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Highly Automated Driving

Current Activities & Further Challenges

Driver Assistance Systems

Ingenieurgesellschaft Auto und Verkehr GmbH

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Chemnitz, May 2017

Agenda

(1) Introduction to IAV

(2) Highly automated driving @ IAV

(3) IAV Development Process

(4) HAD – High Level Functionality

(5) HAD – Controller Functionality

Introduction to IAV

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IAV Introduction

Strong Partner for Automotive Engineering

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What we develop moves you.

- Uniquely broad spectrum of expertise in the entire vehicle
- An eye for detail and the whole system
- At your side from the initial idea to start of production
- Developing innovations for more than 30 years
- Highly competent developers
- First-class equipment
- Close cooperation with universities and partners
- Reliable and trustworthy
- At your side whenever and wherever you need us

IAV Introduction

Customer Proximity Across the Globe

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IAV Introduction
Customer Proximity in Germany

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- Development centers
- Development offices

IAV Introduction
Selection of Customer References

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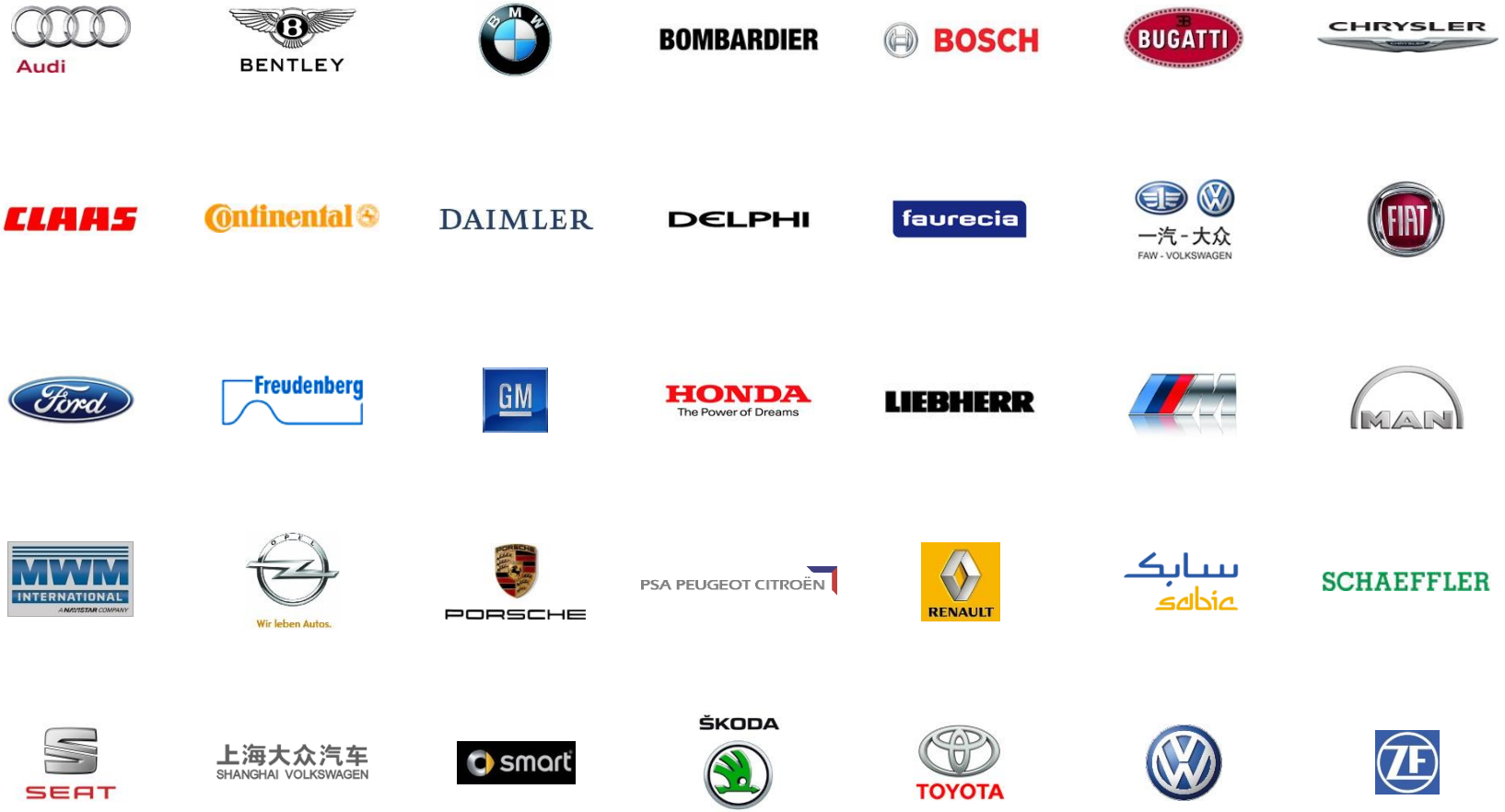

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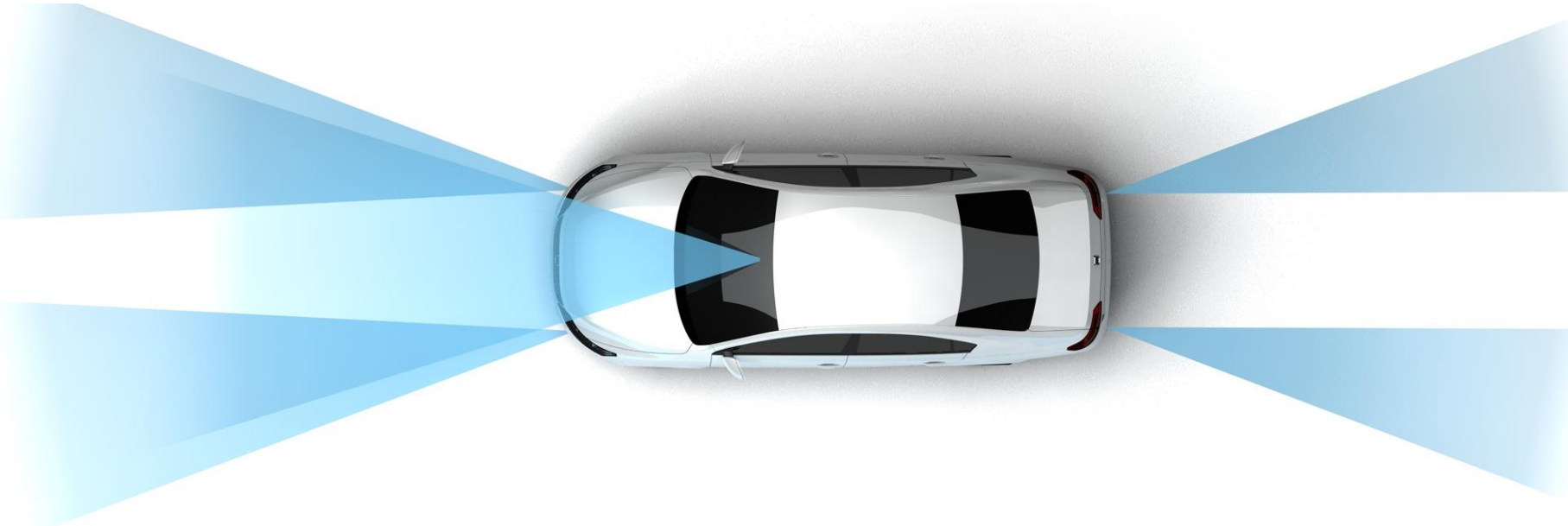
Highly Automated Driving @ IAV

Advanced Driver Assistance Systems & Active Safety



Highly Automated Driving @ IAV
History: ADAS & Active Safety

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ACC
Research

Adaptive Longitudinal Control
Fuzzy-based

ACC Radar
Start Series development

1995 1996 1997 1998 1999

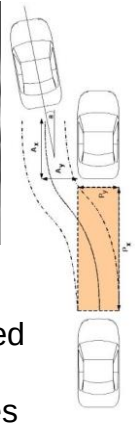
Object Tracking
5-Beam-Lidar

Ultrasonic Park Distance Control

2003 - 2005

- automated driving at the highway or in similar situations

2006 - 2007



- automated parking based on rear view camera dates

2006 - 2007

- participation DARPA Urban Challenge with the TU Braunschweig in the Team Caroline

Highly Automated Driving @ IAV
History: ADAS & Active Safety

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2008 – 2013 – 20XX

Active pedestrian protection
Sensor technology
Camera-based Parking Aid
Semiautomatic

