UNICAR*agil*

Disruptive Modular Architecture for Agile Automated Vehicle Concepts

Modulares Fahrzeugkonzept im Projekt UNICAR*agil*

Ulm/Stuttgart, 30.09.2020

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und Forschung

AGENDA

- Overall Concept
- Geometric Modularity
- Software Modularity
- Safety Concept
- Verification and Validation
- Summary

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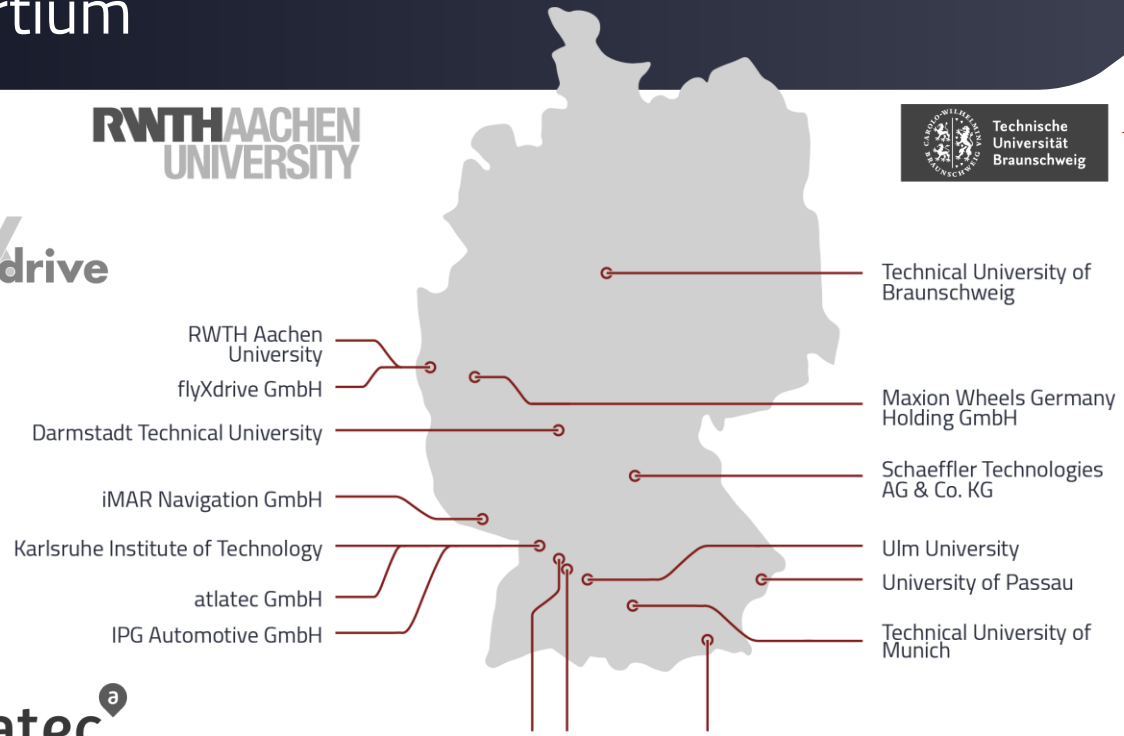
The Consortium



Introduction

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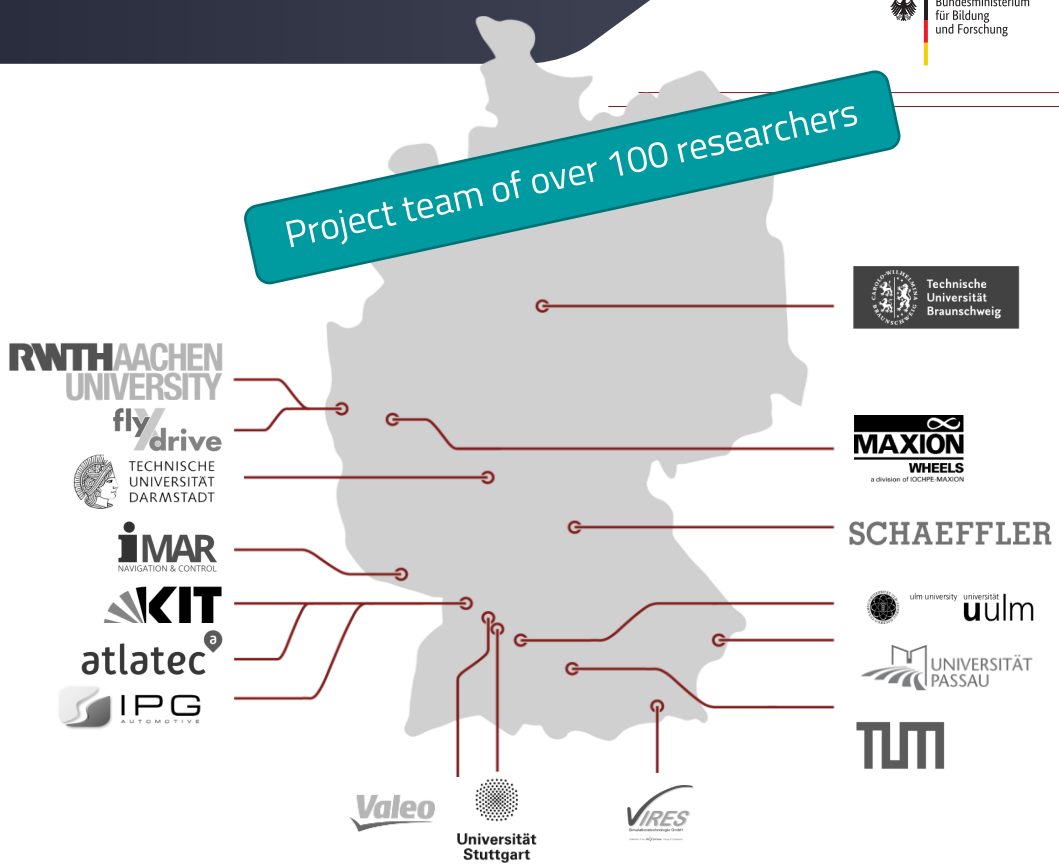
OBJECTIVE

