

Assessment and Validation of AD-Functions

Investigation for Global Industry Harmonization

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TECHNISCHE UNIVERSITÄT BRAUNSCHWEIG

Assessment and Validation of AD-Functions Investigation for Global Industry Harmonization

Roman Henze
Satoshi Taniguchi

Outline



- ❖ 3D Data Collection
- ❖ Methodology, Data Analysis & Test-Case Extraction
- ❖ Towards HAD Urban
- ❖ Global Harmonization

**Assessment and Validation of AD-Functions
Investigation for Global Industry Harmonization**

3D* Data Collection (Standard Equipment)

Chassis



ADAS



Powertrain



Comfort CAN



Vehicle Dynamics



GPS-positions



Video Recording



Radar Signals

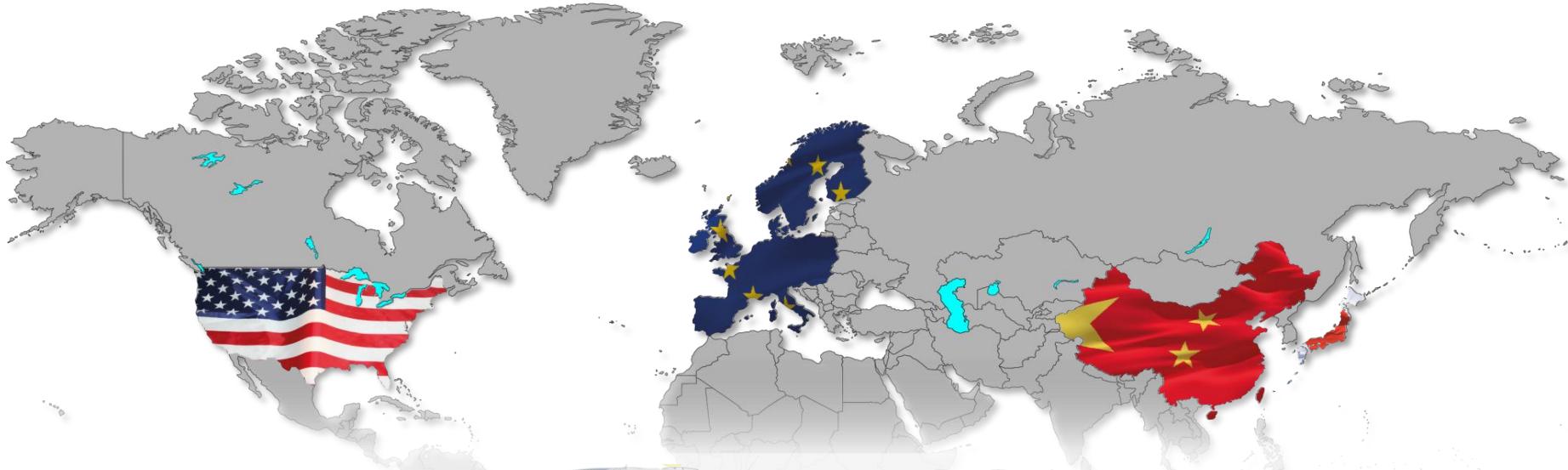
„Labeling“-APP



- Road Type
- Traffic
- Weather
- ...

*3D = Driven Vehicle, Driver, Driving Environ

3D Data Collection – World Wide Measurements



2018/19



Europe > 500.000 km > 8.000 hrs.



United States > 100.000 km > 2.500 hrs.

