SIP-adus Workshop 2017

Impact Assessment for Automated Driving

Tokyo, 15th November 2017

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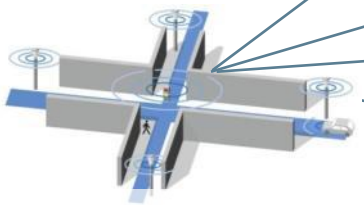
Evaluation Methodology
Modular connected holistic Tool Chain

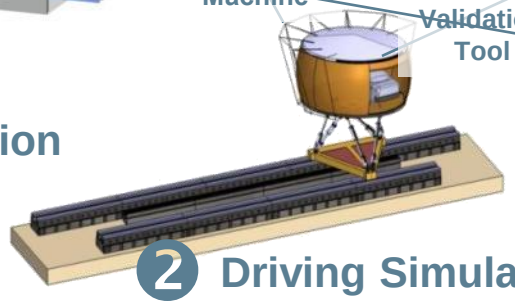
1. Assess the Driver Experience before Technology exists
2. Develop & Calculate virtual Effectiveness
3. Experience & Optimize as Expert in-the-Loop
4. Validate Acceptance & Effectiveness
5. Assess Controllability of Failures
6. Validate Functionality & Controllability
7. Evaluate & sign-off Functionality & Acceptance
8. Measure and Learn from real life
9. Check improvements and update functionality

Concept Experience | Concept Evaluation & Optimisation | Concept Validation | Software in-the-Loop | Hardware in-the-Loop | Component Development | Function Validation | Field Operational Tests | Real traffic

Idea | Specification | SOP

Expert Tool | „Time-Machine“ | Validation Tool | Component Tests | Functional Tests | Traffic Situations with Connectivity





