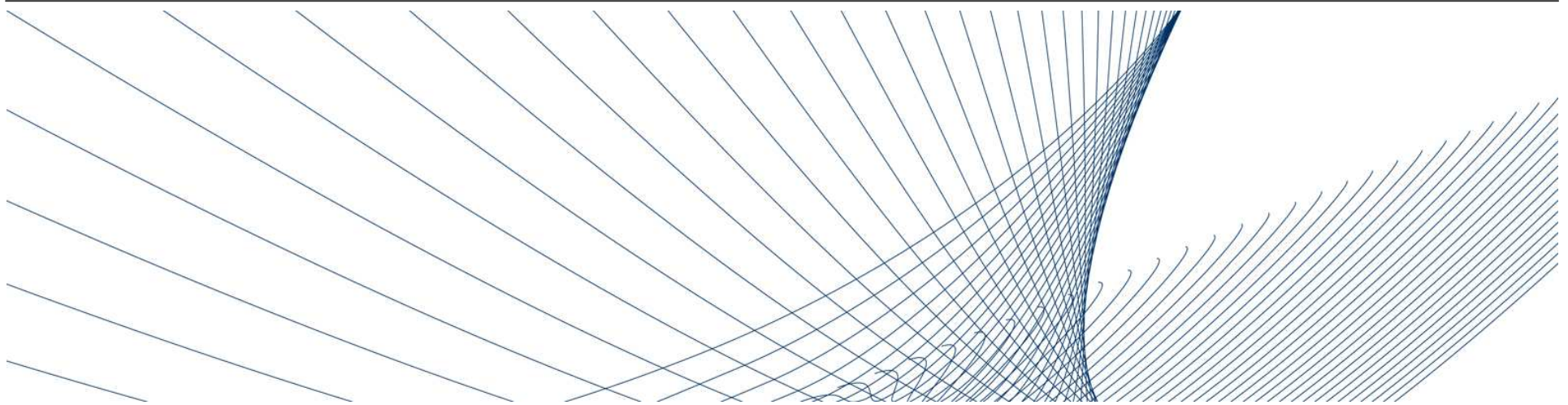


**VOLKSWAGEN**

AKTIENGESELLSCHAFT



# **Driver Assistance – Steps Towards the Seeing Car**

AMAA 2007, Dr. Alexander Kirchner, Volkswagen AG

## Driver Assistance – Steps Towards the Seeing car

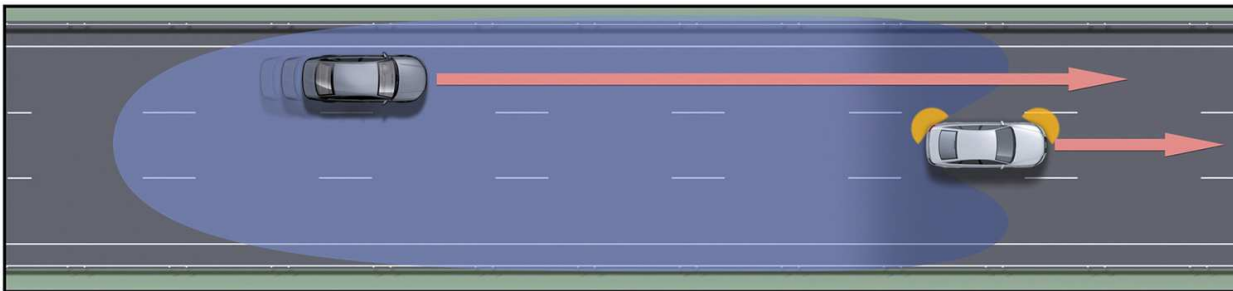
### Contents

- Driver Assistance on the road today – state of technology  
Volkswagen and Audi
- The seeing car tomorrow – state of the art  
Stanley – Winner of the Grand Challenge 2005
- Sensing and Perception  
Vision et al.
- Architecture of the seeing car  
Networks, ECUs and the development process
- Conclusions

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## Driver Assistance today – Audi Side Assist



**Schnelle Annäherung: Blinker gesetzt und Spurwechsel kritisch**  
*Rapid approach: Indicator on and lane-change critical*



**Blinken**  
*Flashing*

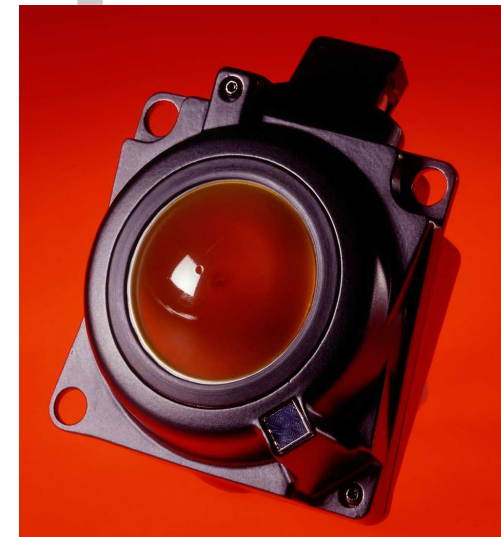
Sensors: Two 24 GHz Medium-Range-Radar (Hella)



## Driver Assistance today – Audi Braking Guard



- Optical Warning
- Acoustic Warning
- Braking Jerk



Sensor: Long-Range-Radar (Bosch)

## Driver Assistance today – Volkswagen Park Assist



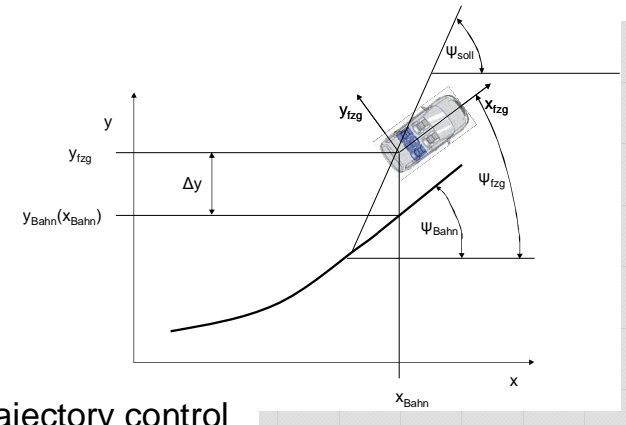
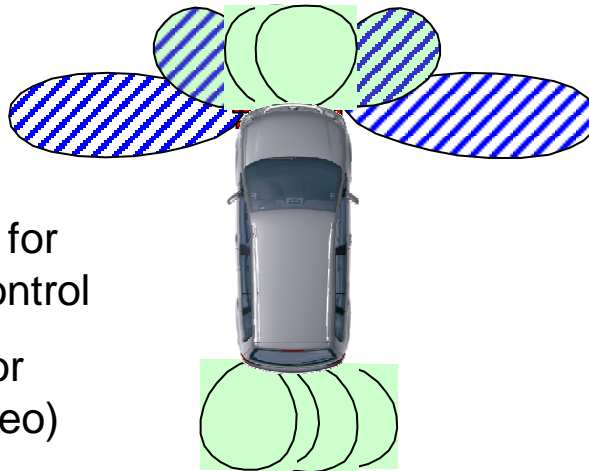


## Driver Assistance today - Volkswagen Park Assist

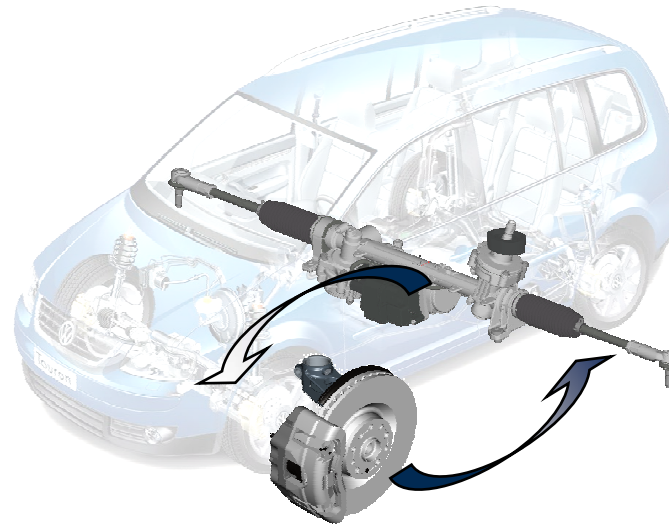
Green: Sensors for  
park distance control

Blue: Sensors for  
Park Assist (Valeo)