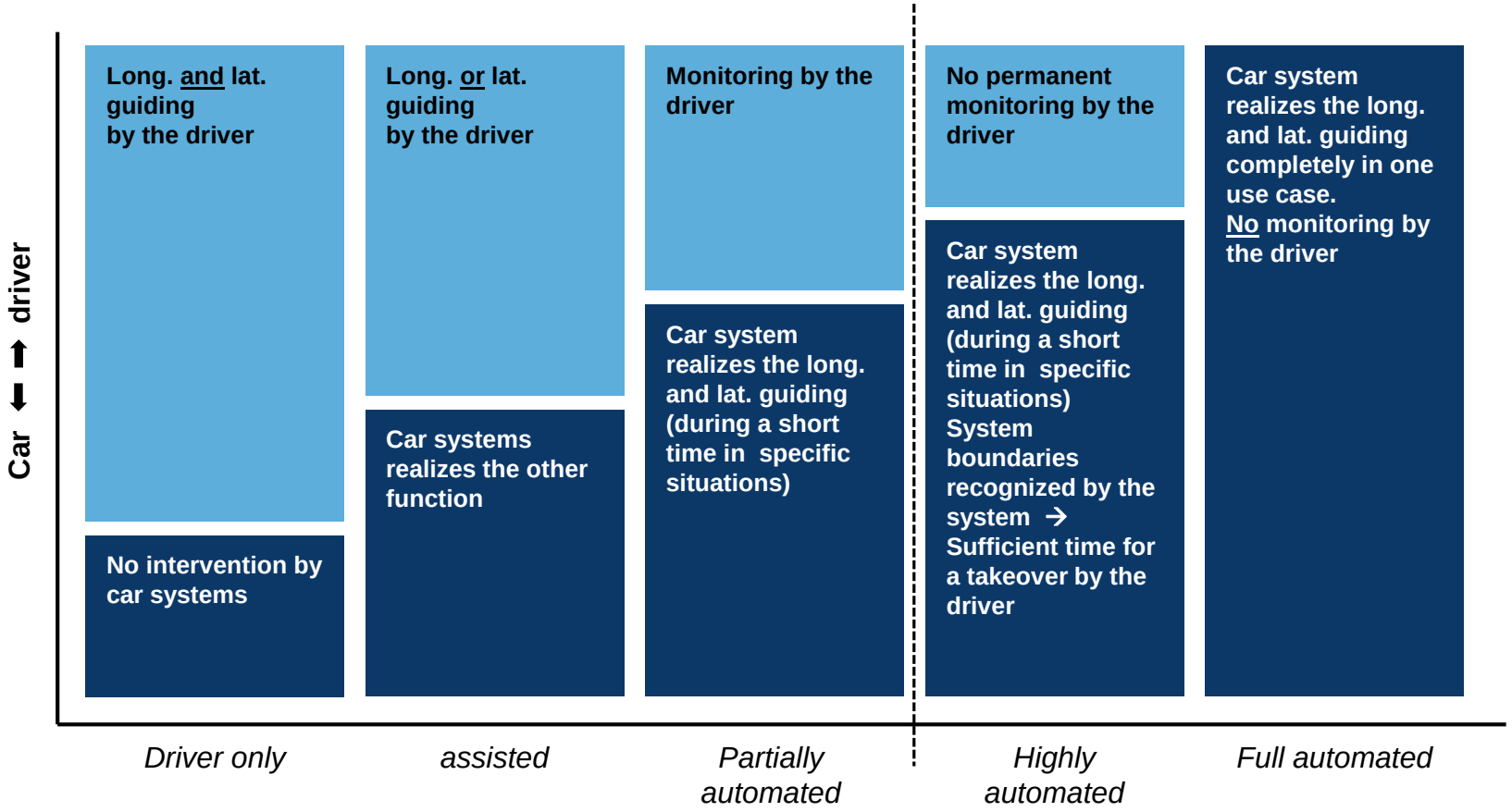
Video-based Parking Aid
Moving object detection

Driver locating
Surround detecting

2009 2010 2011 2012 2013

Definition of Automated Driving

Autonomous / Automated driving



Quelle: VDA

Definition of Automated Driving

Autonomous / Automated driving

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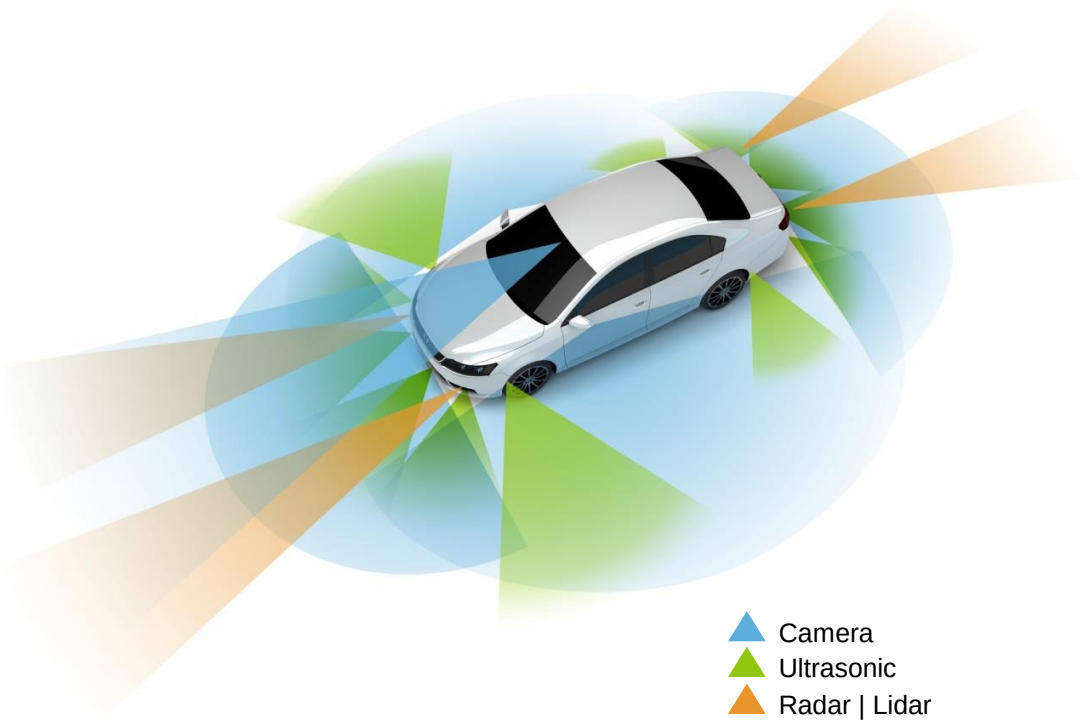

Vehicle functions	
Driver only	Night Vision
	Blind Spot Recognition
	Lane Departure Warning
	Car2X
	Traffic sign recognition
	Parking assistant systems
Assistiert	Adaptive Light Control
	Lane Departure/ Lane Changing assistant
	Parking assistant systems
	Adaptive Cruise Control
	Stop and Go
Teilautomatisiert	PreCrash
	Active pedestrian protection
	Parking assistant systems
	Construction sites assistance
	Traffic jam assistance

Research → Pre & concept developement → Series developement → Support to SOP

Highly Automated Driving @ IAV
HAD Project

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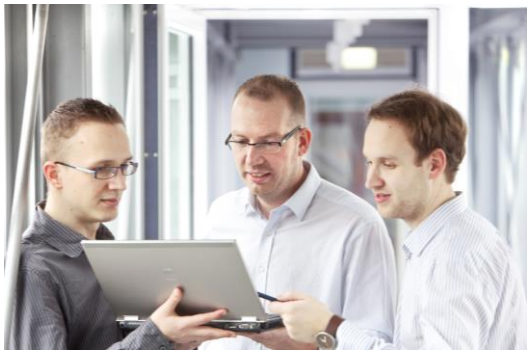

Developing functions for autonomous driving

- Functional definition
- Surrounding sense – programming by using Sensor-Data-Fusion
- Automotive control – modeling strategies
- Functional safety
- System architecture e.g. middleware concepts
- System integration – demonstrator construction and commisioning (technical, functional)
- Validation with test persons