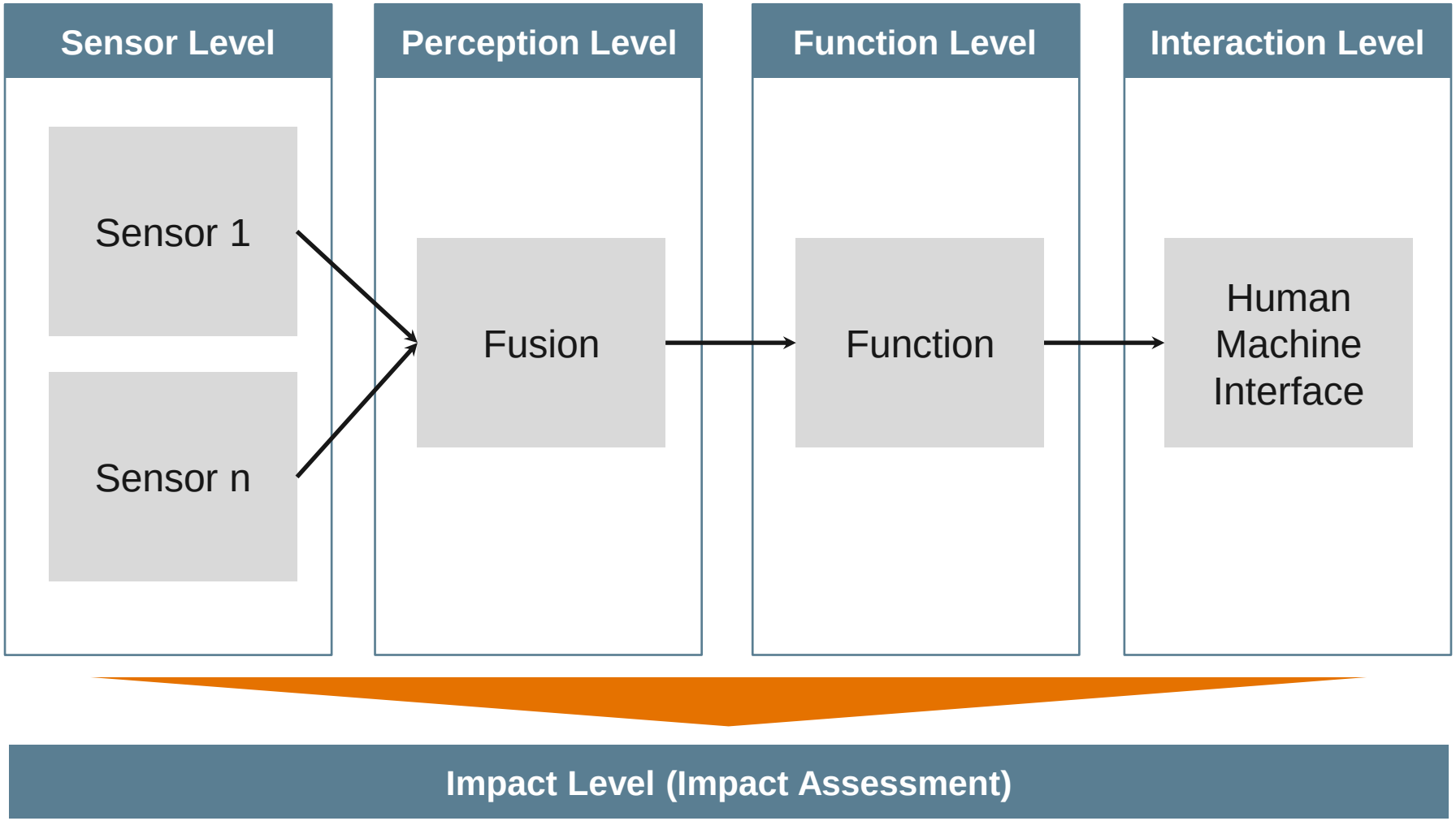
1 Multi-Scale Traffic Simulation

2 Driving Simulator

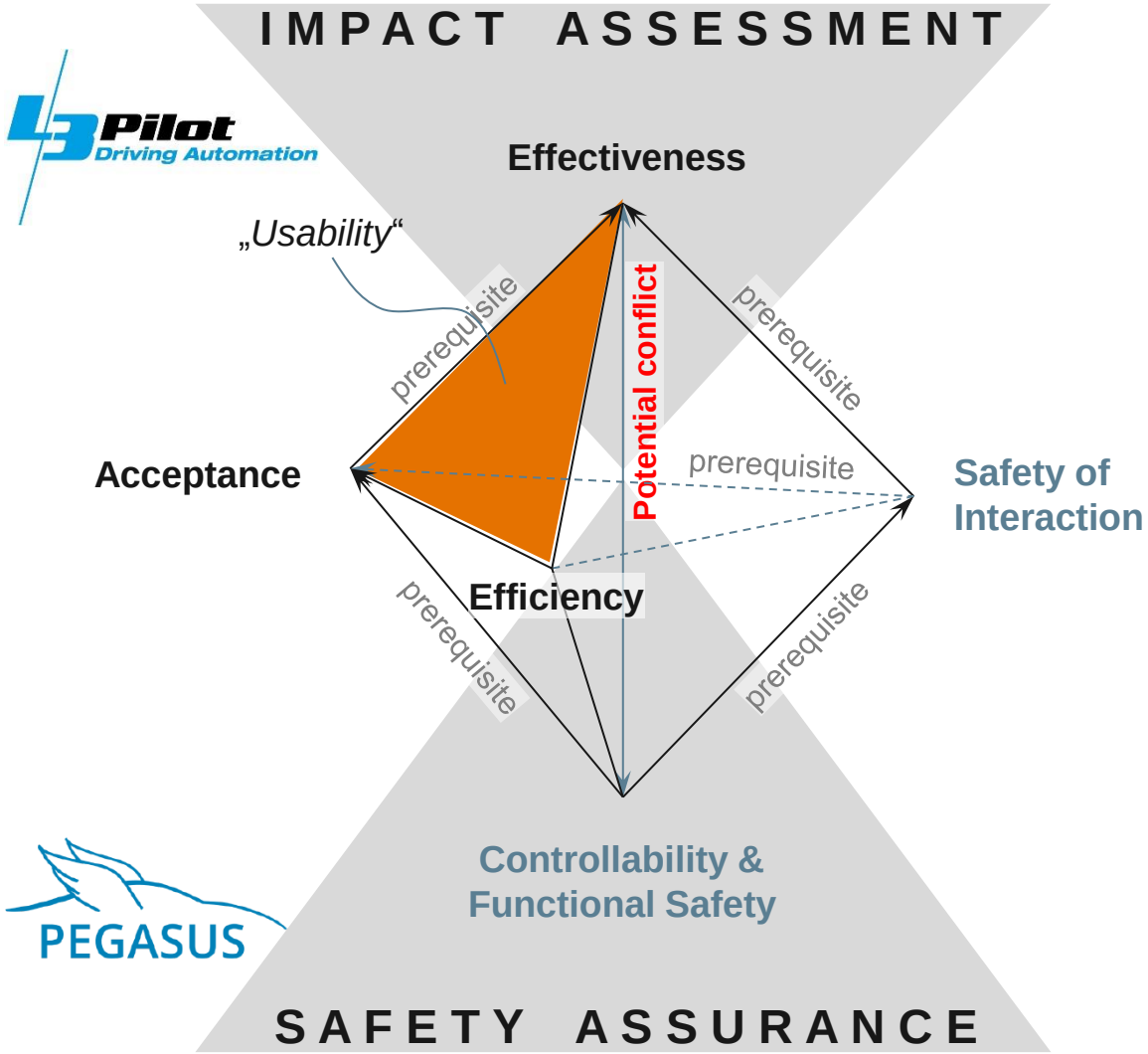
3 Research Platforms

4 Intelligent Proving Ground

Evaluation Methodology
Determination of Test Level



Evaluation Methodology
Dimensions



= **ultimate design goal,** e.g. safety

= **dimensions of interaction**

= **necessary prerequisite**

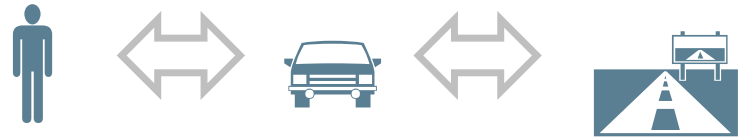
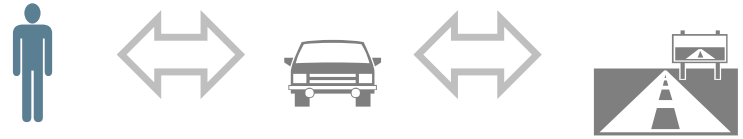
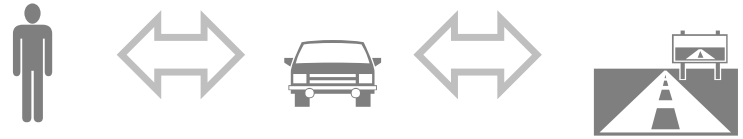
What is the effect of a functional concept in relevant driving situations?

- Valid dynamic behaviour of vehicle with/without system
- Valid & identical presentation of critical situations for every driver

Can drivers control the vehicle, if
- system limits are reached?
- system performance degrades?
- system faults occur?

- Effects on vehicle dynamics should be depicted 1:1
- Exclude risk for people involved.