- narrow field of view
- long range

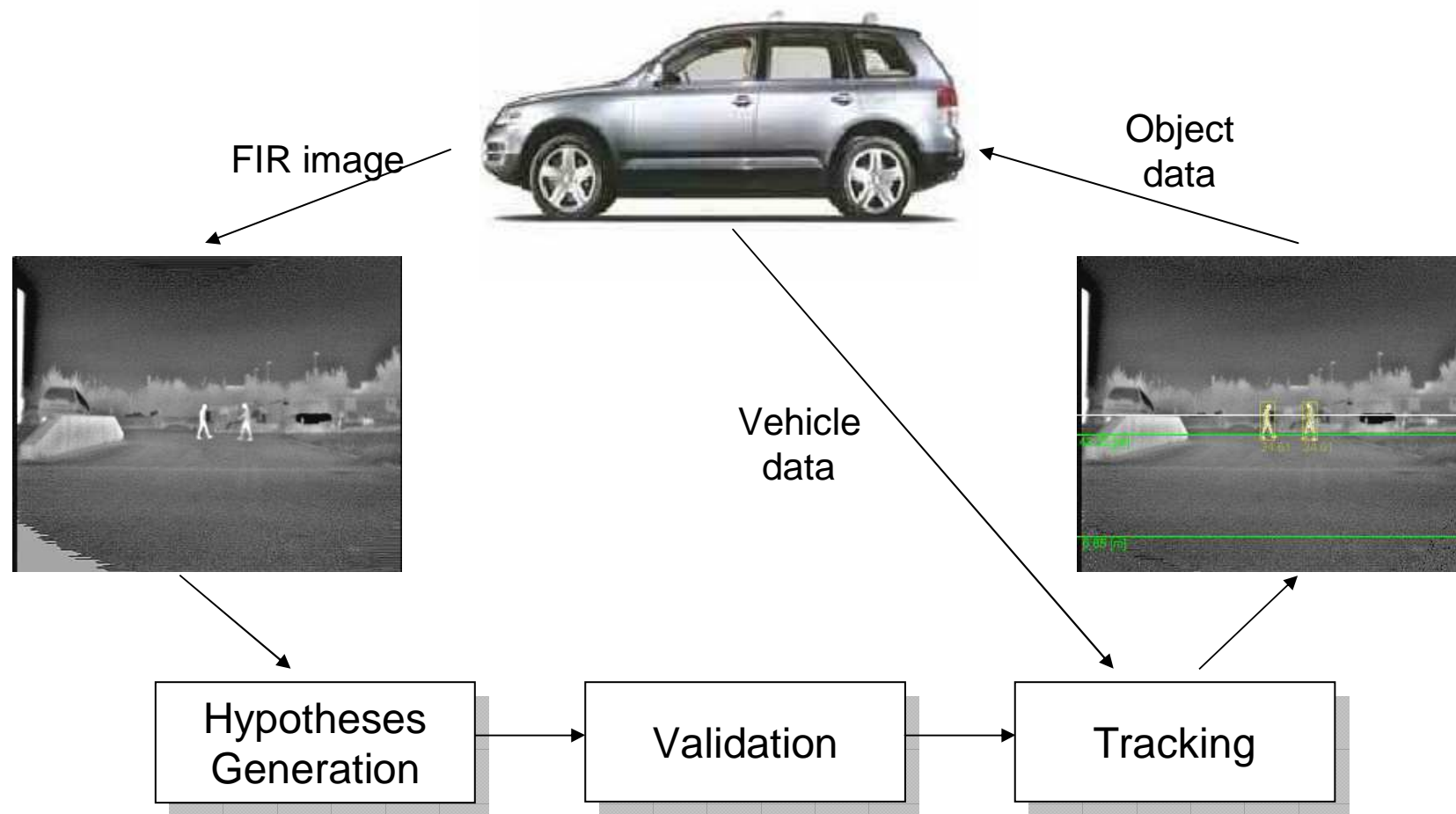


Trajectory control



Actuators: EPS (electronic power steering)

## Driver Assistance today – Volkswagen Research Nightvision





## Driver Assistance today – Volkswagen Research Nightvision

### Event driven Image Display

- Video is shown only in possible dangerous situations
- Detected obstacles can be high-lighted



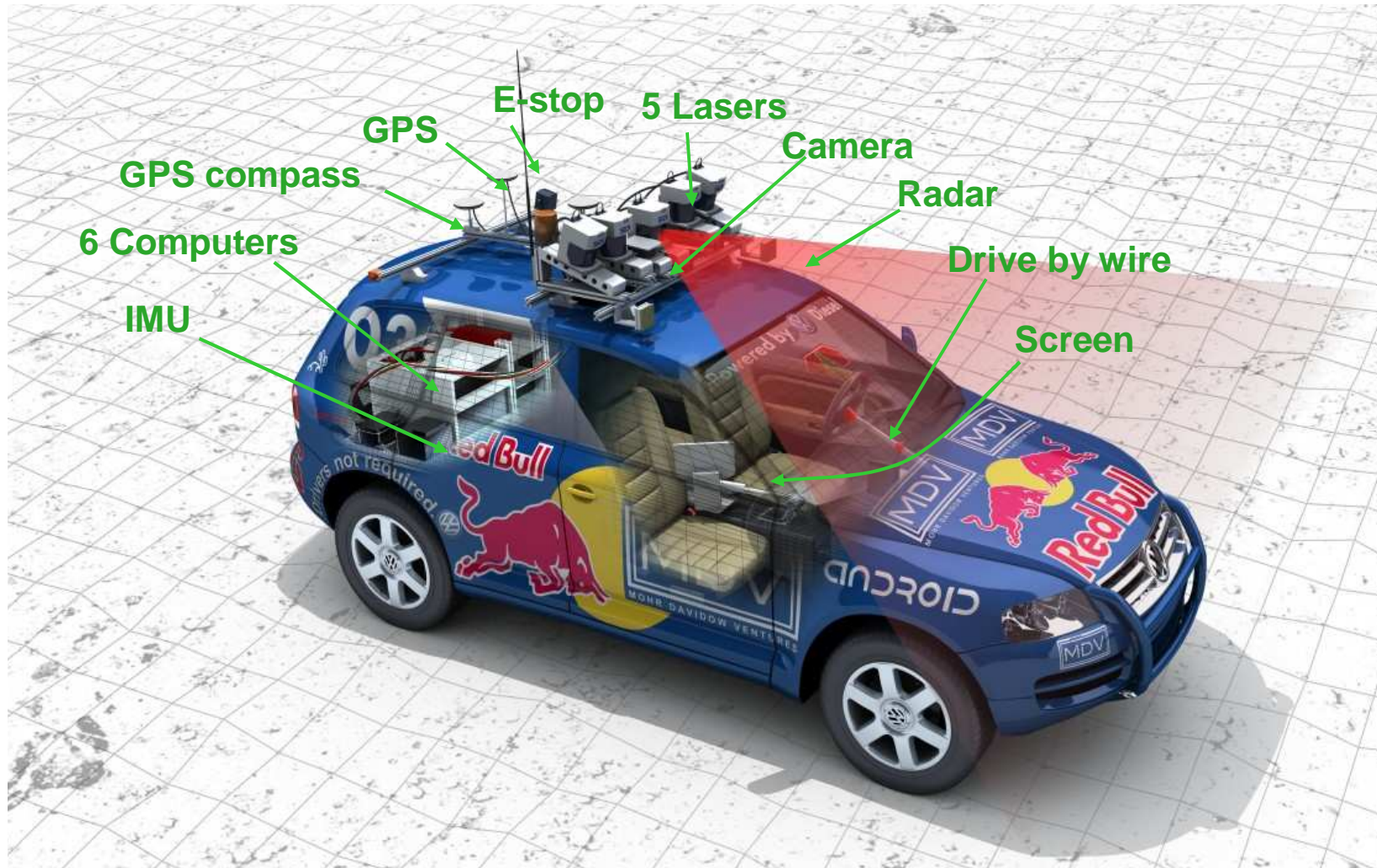
### Abstract LED-HMI

- LED segment indicates direction of detected dangerous obstacles
- Requires only peripheral perception

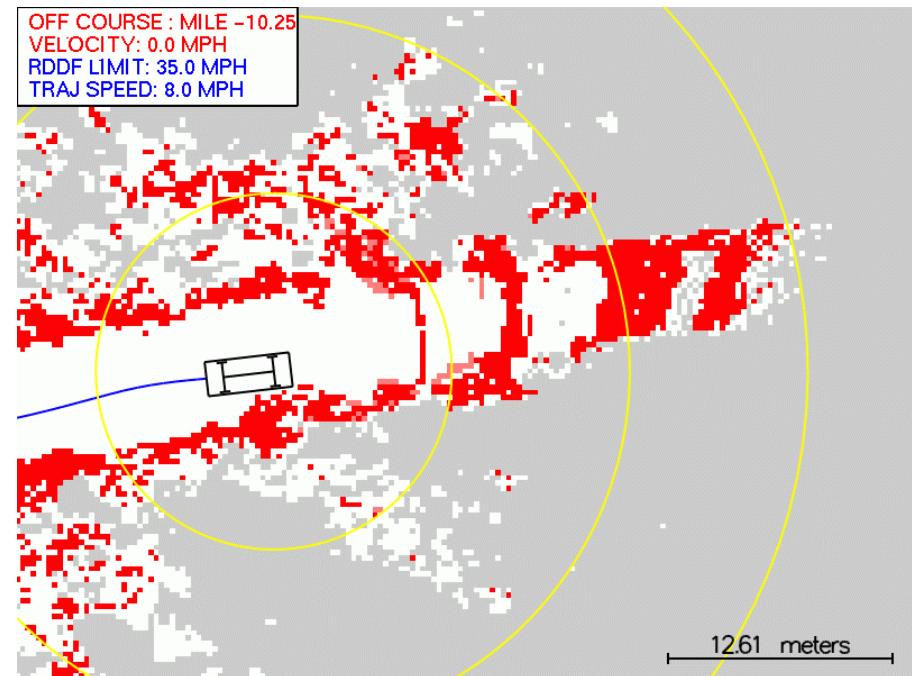
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## The seeing car tomorrow – Grand Challenge Winner Stanley



## The seeing car tomorrow – Stanley and the beerbottle pass



beerbottlepass.avi



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## Sensing and Perception– Monocular Color Vision

- lane detection by color
- lane marking labeling
- building of object hypothesis
- model based car detection
- (no tracking yet)





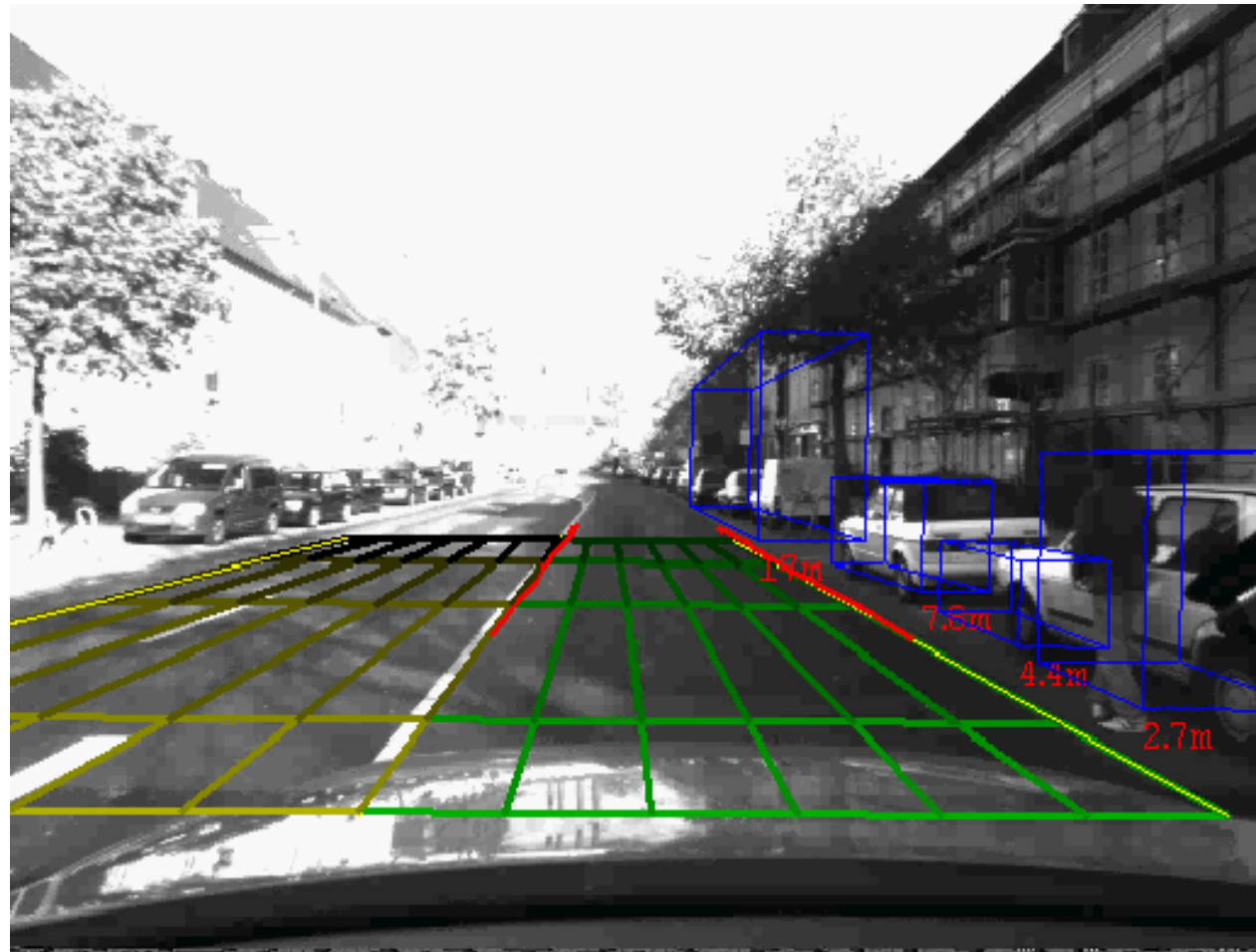
## Sensing and Perception– Stereo Vision: lane and objects