Highly Automated Driving @ IAV
HAD Project

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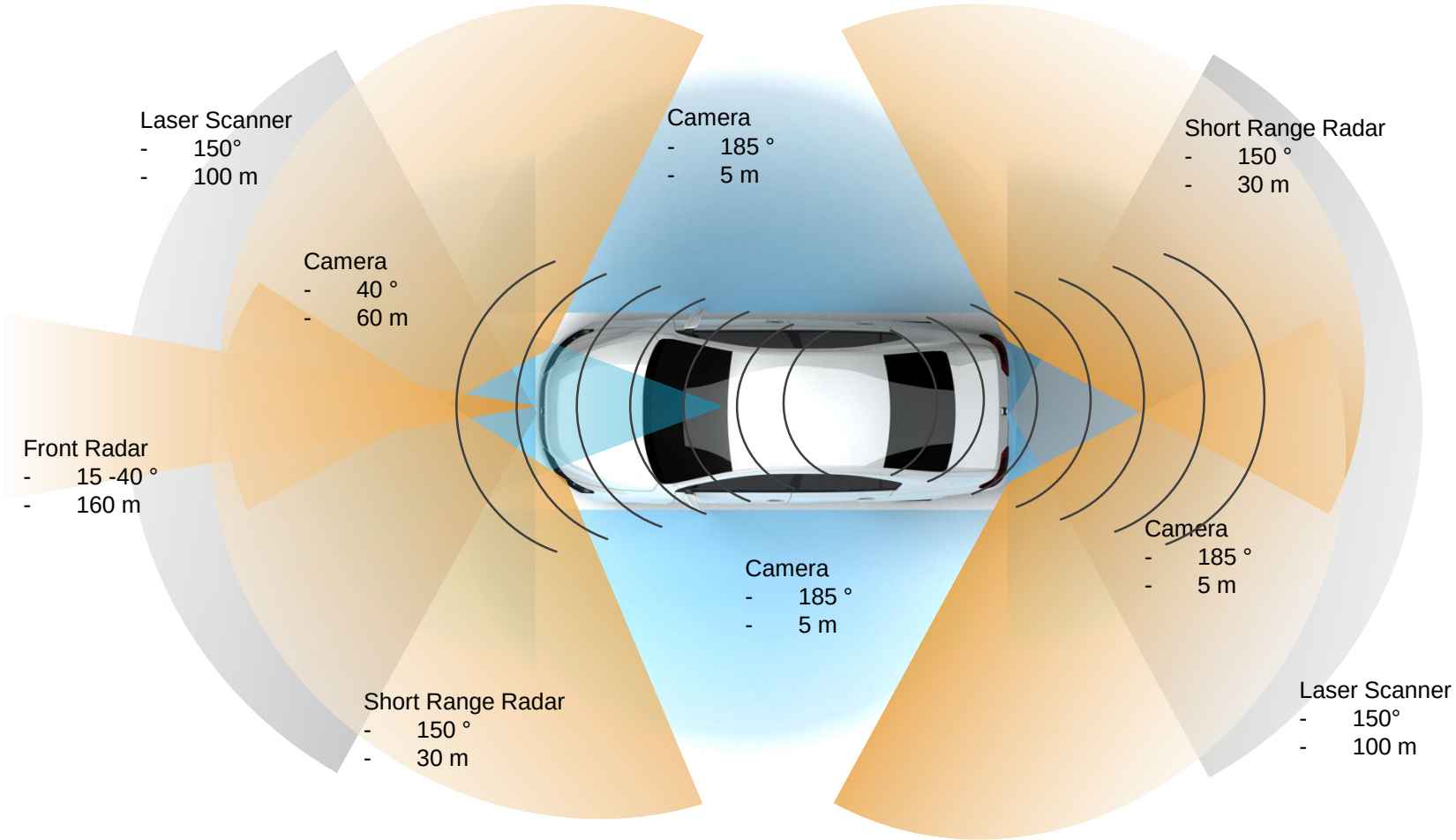
Complete sensor set for 2016



Highly Automated Driving @ IAV
Portfolio: Highway Choiffeur

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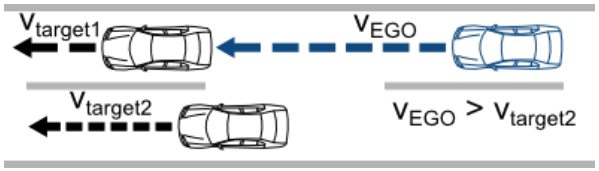
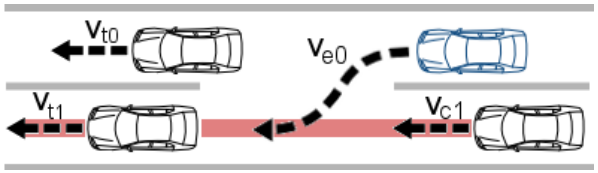
ACC (Adaptive Cruise Control)

- Object validation of each sensor source
- Object fusion of different sensor sources
- Object classification into dynamic & static objects
- Selection of primary target
- Boost Function and Passing Prevention



ALCA (Automatic Lane Change Assist)

- Lane change based on indicator information
- Consideration of objects in the next lane
- Consideration of lane information



LKA (Lane Keeping Assist)

- Lane centering vehicle behavior based on different lane sources
- Generation of lane information based traffic, road boarders…
- Lane fusion of different camera sources

Highly Automated Driving @ IAV
Portfolio: Highway Chauffeur

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Driving in reality in highway situation

Customer Display

Documentation Cam

Health Monitor

Bird View

Highly Automated Driving @ IAV
Portfolio: Parking

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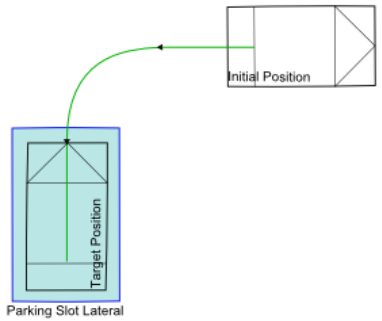
Lateral Parking

- Slot detection by ImageVision and/or ScaLa
- Validation/Occupancy of slot by free space
- Plan one move parking path into slot
- Consideration of surrounding objects → objects in our path → vehicle stops



Longitudinal Parking

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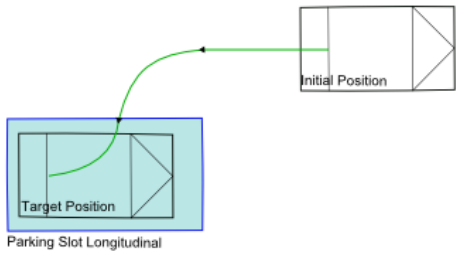
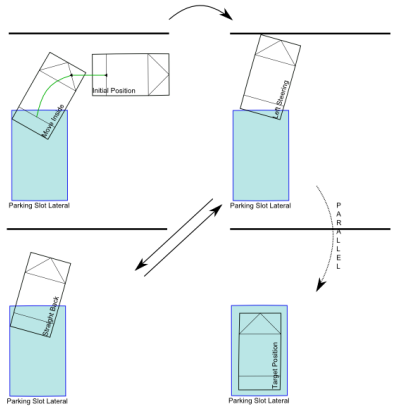
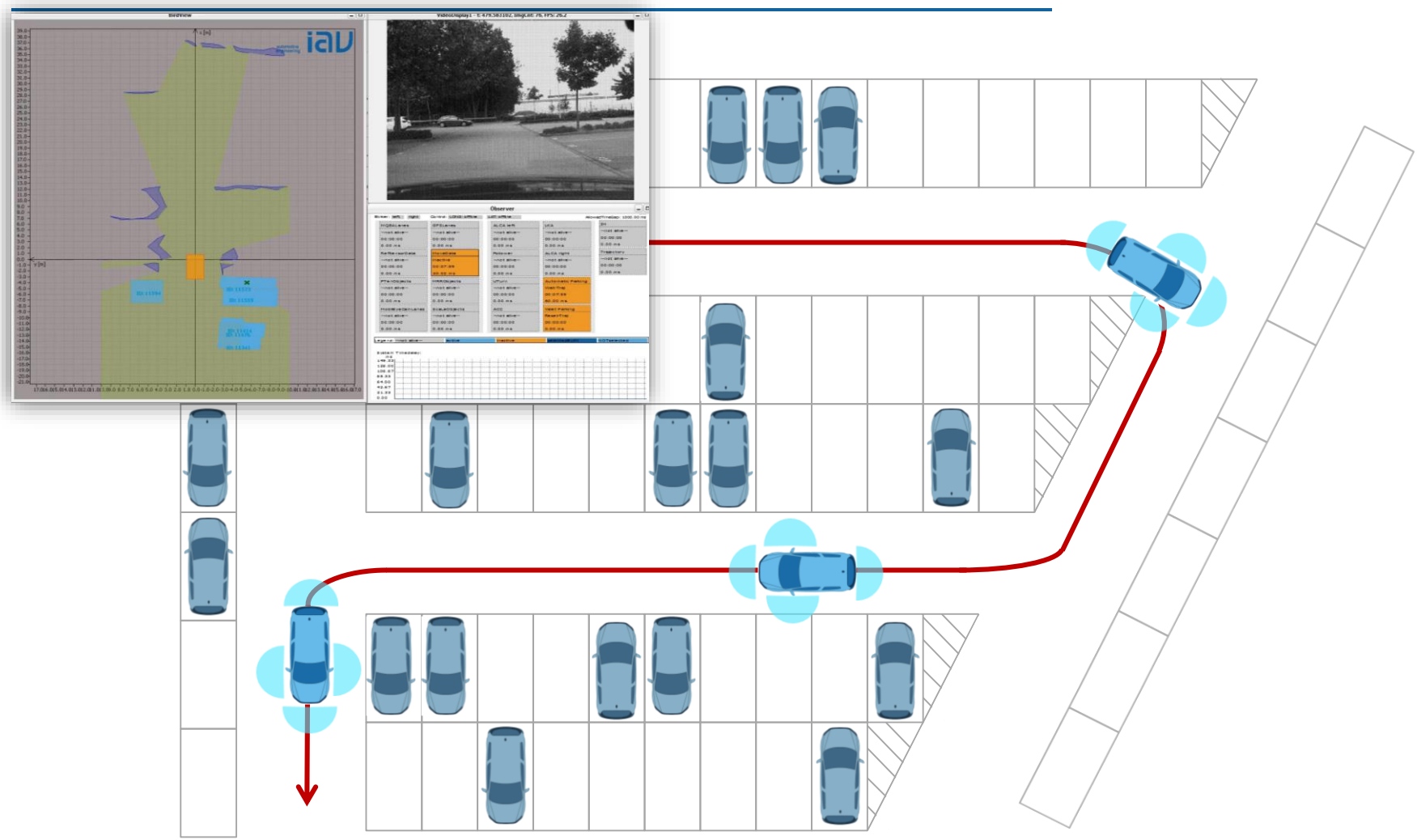


