SHRP2 C20 Freight Model: Simulating Truck Touring to Provide Inputs to Emissions Model

Northern Transportation and Air Quality Summit

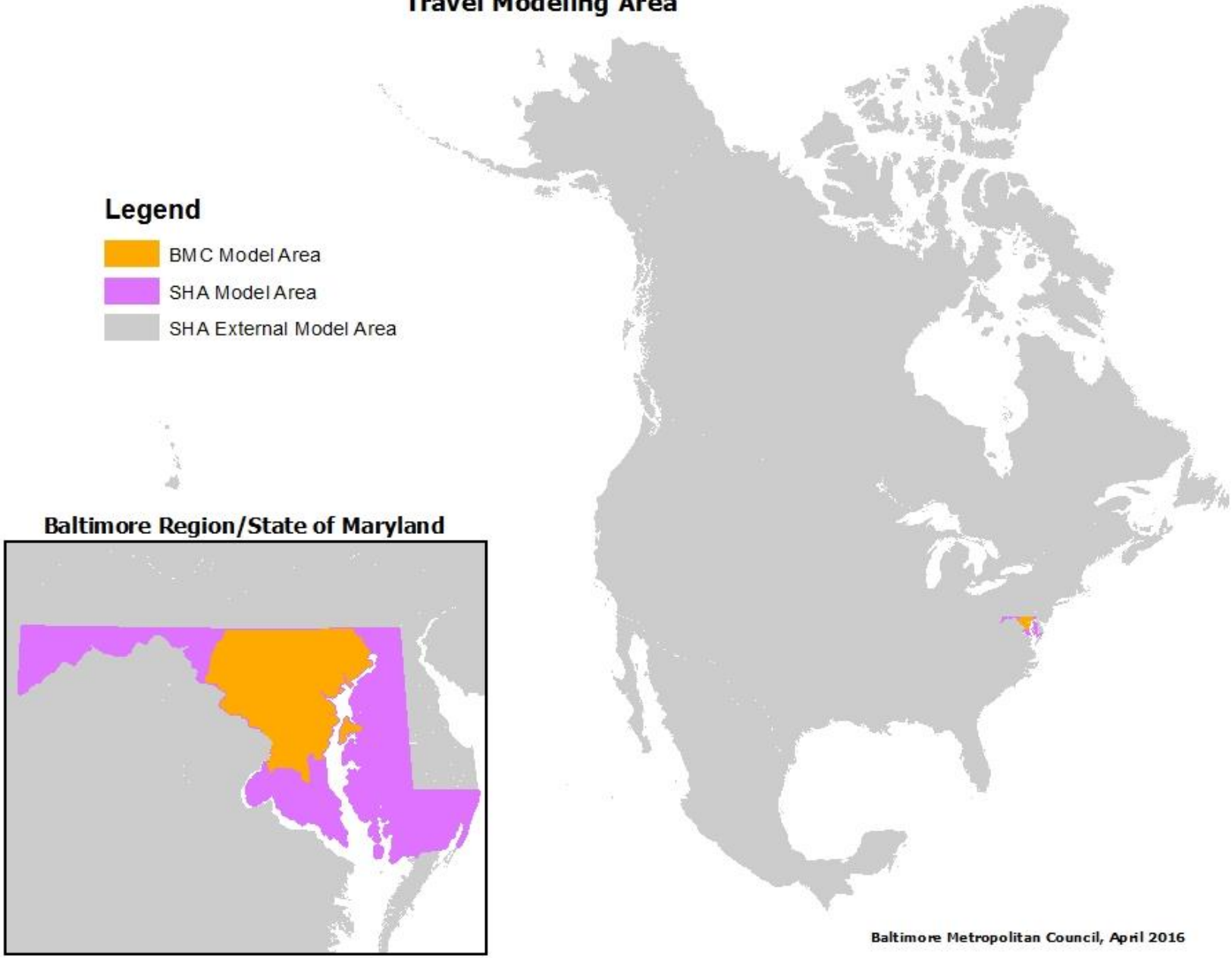
SESSION 6: TRAVEL FORECASTING FOR AIR QUALITY

