

## Advanced Uses of Truck GPS Data: Truck Tour Typologies, Connecting Long-Haul and Short-Haul Trucks, and Longitudinal Analysis

Innovations in Freight Data Workshop

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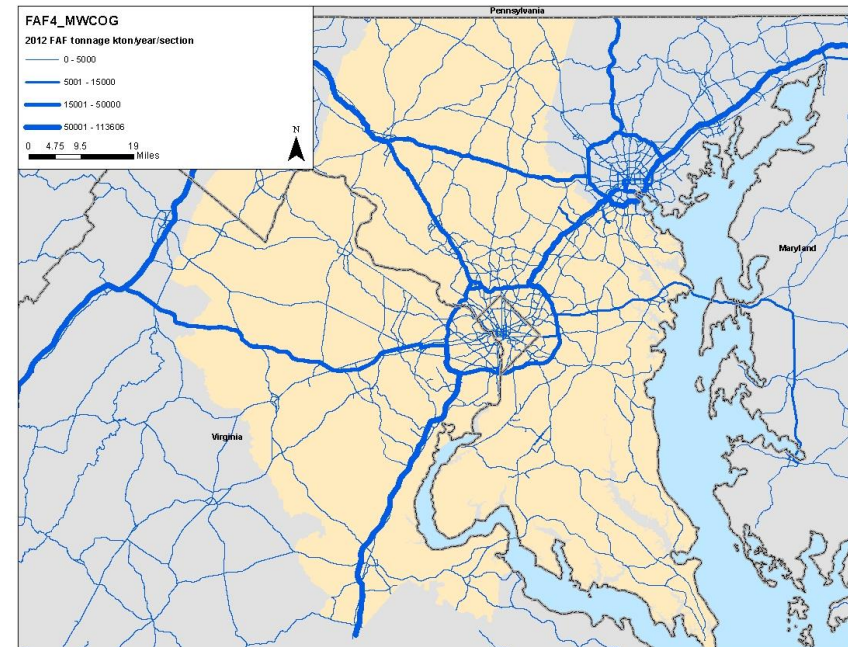
# Introduction

- Motivation
- Processing GPS data
- Tour Typologies
- Long Haul and Short Haul Connections
- Conclusions



# Motivation

- Client requires a truck forecasting tool
- Interested in both short and longer term truck travel behavior
- Required that model be informed by local data
- RSG proposed using passively collected GPS data (procured from INRIX) to develop an aggregate tour-based model
- All steps of the modeling process informed by aspects of the GPS data



Model required to cover the Washington DC region



# Processing GPS Data

# Processing GPS Data

- Objective of processing GPS data is to convert sequence of individual “pings” – a time and location stamp recorded by a GPS device on the truck - into useful data
  - Depot: where the truck starts and ends each day
  - Stop locations: where the truck stops, e.g., to make deliveries
  - Trips: movement between stops
  - Tours: sequence of trips and stops over the course of the day



# What are Depots, Stops, Trips and Tours?

Business – tour start/end location



Stop – a location where the truck stops to make a delivery, provide service or for other purpose such as a meal break

1

2

Tour with 4 stops and 5 trips

4

3

Tour – set of trips that start and end at the same location\*

Trip – a truck movement from stop to stop, including to and from the tour start/end location

\*Some tours might start and end at different locations, particularly for long haul trucks traveling to/from/through the region



# About the Raw Data

Dataset included two weeks of data from each of 2015 and 2017 for any truck in the sample that moved within the model region

Each device records location approximately every minute

Most trucks have multiple days of data

Data aggregated from multiple sources

Covers light, medium and heavy trucks

PROVIDER LABEL	WEIGHT CLASS	UNIQUE DEVICES	PING COUNT	MEDIAN PING FREQUENCY (SEC)	MEAN LATENCY (SEC)
a	Medium	375	98,689	30	97.1
b	Medium	365	501,551	33	201.7
c	Medium	1,611	505,255	60	197.2
d	Medium	6	1,024	248	218.7
e	Heavy	80,118	23,865,934	60	6.9
f	Medium	21,330	19,178,690	90	193.9
g	Medium	678	267,855	61	146.8
h	Medium	1,793	1,022,720	120	200.9
i	Medium	501	173,252	120	129.4
j	Light	285	4,222,640	11	304.5
k	Light	440	1,110,019	6	162.6
l	Medium	3,869	1,861,037	107	165.7
m	Medium	48	15,860	76	144.6
n	Medium	50	7,600	121	37.0
o	Medium	8,559	6,184,398	93	195.1
p	Medium	1	1	290	107.2