### Characteristics

- Model-free object detection
  - 3D-reconstruction possible
  - (on-line) calibration
  - hardware based disparity
- 
- large package
  - more expensive than mono

### Features

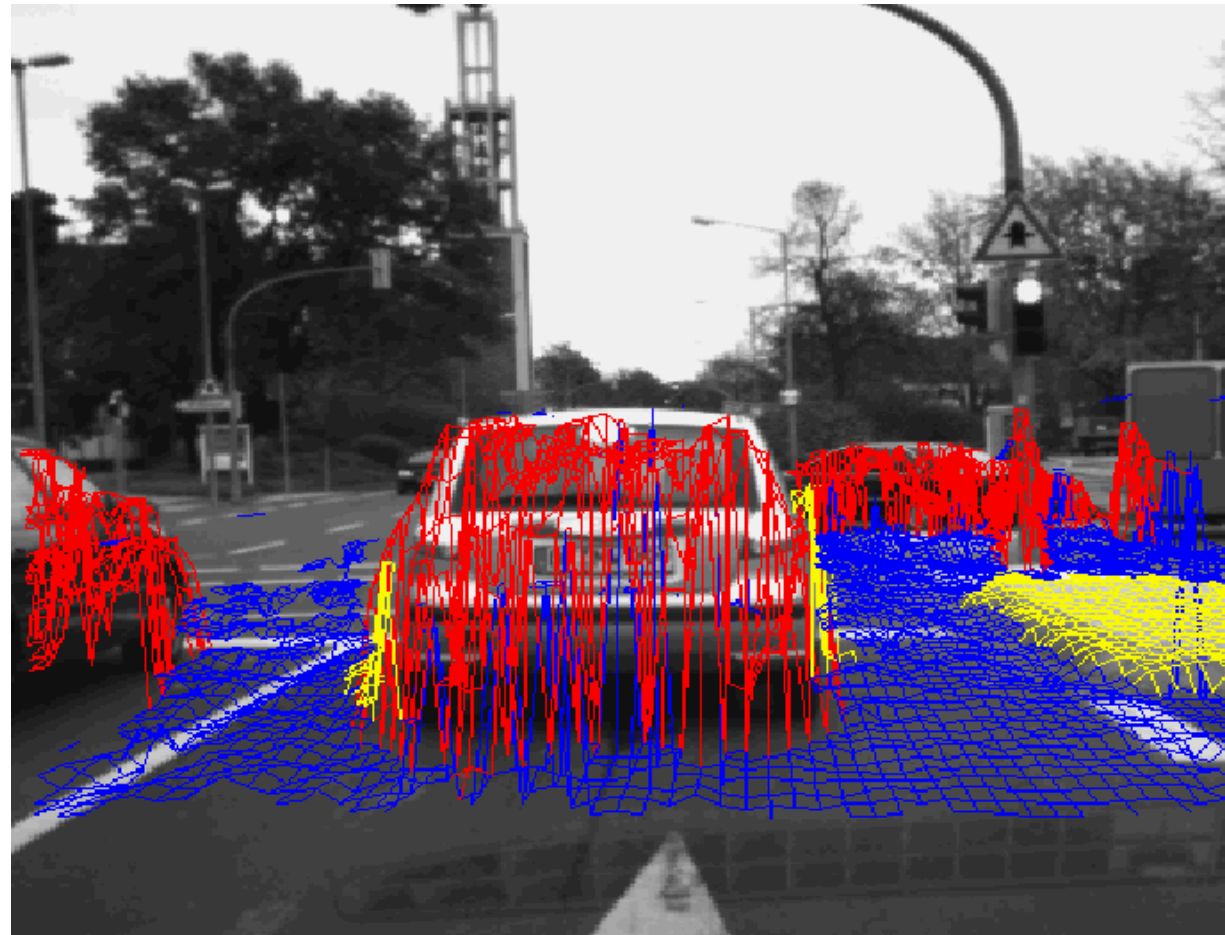
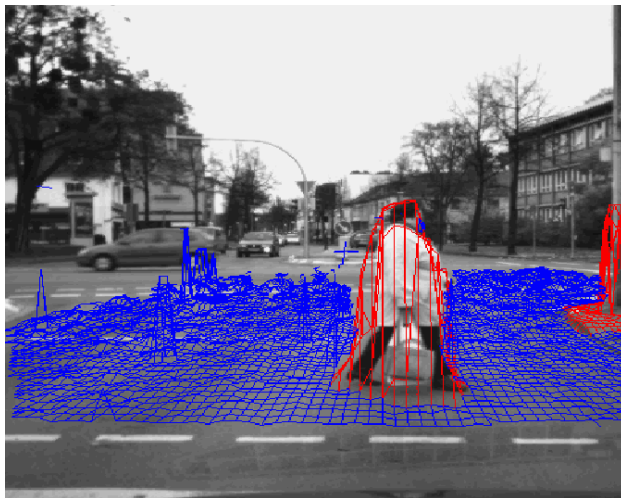
- multi-lane recognition
- obstacle recognition



## Sensing and Perception– Stereo Vision: 3D reconstruction

### Features

- dense disparity
- elevation map
- height classification



## Sensing and Perception – Stereo Vision: Pedestrians



### Features

- classified pedestrians by size and shape
- confidence level

## Sensing and Perception– Thermal Imaging

- generally humans and other „hot“ objects are very well recognizable
- passive system (no additional lighting required)
- extra sensor compared to near infrared night vision





