Autonomous taxicabs in Berlin
– a spatiotemporal analysis of service performance

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Contents

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Motivation

- Developments in AV technology will sooner or later lead to new taxi-like services

- Service provision is expected to be very cheap
  - 0.15 US$ / mile?

- Car usership may decline if AV services are as reliable as car trips

“In less than 20 years, owning a car will be like owning a horse” (Elon Musk)

→ A significantly lower fleet size may be required to serve travel demand

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Motivation

- How many vehicles does it take to cope for the demand handled by cars in Berlin?
- How well will such an AT service perform?
- How do additional empty rides affect service?

Methodology: Model

- MATSim is used as the simulation software
  - Simulation of agents along their daily routines during multiple iterations using multiple travel modes
  - Allows fast simulation of millions of agents

The current MATSim Berlin model:

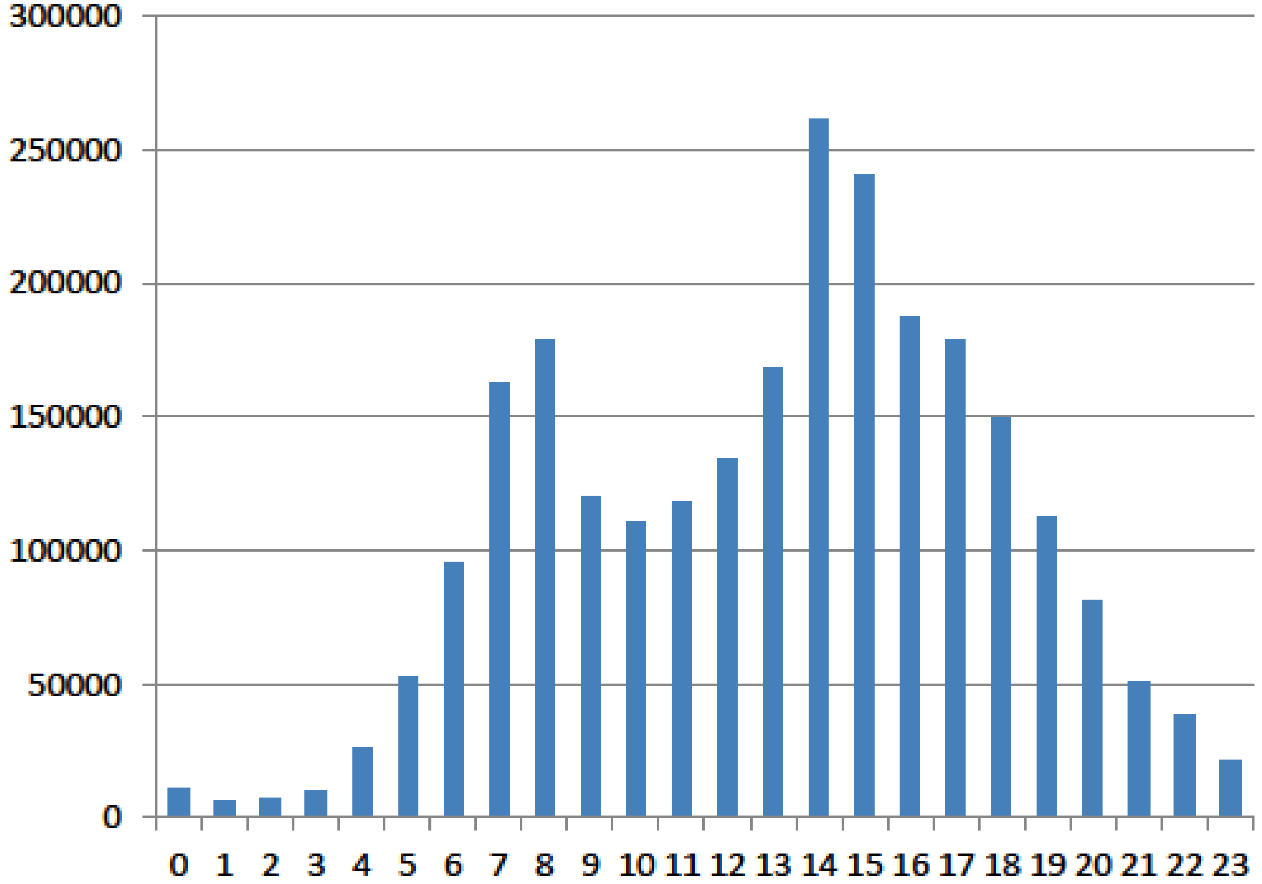
- 6 million agents
- 16 million trips
  - Car 35%
  - Public transport 35%
  - Other (walk, bike) 30%

