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EFFECTS OF DIFFERENT MOBILITY CONCEPTS IN NEW RESIDENTIAL AREAS

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ABSTRACT

Growing cities need new residential areas, which are often either not connected to the existing transport infrastructure or are poorly connected to it. A fast way to connect these areas is the construction of roads. However, this generates a car-depending mobility among the inhabitants, which is in conflict with several sustainability goals. Moreover, the impact of the implementation of new public transport options is only partly known and this fact reduces the willingness to invest in expensive public transport measures. In this work we examine different mobility concepts, including shared mobility, bicycle highways, a high-frequency bus service, suburban trains and car limitations in a new residential area of 2000 households in Berlin, Germany, which is currently under construction. The households and inhabitants are created synthetically using statistical data derived from a survey among the first people moved in. The age and size structure of these households turn out to be different from the neighbouring households. Then, we implement all measures in a microscopic travel demand simulation and quantify the potential modal shifts for four different mobility concepts. The results show that weak and short-term mobility concepts show no significant change in mobility behaviour. Only highly integrated projects like bicycle highways into the inner city combined with suburban trains can reduce the need for car-dependent mobility. Shared mobility only fills in the gaps for special occasions but not for daily mobility due to the high costs. In a final step we examine the usage of the introduced public transport services and compare the change in the occupation of the buses and trains. Here our work shows that interchanging from bus to subways and suburban trains drastically reduces the attractiveness of public transport. Introducing a new suburban train changes this situation and the whole region shows a drop of 40% of car trips.

1. INTRODUCTION

New residential areas need a working mobility concept to fulfil the personal mobility as well as environmental goals of the municipality. The difficulty of new residential area is, that these areas are poorly integrated into the existing infrastructures. Beside extra time to reach the next train stations local infrastructure like schools and super-markets are often not close to the new residential locations. Car-based mobility offers the flexibility and accessibility needed for the daily mobility. However, the individual use of cars produces traffic jams and necessitates a huge amount of parking space in the residential area. To compensate these effects short-term measures like increased bus frequencies and bike lanes are often introduced. The question is: Is this enough? Modelling the travel demand is a feasible way to quantify the effectiveness of several measures. In this work we show the potential of modal shift towards public transport and bikes via different measures.

2. METHODOLOGY

In this work we model a synthetic population of Berlin expanded by the new population of the examined study area (see section 2.1). The synthetic population of Berlin is generated to fit official census data with respect to inhabitants, household size, age and gender. The population of the study area is extrapolated from a survey made among the first wave of inhabitants in 2019 to take the different socio-demographic structure of the new population into account.

Four different scenarios with different mobility concepts to emphasize a modal shift from car-based mobility to other modes of transport are developed to measure their effects (see section 2.2). These scenarios are parameterized to be used in the simulating framework consisting of the two models TAPAS and SUMO (see section 3). Finally, the simulation results of the travel demand and traffic modelling are presented and the potential of the scenarios to reduce car-based mobility is discussed.

2.1. Study area

The study area is located in the north-west of the city of Berlin in the district Spandau on a peninsula and consists of a part of existing buildings, mainly single-family houses built in the late 90's/early 2000, and the new development area, which was partly finished in 2019. In the vicinity of 1km there are almost no shops, schools or medical services (see Figure 1). In total 2000 new apartments inhabited by 3400 persons with 1500 cars are expected to populate the new area.

The next subway station (Haselhorst) is 1.8km away. There is one main road (Daumstraße) where three bus lines are operated with a frequency of 10min per line during the main operating hours.

Figure 1: Black line: study area, green: existing buildings, orange: finished buildings in 2019, yellow: buildings finished after 2020, red line: 1km radius

2.2. Scenarios

In this work we examine four scenarios. The first scenario is called “null” and has no further measures except the new population in the study area. This scenario is only used for comparison of the change in public transport demand. The second scenario represents the planed short-term measures, which are performed with minimum time and effort, including an additional bus line and parking cages for private bikes at the buildings and at the closest subway-station. This scenario is called business as usual (BU) and used as the reference for the demand modelling. The third scenario called Future Way (FW) includes all measures from BU and adds an additional bus lane to the street, where applicable. The bike lane to the next subway-station is designed cross-free to speed up the trip by one minute. Additionally, a parking fee of 1€/hour for non- residents is introduced.

