Truck GPS Data for Freight Performance Measurement, Modeling, and Planning

presented by

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Background on ATRI Data

Background: ATRI Board of Directors

Maverick Transportation LLC

Cummins

GREAT WEST CASUALTY COMPANY The Difference is Service

Con-way

SCHNEIDER NATIONAL

ABILITY TRI-MODAL

FedEx Freight

Trimac

ABF

ATA American Trucking Associations

Tennessee Trucking Association

UPS Freight

COMBINED TRANSPORT INCORPORATED

ATRI American Transportation Research Institute

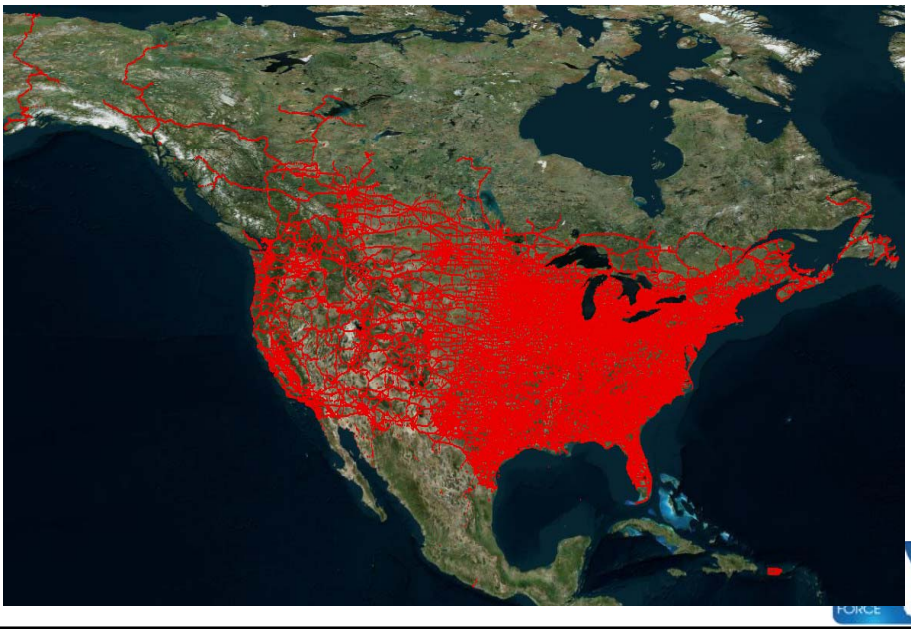
Florida Model Task Force

Background: ATRI RAC

ATRI Truck GPS Dataset

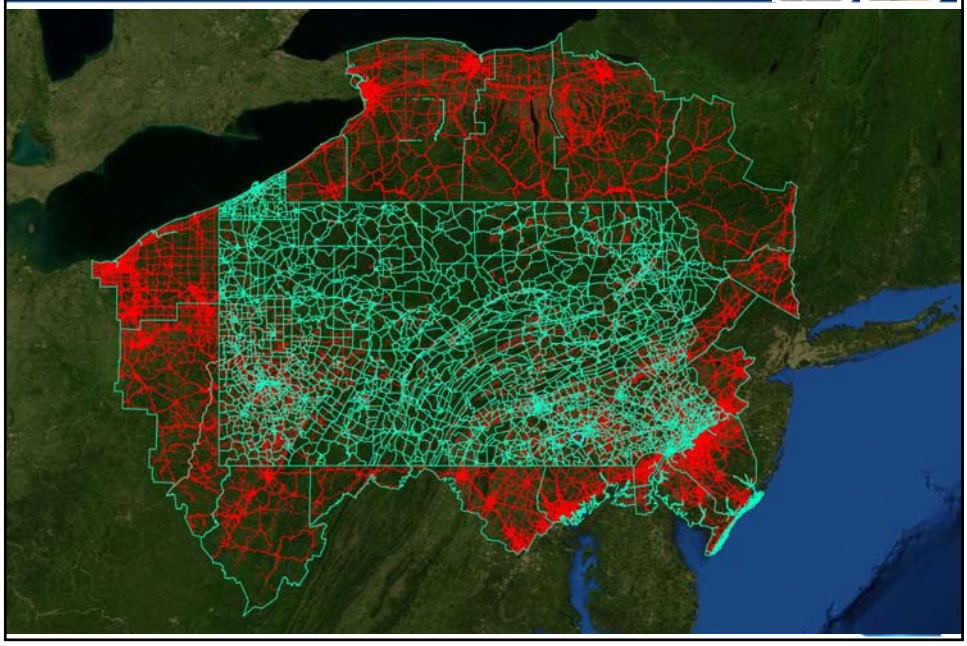
- Ongoing Truck GPS data research beginning in 2001
  - Comprehensive North American Truck GPS dataset
  - "Big Data"
    - Real time data feeds/ significant hardware and software
    - Currently near 100 million data points per day
    - Will approach 1 billion points per week later this year
  - Fully deployed applications
    - Performance measurement/management
    - Freight flow and truck trip modeling
  - Key research areas
    - Economic competitiveness and supply chains
    - Truck volume/intensity/national travel patterns
    - Weather, parking, emergency events

ATRI Truck GPS Dataset – One Day



ATRI Truck GPS Dataset

ATRI Truck GPS Dataset



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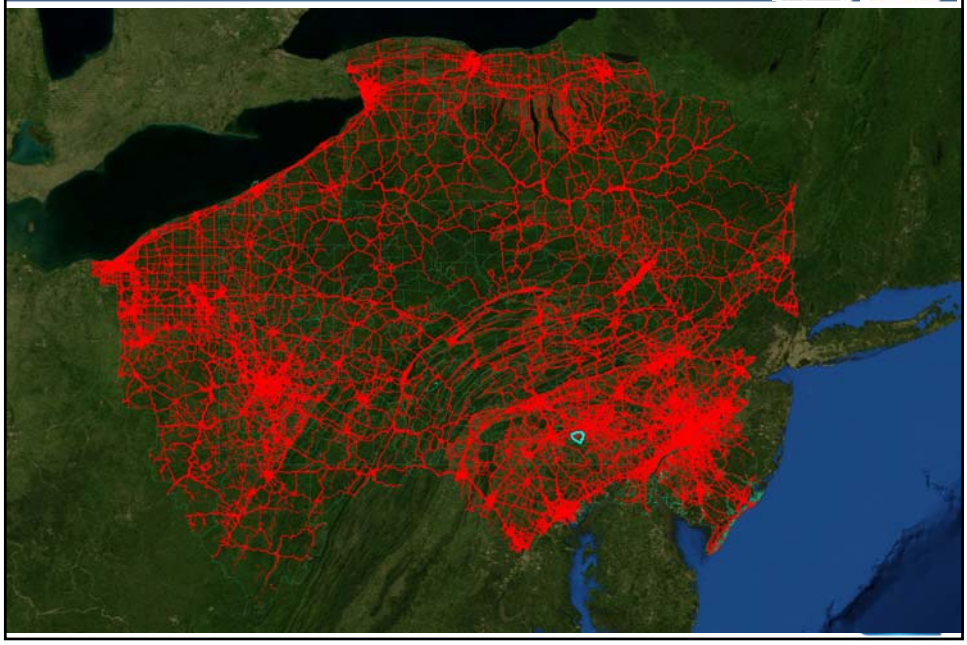