Thousands of unique trucks

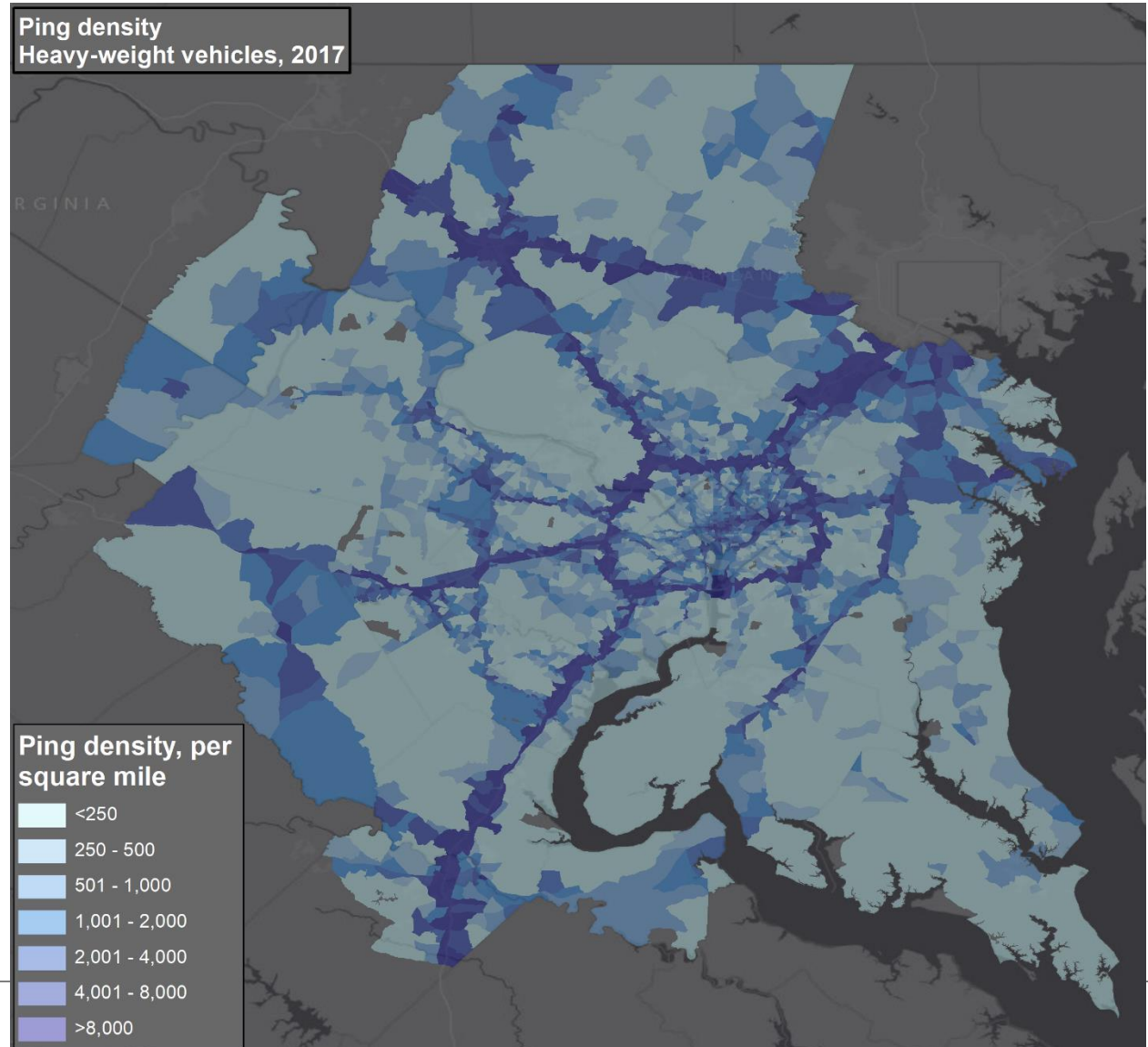
Millions of individual pings





# Raw Data: Heavy Trucks

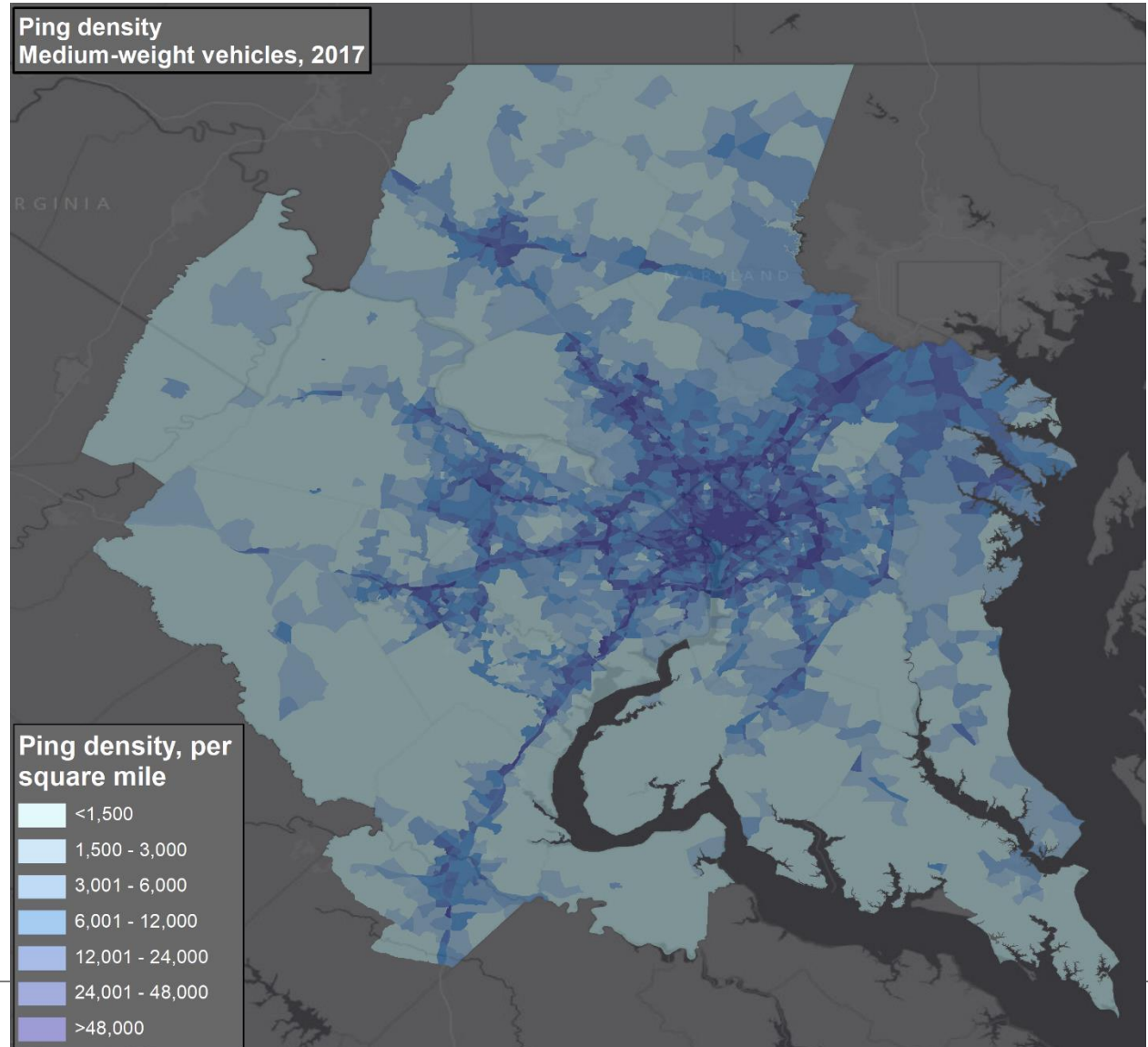
Heavy truck data  
densest along  
highway corridors