Evaluation Methodology
Different Methodologies

Methods	DRIVER VEHICLE ENVIRONMENT	
Field Operational Test		+ trajectory & interaction 1:1 perceptible - reproducibility limited - relevant situations occur rarely - extensive effort
Controlled Field		+ trajectory & HMI quite well perceptible o reproducibility - situation space limited - high effort
Dynamic Driving Simulator		+ trajectory & HMI well perceptible + reproducibility + critical situations possible o medium effort
Simulation		- trajectory bad perceptible o interaction limited perceptible + reproducibility + low effort

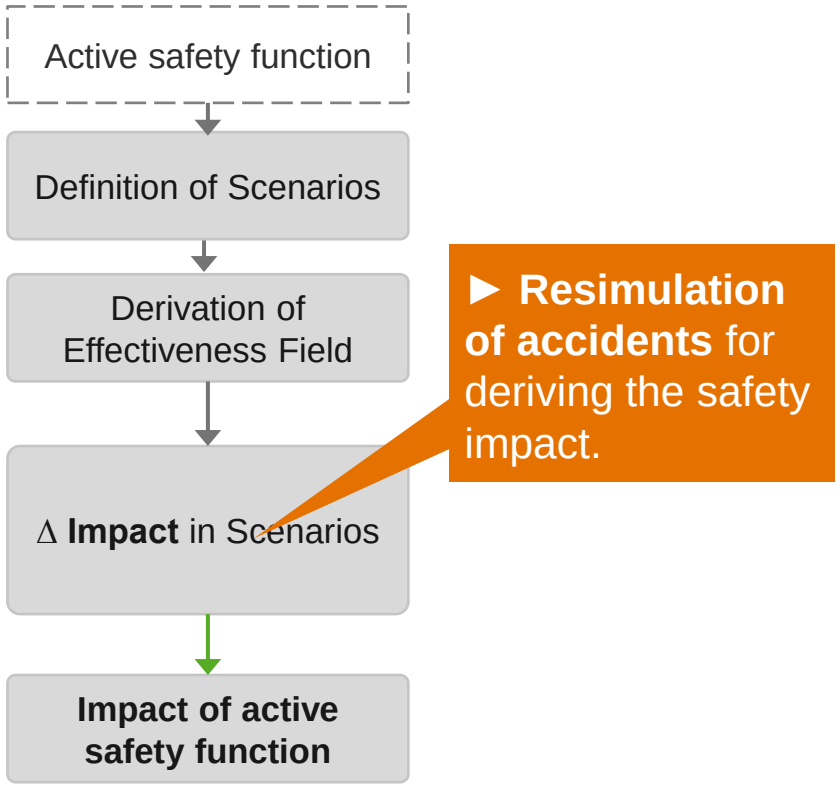
REAL

Increase of validity

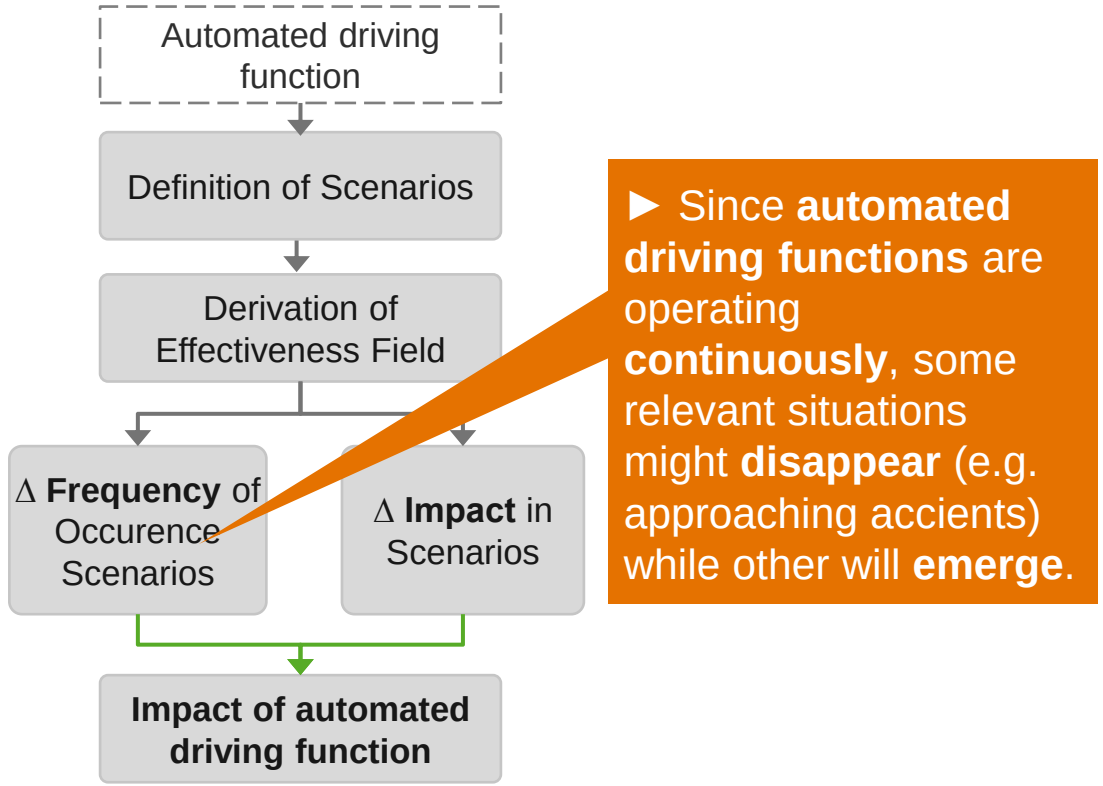
VIRTUAL

Impact Assessment of Automated Driving
Framework for Safety Impact Assessment

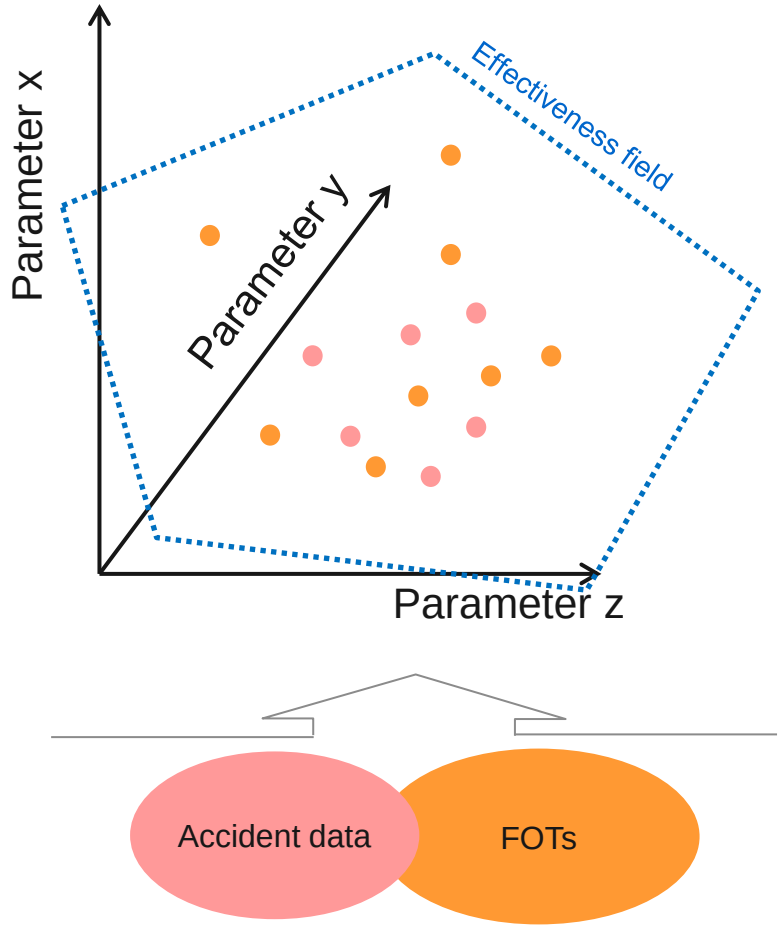
Classical approach for safety impact assessment

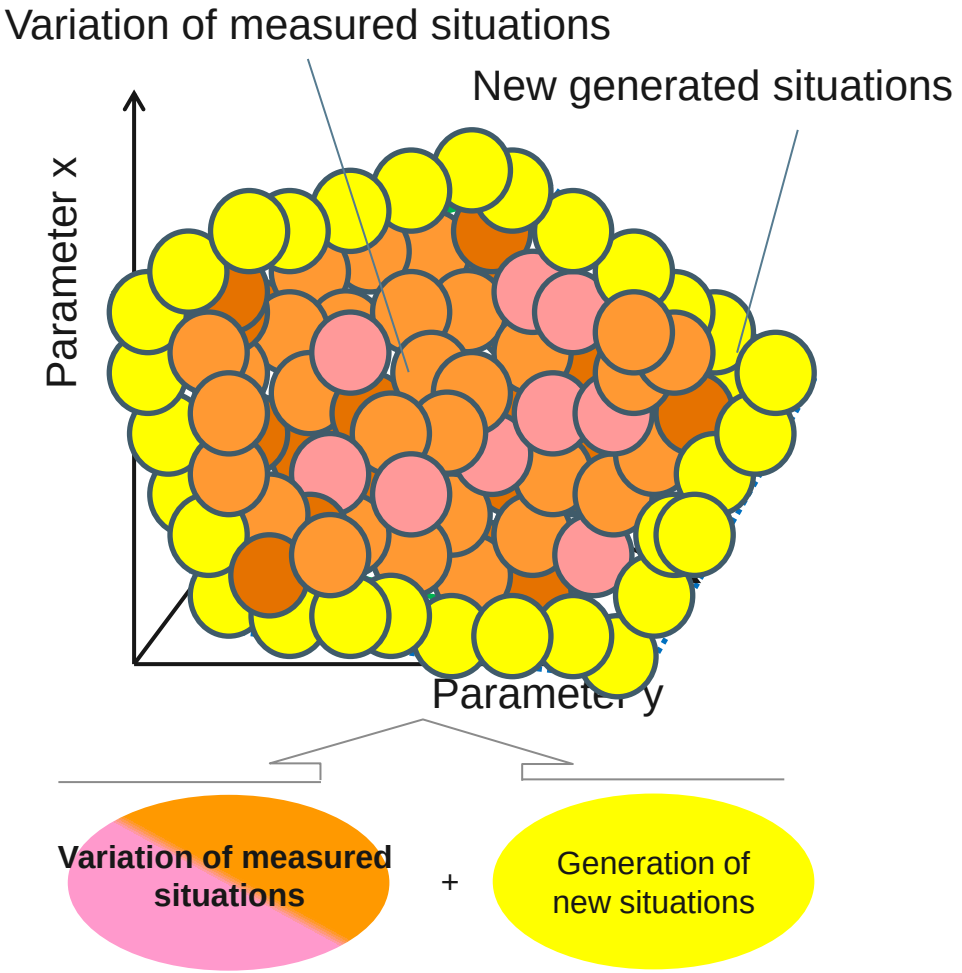


New approach for safety impact assessment of **automated driving functions**



Analysis of Automated Driving Field Test Data
Scenario Classification of Real-World Data





