Integrated Simulation of Microscopic Traffic Flow and Vehicle Dynamics

Integrierte Simulation von mikroskopischem Verkehrsfluss und Fahrdynamik

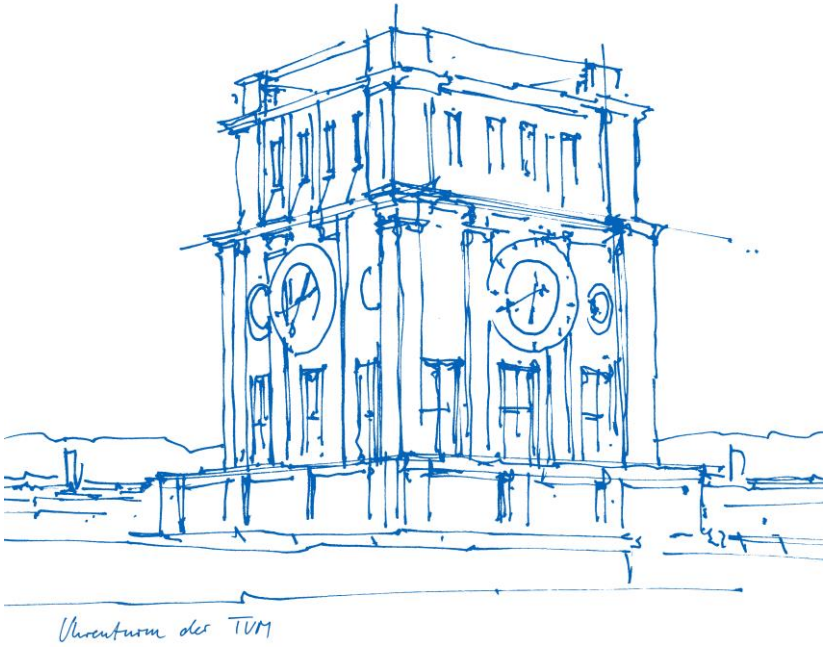
Dipl.-Ing. Jakob Kaths & Sabine Krause, M.Sc.

Lehrstuhl für Verkehrstechnik

Univ.-Prof. Dr.-Ing. Fritz Busch

Ingenieurfakultät Bau, Geo, Umwelt

Technische Universität München



Apply & Innovate 2016 (September 21, 2016)