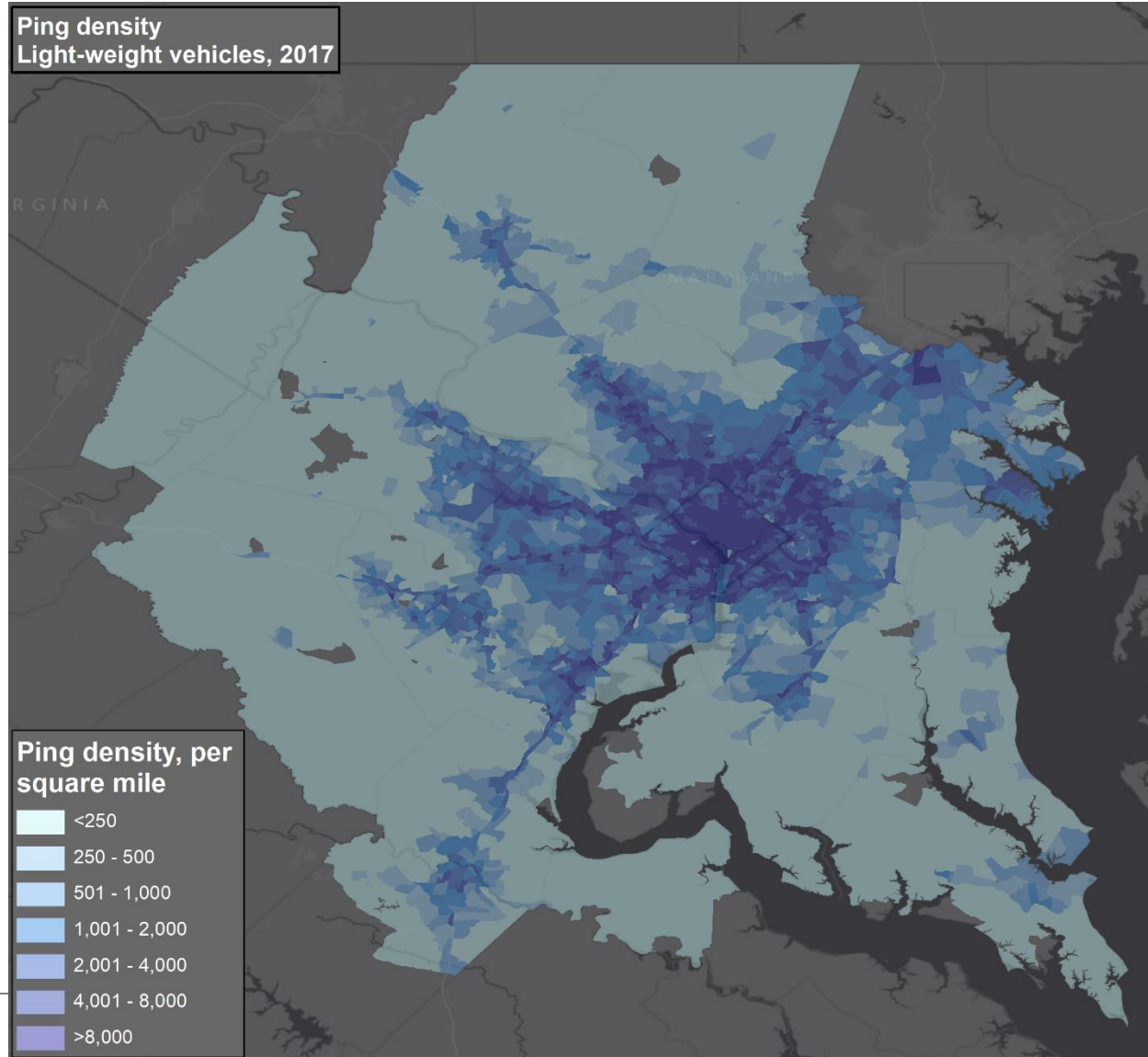
# Raw Data: **Medium** Trucks

Medium truck data denser in urbanized areas



# Raw Data: Light Trucks

Light truck data very dense in urbanized areas, relatively little on highway corridors