Source: Eckstein, L., Zlocki, A.: Safety Potential of ADAS - Combined Methods for an Effective Evaluation, 23rd ESV 2013, Seoul, 2013

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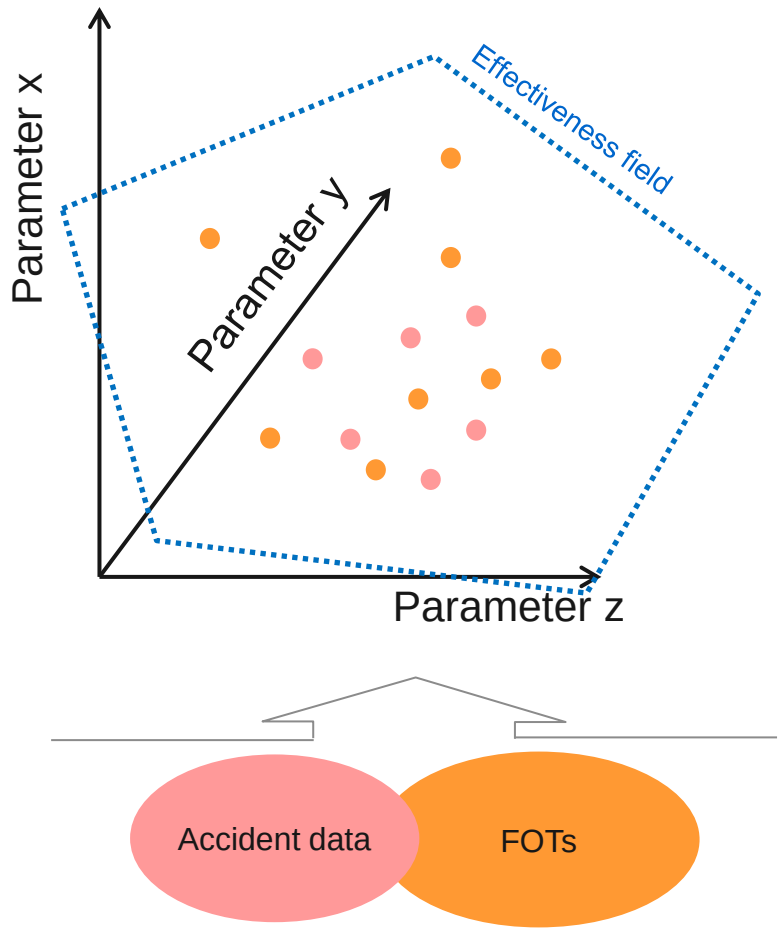
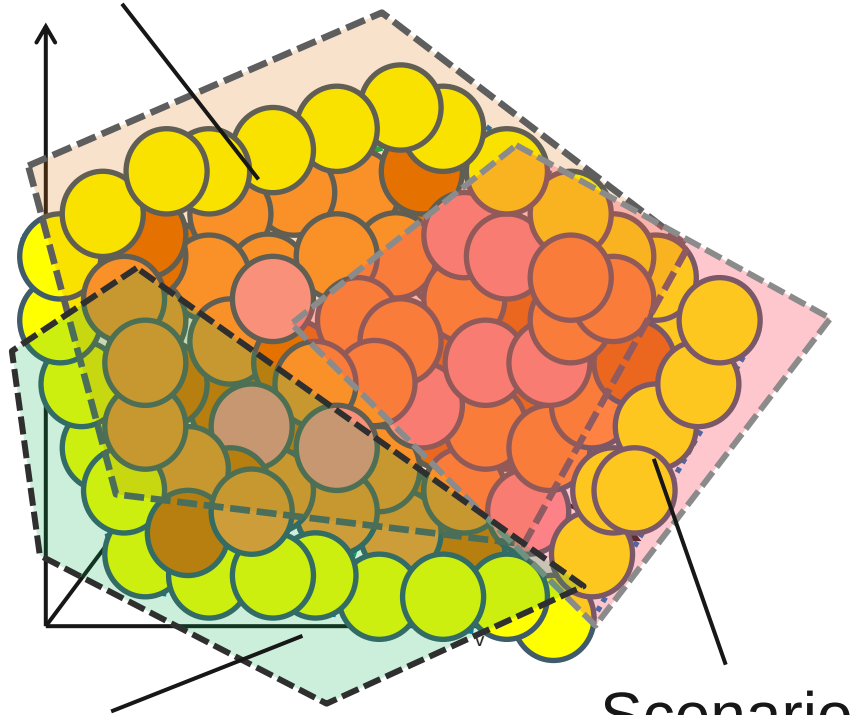


