Development and Application of a Model to Estimate Driverless Autonomous Vehicle Trips

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Presentation Outline

1. Scenarios
2. Twin Cities Model Application
3. Estimating Owned/Shared Mix
4. Assignment of AV trips
5. Feedback and integration with the planning model
6. Examples of Types of Results
7. Additional Research

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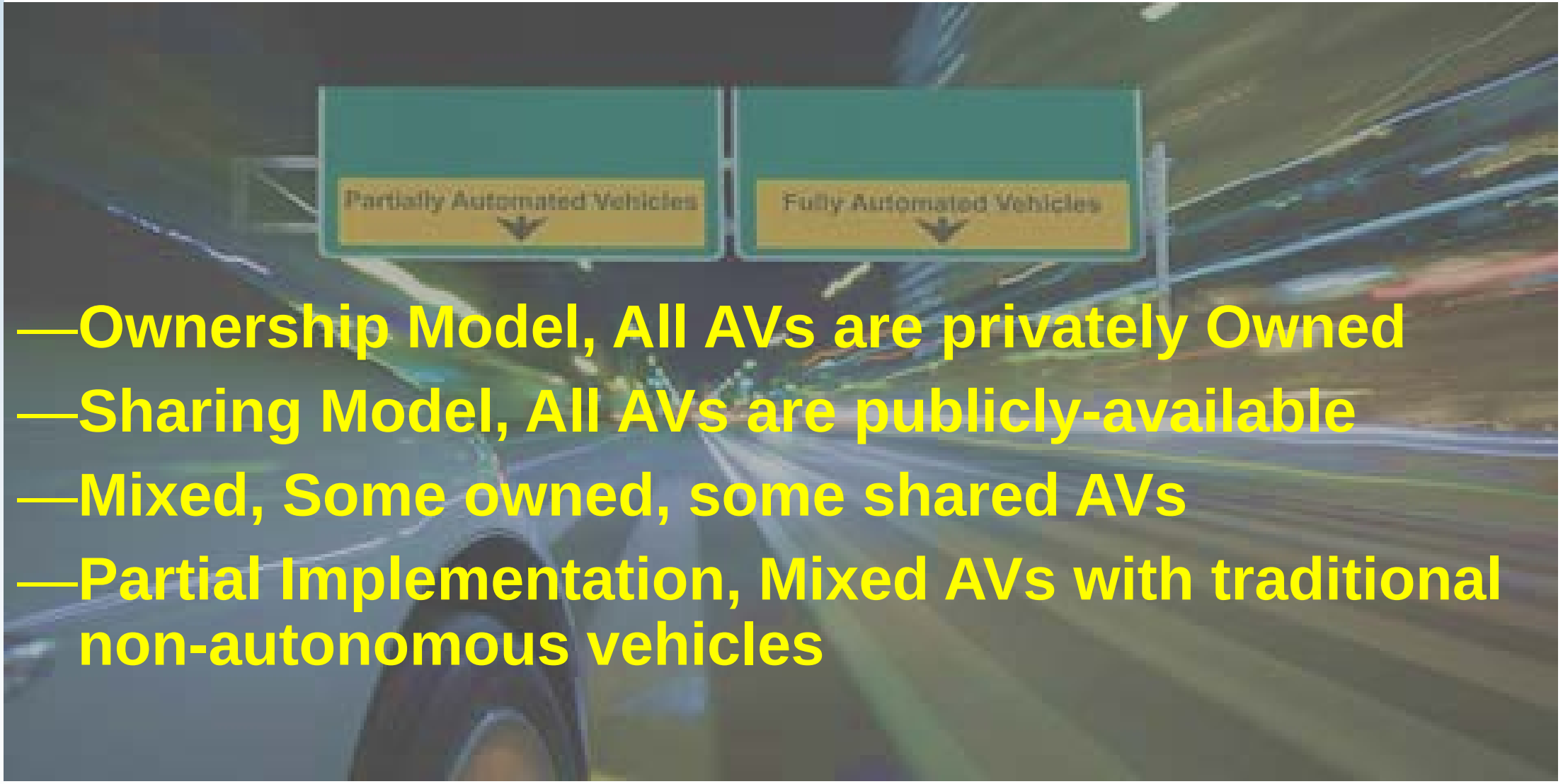
1. Scenarios for AV Use



—Ownership Model, All AVs are privately Owned

—Sharing Model, All AVs are publicly-available

—Mixed, Some owned, some shared AVs

—Partial Implementation, Mixed AVs with traditional non-autonomous vehicles

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2. Model Adjustments for AV Scenarios

1. *Cost*
2. *Auto Availability*
3. *Capacity and Flow Model*
4. *Driverless Vehicle Movements*
    1. Ownership Scenario
    2. Sharing Scenario

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2.1 Cost Assumptions

- Parking Costs
- Auto Operating Costs
- Value of Time

- What are these costs?
- Relatively easy to implement within a model.
- May need to stratify costs between traditional and AVs, Driverless and Occupied.
- Some policy assumptions needed, e.g., tolling

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2.2 Auto Availability Adjustment for AVs

- **AVs will allow access to autos for populations that previously did not have access:**
  - *Elderly and disabled*
  - *Children*
  - *Low income (partially)*
  - *Auto-deficient households*

- **Model Adjustments**
  - *Adjust inputs so that 95% of Households above lowest Income (>25k) have sufficient autos to serve adult population. Adjust to 50% for lowest income group.*

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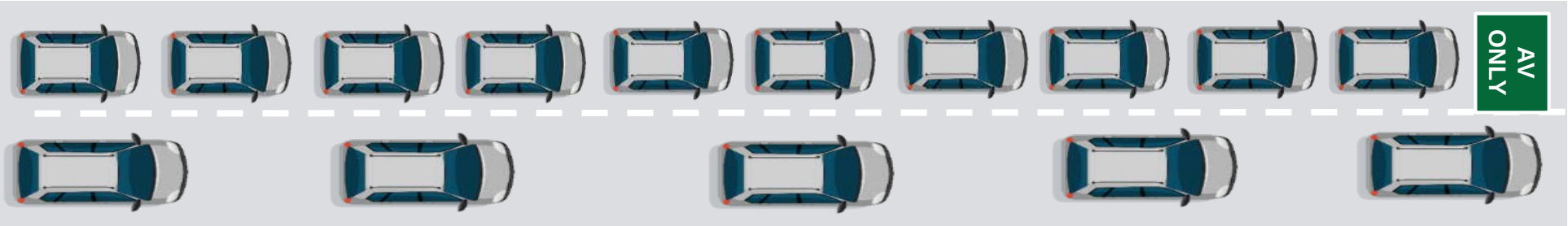
2.3 Capacity Adjustment



- **AV use will increase capacity by**
  - *Ability to maintain shorter headways on freeways and express ways*
  - *AV's have the ability to mitigate the effects of congestion on travel time*

- **Model Adjustments** ***– Owned & Shared Scenarios***
  - *Increase capacity by 50% for freeways and expressways*
  - *Increase capacity by 10% for Arterials*
  - *Modify the relationship between volume and speed to be more "forgiving" with regard to demand*