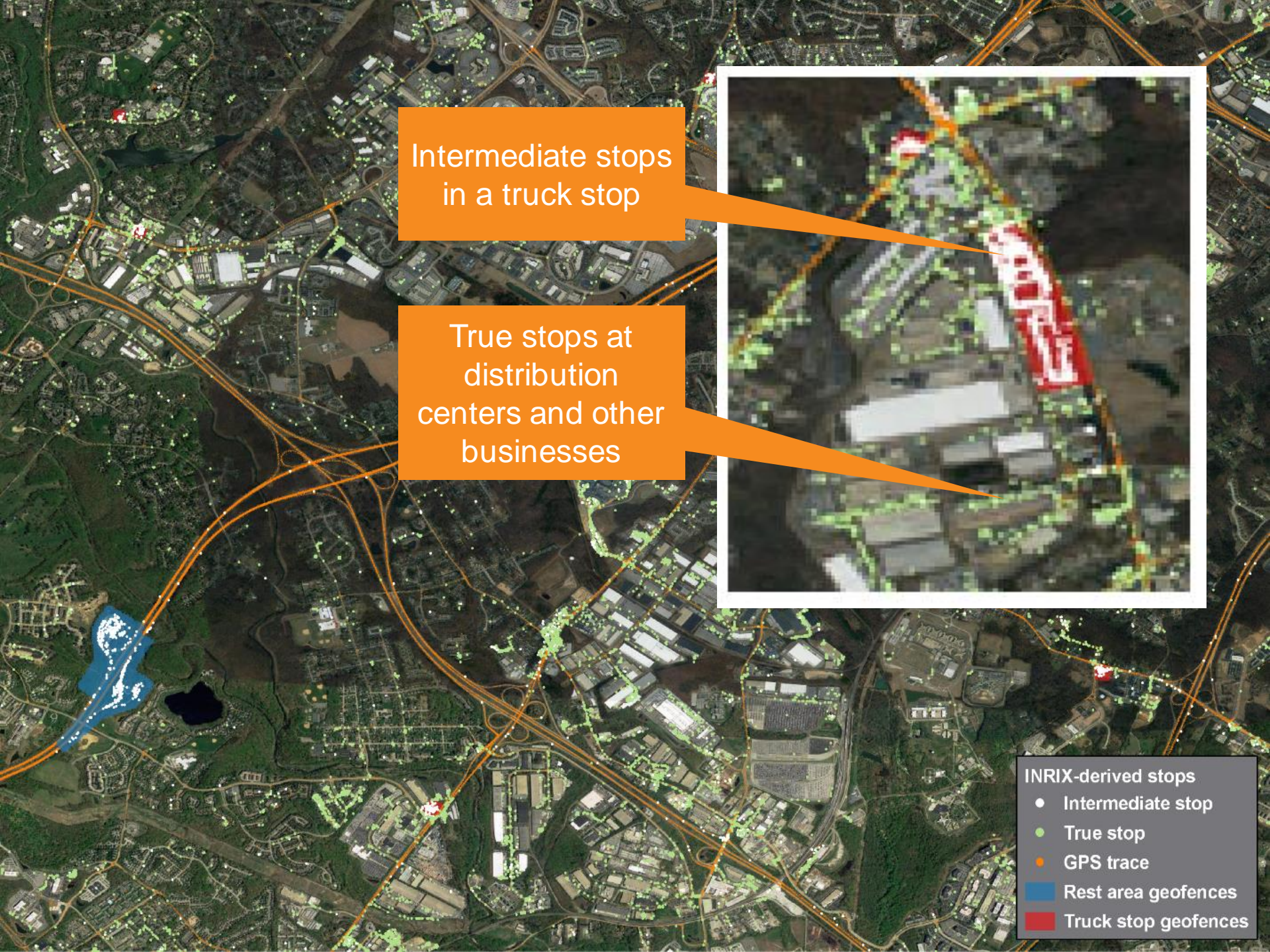


# Processing Steps

- Pings within a highway buffer were tagged
- Intermediate stops in truck stops, service stations, rest areas, and weigh stations were tagged
- Dwells of greater than 7 or more minutes not in the highway and not at intermediate stop location were tagged as stops
- Database was collapsed into a trip list







