Shared Autonomous Vehicles as Park-and-ride Transfer Alternatives Towards Carfree Cities: A MATSim Simulation for Brussels, Belgium

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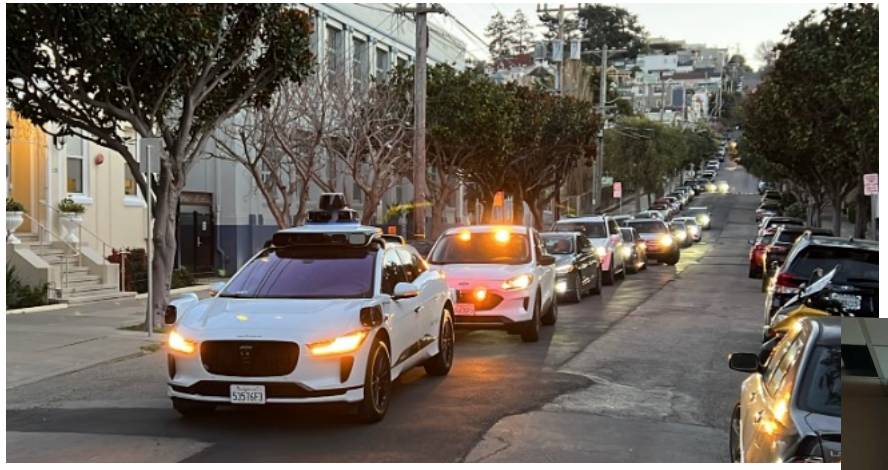
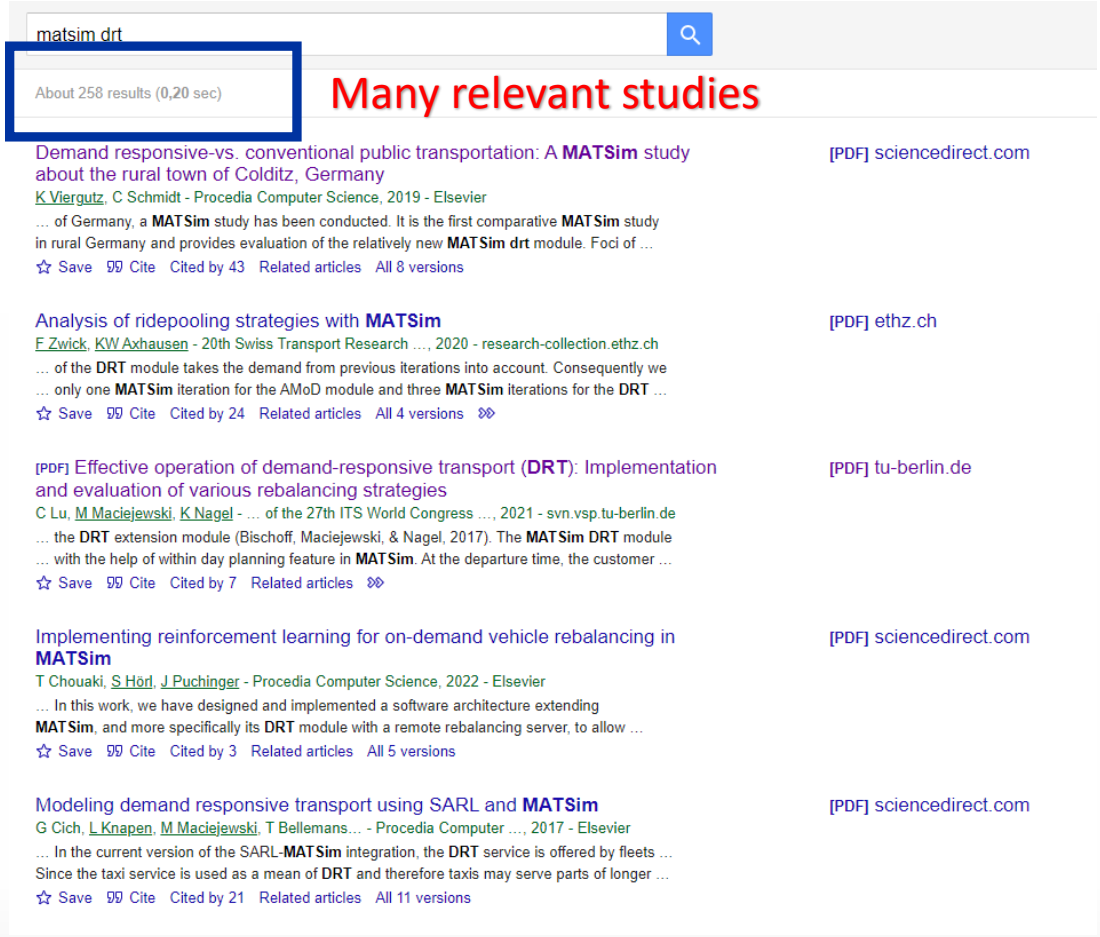
VUB mobi ELECTROMOBILITY RESEARCH CENTRE

