

# Munich Mobility Research Campus

Data fusion from real-time and historical trajectories  
for the microscopic traffic flow simulation  
of the campus of the University of the Bundeswehr Munich

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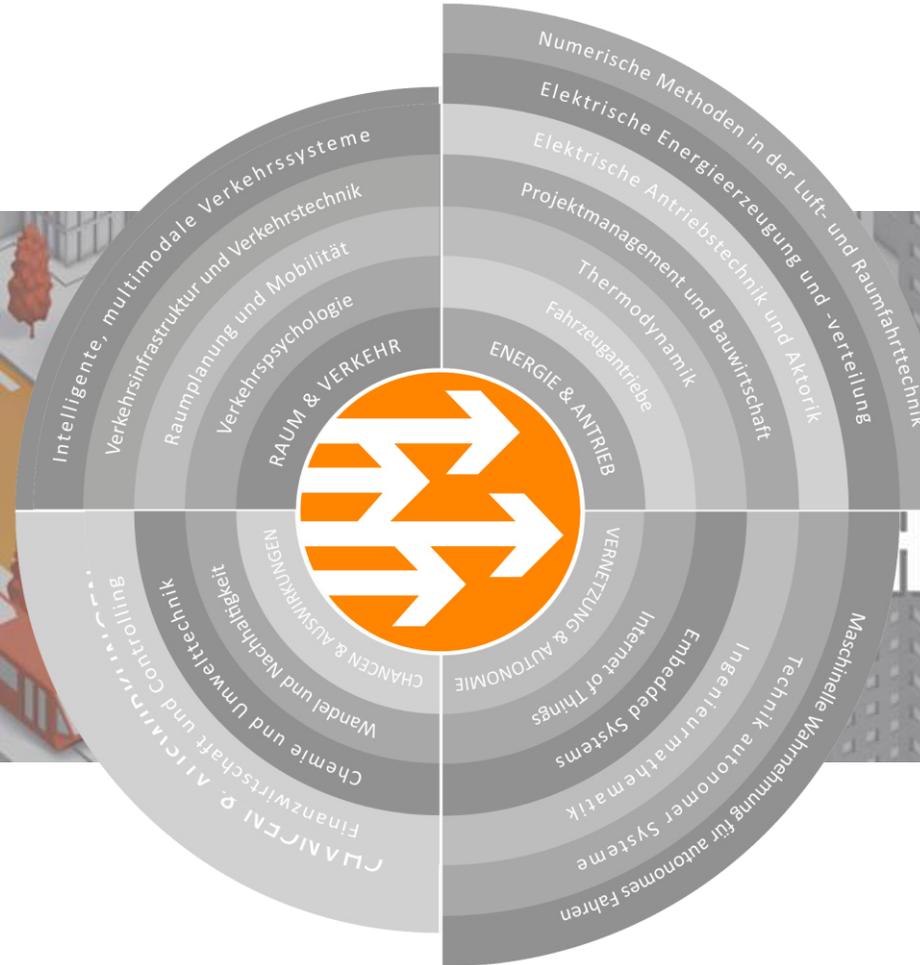
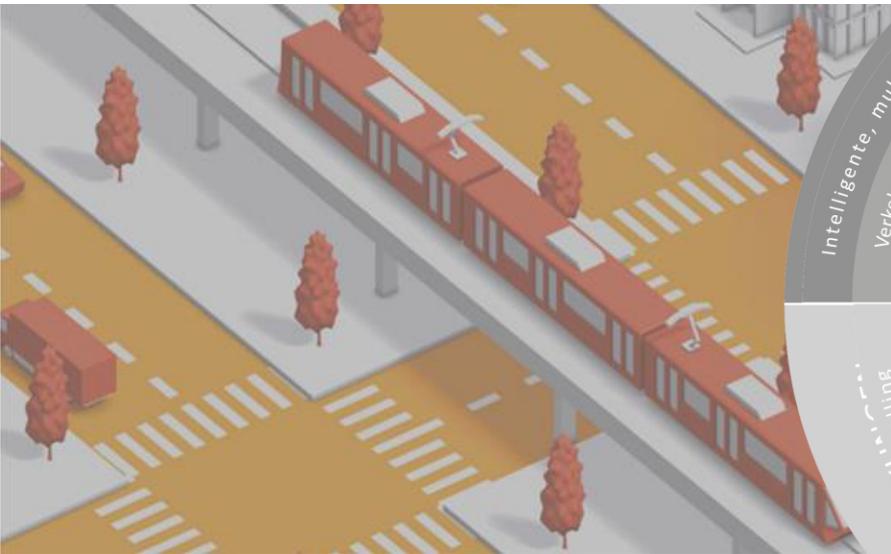
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der Bundeswehr  
Universität München 

# Agenda

- Research project Munich Mobility Research Campus (MORE) of the University of the Bundeswehr Munich (UniBwM)
- Traffic data collection system in the campus of UniBwM
- Research objectives **WHY?**
- Methodology **HOW** 
- Results **WHAT** 
- Summary
- Outlook

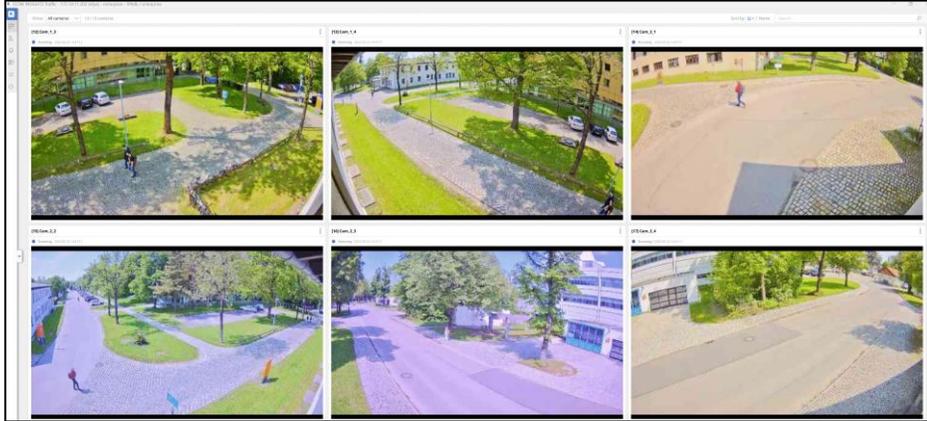
# Project MORE



43,8 Mio € Förderung	7 Fakultäten UniBwM	15 Demonstratoren	26 Labore aufgebaut
24 Nationen	88 Forschende UniBwM	2 Start-Ups	143 Veröffentlichungen
105 Mitarbeitende bei den Partnern	57 Kooperationspartner	 Motivation	1 Patentanträge