Intermediate stops  
in a truck stop

True stops at  
distribution  
centers and other  
businesses

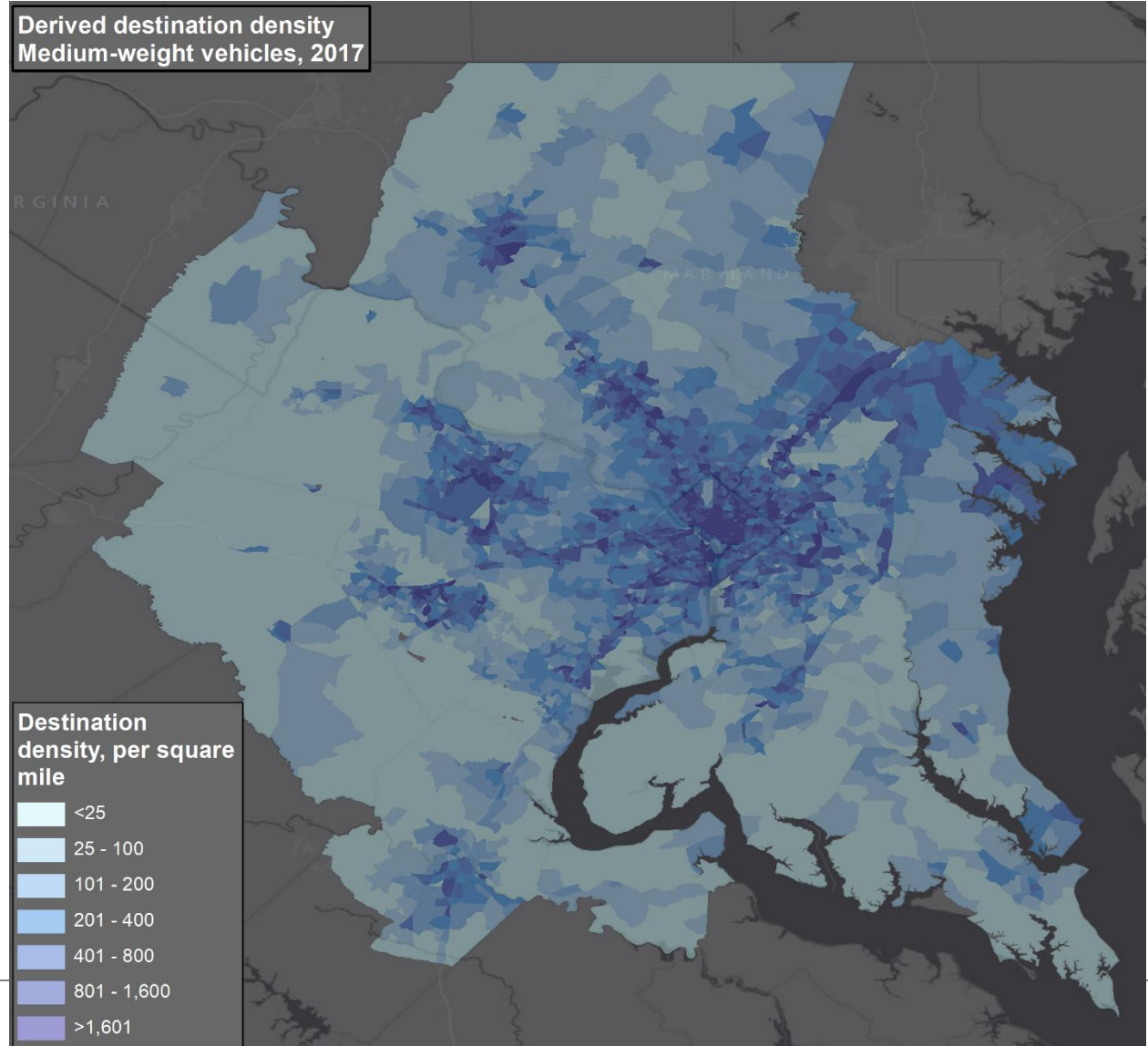


- INRIX-derived stops**
- Intermediate stop
  - True stop
  - GPS trace
  - Rest area geofences
  - Truck stop geofences



# Medium Truck Trip Destinations

Visualization of  
the medium truck  
trip table



# Depot Identification

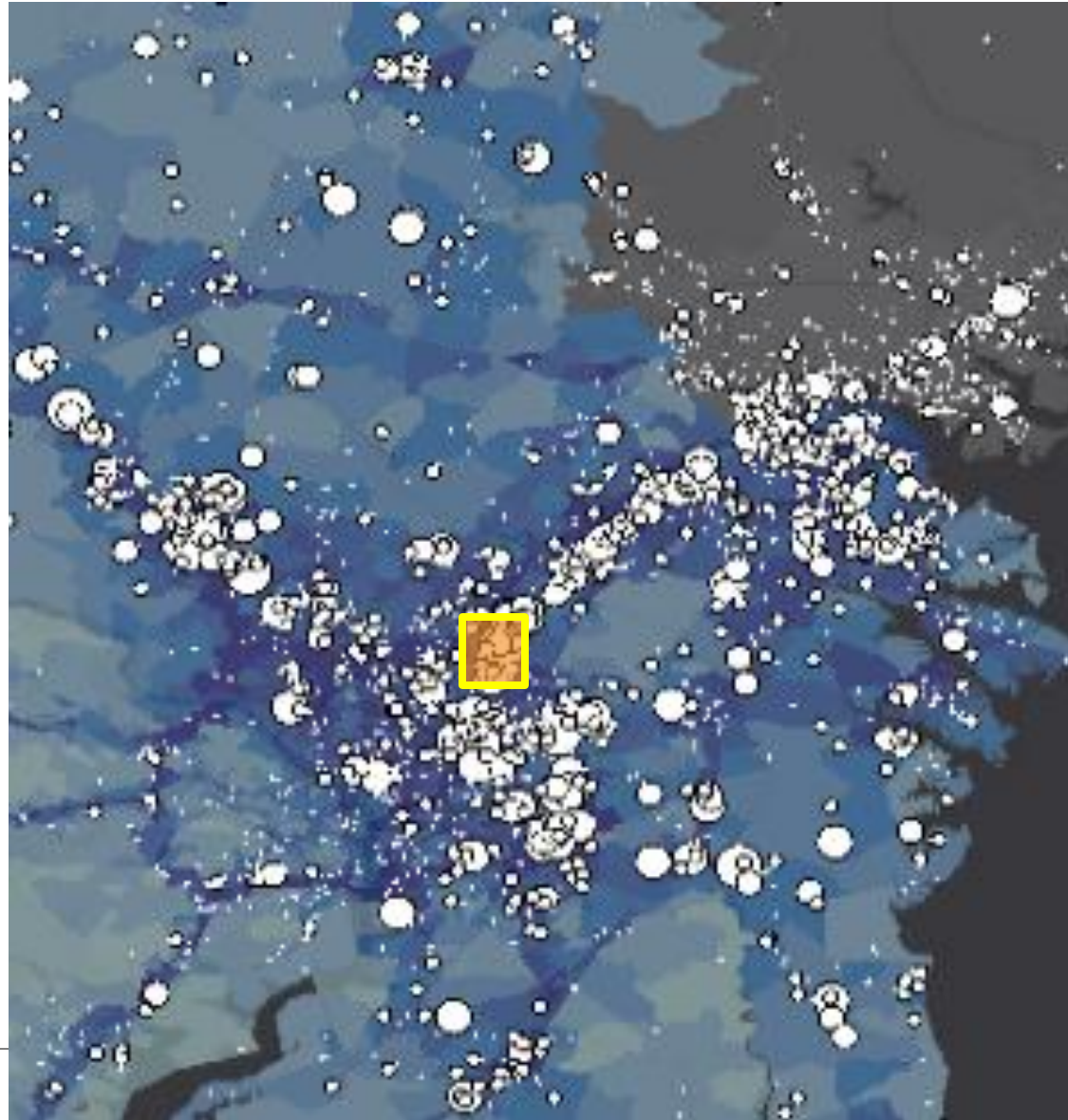
- For a tour based model, we want to know about the truck's depot – where it usually starts and ends a work day
  - Short haul trucks (those that generally stay inside the model region) identified from the trip dataset
  - Identify locations repeatedly visited by the truck
  - Clustering algorithm combined with graphing to look for tour start and end points
  - Weighted higher those locations that are common to multiple trucks





