

VOLKSWAGEN

AKTIENGESELLSCHAFT

KONZERNFORSCHUNG



HERAUSFORDERUNGEN DES AUTOMATISCHEN/AUTONOMEN FAHRENS

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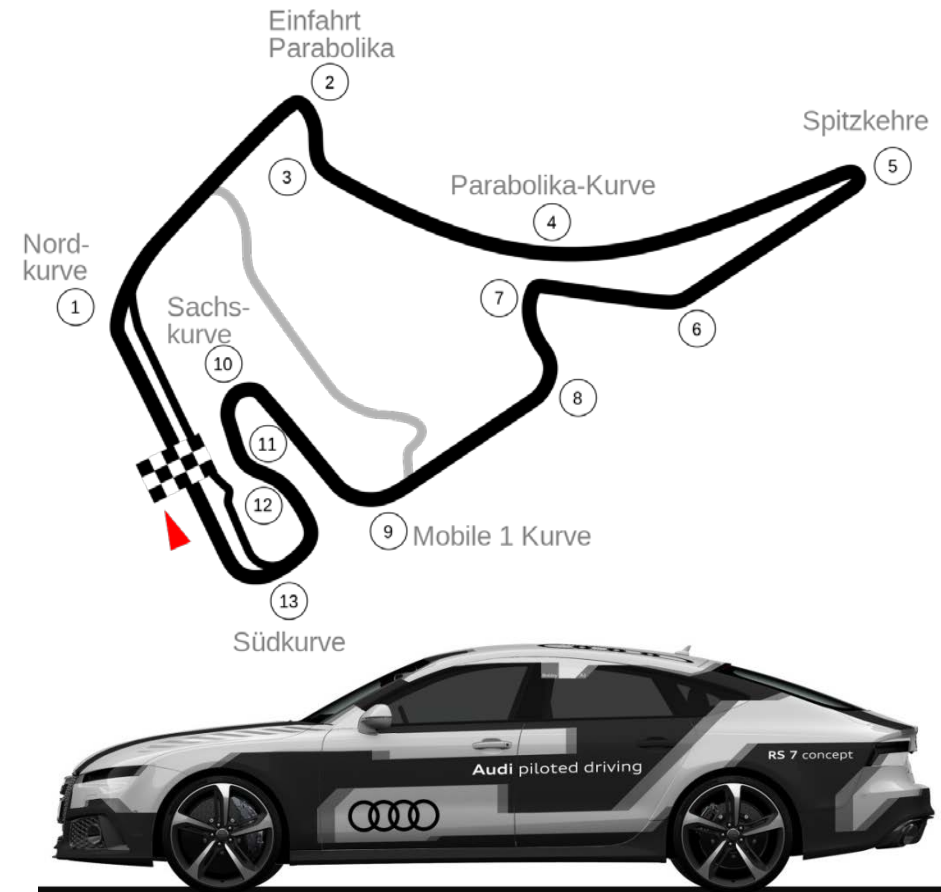
SYMPOSIUM AUTOMOTIVE & MOBILITY | ZWICKAU | 28.06.2018

RACEPILOT – DTM PRÄSENTATION 2014

Demo: L5 Driving at the Friction Limit
Location: Hockenheim – 17 / 19.10.2014
(Public Demo at DTM Final)
Vehicle: Audi RS7 with Auto-Pilot Architectur

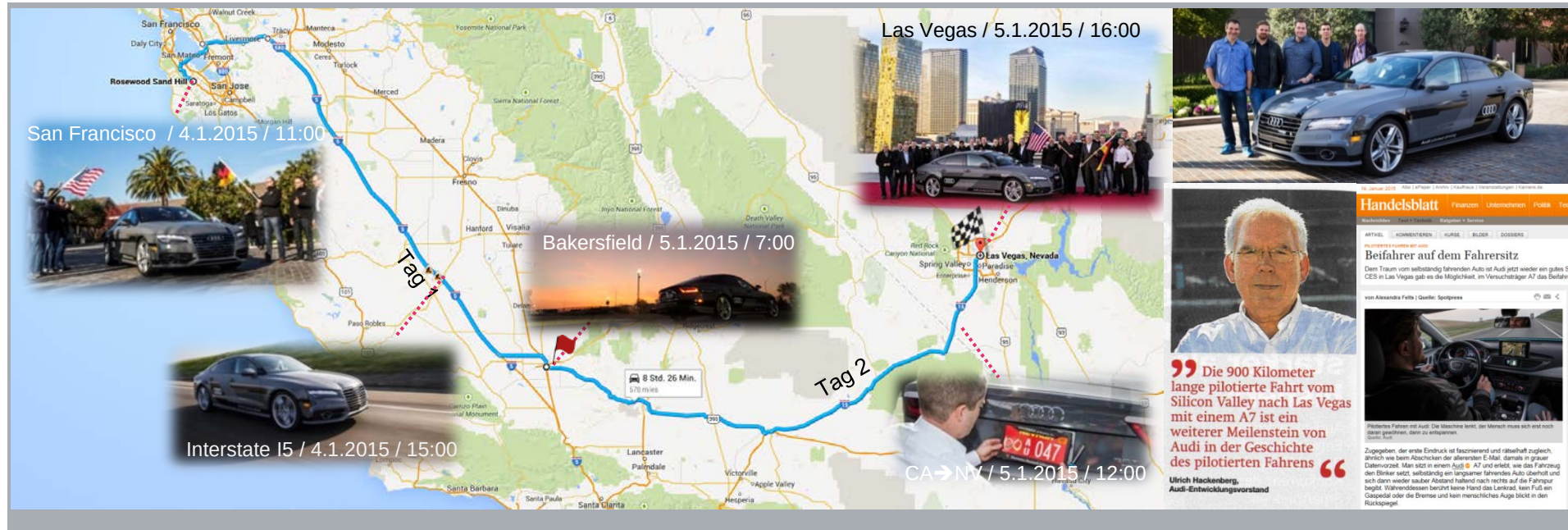
Race Track:

- ➔ Length: 4,574 km
- ➔ Lap Time: ~ 2.10 Min
- ➔ Max. Speed: up to 243 km/h
- Max. Lateral Acceleration: ~ 1G