Content

Motivation

Microscopic Traffic Flow Simulation vs. Vehicle Dynamics Simulation

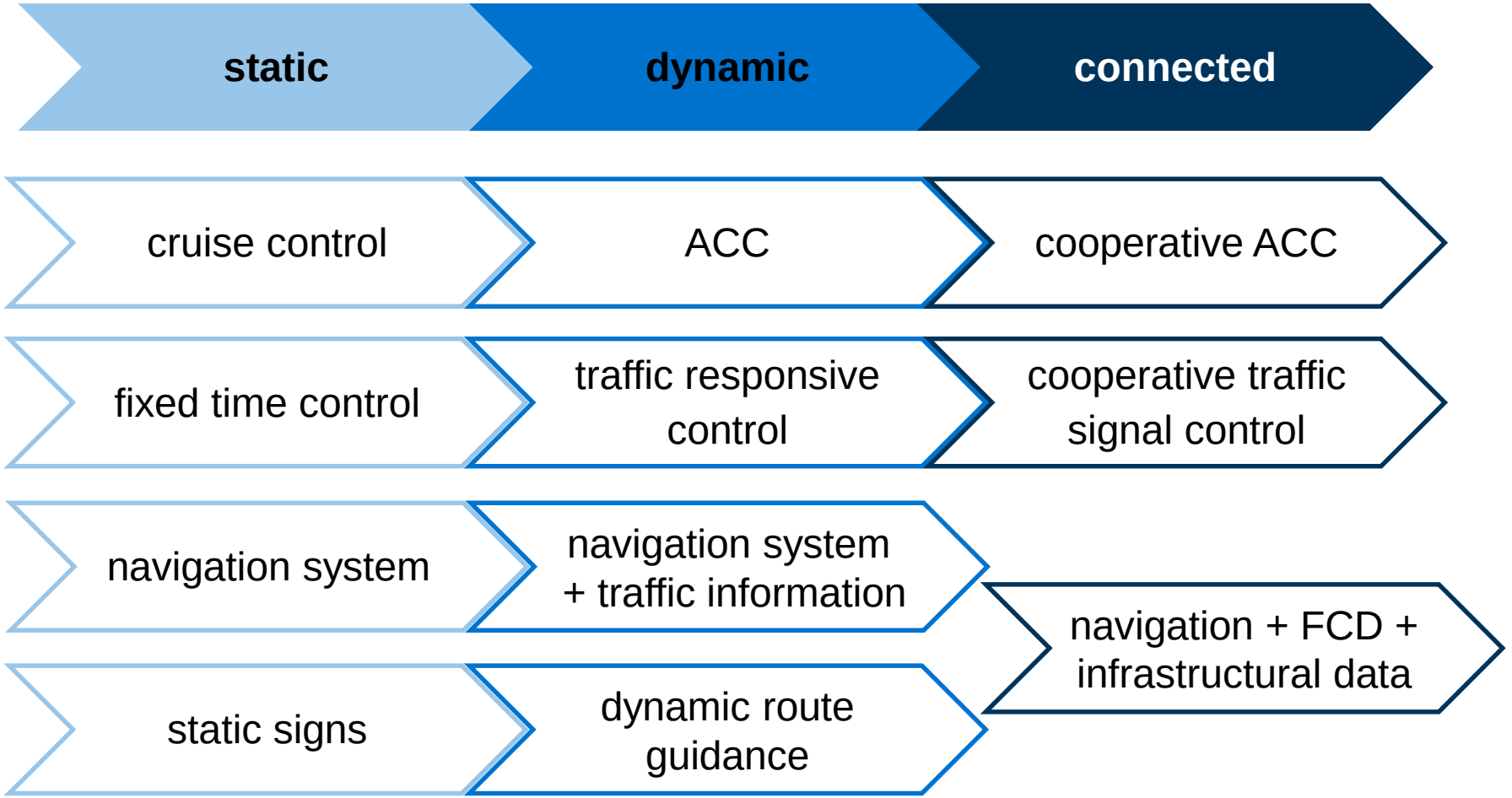
Integration of SUMO und CarMaker

- Goals
- Implementation
- Examples
- Applications

Outlook

Motivation

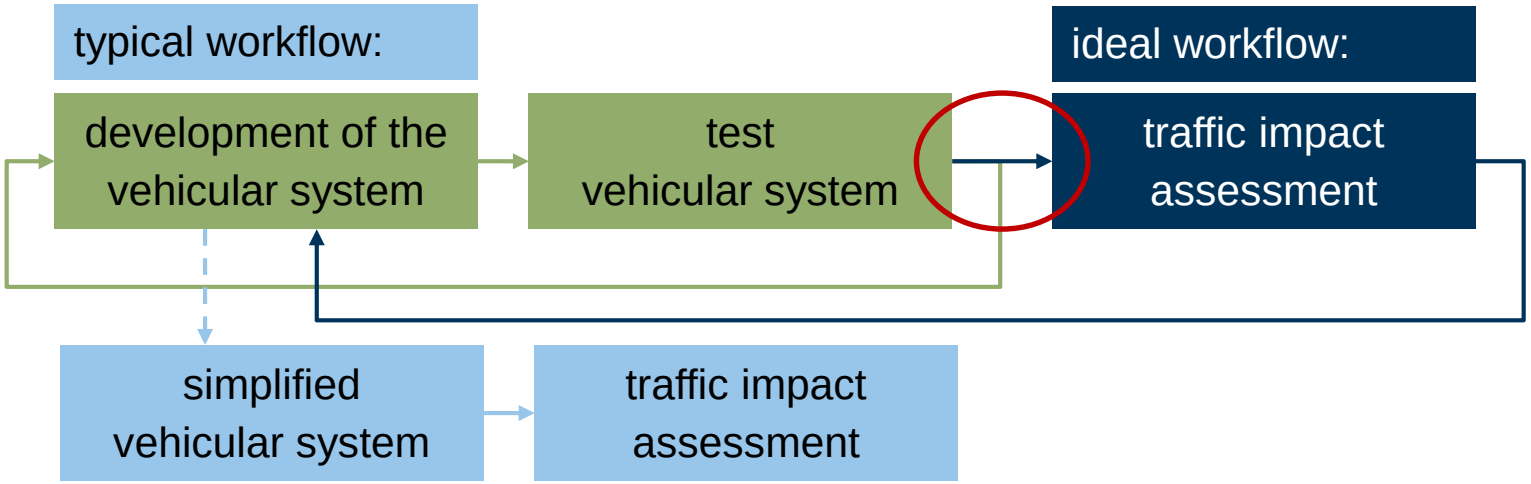
Examples of development steps of vehicular and traffic systems



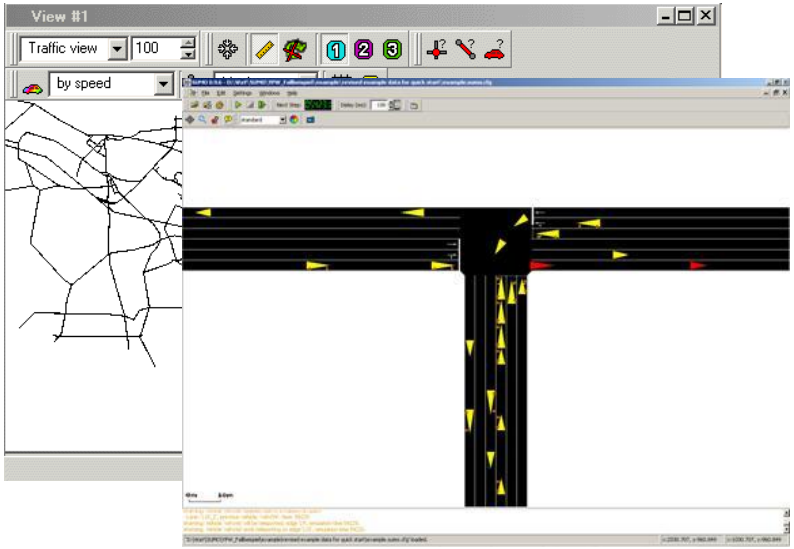
Motivation

- Innovative vehicular systems influence traffic flow, especially due to the major trends of connectivity and automation
- As a result interdisciplinary problems arise:
  - What is the impact on traffic flow of a vehicular system?
  - Which traffic situations does a newly developed vehicular system have to cope with?

Workflow to investigate impacts of vehicular systems on traffic flow



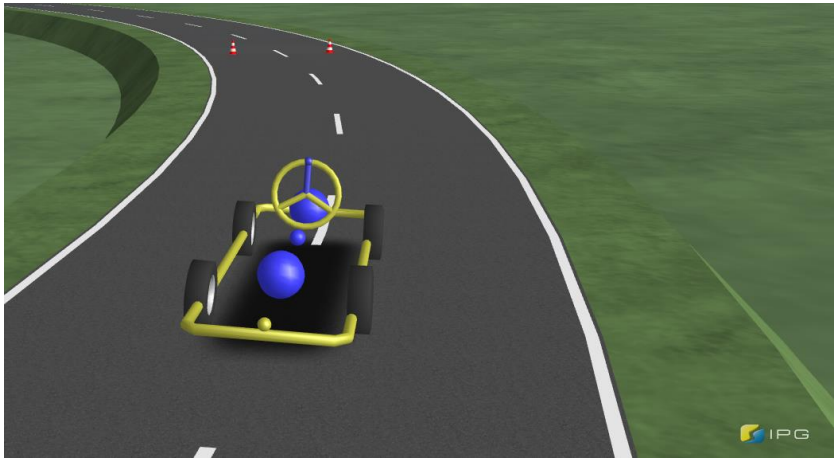
Traffic Flow vs. Vehicle Dynamics Simulation



source: www.sumo.dlr.de

Traffic Flow Simulation

- Representation of complex traffic situations and traffic networks
- Modelling of interactions between drivers
- Simulation of traffic flow
- Limited representation of vehicular systems via external interfaces



Vehicle Dynamics Simulation

- Detailed representation of vehicles including their components
- Simulation of the vehicle dynamics of a single vehicle
- Limited representation of traffic flow via maneuvers

Different Inputs

Traffic Flow Simulation

- Number of vehicles (demand) including route choice and vehicle composition (vehicle type, acceleration behavior)
- Road network with traffic control

Vehicle Dynamics Simulation

- Ego-vehicle (incl. axles, tyres, sensors, etc.) + other vehicles
- Road with detailed surface

Different Outputs

Traffic Flow Simulation

- Number of stops
- Waiting time
- Travel time
- Average speeds

Vehicle Dynamics Simulation

- Yaw, pitch, roll angle
- Lateral acceleration
- Gear
- Brake pressure

Different Problems

Traffic Flow Simulation

How does a new traffic signal control influence the travel times on an urban road network?