1. Modular structures for agile, automated vehicle concepts
2. Disruptive concepts in hardware and software architecture
3. Modular platform with dynamic modules
4. Fully automated and driverless vehicles
5. Four prototypes of different characteristics

KEYFACTS

- ca. 26 Mio. € BMBF funding
- 01.02.2018 – 31.01.2022 (48 months)
- 16 university chairs / institutes
  8 industrial partners



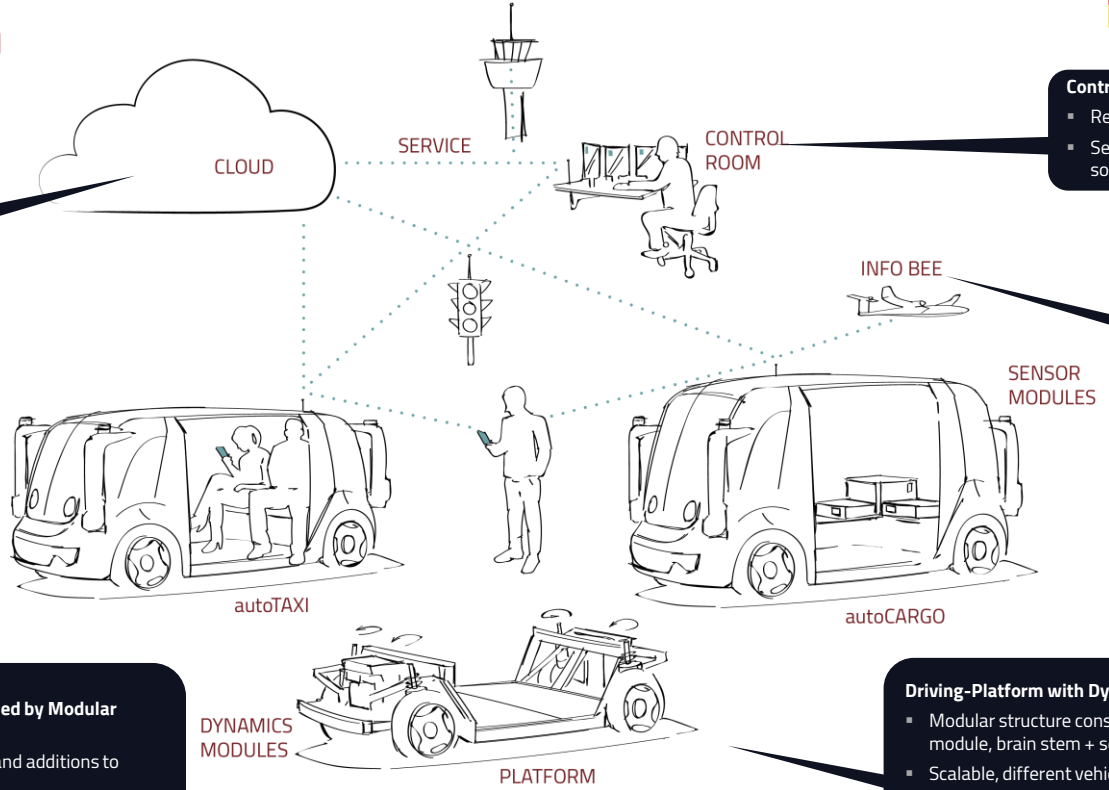
Overall System

Cloud Functionality
- Additional information for automated driving function
- Collective environment model
- Collective traffic memory

