Hochschule Kempten
University of Applied Sciences

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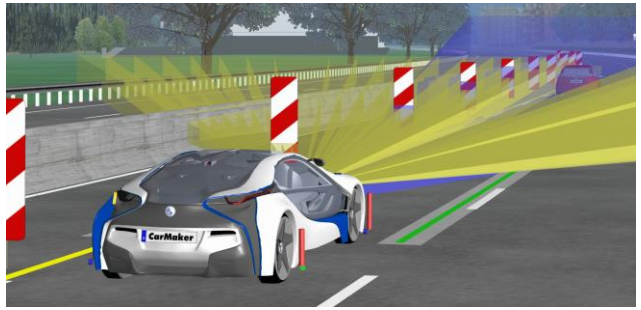
ADAS Master WS 20/21
Lecture 1

Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

Introduction

University of Applied Science	AVL List GmbH	IPG AUTOMOTIVE
2016 - today	2014 - 2016	2007 - 2013
		
		
Research Professorship University of Applied Science / Research Center Allgaeu	Global Business Unit Manager Calibration & Virtual Testing Solutions	Managing Director
Vehicle Dynamics ADAS/Highly Automated Driving Vehicle Efficiency	Calibration Solution Test Information Management Virtual Testing / Model Based Testing	General Vehicle Dynamics, Integrated Controls, ADAS, Fuel Efficiency & E-Mobility

Introduction

TÜV SÜD AUTOMOTIVE

1995 - 2007

General Manager Chassis Systems

Vehicle Dynamics, Tire & Wheels, Brakes, Measurement & Simulation

16 YEARS PRO RACE CAREER

1982 - 1997

250cc, Superbike, Supersport GP, World, European, German Championship

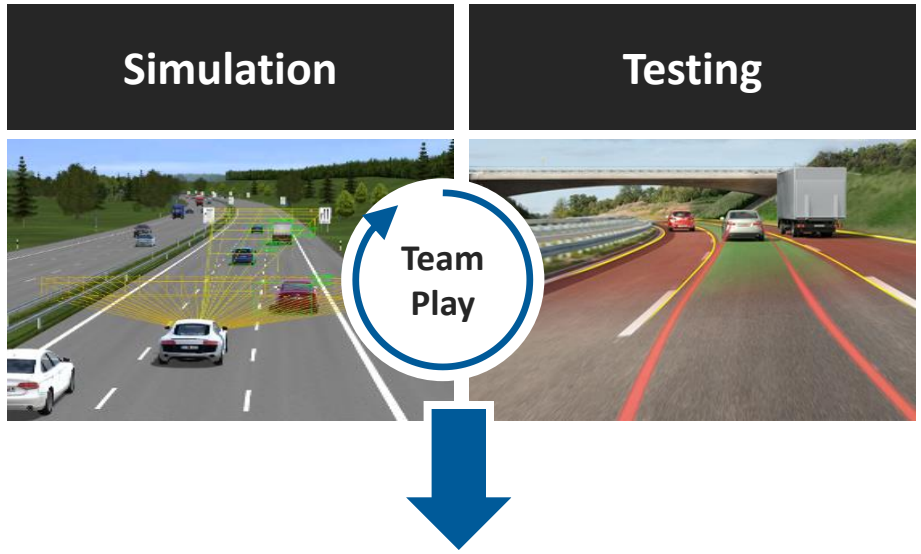
Int. German Champion 1996
ProSuperbike Team Champion 1993 / 1994

Research for Automated Driving

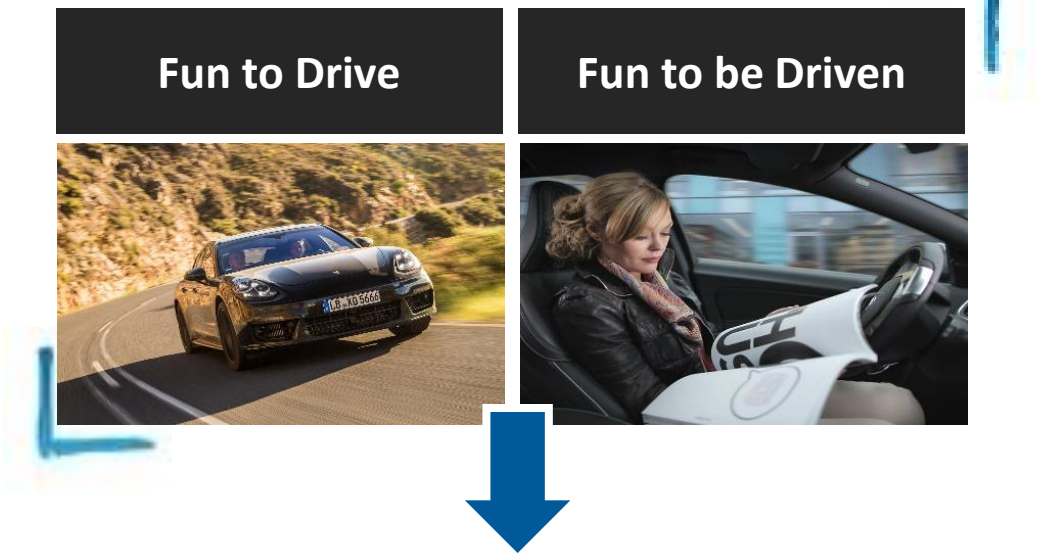
Prof. Bernhard Schick, University of Applied Sciences Kempten

Our Motivation

Complexity of new ADAS/AD systems and upcoming test effort.
The customer acceptance and satisfaction.