Vehicle Dynamics Simulation

How should the parameters of electronic stability control be chosen for a new car model?

Simulation Tools SUMO and CarMaker

SUMO[1]

- Open-source microscopic traffic flow simulation
- Interfaces for external control of the simulation
- Possibilities to integrate external models
- Driving behavior model for each vehicle of the simulation
- Stochastic

– Limited possibility to integrate vehicle dynamics, sensors, driver assistance systems

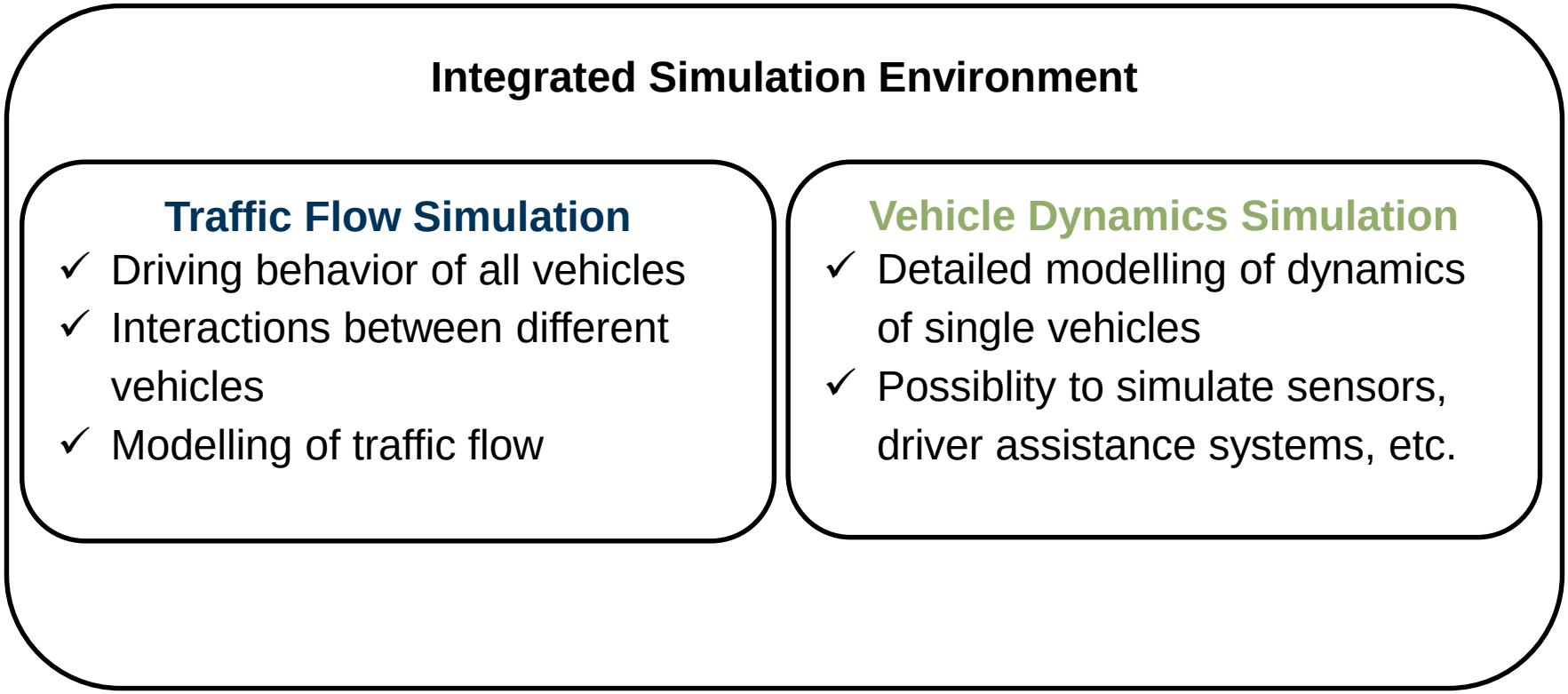
CarMaker

- Commercial vehicle dynamics simulation
- Models for different vehicles, tyres, trailers, sensors etc. available
- Interfaces for HiL and SiL simulations
- Small simulation step size
- Deterministic

