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Agent-based modeling of potential mobility futures using BEAM

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July 16, 2020

Overview

- Why bother modeling?
- Modeling transport systems in general
- Modeling transport systems in particular (with BEAM)
- Incorporating 3 revolutions into transport modeling
- What sorts of questions is this model best equipped to answer?

MODELING TRANSPORTATION SYSTEMS

(In general and in BEAM)

Why bother modeling?

What is the problem?

- Automation, electrification, and other changes will transform transportation systems in unknown ways
- Behavioral change will be just as important as technology change in shaping the future transportation landscape--how do they interact?
- Changes will occur in short term and long term (and interact with land use)

What is needed?

- We still need to make decisions, even if there is uncertainty (we just need to be realistic about accuracy)
- Modeling is especially important for systems where we don't have empirical, observed data
- The act of building a model clarifies important relationships and interactions

Modeling transport systems

Modeling supply and demand independently

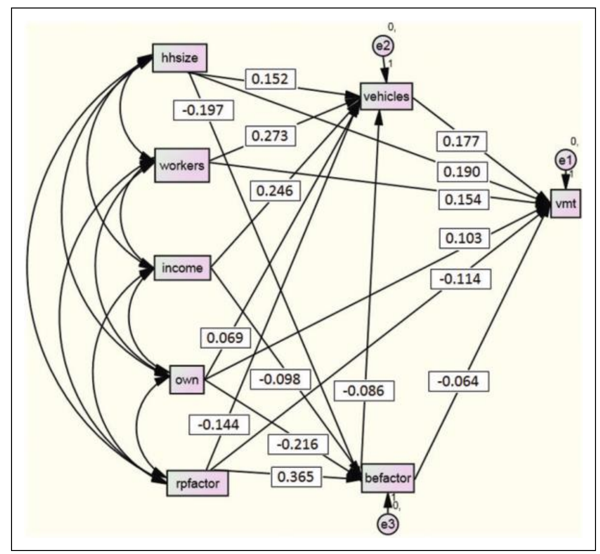
Supply

- What are the travel speeds on the road network?
- How crowded are the buses?
- What are wait times for TNCs?
- How plentiful are empty parking spaces?

Demand

- How many trips do people take?
- Where do they go?
- What mode do they use?
- What route do they take?

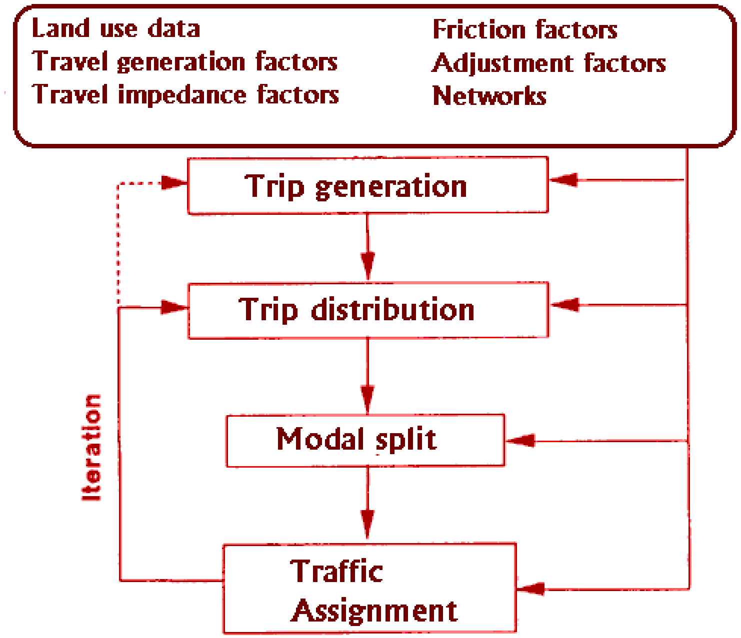
Behrisch, Michael, et al. "SUMO–simulation of urban mobility: an overview." *Proceedings of SIMUL 2011, The Third International Conference on Advances in System Simulation*. ThinkMind, 2011.



Ewing, Reid, Shima Hamidi, and James B. Grace. "Compact development and VMT—Environmental determinism, self-selection, or some of both?." *Environment and Planning B: Planning and Design* 43, no. 4 (2016): 737-755.