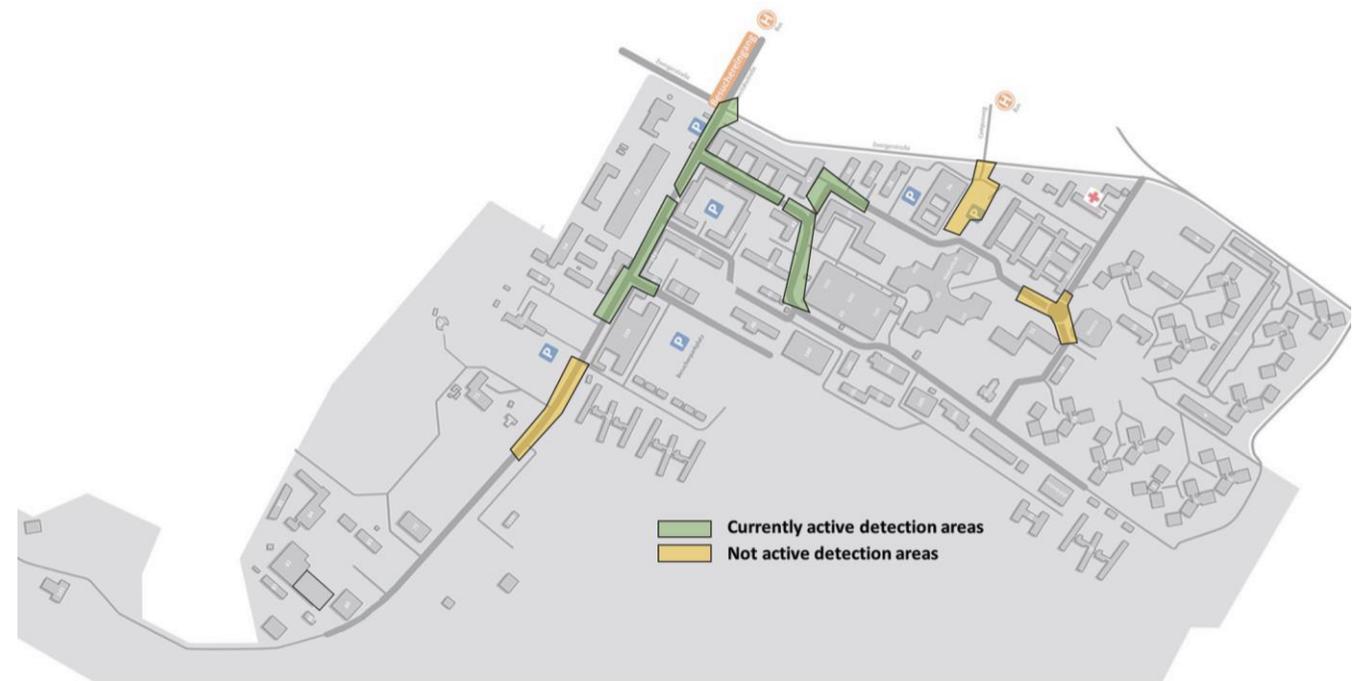
# Traffic Data Collection System

Camera-based data collection system in the campus of UniBwM



## Trajectory and traffic data collection

- Trajectories for offline and online analysis
- Trajectories for simulation and real-time applications



# Research Objectives

## WHY?

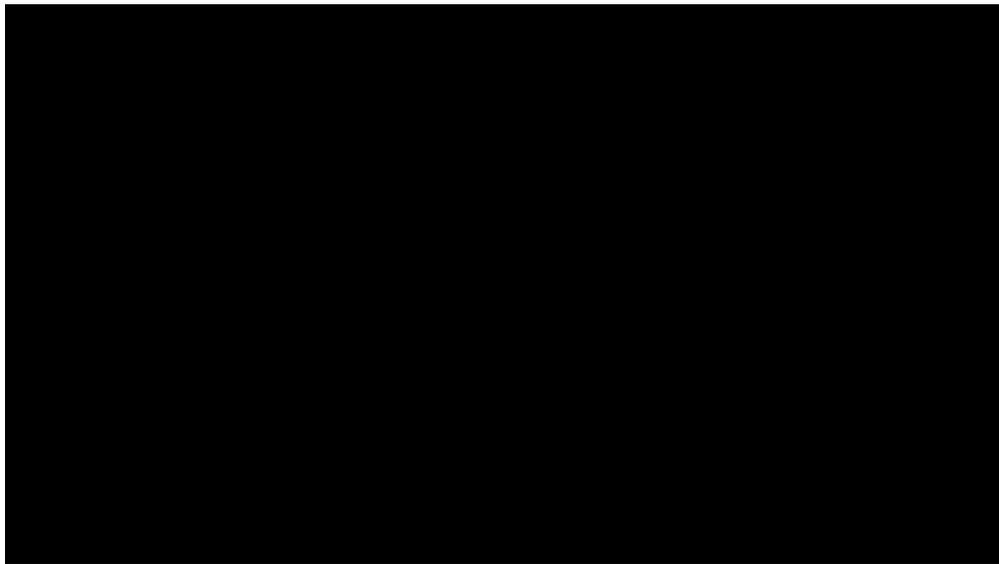
### Goals

- This work aims to give **insights for cities** that (plan to) utilize cameras and simulations:
  - to understand better traffic demand and
  - optimize traffic supply.
- The presented work tries to answer the following two **research questions**:
  - What is the accuracy of the traffic measurements from the trajectory-based data collection system of the campus of the University of the Bundeswehr Munich?
  - What is the potential of data fusion of (historical and real-time) trajectories for the calibration and validation of the multimodal microscopic traffic simulation of the campus of the University of the Bundeswehr Munich?