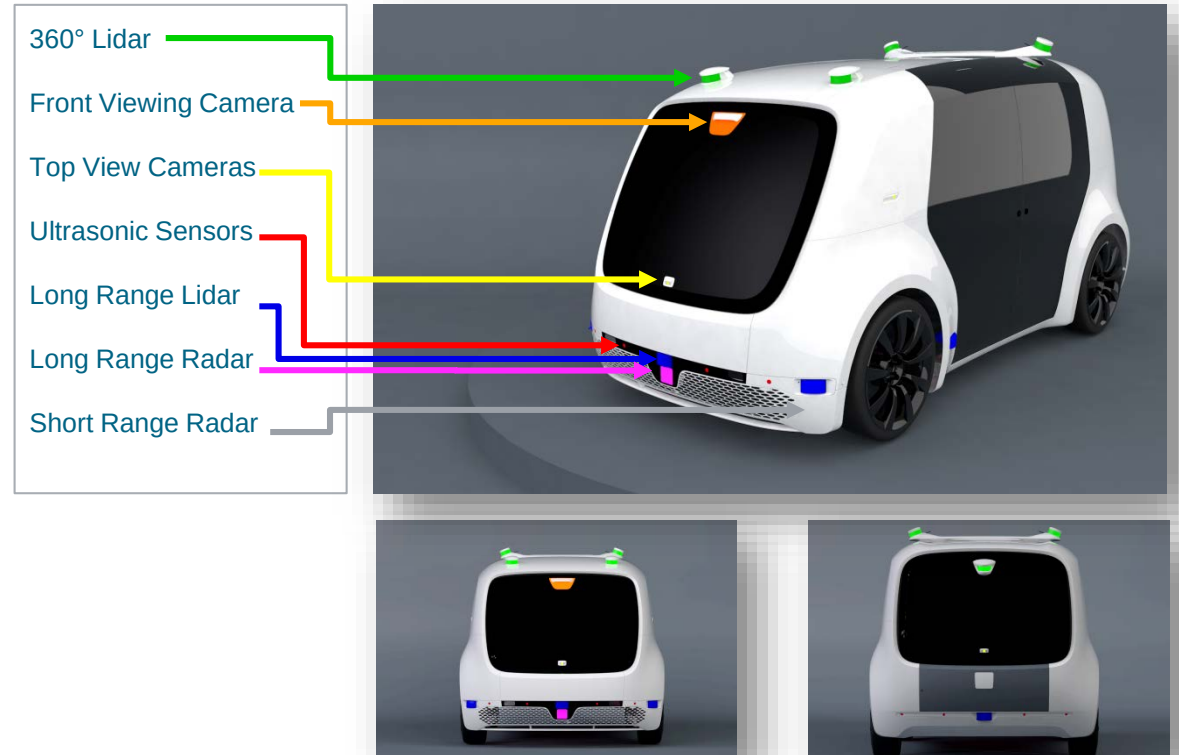
PRÄSENTATION – CES 2015

- From San Francisco to Las Vegas 560 Miles (ca. 900 km), Highway L3
- 5 journalists on the driving seat



FORSCHUNGSFAHRZEUG SEDRIC

GENF MOTOR SHOW 2017



KONZERNFORSCHUNG - HISTORIE DES AUTOMATISCHEN FAHRENS

Stanley



(2005)

Junior



(2007)

PAUL



(2007)

iCar



(2007)

HAVEit



(2011)

eT – Follow me!



(2011)

Race-Pilot (Bobby)



(2014)

Auto-Pilot (Jack)



(2015)

SEDRIC

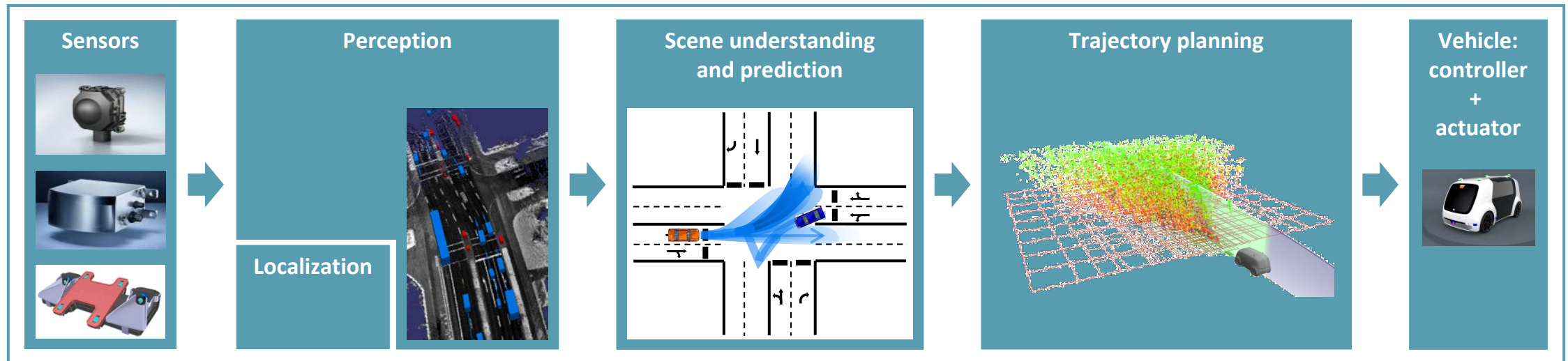


(2017)