AUTONOMOUS TAXIS IN SAN FRANCISCO



CURRENT SAV SIMULATION RESEARCH



By combining SAVs with carpooling, SAVs could effectively reduce the number of CPVs in urban areas and, in most cases, reduce urban congestion

However, **can we further expand the benefits of SAVs (external travellers)?**

CARFREE CITY

Carfree Sunday in Brussels

People Hate the Idea of Car-Free Cities—Until They Live in One

Removing cars from urban areas means lower carbon emissions, less air pollution, and fewer road traffic accidents.

But why are residents so resistant?

PT and bikes still cannot offer the same level of comfort and convenience compared to CPVs!

-(Wired.UK, 2022)

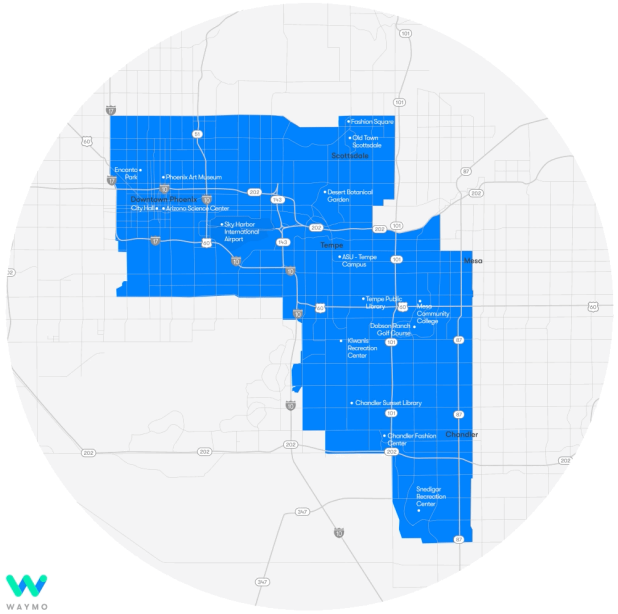
LOW EMISSION ZONE & PARK-AND-RIDE

Low Emission Zone for the whole Brussels Capital Region since 2018;

Most polluting vehicles cannot access the city;

Park-and-ride facilities for transfers to PT.

CURRENT OPERATIONAL STRATEGY OF SAV



May 2023

AV for long-haul trips?

