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Efficient Technologies and Systems for Mobility

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# Action plan digitalization 2019-2020

**SCCER Mobility Annual Conference**

6 September 2019

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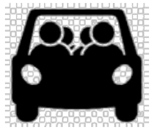
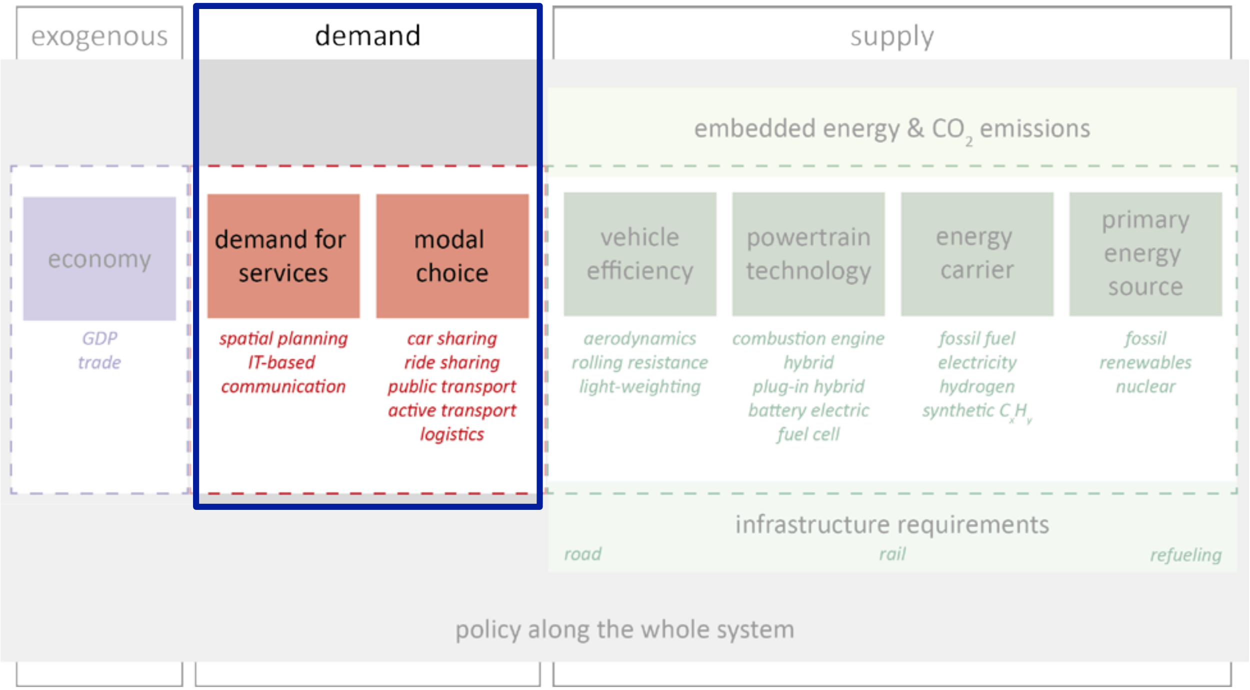
# SCCER Mobility Digitalization Program

## Reduction of pkm/vkm

**Automated Driving Sensor Testing Vehicle**
C. Bach & E. Frazzoli

**Decision Support System for Personalized Ride-Sharing Services**
M. Raubal





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# SCCER Mobility Digitalization Program

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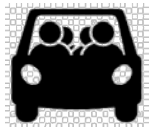

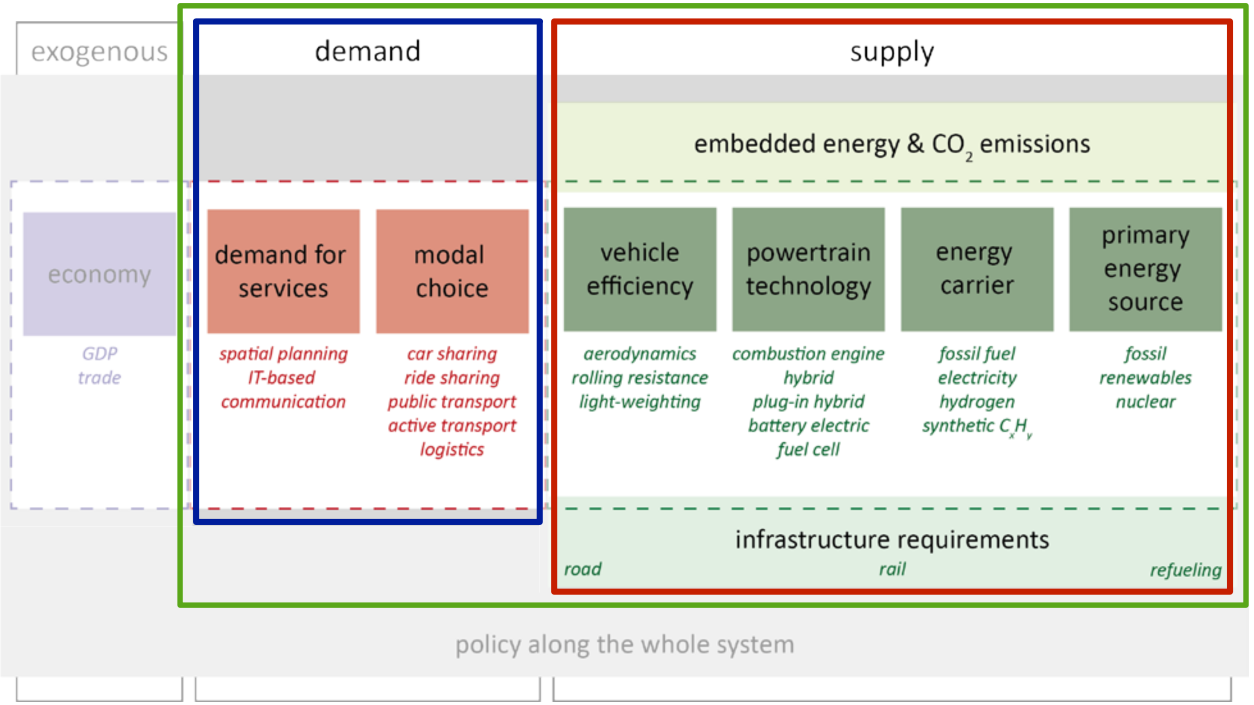


## Efficient coupling: electricity grid and mobility patterns

**Smart Mobility Data Platform**
P. Affolter & A. Laube

**Optimizing the potential impact of personal and autonomous electric mobility on grid stability**
M. Raubal, R. Rudel & L. M. Gambardella

## Link between all digitalization projects

**Impact of digitalization on future mobility**
Learning Lab – Future Transport Systems

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# Identify and explore links among digitalization projects

## *SCCER Mobility Learning Lab - Future Transport Systems*

- To comply with the recommendations of the Steering Committee to identify links between all projects
- Assess ways to contribute to SCCER Mobility's overarching strategy with the entire digitalization portfolio
- Dr. Mireia Roca Riu will join the Learning Lab from November onwards and work on this new activity
- PhD in Statistics and Operations Research from Barcelona Technical University
- Currently a PostDoc at ETHZ-IVT (Dr. Menéndez, Traffic Engineering Group) and working on the impact of different levels of automation within urban deliveries

Dr. Mireia Roca Riu

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# Smart Mobility Data Platform

