D-BAUG Lighthouse Project: E-Bike City
Project Update

E-Bike City Team

08.06.2023
E-Bike City Kolloqium
ETH Zürich, Switzerland

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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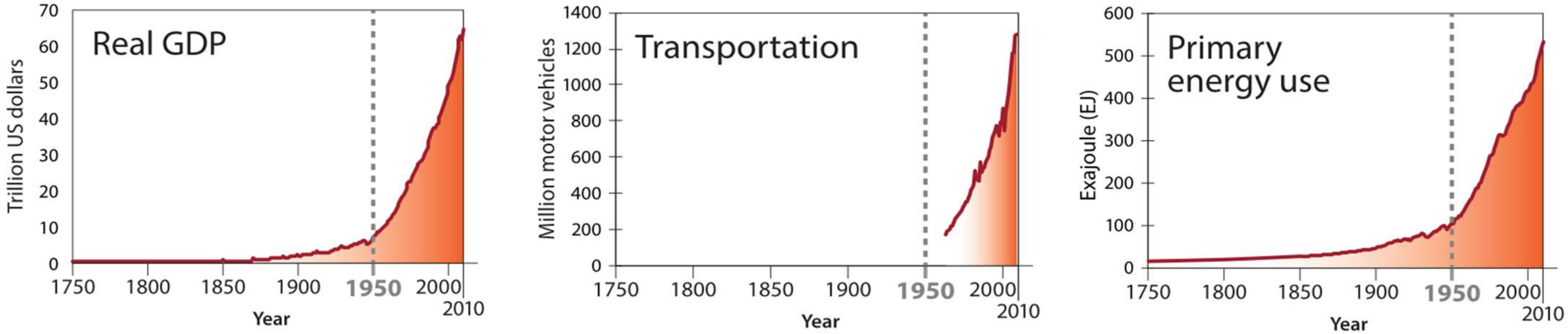
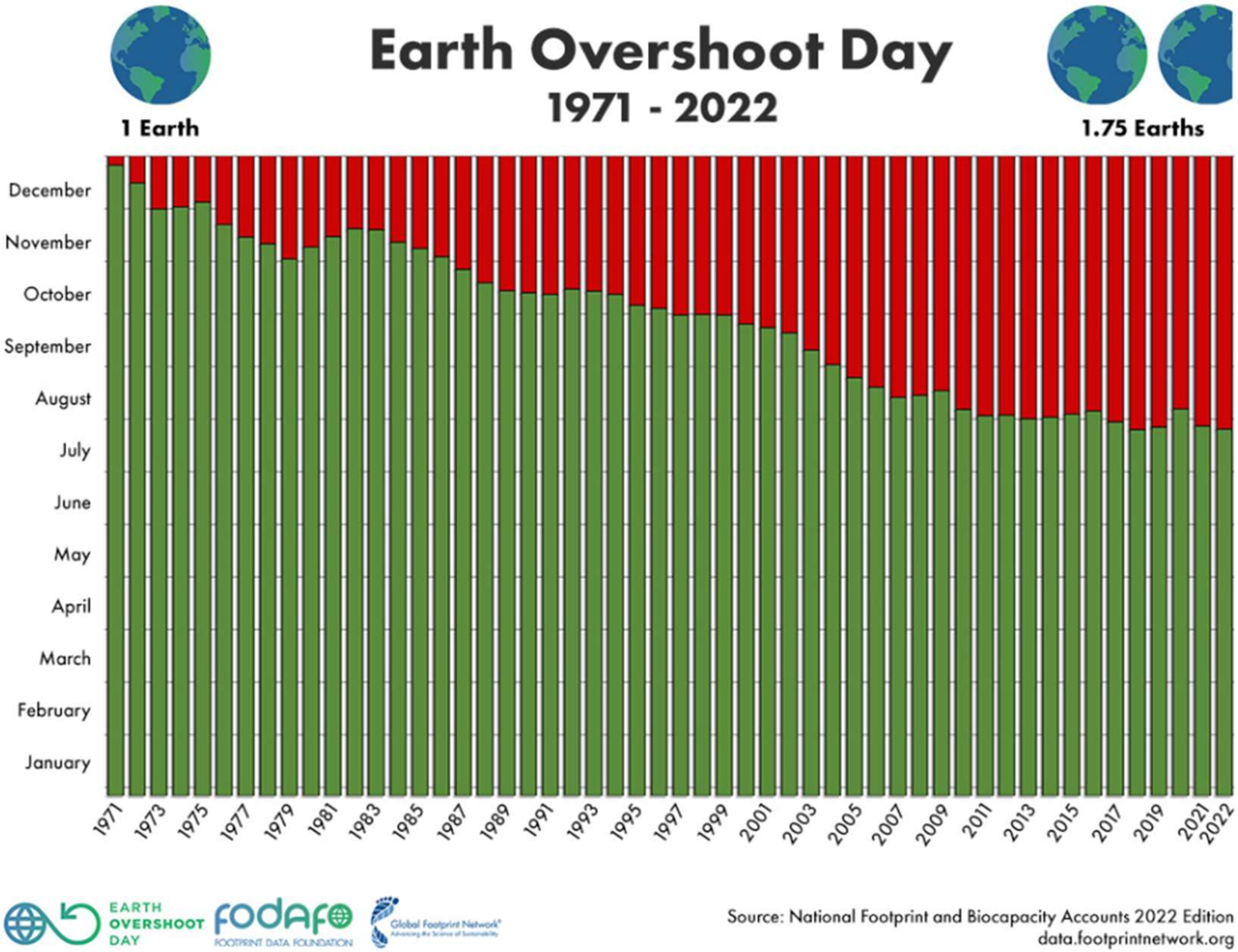
Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

So far: Economic growth ~ growing resource extraction



Steffen, W., et al (2015)



Earth Overshoot Day
1971 - 2022
1 Earth
1.75 Earths
December
November
October
September
August
July
June
May
April
March
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January
1971
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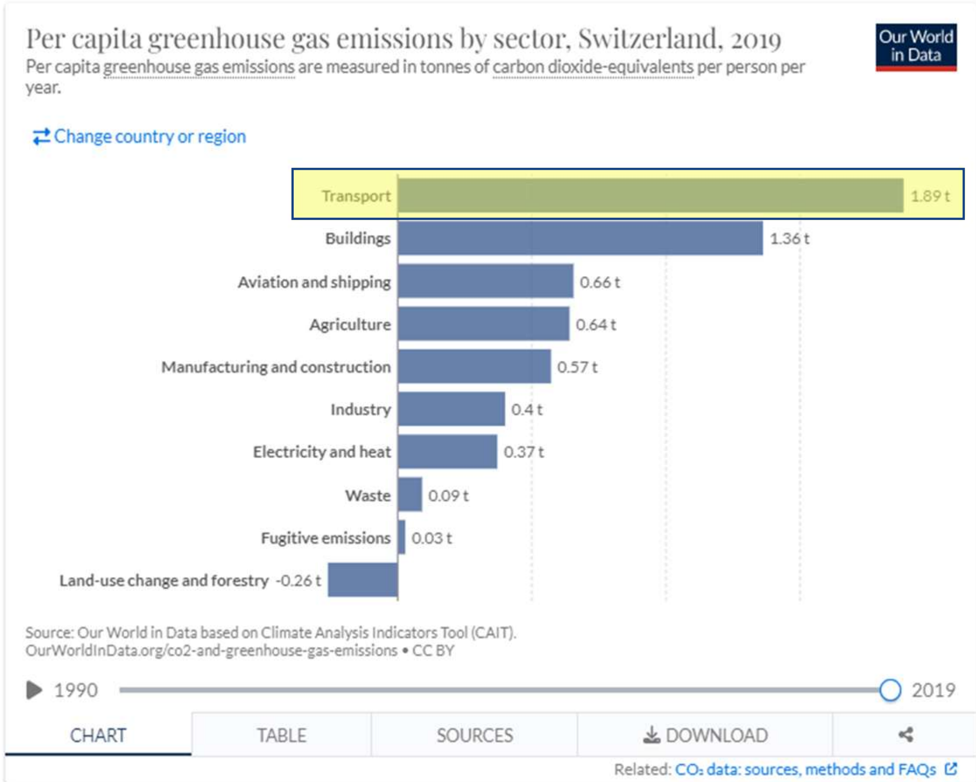
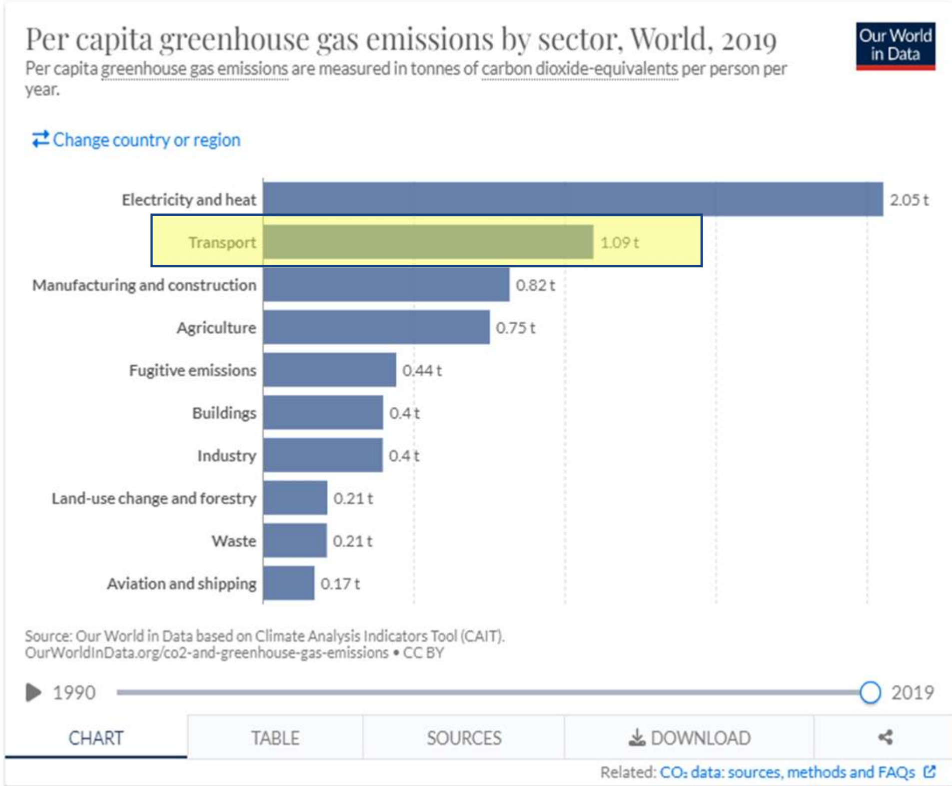
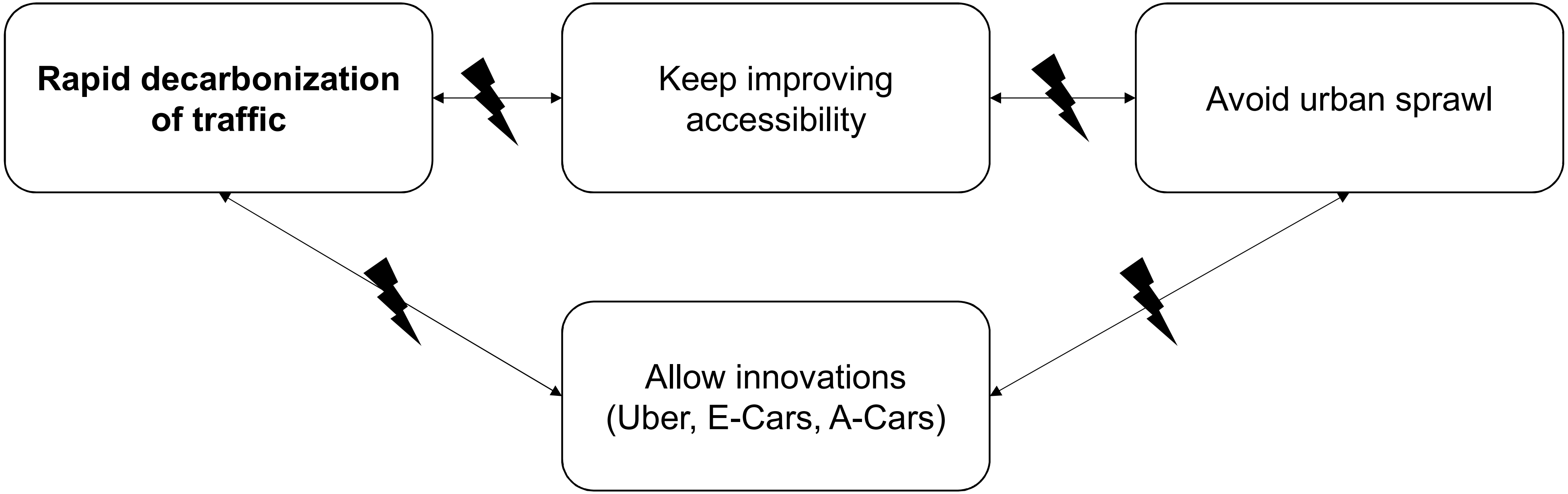
2021
2022
EARTH OVERSHOOT DAY
fodafo
FOOTPRINT DATA FOUNDATION
Global Footprint Network
Source: National Footprint and Biocapacity Accounts 2022 Edition
data.footprintnetwork.org

Transport is the #1 GHG Emitter in Switzerland, #2 Worldwide





The dilemma of transport policy

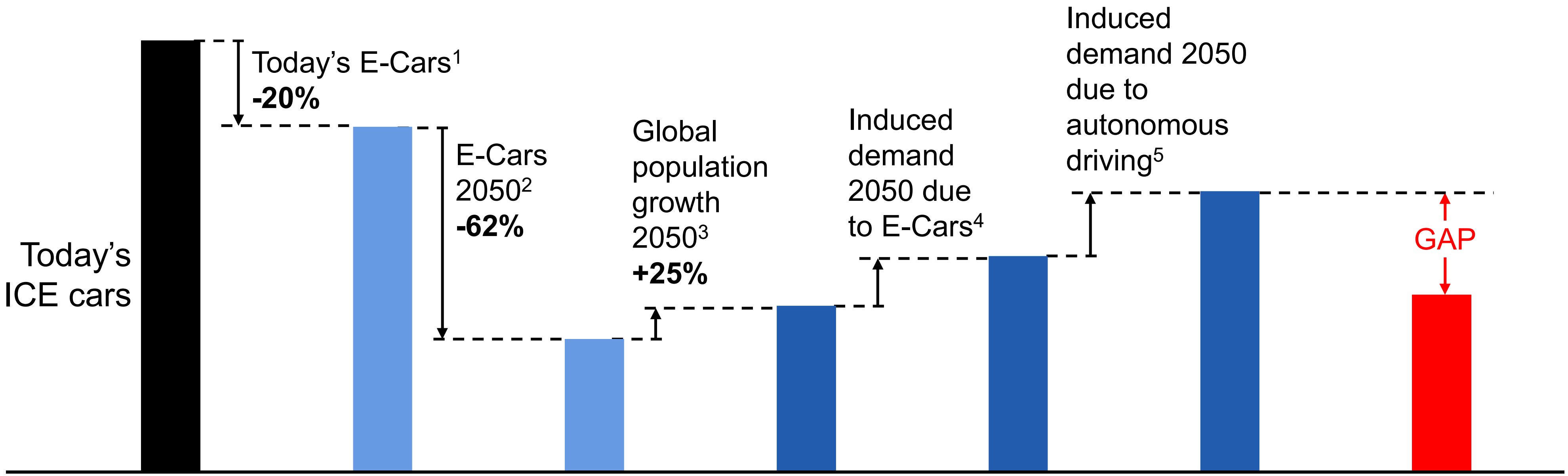


Axhausen, K.W. (2020)

Loo, B.P.Y. and Axhausen (2022)

Alcott, B. (2005)

Decarbonization: The problem of electric and autonomous cars



Note: These are ***optimistic*** estimates of how many CO_2 emissions can be avoided through technology.

[1] ITF (2020)
[2] Cox, B., C.L. Mutel, C. Bauer, A. Mendoza Beltran and D.P. van Vuuren (2018);
[3] UN (2019)
[4] Assumption due to growing wealth, better infrastructure and lower cost of batteries for future E-Cars: Schmidt, O., A. Hawkes, A. Gambhir and I. Staffell (2017)
[5] Assumption based on Bösch, P.M., F. Ciari and K.W. Axhausen (2018)
[6] IPCC (2022)

Other incremental approaches don’t scale

Carpooling

- Low acceptance among users with choice[1]

Road Pricing

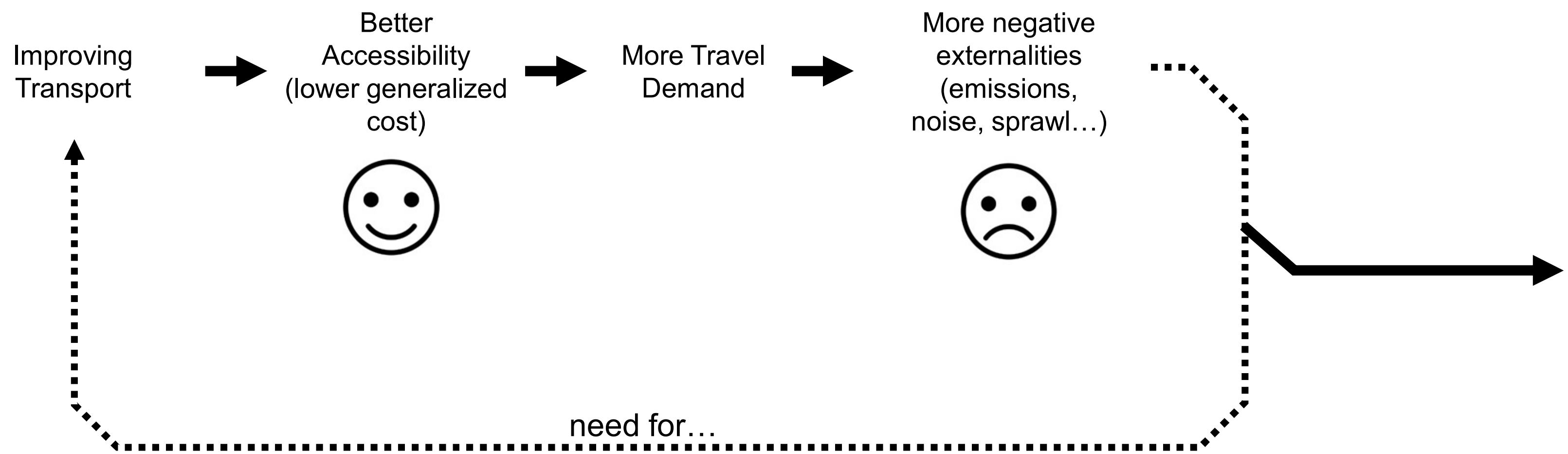
- Low democratic acceptance[2]

Public Transport

- Long planning horizons
- Not feasible for all people[3]

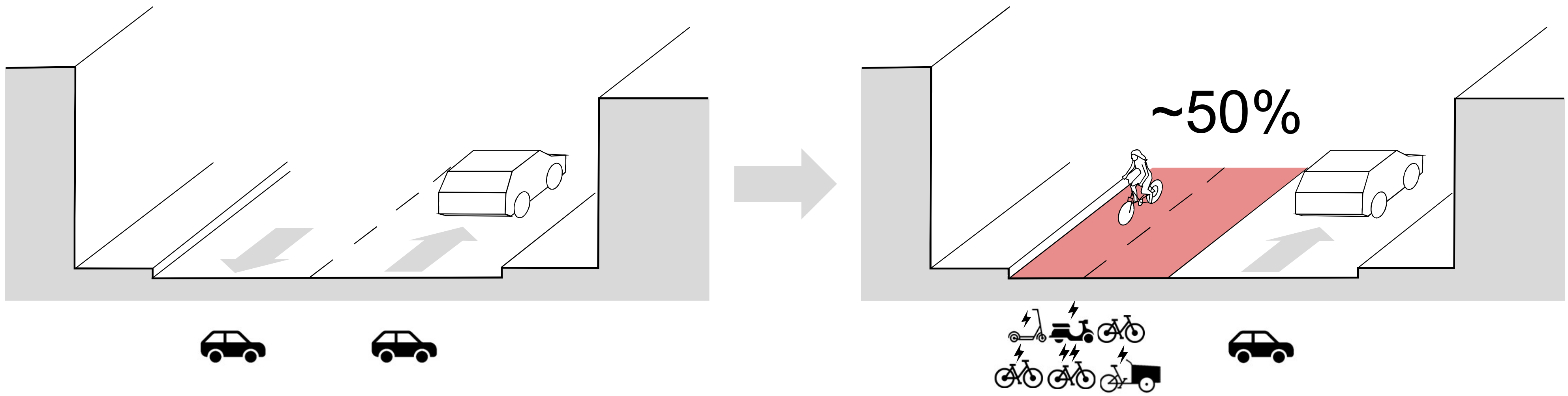
[1] Shaheen, S. (2018)
[2] Lichtin, F., E.K. Smith, K.W. Axhausen and T. Bernauer (2022)
[3] Turner, J. and M. Grieco (2000)

A cycling revolution as a way out?



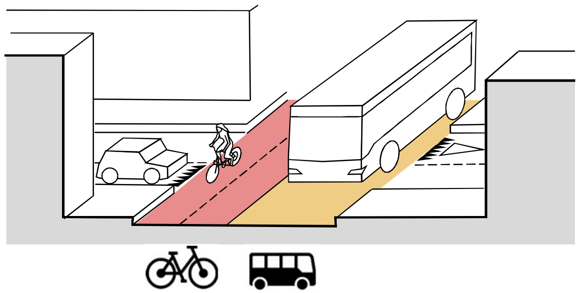
The E-Bike City: Core Idea

Devote ~50% of road space to micromobility e.g. bicycles, e-bikes, cargo-bikes, e-scooters, etc.

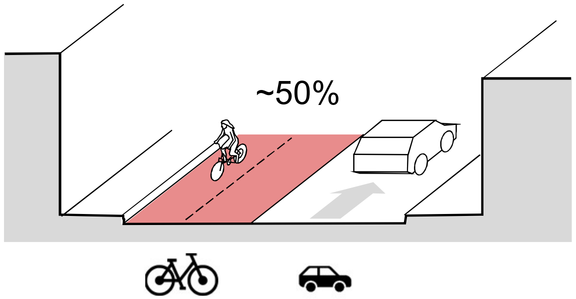


Ballo, Meyer de Freitas, Meister, Axhausen (2022)

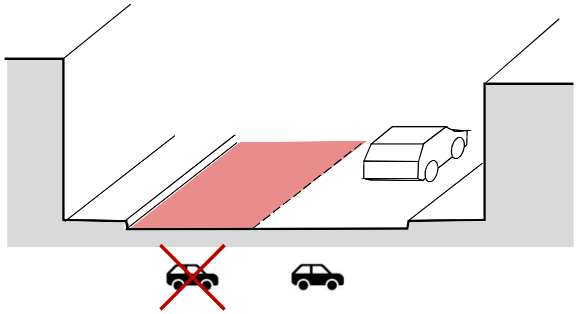
E-Bike City: Basic principles



Absolute priority for cycling and public transport on intersections



Safe cycling infrastructure equally distributed across the e-bike city



Reducing the attractiveness of driving

ETH zürich

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1. Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig (2015) The trajectory of the Anthropocene: The Great Acceleration, *The Anthropocene Review*, **2** (1) 81–98.
2. Axhausen, K.W. (2020) COVID-19 and the dilemma of transport policymaking, disP - The Planning Review, 56 (4) 82–87.
3. Loo, B.P.Y. and K.W. Axhausen (2022) Getting out of energy-intensive and “dirty” transport for sustainable societies, The Innovation, 3 (6) 100339.
4. Alcott, B. (2005) Jevons’ paradox, Ecological Economics, 54 (1) 9–21.
5. ITF (2020) Good to go? Assessing the environmental performance of new mobility, International Transport Forum, Corporate Partnership Board, Paris.
6. Cox, B., C.L. Mutel, C. Bauer, A. Mendoza Beltran and D.P. van Vuuren (2018) Uncertain environmental footprint of current and future battery electric vehicles, *Environmental Science & Technology*, **52** (8) 4989–4995. – middle of the expected range
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8. Assumption due to growing wealth, better infrastructure and lower cost of batteries for future E-Cars: Schmidt, O., A. Hawkes, A. Gambhir and I. Staffell (2017) The future cost of electrical energy storage based on experience rates, *Nature Energy*, **2** (8) 17110.
9. Assumption based on Bösch, P.M., F. Ciari and K.W. Axhausen (2018) Transport policy optimization with autonomous vehicles, *Transportation Research Record: Journal of the Transportation Research Board*, **2672** (8) 698–707.
10. IPCC (2022) Climate change 2022, mitigation of climate change, summary for policymakers, Intergovernmental Panel on Climate Change, Geneva.
11. Shaheen, S. (2018) Shared mobility: The potential of ridehailing and pooling, in Sperling, D. (ed.) Three Revolutions, 55–76, Island Press, Washington DC.
12. Lichtin, F., E.K. Smith, K.W. Axhausen and T. Bernauer (2022) Road pricing policy preferences in Switzerland, paper presented at the *22nd Swiss Transport Research Conference*, Ascona, May 2022.
13. Turner, J. and M. Grieco (2000) Gender and time poverty: The neglected social policy implications of gendered time, transport and travel, *Time & Society*, **9** (1) 129–136.
14. Ballo, L., L. Meyer de Freitas, A. Meister and K.W. Axhausen (2022) The E-Bike City as a radical shift toward zero-emission transport: Sustainable? Equitable? Desirable? [Manuscript submitted for publication], ETH Zürich, Zürich.