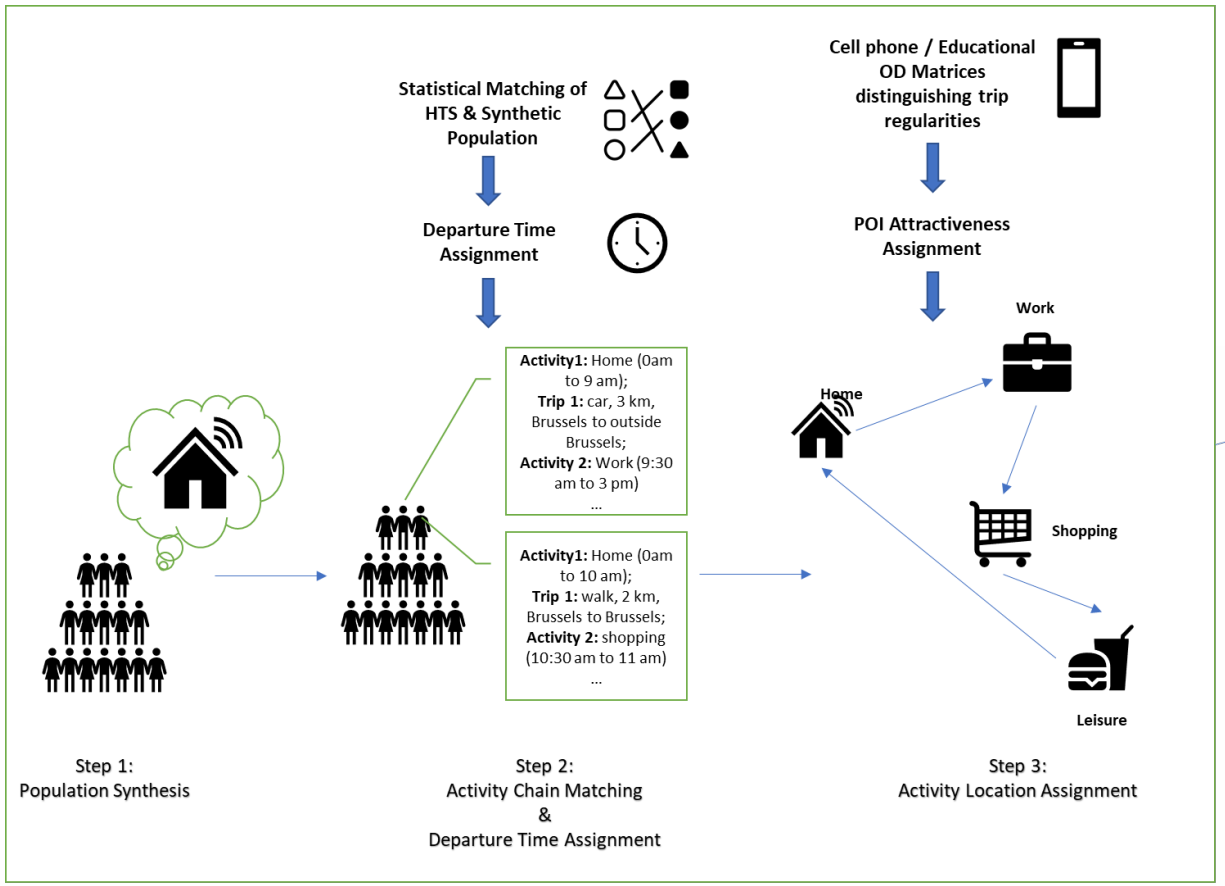
At the current stage, we still expect our service to be served as a first/last mile solution for our customers, which means for long-haul transport, we expect that people **find their ways to the city** and our service will pick them up in the service area

- Talks with Cruise

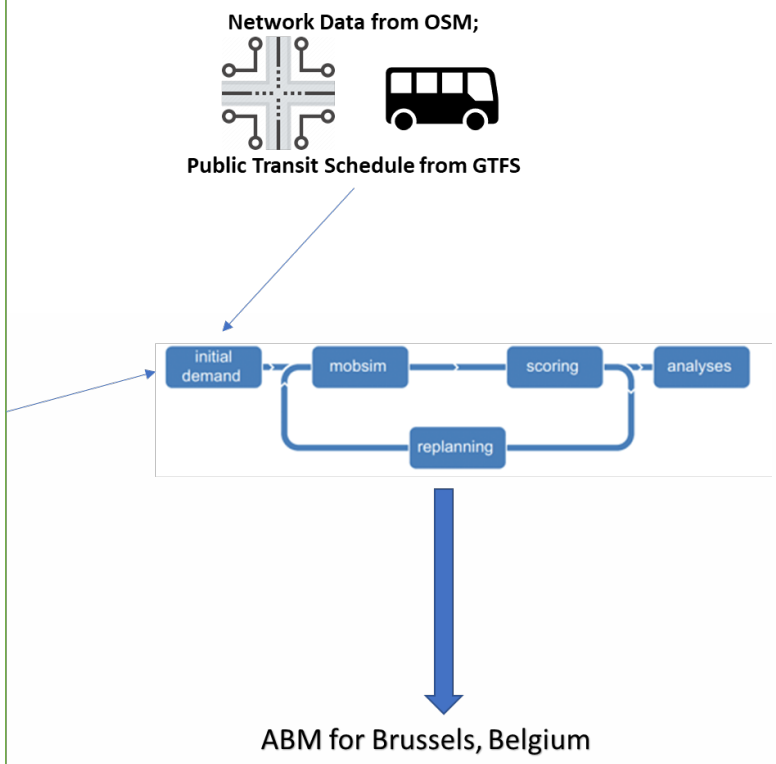
RESEARCH QUESTION

On the basis of substituting current internal CPV trips with SAVs, what will be the potential impacts if we **expand beyond and consider the feasibility of using SAVs as another mode complemented with PT for replacing the external CPV demands (PnR)** in a metropolitan carfree city (Brussels)?

