

## *Scenario-based Validation of Automated Driving Functions with MATLAB*

Dr. Andreas Kuhn

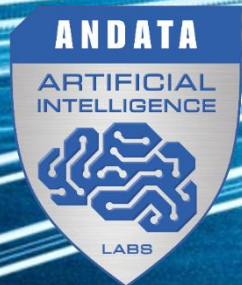
**ANDATA**



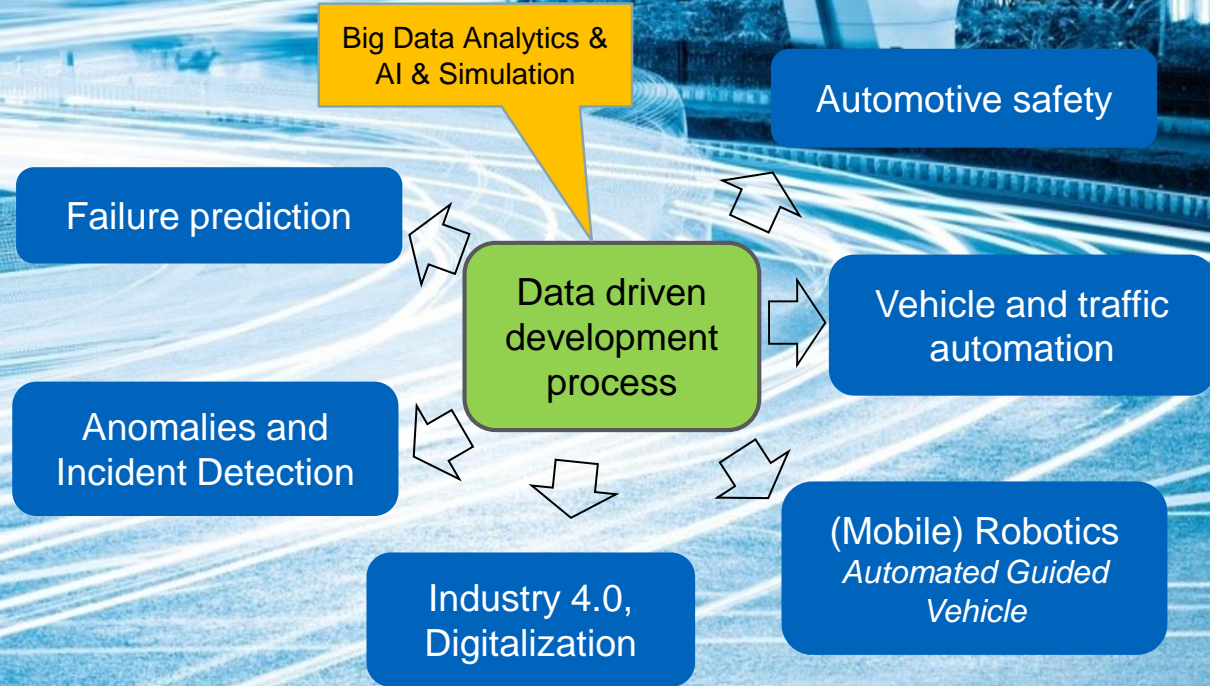
**AUTOMOTIVE CONFERENCE 2019**

## Fields of Competence

- Artificial Intelligence
- Data Mining
- Big Data Analytics
- Modeling and simulation
- Predictive Model based Control
- Distributed Control
- Signal Classification
- Swarm Intelligence
- (Embedded) Software
- Decision Support Systems
- Robustness and Complexity Management

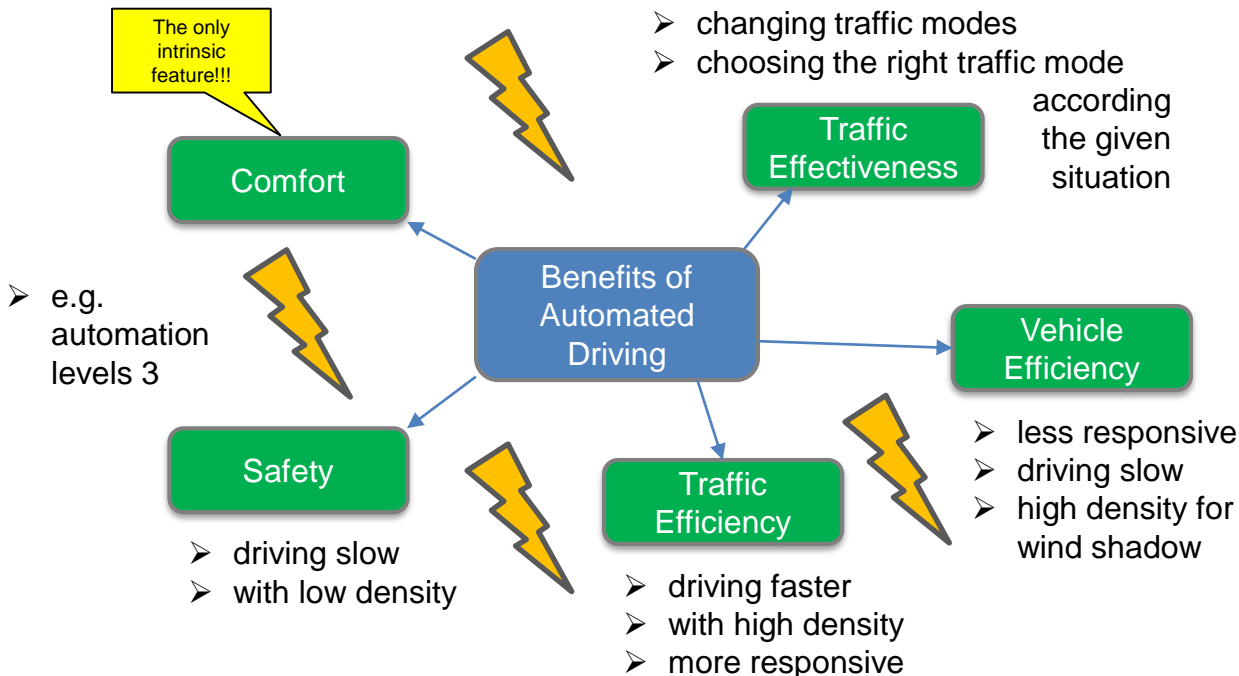


since 2004



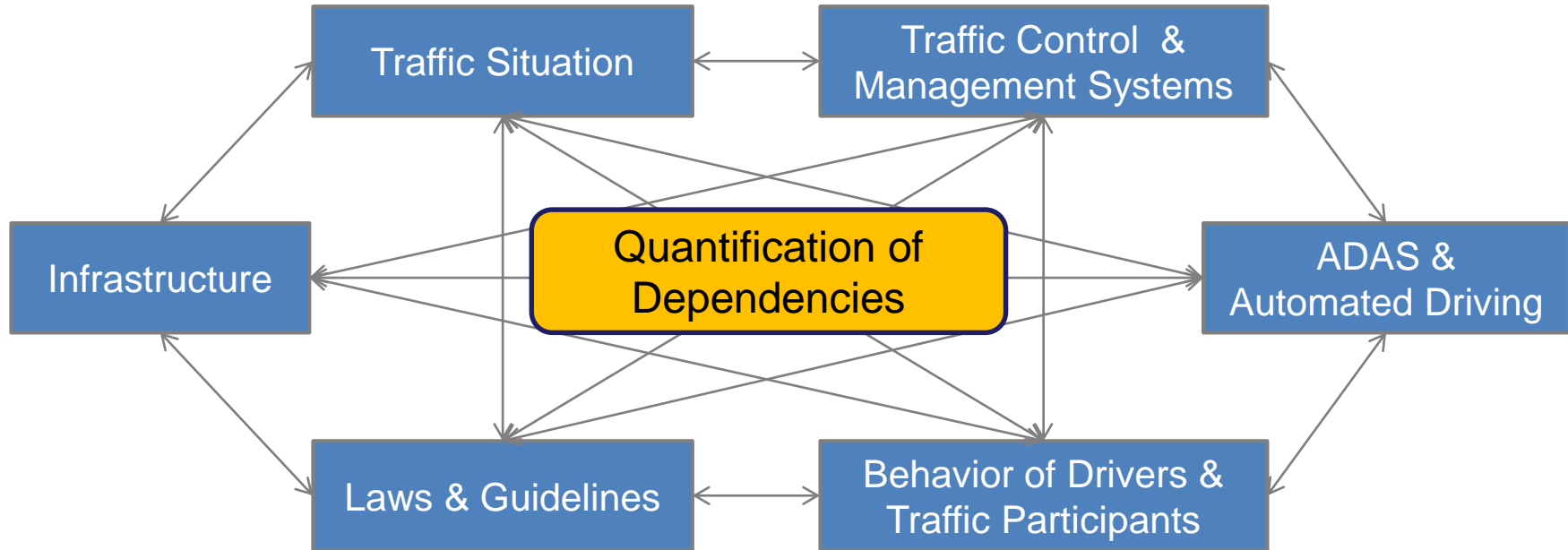
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# Expected Benefit Categories for Automated Driving