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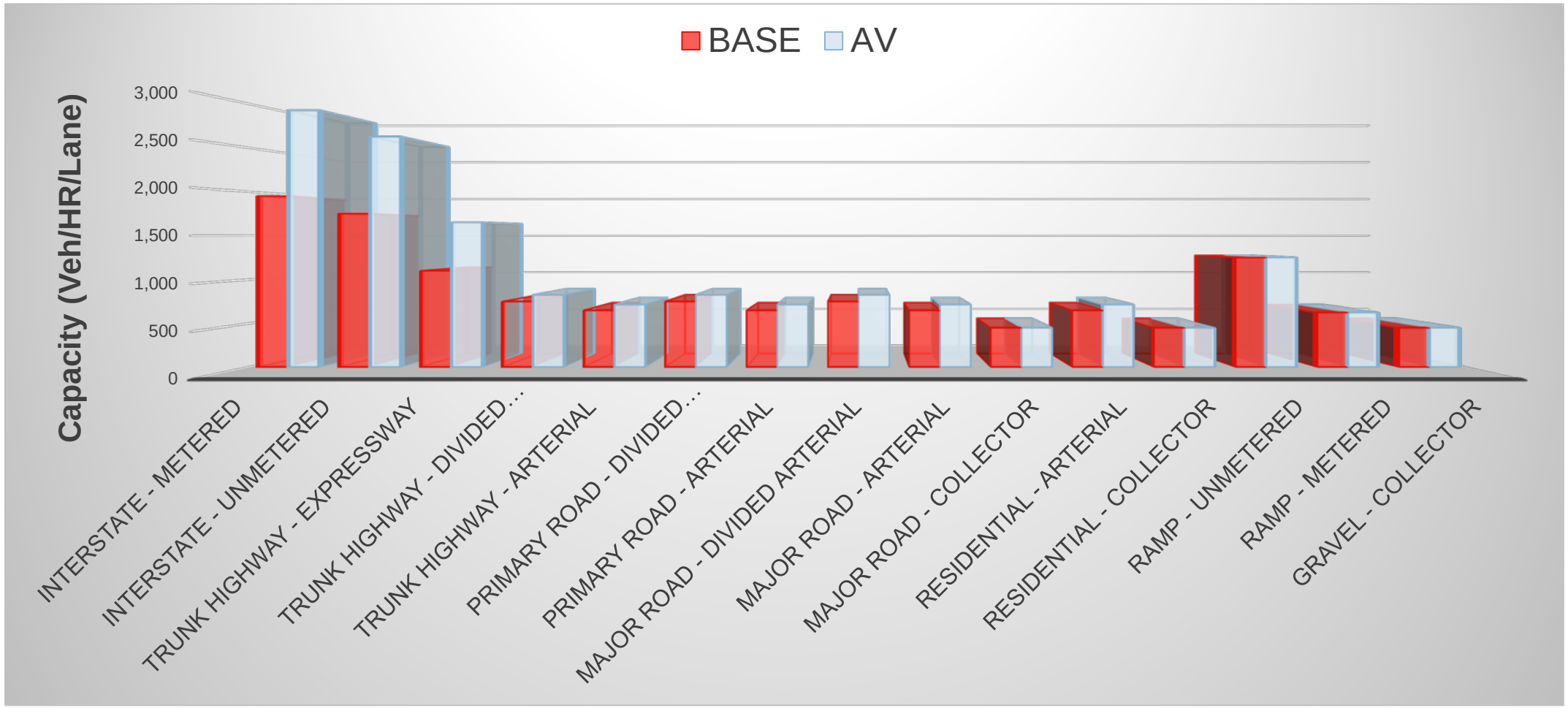
2.3 Capacity Adjustment for AVs



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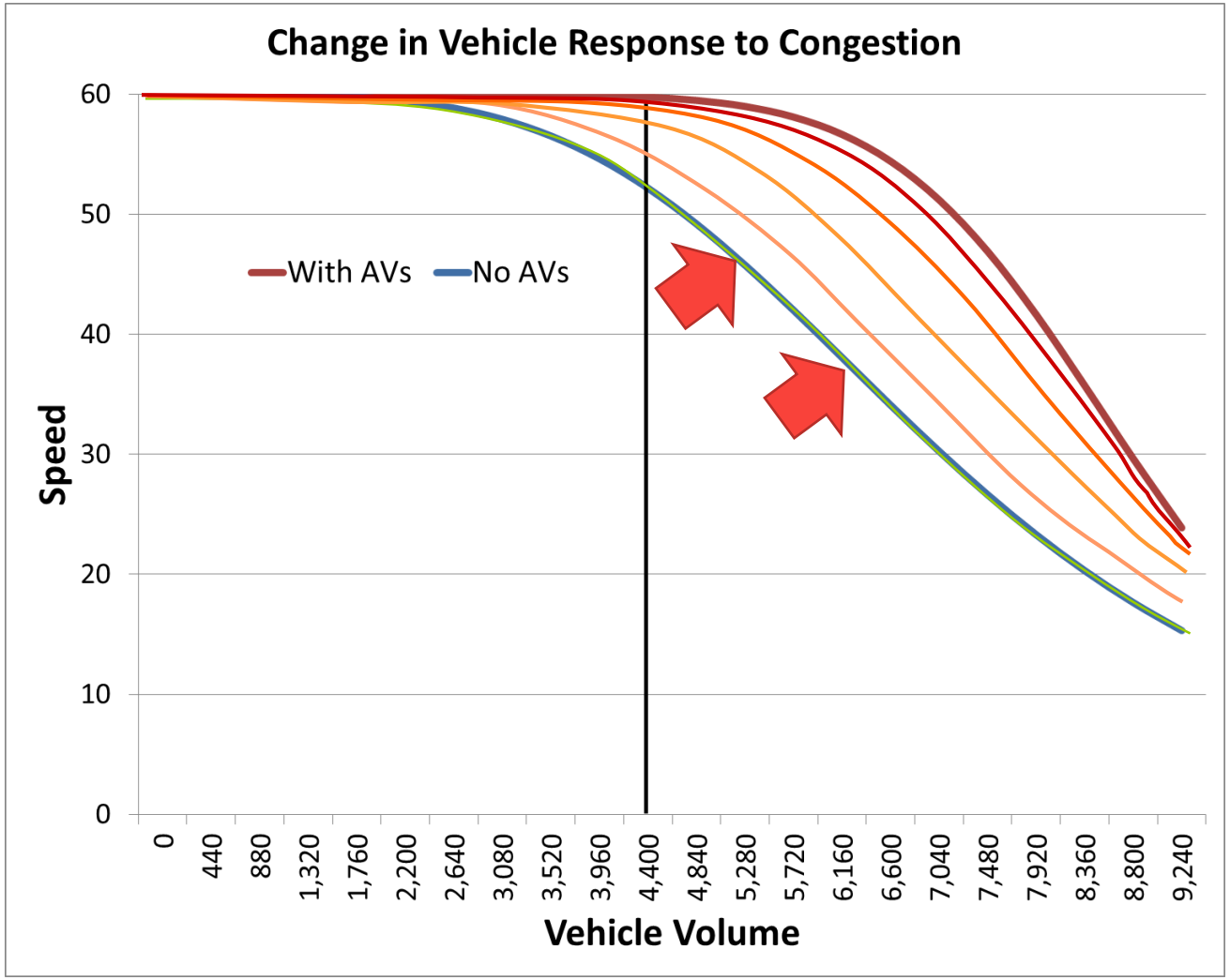
2.3 Adjusting Volume-Delay Functions



2.4.1 Driverless Vehicle Movements for the Ownership Scenario, Using Activity-Based Model Outputs

- Consider all model-estimated vehicle trips for each household, including origin, destination, start and end times
- Create an AV, and connect household vehicle trips sequentially through the day
- Consider time necessary for each driverless trip, and compare with available time
- In some cases consider intermediate parking
- Continue to create new AVs until all household trips are served

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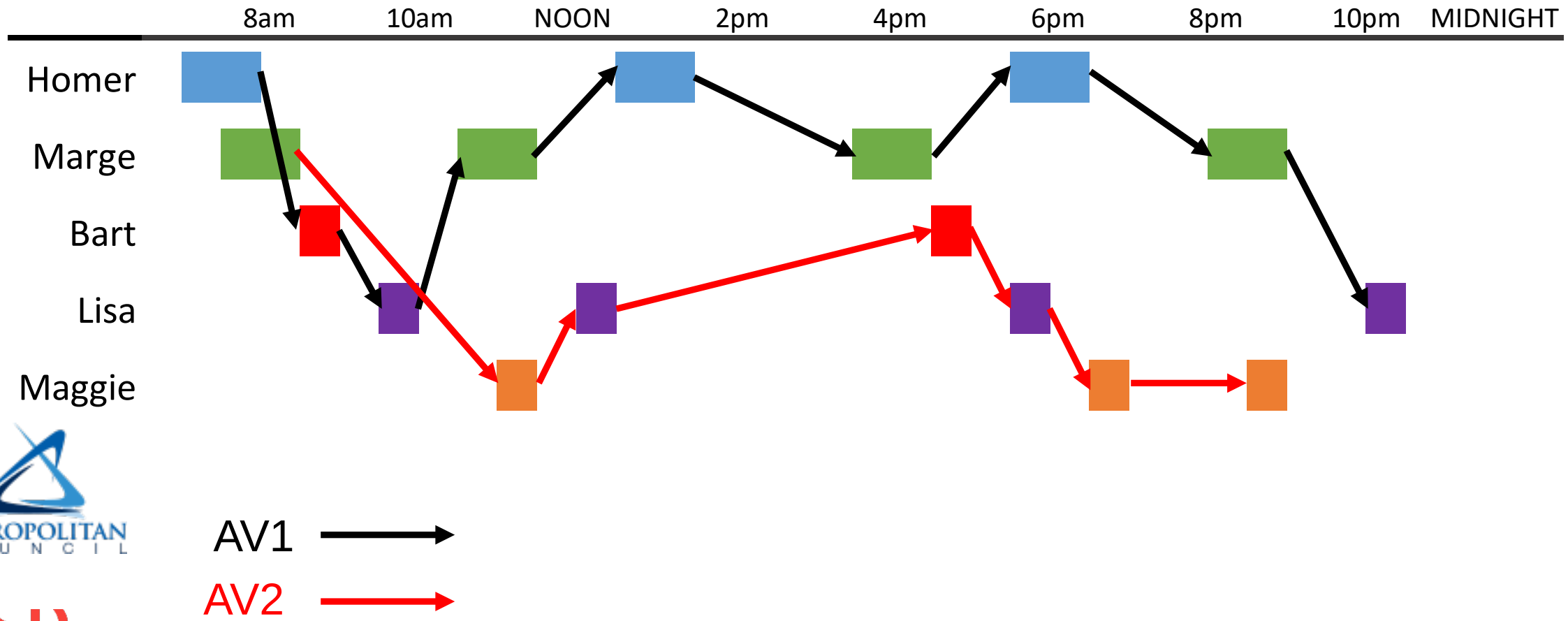
2.4.1 Driverless Vehicle Movements for the Ownership Scenario