## Sensing and Perception

Rear View  
to  
Top-View



## Sensing and Perception – Rear View

### Top-left:

Rearview with  
approaching vehicle  
detection

### Bottom-left:

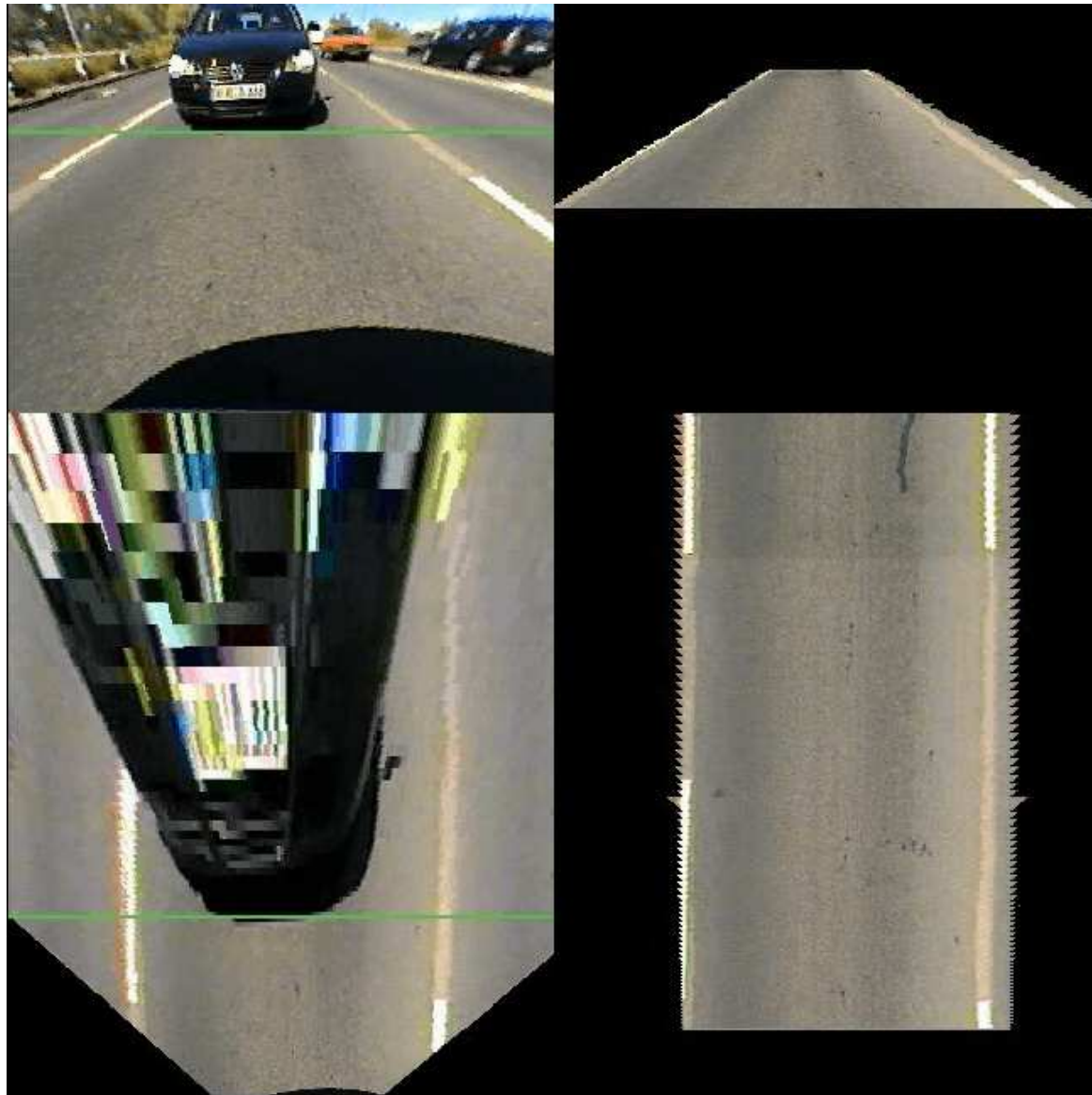
Top-View

### Top-right:

Rear-View street only

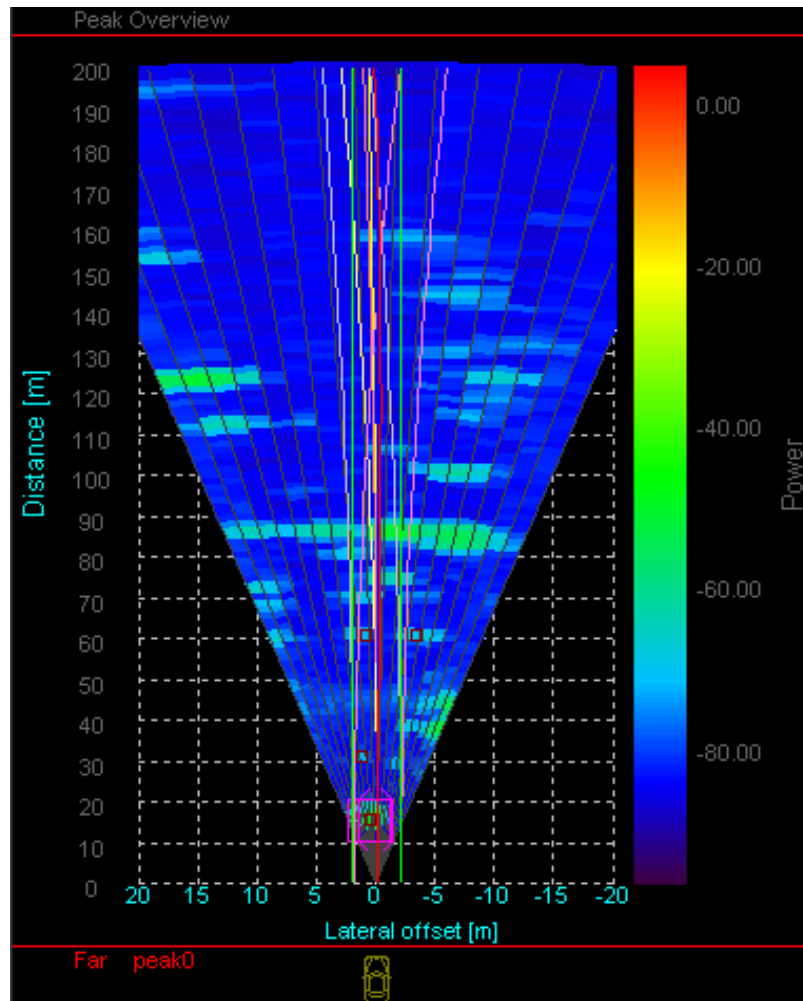
### Bottom-right:

Top-View street only

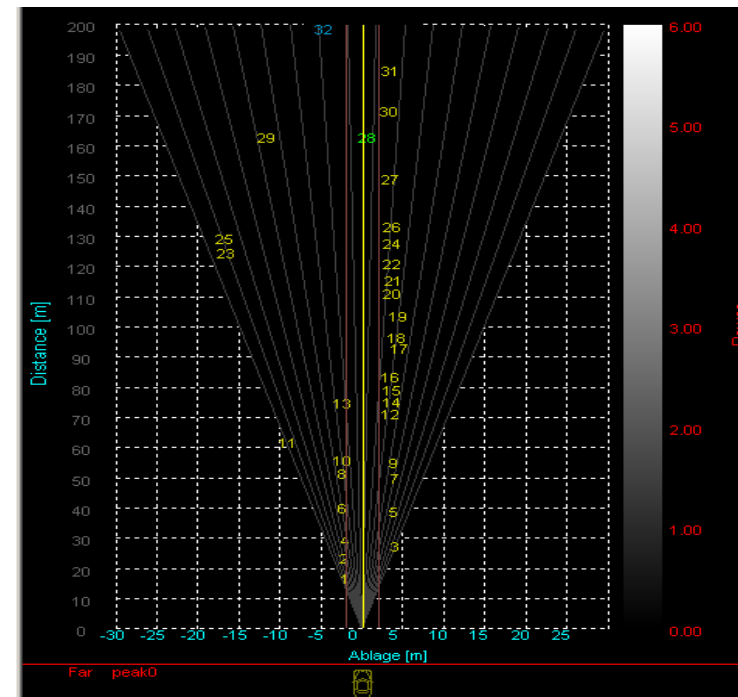




## Sensing and Perception – Radar ARS 300 (Continental)

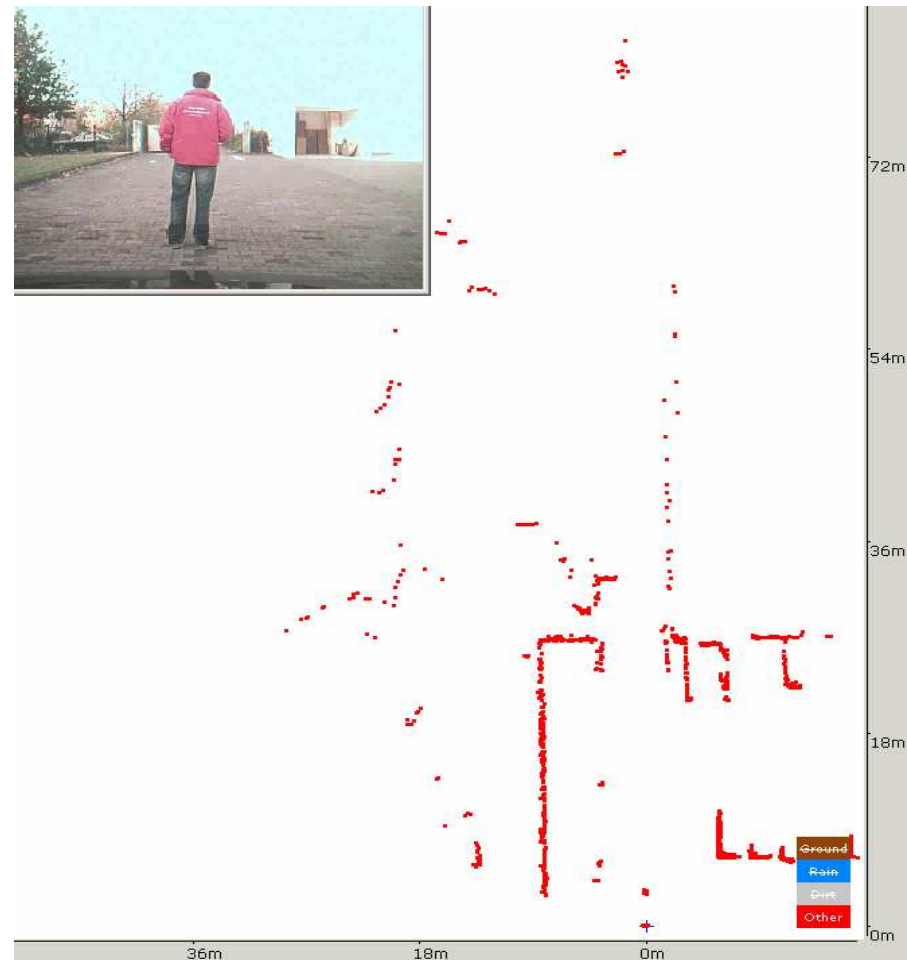


- 77 GHz long/short-range sensor with high resolution
- large field of view: 17° far / 56° near FOV
- continuously scanned beams

