Ko-HAF
KOOPERATIVES
HOCHAUTOMATISIERTES FAHREN





Development of Automated Driving Functions

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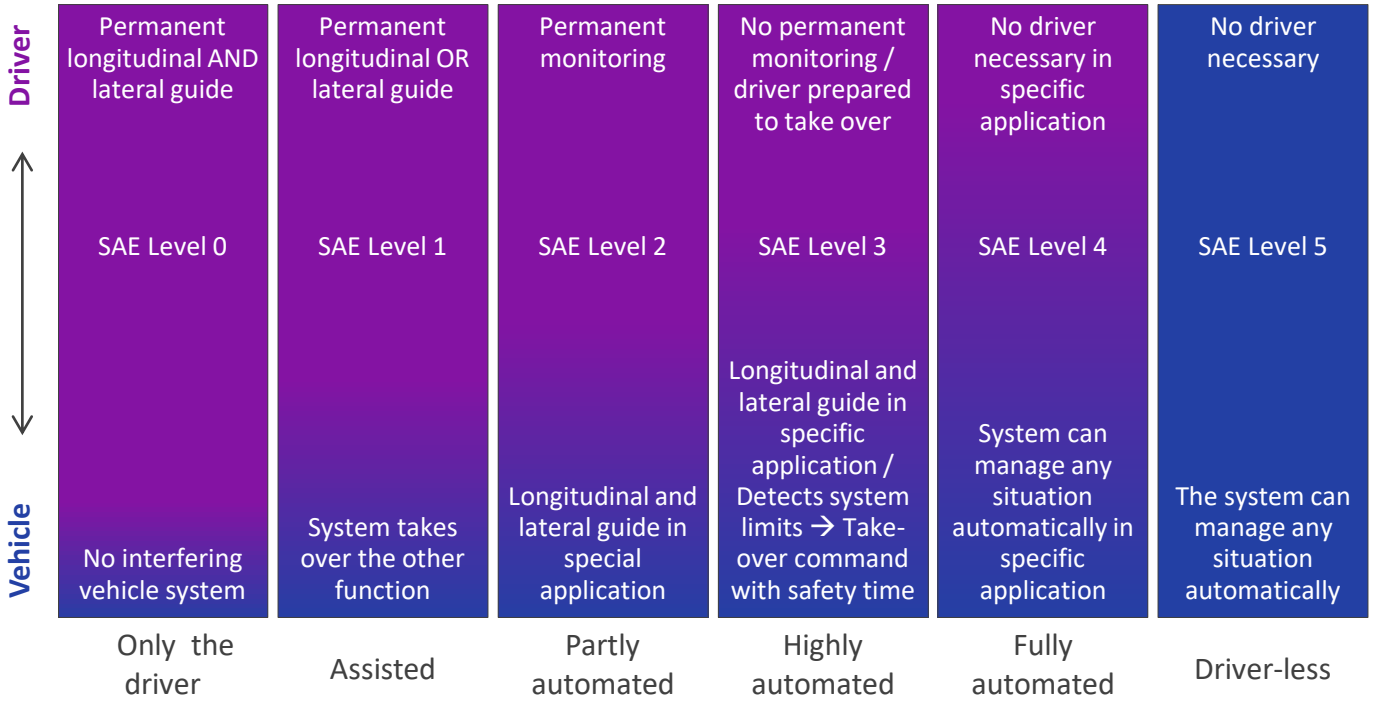
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Outline

- Highly automated driving (SAE Level 3)
- Development of driving functions
- Scenarios and demo rides on test track

Levels of Automated Driving



Source: Verband der Automobilindustrie e. V. (VDA)

SAE Level 3 – Highly Automated Driving

- Driver is prepared for take-over when systems limits occur

- Main objectives of Ko-HAF demonstrator vehicles:
  - Automated **longitudinal and lateral control** while driving
  - Watch out for **system limits**
  - Tell driver to **take over control** before system limit is reached **(HMI, WP3)**