Modeling transport systems

Jointly modeling supply and demand: Four step model



- Generates flows of trips between origins and destinations
- Still very commonly used by many MPOs, can produce very useful results
- Miss out on full-day constraints and interactions
- Struggles to represent some technologies
- Difficult to model multiple modes on a single trip

Rosenbaum, Arlene S., and Brett E. Koenig. "Evaluation of modeling tools for assessing land use policies and strategies." *Transportation and Market Incentives Group* (1997).

Modeling transport systems

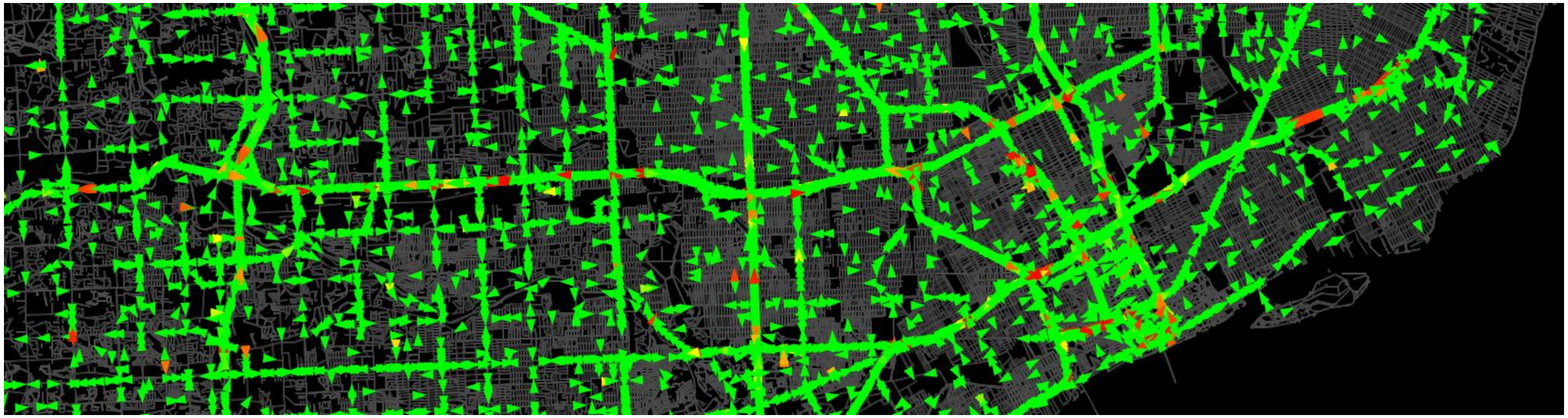
Jointly modeling supply and demand: Mesoscopic ABM

Agent based model

- Discrete agents operate with a set of rules and can interact with each other
- Agents are typically individual travelers
- Computationally hard—difficult to parallelize

Activity based model

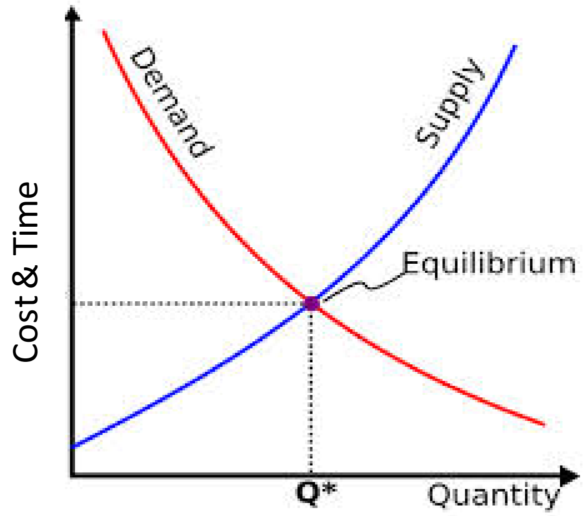
- Rather than trip-based, e.g.
- Travelers structure their daily plans around the sequence of activities they participate in
- Captures whole day correlations and constraints
  - You can't walk to work and drive your car home
  - You can shift activities throughout the day



The philosophy of BEAM

- BEAM is not a MPO model—less focus on precise link-by-link calibration, response to marginal changes in transportation system
- Goal is to develop a model that is more applicable to long-term fundamental changes in the transportation system under different scenarios, including land use change
- **Mechanics of resource markets**:

  - Road Capacity
  - Vehicle Capacity
  - Personal Schedules



  - Ride Hail Availability
  - Parking Spaces
  - Refueling Access

Modeling across time scales

- BEAM can be run in a larger workflow, collection of DOE-funded models
- Designed to capture effects that happen across vastly different time scales

