lost Cargo Consolidation Savings

c) *Service Time Unreliability Costs*: Short Term: Production Schedule Disruption Costs, Longer term: Increased Safety Stock Holding Costs, Loss Of Customers.

#### 2) How Do We Value? What Factors Impact Such Delay Costs?

d) *Vehicle Configurations*: carrying capacity, body type, fuel use, service area, IT use..

e) *Commodity Characteristics*: perishability, unit value, special carriage needs,...

f) *Supply Chain Considerations*: scheduling sensitivity, customer sensitivity/satisfaction, industrial sector, company size, use of outsourcing,...

#### 3) Who Pays (Which) Delay Costs?

g) *Shippers/Carriers/Receivers/Final Customers.....*

## Task 4: Calculating The Costs of Trucking Delay

$$\text{Transportation Cost} = (\alpha_1 * \text{Money}) + (\alpha_2 * \text{Travel Time}) + (\alpha_3 * \text{Travel Time Reliability})$$

for a set of model calibrated cost sensitivity parameters  $\alpha_1 - \alpha_3$ , and where “Money” costs is broken down as follows:

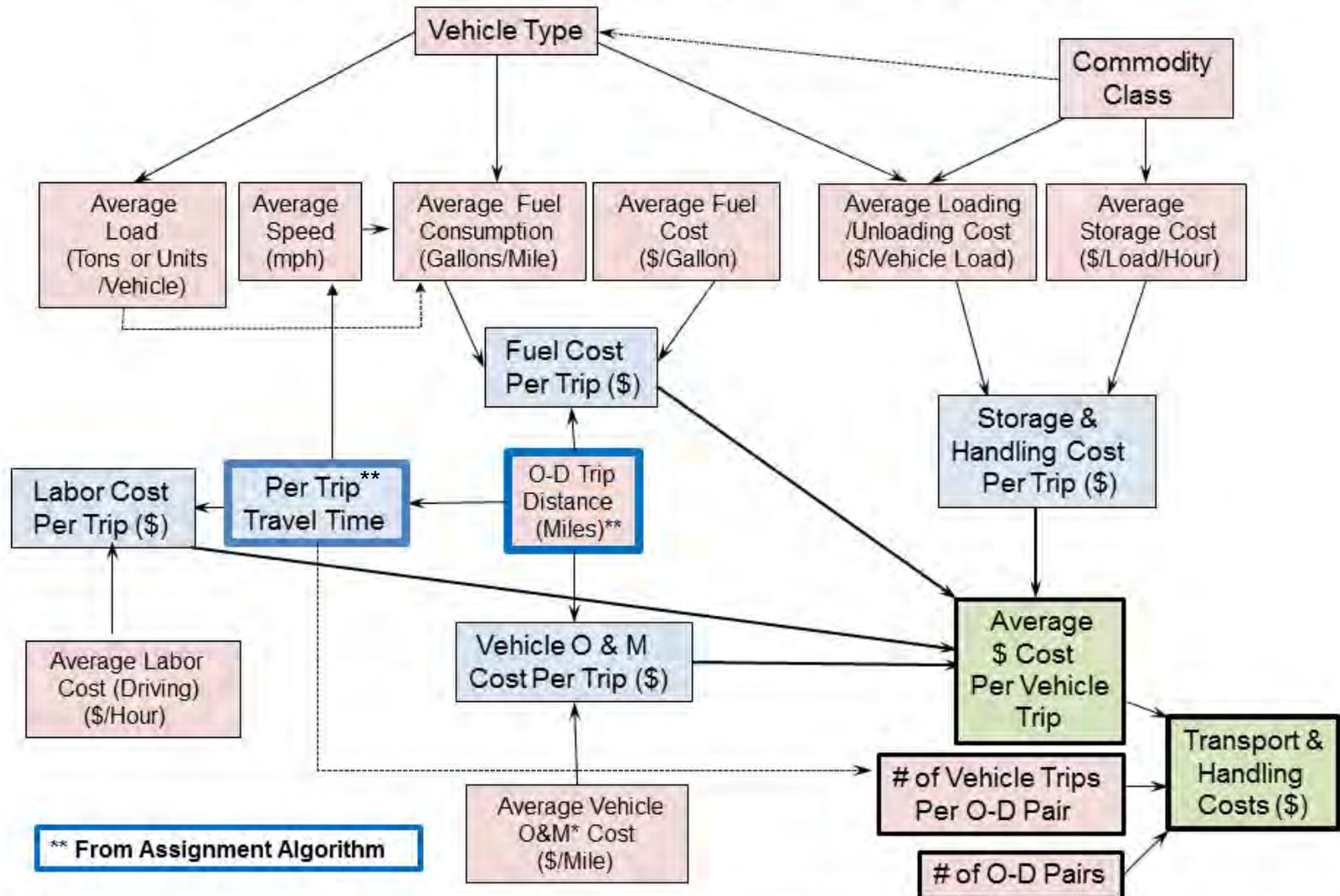
$$\text{Money} = \text{Labor Costs (mainly Driver Wages and Benefits)} + \text{Vehicle O\&M Costs}$$