Control Room
- Remote vehicle operation
- Service center, e.g. for emergencies or sovereign interventions

Intelligent Infrastructure
- Minimal stationary sensors
- Dynamic supplement through sensor cluster = drones

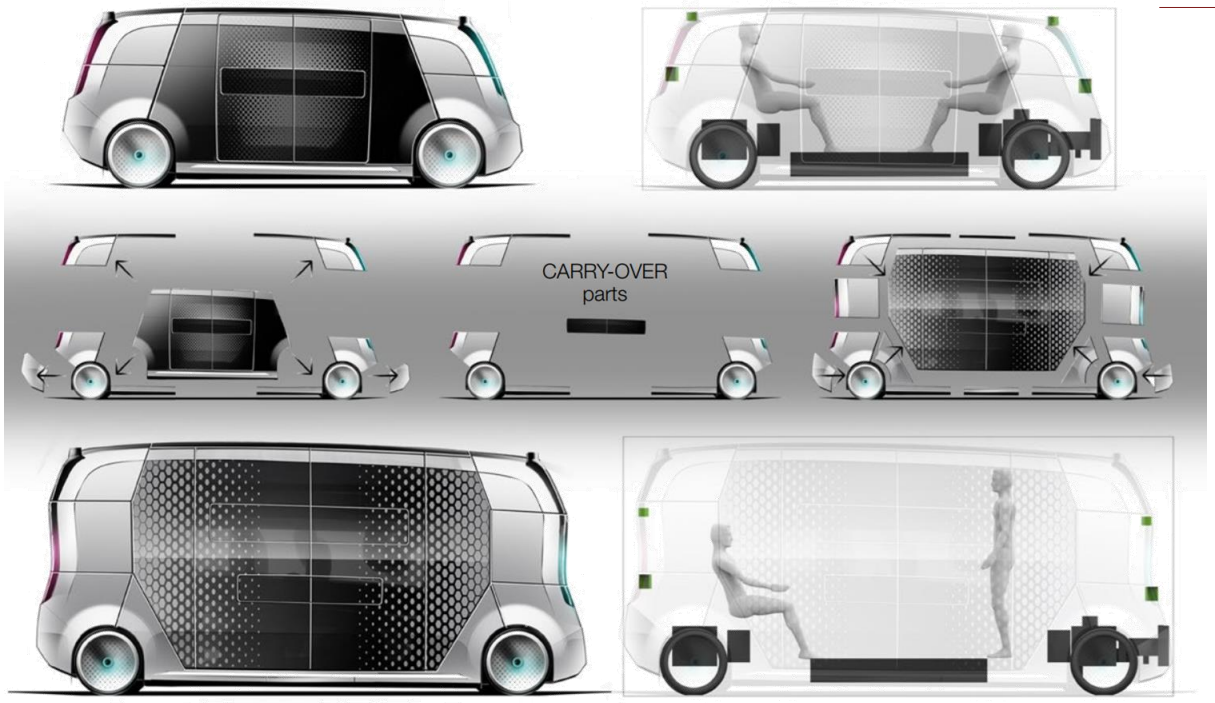
Sensor Modules
- Identical integration for all vehicle variants
- Fail-operational due to 3 physical sensor principles
- Provides environment information as a service



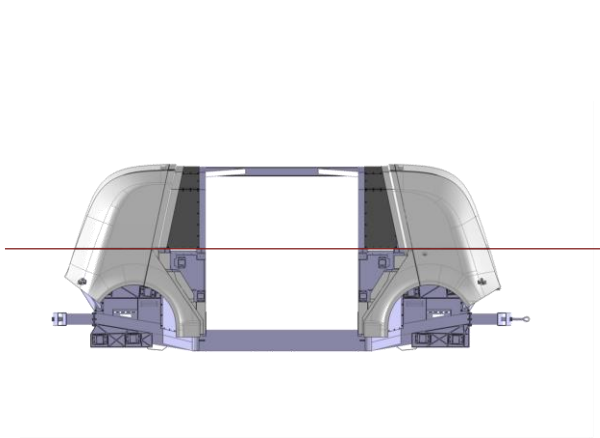
Four Fully Automated and Driverless Vehicles Enabled by Modular Information Processing
- Service-oriented SW architecture allows updates and additions to secure modules
- Vehicle fully functional without external Information