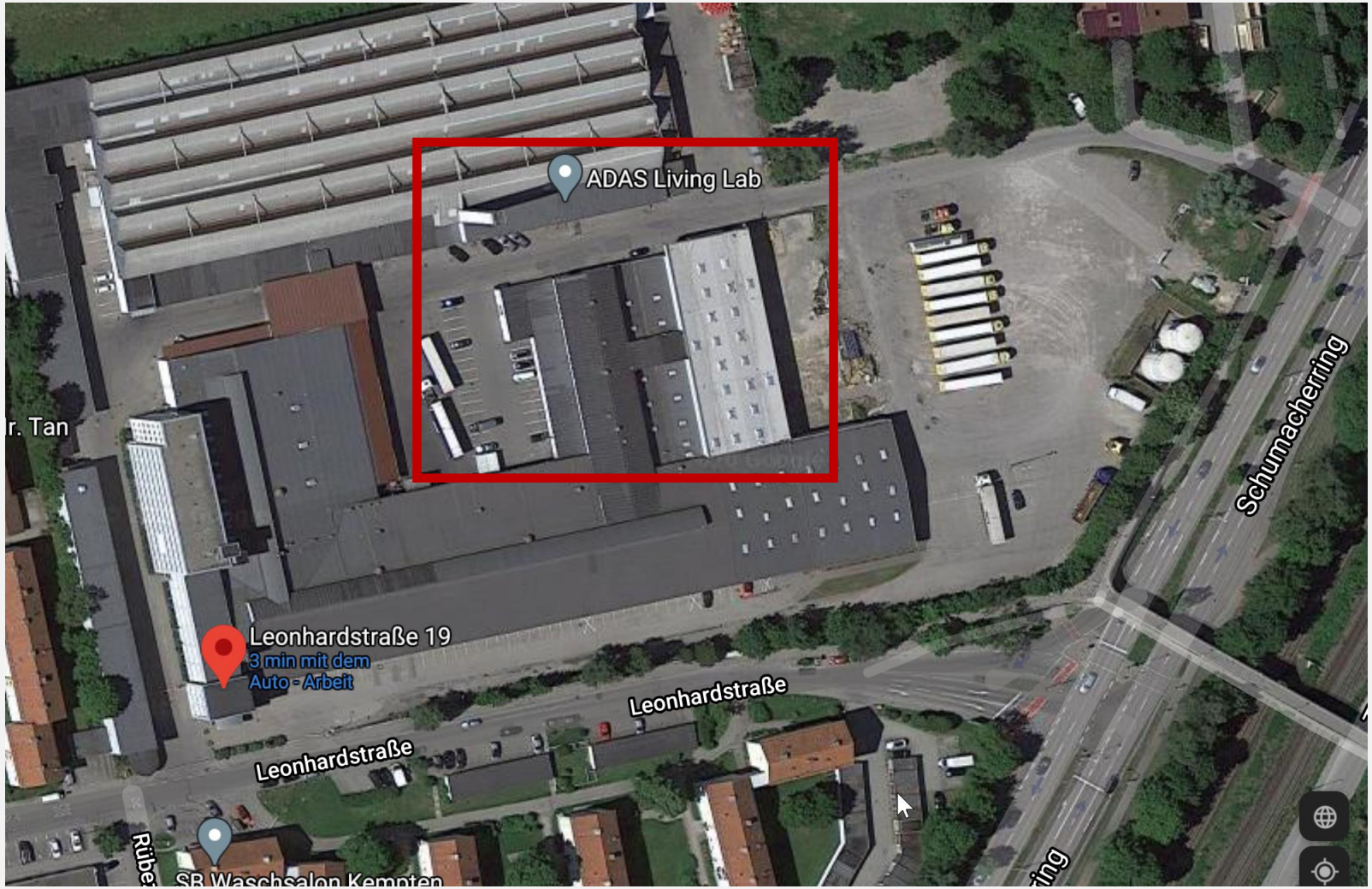


Development Efficiency



Driving Experience

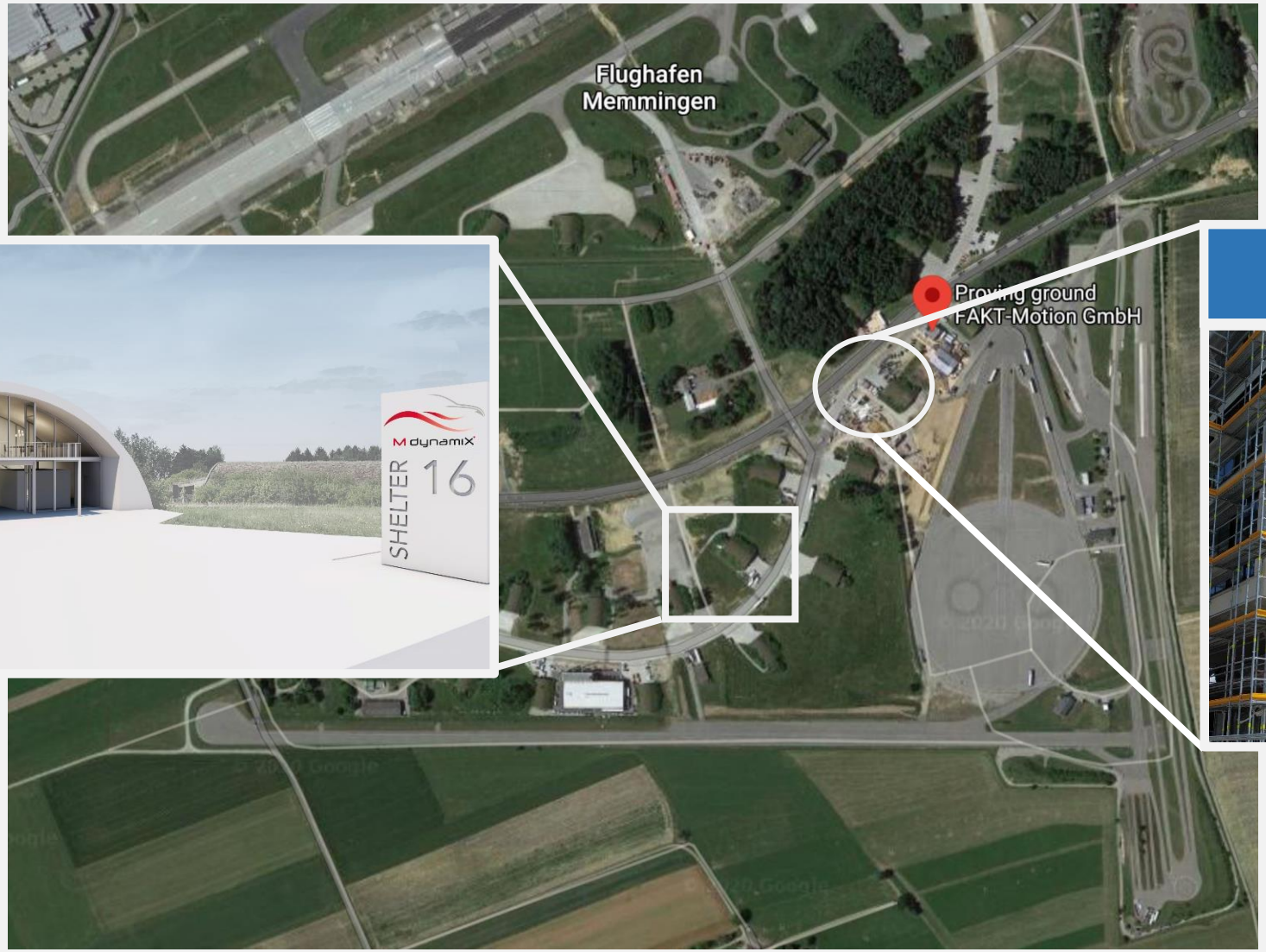
Location Kempten

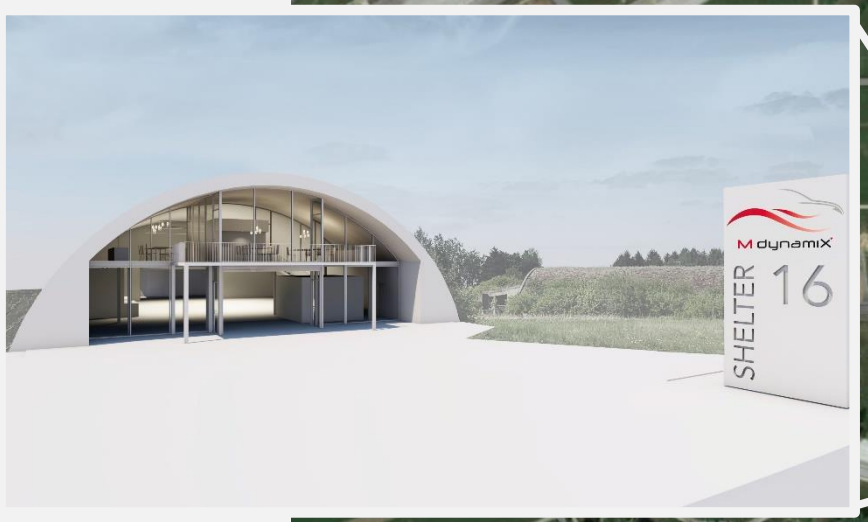


Leonhardstr. 19, Halle 4
87437 Kempten

Kempten University of Applied Sciences

New Location Memmingen





Research Institute
University AS Kempten

Our Research Groups in the Field of Automated Driving

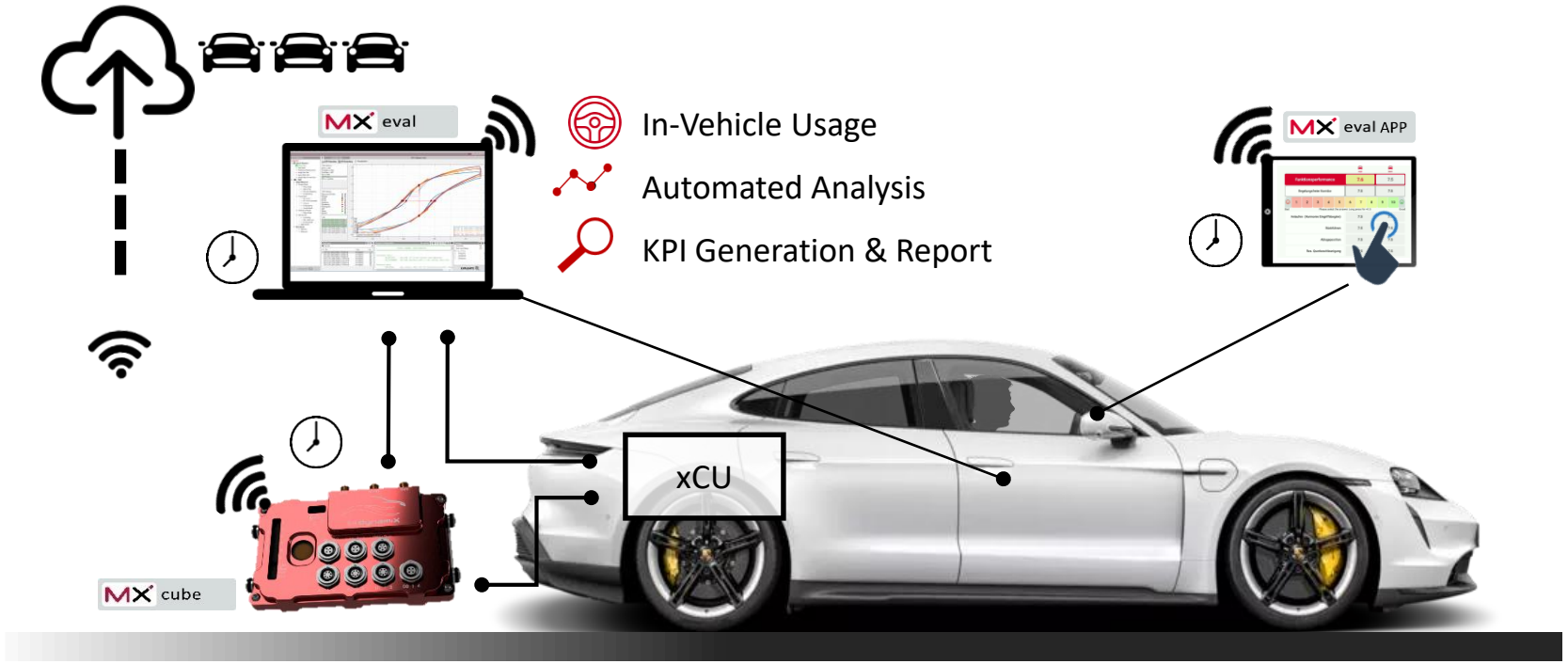
Facts and Figures

50	Staff	23	% Women	Research Groups	4
29	Scientific employees	9	Nationalities		
PhD's	5	Int. Publications* Since 2017	>30		
17	Funded Projects* 10 Industry / 7 Public	3.2	Mio Volume* p.a.		

* Since 2017 without IFM

Digital Evaluation Processes

Efficient and traceable evaluation and knowledge bundling should be applied



- In-Vehicle Usage
- Automated Analysis
- KPI Generation & Report

- On Touch Evaluation
- Evaluation Catalogue
- Multiple User / Vehicles
- Evaluation Guide
- Comments (Text, Audio, Image, Video)
- Co-Pilot Function
- Quick Results

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PORSCHE M dynamiX

Kempten University of Applied Sciences

Validation Source Test (Quellentest)

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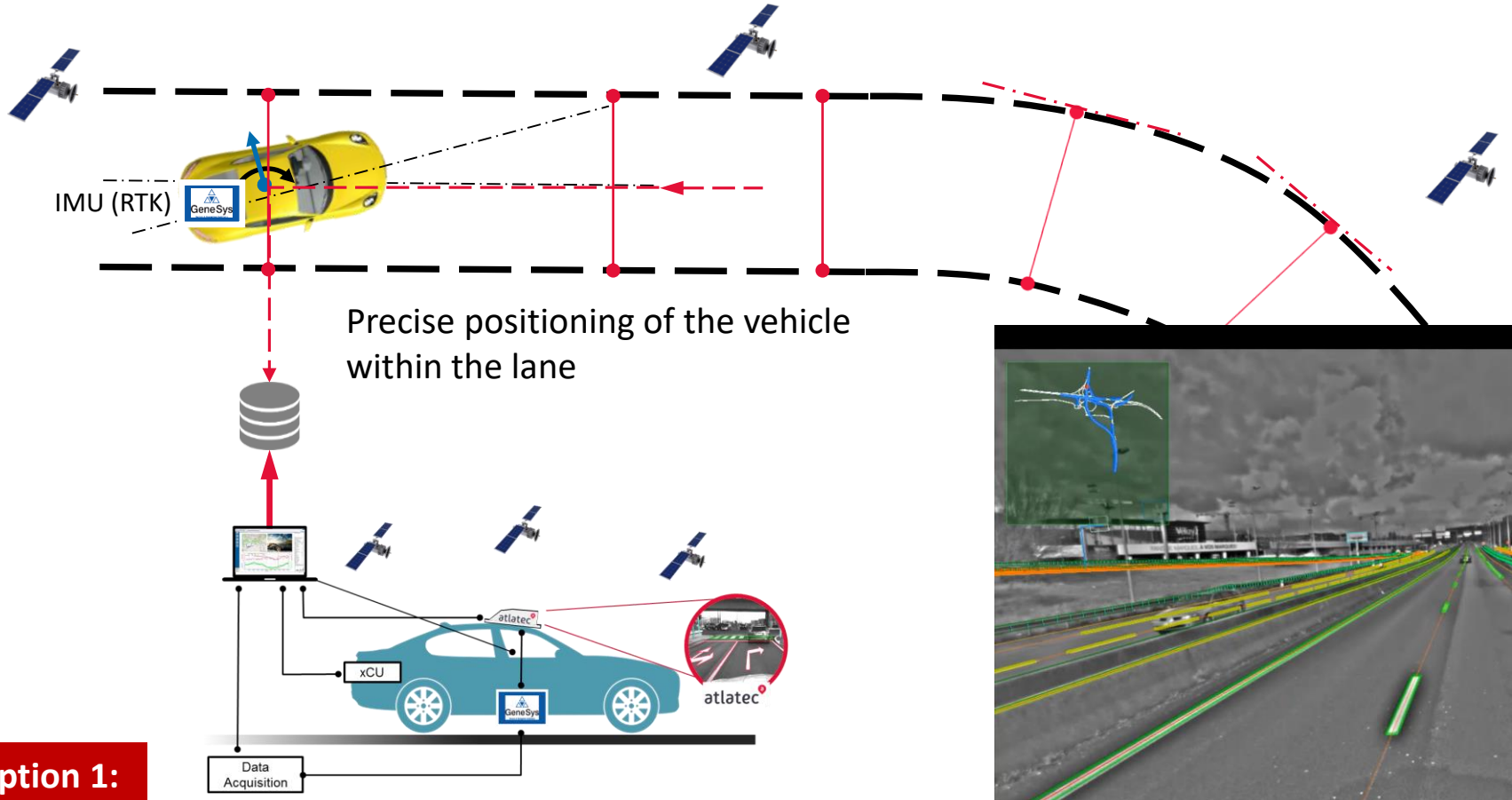
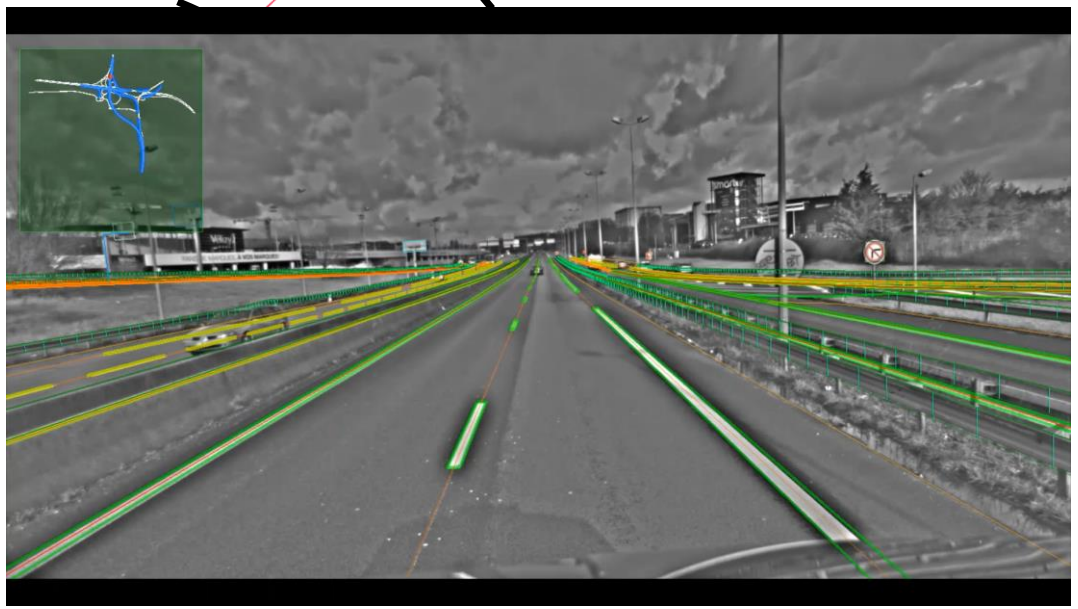
Validation Source Test (Quellentest)

Measurement Method with Ground Truth Approach



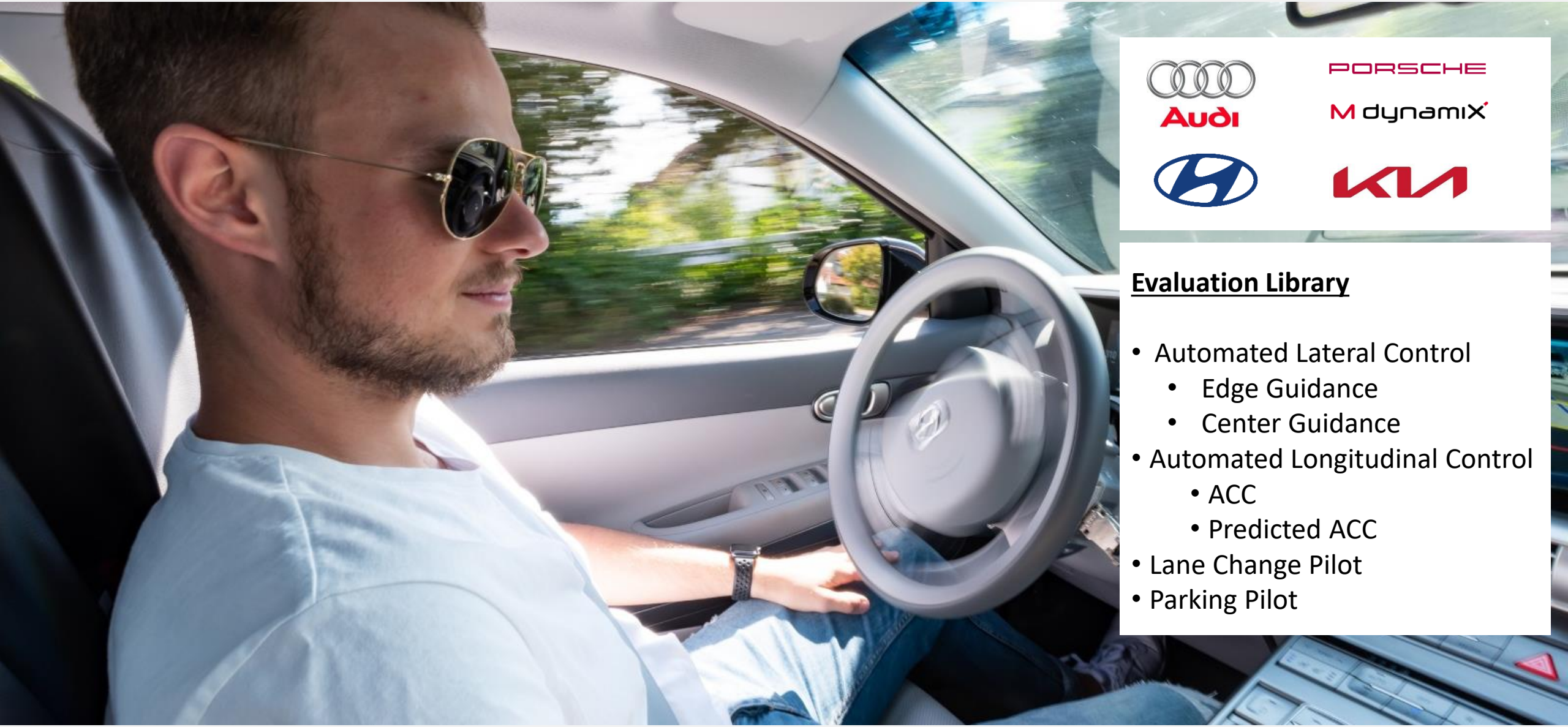


Option 1:

Pre-Measurement of Geo-Referenced Ground Truth Data

Virtual Testing Methods and Activities

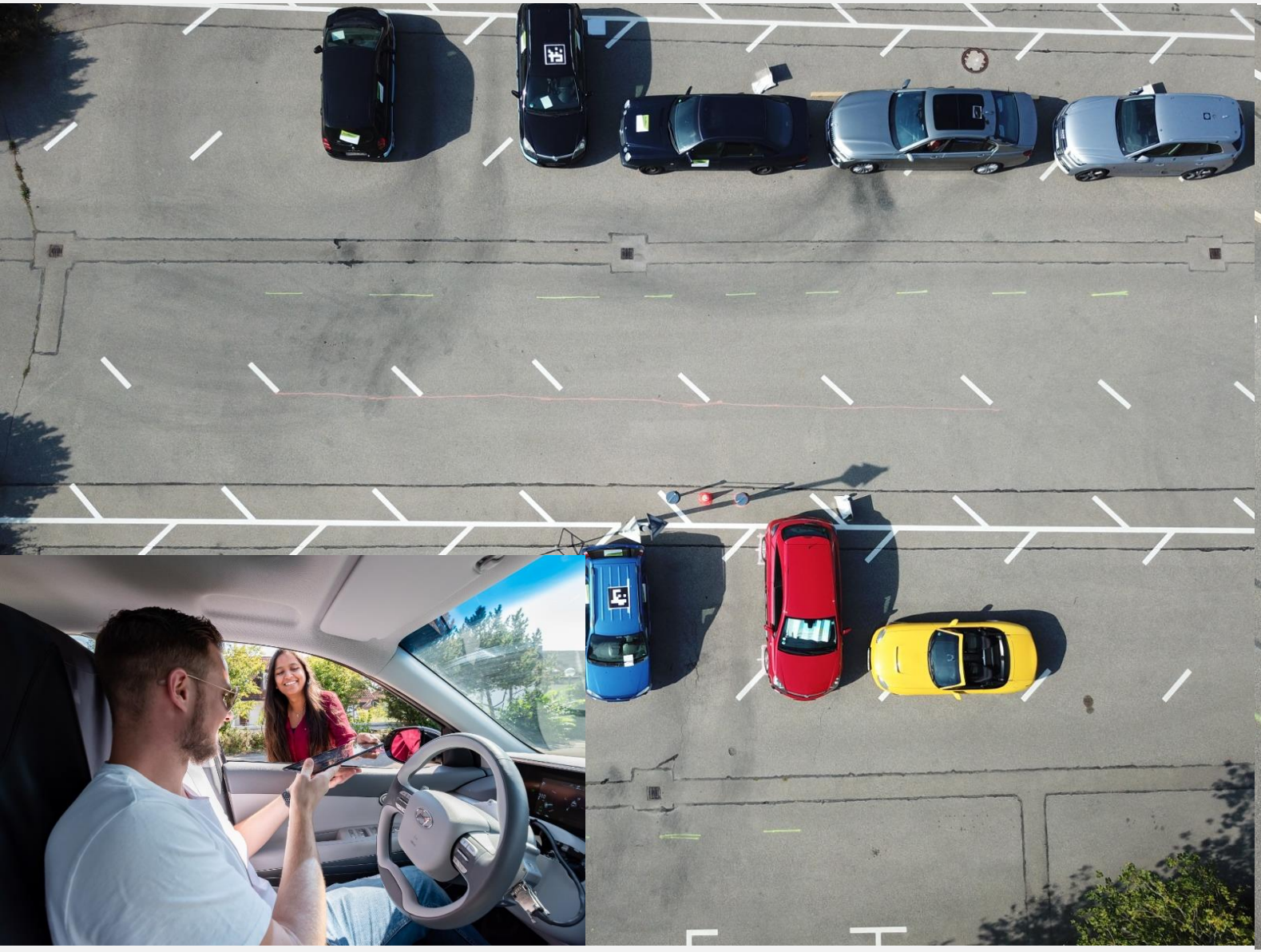
Attribute Based Developement for ADAS/AD



Evaluation Library

- Automated Lateral Control
  - Edge Guidance
  - Center Guidance
- Automated Longitudinal Control
  - ACC
  - Predicted ACC
- Lane Change Pilot
- Parking Pilot

Attribute Based Developement for ADAS/AD



Human Factors Research

Status Driving Simulator

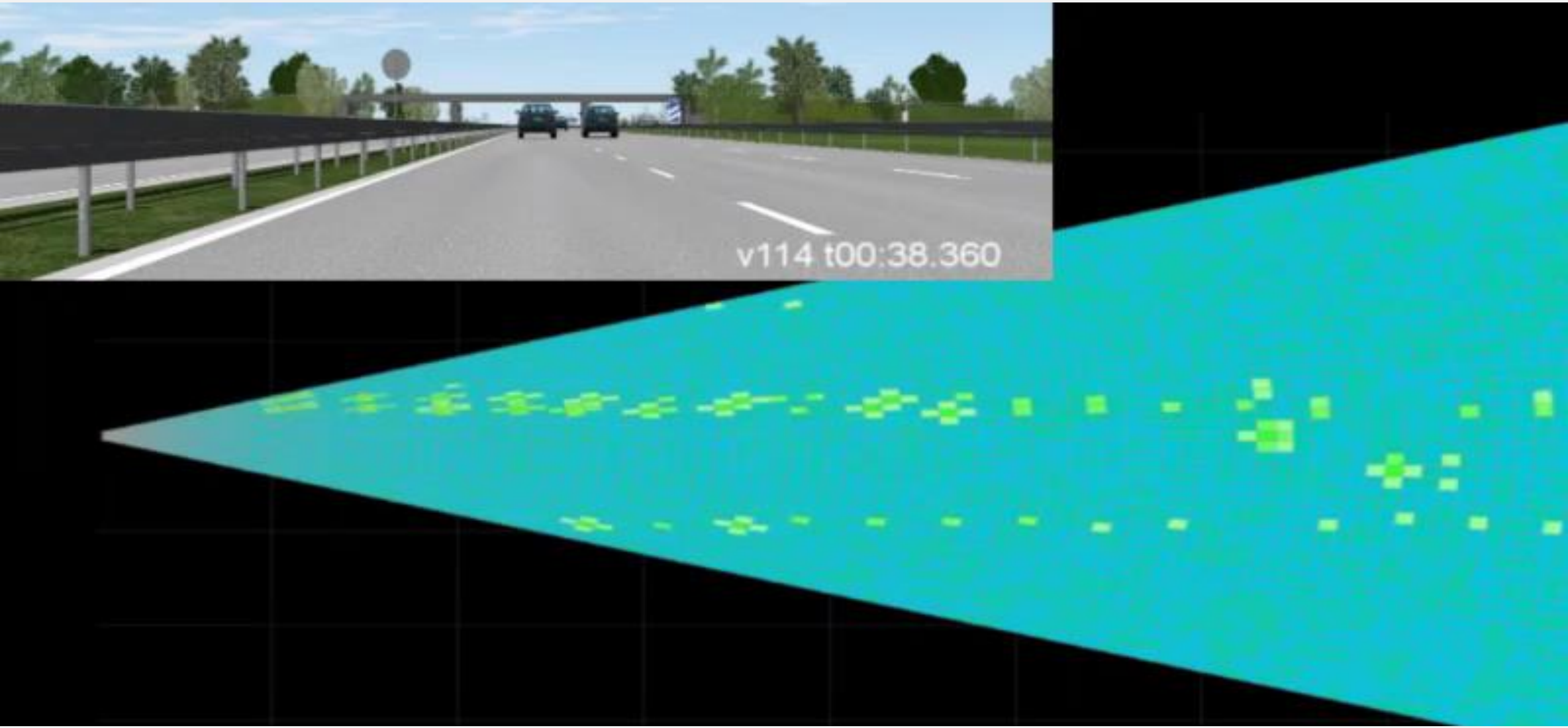
Status Driving Simulator

Virtualization – Early Stage Driving Experience

We started already projects with VW, Hyundai Europe, HMC …

Virtual Testing Methods and Activities

Virtual Testing Methods and Activities



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ADAS Master WS 20/21
Lecture 1

Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

General Infos and Lecture program

https://moodle2.hs-kempten.de/moodle/course/view.php?id=2914

Nr.	Datum	Inhalt	Ort	Von Wem
1	**01.10.**	**Virtual Test Driving (VTD)** **CarMaker Quick Start Guide**	**T314**	**Self-study**
2	08.10.	Requirements for vehicles and their global attributes	T314 Zoom	Schick
3	15.10.	Vehicle dynamics attributes and their target conflicts	T314 Zoom	Schick
3	22.10.	Test and evaluation methods for vehicle attributes (1) **with practical simulation**	T314 Zoom	Schick
4	29.10.	Test and evaluation methods for vehicle attributes (2) **with practical simulation**	T314 Zoom	Schick
5	**05.11.**	**ADAS DRIVING EVENT** Measurement Tech. Introductions	**Living Lab**	Günther/Riedlmüller/ Schwandke
6	12.11.	Basic vehicle dynamics calculation and vehicle models with exercise	T314 Zoom	Schick
7	**19.11.**	Chassis components and functions (1) Tire & Wheels	T314 Zoom	Schick
8	26.11.	Chassis components and functions (2) Axle & Suspension	T314 Zoom	Schick
9	03.12.	**TEND: ADAS Development for a sports car manufacturer**	T314 Zoom	Manuel Höfer (Porsche)
10	10.12.	Chassis controls and functions (1) Overview & Brakes & Steering	T314 Zoom	Schick
11	17.12.	Chassis controls and functions (2) ESP–Functions & Application & Process	T314 Zoom	Herr Lutz (BOSCH)
12	07.01.	**Chassis controls and functions (3)** **ESP–Application & Hands-On Workshop**	T314 Zoom	Herr Lutz (BOSCH)
13	14.01.	Analysis of international standards and application into the simulation	T314 Zoom	Schick
14	**21.01.**	**Exam preparation**	**T314**	**Schick**

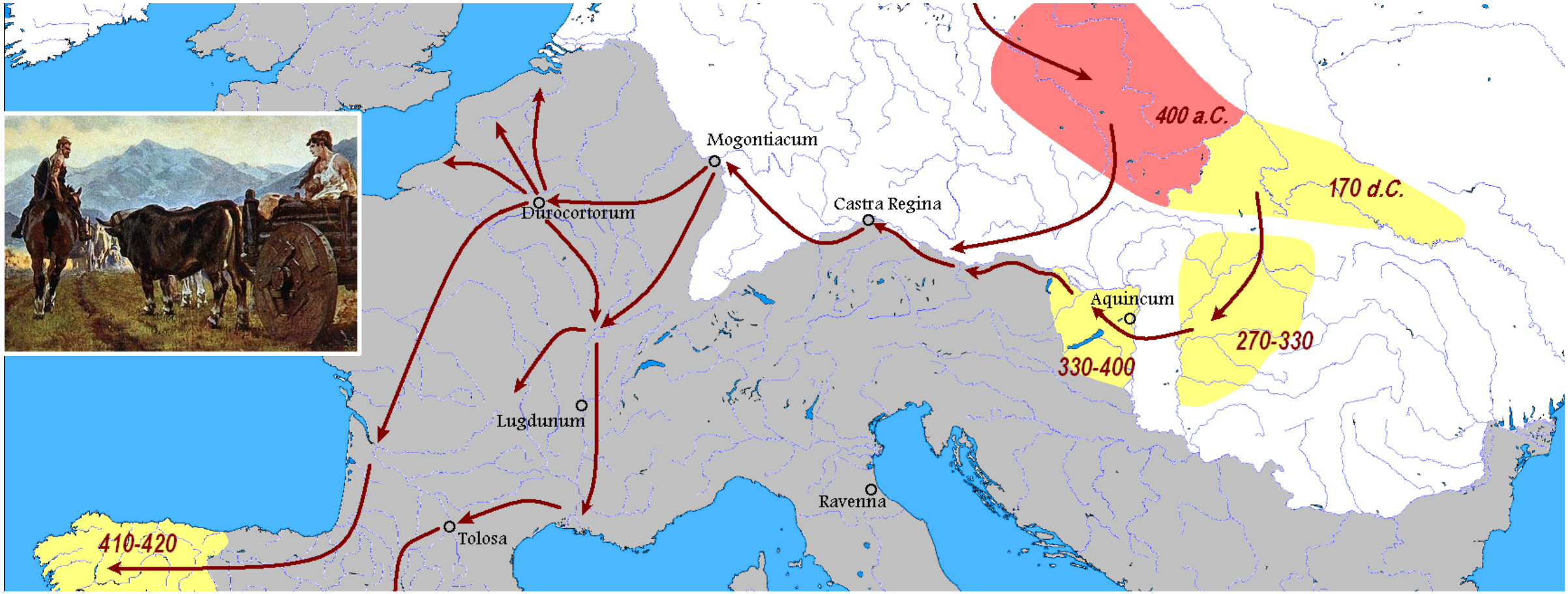
Survey and Introduction of Participants

1. **Zoom survey of pre-knowledge concerning vehicle dynamics**

2. **Introduction round**
    1. Name
    2. Former University
    3. Bachelor study course
    4. Pre-Knowledge of vehicle dynamics simulation
    5. Expectations of the lecture

Requirements for vehicles and their global attributes

Individual mobility was always important for mankind to survive.

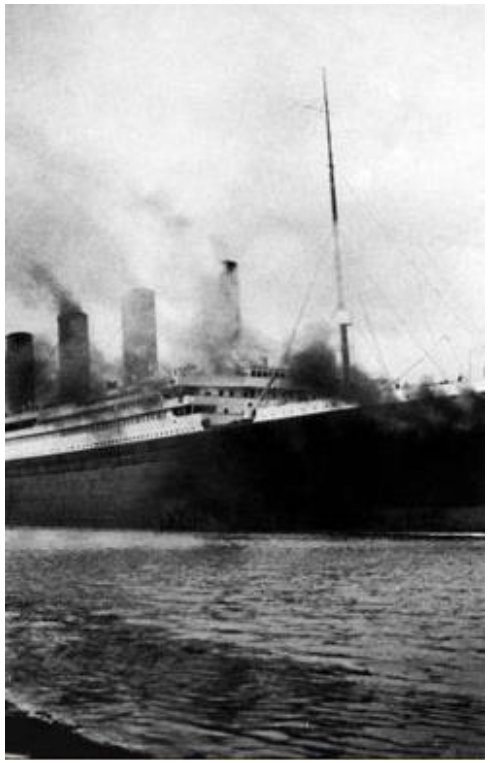


Individual mobility of American emigrants “THE DREAM OF BETTER LIVE”