2.4.1 Service Algorithms for AVs, Ownership Scenario

- Household Members availability based on location and time
- Choice of intermediate parking location compared with home location if there is more than 30 min wait.
- A score is computed for trips to home and the “best” intermediate parking location. Based on total time.
- Parking availability based on a user-supplied share of undeveloped land
- Remote parking demand constrained by capacity

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2.4.1 Example: Owned Vehicle, Household 195302 Home Zone 2881

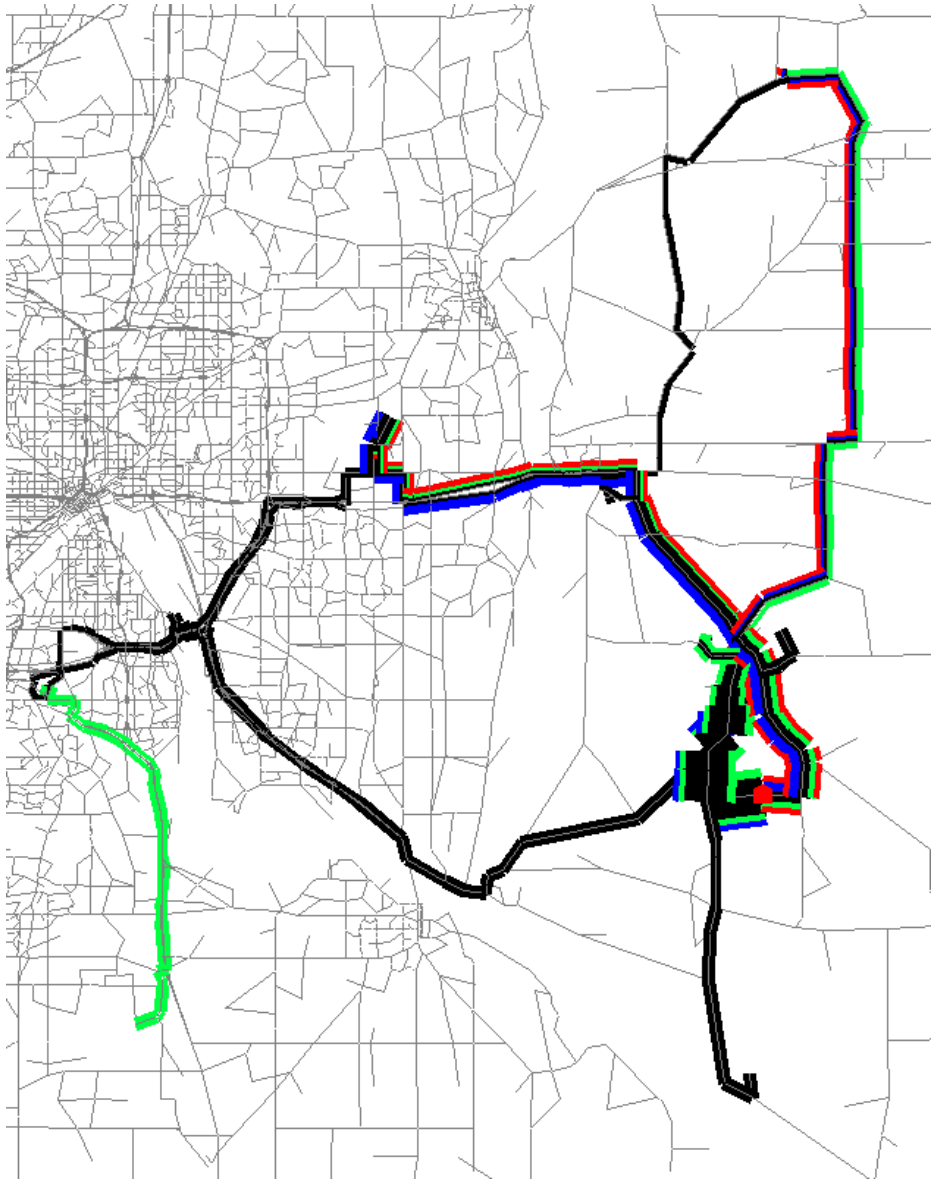
26 Occupied Trips

3 vehicles

Vehicle 1: 9 DL trips

Vehicle 2: 4 DL trips

Vehicle 3: 2 DL trips



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2.4.1 Outputs for Ownership Model

- Selected Households – may be a subset of region
- Driverless trip records – includes
  - *Household ID*
  - *Vehicle ID*
  - *Origin and Destination Zones*
  - *Start and End times*
- Number of AVs required by household
- Number of AVs in intermediate parking, by zone and by time of day

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2.4.2 Driverless Vehicle Movements for the Shared Vehicle Scenario

- Same principal as used for ownership scenario – except all occupied vehicle trips are open to being served
- Search pattern for next available trip seeks to minimize driverless trip time and dwell time between services
- User specifies a minimum and maximum allowable dwell times
- User specifies maximum allowable driverless trip time
- Result is a set of driverless vehicle trip records, and a log of each vehicle's movements throughout the day
- Segmentation of input is permitted to allow for parallel processing

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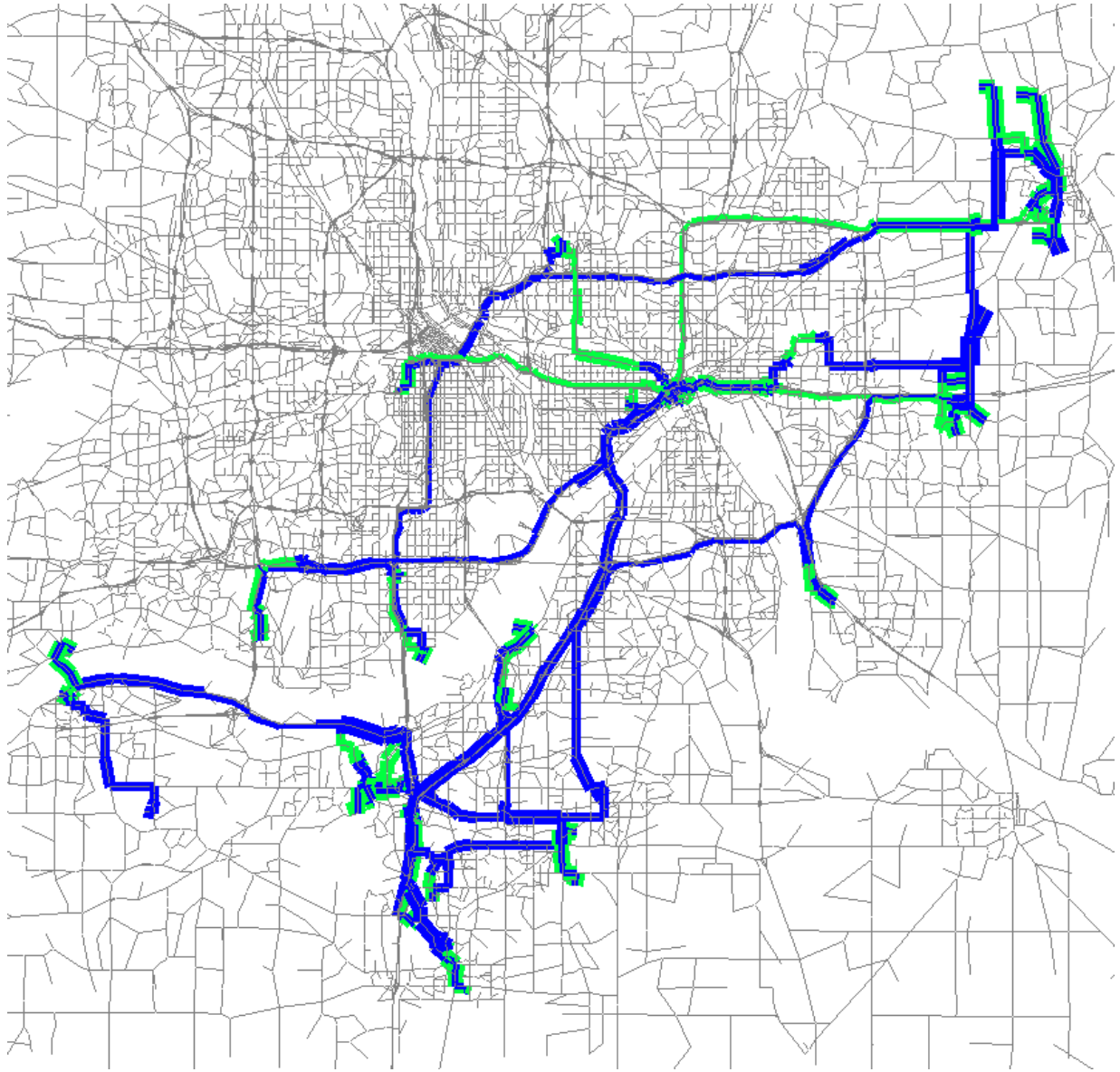
2.4.2 Example: Shared Vehicle 6316