August 31, 2016

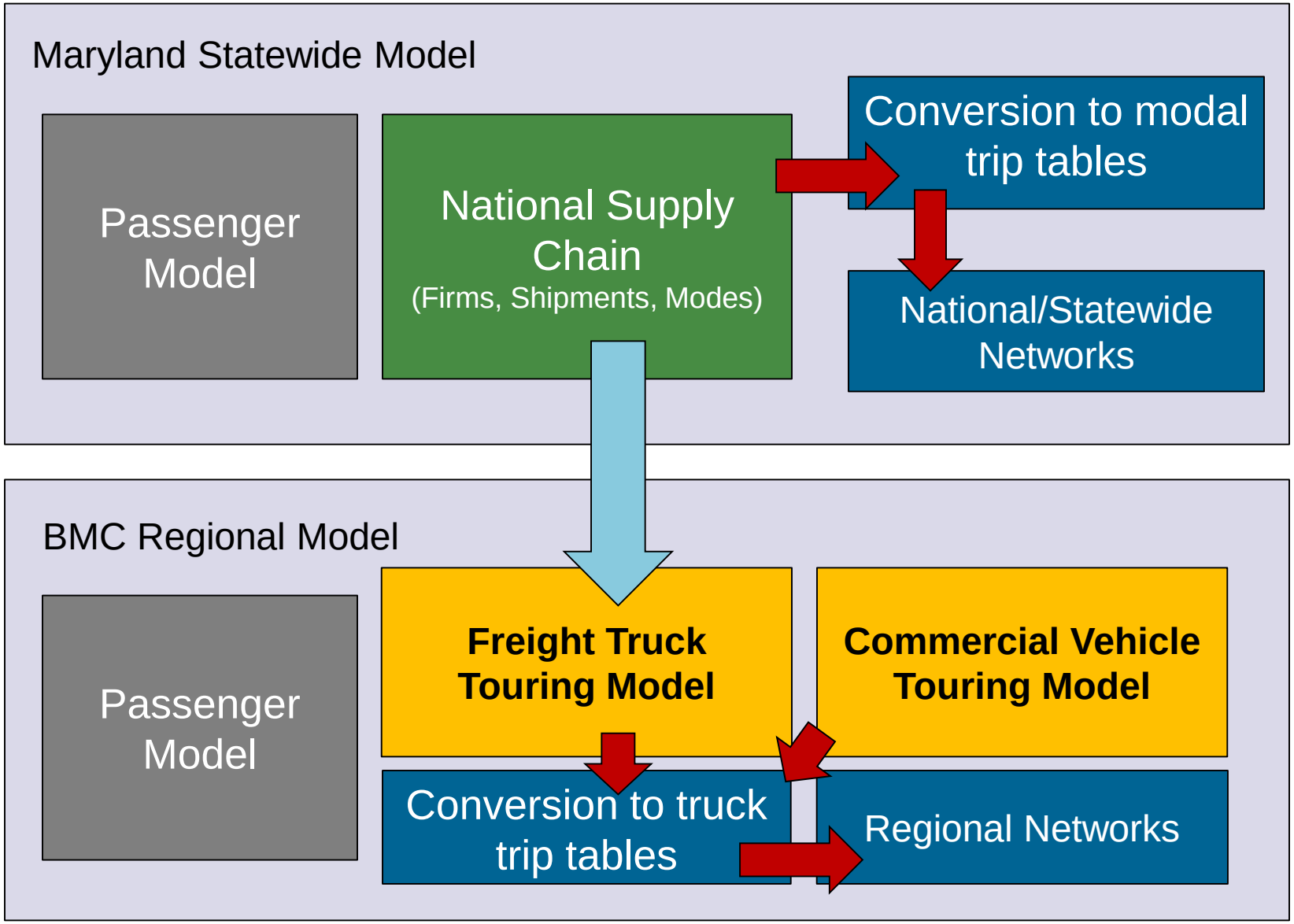
Introduction

- Overview of the SHRP2 C20 Freight Model
- How the Truck Touring Models simulate truck movements
- Model outputs: Truck trip roster
- Deriving information for use in emissions models

Baltimore Metropolitan Council & Maryland State Highway Administration
Travel Modeling Area



SHRP 2 C20 Maryland: Model Design



Commercial Vehicle Touring Model (CVTM)

- **Concept**
  - Focuses on the non-freight, service sector
  - Important differences between commercial service provision and freight flows
  - Estimated using establishment survey data
  - Uses similar algorithms to the freight truck-touring model to build vehicle tours and produce a complete truck trip list for assignment
- **Characteristics of Service Demand**
  - Demand is not generated from regular commodity flows
  - Infrequent demand by individual customers, many of whom are private residences
  - Destinations with no firm or residence are common (public utilities, road construction, parks, schools)
  - Short time horizons for service calls/dispatching of commercial vehicles are common
  - Some destinations may be considered “intermediate stops” (breaks/refueling)

CVTM: Components

- Customers generate service stops by purpose, location and time of day (arrival time)
- Stop durations are predicted.
- Firms then choose whether to group assigned stops into a single tour or multiple-driver tours.
- Drivers sequence stops
- Firms may generate "intermediate" stops in between customer stops and return home.

1. Establishment Type

↓

2. Stop Generation

↓

3. Expected Stop Duration

↓

4. Vehicle Assignment

↓

5. Stop Clustering

↓

6. Arrival Time at First Stop

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7. Routing Sequence

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8. Intermediate Stop Choice

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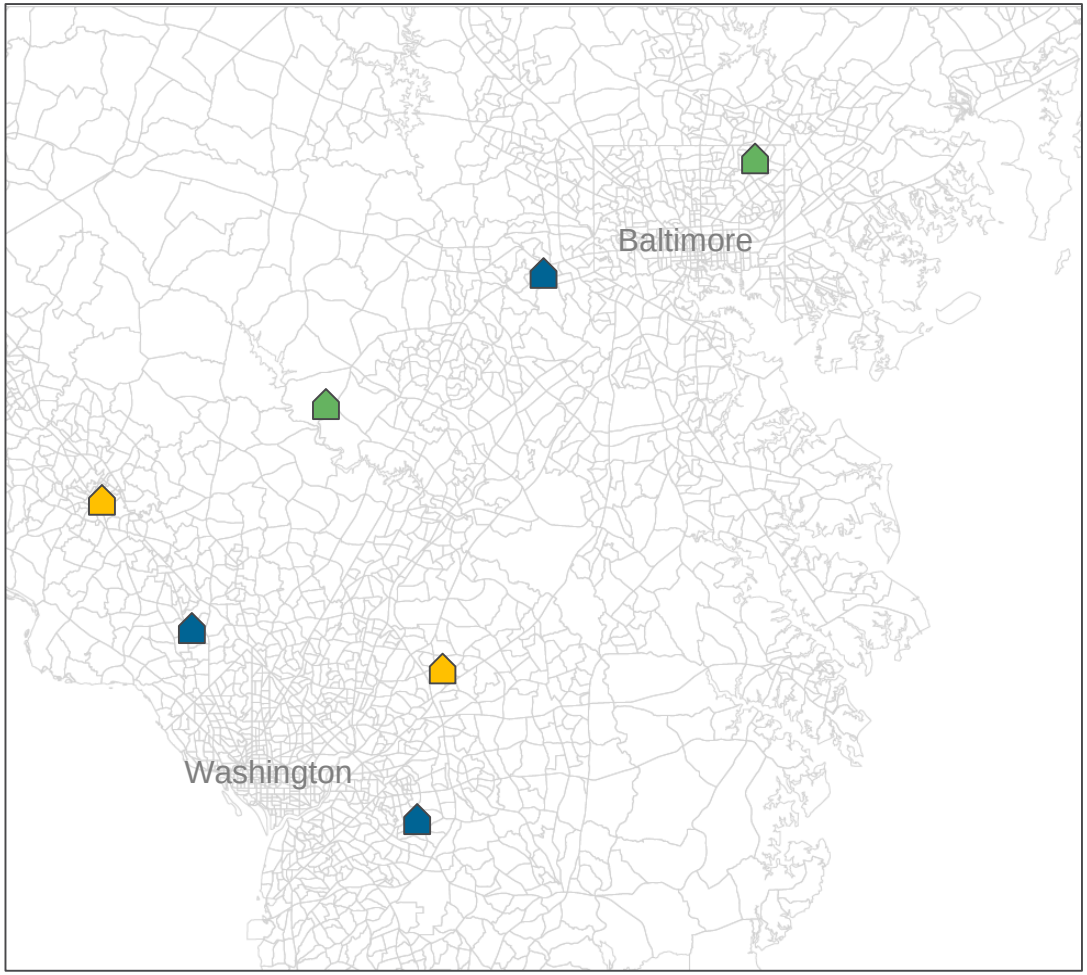
9. Intermediate Stop Destination