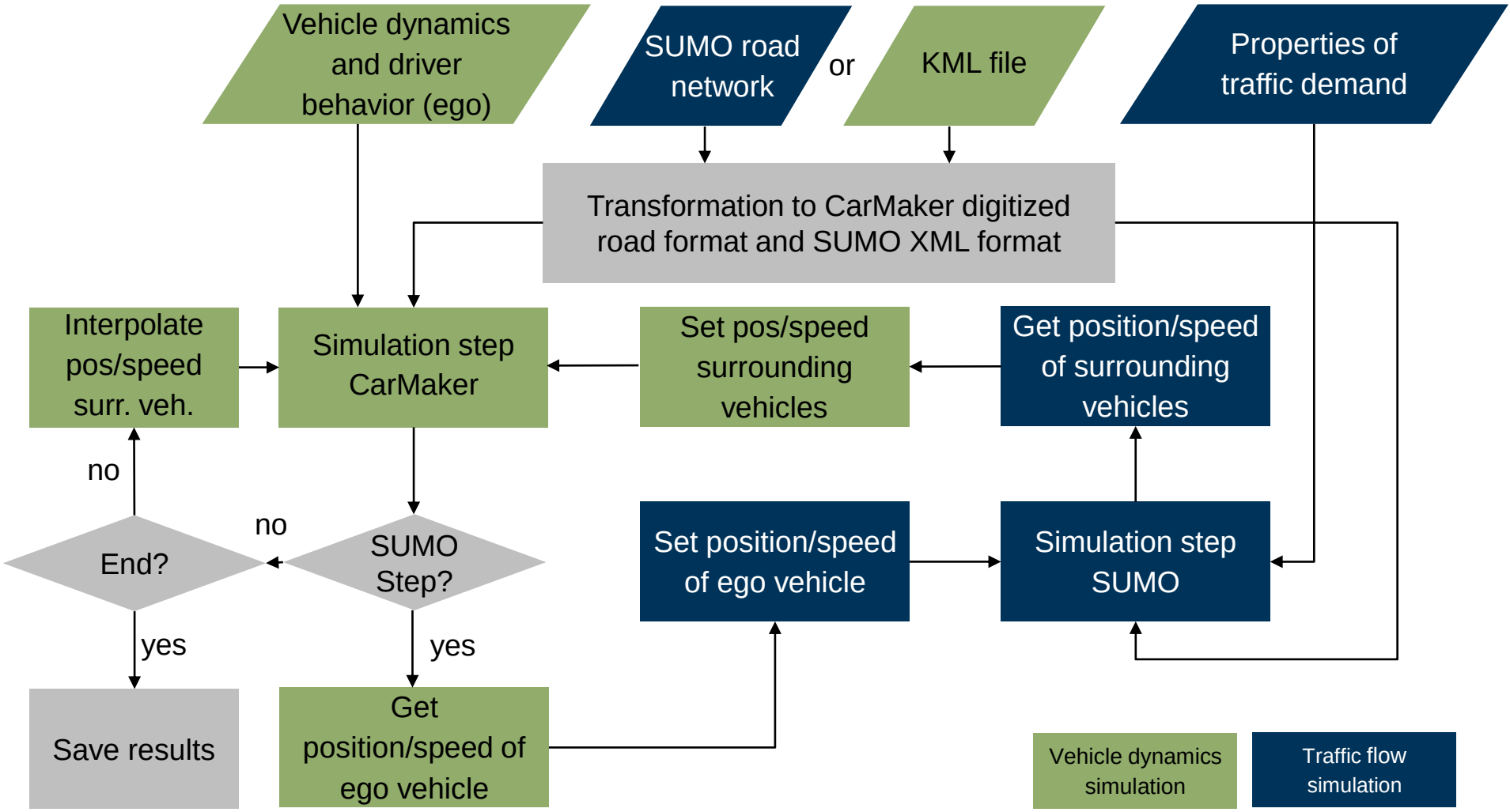
– Limited capability to integrate traffic, since maneuvers for other vehicles have to be defined prior to the simulation

[1]: Krajzewicz, D.; Erdmann, J.; Behrisch, M.; Bieker, L.: Recent development and applications of SUMO--simulation of urban mobility, International Journal On Advances in Systems and Measurements 2012

Integration of SUMO and CarMaker



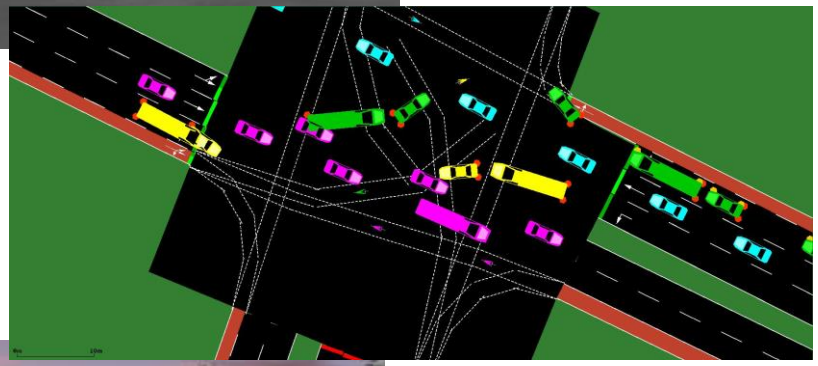
Integration of SUMO and CarMaker



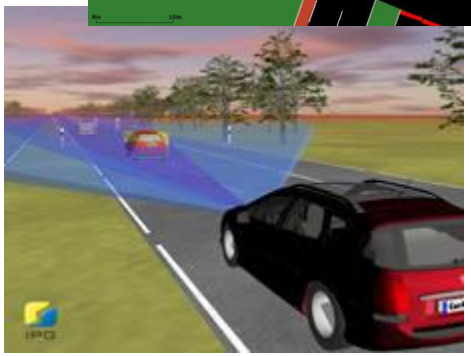
Applications

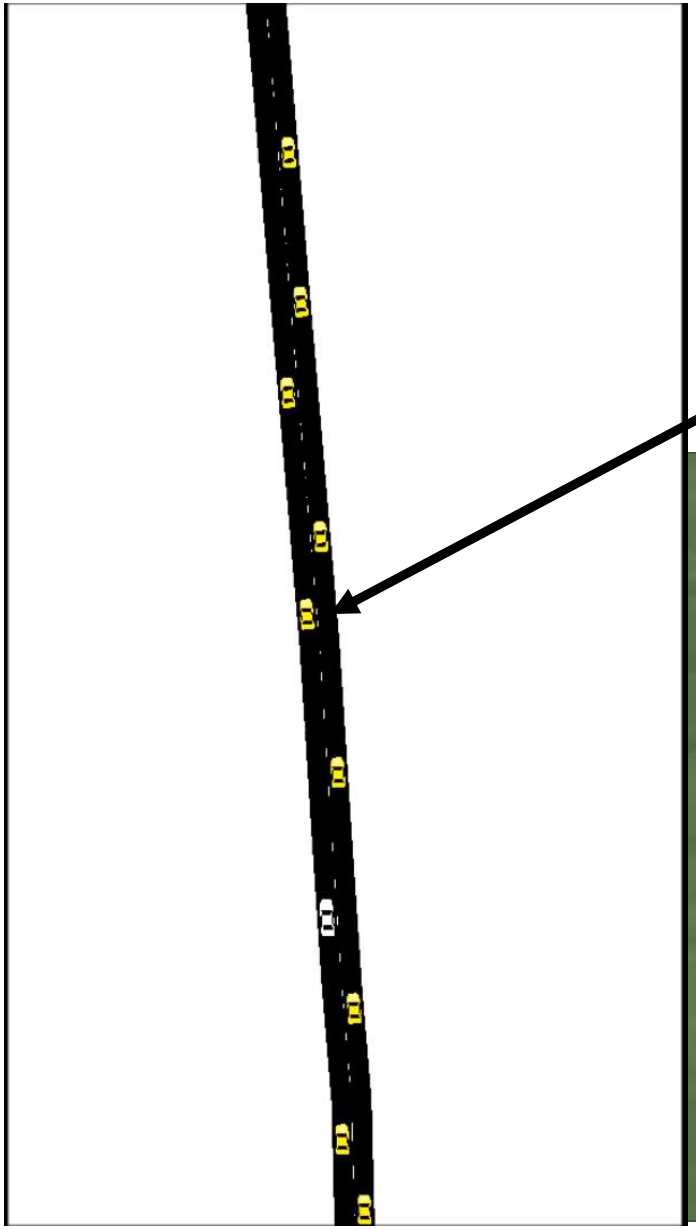
- Realistic modelling of driving maneuvers in traffic flow simulation
  (e.g. to identify areas of slow speed automatically)