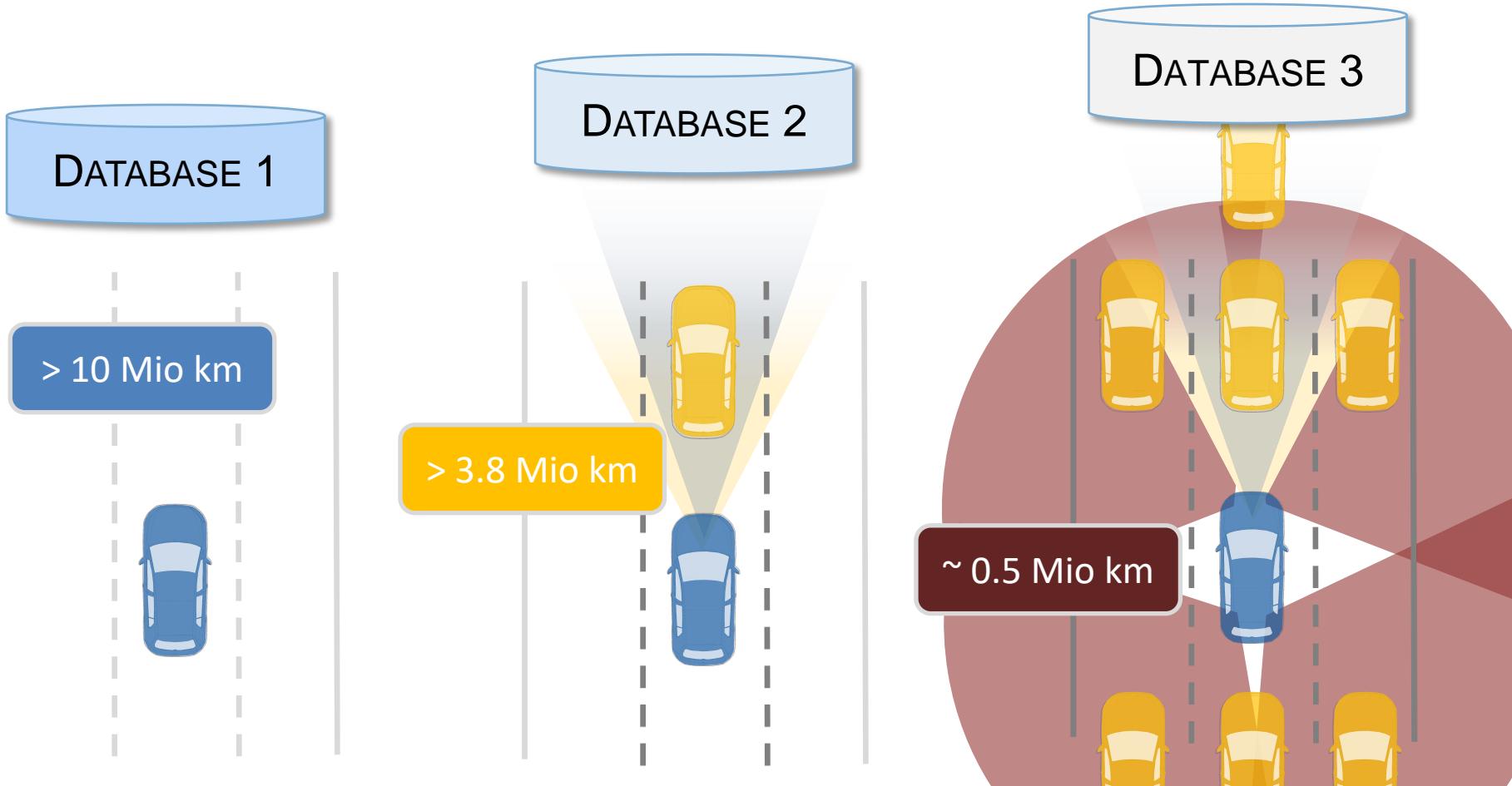


Japan > 100.000 km > 2.500 hrs.



China > 75.000 km > 1.500 hrs.

3D Database Classification



Test Vehicles for HAD Functions & Referencing



- 6** Laser Scanners
for object detection
- 2** Lane Marking Scanners
Pre equipped radar
and camera
- Car-PC + RCP platform



***Testing and Engineering of
Automated driving SYstems**

HAD Approval in Real Driving Environ



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HAD Test Process Development – Overview

Methodology

Process for the efficient Testing for

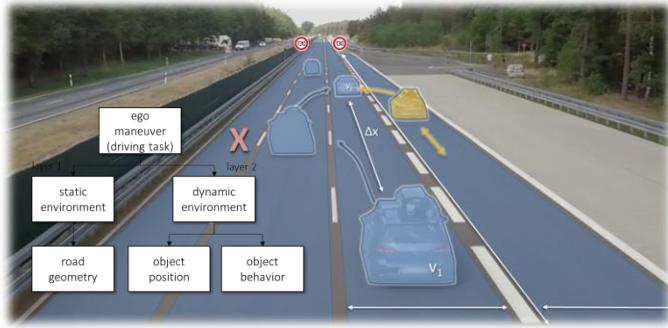
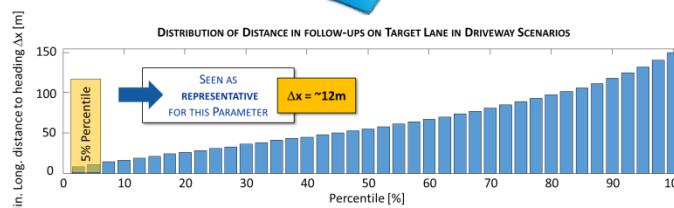
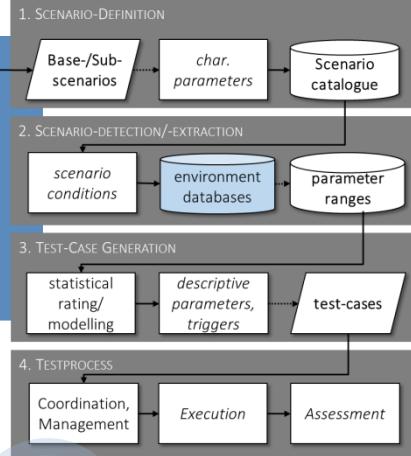
- approval,
- performance tests and
- safety assessment of automated driving functions on highways.



