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Conference Poster

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Tracking a System of Shared Autonomous Vehicles (SAVs) across the Austin, Texas Network using Agent-Based Simulation

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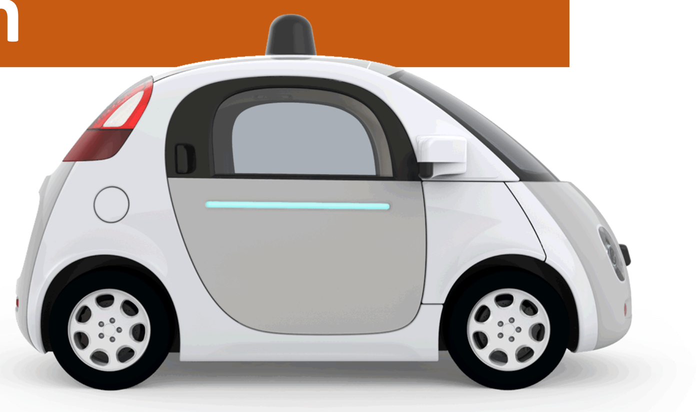
THE UNIVERSITY OF TEXAS AT AUSTIN
WHAT STARTS HERE CHANGES THE WORLD

Background & Motivation

Benefits of AVs (vs. HVs [human-driven vehicles]):



Safety

- Fewer crashes
- Less severe crashes

Sustainability

- Possibly lower emissions
- Better fuel economy
- Electric SAVs may succeed

Mobility

- Easier travel
- Mobility for non-drivers
- Vehicle-sharing & ride-sharing can lower costs
- Possibly lower congestion & greater travel time reliability

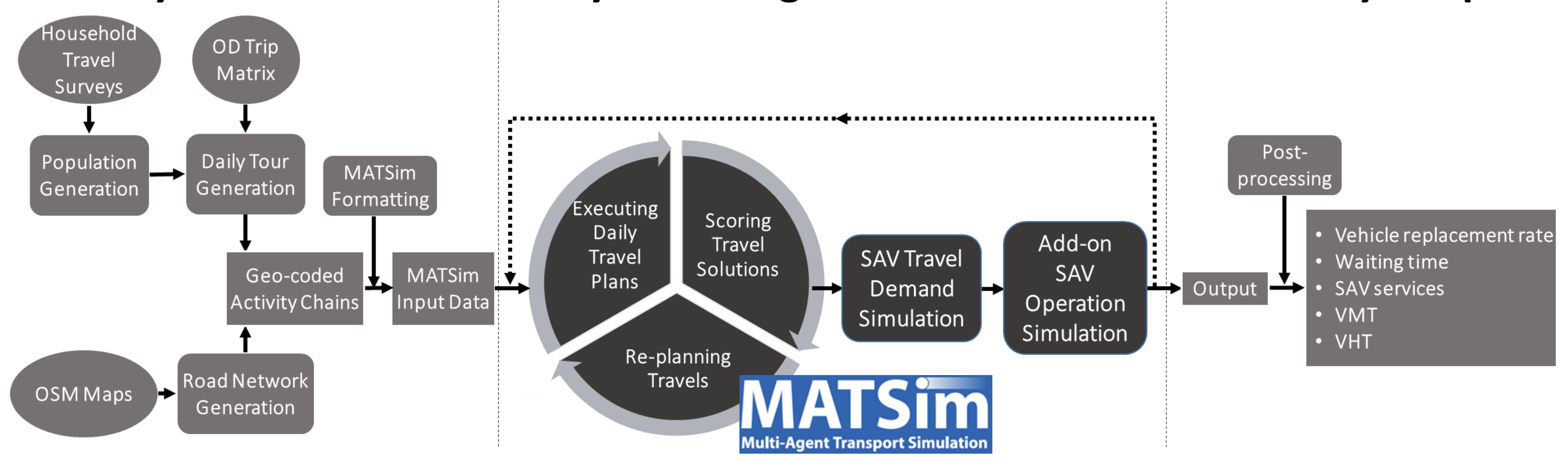


Car-Sharing (SAVs)