Multiple-move parking

- Handle narrow slots and narrow environment
- Plan multi move path into slot



Highly Automated Driving @ IAV
Portfolio: Parking



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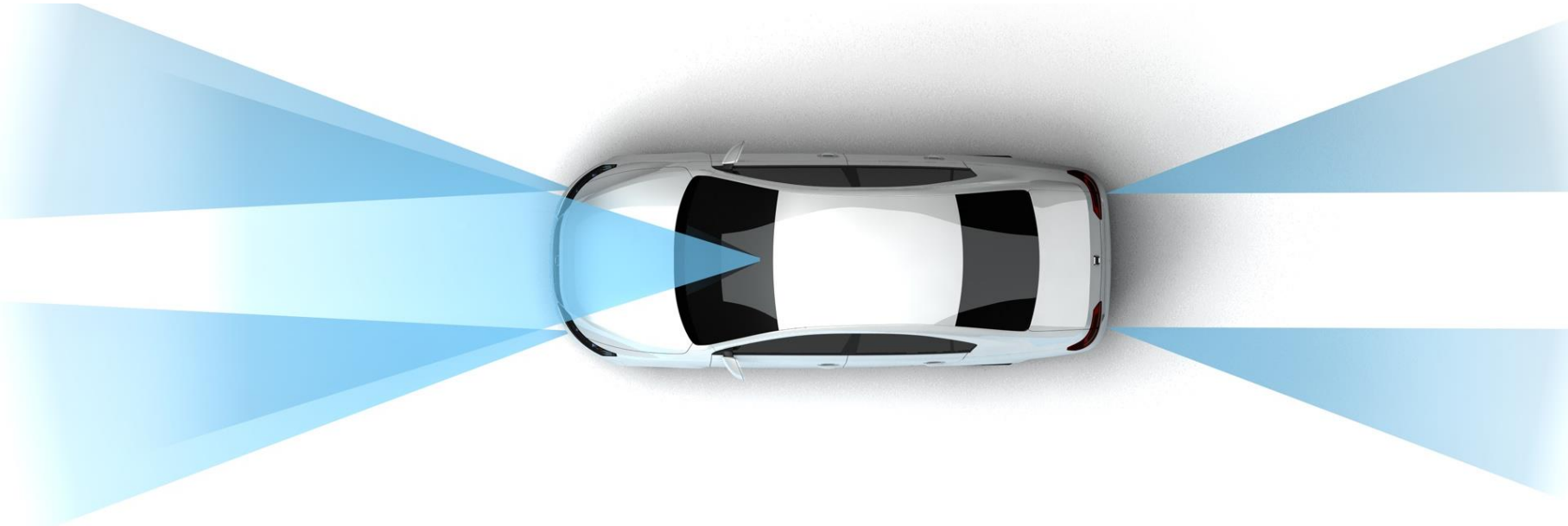
IAV Development Process

Advanced Driver Assistance Systems & Active Safety



IAV Development Process
Scene-based Function Development

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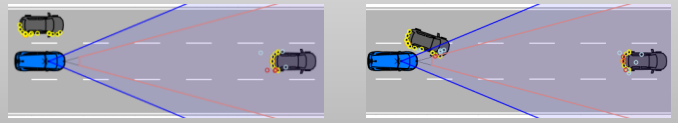
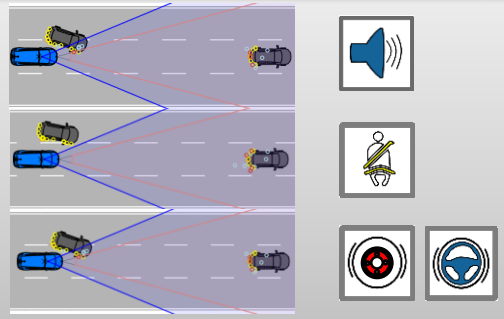
1. Generation of scenes

- Invest of scenes
- Generation of Sensor data (incl. sough)
- Visualization
- Construction of a scene database

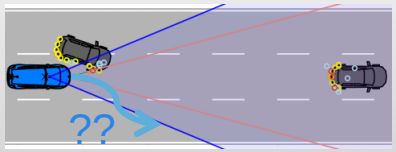


4. Spezification of details



Annotation of desired behavior / events

2. Votum of experts

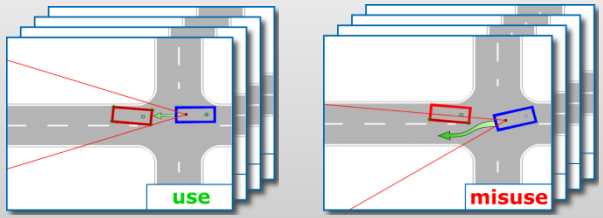


Expert Vote

4	3
use	misuse

- Engineers
- Legal experts
- Marketing
- ….

3. Catalog of scenes



Requirement document

IAV Development Process

Use of scenes in the development process

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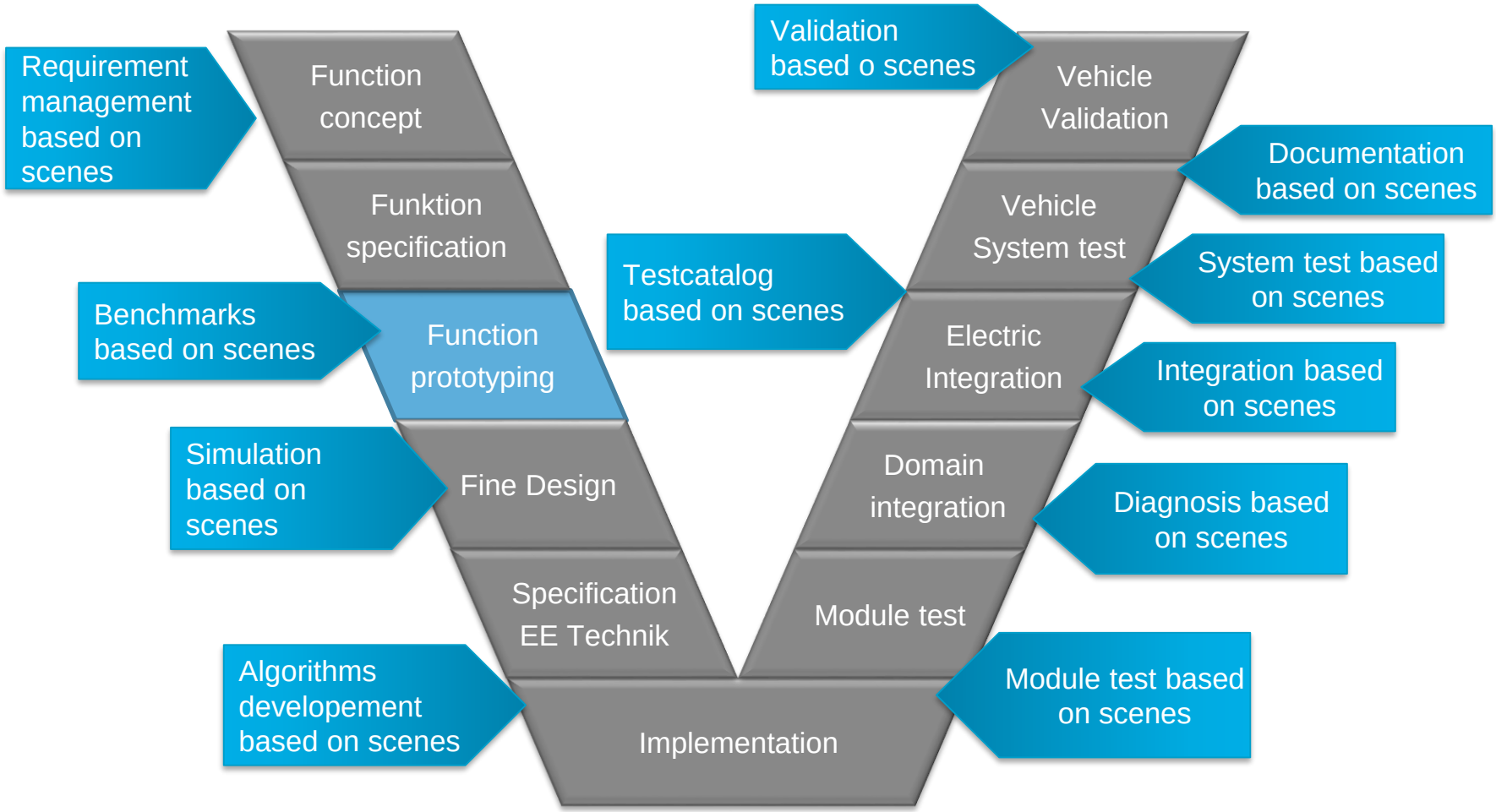

