Traffic flow in a bicycle-centric city

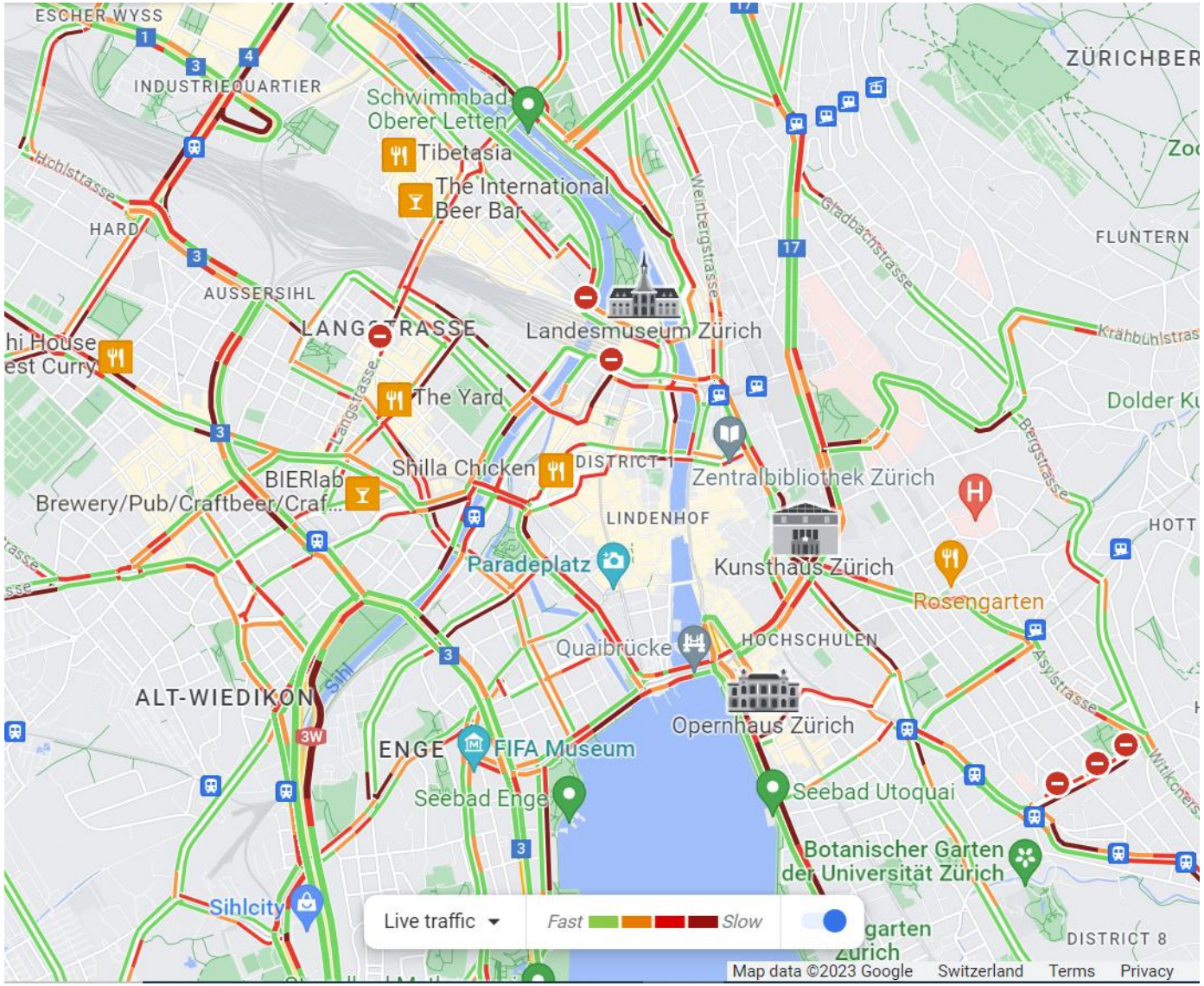
Traffic Flow in a Bicycle-centric City

ASB Meet & Share Your Research Day

26.10.2023

Ying-Chuan Ni
Traffic Engineering group (SVT), Institute for Transport Planning and Systems (IVT), D-BAUG, ETH Zurich