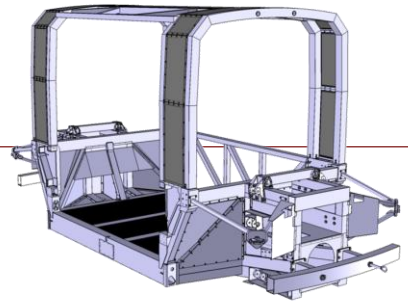
Driving-Platform with Dynamics Modules
- Modular structure consisting of 4 dynamic modules, energy module, brain stem + self-awareness
- Scalable, different vehicle sizes can be displayed
- Electric (48 Volt) and functionally safe

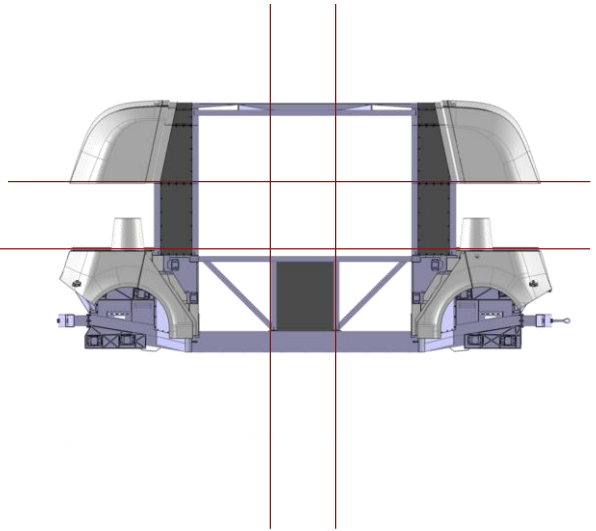
Modular Geometric Architecture



Modular Geometric Architecture







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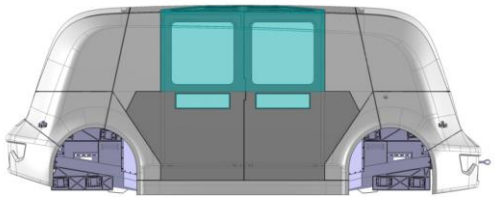
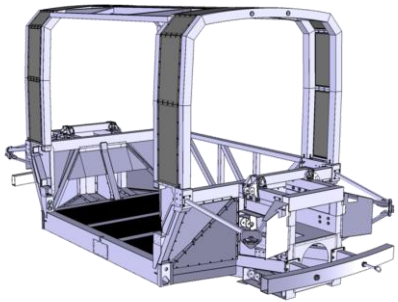
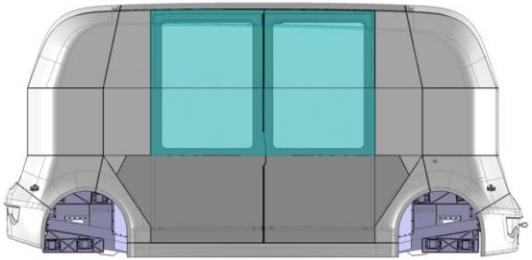
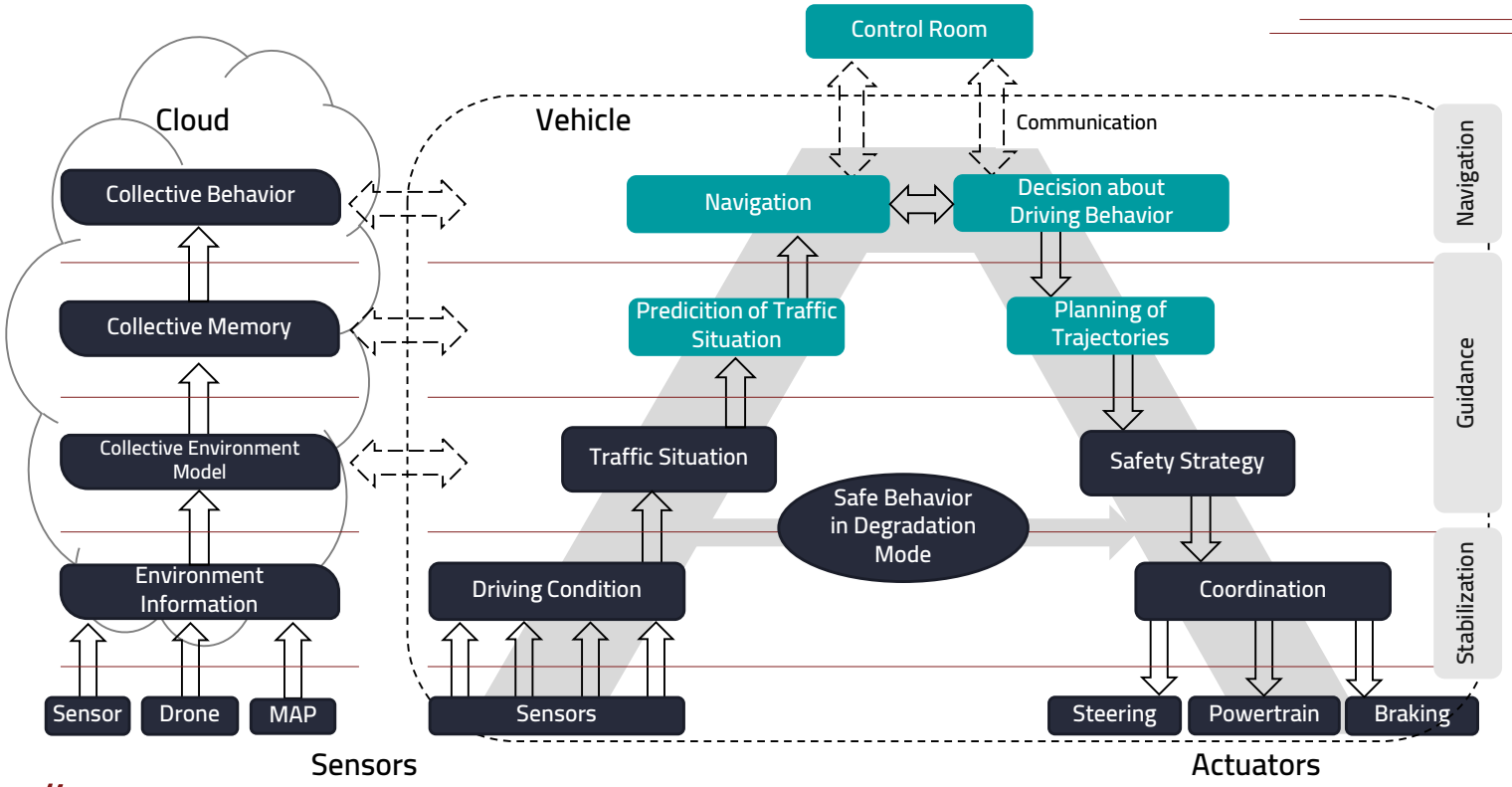