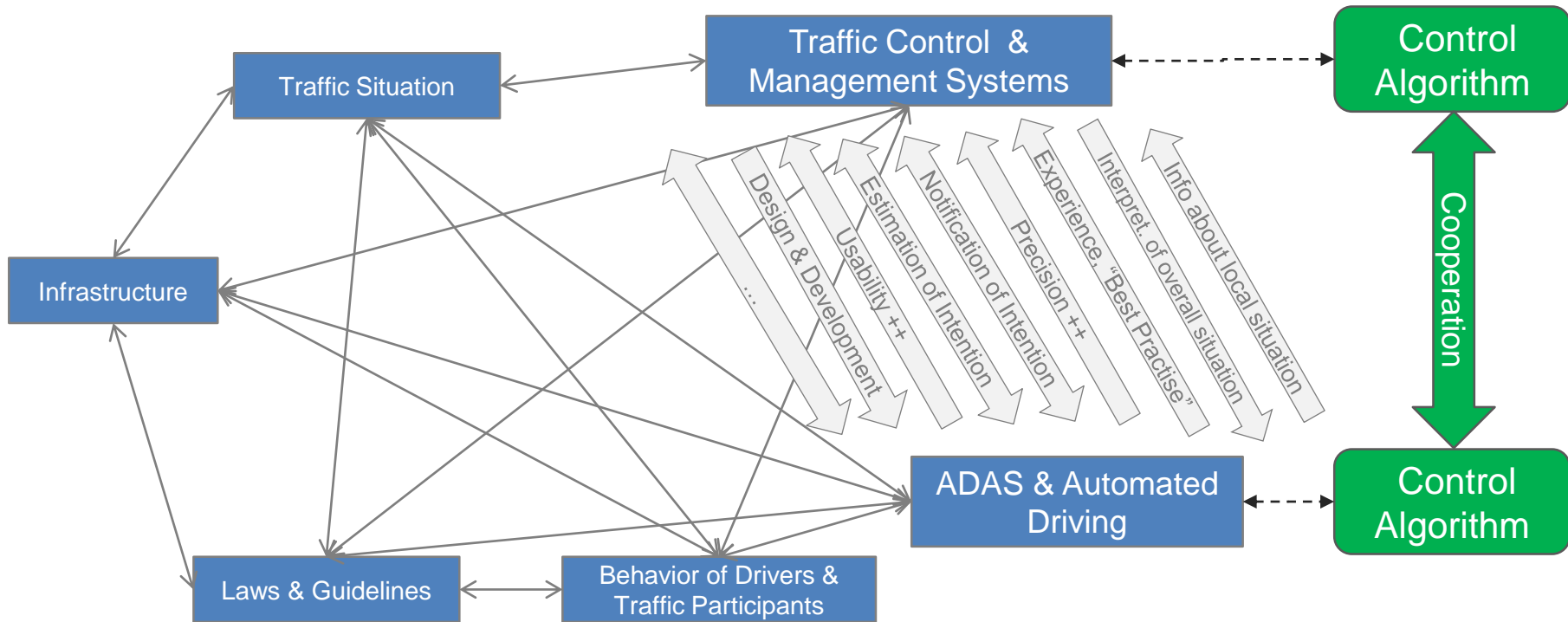


➤ Validation needs quantitative description of the pareto fronts!

## Main Entities Effecting the Performance of Automated Driving



# Main Entities Effecting the Performance of Automated Driving



## *Methods of Choice in Development and Validation of Automated Driving Functions*

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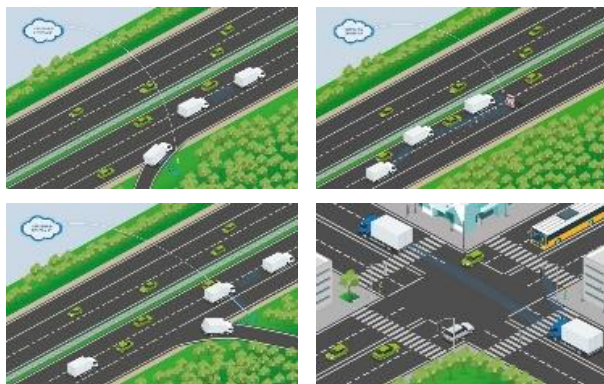
<b>Technology/Method</b>		
Integral and Holistic Top-Down Development Procedures	Targets driven	KPIs
Scenario- & Simulation-based Development Approach	Data driven	Simulations
Machine Learning & AI	Referable performance	Control Functions
Prospective Effectiveness Assessment	Effective	Ratings

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# Connecting Austria



- Lead Project for Automated Driving in Austria
- Platooning as instrument for improved energy and traffic efficiency
- Development and assessment of cooperative, connected, (semi-) automated driving strategies
- 4 Principal Scenarios