Finally, a maximum scenario called Extreme Boost (EB) is examined. In addition to the previous ones a new suburban railway station is introduced. For supporting bike traffic, the existing bike highway net of Berlin is extended from the city-centre to the study area, increasing the travel speed by 2km/h in average due to less stops and good surfaces. The local parking permits are reduced to 0,5 cars per household in average resulting in a reduction of 440 cars. Table 1 gives an overview of the scenarios:

Table 1: Table of measures

Transport means / Scenario	Public transport	Bicycle	Car
Null	No change: two bus lines	No change: regular bike lane	No change
Business as usual (BU)	Additional bus line	Parking cages in study area and in the closest subway station	No change
Future way (FW)	+ Additional bus lane	+ Cross-free bike path to the closest subway station	+ 1 €/h-parking fee for non-residents
Extreme boost (EB)	+ City centre connected through a new urban rail line	+ Fast bike lane	+ Parking permits reduced to 0.5 cars/household

3. SIMULATION FRAMEWORK

3.1. Overall simulation TAPAS/SUMO-COUPLING

The daily mobility of a simulated population is usually modelled by travel demand models. In this case, we used the agent-based travel demand model TAPAS (https://github.com/DLR-VF/TAPAS), (Heinrichs et al., 2018) and the traffic flow simulation software SUMO (https://github.com/eclipse/sumo), (Alvarez Lopez et al., 2018). Both models are described in more detail below.

While TAPAS models the travel demand, meaning the amount of trips to fulfil the daily mobility, SUMO extracts the car and public transport trips from this demand to simulate the routing and the capacity constrained usage of the road- and train-networks resulting in an update for expected travel times. The commuting traffic from outside the modelled region is integrated via external traffic inputs, in this case counts of commuting traffic for public transport and detection loops in the main roads. Finally, the new travel times are fed back into TAPAS and a new iteration of the simulation is started, if there is a significant deviation between the updated travel times and the times from the last iteration. The interaction of the tools can be seen in Figure 2:

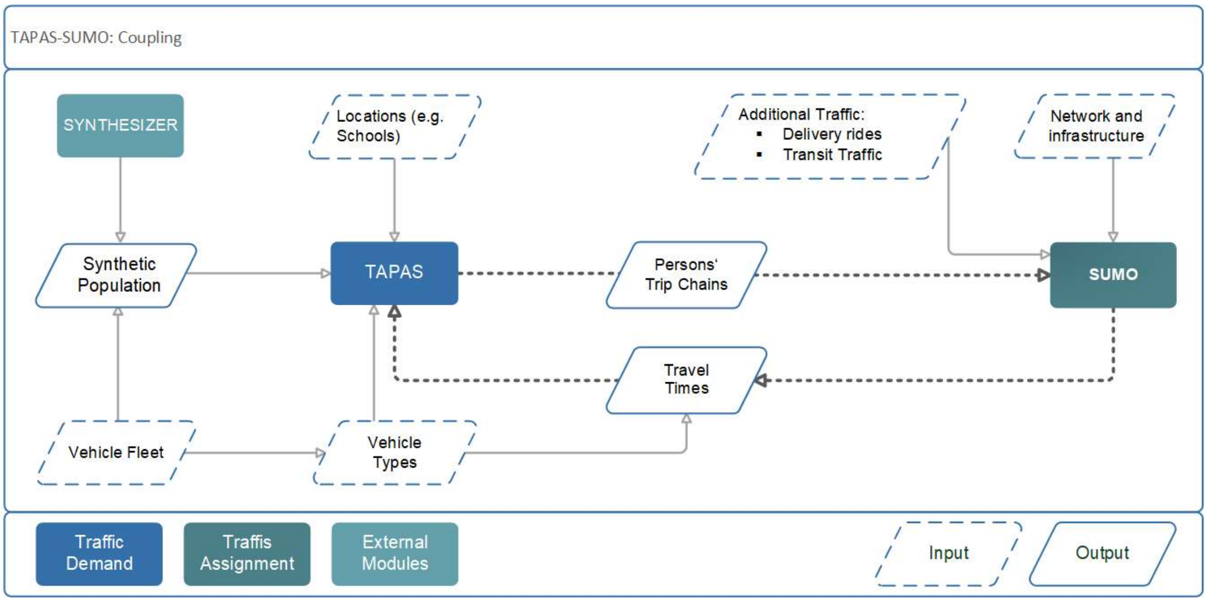

Figure 2: Setup of the different simulation components

3.2. TAPAS

TAPAS simulates the activity patterns for each person in a synthetic population. It searches for matching locations to perform the activities, considering accessibility with respect to the current location via the available modes, and the capacity of the destination. Finally, it selects a mode of transport and performs several feasibility checks. Cars are distributed on a household level and double booking of the same car for the same timeslot is prohibited. The result of TAPAS is a detailed list of location-changes for each scenario consisting of person-id, activity type, start time, end time, start location, end location, mode of transport, duration of activity and in case of a car trip the ID of the used car. The basic program functionality is shown in Figure 3.
In this work, we simulate the whole city of Berlin, Germany, because this way it is possible to consider commuting and capacity constraints due to people living outside the region. Commuting traffic from outside Berlin is included via external traffic od-matrices, which remain static for all runs.

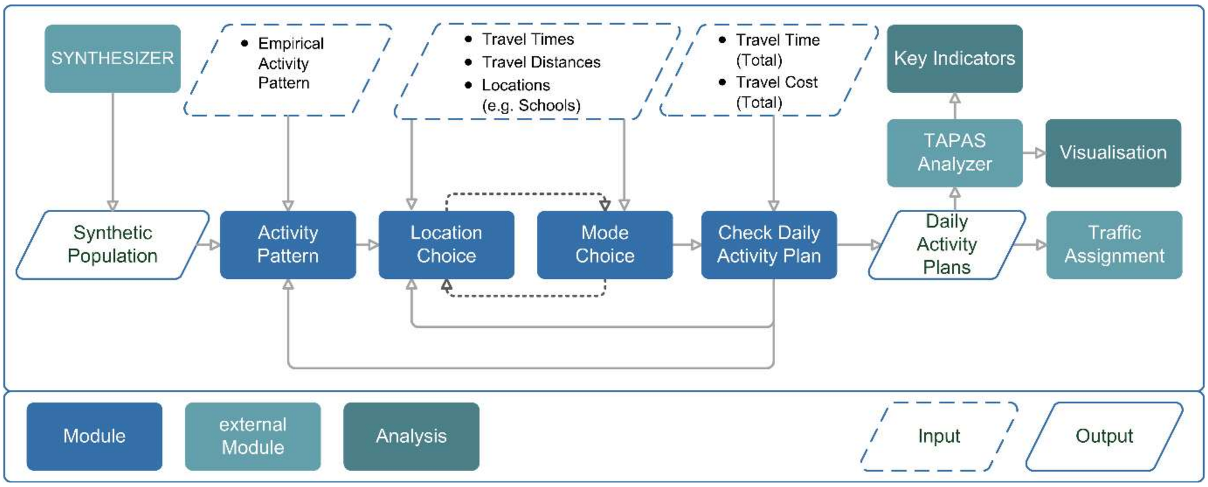

Figure 3: Workflow of the simulation framework TAPAS

A variety of input data is necessary to simulate different scenarios in TAPAS, for example activity locations, a synthetic population or travel time matrices. The tool SYNTHESIZER was used to create a synthetic population for TAPAS. This tool uses socio-economic data from a microdata sample and marginal totals to create a microscopic representation of the population of a given area. On the one hand, a disaggregated microdata sample is available for one percent of the German population and provides information about households and individuals. On the other hand, we use aggregated marginal totals at the neighbourhood-level from the company Nexiga for 2017 (reference year). Mobility-related data, such as the ownership of a driving license, stem from the survey Mobility in Germany. Future scenarios are set for the year 2030. The forecast population is available from the Berlin State Statistical Office at the district-level.

