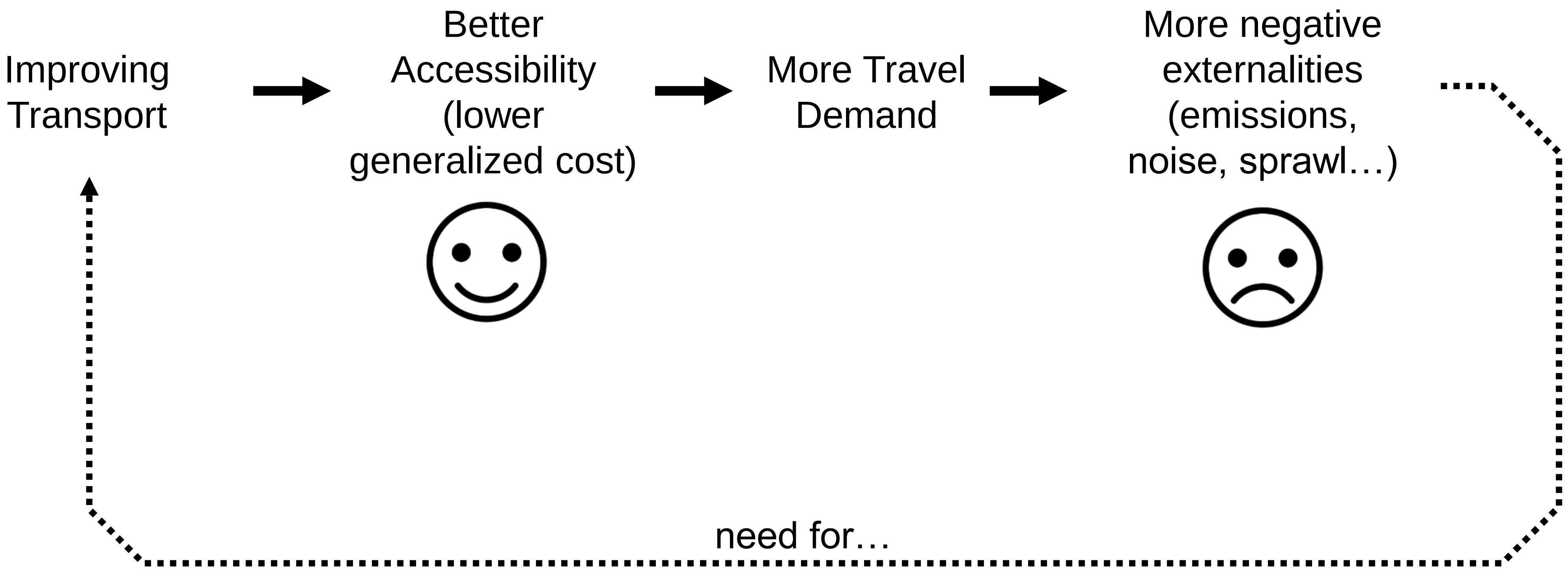
E-Bike City
Designing Sustainable Streets

Clarissa Livingston
E-Bike City Kick-Off Event
23 November 2022, 13:30 – 18:00
ETH Zurich Zentrum, Zurich, Switzerland

Dilemma of current transport policies



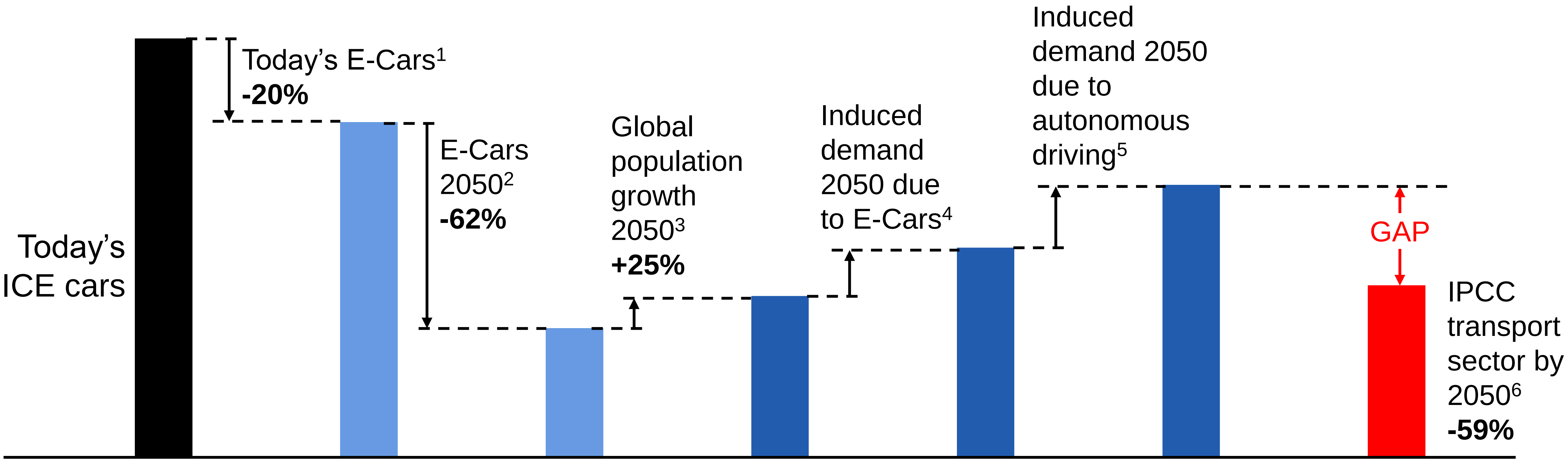
Axhausen, K.W. (2020) COVID-19 and the dilemma of transport policymaking, *disP - The Planning Review*, **56** (4) 82–87.

See also: Alcott, B. (2005) Jevons' paradox, *Ecological Economics*, **54** (1) 9–21.

Dilemma of current transport policies

Rosengartenstrasse, Zürich (Keystone)

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) Good to go? Assessing the environmental performance of new mobility, International Transport Forum, Corporate Partnership Board, Paris.

[2] 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

[3] UN (2019) World urbanization prospects: The 2018 revision, United Nations, Department of Economic and Social Affairs, Population Division, New York.

[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) The future cost of electrical energy storage based on experience rates, *Nature Energy*, **2** (8) 17110.

[5] 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.

[6] IPCC (2022) Climate change 2022, mitigation of climate change, summary for policymakers, Intergovernmental Panel on Climate Change, Geneva.

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 lifestyles[3]

[1] Shaheen, S. (2018) Shared mobility: The potential of ridehailing and pooling, in Sperling, D. (ed.) Three Revolutions, 55–76, Island Press, Washington DC.

[2] 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.

[3] 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.

