Empirical use and **I**mpact analysis of **M**aaS (EIM)

ETH Mobility Initiative Project

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Our society is becoming increasingly mobile!

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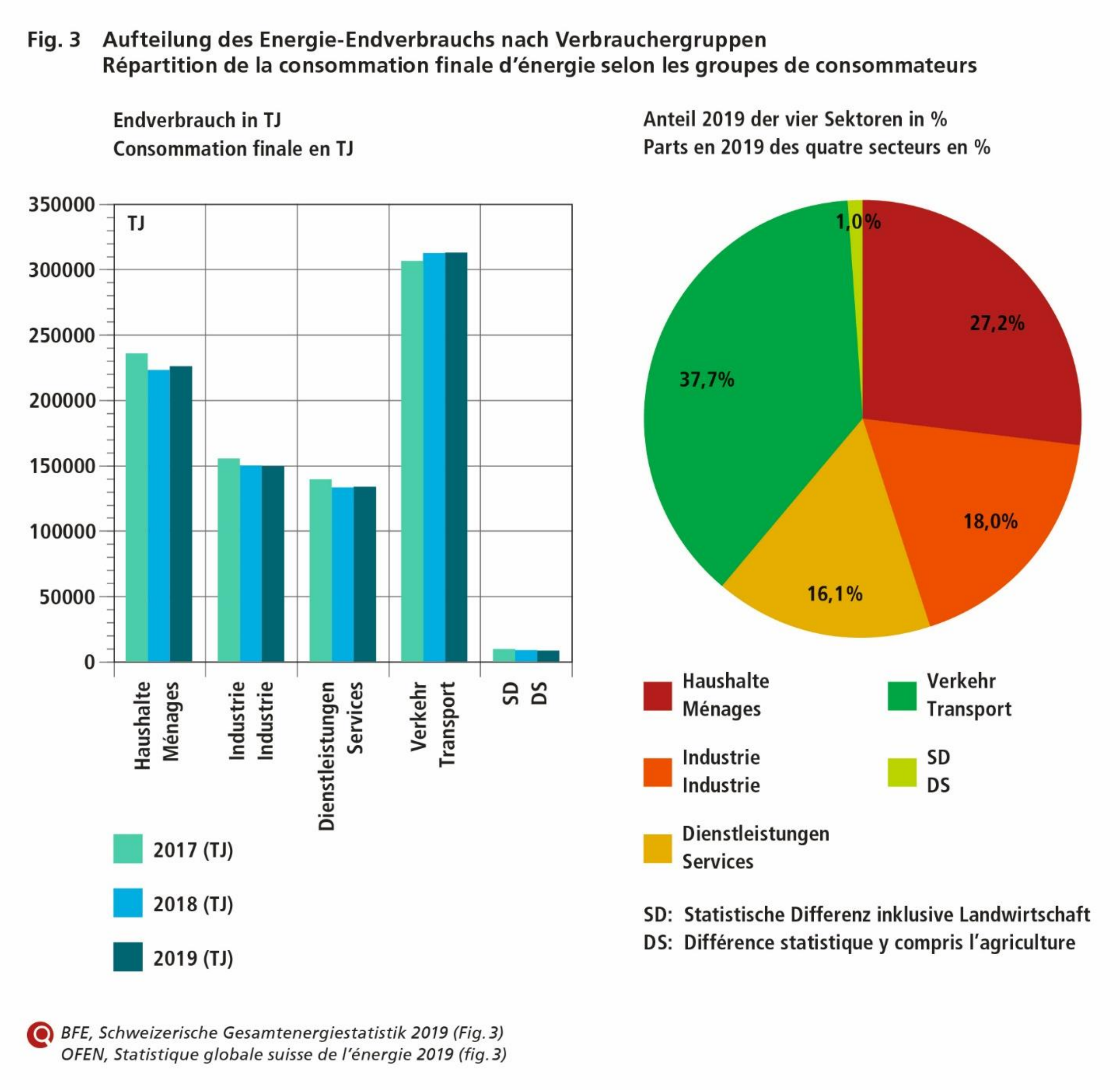
Foto: Keystone