Scenario generation

Long term
- Land use
- Charging infrastructure
- Vehicle fleet

Day to day
- Mode choice
- Fleet behavior
- Traffic patterns

Second by second
- Energy use
- Vehicle interactions

Scenario evaluation

Modeling across time scales

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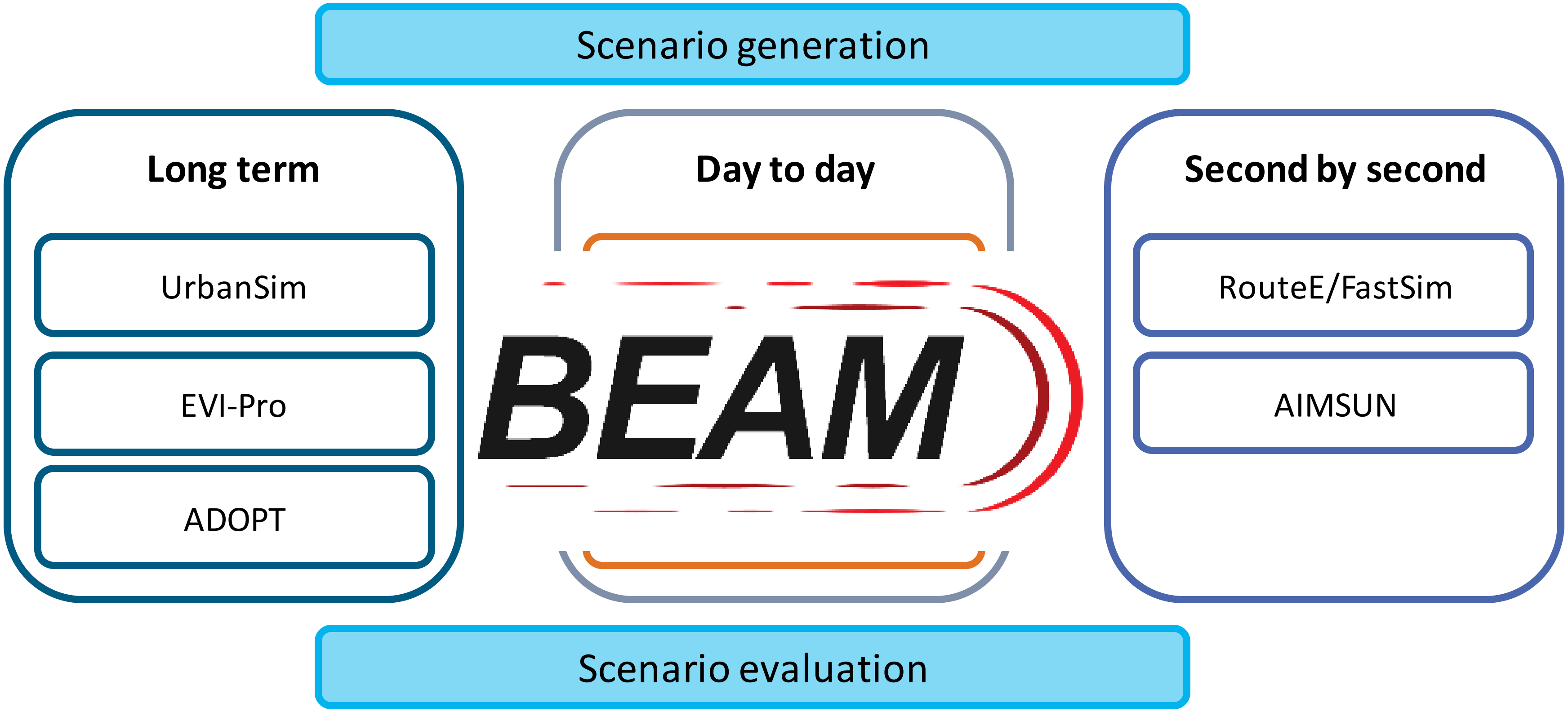
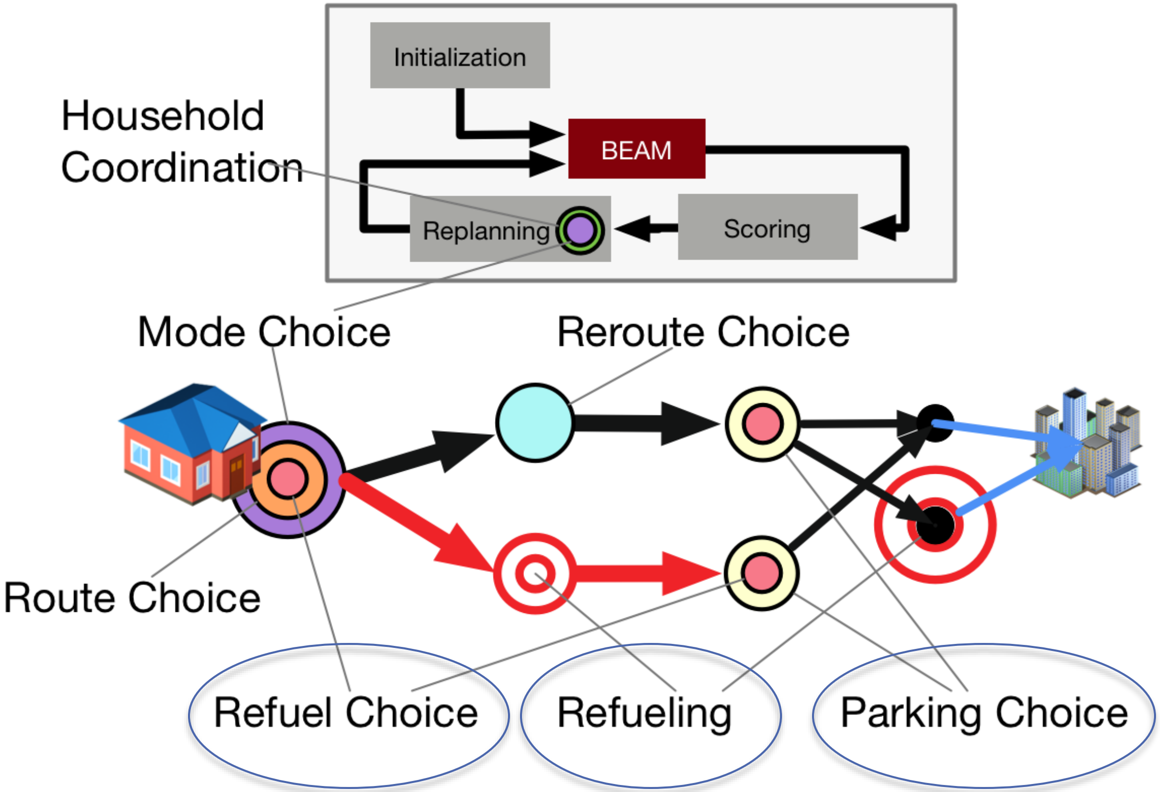