CVTM: Establishment Type Model

A portion of the model area



Note: not all firms depicted

For each synthesized firm…

- Predicts type of establishment:
  - Goods delivery
  - Services
  - Both
- Monte Carlo simulation used to draw from observed distributions of establishment types by industry

CVTM: Stop Generation Model

A portion of the model area

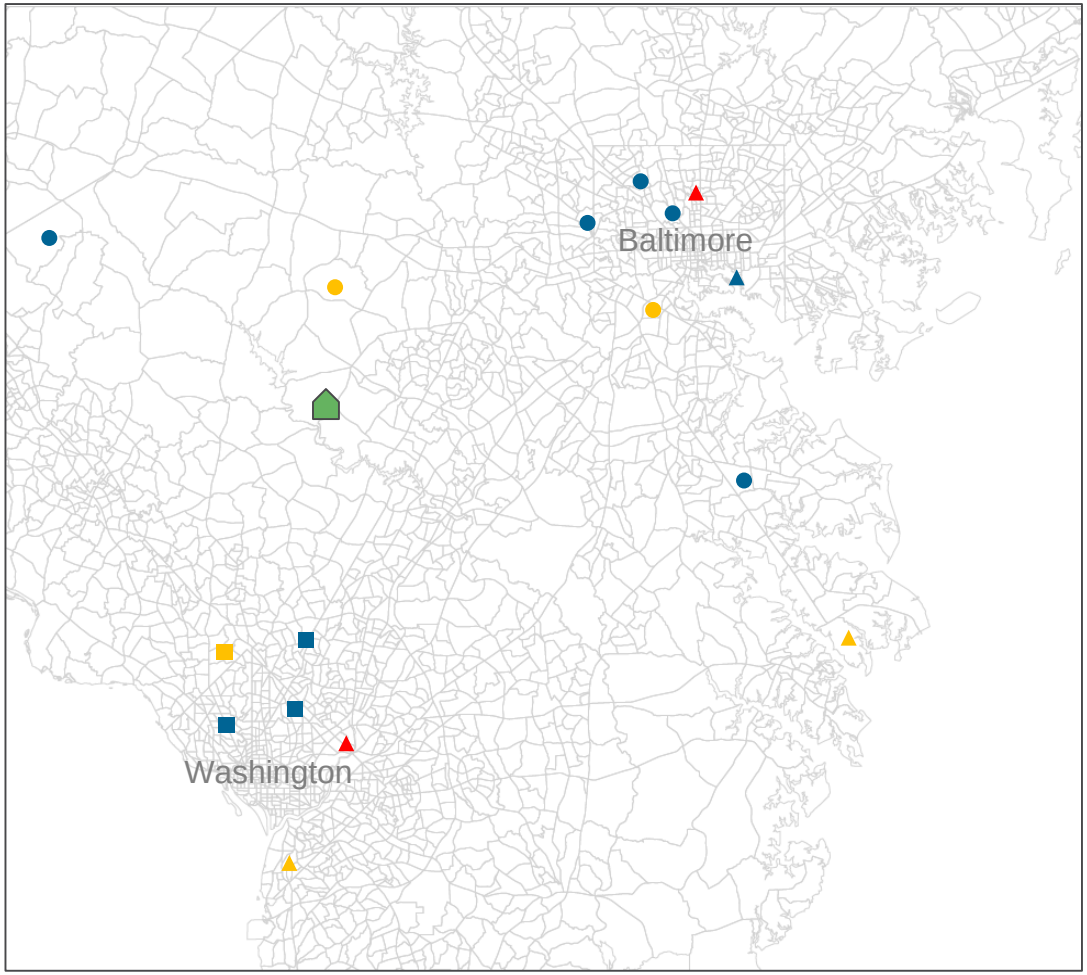
Note: not all system TAZs depicted

For each synthesized firm…

- TAZs sampled as candidates for stops
- Hurdle model predicts number of goods ● and service ● stops in each TAZ as applicable
- All firms may generate meeting stops as well ●
- Number of stops a function of firm size, industry, stop purpose, and TAZ socio-economic characteristics