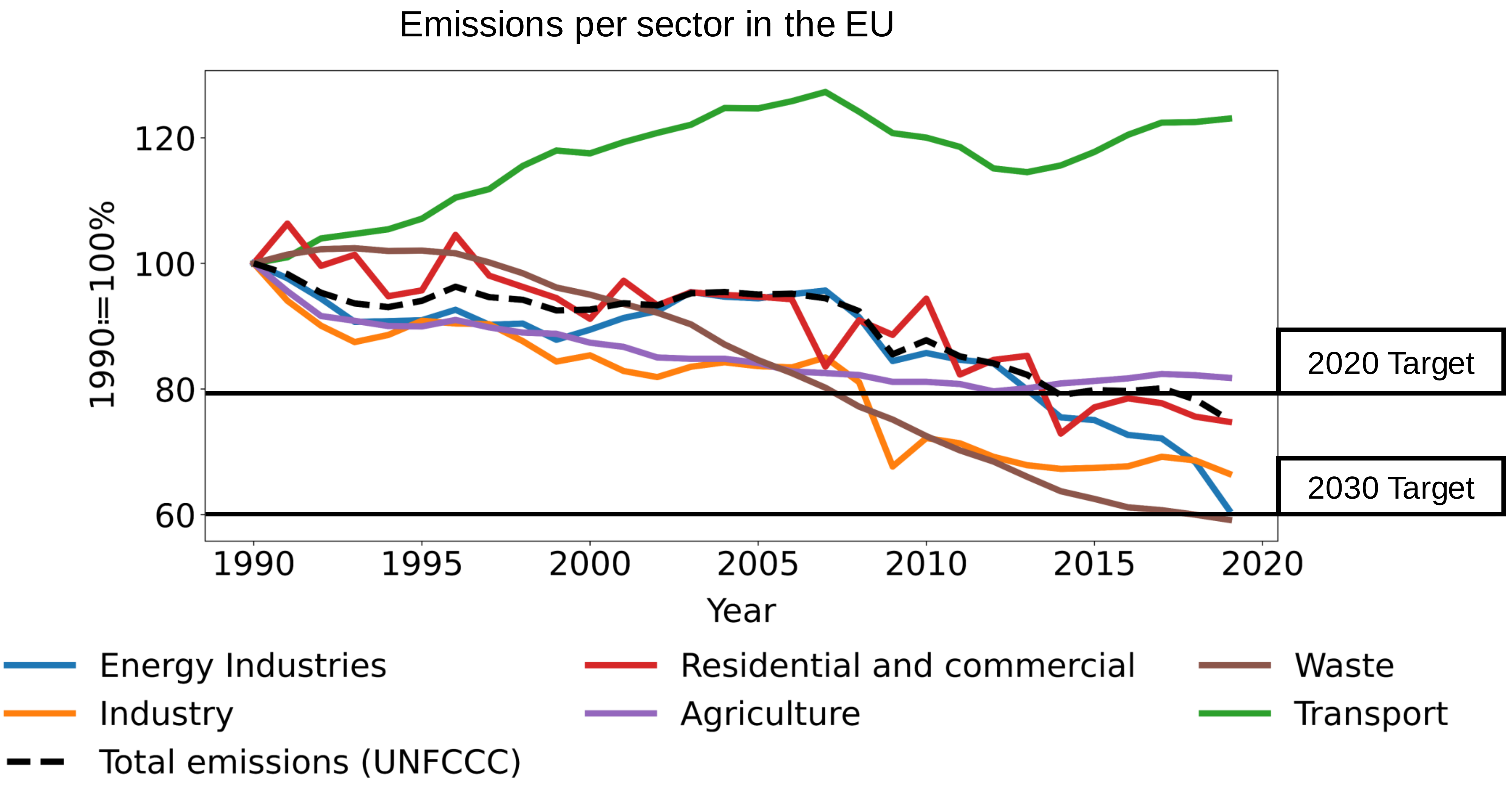
Swiss transport and mobility emissions

- Transport produces 38% of total Swiss GHG emissions.
- 73% of transport GHG emissions are produced on roads.