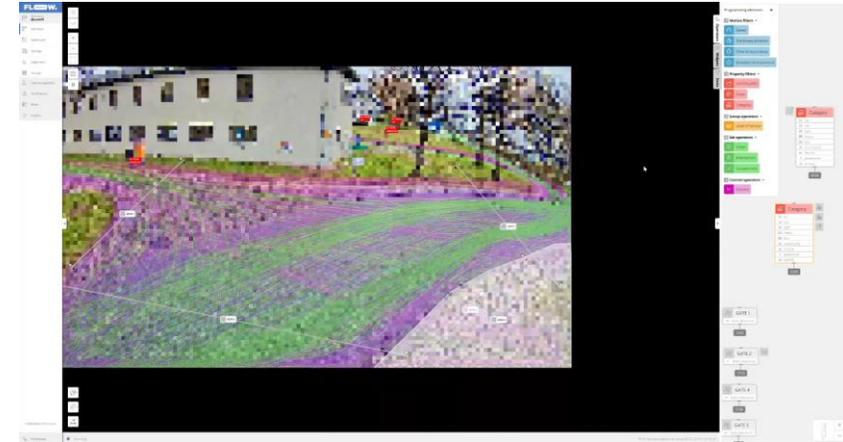
## HOW

### Tools

- The campus of the University of the Bundeswehr Munich offers a great real laboratory environment for mobility research.
- State-of-the-art camera-based traffic data collection system with the software FLOW from DataFromSky



<https://datafromsky.com/flow/>, <https://vimeo.com/505156783>



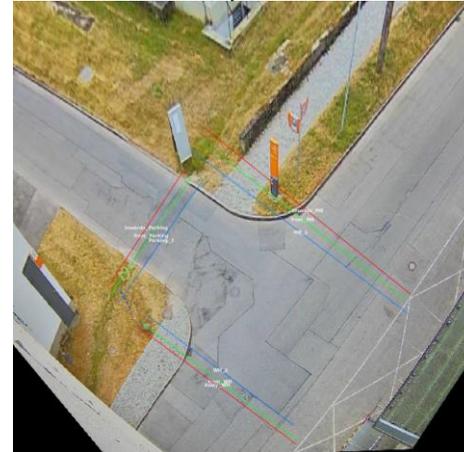
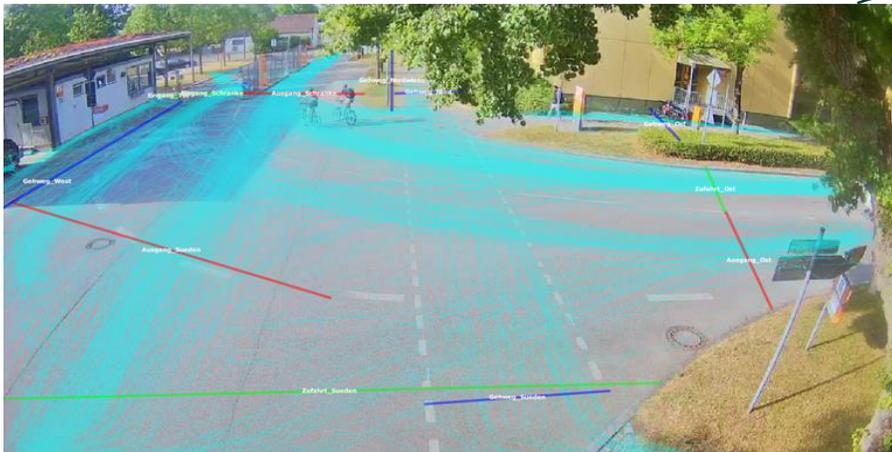
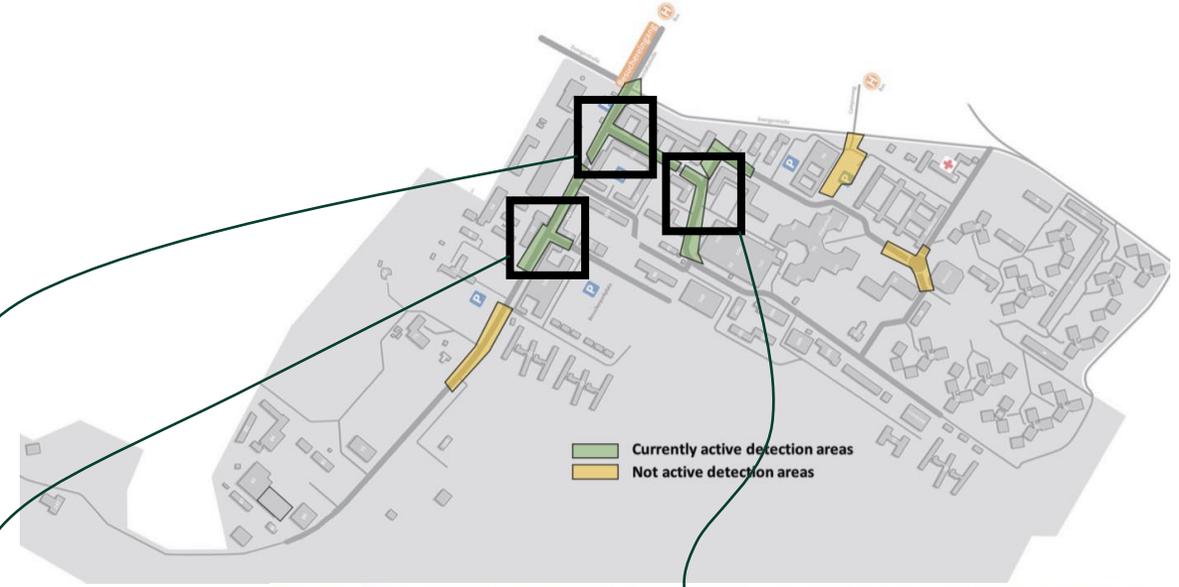
# Methodology

## HOW

### Tasks

Trajectory-based traffic measurements:

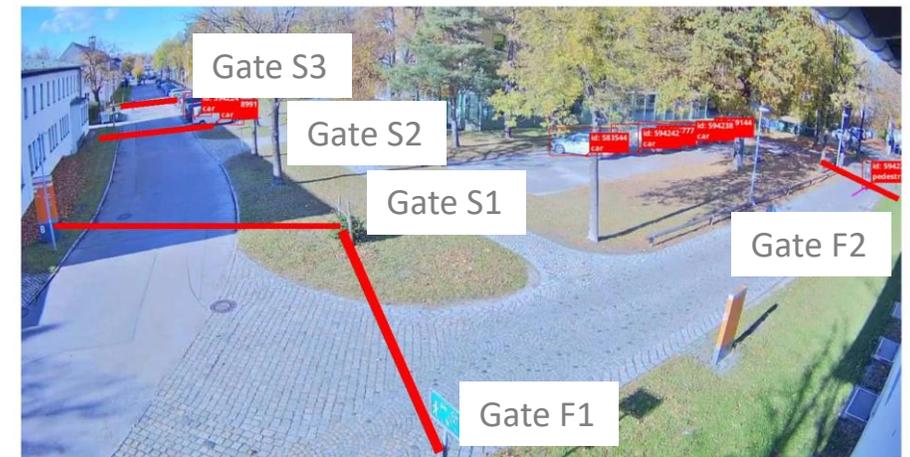
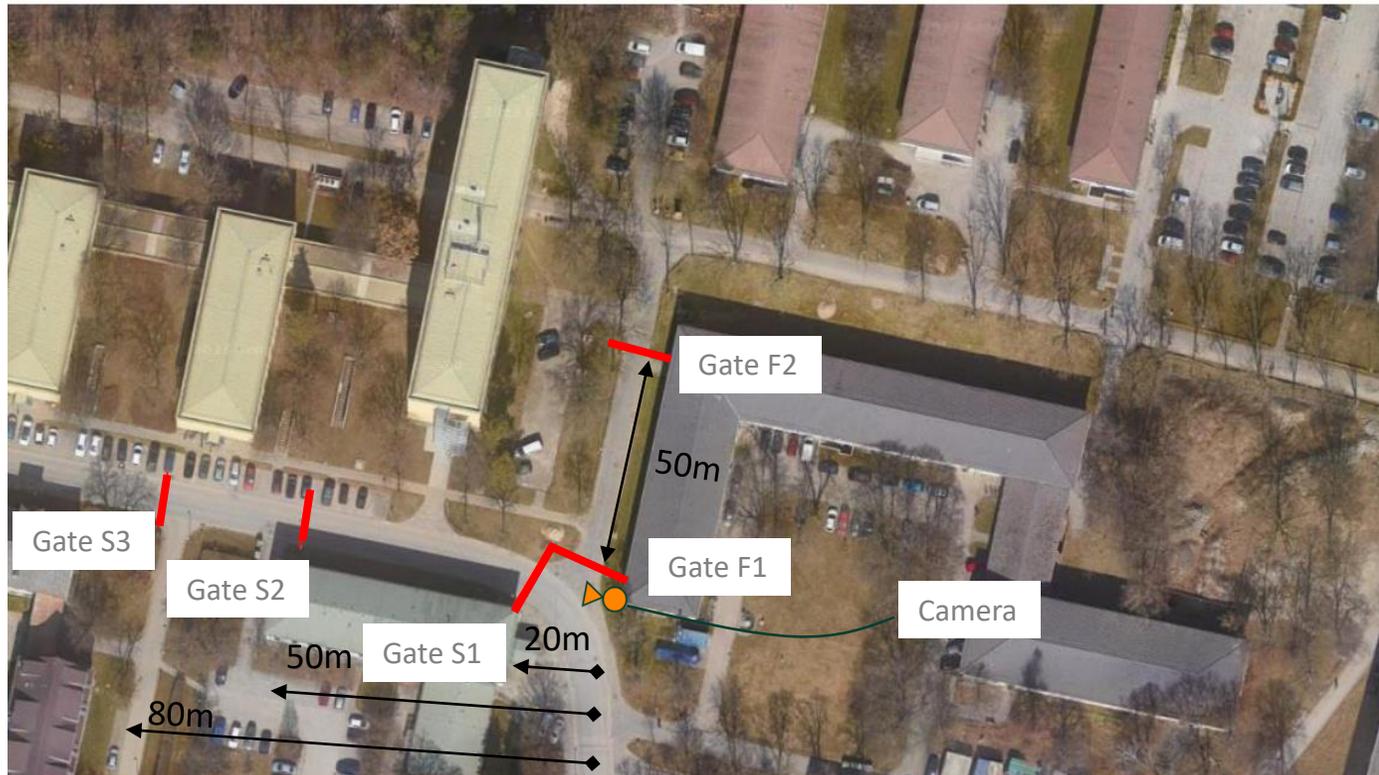
- Collection of traffic measurements from cameras
- Collection of ground truth measurements with manual counting or other sensors
- Comparison and evaluation of the quality of the traffic measurements with statistical methods