AT demand:

~ 2,5 million daily car trips within the city boundaries

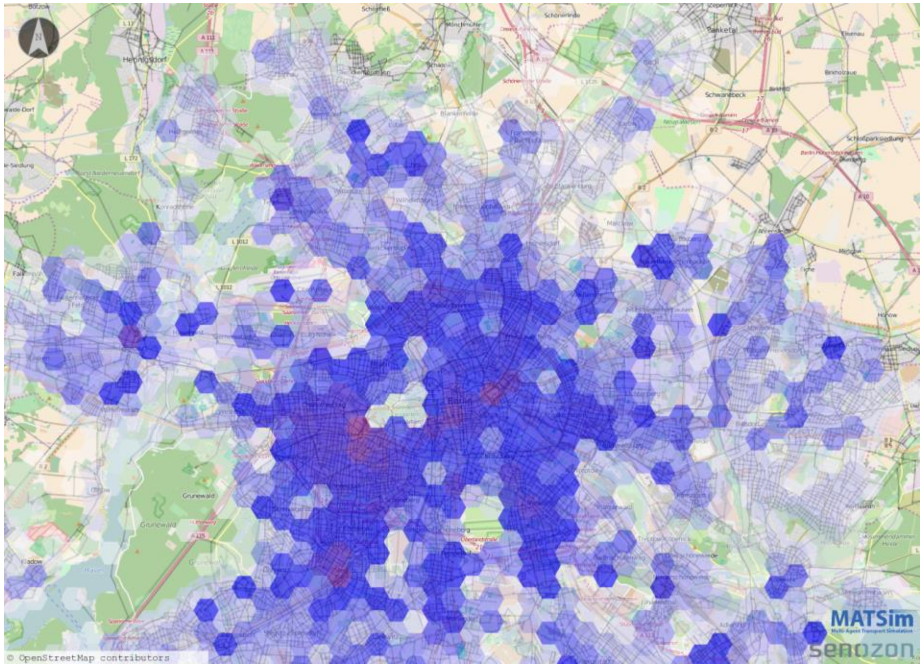
Served by roughly 1.0 - 1.1 million cars

The Berlin scenario

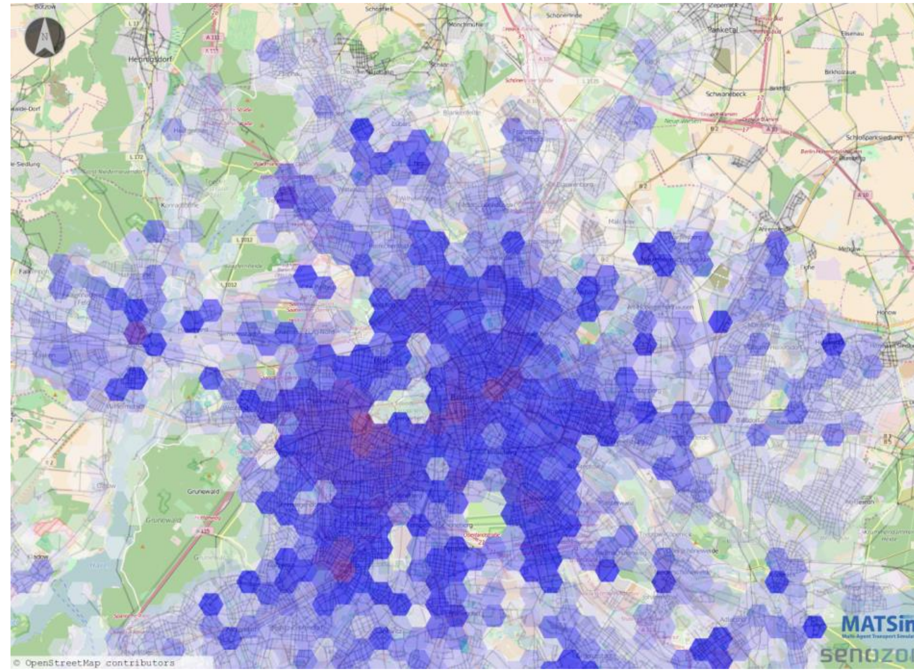


Hourly demand for AT trips over the day

Spatial distribution of AT trips



Trip start locations



Trip end locations

Simulation of dynamic transport services in MATSim

Objectives

- minimize fleet size
- minimize wait time
- minimize empty-to-total drive time ratio