Schweizerische Gesamtenergie-Statistik 2019, Bundesamt für Energie BFE



Need for action in the transport sector



Source: European Environment Agency (EEA), GHG emissions reported to UNFCCC

Motivation

Mobility-as-a-Service (MaaS)

Bild: Transport advancement

- Key factors for success of MaaS offers:
  - easy access to all available modes of transport via single app
  - combined contract for all modes (bundles)
- Current challenges:
  - Unclear how mobility bundles affect mobility behavior
  - MaaS generates mobility & context data from various sources; large-scale analysis of individual mobility requires efficient & versatile mobility data representation
- **EIM tackles both problems**

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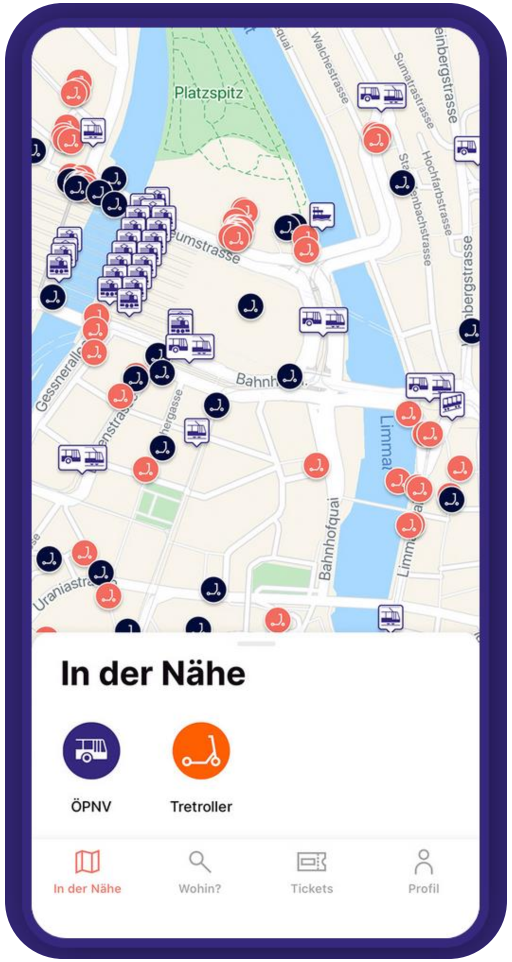
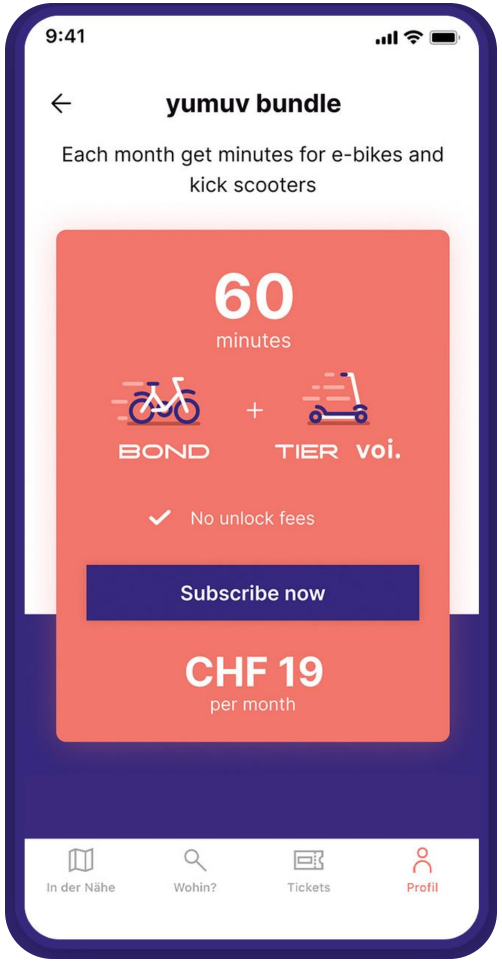




