# Introduction to ADAS and connected driving

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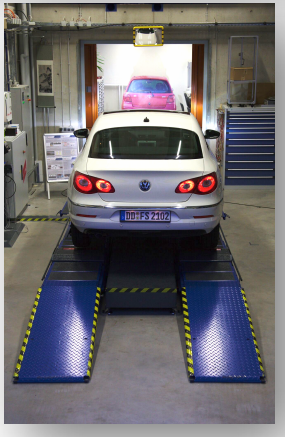
**Internet (only in german):**
**www.mechlab.de**

**Videos (channel of MechLabDE):**
**www.youtube.com/user/MechLabDE**



# Topics



- **Introduction to ADAS**
- Introduction to Vehicle Connection
- Principles of object detection

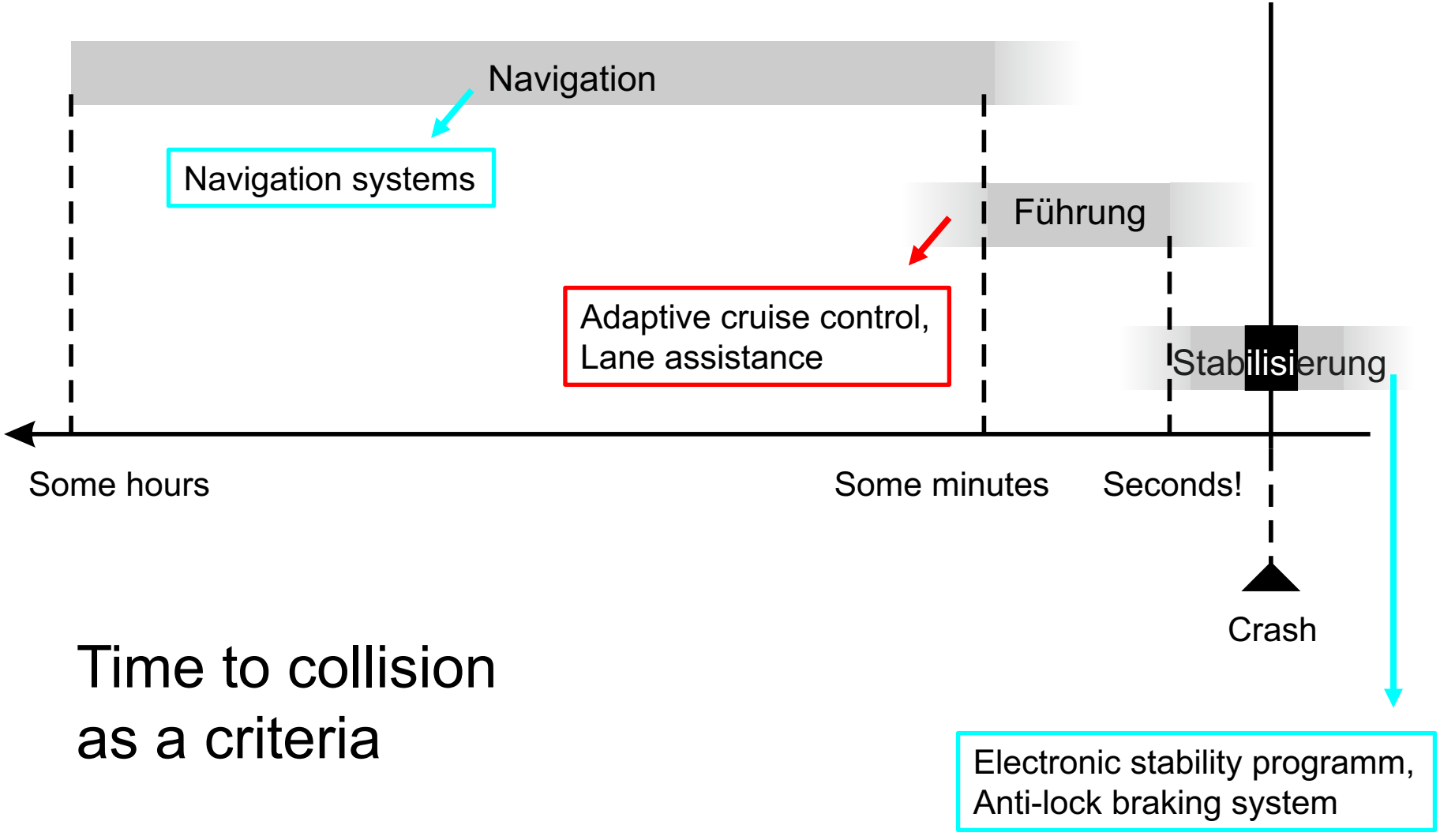
# Definition of ADAS



Advanced driver assistance systems (ADAS) are systems developed to automate/adapt/enhance vehicle systems for safety and better driving. Safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems, or to avoid collisions by implementing safeguards and taking over control of the vehicle. Adaptive features may automate lighting, provide adaptive cruise control, automate braking, incorporate GPS/ traffic warnings, connect to smartphones, alert driver to other cars or dangers, keep the driver in the correct lane, or show what is in blind spots.
Advanced driver assistance systems are one of the fastest-growing segments in automotive electronics. ADAS technology can be based upon vision/camera systems, sensor technology, car data networks, Vehicle-to-vehicle (V2V), or Vehicle-to-Infrastructure systems. Next-generation ADAS will increasingly leverage wireless network connectivity to offer improved value by using car-to-car and car-to-infrastructure data.

Source: www.wikipedia.org

# 3 level model of driving tasks




Time to collision
as a criteria

# History of longitudinal vehicle control



**Cruise Control**

- introduced 1958 by Crysler
- without reaction to surrounding cars

**Adaptive Cruise Control** (ACC)

- introduced 1995 by Mitsubishi (1998 in Germany by Daimler)
- distance to next vehicle (active at v > 30 km/h)

**Emergency brake** → **after 11/2015 obligation for new trucks**

- introduced 2003 by Toyota
- full braking in critical situations

**ACC Stop-and-Go** (ACC+)

- ACC, but active at full speed range
- additional sensors (Camera, Short range radar)

**Connected/Cooperative ACC** (Platooning)

- vehicles are permanently connected with WiFi (802.11p)
- safety critical in truck platoons

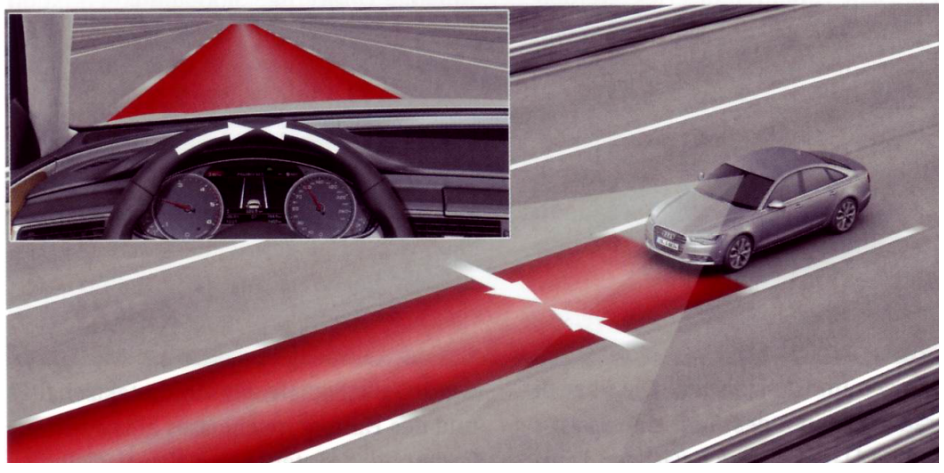
# Roadmap of ADAS



DAS (mass product):
- ABS
- ESP

ADAS (High level class):
- ACC
- Lane Assist
- Congestion Assistance (CAS)