ATRI Truck GPS Dataset

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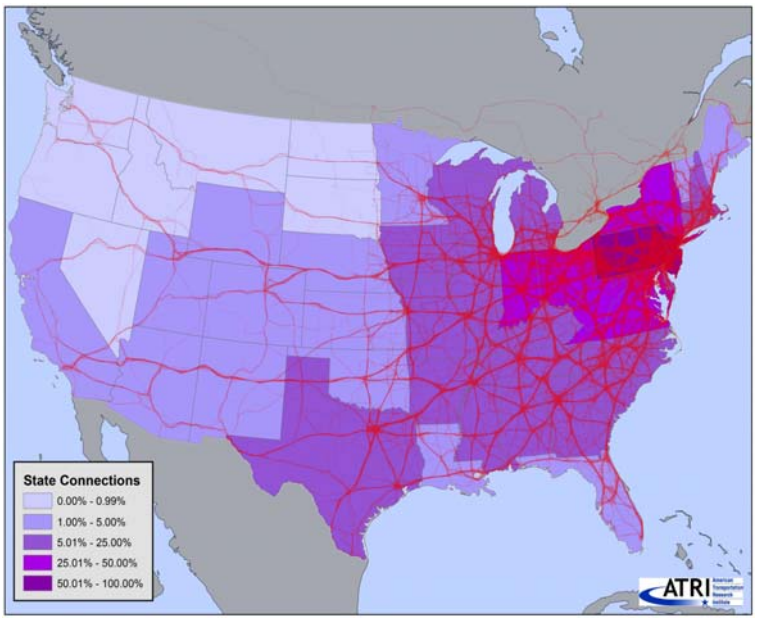

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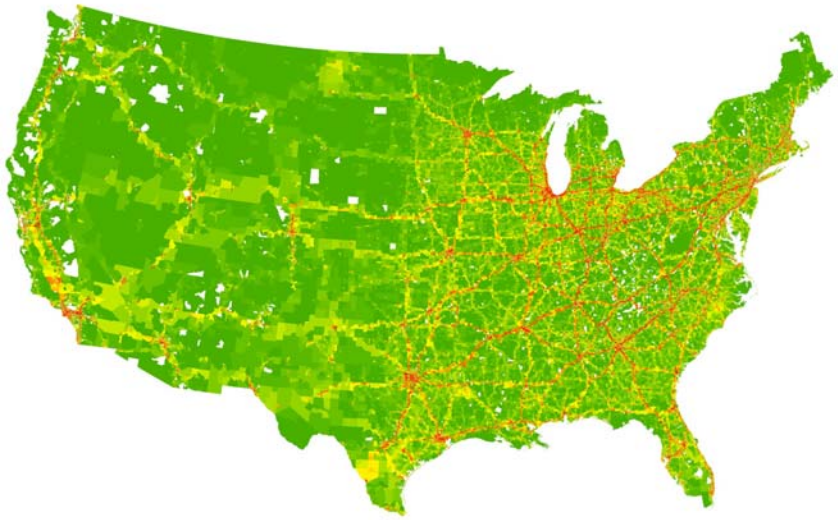

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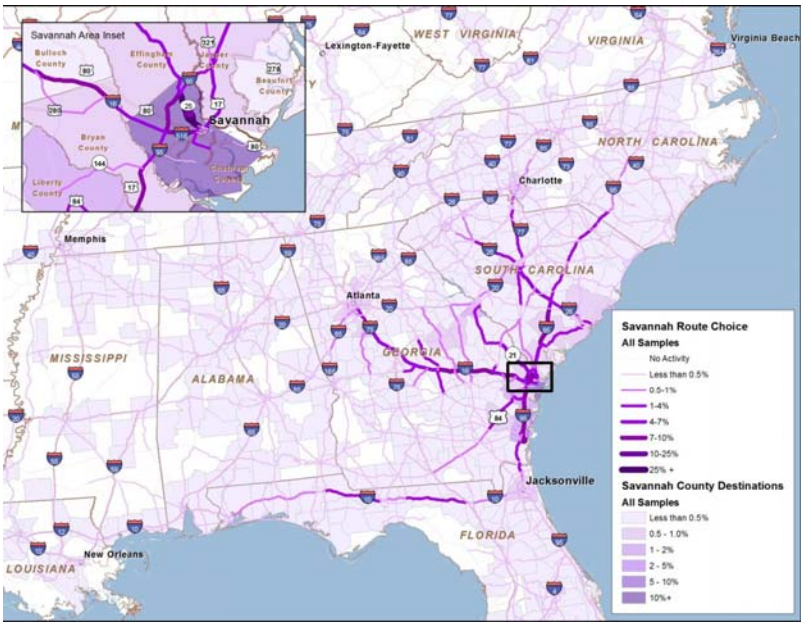
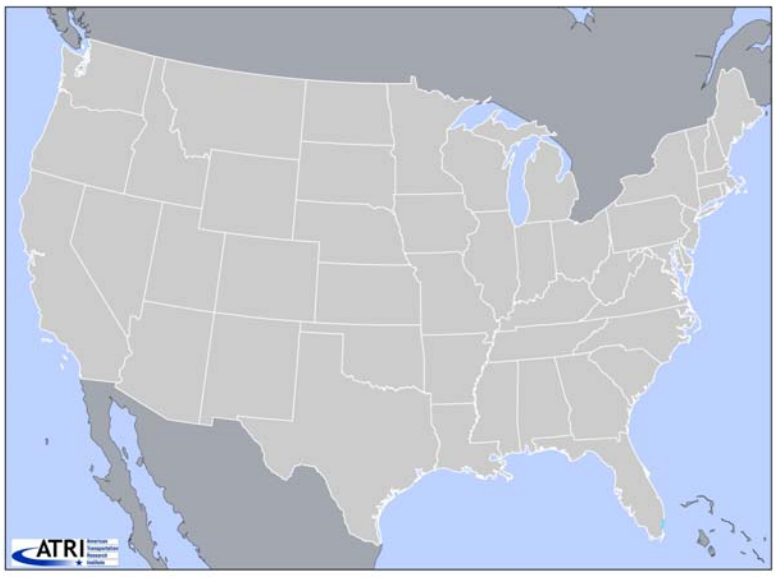


