Horizon 2020

Societal Challenge: Improving the air quality and reducing the carbon footprint of European cities

ICARUS

Project: 690105 – ICARUS

Full project title:

Integrated Climate forcing and Air Pollution Reduction in Urban Systems

Transition pathways for the transport sector – a case-study for the City of Stuttgart

WP 6 Developing pathways to green smart and healthy cities

Lead beneficiary: USTUTT

Date: January 2020

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1 Introduction and executive summary

For the city of Stuttgart, two distinct visions have been created that are broadly in line with the common ICARUS pathways "Smart Tech City" and "Sharing Smart Communities". The overall goal is the same for both visions and can be described as optimized welfare and wellbeing with lower pressures to the environment. In the following both visions are presented. A more detailed description of the two visions and a general description of the foreseen transition pathways can be found in the project deliverable D6.3[1]. This report focuses on the transport sector, for which two distinct scenarios (one for each foreseen vision) are compared to a baseline scenario representing the business as usual. The foreseen visions implicate a change in mode choice alternatives. With fully automatic vehicles becoming available, behavioral changes can be expected. With the help of the macroscopic travel demand model of the Stuttgart Region, it is possible to study and evaluate potential implications for the transport sector, which arise from individual decisions and behavioral choices. The simulation of travel demand patterns helps to identify relevant preconditions which are required for a successful transition in the transport sector and to ensure that the foreseen visions are actually feasible.

Results showed that the introduction of fully automated shared vehicle fleets for car-sharing or ridesharing is suitable to decrease the number of vehicles needed. This assumes that private car ownership is prohibited, as it is the case in the vision scenarios. Although the vision scenarios do not necessarily improve the traffic situation within the city boundaries, they show the importance of pricing and the relevance of a dense public transport supply. For both scenarios, it was not possible to run the system without adding rail-bound public transport (light rail transit, suburban and regional trains). Thus, apart from a certain share of pedestrians and cyclists, transport always consisted of a mixture of rail-bound public transport and autonomously driving taxis (carsharing in "Smart Tech Cities) or minibuses (ridesharing in "Sharing Smart Communities"). In practice, a mixture of both scenarios would most likely be realized.

[1] ICARUS Project Team (2019): D6.3 Report on the transition pathway, WP6 Deliverable, ICARUS, https://icarus2020.eu/wp-content/uploads/2020/03/ICARUS-D6.3.pdf

2 Scenario Outline

According to the visions of "Smart Tech City" and "Sharing Smart Communities", two transport scenarios were defined:

(1) Private Transport scenario according to the "Smart Tech City" vision and

(2) Public Transport scenario corresponding to the "Sharing Smart Communities" vision.

The scenarios provide concrete assumptions for passenger traffic in line with the described visions in the project deliverable D6.3[1] and differ with regard to the available mode choices as well as the availability and use of fully automated vehicles. The applied macroscopic travel demand model estimates the source-destination relation for all persons travelling in the city area. It also allocates the mode of transport used and the route chosen to each source-destination relation. The model is able to consider all relevant modes for private transport in Stuttgart including walking, cycling, rail-bound public transport, busses and private cars. For private cars, it also differentiates between driver and passengers. All choices (destination, mode and route) are based on a target function that includes parameters on which travellers usually base their decisions on, e.g. travel time, cost, waiting time or number of transfers. In order to be able to consider the preferences of different types of people, the model differentiates different person groups, which are characterized by a specific travel demand, car ownership and access to public transport. To identify and evaluate the implications of the made assumptions, the two scenarios are also compared to a baseline scenario, which represents business as usual.