Behavioral modeling in BEAM

- Generate synthetic population with home/work locations
- Simulate within-day decisions, evaluate a “score” at the end of the day
- Iterate until convergence; models equilibrium and allows reinforcement learning

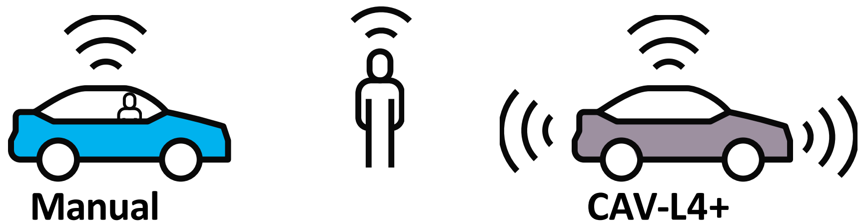


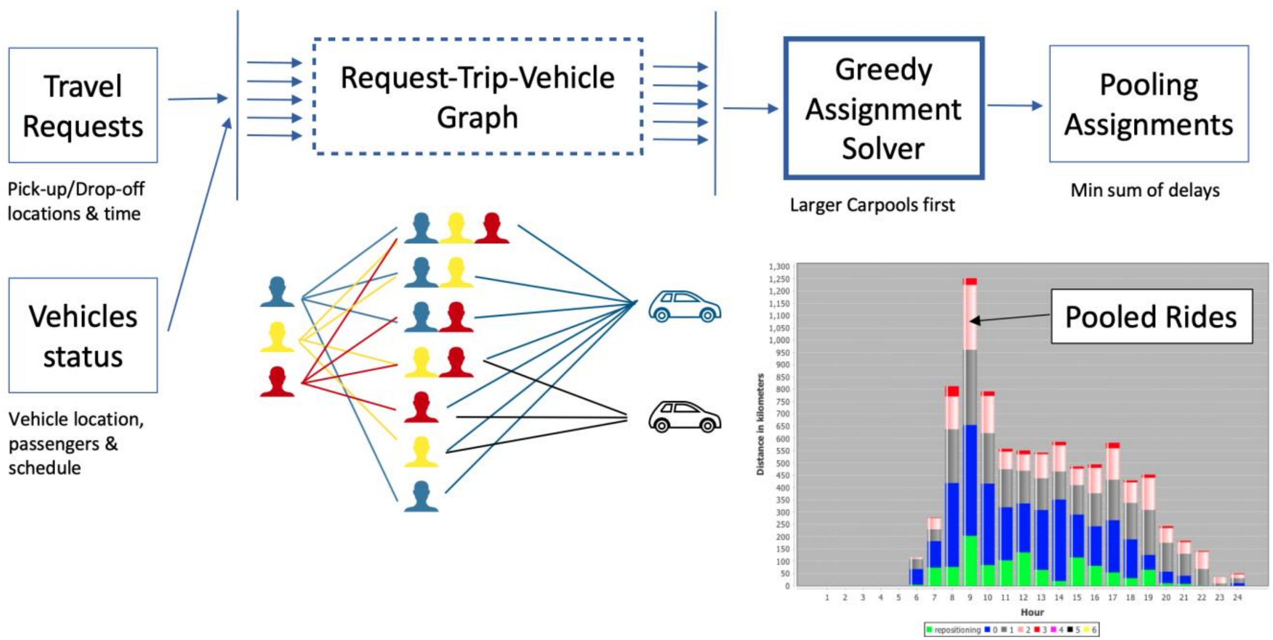
MODELING 3 REVOLUTIONS IN BEAM

(Vehicle/ride sharing, automation, and electrification)

Sharing: Ride hail operations

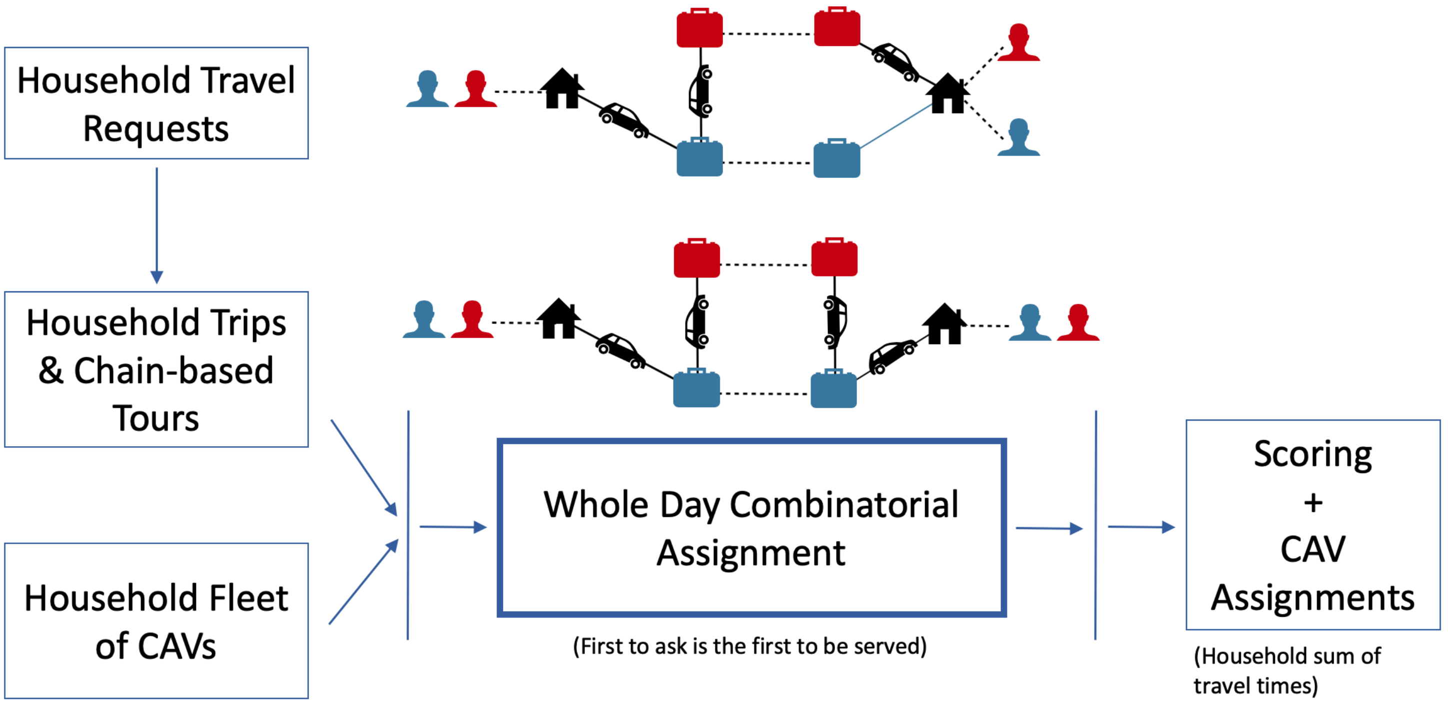
- Dynamic allocation of vehicles to customers, including pooled trips
- Real time price and wait time quotes