IAV Development Process
Classic Development Process

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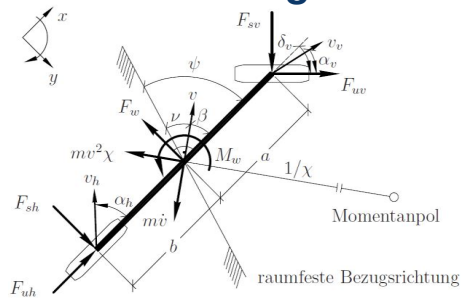
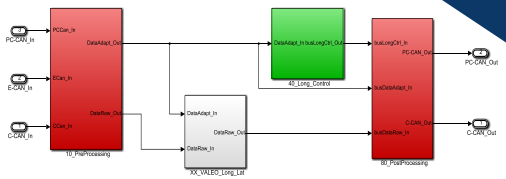
Modelling



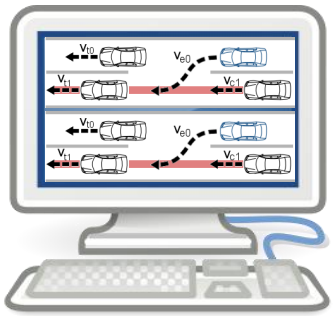
$$\dot{\psi}\left(\delta_v k_v \frac{a}{v} - mv\beta\right) + \dot{\beta}mv\beta - \delta_v k_v \beta - \delta_v^2 k_v + F_{uv} + F_{uh} = 0,$$
$$\dot{\psi}\left(k_h \frac{b}{v} - k_v \frac{a}{v} - mv\right) + \dot{\beta}mv + \beta(k_v + k_h) + \delta_v(k_v + F_{uv}) = 0,$$
$$\ddot{\psi}\Theta + \dot{\psi}\left(k_v \frac{a^2}{v} + k_h \frac{b^2}{v}\right) + \beta(k_h b - k_v a) + \delta_v a(-k_v - F_{uv}) = 0.$$

Iterative Improvement

Prototype Application



SiL and HiL



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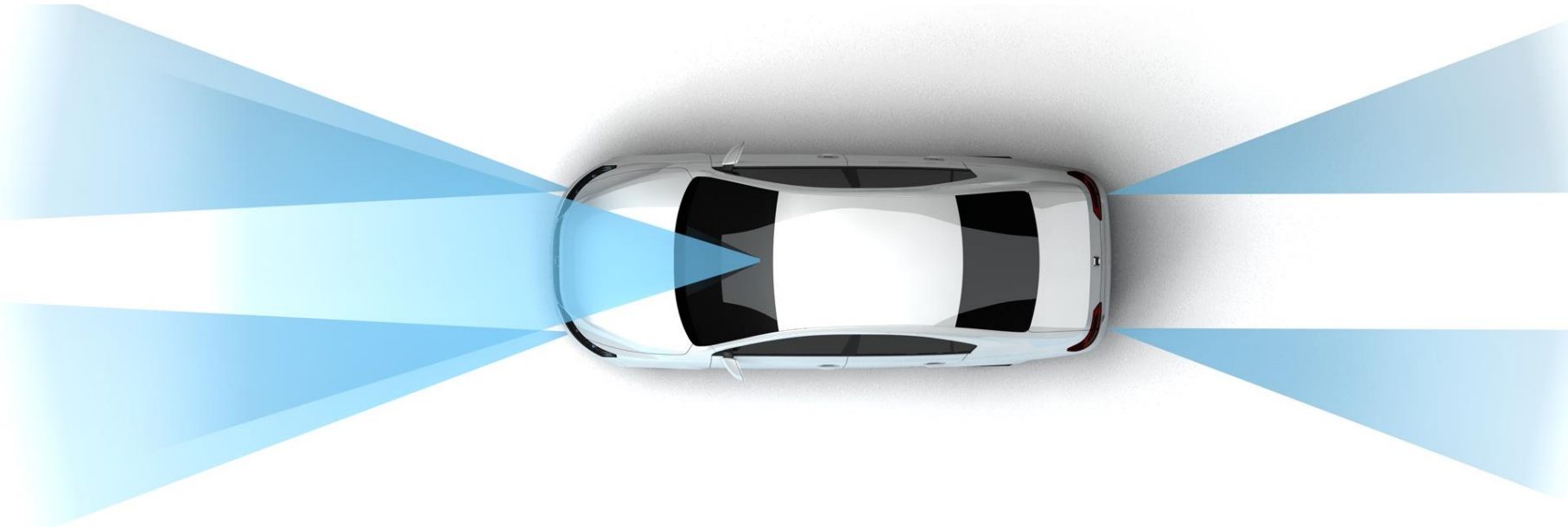
HAD – High Level Functionality

Advanced Driver Assistance Systems & Active Safety



HAD – High Level Functionality
Implementation Concept

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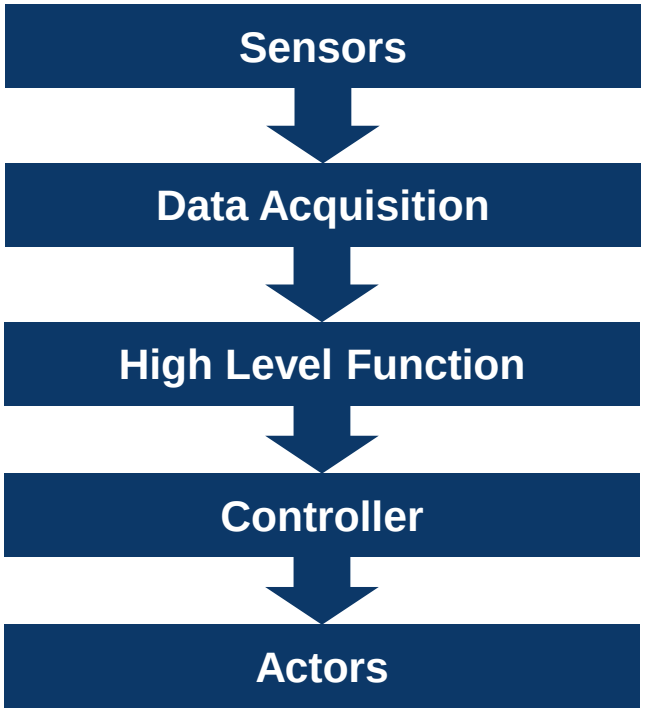
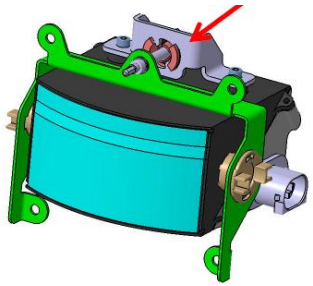


HAD – High Level Functionality
Perception – Standard Sensors



Laserscanner

IR Laser LED Array using time of flight measurement

(+) Great Range and measurement angle: 200m/ 160°

(+) Classification of Objects

(-) heavily weather dependent

Automotive Radar

FMCW radar using Doppler effect and time of flight measurement

(+) robust against most weather condition

(-) poor data quality

(-) poor ranges/measurement angle

HAD – High Level Functionality
Sensor Data Fusion

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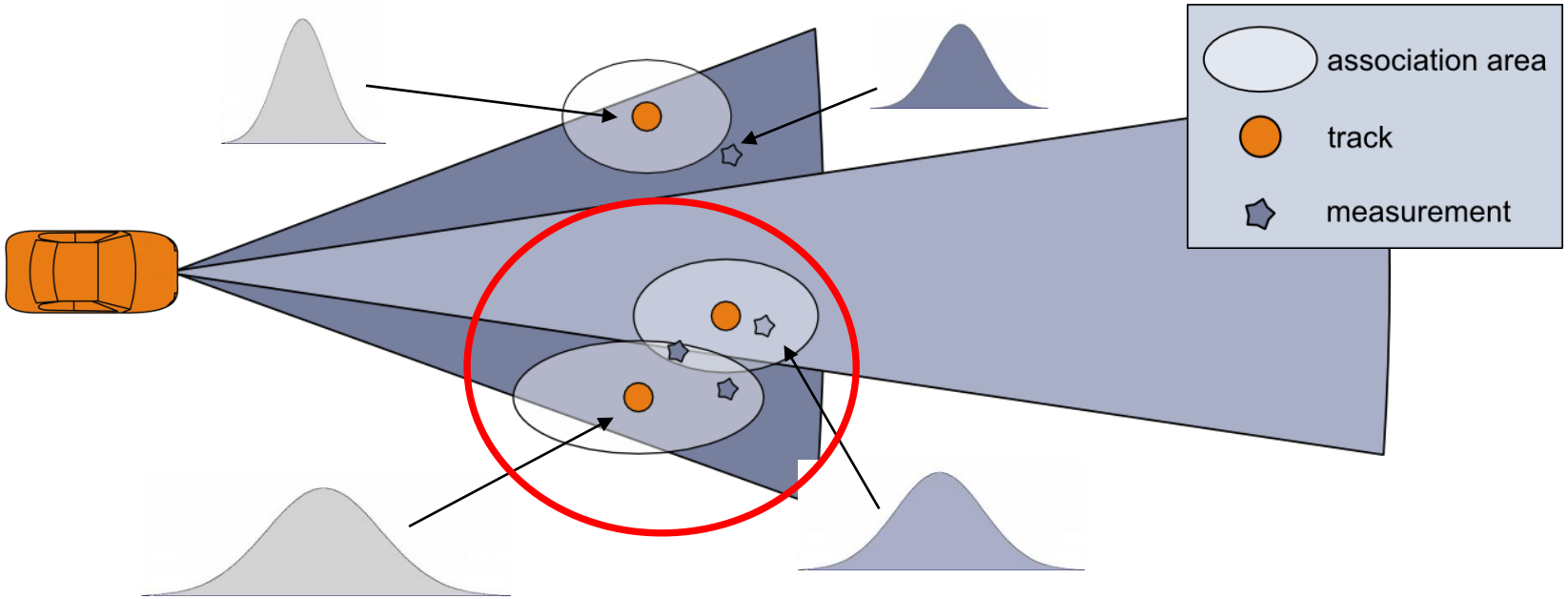
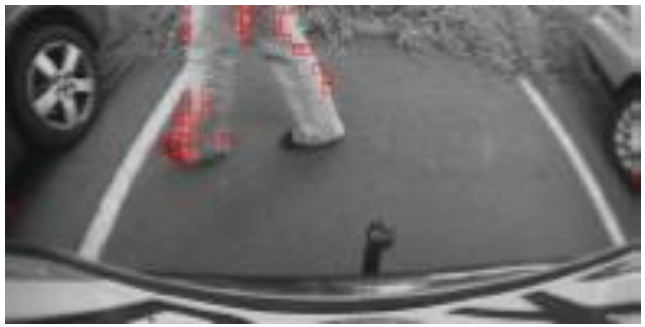
Sensor fusion of radar and camera