# Medium truck depots

- Locations of medium truck depots





**Cluster-derived potential depot locations  
Medium weight truck provider  
>1 unique device present**



# Processing Summary

- Raw ping data of 142 million records from 283,000 trucks
- Processed into 2.7 million trips (representing a total of ~ 3.5 million miles of truck travel)
- Expanded and scaled to daily trucks using traffic counts, resulting in ~1 million daily trips
- Approximately 64,000 unique depot locations identified

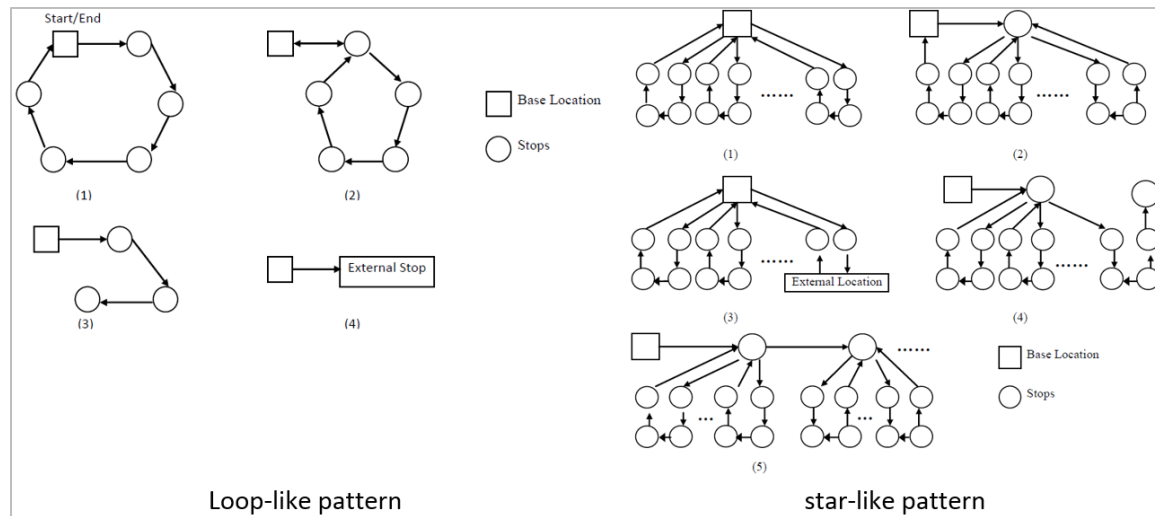




## Tour Typologies

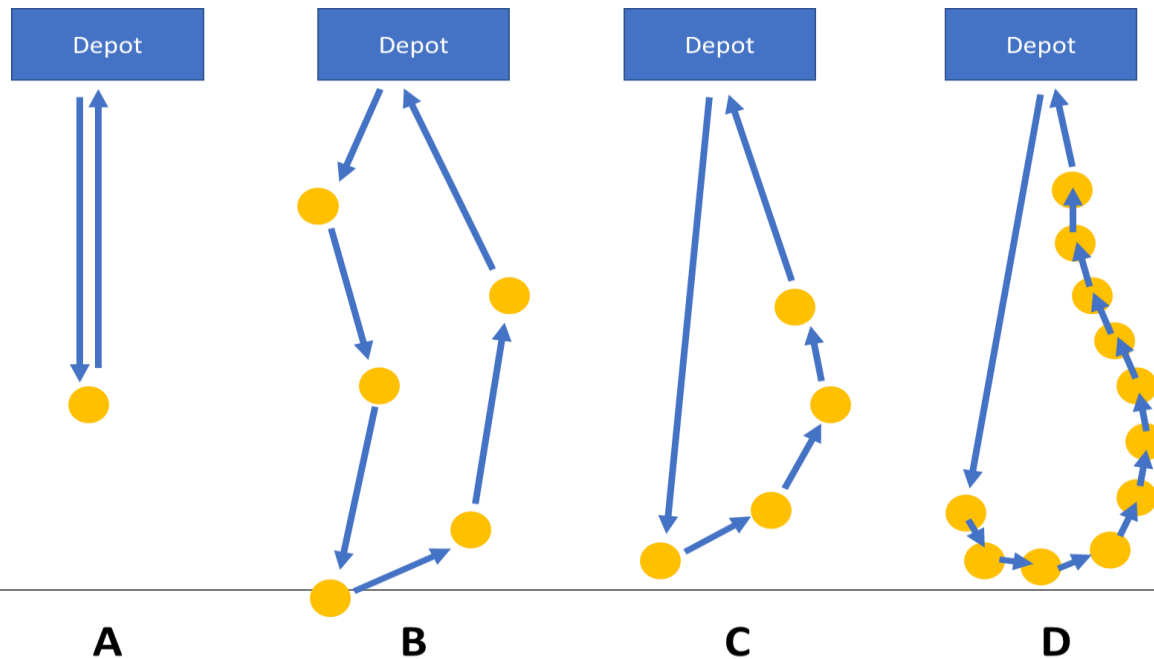
# Tour Typologies

- In the literature, there are several papers suggesting tour typologies, often based on relatively small data samples
- In this study, we used the dataset to segment truck travel into five tour types
- Each segment is then modeled separately



# Tour Typology Identification

- No stops between depots: depot to depot tours
- A: Single stop: single stop tours
- B: Long trips between stops: multi-sparse stop
- C: Short distance between stops: multi-clustered stop