The synthetic populations of the study and the reference area were generated separately based on the survey results. Approximate population and household figures of the study area were extracted from the available information of the construction project. Since the project started before the first residents moved into the study area, we extracted the social structure of the reference area from the survey and extrapolated it to the new neighbourhood. Besides, the car ownership for the study area was set to 0.7 cars per household for the scenarios Null, BU and FW.

3.3. SUMO

SUMO is an open source tool for microscopic, agent-based traffic modelling and simulation that was developed at the Institute of Transportation Systems of the German Aerospace Center. It enables multi-modal mobility simulation and hence includes road vehicles, pedestrians and public transport (see https://www.eclipse.org/sumo/). In this work it was used to generate a model of both the infrastructure and the traffic in the surrounding area of the new neighborhood in Berlin Spandau.

The data for traffic demand, being generated with TAPAS as shown above, is converted to SUMO trips, that are simulated on the network. To represent commuter and background traffic, the trip requests are initially created for the whole Berlin region. They contain start and end points, starting time and mode of transport. Because the

microscopic simulation of all trips of the whole Berlin region would not be feasible, a simulation area was defined that includes the greater Spandau area and cut out of both the infrastructure and the trip requests. In the simulation itself all trips are represented by “agents” (cars, trucks, pedestrians, trains, busses), that moves along the streets, following their desired route and interacting with one another and with infrastructure elements such as traffic lights or pedestrian crossings. For public transport, the trips can contain numerous vehicles as well as ways on foot.
The traffic related infrastructure was imported from Open Street Map and leads to a corresponding faithfulness to reality and detail level. To ensure meaningful results of the simulations nonetheless, the research is done by comparing different scenarios that are based on the same infrastructure data. The only supplements to the infrastructure for the analyzed traffic measures are described in the section 2.2.
SUMO provides a variety of output possibilities. In order to evaluate passenger volumes and routes across the public transport network, a combined approach is taken: SUMO *tripinfo-output* contains information on the actual trip of a simulation agent (which can, at times, deviate from the planned trip e.g. due to missed connections). Details on taken public transport vehicles such as busses were extracted and combined with SUMO *stop-output* functionality, which counts passengers both entering and leaving a public transport vehicle per stop. As a result, passenger volumes between two stops aggregated over all vehicles within all means of transport can be extracted and visualized in order to analyze effects of the different described scenarios on passenger volumes in public transport.

4. RESULTS

4.1. Demand modelling

The results of the demand modelling software are given in Figure 4 and Figure 5. For the mode-share the total mode-share of the city of Berlin is given in the first row as comparison. One sees, that the BU and FW scenarios show a high share of car trips and a very low share of bike trips. The other modes are almost the same compared to the shares of Berlin. The EB scenario shows strong modal shift from car and co-driving to public transport, while bike usage still remains at a low level. The number of car trips is reduced from 30% in the BU scenario to 17% in the EB scenario, resulting in a relative reduction of 43% of all car trips.
The main reason for the low bike share can be found in Figure 5: The average trip length for bike trips is about one kilometre longer compared to the city average (blue values in Figure 5). Except for walking this can be observed for the other modes as well, indicating that the study area as a reduced accessibility to shops, schools and work-locations. This can also be seen by the high trip durations. Next, we look at the traffic simulation of public transport to see the net-effects of the change of the demand.