Strong increase of complexity



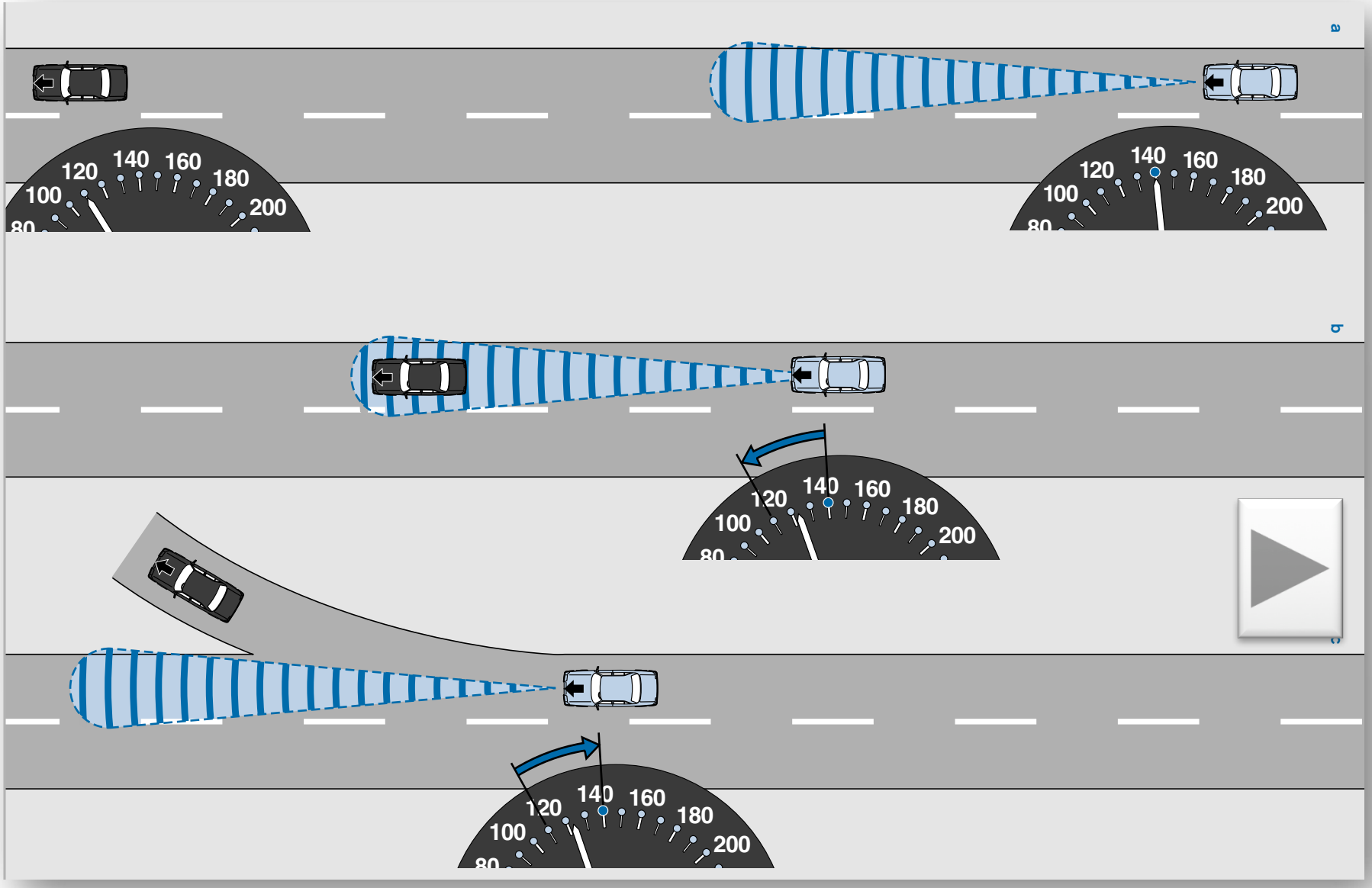
ADAS+ (in development):
- Intersection Assistance

Autonomous Driving:
- Fully automated vehicles, „Google-Car“

What ADAS are already mass products?