**Peter Affolter**

Bern University of Applied Sciences

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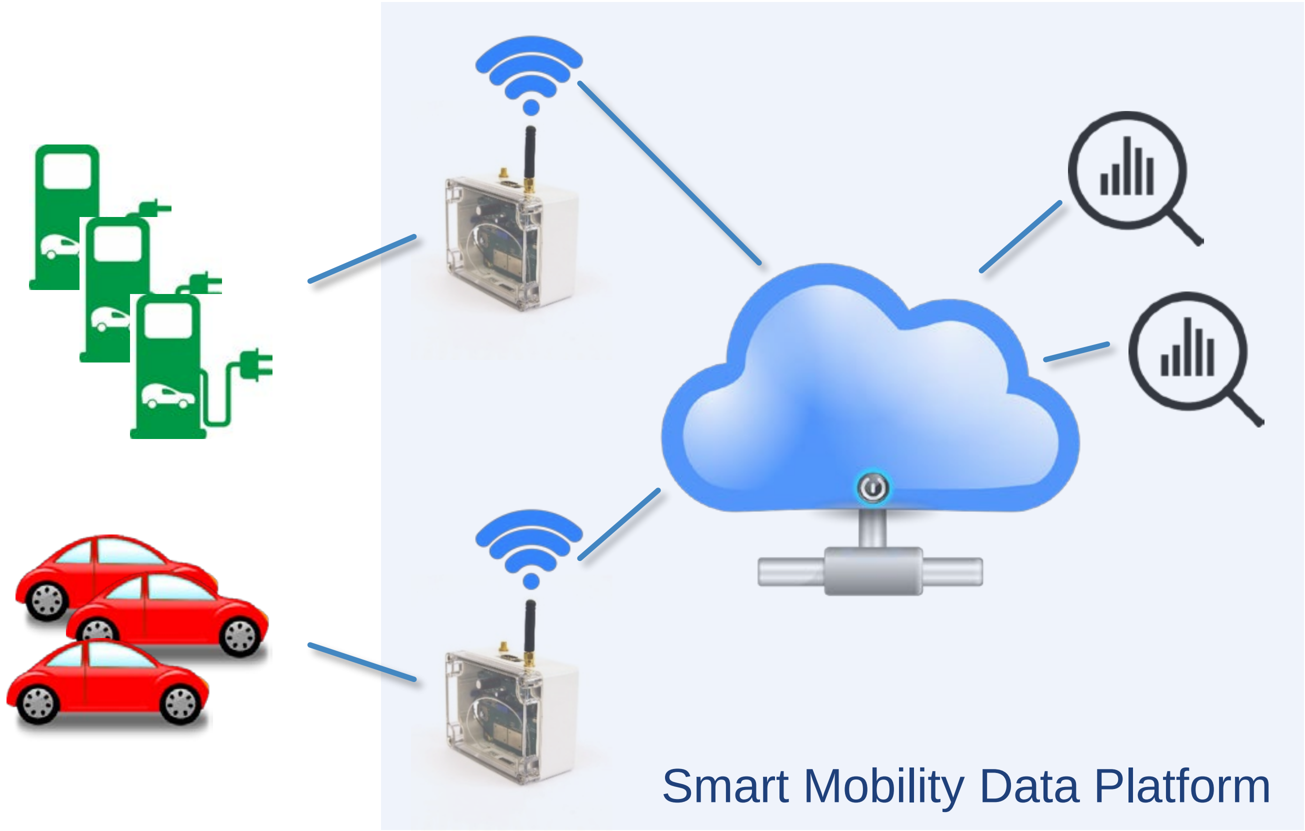
# Smart Mobility Data Platform

## Motivation & objectives




- The demonstrator Smart Mobility Data Platform will reveal the potential to answer **research questions** surrounding the **real use** of electric vehicles, batteries and charging stations of the "Braunwald autofrei" initiative
- This will be done by respecting user **privacy**, under harsh and changing **environmental/seasonal** conditions, over a **long period** and **independent** of the utilized product specifications

Peter Affolter & Annett Laube (BFH)

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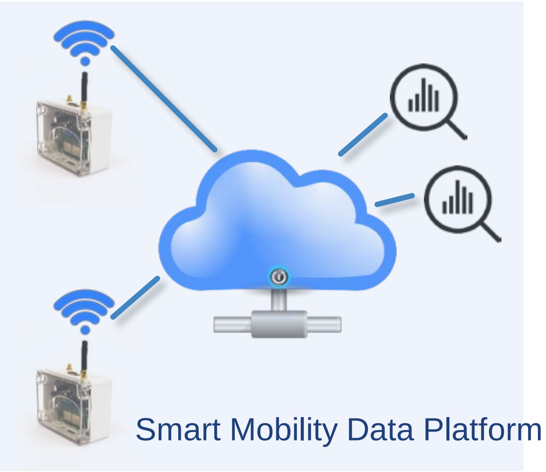
# Smart Mobility Data Platform

## Work plan & methods

**Build up trust** by getting user and labor union involved from the beginning


**Respect** the European Global Data **Privacy Regulation**




Test and **demonstrate** under **real conditions**

Based on **established** and well known **technology and products**

Peter Affolter & Annett Laube (BFH)

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# Smart Mobility Data Platform

## Involved partners

### *New academic partners*

**Prof. Dr. Annett Laube**
Bern University of Applied Sciences
Head of Institute for
ICT Based Management

- Data privacy and security
- Data lake and data enrichment
- Data analysis and big data

**Prof. Peter Affolter**
Bern University of Applied Sciences
Head of Institute for
Energy and Mobility Research

- Data acquisition
- Data communication
- System integration

### *Implementation partners*

**Community Glarus Süd**

- Initiator “Braunwald autofrei”
- Vehicle Sponsoring
- Field test location

**SBB Fleet Engineering**

- Use case fleet electrification
- User and labor union contact

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# Smart Mobility Data Platform

## New competences

- *vehicle data acquisition technology*
- *vehicle data analysis and big data*
- *data privacy and security*


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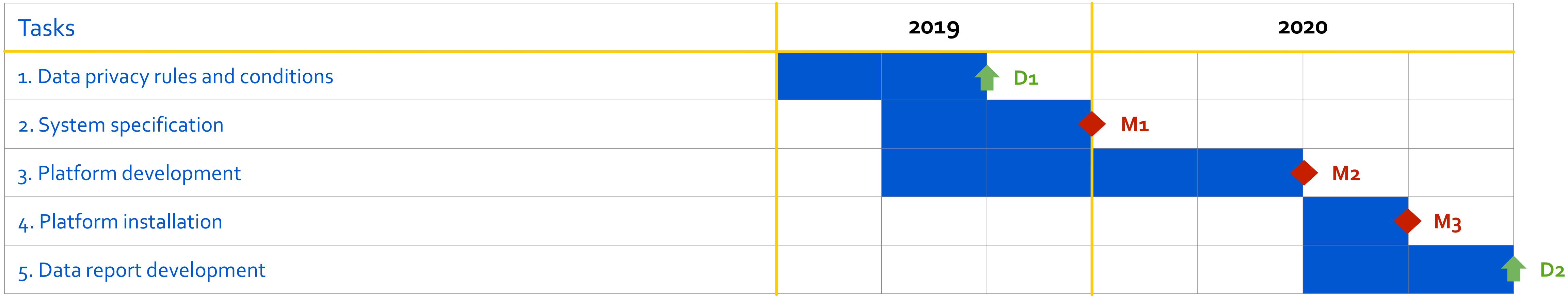
# Smart Mobility Data Platform

## Timeline, milestones & deliverables




**Milestones**

- **M1** System design freeze
- **M2** Platform ready for deployment
- **M3** Demonstrator active

**Deliverables**

- **D1** Summary report of the user / labor union interviews
- **D2** First data report

# Smart Mobility Data Platform

## Knowledge & technology transfer


- Depending on the data protection regulations and analytics, parts of the platform may be made available to the research community and public

Regionalkonferenz BernMittelland

- Follow up project “Community based charging infrastructure in rural based regions” (A-priority project in financial plan 2020-2023)

SBB CFF FFS

- Operational data analytics of the transport fleet to obtain a decision basis for fleet electrification

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Bundesamt für Energie BFE

EDUMPER

- Lifetime energy consumption, efficiency and state of health monitoring of an electric mining truck, based on components of the Smart Mobility Data Platform (since 2018)

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# Automated Driving Sensor Testing Vehicle