Traffic congestion



Solution to traffic congestion

Craig Lee/The Examiner

Solution to traffic congestion

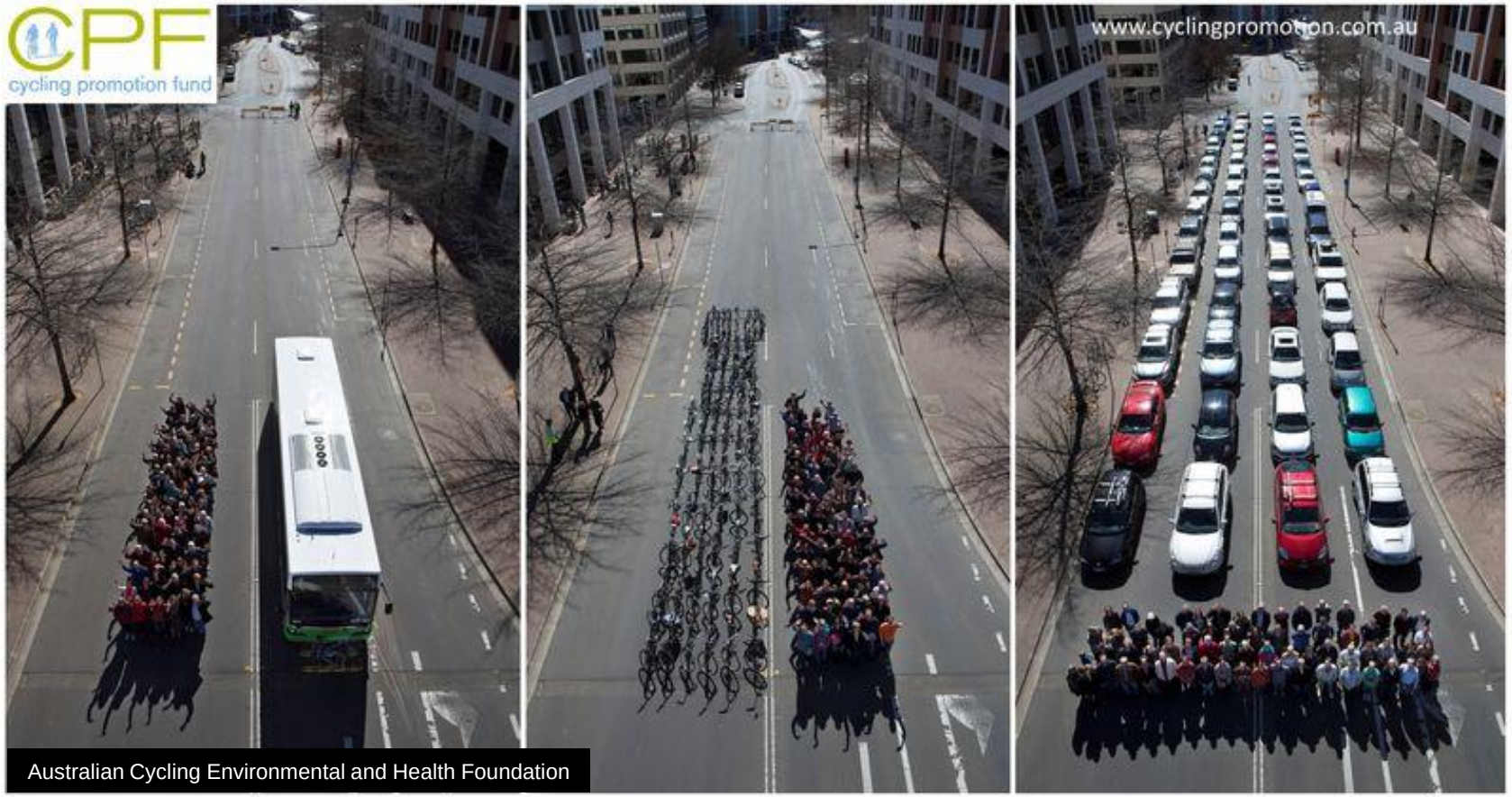
peepo/E+ via Getty Images

https://www.rolandberger.com/en/Insights/Publications/Cargo-drones-The-urban-parcel-delivery-network-of-tomorrow.html

Solution to traffic congestion

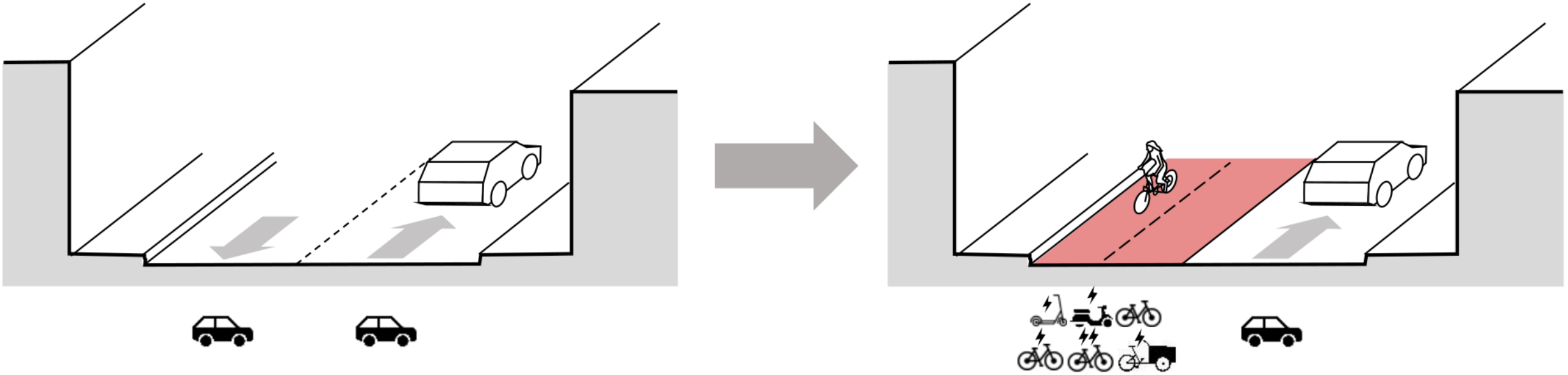
https://en.wikipedia.org/wiki/Cycling_in_Copenhagen

Solution to traffic congestion



D-BAUG lighthouse project: E-Bike City

- Motivation: Developing a sustainable urban environment
- Idea: Allocating road space to slow modes



E-Bike City concept [1]

[1] https://ebikecity.baug.ethz.ch/en/

D-BAUG lighthouse project: E-Bike City

A: Overall design and co-ordination

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

C: Designing the new network and its capacity

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

E: Data-driven mobility behavior analysis for e-bike-city feasibility assessment

F: Assessment of environmental impacts of e-bike mobility scenarios (Li-ion batteries)

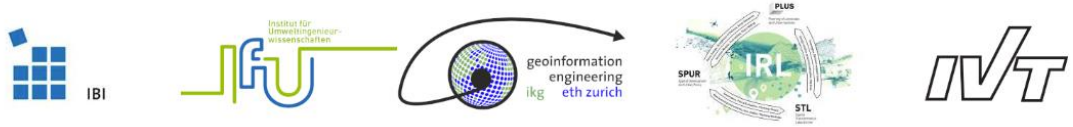
G: Mobility behavior change and implementation of an e-bike-city