Modular Geometric Architecture

Functional Architecture



ASOA - Automotive Service Oriented Software Archi

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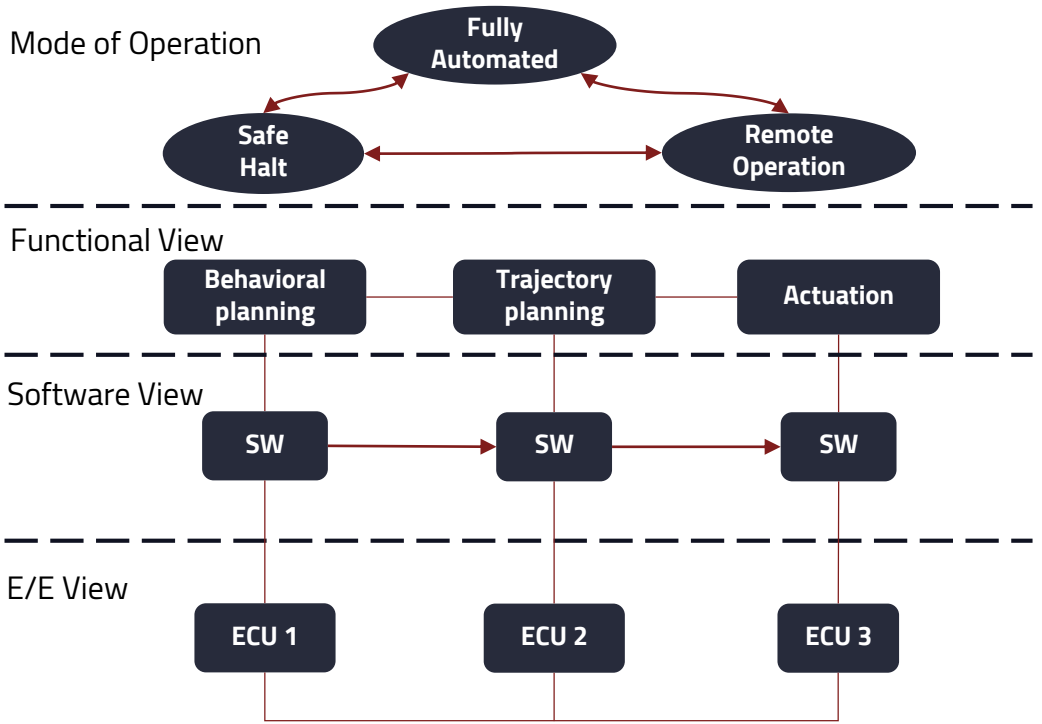
Classic Approach