AUTOMATISCHES UND VERNETZTES FAHREN

TECHNISCHE HANDLUNGSFELDER



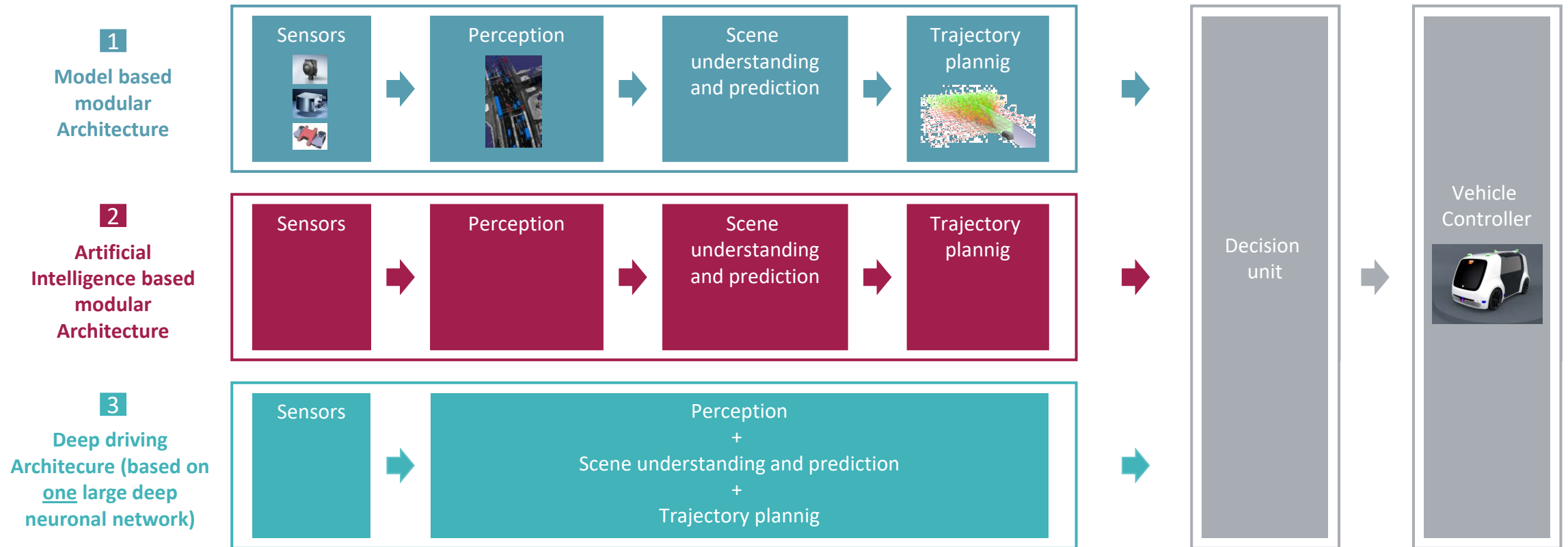
Architecture: Redundancy, security mechanisms, interfaces, AI-Architecture and fundamentals

Validation, quality criteria: Methods, simulation, test tools (system, modules)

Training Data for Artificial Intelligence: Data collection based on fleet data

AUTOMATISCHES UND VERNETZTES FAHREN

FUNKTIONALE SICHERHEIT ERFORDERT REDUNDANZ DURCH MIND. 2 KOMPLEMENTÄRE HW/SW-MODULE



VERBLEIBENDE TECHNISCHE HERAUSFORDERUNGEN DES AUTOMATISCHEN FAHRENS



ERFASSUNG DURCH UNTERSCHIEDLICHE SENSOR-TECHNOLOGIEN



Camera:

- detection
- classification
- size
- distance
- velocity

Radar :

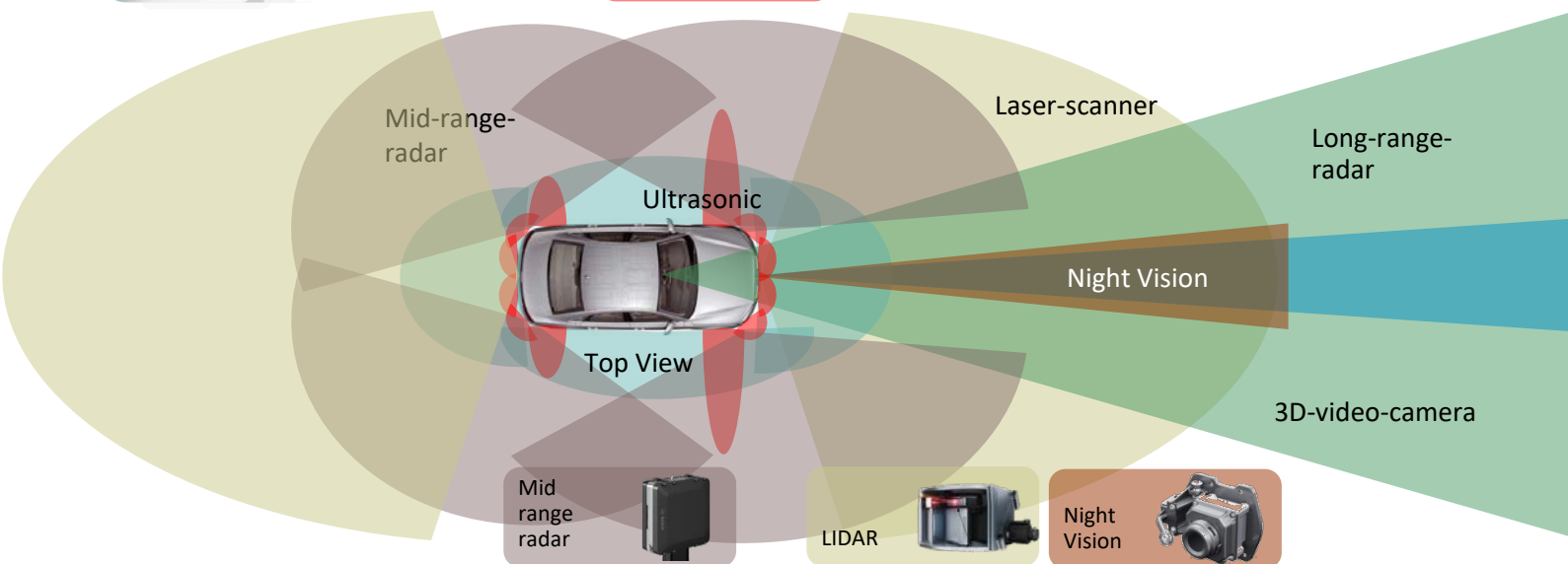
- detection
- classification
- size
- distance
- velocity

Lidar :