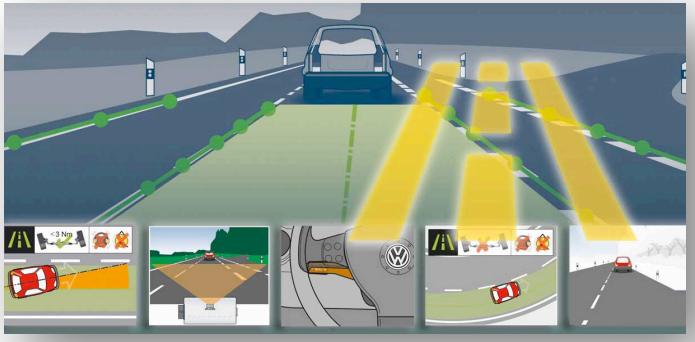
# ADAS-Example 1: ACC

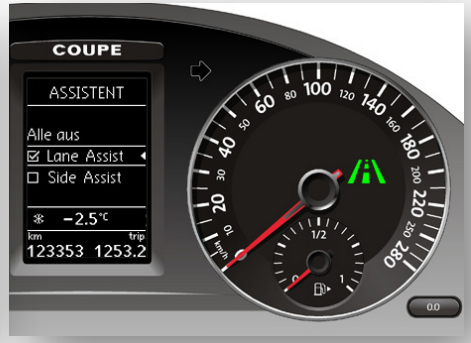




# ADAS-Example 2: Lane Assist and others

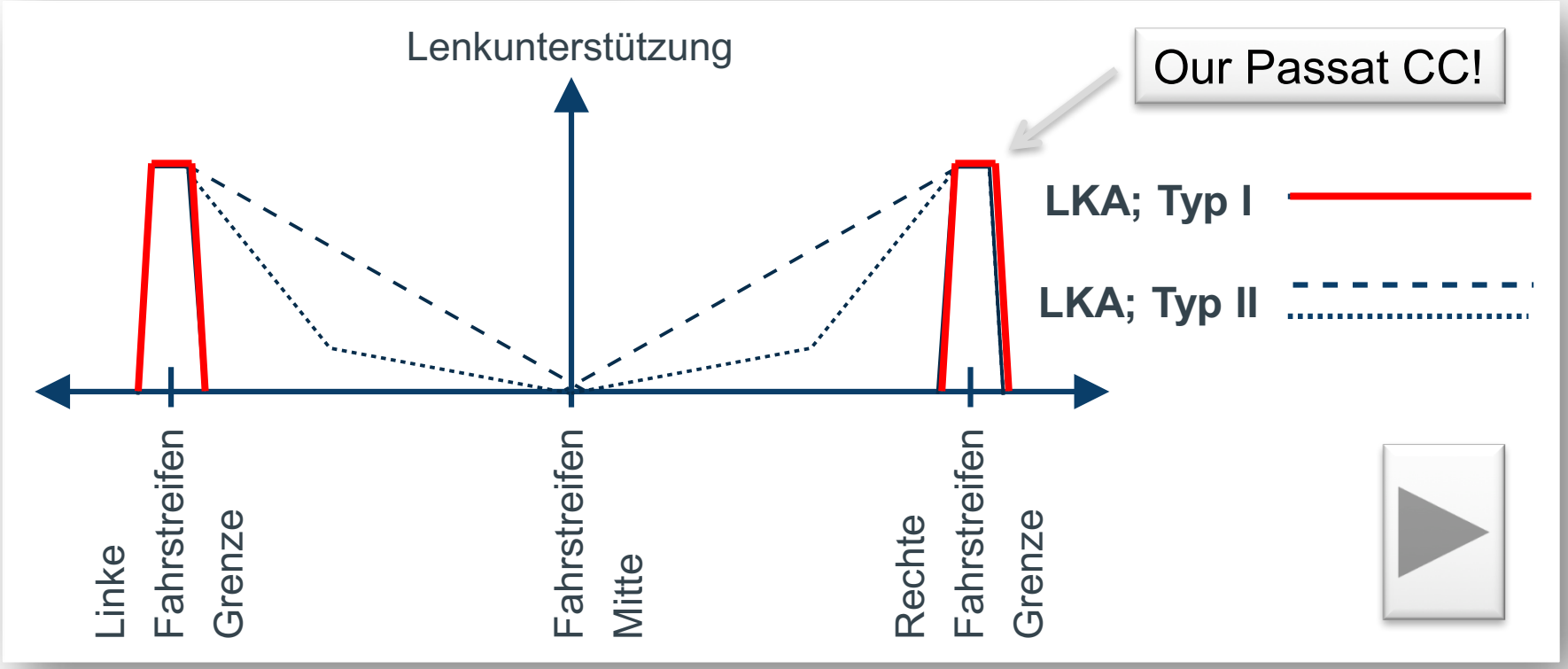






not active

active



# ADAS-Example 3: Traffic Jam Assistent

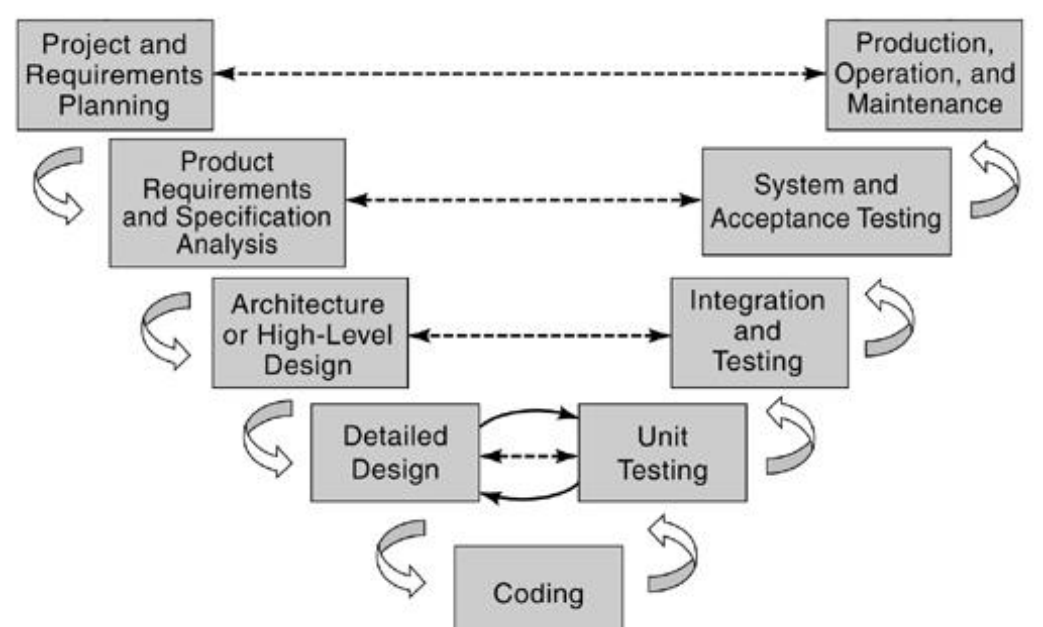
# ADAS: SAE/NHTSA-Levels of Automation



| SAE level | Name | Narrative Definition | Execution of Steering and Acceleration/ Deceleration | *Monitoring* of Driving Environment | Fallback Performance of *Dynamic Driving Task* | System Capability *(Driving Modes)* |
|---|---|---|---|---|---|---|
| ***Human driver* monitors the driving environment** | | | | | | |
| 0 | **No Automation** | the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems | Human driver | Human driver | Human driver | n/a |
| 1 | **Driver Assistance** | the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task* | Human driver and system | Human driver | Human driver | Some driving modes |
| 2 | **Partial Automation** | the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task* | **System** | Human driver | Human driver | Some driving modes |
| ***Automated driving system* ("system") monitors the driving environment** | | | | | | |
| 3 | **Conditional Automation** | the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene* | System | **System** | Human driver | Some driving modes |
| 4 | **High Automation** | the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene* | System | System | **System** | Some driving modes |
| 5 | **Full Automation** | the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver* | System | System | System | **All driving modes** |

## What is necessary for ADAS development:

- detailed model-based simulation for algorithm development
- tools for automated production of series code
- procedures for software tests
- ...and a lot of real time test procedures



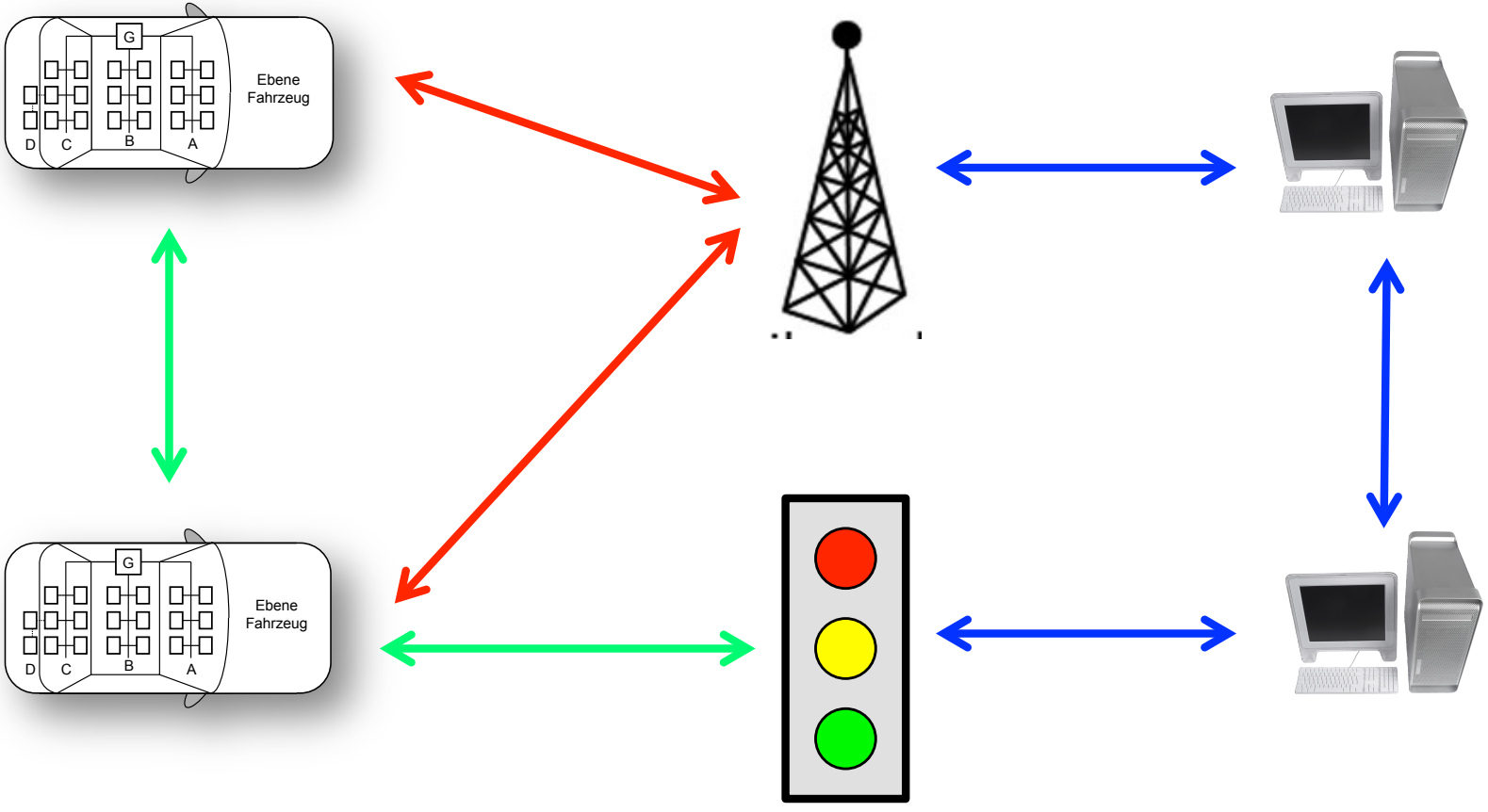

The V-Shaped Software Development Life Cycle Model

# Topics



- Introduction to ADAS
- **Introduction to Vehicle Connection**
- Principles of object detection