Automation: Household automated vehicles

- Households coordinate to deploy L4+ CAVs to best serve mobility of all members
- Access to automated vehicles in a household leads to more individual trips and more empty VMT between trips



Electrification: Constrained charging availability

- BEAM simulates limited EV range and charging requirements, separately for personal EVs, human driven ride-hail, and automated ride-hail (AEV)
- Personal EV~~s~~ charging is part of parking choice process
- Human driven ride-hail competes with personal vehicles for plugs
- Automated ride-hail (AEV) has its own network of charging depots

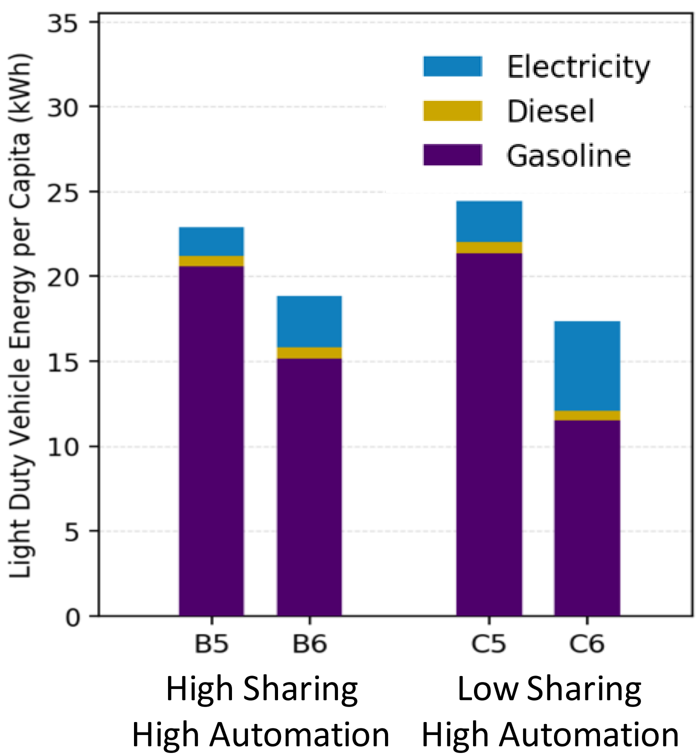
Beam simulation | Charging demands | Charging station planning

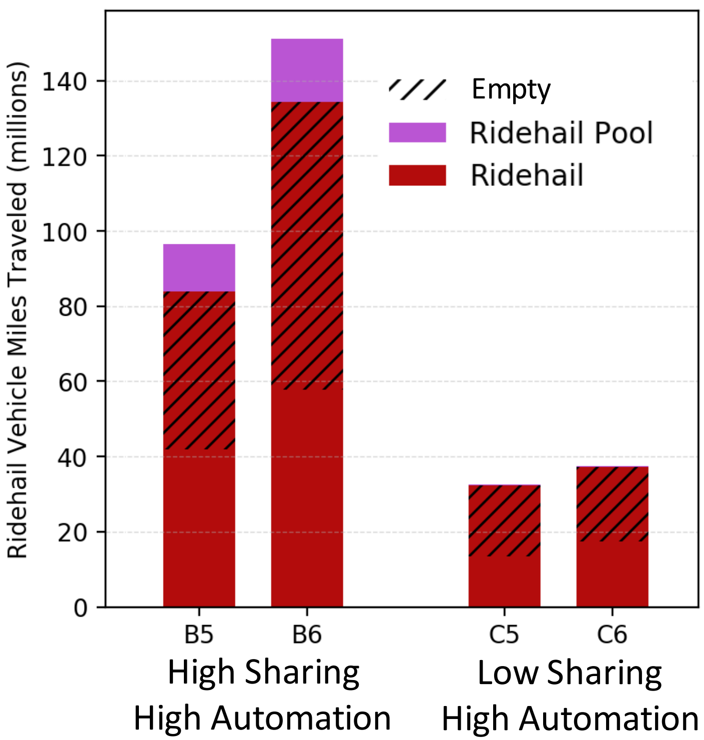
WHAT KINDS OF QUESTIONS SHOULD WE TRY TO ANSWER?