Need for a behavior change

"…technological innovations can only get us part of the way to sustainable transport, and this may facilitate more travel"[1]

"…it is most unlikely that technical solutions alone can deliver anywhere near the reductions needed"[2]

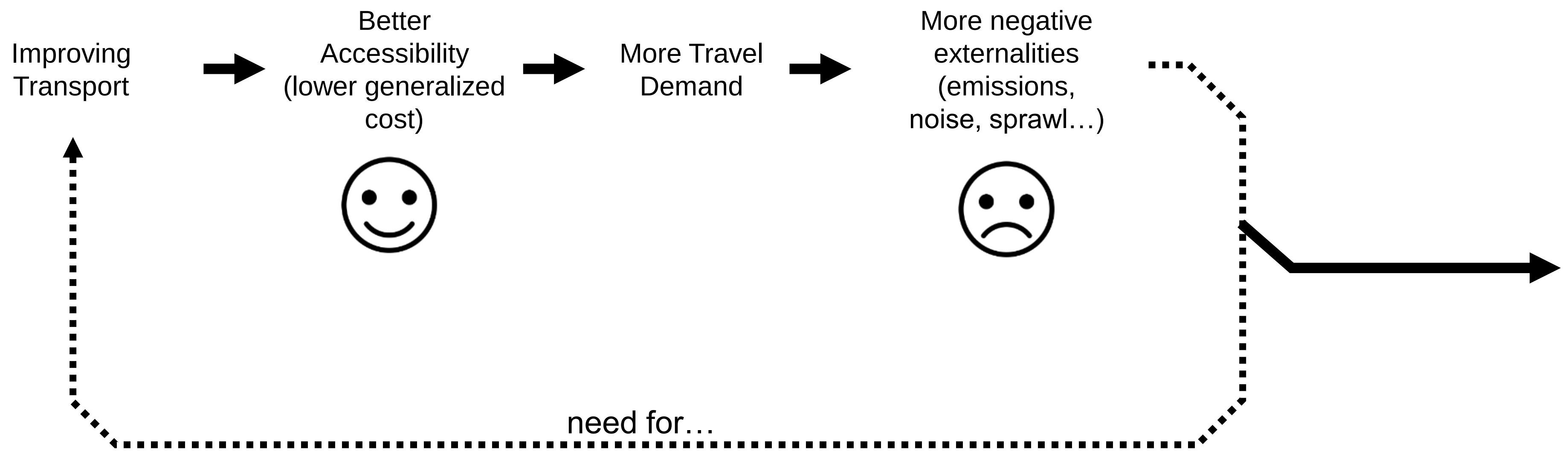
"The only strategy that can achieve the objectives … combining a quick radical shift to lighter electric vehicles and non-motorized modes ..."[3]

[1]Banister, D. (2011) Cities, mobility and climate change, *Journal of Transport Geography*, **19** (6) 1538–1546.

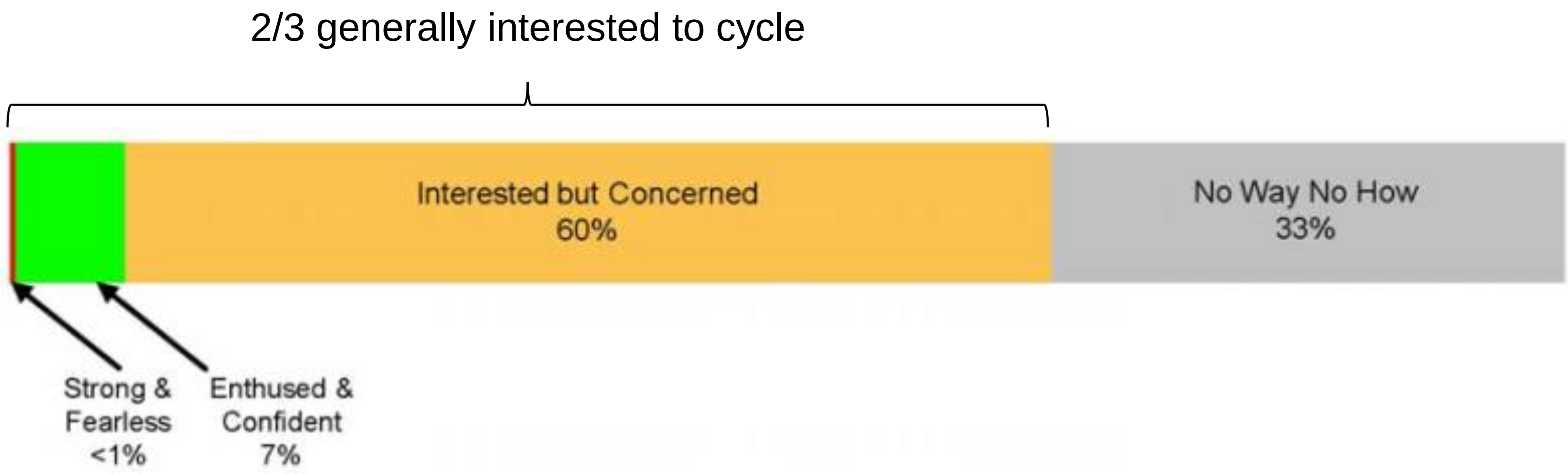
[2]Moriarty, P. and D. Honnery (2013) Greening passenger transport: A review, *Journal of Cleaner Production*, **54**, 14–22.

[3]de Blas, I., M. Mediavilla, I. Capellán-Pérez and C. Duce (2020) The limits of transport decarbonization under the current growth paradigm, *Energy Strategy Reviews*, **32**, 100543.

A cycling revolution as a way out?



Cycling: Four types of transportation cyclists



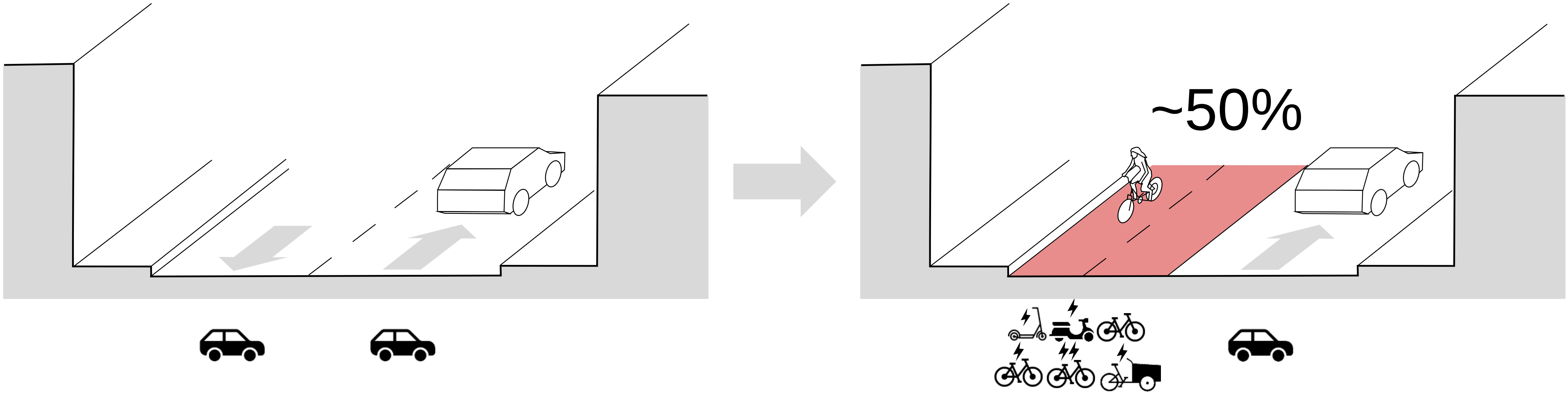
Geller, R. (2009) Four types of transportation cyclists, https://www.portlandoregon.gov/transportation/article/158497, City of Portland Oregon, Portland, April 2022.