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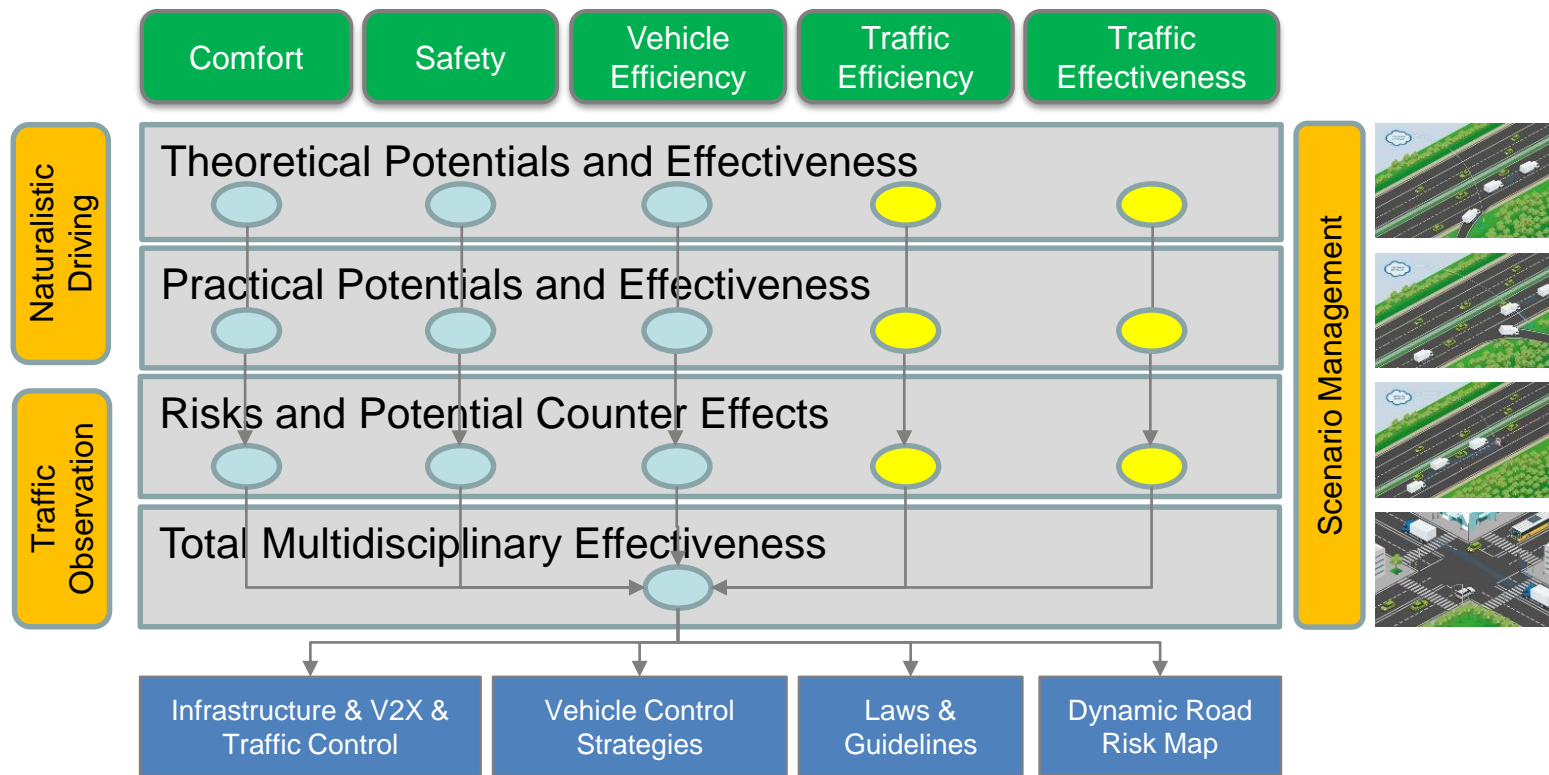


administered by

co-financed by

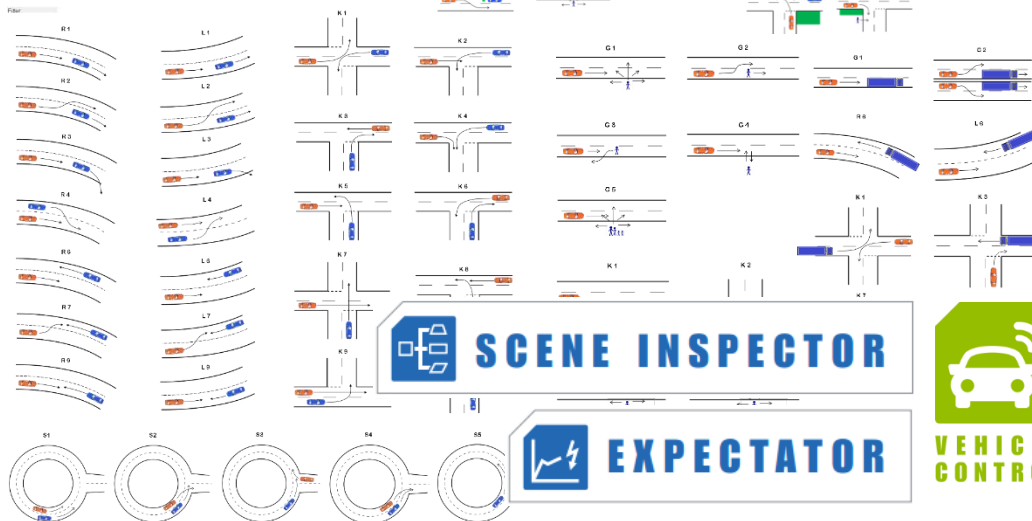
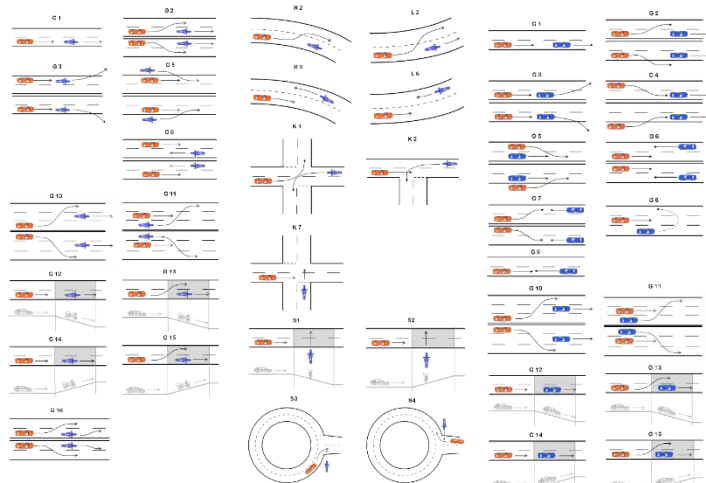
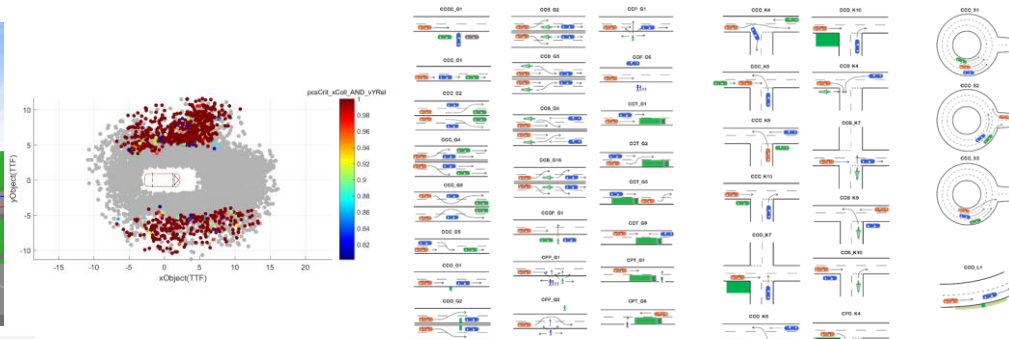
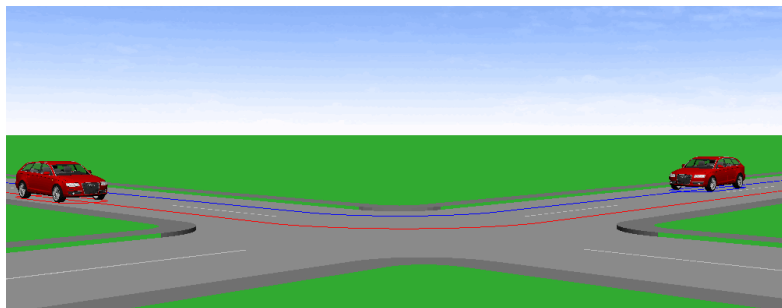