**Dejan Milojevic**
Empa & ETH Zürich

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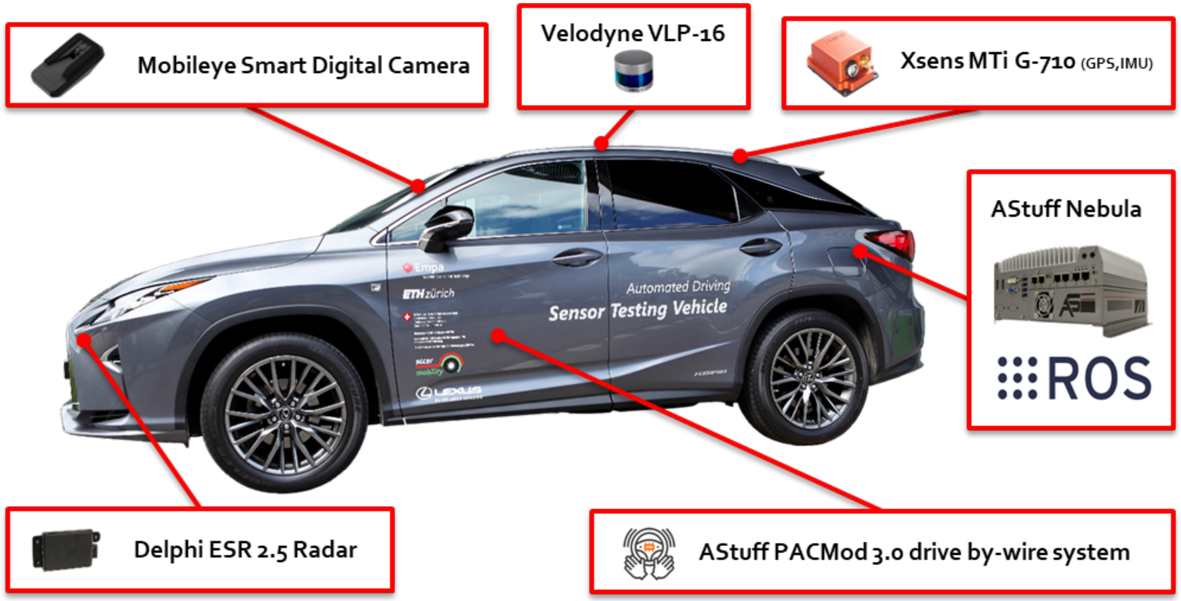
# Automated Driving Sensor Testing Vehicle

## Motivation & Objectives

- Autonomous vehicles might play an important role in future mobility
- Real world experience with such systems is crucial for further development
- Targets:
  - Assess real world behavior of sensors
  - Enable field testing activities
  - Provide an open platform for Swiss SMEs
- Work towards digitalized mobility to support the action plan "Digitale Schweiz" and help achieve the targets of the Energy Strategy 2050




Lexus RX 450h with AutonomouStuff Perception-Kit

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# Automated Driving Sensor Testing Vehicle

## Technical investigations of autonomous vehicle systems – joint activities with ASTRA

**Empa investigations to support ASTRA,** technical investigations at APTL

- Establishing a vehicle platform for testing of autonomous vehicle sensors/systems
- AD-Sensor reliability testing to investigate sensor behavior in real world scenarios
- Investigation of advanced data management strategies for AD-perception decision analysis
- Support the development of a AD-field test strategy for Switzerland

Empa
Materials Science and Technology

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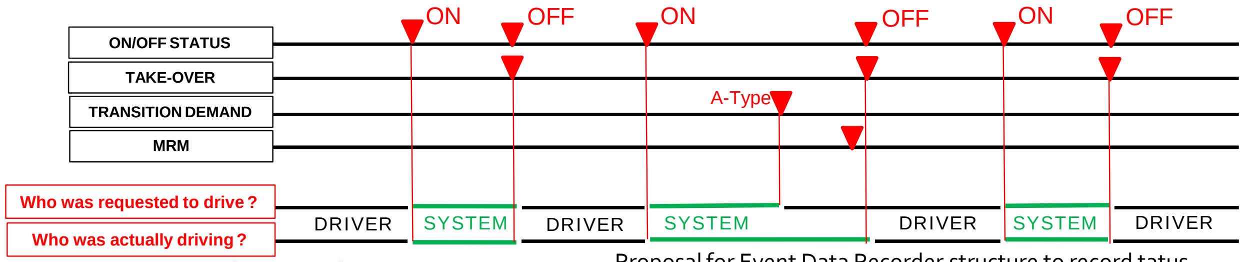
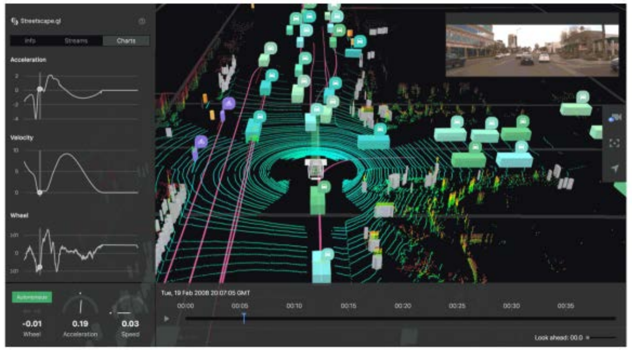
Bundesamt für Strassen ASTRA




Proposal for Event Data Recorder structure to record tatus information on the automated driving functions
Image credit: OICA Presentation, 14. IWG ITS/AD, Geneva 2018

**Lean data storage format for AD vehicles**



Data Stream of an autonomous vehicle and ist sensor information
Image credit: Xiaoji Chen, Joseph Lisee, Tim Wojtaszek, and Abhishek Gupta
Uber Engineering, https://eng.uber.com/avs-autonomous-vehicle-visualization/

Dejan Milojevic (Empa, ETH Zürich)

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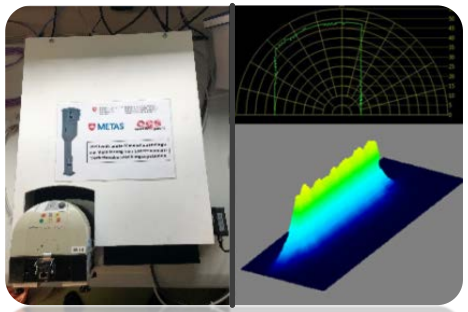
# Automated Driving Sensor Testing Vehicle

## Accuracy and repeatability measurements with automotive radar and laser systems in a lab/simulation environment and under real world conditions – joint activities with METAS

**Lab measurements at METAS**, in collaboration with Dr. Fabiano Assi and Eric Chatagny from the division "Verifications and Tests"

Radar simulation



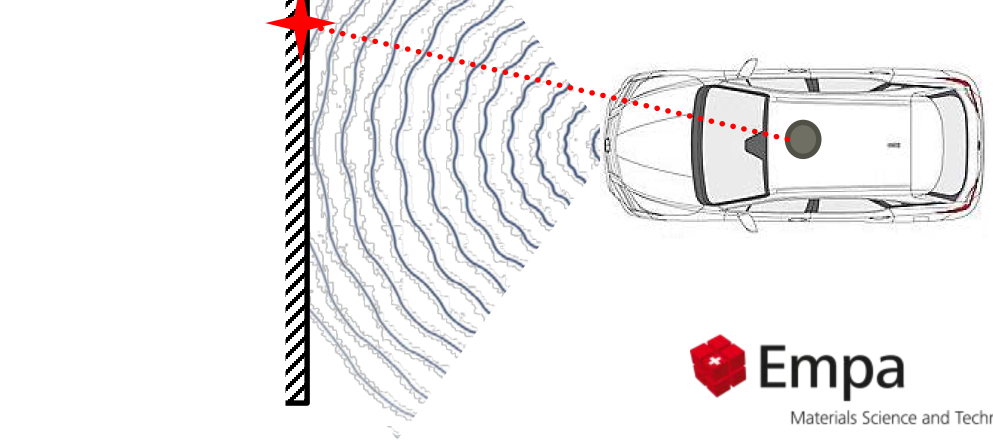
Scanner characterisation

METAS

**Real-world measurements at Empa**, in the Automotive Powertrain Laboratory of Christian Bach

**Velodyne Puck**

**Delphi Radar**



Empa
Materials Science and Technology

Dejan Milojevic (Empa, ETH Zürich)