30 Occupied Trips
29 Driverless Trips

292 Occupied Miles
115 Driverless Miles



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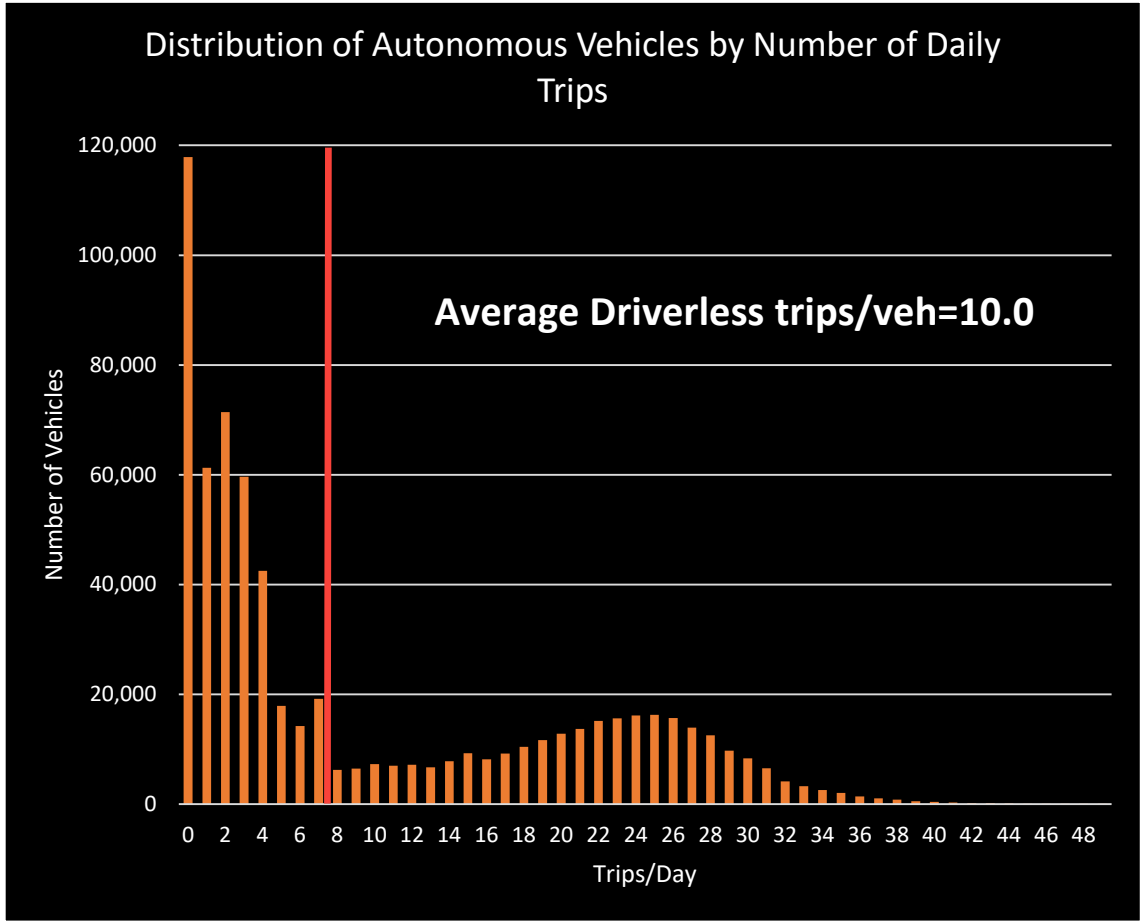
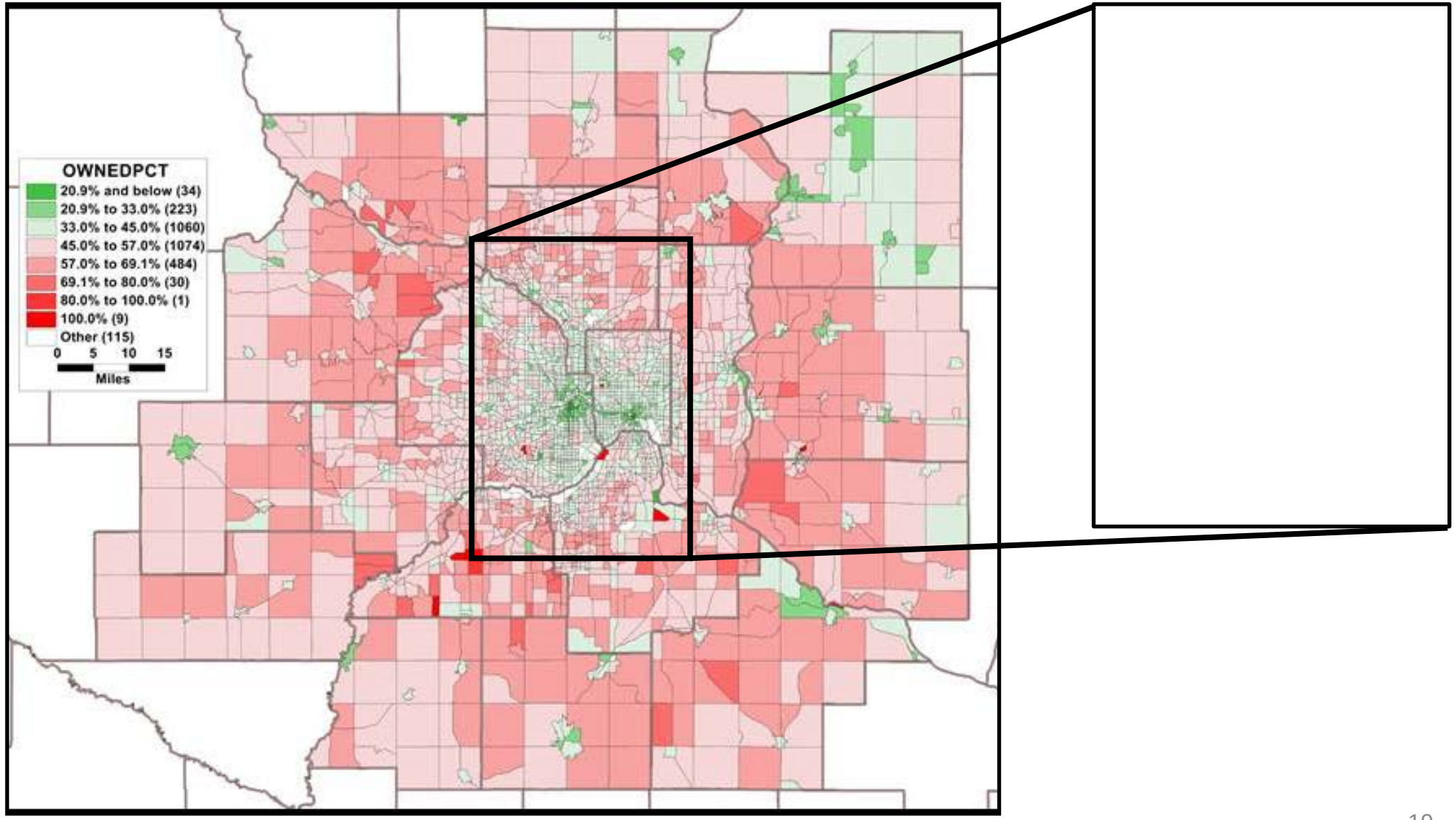
3. Estimating Ownership or Sharing by Household for the Mixed scenario