Subproject B: Multi-scale responsive public transport planning for bi-modal demand

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Silvano Fuchs, Francesco Corman
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Schweizerische Eidgenossenschaft
Confédération suisse
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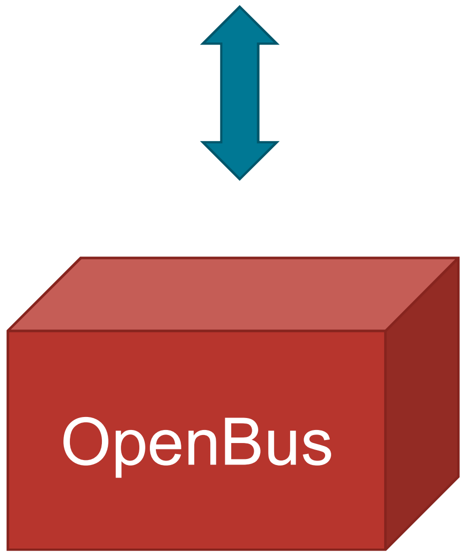
Goal

How does the ***public transit system*** need to look, to support a ***major shift to cycling/e-biking***, considering that cycling is not appropriate for all situations/***weather conditions***?

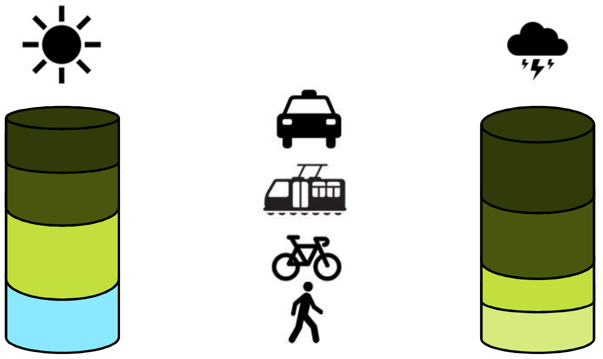
Developing a tool to adjust transit system during unexpected capacity situations



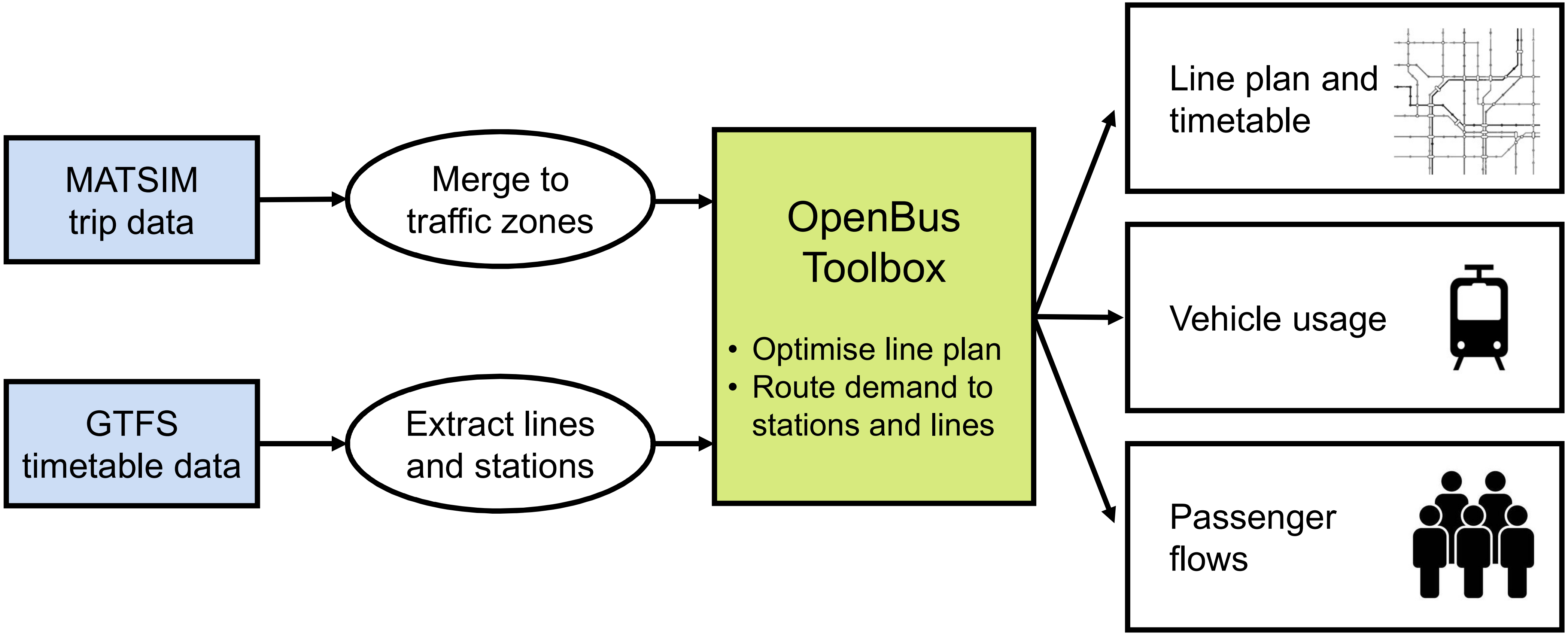
Study weather effects on transport demand

How much rain, temperature, seasons, etc… affect bike usage? How much other modes?

What is the mode shift in adverse weather conditions?

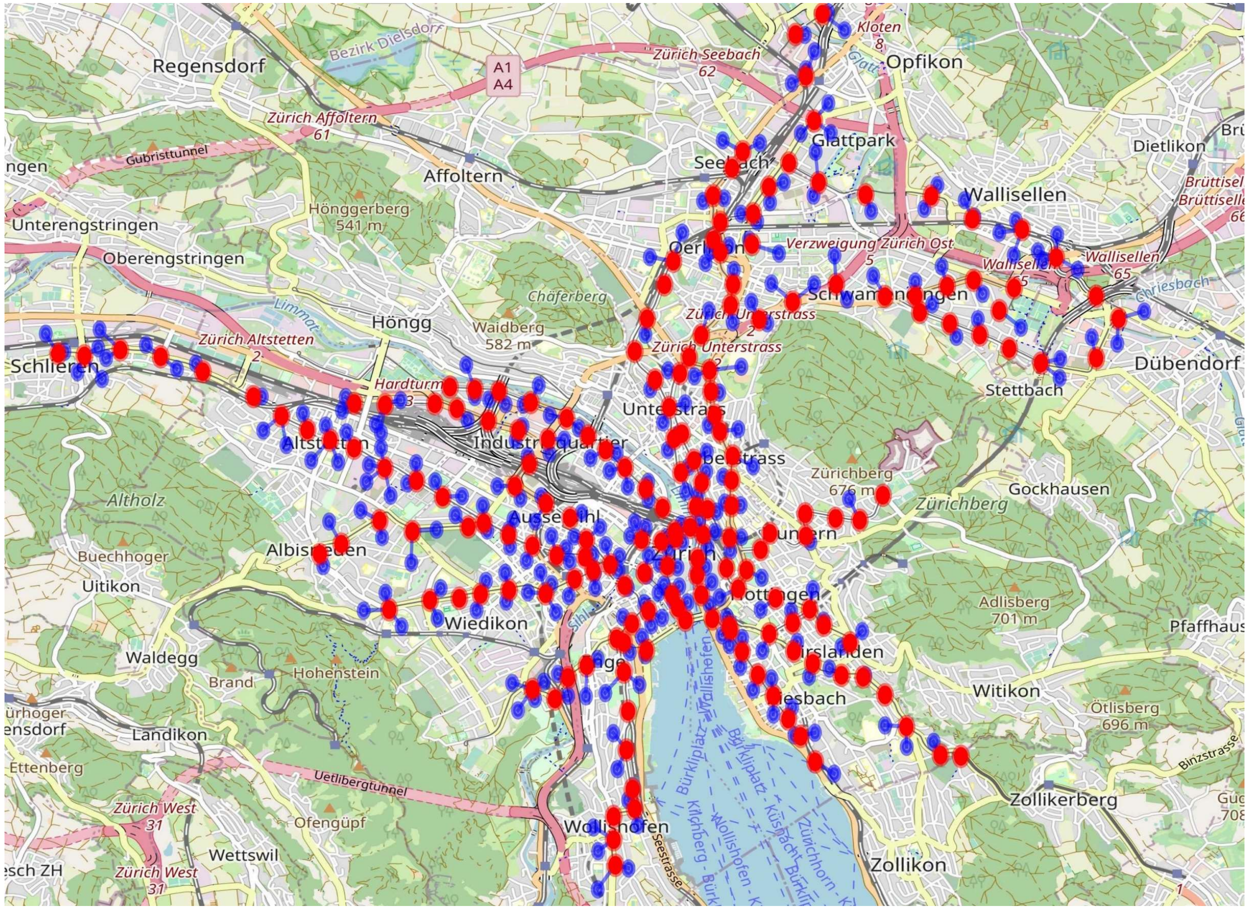


OpenBus for Zürich - Workflow



Source: RF123

OpenBus for Zuerich – Served stops and demand

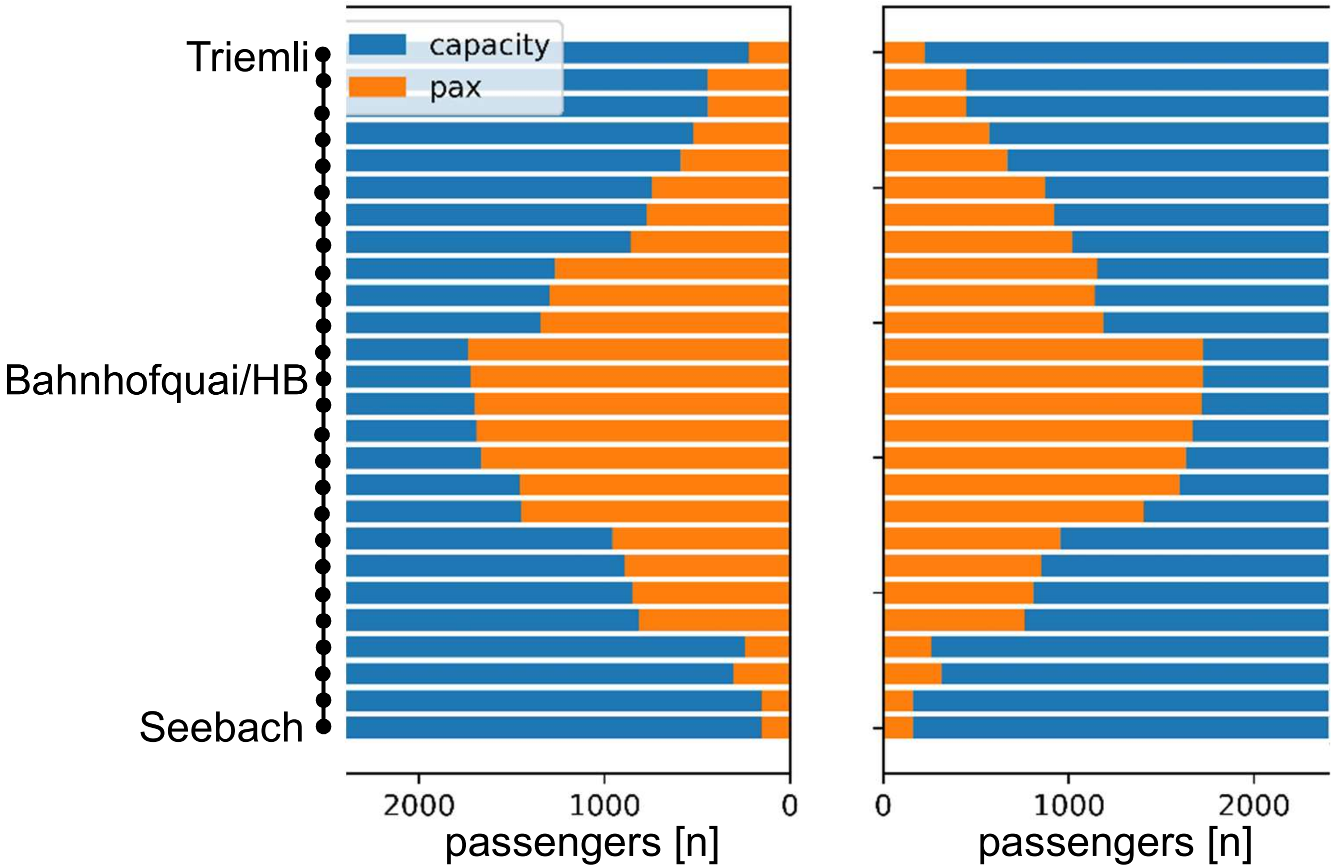


Served demand

Served stops

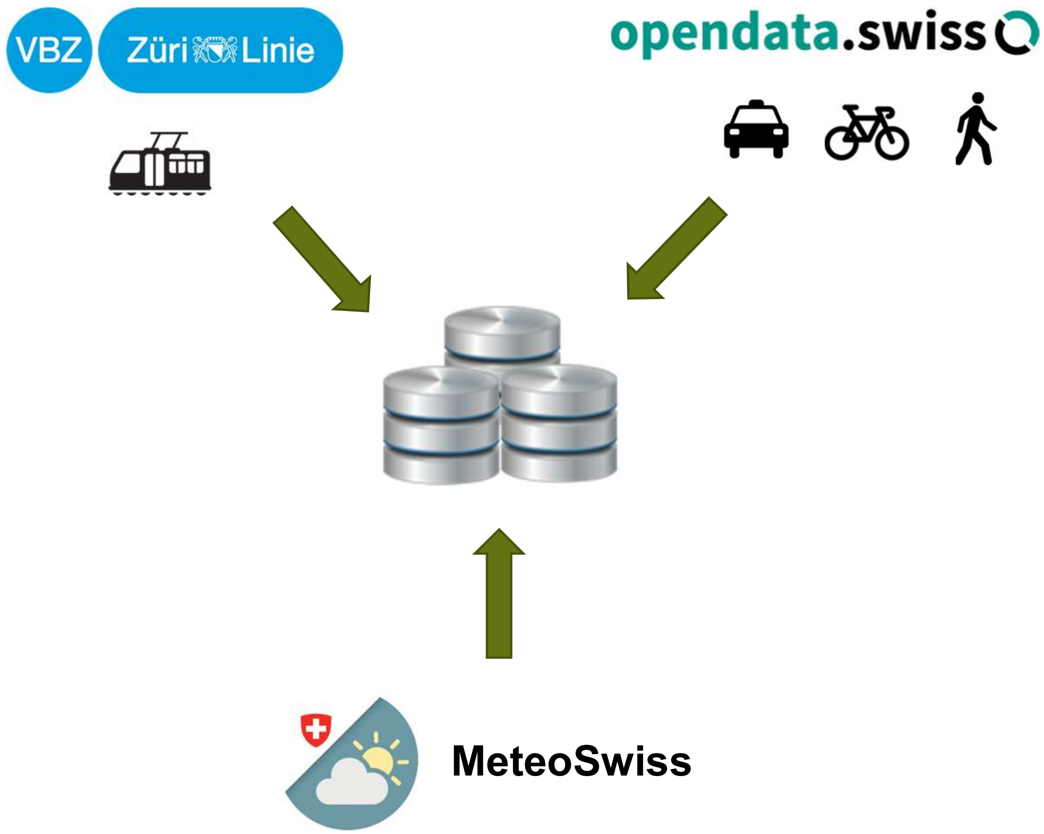
Source: OpenStreetMaps

OpenBus for Zuerich – Average Vehicle Load



Source: VBZ

Weather effects – Methods



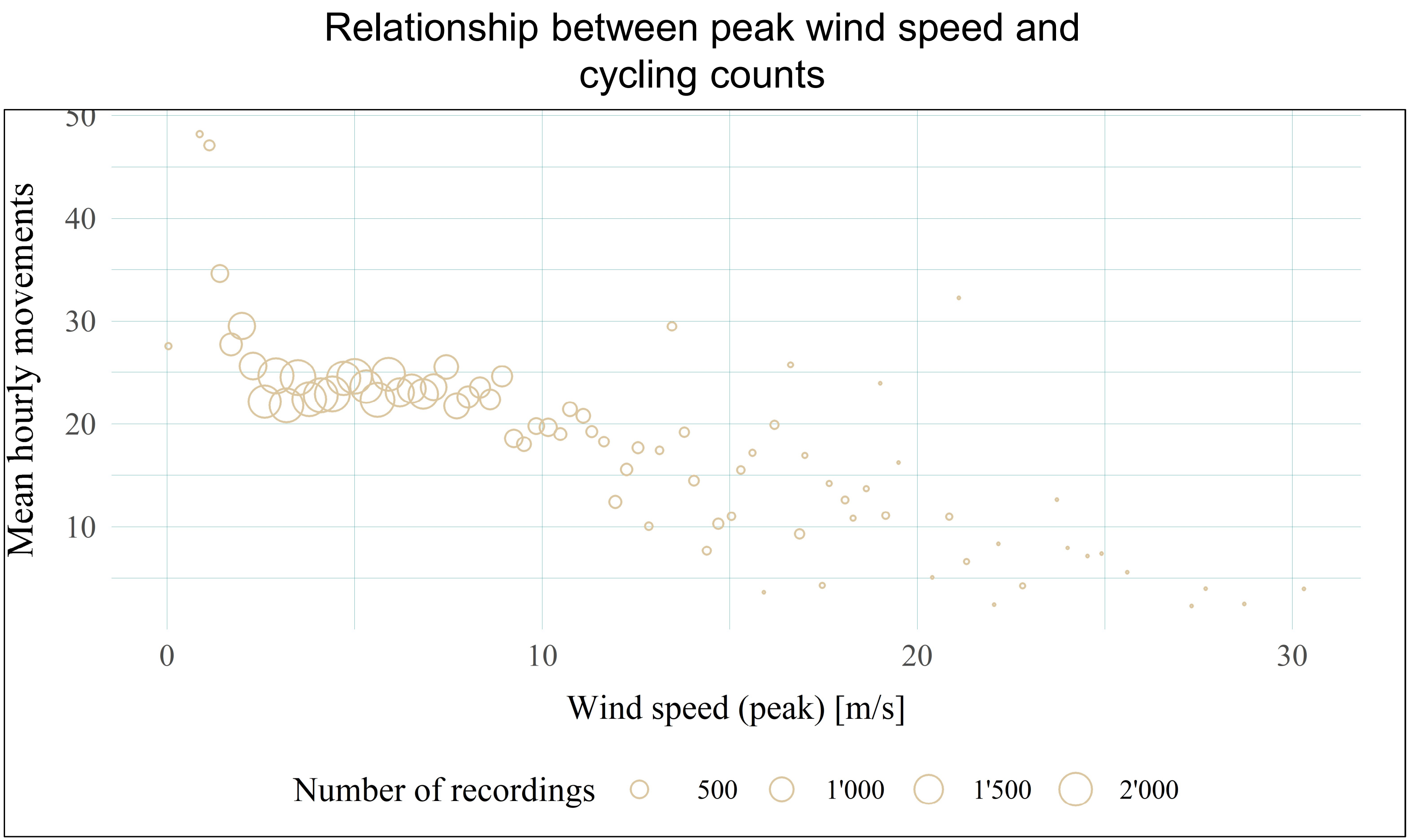
Prediction Models

- Past Travel Demand
- Weather

Machine Learning

- Future Travel Demand
- Mode shift

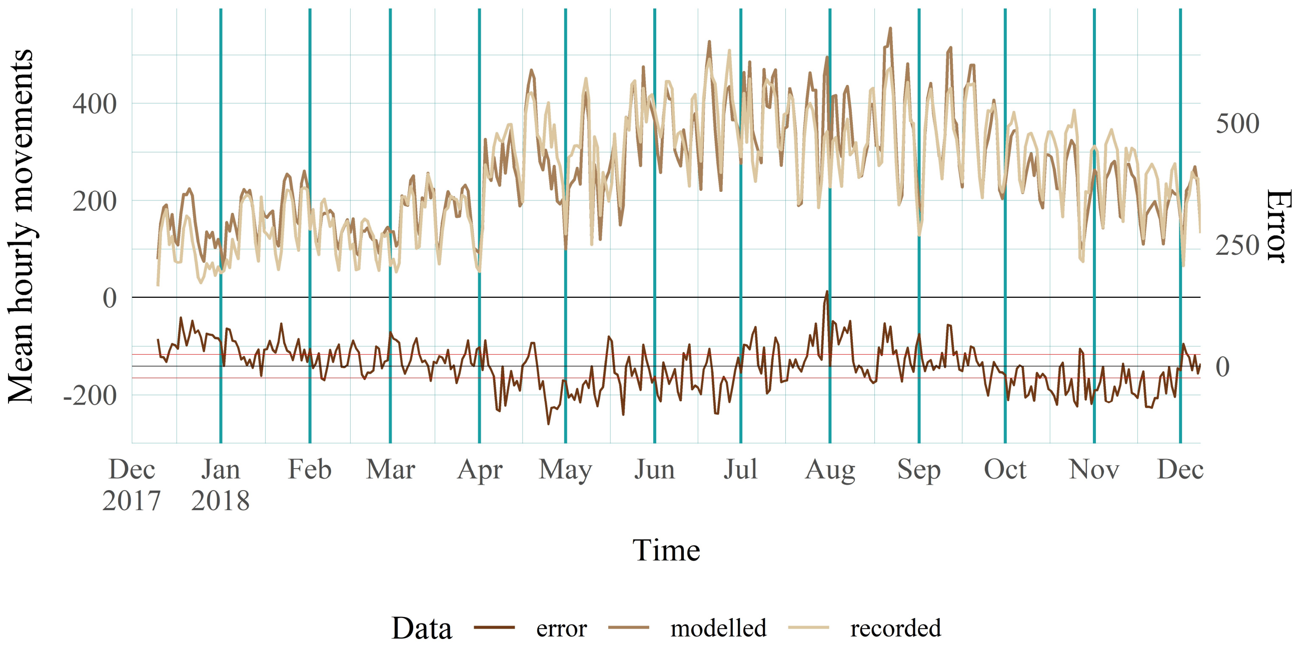
Weather effects – Preliminary results



Weather effects – Mode shift

Weather variables

Precipitation, temperature, humidity, sunshine, wind speed, pressure



Current Mode share*

	25%	24%
	41%	**46%**
	8%	**5%**
	26%	25%

Higher bike usage*

	5%	6%
	45%	**55%**
	30%	**18%**
	20%	21%

Expected results

Future plans

- Scale-up and optimize the prototype based on OpenBus
- Improve data collection, cleaning and analysis
- Testing different prediction models for demand variation from weather

Feedback

- How to manage variable demand? Is OpenBus a valid choice?
- Which external factors to consider primarily for demand variation? E.g. weather, weekday, season, holiday, …

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References

RF123:
https://de.123rf.com/photo_154640727_people-vector-icon-person-symbol-work-group-team-persons-crowd-vector-illustration-icon-group-of.html
https://de.123rf.com/photo_24359005_fictive-network-map-for-urban-public-transport.html
Openstreetmaps
https://www.openstreetmap.org
VBZ:
https://www.stadt-zuerich.ch/vbz/de/index/fahrplan/haltestellen_linien.html

Subproject C: Designing the new network and its capacity

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08.06.2023

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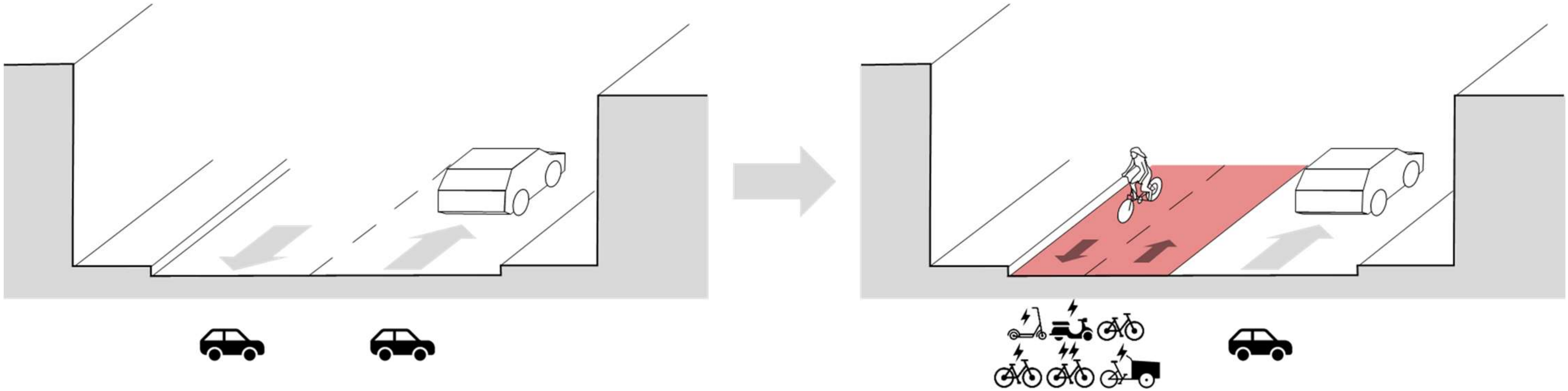
Designing the E-Bike City

