UNICAR agil
Disruptive Modular Architecture for Agile, Automated Vehicle Concepts
The UNICAR agil Project

KEYFACTS
ca. 32 Mio. € BMBF funding
01.02.2018 – 31.05.2023 (64 months)
15 university chairs / institutes
8 industrial partners

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
The Consortium

RWTH Aachen University
flyXdrive GmbH
Darmstadt Technical University
iMAR Navigation GmbH
Karlsruhe Institute of Technology
atlatec GmbH
IPG Automotive GmbH

Valeo Schalter und Sensoren GmbH
University of Stuttgart
VIRES Simulationstechnologie GmbH

Technical University of Braunschweig
Maxion Wheels Germany Holding GmbH
Schaeffler Technologies AG & Co. KG
Ulm University
University of Passau
Technical University of Munich
Core Innovations

User-centered Design Approach

Consequent Modularization

Innovative Electronics System Hardware Architecture

Automotive Service-oriented Software Architecture

Collective Cloud Functions

Safety by Design
Our user-centered design approach focusses on the human being as the center for future mobility system development.
Modular Driving Platform with Dynamics Modules
use cases derived from human needs

four Vehicles built up

fully self driving

connected and driverless
• Supplementing the public transport system
• 6 – 8 persons

• Order, open, interact with CE device
• Cooperative and agile

• Private „Butler / Nanny“
• Private, individual, accessible & trustworthy

• Pick up and delivery service
• Automated handover
Consequent modularization creates flexibility in the usage of automated vehicles.
Modular Driving Platform with Dynamics Modules

- scalable in length
- 4 Individual Dynamics Modules
- 48 V energy supply
- redundant platform sensors
Add-On and Sensor Modules

- Add-on modules scalable in height
- Different use-cases possible
- Sensor modules as carry over part
- Sensor modules combine three different sensor principles
  - Sensor modules fail-operational environment perception
Our innovative electronics system hardware architecture enables the implementation of efficient and safe ECUs.
Mechatronic Architecture
The automotive service-oriented software architecture (ASOA) is the basis for upgradeable and updatable software for automated mobility.
ASOA - Automotive Service Oriented Software Architecture

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

Mode of Operation
- Fully Automated
- Safe Halt
- Remote Operation

Functional View
- Behavioral planning
- Trajectory planning
- Actuation

Software View
- SW

E/E View
- ECU 1
- ECU 2
- ECU 3
ASOA - Automotive Service Oriented Software Architecture

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

Flowchart:
- Mode of Operation:
  - Fully Automated
  - Safe Halt
  - Remote Operation

- Functional View:
  - Behavioral planning
  - Trajectory planning
  - Actuation

- Software View:
  - Service

- E/E View:
  - ECU 1
  - ECU 2
  - ECU 3
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

Mode of Operation
- Safe Halt
- Remote Operation
- Fully Automated

Functional View
- Behavioral planning
- Trajectory planning
- Actuation

Software View
- Service
- Dynamics Control
- Actuation
- Trajectory Generation

E/E View
- ECU 1
- ECU 2
- ECU 3
Example: Safe Halt

- Capable to transfer the vehicle into a risk-minimal state
- Additional sensors to check the free space
- Separate emergency trajectory
Cooperative and collective cloud functions and an accompanying control room support the vehicle automation.
Remote or trajectory approval vehicle operation

Service center for emergencies or sovereign interventions
Additional information for automated driving function

**Collective Environment Model**

**Collective Traffic Memory**
minimal stationary sensors

dynamic supplement through flying sensor cluster = drones

Info Bee gathers environment data
Safety and Security by Design

Consistent safety orientation enables the development of safe autonomous vehicles from idea to approval.
SAFETY – Key Property of Automated Vehicles

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
IT - Security

Objectives

- Authentication of communication ➔ Avoid manipulation of network traffic
- Mutual ECU attestation ➔ Avoid manipulation of ECU software
- Secure storage of cryptographic keys ➔ Avoid theft of cryptographic keys
- Runtime security measures ➔ Detect attacks on runtime
- Secure over-the-air ECU updates ➔ Enable software updates in a secure way
- Privacy protection ➔ Avoid passenger tracking

Challenges

- Low impact on latencies and transparent integration
- Security-safety concept: map security issues on safety measures
Verification and Validation

Safety approval by test drives for an autonomous vehicle requires billions of test kilometers\(^4\), for each revision.

Verification and Validation

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

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

2018
- Concept Defined
- Specification Books

2019
- Module Hardware
- Digital Halftime Event

2020
- First Platform ready to drive
- Hardware Assembly
- Testing

2021
- IEEE IV 2022
- End of Project

2022
- First vehicle in automated operation
- IAA Transportation 2022

2023
- www.unicaragil.de
Contact

Overall Coordinator:
Univ.-Prof. Dr.-Ing Lutz Eckstein
lutz.eckstein@ika-rwth-aachen.de

Project Manager:
Timo Woopen, M.Sc.
timo.woopen@ika-rwth-aachen.de