H: Accessibility, behaviour and equity in the e-bike-city

I: Costs of creating an e-bike-city

J: Estimating choice models for daily schedules

Participating institutes at ETH Zurich



Meet the E-Bike City team

Principal Investigators


Prof. Kay Axhausen


Prof. Bryan Adey


Prof. Michel Bierlaire


Prof. Francesco Corman


Prof. Stefanie Hellweg


Prof. David Kaufmann


Dr. Anastasios Kouvelas


Dr. Michail Makridis

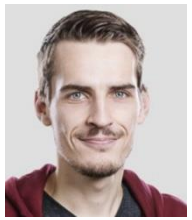

Prof. Stephan Pfister


Prof. Martin Raubal

Researchers


Dr. Milos Balac


Lukas Ballo


Florian Fuchs


Ayda Grisiute


Clarissa Livingston


Dr. Alessio Daniele Marra

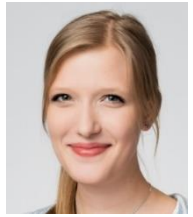

Adrian Meister


Lucas Meyer de Freitas

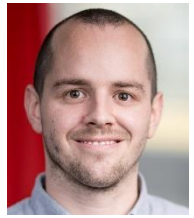

Dr. Marco Miotti


Ying-Chuan Ni


Janody Pougala


Vanessa Schenker


Claudia Sinatra


Dr. Michael Wicki

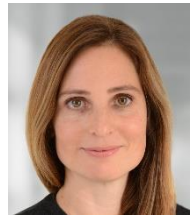

Nina Wiedemann


David Zani

Coordinator


Dr. Catherine Elliot

Media Relations


Iris Mickein

Webmaster


Patrick Scherer

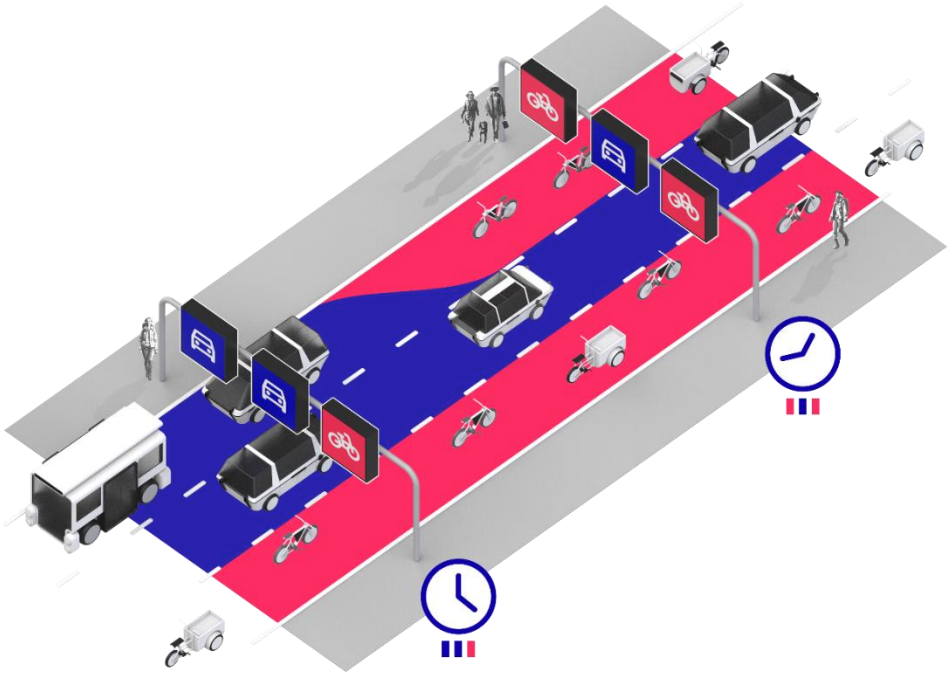
Problem in an E-Bike City

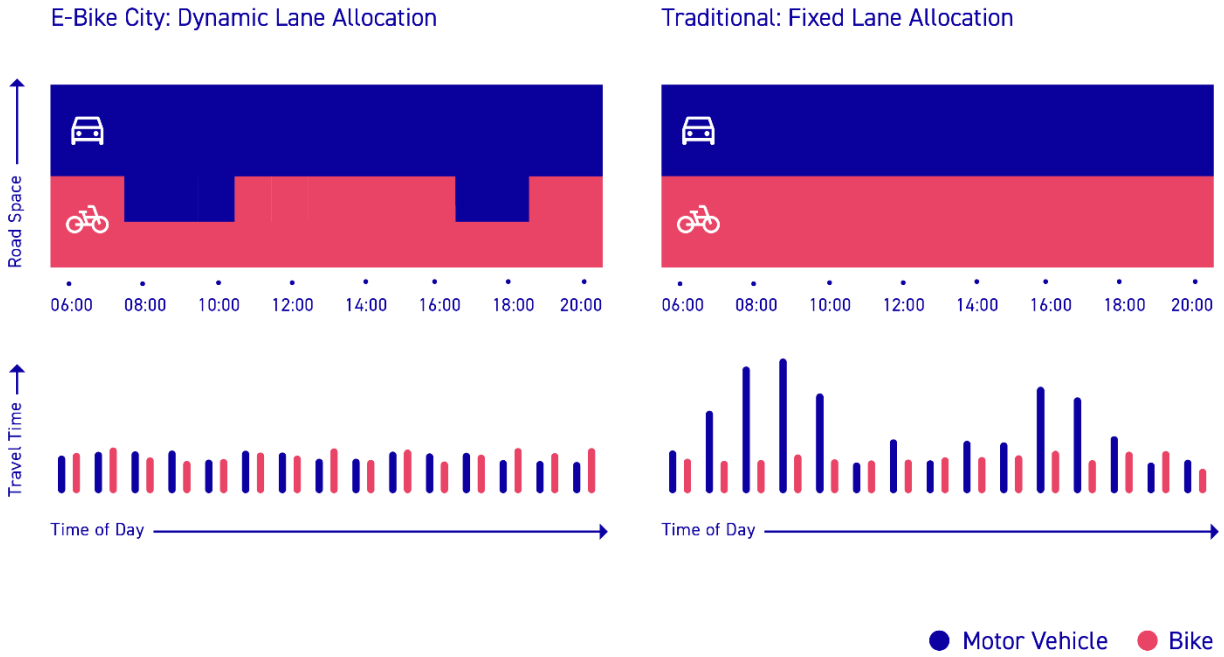
- Concern: Traffic congestion induced by the reduced road capacity for cars

Status-quo network and E-Bike City network in ArcGIS
(source: Lukas Ballo, EBC subproject C)

Subproject D: Dynamic road space allocation

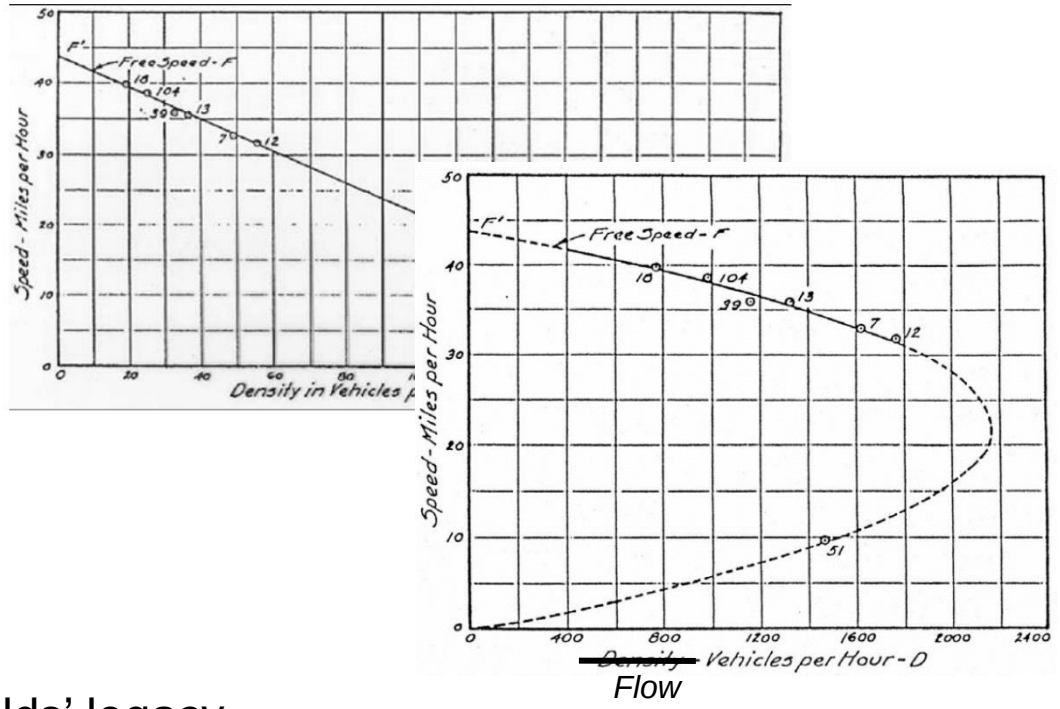
- Allocating road space to cars and bicycles based on trip pattern
- Maximizing the road space utilization efficiency
- Mitigating the negative effect (increased travel time) caused by limited space
- Taking the traffic performance of bicycles into account