ATRI Truck GPS Dataset



ATRI Truck GPS Dataset

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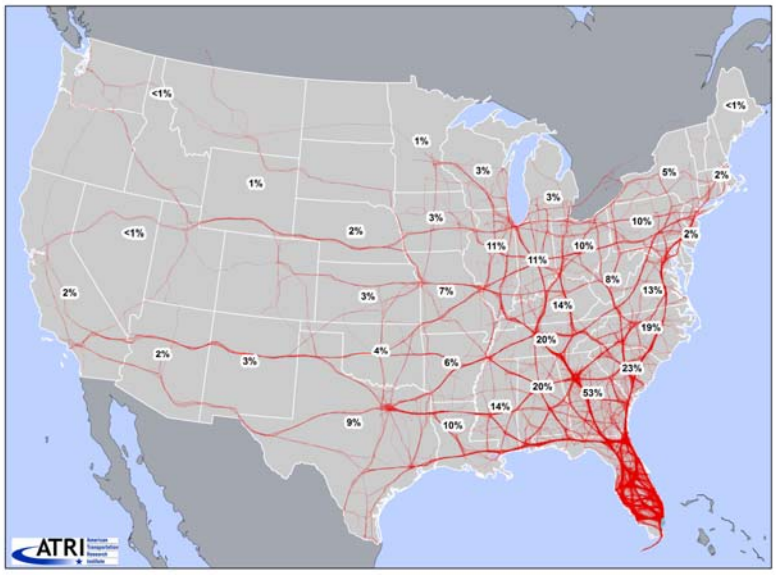


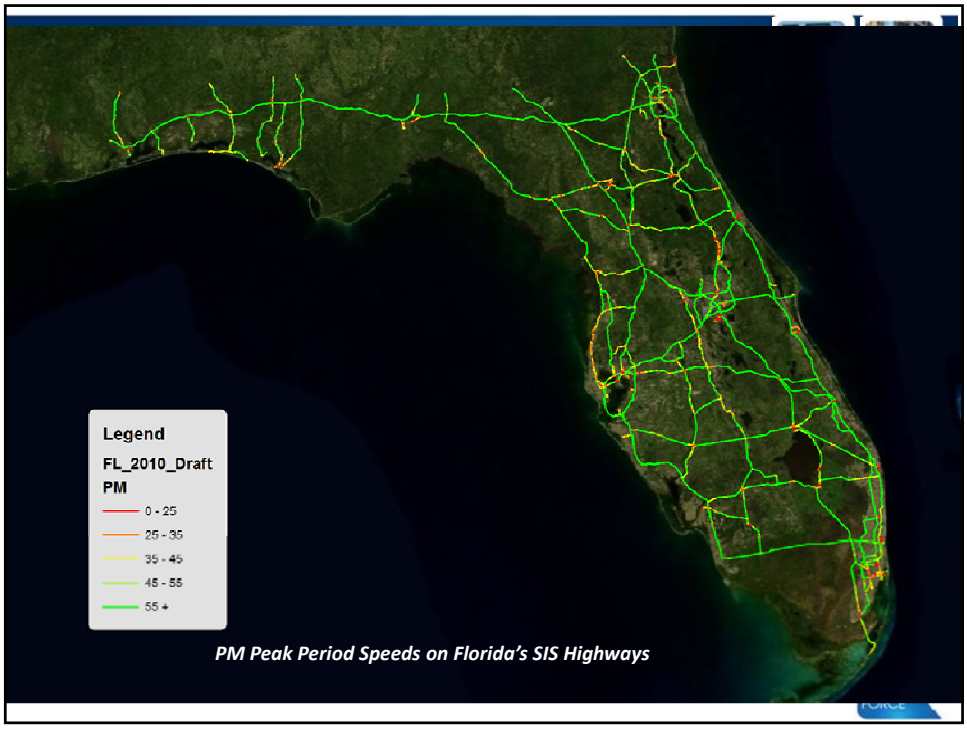
Project Outcomes

Project Objectives


- Project Objectives
  - Investigate the use of ATRI-FPM data for freight performance measurement and planning in Florida.
  - Use the data for the following applications
    - Derive freight performance measures (speeds) for Florida's highways
    - Convert the raw GPS data into a database of truck trips
    - Understand truck travel characteristics in Florida
    - Derive tuck-trip OD tables for the Florida Statewide Model
  - Other
    - Assess the data – its coverage of freight truck traffic in Florida
    - Exploratory analysis of the use of data for different applications
      - Truck flows from Ports
      - Truck travel time skims
      - Truck routes

Freight Performance Measurement


- Average speeds on Florida's Strategic Intermodal System (SIS) highways
  - ATRI data used to measure average truck speeds on the entire SIS network
  - Speeds measured for different time-of-day periods for each 1-mile segment on the SIS network (half-mile segments in urban regions)
    - AM peak
    - PM peak
    - Mid day
    - Off peak
    - Daily average
  - Speeds measured based on 3 months of data in year 2010



PM Peak Period Speeds on Florida's SIS Highways

Convert GPS Data into Truck Trips


- Algorithms to convert raw GPS data into a database of truck trips
- Product from this task
  - Database of over 2 Million truck trips derived from over 145 Million GPS records
  - 1.27 Million trips starting and/or ending in Florida

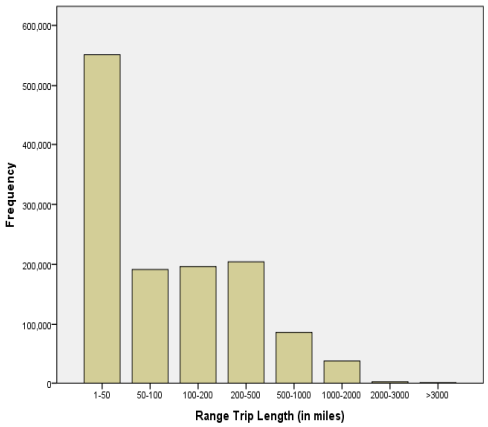
	# GPS records (Millions)	# Trucks (Thousands)	# Trips starting and/or ending in Florida (Thousands)
March 2010	39.0	61.7	340
April 2010	35.7	58.7	320
May 2010	35.1	45.6	306
June 2010	35.2	45.4	305
Total	145 Million GPS records		1.27 Million truck trips