Requirements for vehicles and their global attributes

Human & good transportation improves our live

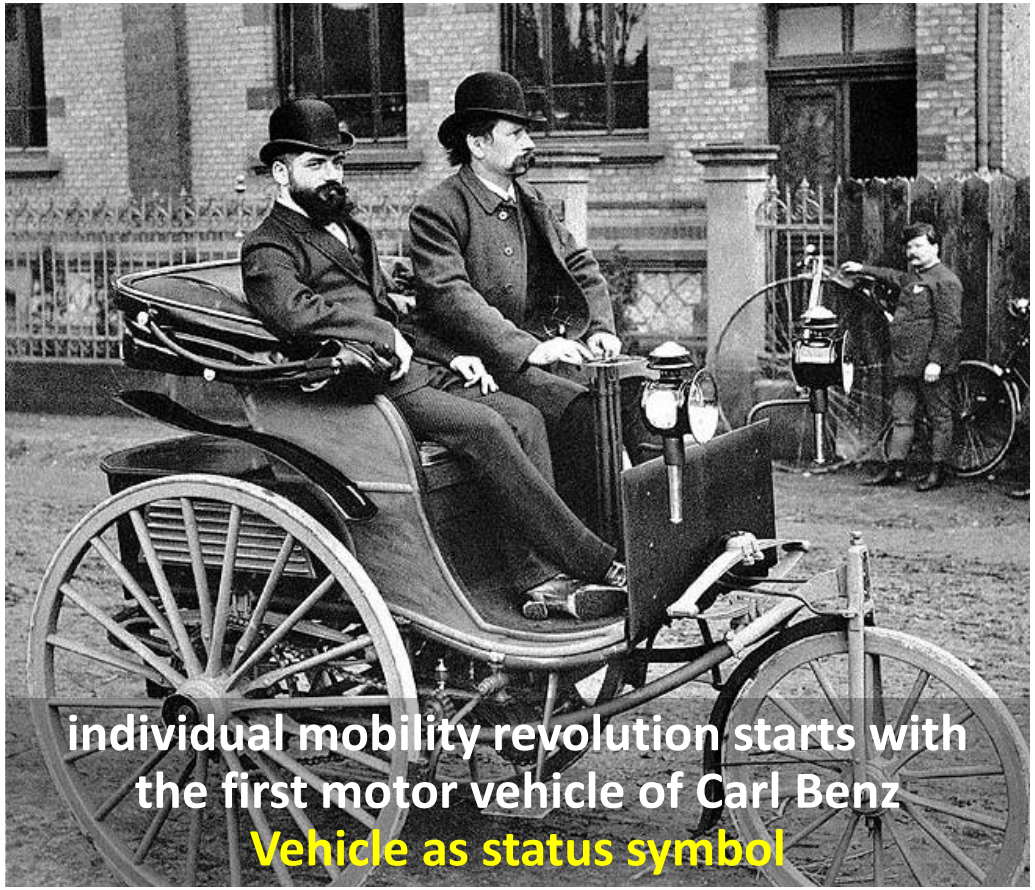
Horse Based



Ship Based

Rail Based

Motor driven mobility chances our live

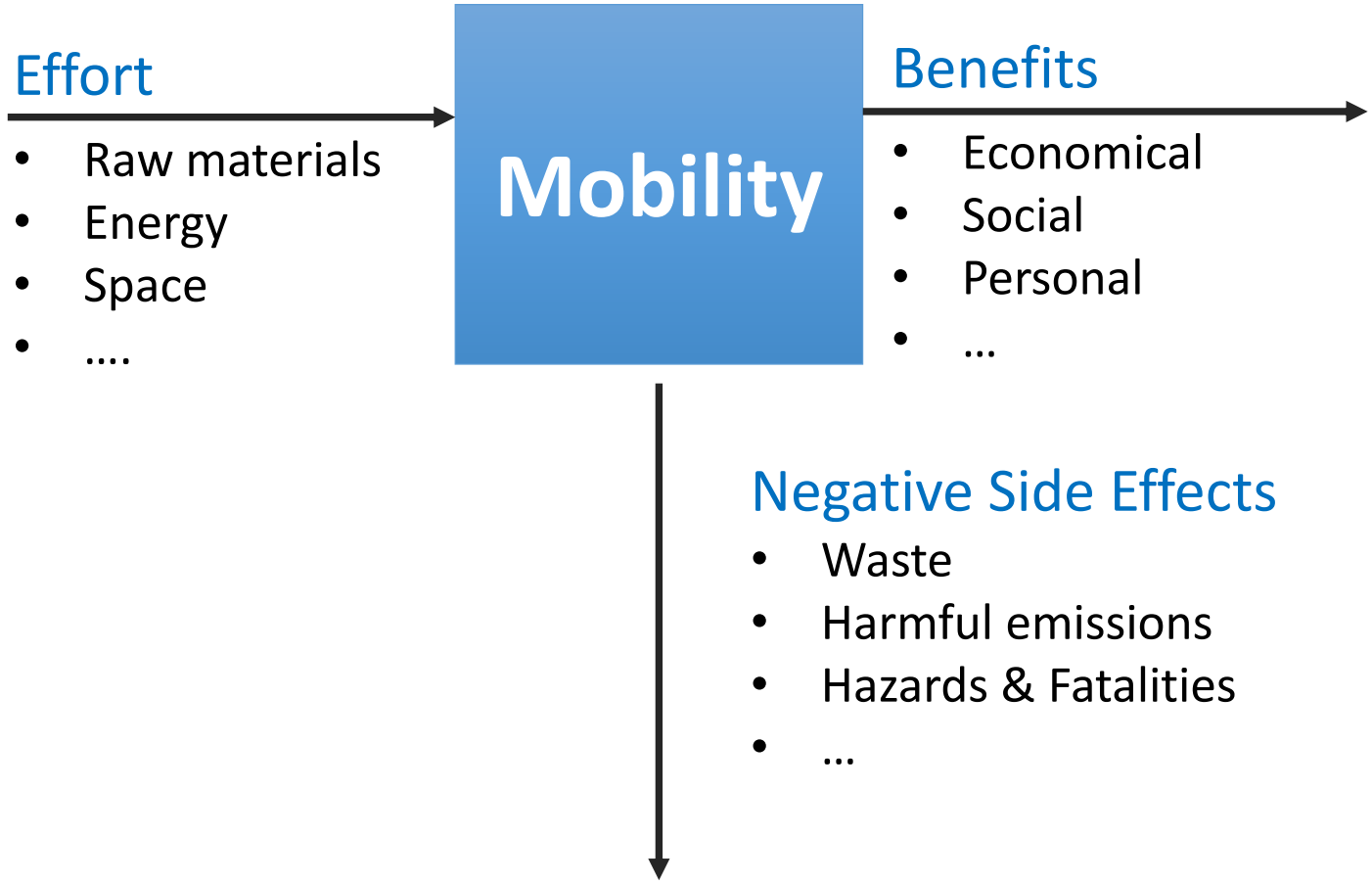


individual mobility revolution starts with the first motor vehicle of Carl Benz
Vehicle as status symbol

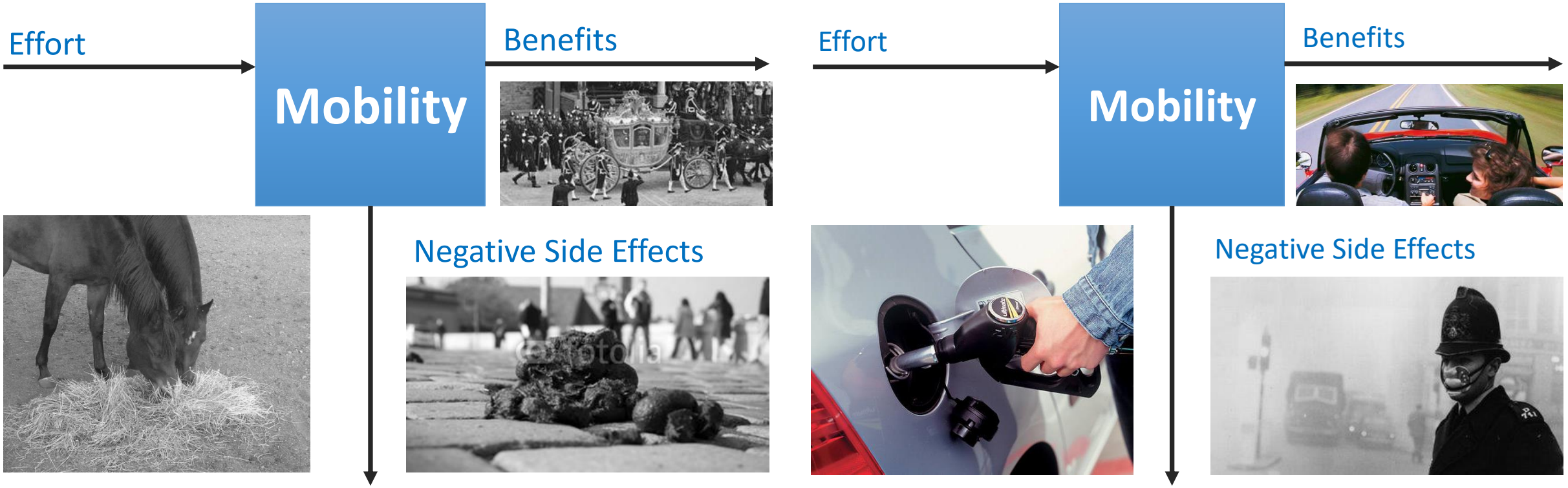
Individual mobility was democratized through vehicles mass production by Henry Ford

Requirements for vehicles and their global attributes

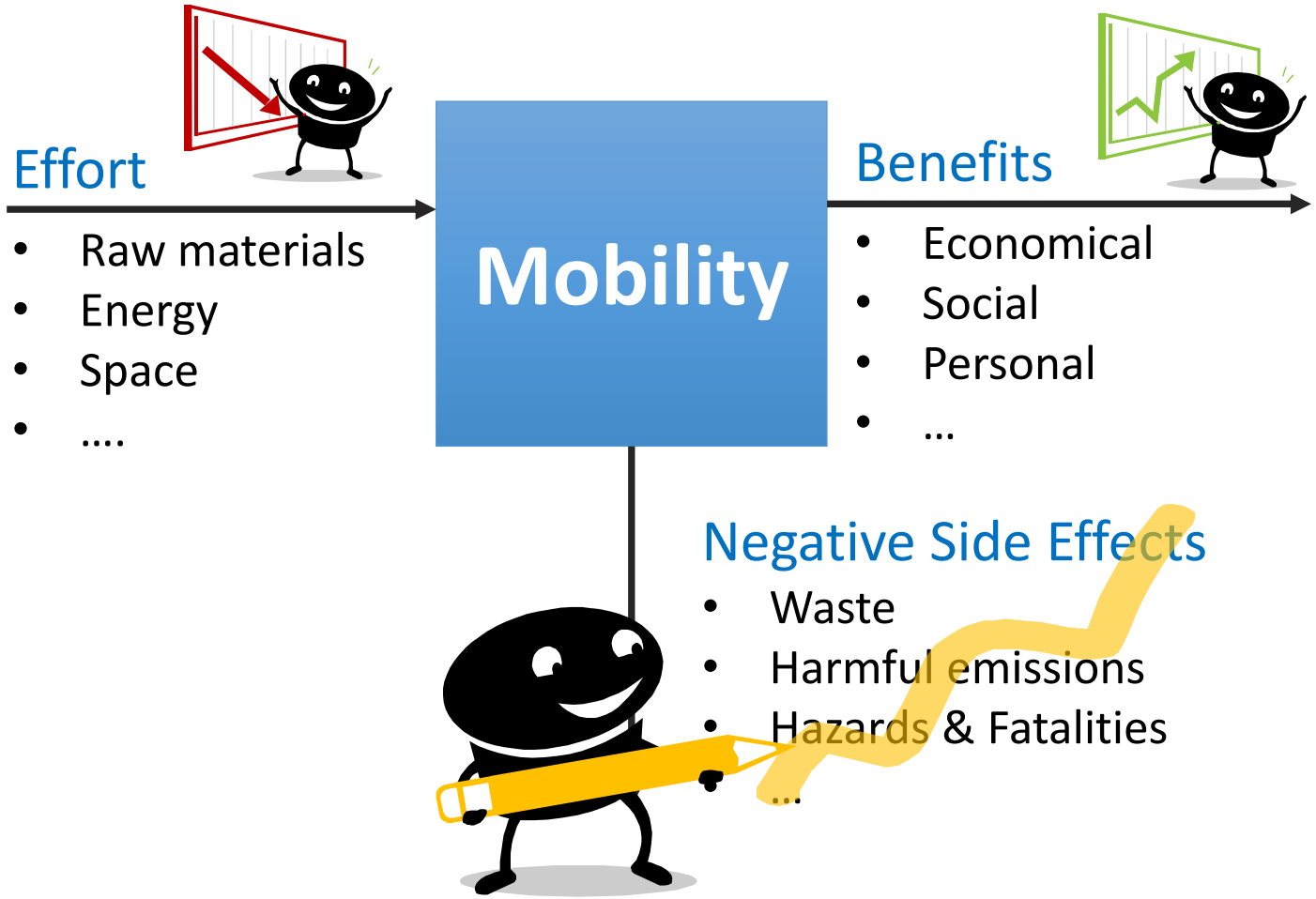
Mobility as a system has efforts and side effects



Mobility as a system has efforts and side effects



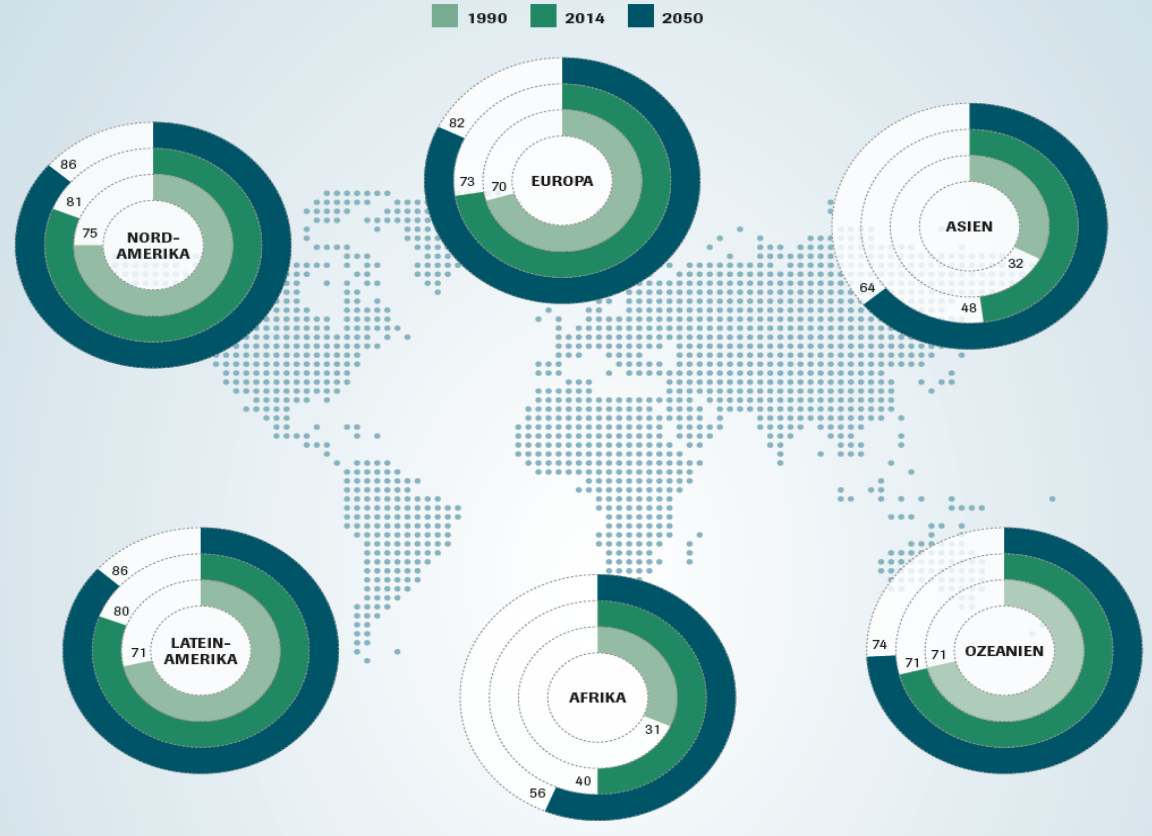
Motivation: Improvement of the mobility system