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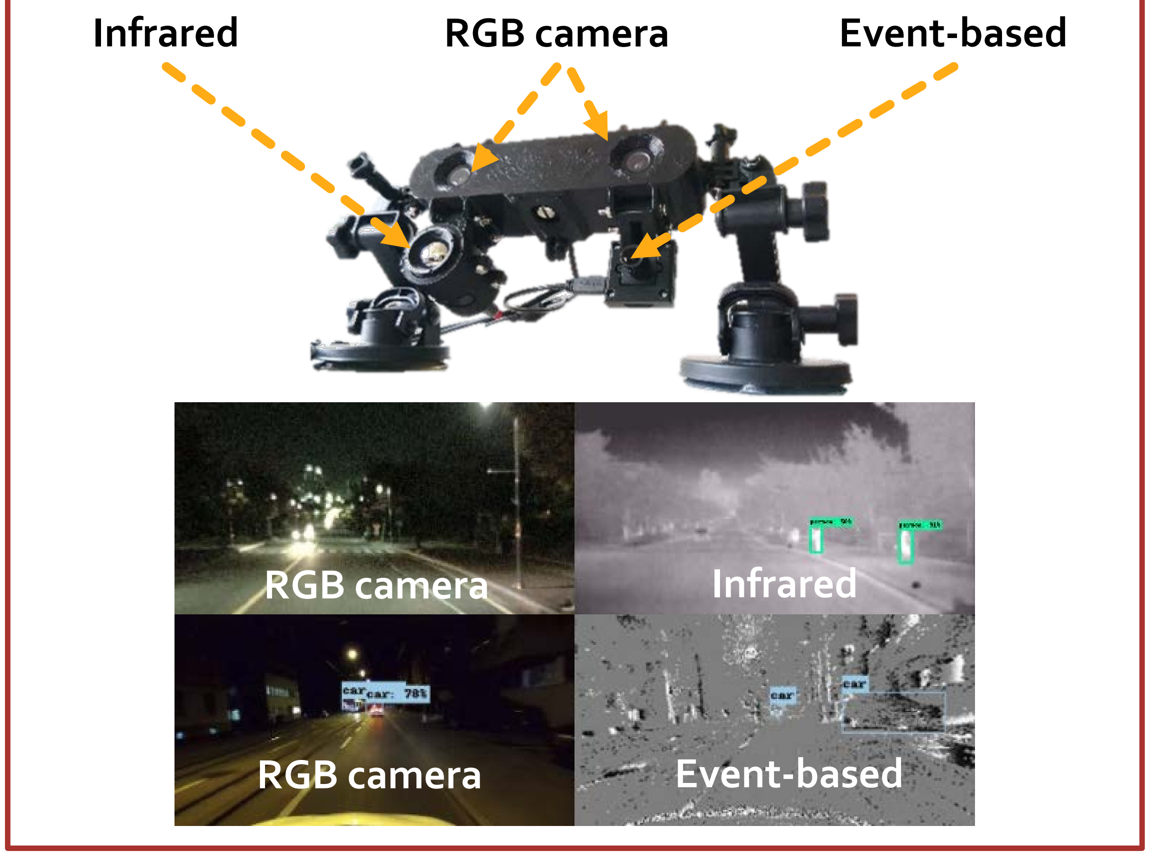
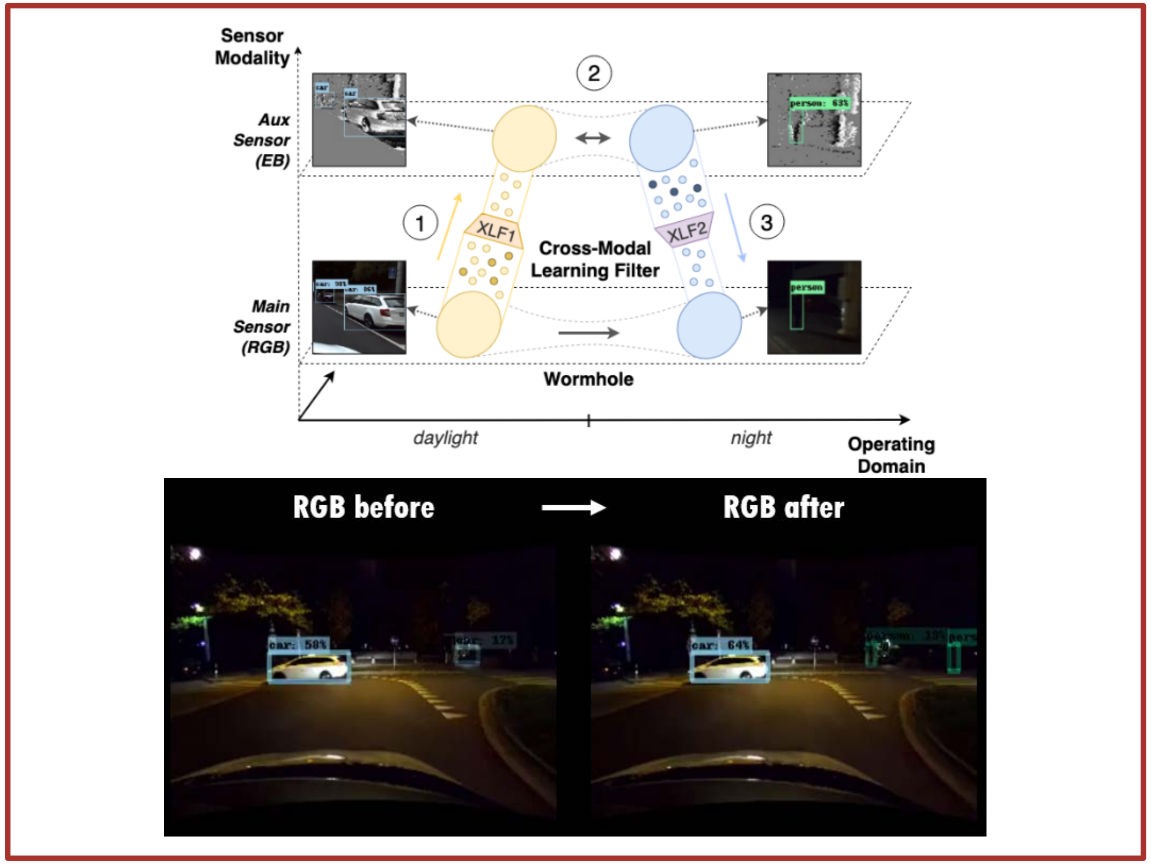
# Automated Driving Sensor Testing Vehicle

## Wormhole Learning: student-teacher relation between sensors – joint activities with ETH




Research group IDSC of Prof. Dr. Emilio Frazzoli, ETH Zürich

A. Zanardi et al., «Wormhole Learning», ICRA, 2019

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# Automated Driving Sensor Testing Vehicle

## New competences

- Automated driving
  - Operation in different ambient conditions
  - Handling of rare events
- Sensor technology
  - Sensor physics
  - Real world behavior
- Big Data Management
  - Sensor Data Storage
  - Event Data Recorder

# Automated Driving Sensor Testing Vehicle

## Project partners

### Main funding

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Confederaziun svizra
**Innosuisse – Schweizerische Agentur für Innovationsförderung**

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Confédération suisse
Confederazione Svizzera
Confederaziun svizra
**Bundesamt für Strassen ASTRA**

### Project team

Empa – Materials Science and Technology

ETH – Eidgenössische Technische Hochschule Zürich, Swiss Federal Institute of Technology Zurich