Constraints

- immediate requests
- destinations unknown in advance
- online vehicle monitoring, but no diversion
- vehicles move according to the current travel times
- pickups and drop-offs take time
- Initial vehicle distribution: According to population density

Dispatching strategies

Rules

- **taxi call** – dispatch the nearest idle taxi **OR** queue request
- **drop-off** – wait **OR** serve the **longest** waiting request

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Dispatching strategies

Rules

- **taxi call** – dispatch the nearest idle taxi **OR** queue request
- **drop-off** – wait **OR** serve the **nearest** waiting request

= demand-supply balancing

Results

- Initially, between 60.000 and 250.000 ATs were used to serve the demand

- 100.000 vehicles provide a sufficiently good service

  - Average waiting times of around 5 minutes during peaks, less than 3 minutes in average

  - Overall daily driving distance per vehicle: 274 km
    - 239 km with passenger
    - 35 km empty (13 %)
    - Average trip length: 9,4 km

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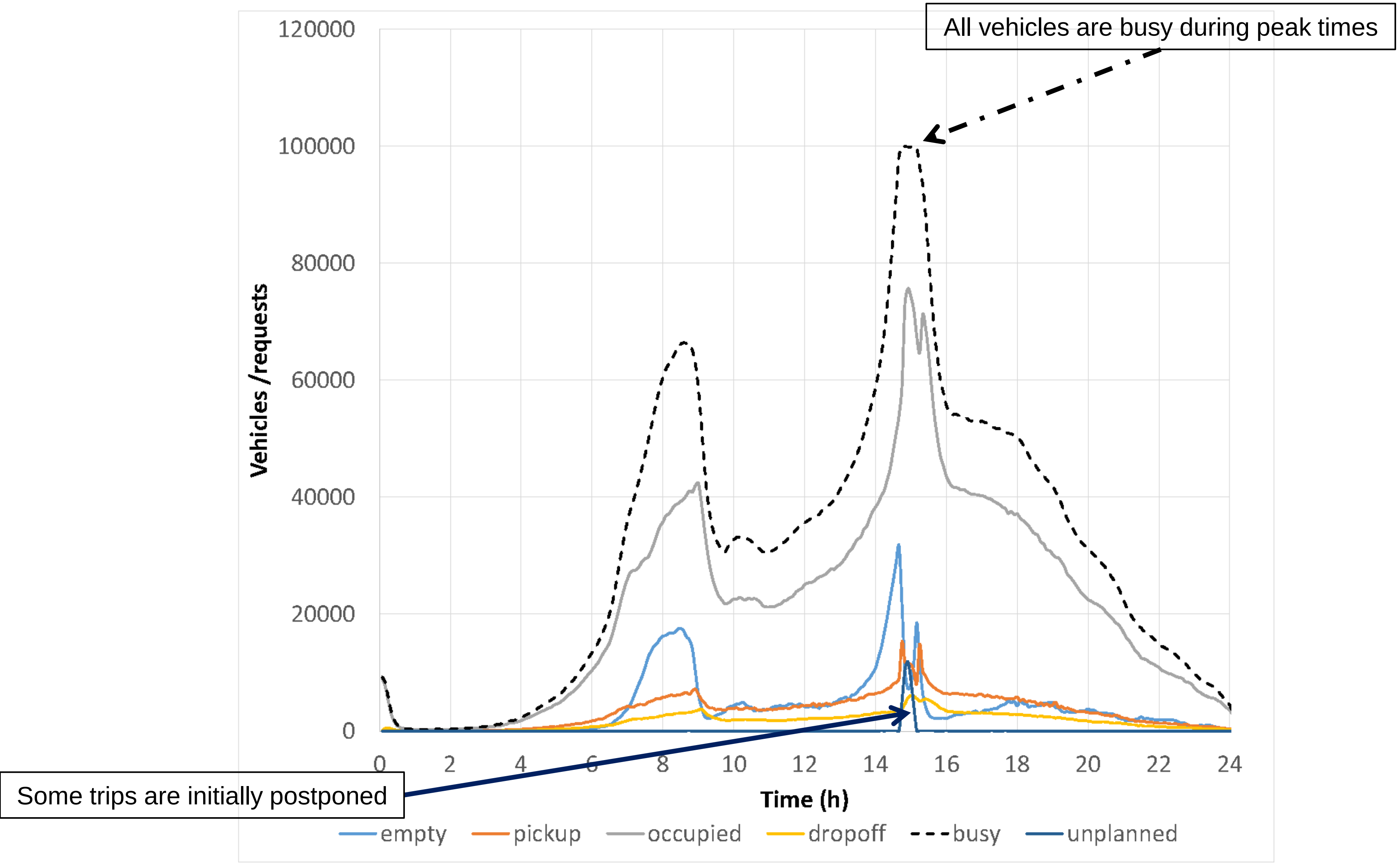
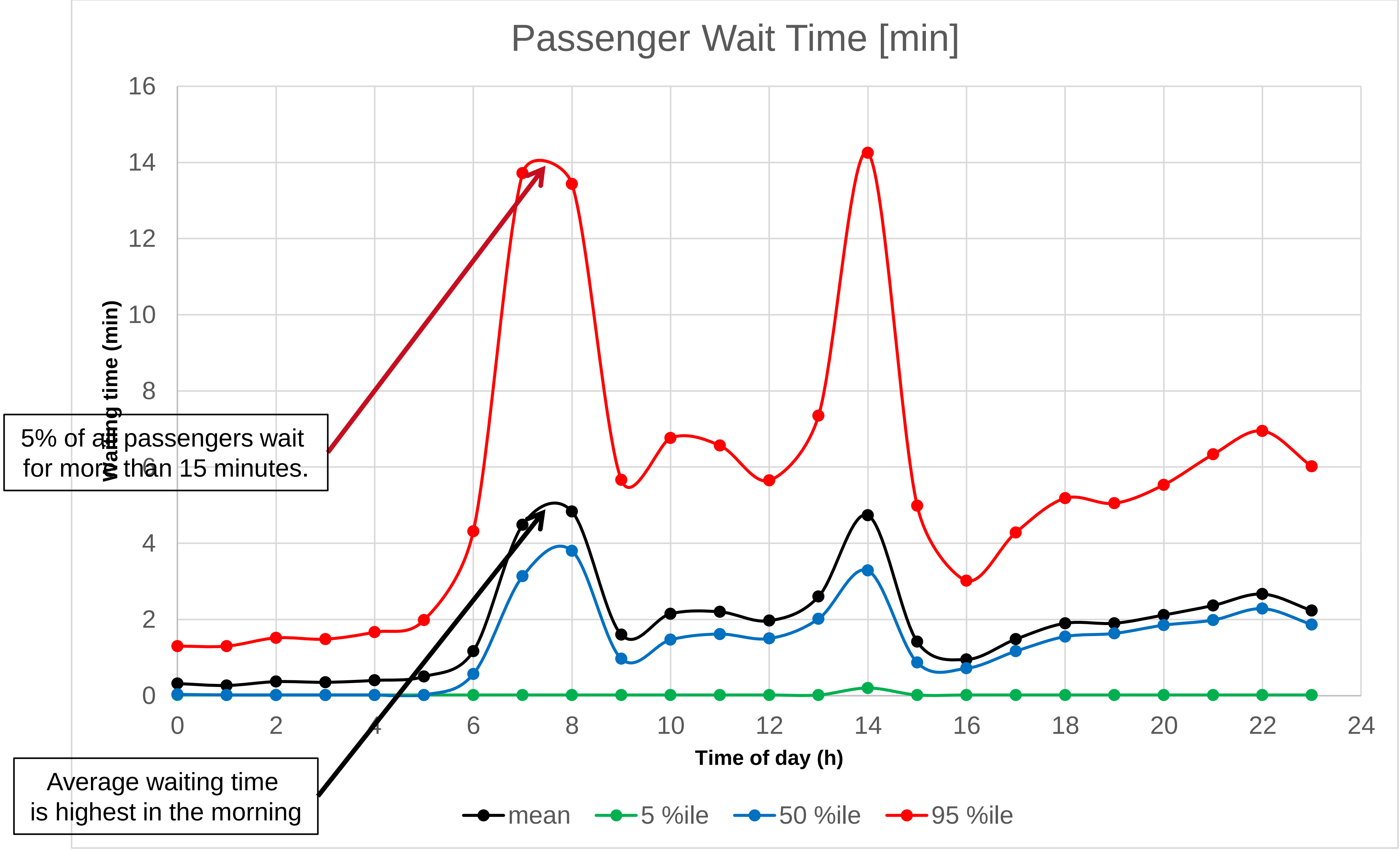
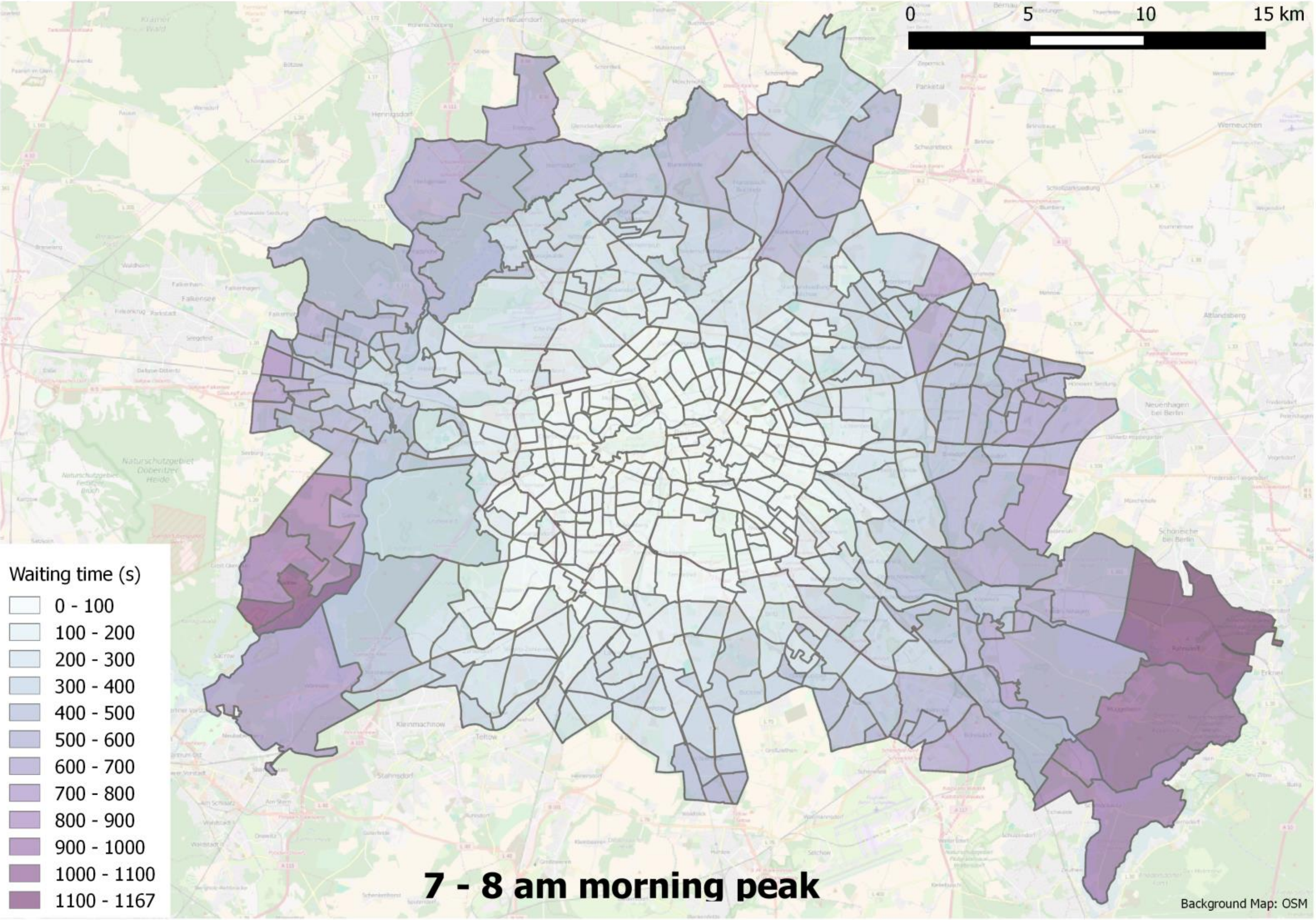
Results: 100.000 vehicles