MATSIM BRUSSELS SCENARIO

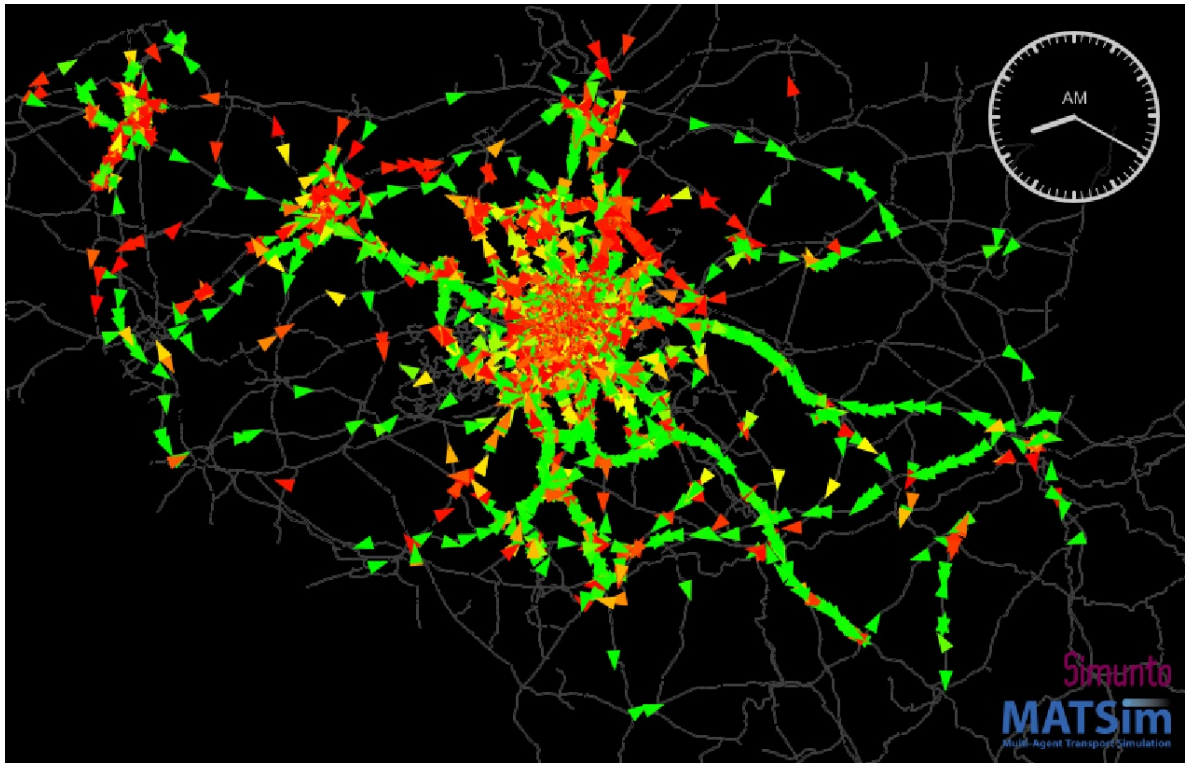


Synthetic Travel Demand Generation



Open pipeline + Ubiquitous data + Model Calibration = MATSim Brussels Scenario

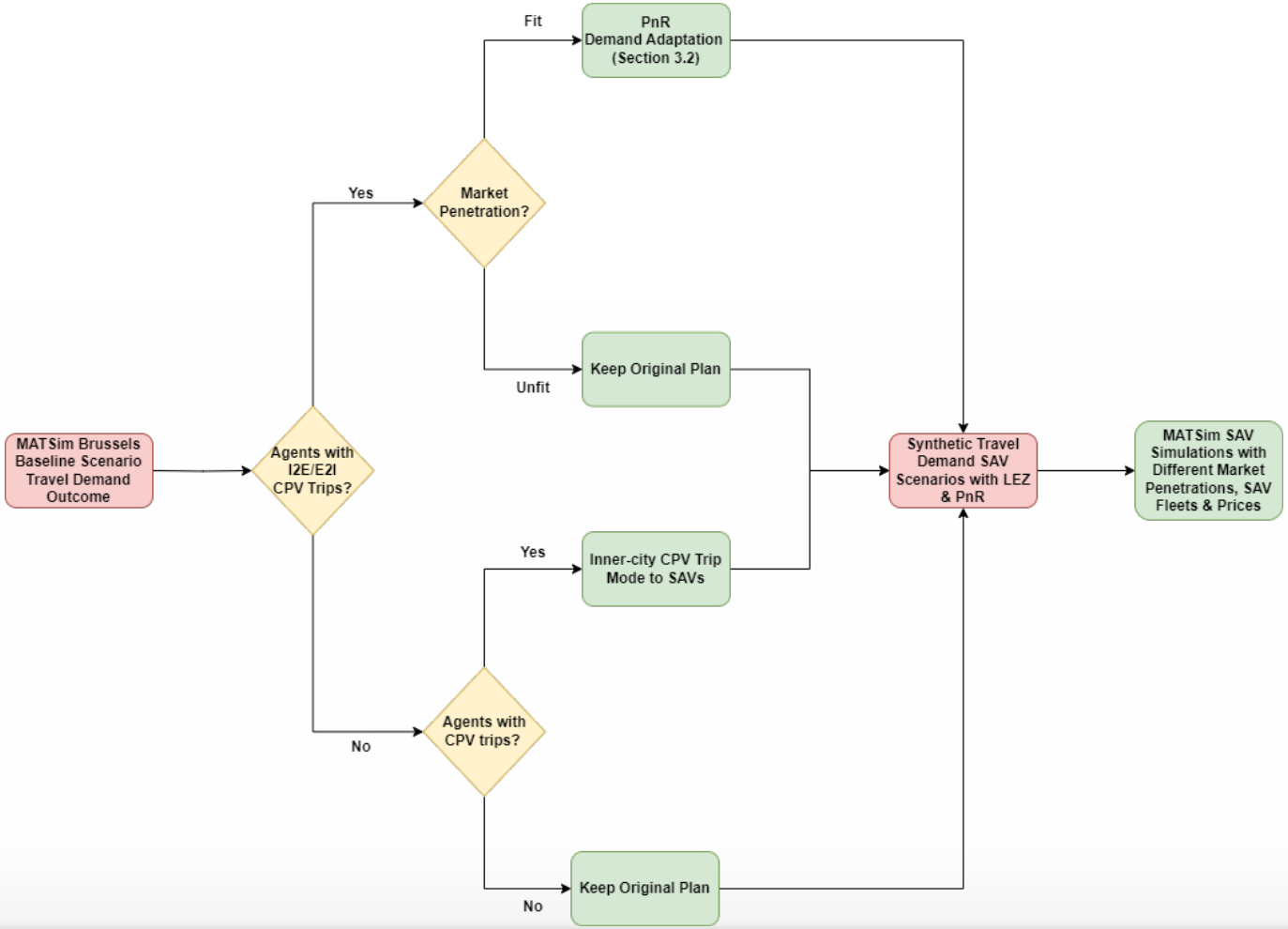
MATSIM BRUSSELS SCENARIO