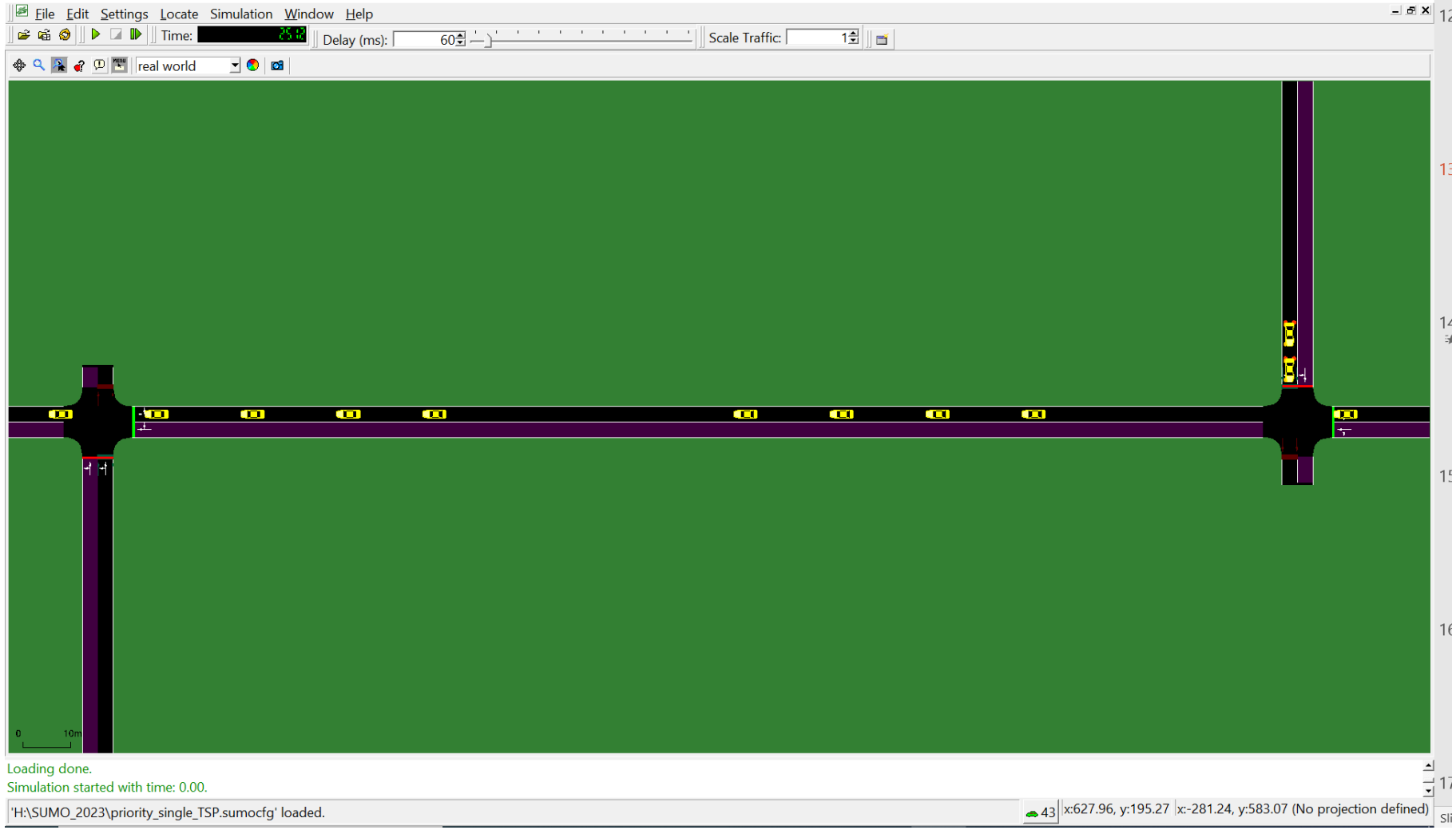
Traffic flow theory

- Fundamental diagram (FD): A relationship between flow [veh/h] and density [veh/km]