where O&M refer to the marginal (per mile or per hour) costs of vehicle operation and maintenance, including fuel costs, vehicle repair, maintenance and insurance costs, lease or purchase payments, permits and licenses, and tolls.

\*E.G. Using Standard Deviation in Truck O-D Travel Times

# Task 4: Estimating the Dollar Value of Truck Travel Time Savings

## Truck Transport and Logistics Cost Modeling Concept



\* Vehicle O&M cost includes costs associated with tires, oil, parts maintenance and replacement, insurance and licenses

# Task 4: Calculating The Costs of Trucking Delay

## A. European Studies\*:

### Value of Travel Time (Dollar/Hour):

	Vehicle VTT		Goods VTT		Goods+Vehicle VTT	
	Low	High	Low	High	Low	High
2015 Dollars/Hour	46.26	104.07	5.78	34.69	50.59	117.08

### Reliability Ratio (Travel Time) = Value of SD of Travel Time / Value of Travel Time

#### TTRR (Shippers and Carriers)

	Low	High
	0.10	1.24

\* See De Jong (2014), Tables 9.2 and 9.4

## B. U.S. Studies: \*\*

### Vehicle VTT

	Low	High
Dollars/Hour	25	200

### ATRI (2014 Update):

\$1.676/Mile \$76/Hour

\*\* See Hussein and Petering (2009) Mei and Horowitz (2011), Southworth and Gillette (2011), Gong et al (2012)

ATRI (2014) *Analysis of the Operational Costs of Trucking: A 2014 Update*. American Transportation Research Institute. Arlington, VA. <http://atri-online.org/2014/09/24/3708/>

Bone, I., Wallis, I., O'Fallon, C. and Nicholson, A. (2013) *Reliability and Freight Literature and Practice Review*. Research Report 538. NZ Transport Agency, Wellington, New Zealand,

De Jong, G. (2014) *Freight Service Valuation and Elasticities*. Chapter 9 in *Modelling Freight Transport*. Tavasszy, L. and Do Jong, G. (Eds.)

Gong, Q. , Miao, Q., Wang, B. X. and Adams, T.M. (2012) *Assessing Public Benefits and Costs of Freight Transportation Projects: Measuring Shippers' Value of Delay on The Freight System*. CFIRE Project 04-14. Texas Transportation Institute. College Station, TX.

Hussein, M.I. and Petering, M.H.E. (2009) *A Policy Oriented Cost Model For Shipping Commodities By Truck*. CFIRE Paper 09-4. University of Wisconsin, Madison.

Mei, Q. and A.J. Horowitz (2011) *Incorporating toll pricing policy into a microsimulation model for long-distance freight transportation*. National Center for Freight & Infrastructure Research & Education, University of Wisconsin – Milwaukee. Paper No. 11-2.

Southworth, F. and Gillette, J. (2011) *Trucking in Georgia: freight performance measures*. Georgia Department of Transportation, Research Project 10-16. Final Report. Atlanta, GA.