Test-Case Identification

Extraction process of relevant parameter specifications out of real environment databases.

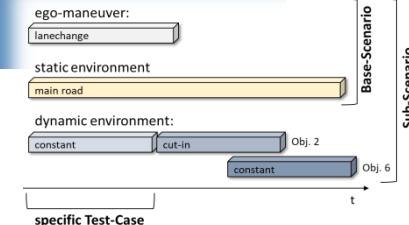
- Expected Cases (mean)
- Corner-Cases (critical)



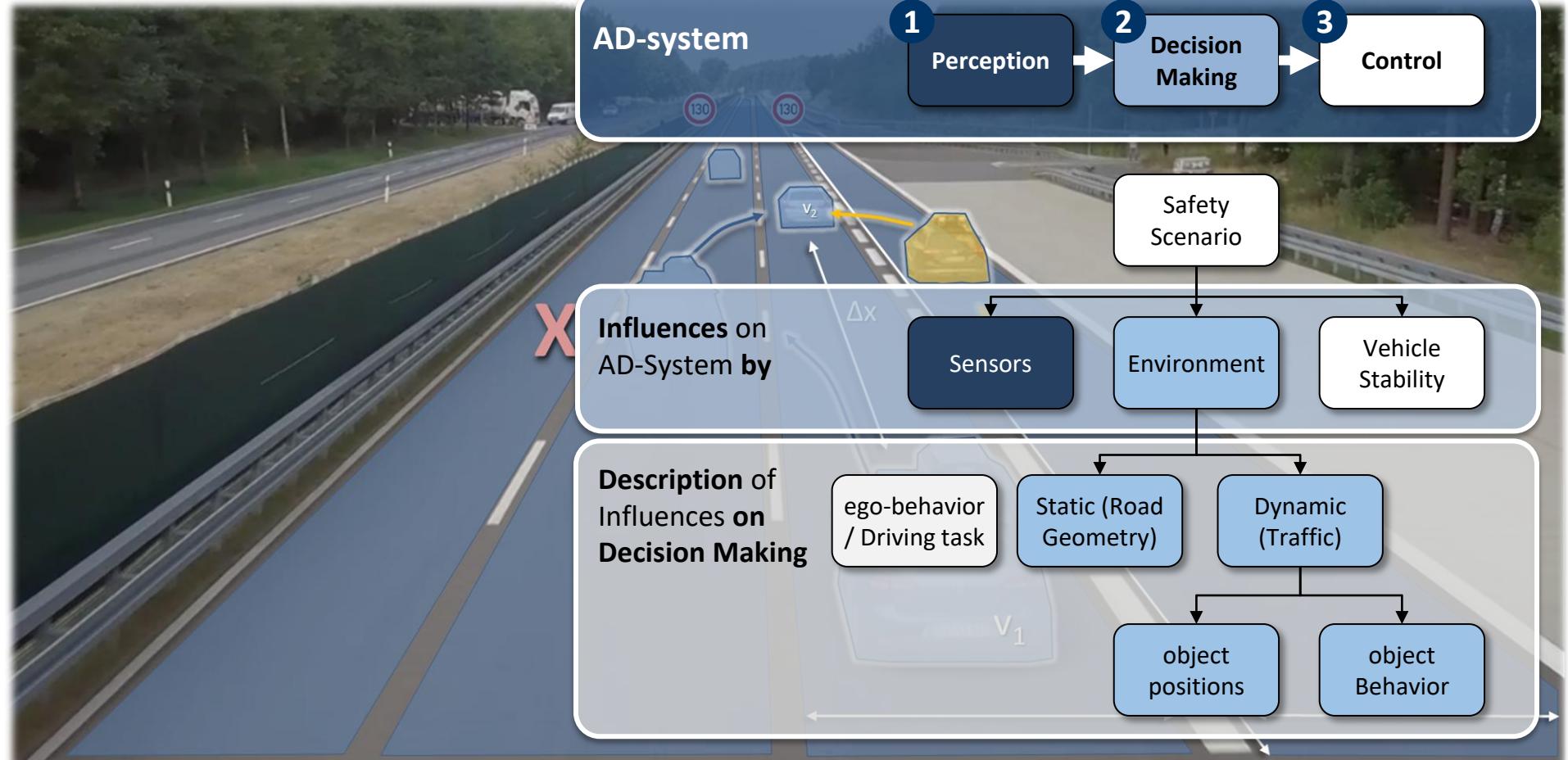
Scenario Structure

Schematic description of relevant environment on different levels. Related to ego driving task. parameter definition.