E-Bike = A change enabler?

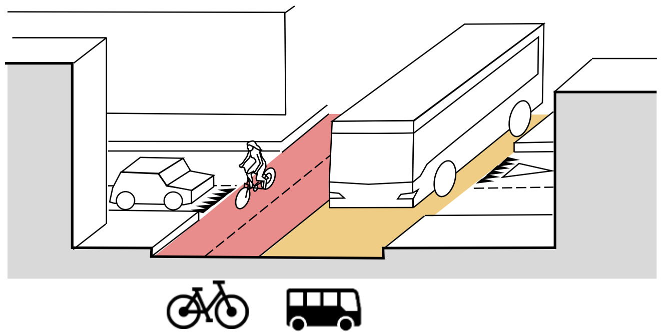
See more here: Rérat, P. (2021) The rise of the e-bike: Towards an extension of the practice of cycling?, *Mobilities*, **16** (3) 423–439.

The E-Bike City

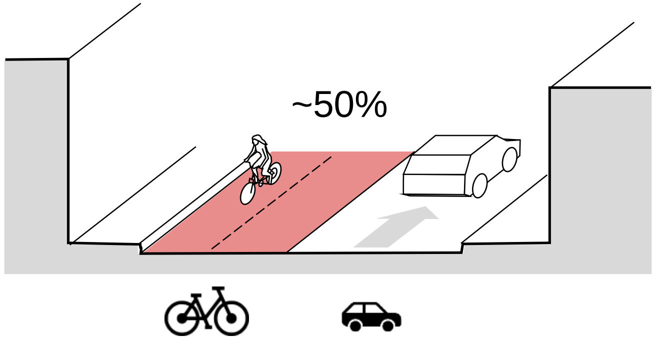
Devote ~50% of road space to micromobility e.g. bicycles, e-bikes, cargo-bikes, e-scooters, etc.



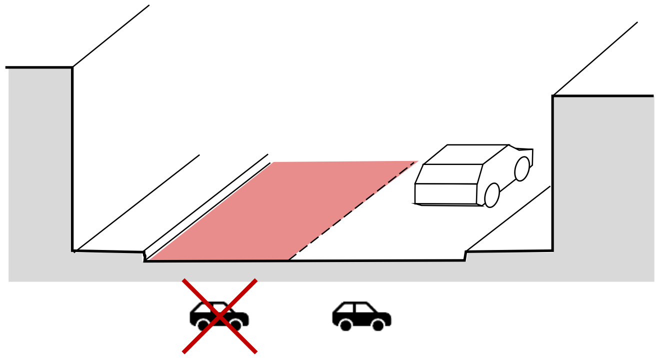
E-Bike City: Basic principles



Absolute priority for cycling and public transport on intersections



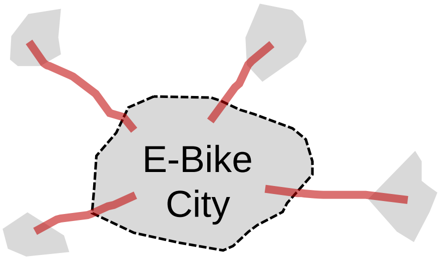
Safe cycling infrastructure equally distributed across the e-bike city



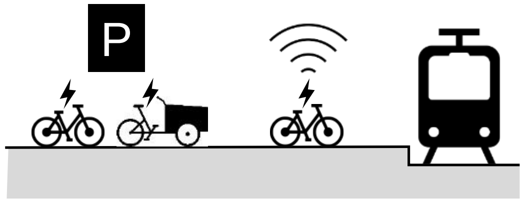
Reducing the attractiveness of driving

E-Bike City: Design Elements

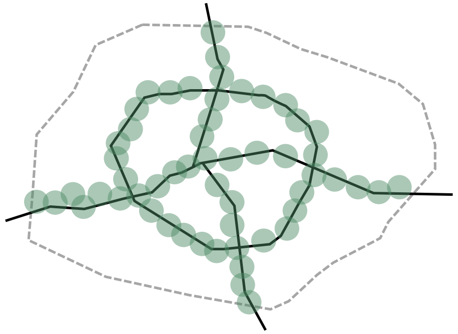
Special arrangements for emergency and utility vehicles



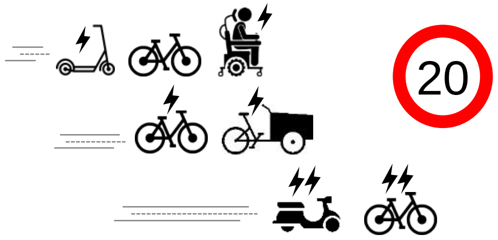
Intercommunal e-bike highways



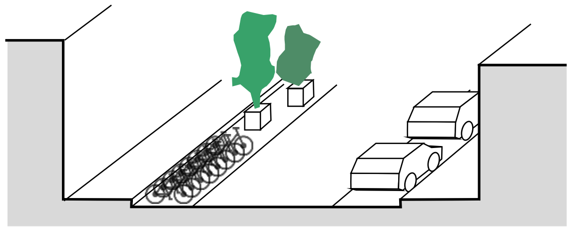
Integration with public transport for longer distances / bad weather



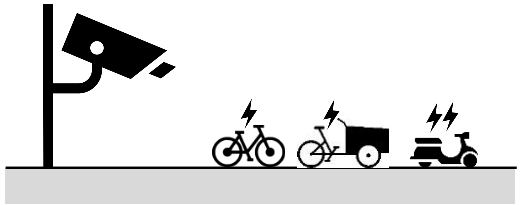
A basic cycling network with weather protection, e.g., by trees



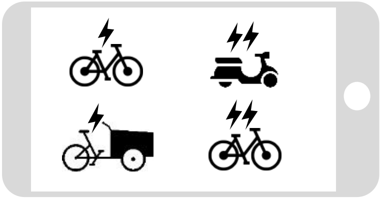
Infrastructure for heterogeneous micromobility vehicles and/or local speed limits