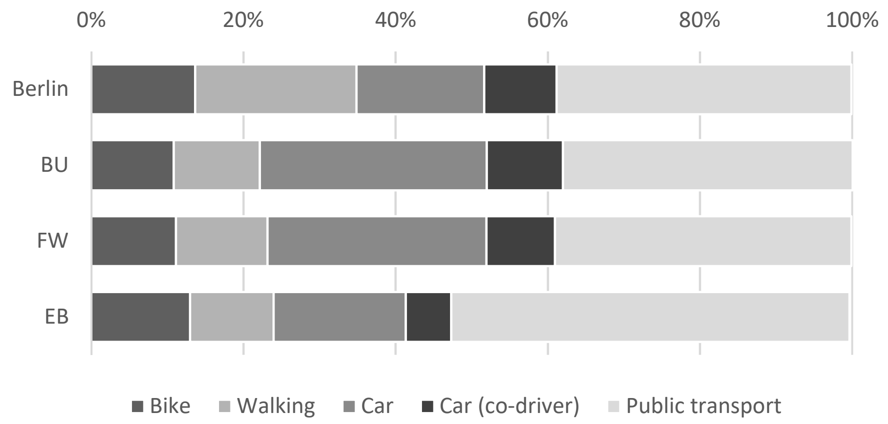

Figure 4: Mode-share of different scenarios

Transport means	Average trip length in km BU	FW	EB	Average trip duration in minutes BU	FW	EB
Bike	6.8 | *5.7*	6.7 | *5.7*	6.5 | *5.9*	37.7 | *32.1*	37.3 | *32.1*	34.5 | *31.7*
Walking	2.3 | *1.8*	2.3 | *1.9*	2.3 | *1.9*	31.6 | *27.2*	31.9 | *27.2*	32.2 | *28.3*
Car	10.3 | *9.2*	10.6 | *9.2*	10.5 | *9.2*	33.7 | *31.2*	34.2 | *31.2*	34.1 | *31.1*
Car (Co-driver)	11.1 | *9.9*	11.1 | *9.9*	11.2 | *9.7*	34.9 | *32.6*	35.3 | *32.6*	35.6 | *32.2*
Public transport	14 | *12.7*	13.8 | *12.7*	13.5 | *12.5*	59.2 | *54.1*	57.8 | *54.1*	55.4 | *53.3*

Figure 5: Average trip length and durations of the different scenarios (black) and for the rest of the city of Berlin (blue)

4.2. Traffic simulation

Aggregated simulation output as described in section 3.3. is mapped on georeferenced station data including path shapes of public transportation routes. Figure 6 depicts the resulting network passenger volumes in Berlin-Spandau, Germany for the reference scenario *Null.*