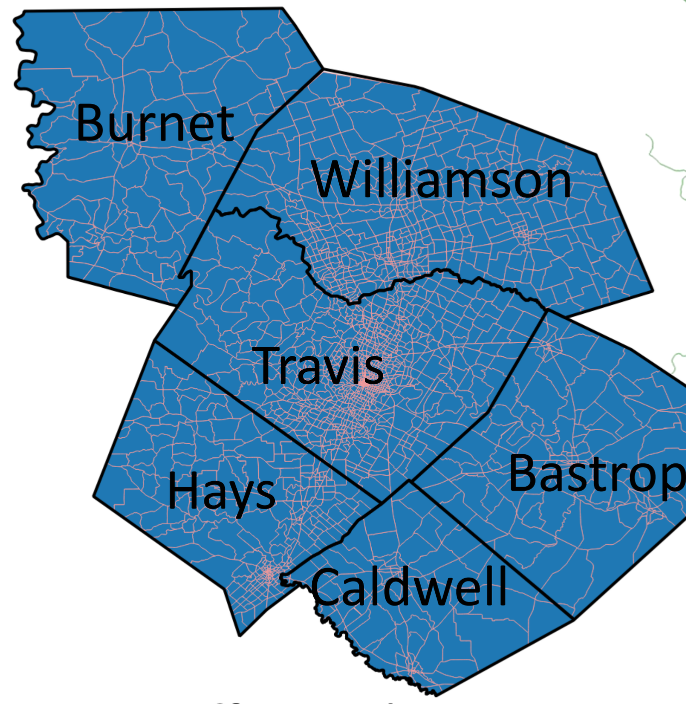
- **SAVs** allow users to **obtain AV benefits without** all the **costs & responsibilities of AV ownership**.
- **Car-sharing is now common** in many US & world cities.
- **SAVs** reduce the access hurdles of traditional (human-operated) shared vehicles **(shared HVs)**.

 +  = **S**hared **A**utonomous **V**ehicles (**SAV**s)

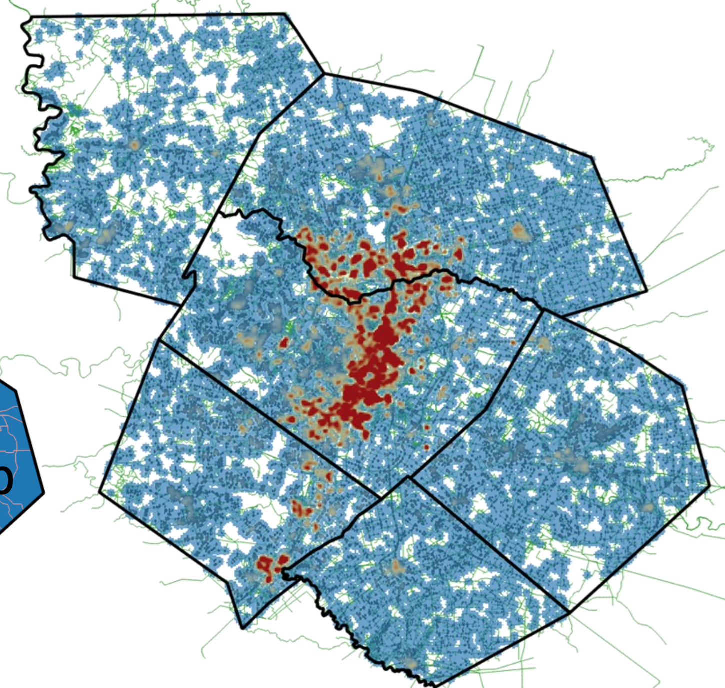
Mode Choice & Traffic Simulation for SAVs



Case Study Site & Key Assumptions



Traffic Analysis Zones (n = 2102 zones)



Population (n= 2.3 M travelers)