# Traffic Measurements - Traffic Counts

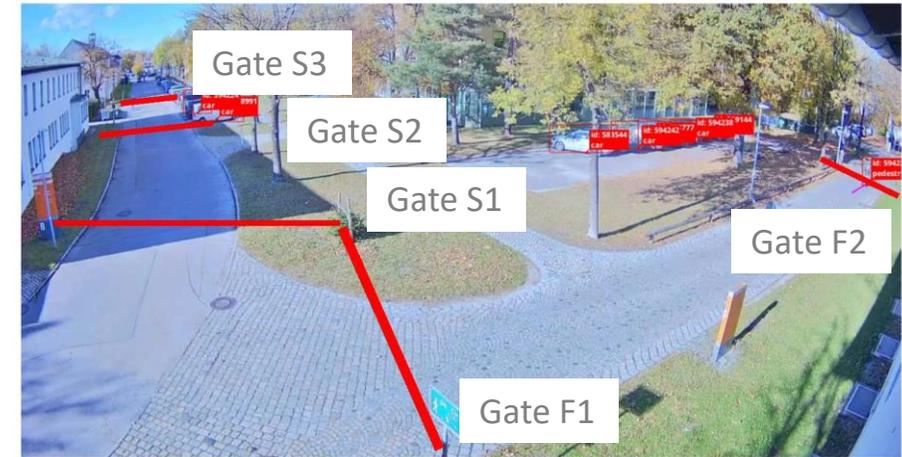
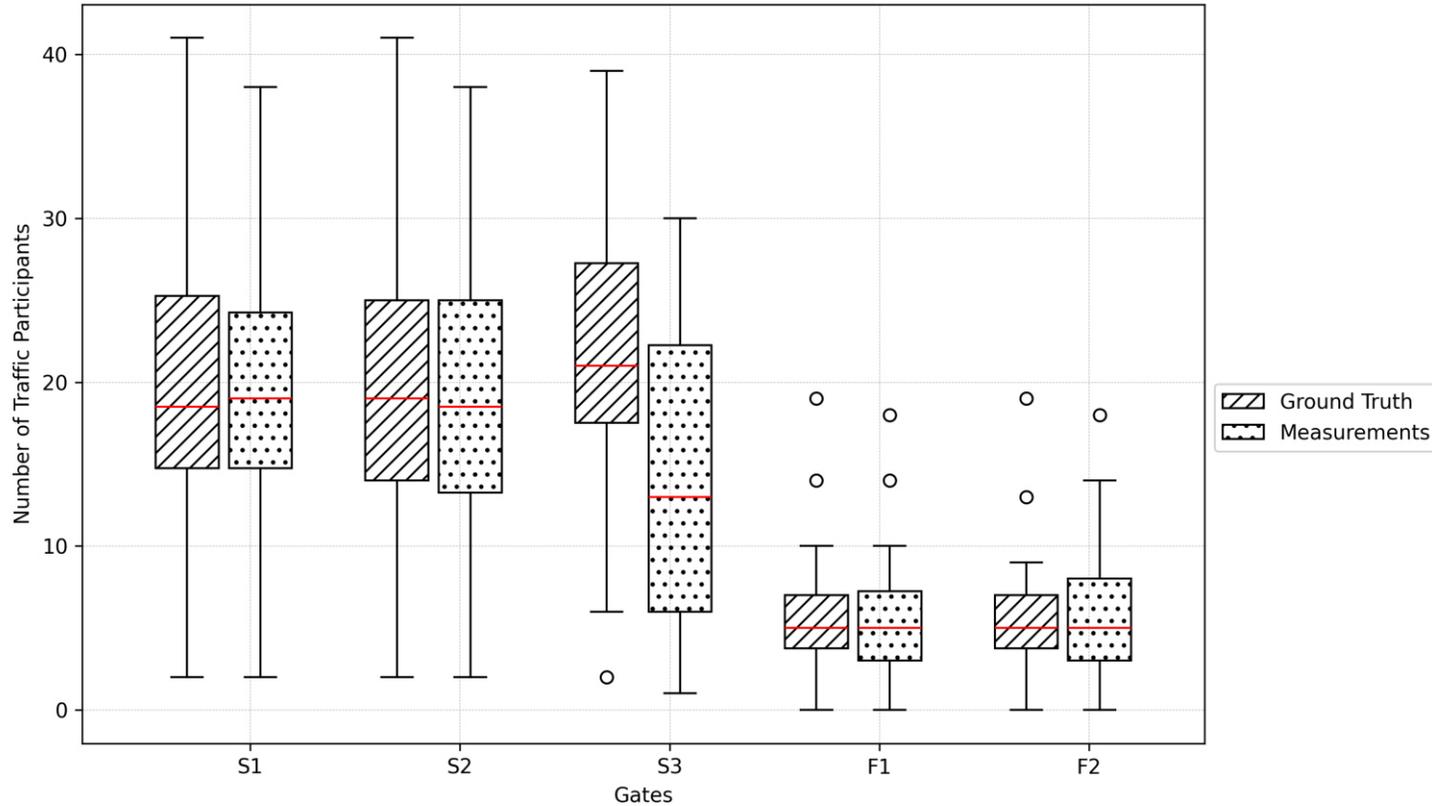
WHAT 

Auswertung der Verkehrserfassung mit Videoanalyse auf dem Campus der Universität der Bundeswehr München (Klose, M.. 2024)



# Traffic Measurements - Traffic Counts

Car - Ground Truth vs Measurements

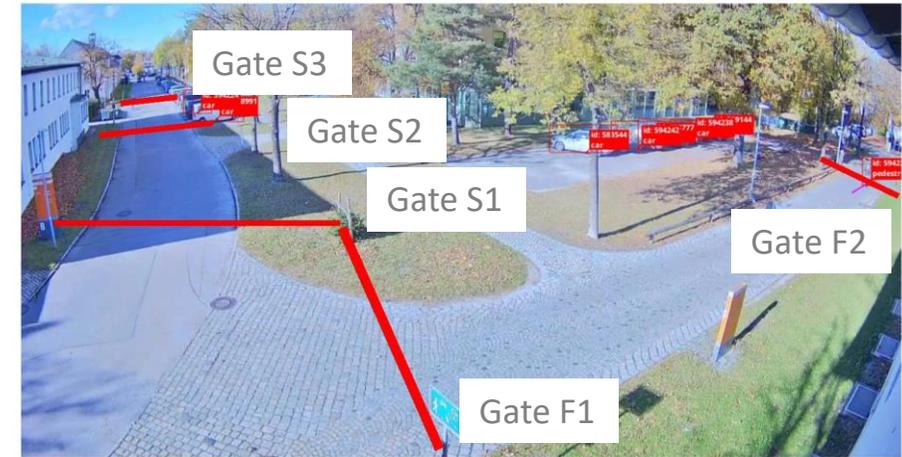
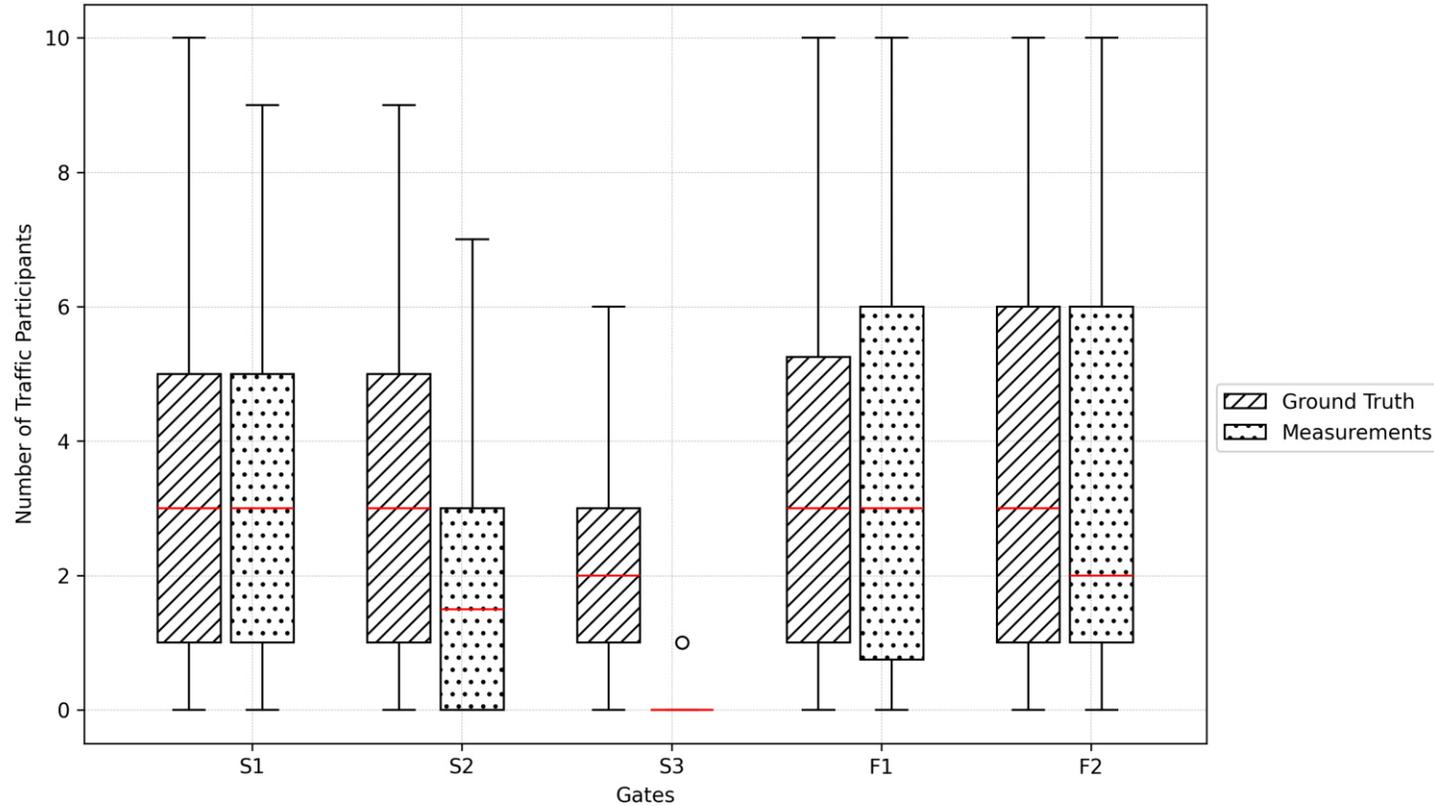