Inclusion of agents that have trips (external travellers) in Brussels

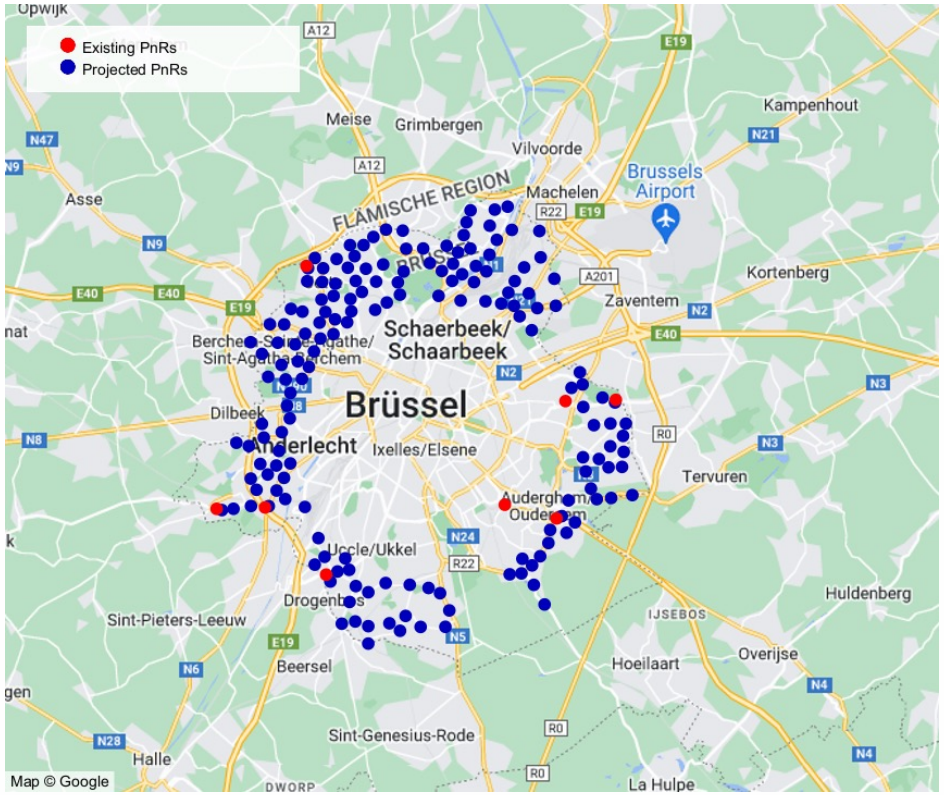
- Nearly 400,000 non-Brussels residents have travel plans in Brussels during a typical workday;
- 22% of Brussels residents (among 1.2 million) have at least one activity outside of Brussels