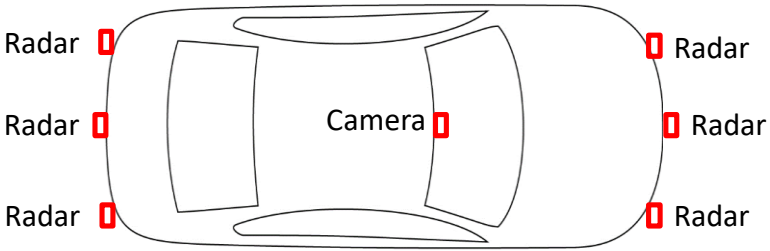
Highly Automated Driving on Highways

- Objective: Drive on **highway** from A to B with **preferred set speed** and **without collision**
- Problem: **"Obstacles"** on the road: speed limits, slower vehicles, traffic jams, road works, break-down vehicles, …
- Automated Driving Functions can be divided into 3 tasks: **Sense – Plan – Act**

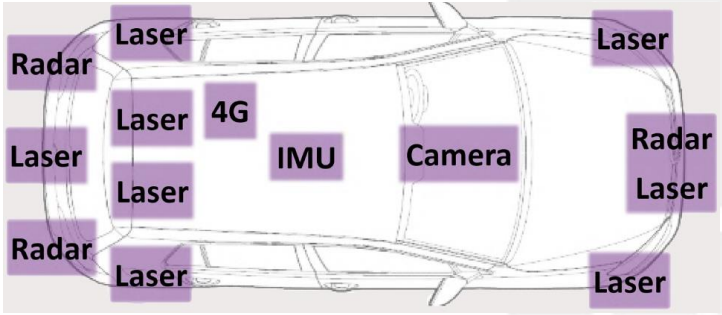
Sense – Plan – Act

- Sensors: camera, radar, lidar, …

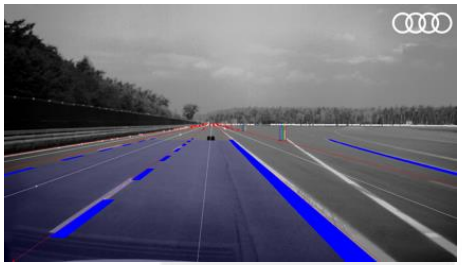
Ko-HAF Partner 1:



Ko-HAF Partner 2:



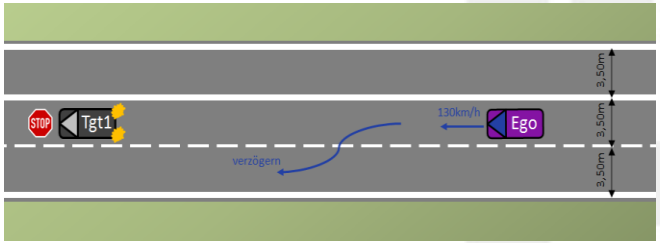
Sense – Plan – Act



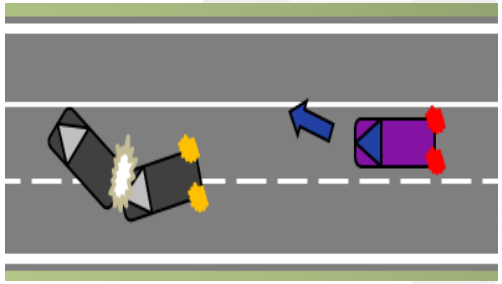
- Environmental detection:
  Lane markings, objects (static + dynamic), landmarks
- Lane markings → **lateral localization (WP2)**
- Landmarks (= e. g. traffic signs, bridges) → **longitudinal localization**
- Static objects → **road hazards** (exchange information via Safety Server, **WP1**)
- Dynamic objects (= other traffic participants) → **driving strategy**
- Gaps in neighboring lanes → maneuver planning
- **Not only sense** current environment **but also predict** future motion of dynamic objects
  → Tomorrow: Presentation on motion prediction, 12:00, **D. Augustin**, Opel