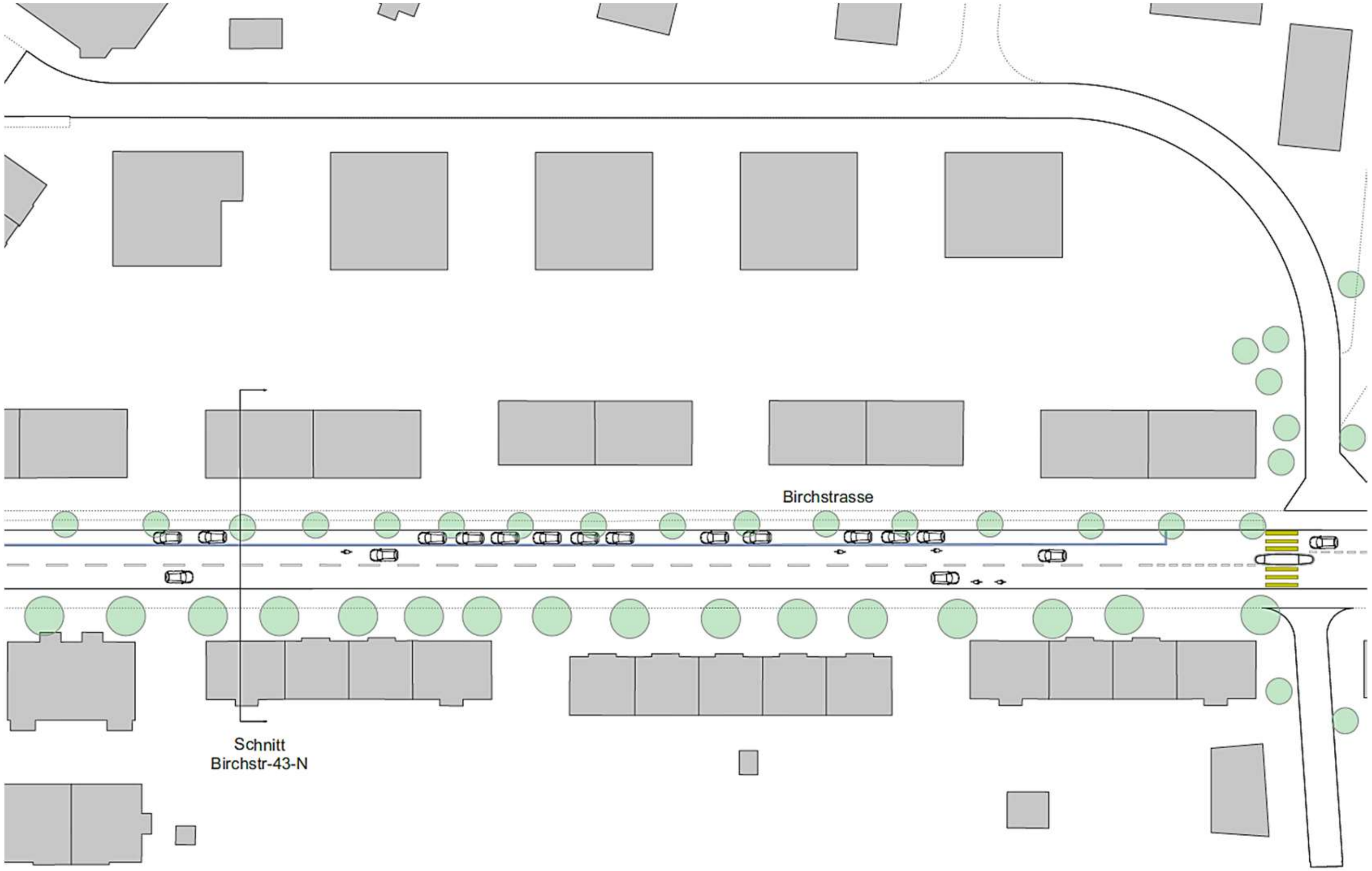


1. 50% of road space for cycling
2. Making the policy direction tangible
3. Visualizations and design manuals

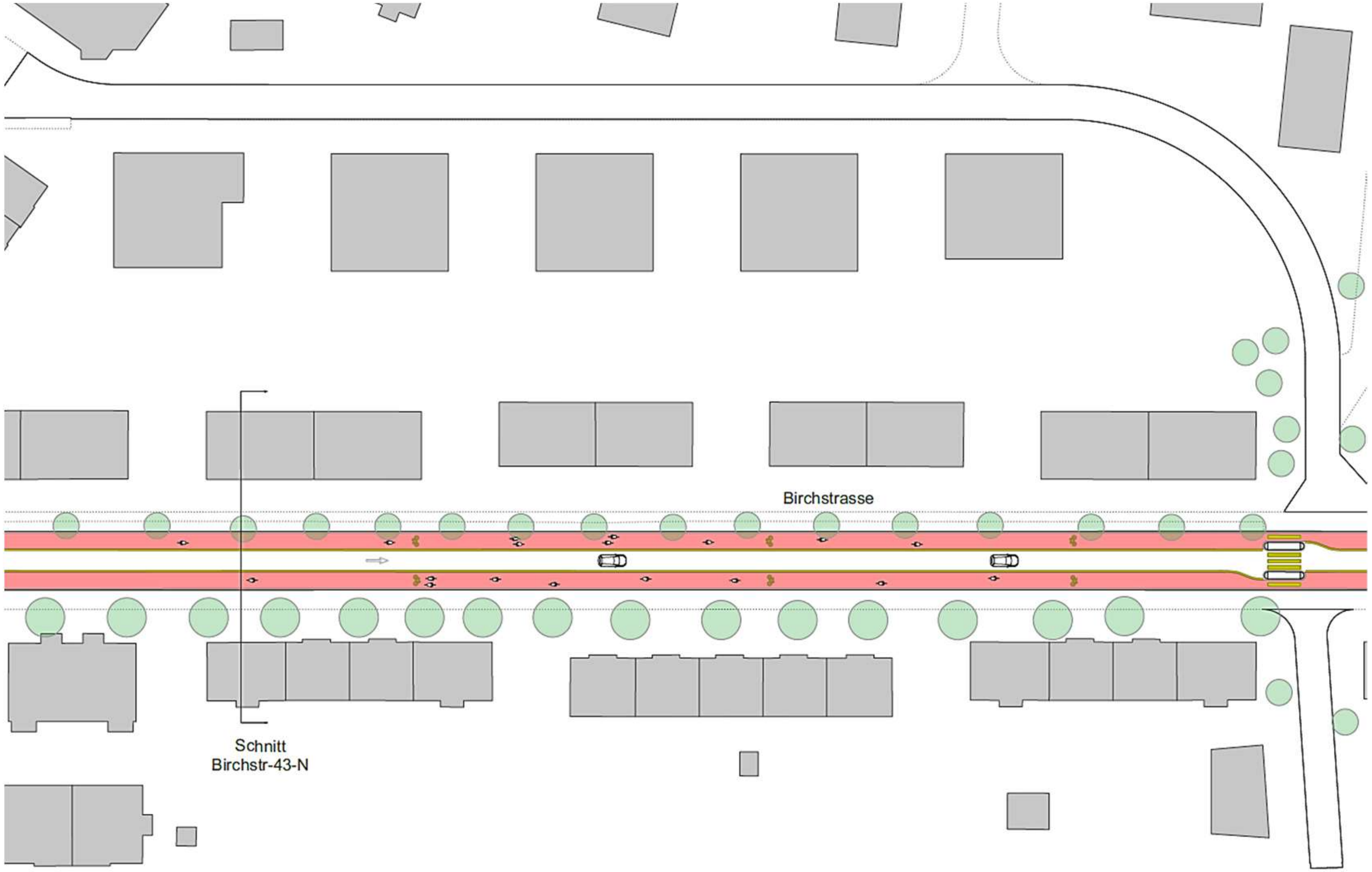
Example Birchstrasse, Zurich

Example Birchstrasse, Zurich

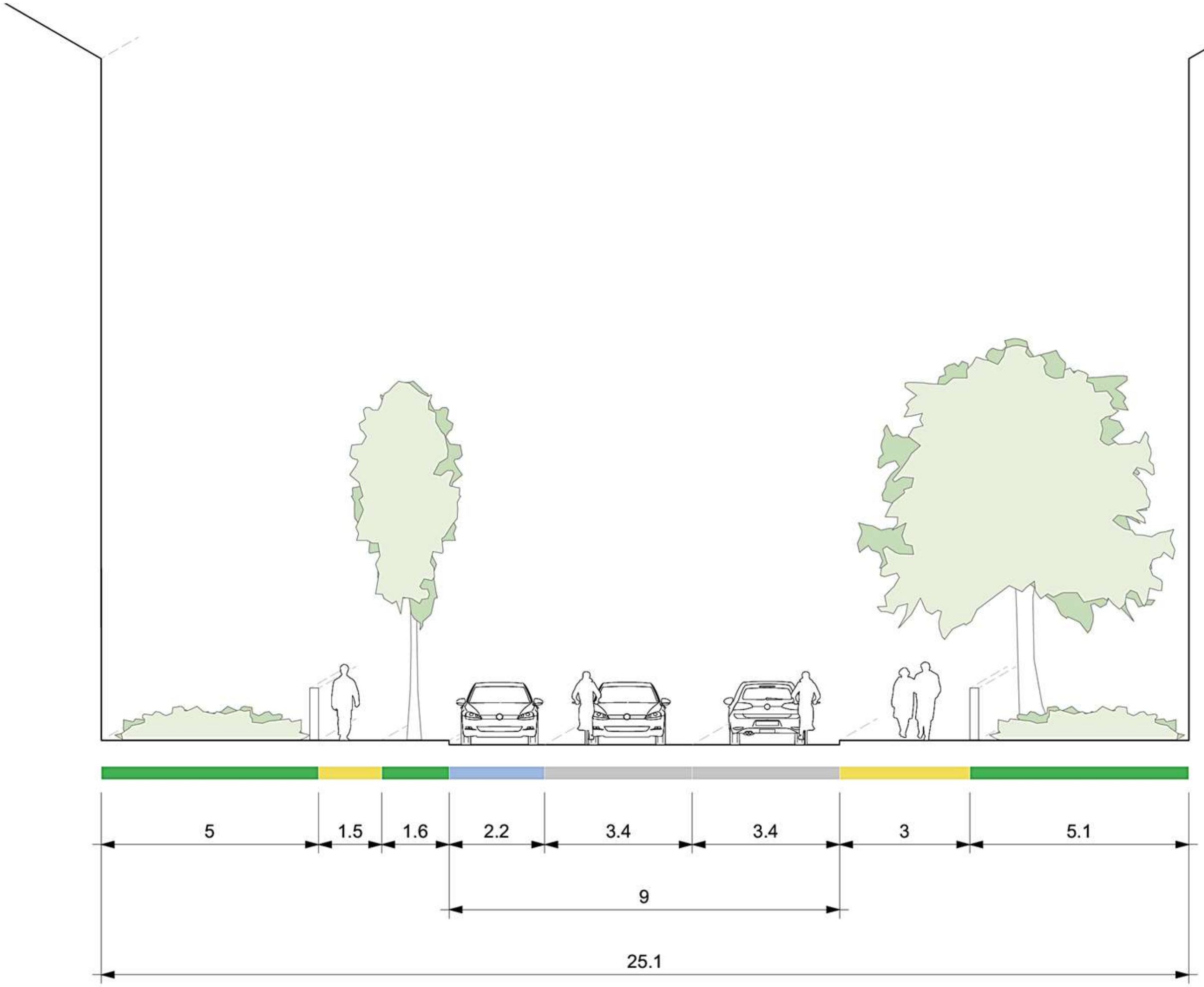
Drafting



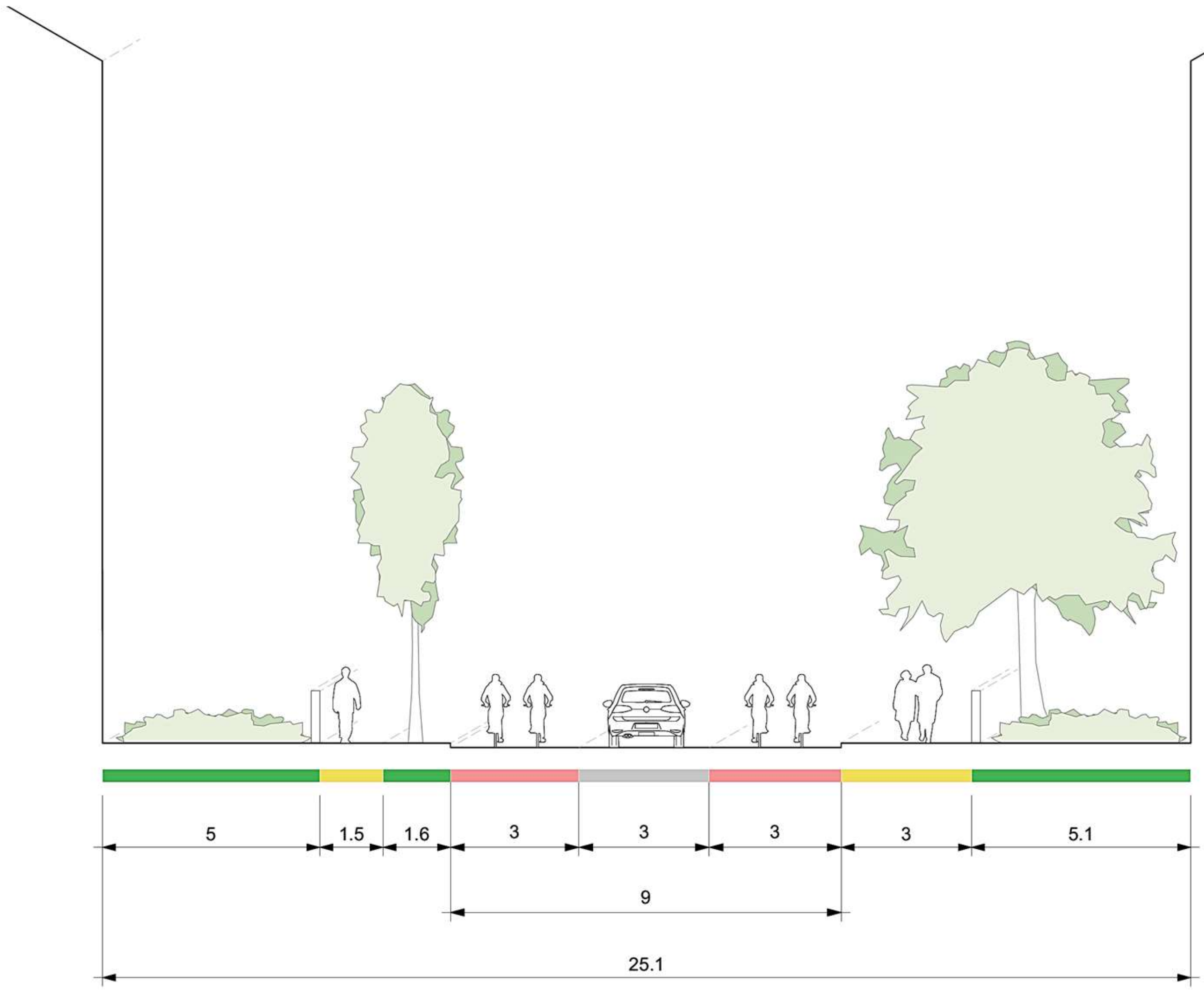
Drafting



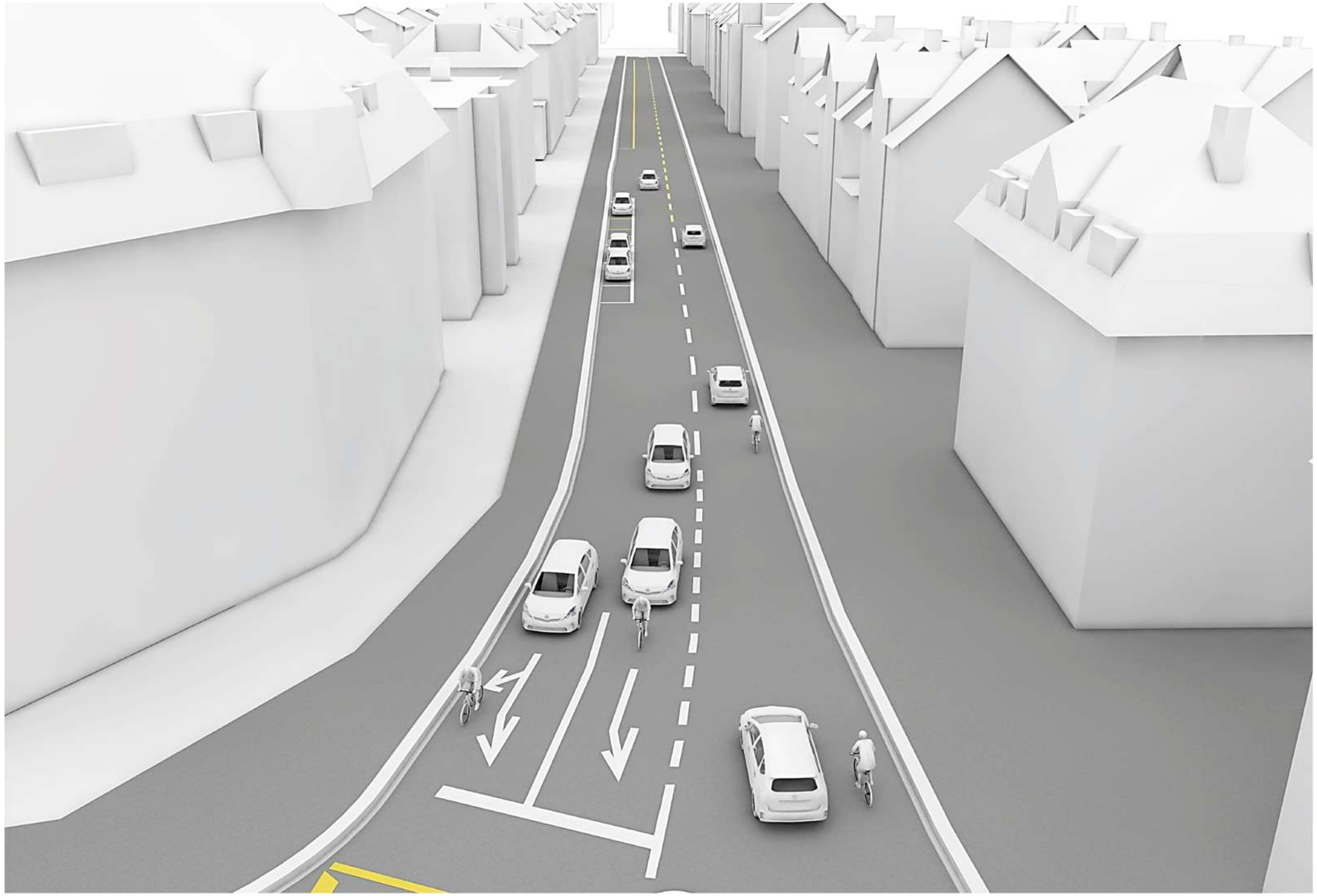
Drafting



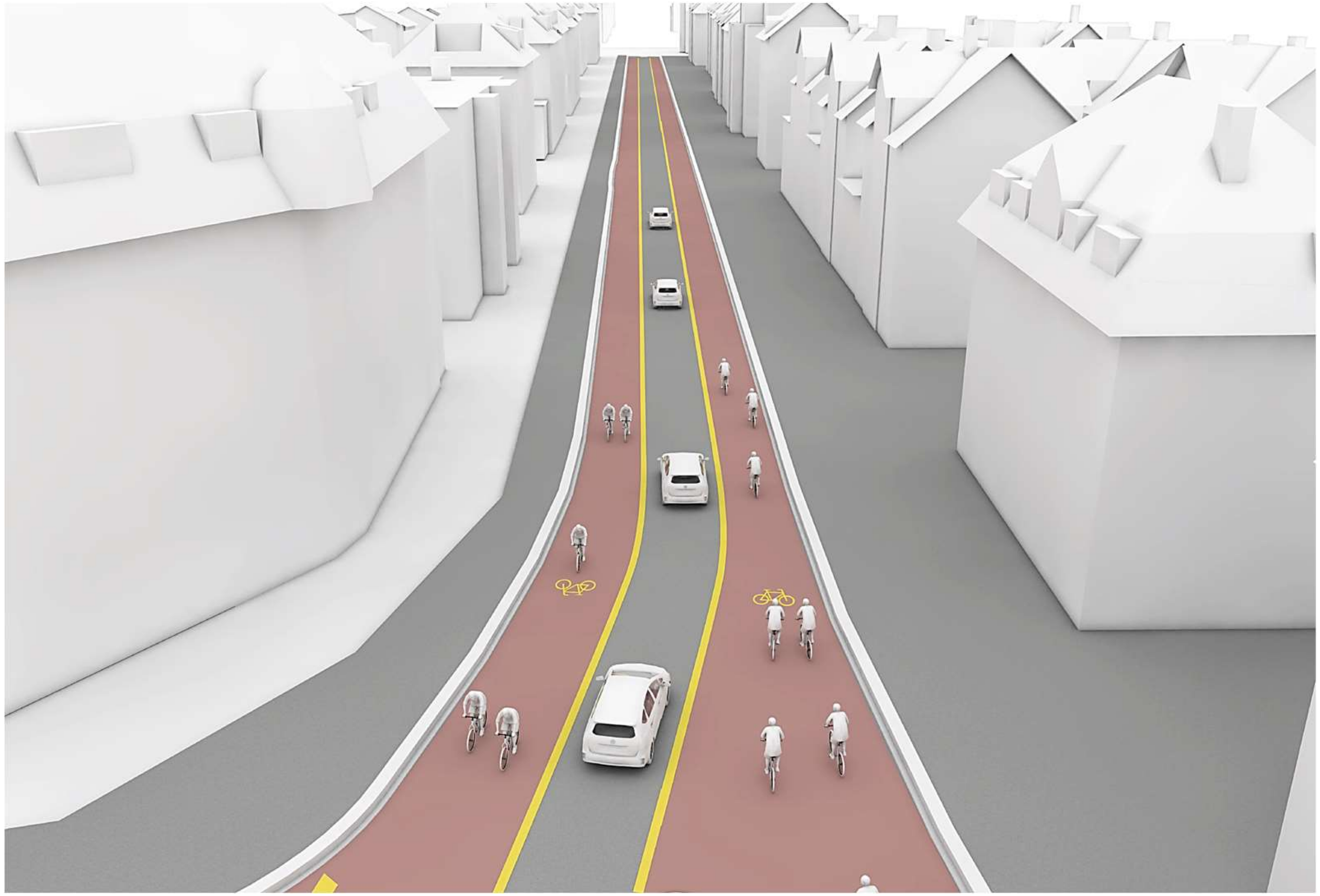
Drafting



3D model for visualizations



3D model for visualizations



What about the resulting networks?

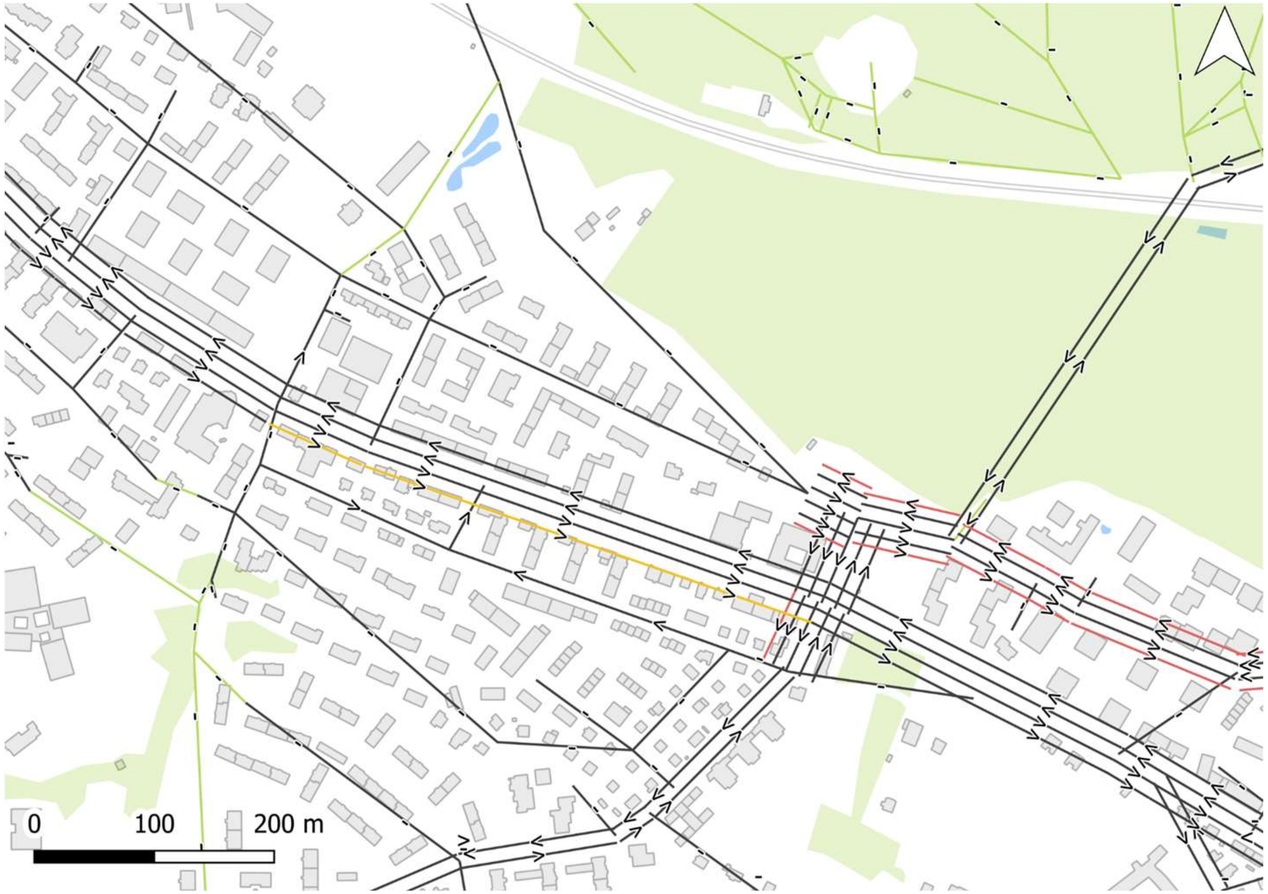
Goals

1. Realistic networks for a transport model
2. A scalable process across many cities worldwide

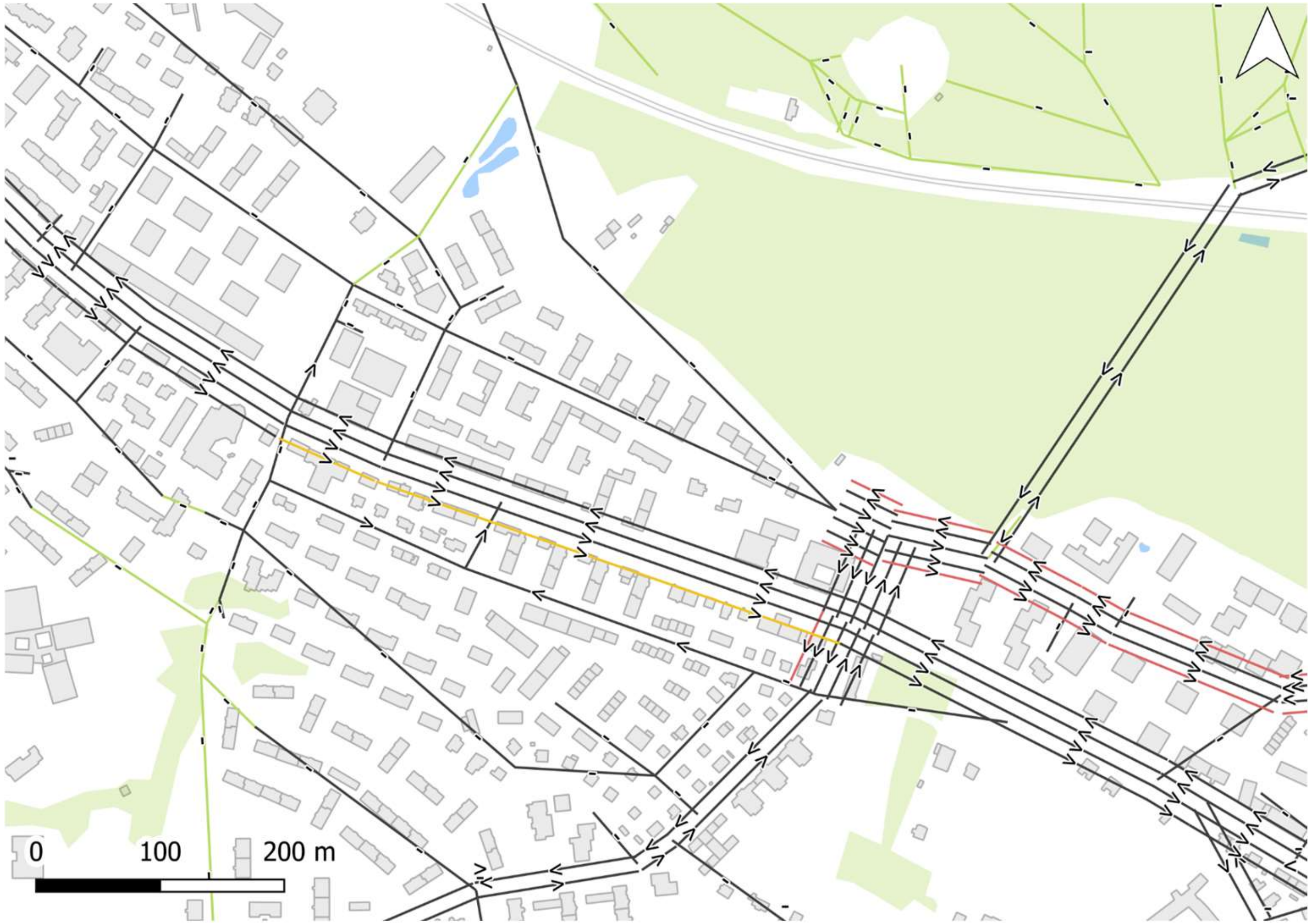
Network redesign: Design philosophy

Converting all vehicular lanes to cycling infrastructure, except a minimum set, ensuring:

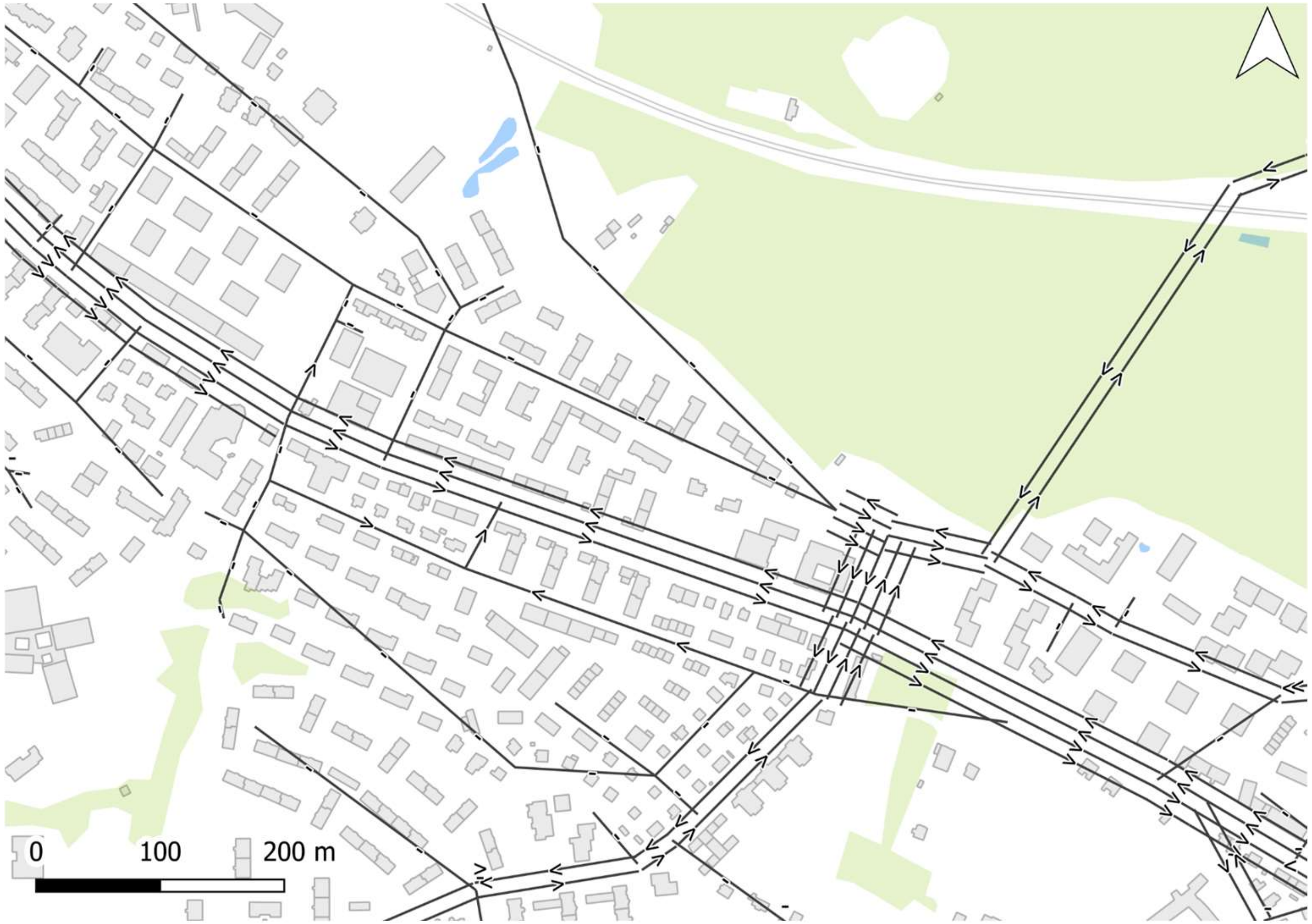
1. Vehicular access to all intersections
2. Operation of current major transit routes



Network redesign: Status quo



Network redesign: Only vehicular lanes



Network redesign: Only essential vehicular lanes

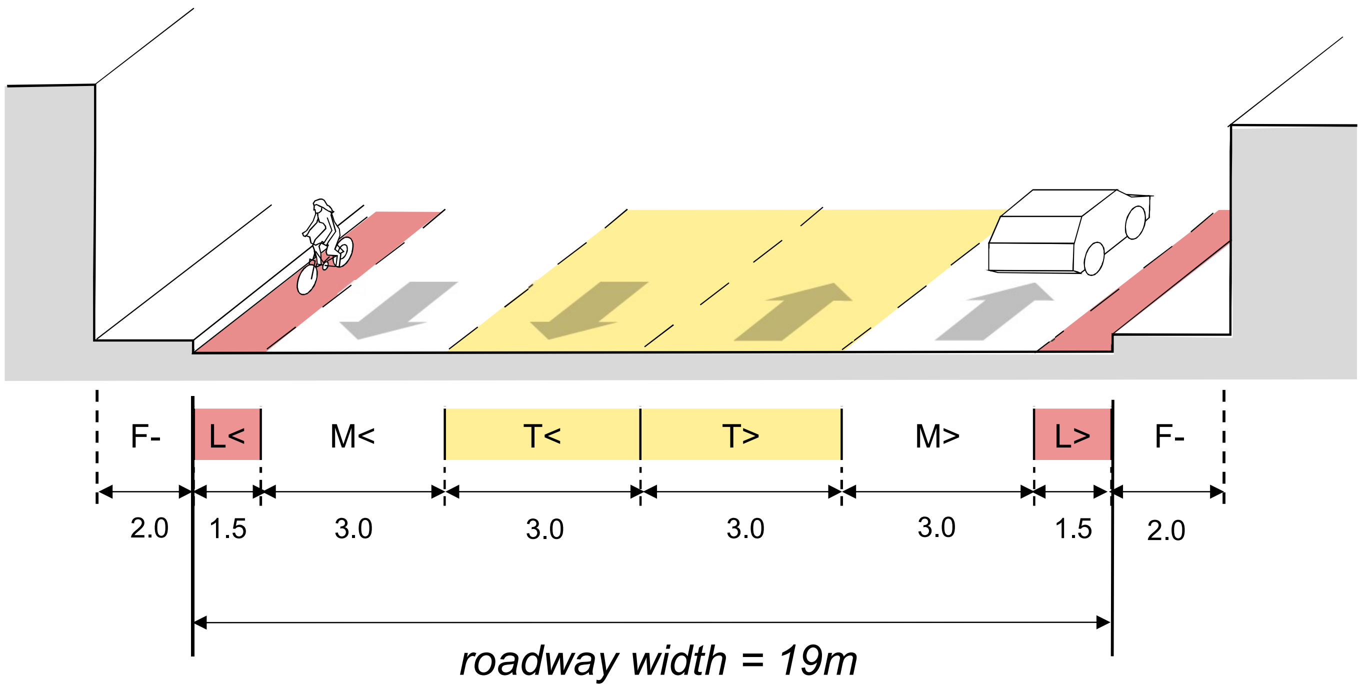
Network redesign: Converting the remaining lanes to cycling

Network redesign: Street network simplification

Original OpenStreetMap data

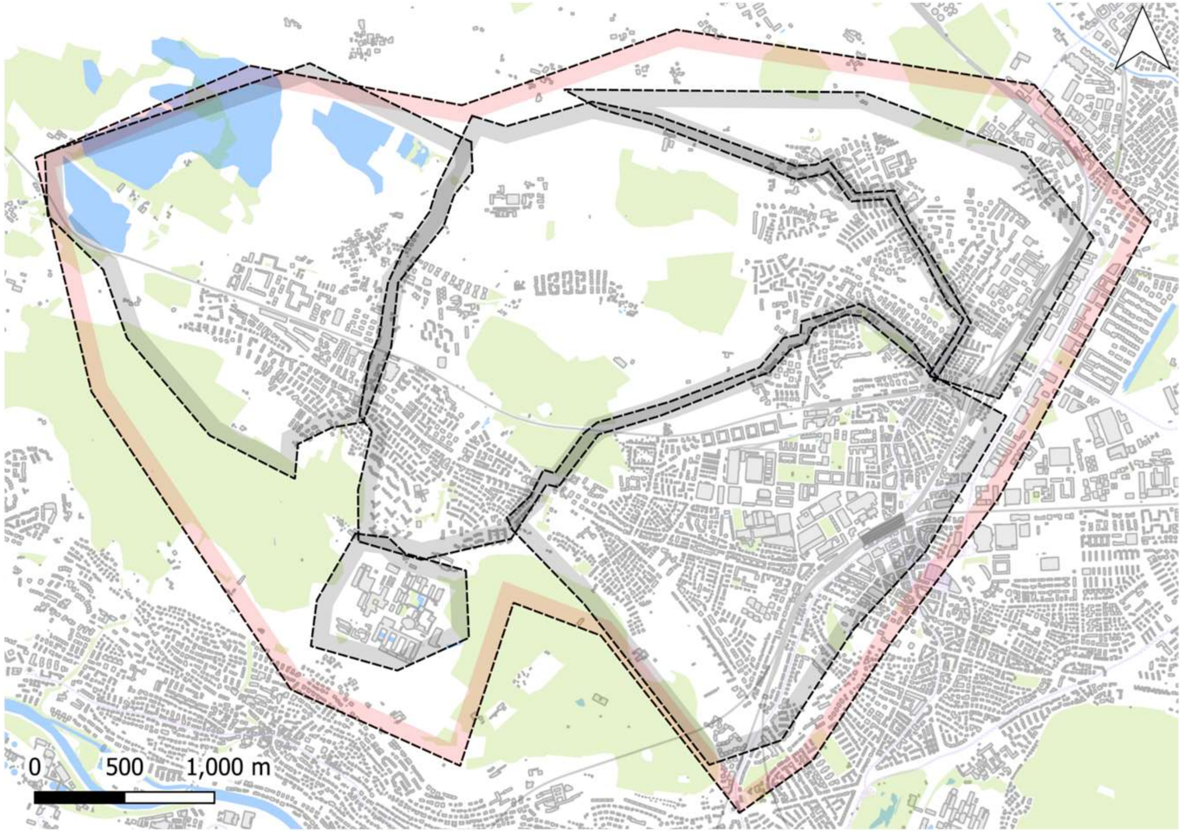
Simplified *Centerline Graph*

Network redesign: Data structure

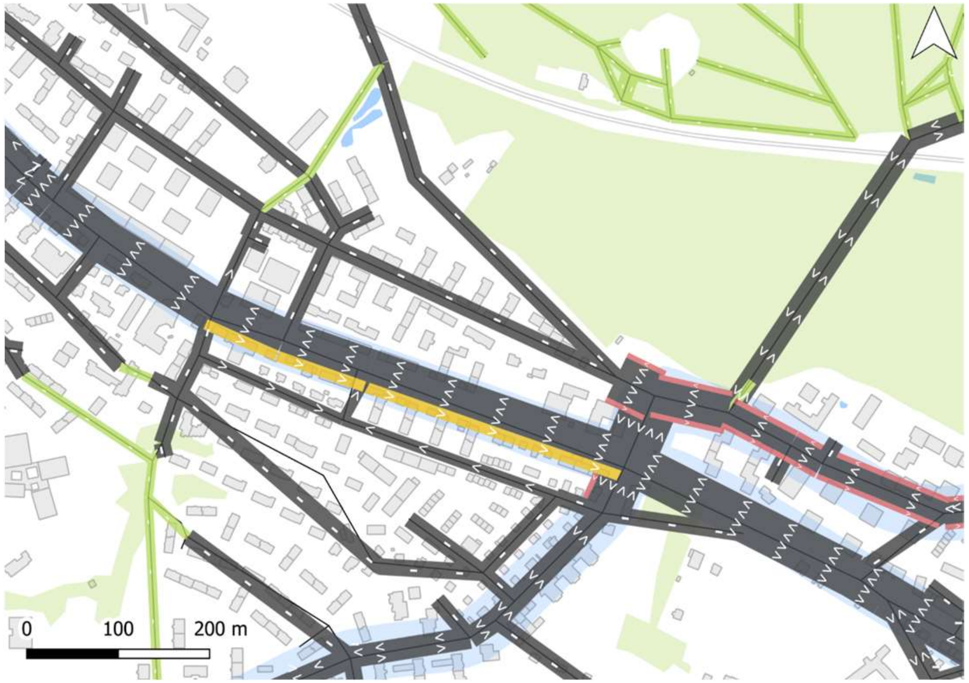


Network redesign: Planer’s inputs

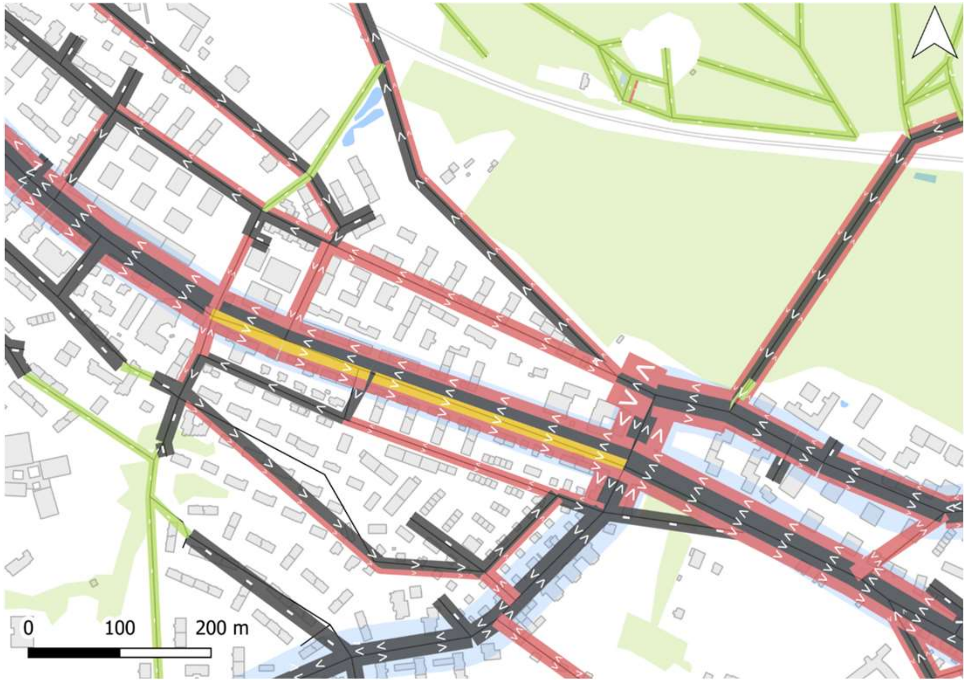
1. Network hierarchies
2. Segmentation
3. Network constraints:
    1. Access to every intersection?
    2. Maintain vehicular traffic on every street?
    3. Dedicated bus lanes?
4. Order of graph reduction
5. minimum capacity for vehicular traffic (to be added in the future)



Network redesign: Lanes before and after



Before



After

Zusammenfassung Entwurf

- E-Bike City becomes more concrete through the first designs of streets and intersections
- Automated generation of alternative street networks
- Software SNMan (Street Network Manipulator)

Nächste Schritte:

- What are the effects of these alternative networks on traffic?
- Professional Visualizations

Subproject D: Congestion-informed dynamic space allocation for different transport modes

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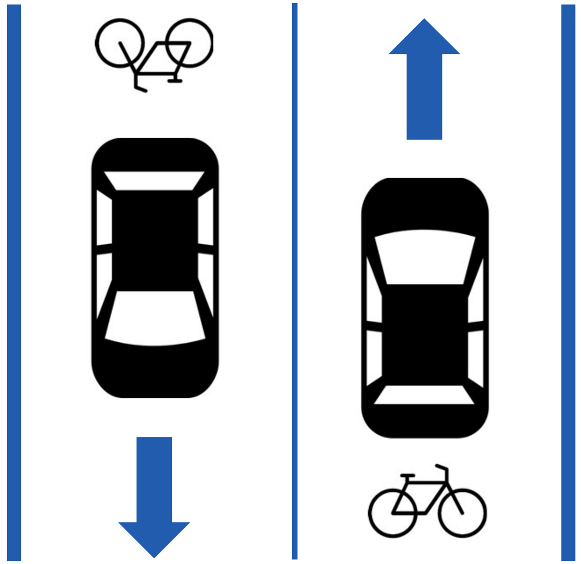
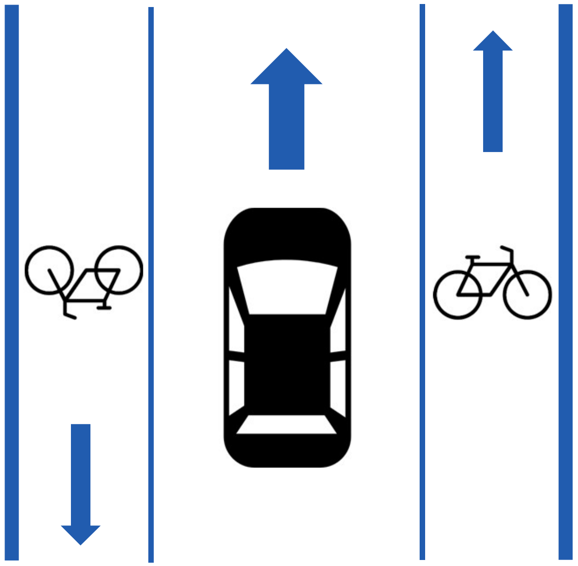
Objective: Urban road space allocation to different modes

Trade-off between eco-friendly/active transport mode enhancement and car traffic performance degradation:





Subproject D framework

D1 (modeling):
Multi-modal macroscopic fundamental diagrams

↓

D2 (prediction):
Multi-modal network traffic assignment

↓

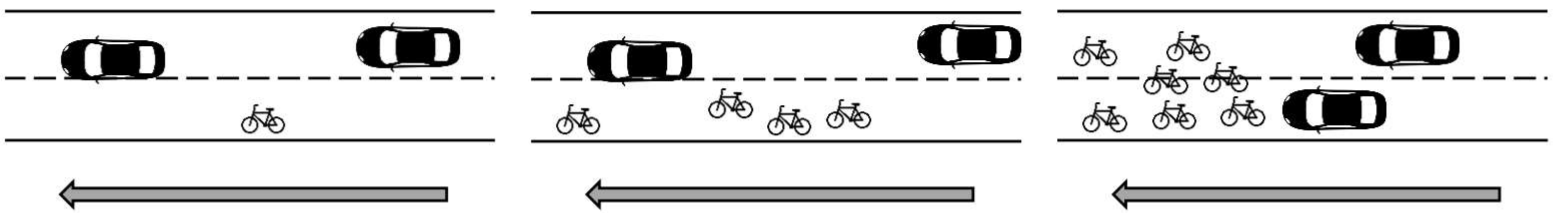
D3 (management / control):
Dynamic road space allocation strategies & others

Problem --- Bicycle traffic dynamics

Characteristics:

1. Non-lane-based traffic flow
2. Large behavioral heterogeneity, e.g., desired speed, overtaking incentive, etc.
3. Different dynamics in a mixed traffic stream

$k_v < k'_v$ $\qquad$ $k'_v < k_v < k''_v$ $\qquad$ $k_v > k''_v$



Loder et al. (2021)

Problem --- Multi-modal interaction

1. Signal priority & other multi-modal adaptive signal control strategies
2. Public transport (PT) vehicle operation on car/bike lanes
3. Mixed bicycle-car traffic flow

Intelligent traffic light in Copenhagen
(Gunnar Bothner-By / Flickr)

A bus line in Ipswich
(Scenic Bus Photos-By / Flickr)

Bicycles in general traffic
(Photo credit to ©Toby Jacobs)

Method --- Microscopic bicycle simulation

- A new rule-based continuous space model considering two-dimensional (longitudinal and lateral) maneuvers with mental-level decision-making
- Goal: Deriving desired macroscopic parameters in various scenarios

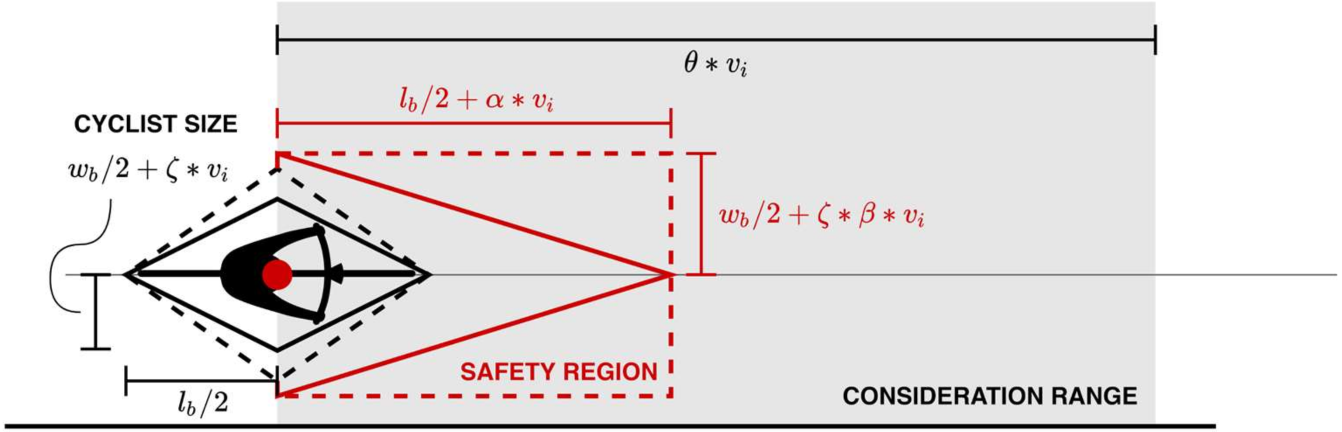
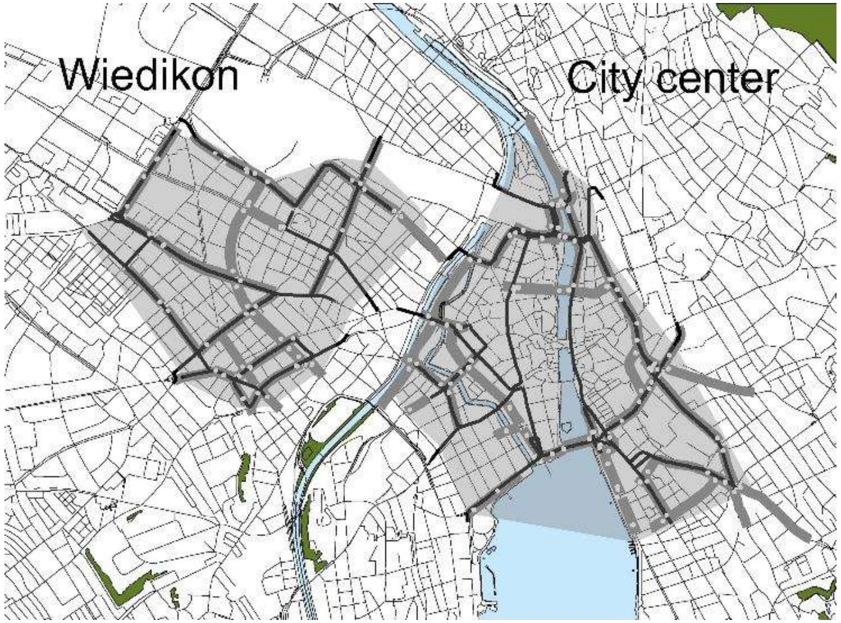


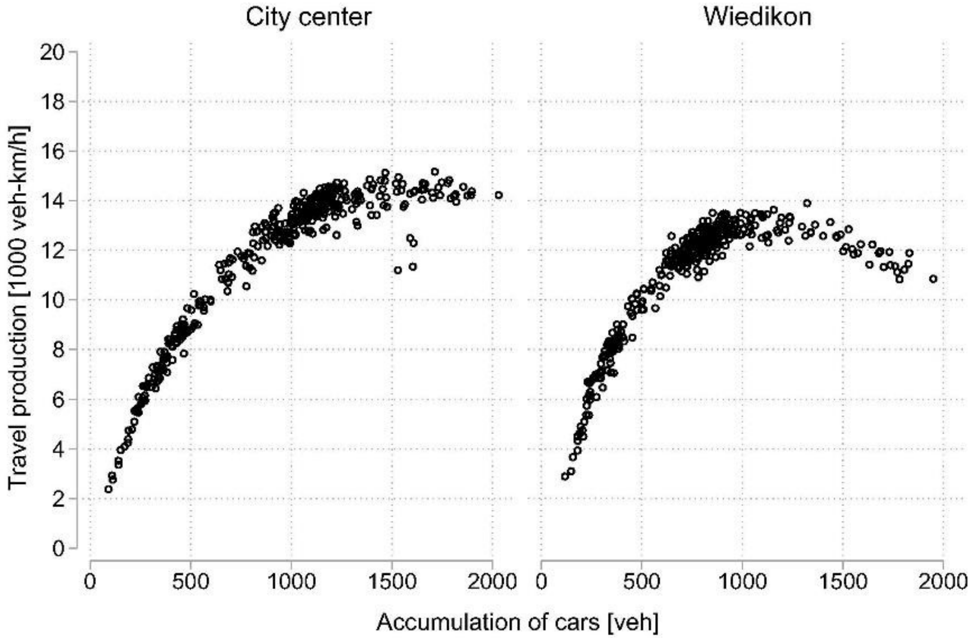
Diagram of the cyclist size, safety region, and consideration range defined in the proposed model
(Brunner et al., 2023)

Method --- Multi-modal macroscopic fundamental diagram (mMFD)

MFD describes the relationship between network accumulation (density) and production (flow).