The urbanization lead to new challenges

Requirements for vehicles and their global attributes

Growing cities – shrinking villages



„Pusher“ in Tokyo

Scooter traffic jam

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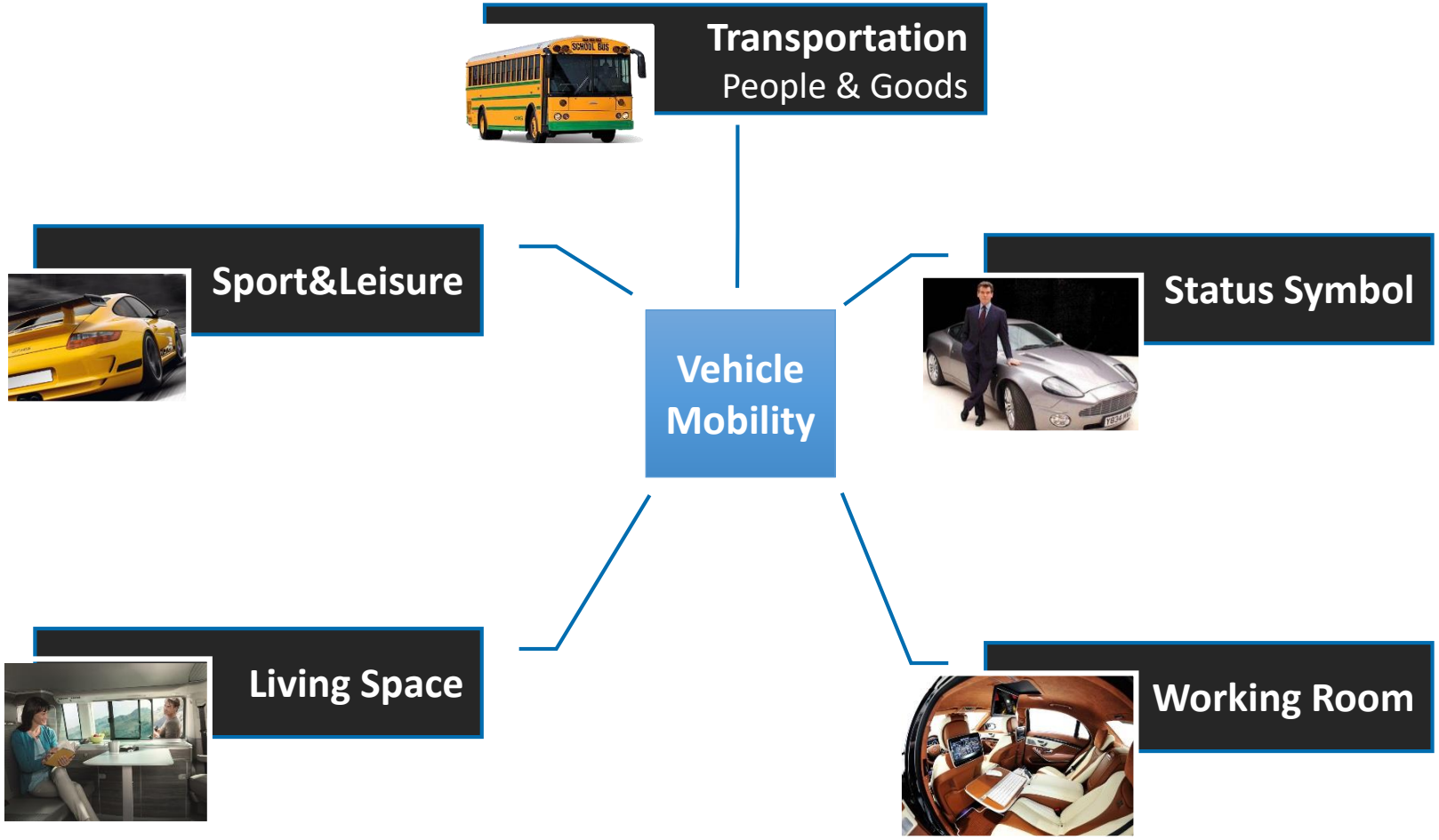
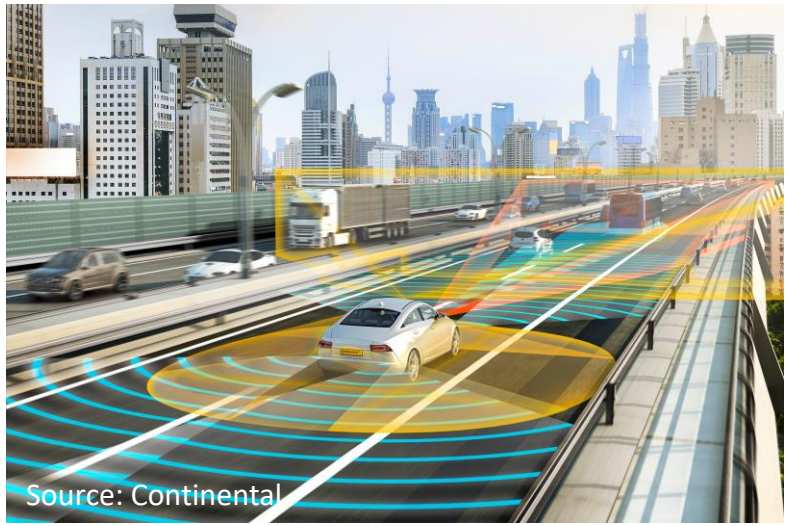
Requirements for vehicles and their global attributes

Benefit of the vehicle mobility system.



Requirements for vehicles and their global attributes

Trend: Our world is changing in a disruptive way



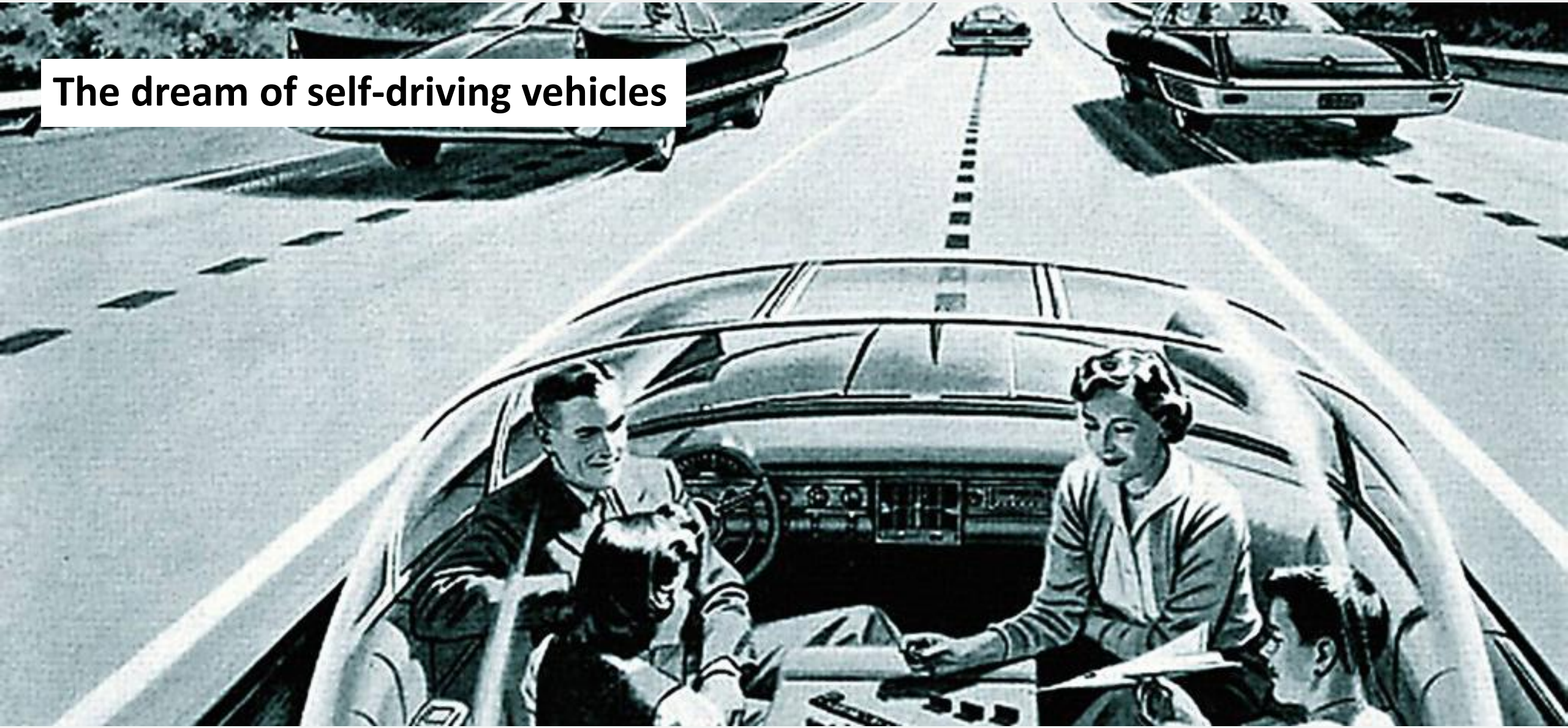
Automated Driving

Electrification

Connectivity

IN THE AGE OF **DIGITAL TRANSFORMATION**

Requirements for vehicles and their global attributes



Requirements for vehicles and their global attributes

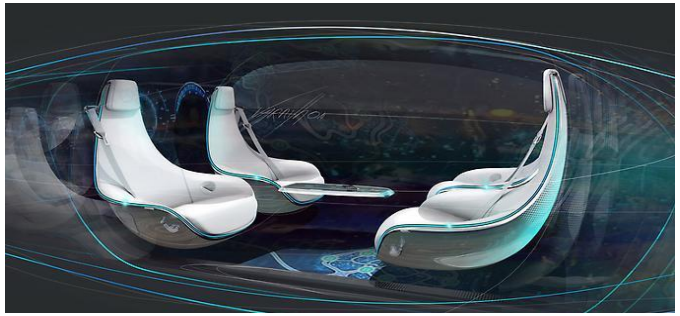
Requirements for vehicles and their global attributes

What drives ADAS and “Automated Driving” technologies?

Usage of wasted time

Keeps handicapped people mobile

Gain in safety



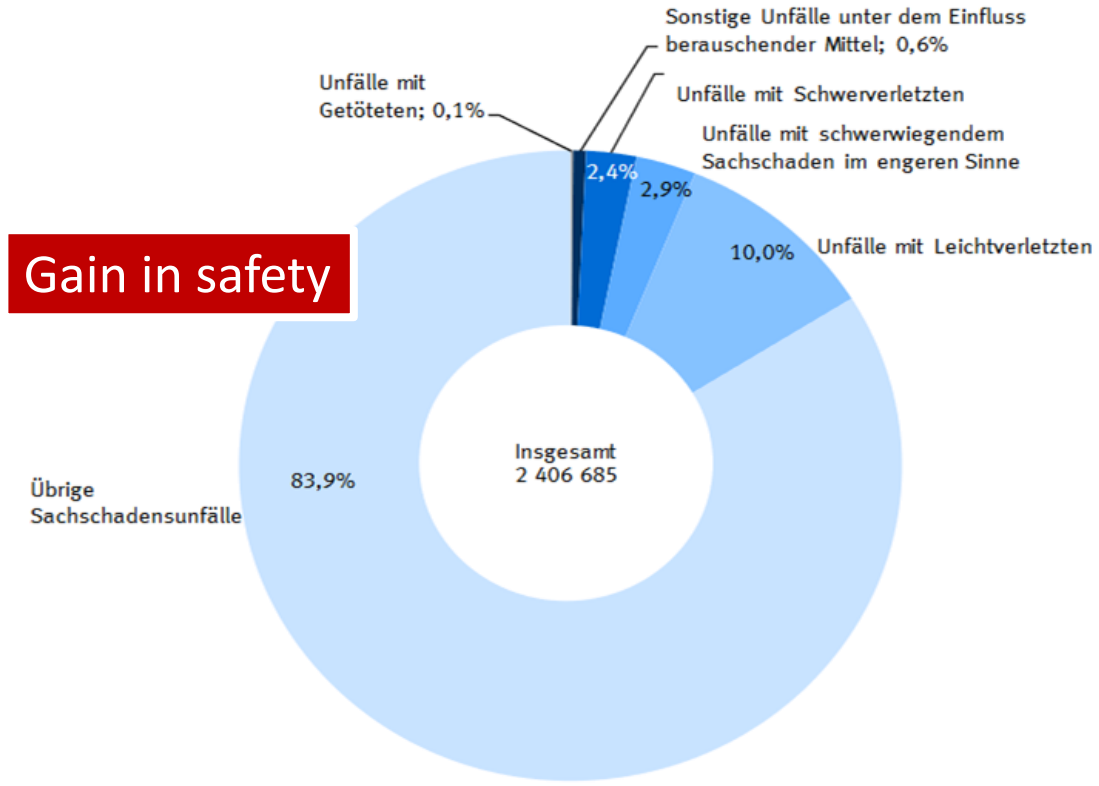
Gain in comfort

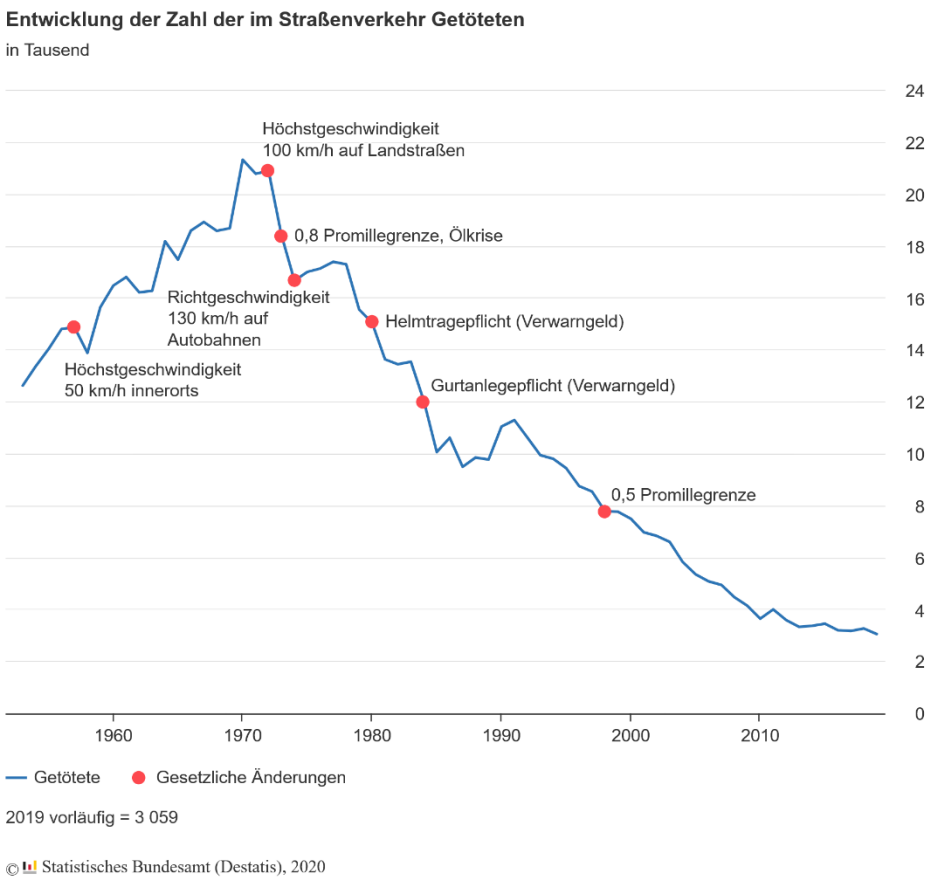
Keeps elderly people mobile

Gain in Efficiency

What drives ADAS and “Automated Driving” technologies?