  - Information available for each trip: Trip start & end times, distance, travel time, Origin and Destination TAZs based on FL statewide model

Truck Travel Characteristics

- Analyzed the characteristics of truck trips derived from previous task
  - Time of day profiles for trips starting & ending in different regions in FL
  - Travel Distances
  - Measurements of Origin-Destination (OD) Travel Times and Speeds
  - Truck trip travel routes for several OD pairs

Trip Length Distribution (Trips starting and/or ending in FL)



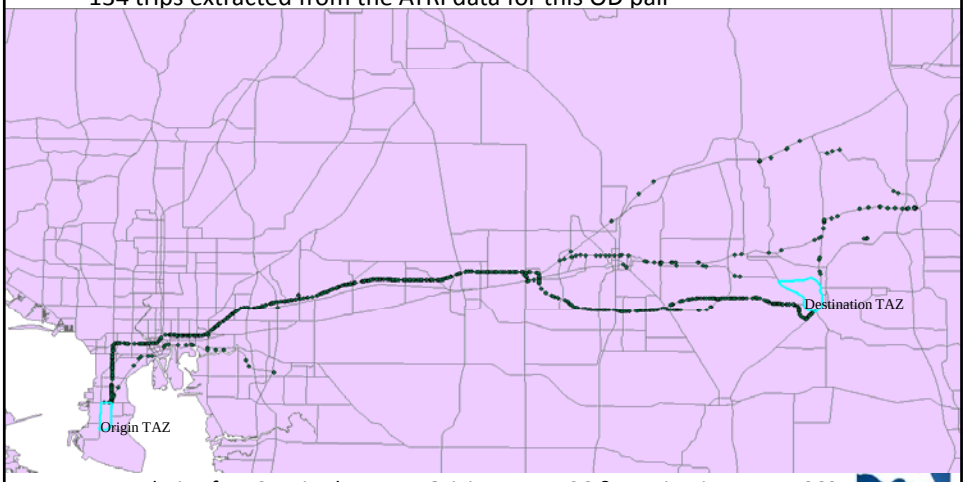
Range of Trip Length (miles)	Frequency	Percent	Cumulative Percent
1-50	551,201	43.3	43.3
50-100	191,552	15.1	58.4
100-200	196,378	15.4	73.8
200-500	204,230	16.1	89.9
500-1000	86,578	6.8	96.7
1000-2000	38,937	3.1	99.8
2000-3000	2,190	.2	99.9
>3000	754	.1	100.0
Total	1,271,820	100.0	

OD Travel Time and Speed Measurement


- Product from this task
  - Origin-to-Destination (OD) travel time and speed measurements derived for over 1200 OD pairs
- For each of the 1200 OD pairs…
  - Distribution of travel times (min, max, mean, 5th, 15th, 50th, 85th percentile values)
  - Distribution of travel speed (min, max, mean, 5th, 15th, 50th, 85th percentile values)
  - Distributions by time-of-day (to the extent possible)
  - Two types of travel times and speeds:
    - Total travel times and speeds, including rest stops
    - Travel times and speeds, excluding rest stops
- Useful for
  - Validating the freight component of Florida Statewide Model
  - Truck travel time skim inputs to the model
- See next few slides for the derived information on a sample OD pair

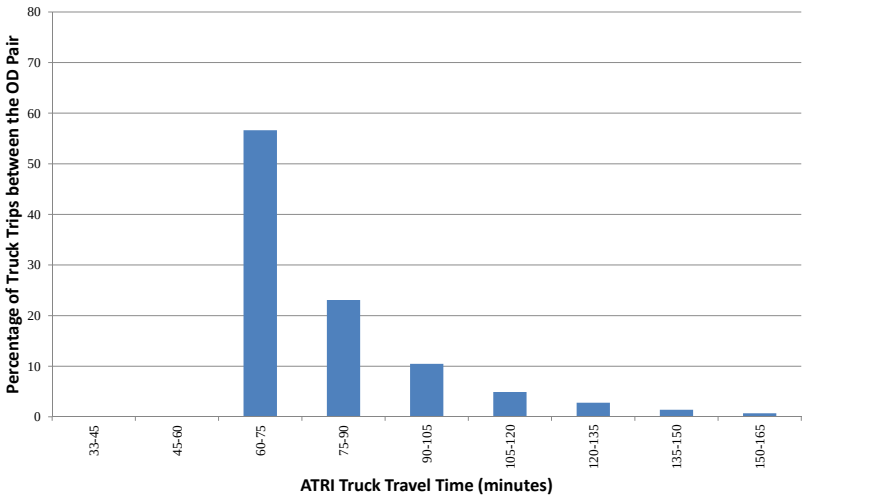
Travel Time Measurements for a Sample OD Pair


- Origin TAZ #4526 and Destination TAZ #1863
- 134 trips extracted from the ATRI data for this OD pair



Route choice for 134 trips between Origin TAZ #4526 & Destination TAZ #1863

Travel Time Measurements for a Sample OD Pair



Distribution of Measured Travel Time Between TAZ #4526 & TAZ #1863

Travel Time Measurements for a Sample OD Pair

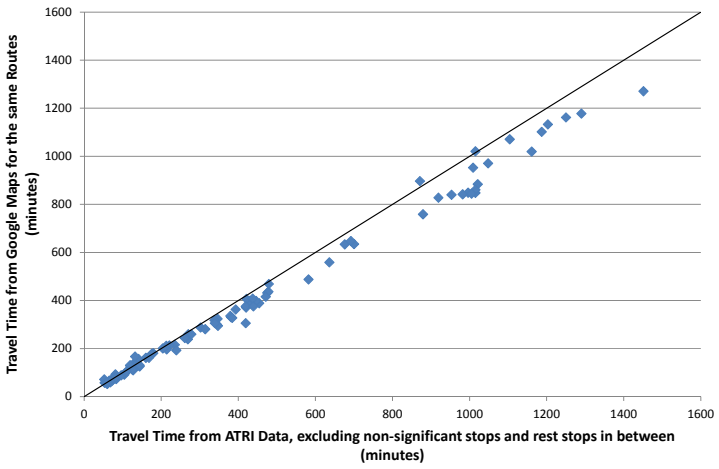
- Origin TAZ #4526 and Destination TAZ #1863 with 134 trips

	Min	5th percentile	15th percentile	Max
ATRI Trip length	55 miles	56.7 miles	57.2 miles	78.4 miles
ATRI Travel Time	62 min	63 min	65 min	165 min

