Innovative Tour-Based Truck Travel Model using Truck GPS Data

*presented to*

**TRB SHRP2: Innovations in Freight Demand Modeling and Data Improvement – Second Symposium**

*presented by*

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Arun Kuppam

c*co-authored by*

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Dan Beagan, CS
Vladimir Livshits, MAG
Lavanya Vallabhaneni, MAG
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October 21, 2013
Overview

Why?
• Truck trip diary surveys are expensive, with poor response rates

Who?
• Third party commercial GPS vendors

What?
• Deploy GPS units and collect GPS records from truck fleets

How?
• Process GPS data to obtain truck trips and tours

Where?
• CS applied in Los Angeles, Chicago, Phoenix, Baltimore

• Example focuses on specifics from the Phoenix experience
GPS devices are widely deployed in cell phones, autos, and trucks.

Truck fleet operators subscribe to GPS services for operational and maintenance purposes.

Automatic Vehicle Location (AVL); Events Activated Tracking Systems (EATS); Fleet Telematics Systems (FTS).

Entities (e.g., ATRI) collect and store historical GPS from operators (2004 to present).

Condition of dissemination is that truck ID’s are anonymized.

GPS information should be processed before it can be used for truck travel models.
ATRI Data Specifics

**Cost for one month of data – $10K**

ATRI was purchased to supplement heavy truck (FHWA Classes 8-13) trip diary surveys

3.5 million positional records from 22,000 trucks

Close to 60,000 truck tours

**Heavy Trucks**

**Large Sample of Trucks**

**Relatively Cheap**
Truck GPS Data from Phoenix
All Trucks in April 2011

All Trucks

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Truck GPS Data from Phoenix
One Truck in April 2011

One Truck
(ID 357042)  April 2011

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Truck GPS Data from Phoenix
One Truck on April 1, 2011

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## Processing of One Truck Tour

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### One Truck (ID 357042) April 1, 2011

- GPS Transition Events: 6
- Truck Trip Ends: 4
- Trucks: 1

### One Truck (ID 357042) April 1, 2011

- GPS Events: 3
- Truck Trip Ends: 3
- Truck Tours: 1
- Trucks: 1

### Primary Anonymized Data

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### One Truck (ID 357042) April 1, 2011

- GPS Transition Events: 6
- Truck Trip Ends: 4
- Trucks: 1

### One Truck (ID 357042) April 1, 2011

- GPS Events: 3
- Truck Trip Ends: 3
- Truck Tours: 1
- Trucks: 1

### Primary Anonymized Data

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Truck GPS Data from Phoenix
Processing of One Truck on April 1, 2011

Processed One Truck

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ATRI GPS Truck ID 357402 - April 1, 2011 – Actual Stops
Truck GPS Data from Phoenix
TAZ of Trip Ends for One Truck on April 1, 2011

Processed
One Truck

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Map showing Industrial Land Fill, Sand, Gravel locations.
Truck GPS Data from Phoenix
LU of Trip Ends for One Truck on April 1, 2011

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<td>Trucks</td>
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Map showing truck routes from Industrial, Landfill, Sand & Gravel to Industrial.
Trip- and Tour-Based Truck Models

**Truck Trip Ends (7 trips, 6 LU)**

- **Origin (Truck Home Base)**
- **Stop 3 (Household)**
- **Stop 4 (Home Base)**
- **Destination (Home Base)**

**Stop 1 (Warehouse)**

**Stop 2 (Retail)**

**Stop 5 (Retail)**

**Stop 6 (Retail)**

**Truck Tours (2 tours, 6 LU)**

- **Origin/Destination**
- **Stop 3 (Household)**
- **Stop 2 (Retail)**
- **Stop 6 (Retail)**
- **Stop 5 (Retail)**
- **Stop 1 (Warehouse)**