## Principle:




WLAN Ad-hoc (802.11p)

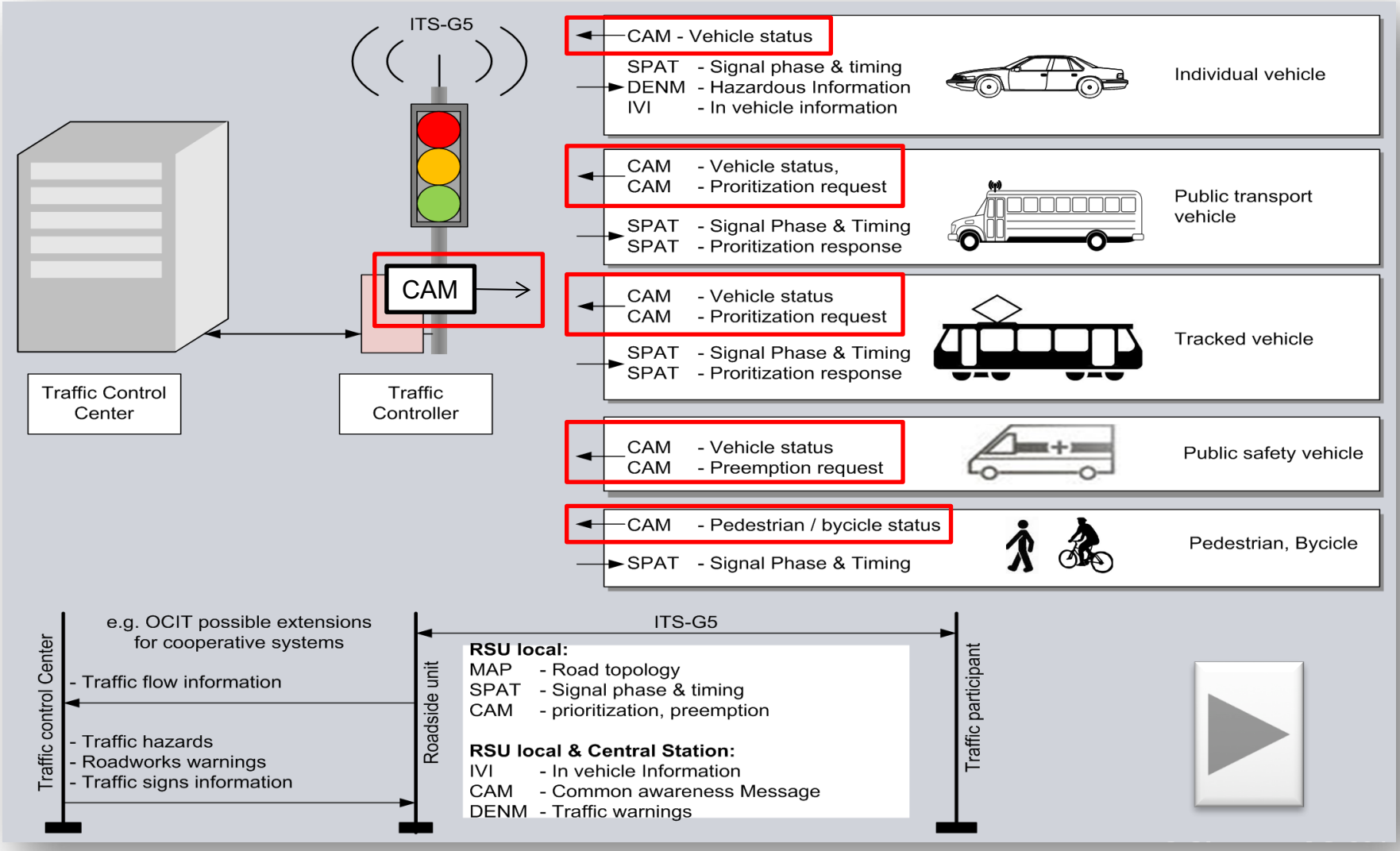
Mobilfunk (UMTS, LTE, G5)

Internet

# Vehicle Connection

HOCHSCHULE FÜR TECHNIK UND WIRTSCHAFT DRESDEN
UNIVERSITY OF APPLIED SCIENCES

## Messages:



## CAM-Message:

# Messaging/Facilities: CAM (1) Cooperative Awareness Message

"Heartbeat"

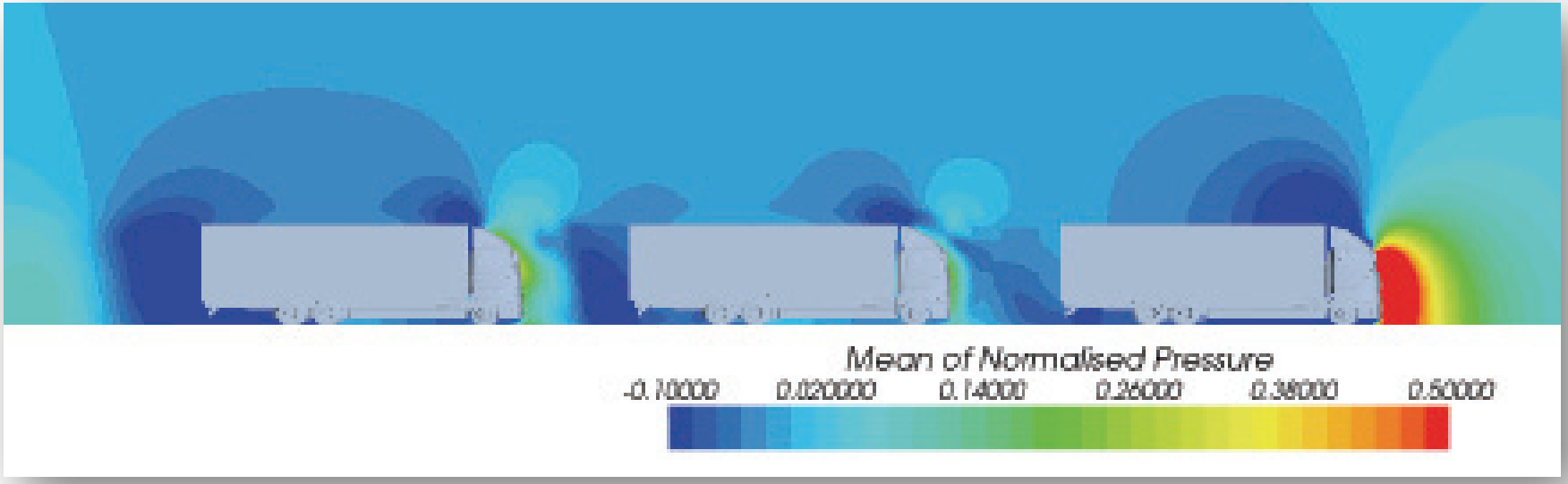
- Periodic (1 - 10Hz), broadcast, single hop
- Transmitted as Geocast Single-Hop Broadcast (SHB) packet

**CAM generation rules:**

Minumum interval 100 ms; maximum interval 1 s
CAM is generated (immediately) when

- ITS station status changes
  - Heading changes by 2° or more
  - Position changes by 10 m or more
  - Speed changes by 1 m/s or more
- Application requests (for RHS conformance class A)
  - Time since last CAM generation ≥ T requested by app
- Decentralized congestion control (DCC) demands
  - Time since last CAM generation ≥ T setd by DCC (rate control)

# Critical Use Case: Truck Platooning




CFD simulation results when the trucks are driving at 80 km/h with the gap of 4 m.