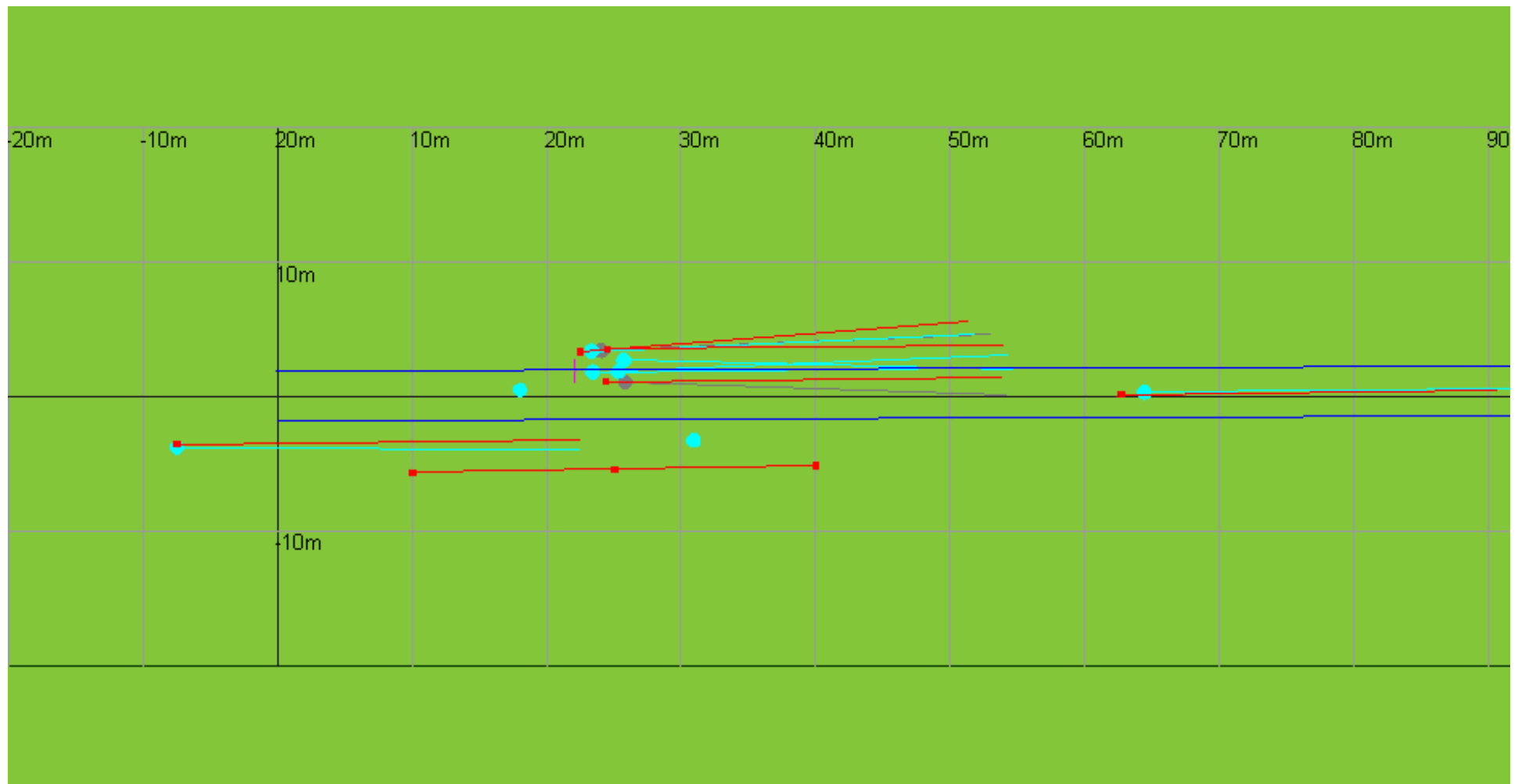


## Sensing and Perception – Laser scanner Alasca XT (IBEO)

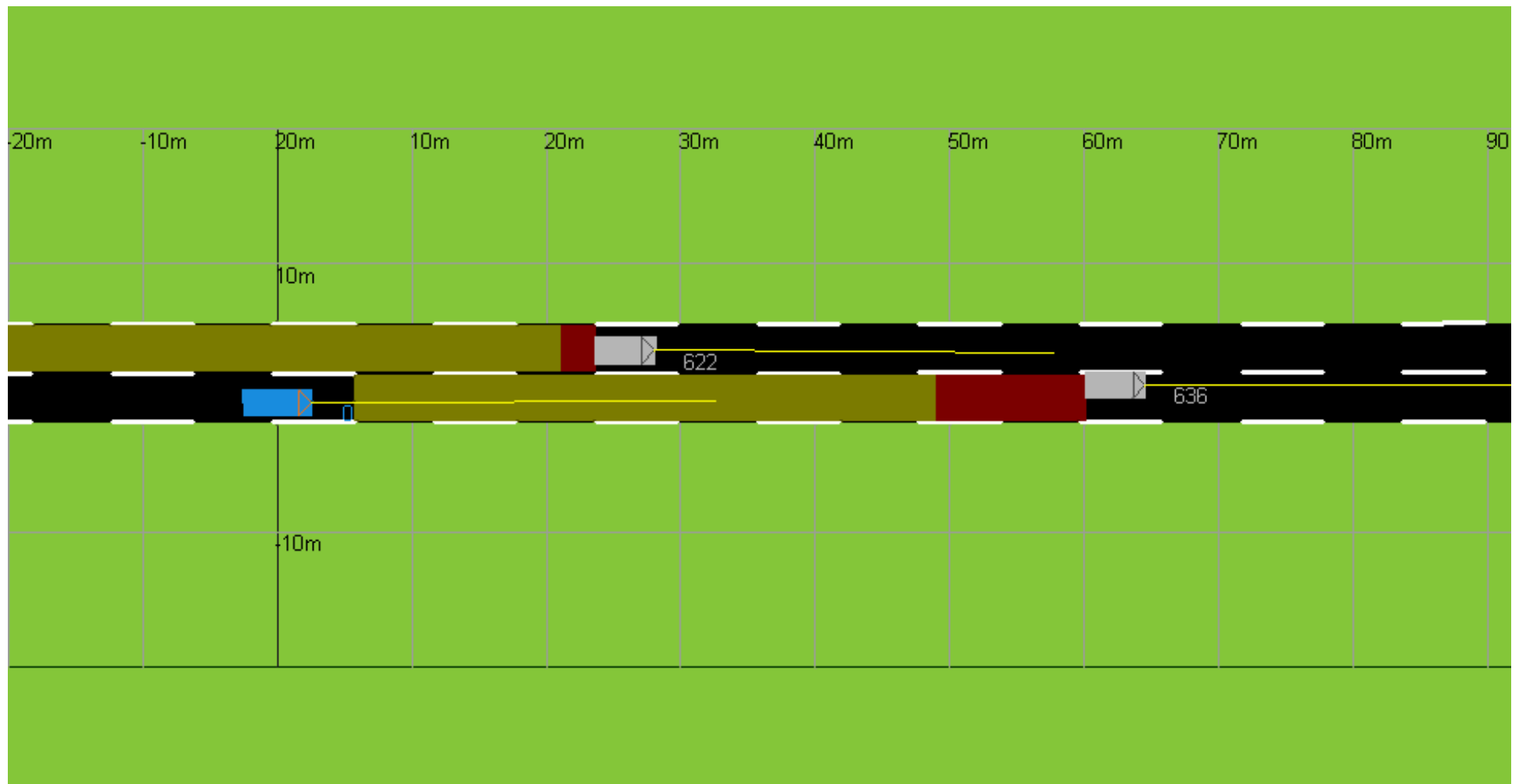
- Near infrared pulse laser
- very large field of view up to 240° and far range (200 m)
- mechanical scanning



## Sensing and Perception – From raw data ...



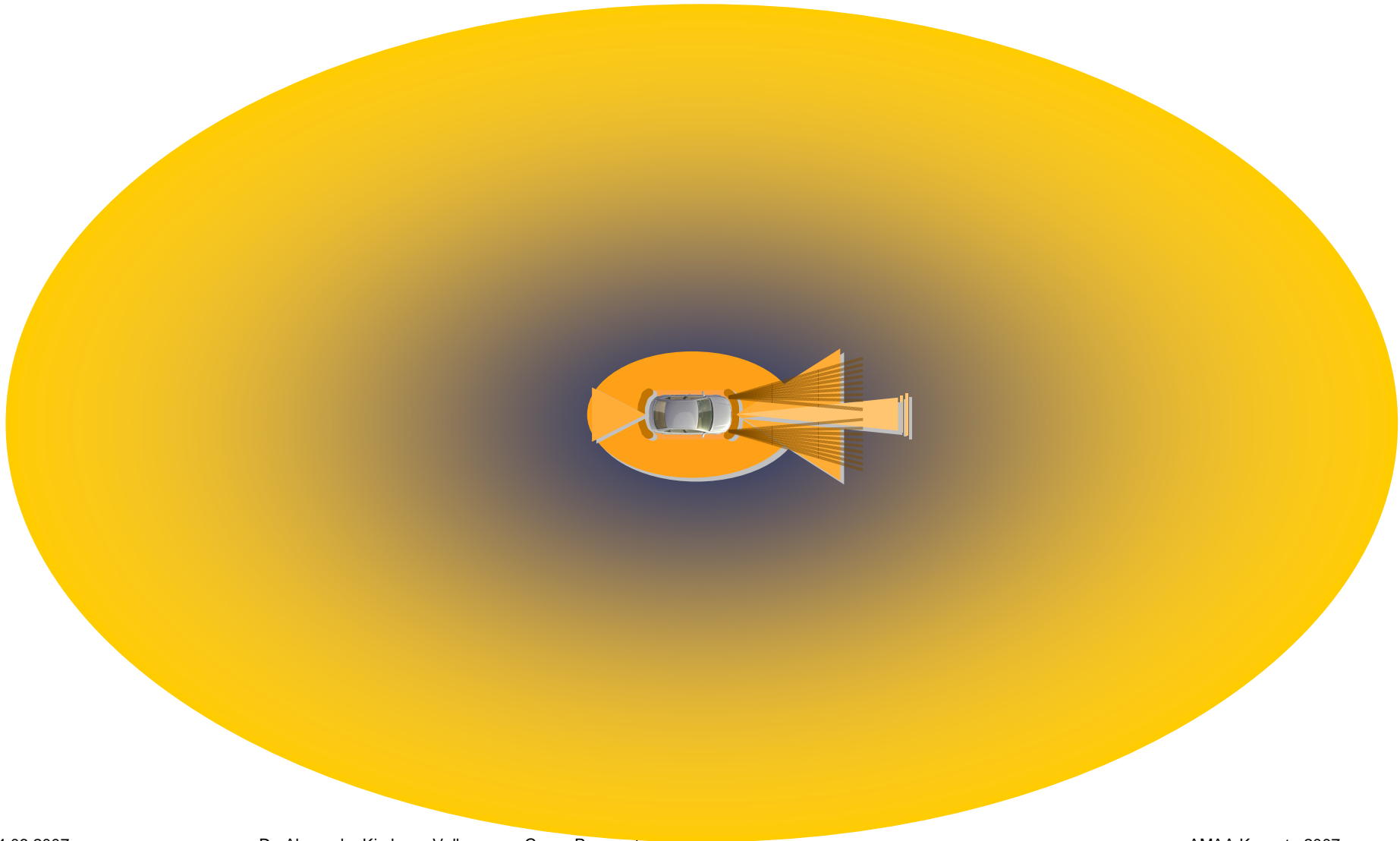
## Sensing and Perception – ... to the environment model



## Sensing and Perception – What else is out there

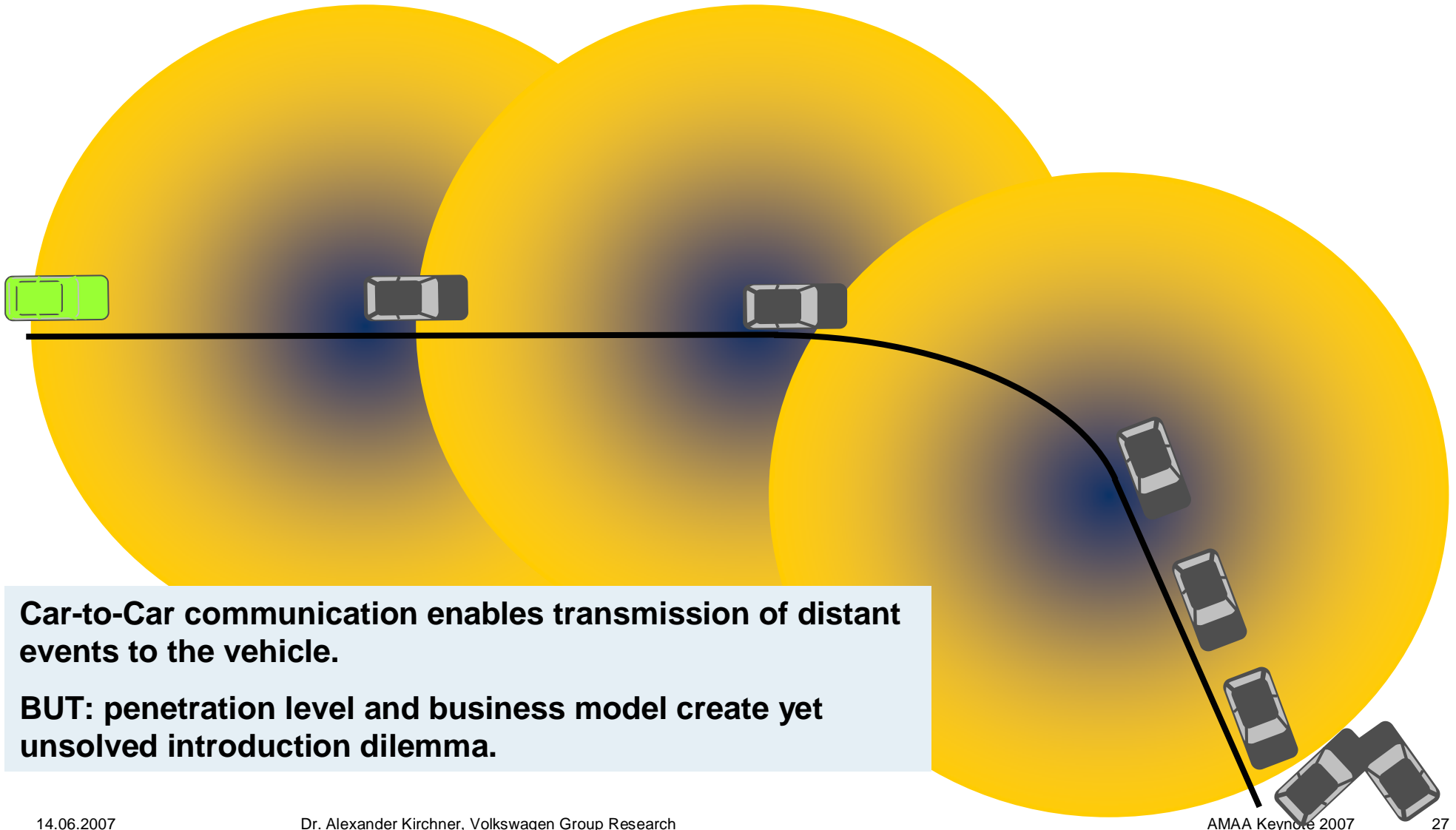
- ADAS Maps: e.g. curvature, traffic signs
- Active 3D Cameras: e.g. Photonic-Mixing-Device (PMD)
- 24 GHz high resolution radar
- High performance Ultrasonics
- Multibeam Laser
- and
- ...