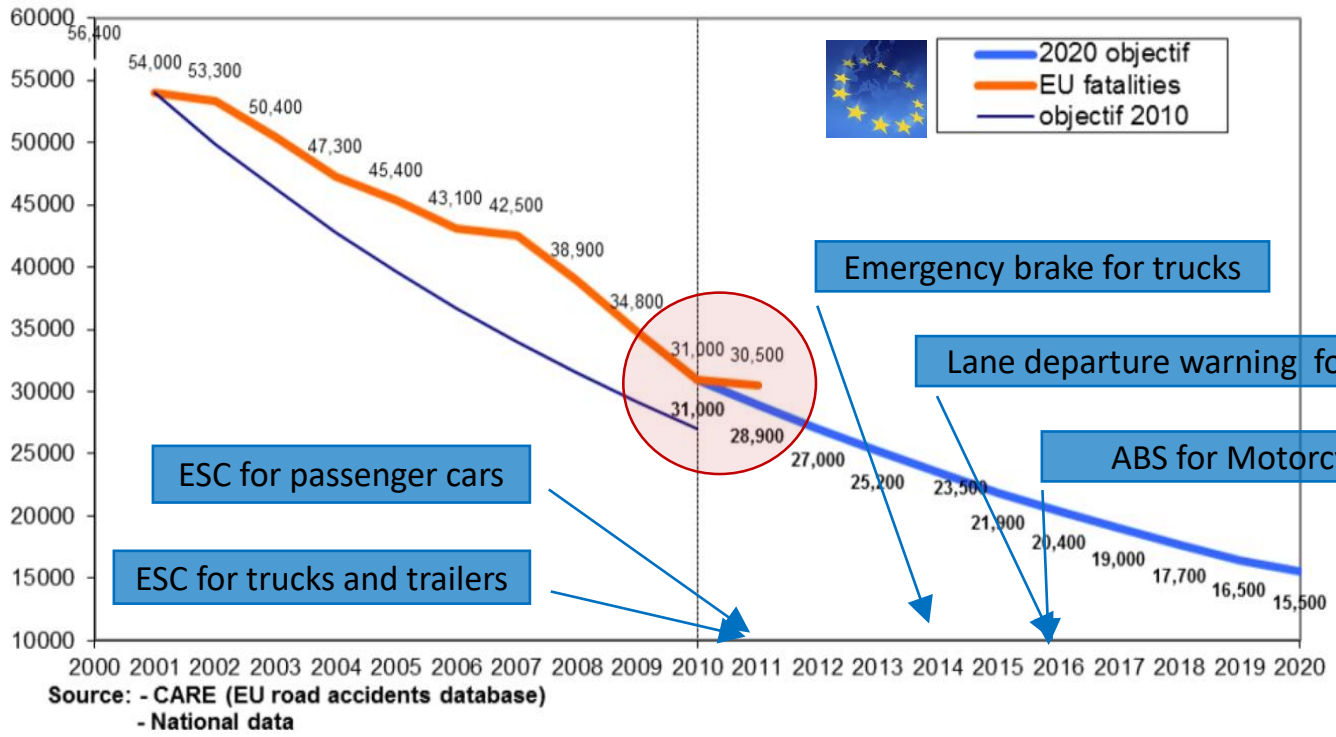
Gain in safety





Requirements for vehicles and their global attributes

Target of the EU is to reduce thee fatalities 50% each decade.



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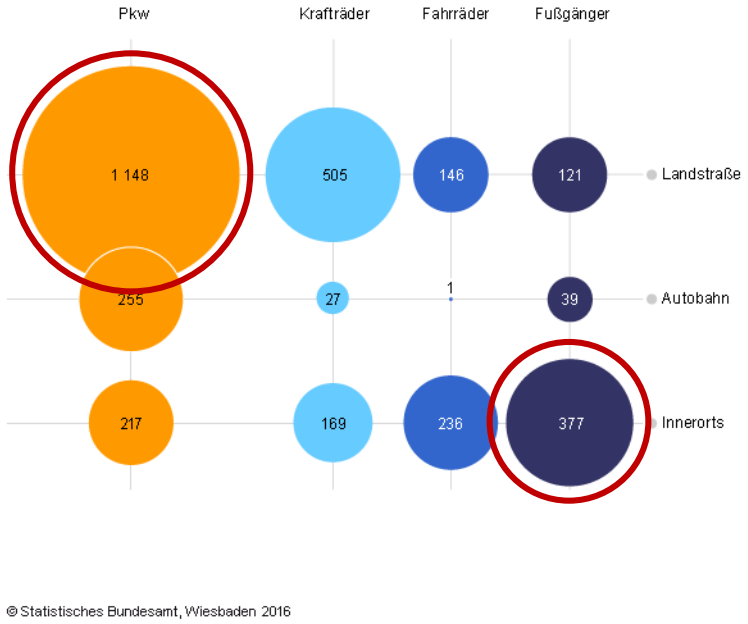
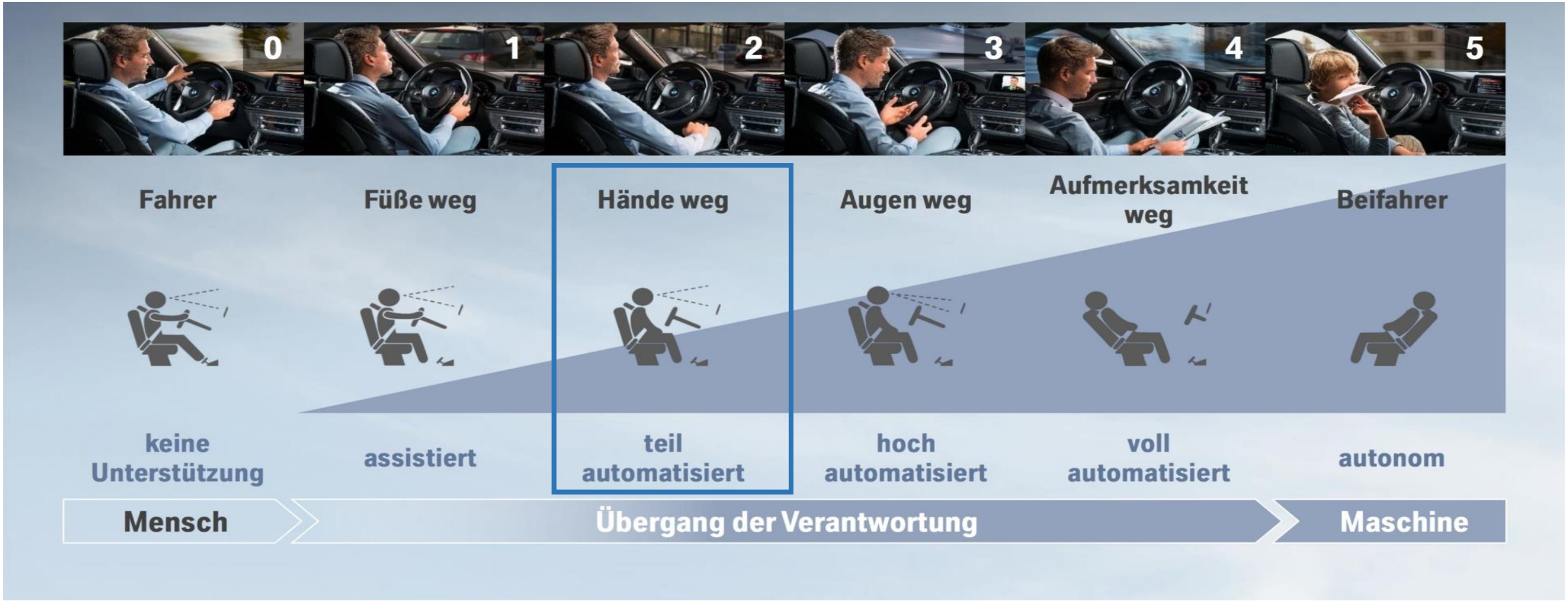
What drives ADAS and “Automated Driving” technologies?

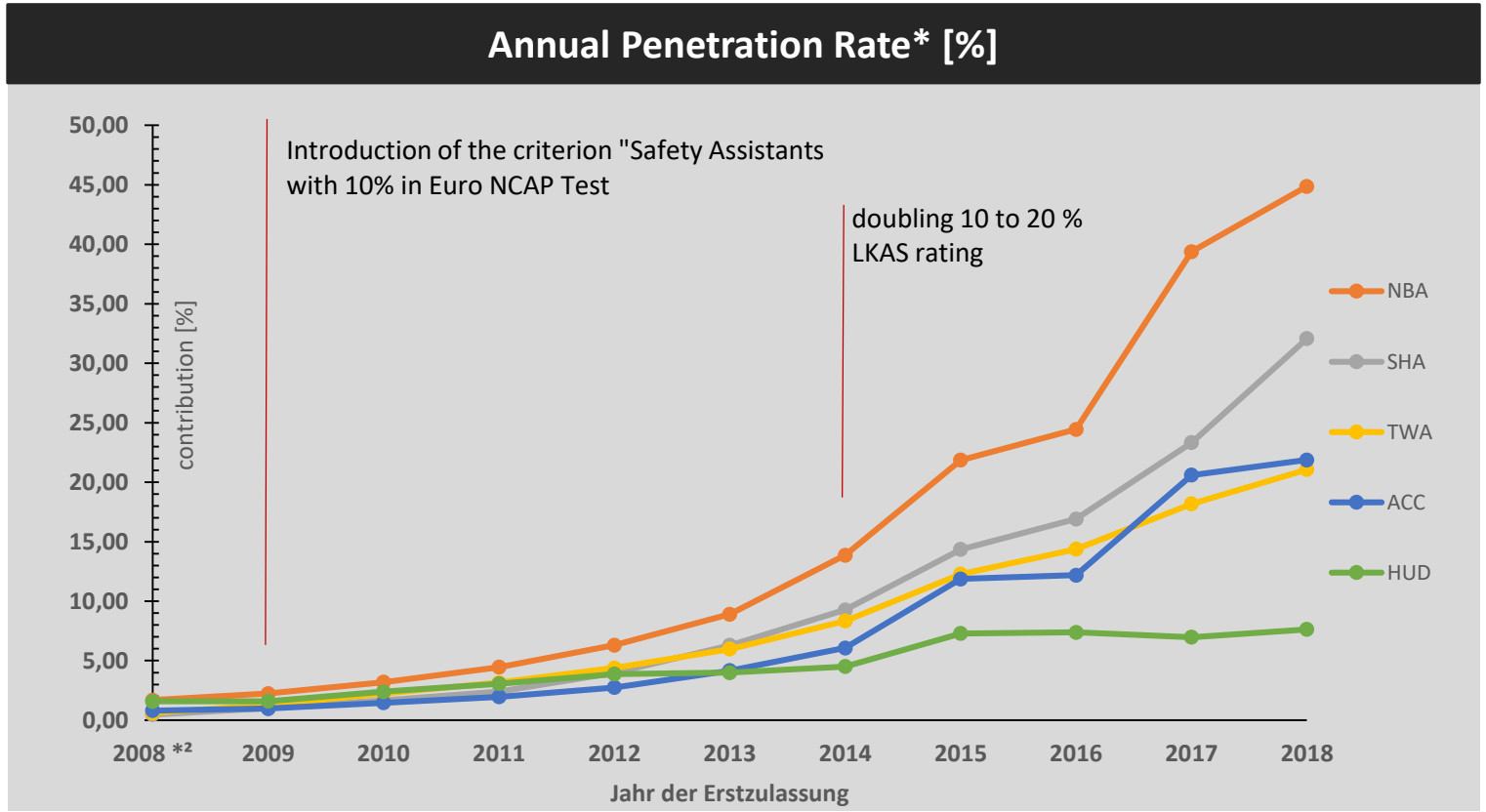
Fatalities by kind of involvement and location

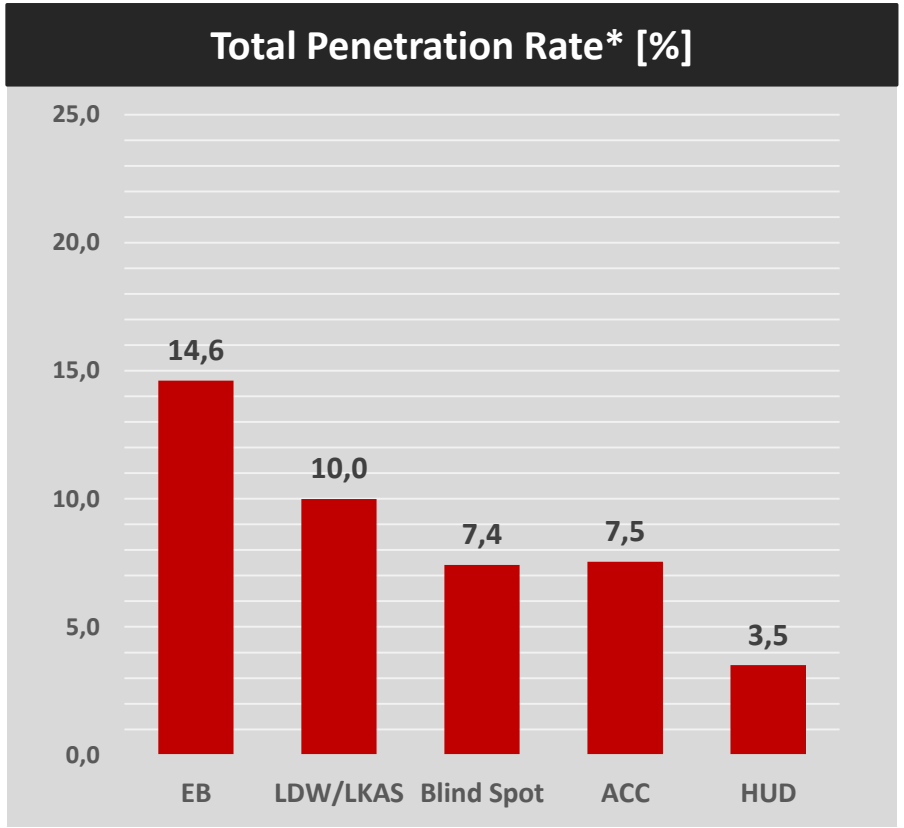


Taxonomy definition of Autonomous Driving (SAE J3016)



Vehicle fleet show a relative low technology penetration of ADAS.





