Shared Autonomous Electric Mobility:
Opportunities & Challenges

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Why Shared Autonomous Electric Vehicles (SAEVs)?

Autonomous

Eliminates driver labor cost. Enables strategic relocation (avoiding spatial mismatch of demand & supply).

Electric

Alleviates “range anxiety.”

Automated charging/fueling is easier to achieve w/ electric vehicles

High cost of automation technology incentivizes shared use.

Accelerates EV adoption to meet urban air quality & transport emissions goals.

Fewer components lead to reduced maintenance (compared to internal combustion engine vehicles).

Shared

Alleviates “range anxiety.”
Shared Autonomous Electric Vehicle
Chen Research Group

Vehicle Automation

Vehicle Electrification

Use Case

EV-Grid Interaction

SAEV Modeling Framework

**Trip Generation**
- Use local travel demand model data to generate trips to simulate origin-destination travel demand

**Charging Station Generation**
- Charging station site selection to ensure sufficient infrastructure coverage

**SAEV Fleet Generation**
- Determine the necessary fleet size to serve travel demand

**Operation**
- Continuous daily operation based on the station and fleet configuration
SAEV Simulator Implementation

- Available vehicles
- Vehicles at capacity
- Relocating vehicles
- Trip origins
- Trip destinations
SAEV Use Case: **Door-to-Door Service**

Case studies in Austin, Texas
Door-to-Door SAEV Service (Single Occupant): Fleet Size by Vehicle & Charging Infrastructure

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<th>SAEV Fast Charge</th>
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- **Fast charging** infrastructure & longer **EV range** reduces required fleet size.

- Each SAEV can **serve 11 to 21 trips per day**, equivalent to **replacing 3.7 to 6.8 privately owned vehicles**. (SAVs serve, on average, 22 trips/day)

- “Empty” VMT constitutes **7 to 14%** of all miles traveled.
Door-to-Door SAEV Service (Single Occupant): Operational Cost Per Occupied-Mile Traveled

- SR SAEVs with Level II charging are cheapest to operate on a per-mile basis, even if this configuration incurs highest % “empty” VMT (increases congestion) and require biggest fleet (requires more land for charging spots).
SAEV Door-to-Door Service with Dynamic Ridesharing

• “Empty” VMT comprises 9-16% of total VMT for SAEV with ridesharing.
• Assuming all travelers are willing to participate in ridesharing, about 35% of all VMT include at least two passengers.
• One SAEV with dynamic ridesharing can replace 8 to 13 privately owned vehicles.
SAEV Door-to-Door Service w/ Dynamic Ridesharing

• Though the total % of trips served exceeds 96% in all scenarios, the likelihood of matching a vehicle with a passenger varies by time of day. During peak hours, matching rates can be as low as 85%.

![Likelihood of Finding a SAEV by Time of Day](chart.png)
SAEV Use Case: *First/Last Mile Connection*

Case study in Seattle, Washington
SAEVs for First/Last Mile Connection

- SAEVs can help decrease the demand for scarce parking spots at Park & Rides, and reduce the parking infrastructure requirements on valuable real estate.

Case study at Tukwila Light Rail Station in Seattle, Washington
- 2016 survey of rider origin-destinations
- Hourly boarding & alighting data
Enabling ridesharing in SAEVs for first/last mile mobility reduce system-wide VMT by 37% (compared to single occupancy).

If all travelers participate in ridesharing, 40-45% of all VMT include at least two passengers, and ridematch rate is higher during AM & PM peaks.

“Empty” VMT remains around 20% with ridesharing in all vehicle & charging infrastructure scenarios.

One SAEV with dynamic ridesharing can replace 20 to 34 “park & ride” vehicles.
SAEV-Grid Interaction

Case study in Seattle, Washington
Charging “as needed” minimizes SAEV “empty” travel distance for charging, but exhibits **peak charging periods** which coincide with existing peak hours of electricity use.
With increased battery capacity, **LR vehicles** exhibit superior ability to **avoid charging on-peak**. Compared to unmanaged charging, electricity costs can reduce 10% (SR SAEVs) to 34% (LR SAEVs).
SAEVs: Key Takeaways

• When ridesharing is considered, SAEVs are more efficient at serving first/last mile connection trips than door-to-door trips (higher average occupancy, better ridematch rates during peak hours).
  • How will we encourage disruptive mobility as part of a multimodal trip rather than a new replacement mode?
• “Empty” VMT as a singular measure is not indicative of service efficiency. Service configurations & use cases with higher “empty” VMT can mean higher average vehicle occupancy across all VMT.
  • Don’t let the bad publicity of the empty autonomous car get in the way of the real focus: higher average occupancy.
• Charging station capacity can be reduced with longer range vehicles, fast charging infrastructure, and higher ridematch rates.
  • But shorter range vehicles & Level II charging infrastructure are cheaper for the fleet operator to acquire & implement.
• Battery capacity plays an essential role in SAEV-grid interactions. Larger batteries enable SAEVs to act simultaneously as mobile energy user & storage. But with current battery costs & static electricity pricing, fleet operators are not incentivized to adopt LR vehicles.
  • Electricity pricing structures should considered in the conversation about disruptive mobility.
Thank you for your time!

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