CVTM: Vehicle Assignment Model

A portion of the model area

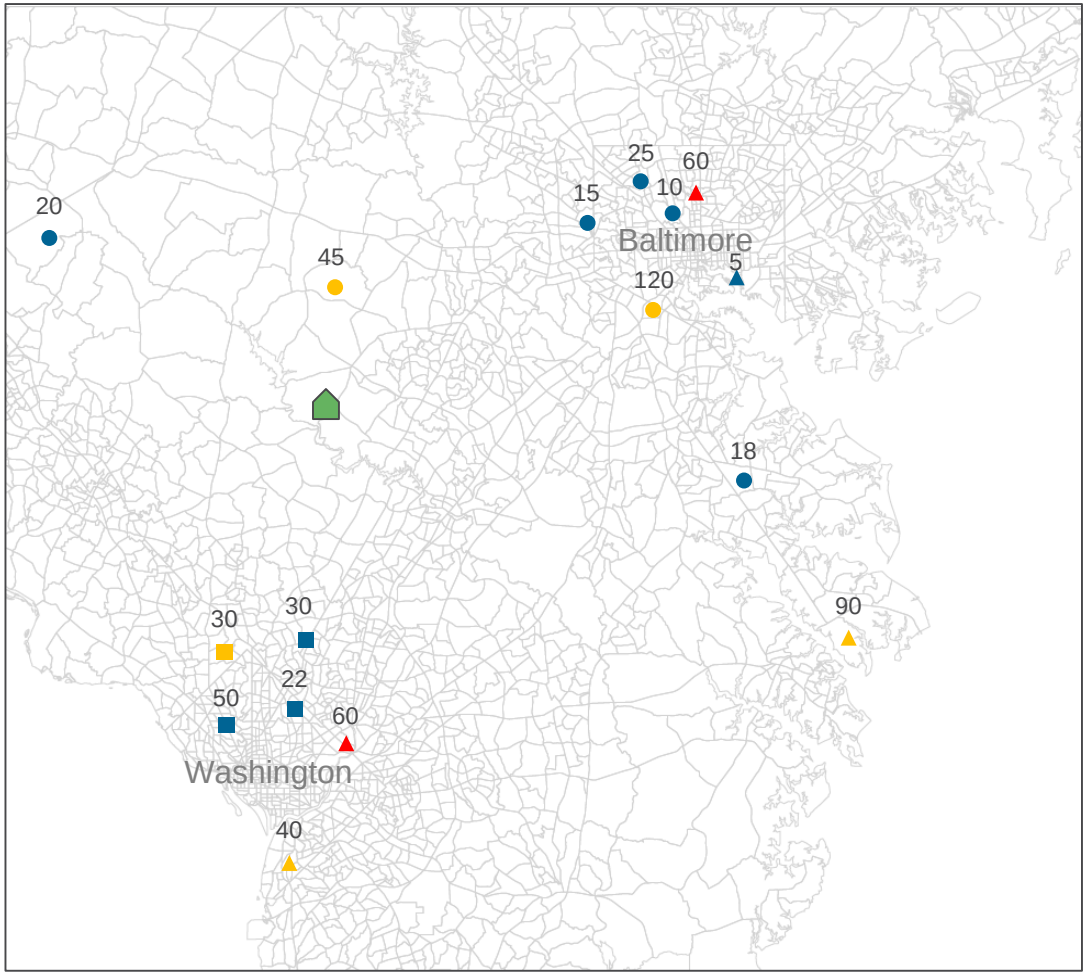


For each stop…

- MNL model predicts commercial vehicle type for each stop:
  - Light: car, van, pickup ▲
  - Medium: single-unit truck ●
  - Heavy: multi-unit truck ■
- Vehicle type a function of:
  - Firm industry
  - Distance
  - Stop purpose

CVTM: Stop Duration Model

A portion of the model area

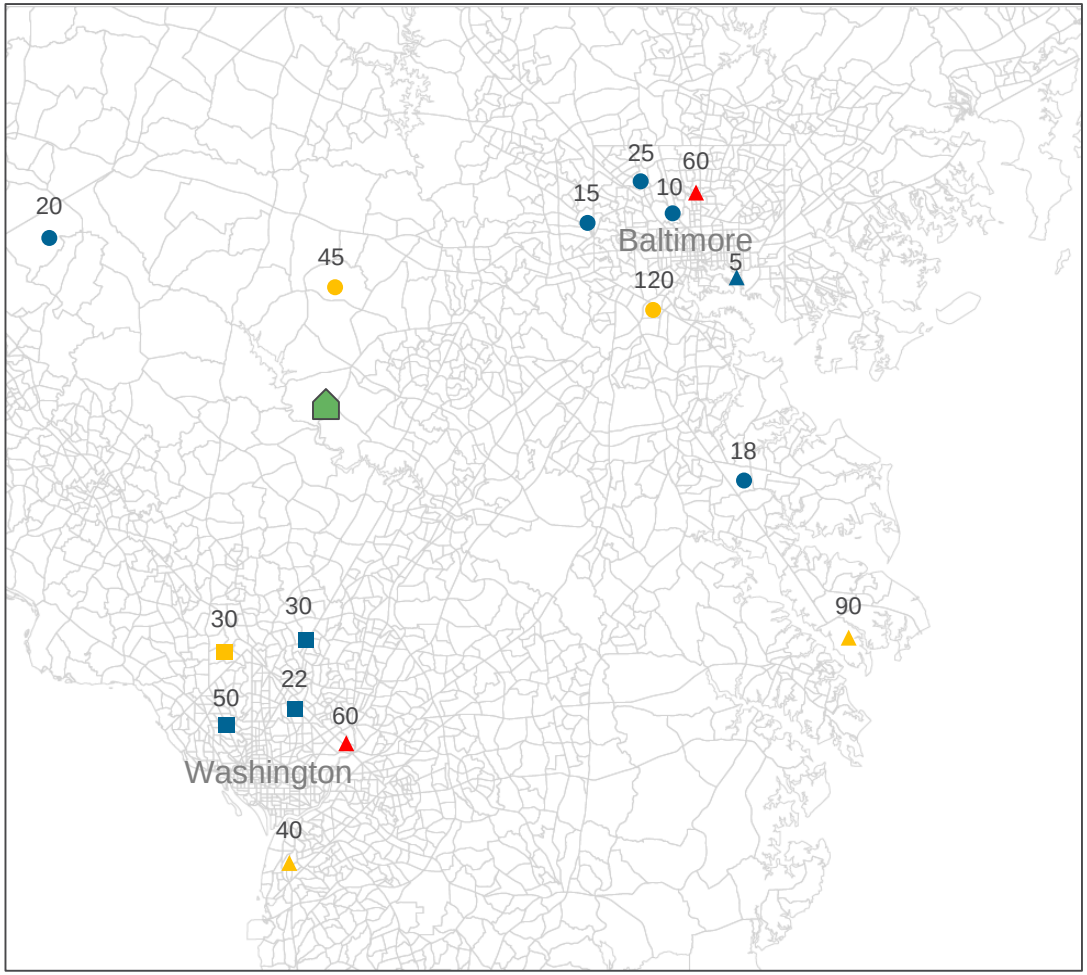


For each stop…

- Stop duration (minutes) drawn via Monte Carlo simulation from empirical distributions by:
  - Industry
  - Stop purpose