- detection
- classification
- size
- distance
- velocity

AUTOPILOT: SENSOR SETUP

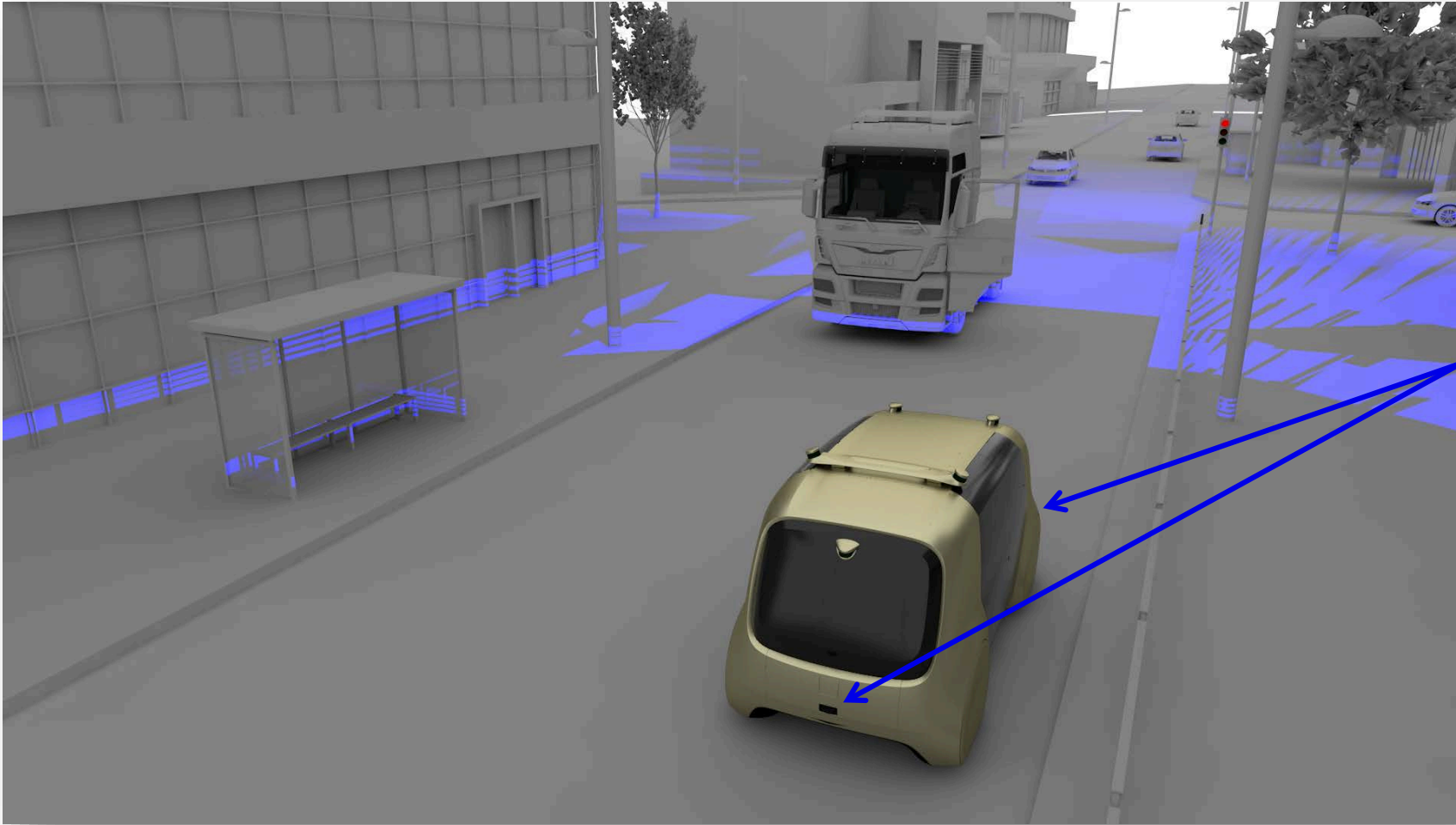
FOKUS AUTOBAHNEN / SCHNELLSTRAßEN



2x Laser-scanner	1
4x Mid-range-radar	2
4x Top View	3
2x Long-range-radar	4
1x 3D-video-camera	5
4x Ultrasonic	6
1x Stock GPS	7
2x Short Range Radar	8