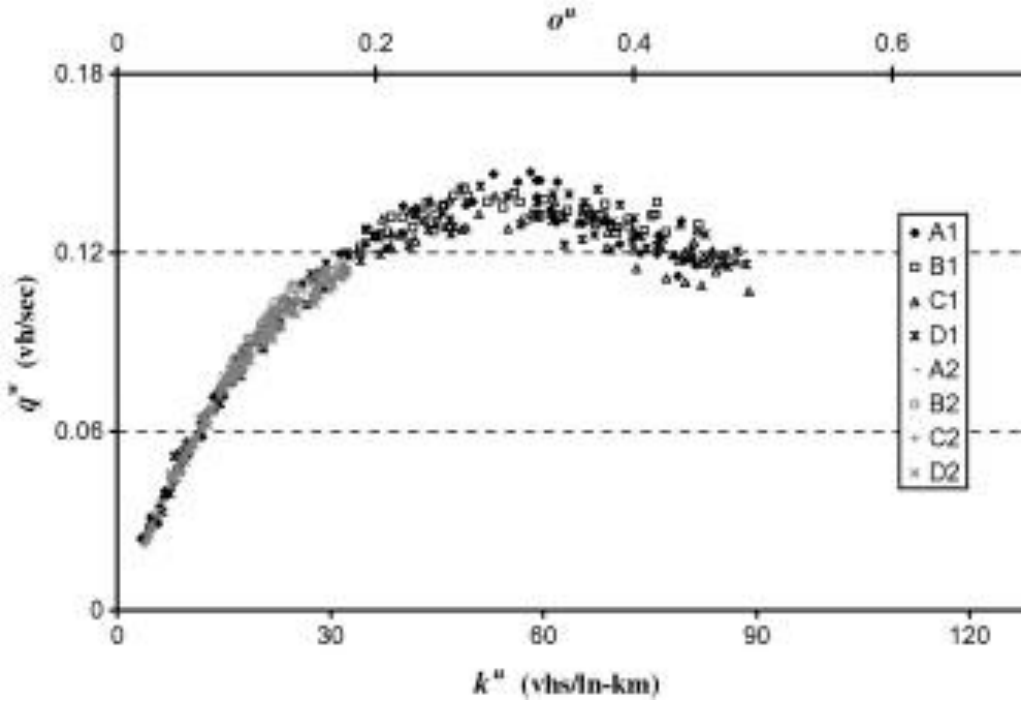
Greenshields' legacy

Microscopic traffic simulation

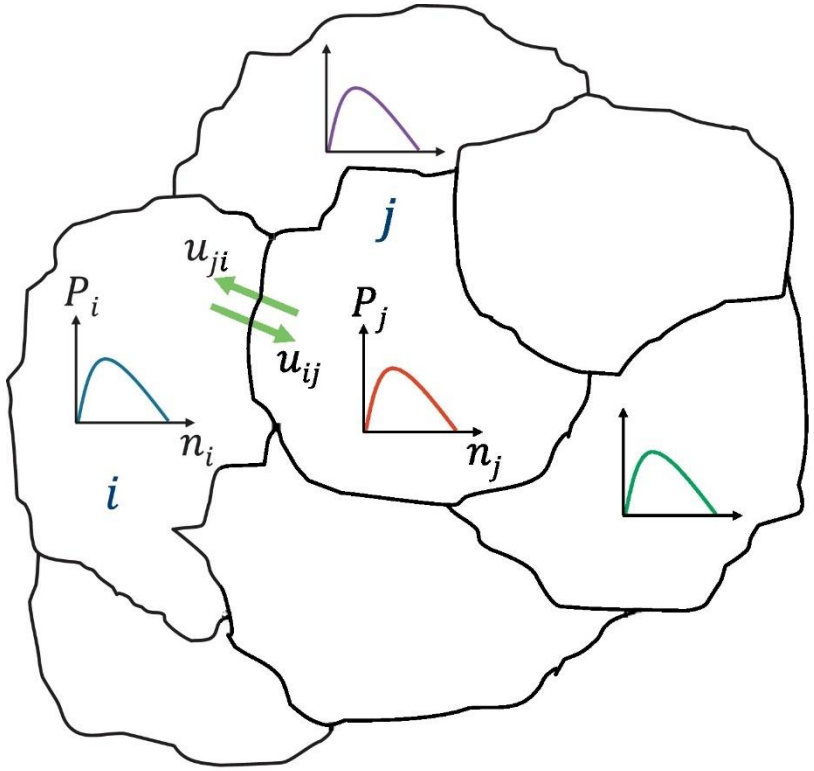


Simulation of Urban MObility (SUMO)

Macroscopic traffic modeling



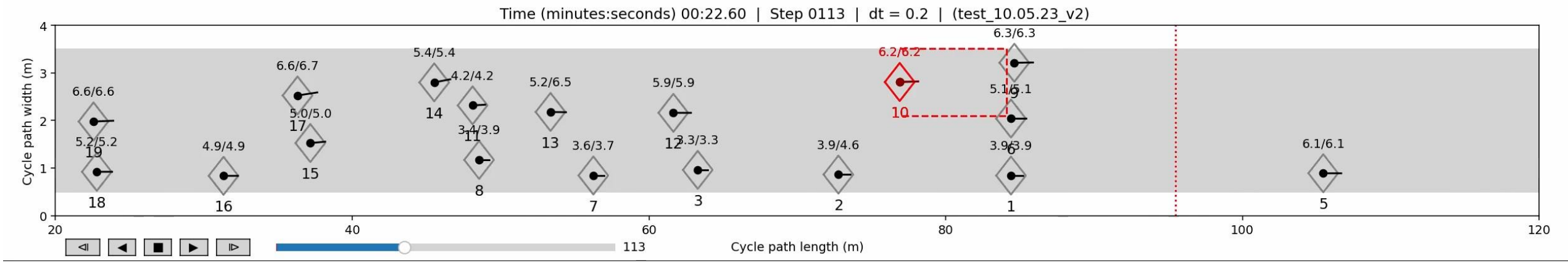
Macroscopic fundamental diagram (MFD) of a road network region in Yokohama [1]



Transmission of traffic between subnetworks [2]

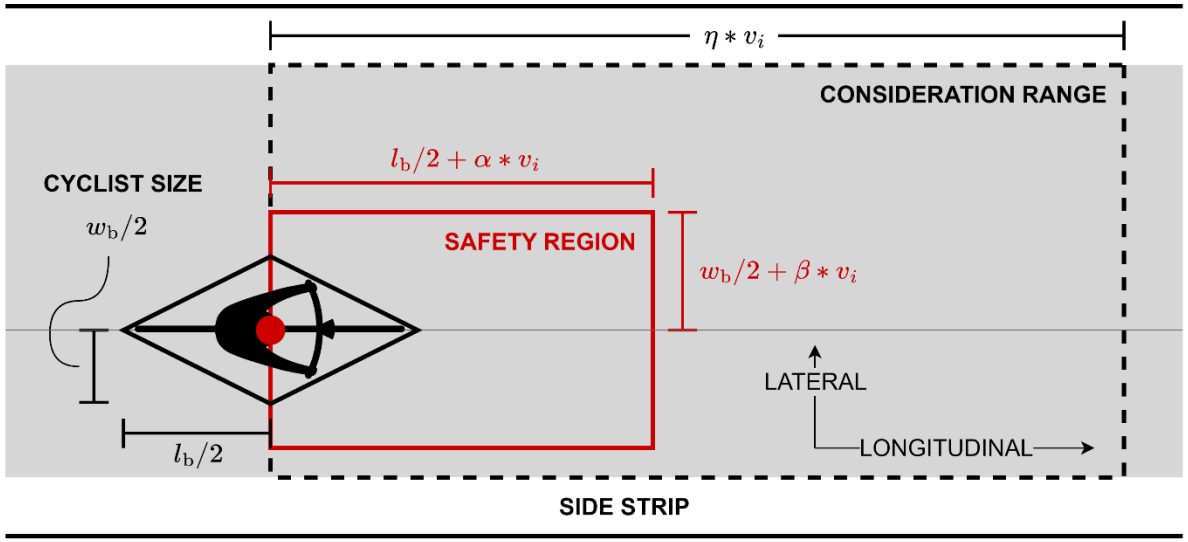
[1] Geroliminis, N., & Daganzo, C. F. (2008). Existence of urban-scale macroscopic fundamental diagrams: Some experimental findings. *Transportation Research Part B: Methodological*, *42*(9), 759-770.
[2] Kouvelas, A., Saeedmanesh, M., & Geroliminis, N. (2017). Enhancing model-based feedback perimeter control with data-driven online adaptive optimization. *Transportation Research Part B: Methodological*, *96*, 26-45.