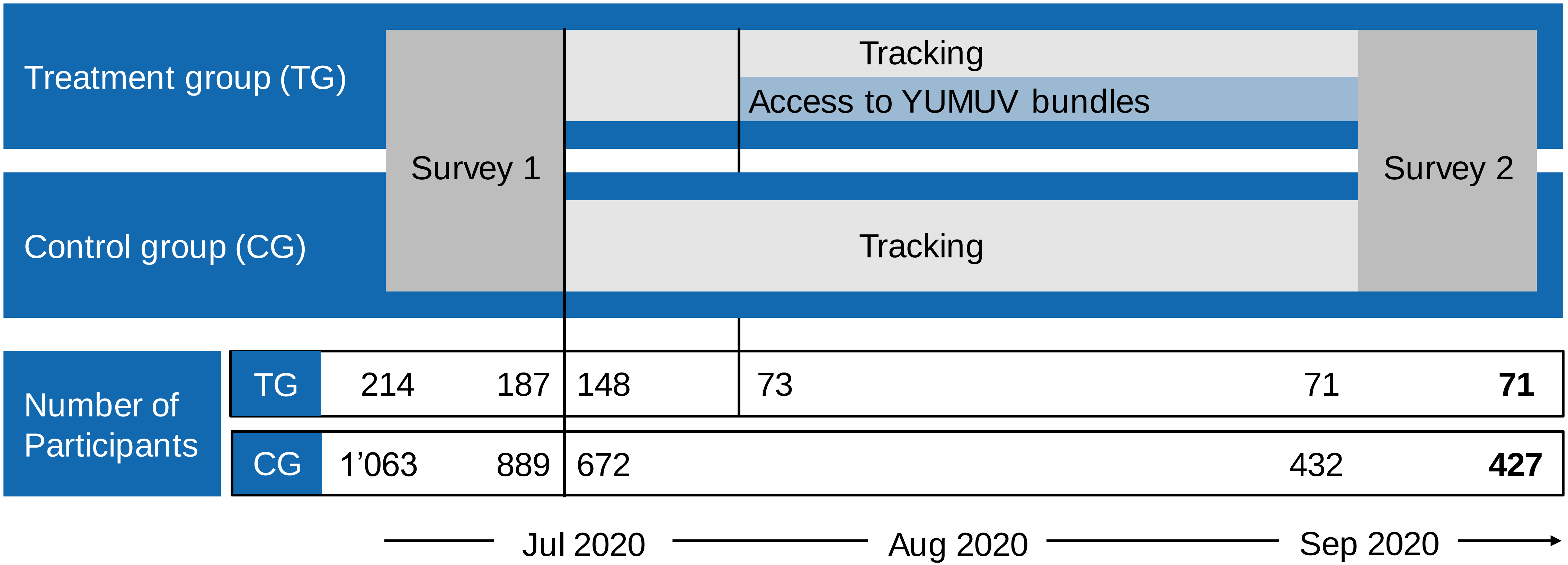
Yumuv.ch

yumuv

Goals:

- Advance understanding of MaaS mobility bundles' impact on human mobility behavior
- Create application that generalizes over different datasets using an integrated representation of mobility, booking and context data

Study design



Data sources

Source	**Description**
SBB MyWay App	Tracking data (24h/day GPS based travel survey). App collects triplegs (=trajectories) and staypoints
Yumuv app (TG)	Shared vehicle booking information: price, position, timing and duration.
Surveys	Detailed information on socio-demographics and mobility behavior of participants
Availability of shared vehicles	Position of all relevant available shared vehicles in 5-minute resolution (~600’000 entries per day)
Weather data	Temperature, wind and precipitation in hourly resolution on a 30x30 km grid (ERA5T)
Elevation data	Trip level elevation data extracted from a 25m resolution DEM (Swisstopo DHM25 – Basismodell)

Collected tracking data

Tracking data	Control group	Treatment group
# users	672 (**427**)	148 (**71**)
Triplegs	371’000	112’000
Staypoints	248’000	65’000
Labels	Mode of transport + activity label	
Tracking time	3 - 4 months	
Total km tracked	3.9 M km	1.5 M km

Preprocessing methods are open source:
https://github.com/mie-lab/trackintel

trackintel

Mode choice analysis: effect of yumuv bundle on mobility behavior

Results of the trip-level mode choice model with preprocessed tracking and context data show that the yumuv bundle influenced the mode choice of participants in the following way:

- Increased usage*: public transport (0.23) and shared e-scooters (1.74)
- Decreased usage*: owned bikes (-0.75) and owned e-bikes (-1.99)
- No statistically significant effect: owned car, shared E-bike, owned e-scooters

*95% significance level

Reck, D.J., Martin, H., Raubal, M., Axhausen, K.W., 2022. How do MaaS bundles influence travel behavior? Empirical evidence from the yumuv trial. (in preparation)