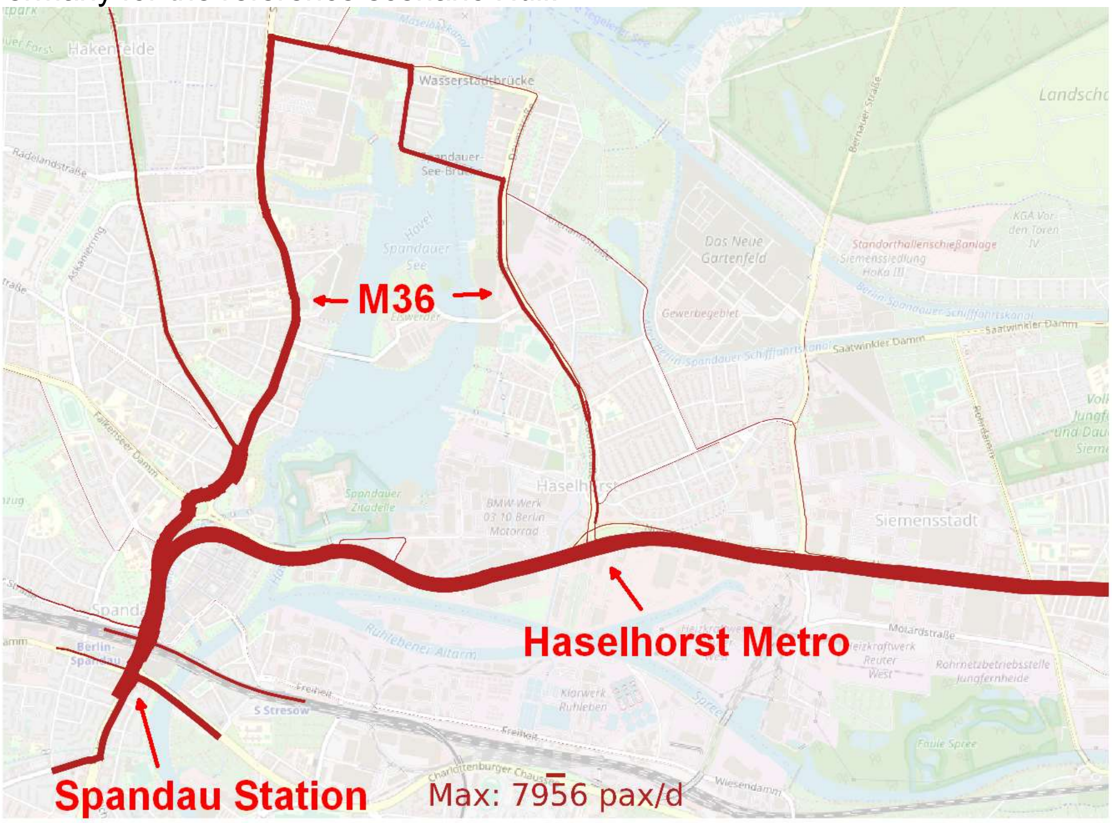

Figure 6: Public transport passenger volumes scenario Null

The red lines indicate public transport passenger flows scaled by their thickness. The thick horizontal line clearly represents the metro line U7 going from Spandau main station (located in the bottom left corner) towards Berlin downtown. Other lines mainly represent bus lines, functioning as connecting vehicles to rail mass rapid transport. Hereby the line M36 is of special importance for the new residential area, going north from Spandau station, then turning right to cross the river Havel and afterwards turning south again to end at Haselhorst Metro station, located in the very center of the figure.

In order to understand the effects that the scenarios as shown in Table 1 have on passenger volumes in the SUMO simulation model, differences in passenger volumes are calculated for these three scenarios:

The BU scenario “business as usual” only has slight changes in public transport, specifically reducing the interval of the bus line M36 by half (from every 10 to every 5 minutes). It effects in only small shifts in passenger volumes, e. g. a rise of approximately 200-300 passengers/day for metro line U7. Moreover, passenger volumes for the M36 bus slightly decrease on the west side of river Havel but marginally rise on the east side. This can possibly be explained by the better connection to the metro via Haselhorst station coming from the north, avoiding the longer and more congested route via Spandau station.

Scenario FW shows only slight changes in passenger volumes as well: The additional bus line affects only slightly higher passenger volumes for bus line M36, comparable to the described changes in the BU scenario. While the additional bus line can avoid traffic congestions it is still prone to implications from traffic lights.

In contrast to the two scenarios FW and BU, the EB scenario results in considerable additional passenger volumes for public transport: while building a completely new metro line does mean large investment and long construction time, it does also result in substantial rises in passenger volumes, as shown in Figure 7: it clearly shows the additional passenger volumes for the newly built metro line in comparison to Figure 6 above. Note, that the volume of the bus M36 has not declined, meaning, that all traffic on the new subway line is indeed from the modal shift towards public transport.

Figure 7: Public transport passenger volumes scenario EB

5. CONCLUSION

In this work we presented the simulated results of several mobility measures for a newly built residential area. We showed that short term measures cannot compensate the difficult geographical layout of the study area. On average the trips are substantially longer compared to the city average. Promoting bike trips is not enough because of the limited range of bikes. Public transport has many advantages for long trips into the city centre because of no traffic jams and no searching for parking lots. Therefore, the last scenario including a new suburban train shows the biggest change in modal shift. Looking at the passenger counts on the multiple bus and train lines we see similar effects. To summarize, it can be stated that extensive measures such as building new metro infrastructure are needed to achieve noticeable and effective change in public transport passenger volumes: Connecting the bike lanes to a city-wide network and extending the high-performance public transport enables the people in the study area to perform their daily mobility by public-transport without reducing bike trips and reducing car based mobility by more than 40%.

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