Trip length in FL statewide model	55 miles
Travel time in FL statewide model skims	54 min

- The travel time skims used in the FL statewide model appear to be smaller than those measured using ATRI GPS data
- Travel times in Google maps appear to be smaller than those measured using ATRI GPS data, perhaps because Google measurements are predominantly based on light duty vehicles.
- The ATRI data can be used to update truck travel time skims for models

ATRI Truck Travel Times Vs. Google Maps



Truck Travel Routes

- Truck Travel Routes for several trips between over 1200 OD pairs
- Useful for
  - Truck route choice analysis
  - Research on improvements to truck traffic assignment procedures

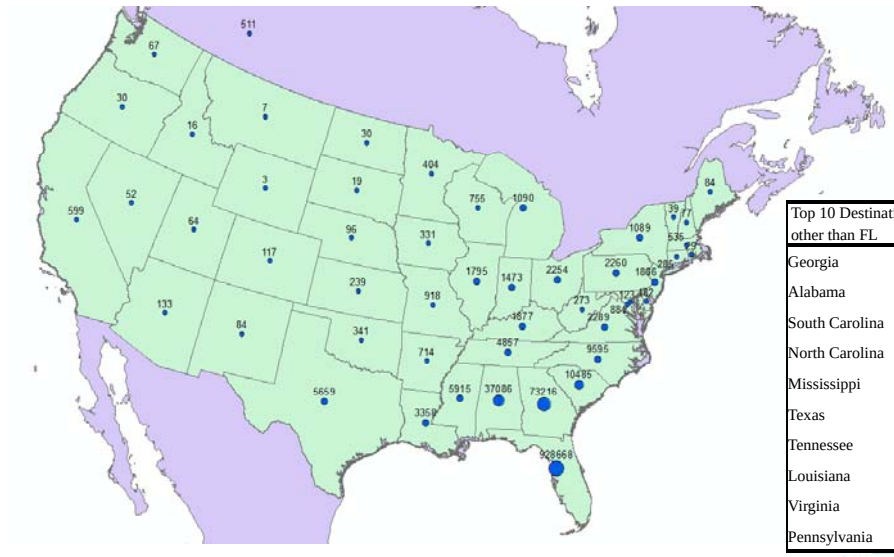
Truck OD Flow Patterns

- Product from this task
  - Truck trip OD tables at different levels of geography
    - State-level
    - County-level
    - FL Statewide Model (FLSWM) TAZ level

    OD tables available for use in the form of spread sheets

  - Generated using 4 months of raw GPS data (March to June 2010)
  - Additional procedures used to remove trucks that are not considered to be freight-carrying heavy trucks
    - Trucks that do not make at least one trip of 100 miles in a month
    - Trucks that remain within an urban region as opposed to travel across regions
    - Truck that make a large number of short trips per day

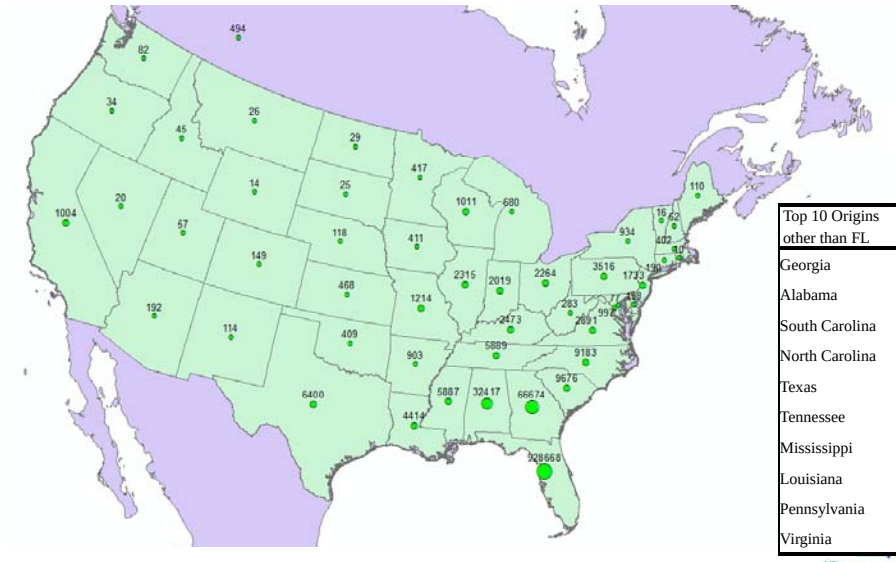
Destinations of Trips Starting in FL



Top 10 Destinations other than FL
Georgia
Alabama
South Carolina
North Carolina
Mississippi
Texas
Tennessee
Louisiana
Virginia
Pennsylvania

Total number of trips starting in FL: 1,102,873

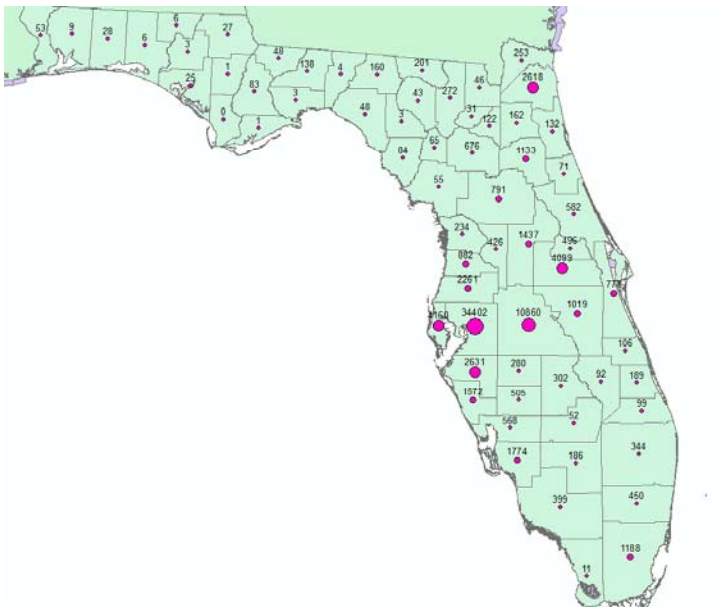
Origins of Trips Ending in FL



Top 10 Origins other than FL
Georgia
Alabama
South Carolina
North Carolina
Texas
Tennessee
Mississippi
Louisiana
Pennsylvania
Virginia