- Using the 100% shared scenario, Identify vehicles that are used 7 or fewer times/day
- Compute for each household the average number of trips by shared autos used
- For households served inefficiently by shared autos, tag these as “ownership” households.
- This resulted in about 45% of households owning AVs, 55% of households using shared AVs



3. Mixed Scenario: Map of Zones by Share of Households Owning AVs



4. Assignment of Driverless Vehicles

- Added driverless vehicles as an additional class
- Model information available to plot where AVs would dwell when not in use.
- End of Day re-positioning
- Wealth of MOE's available for both occupied and driverless vehicles
- Feedback ensures that congestion imposed by driverless vehicles influences other behavior

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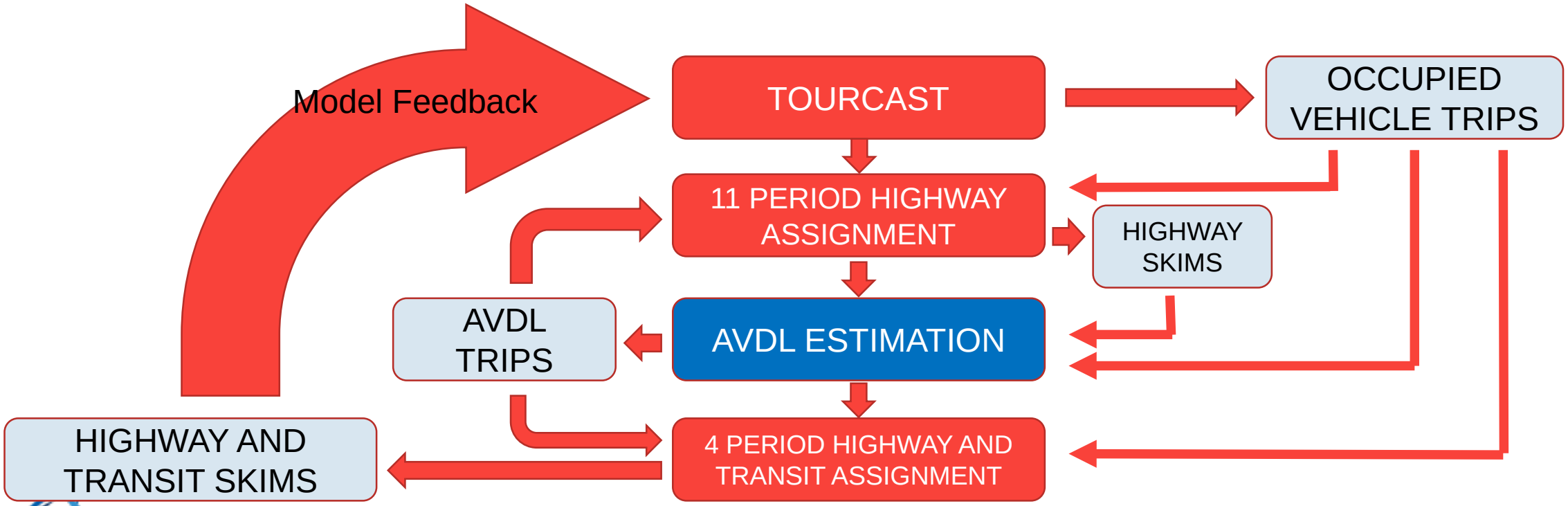
5. Autonomous Vehicle Model Flowchart – Twin Cities ABM



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6. Examples of Results that are Available

1. Vehicle Fleet Size Estimates
2. Trip Length Frequency Distribution
3. Efficiency of Use by Shared AVs
4. VMT by Level of Service by Scenario
5. End of Day Vehicle Re-positioning Map

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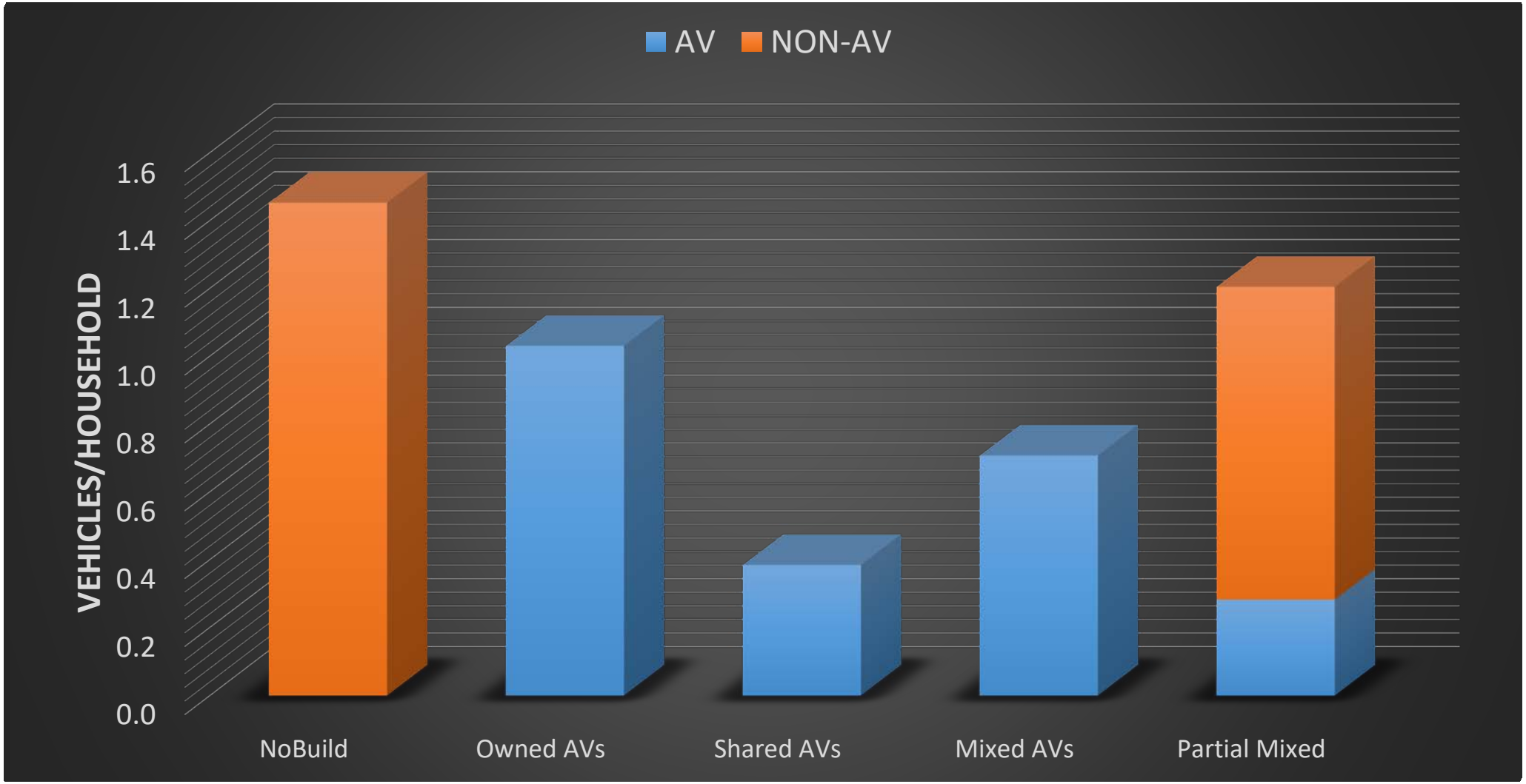
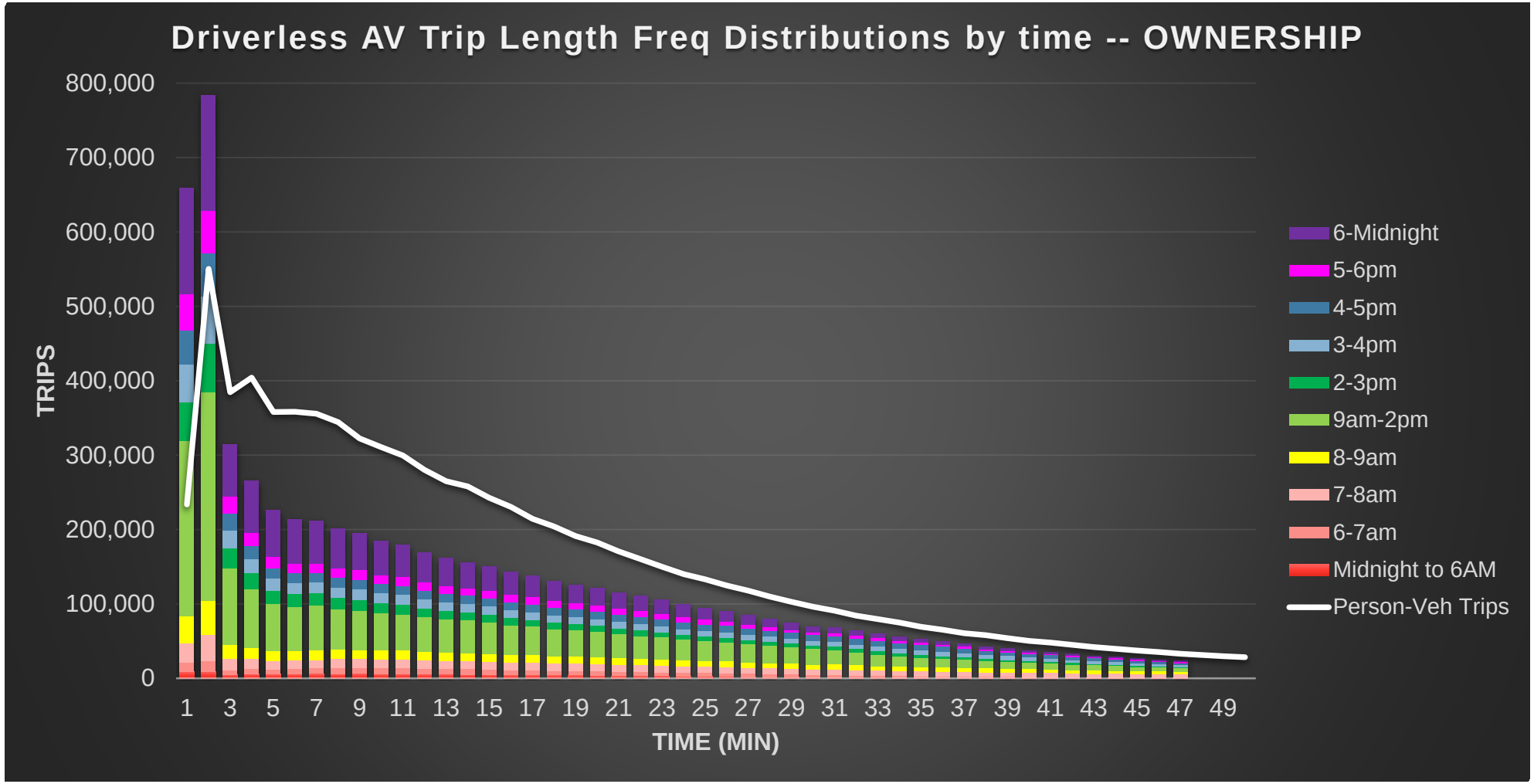
6.1 Vehicle Fleet Requirements