IDSC

METAS

### Project partners

AXA

embotech

LEXUS – EXPERIENCE AMAZING

Orthotec

TCS

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# Decision Support System for Personalized Ride-Sharing Services

**Martin Raubal**

ETH Zürich

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# Decision Support System for Personalized Ride-Sharing Services

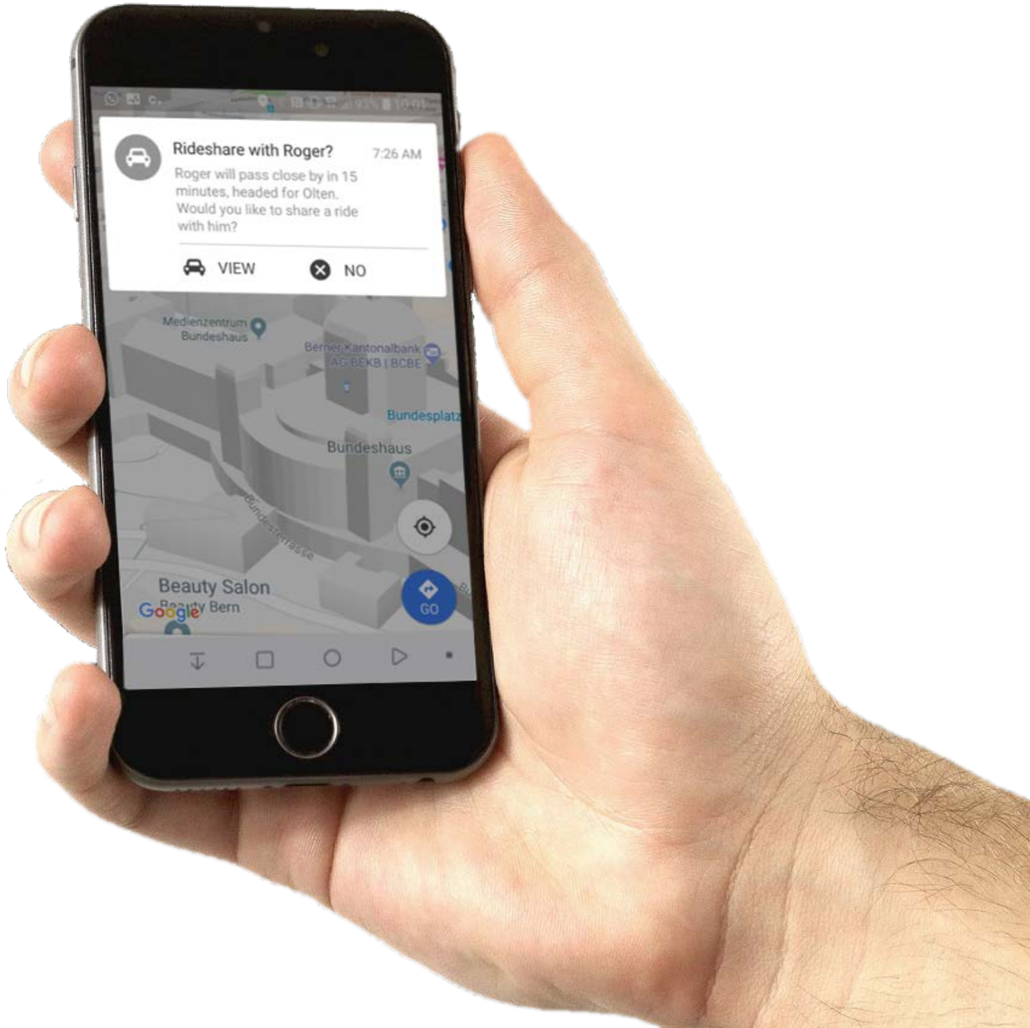
## Motivation & objectives

Ridesharing and carpooling can help reduce:

- Traffic congestion
- $CO_2$ emissions
- Fuel / energy consumption
- Travel costs

However, there is little support for robust short-term as well as automated rideshare planning!

➢ Prototype for **personalized**, **short-term** and **automated (proactive)** rideshare planning



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# Decision Support System for Personalized Ride-Sharing Services

## Work plan & methods

**Data integration and schedule extraction** (2019 Q2/3)

- Human movement (GPS tracks)
- Travel preferences and context (when, where, how, depending on weather, day of the week, traffic, etc.)
- Calendar information

**Trip identification** (2019 Q4)

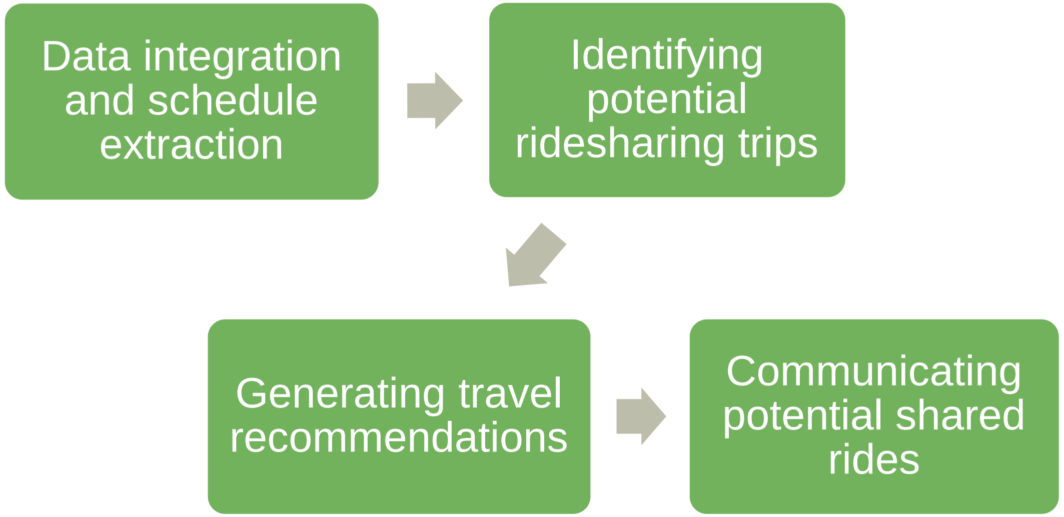
- Spatio-temporal clustering of historical and forecasted trips

**Travel recommendations** (2020 Q1/2)

- Context- and preference-based recommender system (would a similar user take a recommended trip?)

**Communication** (2020 Q2/3)

- Prototype application with tracking, calendar integration and decision support system




Martin Raubal (ETH Zurich)

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# Decision Support System for Personalized Ride-Sharing Services

## Involved partners

*Academic partner*

### Martin Raubal, Geoinformation Engineering / IKG, ETH Zurich

- The Mobility Information Engineering (MIE) Lab develops methods, systems and applications to **support individuals** in the use of **future mobility** concepts
- Experience with projects such as *GoEco!*, SBB Green Class and collaboration with the Swiss Data Science Center

*Implementation partners*

### HERE Technologies

- Global **mapping and location data** company and interested in machine learning methods for optimizing transport
- Project support through **coaching**, **experience exchange** (four workshops, plus collaboration on scientific publications) and provision of **mobility and movement data**

### ESRI Schweiz AG

- Leading supplier of **geographic information system** (GIS) software and **ancillary services** (data, cloud services, visualization tools)
- Interested in novel and generalizable methods for movement data analysis (using GIS)
- Project support through provision of data on **transport networks** and their use as well as **traffic status**

ETH zürich

MIE lab
Mobility Information Engineering
Lab at ETH Zurich

here

IARAI

esri Suisse

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# Decision Support System for Personalized Ride-Sharing Services

## New competences

- Spatially enhanced machine learning methods:
  - Prediction of high-level **mobility choice plans** (based on individually tracked past behavior)
  - Context integration, such as available modes of transport, weather, or individual calendar information
  - Assessment and **recommendations** for **collaborations**
- Novel data analysis methods:
  - Context-aware spatio-temporal **similarity measurement** (of past and predicted trips)
  - Financial and temporal **cost assessment** for detours within a ridesharing setting (considering real-time traffic and alternative transport options)
- Real-time travel choice recommendations using smartphone apps