n=32	S1	S2	S3	F1	F2
RMSE:	1.4895	1.9605	8.3666	0.5356	0.7289
p-value	0.9077	0.6593	1.577e-10	0.5590	0.8127

Camera measurements have no significant errors (p-value > 0.05)	Camera measurements have significant errors (p-value < 0.05)
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# Traffic Measurements - Traffic Counts

Bicycle - Ground Truth vs Measurements



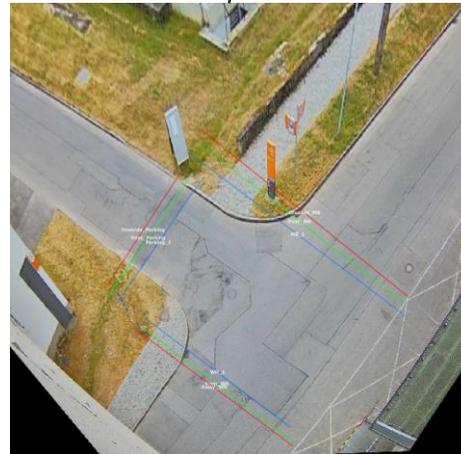
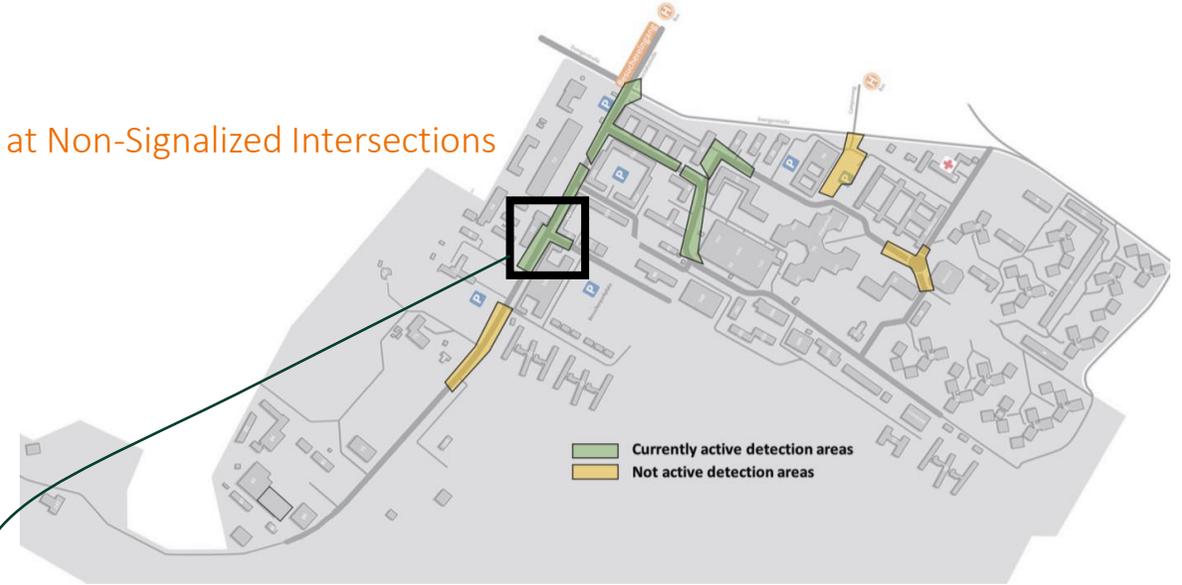
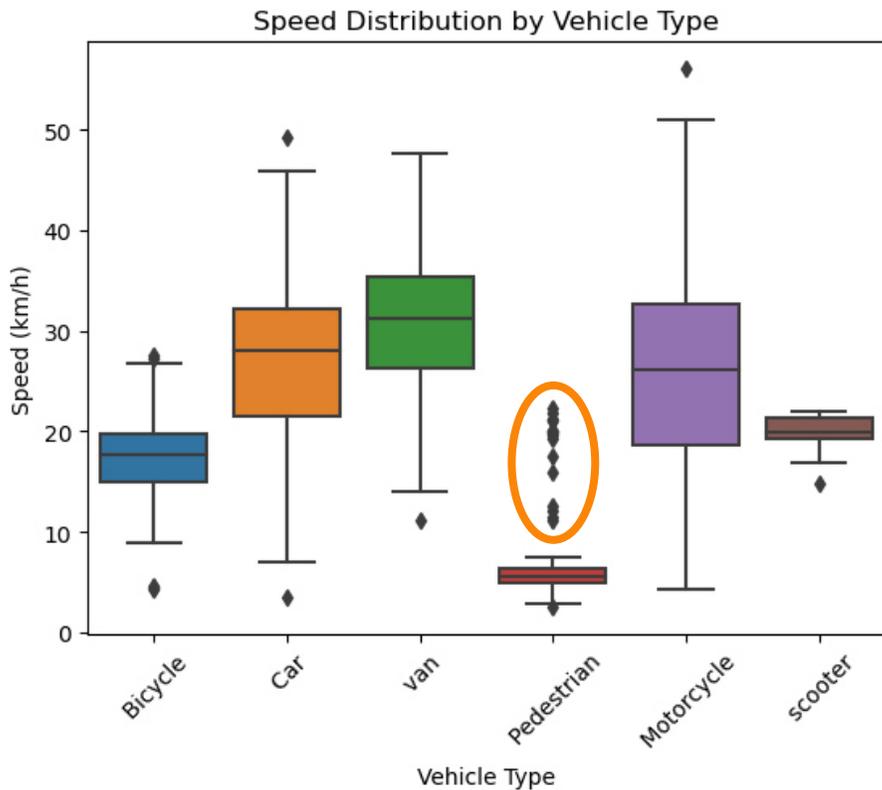
n=32	S1	S2	S3	F1	F2
RMSE:	0.6124	2.1065	2.6339	0.5863	0.8101
p-value	0.5720	0.0006	7.202e-08	0.7683	0.0478