Microscopic bicycle simulation model

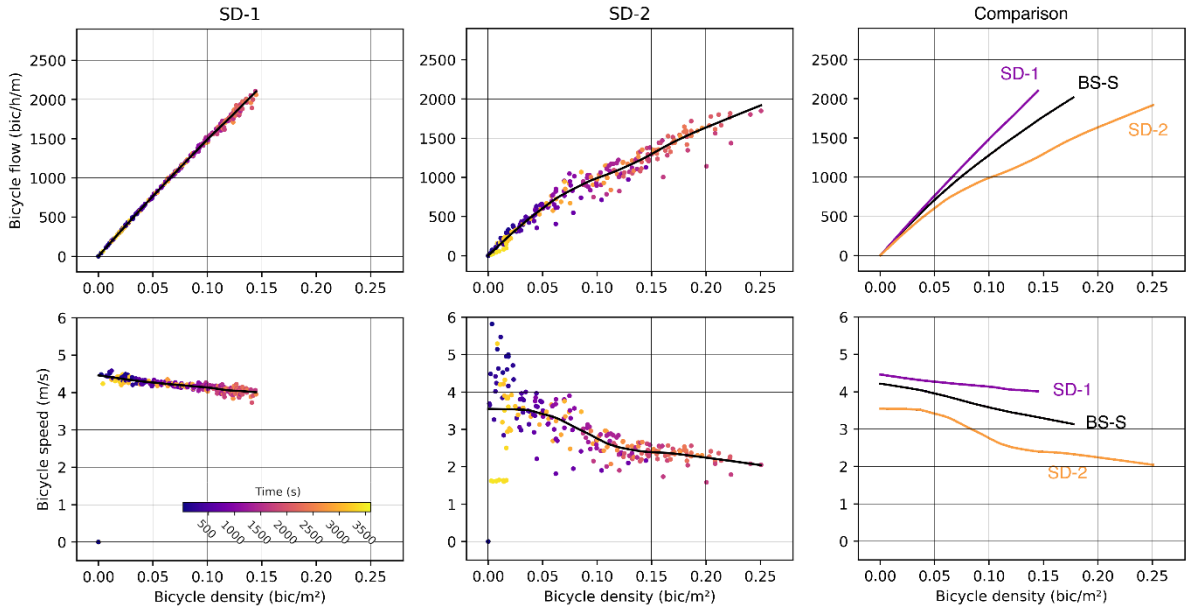


Microscopic bicycle simulation model

- A three-layer microscopic bicycle simulation model considering cyclists' movement strategy and behavioral heterogeneity [1]
- Model structure: (1) Maneuver plan (2) Moving angle (3) Acceleration and execution



Spatial representation of the proposed bicycle microsimulation model

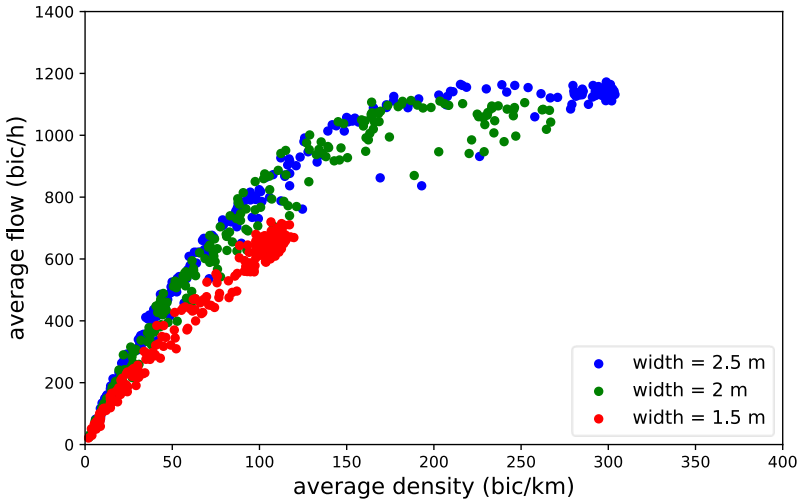


FDs under different desired speed distributions

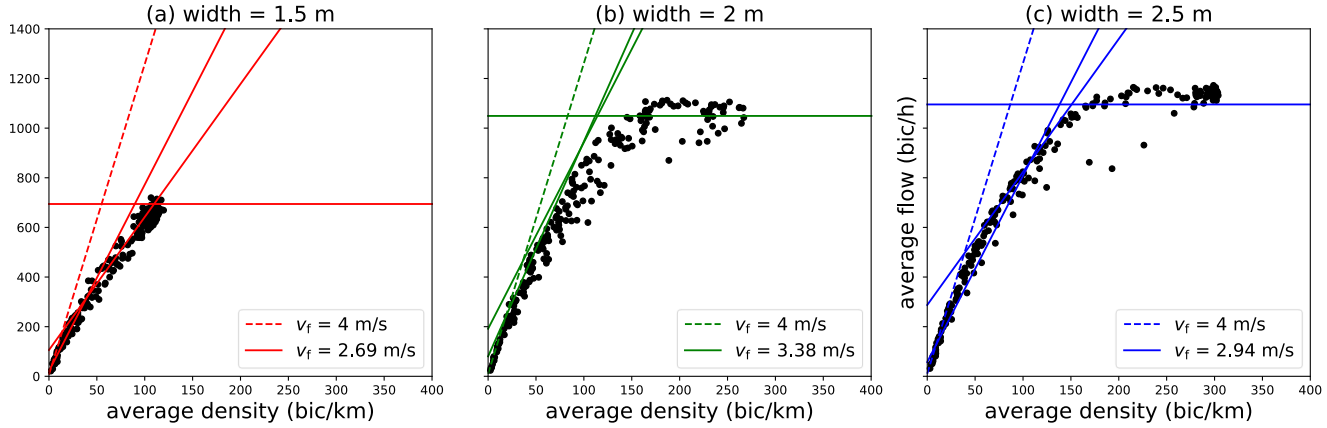
[1] Brunner, J. S., Ni, Y.-C., Makridis, M. A., & Kouvelas, A. (2023). Simulating microscopic bicycle flow considering behavioral heterogeneity and non-lane-based traffic characteristics. In: the 103rd Annual Meeting of the Transportation Research Board (TRB 2024), Washington DC, USA.