Quelle: S.Tsugawa u.a.

**Potential:**
Reduction of 15 % of fuel consumption for the whole platoon.

# Critical Use Case: Truck Platooning

Quelle: European Truck Platooning Challenge 2016

| Aspect | 2016 | 2020 | 2025 |
|---|---|---|---|
| **SAE Level: Platooning capability** | Level 1 | Level 3 | Level 4 |
| **Platoon brand composition** | Mono-brand | Multi-brand | |
| **Platoon length** | Max. 2 or 3 vehicles, more vehicles on dedicated infrastructure | 3+ vehicles per platoon | |
| GAP: | ≥ 0,5 s | ≥ 0,3 s | |
| **Business case for transport companies (direct benefits** | Fuel savings from improved aerodynamics, $CO_2$ emission abatements | Fuel savings from improved aerodynamics, $CO_2$ emission abatements | Fuel savings from improved aerodynamics, $CO_2$ emission abatements, improved asset utilization, wage cost reductions |
| 80 km/h | | >>> 6,66 m distance | |
| **Human factors** | All drivers in the loop situationally aware | All drivers in the loop situationally aware | Lead driver in the loop, following drivers situationally unaware |

# Topics



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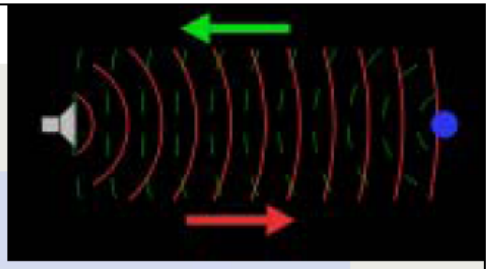
- Introduction to Vehicle Connection
- **Principles of object detection**

Distance measurement:

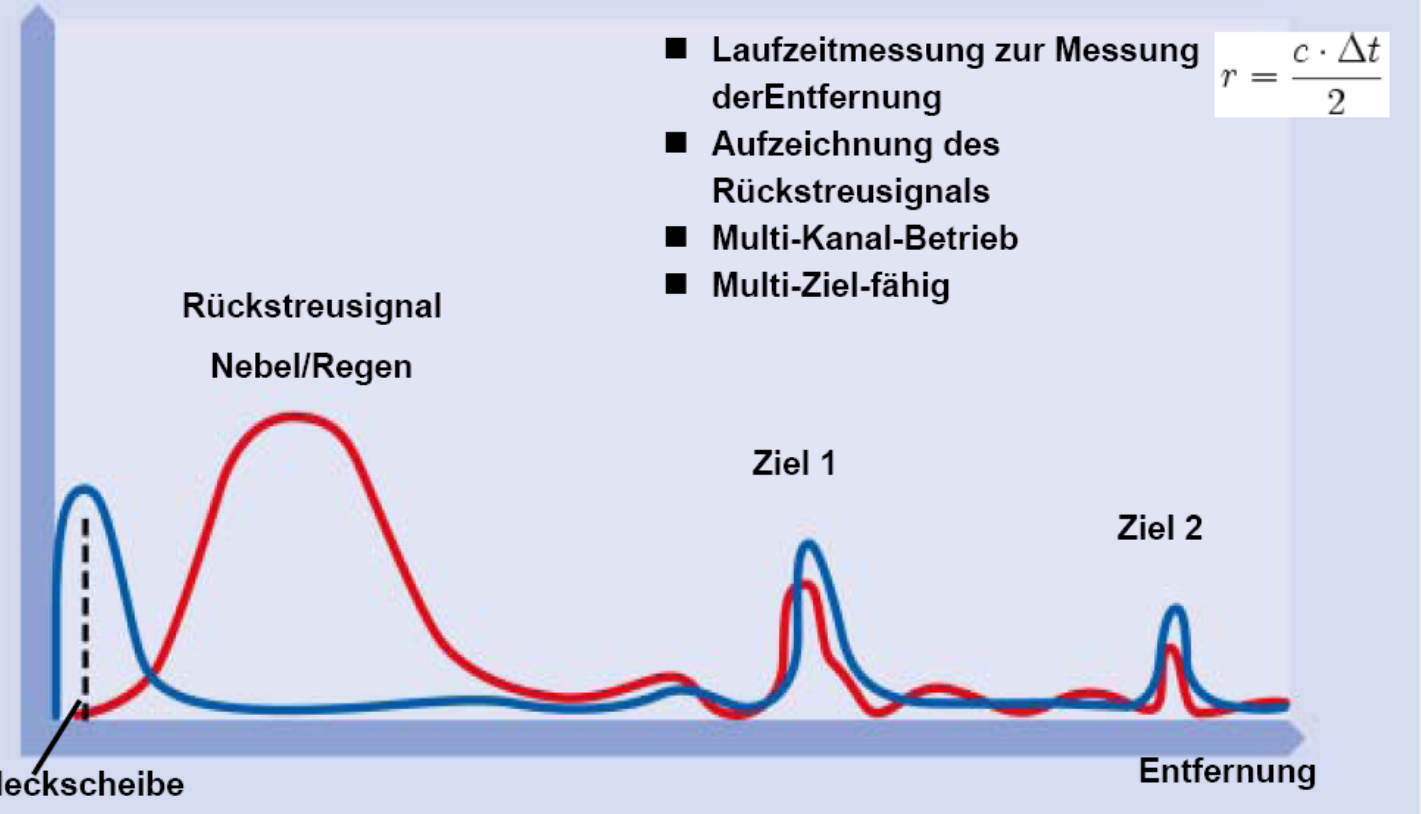
## *Laufzeitmessung* (Time of Flight Measurement)



Empfängersignal

- Laufzeitmessung zur Messung derEntfernung
- Aufzeichnung des Rückstreusignals
- Multi-Kanal-Betrieb
- Multi-Ziel-fähig