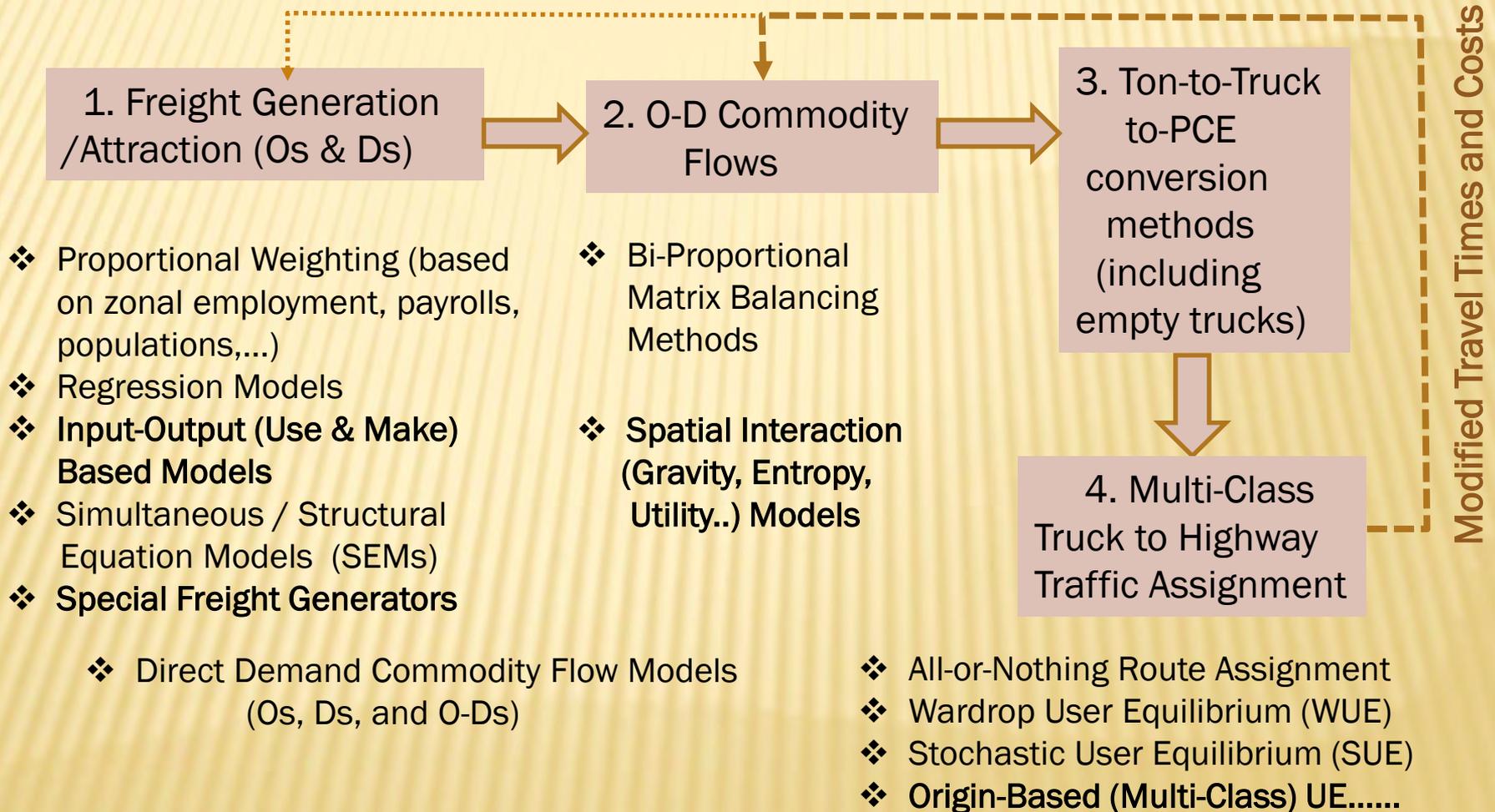
## Summary- Project Innovations

The R&D looks to improve current planning practice through:

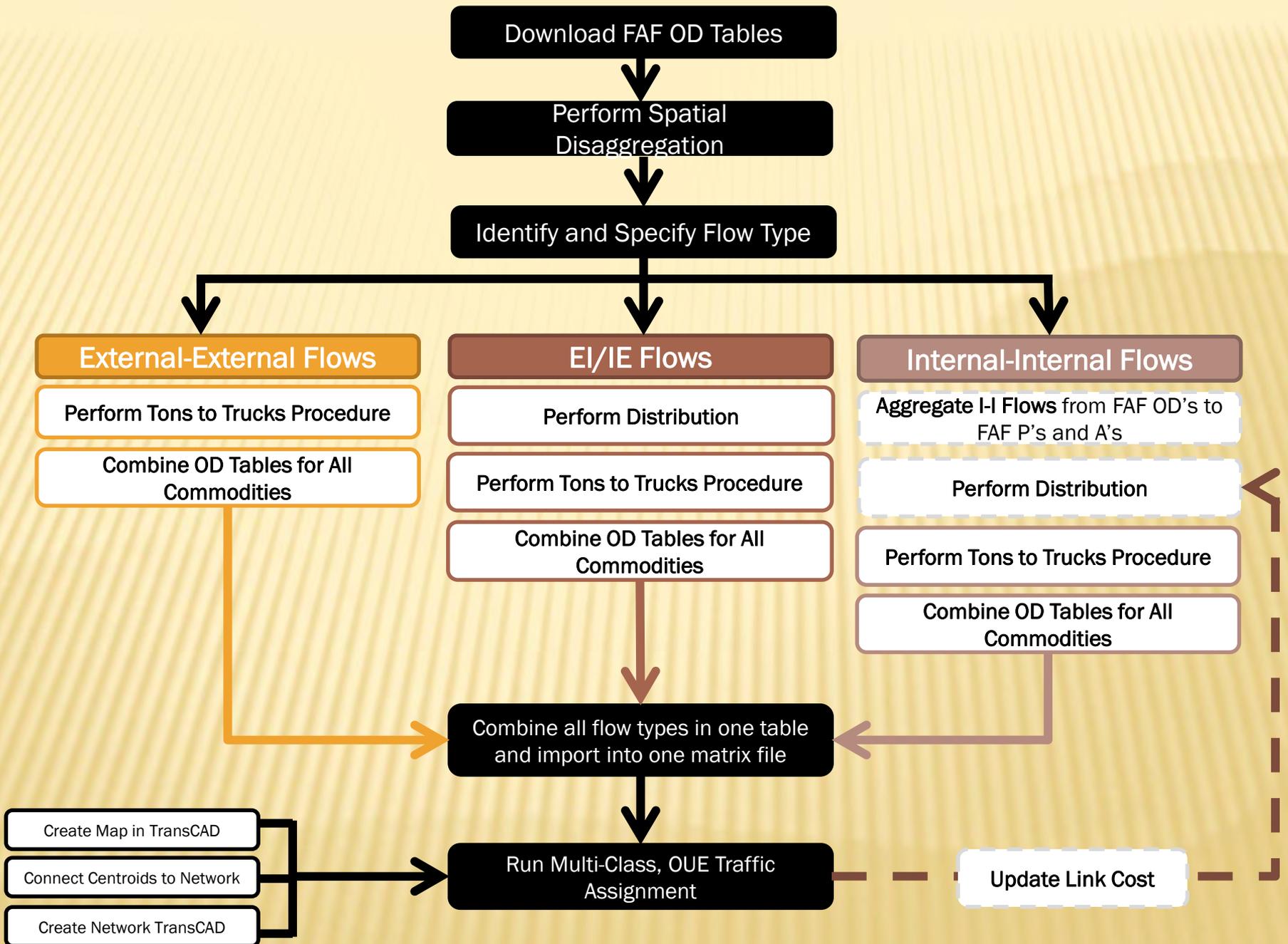
- ❖ The Use of alternative spatial and industrial sector disaggregation methods.
- ❖ The Use of recent advances in origin-based network route assignment modeling to connect detailed O-D-Commodity specific flow estimates to specific corridor movements.
- ❖ The Use of the latest theoretical developments in value of time modeling to produce monetized benefits estimates grounded in travel behavior and spatial economic theory
- ❖ Combining All of The Above Within A Single Data-Driven Modeling Framework

## Task 2: Generating a Disaggregated Matrix of Origin-Destination-Commodity-Truck Class (O-D-C-V) Flows

Alternative Flow Disaggregation Methods recently reviewed in Southworth, F. "On The Creation of Spatially Disaggregated Commodity Flow Matrices: An Overview of U.S. Studies" (Draft report to Oak Ridge National Laboratory, January, 2014)\*



\* Some 30 Past Studies Reviewed



## 2.1a County Level Freight Generation (Commodity Production) Modeling

**Coal Production and Imports:** The amount of coal mined and shipped does not correlate well with either employment or payroll data, and its spatial disaggregation was therefore treated separately. There is a limited amount of coal production in the six state south-eastern region, most of it concentrated in just 10 Alabama and 3 Tennessee counties. Annual coal plant production data for these counties, reported in kilotons, was created from individual coal plant data reported by the Energy Information Administration (EIA, 2014). To this data were added FAF3 seaport region-specific imports, extracting only those moved inland by truck. Over 94% of these within- region shipments came in through the five ports Charleston SC, Jacksonville and Tampa FL, Mobile AL, Savannah GA, with a small volume also entering through the port district covering the Remainder of North Carolina: a result found to be consistent with the EIA's 'Monthly Report IM 145' data series for 2007. This combined production and import data was then used to share internal coal originating shipment volumes across study area counties in a manner that matched the volumes reported by FAF3 truck shipments.