- D: Large number of close stops: many-short-trip clustered stop





# Tour Typology Distribution

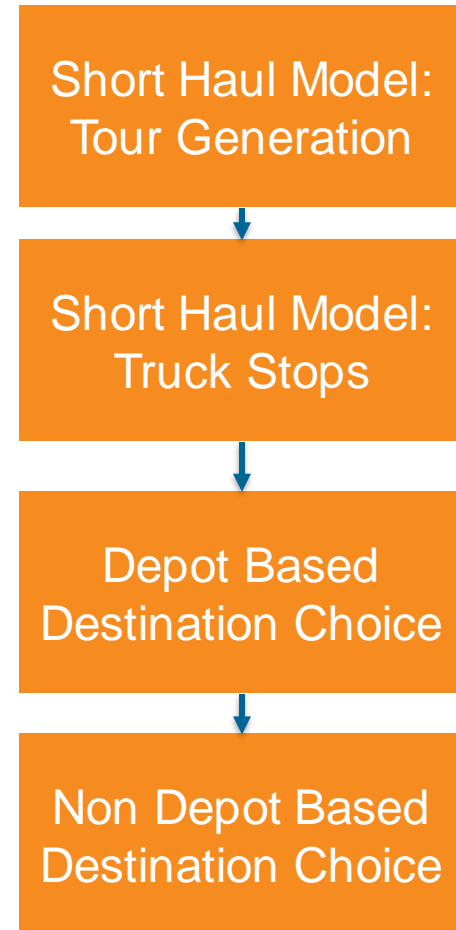
- Over 80% of heavy truck tours are depot to depot or single stop
- Light and medium trucks have a larger proportion of multi stop tours, particularly “sparse” tours
- Relatively few trucks are making multi-stop clustered tours, those that are are generally light and medium trucks

Tour Type	Heavy	Medium	Light	Total
Depot	30.49%	20.55%	15.41%	19.00%
SS	53.33%	43.99%	47.43%	46.15%
MSS	13.94%	29.74%	31.54%	29.41%
MSC	0.35%	3.77%	4.40%	3.80%
MSSC	1.90%	1.96%	1.21%	1.63%
Total	100.00%	100.00%	100.00%	100.00%



# Using Segmented Data to Support Model Estimation

- Data processed into tours and segmented by truck type and tour type
- Used to estimate tour generation, stop generation, and destination choice models
- Captures the characteristics of the different tour types

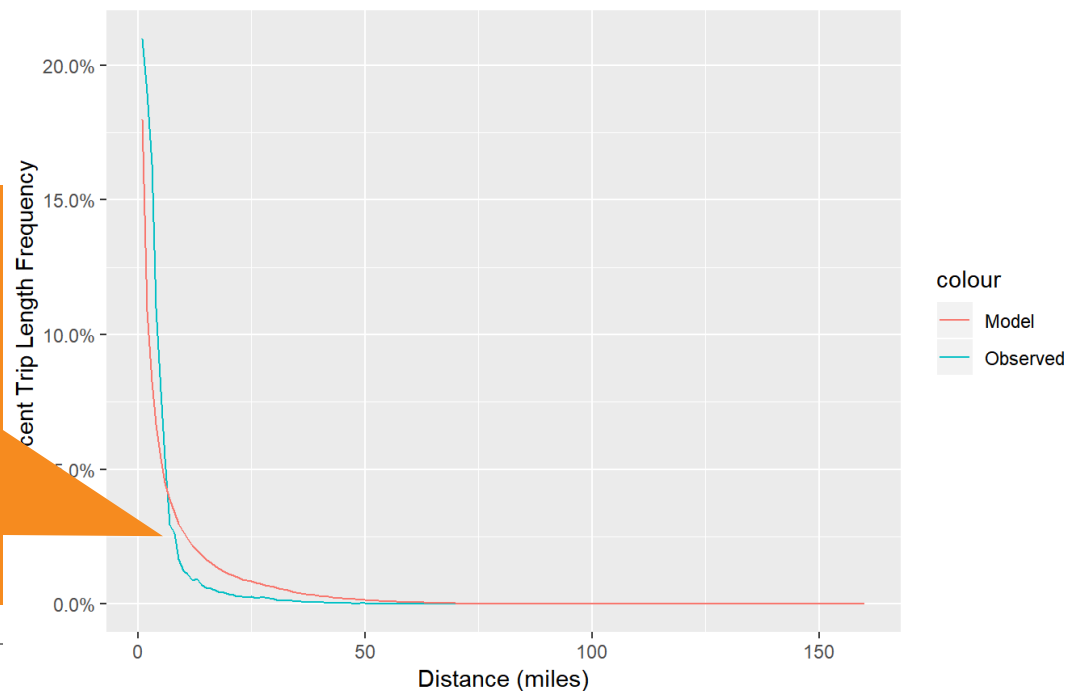


# Example: Destination Choice

- Model should reflect trip lengths by segment:
  - Sparse tours have longer trips,
  - Tours with clusters have short trips