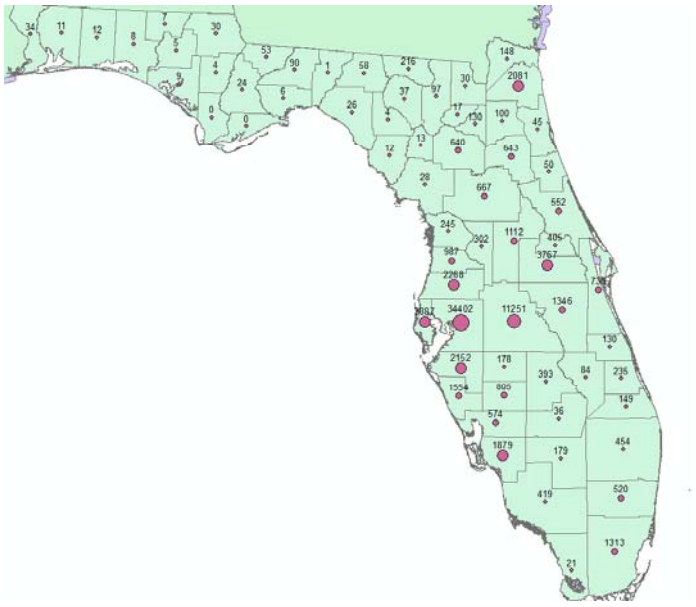
Total number of trips ending in FL:1,097,614

Destinations of Trips Starting in Hillsborough County (where are trips going to?)



Top 10 Destinations other than Hillsborough
POLK
PINELLAS
ORANGE
MANATEE
DUVAL
PASCO
LEE
SARASOTA
LAKE
MIAMI-DADE

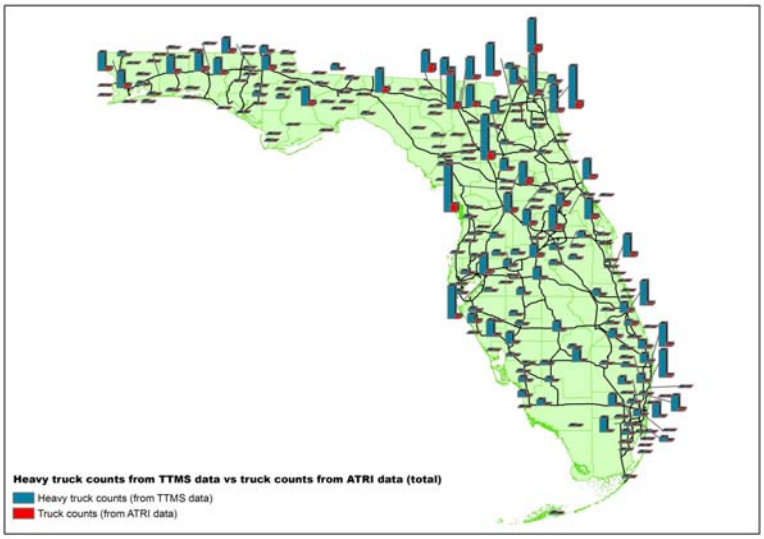
Origins of Trips Ending in Hillsborough County (where are trips coming from?)



Top 10 Origins other than Hillsborough
POLK
PINELLAS
ORANGE
PASCO
MANATEE
DUVAL
LEE
SARASOTA
OSCEOLA
MIAMI-DADE

How Much Heavy-Truck Traffic in Florida is Covered by the OD Tables from the ATRI Data?

Heavy truck (class 9 - 13) counts from TTMS data vs truck counts from ATRI data
May 9-15, 2010

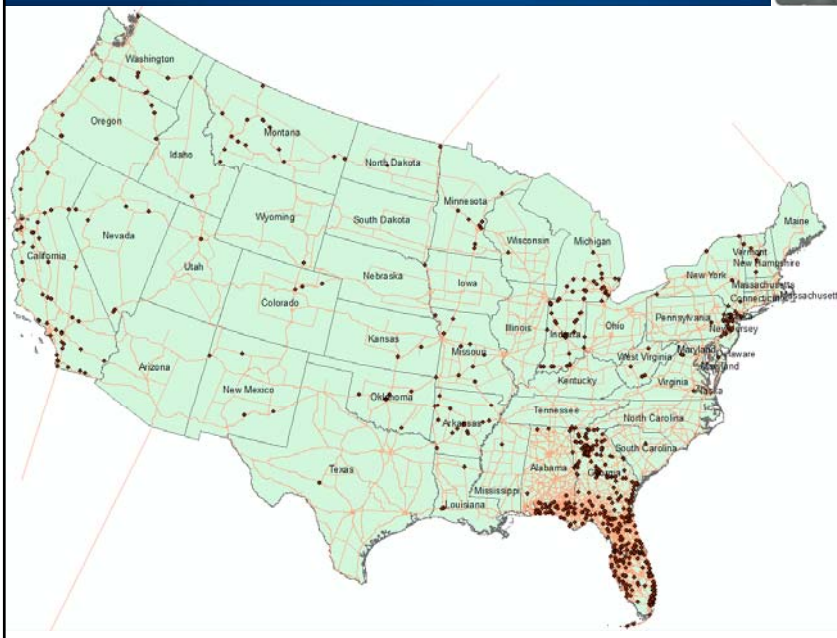


OD Matrix Estimation of Statewide Truck Flows


- The OD patterns shown so far are from a **sample** of trips (large sample)
- Need to arrive at the **population** of truck flows
- Perform OD Matrix Estimation (ODME) to…

  "Inflate" the **sample** OD table to a **population** OD table such that, when loaded onto the network, the resulting flows match with observed truck traffic counts at different locations.

Truck Traffic Count Locations Used for ODME

State	# sites
FL	413
GA	270
CA	55
IN	55
MI	32
AR	30
NJ	30
MO	17
MT	17
OR	13
NV	12
OK	12
WA	10
MN	11
WV	8
AL	8
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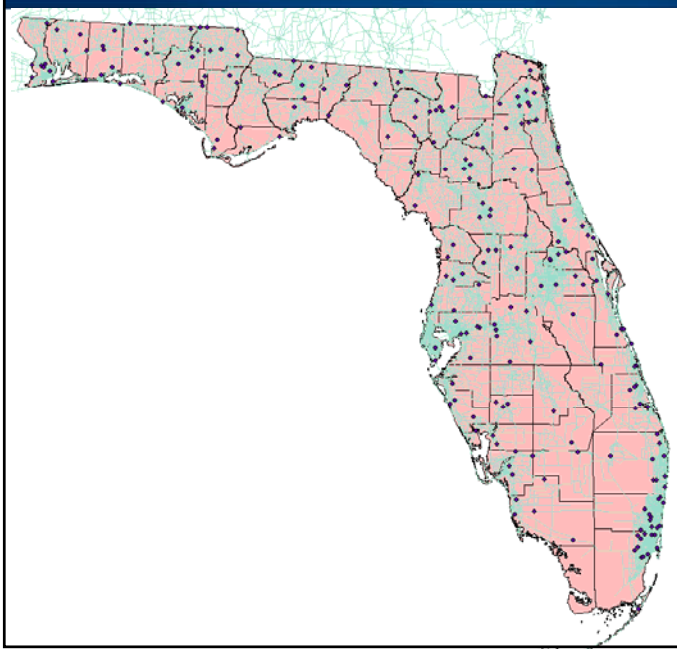
.	.
.	.
Total	1048