# R&D Approach / Procedures



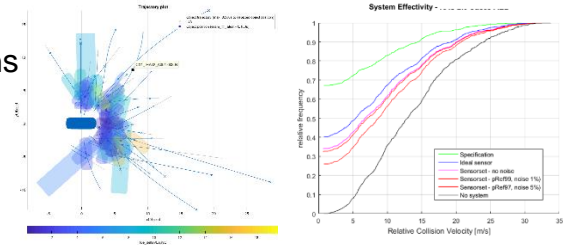
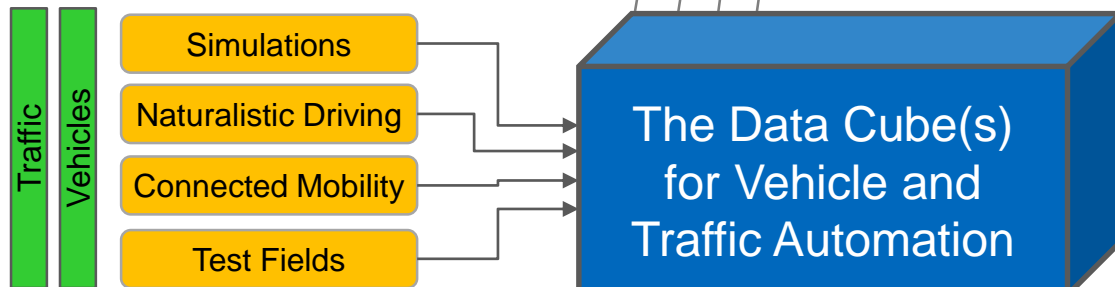


# Scenario-Management and Development/Approval of Actions

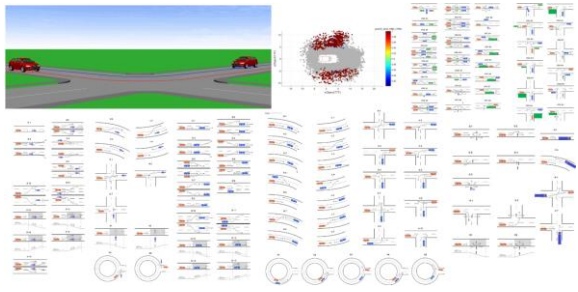


# VERONET Solution Concept for Automated Driving and Traffic

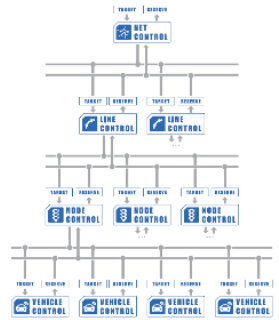
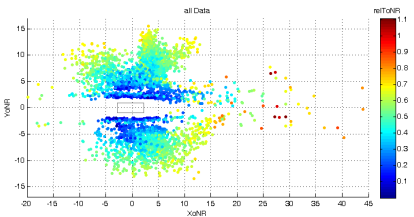
## Scenario Catalog



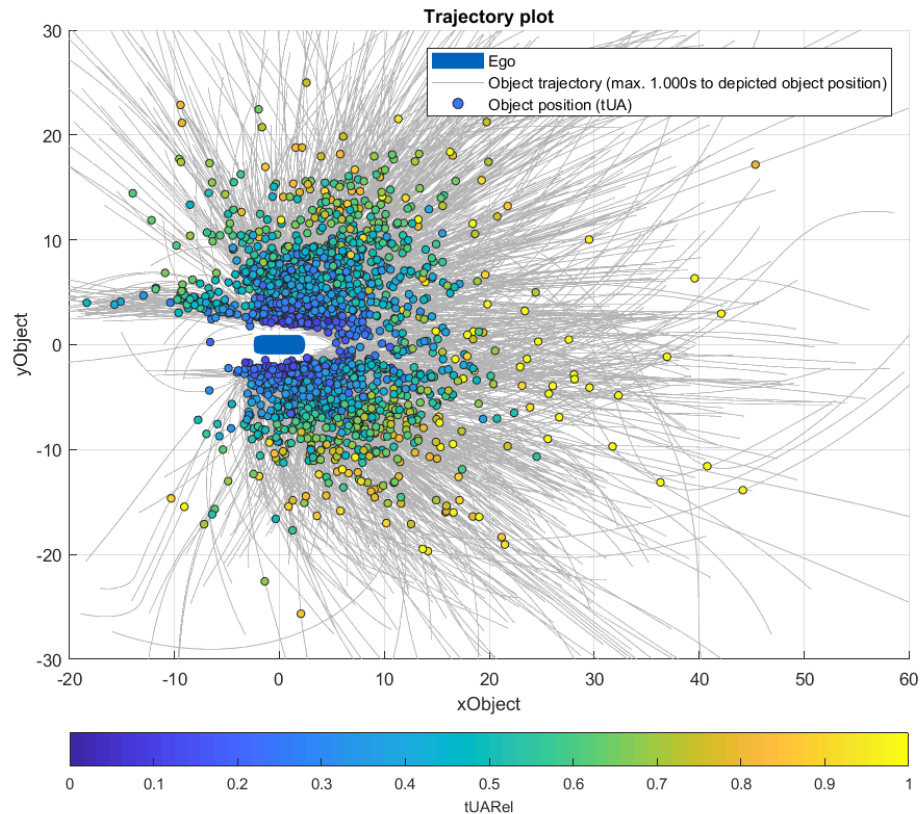
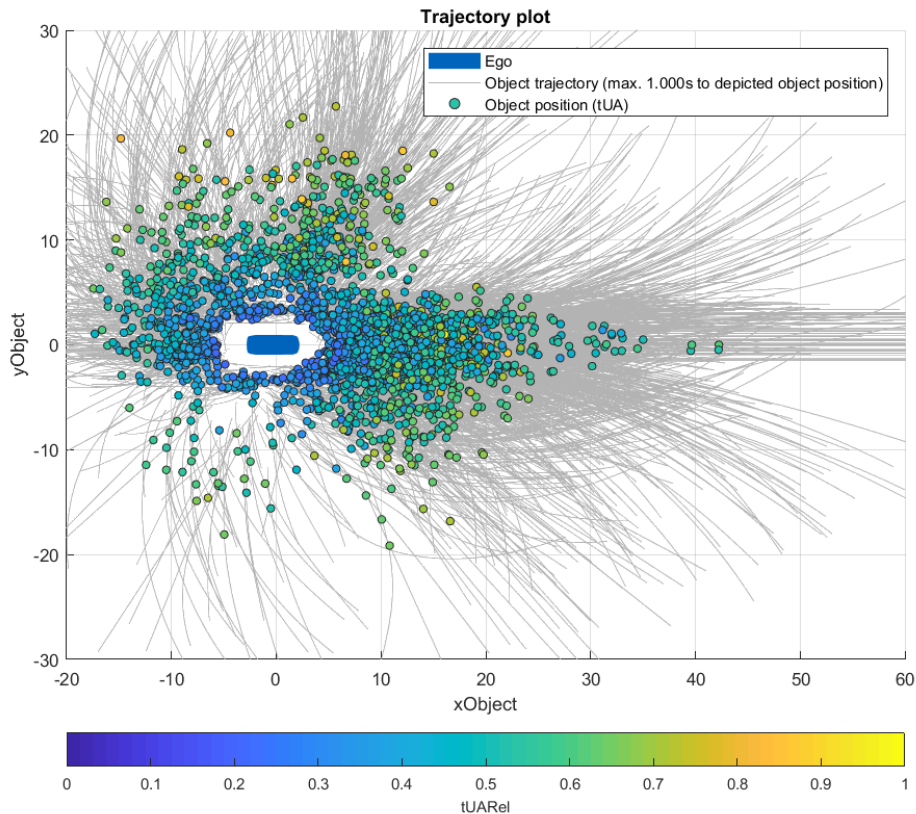
- Quick Identification and Resolution of Requirement Conflicts
- System Understanding
- Conform Specification of Components
- Realistic Performance Ratings
- Excellent Control Algorithms



- Artificial Intelligence
- Big Data Analytics
- Robustness Mngt
- Complexity Mngt
- Effectiveness Rating
- Reference Systems
- System-of-Systems
- Conflict Analysis
- Cond. Probabilistics
- Var. Labellings