Sense – **Plan** – Act

- **Determine possible driving maneuvers**, e.g.
  - Lane Change Left, LCL
  - Lane Change Right, LCR
  - Keep Lane, KL

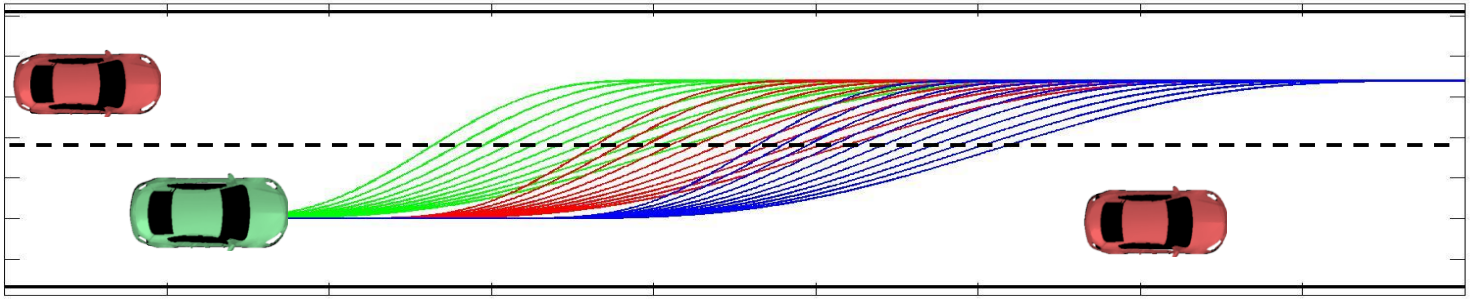


- **Decision making**
  - Cost functions
  - Low cost for legal maneuvers (e.g. changing lane)
  - High cost for illegal maneuvers (crossing solid line)
  - Very high cost for collision-afflicted maneuvers
  - → Choose maneuver with lowest cost



- **Trajectory Planning**

Trajectory = path + time information



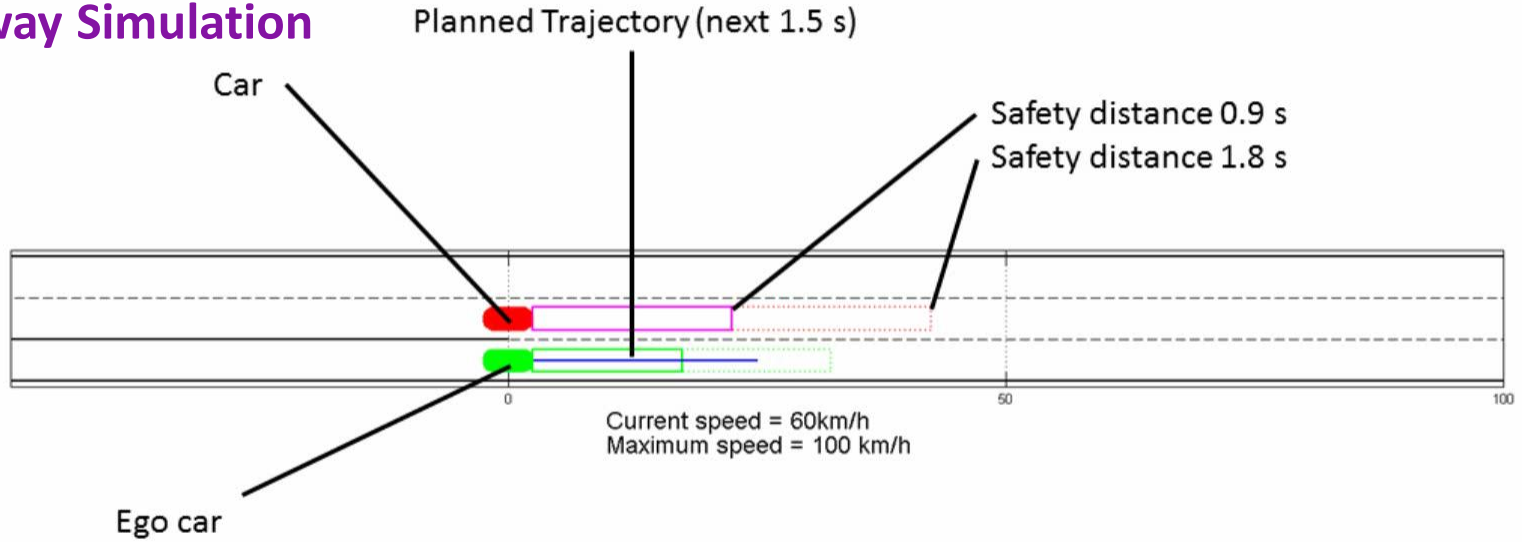
What is the best trajectory for the lane change?