Converting a part of car parking into bicycle parking + parklets



Monitored parking for expensive e-bikes



Sharing schemes provide everybody an access to the right vehicle

The Subprojects of the E-Bike City

Challenges

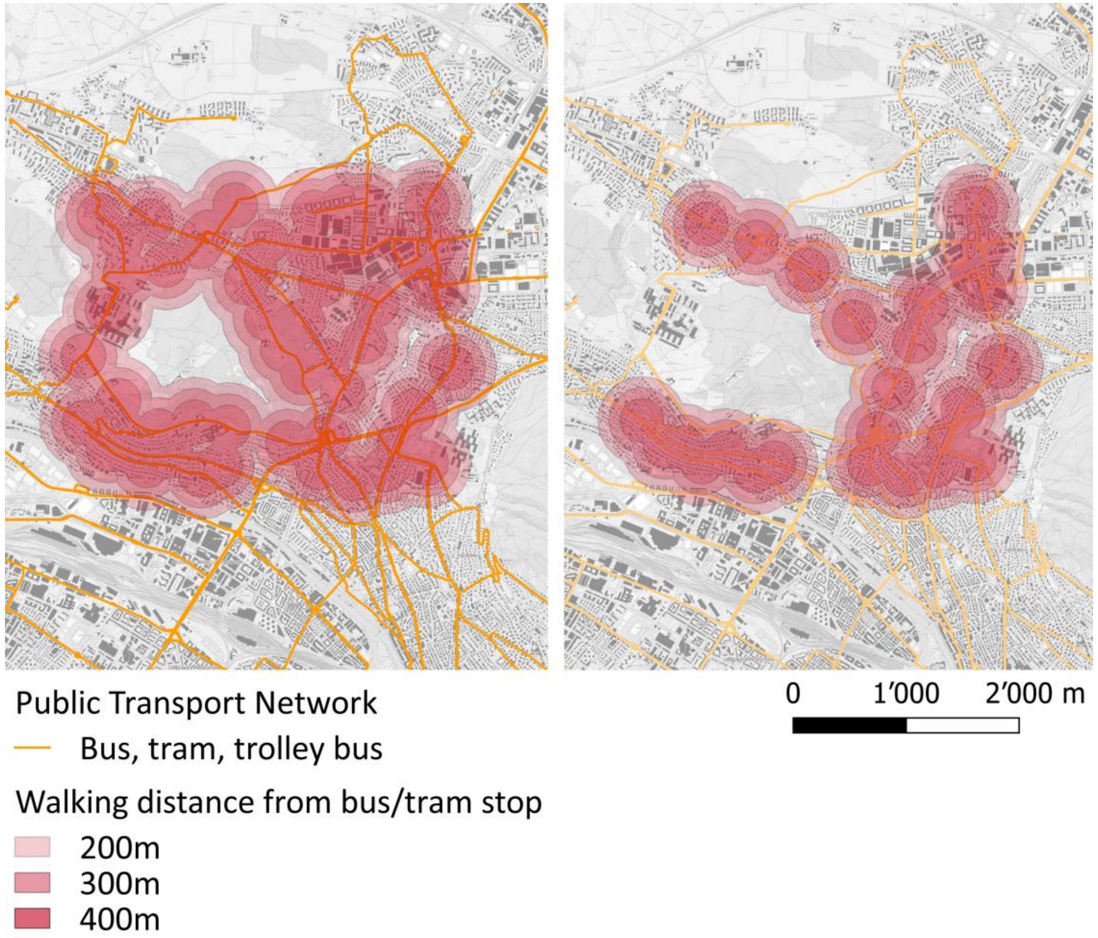
E-Bikes and bicycles are generally not considered to be “all weather” or “all purpose” modes.

Thus, public transit will be an essential element to the E-Bike City, and will need to cope with “bi-modal” demand.

Challenges

- *“Flexibility”:*
  Expect considerable variations in demand:
  “Good” weather → use E-Bike,
  “Bad” weather → use public transport
  Requires a flexible network that can adapt.
- *“Accessibility”:*
  Public transport provides basic accessibility.
  Must be guaranteed for both low- and high-demand scenarios.
- *“Efficiency”:*
  Varying demand affects the number of required vehicles/drivers etc., threatening the overall efficiency.
- *“Stability”:*
  Reducing road capacity for cars is likely also reducing capacity for buses (public transport)

Accessibility by Network:

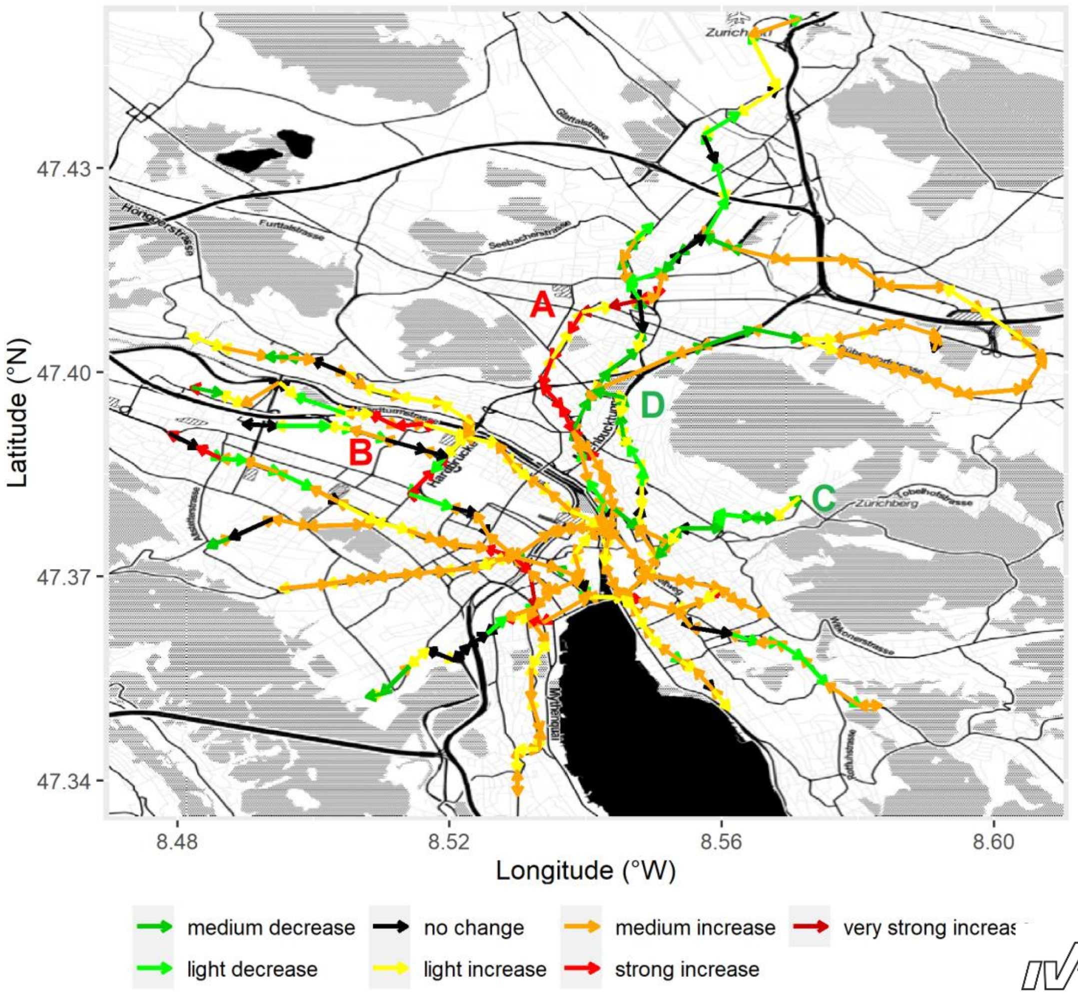


Subproject B: Multi-Scale Responsive Public Transport Planning for Bi-Modal Demand