Macroscopic bicycle flow model

- Applying traffic flow theoretical knowledge to develop macroscopic bicycle flow models
- Approximating bicycle flow MFDs using analytical methods



Simulated bicycle flow MFDs in scenarios with different lane widths [1]

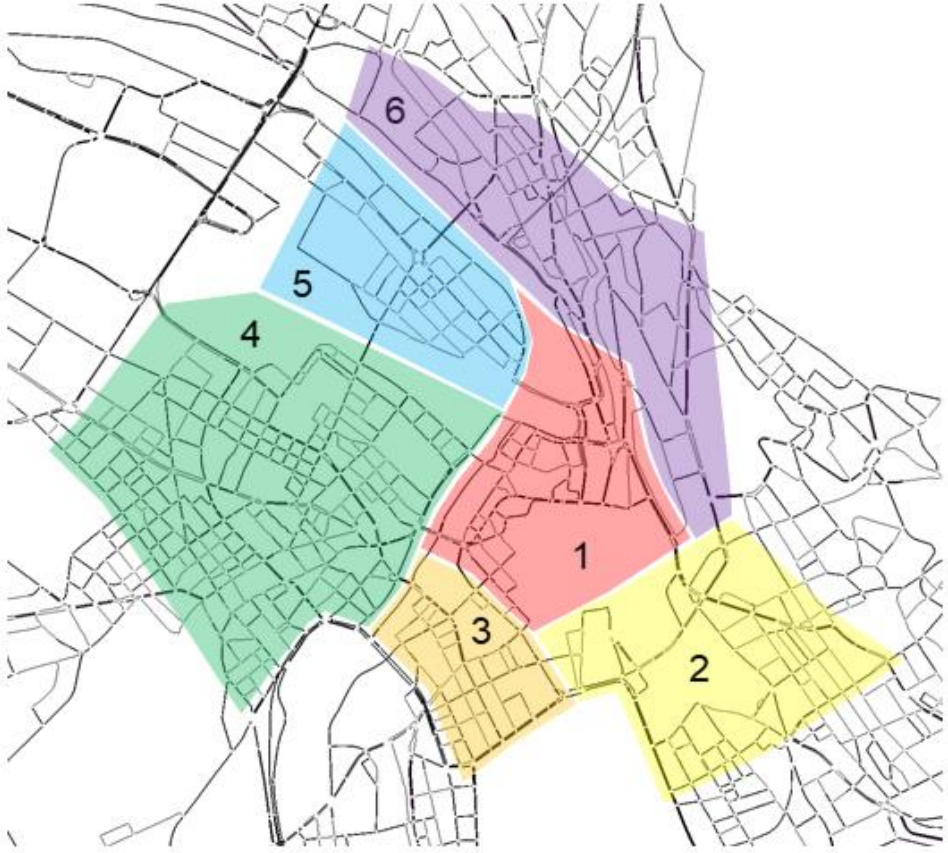


Analytical cuts of bicycle flow MFDs in scenarios with different lane widths [1]

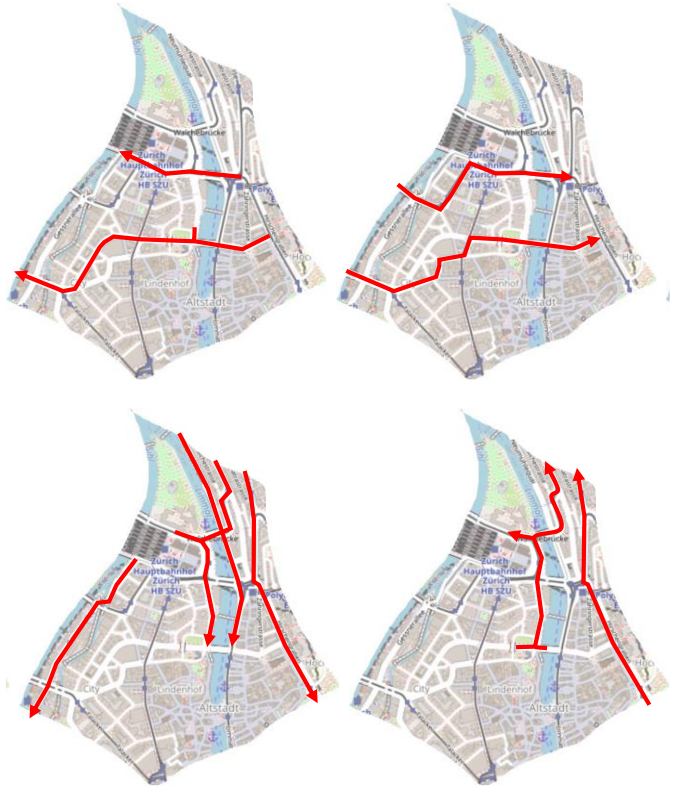
[1] Ni, Y.-C., Makridis, M. A., & Kouvelas, A. (2023). Bicycle as a traffic mode: From microscopic cycling behavior to macroscopic bicycle flow. Manuscript under review. ETH Zurich.