Analysis of scooter emissions under consideration of substitution patterns

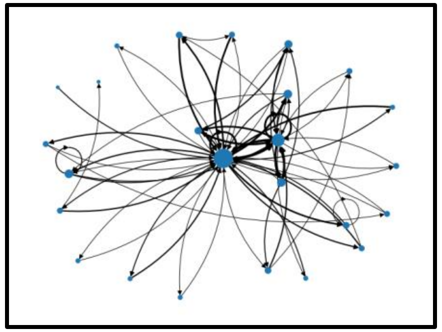
Substituted mode	Gross emissions [g CO_2 / pkm]	Substitution rates (km-level) by micro-mobility mode			
		E-Bike (personal)	E-Bike (shared)	E-Scooter (personal)	E-Scooter (shared)
Walk	0†	9%	9%	19%	25%
PT (avg.)	72†	29%	43%	27%	38%
Car (avg.)	135†	48%	15%	25%	15%
Bike	17†	14%	29%	27%	13%
E-Bike (personal)	34†		5%	1%	2%
E-Bike (shared)	83†	0%		0%	5%
E-Scooter (personal)	42†	1%	0%		1%
E-Scooter (shared)	106†	0%	0%	0%	
Emissions of substituted modes		88	58	58	55
Emissions of micro-mobility mode		34†	83†	42†	106†
Net emissions [g CO_2 / pkm]		**-54**	**25**	**-16**	**51**

† Emission calculations drawn from ITF (2020a).

Reck, D. J., Martin, H., & Axhausen, K. W. (2022). Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. *Transportation Research Part D: Transport and Environment*, *102*, 103134.

Mobility profiling using graph-based representation

Development of a graph representation of individual mobility



- \+ Efficient (computation + storage)
- \+ Privacy friendly
- \+ Flexible to integrate heterogenous context data
- \+ Few dataset specific assumptions (allows generalization over datasets)

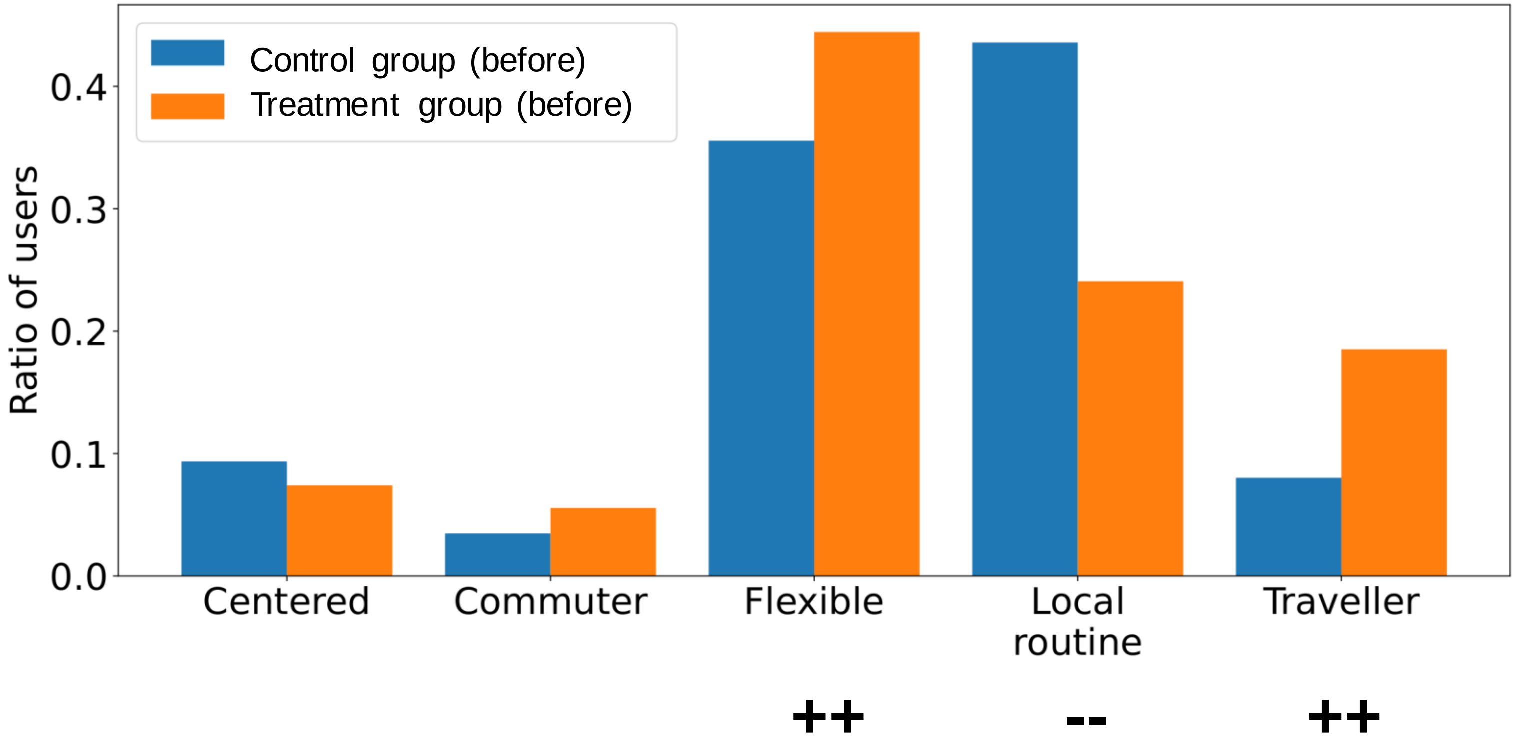
Development of a method to identify and analyze user groups with similar mobility behavior that are stable across different datasets