## Sensing and Perception: Car2X communication





## Sensing and Perception: Car2car safety application



## Driver Assistance – Steps Towards the Seeing car

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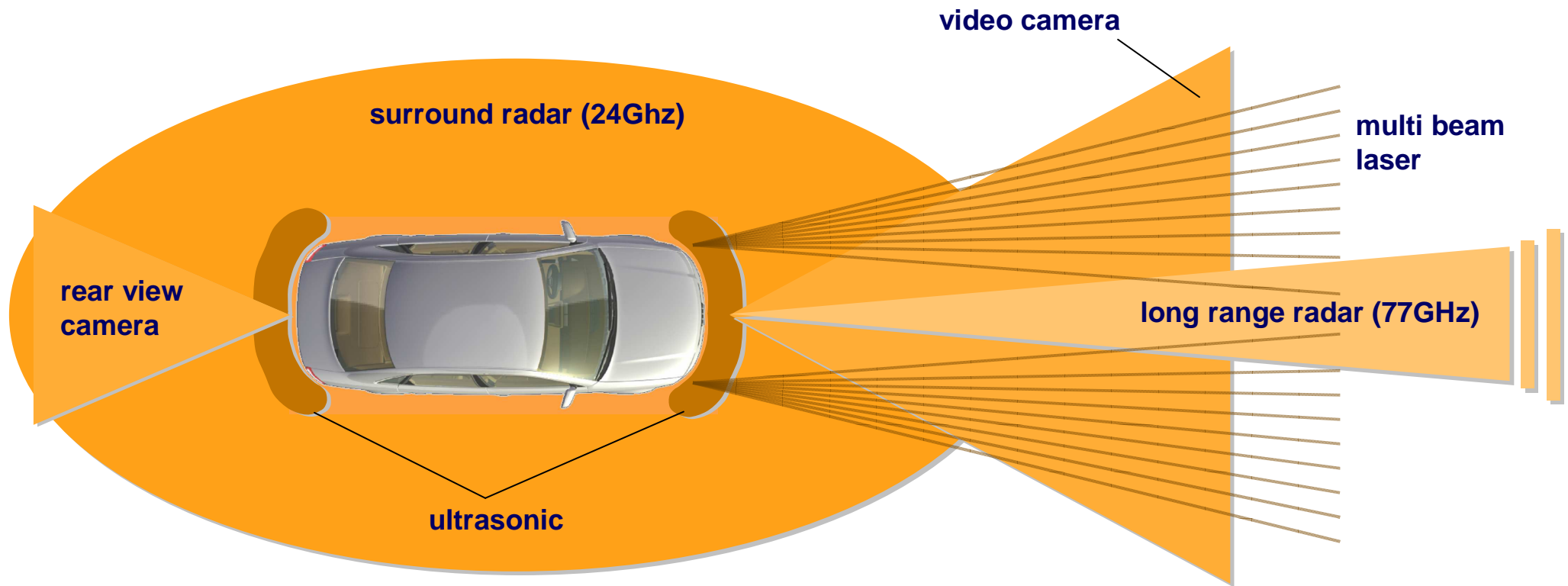
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## What is "Architecture" ?

Architecture is the fundamental organisation of a system, represented by its components, the interfaces between them and the environment, and the guidelines for the system design and development.