- Test of detailed driving behavior and vehicle dynamics models in complex, stochastic traffic situations



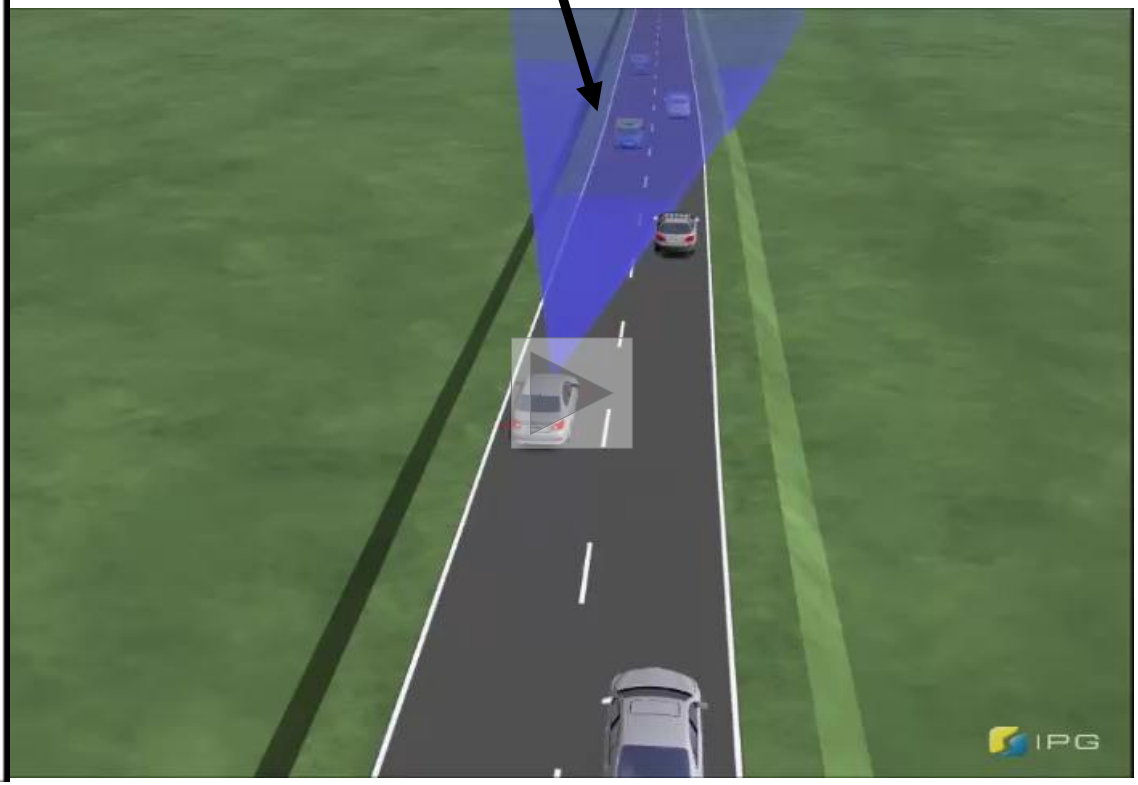
- Test of vehicle communication and driver assistance systems including realistic sensor models and driving dynamic controllers