- SW integrated at design-time
- Hard to update, repurpose, replace

ASOA

- SW integrated at run-time
- Machine interpretable service specification
- Easy to repurpose, update, replace
- Transparent implementation across various computer platforms



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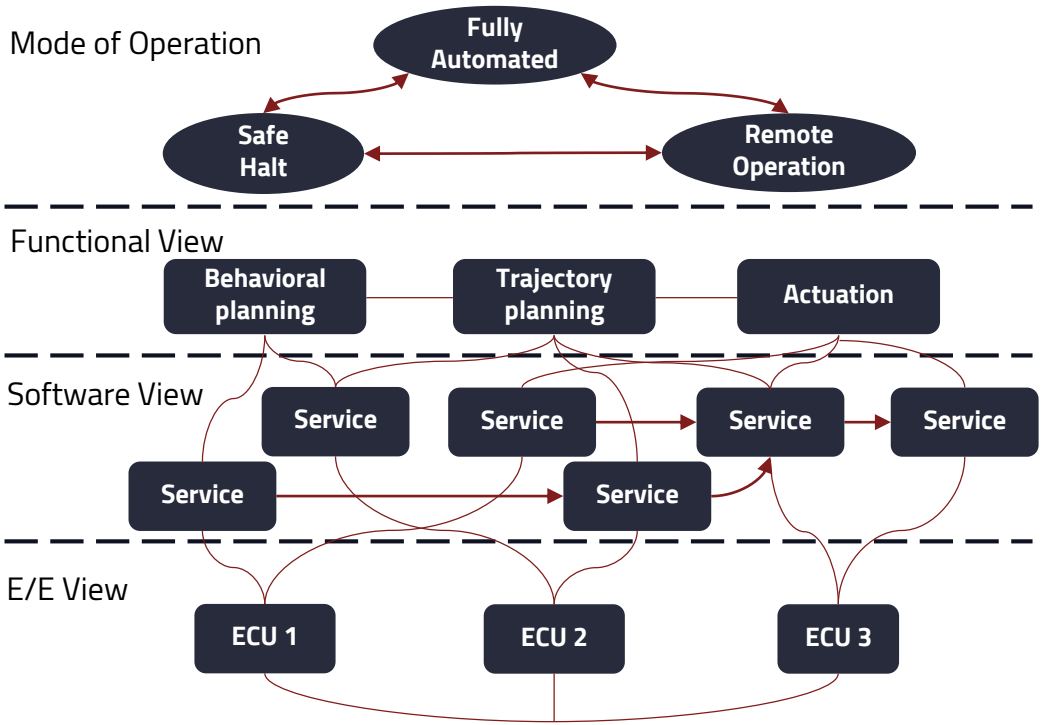