- Modeling of measurements and tracks (both have some kind of variance)
- Association of measurements to existing tracks
- Solving of conflict situations

HAD – High Level Functionality
Perception - Image Processing



Range

- Short and long range (0 – 70m)
- Front-, Side- and RearView
- ROI adaptable to speed
- Lane parameter (number)
- Vehicle position in lane

Object and obstacle

- Position
- Size
- Speed and Moving direction
- Classification

HAD – High Level Functionality
Lateral control

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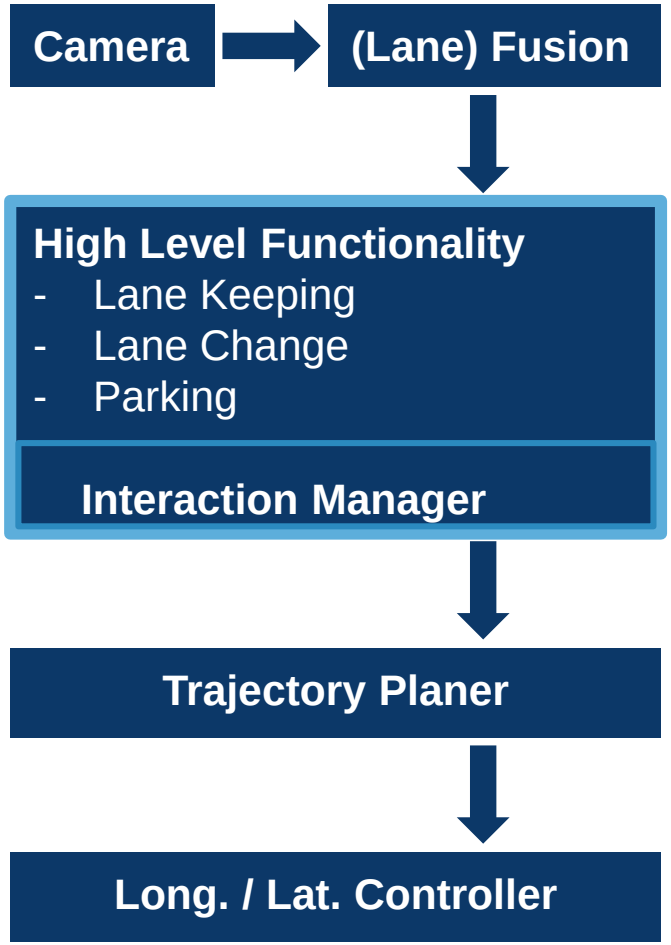

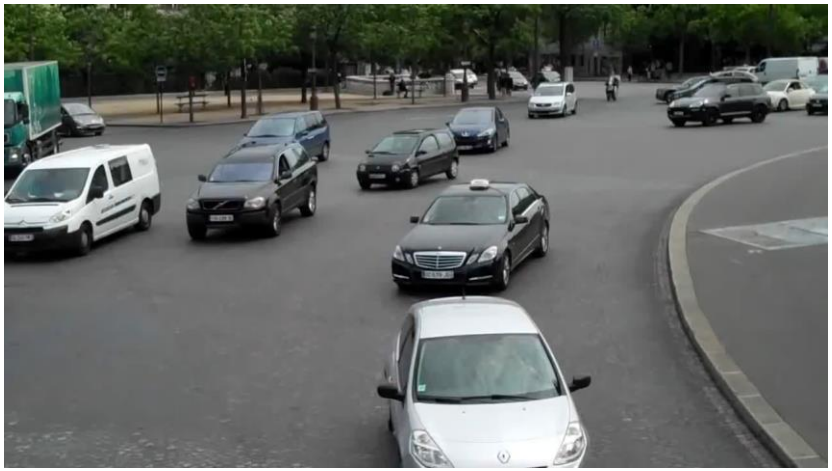

>> Well approach exist
>> Some expansions are needed

HAD – High Level Functionality
… Inspirations …

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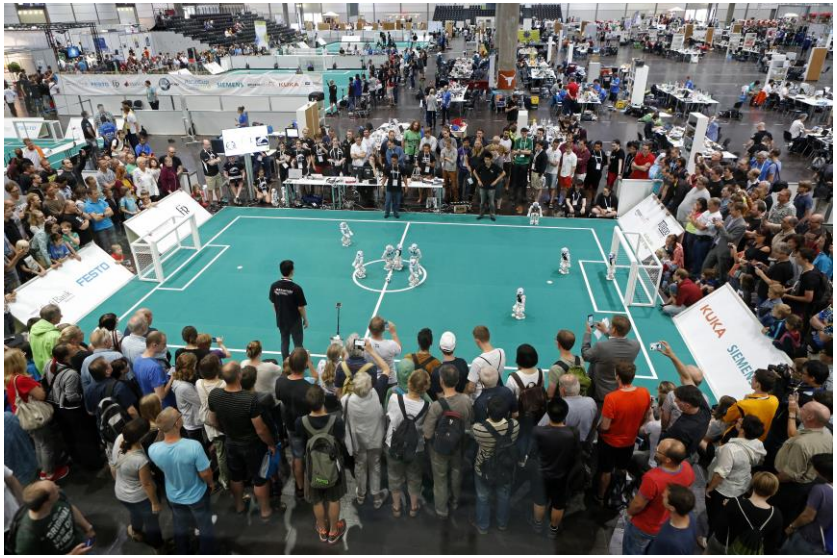

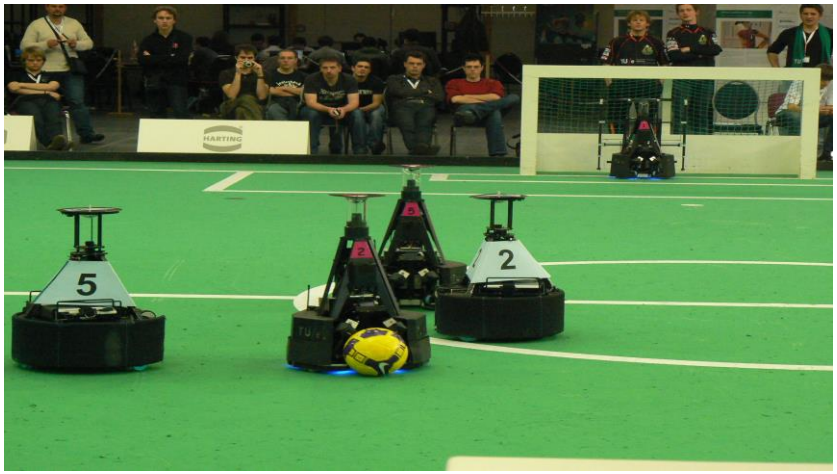

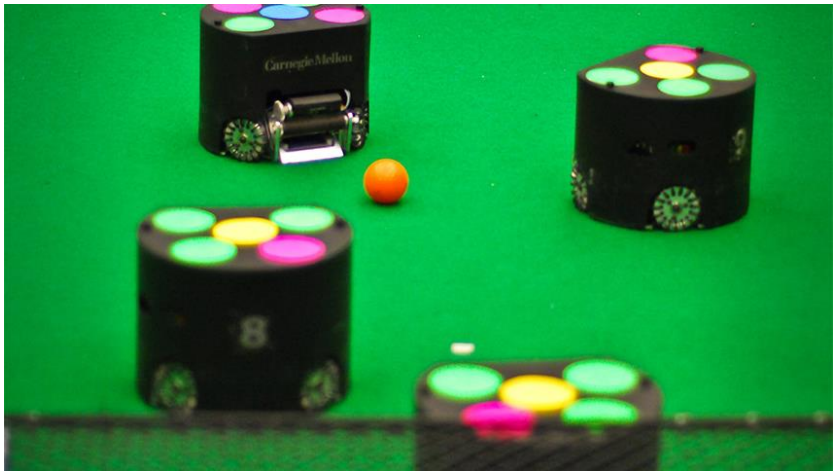

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HAD – **Controller Functionality**