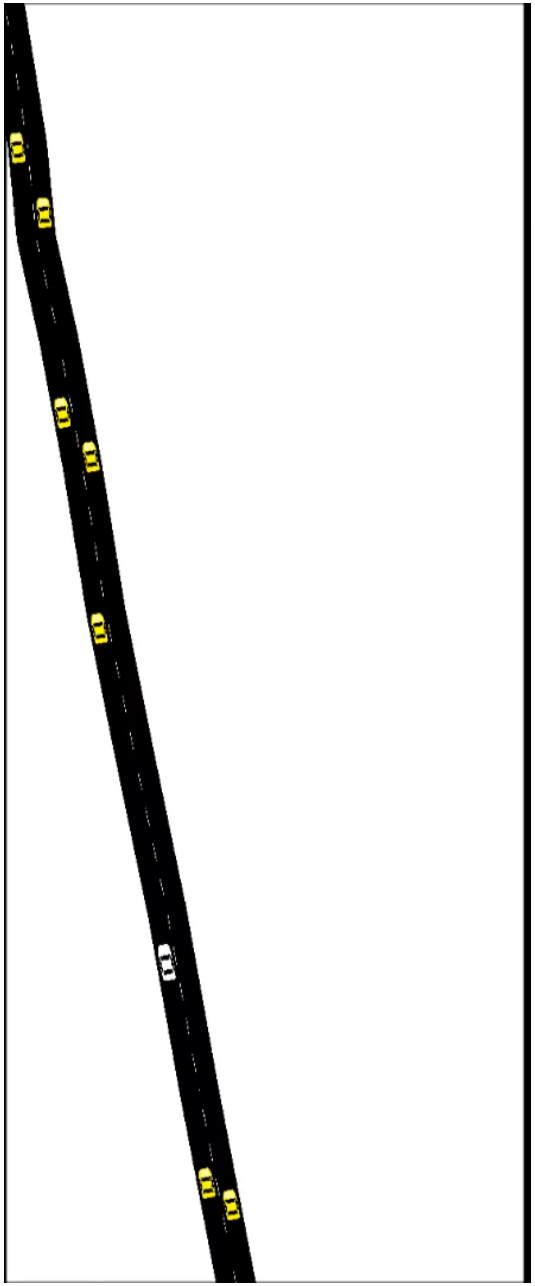




Vehicle Front

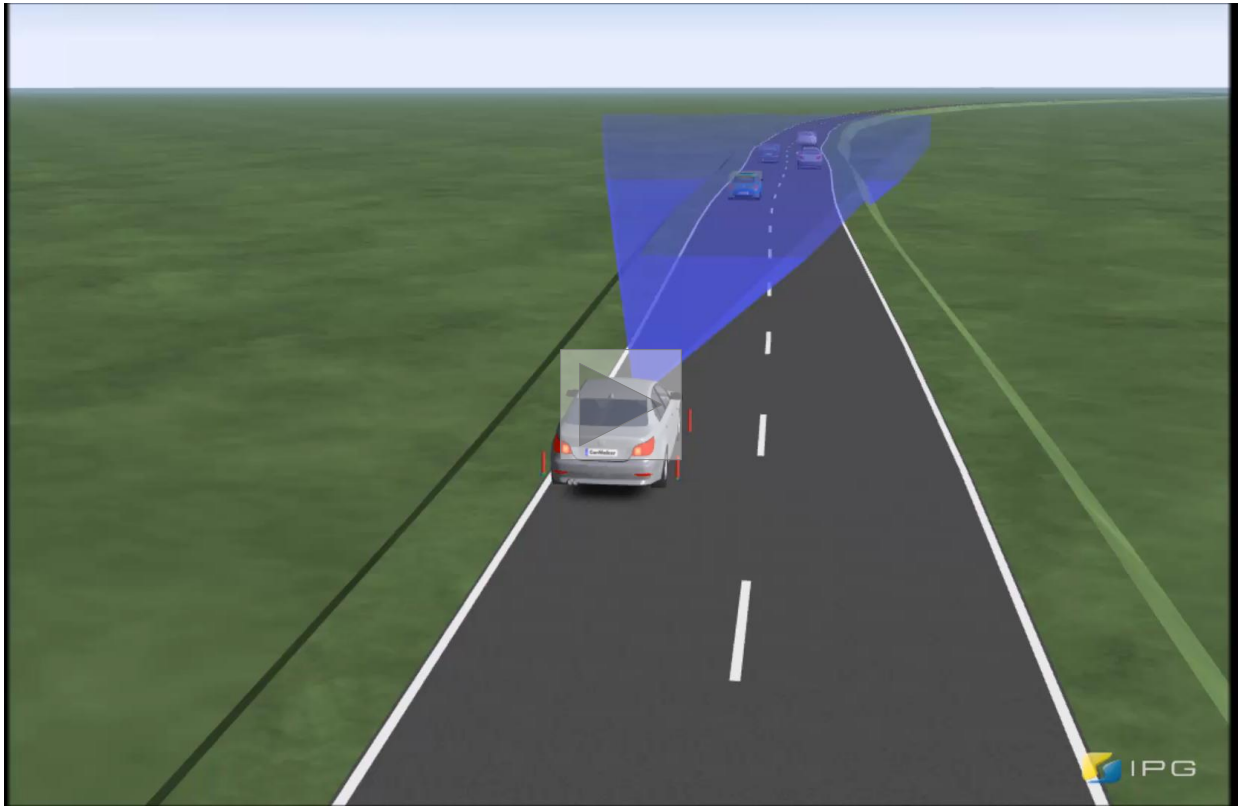
In total, eight surrounding vehicles are synchronized with the traffic objects in CarMaker.