6.2 Ownership Scenario Driverless Trips by Vehicle



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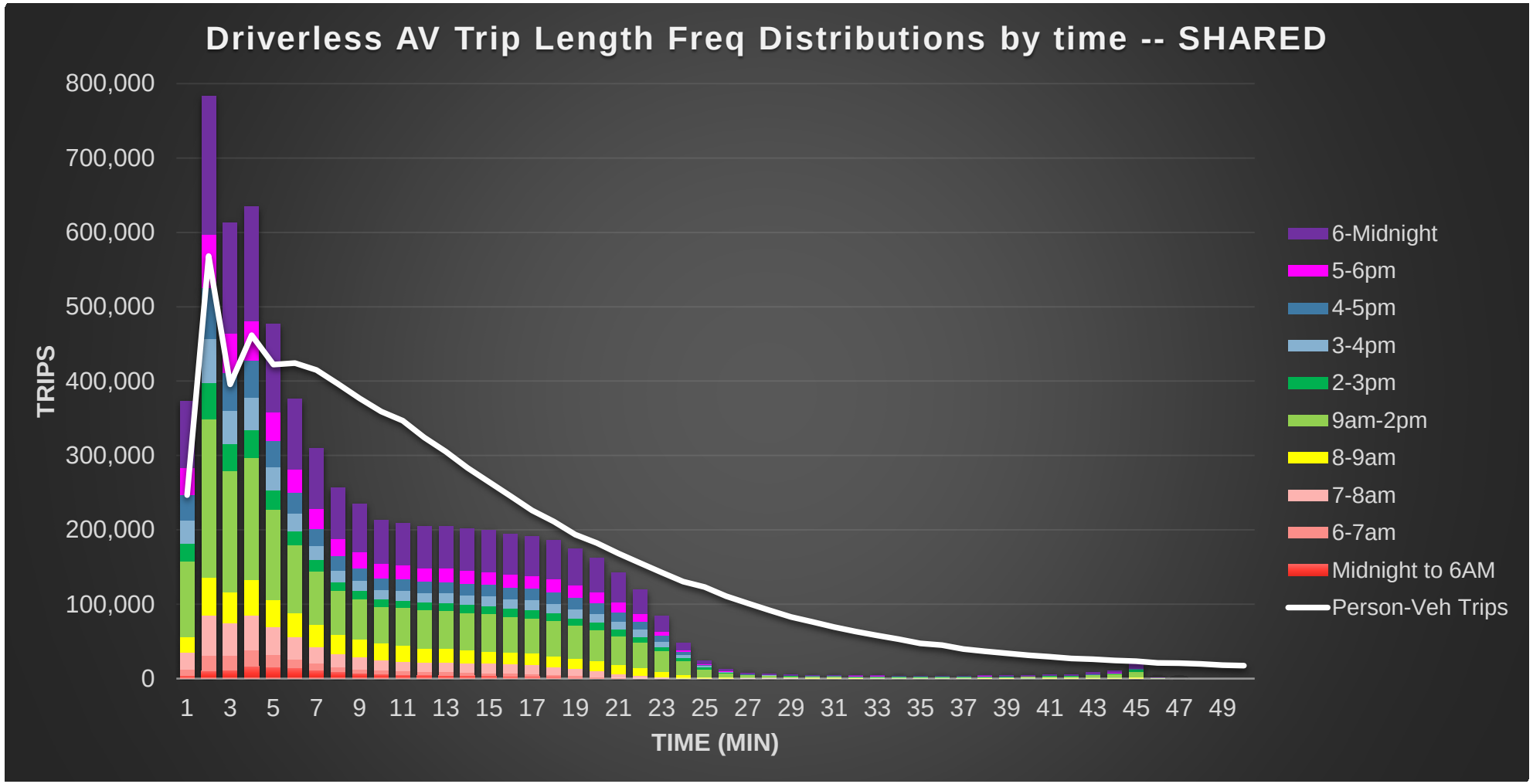
6.2 Shared Scenario Driverless Trips by Vehicle