Camera measurements have no significant errors (p-value > 0.05)	Camera measurements have significant errors (p-value < 0.05)
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# Measurements - Speeds and Conflicts

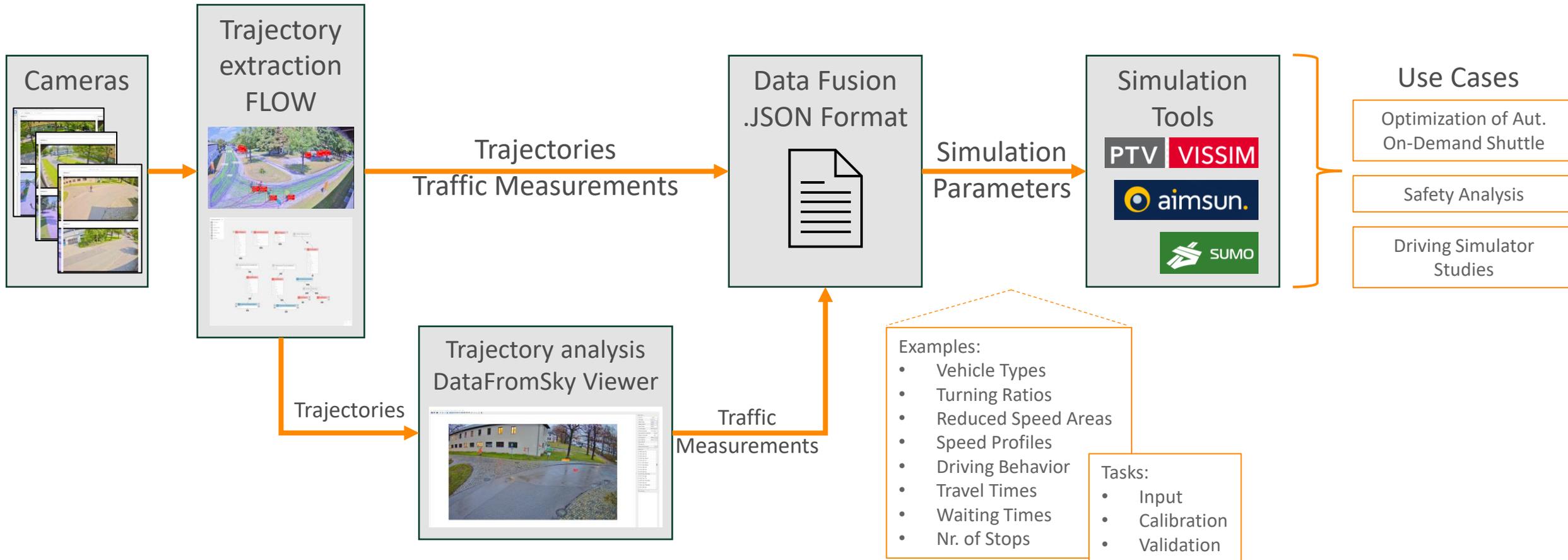
## WHAT

Simulation-based Analysis of the Impact of Novel Modes of Transportation at Non-Signalized Intersections (Sathya Kumar, 2024, to be published)



## WHAT

### Functional Architecture



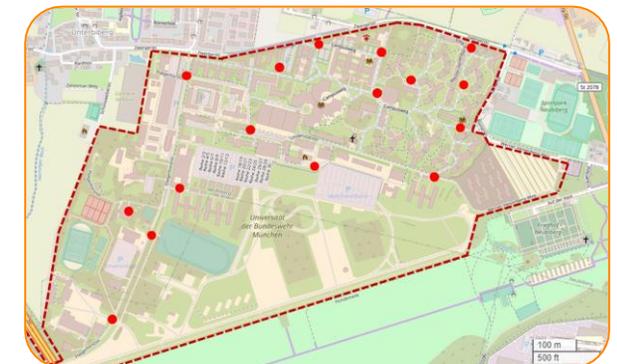
## WHAT

### Optimization of Autonomous On-Demand Shuttle Operation

- Traffic demand based on trajectories from MORE-Sharing
- Multimodal microscopic traffic simulation of the campus
- Evaluation of operation scenarios



	Scenario I	Scenario II	Scenario III	Scenario IV
Operation type	Ride-hailing	Ride-pooling	Ride-hailing	Ride-pooling
Vehicle capacity	1	3	1	3
Fleet size	1	1	2	2
Number of denied requests	8	5	2	0
Average occupancy (per shuttle)	0.58	1.25	0.56	1.12
Average waiting time (per served request)	6.55 min	4.96 min	5.58 min	3.69 min
Average distance travelled (per shuttle)	25735 m	26050 m	19392 m	19750 m



O. Arslan, S. Hoffmann. (2024). Implementierung eines spontanen Matching-Algorithmus für On-Demand Shuttle-Systeme in der Mikrosimulation. In HEUREKA – Optimierung im Verkehr und Transport.