- Static Road Geometry
- Dynamic object Behavior and Motion

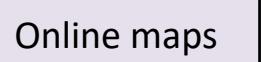
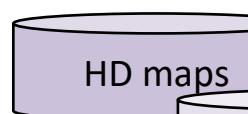


Scenario Structure



Databases for Extraction

Static Environment Information



BS-H-SZ-WOB

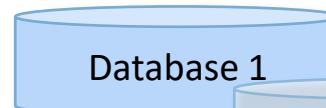
3D-Scan

Open-Street-Maps®

- Frankfurt (A3, A5, A661)
- Braunschweig, Hannover, Salzgitter, Wolfsburg (A2, A7, A39)
- Tokio, Japan



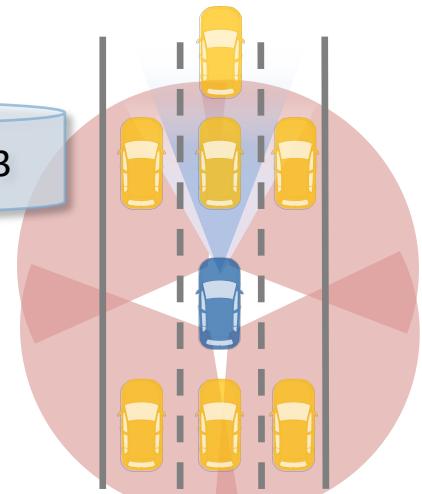
Dynamic Environment Information



Series Sensors, LIDAR

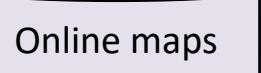
- CAN
 - Video
 - dGPS
- Radar
 - Camera

LIDAR



Databases for Extraction

Static Environment Information



BS-H-SZ-WOB

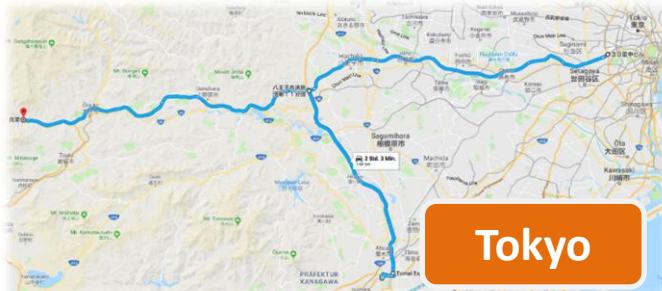
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Frankfurt