# Folding Various Decision Variables (e.g. collision probabilities)

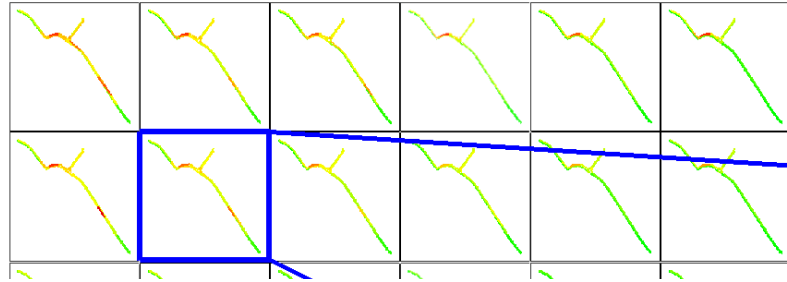


## *Scenario Management for Traffic Automation*

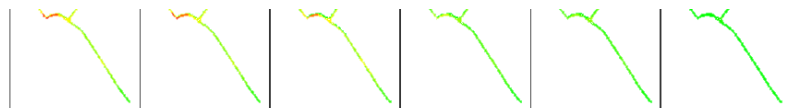
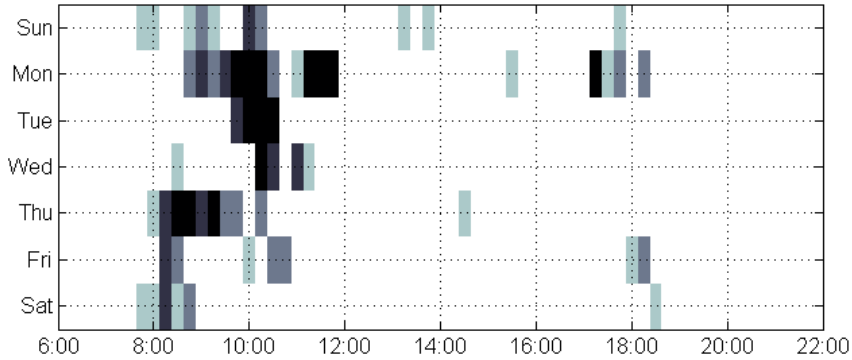
- Development/approval of cooperative vehicle and traffic control
- Building up a scenario database including variations of
  - traffic situations (volume and composition)
  - traffic control algorithms
  - vehicle control algorithms
  - interactive behaviours of drivers, pedestrians, etc.
  - road conditions, weather
  - road/lane geometries/topologies



# Identification and Clustering of the Relevant Traffic Situations

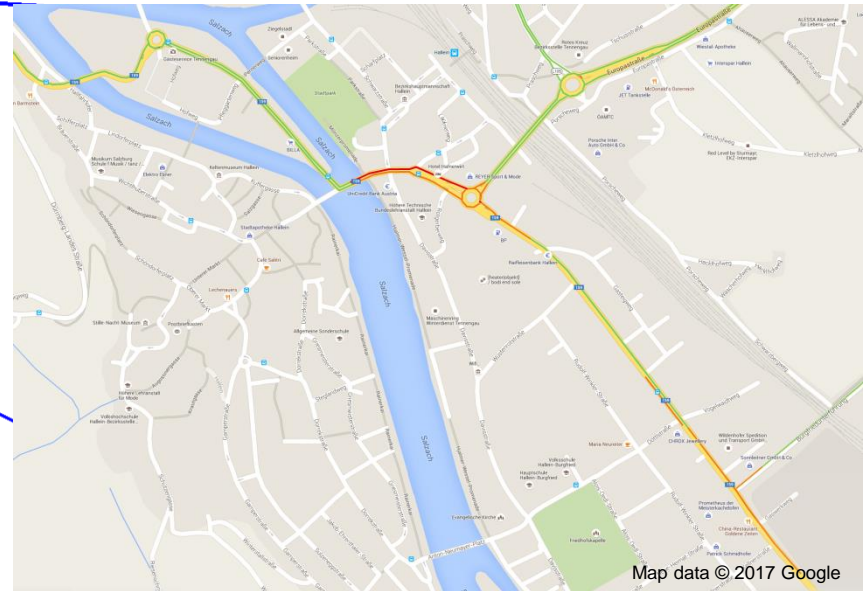


Time distribution of similar situations



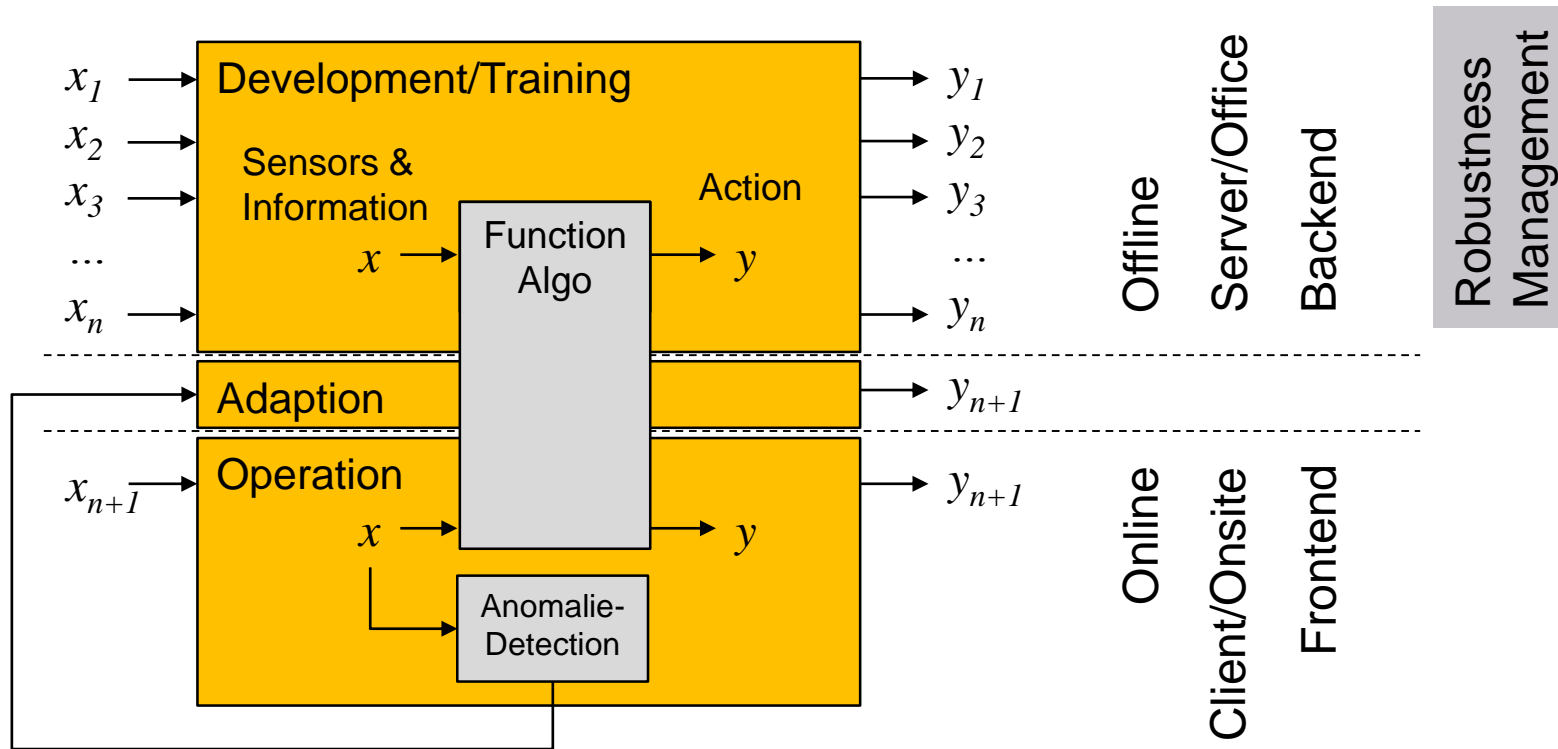
Automated evaluation of floating car data and various traffic sensors