Goals

- Understand the effects of exogenous uncontrollable factors (such as weather) on modal split
- Develop a mode choice model able to predict the modal split given information on these exogenous, uncontrollable factors
- Develop new and robust time-table and network optimization tool to help create both transit networks and operational plans which allow transit agencies to react to the bi-modal demand resulting from such varying modal splits

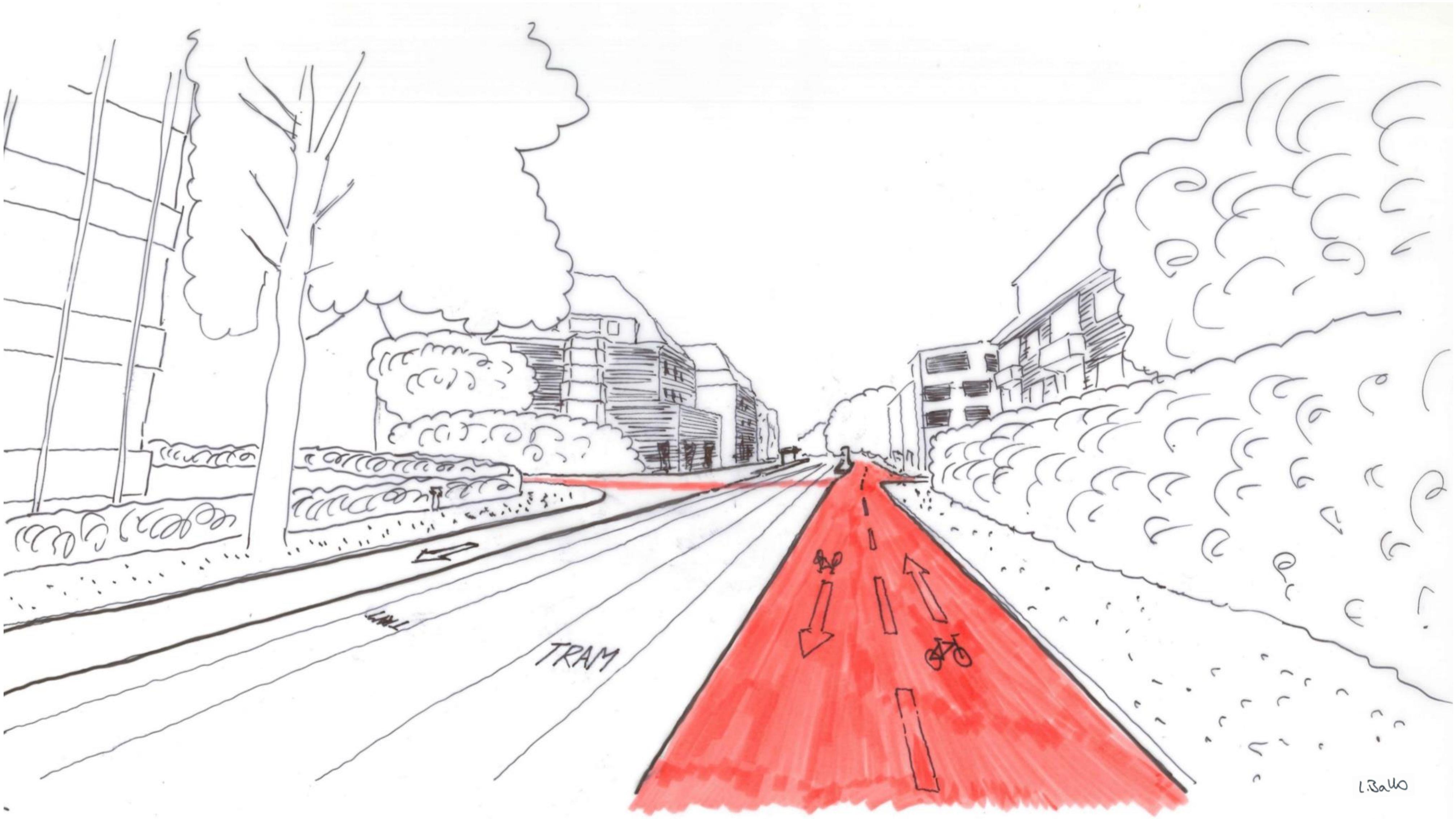
Effect of Rain on Usership:



Challenges

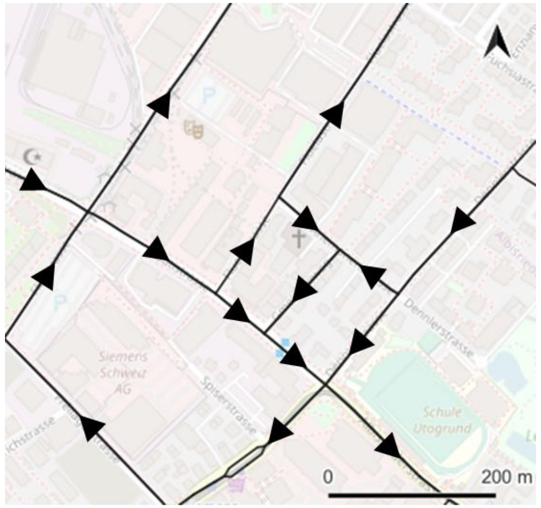
- Devoting 50% of the road space to bikes, E-Bikes, and other micro-mobility modes will require the transformation of many streets into one-way streets.
  - How best to do so, and still provide vital access to all parts of the city and keep travel time increases and emissions from detours minimized?
- Simply providing more space is not enough:
  - How does this space need to be designed to be attractive enough to convince more people to use active modes (bikes, E-Bikes, etc.)
  - How should this space be design to ensure the different forms of micro-mobility, with their different needs and speeds, can share this space safely and comfortably?