In the following, the three modelled scenarios are shortly characterized with their main assumptions regarding their implementation in the travel demand model:

Baseline Scenario

- Available mode choice alternatives:
  - Private car driver, private car passenger,
  - public transport (including busses, Light Rail Transit (LRT), suburban and regional trains),
  - walking, cycling
- Private car costs:
  - depending on distance
  - 0.105 €/km + parking costs

Private Transport (PrT) Scenario

- Fully automated carsharing (CS) replaces private cars within the Stuttgart Region
- CS as feeder replaces bus and LRT lines
- Direct CS costs:
  - depending on distance
  - 0.25 €/km
- Feeder CS costs: included in public transport ticket (no additional costs)
- Additional waiting time (4 min) for direct or feeder CS trips (in comparison to private car)
- Changes regarding assignment of inhabitants to person groups:
  (1) Inhabitants without car availability are assigned to corresponding groups of people with car availability (influence of fully automated CS)
  (2) Shifts between groups to represent influence of e.g. increased use of robots

Public Transport (PuT) Scenario:

- Public transport supplemented by fully automated ridesharing (RS) on od-pairs with insufficient public transport travel times replaces private cars within the Stuttgart region
- RS as feeder replaces bus lines
- Direct RS costs:
  - depending on distance
  - 0.22 €/km
- Feeder RS costs: included in public transport ticket (no additional costs)
- Detour factor and additional waiting time (4 min) for direct or feeder RS trips (in comparison to private car)
- Changes regarding assignment of inhabitants to person groups:
  (1) Inhabitants without car availability are assigned to corresponding groups of people with car availability (influence of fully automated RS)
  (2) Shifts between groups to represent influence of e.g. increased part time work
- For the region's origin, destination and through traffic generated by private cars, an increase of the occupancy rate to 2.5 persons per vehicle is assumed to reflect demand pooling in accordance with the mandatory RS for intraregional travel

3 Findings and Cause-Effect Relationships

In the following, core findings of the scenario evaluation are presented (comparison of the vision scenarios with the baseline scenario).

Total number of trips

As shown in Figure 1, the number of person trips increases slightly in the PrT scenario and to a greater extend in the PuT scenario. These fluctuations are due to the changed allocation of inhabitants to person groups.

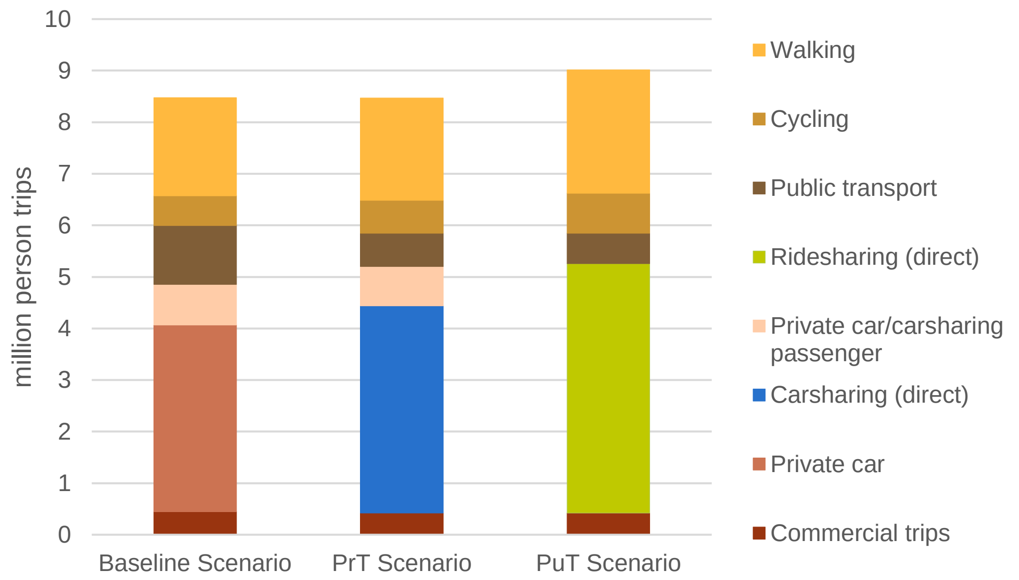

Figure 1: Person trips within the Stuttgart Region (feeder trip legs are included in the main mode).

Person kilometers travelled for trips within the region

Due to the more than twice as high marginal costs ("out-of-pocket costs") per person kilometer (carsharing/ridesharing in comparison to private cars), destination choice is strongly influenced (Figure 2). The total person kilometers of the region's internal traffic in both PrT and PuT scenarios decrease considerably compared to the baseline scenario.