Sense – **Plan** – Act

- **Trajectory Planning**
  - Calculate several trajectories
  - Calculate maximum accelerations (longitudinal and lateral)
  - Check for physical limits
  - Check for collisions with other objects
  - Include motion prediction of other traffic participants
  - Add cost function with penalty for low comfort, too small distances to neighboring vehicles, etc.
  - Choose best trajectory (with lowest cost)

→ Tomorrow: Presentation on motion planning, 12:30, **B. Reuber**, IfF

Highway Simulation



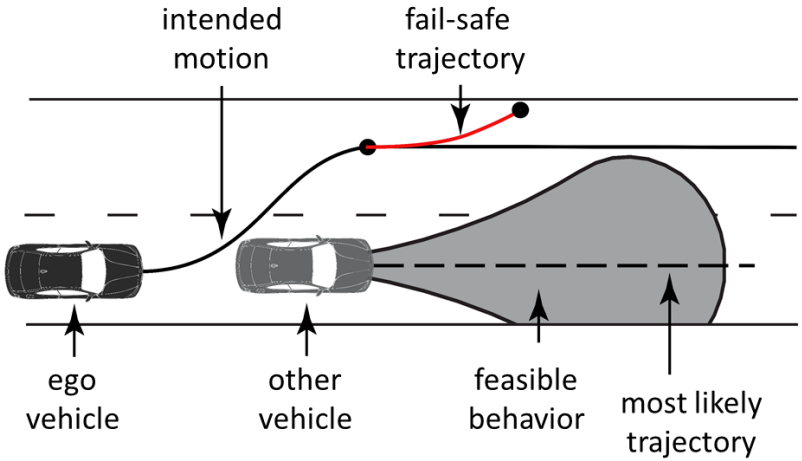
Sense – Plan – **Act**

- **Trajectory Control**
  - Control concepts for engine, steering, brake
- **Safety Concept – What to do when system failures occur?**
  - No driver reaction after take-over request
  - Sensor fault due to heavy rain, snowfall, fog
  - Digital map outdated
  - System limits reached (e.g. roadworks, accident, earthquake)
  - Unexpected motion of other traffic participants
  - → Minimal risk maneuvers, fail-safe trajectories

→ Tomorrow:
Presentation on minimal risk maneuvers, 13:00, **Th. Leonhardt**, Audi