ERFASSUNG DES URBANEN UMFELDES

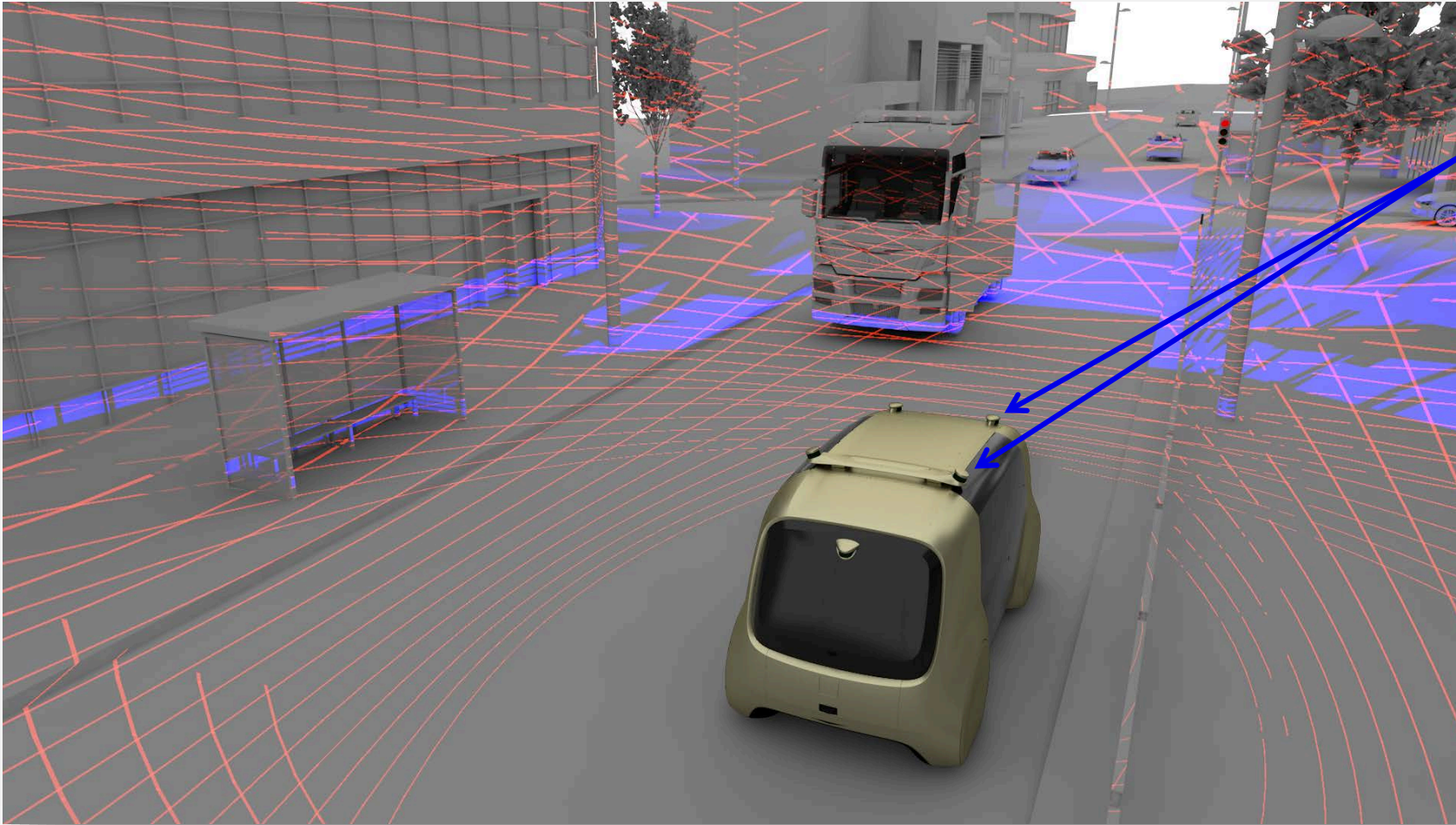


Detection of obstacles at large distances
with six high-precision long range lidars:

→ Dynamic objects

→ Static objects

ERFASSUNG DES URBANEN UMFELDES



Detection of near obstacles by five overlapping 360° lidars:

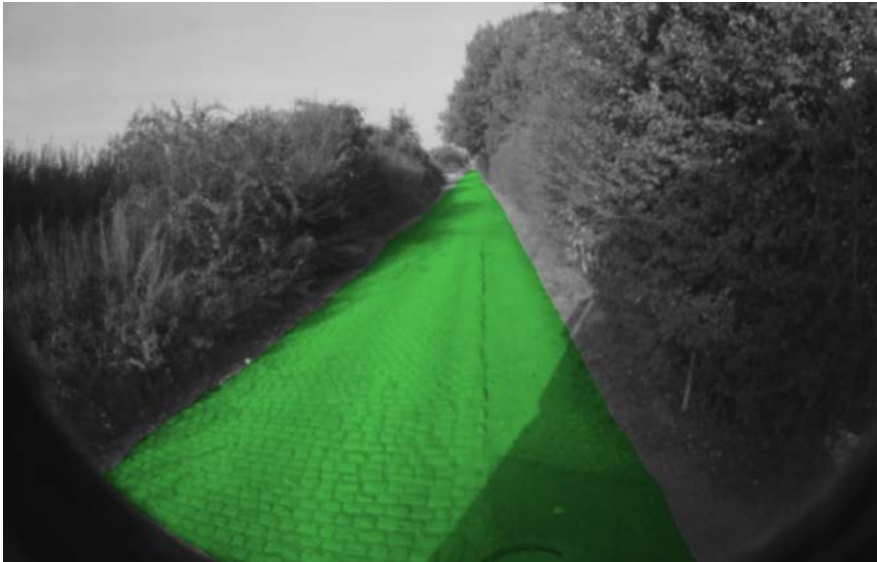
→ High precision volumetric detection of obstacles at different elevation levels (e.g. open truck door)