* Overall Vehicle Fleet 59,1 % >10 years, 40,1 % > 10 years Source: Mobile.de

1. What is vehicle dynamics?

2. Why is vehicle dynamics of immense importance for ADAS/AD?

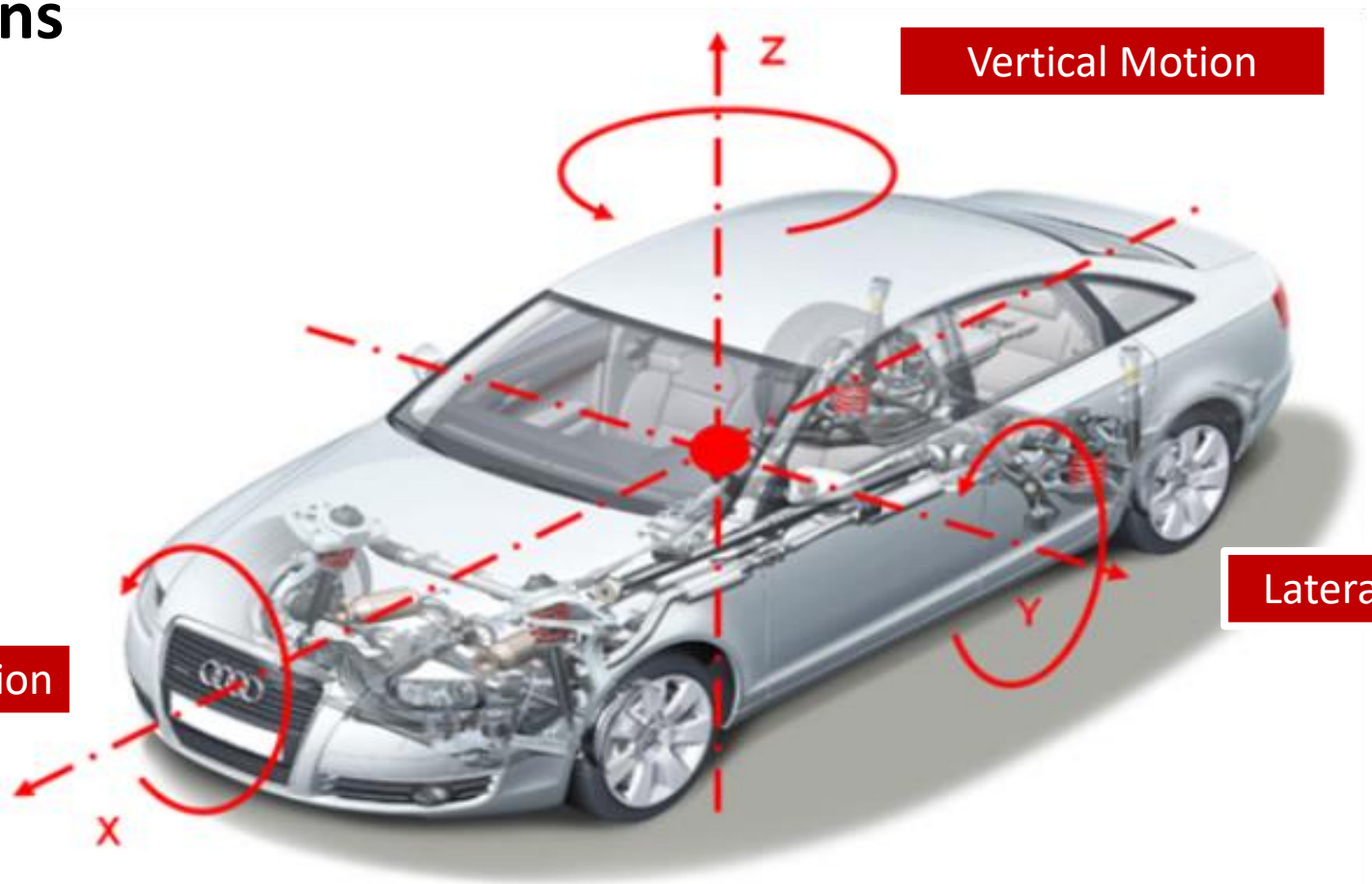
Requirements for vehicles and their global attributes

Automated Driving - Impact of Vehicle Dynamics Behavior

“Driver – Vehicle – Environment” – a closed loop!

Automated Driving - Impact of Vehicle Dynamics Behavior

Vehicle dynamics behavior remains very important in all driving modes and situations



Automated Driving - Impact of Vehicle Dynamics Behavior

Vehicle dynamics behavior remains very important in all driving modes


Source: MdynamiX

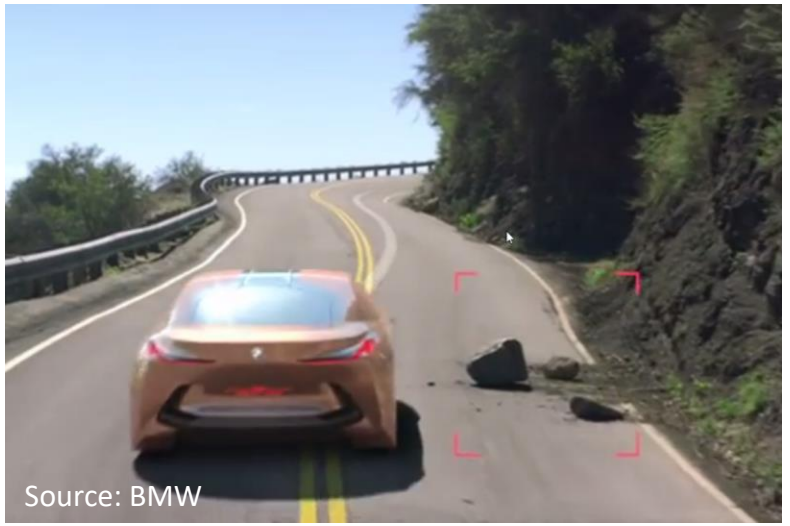
Fun to Drive

- Good steering feeling & precision
- High agility & controllability
- Low roll /pitch recognition
- …


Source: istock

Fun to be Driven

- Good straight running & precision
- Low body movement & ride comfort
- Low acceleration & jerks & oscillation
- …


Source: BMW

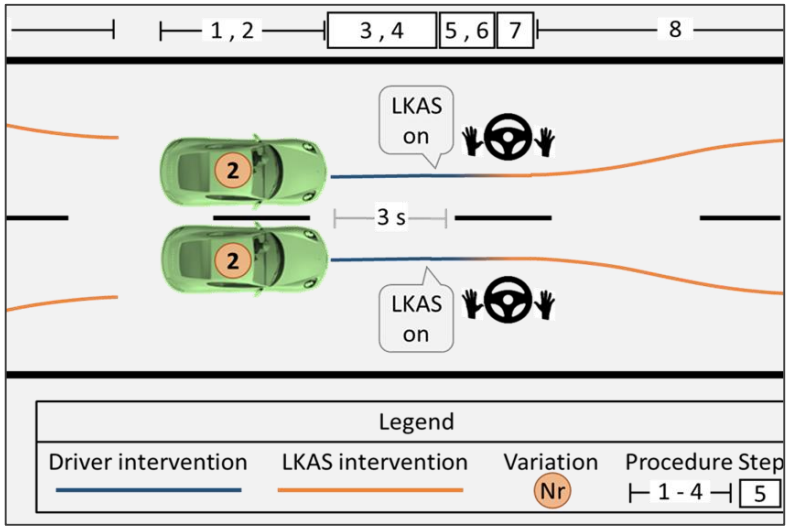
Confident to be Safe

- High longitudinal & lateral performance
- High stability
- Good maneuverability & controllability
- …

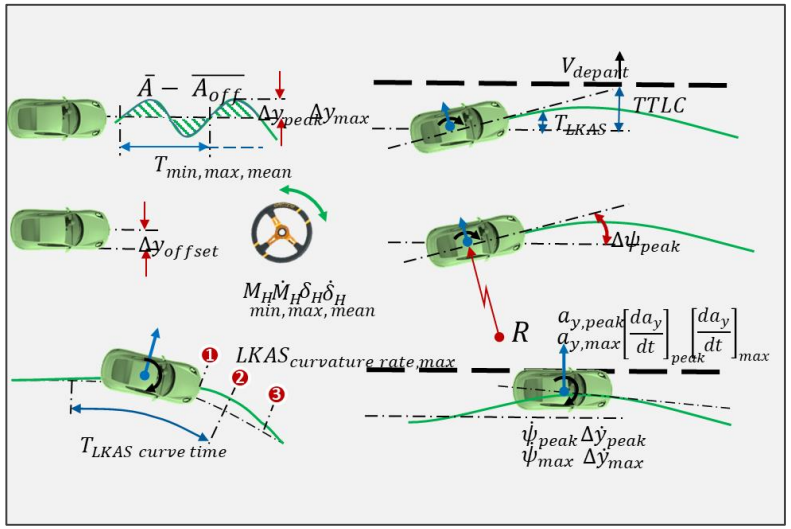
Automated Driving - Attribute Driven Development

Evaluation process for driving attributes will play a key role for ADAS/AD to satisfy customer!

Subjective Evaluation



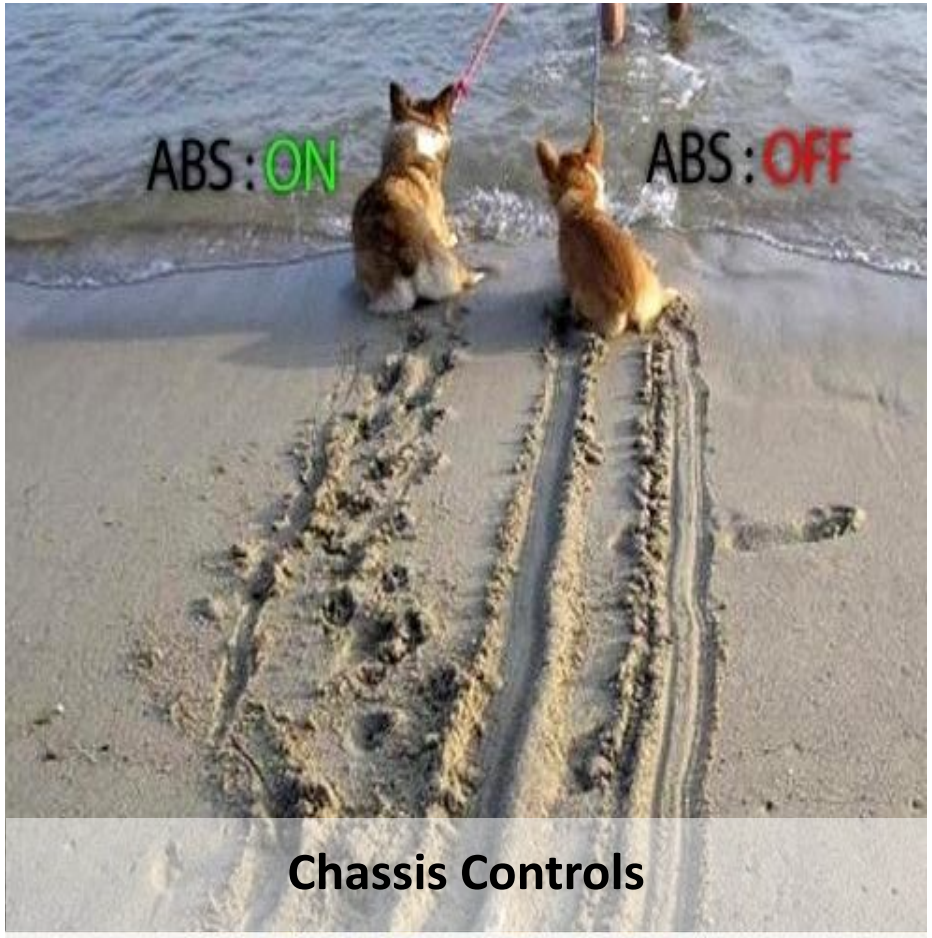
Driving Maneuver Catalogue



Objective Evaluation

This is where driving dynamics competence is required. Homework have to be done!

Control systems are core technologies for ADAS/AD

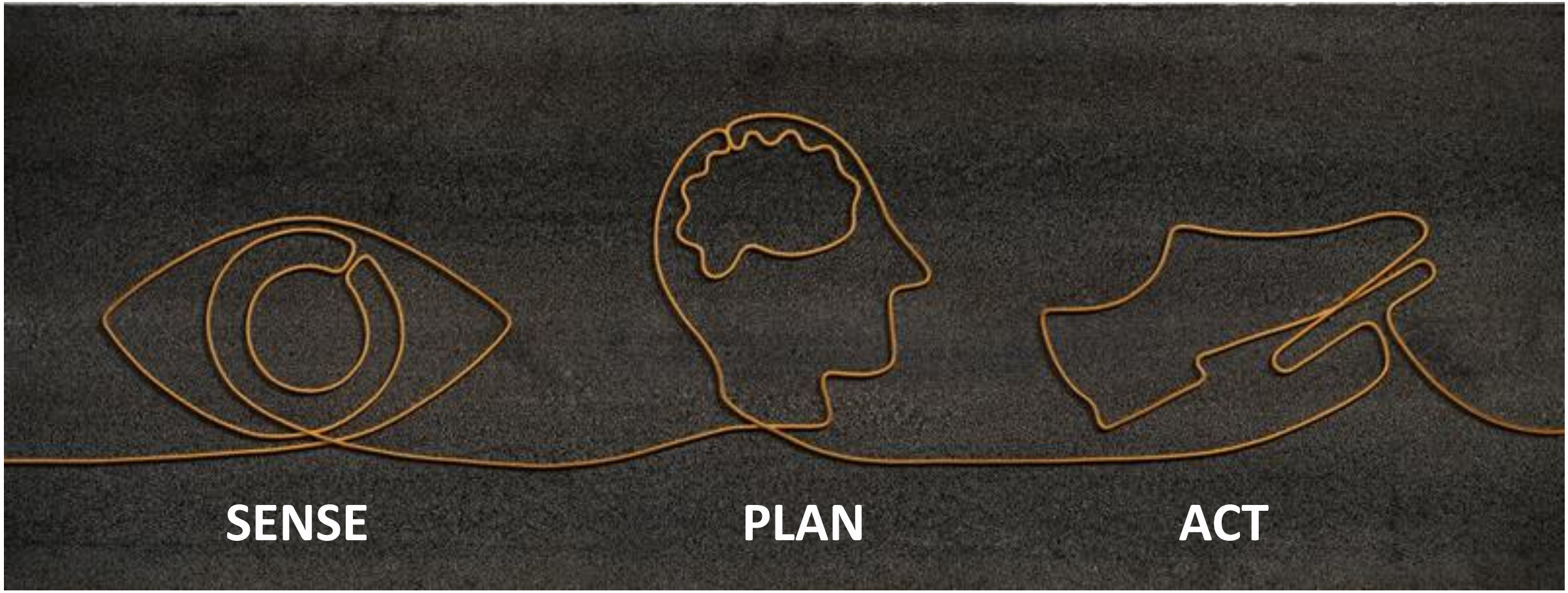


Chassis Controls

ADAS / HAF / AD

Requirements for vehicles and their global attributes

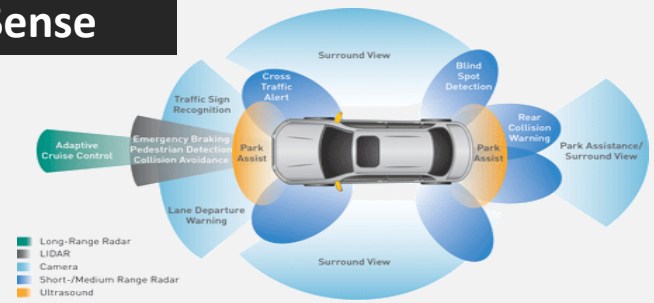
Vehicle dynamics control are very important for ADAS



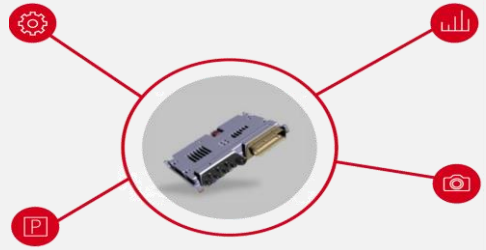
Requirements for vehicles and their global attributes

Vehicle dynamics control are the actuators of ADAS/AD

Sense



Plan



Antreiben


Verbrennungsmotor


Elektromotor


Porsche Doppelkupplungs-getriebe (PDK)

Bremsen


Elektromechanischer Bremskraftverstärker


Elektronische Stabilitätskontrolle (ESC)


Parkbremse

Lenken


Hinterachslenkung


Elektrische Lenkkraft-unterstützung (EPS)

Act

Automated Driving - Motion Sickness and Comfort Feeling

The railway becomes the benchmark

Motion Sickness will be a big challenge and depends strongly on the driving behavior and chassis system

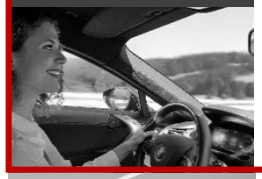

The railway becomes the benchmark

Automated Driving - Motion Sickness and Comfort Feeling

We will need the best chassis systems ever - but with different focus!