Sense – Plan – **Act**

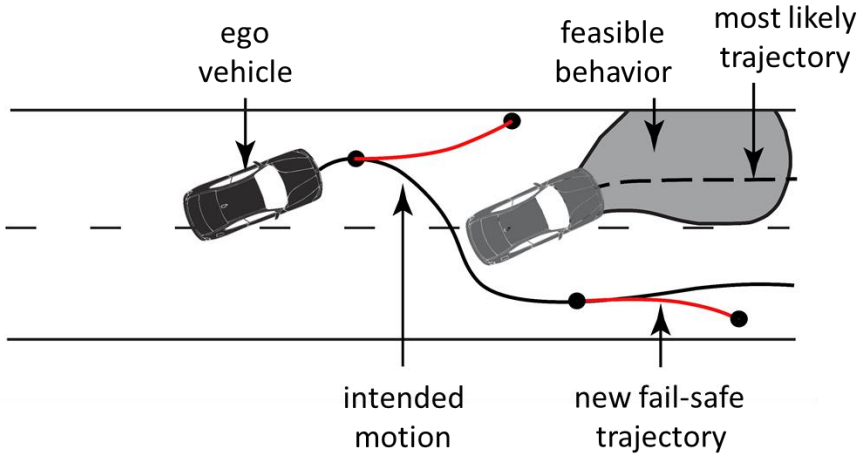
- **Fail-safe trajectories**



- Fail-safe trajectories are collision-free with respect to any feasible future behavior of obstacles
- Ensure that the ego vehicle is able to execute a fail-safe trajectory at any time

Sense – Plan – **Act**

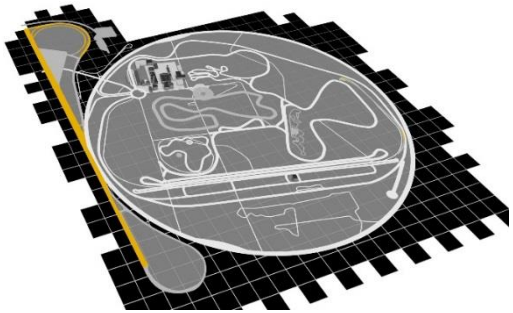
- **Fail-safe trajectories**



- When traffic participants deviate from predicted motion, the ego vehicle has two options:
  - Execute previous fail-safe trajectory
  - Find a new pair of an intended motion and fail-safe trajectory

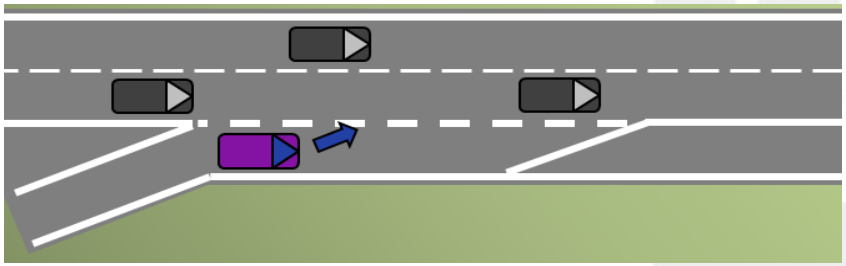
Scenarios and Demo Rides on Test Track

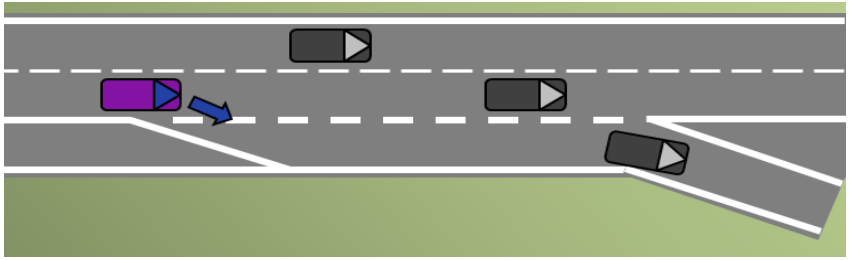
"Lange Gerade" ("Straight")