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# Decision Support System for Personalized Ride-Sharing Services

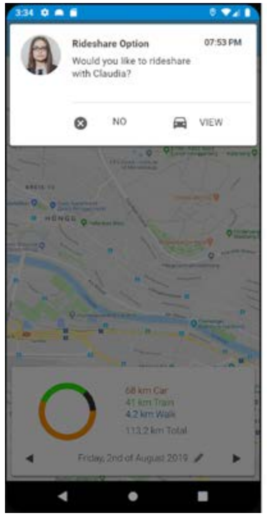
## Current status

- *trackintel* framework for mobility data analysis
  - ✓ Segmentation of tracking data
  - ✓ Map matching and transport mode identification
  - ⇨ Movement and mobility prediction
  - ✗ Trip / context-aware trajectory similarity
- Travel recommendations
  - ✓ General transport mode recommendations
  - ✗ Detour cost assessment
- *Rideshare* Android app development
  - ✓ Movement tracking
  - ⇨ Basic (eco-)feedback
  - ✗ Proactive notifications and user communication
- Data acquisition and generation
  - ✓ Datasets containing GPS trajectories and context
  - ⇨ *MATSim* to generate movement trajectories for a whole city

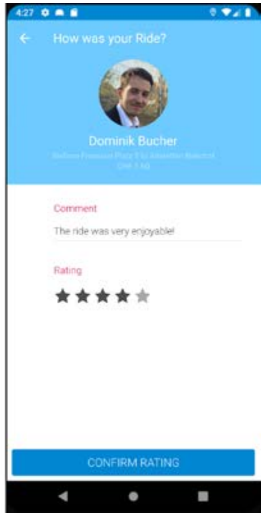
trackintel
github.com/mie-lab/trackintel

MATSim
Multi-Agent Transport Simulation
github.com/matsim-org/matsim


Passive tracking and mobility prediction




Proactive and real-time rideshare suggestions


Integrated communication and booking

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# Optimizing the potential impact of personal and autonomous electric mobility on grid stability

**Roman Rudel**

University of Applied Sciences and Arts of Italian Switzerland

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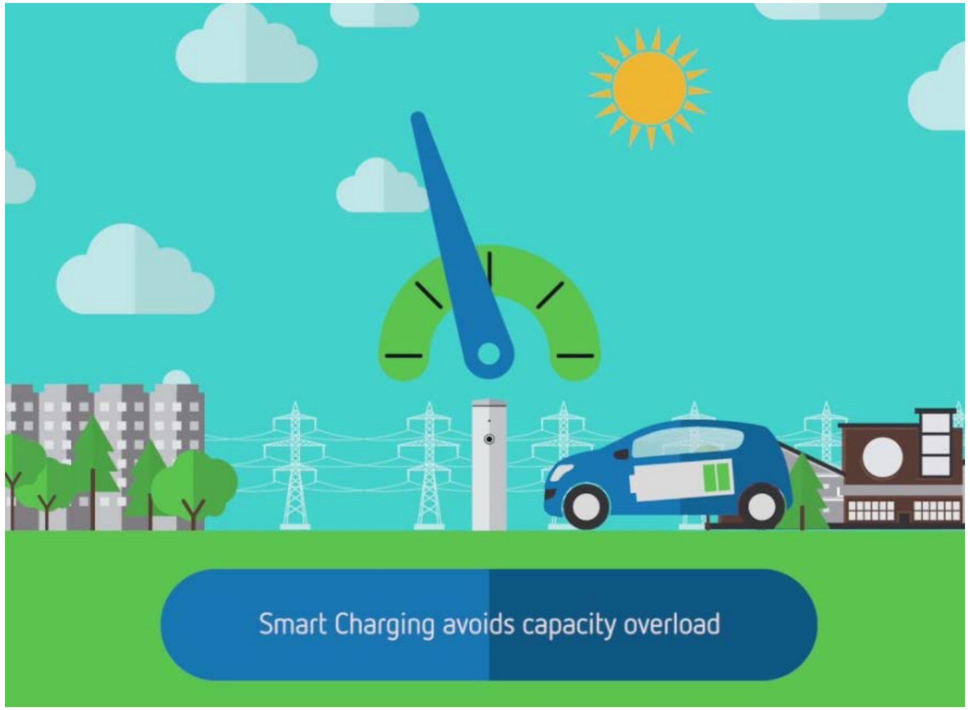
# Optimizing the potential impact of electric mobility on grid stability

## Motivation & objectives

Favor the integration of electric vehicles (EV) in the distribution grid using **smart charging strategies** (e.g. **vehicle-to-grid**) by:

- Optimizing mobility patterns (e.g. autonomous car fleets)
- Offering ancillary services to the distribution system operators (DSOs), e.g. to lower peak consumption
- Reducing CO2 emissions

➢ Investigating the **interaction** between the grid and electric vehicles considering **three different strategies** to **cover the mobility needs** of a broad population




Martin Raubal (ETH Zurich), Roman Rudel & Luca Maria Gambardella (SUPSI)

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# Optimizing the potential impact of electric mobility on grid stability

## Work plan & methods

**Generation of spatio-temporal activity schedules** (2019 Q2/3)

- spatio-temporal activity schedules
- movement data with simulated pickup and delivery locations

**Generation of power grid and usage** (2019 Q3)

- a tool for the generation of realistic synthetic grid topologies

**Generation of different scenarios** (2019 Q4)

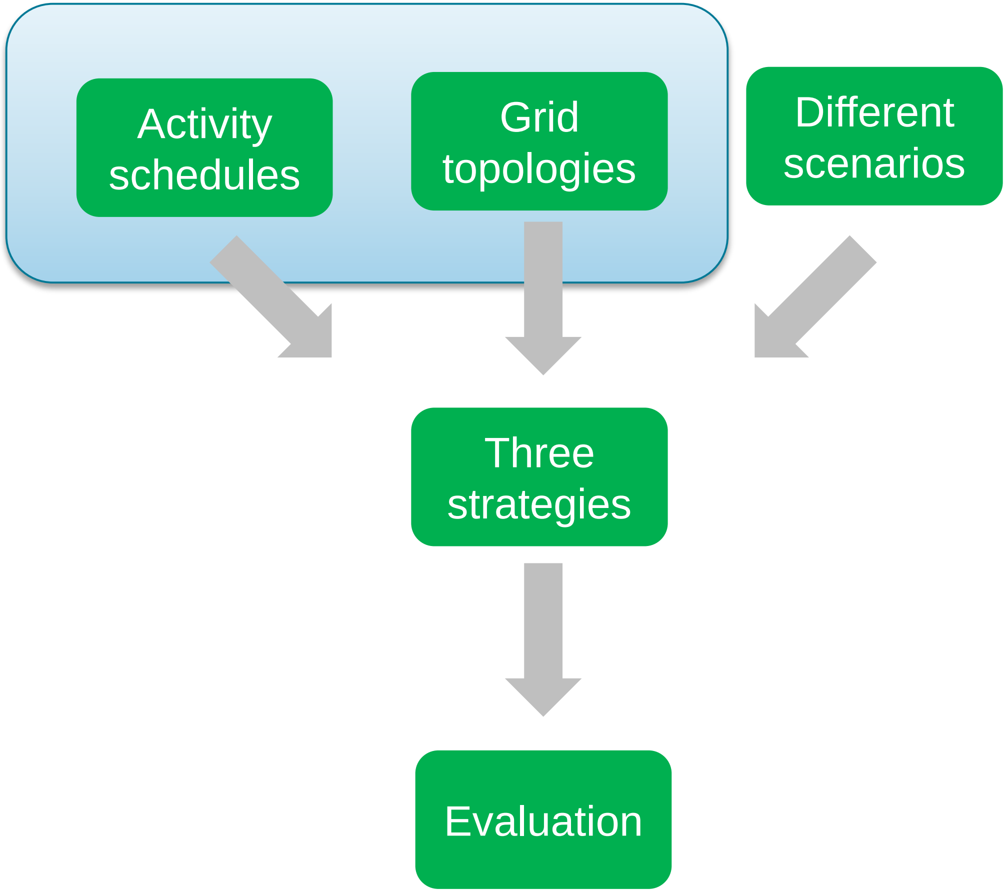
- model the penetration of distributed energy resources, EVs and charging stations