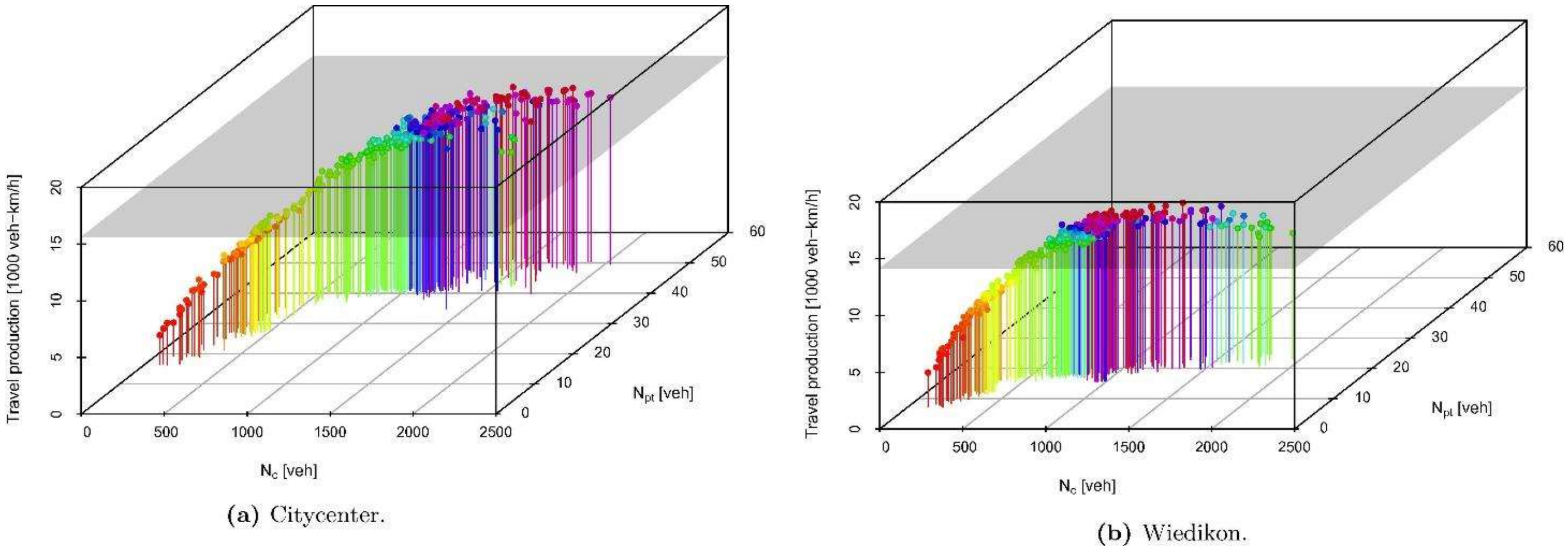
Two subregions in the city of Zurich
(Loder et al., 2017)



Empirical car MFDs of the city of Zurich
(Loder et al., 2017)

Method --- Multi-modal macroscopic fundamental diagram (mMFD)

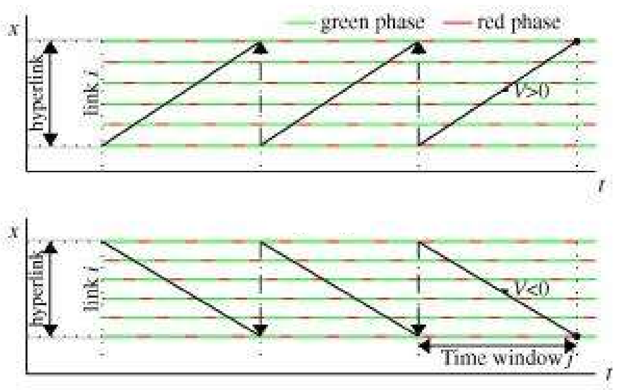
3D-MFD additionally captures the influence of public transport (buses, trams, etc.) on network traffic performance.



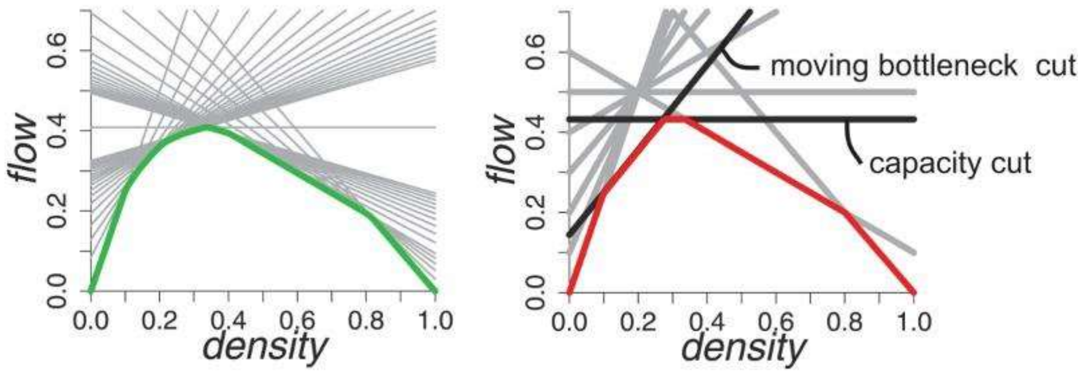
Empirical 3D-MFDs in the city of Zurich
(Loder et al., 2017)

Method --- Multi-modal macroscopic fundamental diagram (mMFD)

Variational method (analytical):

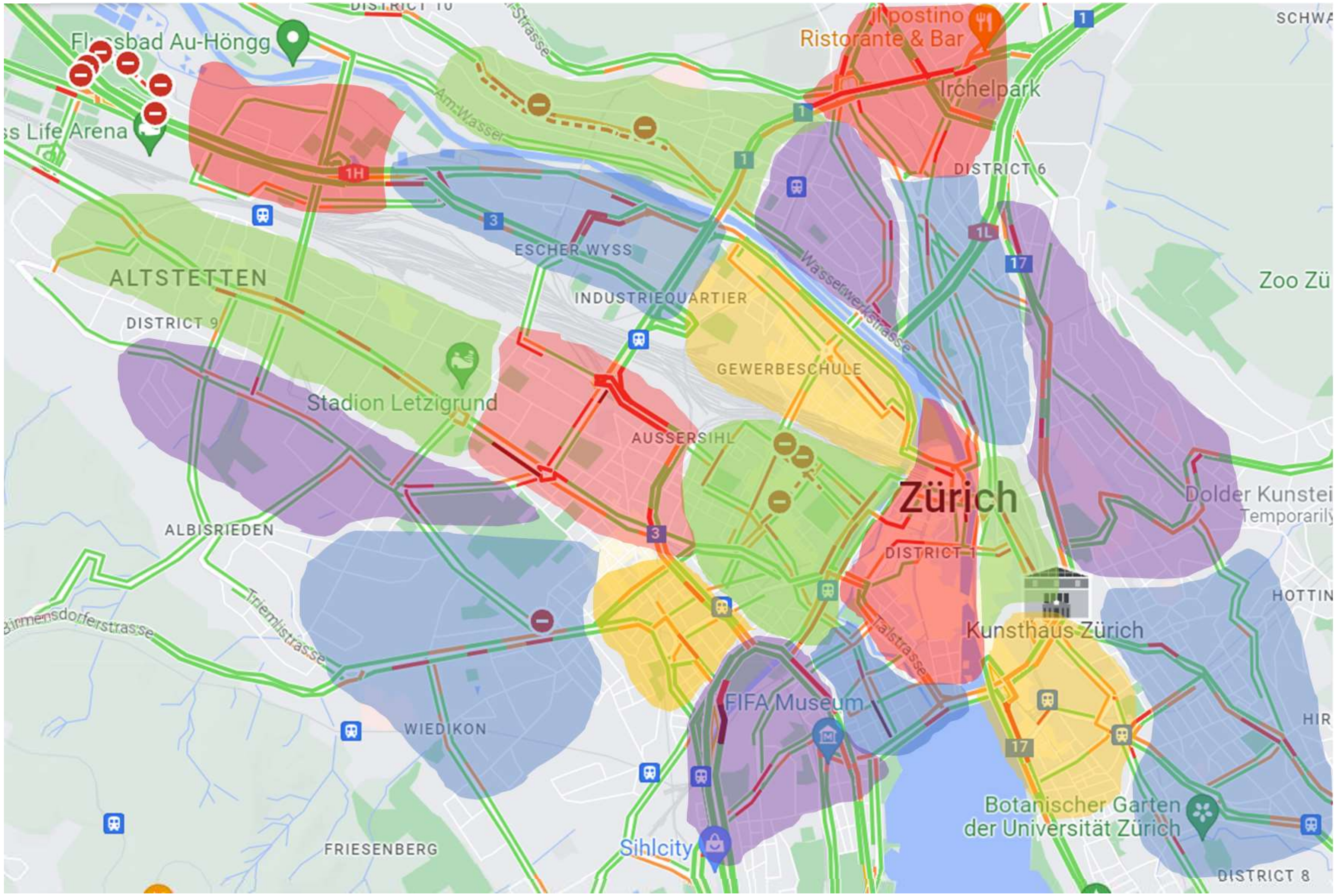


A variational graph of a route in the network (Leclercq and Geroliminis, 2013)

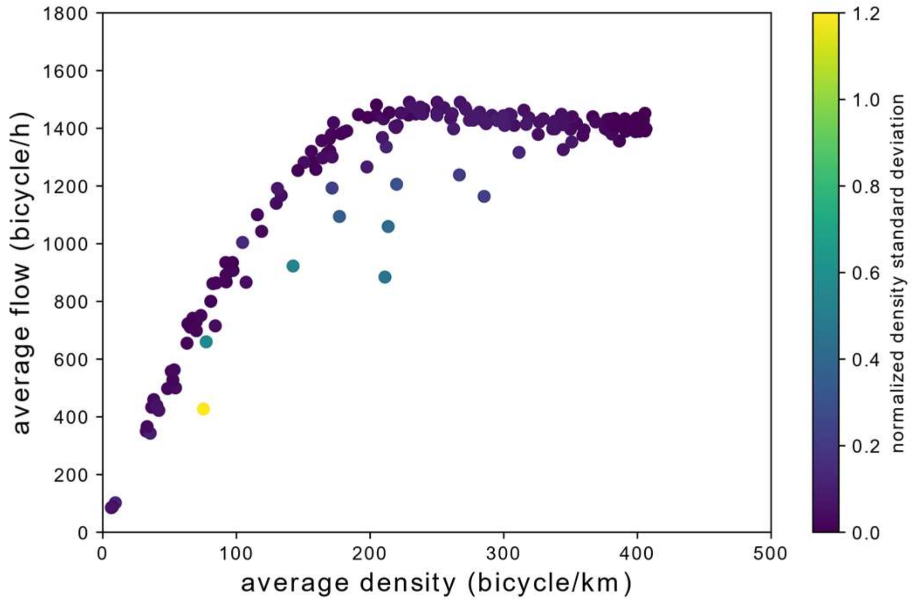


Left: MFD generated by the variational method
Right: Adding additional cuts to account for the impact of bus lines operating on car lanes (Castrillon and Laval, 2018)

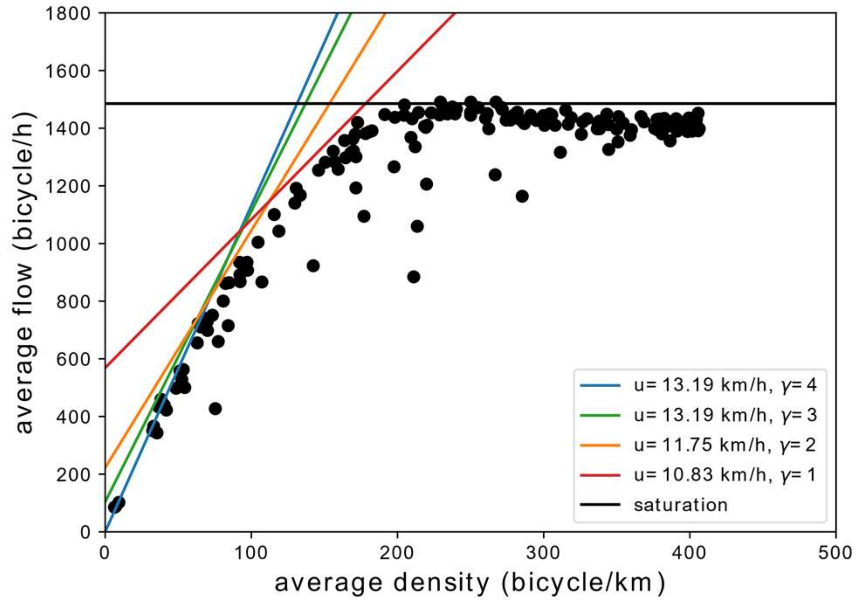
Method --- Network partition



Preliminary results --- Bicycle MFD

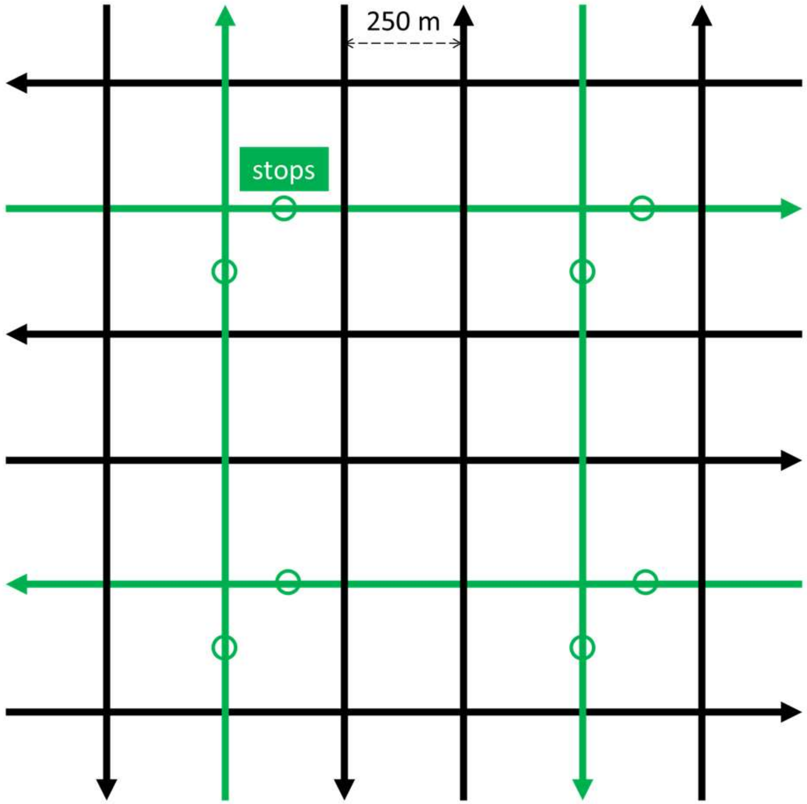


Bicycle MFD of a bike path arterial (block length = 150m, green time = 40 s, cycle time = 70 s, offset = 35 s) generated with Vissim

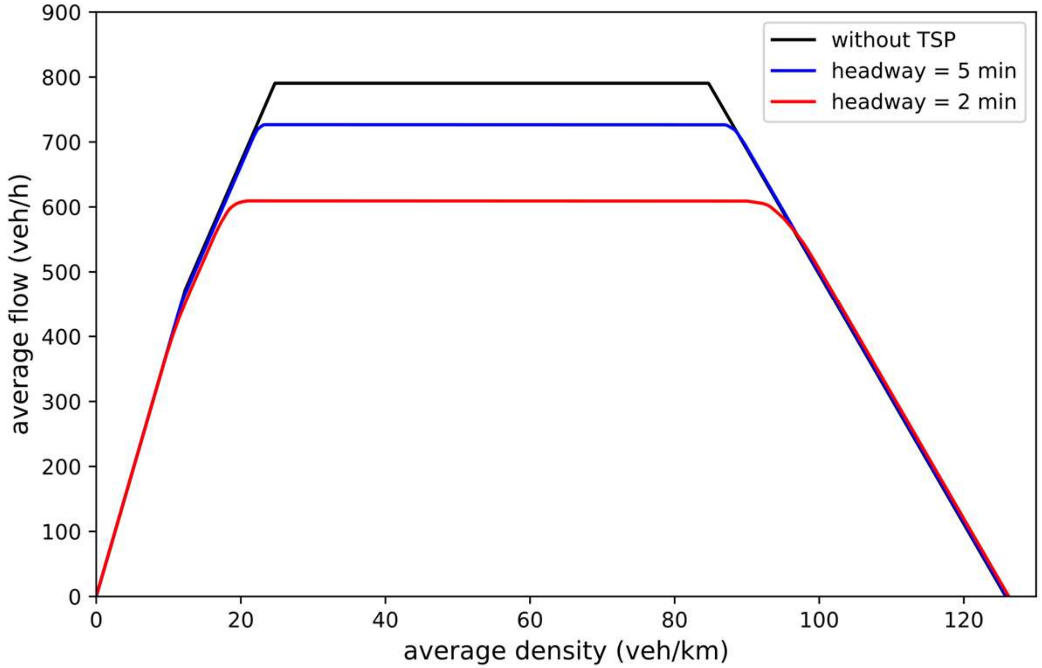


Analytical cuts for the bicycle MFD

Preliminary results --- Analytical MFDs considering the impact of transit signal priority (TSP)



Network grid with two horizontal and two vertical PT lines



Analytical MFDs of the network grid considering different TSP configurations

Ongoing work

1. Developing the analytical methods for mixed traffic scenarios
2. Partitioning the large-scale network with a heuristic (rule) and a suitable algorithm
3. Applying the developed mMFD framework to each subnetwork

Literature list:

Loder, A., Bressan, L., Wierbos, M. J., Becker, H., Emmonds, A., Obee, M., Knoop, V. L., Menendez, M., & Axhausen, K. W. (2021). How many cars in the city are too many? Towards finding the optimal modal split for a multi-modal urban road network. *Frontiers in Future Transportation*, *2*, 665006.

Brunner, J., Ni, Y.-C., Makridis, M., & Kouvelas, A. (2023, May 10-12). A new microscopic bicycle simulation model considering non-lane-based traffic characteristics. 23rd Swiss Transport Research Conference (STRC 2023), Ascona, Switzerland.

Loder, A., Ambühl, L., Menendez, M., & Axhausen, K. W. (2017). Empirics of multi-modal traffic networks–Using the 3D macroscopic fundamental diagram. *Transportation Research Part C: Emerging Technologies*, *82*, 88-101.

Leclercq, L., & Geroliminis, N. (2013). Estimating MFDs in simple networks with route choice. *Transportation Research Part B: Methodological*, *57*, 468-484.

Castrillon, F., & Laval, J. (2018). Impact of buses on the macroscopic fundamental diagram of homogeneous arterial corridors. *Transportmetrica B: Transport Dynamics*, *6*(4), 286-301.

Subproject E: Spatial optimization of street networks

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

Spatial optimization of street networks

- Spatial optimization is a key part of GIS and transportation literature
- Many *iterative* approaches exist for bike lane placement
- New opportunities arise from *radical* street network changes as in the E-bike City project, in particular **global** optimization

→ Goal: Optimize the bike lane allocation for the e-bike city, with respect to evaluation metrics that assess the goodness of the network

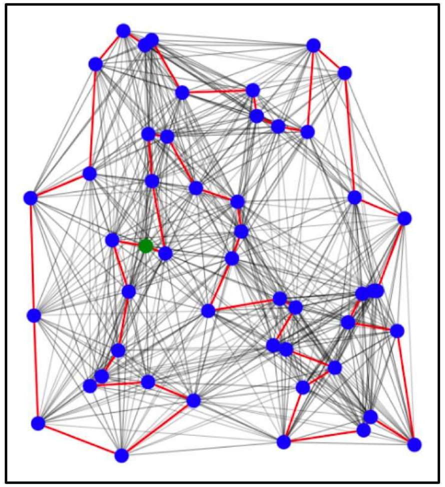
Combinatorial optimization

Combinatorial optimization: Finding an optimal solution in a discrete set of possibilities that maximizes / minimizes an objective function

Bike lane optimization: In a street graph with n edges, allocate a subset of edges as bike lanes

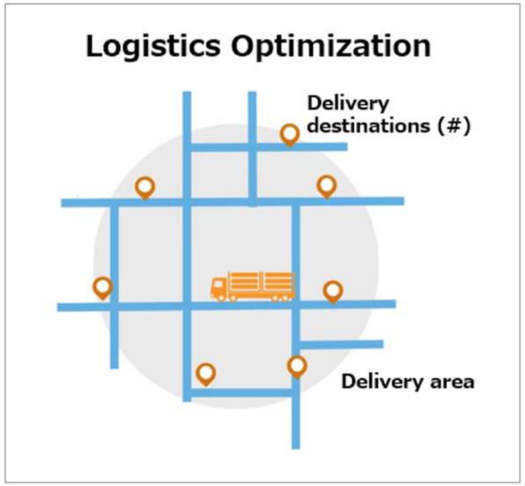
Problem: In a set of *n* elements, there are 2^n possible subsets

→ 2^n possible bike lane networks in a street network with n edges!

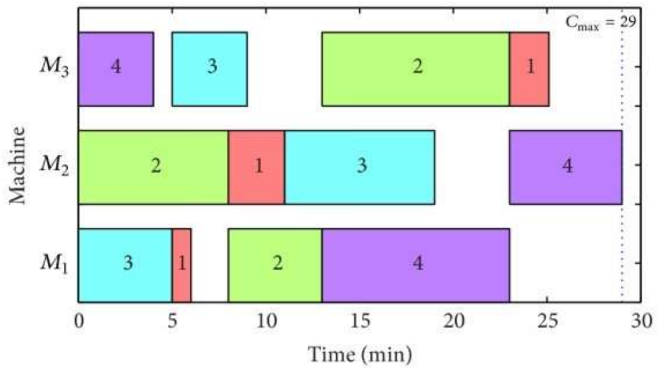


```
2 by the power of 5 : 32
2 by the power of 10 : 1024
2 by the power of 20 : 1048576
2 by the power of 30 : 1073741824
2 by the power of 50 : 1125899906842624
```

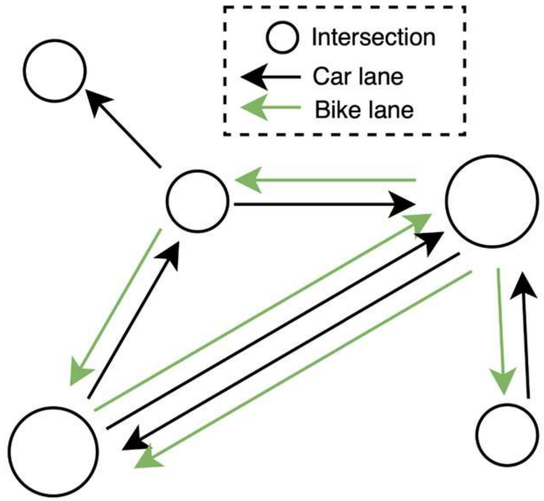
Examples:



Scheduling



Bike lane optimization as a combinatorial problem



However, smart solutions exist for many combinatorial problems, e.g.