Austin's MPO (CAMPO's 6 counties)

Realistic Home locations (n = 0.9 M homes)

Mode Choice

The utility function for **using a HV** is:

$$V_{HV} = -0.2 \times Distance - 17.67 \times IVTT$$

The utility function for **using bus services** is:

$$V_{PT} = -2 - 8.84 \times IVTT_{Bus} - 35.34 \times (OVTT_{walking} + OVTT_{waiting})$$

The utility function of **using SAVs** is:

$$V_{SAV} = -Fixed\ Cost - Fare \times Distance - 8.84 \times IVTT - 35.34 \times OVTT_{waiting}$$

For travelers **with privately owned HVs**:

$$P_{SAV} = \frac{exp(V_{SAV})}{exp(V_{SAV}) + exp(V_{HV}) + exp(V_{PT})}$$

For travelers **without** access to **privately owned HVs**:

$$P_{SAV} = \frac{exp(V_{SAV})}{exp(V_{SAV}) + exp(V_{Bus})}$$

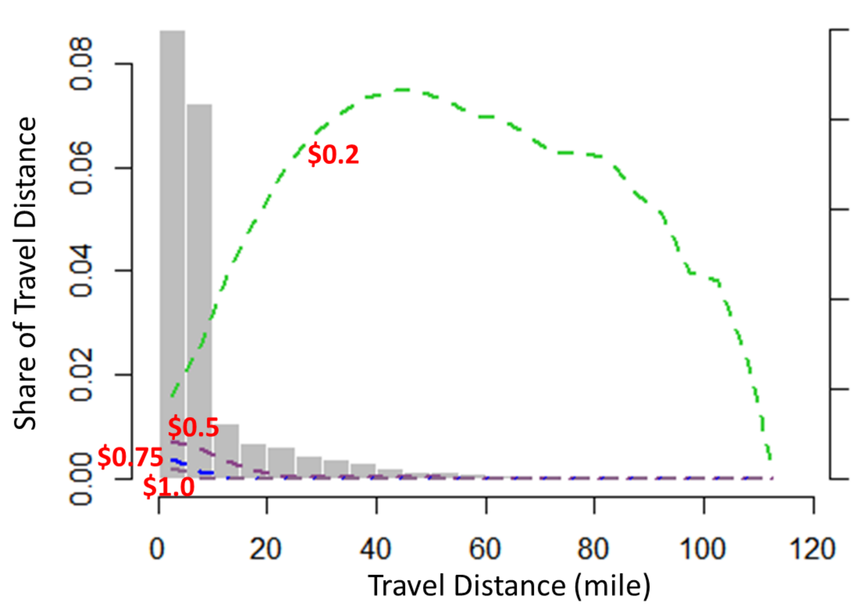
where V = Mode's systematic utility; IVTT = in-vehicle travel time (based on HV trips); OVTT = out-of-vehicle travel time; $IVTT_{Bus}$= 1.5 IVTT; Distances based on HV trips; **SAV trips' cost = $1 per ride + $0.20, $0.50, $0.75, $1.0 per mile.**