Advanced Driver Assistance Systems & Active Safety

HAD – Controller Functionality
Implementation Concept

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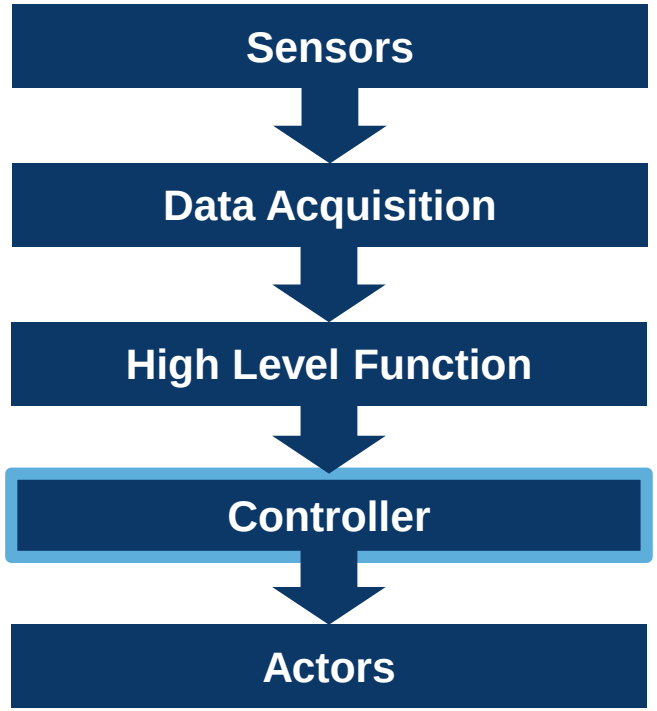
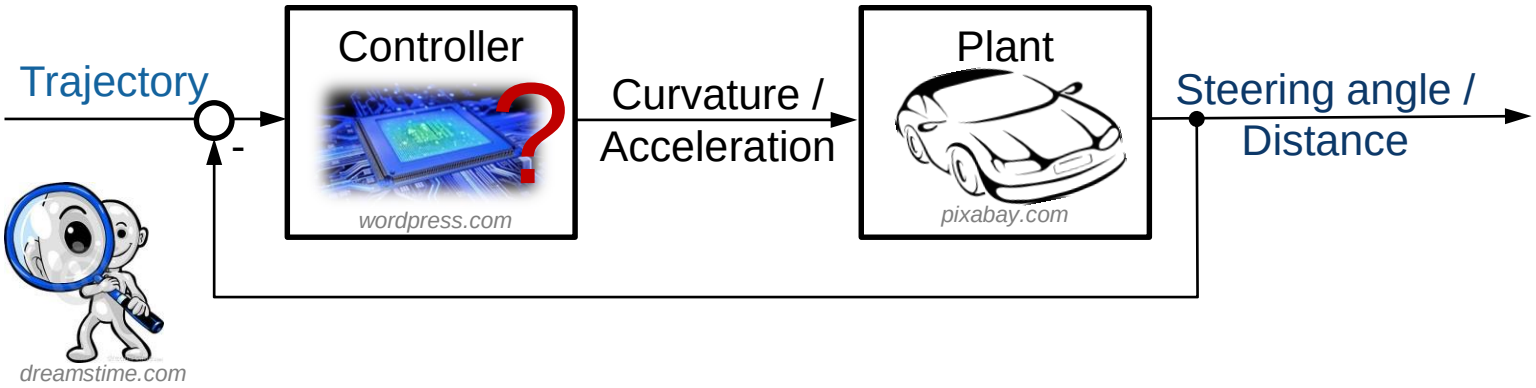
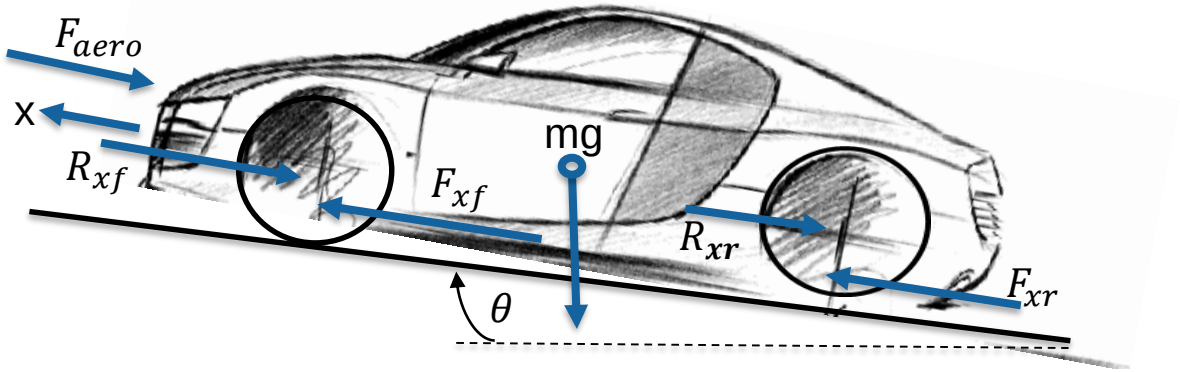


Controller
Find a sufficient control approach

A: Looking through a hole in the vehicle floor
B: Has a system model and is looking forward



HAD – Controller Functionality
Long. dynamic model

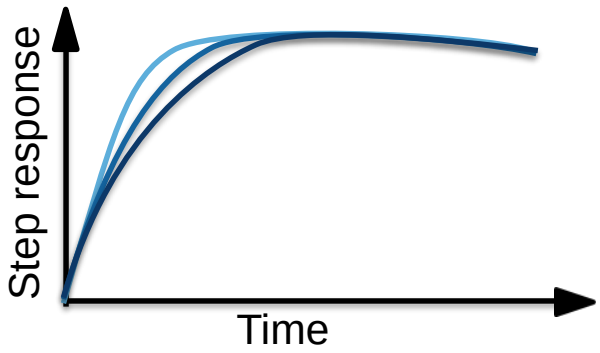


A force balance along the vehicle longitudinal axis yields

$$m\ddot{x} = F_{xf} + F_{xr} - F_{aero} - R_{xf} - R_{xr} - mg\sin(\theta)$$

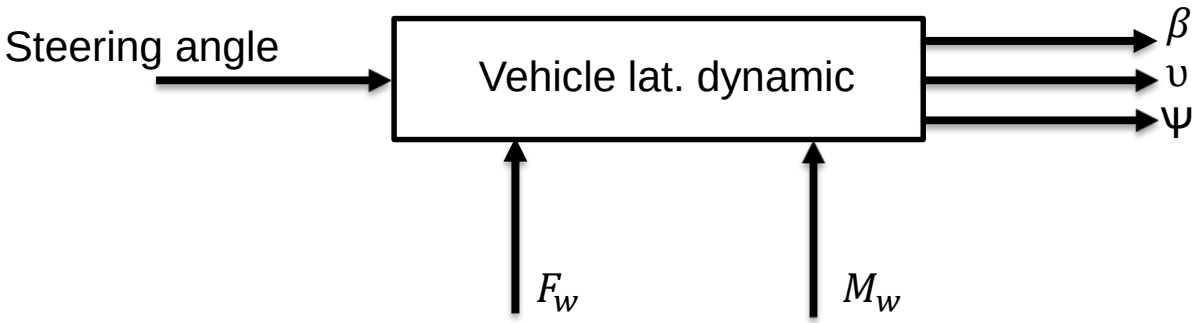
where

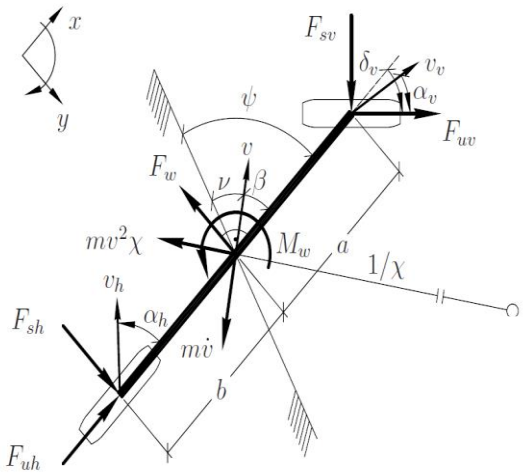
F_{xf}	longitudinal tire force at the front tires
F_{xr}	longitudinal tire force at the rire tires
F_{aero}	equivalent longitudinal aerodynamic drag force
R_{xf}	force due to rolling resistance at the front tires
R_{xr}	force due rolling resistance at the rire tires
m	mass of the vehicle
g	acceleration due to gravity
θ	angle of inclination of the road on which the vehicle is travelling