$$r = \frac{c \cdot \Delta t}{2}$$

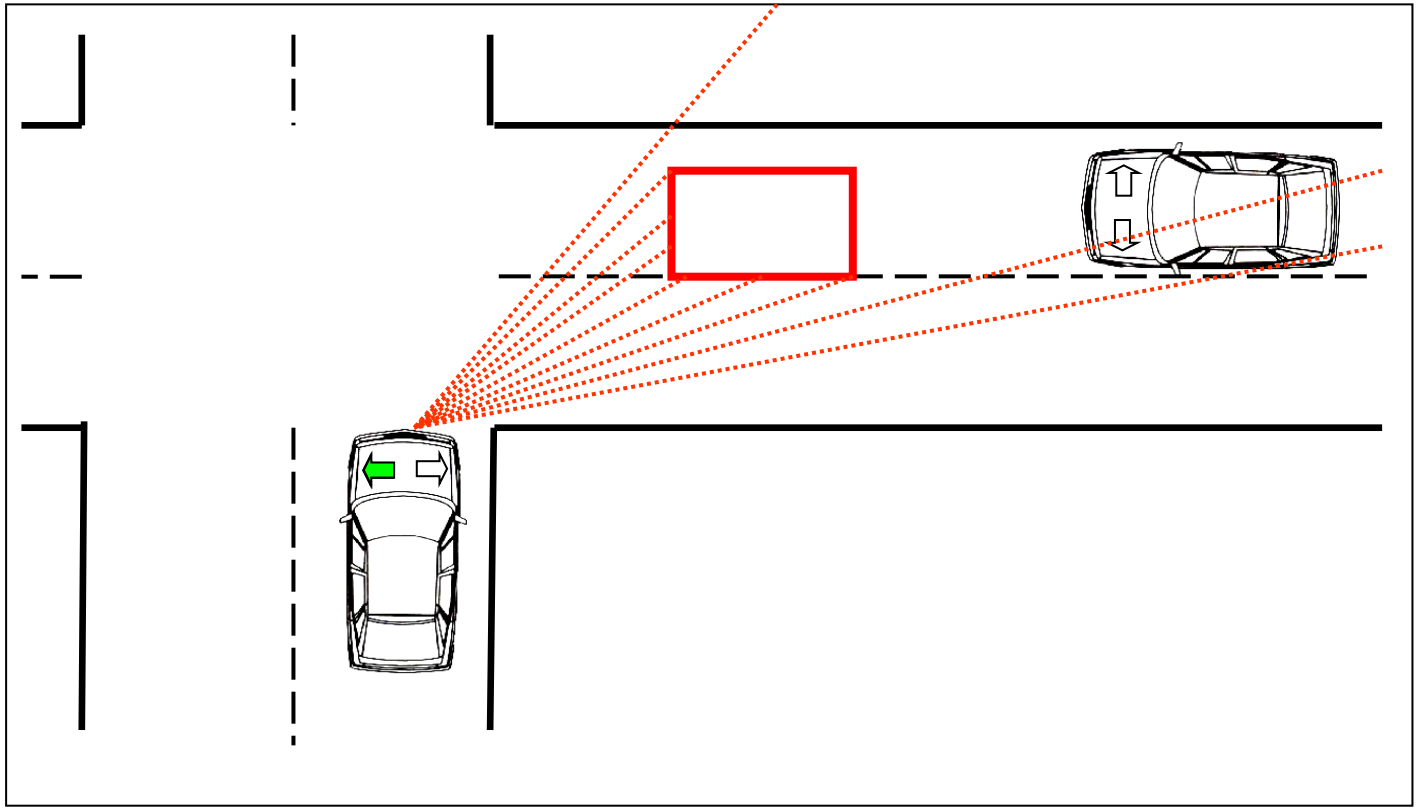


# Laser scanner (2)



Basic principle: - Use of Laser-Scanner for detailed detection of environment

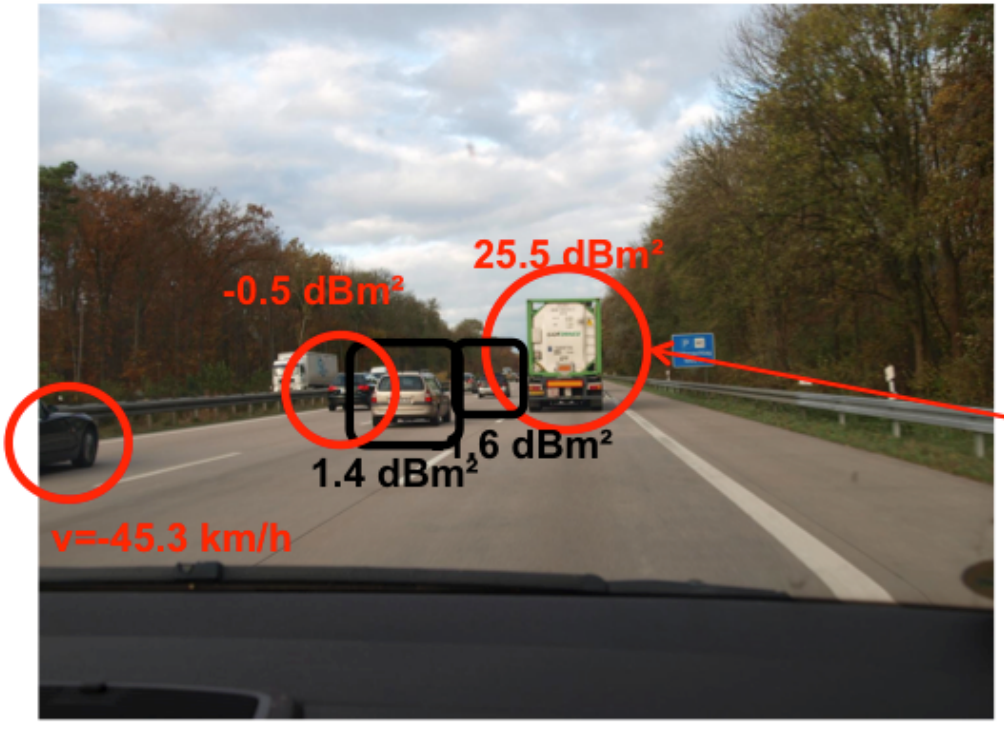
- proprietary development of HTW Dresden

