Shared autonomous vehicles as a replacement for buses. A simulation study in Berlin

Gregor Leich (leich@vsp.tu-berlin.de), Joschka Bischoff | Technische Universität Berlin | 2018-06-26

Motivation

- USA: transportation network companies like Uber on the rise
- Clewlow and Mishra (2017): ride-hailing users report 6% decrease in bus use, but 3% increase in heavy rail use
- Partnerships between Uber and transit authorities for last-mile services
- autonomous vehicles will likely reduce costs

→ more frequent service using many small vehicles instead of a few large buses

post-gazette.com

Simulation study

– replace conventional buses with SAVs (shared autonomous vehicles) in a district of Berlin

– fully demand-responsive service: no fixed schedule, no fixed route, door-to-door service

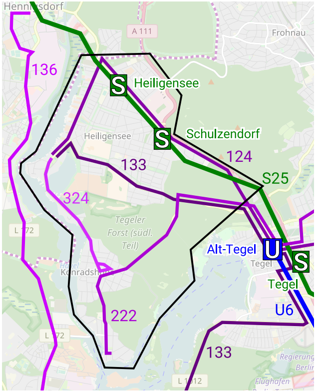
→ more attractive for the customer?

→ less costs for the operator?

– simulation with MATSim (drt and av extensions by Bischoff and Maciejewski)

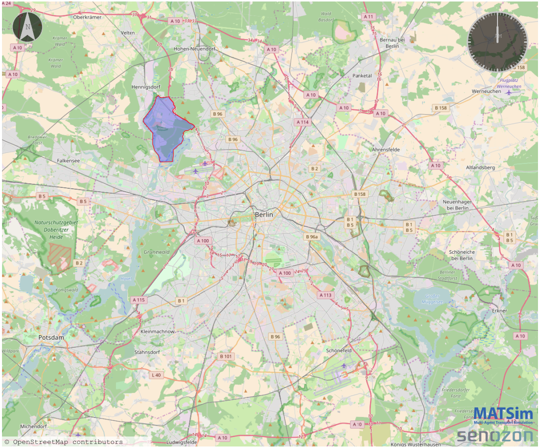
– varying SAV fleets

– SAVs are part of public transit system, no mode choice

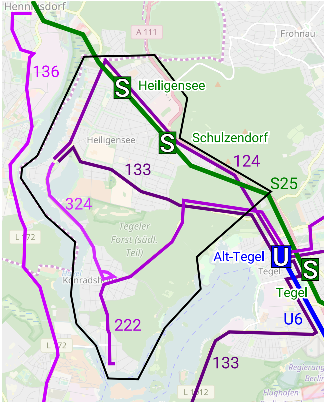


based on OpenStreetMap

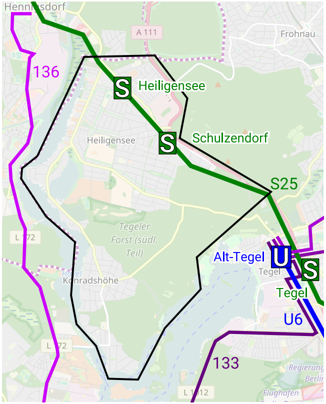
Study area in Berlin



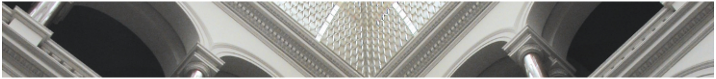
Public transit base case vs. SAV scenarios



base case
based on OpenStreetMap



SAV scenarios
based on OpenStreetMap



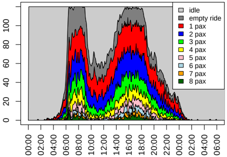
Technische Universität Berlin

Scenario overview

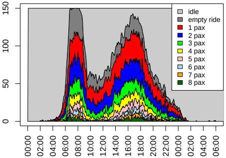
Scenario	number of vehicles	capacity per vehicle [persons]	share of rejected requests ρ	avg. wait + travel per SAV leg [mm:ss]
D2D_50_Cap20	50	20	0.35	18:10
D2D_75_Cap12	75	12	0.19	17:58
D2D_100_Cap12	100	12	0.09	17:55
D2D_100_Cap8	100	8	0.10	17:56
D2D_120_Cap8	120	8	0.05	18:05
D2D_150_Cap8	150	8	0.02	18:13
D2D_150_Cap4	150	4	0.05	18:15
D2D_200_Cap4	200	4	0.01	18:28
D2D_400_Cap1	400	1	0.05	17:40
D2D_1000_Cap4	1000	4	0.00	17:42

– min. 120 vehicles necessary to keep share of request rejections low (ride request could not be served within minimum service quality time constraints)
– capacity per vehicle >8 passengers does not seem to be useful
– fleet structure has little influence on wait and travel time in this model

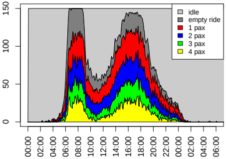
Vehicle occupancy



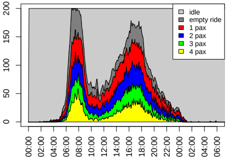
(a) 120 SAVs capacity 8



(b) 150 SAVs capacity 8



(c) 150 SAVs capacity 4



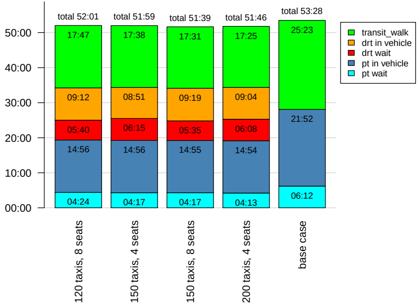
(d) 200 SAVs capacity 4

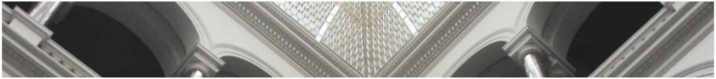
Travel times for the entire trips from origin to destination

- travel times very similar among all scenarios
- less time spent walking, but increase in wait and travel times
- door-to-door service: less walk time, but detours

→ new ride requests can be added after departure, so travel time is hard to predict and connecting trains can be missed

- small travel time savings for the entire trip





Technische Universität Berlin

Costs

Scenario	vehicle type	operation cost [€/a]	capital cost [€/a]	total cost [€/a]
D2D_120_Cap8	Ford Transit	1 832 556	813 142	2 645 698
D2D_150_Cap8	Ford Transit	1 963 830	1 016 428	2 980 258
D2D_150_Cap4	Skoda Octavia	1 556 940	678 957	2 235 897
D2D_200_Cap4	Skoda Octavia	1 715 780	905 276	2 621 056

- driverless conventional bus vs. SAV
- cost savings for shortened conventional bus lines (without driver costs): 2 138 529 €/a
- high uncertainties in cost rates
- SAVs appear to be cheaper than conventional buses with drivers but more expensive than conventional buses without drivers
- driver costs saved: reduce subsidies, lower fares or increase service level?