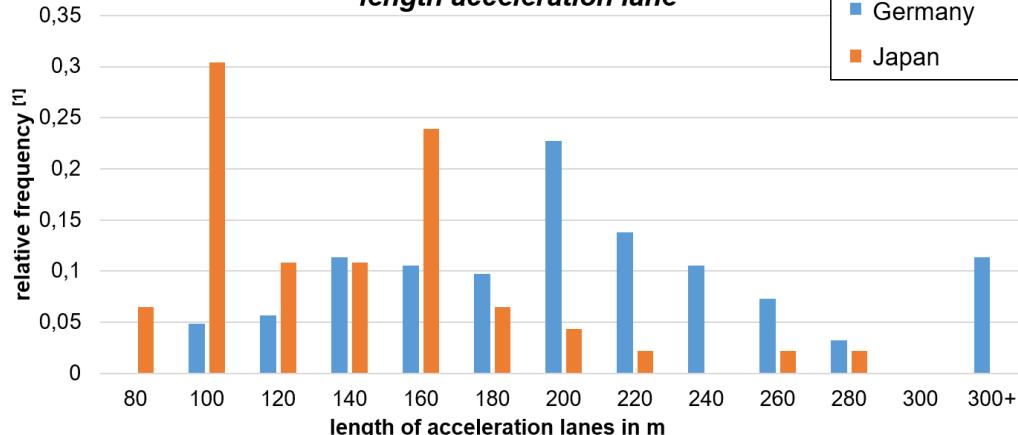


Tokyo



modal	200 m	100 m
mean	224 m	131 m
min	95 m	20 m
max	1090 m	350 m

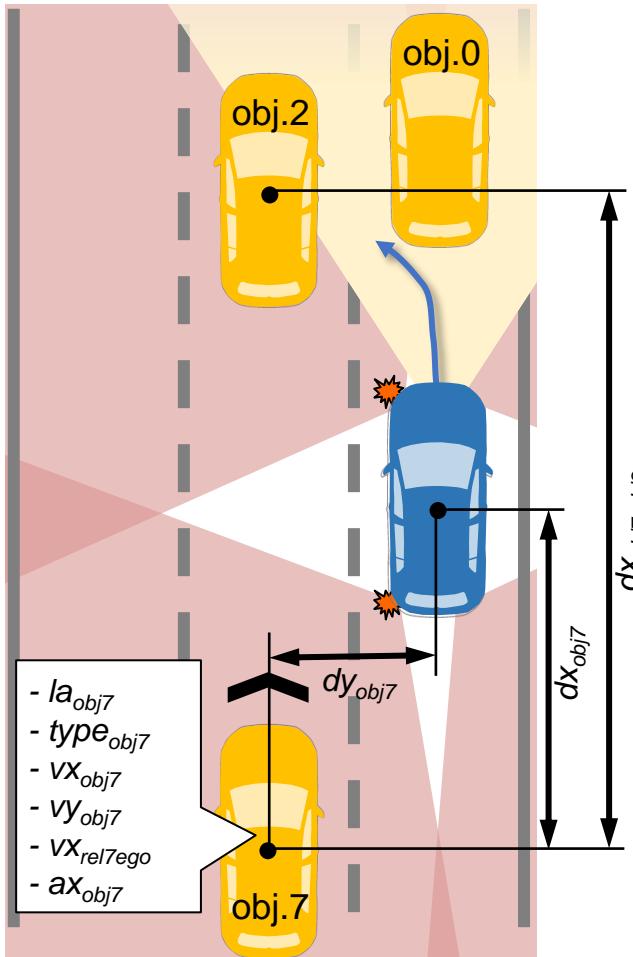
length acceleration lane



Measurement and Detection Process

Lane-Change Scenario

- ego - parameter (Reference)
- object0-parameter
- object2-parameter
- **object7-parameter**
 - lane assignment obj.7 la_{obj7}
 - type of object type $_{obj7}$
 - long. velocity obj.7 vx_{obj7}
 - lat. velocity obj.7 vy_{obj7}
 - rel. velocity obj.7 $vx_{rel7ego}$
 - long. acceleration obj.7 ax_{obj7}
 - long. distance to obj.7 dx_{obj7}
 - lat. distance to obj.7 dy_{obj7}
 - distance obj.7 to obj.2 $dx_{obj7-obj2}$



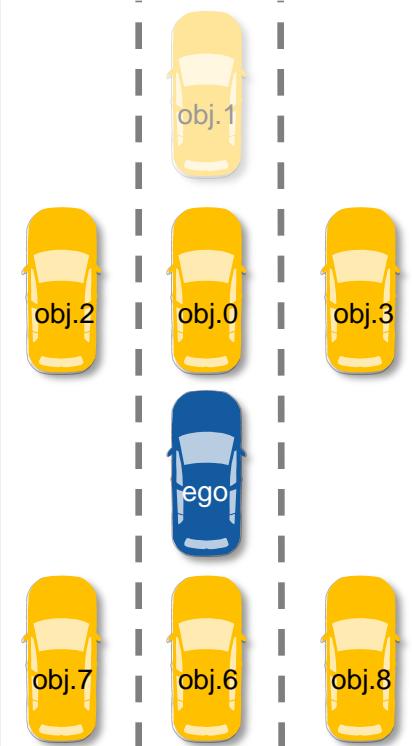
Measurement of
ego Vehicle and
Surrounding Traffic
Parameters using:

- Series Sensors
Radar, Camera
- **High Precise 360°
reference LIDAR-System**



Environment Classification: Dynamic objects

Classification of object position



Classification of object behavior

Classification of object behavior

	Cut-In	Cut-Out	accl.	decl.	sync.
object 1				x	
object 0		x		x	(x)
object 2	x			x	(x)
object 3	x			x	(x)
ego					
object 6			(x)		
object 7	(x)		(x)		(x)
object 8	(x)		(x)		(x)