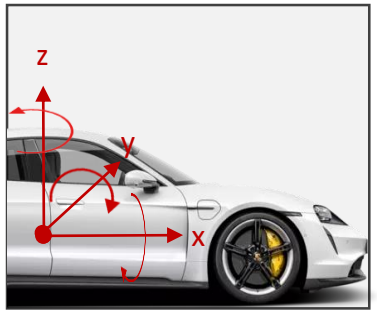
- Road Type
- Driving style
- …

Driving Strategy



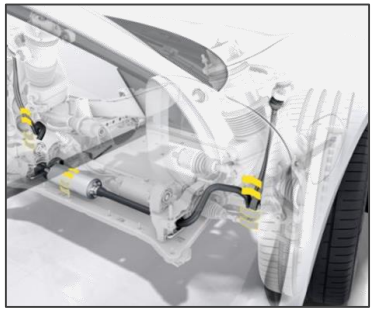
Driving Scenario

- Longitudinal
- Lateral
- Vertical



Vehicle Motion

- Passive systems
- Active Control
- …

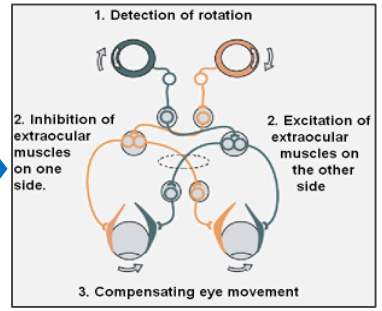


Chassis Systems and Controls

- Seat Position
- Task
- …

Head Motion

- Type
- Age
- …



Vestibular System

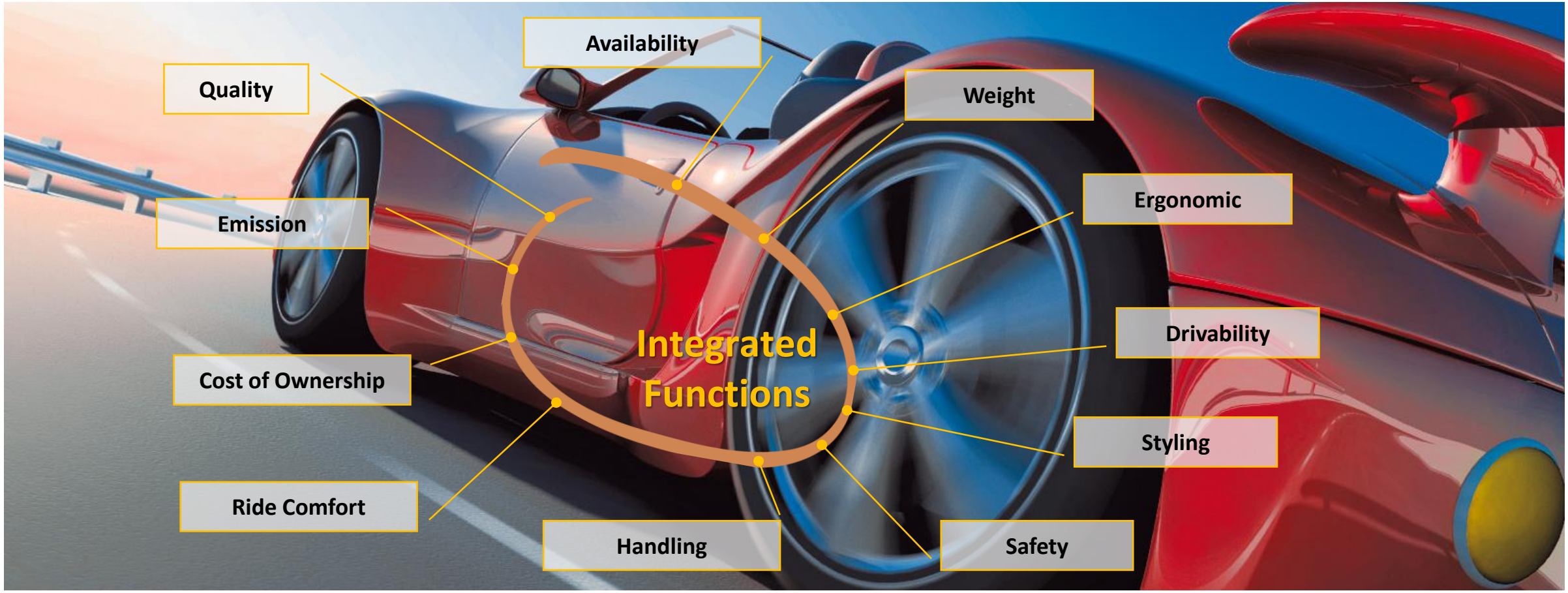
Comfort Feeling

Motion Sickness

Improved chassis systems and driving dynamics are required!

Requirements for vehicles and their global attributes

Major issue for customer values are the global vehicle attributes



Requirements for vehicles and their global attributes

How can we evaluate the global vehicle attributes?

TECHNISCHE DATEN UND MESSWERTE

Fahrzeugtyp	Kia Cee'd 1.6 CVVT ISG Spirit	Opel Astra 1.4 Turbo Ecotec Edition	Renault Mégane TCe 130 Luxe	Toyota Auris 1.6 Valvematic Club	VW Golf 1.4 TSI Comfortline
Motorbauart/Zylinderzahl	Reihe/4	Reihe/4	Reihe/4	Reihe/4	Reihe/4
Hubraum cm³	1591	1364	1397	1598	1390
Leistung kW (PS) bei 1/min	92 (125) 6300	103 (140) 4900	96 (130) 5500	97 (132) 6400	90 (122) 5000
max. Drehm. Nm bei 1/min	154 bei 5200	200 bei 1850	190 bei 2250	160 bei 4400	200 bei 1500
Schadstoffeinstufung	Euro 5	Euro 5	Euro 5	Euro 5	Euro 5
CO_2-Ausstoß g/km	142	138	153	154	144
Leergewicht/Zuladung kg	1258/452	1443/497	1323/421	1312/438	1313/507
Länge × Breite × Höhe mm	4260 × 1790 × 1480	4419 × 1814 × 1510	4295 × 1808 × 1471	4245 × 1760 × 1515	4199 × 1779 × 1480
Radstand mm	2650	2685	2641	2600	2575
Wendekreis links/rechts m	11,7/11,5	11,8/11,8	11,2/11,2	10,9/11,2	10,7/10,8
Gepäckraum L/VDA	340/1300	370/1235	405/1162	354/1335	350/1305
Anhängelast ug/gbr. kg	550/1200	680/1400	645/1300	450/1300	640/1300
Tankinhalt L	53	56	60	55	55
Innenbreite vorn/hinten mm	1475/1455	1460/1440	1460/1420	1425/1425	1465/1445
Innenhöhe vorn/hinten mm	970/970	1015/970	1030/970	1020/965	1040/975
Normalsitzraum mm	735	720	660	685	720
Testwagenbereifung	225/45 R 17 W Michelin Pilot Primacy HP	205/60 R 16 H Michelin Energy	205/50 R 17 V Michelin Pilot Primacy HP	225/45 R 17 W Bridgestone Potenza RE050A	205/55 R 16 V Continental Sport Contact 2
Kraftübertragung	Vorderradantr. Fünfganggetr.	Vorderradantr. Sechsganggetr.	Vorderradantr. Sechsganggetr.	Vorderradantr. Sechsganggetr.	Vorderradantr. Sechsganggetr.
Beschleunigung s					
0 – 40 km/h	2,4	2,2	2,2	2,2	2,3
0 – 80 km/h	7,2	6,6	6,6	6,6	6,5
0 – 100 km/h	10,8	10,1	9,9	9,9	9,7
0 – 120 km/h	15,1	14,1	13,7	14,0	13,9
0 – 130 km/h	18,0	16,5	16,5	16,4	16,8
0 – 140 km/h	21,6	20,9	19,5	20,0	19,6
0 – 160 km/h	31,1	27,8	27,9	28,5	28,1
Elastizität[1] s					
60 – 100 km/h (IV./V. G.)	11,4/16,0	9,7/14,9	7,8/10,2	12,1/16,3	8,4/11,5
80 – 120 km/h (V./VI. G.)	17,8/–	14,7/23,1	10,8/13,6	16,8/24,4	12,4/15,5
Höchstgeschw. km/h	192	202	200	195	200
Bremsweg m					
aus 100 km/h kalt leer	37,2	37,6	36,7	36,2	36,4
aus 100 km/h kalt beladen	36,4	38,5	37,1	37,3	37,0
aus 100 km/h warm beladen	37,5	37,7	38,2	37,5	37,4
aus 140 km/h kalt leer	70,7	72,9	74,9	69,8	71,2
µ-split-Bremsweg	98	101	124	108	111
aus 100 km/h nass	44	46	47	43	46
Testverbrauch L/100 km	8,3	8,1	9,3	8,6	8,5
min. (ams-Verbrauchsrunde)	5,3	5,2	6,5	5,4	5,6
maximal	11,4	10,8	12,4	10,9	11,2
Reichweite km	639	691	645	640	647
ECE-Verbrauch L/100 km	Superbenzin	Superbenzin	Superbenzin	Superbenzin	Superbenzin
Stadt	7,1	7,9	8,8	8,6	8,2
über Land	5,4	4,7	5,3	5,5	5,1
gesamt	6,0	5,9	6,6	6,6	6,2
Innengeräusch dB(A)					
bei 50 km/h	62	60	62	62	60
bei 80 km/h	66	64	66	64	65
bei 100 km/h	70	67	67	68	67
bei 120 km/h	72	69	71	70	68
bei 140 km/h	75	71	73	73	70
bei 160 km/h	77	74	75	75	73
Fahrversuche leer/bel. km/h					
Slalom 18 m	62,4/61,9	60,0/58,4	61,5/61,0	60,7/61,3	60,7/59,5
ISO-Wedeltest	130,7/128,2	123,8/122,6	126,5/126,1	127,7/124,5	126,1/124,1
VDA-Ausweichgasse					
Einfahrgeschwindigkeit	71/70	71/69	70/69	71/70	70/67
Ausfahrgeschwindigkeit	53/53	53/53	51/51	48/56	48/52
Fixkosten Euro					
Steuer	76,–	64,–	94,–	100,–	76,–
Haftpflicht	253,–	245,–	297,–	238,–	203,–
Teilkasko[2]	77,–	95,–	104,–	70,–	87,–
Vollkasko[3]	542,–	382,–	635,–	586,–	440,–
Unterhaltskosten im Monat[4]					
bei 15 000 km/Jahr Euro	201,–	186,–	215,–	210,–	186,–
bei 30 000 km/Jahr Euro	362,–	339,–	389,–	385,–	337,–
Grundpreis Euro	18 955,–	20 575,–	22 950,–	20 700,–	21 665,–
Einparkhilfe hinten	600,–[5]	380,–	○	290,–	○
Metallic-Lackierung	410,–	490,–	500,–	490,–	490,–
Navigationssystem	1999,–	1300,–	1300,–	950,–[6]	2150,–
Sitzheizung	600,–[5]	330,–	○	–	405,–[7]
Bi-Xenon-Scheinwerfer	–	1250,–	1000,–	–	1295,–

[1] für die Punktwertung sind die im zweithöchsten (60 bis 100 km/h) und höchsten (80 bis 120 km/h) Gang erzielten Werte maßgebend; [2] ohne SB; [3] mit 150 Euro SB; [4] ohne Wertverlust; [5] Komfort-Paket: Klimaautomatik, Regensensor, Einparkhilfe, Sitzheizung, beheizbare Frontscheibe; [6] SD-Navigation; [7] Winterpaket; ○ = Serie; – = nicht lieferbar

- **Availability**
- **Cost of Ownership**
- **Weight**
- **Quality**
- **Ergonomic**
- **Styling**
- **Safety**
- **Emission**
- **Drivability**
- **Handling**
- **Ride Comfort**

1 **Evaluation criteria (measureable)**

2 **Test Method**

3 **Target**

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How can we evaluate the global vehicle attributes?

					Measurable (sample)
Availability	Millage Range	Service Intervals	Times for fuelling	…	Interrupt times
Cost of Ownership	Invest	Fuel	Service	Insurance	Money
Weight	Total weight	System weight	Component weight	..	Weighting
Quality	Service intervals	Clearance (optical)	Defect rates	Breakdown statistics	Statistics
Ergonomic	Seat position	Seat pressure	Accessibility	..	Ergonomic measurement
Styling	Exterior	Interior	..	…	Customer survey
Safety	NCAP Rating	Stability	Controlability	Brake distance	Crash tests
Emission	CO2	HC	NOx	CO	Emission measurement
Drivability	Acceleration performance	Tip In Jerk	Tip In Latency time	Tip Out oscillation	Vehicle measurement
Handling	Cornering behavior	Steering behavior	Braking behavior	Straight running	Vehicle measurement
Ride Comfort	Primary Ride	Secondary Ride	NVH	Noise	Vehicle measurement