Identified situation



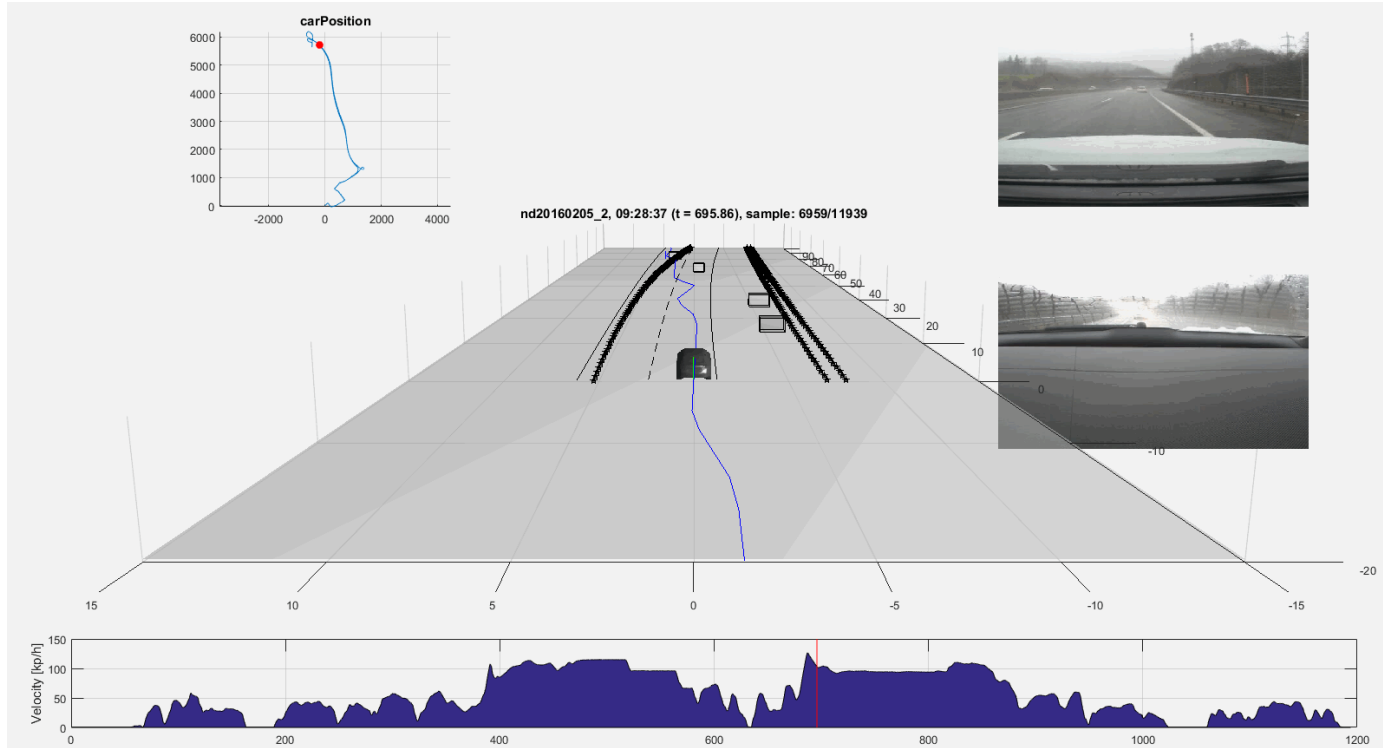
Map data © 2017 Google

# Procedure for „Connected Development“



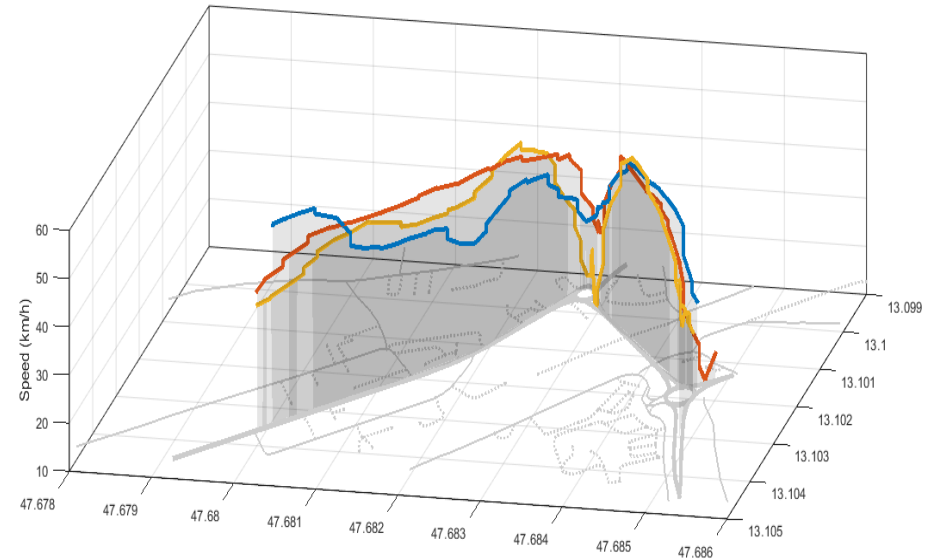
➤ Collective (Co-)Learning Systems

# Data Acquisitions from Fleet Data



## *Evaluation of Tracks from Single Vehicles*

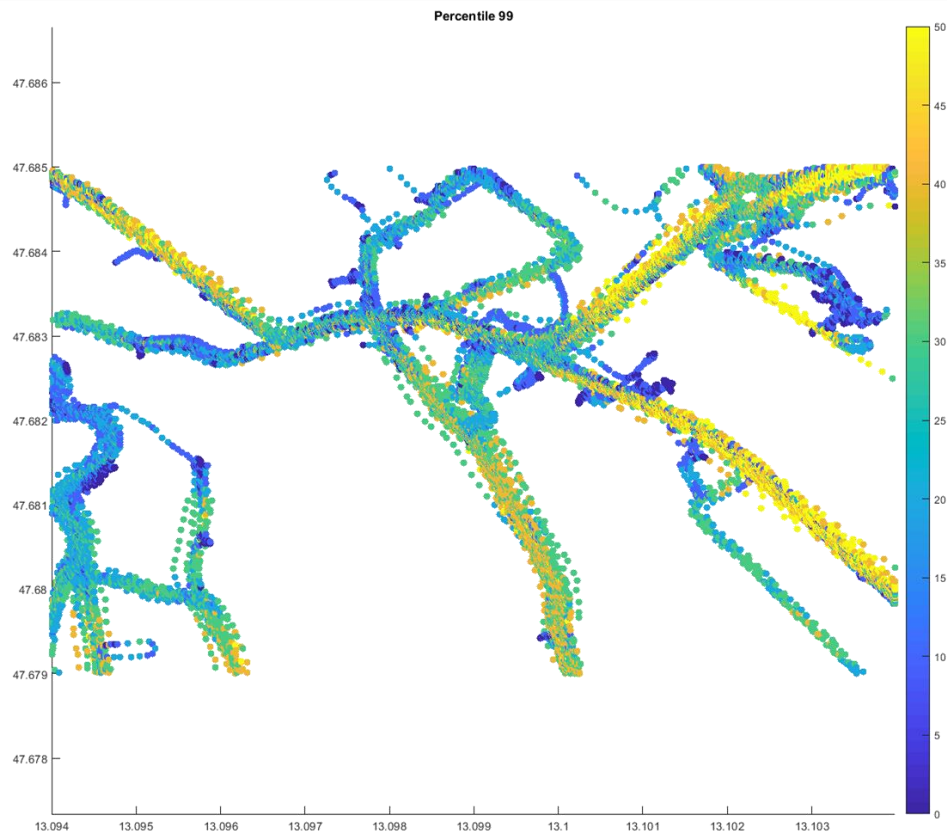
- Development of individual, context aware behavioural driver models
- Spatial statistics of street sections
- Validation of microsimulation model