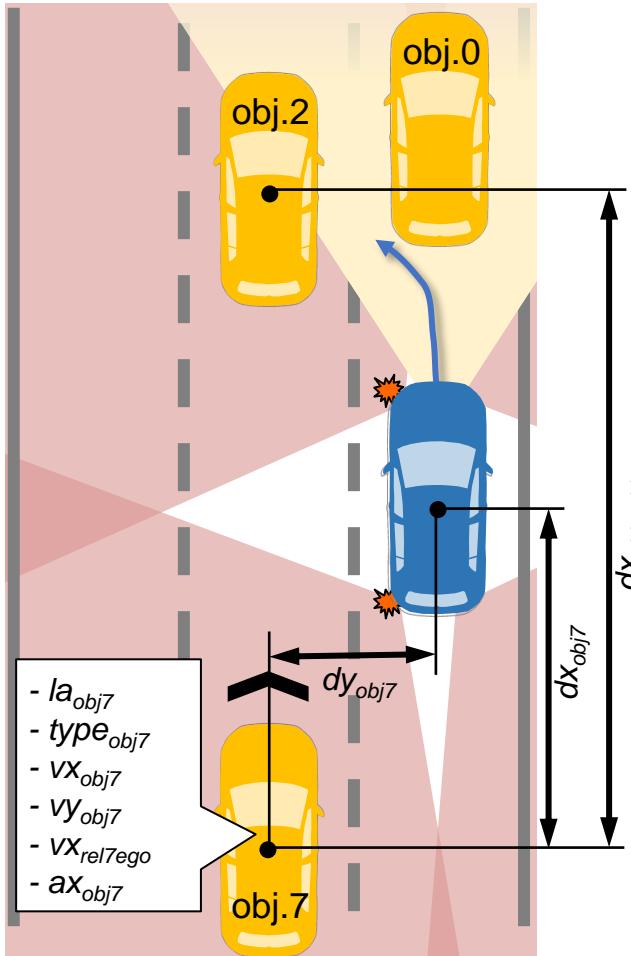
x – relevant for validation

(x) – relevant in combination

Measurement and Detection Process

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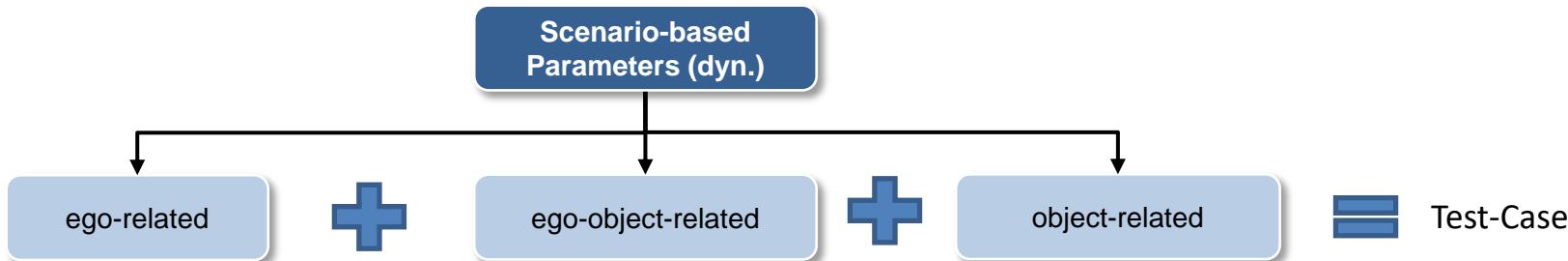


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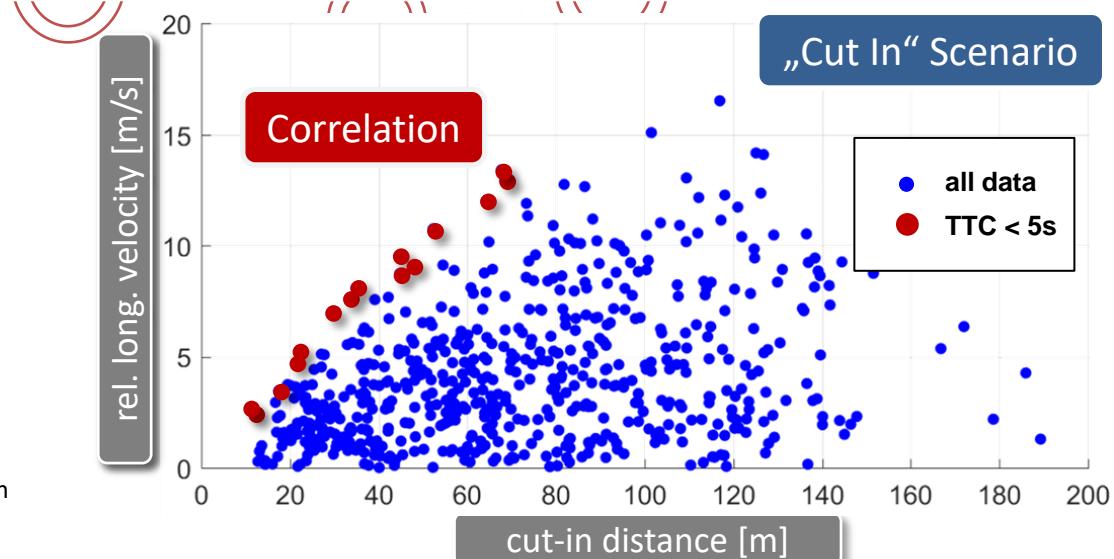