CVTM: Stop Clustering Model

A portion of the model area

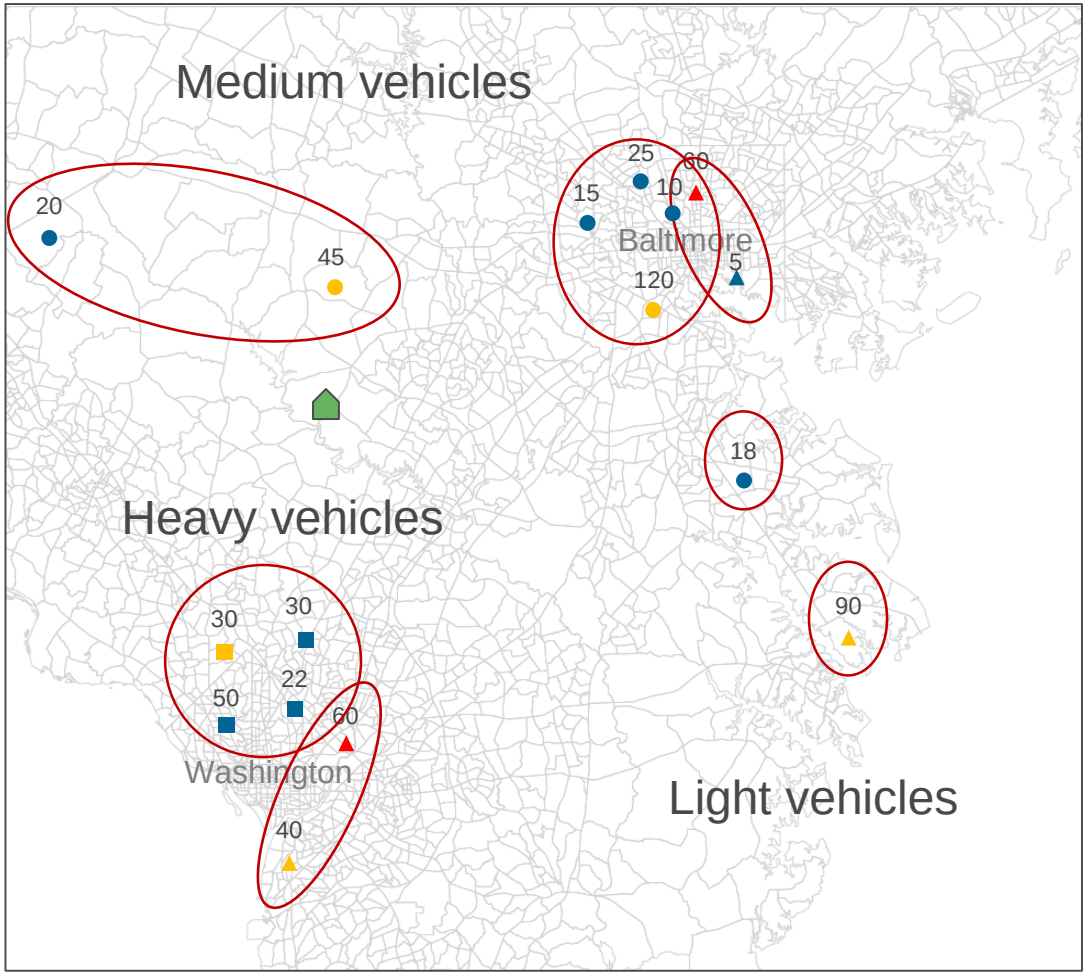


For each vehicle type…

- Hierarchical clustering groups spatially similar (travel time) stops into tours
- Weighted branch trimming prevents overly long tours without creating too many short tours
  - Based on stop duration as travel not known (stops not yet sequenced)

CVTM: Stop Clustering Model

A portion of the model area



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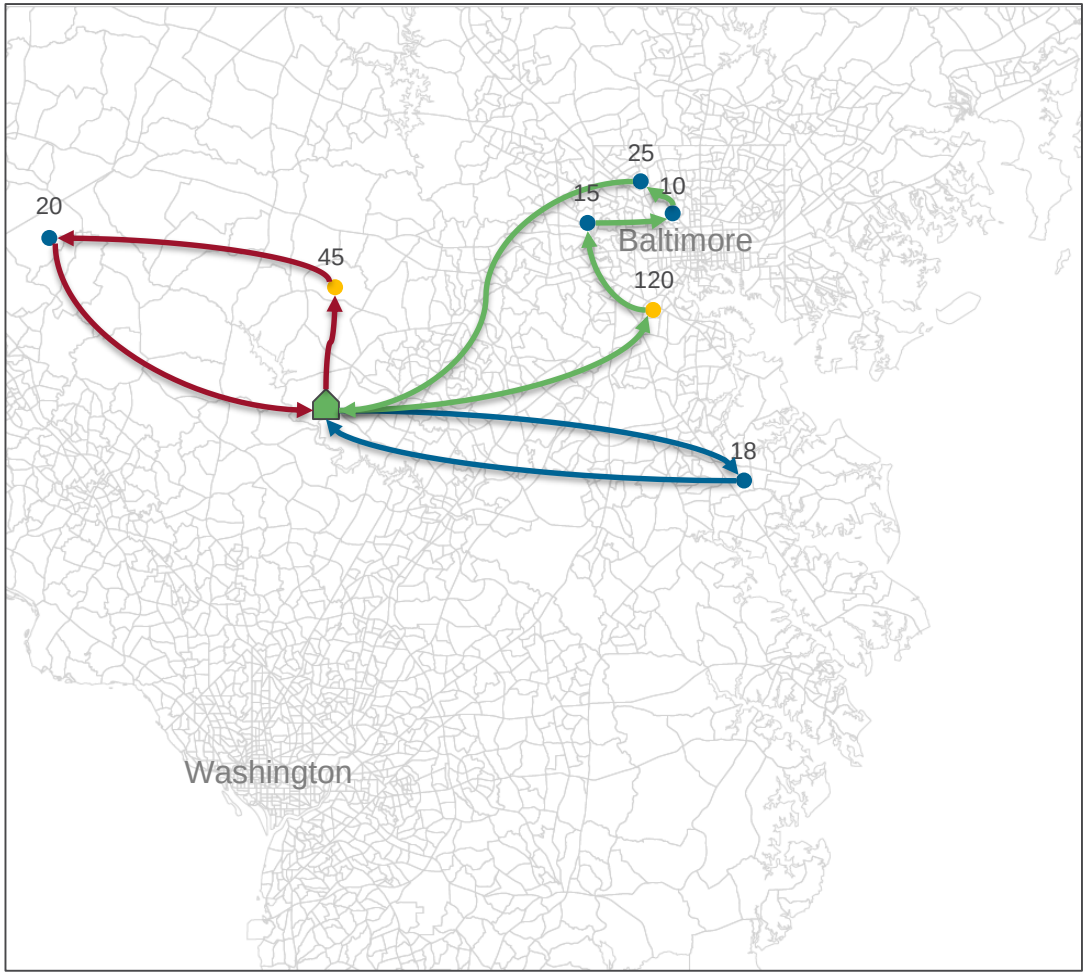
CVTM: Stop Sequencing Model