ASOA - Automotive Service Oriented Software Architecture

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Example: Motion Control

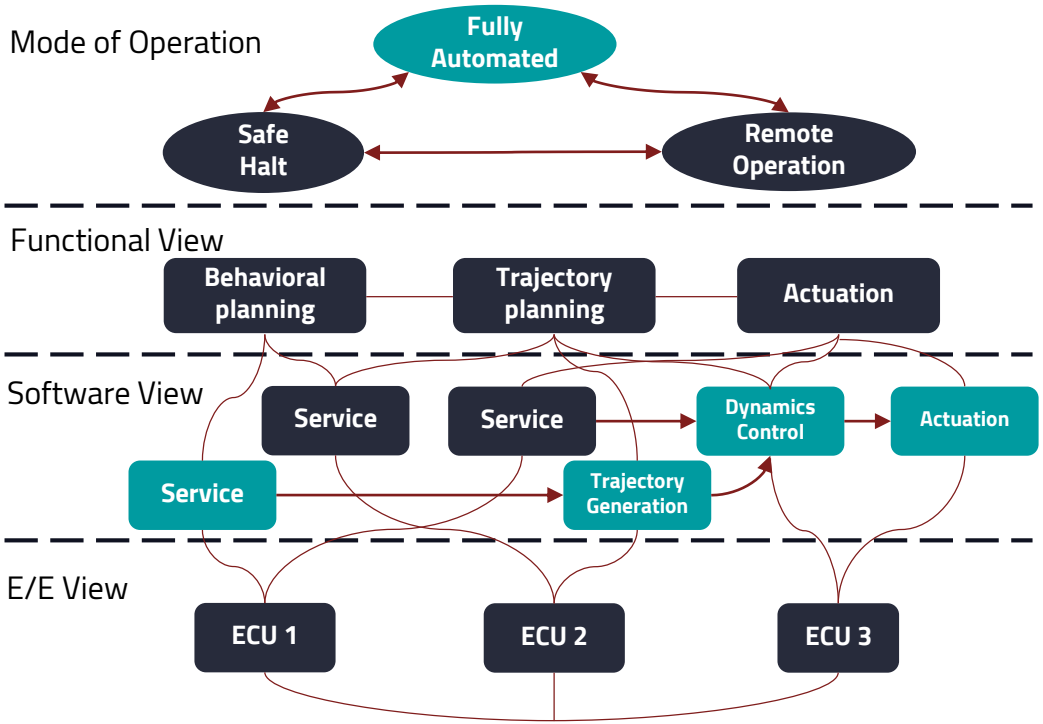
Vehicle Dynamics State Estimation

- High demands on availability and accuracy
- Two dissimilar multi-sensor data fusion setups

Vehicle Dynamics Control

- 3-DoF motion control: x,y,ψ
- High over-actuation

→ New possibilities in vehicle's driving dynamics design



ASOA - Automotive Service Oriented Software Architecture

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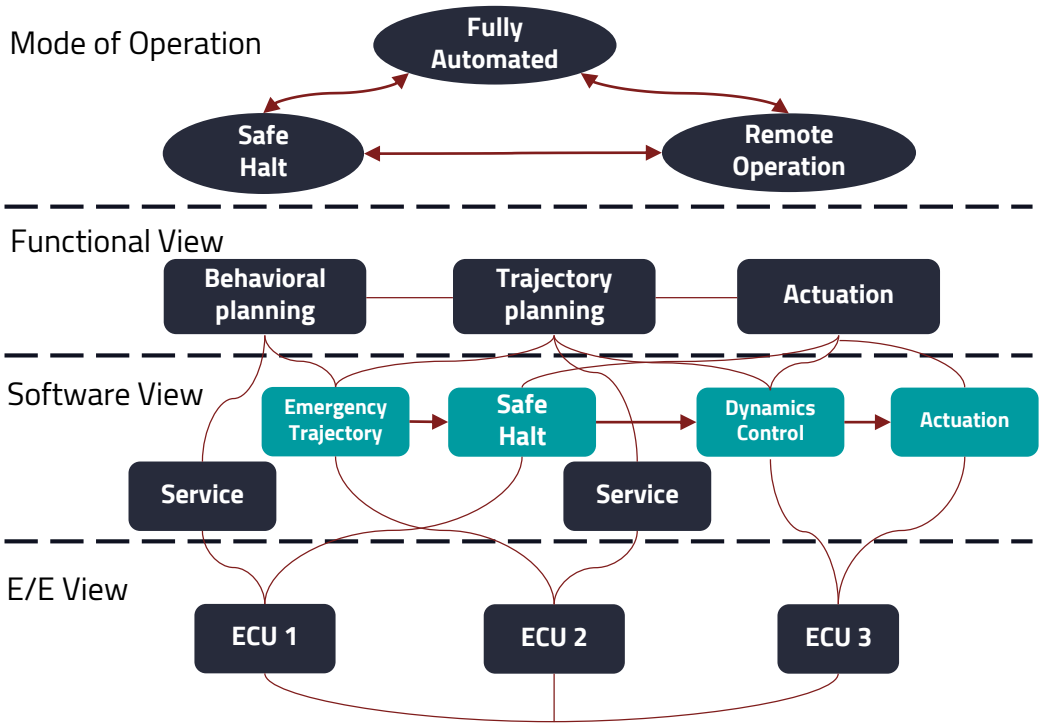
Example: Safe Halt

- Capable to transfer the vehicle into a risk-minimal state
- Additional sensors to check the free space
- Separate emergency trajectory



Mechatronic Architecture

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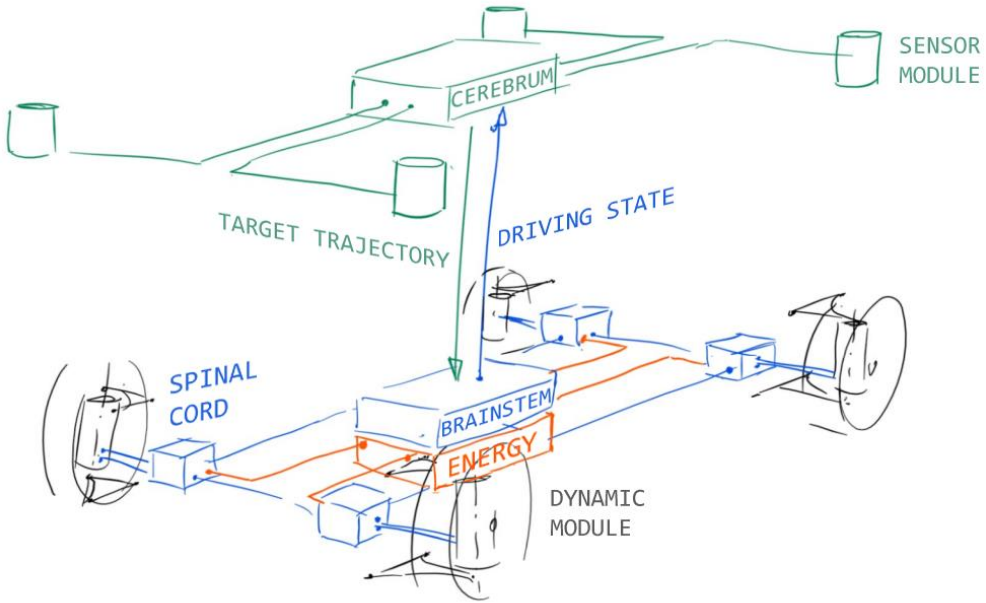