SENSOR SETUP



DEEP LEARNING

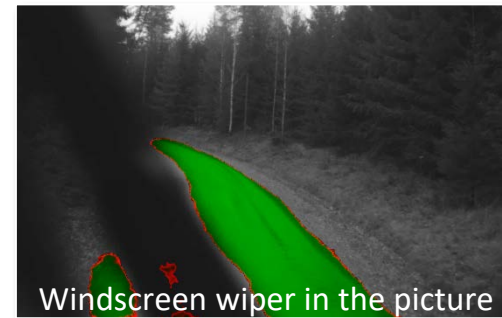
ERMITTLUNG DER FREIEN FAHRTSTRECKE



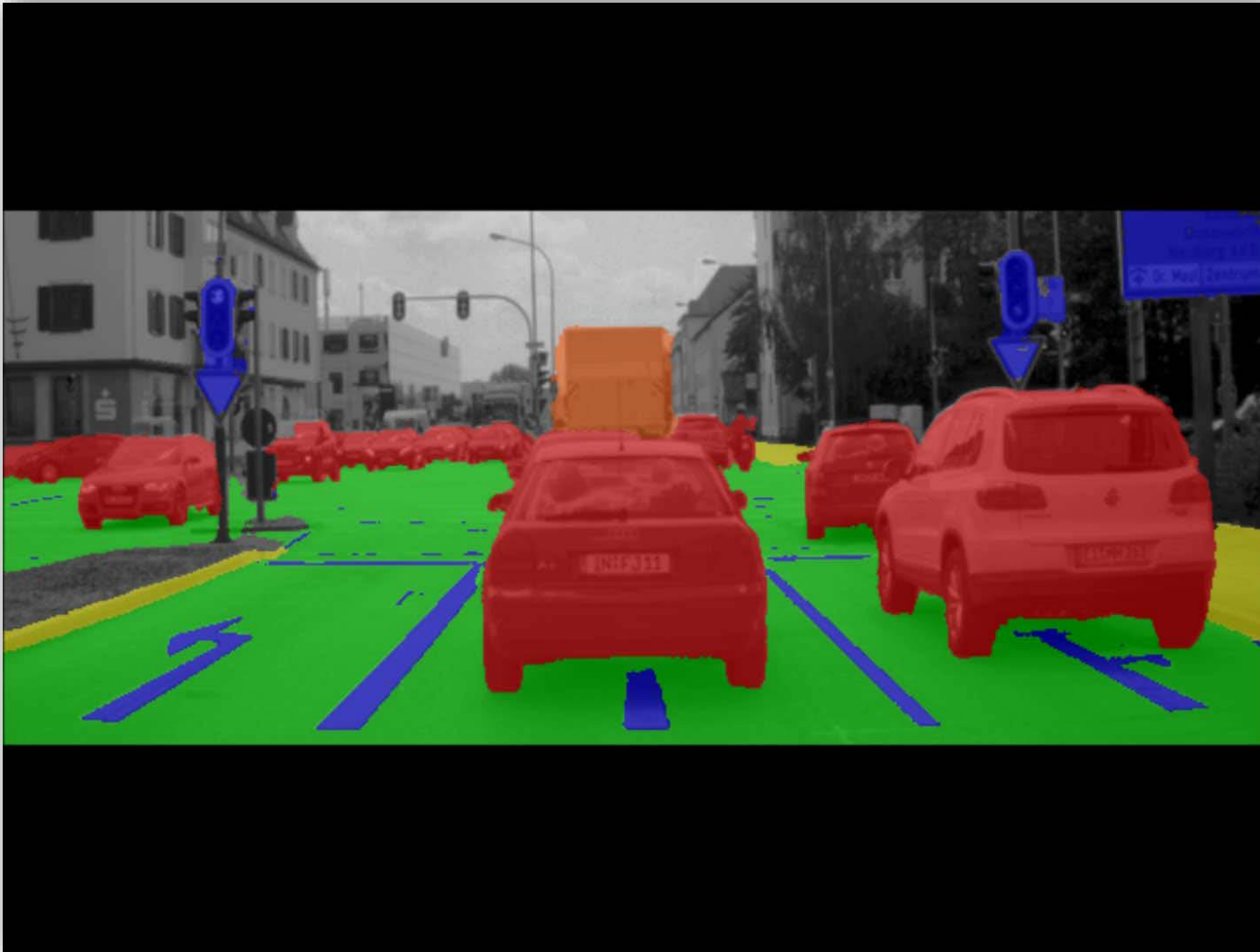
AKTUELLE HERAUSFORDERUNGEN – AI-MODELLE

LEISTUNG UND PROBLEME VON TRAINIERTEN MODELLEN

- Understanding of **deep neuronal networks**
- Implementation of **certificated functions**
- Prevention of **overfitting**: has the system only memorized the training data?
- How can we prevent **neural hacking**?
- **Robustness** respectively handling of extreme weather conditions
- Has the AI-model **learned all** necessary informations?



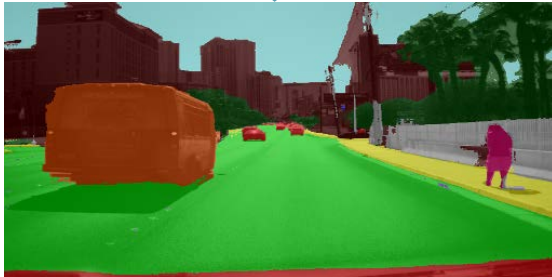
SZENEN-VERSTÄNDNIS



- Complete environment perception using several cameras
- Object and free space classification by image segmentation with artificial neural networks
- Image processing on specialized, high capacity GPUs