SYNTHETIC TRAVEL DEMAND CONVERSION



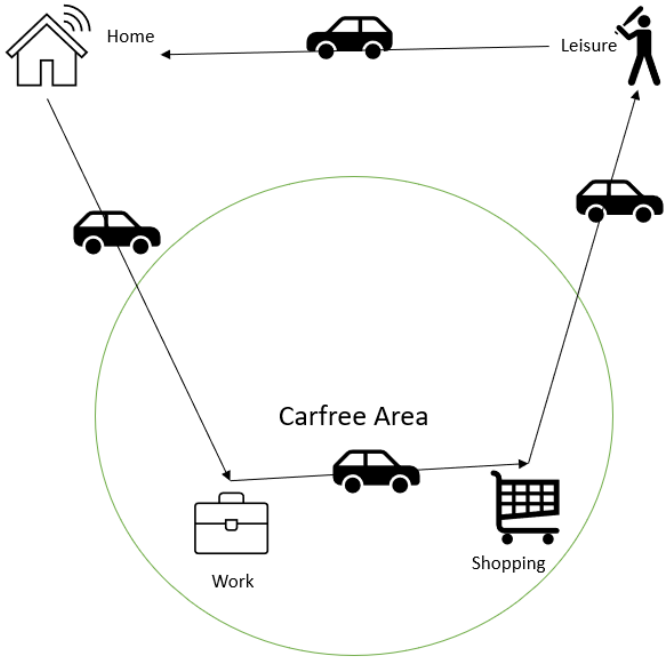
Filter agents with external CPV trips

PNR LOCATION PROJECTION



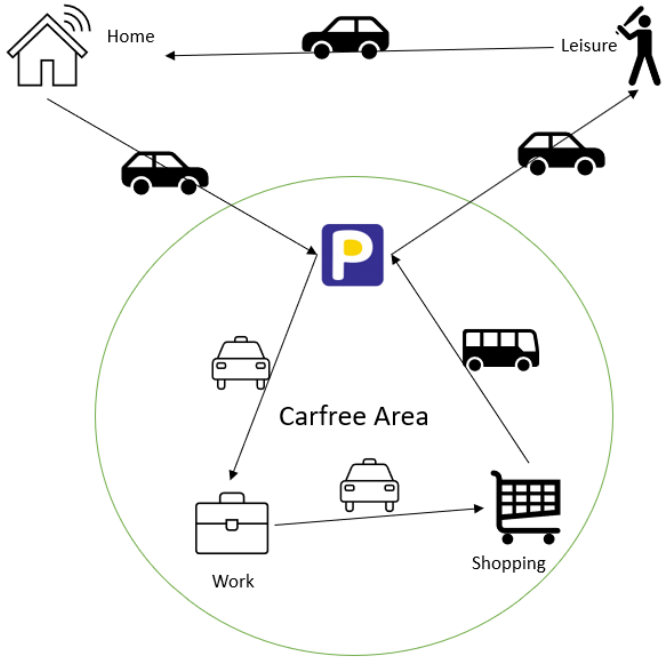
- The existing 8 PnR facilities cannot accommodate all external travel demands;
- Points extractions from PT stops based on relevant PnR location assignment studies;
- 169 new PnR facilities assigned at the end.