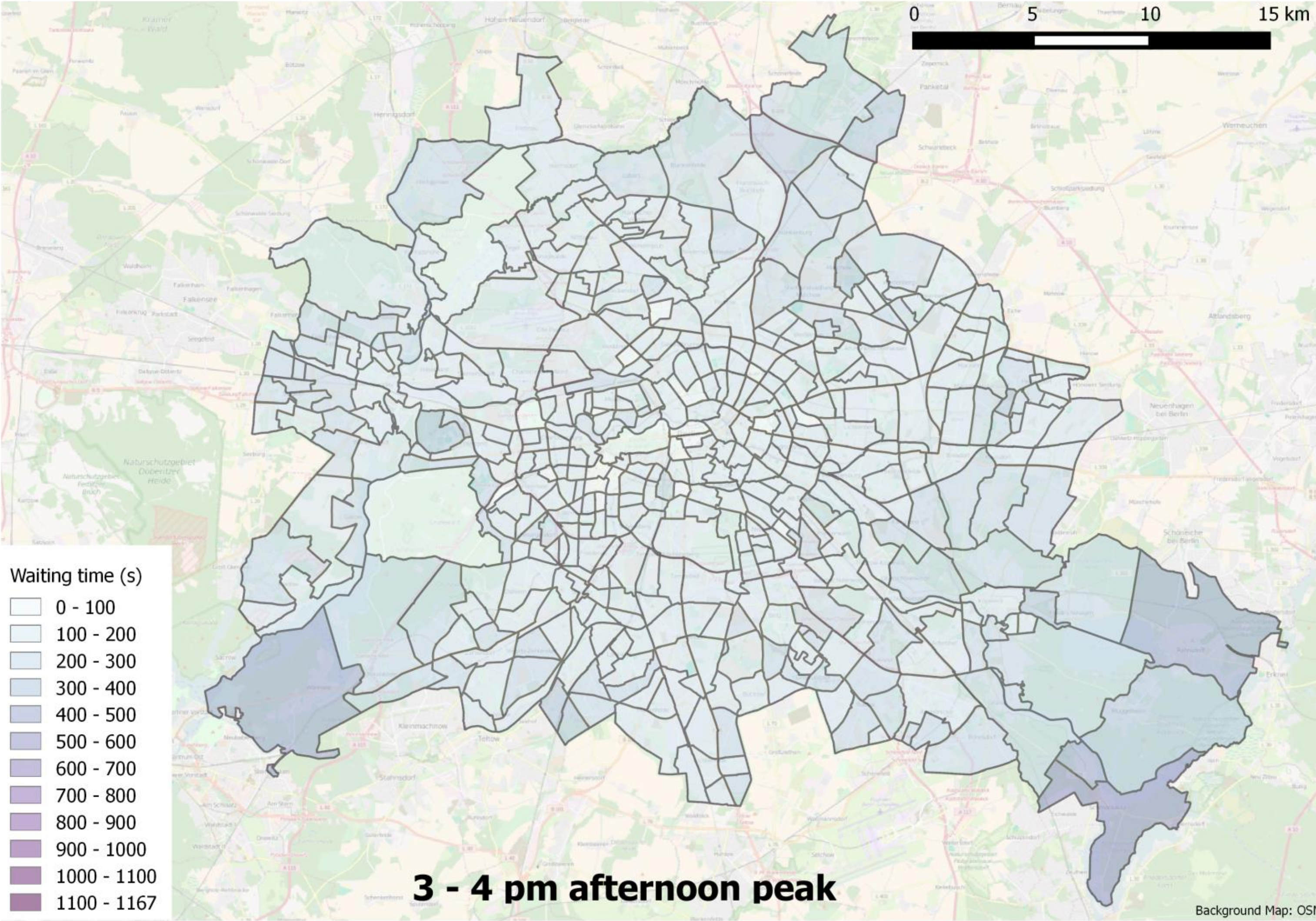
Results: 100.000 vehicles



Results: 100.000 vehicles



Results: 100.000 vehicles



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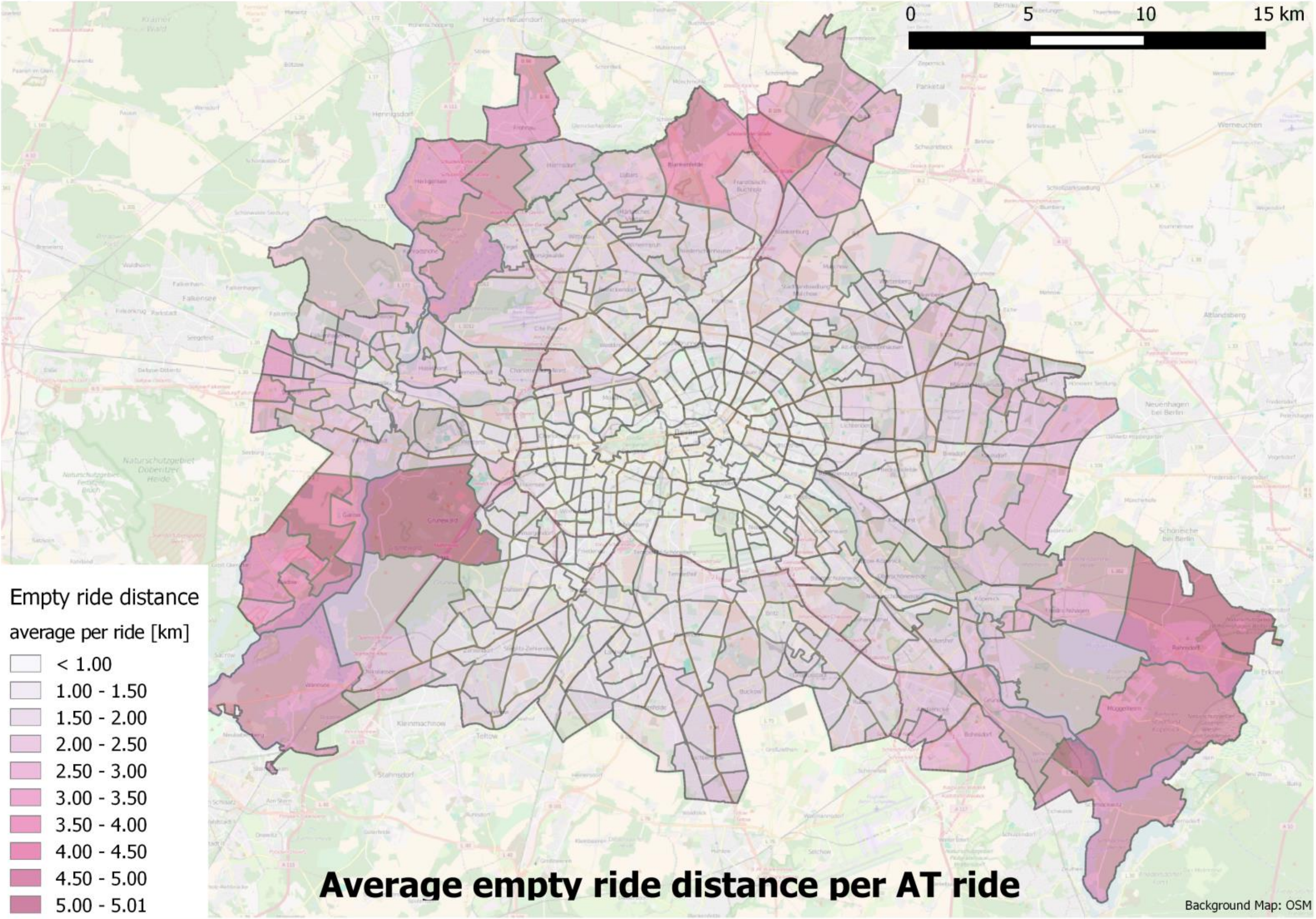
The effect on traffic

- 13 % of all mileage is empty and did not exist beforehand

- Effects on congestion are hard to measure:
  - Increased flow of AVs could compensate for this
  - → Further research on congestion effects

- Extra mileage is not evenly spread over the city
  - In the city centre, pick up trips are generally short (or even non existent)
  - Demand from outskirts attracts longer pickup trips