Subproject C: Designing the New Network and Its Capacity



Subproject C: Designing the New Network and Its Capacity

Step 1
Network redesign



Step 2
Redesign of Streets and Nodes

Step 3
Agent-based modelling (MATSim) of the resulting effects

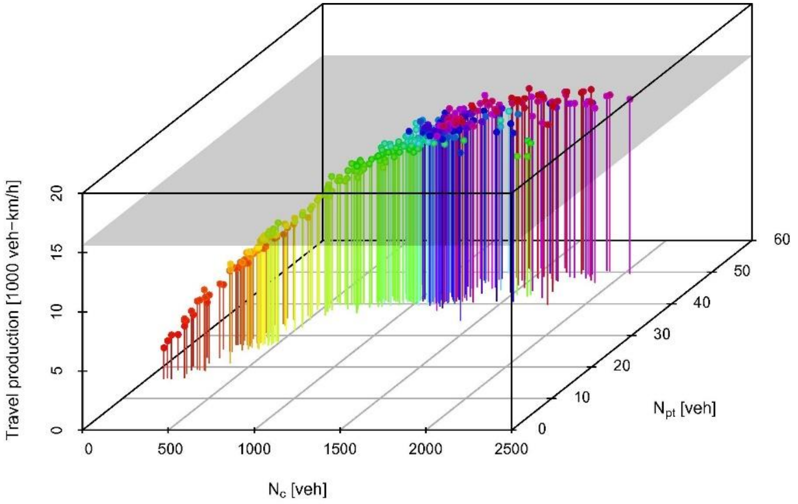
Ziemke, D., K. Nagel and R. Moeckel (2016) Towards an agent-based, integrated land-use transport modeling system, *Procedia Computer Science*, **83**, 958–963.

Challenges

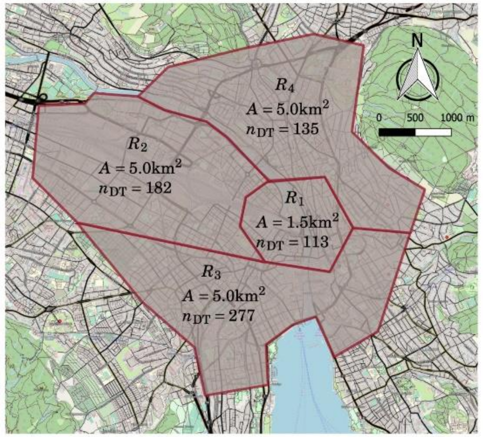
- Devoting 50% of the road space to bikes, E-Bikes, and other micro-mobility modes will require the transformation of many streets into one-way streets – which reduces capacity for cars.
  - Will this reduction in capacity cause more congestion? Or will the separation of modes and a shift to cycling perhaps improve it?
  - If congestion is increased, how can it be managed? Could road space be flexibly allocated to manage peak flows?

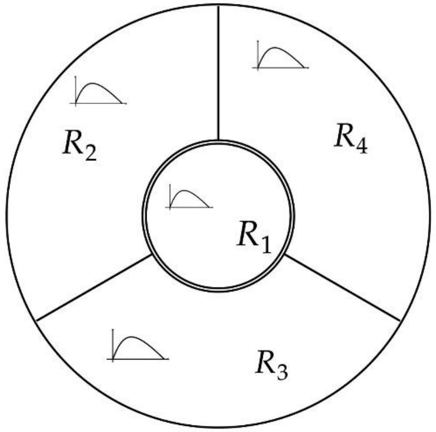
Subproject D: Dynamic Space Allocation for Different Transport Modes

1. Motivation: Achieving a balance between facilitating eco-friendly transport modes and preserving network traffic efficiency
2. Objective: Ensuring an efficient utilization of limited urban road space
3. Multi-modal network traffic modeling using macroscopic fundamental diagrams (MFDs)



3D-MFD for cars and buses in the city center of Zurich [1]





Subregions design and network model for traffic assignment based on MFDs in the city of Zurich [2]

- Forecasting the influence of new road space reallocation design on urban traffic performance
- Optimizing road space allocation strategies based on the spatial-temporal variation of traffic demand

[1] 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.
[2] Genser, A., & Kouvelas, A. (2022). Dynamic optimal congestion pricing in multi-region urban networks by application of a Multi-Layer-Neural network. *Transportation Research Part C: Emerging Technologies, 134*, 103485.

Challenges

- Devoting 50% of the road space to bikes, E-Bikes, and other micro-mobility modes is a base value –
  - Exactly how much space is devoted solely to micro-mobility could vary across the network. But how best to design this micro-mobility network?

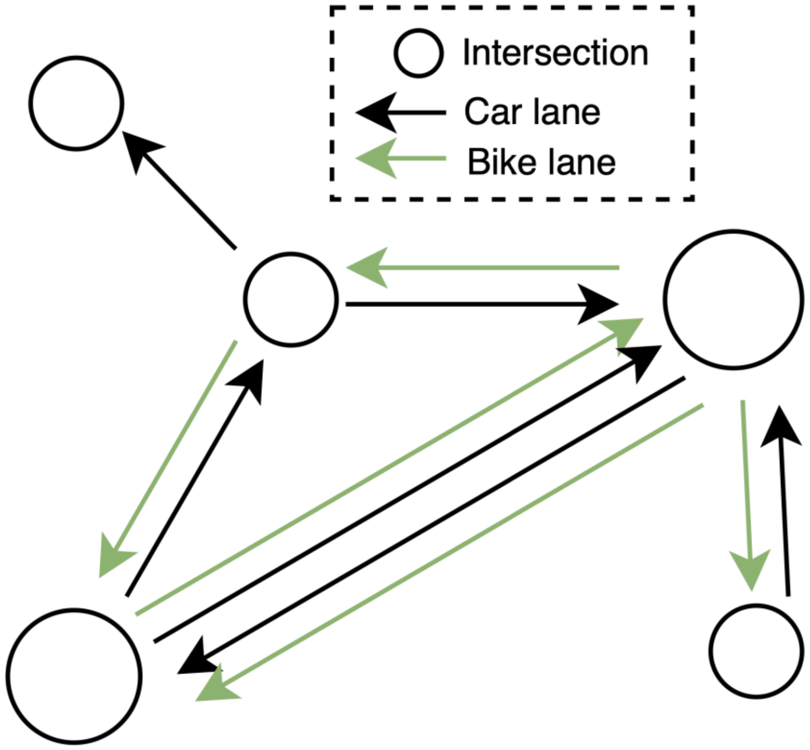
Subproject E: Spatial Optimization of Large-Scale Street Network Redistribution

Motivation:

1. Complimenting Subproject C (network design)
2. Desired: (Global) optimization with spatial criteria

Goals:

1) Develop GIS tools
2) Optimize lane allocation according to spatial constraints



Subproject E:
Spatial Optimization of Large-Scale Street Network Redistribution

1) GIS tools: Compute

1. Multi-modal accessibility
2. Exposure levels of cyclists

a) Air quality (Opensense) b) Mutli-modal accessibility c) Noise levels (BAFU)