# Summary

## Research questions

- What is the accuracy of the traffic measurements [...]?
  - (+) Reliable traffic measurements (counts, section speeds, travel times) with typical angles and distances of detection gates and zones.
  - (-) Difficulties in distinguishing between pedestrians and e-scooters.
  - (\*) Instantaneous speed and acceleration measurements need further detailed evaluation.
- What is the potential of data fusion [...]?
  - Good question! Work in progress...

## Insights for cities

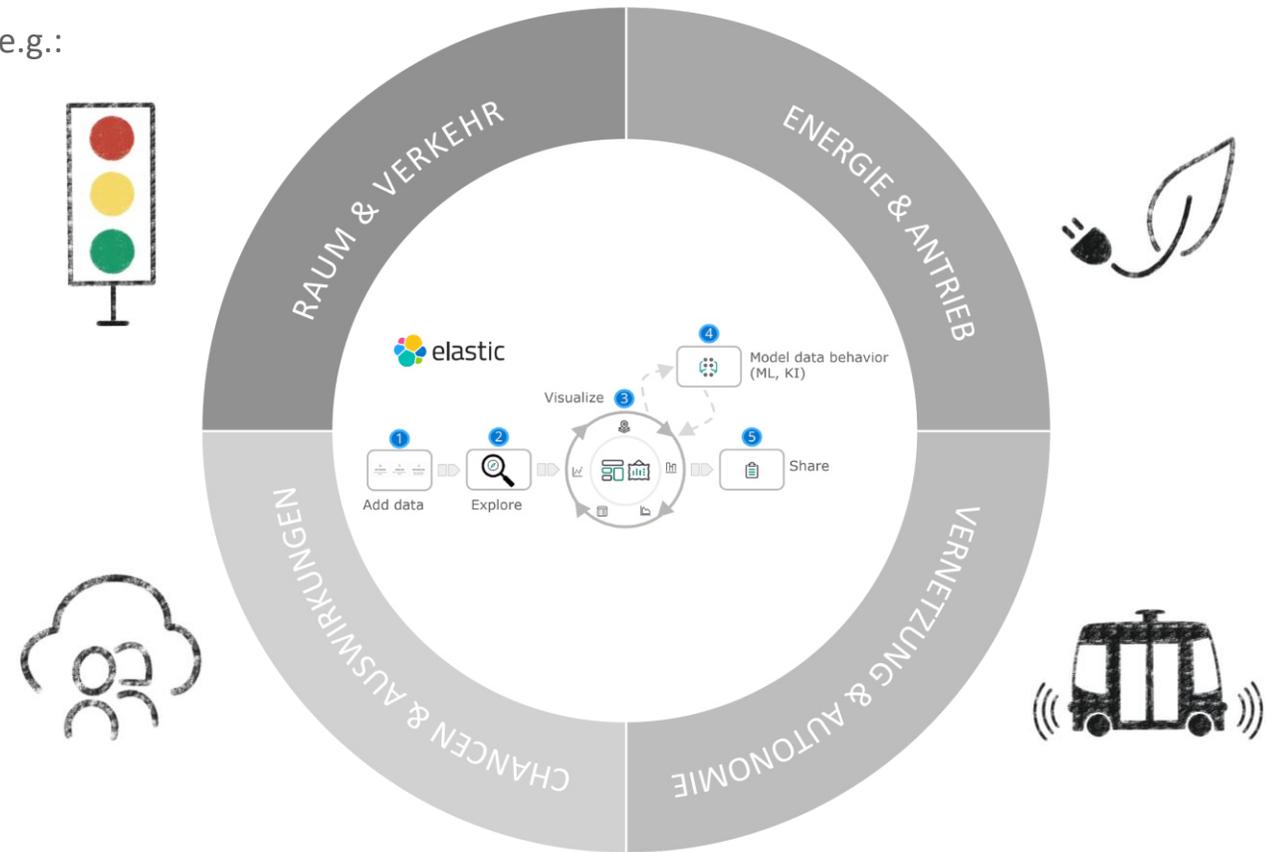
- Choose the position of the detection gates/zones (i.e., angle, distance) after video observations from your experienced engineers.
- Perform statistical analysis to establish the positions of the detection gates/zones (e.g.,  $n > 30$ : 8 hours  $\rightarrow$  32 x 15-minute intervals).
- Define your Use Cases first! Then choose the relevant traffic measurements for the simulation parameters (input, calibration, validation).
- Data Privacy and Data Security concerns are understandable but technically and organizationally solvable.





### Data Fusion Analytics Engine based on elasticsearch

- Data Fusion for offline/online simulations and real-time applications, e.g.:
  - Shared-Space simulation
  - Automated Vehicles and Vulnerable Road Users
- Machine Learning functionalities for offline/online analysis, e.g.:
  - Mobility pattern recognition
  - Traffic demand prediction



<https://www.elastic.co/de/elasticsearch>

# Credits and Thanks!



**Sagar Meda Badareesh**

Wiss.Hilfskraft

Meda Badareesh, S. (2024). *Integration of a Driving Simulator and SUMO for Evaluation of Safety in UniBwM Campus with Future Mobility Scenarios*. Chair of Traffic Engineering and Control, Faculty of Civil, Geo and Environmental Engineering, Technical University of Munich



**Hanna Charlot Grüsner**

Wiss.Hilfskraft

Grüsner, H. (2023). *Entwicklung eines Algorithmus zur Auswertung des Mobilitätsverhaltens mittels Trajektorienerfassung im begrenzten mobilen Umfeld*. Hochschule München Fakultät für Maschinenbau, Fahrzeugtechnik, Flugzeugtechnik



**Maximilian Klose**

Wiss.Hilfskraft

Klose, M. (2024). *Auswertung der Verkehrserfassung mit Videoanalyse auf dem Campus der Universität der Bundeswehr München*. Institut für Verkehrswesen und Raumplanung, Fakultät Bauingenieurwesen und Umweltwissenschaften, Universität der Bundeswehr München



**Pavithra Sathya Kumar**

Wiss.Hilfskraft

Sathya Kumar, P. (2024, to be published). *Simulation-based Analysis of the Impact of Novel Modes of Transportation at Non-Signalized Intersections*. Chair of Traffic Engineering and Control, Faculty of Civil, Geo and Environmental Engineering, Technical University of Munich

**Thank you!**



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