A portion of the model area

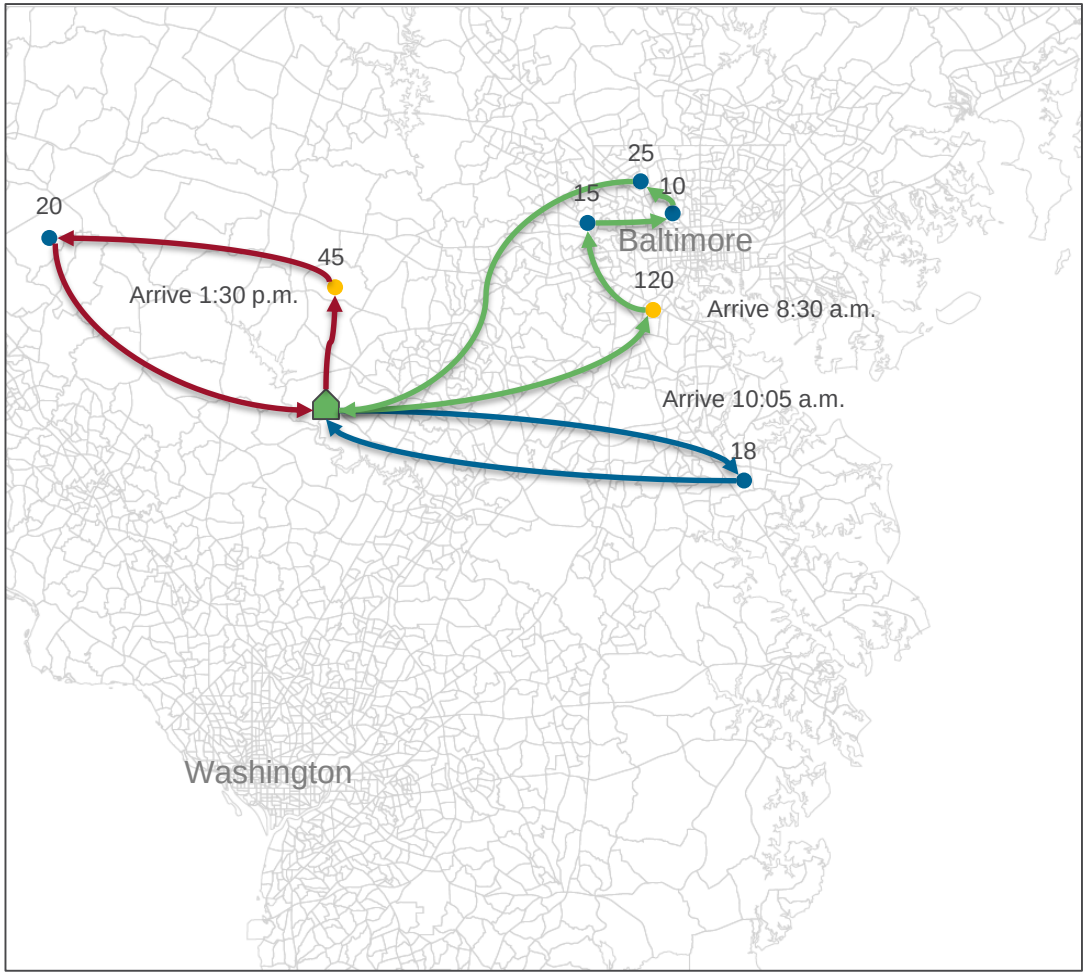


For each tour…

- Stops sequenced using Traveling Salesman algorithm on travel time combinations
- Provides reasonably short Hamiltonian circuits
- Avoids unrealistic tour patterns but not a true optimization
- Computationally feasible and generates realistic touring patterns