Trip length frequency shows the model replicating the very short trip lengths between stops in the tours with closely clustered stops

Percent Trip Length Frequency - Multi-Short-Trip-Clustered-Stop Non-Depot Bas Medium Truck





# Connecting Long Haul and Short Haul Truck Movements

# Long Haul and Short Connections

- In theory, a freight model should connect long haul and short movements.
  - Long haul movements to and from a region provides demand for short haul truck movements
  - However, historically it has been hard to comprehensively identify the connection locations between those flows and understand how they operate without extensive survey work
- In this study, we used the processed GPS data to identify high activity truck locations
  - Classified them by truck type and by quantity of short and long haul trip
  - Identified transshipment locations where long haul flows and short haul flows meet
  - Used this to inform short haul truck tour generation based on commodity flow forecasts at these locations



# Example Location 1: Costco

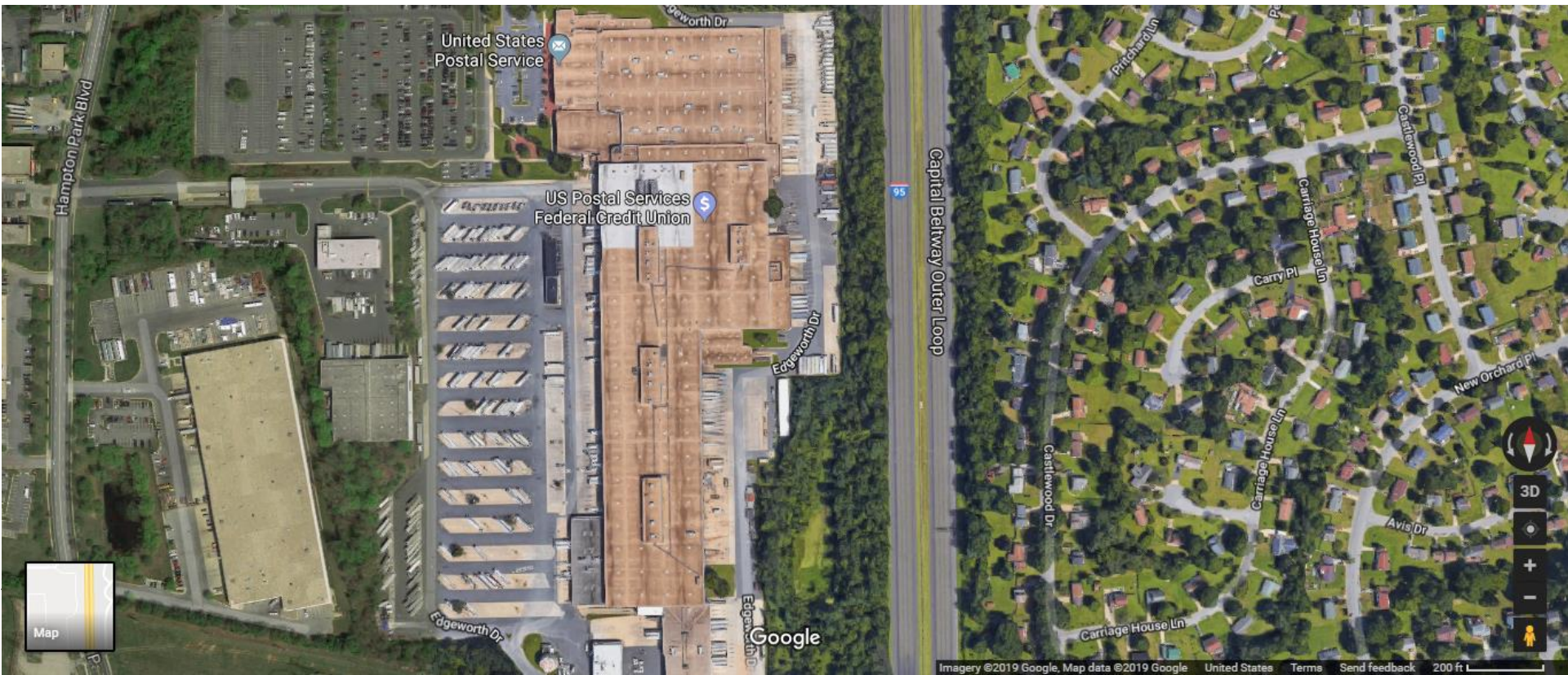
- Costco distribution near Frederick, MD is one of the highest intensity locations in the region for both long haul and short haul (within region trucks)
- Relatively low employment on site means it does not stand out using more traditional employment based truck trip rates





## Example 2: USPS

- US Postal Service depots are also important interchange locations between long haul mail movement and local distribution.
- Two major USPS depots (including this one by the beltway) stood out in the GPS data and are represented in the model as special generators



# Conclusions

- Large sample truck GPS data can be used to develop an understanding of truck travel behavior
- Processing techniques allows for creation of trip tables, tour lists, and depot identification
- Trucks can be categorized by tour typologies to segment truck operating practices
- Linkages between long haul and short haul movements can be observed region-wide and modeled





## Contacts

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