- Finding shortest paths
- Maximizing the flow through a network

→ Goal: Draw from these solutions to optimize the bike lane allocation

Modelling approach:

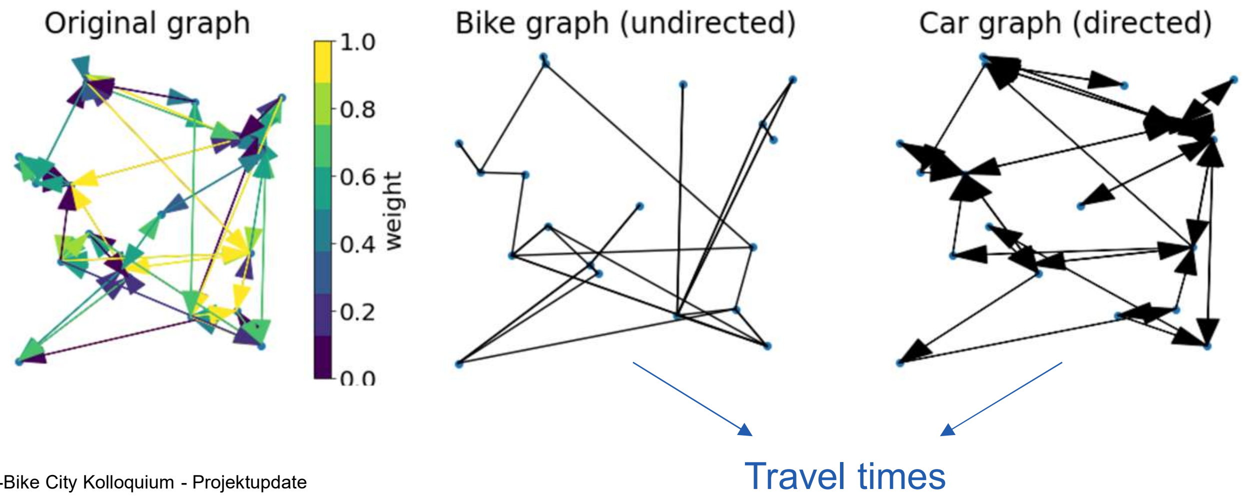
→ Each edge is one lane, and a lane can be allocated either to bikes or to cars

→The objective is to find a division into bike lanes and car lanes that minimizes the travel times for both bikes and cars

Modelling as a maximum flow problem

→ Can be modeled as a flow problem

- **Variables:** Capacity allocated to bikes and cars (per edge)
- **Objective:** Minimize a weighted average of the point-to-point travel times in car and bike networks
- **Constraints:**
  - There must exist a path between every pair of nodes (via flow constraint)
  - The sum of car- and bike- paths going through one edge is limited by the edge capacity



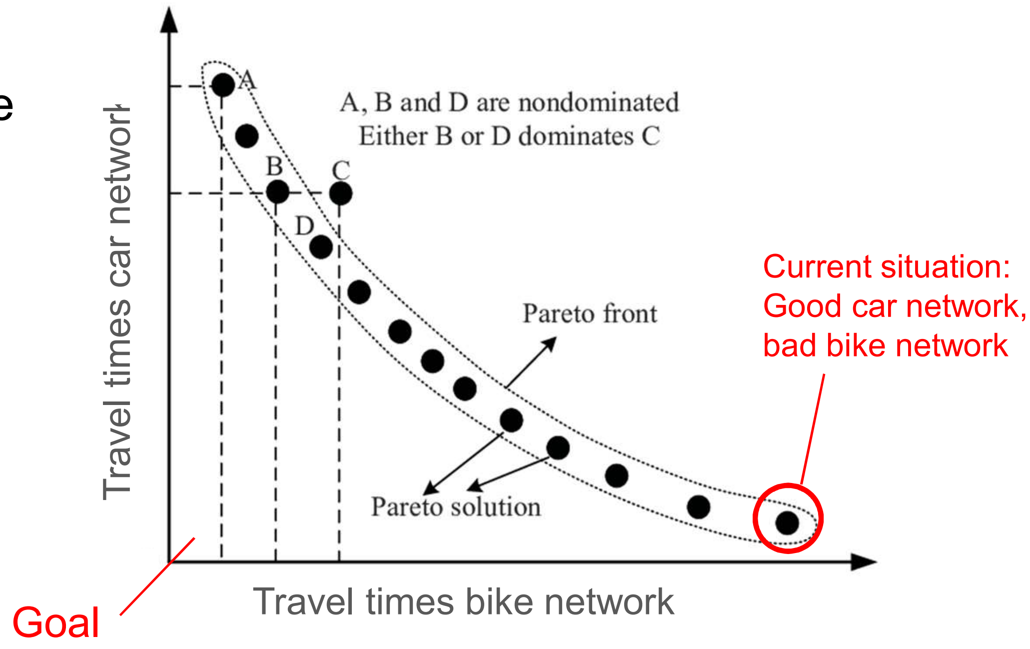
Modelling bike lane optimization as a flow problem

Challenges:

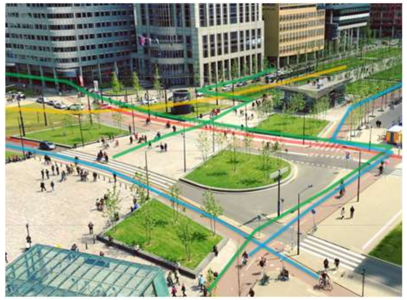
+ : Linear program → efficiently solvable

- : The solutions from the linear program will have to be post-processed (might allocate 70% of a lane to bikes and 30% to cars)

Trading-off car and bike network:
Pareto-optimality

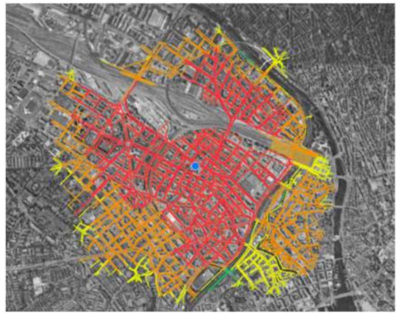


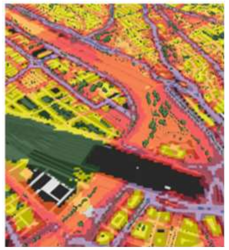
Evaluation tools for street networks



GIS-based street network metrics

- Network topology
  - Centrality measures
    - Betweenness centrality
    - (Weighted) closeness centrality
  - Shortest path length
  - Network robustness
- Network morphology
  - Angular shift (turns)
  - Accessibility
  - Topography (slope)
- Network context
  - Heat
  - Green-Blue infrastructure
  - Noise levels (BAFU)





Open-source bike lane optimization and evaluation tools

NinaWie add installation instructions and file documentation — a7ae72e 2 weeks ago — **7** commits

ebike_city_tools	Add RL environment and greedy method to flip edges for optimizin...	5 months ago
.gitignore	Add scatterplot	5 months ago
LICENSE	Initial commit	5 months ago
README.md	add installation instructions and file documentation	2 weeks ago
compare_algorithms.py	add installation instructions and file documentation	2 weeks ago
setup.py	add installation instructions and file documentation	2 weeks ago

README.md

Bike lane optimization

Tools for evaluating street networks with radical redesign by splitting into bike and car lanes

Installation

The required packages and our sprf package can be installed via pip in editable mode in a virtual environment with the following commands:

```
git clone https://github.com/mie-lab/bike_lane_optimization
cd spatial_rf_python
python -m venv env
source env/bin/activate
pip install -e .
```

No description, website, or topics provided.

Readme
MIT license
0 stars
3 watching
0 forks
Report repository

Releases

No releases published

Packages

No packages published

Languages

Python 100.0%

Next steps

1. Implement and evaluate optimization algorithm on real street networks

2. Compare results quantitatively and qualitatively to the iterative algorithms by means of the Pareto curve

3. Implement GIS-based evaluation tools to give a more comprehensive picture about the goodness of the street network

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Literature:

[1] Christoph Steinacker et al. “Demand-driven design of bicycle infrastructure networks for improved urban bikeability”. In: *Nature Computational Science* (2022), pp. 1–10.
[2] Luis Guillermo Natera Orozco et al. “Data-driven strategies for optimal bicycle network growth”. In: *Royal Society open science* 7.12 (2020), p. 201130.
[3] Guo-Ling Jia, Rong-Guo Ma, and Zhi-Hua Hu. “Review of urban transportation network design problems based on CiteSpace”. In: *Mathematical Problems in Engineering* 2019 (2019).
[4] Szell, Michael, et al. "Growing urban bicycle networks." Scientific reports 12.1 (2022): 6765.
[5] Natera Orozco, Luis Guillermo, et al. "Data-driven strategies for optimal bicycle network growth." Royal Society open science 7.12 (2020): 201130.

Figure sources:

- https://www.ipam.ucla.edu/wp-content/uploads/2019/12/DLC2021_pic_cropped.jpg
- https://www.researchgate.net/publication/301279276/figure/fig2/AS:1086749480628252@1636112675624/The-schedule-of-4-3-job-shop-scheduling-problem.jpg
- https://images-cdn.welcomesoftware.com/Zz1kMTI4NjIyZmZkNzExMWVhOTU0YjBlNWM0MDVjZmU1MQ==
- Pareto curve: Figure adapted from https://www.researchgate.net/figure/Graphical-illustration-of-Pareto-optimal-solution-and-Pareto-front_fig1_286331285
- Zürich Heatmap: Hess, J. (2021) Walkability in ZH during Summer months, *Master Thesis*, IVT, ETH Zurich, Zurich.

Subproject F: Environmental benefits and impacts of the e-bike city

Vanessa Schenker, Prof. Stephan Pfister, Prof. Stefanie Hellweg

08.06.2023

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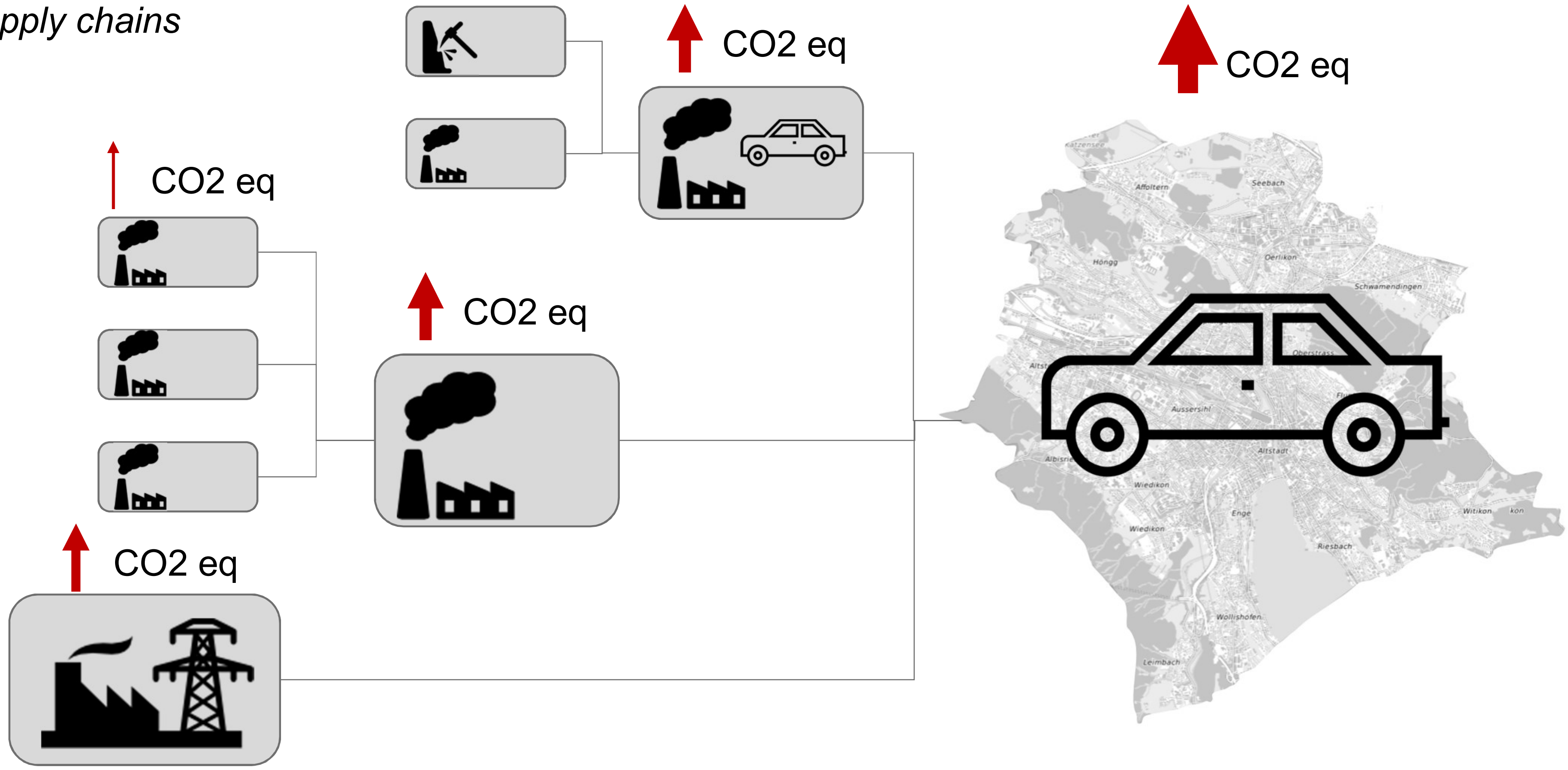
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

Environmental impacts of **our current mobility system**

Relevant supply chains



Environmental benefits and impacts of an **e-bike city**

RQ: How do the environmental impacts of **metal mining for e-bike batteries** vary and what **influence** does this have on the overall performance of an e-bike-city?

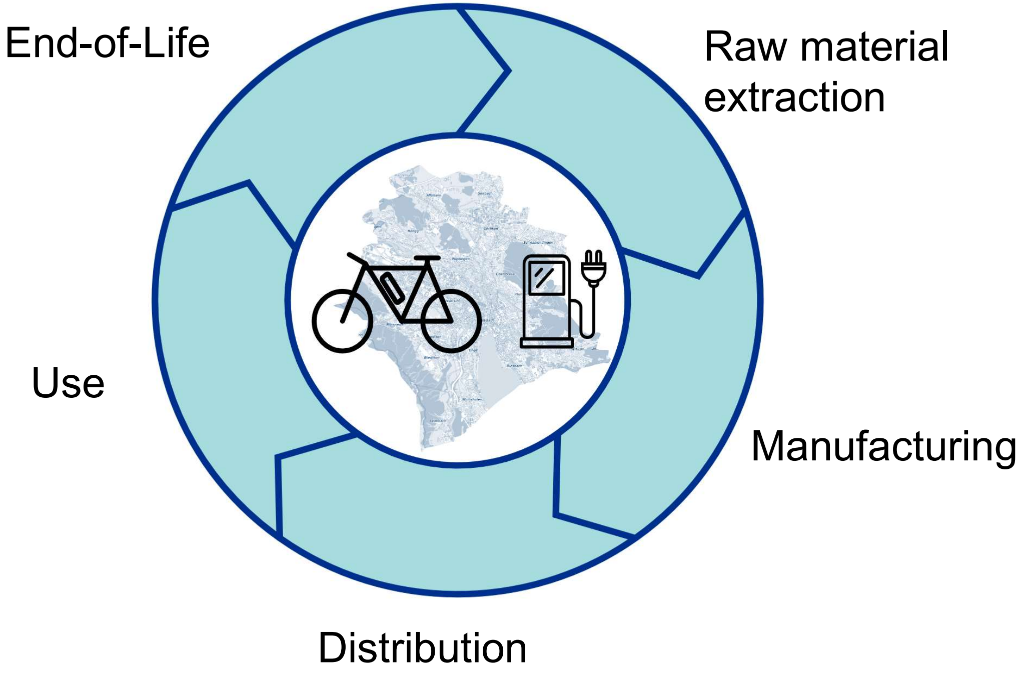
CO_2 eq

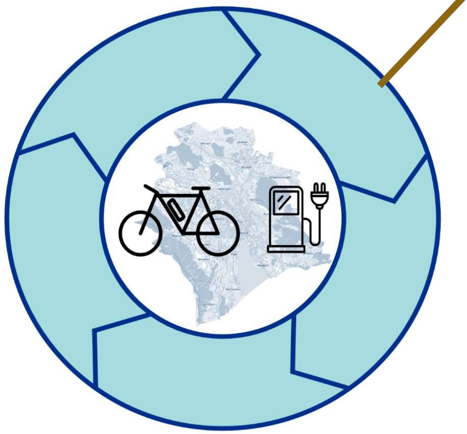
RQ: How do various factors, such as **vehicle technology, battery types, and electricity mix**, influence the env. performance?

RQ: What are the **environmental benefits and impacts** associated with the implementation of an e-bike city?

Environmental benefits and impacts of the e-bike city

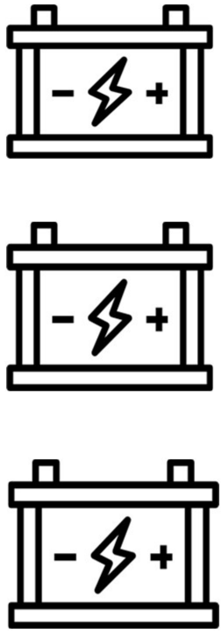
Life cycle assessment





Raw material extraction & manufacturing

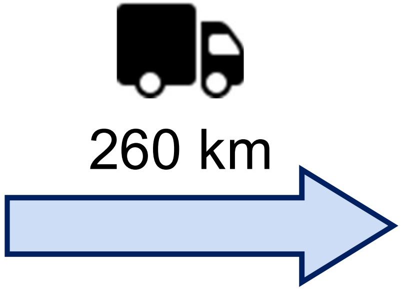
- Lithium
- Graphite
- Cobalt
- Nickel
- Manganese



Lithium carbonate production from Salar de Atacama

Evaporation ponds

Tom Hegen

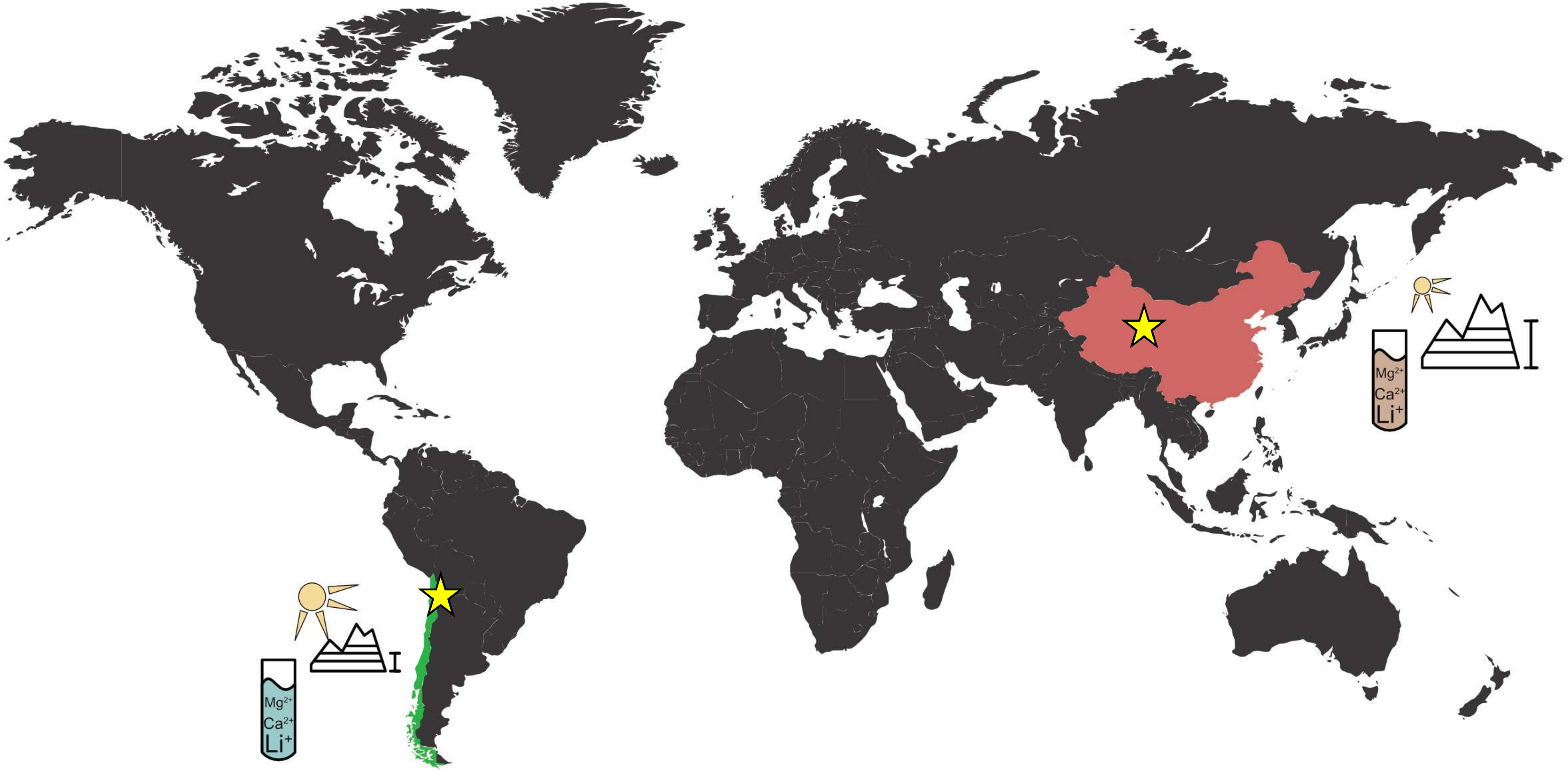


Processing plant

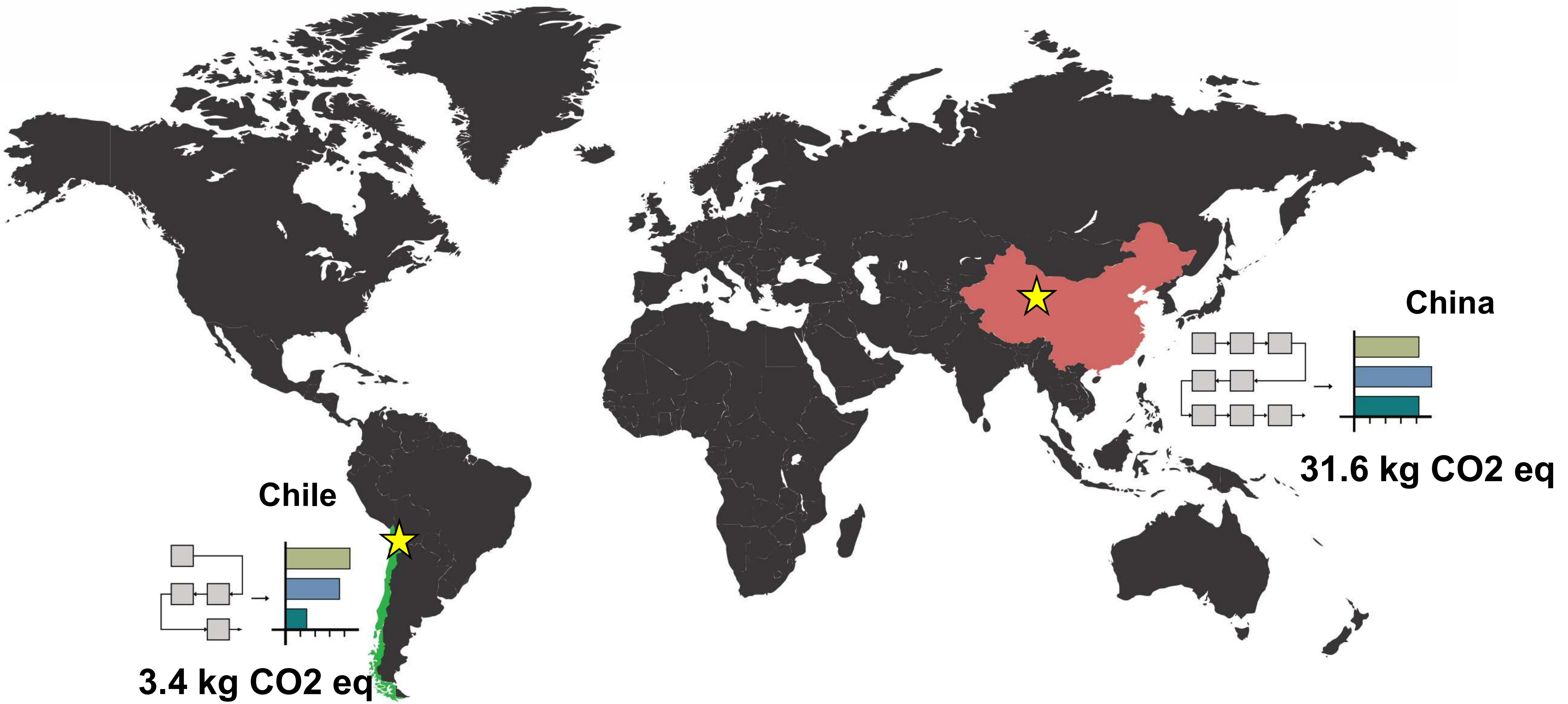
Google maps, 18.10.22

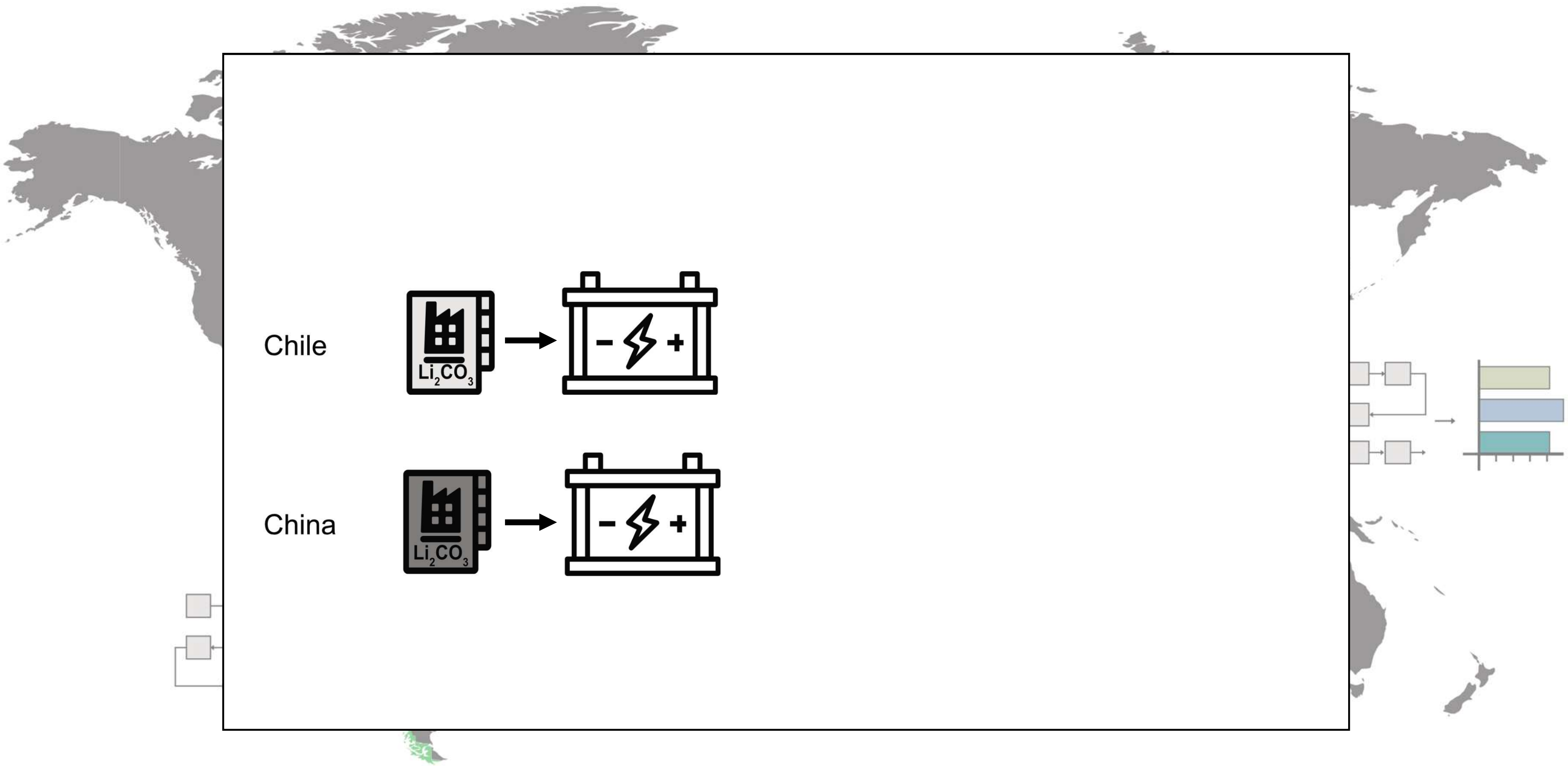
Energy | Chemicals | Water | Waste

→ Assessment of environmental impacts


Mg2+
Ca2+
Li+
Mg2+
Ca2+
Li+

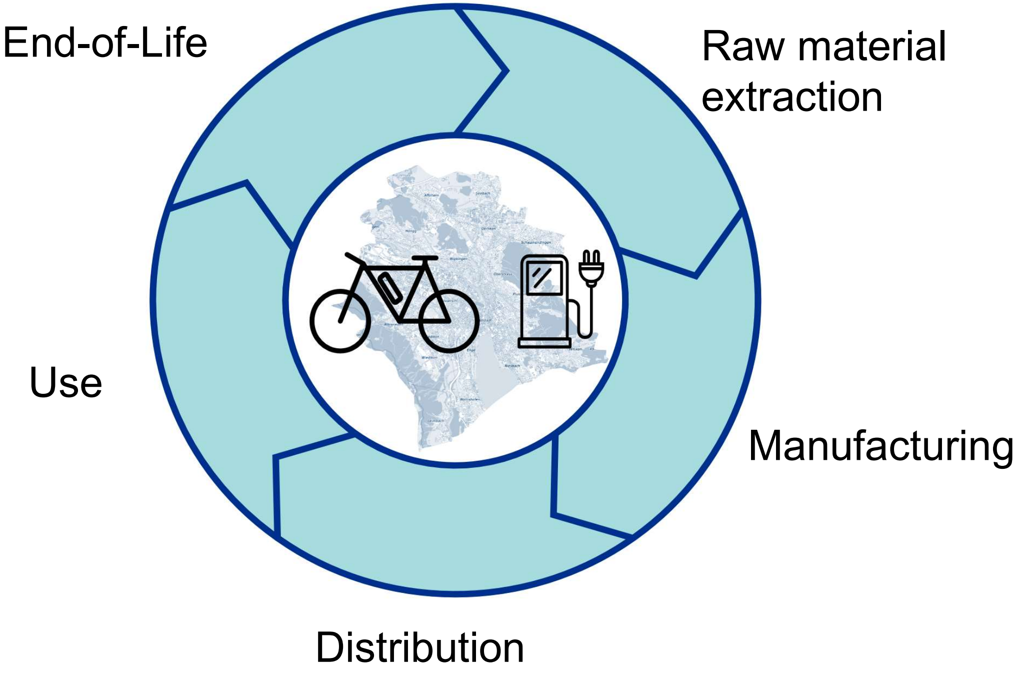
For one kg of lithium carbonate:




Chile
Li2CO3
China
Li2CO3

Ongoing work

<u>Life cycle assessment</u>



Data collection and assessment:

- Improvement of metal mining data
- E-bike production, maintenance
- Battery recycling
- Current mobility

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References

- Bundesamt für Umwelt (BAFU), 2023. Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990 – 2021, https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/greenhouse-gas-inventory/transport.html
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- Schenker, V., Oberschelp, C., Pfister, S., 2022. Regionalized life cycle assessment of present and future lithium production for Li-ion batteries. Resour. Conserv. Recycl. 187, 106611. https://doi.org/10.1016/J.RESCONREC.2022.106611
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- Huijbregts, M.A.J., Steinmann, Z.J.N., Elshout, P.M.F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A., van Zelm, R., 2017. ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. Int. J. Life Cycle Assess. 22, 138–147. https://doi.org/10.1007/s11367-016-1246-y

Subproject G: Mobility behavior change and implementation of an e-bike city

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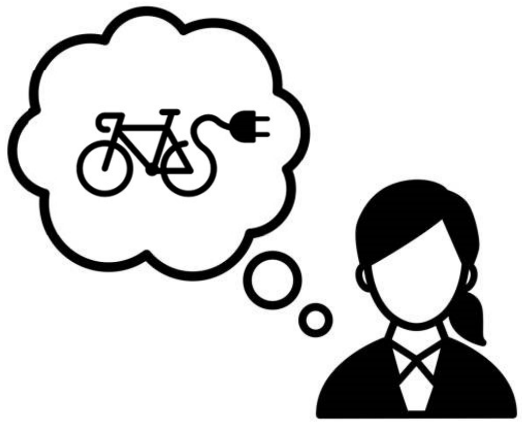
RQ: What Requirements do Residents Place on the Policy Implementation of an E-Bike City?

- Assessing citizen attitudes towards e-Bike-City policy implementation using survey experiments
- Focus on policy scenarios and cumulative information provision, building on findings of other work packages

Measure public acceptance…
- over time
- and with cumulative information provision

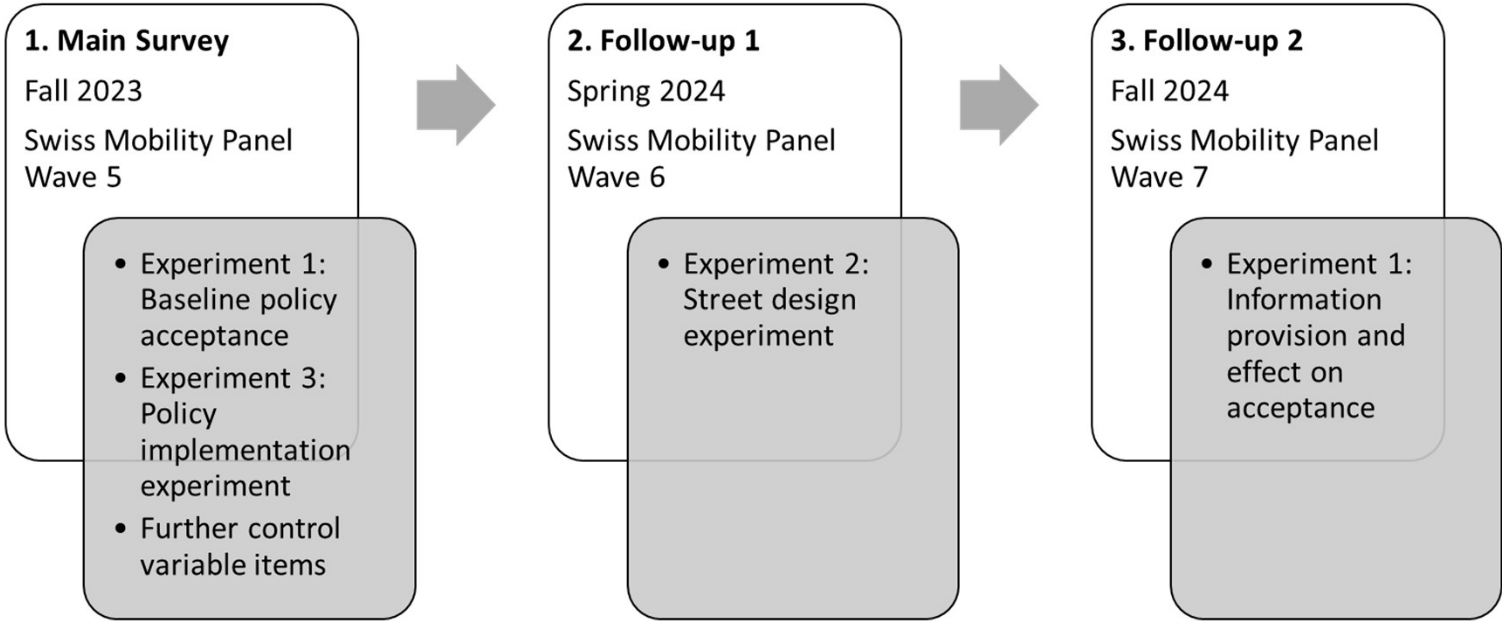
Assess how street space allocation affects public acceptance

Ancillary policies to mitigate (perceived) negative impacts



Panel Survey and Research Method

- Longitudinal panel survey with survey experiments, focus groups
- Survey a nationally representative panel (N≈6000, Swiss Mobility Panel) to understand resident attitudes towards an e-Bike-City



Experiment 1:
Individual E-Bike City Policy Assessment and Information Provision

E-Bike City description
Main Survey & Follow-up 2

The proposal stipulates to re-allocate 50 percent of the traffic space in Zurich exclusively to cycling, other micromobility vehicles, and public transport. Most streets would be bisected into a one-way lane for cars and a double lane for micromobility. The necessary space is won by consciously removing capacity and connectivity from private cars. Today's access of buildings by car as well as by utility and service vehicles will still be maintained. Special arrangements for emergency vehicles ensure their proper operation. The infrastructure is optimised for the mass use of diverse types of micromobiles, addressing speed differences, varying vehicle sizes, parking and charging opportunities, and use for freight transport.

Randomized information provision
From other subprojects
Follow-up 2

Based on calculations by researchers at ETH, the project is estimated to cost CHF XX for the implementation in the entire city of Zurich.

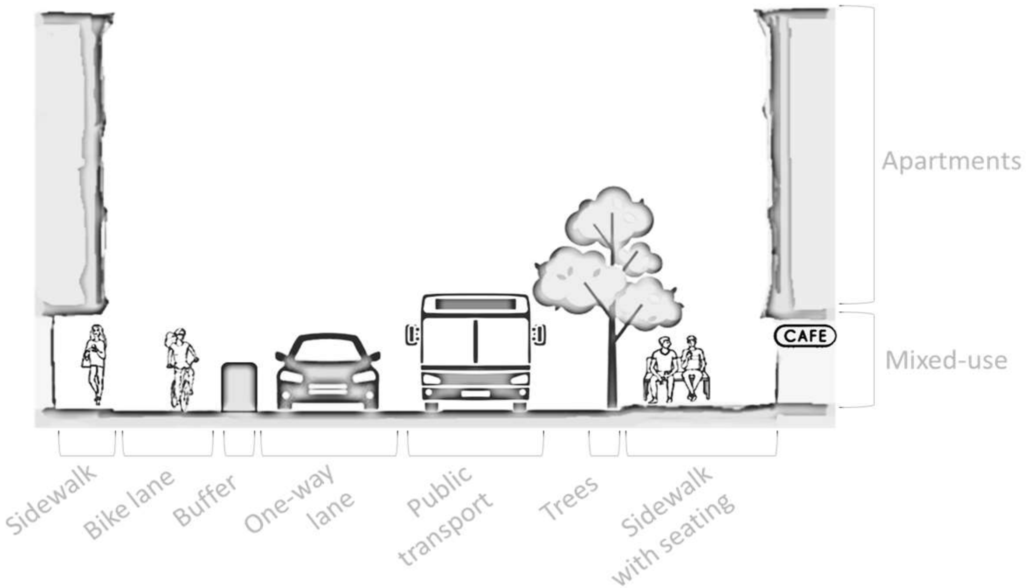
Outcome variables
- General acceptance
- Perceived effectiveness
- Perceived fairness
- …

In a ballot, would you vote in favour or against the creation of an e-Bike City?

1: Strongly reject	2	3	4	5	6	7: Strongly support
○	○	○	○	○	○	○

Experiment 2 & Workshops:
How Street Design Affects Public Opinion

- Evaluating preferences for the built environment
  - Pre-evaluation of attributes with expert and citizen workshops
  - Identify the most relevant attributes of the street-scale built environment using a survey experiment with randomly allocated street-level attributes



Experiment 3:
Policy Design Implementation and Ancillary Measures

- Evaluate acceptance of ancillary policy measures for E-Bike City project implementation.
- Conjoint experiment to asses relative importance of different policy design characteristics for acceptance of an E-Bike City implementation

2 proposals

Attributes with randomly varied attribute characteristics

Choice & rating tasks

What are your views on the two proposals for the e-Bike City?

	Proposal 1	Proposal 2
Share of street realocation from motorized private transport	30%	60%
Implementation Costs	CHF X Million	CHF Y Million
Funding	City budget	Corporate income tax
Ensuring city-wide E-Bike-Sharing	Yes, subsidised for low-income households	Yes, free of charge for municipal residents
Public transport subsidies	Yes, for low-income households	No
Measures to ensure accessibility into the city	Yes, fast bike routes leading into the city	Yes, park-and-ride infrastructure outside the city

Which of the two proposals would you prefer if implemented?

O Proposal 1 O Proposal 2

Would you accept proposal 1?

O Yes O No

Would you accept proposal 2?

O Yes O No

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Subproject H: Impact Assessment

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Prof. Kay W. Axhausen**

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Confédération suisse
Confederazione Svizzera
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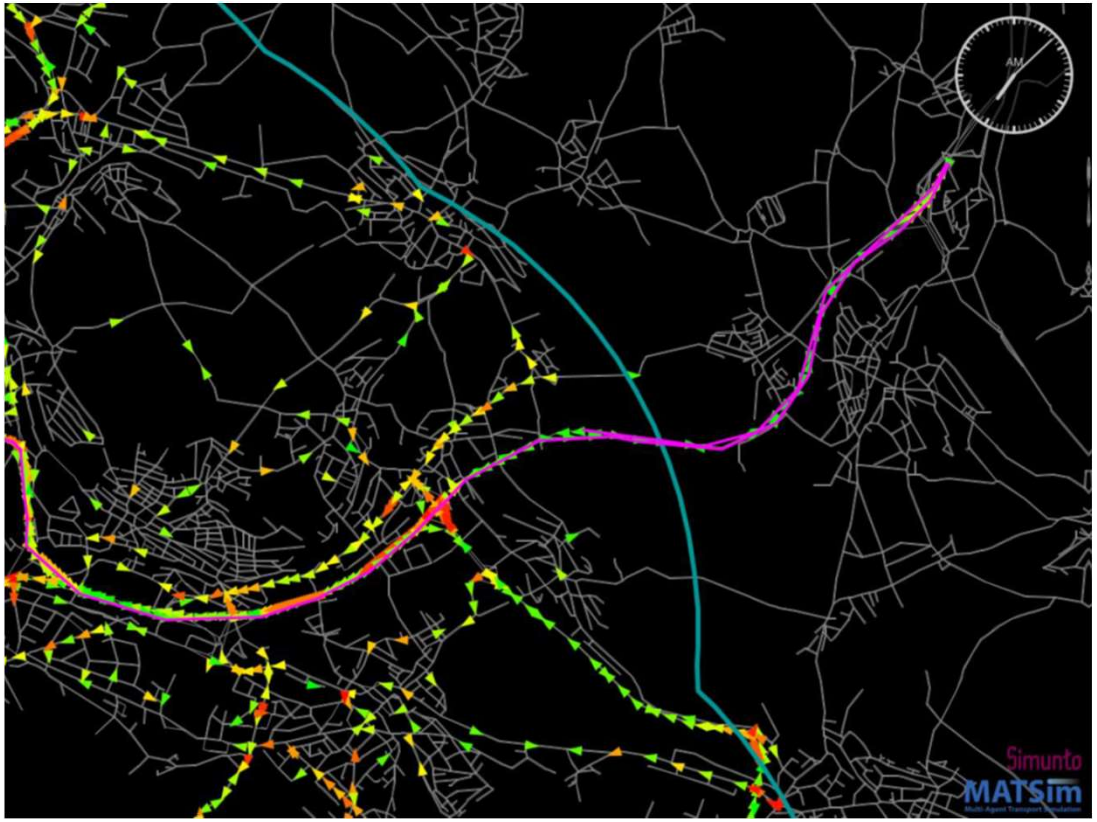
Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

EPFL IBI IFU geoinformation engineering IRL IVT D BAUG

Impact assessment in MATSim

1. How will the E-Bike City change our travel?
2. Who will be impacted and how?
3. Agent-based simulation



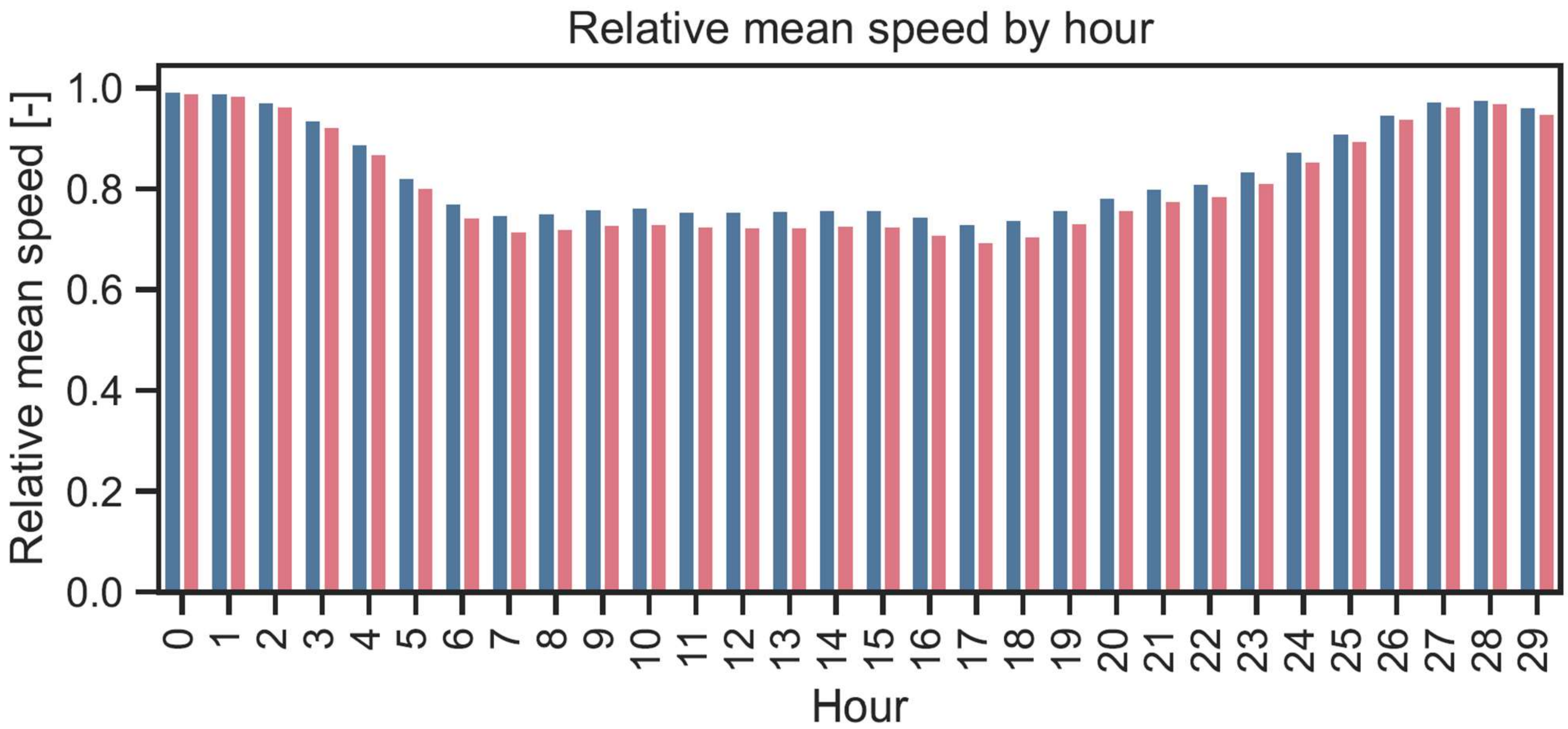
Sonnak (2023)

Challenge 1: Using a «modular» network

Original OpenStreetMap data

Simplified *Centerline Graph*

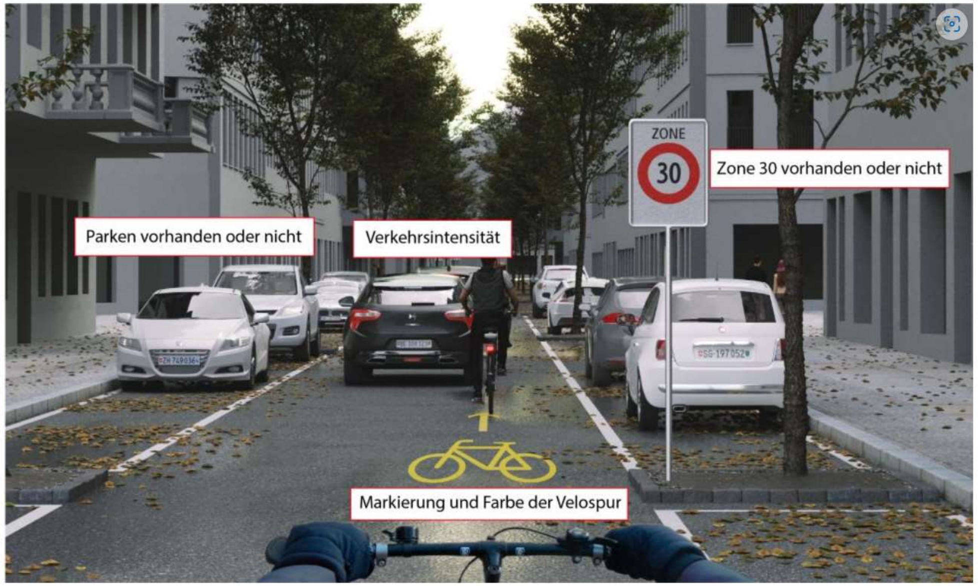
Challenge 1: Using a «modular» network



Sonnak (2023)

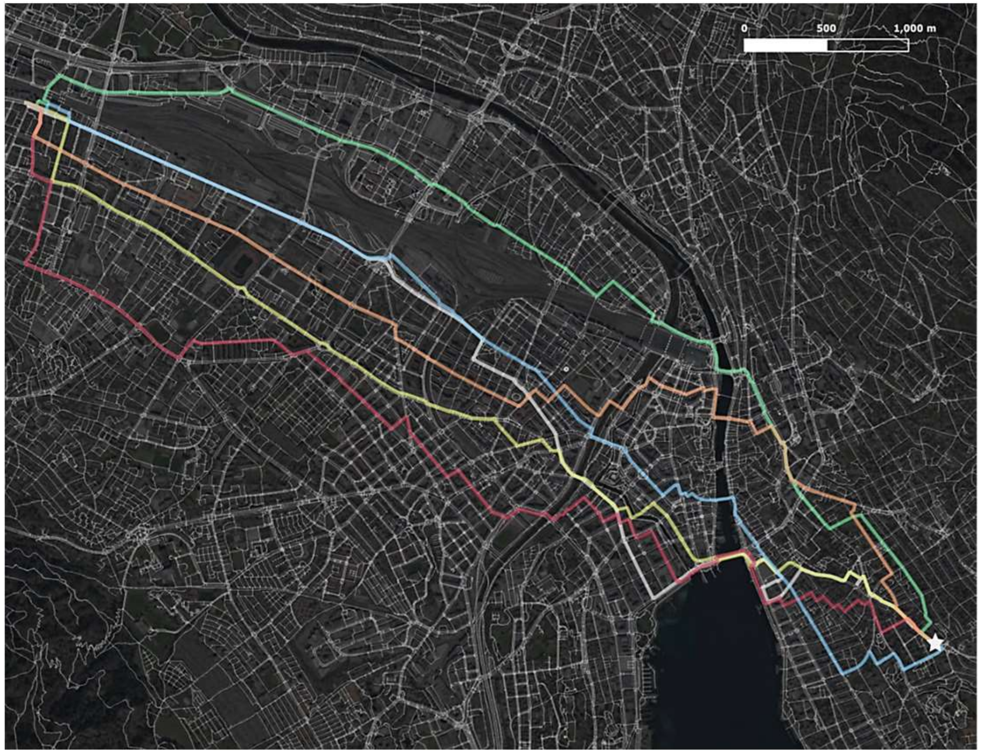
Challenge 2: Behavior of cyclists

Erster Block: Vergleiche zwischen Hauptstrassen und Quartierstrassen
Unten sehen Sie Beispielabbildungen sowie die jeweiligen Merkmale aufgeführt, die variiert werden.



Meyer de Freitas' SP Survey in E-Biking in Switzreland (EBIS)

Challenge 2: Behavior of cyclists



Meister (2022)

Value of Distance «VoD»

- 1 km of bike path feels like 0.22 km

Challenge 3: Mode choice and change of acitivities

1. Large changes of road infrastructure
2. But traditional models typically account only for marginal change
3. Combined activity-based & agent-based model system (SBB SIMBA MOBi)

Challenge 4: Calibration

- Analysis tool, developed by Eduardo Falbel

Summary Subproject H

- Assessing the impacts of the E-Bike City policy direction
- Extending the traditional transport planning toolkit with methods for cycling and large changes

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Subproject I: Costs to convert into an E-bike city & expected change in accident risks

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Swiss Federal Office of Energy SFOE

EPFL IBI IFU geoinformation engineering eth zurich IRL IVT D BAUG

Costs of creating the E-Bike City & expected changes in accident risks.