What are the important interactions in constraints associated with new mobility paradigms?

Examine trade-offs and constraints

- Can reveal important trade-offs and constraints when we extrapolate a mobility paradigm (e.g. ride-hailing) into the future
- Here, we found that operations of ride-hail fleets are critical; increased ride-hailing, even if pooled, also results in increased deadheading (you can't have your cake and eat it too)
- High penetration of EVs necessary to reduce energy use under any scenario

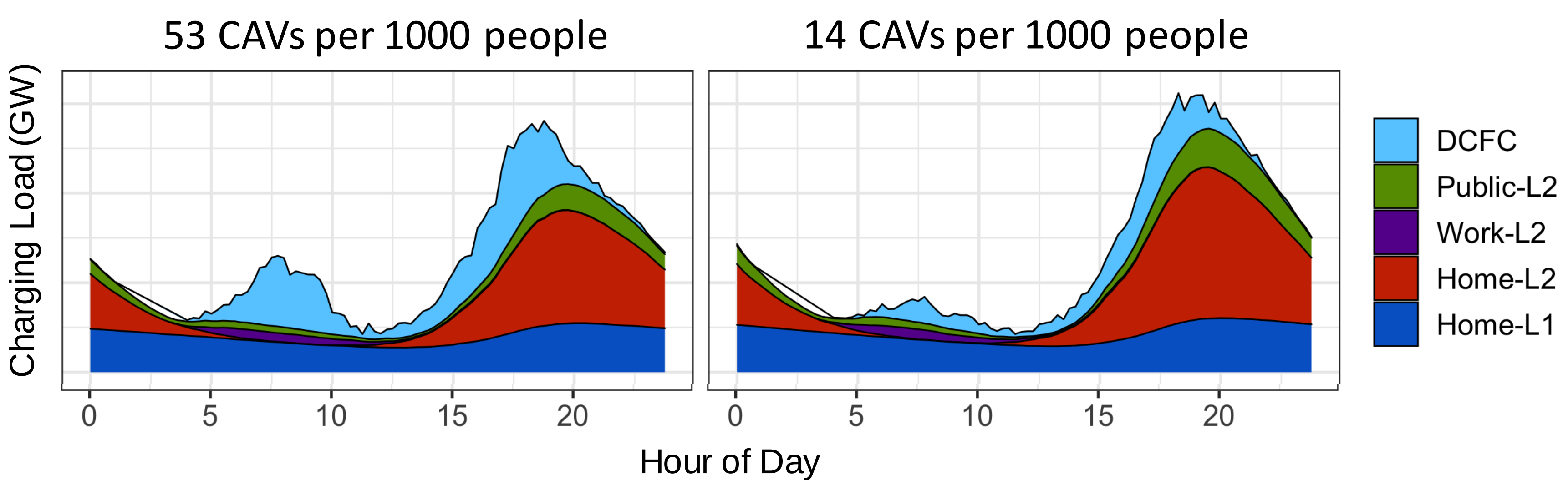




What are the order-of-magnitude-sized effects of competing processes?