## *Evaluation of Tracks from Single Vehicles*

- Development of individual, context aware behavioural driver models
- Spatial statistics of street sections
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# Traffic Observation with Video Tracking and Further Sensors

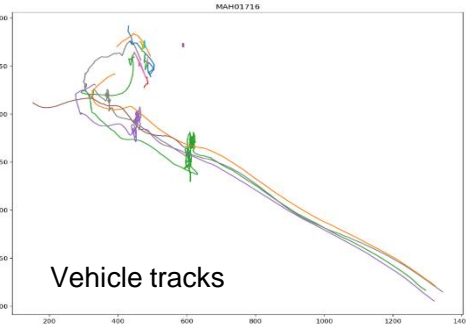
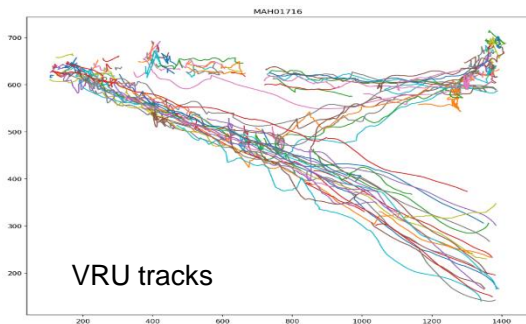


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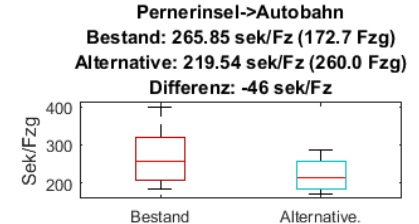
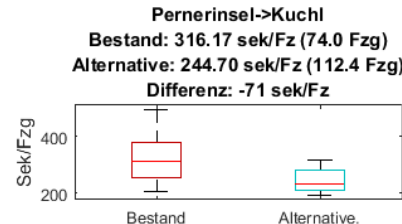
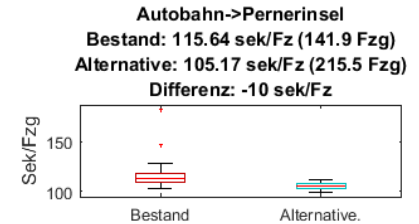
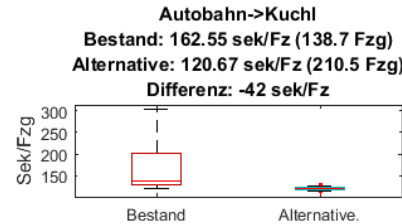
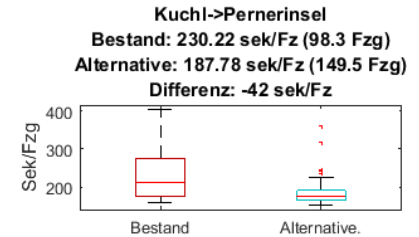
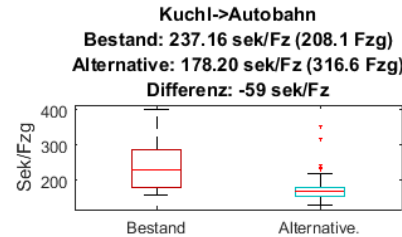
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- Generating tracks of all traffic participants by video
- Fusion with further sensors (radar, lidar, ToF) in work
- Data for development of interactive behavioural models (extrinsic)

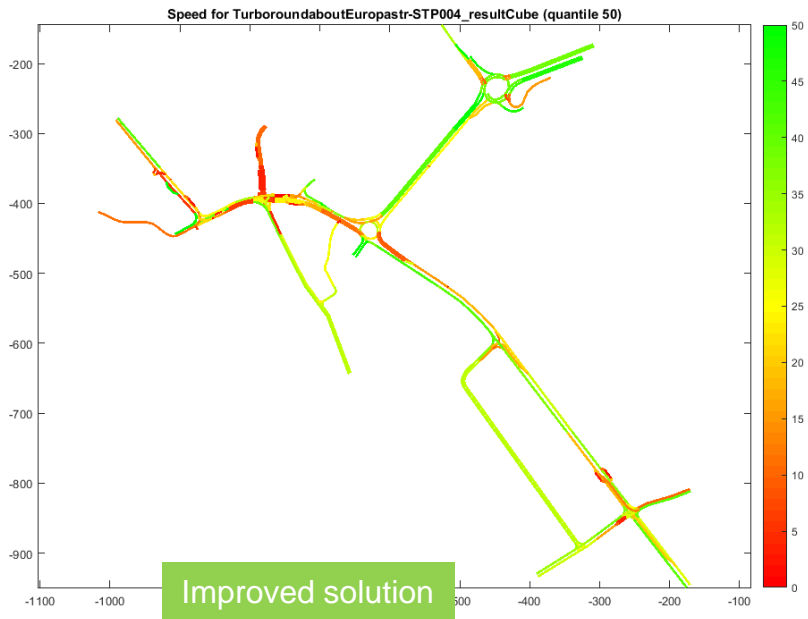
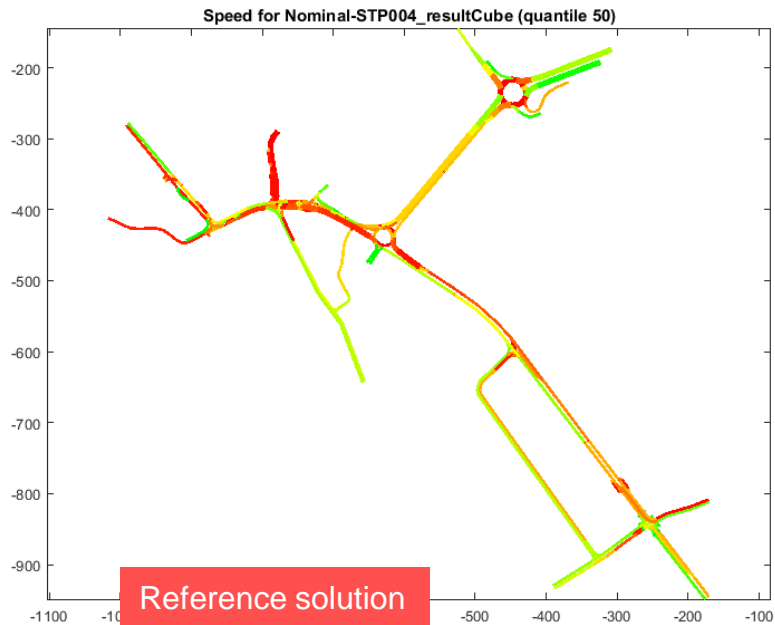