Mode Choice Results

4 SAV fare scenarios = $0.20, $0.50, $0.75 & $1 *per mile plus* $1 per trip

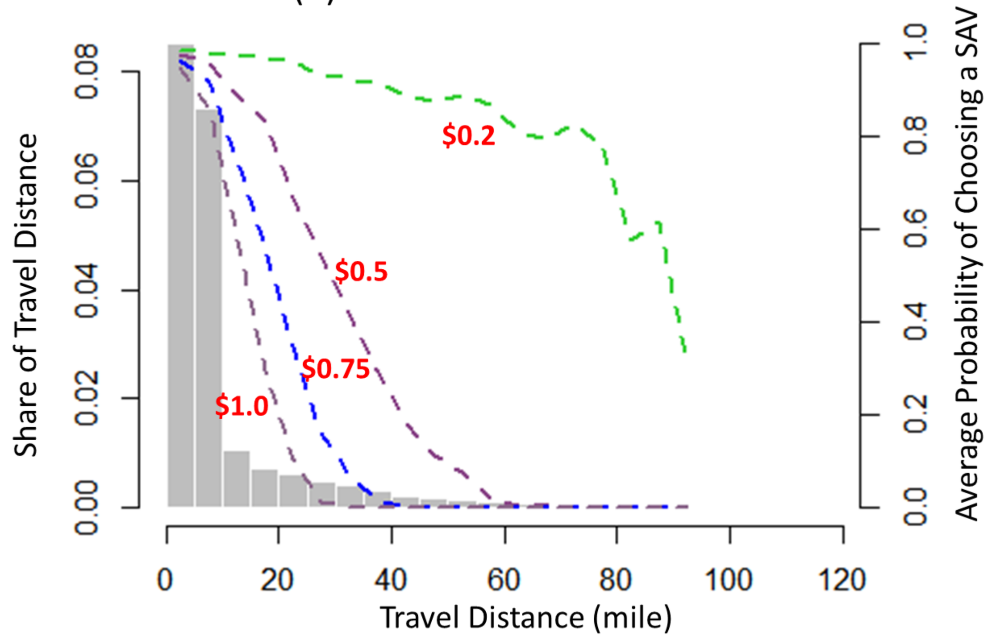
Choice between HV, Bus & SAV

(a) For travelers with HVs



Choice between Bus & SAV

(b) For travelers without HVs

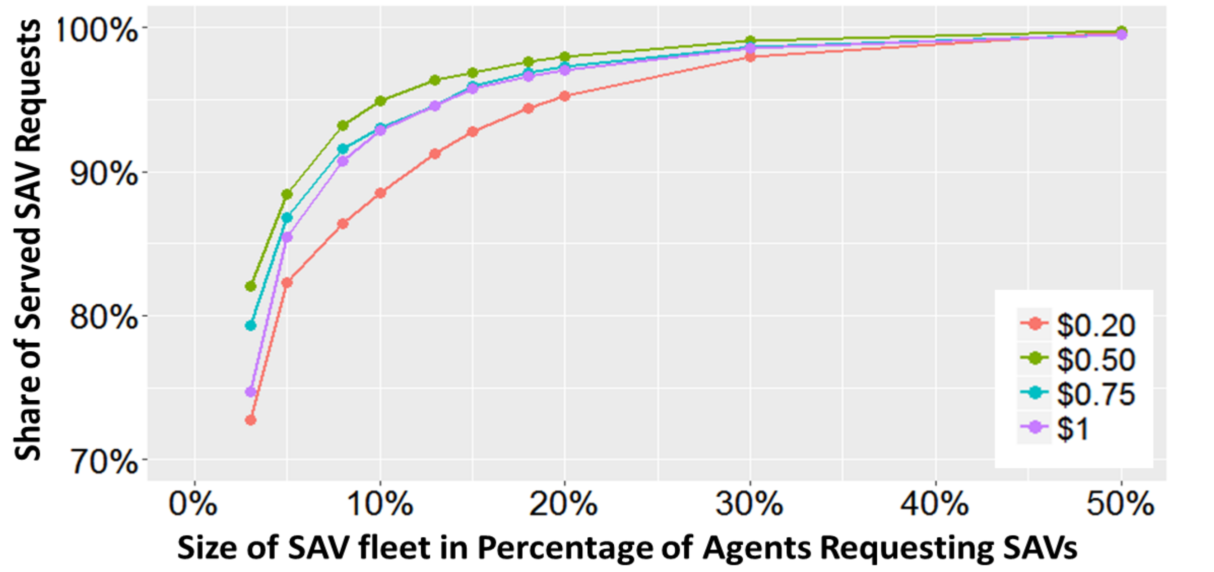


SAV Service Performance Results

SAV Mode Splits:
$0.20 per mile → 36.6% of trips
$0.50 per mile → 12.1 % of trips
$0.75 per mile → 8.0% of trips
$1 per mile → 6.4% of trips

Served Requests include:

- on-time service (waiting = 0 ~ 5 minutes)
- late service (waiting = 5 ~ 10 minutes).