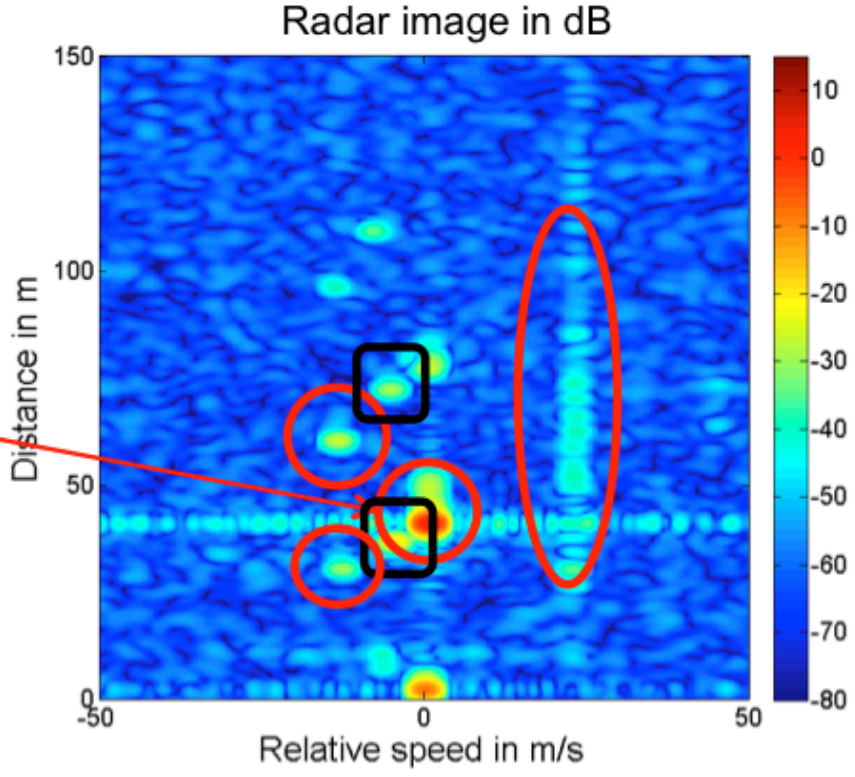


Radar (Volvo): http://www.youtube.com/watch?v=C_0HvkwB5dE

# Radar (1)



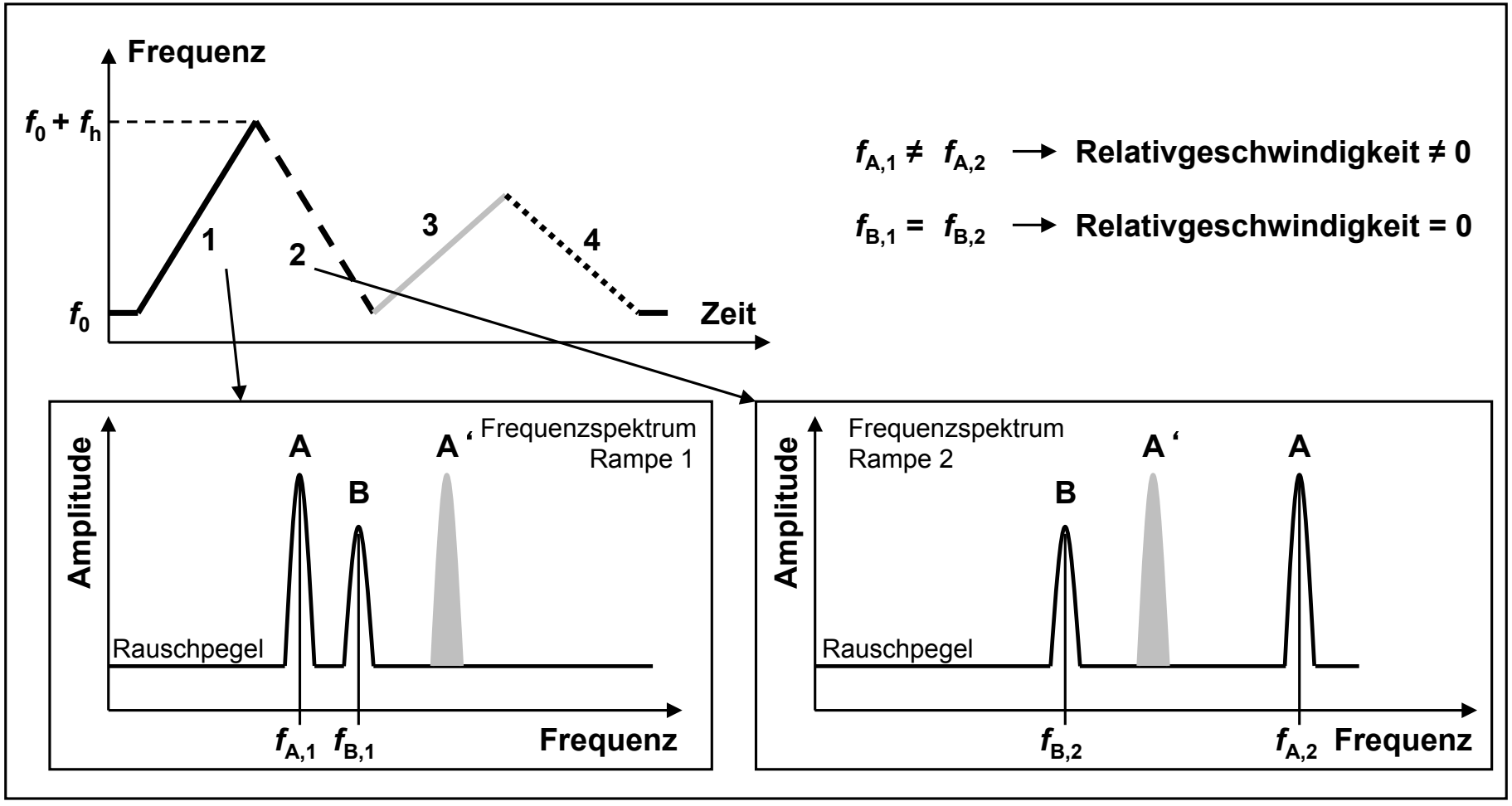



Quelle: www.ihe.kit.edu/img/content/radarbild.jpg, Zugriff Juni 2010

Radar > only point-information

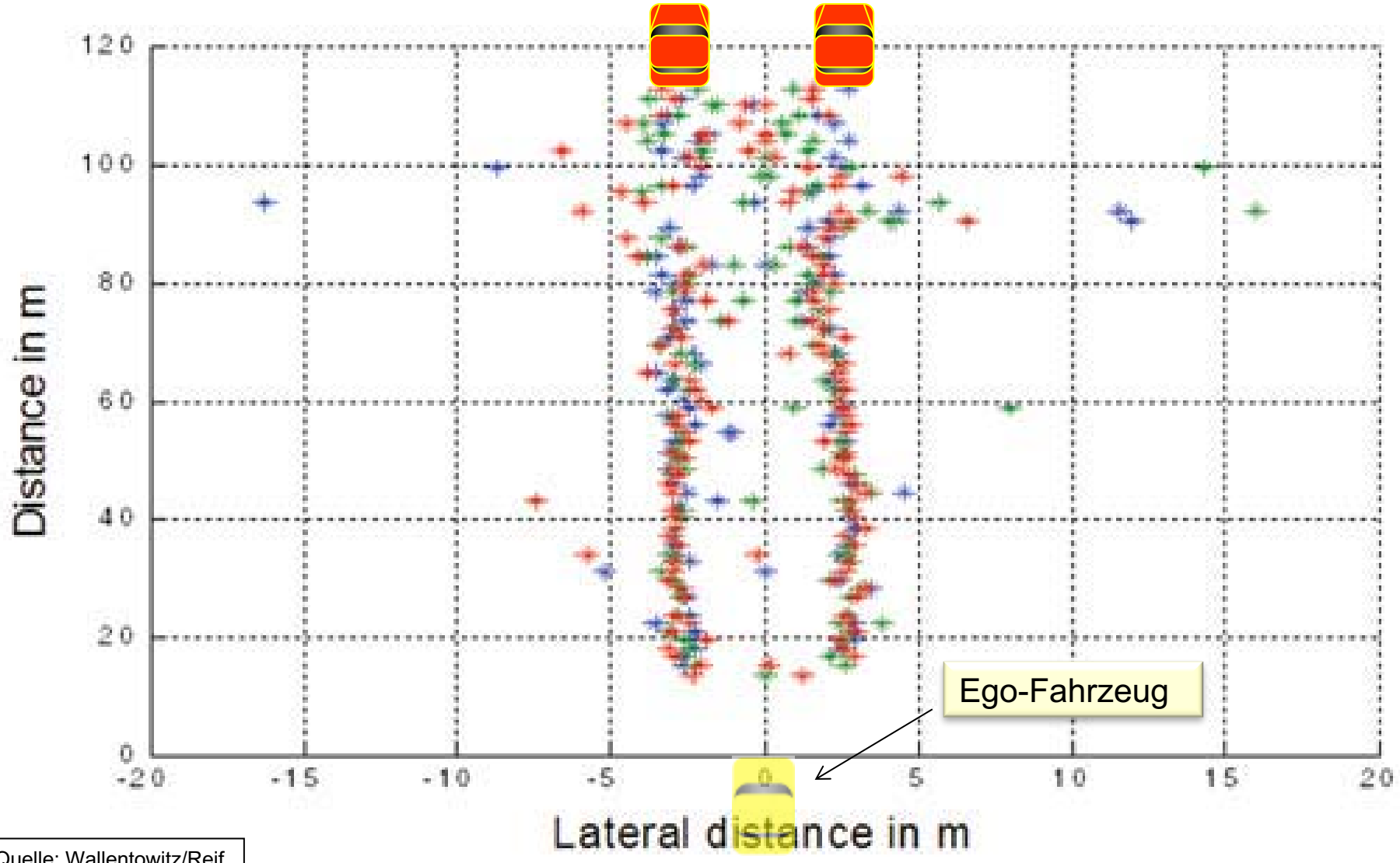
# Radar (2)