Corridors in Zurich

- Corridor-level decision for the road space allocation strategy



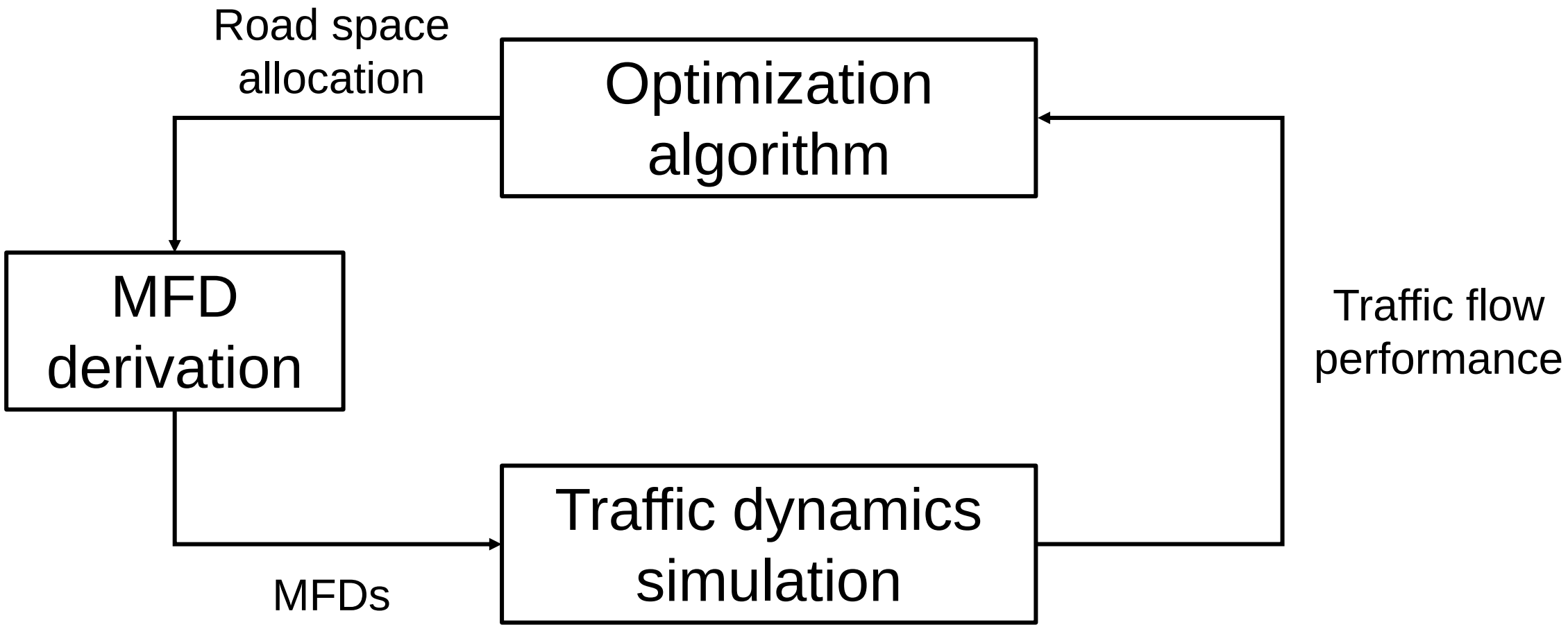
Network of Zurich partitioned into six zones



Corridors in zone 1

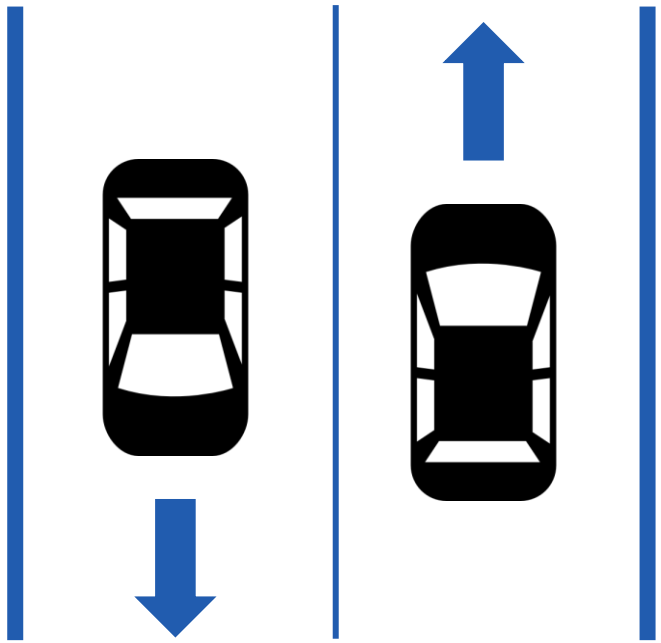
Road space allocation strategy

- Simulation-based optimization framework

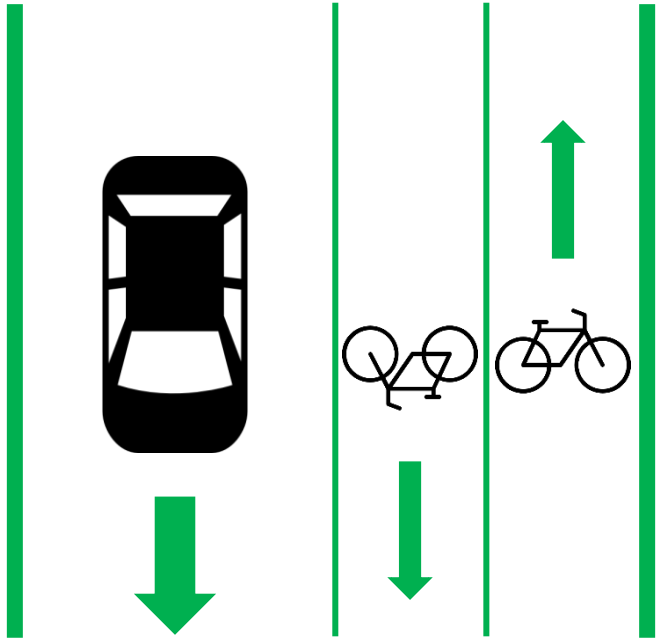


Road space allocation strategy

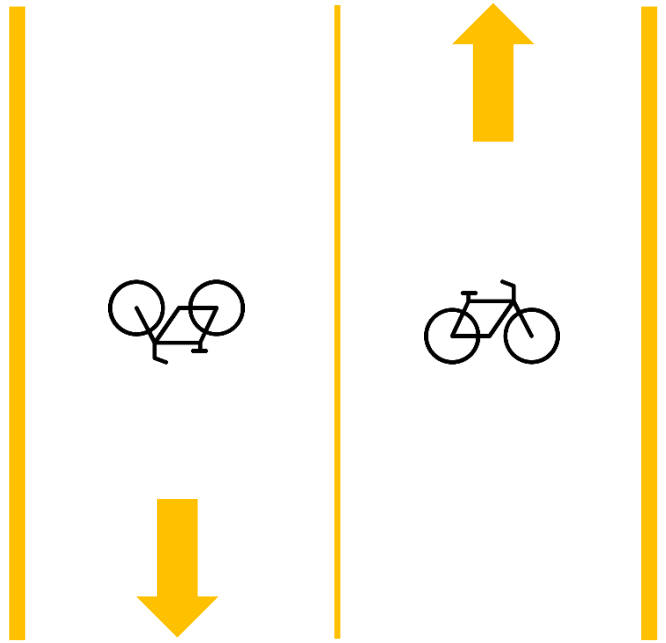
- Strategy 1: A fixed strategy for both trip patterns in the morning and evening peaks
- Strategy 2: Different strategies for trip patterns in the morning and evening peaks
- Possible lane configurations:



Two-way car road
(bicycles also allowed
but only on the sides)



One-way car road
(direction switchable)



Two-way bicycle road

Thank you very much

Ying-Chuan Ni
ying-chuan.ni@ivt.baug.ethz.ch

ETH Zürich
HIL F 33.2
Stefano-Franscini-Platz 5
8093 Zürich

www.ivt.ethz.ch
https://www.ivt.ethz.ch/en/people/profile.ying-chuan-ni.html