"Brain" Structure

"Cerebrum":
- Environment representation
- Behavior and trajectory planning

"Brainstem":
- Realization of desired trajectory
- Safety ECU
- Dedicated HW developed

"Spinal Cord":
- Steering angle and drive control
- Fallback in case of "Brainstem" failure

SAFETY – Key Property of Automated Vehicles

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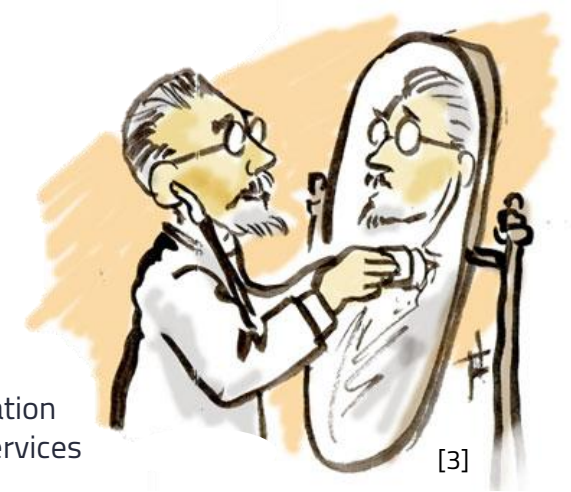
Self-Awareness

No Human Driver to Monitor Vehicle Health and Behavior

➔ Vehicle needs to become aware of its current capabilities

➔ Self-perception & self-representation as key safety feature

- Self-Perception
  - Software & hardware components provide information about their current quality of service, also including security aspects
- Self-Representation
  - Aggregation of all quality of service information into a holistic representation
  - Provides this information of the vehicle's current capabilities for other services
  - Vehicle behavior can be adapted to its current capabilities


[3]

[3] travelingboy.com

Verification and Validation

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Safety approval by test drives for an autonomous vehicle requires billions of test kilometers[4], for each revision

„Approval Trap“ [4]

High System Complexity

Real World Complexity

Modular Safety Approval

Categorization of the Road Network

[4] Wachenfeld and Winner, 2016. The Release of Autonomous Vehicles. In: Winner et al. Autonomous Driving.

Verification and Validation

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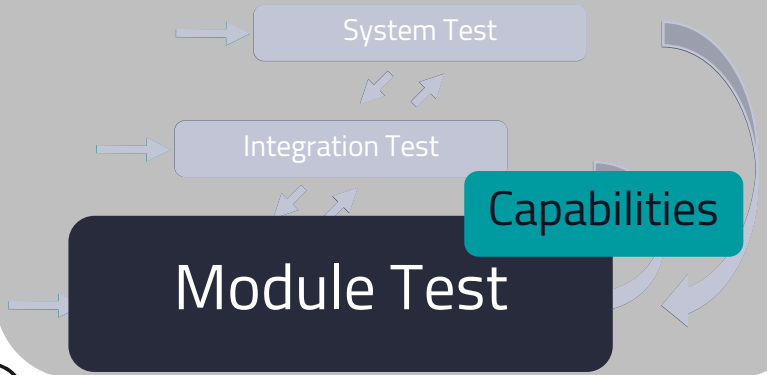
Modular Safety Approval

- More control of the parameter space
- Changes of one module shall not require verification of other modules



Approved ?

Categorization of the Road Network

- Segments of different requirements
- Safety approval for each category
- Verification of the required capabilities for segment categories

Summary

- Modularity in different research domains
- Geometric Modularity Allowing for Equal Parts in Different Vehicle Sizes
- Software Modularity by Service-oriented Architecture
- Safety for Supervision of Modulare Services
- Modular Verification and Validation Allowing for Easier Updates
- Realization in Four Prototype Vehicles

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Thank you for your attention.

Any Questions?

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