**Strategies to cover mobility needs** (2020 Q2)

- baseline strategy, considering commonly applied charging patterns
- robust control strategy based on probabilistic personalized mobility forecast
- grid-aware dial-a-ride problem using an autonomous electric vehicle fleet

**Evaluation using a power system simulation** (2020 Q3)

- validate the potential benefits of the three strategies for the energy system

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# Optimizing the potential impact of electric mobility on grid stability

## Involved partners

### *Academic partners*

**Martin Raubal, Geoinformation Engineering / IKG, ETH Zurich**

- Generation of spatio-temporal activity schedules and movement data based on multisource data and state-of-the-art simulation models
- Develop user-specific models for personalized mobility forecasts

**Roman Rudel, SUPSI-ISAAC - SCCER FURIES Team**

- Develop a tool for the generation of realistic synthetic grid topologies
- Realistic penetration scenarios by modelling the penetration of distributed energy resources, EVs and charging stations
- Evaluate the impact of EV charging and discharging on the quality of service of the distribution grid

### *New academic partner*

**Luca Maria Gambardella, SUPSI-IDSIA (Dalle Molle Institute for Artificial Intelligence)**

- Develop optimization algorithms for the Grid-aware Electric Dial-a-Ride Problem (GE-DARP)

ETH zürich

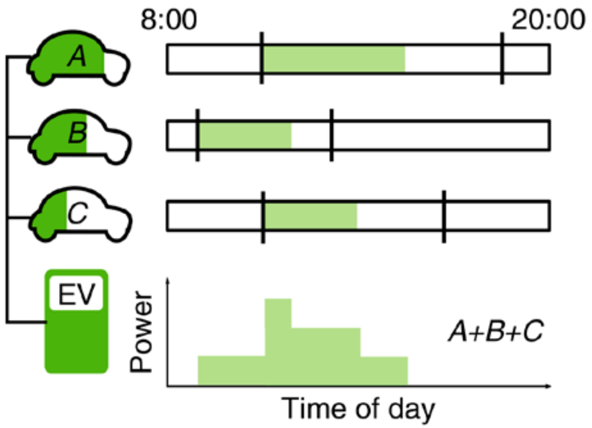
University of Applied Sciences and Arts of Southern Switzerland
SUPSI

USI/SUPSI
Istituto Dalle Molle di studi sull'intelligenza artificiale
IDSIA

# Ongoing activities on Generation of activity schedule of EV users

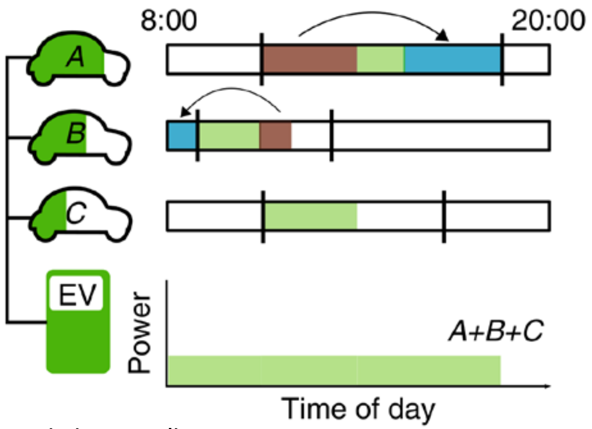
## Requirements

Planning and optimizing the future grid expansion and operation under high penetration of electric vehicles requires the consideration of the people's mobility behavior.




Approach has strong **requirements** on the data:

- High spatio-temporal granularity of charging behavior
- Specific spatio-temporal extent
- Large and geographically concentrated sample




Graphic based on: Xu, Y., Çolak, S., Kara, E. C., Moura, S. J., & González, M. C. (2018). Planning for electric vehicle needs by coupling charging profiles with urban mobility. *Nature Energy*, 3(6), 484.

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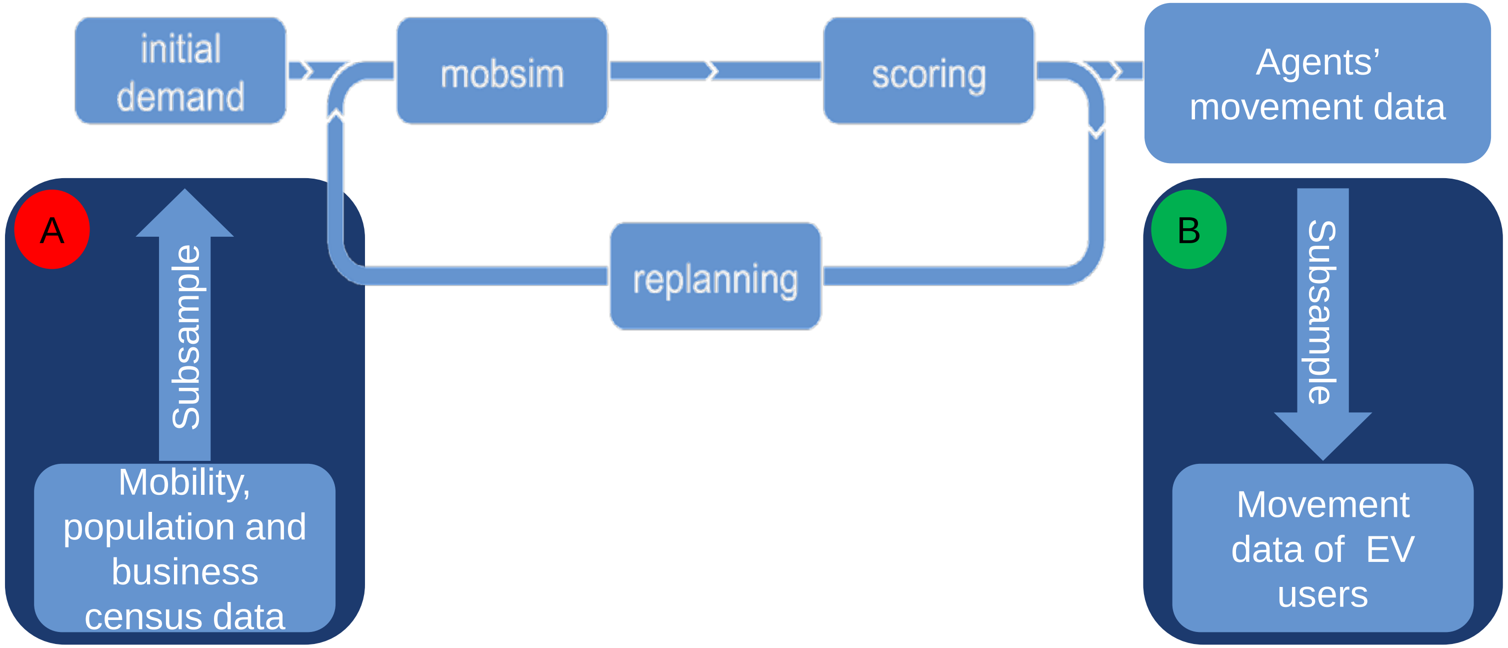
# Ongoing activities on Generation of activity schedule of EV Users

## Approach using MATSim




Challenges/work in progress:

- Correct consideration of the influence of e-mobility on mobility behavior (e.g. charging stops, possible range anxiety, … )
- Sampling of EV users (**who** is buying **which** EV **where**) by
  - **(A)** subsampling the input data
  - **(B)** subsampling the resulting mobility profiles.