Performance metrics at different fare schedules...

Metric	$0.20	$0.50	$0.75	$1
SAV demand in % of total trips	36.6%	12.1%	8.0%	6.4%
SAV fleet size in % of travelers	20%	10%	13%	13%
HV replacement rate	5	10	7.7	7.7
Average number of services per SAV	8.6	16.1	14.7	16.5
Extra VMT	3.5%	11.0%	11.8%	13.7%
Average waiting time (minute)	3.6	3.2	3.3	3..1
Average service time (minute)	18.0	9.5	8.3	7.9
% on-time service (wait < 5 min.)	82%	80%	81%	80%
% late service (wait 5 - 10 min.)	14%	15%	14%	14%

$0.50/mi fare → Greatest vehicle replacement rate, because... SAVs serve **more short trips** in $0.50/mi scenario, vs. $0.20/mi scenario, & trip request density/ demand is higher, vs. $0.75+ scenarios.

Essentially, **SAV systems are more efficient for denser, shorter-distance trip request settings.**

Final Thoughts & Emissions Estimates

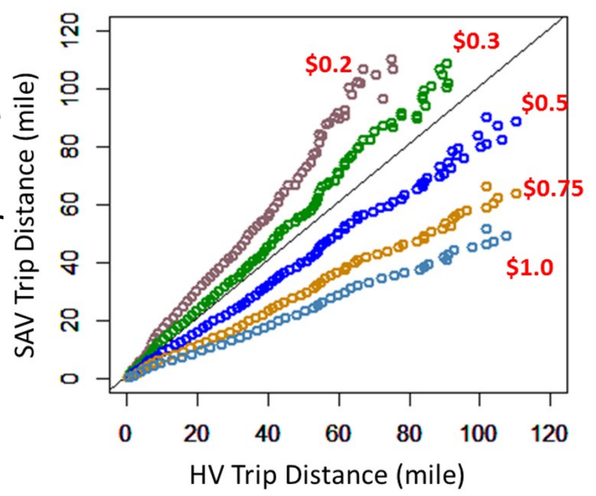
Who is selecting SAVs?

- Low per-mile rates → longer-distance trips
- High rates → shorter-distance trips
- Transit use falls in this setting.

How do SAVs serve requests?

- Long-distance travelers → low HV replacement rate
- Short-distance requests → high HV replacement rate
- Dense request → high HV replacement rate

SAV user trips average **50% longer** than HV user trips, under $0.20-per-mile rate.



Sustainability Elements		Fuel con.	GHG	PM	CO	NOx	SO_2
Average Light-duty HVs vs. SAVs	Macroscopic estimates (life-cycle based)	-12.0%	-5.6%	-6.5%	-34.0%	-18.0%	-19.0%
	Microscopic estimates (driving-cycle based)	-8.6%	-8.7%	-21.2%	-15.3%	-17.2%	-8.7%
	Total savings (distance-based)	-19.6%	-13.8%	-26.3%	-44.1%	-32.1%	-26.0%
Fare = $0.20	Extra VMT=3.5%	-16.8%	-10.8%	-23.7%	-42.1%	-29.7%	-23.5%
Fare = $0.50	Extra VMT=11%	-10.7%	-4.3%	-18.2%	-37.9%	-24.6%	-17.9%
Fare = $0.75	Extra VMT=11.8%	-10.1%	-3.6%	-17.6%	-37.5%	-24.1%	-17.3%
Fare = $1	Extra VMT=13.7%	-8.5%	-2.0%	-16.2%	-36.4%	-22.8%	-15.9%

Greater energy & emissions savings when **SAV fares** are **lower**. **Extra VMT** by empty SAVs does not overcome other emissions benefits (of smaller vehicles & warm starts, eco-driving, etc.).

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