Scenario
„*Approaching vehicle*“



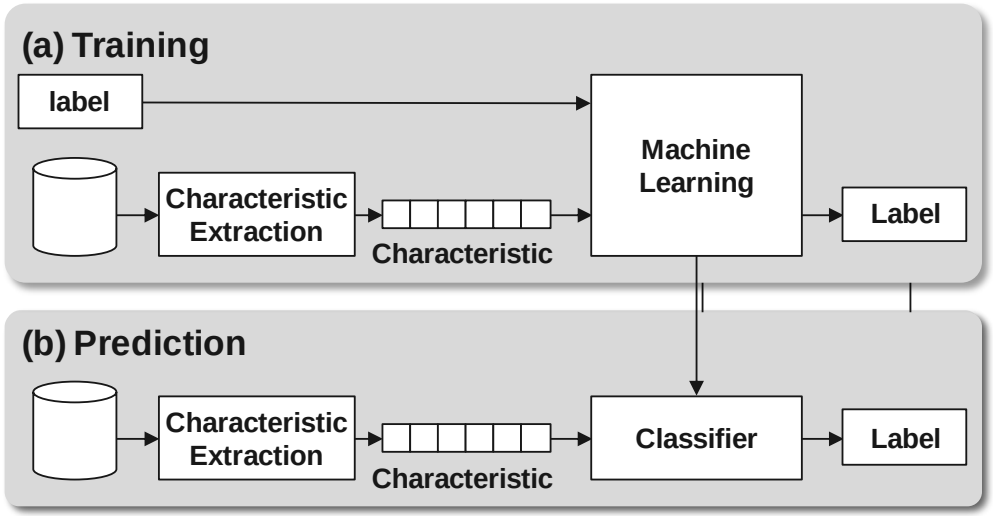
Scenario
„*Cut-in of other vehicle*“

Scenario
„*Lane change*“

Analysis of Automated Driving Field Test Data
Scenario Classification of Real-World Data

- **Rule-based Classification**
  Benmimoun (2011)
  - Offline classification
  - Uses decision trees parameterized by hand
  - No easy adaptation, no consideration of time series

- **Machine-learning based Classification**
  Reichel (2010), Roesener (2016)
  - Proficient using of Machine Learning Techniques
  - Partial automated
  - Choice of classifier based on expert knowledge

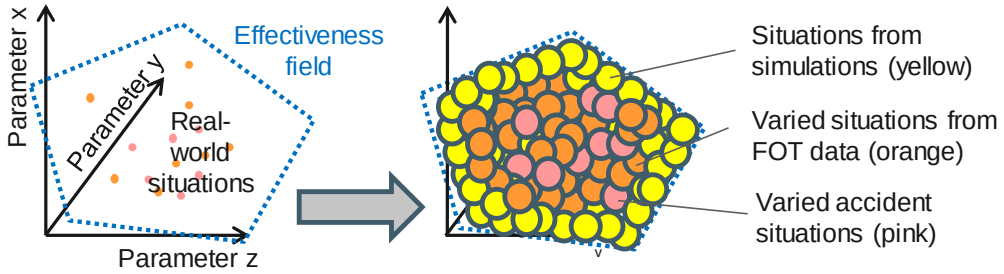


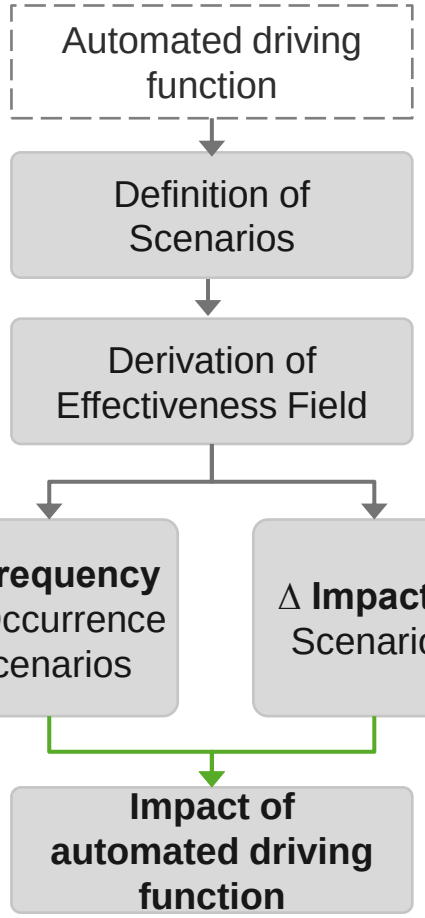
Reichel (2010), Roesener (2016)

► Machine learning techniques provide an efficient & automated data clustering

Source: C. Rösener, F. Fahrenkrog et al.. A Scenario-Based Assessment Approach for Automated Driving by Using Time Series Classification of Human-Driving Behaviour, ITSC 2016, Brasilia, 2016