## 2.1b County Level Freight Attraction (Commodity Consumption) Modeling

Preferred Approach = A “Supply-Side Input-Output Model”

**B Coal Consumption and Exports.** To obtain the likely destination “U county for coal shipments, a surrogate for annual coal delivery data was obtained from the (EPA’s eGrid website, in the form of utility plant-specific and coal-based net electricity generation, reported in megawatt-hours, or MWh (EPA, 2014). According to FAF3, coal exports resulting from truck trips into a port county were limited in 2007, principally through Mobile AL, with a small volume also passing through Miami FL.

Let  $V(C)$

$U(C,g)$  = FAF3 regional coal truck freight destination totals were then shared to these utility plant-located counties using the MWh data, total (\$) again rectified to match FAF3 intra-regional truck destination totals. The most likely error introduced by this method is the  $T(C,j)$  = assumption that truck mode shares are similar across within-region counties.

where  $T(C,j)$ ,  $T(C,F)$  = the tons of commodity C destined for county j and for FAF region F, respectively,  $E(j,g)$  = the annual employment in industry g in county j receiving commodity C; and the summation is over all industries that consume commodity C.

\* BEA I-O Tables for 377 detailed NAICS industrial classes

## 2.2 Inter-County (O-D) Commodity Flow Modeling

**Approach 1: Cross-Product Multiplication.** For each Commodity Class C:

$$\text{Tons}(i,j) = \text{FAF}(i,j) * [ O(i) / \text{OFAF}(i) * D(j) / \text{DFAF}(j) ]$$

where  $\text{Tons}(i,j)$  = the annual tons of the commodity being flowed moving between counties  $i$  and  $j$ ;  $O_i$  = county  $i$  production (originations),  $D_j$  = county  $j$  attraction (destinations), and  $\text{OFAF}(i)$  and  $\text{DFAF}(j)$  = the county aggregated FAF3 regional activity totals for the commodity being flowed

**Approach 2 (Preferred): Cost Sensitive Spatial Interaction Modeling:** For each Commodity Class C

$$\text{Tons}(i,j) = O(i) * D(j) * G[\text{Cost}(i,j)] * A(i) * B(j)$$

where the  $A(i)$  and  $B(j)$  = the usual iteratively derived balancing factors\* (after Wilson, 1967); and where  $G[\text{Cost}(i,j)]$  = a function of marginal cost of inter-county transportation; and where each  $i$ -to- $j$  cost element is itself a multi-component function of the form:

$$\text{Transportation Cost} = \alpha_1 * \text{Money} + \alpha_2 * \text{Travel Time} + \alpha_3 * \text{Travel Time Reliability}$$

\* i.e.  $A(i) = 1 / \sum_j B(j).D(j).G[\text{Cost}(i,j)]$  for all  $i$ ; and  $B(j) = 1 / \sum_i A(i).O(i).G[\text{Cost}(i,j)]$  for all  $j$ .

## 2.3a Truck Equivalency and Empty Loading Factors (based on Battelle, 2011)

First, Identify O-D shipment distance and assign to a distance interval range.

Distribute truck types  $v=1,2,..5$  across 5 distance intervals (based on VIUS)

### Distance Intervals

(1,2,..5):

< 51 mi.,

51-100 mi.,

101-200 mi.,

201-500 mi.,

> 500 miles.

Truck type  $v$  ( $=1,2,..5$ ) trips are then assigned to each distance-bin specific O-D-C flow as:

$$Y_v + E_v$$

For:

$$Y_v = \sum_{k=1}^{k=9} \frac{X_{Cv} \beta_{Cvk}}{\omega_{Cvk}}$$

where,

$Y_v$  = number of trucks of truck type  $v$

$X_{Cv}$  = tons of commodity  $C$  moved by truck type  $v$

$\beta_{Cvk}$  = the proportion of commodity  $C$  moved by truck type  $v$  with body type  $k$

$\omega_{Cvk}$  = the average payload of truck type  $v$  with body type  $k$  transporting commodity  $C$

### Truck Body Types

( $k=1..9$ ):

*auto,*

*livestock,*

*bulk,*

*flatbed,*

*tank,*

*dry van,*

*reefer,*

*logging*

*other.*

And:

$$E_v = \sum_{k=1}^{k=9} \frac{X_{Cv} \beta_{Cvk} E_{vk}}{\omega_{Cvk}}$$

where,

$E_v$  = number of empty trucks of truck type  $v$

$X_{Cj}$  = tons of commodity  $C$  moved by truck type  $v$

$\beta_{Cvk}$  = the percent of commodity  $C$  moved by truck type  $v$  with body type  $k$

$\omega_{Cvk}$  = the average payload of truck type  $v$  with body type  $k$  transporting commodity  $C$

$E_{jk}$  = empty truck factor for truck type  $v$  with body type  $k$