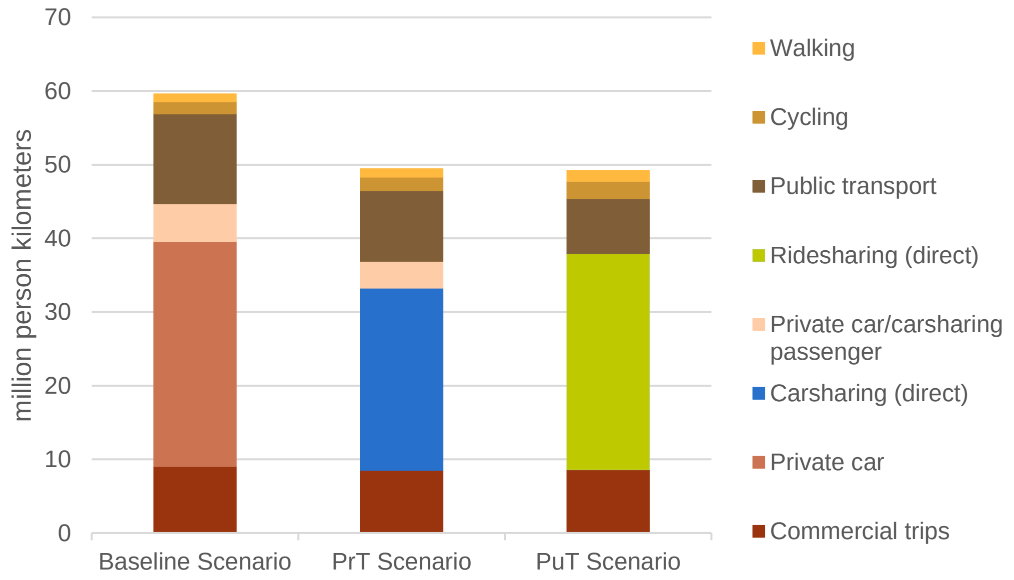

Figure 2: Person kilometers travelled for trips within the Stuttgart Region (feeder trip legs are included in the main mode).

Person kilometers travelled for trips within the city

In contrast, however, the number of person kilometers travelled for trips within the City of Stuttgart increases slightly (Figure 3). This is mainly due to the fact that parking costs charged in the baseline scenario for private car traffic do not apply in the vision scenarios. This omission of parking costs has an especially strong influence on trips with origin and destination within Stuttgart. Here the new mobility supply offers cheaper alternatives compared to the car in the baseline scenario. In addition, the public transport price per person kilometer is higher in the city compared to the entire region. At the same time busses (and LRT), which play an important role in the baseline scenario for trips within Stuttgart, are omitted in the vision scenarios. Especially in the PrT scenario where LRT lines are omitted, the person kilometers travelled by public transport decrease.