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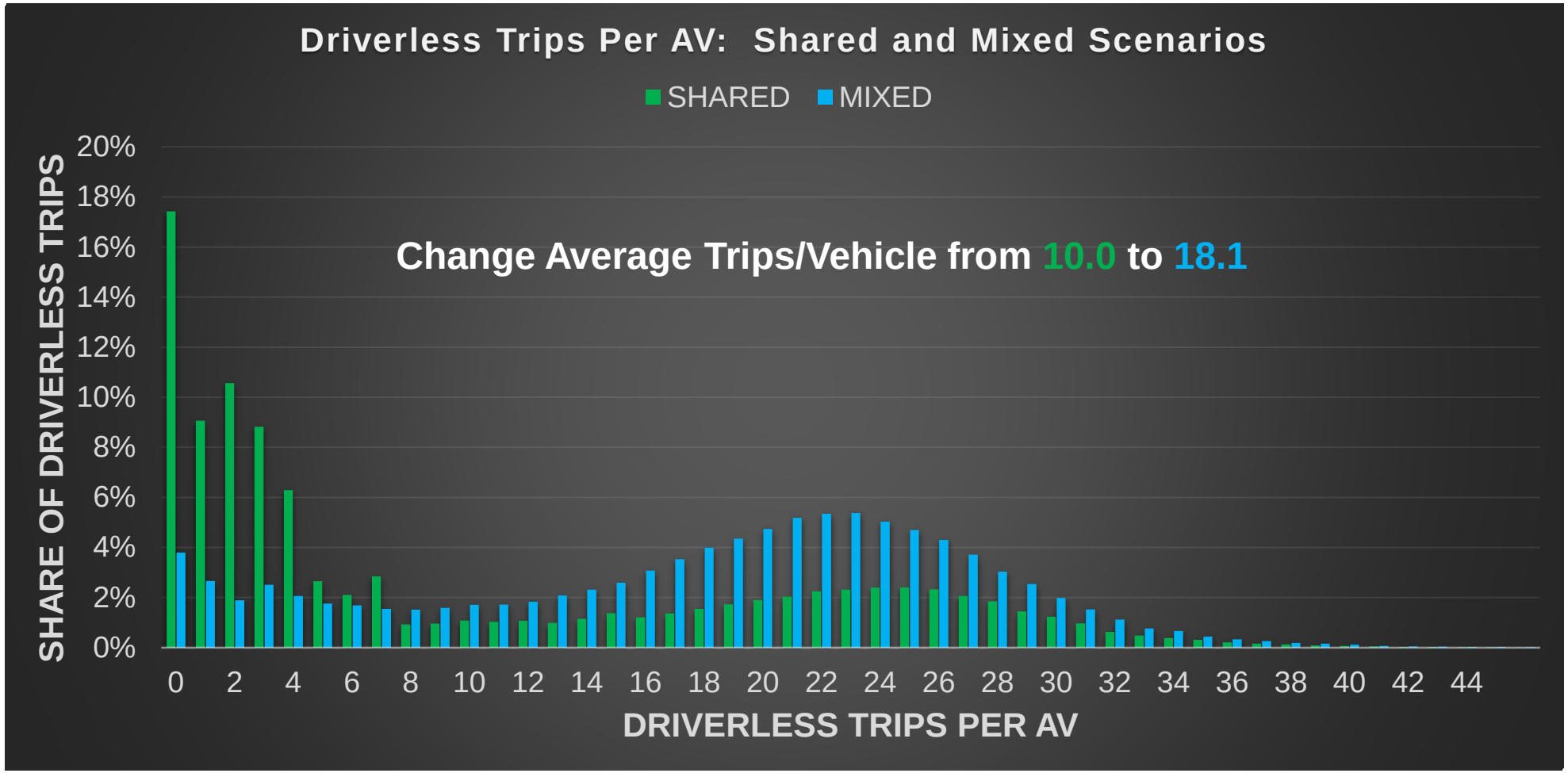
6.3 Efficiency of Use: Shared Scenario Driverless Trips by Vehicle



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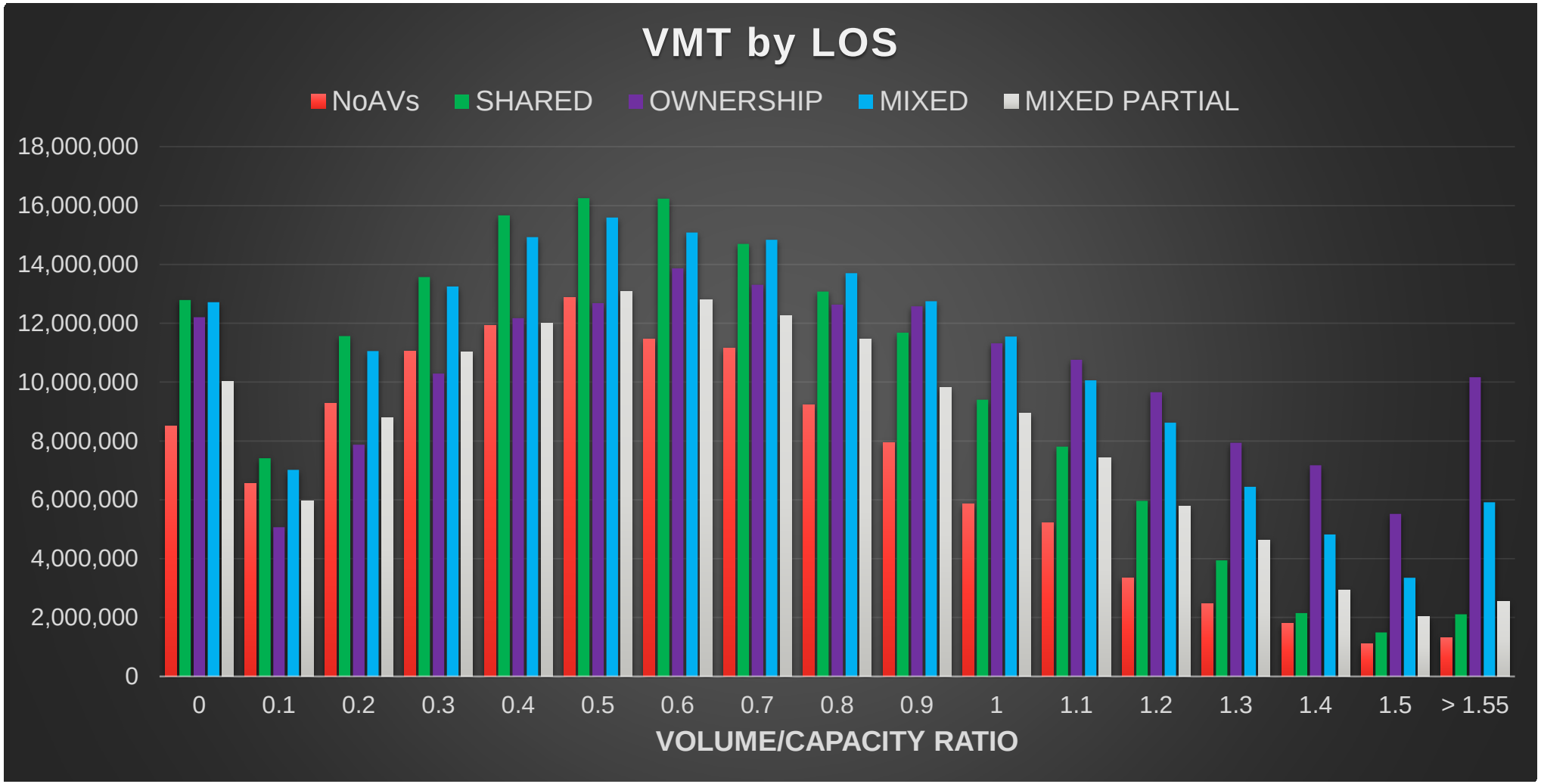
6.4 VMT by Level Of Service