Transform datasets into graph representation → Identify user groups present in all datasets using graph-based mobility features → Analyze groups with respect to yumuv offer

Martin, H., Perez-Cruz, F. Raubal, M., 2022. A graph-based representation for human mobility data. (in preparation)
Martin, H., Wiedemann, N., Suel, E., Hong, Y., and Xin, Y., 2022 Influence of tracking duration on the privacy of individual mobility graphs (under review)
Martin, H., Wiedemann, N. Reck, D.J., Raubal, M., 2022. Graph based mobility profiling (under review)

Mobility profiling using graph-based representation

- Identification of 5 stable user groups that appear in all analyzed datasets
- Allows comparison between distributions of control group and treatment group
- ➢ Participants assigned to the groups *Flexible* and *Traveller* are more interested in yumuv
- ➢ Participants assigned to *local routine* are less interested in yumuv



Martin, H., Wiedemann, N. Reck, D.J., Raubal, M., 2022. Graph based mobility profiling. (under review)

Close collaboration with project partners to ensure mutual benefit

- Bundle design: ETH-led workshops to consult on bundle design.
- Data elicitation: Collaborative planning of research study to ensure synchronization with product roll-out.
- Data preparation: Working in a joint team on partner infrastructure with a joint code base to ensure reproducibility and long-term impact of research project.

Summary

- The EIM project collected the most comprehensive data set worldwide on the use and impact of MaaS.
- Over the course of the project, the following key questions have been advanced:
    - **Bundle impact on mobility behavior:**
      The investigated bundle *yumuv easy* increases the usage of shared e-scooter and public transport. An impact on the usage of personal cars was not shown.
    - **Efficient analysis of multi source mobility data:**
      Individual location graphs used to represent mobility behavior can be used as a basis for a joint analysis of multiple different tracking data sets.

ETH zürich

geoinformation engineering ikg eth zurich

IVT Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Publications

Published

- Reck, D.J., Martin, H., Axhausen, K.W., 2021. Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. Presented at the *21st Swiss Transport Research Conference* (STRC 2021), Ascona, September.
- Martin, H., Reck, D.J. and Raubal, M., 2021. Using Information and Communication Technologies to facilitate mobility behaviour change and enable Mobility as a Service. *GI_Forum Journal for Geographic Information Science*, (1).
- Reck, D.J., Martin, H., Axhausen, K.W., 2021. Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. T*ransportation Research Part D: Transport and Environment.*
- Martin, H., Reck, D. J., Axhausen, K. W., & Raubal, M. 2021. *ETH Mobility Initiative Project MI-01-19 Empirical use and Impact analysis of MaaS*. ETH Zurich.

Under review:

- Martin, H., Wiedemann, N., Suel, E., Hong, Y., and Xin, Y., 2022 Influence of tracking duration on the privacy of individual mobility graphs
- Martin, H., Wiedemann, N. Reck, D.J., Raubal, M., 2022. Graph based mobility profiling for longitudinal and cross-sectional tracking studies.

In Preparation:

- Reck, D.J., Martin, H., Raubal, M., Axhausen, K.W., 2021. How do MaaS bundles influence travel behavior? Empirical evidence from the yumuv trial.
- Martin, H., Perez-Cruz, F. Raubal, M., 2021. A graph-based representation for human mobility data.