Statistical Parameter Analysis



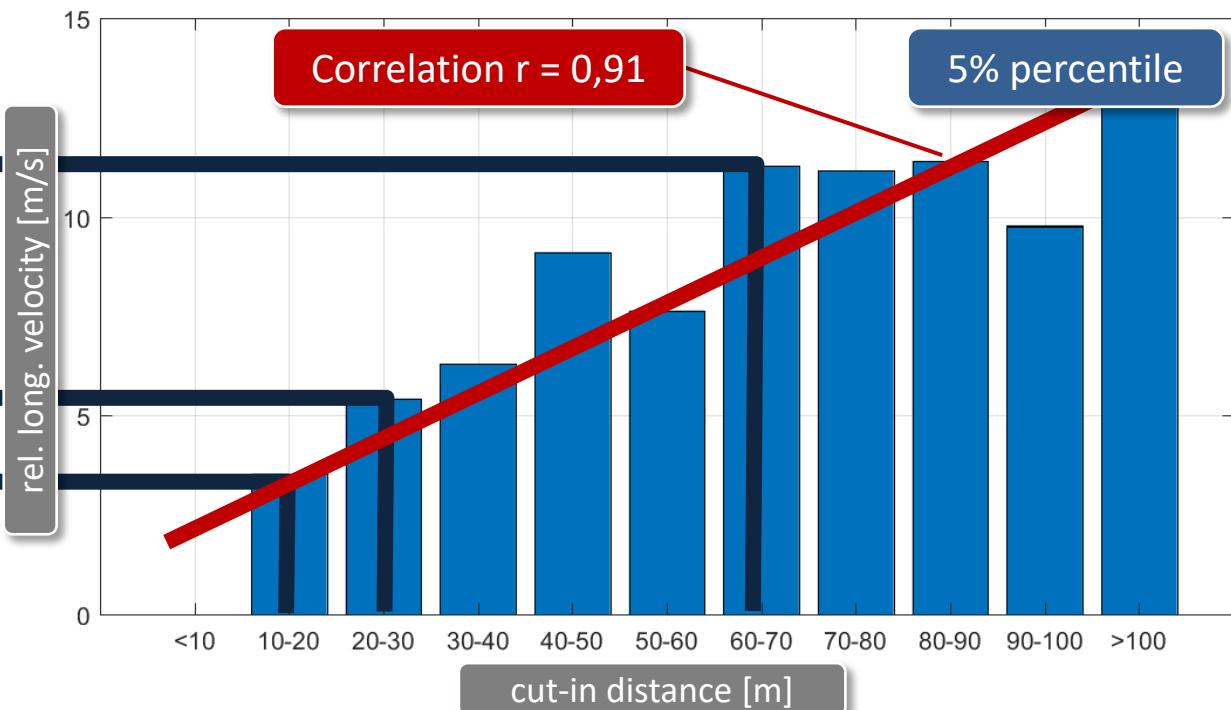
Correlation tests
for extraction of
realistic
and
critical
parameter combinations!

Example: Different $vx_{obj/rel}/dx_{obj}$
combinations if the combinations depend on
different ego velocities



Test-Case Extraction from 3D Data Base

Test-Case	dx_{obj} [m]	$vx_{obj/rel}$ [m/s]
n	61.4;	11.6
...		
2	24.5;	5.8
1	12.6;	3.2



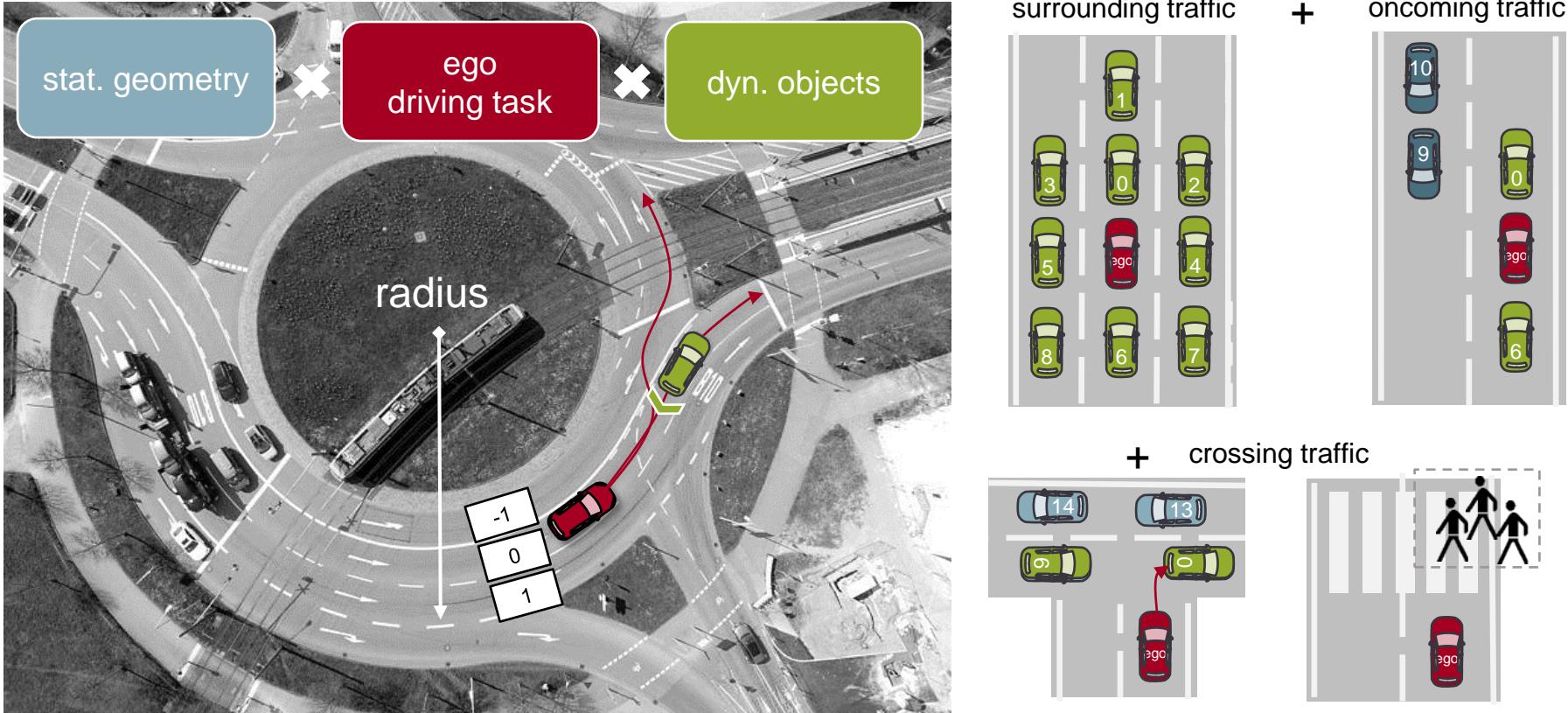
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Transfer of AD Validation in urban scenarios