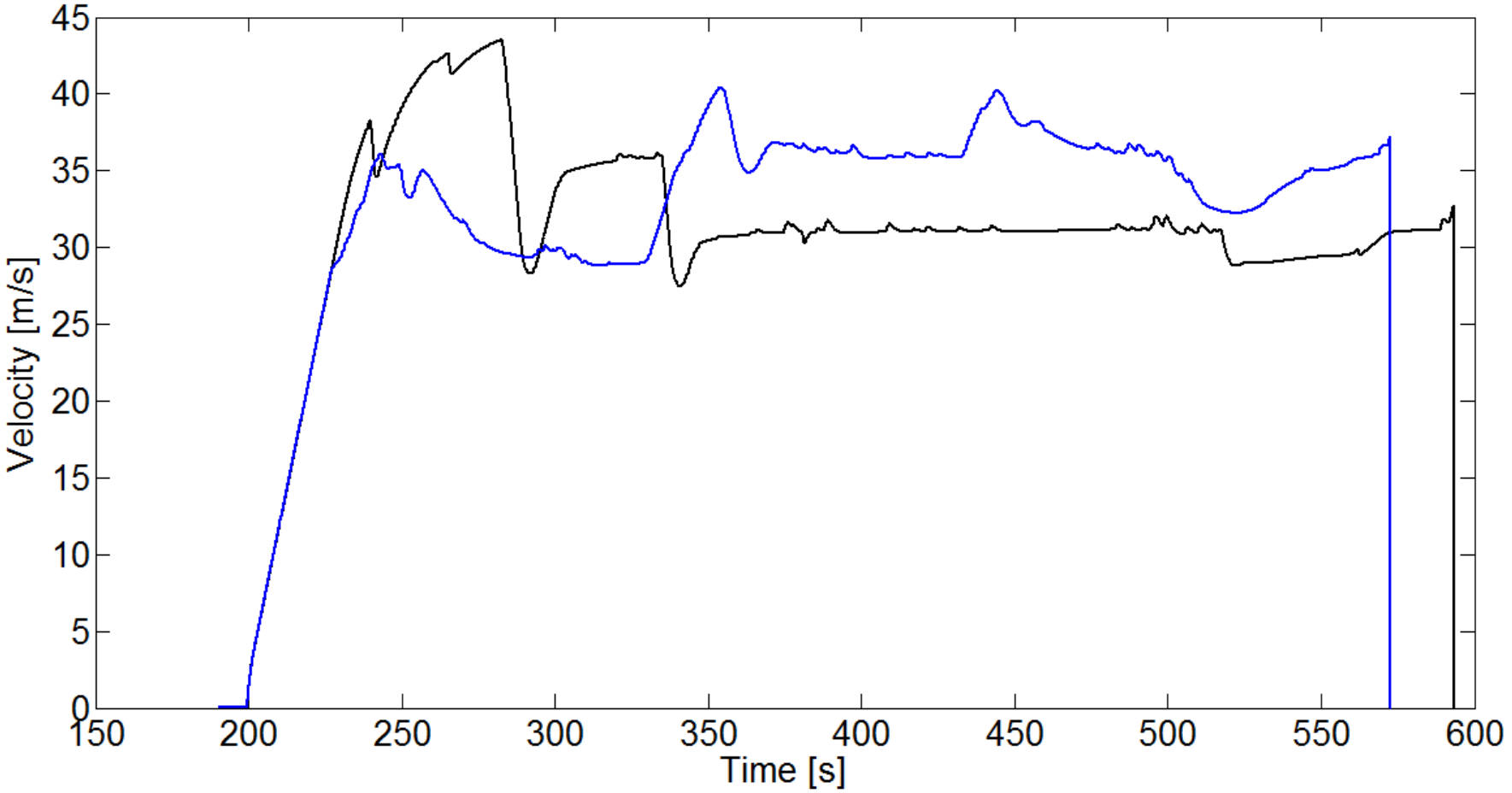
Applications

Test of driving dynamic controllers in realistic traffic situations without necessity for prior maneuver definition



Applications

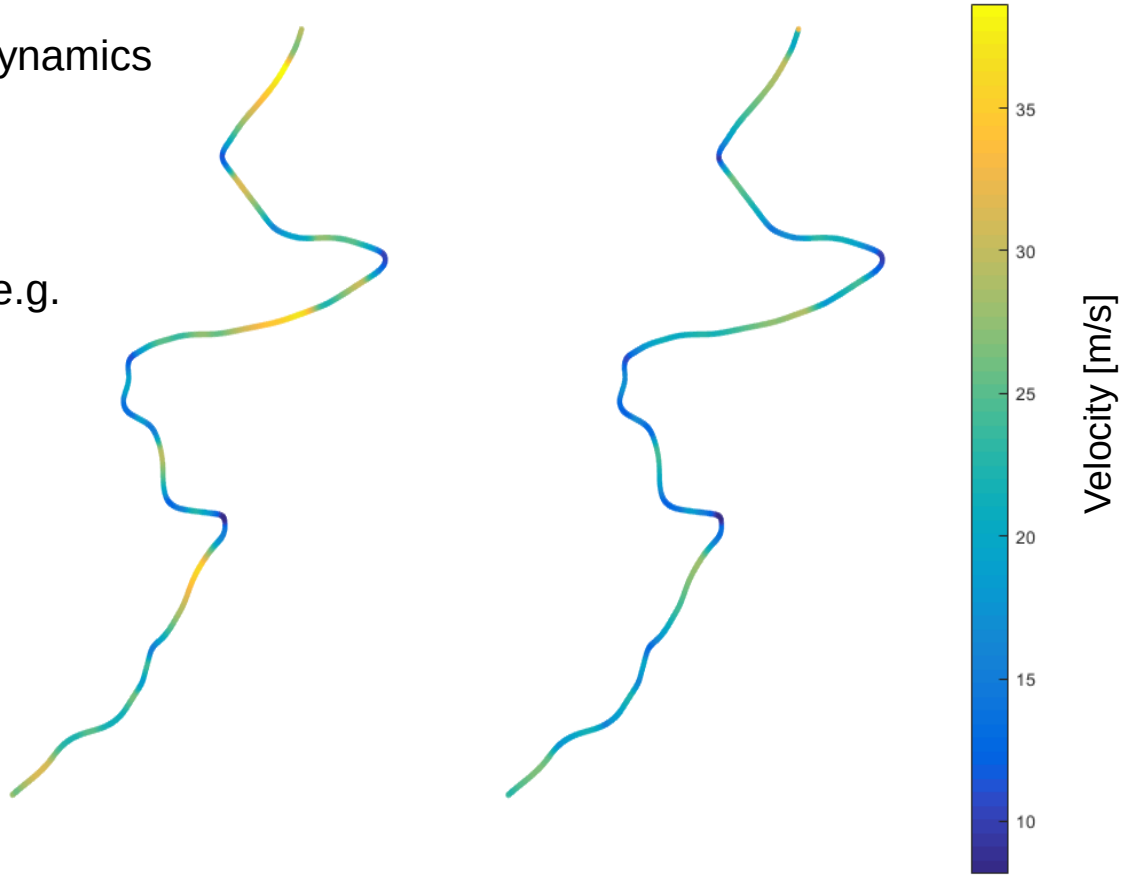
Speed profiles of the ego vehicle with enabled ACC in two different simulation runs



Applications

Realistic Modelling of driving dynamics in traffic flow simulation

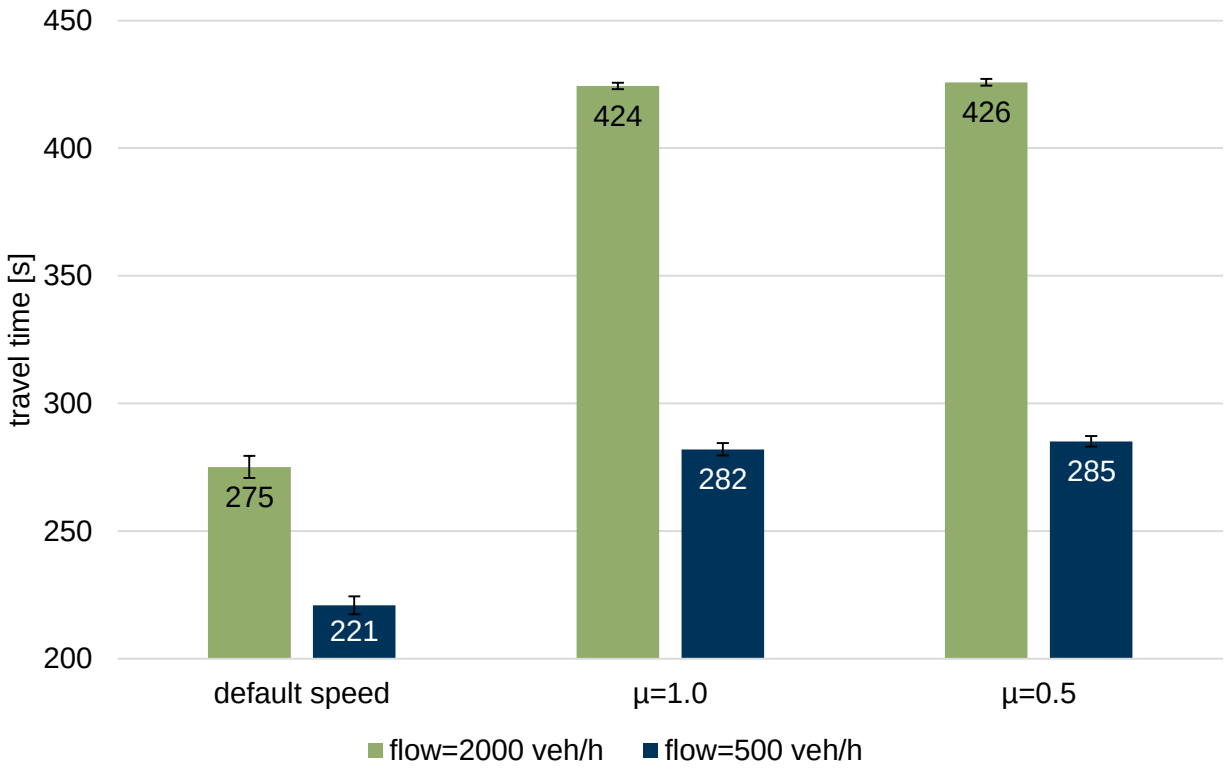
Example: Reduction of speeds dependent on road geometry, e.g. curvature or friction