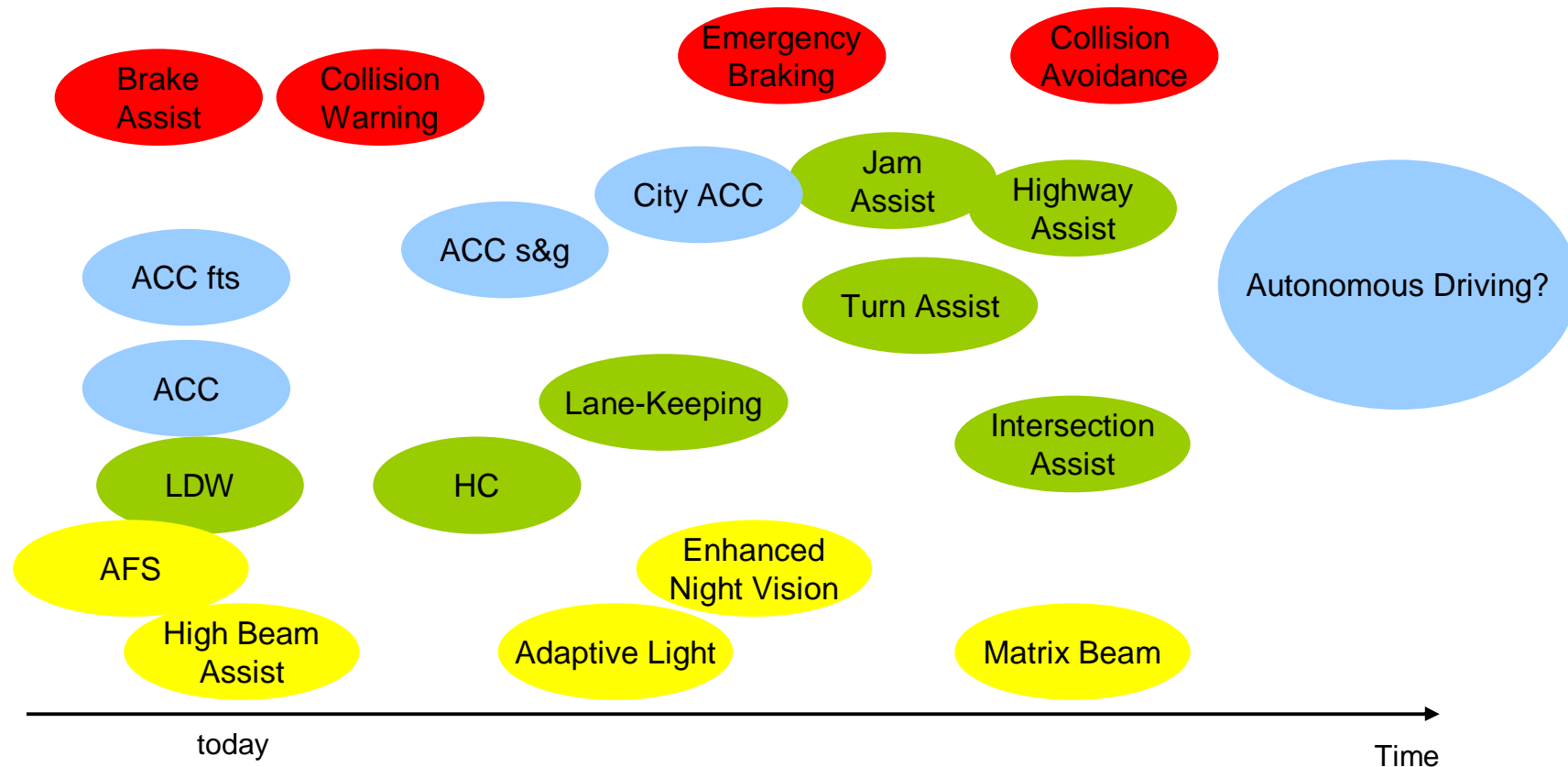
IEEE Standard 1471

## Architecture – Challenges from Sensors Generic Surround Perception



## Architecture – Challenges from Applications

### Generic Roadmap for Driver Assistance



## Architecture - Challenges

**Many Sensors**

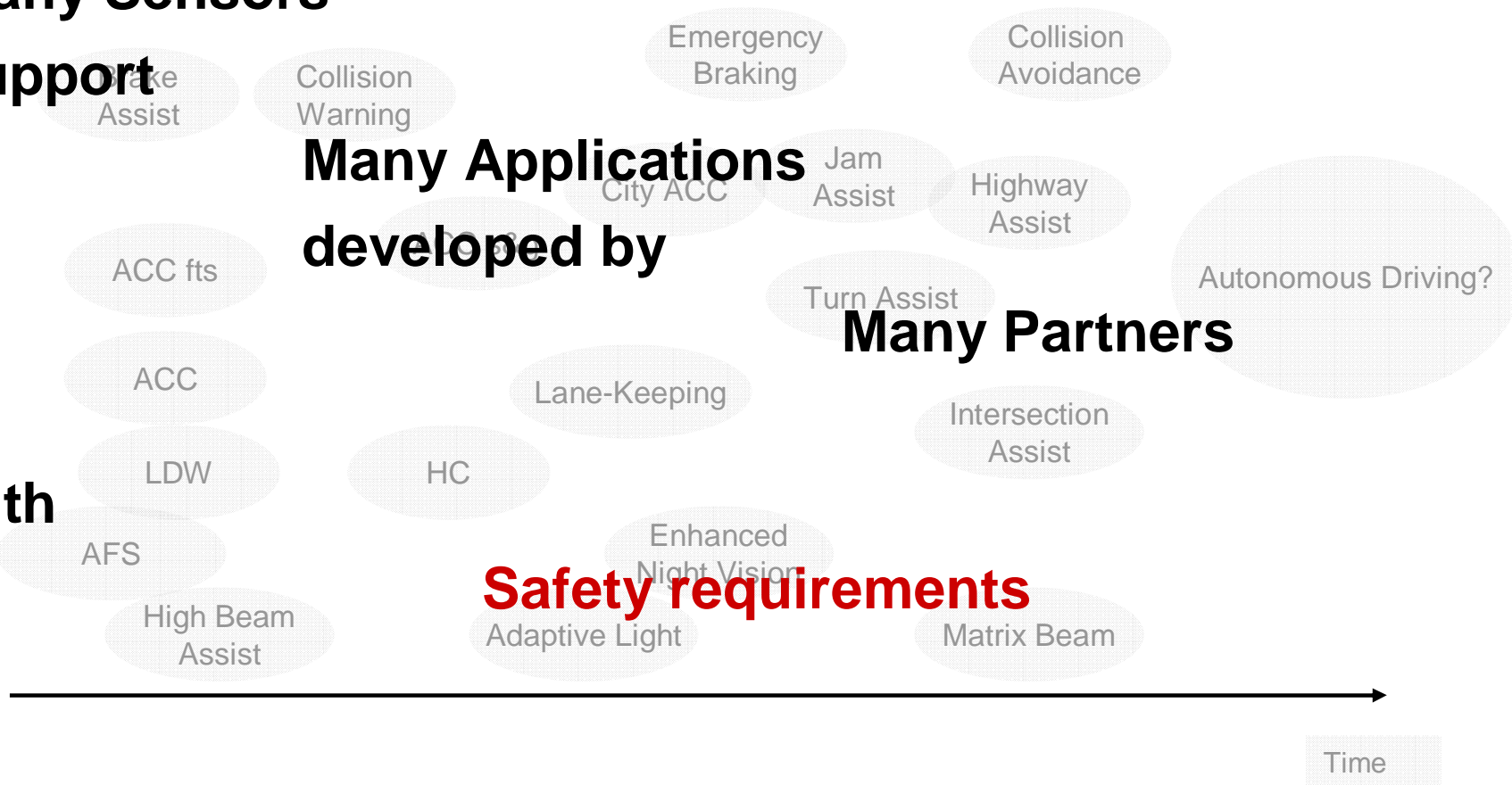
**support**

**Many Applications  
developed by**

**Many Partners**

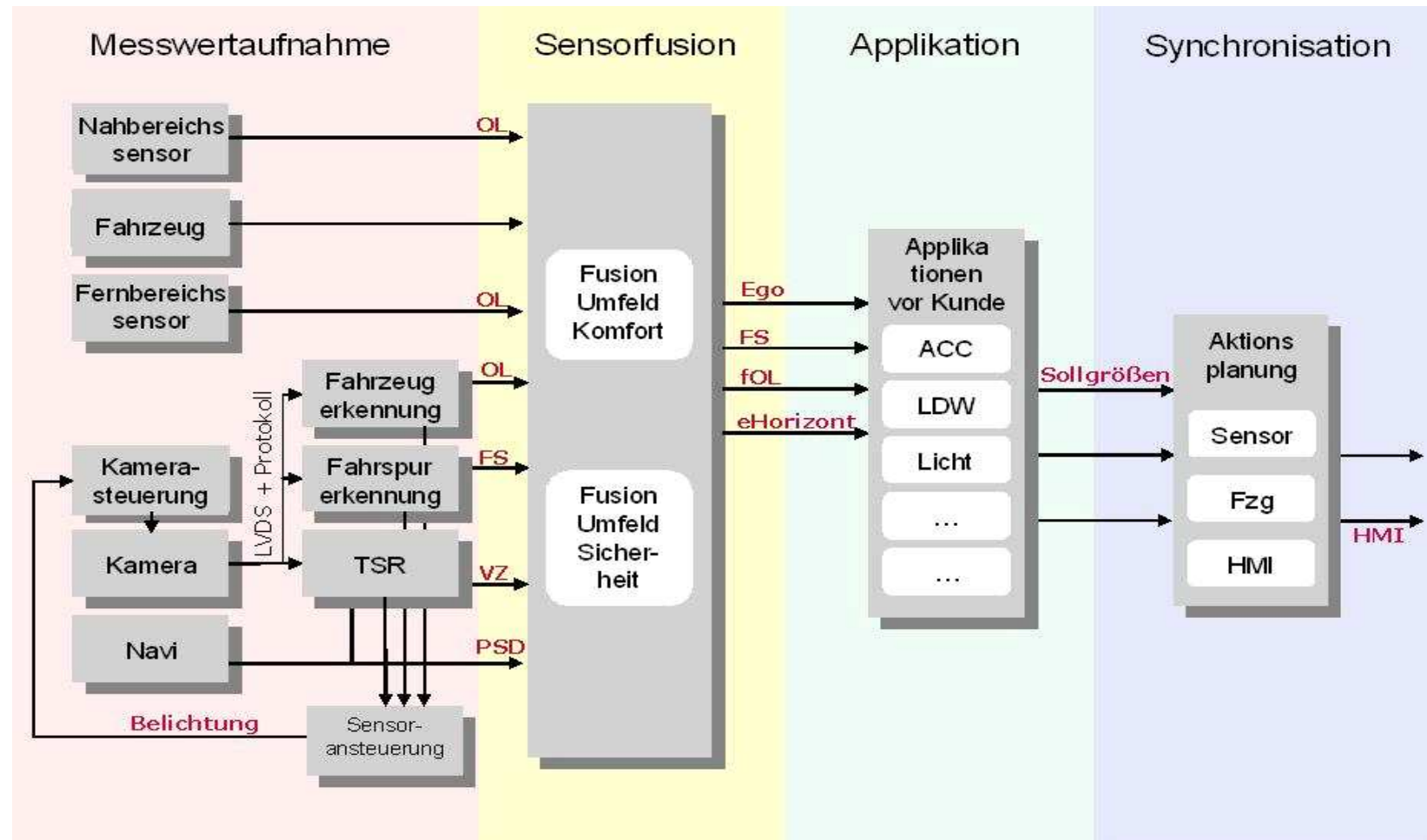
**with**

**Safety requirements**





# Generic Functional Architecture



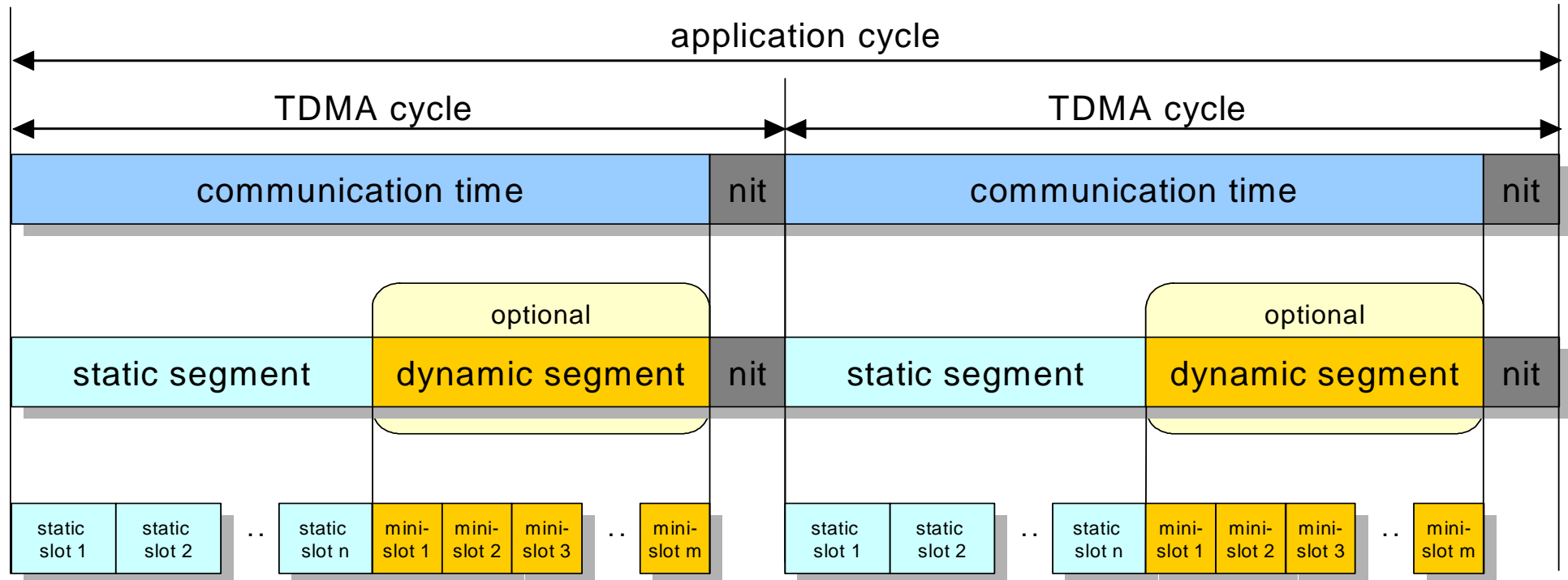
# Communication Architecture - Requirements

1. sensors
  - a) bandwidth
  - b) cycle time
2. data fusion
  - a) global time base
  - b) constant and predictable latencies
  - c) predictable time of data sampling and transmission
  - d) controllable sampling point
3. system view
  - a) automotive feasibility
  - b) reliability of data transmission
  - c) flexibility

GPS	0,15 KBit/s
video lane detection	5 KBit/s
vehicle data	20 KBit/s
internal vehicle data	10 .. 20 ms
radar	20 .. 40 ms
laser	40 .. 100 ms
video processing	40 .. 160 ms
GPS	1000 ms