1 Scenario Structure

2 Validation of relevant scenarios

3 Test-Case Generation

Transfer of AD Validation in urban scenarios



stat.
geometry



ego driving
task



dyn. object
interactions

1

Scenario Structure

2

derivation of relevant
scenarios

3

Test-Case
Generation

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International Collaboration JAMA - JARI - NFF



- JPN / GER (EU) Database
- Data Analysis Methodology
- Support by exchanges of each expert researchers



The main objective of our collaboration:

Develop a **Methodology** to derive realistic **Evaluation Scenarios** for AV's

1. Data collection and Analysis with NDS approach
2. Scenario detection and generation
3. Comparison of Japanese vs. German traffic



Global Harmonization

International JP-GER Collaboration – Current Activities

... significant country specific differences

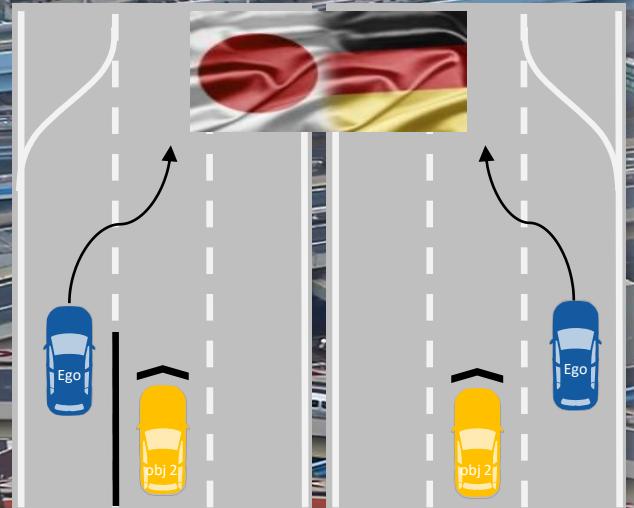
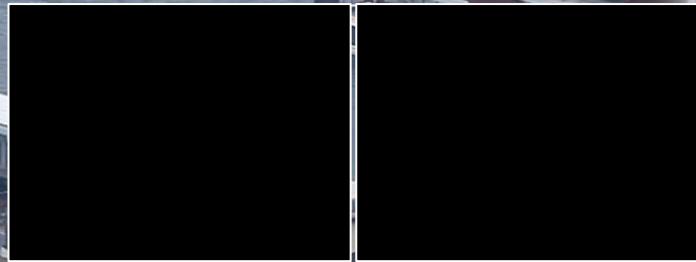
- Occlusions, different Levels of Lanes
- Left Hand Traffic
- Speed Limits
- Parameter Specifications
- ...



Harmonization of

- Processes
- Scenario Structure and
- Test-Case Identification

But consider **differences in relevant environment**



SAKURA - Project



The SAKURA project activities are led by JAMA (Japanese Automobile Manufacturers Association) in collaboration with JARI (Japan Automobile Research Institute), for which JARI is getting support from the government (METI).

The project has been running since 2018



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Thanks for your Attention!



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