CVTM: First Stop Arrival Model

A portion of the model area

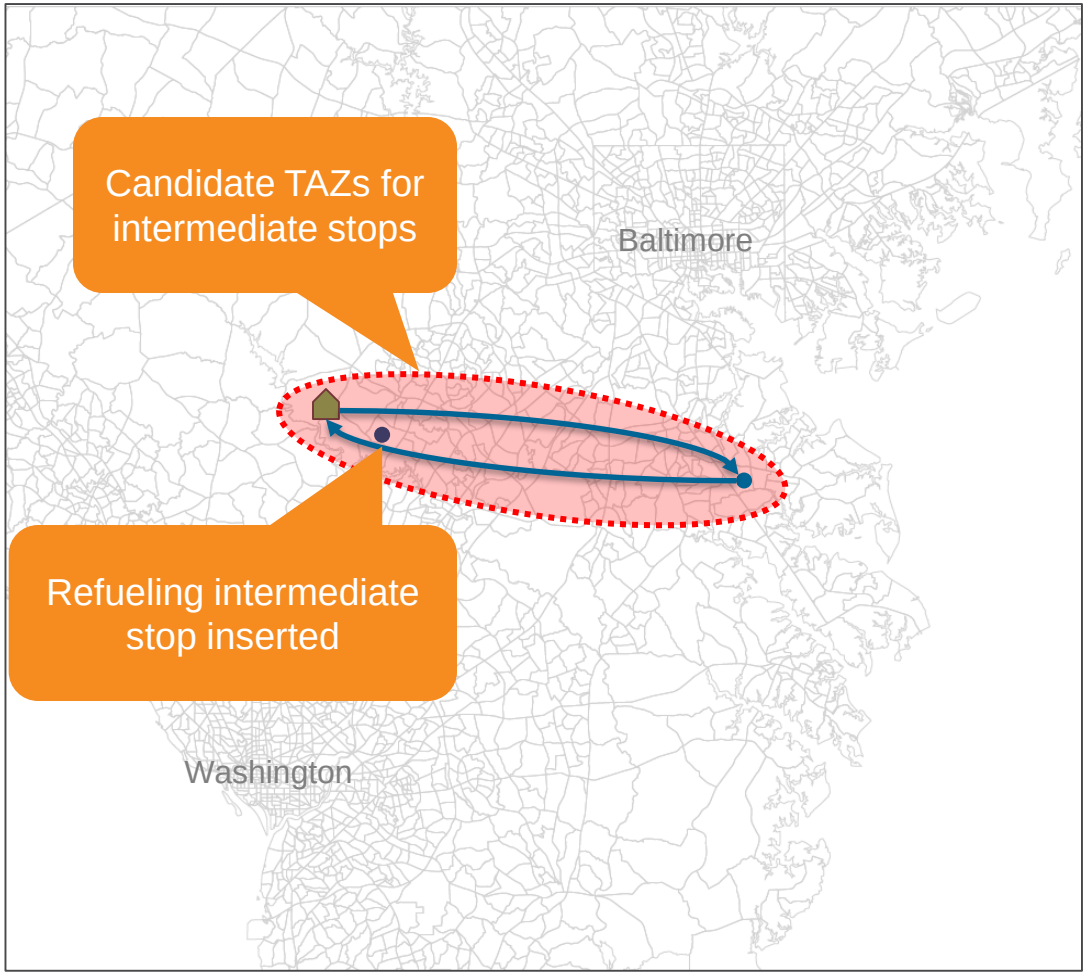


For each tour…

- MNL predicts arrival time at first scheduled stop as function of tour length
- Simulated arrival time windows of 30 to 60 minutes
- Monte Carlo simulation uniformly draws from selected arrive time window for precise arrival time

CVTM: Intermediate Stop Model

A portion of the model area



For each trip…

- Intermediate stop MNL model predicts whether an intermediate stop is inserted
  - Meal/break
  - Refueling/vehicle service
  - Other
- TAZs considered do not extend length of trip by some threshold (e.g., 3 miles)
- Stop duration model applied to any inserted stops
- Once all stops and order are known, trip is re-timed to determine arrival/departure times

CVTM: Intermediate Stop Model (cont.)

A portion of the model area

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- Intermediate stop MNL model predicts whether an intermediate stop is inserted
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  - Other
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- Stop duration model applied to any inserted stops
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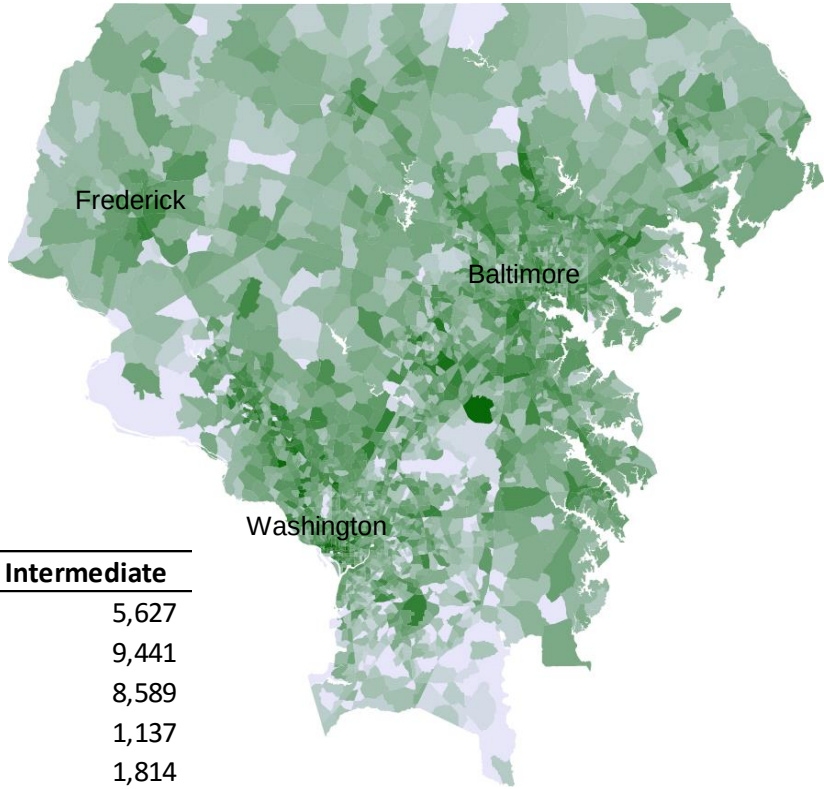
Model Outputs

- The model produces a trip list analogous to a truck trip diary
- This output can be processed into various forms:
  - Trip tables for assignment
  - Tabular outputs such as stops by county
  - Map based outputs such as stop by purpose by TAZ