Quelle: Trautmann

# Radar (3)

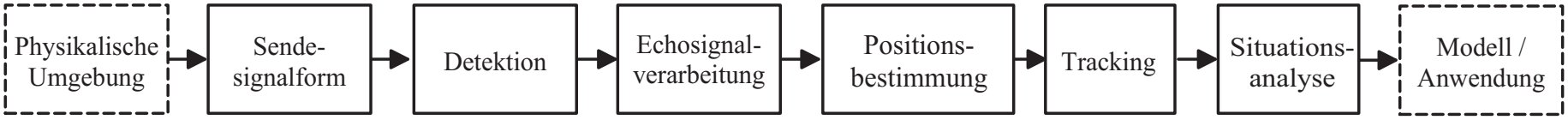




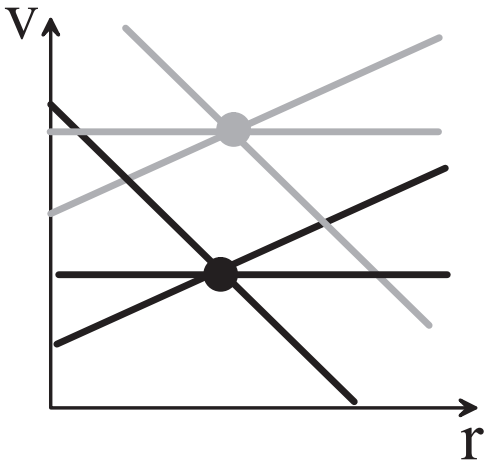

Quelle: Wallentowitz/Reif

# Radar (4)

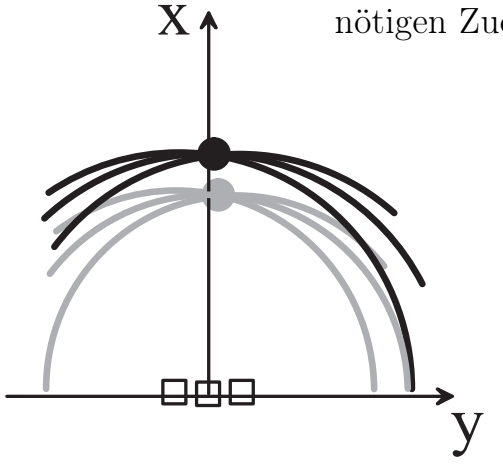




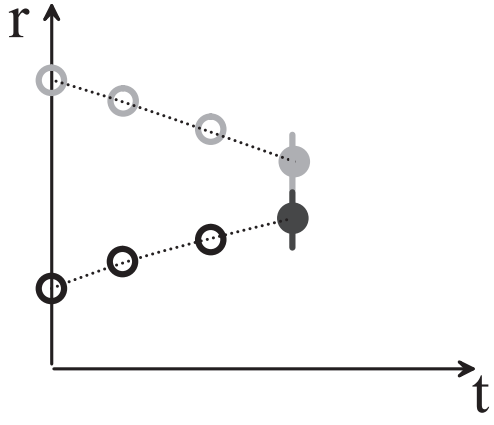

Zusammenfassung der möglichen Mehrdeutigkeiten (a)-(c) und nötigen Zuordnungsschritte (d) in einem Radarnetzwerk



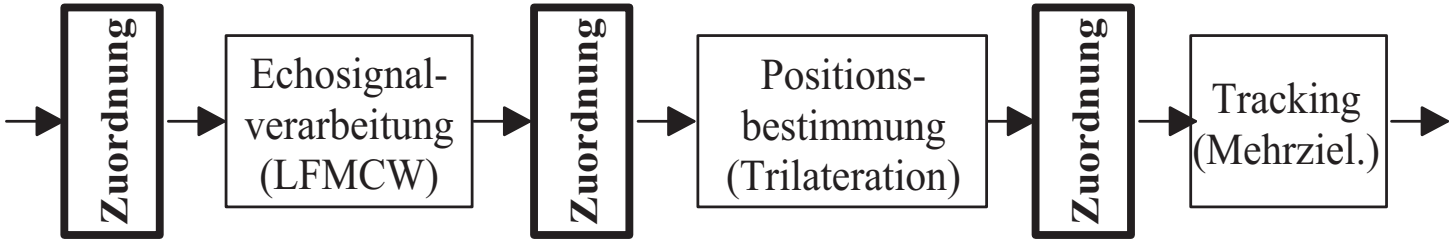

(a) LFMCW-Sendesignal




(b) Trilateration im Netzwerk




(c) Mehrziel-Tracking




(d) Nötige Zuordnungsschritte innerhalb der Signalverarbeitung

Quelle: Fölster

# Camera (1)

**Abb. 20.3** Kombination eines Kamerasystems mit einem Lidarsensor (Continental SRLCam) (Quelle: Continental)

Quelle: Winner

# Camera (2)

**Abb. 20.6** Effekt einer abnehmenden Auflösung am Beispiel eines Verkehrszeichens (480×650/72×96/36×48/24×32/18×24/12×16) (Quelle: Boris Werthessen)

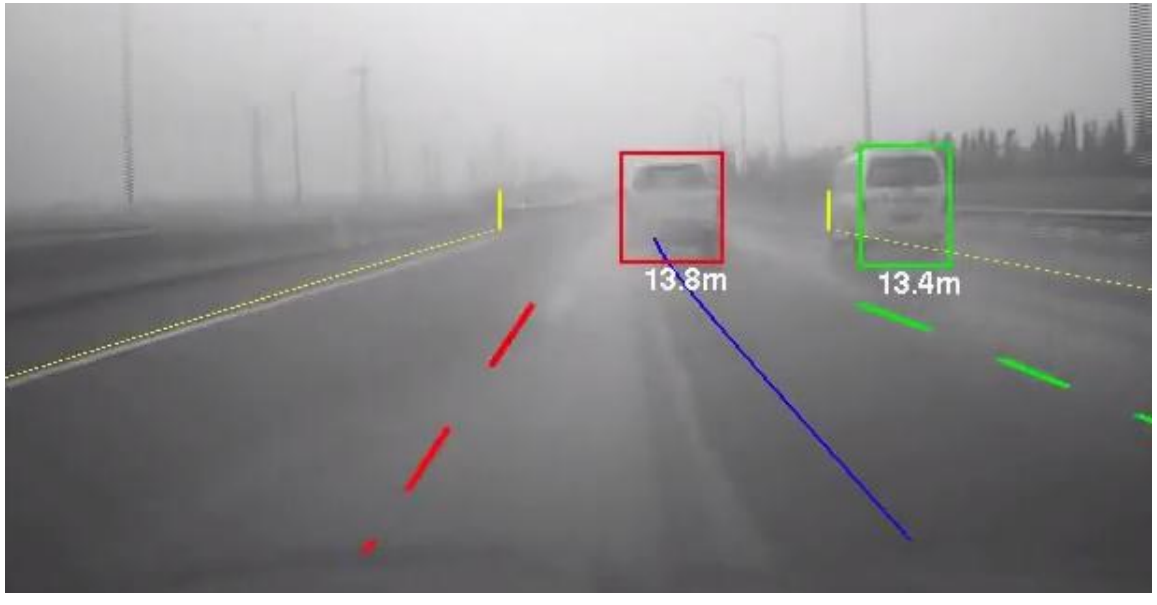
**Abb. 23.1** Innenstadtszene mit Fußgänger in unterschiedlicher Auflösung (normalisierte Darstellung)

Quelle: Winner

# Camera (3)

**Abb. 21.5** Links: Originalbild; Rechts: Ergebnisbild des a) Canny-Kantendekektors; b) Harris-Eckendetektors

Quelle: Winner




Quelle: Richter