Impact Assessment of Automated Driving
Framework for Safety Impact Assessment





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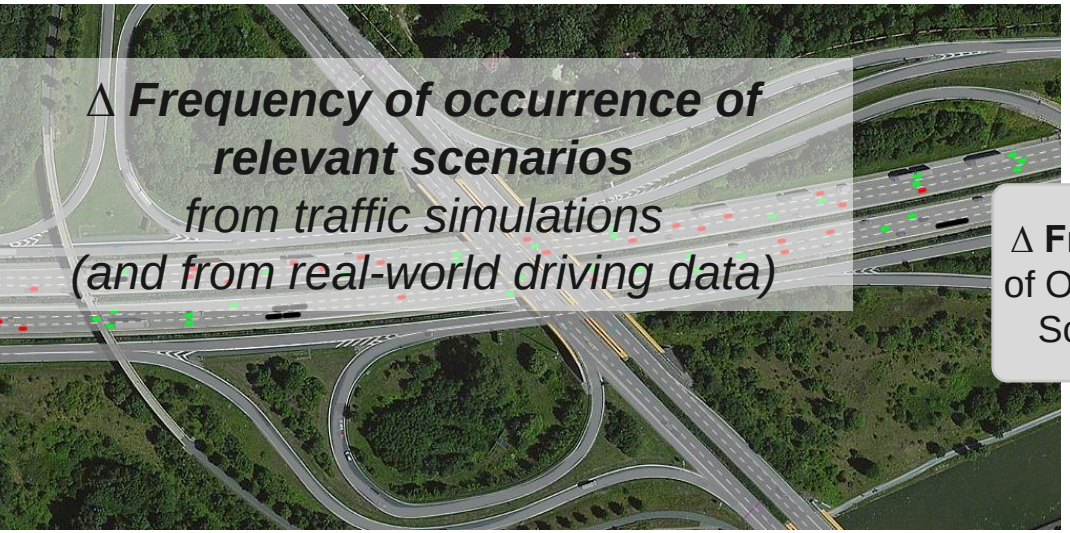
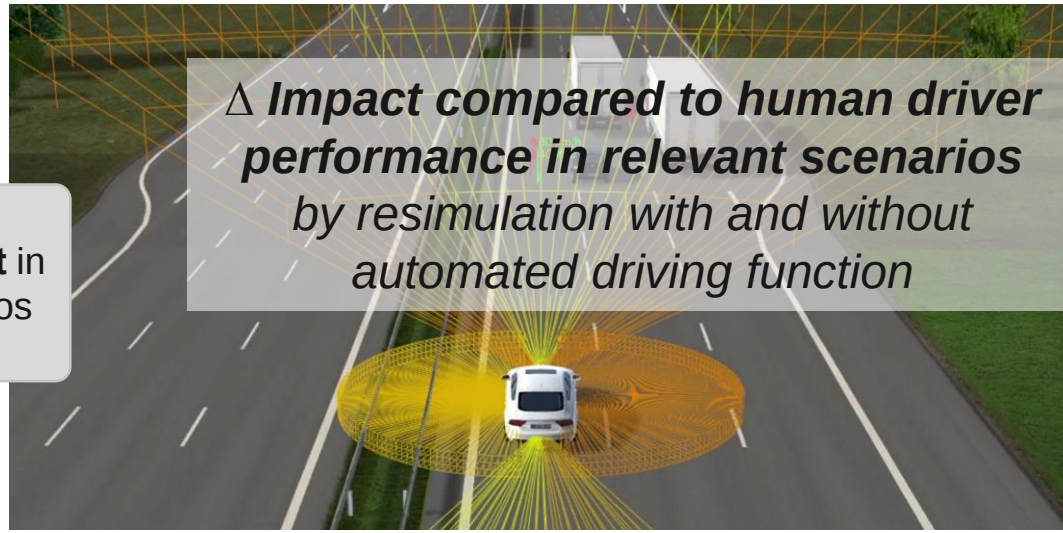
Potential societal benefits of vehicle automation



Δ Frequency of occurrence of relevant scenarios
from traffic simulations
(and from real-world driving data)



Δ Impact compared to human driver performance in relevant scenarios
by resimulation with and without automated driving function

Impact Assessment of Automated Driving
Framework for Safety Impact Assessment

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Potential societal benefits of vehicle automation

- **Project finalized in Summer 2017.**
- **Results will be published and available in the coming months.**

Testing Automated Driving in Field Tests
Scenario-based Assessment of Automated Driving

Data Source

Demonstrator Function

Reference: FOT

Classification of Scenarios

Classification of Scenarios

Classifier Scenario 1

Classifier Scenario 2

Classifier Scenario x

PIs

Scenario-based Assessment

Assessment

Calculation of:
- Derived Measures
- Performance Indicators

Δ Frequency (Scenario)

Δ Effect (Scenario)

► **Human driving** as a **baseline**

► Classification of scenarios by using **time series classification algorithms (Hidden Markov Models)**

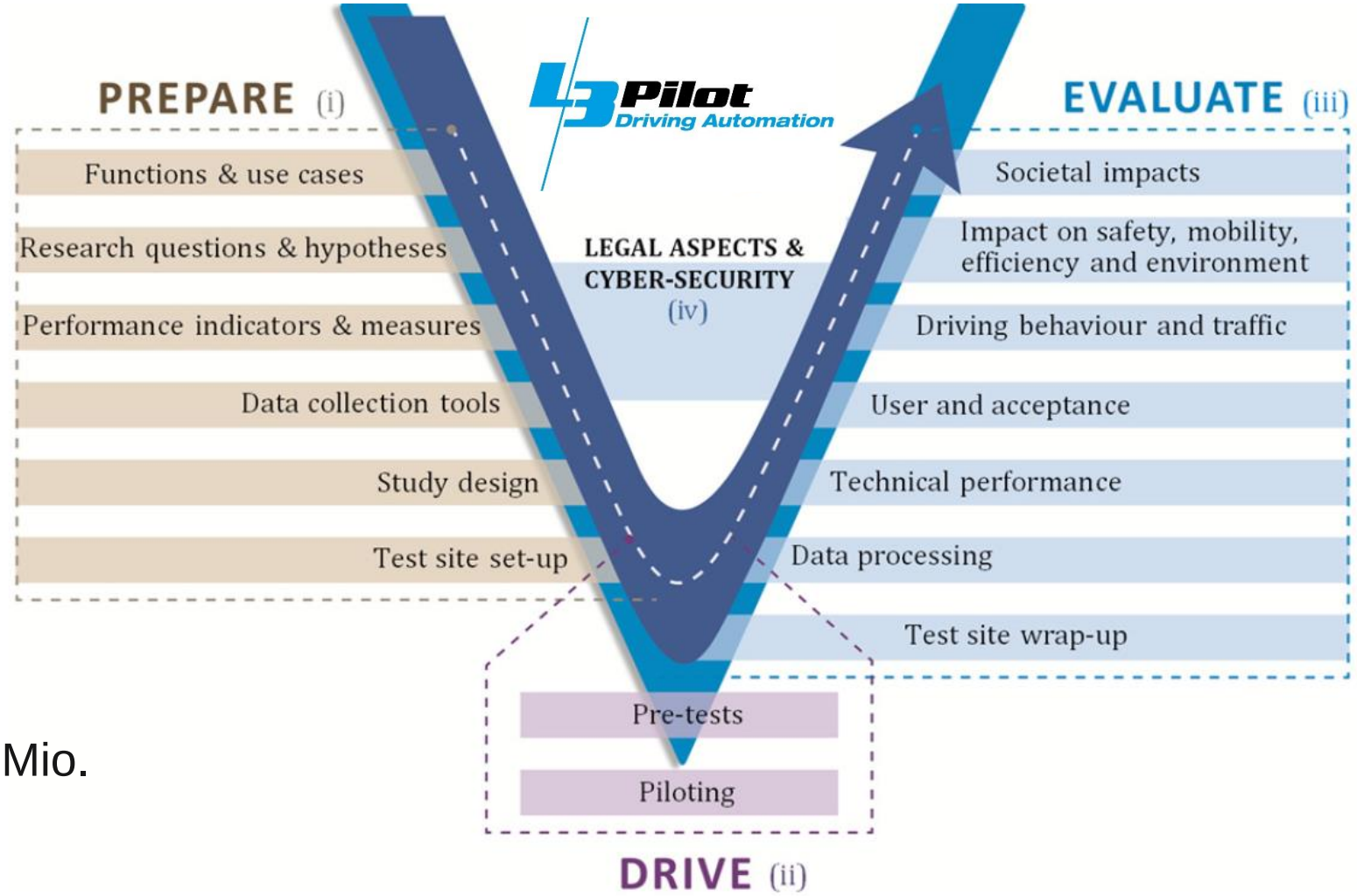
► Assessment of Δ**frequency** and Δ**effect** induced by system in **scenario**