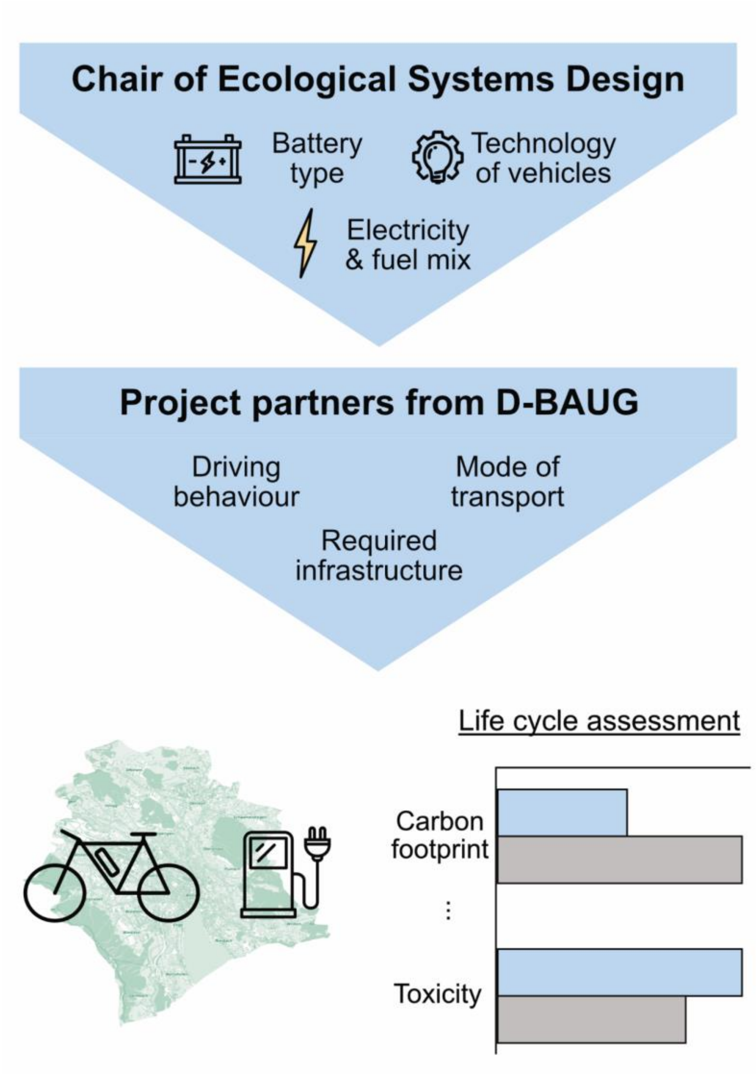
2) Optimization:

1. Maximize flows and accessibility
2. Minimize exposure on bike lanes
3. Subject to street capacity constraints

Challenges

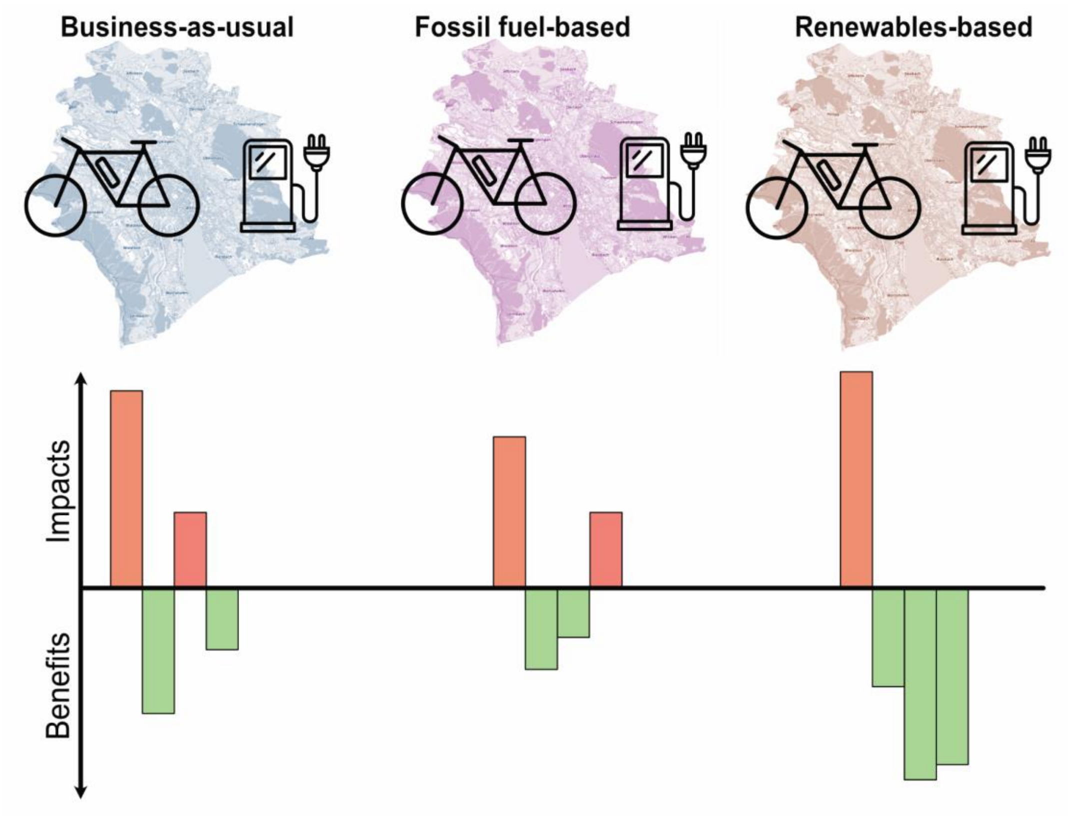
- The creation of streets that feel safe and are comfortable to use for cyclists, e-bikers, and other micro-mobility users will increase the purchase, use, and disposal of battery-powered micro-mobility.
  - What kind of effect will this have on the environment from a life cycle perspective?
- How will the entirety of the changed transport system affect the environment? CO2 emissions are part of this, but also other emissions, the use of resources, and pollution caused by the proposed changes should be evaluated.

Subproject F:
Assessment of Environmental Benefits and Impacts of the E-Bike City



1. Collection & improvement of life cycle inventories of relevant supply chains
2. Assessment of technology trajectories & use-patterns
3. Assessing a comprehensive set of environmental impacts

Subproject F:
Assessment of Environmental Benefits and Impacts of the E-Bike City



1. Optimization of environmental benefits of an e-bike city by developing scenarios and identifying relevant parameters (e.g., energy supply)