Scenario catalogue

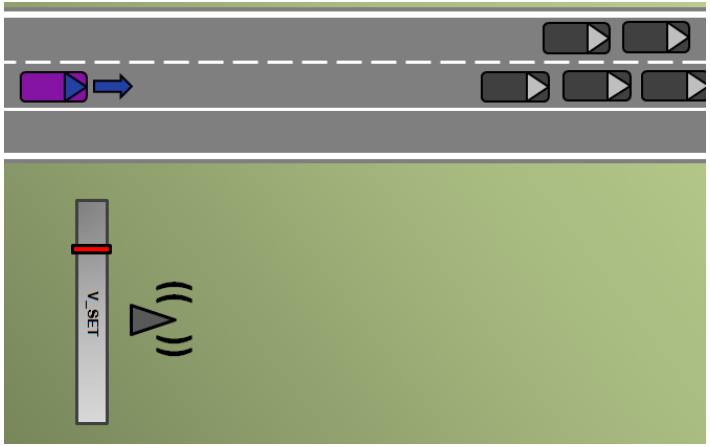
Enter highway and merge



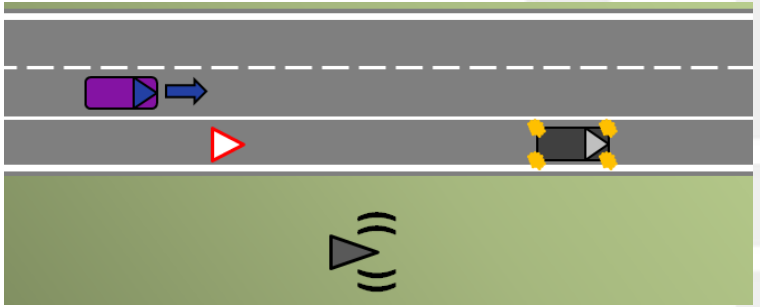


Exit highway

Scenario catalogue

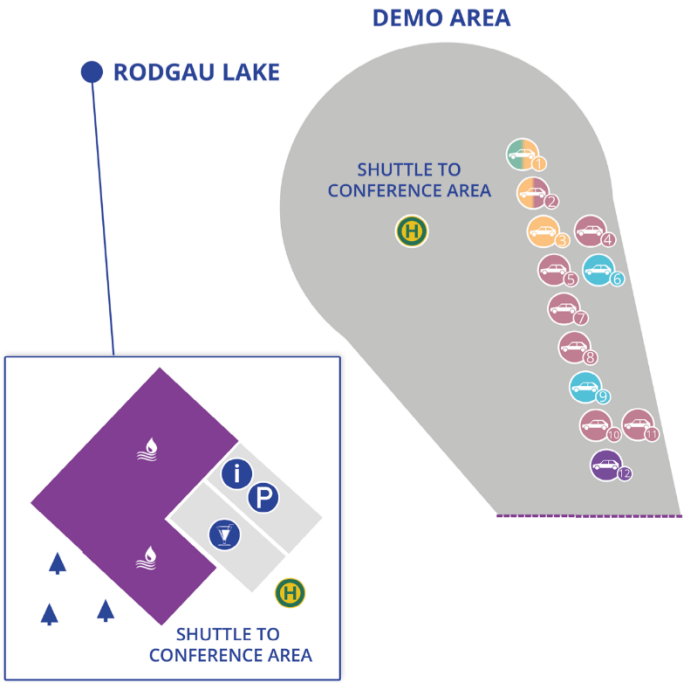


Road Hazard (Traffic Jam)



Road Hazard (Break-down vehicle)

Demonstration Activities



Driving Demos

#	Titel
1	LTE measurements and prediction
2	Cooperative HAD from Motorway Entry to Exit
3	Visual Localization & Preaggregation
4	HAD-Functions in public traffic
5	Tactical Decision-Making for HAD
6	Testmanager - A Tool for reproducible Test Execution
7	Highway Drive and Hazard Detection
8	Autonomous Reaction to Safety-Critical Situations on Highways
9	Testtool
10	HAD-Functions: Merging, Strategic Handling of break down vehicles, MRM
11	HAD-Functions in public traffic
12	Wizard-of-Oz Vehicle for Automated Driving Experience





Thank you

for your attention!

Gefördert durch:
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