μ = 1.0 μ = 0.5

Applications

Lower speeds in curves lead to higher travel times. The effect is bigger with higher traffic volumes, since congestion can build up upstream of tight curves.



Outlook

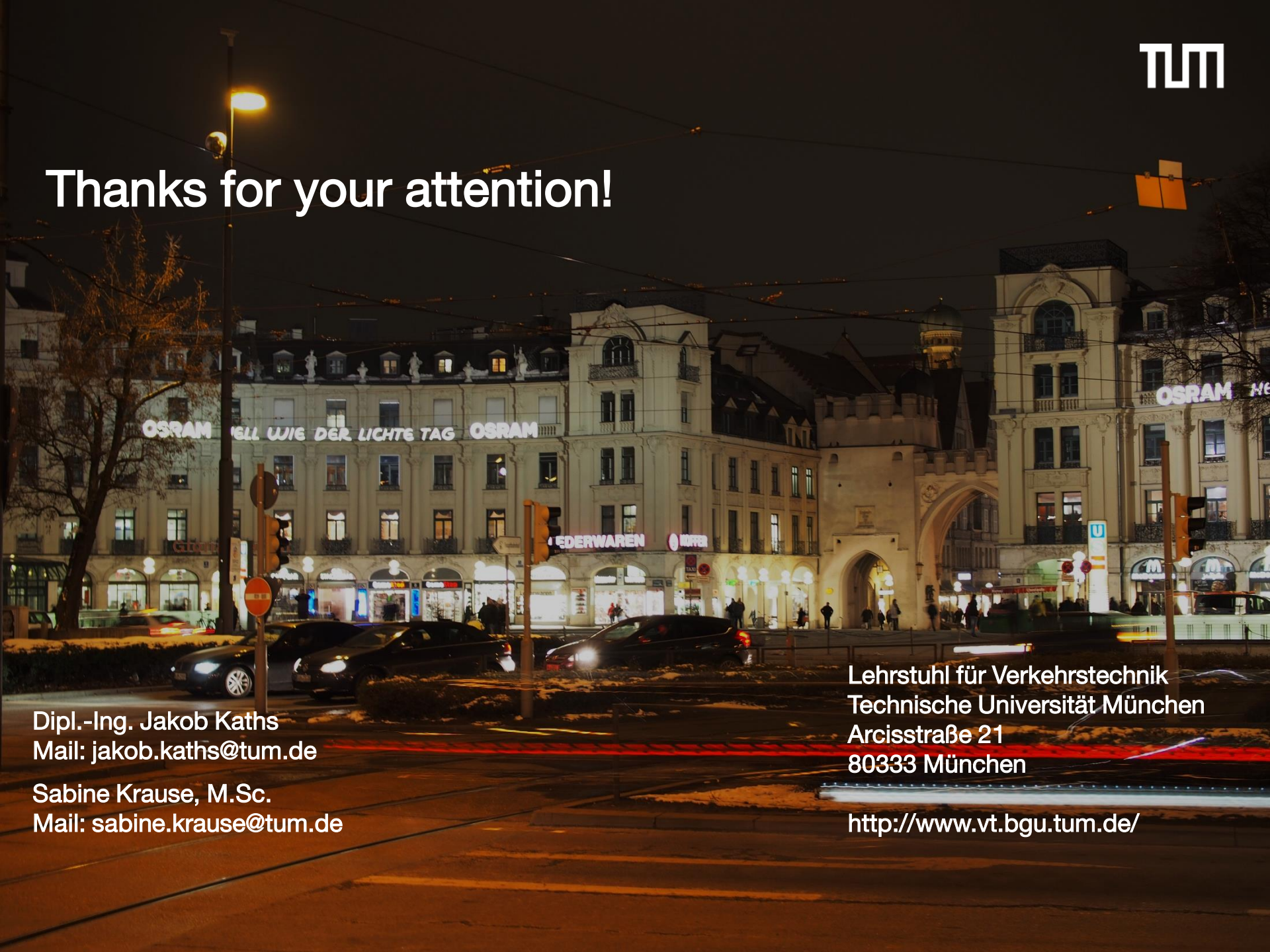
- Integration of networks in CarMaker Road 5 format
  e.g. to model traffic signals, complex intersection geometries

- Usage of native interfaces CarMaker C-APO and SUMO TraCI for Python to increase simulation speeds compared to Matlab/Simulink solution

- Usage of new SUMO sublane mode for more detailed lateral movements of surrounding traffic

- Integration of multiple CarMaker vehicles

Thanks for your attention!



Dipl.-Ing. Jakob Kaths
Mail: jakob.kaths@tum.de

Sabine Krause, M.Sc.
Mail: sabine.krause@tum.de

Lehrstuhl für Verkehrstechnik
Technische Universität München
Arcisstraße 21
80333 München

http://www.vt.bgu.tum.de/