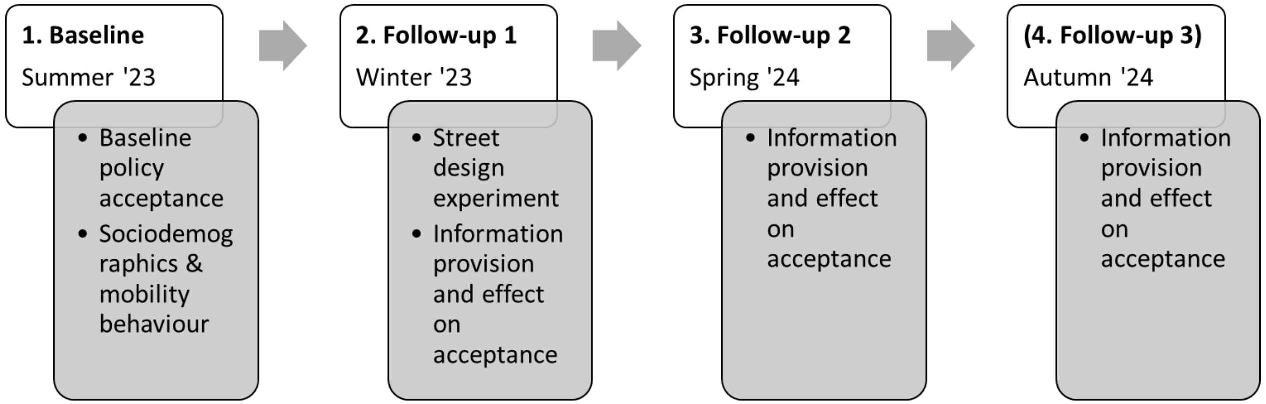
ESD ecological systems design

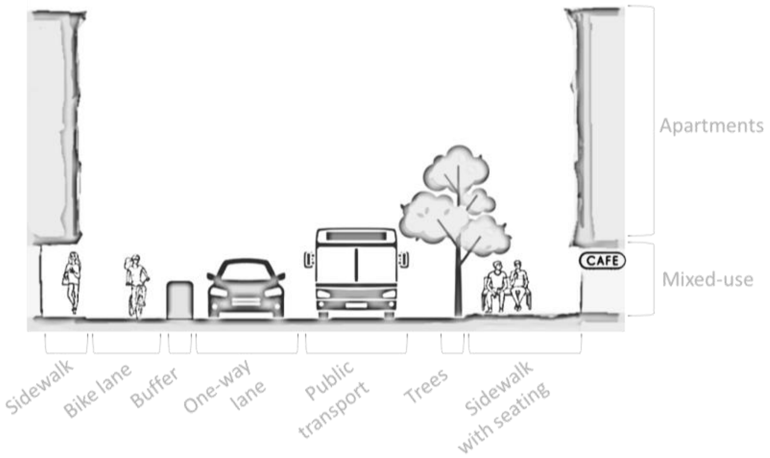
Challenges

- The E-Bike City can only become reality if the public thinks it is a good idea – if the public accepts it. Is it likely that such a radical idea will gain enough public support to be implemented?

Subproject G: Policy Implementation of an E-Bike-City

- **RQ: What requirements do residents place on the policy implementation of an e-Bike City?**
- Assess acceptance of an e-Bike-City policy implementation
  - Panel survey with a representative population sample of the city of Zurich
  - Role of ancillary policies and different financing mechanisms to influence public opinion
  - Measure public acceptance over time with varying scenarios and cumulative information provision (e.g. results of other subprojects)
  - Assess how street space allocation affects public acceptance





Michael Wicki, Jake Stephan, David Kaufmann
Spatial Development and Urban Policy, Institute for Spatial and Landscape Development, ETH Zürich

Challenges

- By reallocating 50% of the road space to e-bikes, bicycles, and other forms of micromobility, the accessibility of the city might (will) change.
  - By how much?
  - And how will this change affect people's daily schedules? Will they (have) to adjust the order of their activities, the location, or the number, or some combination of order, location, and number?
  - And will changes in accessibility be distributed equally? What kinds of effects of social equity might the E-Bike City have?

Subproject H: Impact Analysis of the E-Bike City

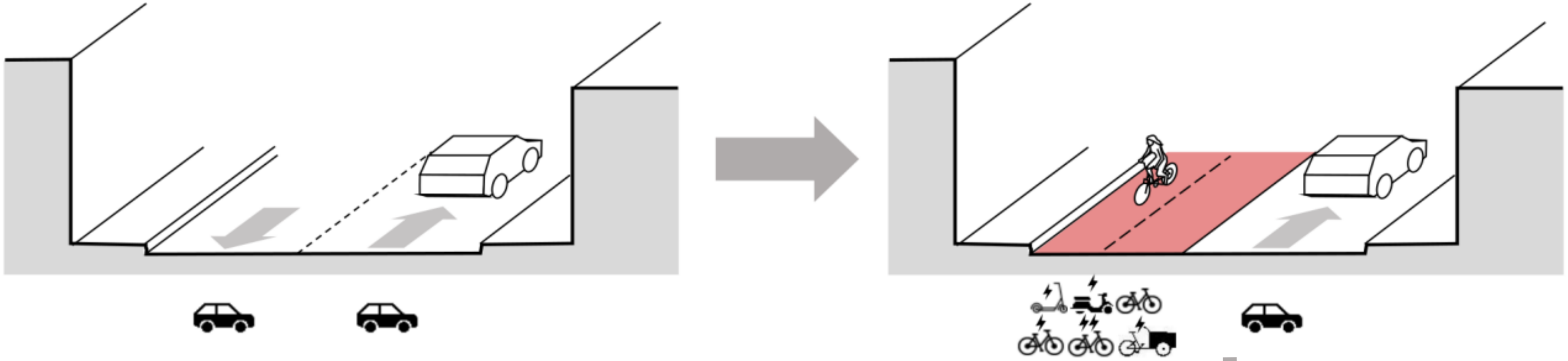
Goals:

- Assess, model, and analyze **changes in accessibility** due to the different proposed designs and policies
- Explore and model the possible **changes in activity chains** (daily schedules) due to the different proposed designs and policies
- Assess, model and analyze **changes in equity** due to the different proposed designs and policies
- Assess, model, and analyze **changes in emissions** due to the different proposed designs and policies
- Perform a series of **cost-benefit analyses** using the results of the other goals & subprojects

Challenges

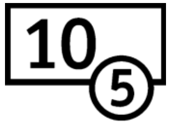
- The E-Bike City needs to be built and maintained.
  - How much will that cost?
- The E-Bike City proposes large changes how road space is distributed and designed.
  - How will accident rates and severity change if the proposed designs and policies are implemented?

Subproject I:
Costs of converting into an E-bike city and the change in accident risks



Existing Infrastructure

Infrastructure Conversion Costs



Sourced from:
- Public data
- Collaborations with private and public infrastructure providers

?

Changed Accident Risks

Sourced from:
- New studies
- Past studies

IBI

Expected Outcomes

- **A comprehensive assessment of the E-Bike City:**
  - Will it fulfill the mobility needs of the residents and other users?
  - Will it reduce the transportation system’s CO2 emissions – and perhaps other externalities?
  - What will it cost?
  - What will it look like, and operate?
  - What kind of effects will it have on accessibility, equity, and other aspects of urban life?
- **A suite of assessment and design tools – in “beta” versions**
  - Algorithms to optimize both the network and its operations
  - Methods to support the assessment of the above questions
  - Design guidelines
- **Data to support assessment**
  - Through surveys and other methods

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Special thanks to Lukas Ballo for helping to prepare these slides!
The content of the subproject-specific slides was prepared by the respective researchers – thank you!

ETH zürich

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The letter inside the () designate the subproject the chair or researcher is working on.

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