**Stop 2 (Retail)**
Truck Tour-Based Model Structure

**Tour Generation**
- Heavy truck tour rates by industry type
  - 1 stop
  - 2 stops
  - ......
  - 11 stops

**Stop Generation**
- 1 stop
- 2 stops
- ......

**Stop Completion**
- Yes – return to home base
- No – does not return

**Stop Purpose**
- One of 10 stop types
  - Retail
  - Constr.
  - Farming
  - Resid.
  - Govt.
  - Warehs.
  - Transp.
  - Office
  - Industrial
  - Service

**Stop Location**
- One of 3,000 TAZs

**Stop TOD Choice**
- 1st Stop TOD (24 1-hr periods)
- Next Stop TOD (24 1-hr periods)
Stop Generation Model
*Predicts number of stops on each truck tour*

**Available Set of Choices**

- 1 Stop
- 2 Stops
- 3 Stops
- ... 
- 11 Stops

**Model Structure = MNL**

**Outputs = Number of stops made on tour (any value between 1 & 11)**

**Decision Making Variables**

- Starting LU of the tour
- Employment and households at starting TAZ
- Accessibility to employment

**No of Stops by Industry Type**

- constr
- farm
- govt
- ware
- ind
- other

Utility vs No of Stops graph
Tour Completion Model

Predicts if truck returns to home base

Available Set of Choices

- Yes
- No

Model Structure = Binary Logit

Decision Making Variables

- No of stops by industry type
- Total employment in starting TAZ
- Employment by industry type

Outputs = Tour is complete or not
Stop Purpose Model

_Predicts purpose of stop_

Available Set of Choices

- Retail
- Constr.
- Farming
- Resid.
- Govt.
- Warehs.
- Transp.
- Office
- Industrial
- Service

1 of 10 Stop Types

Decision Making Variables

- Previous purpose type
- Accessibility to employment
- No of stops on tour
- Tour purpose type
- Log (1 + stop sequence no.)

Model Structure = MNL

Outputs = One of 10 stop purpose types
Stop Location Model
Predicts location TAZ of each stop

Available Set of Choices

- TAZ 1
- TAZ 2
- TAZ 3
- ...
- TAZ 3000

Model Structure = MNL

Outputs = Location TAZ of each stop

Decision Making Variables

- Travel time between stops
- No of stops by type and Employment by type
- Accessibility to employment

Impact of Travel Time on Utility

Utility vs. Travel Time (minutes)

-12 -10 -8 -6 -4 -2 0 20 70 120

-30 0 2 4 6 8 10 12

1 Stop Tour
2 Stop Tour
3 Stop Tour
5 Stop Tour
8 Stop Tour
11 Stop Tour
Stop TOD Choice Model

*Predicts TOD of each stop*

**Available Set of Choices**
- 12-1 am
- 1-2 am
- ...
- 11 pm – 12 am

**Decision Making Variables**
- Indicator for tour completion
- Travel time between stops
- No of stops on tour
- Departure shift variable
- Time / No of stops remaining

**Model Structure = MNL**

**Outputs = One of 24 hour intervals**
Initial Findings

**Number of Stops by Tour Type**

- **No of Stops**
  - Retail
  - Construction
  - Farming
  - Households
  - Government
  - Warehouse
  - Transportation
  - Office
  - Industrial
  - Service
  - Total

**TOD of First Stop**

- **Model**
- **Target**

**Stop Purpose Distribution**

- **Percent of Stop Purposes**
  - Retail
  - Construction
  - Farming
  - Min. Hhs
  - Gov.
  - Trn.
  - Off.
  - Ind.
  - Srv.

**TOD of Subsequent Stops**

- **Model**
- **Target**
Next Steps

Perform more rigorous model calibration and validation

Determine adequacy of GPS data both in terms of sample sizes and biases

Implement truck tour model and compare with trip-based model applications

Acquire GPS data for medium trucks and develop a medium truck tour model
Conclusions

Truck model parameters are difficult and expensive to obtain by surveys.

Truck GPS data is cost-effective to obtain large volume of information from trucks.

Tour-based models capture trip chaining patterns of trucks by type.

Truck tour-based models require large samples by industry type.