Log(Number) of Service Stops by TAZ



	Stop Purpose			
County	**Goods**	**Service**	**Meeting**	**Intermediate**
Anne Arundel County, MD	28,972	30,743	19,036	5,627
Baltimore City, MD	29,781	57,012	36,985	9,441
Baltimore County, MD	40,935	58,665	31,336	8,589
Carroll County, MD	3,467	6,784	2,294	1,137
Frederick County, MD	5,802	11,165	4,475	1,814
Harford County, MD	4,124	10,165	3,925	1,542
Howard County, MD	17,811	21,523	11,265	3,570
Montgomery County, MD	56,734	83,324	36,520	11,643
Prince George's County, MD	19,881	31,974	13,766	5,399
District of Columbia	52,629	143,370	70,374	19,004
Total	**260,136**	**454,725**	**229,976**	**67,766**

Model Outputs: Trip List

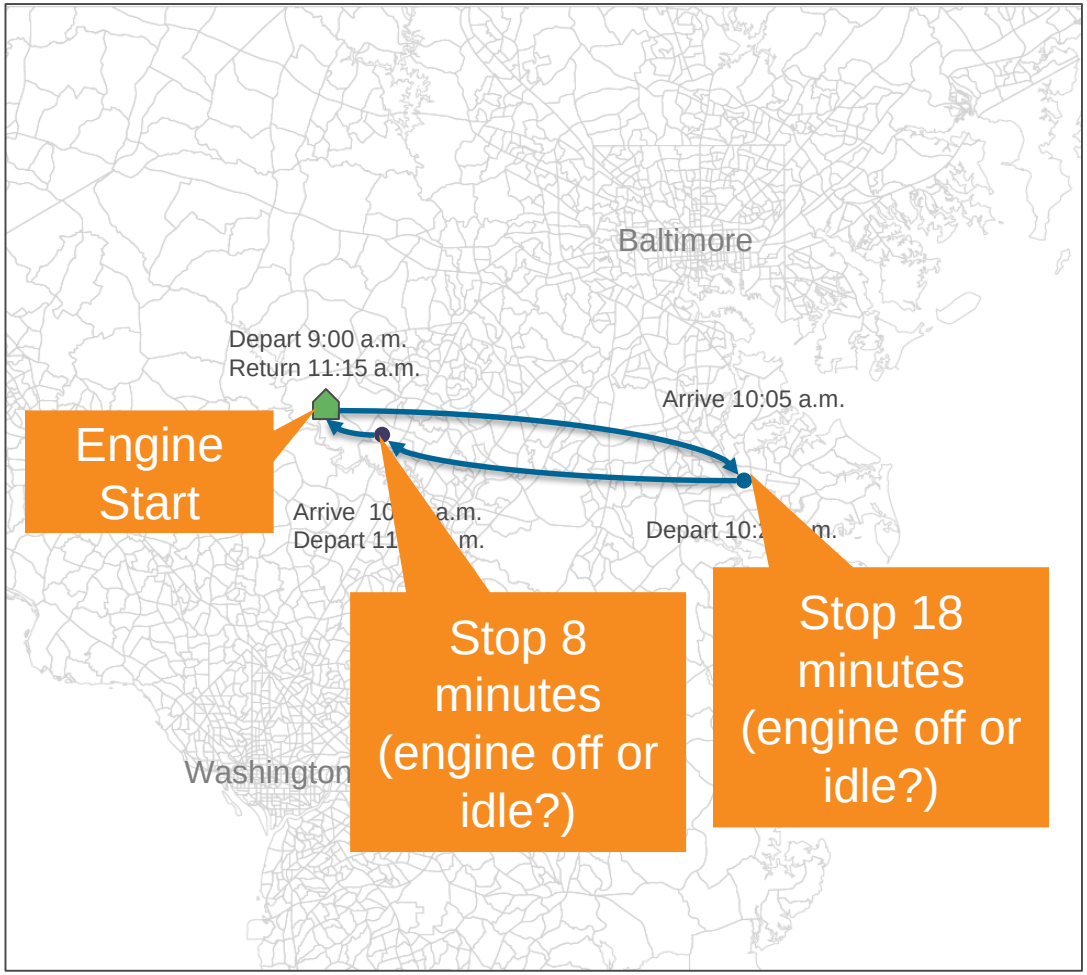
Origin	Dest.	Vehicle	TourID	TripID	Activity	Depart	Arrive	Travel Time	Distance	Stop Duration
1995	1999	Light	1	1	Service	15:30	15:33	3	1.3	4
1999	1986	Light	1	2	Service	15:37	15:47	10	4.9	9
1986	1995	Light	1	3	Return	15:56	16:07	11	4.2	0
1995	1999	Medium	1	1	Service	12:18	12:21	3	1.3	91
1999	1999	Medium	1	2	Service	13:52	13:53	1	0	12
1999	1999	Medium	1	3	Service	14:05	14:07	1	0	7
1999	2042	Medium	1	4	Service	14:14	14:33	19	9.2	46
2042	1461	Medium	1	5	Service	15:19	15:35	16	6.8	33
1461	1428	Medium	1	6	Service	16:08	16:12	5	1.9	36
1428	2313	Medium	1	7	Service	16:48	17:08	20	10.2	7
2313	2333	Medium	1	8	Service	17:15	17:21	6	2.2	39
2333	2333	Medium	1	9	Service	18:00	18:03	3	0	61
2333	1995	Medium	1	10	Return	19:04	19:10	6	3.3	0

Model Outputs for Emissions Models

- Outputs by truck type
- Simulation models individual truck itineraries
- For each truck:
  - Spatial location: TAZ and (potentially with connection to a dynamic traffic assignment - C10 project) link
  - Profile of starts and stops over the course of the day at deliveries and stops for other reasons
  - Potential to use these data to simulate cold starts, other starts, and idling

Model Outputs: Starts and Idling

A portion of the model area



For each <u>truck</u>

- Sequence of starts, trips, and stops with durations
- Potential to simulate cold starts, other starts, and idling using assumptions by vehicle type

Model Outputs: Freight and commercial stops by location and time of day

3:00 AM

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