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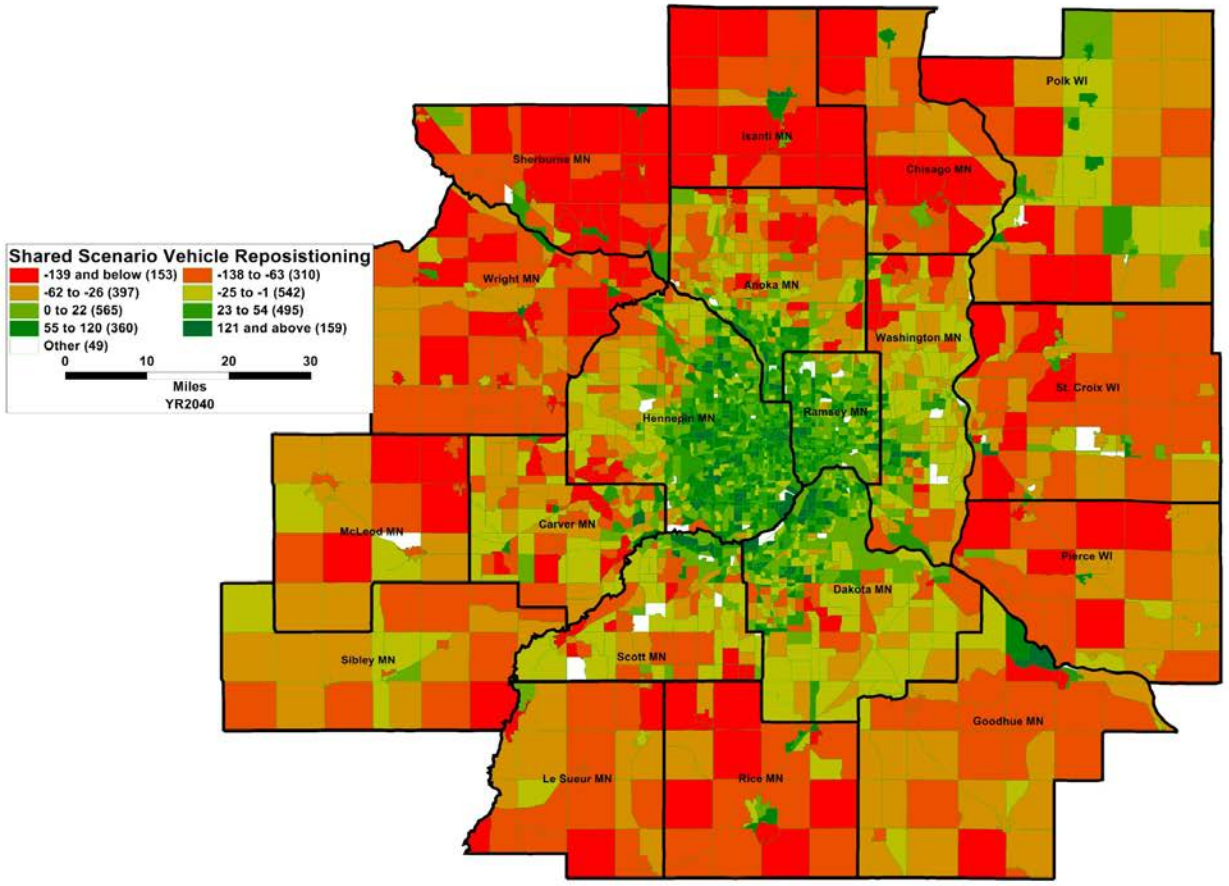
6.5 Shared Vehicle Repositioning – Shared Scenario 3.6M VMT, 64K VHT



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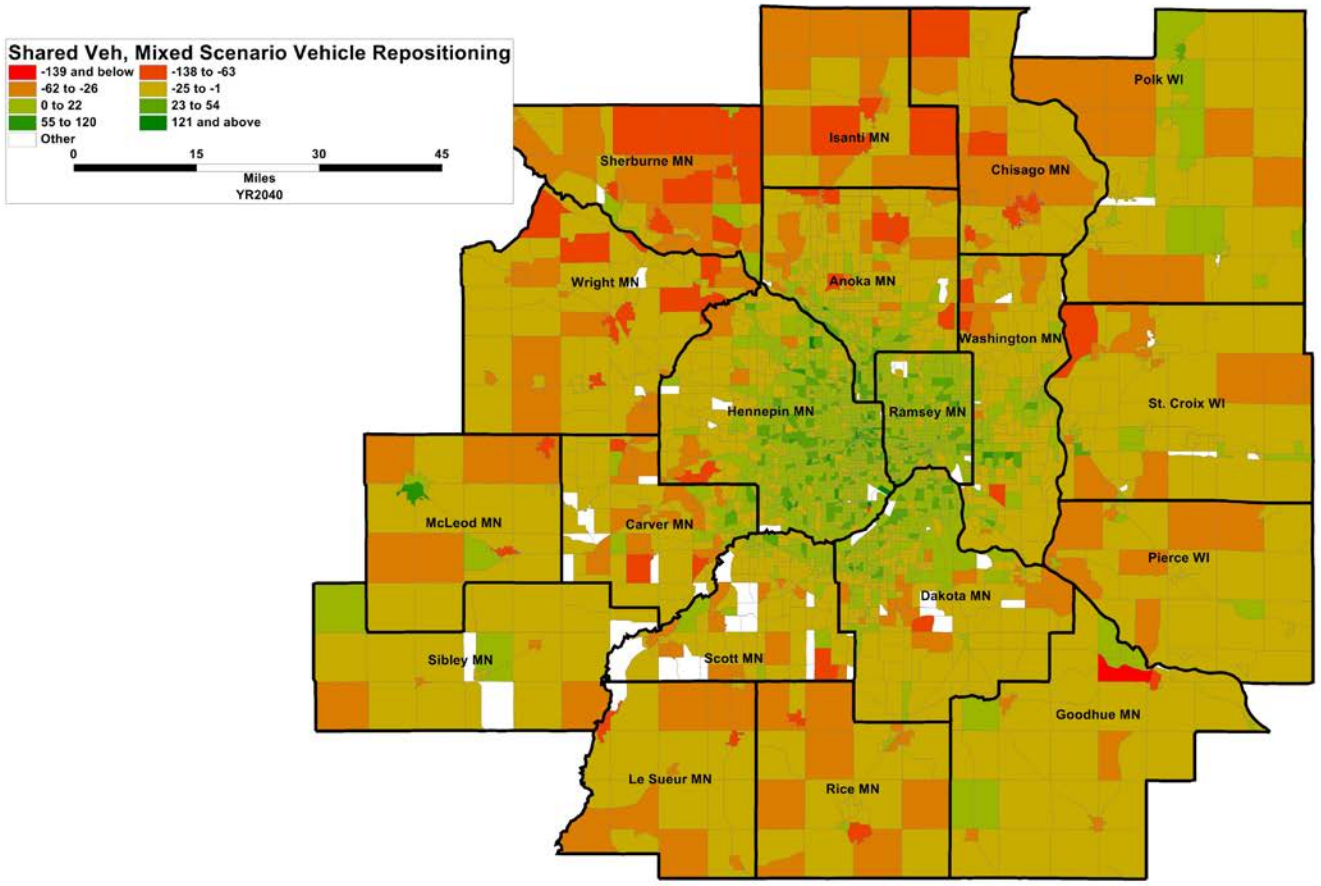
6.5 Shared Vehicle Repositioning – Mixed Scenario 0.9M VMT, 15K VHT



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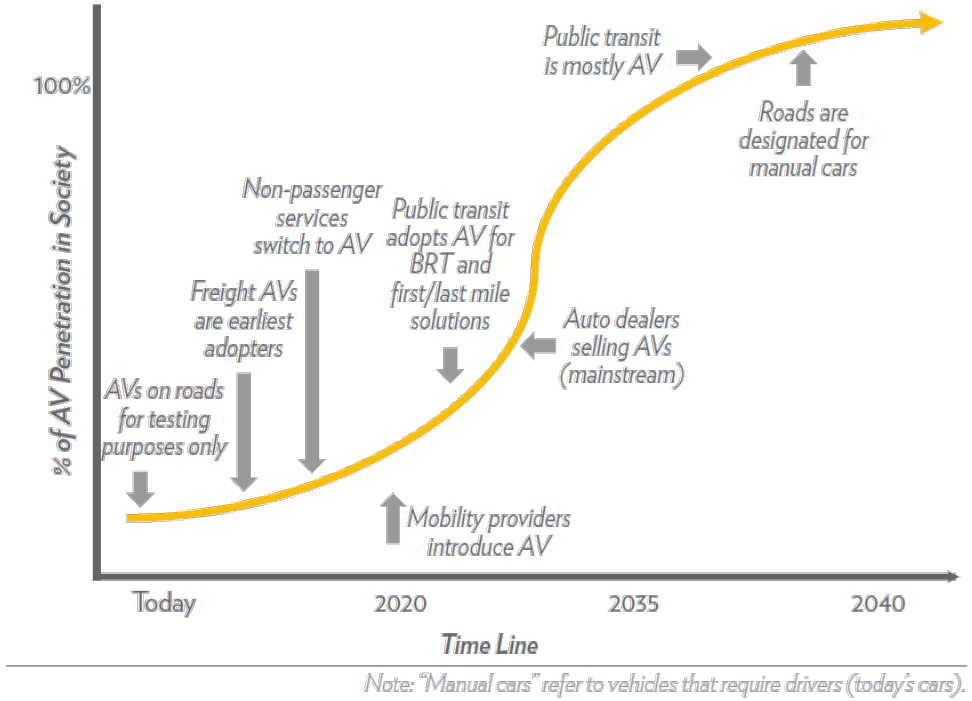
7. Additional Research

- AV Driving Characteristics
- Vehicle Capital Cost for each scenario
- Vehicle Operating Cost for each scenario
- Behavioral Changes for
  - *Former non-drivers*
  - *Activity pattern changes as a result of AVs*



Isaac, Lauren, "Driving Towards Driverless: A Guide For Government Agencies. WSP|Parsons Brinckerhoff. 2016. Page 13.

Questions?

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