Estimated bounds of large-scale changes

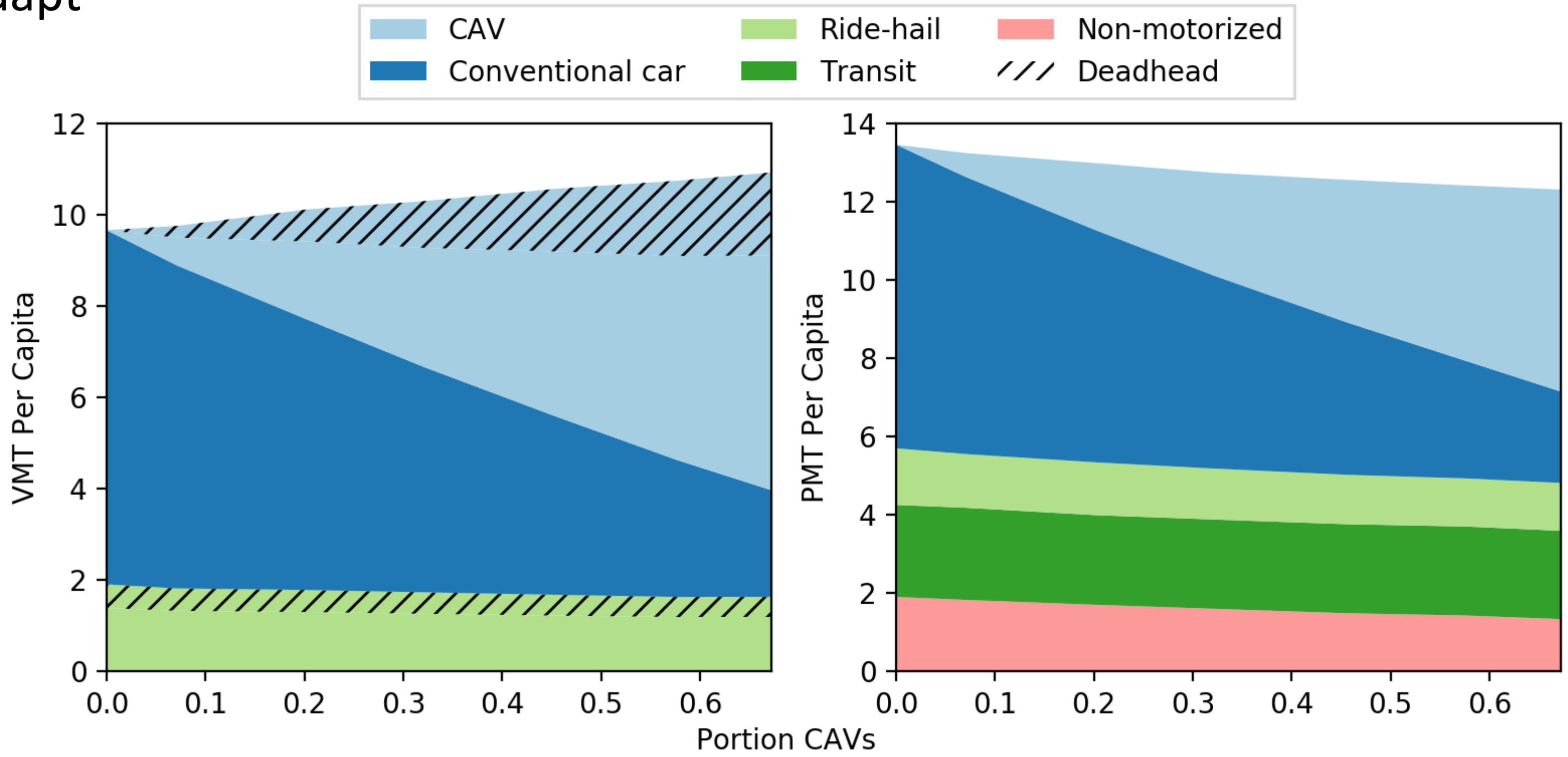
- Can put order-of-magnitude bounds on important quantities as a function of critical assumptions
- Here, we are looking at grid capacity constraints associated with operating a large fleet of automated, electric ride-hail vehicles
- We can compare the size of the peaks in electricity demand due to home (slow) charging versus (fast) depot charging of ride-hail CAVs as a function of fleet size



What can the distributional effects of large scale changes look like?

Look at distributional effects of big changes

- Can trace macro-scale trends back to their impacts on individuals
- Here, modeled scenarios of varying levels of household AV ownership, looked at impacts on households with and without AVs
- As AV ownership increases, total travel decreases (mostly from households without AVs). Empty AV movements lead to congestion, non-AV owners need to adapt



Thank you!

- Questions?

- Source code available:

  https://github.com/LBNL-UCB-STI/beam

- email: zaneedell@lbl.gov