Piloting Automated Driving on European Roads

L3Pilot – Real World Data for Impact Assessment

- Large-scale Level 3 piloting
- 1,000 test drivers,100 vehicles in 11 European countries
- EC funded in Horizon 2020
- 34 partner
- Budget: 68 € Mio., Funding: 36 € Mio.

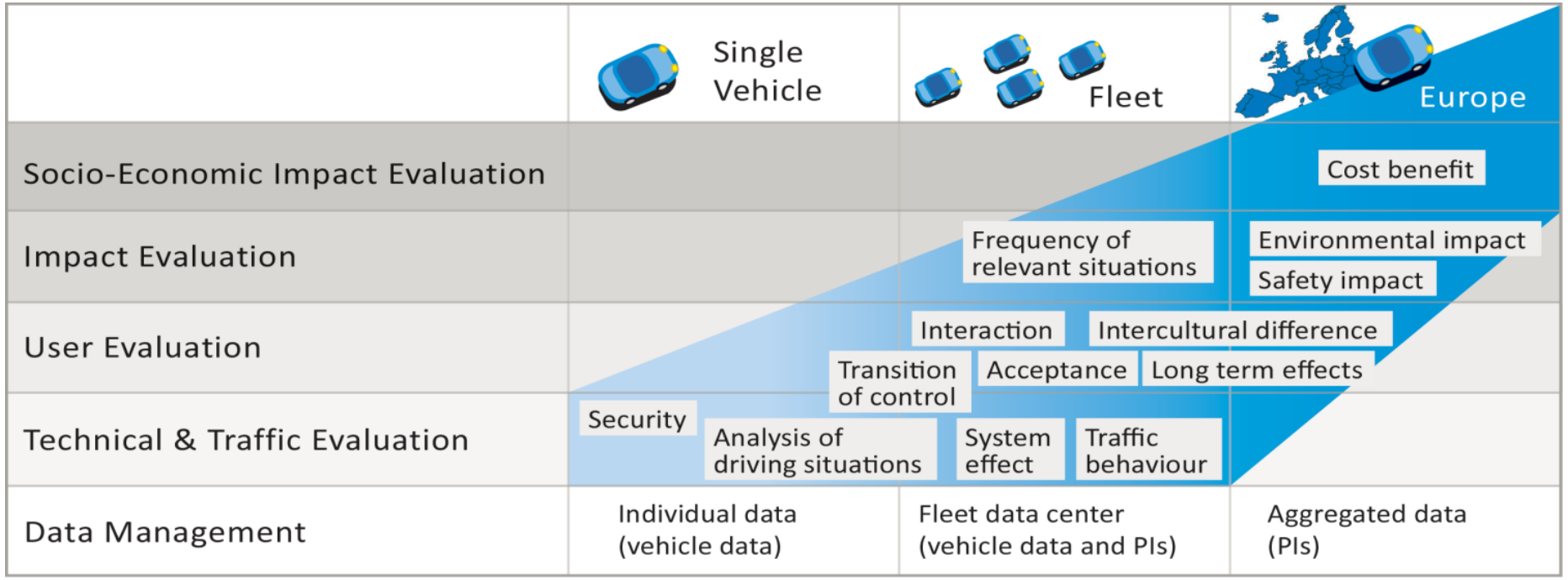
- Website: **http://www.l3pilot.eu**



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723051.

L3Pilot
Impact Assessment is Evaluation Scope

- Objectives:
  - Overall evaluation of automated driving function with respect to the influence on technical, user & acceptance and driving & travel behavior aspects.
  - Assessment of long-term effects of automated driving on user attitudes and acceptance.
  - Investigation of interactions between different traffic participants in different automation modes.
  - Assessment of the readiness and reliability of automated driving functions.



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Contact

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?

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