Truck Traffic Count Locations Inside Florida



Location	# sites
FL. TURNPIKE	24
MIAMI-DADE	18
BROWARD	17
DUVAL	17
BREVARD	14
ESCAMBIA	14
HILLSBOROUGH	14
PALM BEACH	14
POLK	14

Validation of ODME Outputs

Root Mean Square Error (RMSE): Measure of the differences between estimated truck traffic volumes and observed traffic counts. Closer to zero, better estimation.

$$RMSE = \frac{\sqrt{\frac{\Sigma_{i=1}^{N}(V_i - C_i)^2}{N}}}{C_{avg}}$$

Coefficient of determination (R^2) : How well are the observed traffic counts replicated by the ODME results, as the proportion of total variation of traffic counts.
Closer to 1, better replication of observed outcomes by the model

$$R^2 = 1.0 - \frac{\Sigma_{i=1}^{N}(V_i - C_i)^2}{\Sigma_{i=1}^{N}(C_{avg} - C_i)^2}$$

V_i : Estimated truck traffic volume corresponding to counting location *i*

C_i : Observed traffic count value at location *i*

C_{avg} : Average truck traffic count value of the set

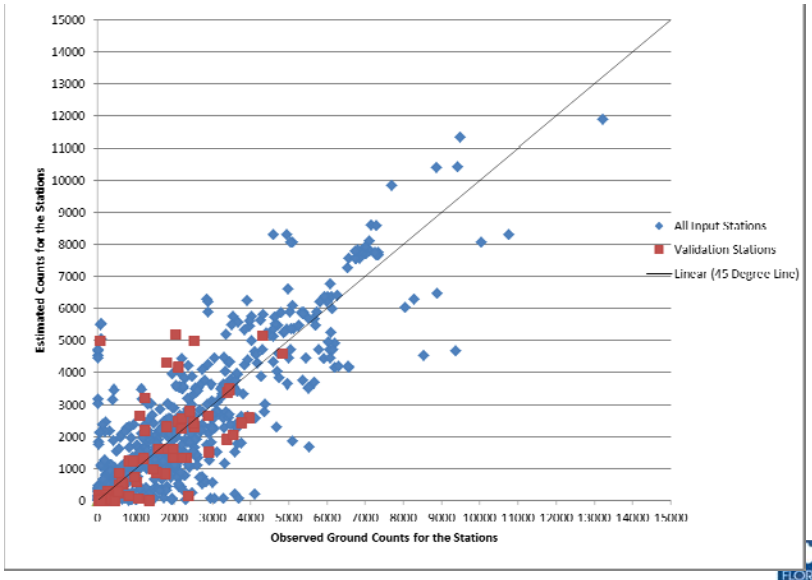
N : Total number of truck counting locations *i* in the set

Validation of ODME Outputs – Preliminary Results

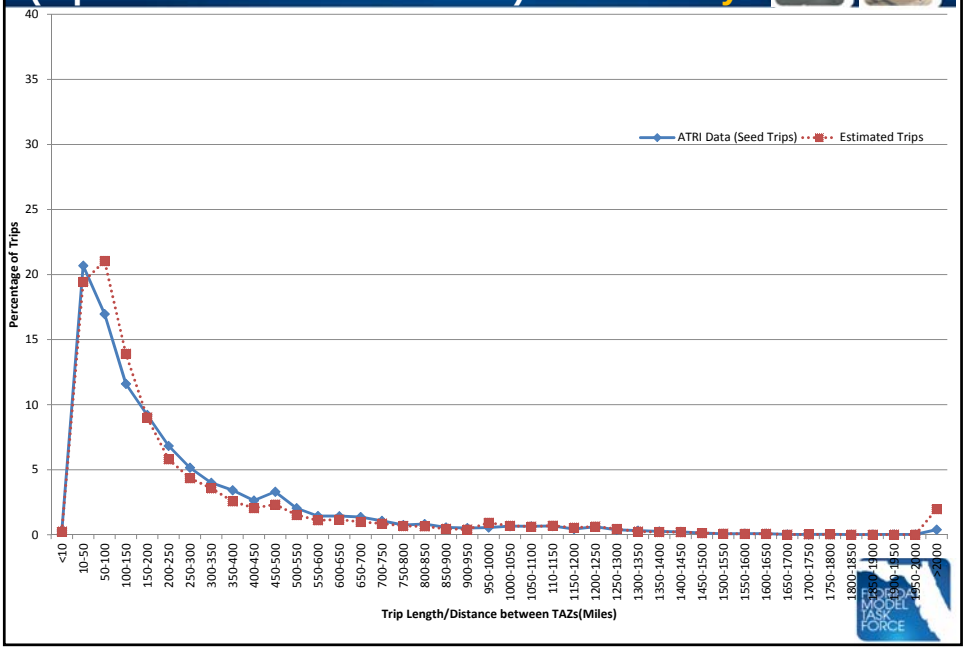

- Estimated vs. observed truck traffic counts **input to ODME**
  - All traffic counting sites in the nation (963 sites)
    - R^2= 0.750, RMSE = 60%
  - Traffic counting sites in Florida (365 sites):
    - R^2= 0.808, RMSE = 59%

- Estimated vs. observed truck traffic counts **kept aside for Validation**
  - All traffic counting sites in the nation (85 sites)
    - R^2= 0.349, RMSE = 84%
  - Traffic counting sites in Florida (48 sites):
    - R^2= 0.765, RMSE = 58%

ODME vs. Observed Truck Volumes – Preliminary Results

ODME Vs. ATRI Trip Length Distribution (Trips with at least one end in FL) – Preliminary Results