AI-PROJEKTE BEIM AUTOMATISCHEN FAHREN

WAS WURDE BISHER ERREICHT? – SELBSTPRÜFUNG



Uncertainty estimation

Group Research



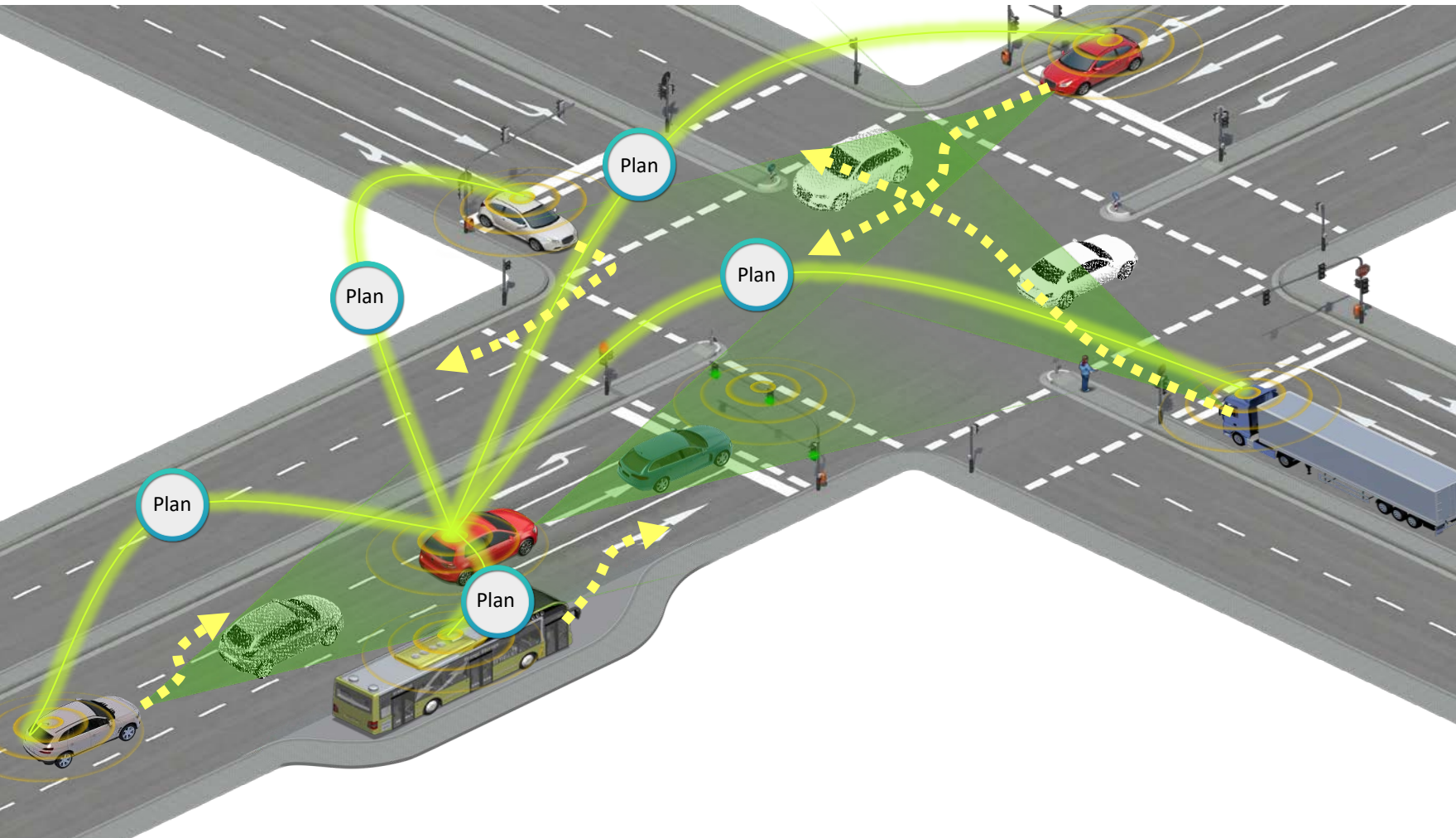
Deep driving introspection

Group Research



VERNETZTES FAHREN MIT CAR2X

BLICK IN DIE ZUKUNFT



Local perception



V2X communication



Collective perception



Exchange of intentions /
coordinated trajectory
planning

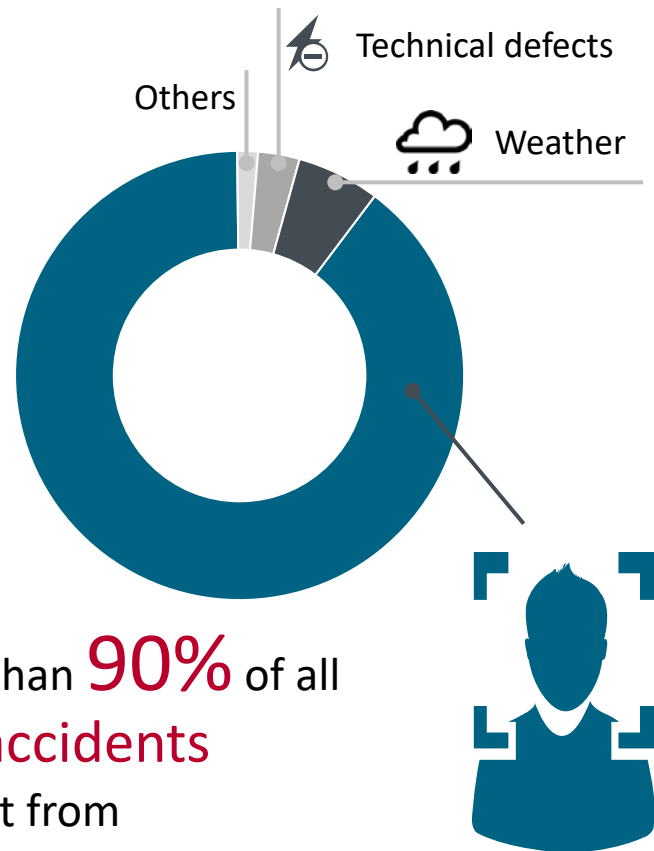


STANDARDISIERUNG DES AUTOMATISCHEN FAHRENS, WIE SICHER IST SICHER GENUG UND WIE SICHERT MAN ES AB?



WIE “GUT” MUSS EIN AUTOMATISCHES FAHRZEUG SEIN?

Accident causalities



More than **90%** of all
accidents
result from
human misbehavior.

	Number of accidents with casualties	Driven distance between accidents with casualties
Germany All vehicle types	300.000	2.0 Mio. km
Germany Passenger cars only	180.000	3.3 Mio. km
Highways All vehicle types	ca. 18.000	12.0 Mio. km

On a German Highway a **human driver** will have to drive in average **12 Mio. km** between two accidents with casualties

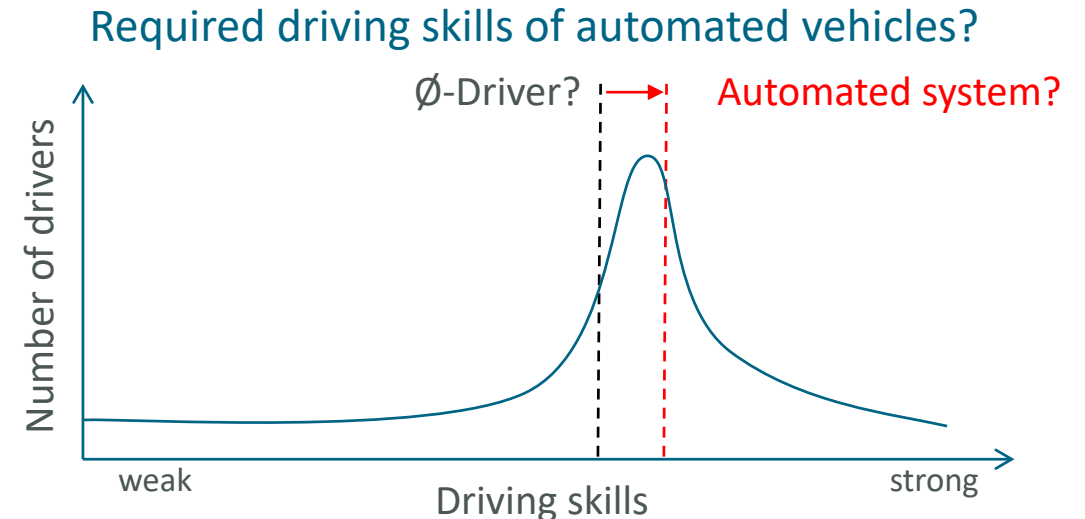
**How many test kilometers we will need to prove that
an automated driving vehicle is performing at least
as well ?**

WIE “GUT” MUSS EIN AUTOMATISCHES FAHRZEUG SEIN?