PNR FACILITIES ALLOCATION BASED ON ACTIVITY CHAINS



Home – Work – Shopping – Leisure – Home

Current



Home – PnR – Work – Shopping – PnR – Leisure – Home

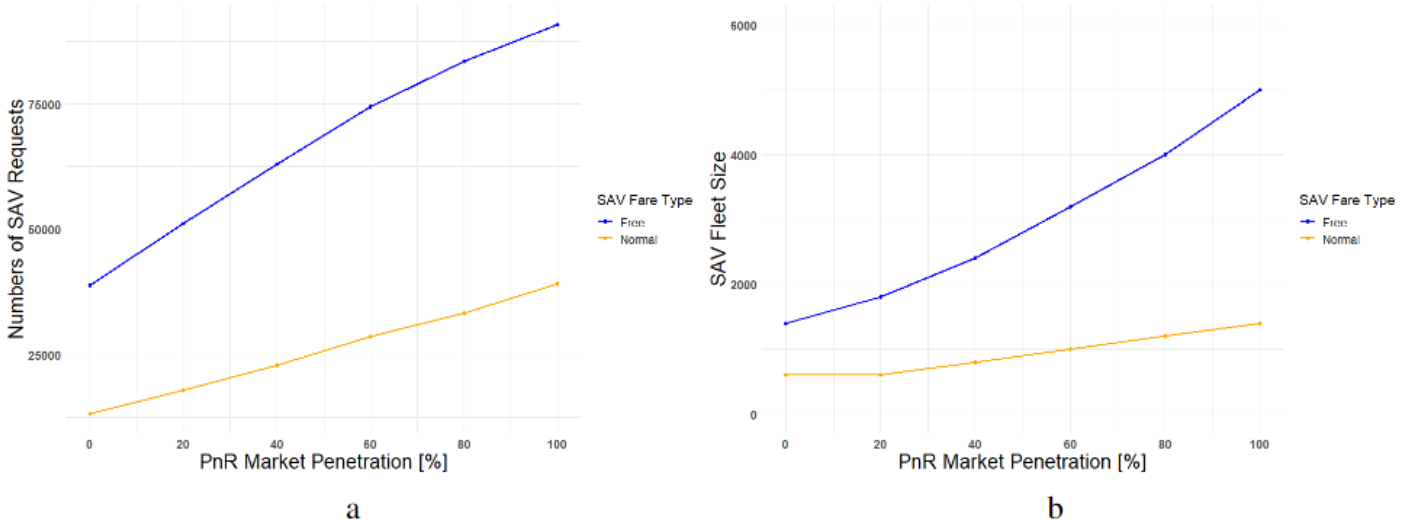
With PnR

- No existing MATSim contrib for PnR location assignments;
- Assign the most convenient PnR facilities, even agents holding E2I and I2E activities on the same day.

ADDING SAV AS AN ADDITIONAL MODE OF TRANSPORT

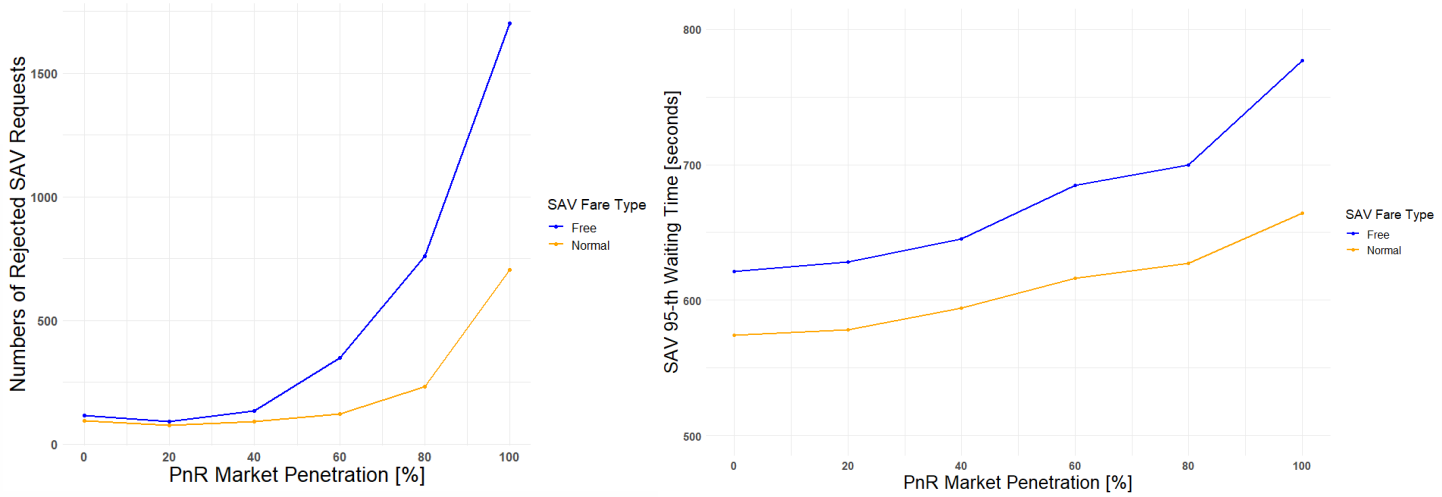
- 6 levels of PnR market penetrations (0% to 100% at intervals of 20%);
- 2 SAV fare strategies: free fare & competitive market fare (refers to Cruise fare structure);
- 4-seat SAVs with carpooling with carpooling and min-cost-flow rebalancing strategy;
- Enable mode choice between SAVs and PT for PnR users.