1

2

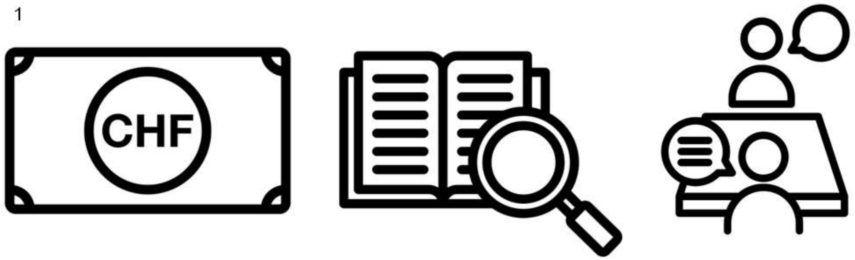
Research Questions: Costs and Safety

1

2

Research Methods: Literature, Interviews & spatial analyses

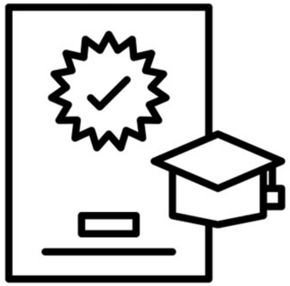
1



2

Results so far

12



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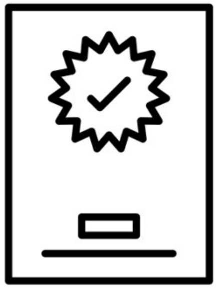

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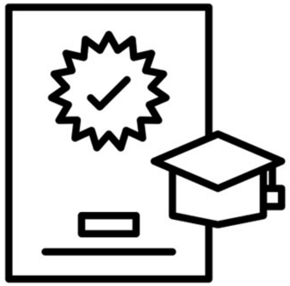
Results so far

12



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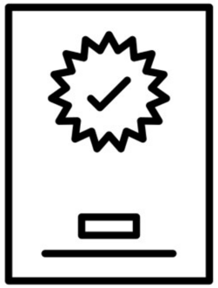

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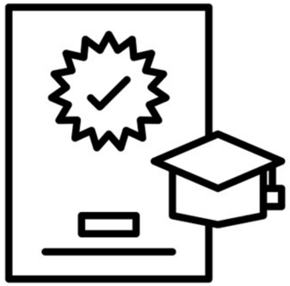
Results so far

12



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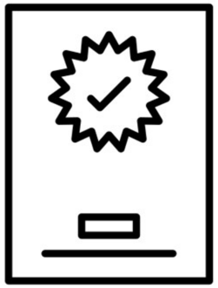

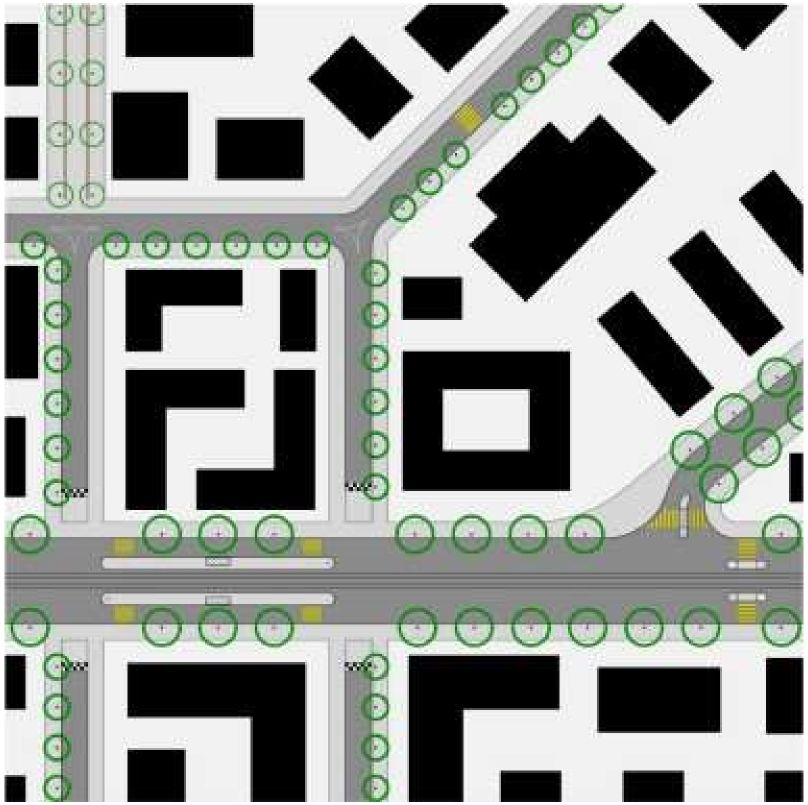

5

Open Questions

Where/how can we find reliable data about completed bicycle infrastructure projects?

200 square meters of paint
3 Signs
1 Bicycle symbol
+ 1 Crosswalk

10’000 CHF ± 10%

≠

6 Velovorzugsroute Altstetten

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References

1 Christian Beutler / Keystone
2 Steffen Schmidt / Keystone
3 Annick Ramp / NZZ
4 Stadt Zürich https://www.stadt-zuerich.ch/site/velo/de/index/randsteine.html
5 Stadt Zürich https://www.stadt-zuerich.ch/ted/de/index/taz/erhalten/standards_stadtraeume_zuerich/raumtypen/strassen_wege.html
6 Ennio Leanza / Keystone
Icons from Noun Project

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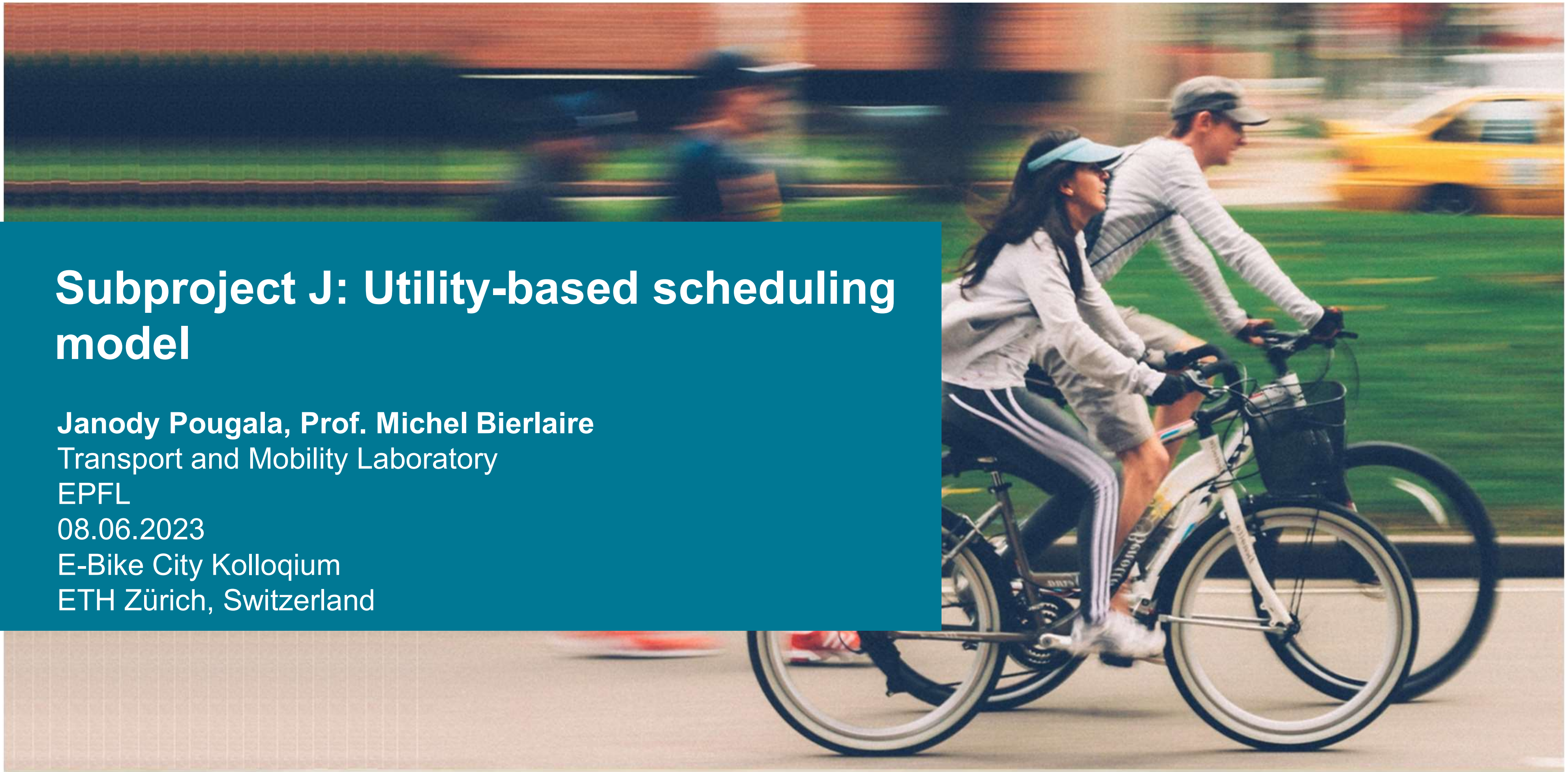
E-Bike City / D-BAUG Lighthouse Project



Subproject J: Utility-based scheduling model

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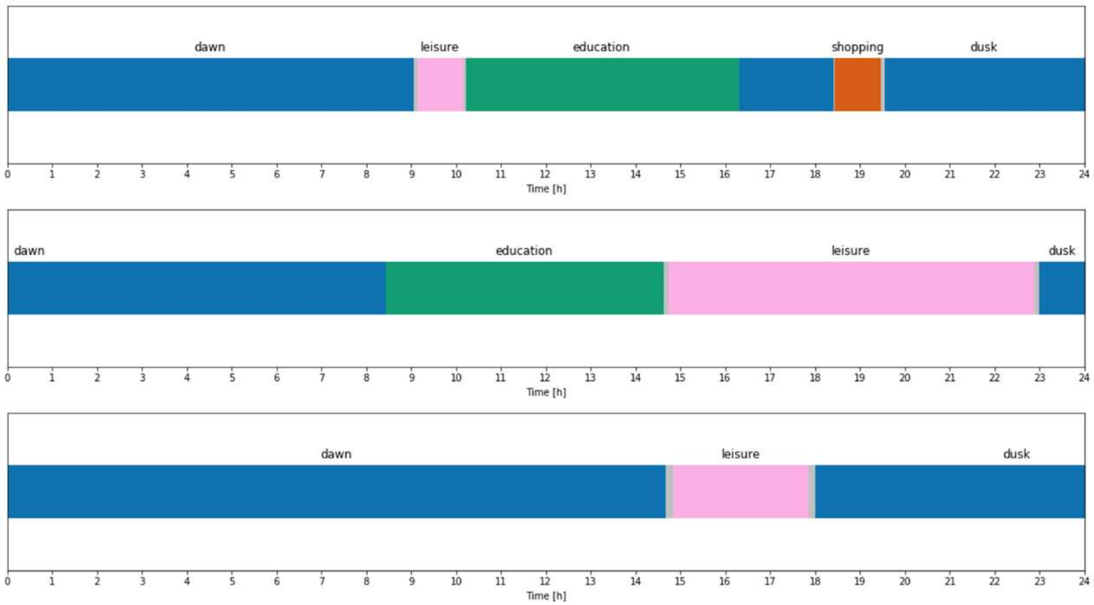
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

EPFL IBI IfU geoinformation engineering IRL IVT D BAUG

Motivation

Main goal: estimating robust and behaviorally interpretable parameters to model activity-travel behavior

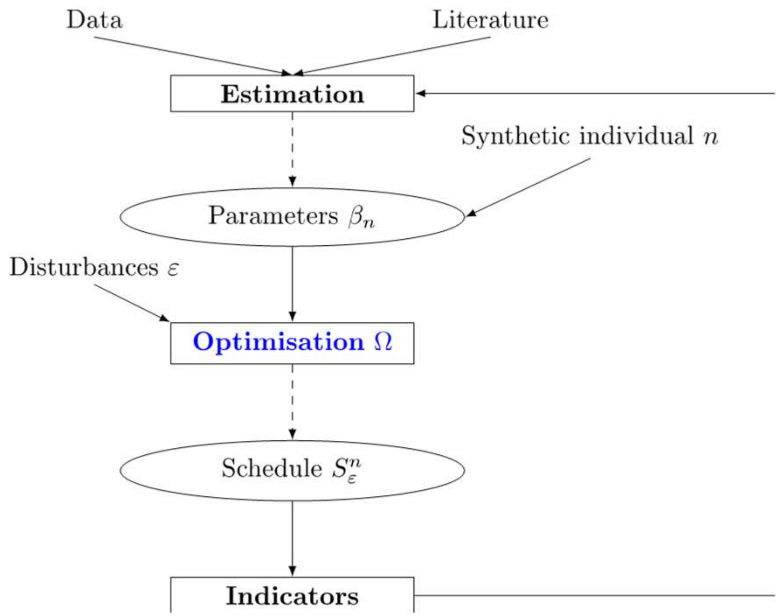
- Particularly, deriving behavioral indicators (value of time, elasticity) to evaluate impacts of e-bike city
- Improving the realism of microsimulations, including activity and travel dimensions



Methodology

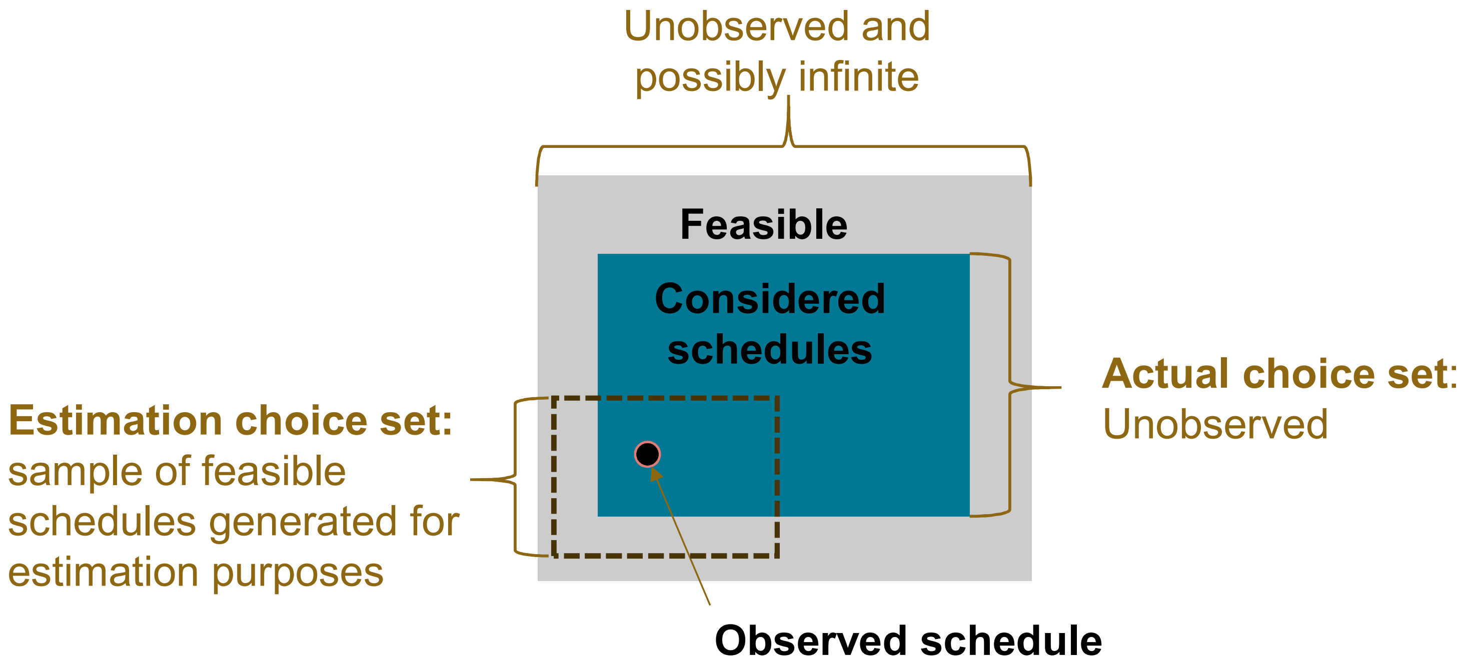
1. Application of OASIS: optimisation framework to simulate daily activity schedules, with simultaneous integration of activity choice dimensions (activity participation, timiing, location, mode…)

2. Parameter estimation component of the framework:
   1. Choice set generation
   2. Discrete choice estimation of parameters



Methodology

1. Choice set generation: generate a choice set of feasible schedules containing a mix of high and low probability schedules using the Metropolis-Hastings algorithm



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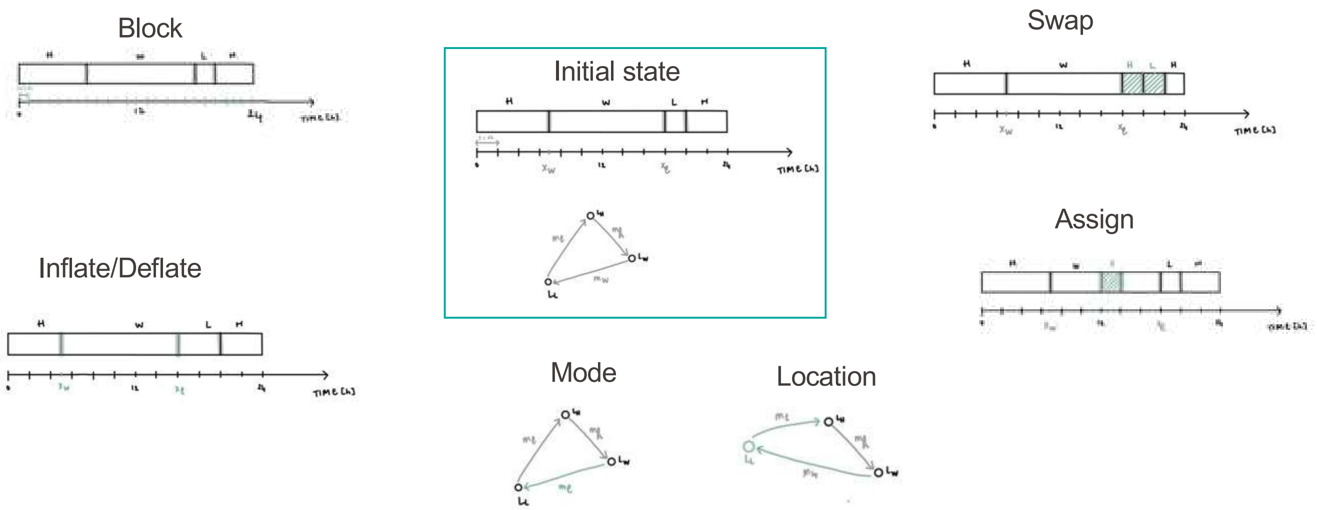


Methodology

1. Utility specification:
   - MATSim default scoring function (Charypar & Nagel 2005): linear-in-parameters start time utility, non-linear (log) duration

$$U_S = U \sum_{a=0}^{A-1} (U_a^{\text{duration}} + U_a^{\text{start time}} + U_a^{\text{travel}})$$

$$U_a^{\text{duration}} = \max\left[0, \beta_{\text{act}} \tau_a^* \ln\left(\frac{\tau_a}{\tau_a^* \exp(-A/(\rho \tau_a^*))}\right)\right] + \beta_a^{\text{short}} \delta_a^{\text{short}}$$

$$U_a^{\text{start time}} = \beta_a^{\text{early}} \delta_a^{\text{early}} + \beta_a^{\text{late}} \delta_a^{\text{late}}$$

2. Comparison with other utility specifications:

OASIS (Pougala et al, 2022)
Linear start time and duration

$$U_S = U + \sum_{a=0}^{A-1} (U_a^{\text{participation}} + U_a^{\text{start time}} + U_a^{\text{duration}} + \sum_{b=0}^{A-1} U_{a,b}^{\text{travel}})$$

$$U_a^{\text{start time}} = \theta_a^{\text{early}} \max(0, x_a^* - x_a) + \theta_a^{\text{late}} \max(0, x_a - x_a^*) + \varepsilon_{\text{start time}}$$

$$U_a^{\text{duration}} = \theta_a^{\text{short}} \max(0, \tau_a^* - \tau_a) + \theta_a^{\text{long}} \max(0, \tau_a - \tau_a^*) + \varepsilon_{\text{duration}}$$

PlanomatX (Feil, 2010)
No start time, “S-shaped” duration

$$U_S = \sum_{a=0}^{A-1} (U_a^{\text{act}} + U^{\text{travel}})$$

$$U_a^{\text{act}} = U_a^{\min} + \frac{U_a^{\max} - U_a^{\min}}{(1 + \gamma_a \exp \beta_a [\alpha_a - \tau_a])^{1/\gamma_a}}$$

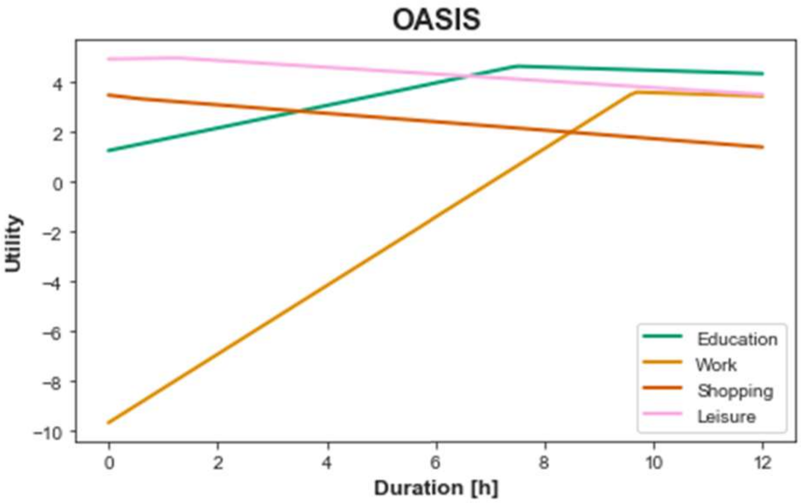
Initial tests

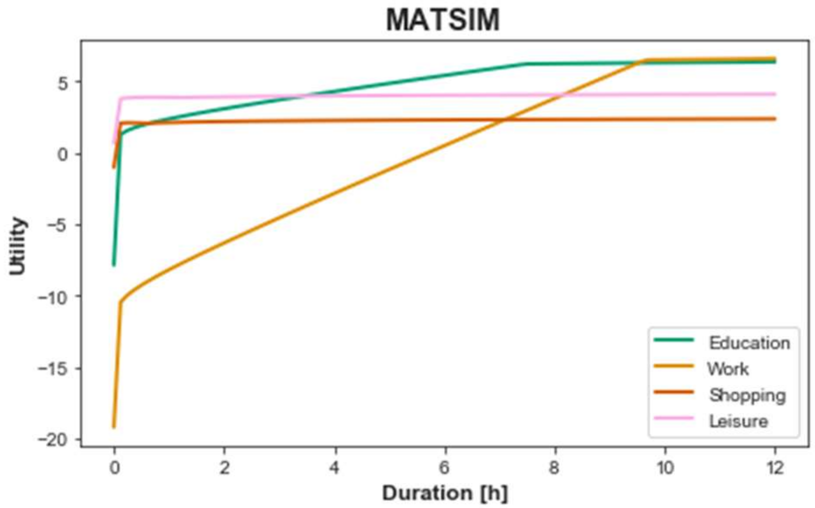
1. Parameters estimated with Biogeme (Bierlaire, 2023)
2. Dataset: Swiss MZMV 2015 (BFS & ARE, 2015), sample of Lausanne students (236 individuals)

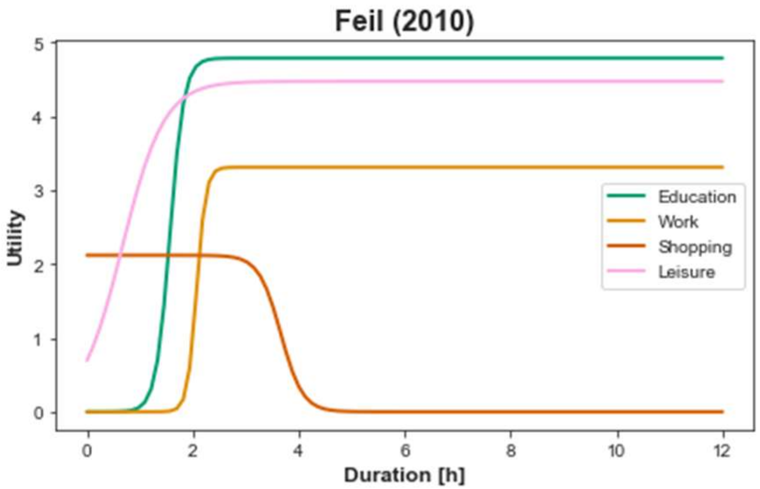
MATSim

Parameter	Param. estimate	Rob. std err	Rob. t-stat	Rob. p-value
β_{act}	0.0514	0.00974	5.27	1.34e-07
Education: early	-1.6	0.449	-3.57	0.00036
Education: late	-1.01	0.291	-3.48	0.00051
Leisure: late	-0.467	0.122	-3.84	0.00012
Shopping: early	-0.476	0.119	-4.01	6.04e-05
Shopping: late	-0.293	0.0842	-3.48	0.00049
Work: early	-2.75	0.712	-3.87	0.000111
Work: short	-1.59	0.493	-3.22	0.00126
Summary statistics				
$L(0) = -593.8925$				
$L(\hat{\beta}) = -248.568$				
$\bar{\rho}^2 = 0.56$				

Initial tests







Next steps

1. Next step: Improving utility specification
   - Non-linear specification for start time component
   - Estimation of travel components (time and cost) – with PostCarWorld data
   - Latent class analysis for activity desired timings

2. Next step: Integration of OASIS and MATSim
   - Input-output compatibility
   - Potential contributions (e.g. input only or other stage of the simulation?)

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Literature List

Bierlaire M. (2023). A short introduction to Biogeme. Report TRANSP-OR 230620

Charypar D. and Nagel K., (2005) “Generating complete all-day activity plans with genetic algorithms,” *Transportation (Amst).*, vol. 32, no. 4, pp. 369–397

Feil M., (2010) “Choosing the Daily Schedule: Expanding Activity-Based Travel Demand Modeling,” ETH Zürich

Pougala J., Hillel T., Bierlaire M. (2022). OASIS: Optimisation-based Activity Scheduling with Integrated Simultaneous choice dimensions. Report TRANSP-OR 221124

BFS & ARE (2015) “Verkehrsverhalten der Bevölkerung” Neuchâtel, Bern

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Confederaziun svizra

Bundesamt für Energie BFE
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