Different system behaviors for different vehicle speed

HAD – Controller Functionality
Lat. dynamic model





The forces in the direction of the vehicle longitudinal axis provides

$$F_{uh} + F_{uv}\cos\delta_\upsilon - F_{sv}\sin\delta_\upsilon = m\upsilon^2\,\chi\sin\beta + m\dot{\upsilon}\cos\beta$$

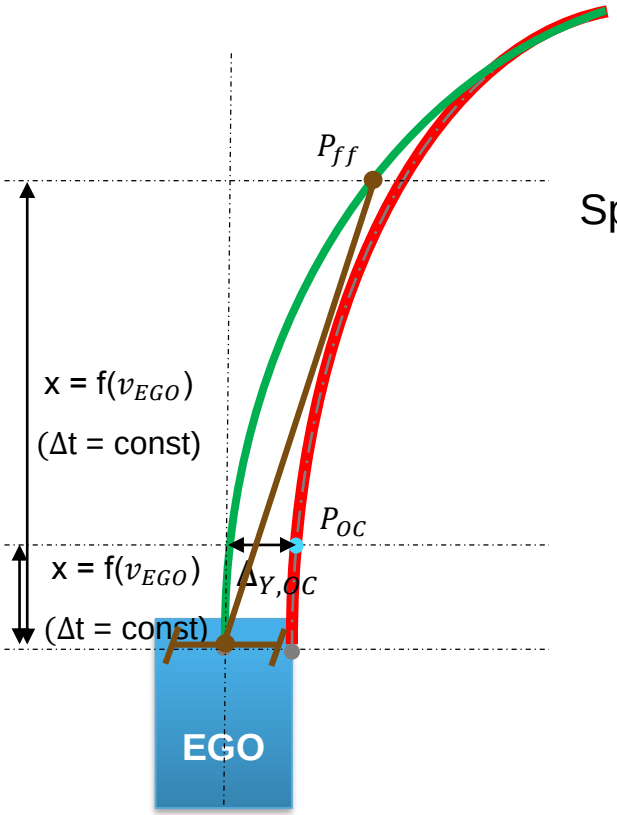
and in the direction of the vehicle transverse axis

$$F_{sh} + F_{uv}\sin\delta_v + F_{sv}\cos\delta_v - F_w = mv^2\,\chi\cos\beta - m\dot{v}\sin\beta.$$

The windpower becomes perpendicular to the vehicle axis. The torque rate in terms of the high axle through the main emphasis provides

$$F_{sv}a\cos\delta_v + F_{uv}a\sin\delta_v = \theta\ddot{\Psi} + M_w + F_{sh}b.$$

HAD – Controller Functionality
Lateral Control



Speed depending length of drawbar

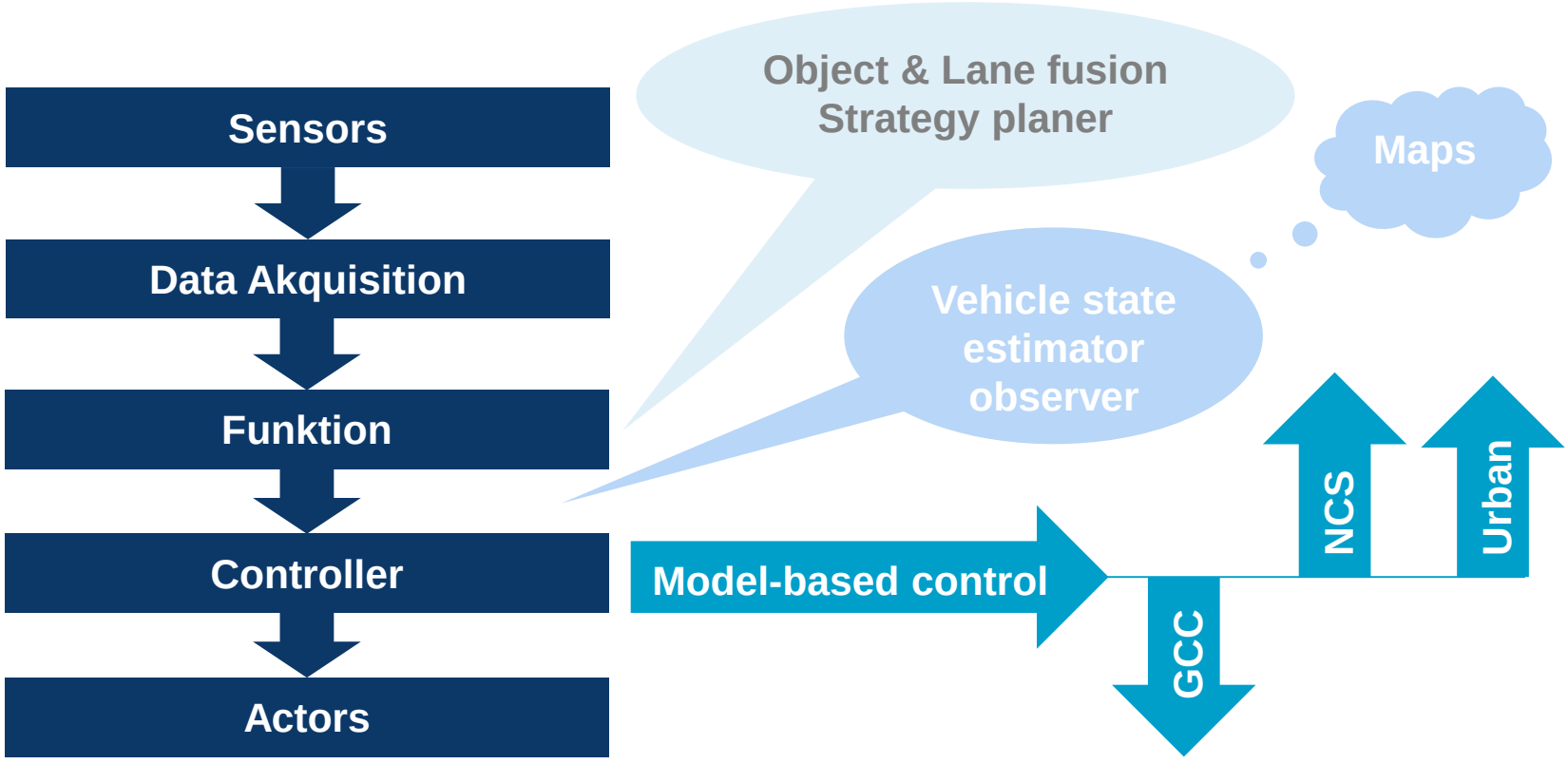
Offset controller: with speed depending preview length (constant timegap to P_{oc})

- input: offset of P_{oc} to reference curve

Goal:

- offset compensation
- compensation of disturbances

Conclusion/Outline



Thank You

Frank.Schroedel@iav.de

We want YOU!

automotive engineering iav

We offer:

- International environment
- Sophisticated and pioneering tasks with enough space for own ideas
- Flat hierarchies
- Flexible working hours
- Team-orientied work
- Autonomus and independant work in the team
- Assisting in developement projects
- Interships, thesis and graduation work

We want YOU!
Career page

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Jetzt einsteigen und Fahrt aufnehmen

Starten Sie durch bei IAV, dem Partner für Automotive Engineering. Wir setzen im doppelten Sinne auf Innovationen der neusten Generation: Engagierte Menschen, die sich als Engineering-Experte profilieren wollen, erhalten in unserem Unternehmen ein Zuhause. Zusammen entwickeln wir die Fahrzeuge von morgen. Mit Leidenschaft und Know-how. Informieren Sie sich hier über Ihre persönlichen Einstiegsmöglichkeiten und Karrierechancen.

Berufserfahrene

Zusammen mit ihren Teams stehen unsere erfahrenen Mitarbeiter für langjährig gewachsene Kompetenz auf allen Ebenen. Unsere Führungskräfte haben eine Menge zu erzählen – lassen Sie sich begeistern.

› offene Stellen (155)

Nachwuchskräfte

Erste Berufserfahrung und volles Engagement: Unsere Nachwuchskräfte können aus einer Vielzahl an Stellenprofilen wählen – und ihren Traumberuf finden. Lassen Sie sich aus erster Hand überzeugen.

› offene Stellen (142)

Studenten

Interesse an einem Praktikum, bei dem es nicht ums "Kaffeekochen", sondern um Autos geht? Dann sind Sie richtig bei IAV. Denn persönliche Eindrücke sagen mehr als tausend Worte. Erfahren Sie hier, was alles möglich ist bei uns.

› Stud. Mitarbeit (52) › Fachpraktikum (66) › Abschlussarbeit (84)

Auszubildende

Wir tun heute etwas für unsere Experten von morgen. Unseren Auszubildenden bieten wir einen spannenden und praxisnahen Einstieg in das Berufsleben. Aber machen Sie sich doch selbst ein Bild.

› offene Stellen (10)

IAV Stellenmarkt

Alle Berufsgruppen

Alle Berufsfelder

Alle Standorte

Stellen suchen »

583
Jobs an 25 Standorten

Initiativbewerbung

Die passende Ausschreibung ist für Sie nicht dabei? Bewerben Sie sich initiativ und teilen Sie uns Ihr Profil und Ihre Vorstellung mit.

› **Online-Bewerbung**

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