PEGASUS: ÖFFENTLICH GEFÖRDERTES PROJEKT

Key questions

- Which functional performance is required for automated driving functions?
- How can the completeness of the relevant test cases be guaranteed?
- What kind of test cases can be tested in a simulation and which ones on the road?
- Which quality criteria, tools, methods and processes are necessary?



Funded Project PEGASUS

Fundamental research for the development of testing methods for highly automated driving.
(Project volume 34 Mio. Euro, Duration 2016-2018)



AUSWIRKUNGEN DES AUTOMATISCHEN FAHRENS, WIRD L5 UNSERE VERKEHRSPROBLEME LÖSEN?



MOTIVATION

- ▶ Various companies are developing mobility services
- ▶ Autonomous vehicles (AV) as a key driver
- ▶ Potential shift in customer behavior expected
- ▶ Inconsistent expectations

Inconsistent expectations



"Self-driving 'taxibots' could replace 90% of cars: Study claims driverless cabs will dramatically ease congestion in major cities"

Daily **Mail**

"Do Uber, Lyft worsen Seattle's traffic congestion?"

The **Seattle Times**

"Taxi-sharing could end traffic jams, suggests MIT study."

BBC NEWS

- ▶ **Major Objective:** Transparent impacts assessment of mobility services within calibrated and validated city demand scenarios



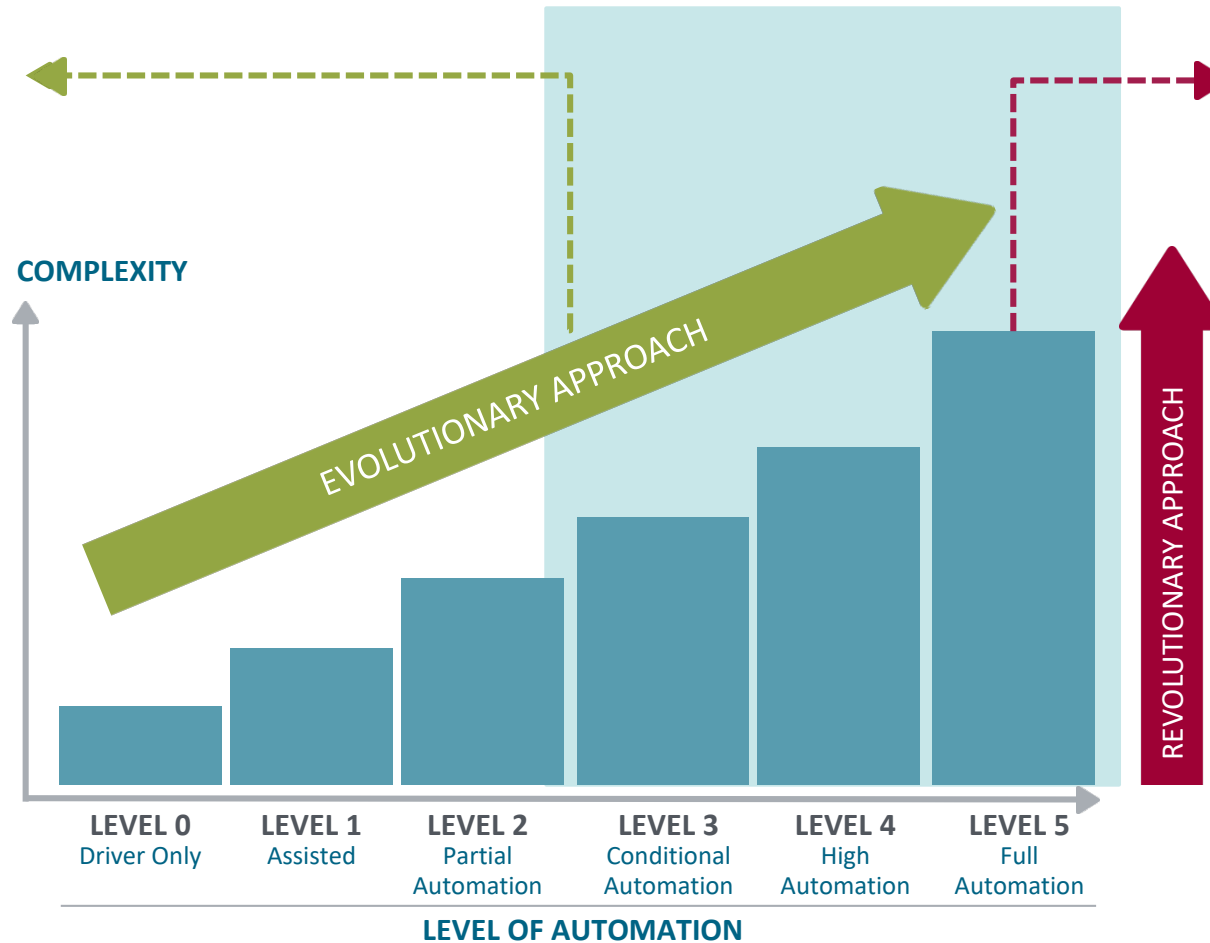
ENTWICKLUNG DER AUTOMATISCHEN FAHRFUNKTION

UNTERSCHIEDLICHE VORGEHENSWEISEN FÜR VERSCHIEDENE GESCHÄFTSMODELLE

SOMETHING EVERYWHERE



EVOLUTIONARY (OEM)

EVERYTHING SOMEWHERE



REVOLUTIONARY



EINE MÖGLICHE AUSWIRKUNG DES AUTOMATISCHEN FAHRENS?



EINE MÖGLICHE AUSWIRKUNG DES AUTOMATISCHEN FAHRENS?



www.istockphoto.com

High parking charge



?

**Driving while waiting ist more
cost-efficient**

EINE MÖGLICHE AUSWIRKUNG DES AUTOMATISCHEN FAHRENS?



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VIELEN DANK FÜR IHRE AUFMERKSAMKEIT!