Summary of Project Outcomes

- Freight Performance Measures
  - Truck travel speeds by time-of-day for each mile on SIS highways
- A large database of truck trips within, to, and from Florida
- Measurements of travel times & speeds between 1200 OD pairs
- Truck flow OD patterns at different geographies
  - FLSWM statewide TAZ level, County-level, State-level
- Exploratory work
  - Analysis of truck travel characteristics in Florida
  - Assessment of the coverage of truck traffic in Florida
  - Exploratory analysis of truck flows from ports and truck routes
- Draft final report to be submitted in April

Thoughts for Way Forward

- This project focuses on statewide truck movements for FLSWM
- There is an opportunity to use the data to extract truck travel patterns for regional models
  - A small but useful portion of trucks in the data are smaller trucks, which are more likely to be local delivery trucks
  - ATRI's estimate: 11% of their database are trucks of class 7 or lower, 6% are straight trucks or box-trucks
- Most of the project focuses on generating data - truck trips, OD tables, travel times, truck routes, etc.
  - Using the generated data for further analysis, freight modeling and planning applications will be fruitful
  - Examples:
    - Truck travel time skims for all OD pairs in the state
    - Truck route choice analysis

Thank you

Questions and Discussion

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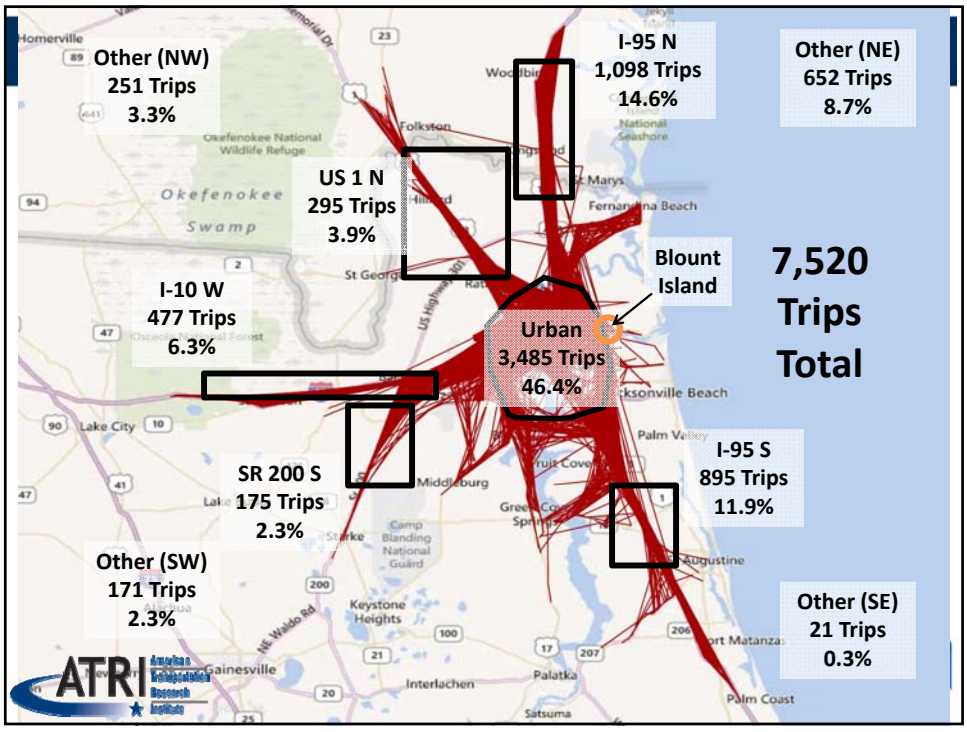
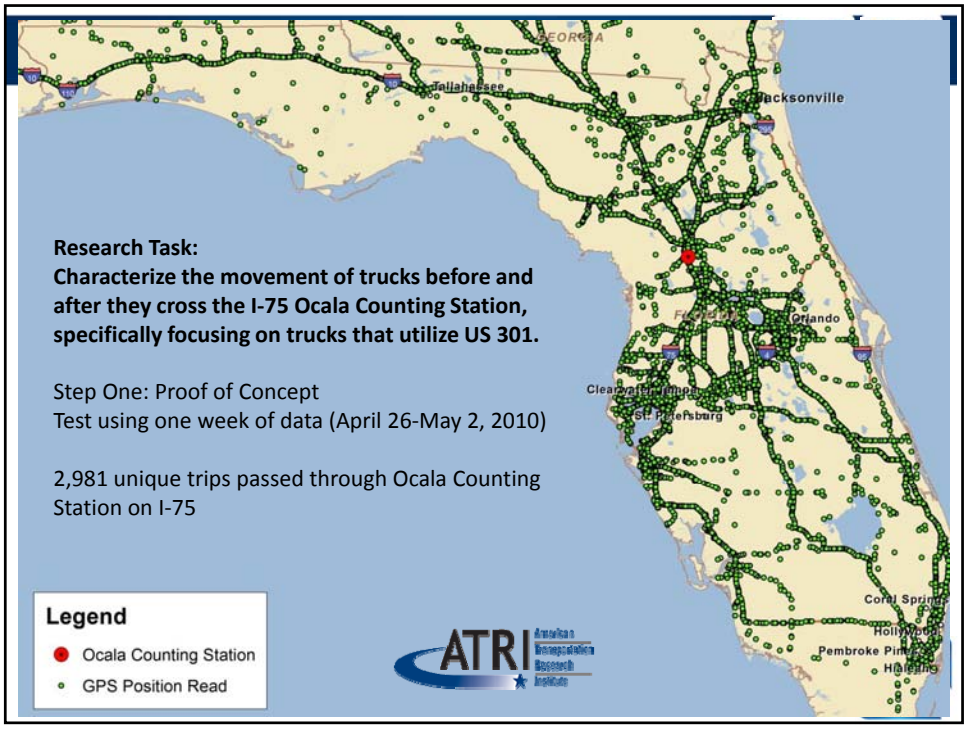
More details about ATRI data and its products derived in this project will be presented at FDOT's **Statewide Transearch & Freight Data Workshop** (Orlando, May 14-15, 2014)

www.fsutmsonline.net/training_register.aspx?id=105

Other Applications

- Truck Flows from Ports
- Truck travel routes




GEORGIA
Tallahassee
Jacksonville
Orlando
Clearwater
St Petersburg
Coral Springs
Hollywood
Pembroke Pines
Hialeah
Research Task:
Characterize the movement of trucks before and after they cross the I-75 Ocala Counting Station, specifically focusing on trucks that utilize US 301.
Step One: Proof of Concept
Test using one week of data (April 26-May 2, 2010)
2,981 unique trips passed through Ocala Counting Station on I-75
Legend
Ocala Counting Station
GPS Position Read
ATRI