OUTCOME: SAV MARKET SCALE



- Without PnR: 600 SAVs needed under normal pricing, 1400 SAVs needed for free strategy;
- 100% PnR scenario: 1400 and 5000 SAVs needed for normal and free strategies.

OUTCOME: SAV REJECTION RATE



- Higher PnR market penetration, more rejections & longer waiting time;
- After 60% PnR market penetration, there is a substantial increase in average and 95th-percentile waiting time in both free and normal scenarios.

OUTCOME: TRAVELLER ACCESSIBILITY

TABLE 1 Average Travel Time Comparison for CPV Users Shifting to SAVs and PT Modes Under Different PnR Market Penetrations and Pricing Strategies

PnR Market Penetration	Fare	Baseline CPV [min]	SAV Users [min]	PT Users [min]
20%	Free	16.2	27.7	27.9
	Normal		21.0	41.9
40%	Free	16.1	27.7	31.7
	Normal		21.2	42.3
60%	Free	16.0	28.4	33.6
	Normal		21.6	42.5
80%	Free	16.1	29.1	35.3
	Normal		22.5	43.8
100%	Free	16.1	29.5	37.5
	Normal		23.8	44.3

Travellers spend more time travelling.
Nevertheless…

OUTCOME: CONGESTION & EMISSION

PnR Market [%]	Fare	Vehicle Distance Travelled	CO2	SO2	NOx	PM2.5
0	Free	-2.54%	-32.91%	-32.91%	-31.61%	-32.06%
0	Normal	-23.13%	-32.26%	-32.27%	-30.44%	-30.99%
20	Free	-0.32%	-39.91%	-39.92%	-38.85%	-39.07%
20	Normal	-26.82%	-39.22%	-39.22%	-37.50%	-37.83%
40	Free	2.08%	-46.35%	-46.35%	-45.60%	-45.59%
40	Normal	-30.03%	-45.89%	-45.89%	-44.48%	-44.57%
60	Free	5.08%	-52.48%	-52.48%	-52.07%	-51.83%
60	Normal	-31.96%	-52.20%	-52.20%	-51.16%	-51.03%
80	Free	7.47%	-57.68%	-57.68%	-57.61%	-57.18%
80	Normal	-33.68%	-57.48%	-57.48%	-56.82%	-56.49%
100	Free	6.55%	-63.42%	-63.43%	-63.75%	-63.12%
100	Normal	-34.37%	-62.91%	-62.92%	-62.79%	-62.23%

Compared to the current scenario:

- Network less congested (in most cases);
- Much less transport emission (if SAVs are electric).

TRAFFIC VOLUME CHANGE

60% PnR Market Penetration Free SAV Fare Scenario

60% PnR Market Penetration Normal SAV Fare Scenario

FIGURE 13 Change In Daily Traffic Volume (Sum of CPV and SAV) per Road Segment After the Carfree Strategies

CONCLUSION

- SAVs combined with PnR for external travellers for carfree cities hold both pros and cons: current CPV travellers lose (more or less) accessibility but less transport emissions and urban space savings;

- Current road infrastructure cannot afford 100% of proposed carfree strategies with PnR (even with more PnR facilities);

- In terms of the overall system perspective, the pricing strategies of SAVs cannot be too cheap. Otherwise, the network load will be very heavy (SAVs should serve as a complement to PT in order to maximise their benefits).

THANKS!

Full paper available soon…

Always Happy to Have a Coffee Discussion 😊

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