The effect on traffic



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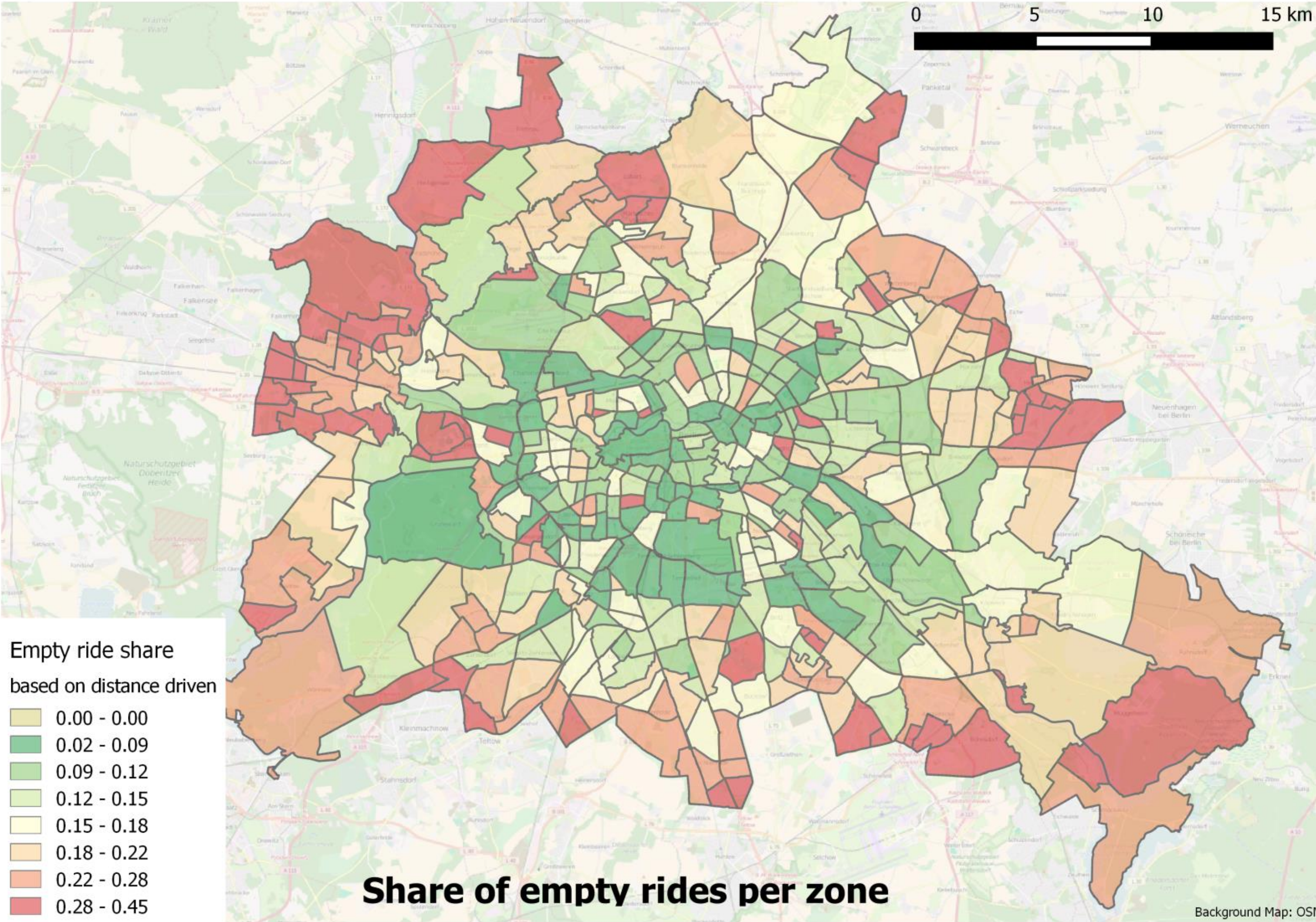
The effect on traffic



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Generalisation

- Based on today‘s travel behaviour and the given constraints, 100,000 ATs could replace inner city car traffic in Berlin

- Waiting times seem acceptable, so does fleet occupancy
  - In terms of profit: City centre more promising, pick up trips are significantly shorter

- Fleet is mainly occupied during peak hours

  - ATs are occupied for roughly 7.5 hours a day, so a majority of the fleet could run different services during off-peak times

Further steps

- The influence of other modes
  - Not only car users are expected to use AT services
    - The attractiveness of public transport could decline
    - A combination of AT and PT services
    - Requires a behavioral model for mode choice of a currently non-existing mode

- Better flow performance of AVs
  - Can be assessed in MATSim

- Shared rides
  - Assumes a willingness-to-share

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Thank you!