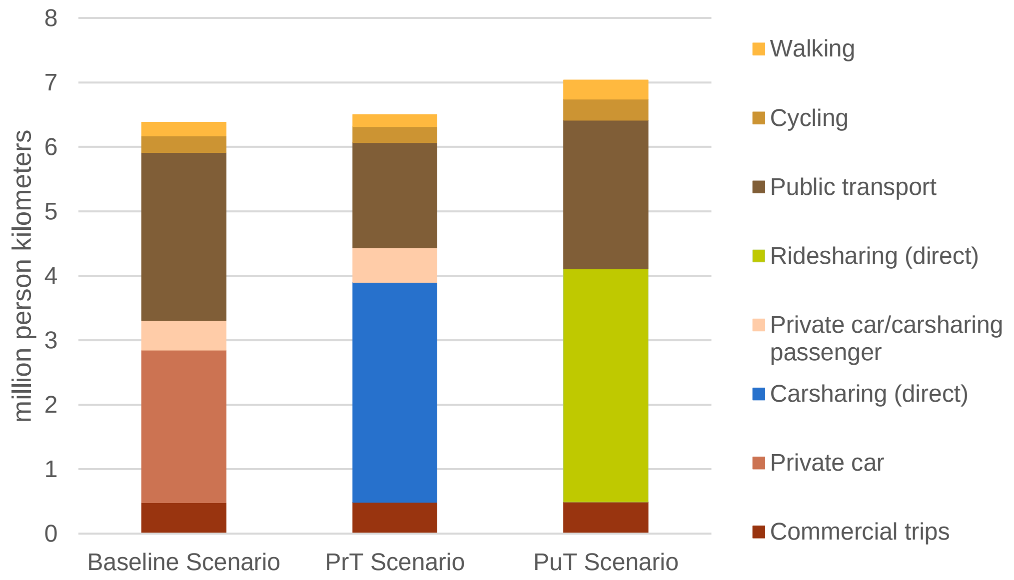

Figure 3: Person kilometers travelled for trips within the City of Stuttgart (feeder trip legs are included in the main mode).

<u>Vehicle kilometers travelled within region and city:</u>

In principle, similar developments can be observed for vehicle kilometers as for person kilometers. In the region, vehicle kilometers are reduced to varying degrees. In the city, however, the vehicle kilometers travelled increase for both vision scenarios (compared to the baseline scenario, the traffic volume is mostly reduced outside the city boundaries, but increases especially in the city center as visualized in Figure 4). However, the pooling of external car traffic in the PuT scenario decreases the total vehicle kilometers (see Figure 5). Empty runs of carsharing and ridesharing vehicles account for a comparatively small proportion of the vehicle kilometers travelled.

Due to the pooling of ridesharing passenger trip requests, the number of vehicle kilometers travelled in the PuT scenario is generally lower than in the PrT scenario. However, the occupancy rate of ridesharing vehicles is unexpectedly low at about 1.5 person kilometers per vehicle kilometer. Possible reasons for this may lie in the temporal and spatial distribution of the demand for ridesharing trips or characteristics of the algorithm for the pooling of trip requests.

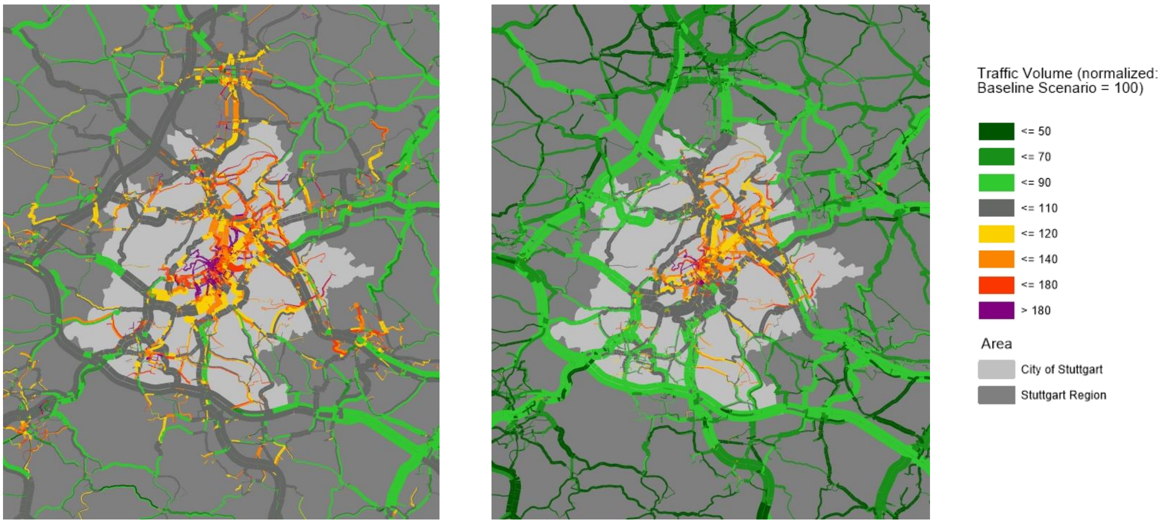

Figure 4: Change of traffic volume for PrT scenario (left) and PuT scenario (right) in comparison to the baseline scenario.