# Comparison of different control variants and their effects wrt traffic performance for a selected traffic situations

- Statistics of Key Performance Indices
- including robustness assessment



# Comparison of different control variants and their effects wrt traffic performance for a selected traffic situation

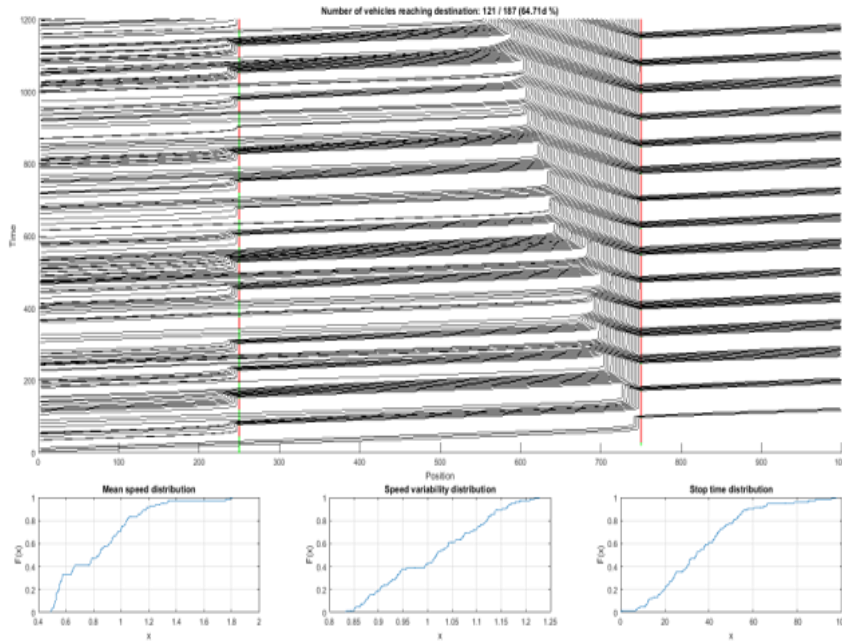


Filter: \*Abendspitze\*

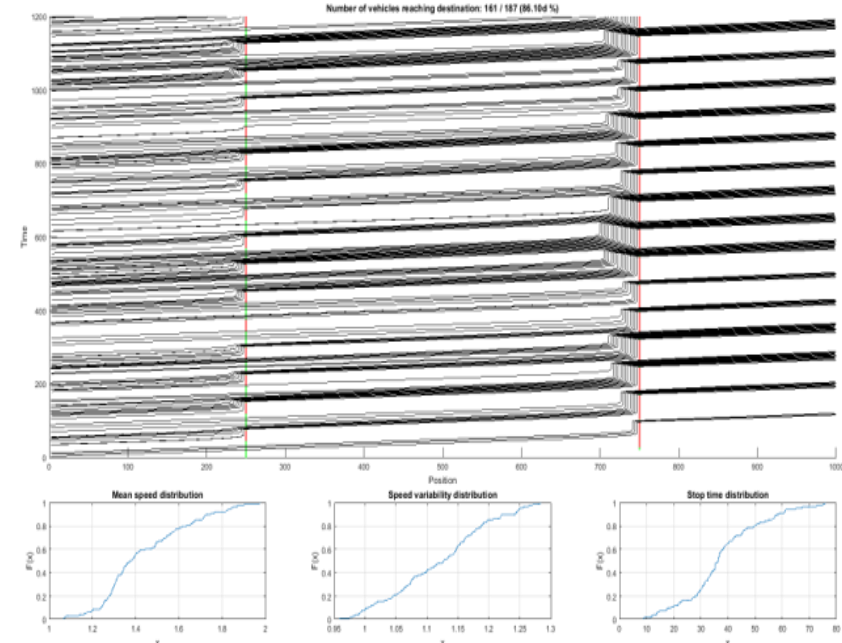
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# Postprocessing and Rating of Different Control Strategies

Mainly Human Drivers



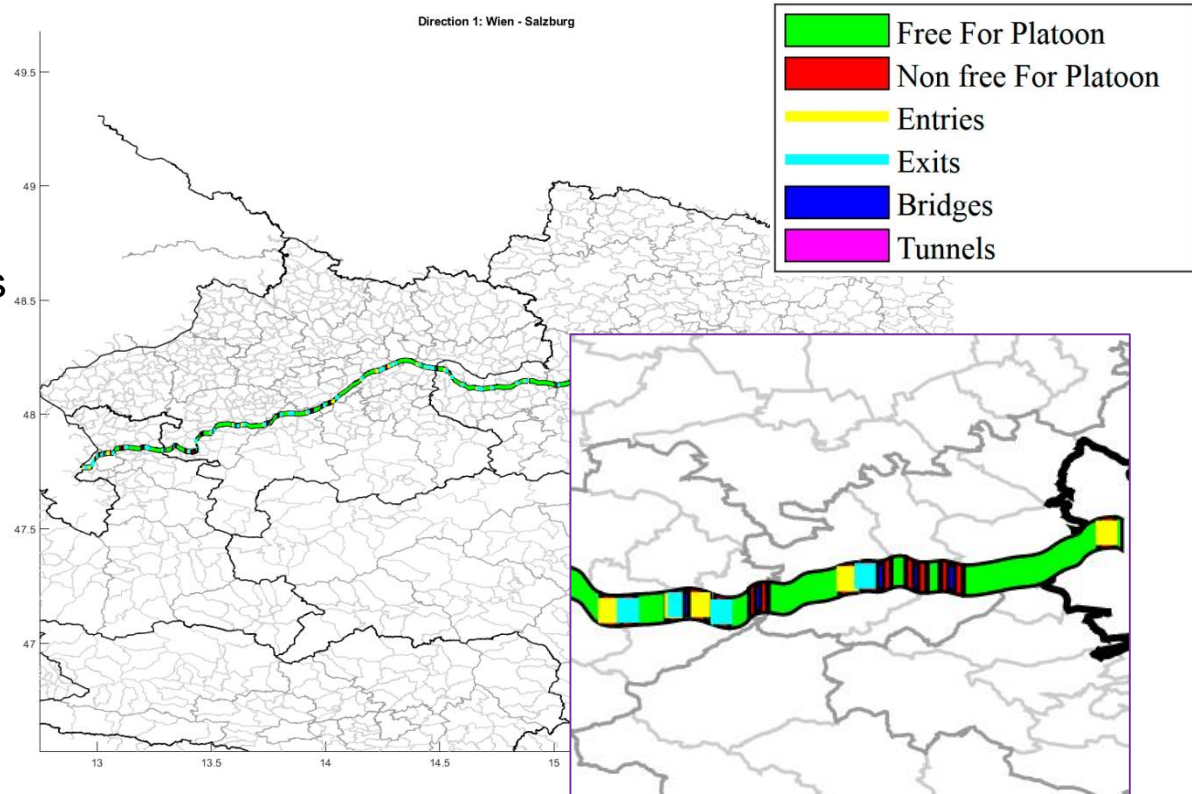
Mainly Robot Drivers



# Dynamic Risk Rated Map

Adaptive wrt

- local conditions
- traffic situation
- weather
- temporal incidents



## ANDATA Software and Tools



- Data collection, preparation and normalization
- Data cleaning
- Sensor models
- Signal preparation
- Requirements definition ("labelling", etc.)



- Scenario management
- Multilevel stochastic simulation
- Execution of distributed simulations



- Data analysis
- Training, adaption and evaluation of Machine Learning models
- Meta modelling, feature selection, etc.



- Data plausibilization
- Anomalies and incident detection



## *Summary and Conclusion*

- Automated driving functions cannot be validated effectively without massive utilization of numerical simulation
  - Scenario Management and simulation-based system assessment is core technology for functional validation
  - Example/data based approaches are the most effective for complex and multi-disciplinary functions
- Intrinsic requirement conflicts for automated driving functions cause the must to multi-criteria optimization respectively pareto surfing
  - MATLAB is a supreme platform to bring arbitrary disciplines and domains into one common environment for development and assessment





Thanks, for listening!

The singularity is near, let's be prepared!

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