Graphic based on: Axhausen, K. W., Nagel, K. and Horni, A. (eds) (2016) *The Multi-Agent Transport Simulation MATSim*. London: Ubiquity Press. DOI: https://doi.org/10.5334/baw

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# Ongoing activities on automatic distribution grid generation

The aim is to enable the detailed simulation of a distribution grid in a zone of interest, starting from geospatial and urbanistic data.
Main features already in good shape:

- Automatic routing and connection considering street paths
- TAHC[1] clustering
- Automatic cable sizing
- Balancing of 1-phase connections

*Example of routing and feeder identification: Arogno (TI)*

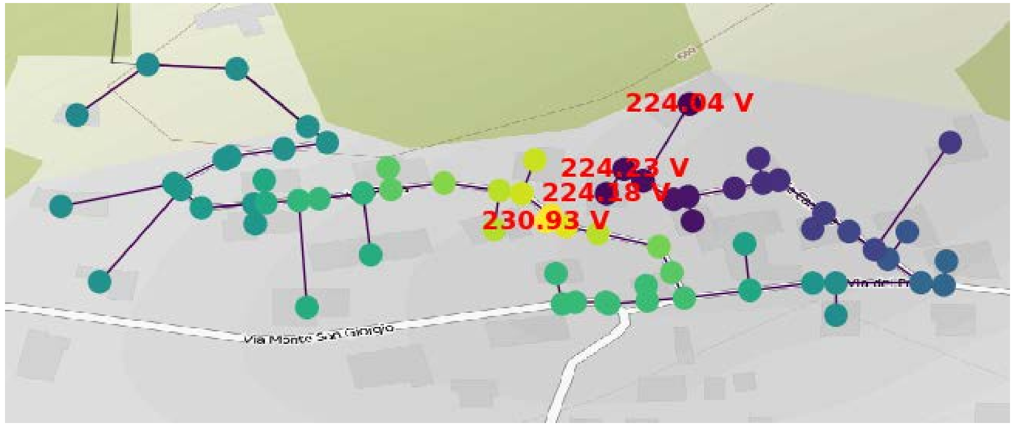
*[1] Yu, M., Hillebrand, A., Tewarie, P., Meier, J., van Dijk, B., Van Mieghem, P., & Stam, C. J. (2015). Hierarchical clustering in minimum spanning trees. Chaos, 25(2), 1–10. https://doi.org/10.1063/1.4908014*

# Ongoing activities on automatic distribution grid generation

The automated sizing is performed by identifying a diversified current for each cable segment $i$ in the following way:

$$I_{d,i} = d_f(K) \sum \boldsymbol{P_{i,k}} \quad \forall i$$

Where $\{1 \dots k \dots K\}$ identify the buildings served by the segment $i$, $P_{i,k}$ their power and $d_f$ a diversification factor. The circuit can be then directly simulated with the in-house tool krangpower.




*Example of voltage simulation of a 1-feeder syntetic grid solution: Tremona, TI*

Challenges/work in progress:

- Set preferred cluster sizes for fitting commonly available transformer sizes
- The clustering mechanism is sensible to certain corner cases
- Advanced customer power estimation based on complementary GIS data
- MV routing

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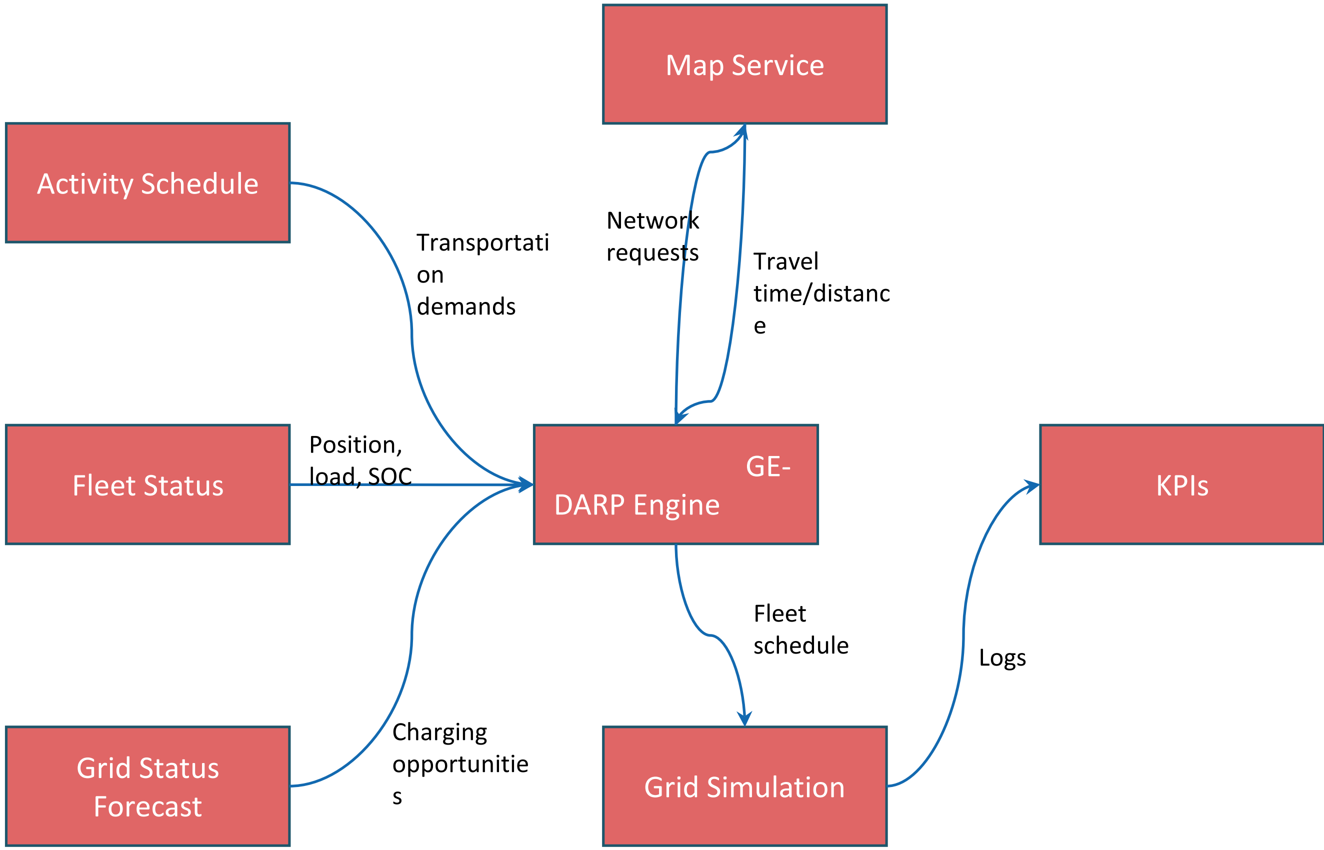
# The concept of the Grid aware – Dial for a Ride Problem (IDSIA)

- **Input:**
  a. The enriched personalized agendas of users
  b. EV fleet: type (capacity, power, available charging technology), status (position and SOC)
  c. Charging infrastructure: type (max power and technology), position in the network, network status
- **Output:**
  a. The pick-up/delivery schedules of the Evs
  b. The battery charging (optional discharging) schedule

- Algorithms:
  a. Small-medium sized instances are solved to optimality with the use of Branch&Cut&Price techniques to obtain bounds
  b. Realistic sized instances are solved with metatheuristics



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# Optimizing the potential impact of electric mobility on grid stability

## Knowledge & technology transfer

### Scientific publications

- On the personalized mobility forecast problem
- On the Grid-aware Electric Dial-a-Ride Problem based on autonomous electric vehicles

### Existing and potential collaborations

- SCCER Mobility and FURIES networks
- Communicating the results of the project through our industry contacts and partners (e.g. the Swiss Federal Railways SBB, BMW, electric grid operators, Energie360°, etc.)

### Conferences

Martin Raubal (ETH Zurich), Roman Rudel & Luca Maria Gambardella (SUPSI)