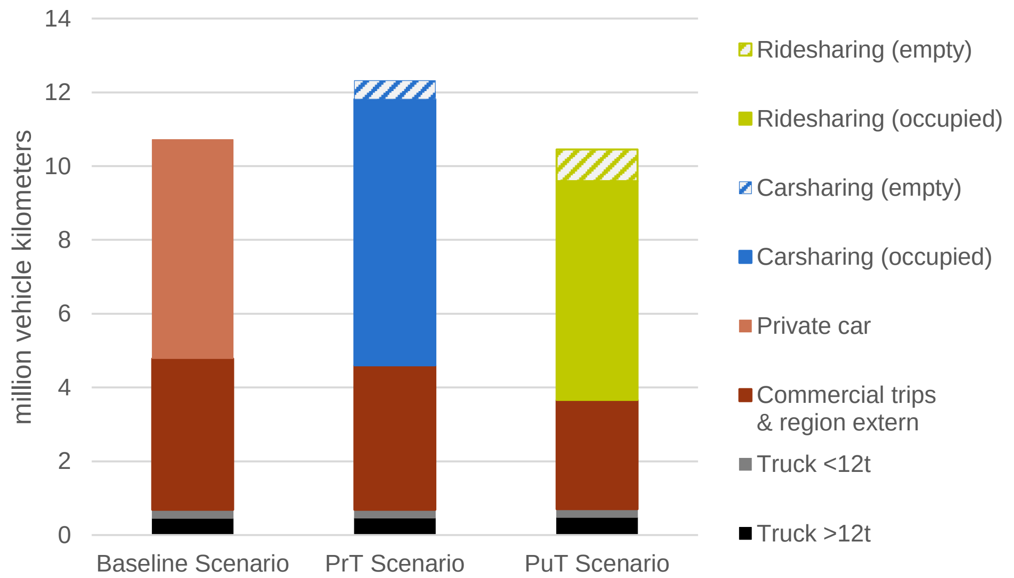

Figure 5: Vehicle kilometers travelled within the City of Stuttgart (not including intrazonal trips, but external traffic).

Number of vehicles required

In the PrT scenario, the use of carsharing reduces the vehicles required for private car trips in the Stuttgart Region by approximately 50 %. In the PuT scenario, less than one fifth of the number of carsharing vehicles is required.

This difference between the number of vehicles needed in the PrT and PuT scenario is unexpectedly high as the vehicle kilometers travelled do not differ that much (for occupied ridesharing trips about 65 % of the vehicle kilometers for occupied carsharing trips are travelled). The algorithm used for vehicle scheduling and assessing the number of required vehicles probably overestimates the number of carsharing vehicles. This is due to two main reasons: (1) The absolute number of occupied carsharing trips is more than twice as high as the number of occupied ridesharing trips. (2) The average duration of an occupied carsharing trip is approximately 10 minutes per trip whereas for ridesharing it lies at 17 minutes per trip. The vehicle-scheduling algorithm assumes an average vehicle layover time of 7 minutes before a subsequent trip. With more and shorter occupied vehicle trips this idle time increases in the PrT scenario. Hence, more vehicles are needed to meet the same vehicle kilometers travelled for occupied vehicle trips.

4 Conclusions

The introduction of fully automated shared vehicle fleets for carsharing or ridesharing is suitable to decrease the number of vehicles needed. This assumes that private car ownership is prohibited, as it is the case in the vision scenarios. The new mobility options influence the person kilometers travelled as they assume different costs for travelling. Because of increased distance-dependent costs and omitted parking fees in the city, the cost effects differ between region and city: Trips in the region become more expensive, causing travelers to travel shorter distances. On the contrary, prices for trips with car-like modes (direct carsharing or direct ridesharing) are reduced within the city. As a result, no reduction of person and vehicle kilometers travelled can be achieved in the city. A factor that reduces vehicle kilometers travelled is the pooling of person trips: a higher mean occupancy rate of the vehicle fleet reduces the vehicle kilometers for a given demand. However, the degree to which person trips can be pooled to one vehicle trip depends on a variety of spatial and temporal factors.

In summary, the vision scenarios do not improve the traffic situation within the City of Stuttgart. They rather show the importance of pricing and a dense public transport supply including LRT and bus lines.