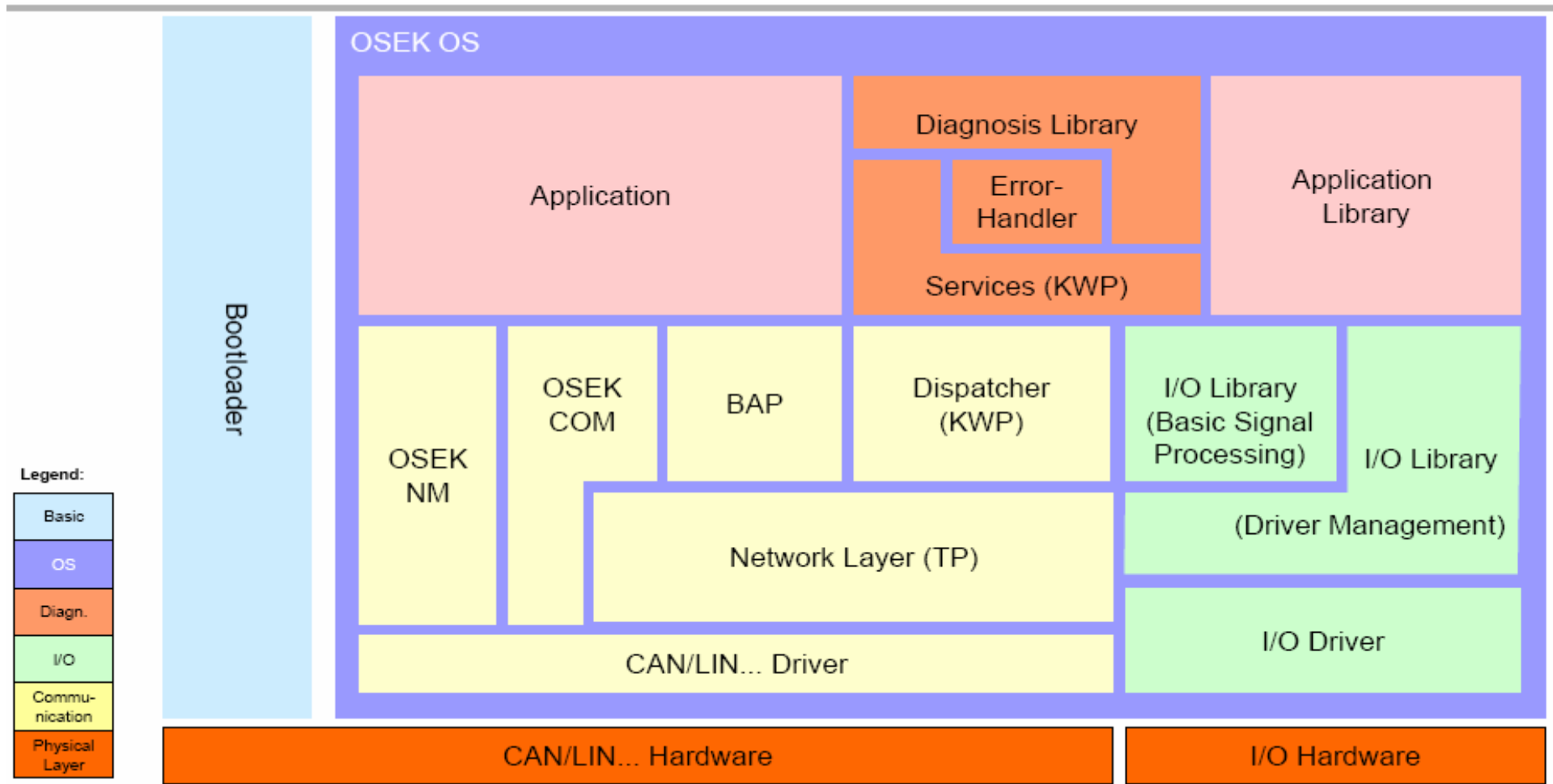
wire length	> 10 m
number of bus nodes	> 20
other requirements	e.g. EMI compatible

## Communication Architecture - Time Triggered Bus (FlexRay)

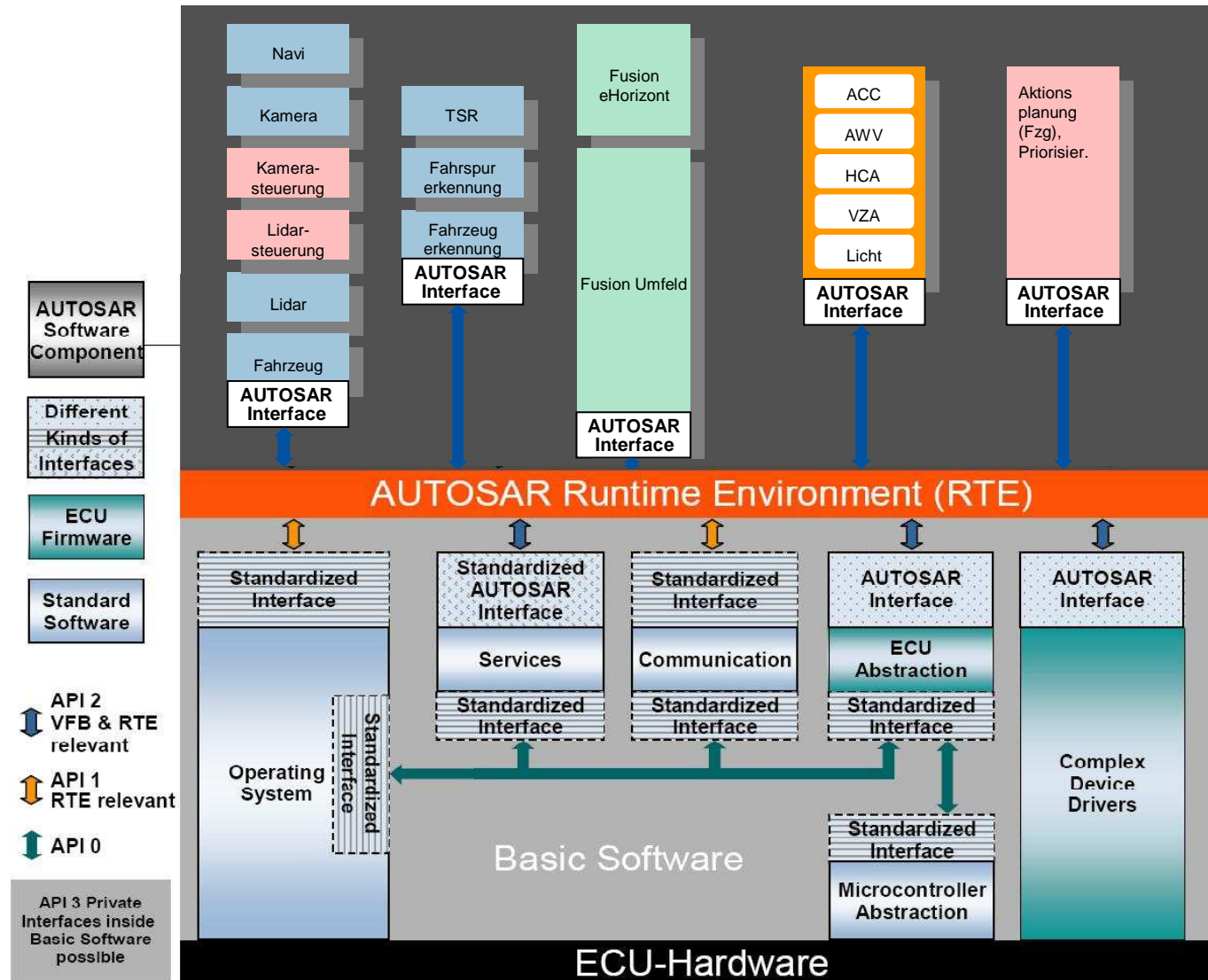


- deterministic: fulfills safety requirements
- requires early fix during development process

## Architecture - ECU



# Architecture - AUTOSAR

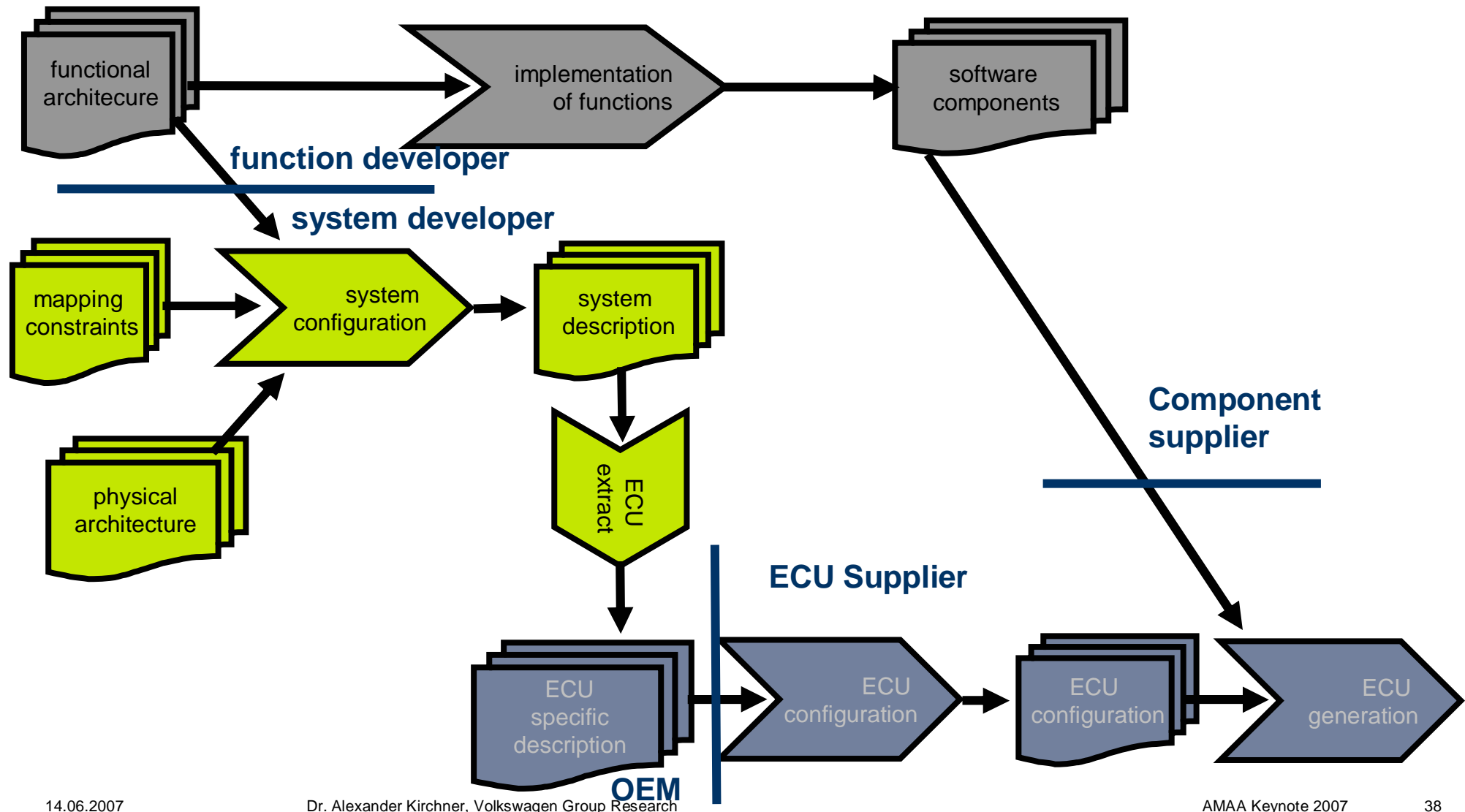


Hardware independent implementation of the system architecture by AUTOSAR software components

Hardware abstraction by virtual bus. Adaption to the physical communication architecture only by the time of code generation.

Standardized AUTOSAR software stack enables porting of software components to all kinds of electronic control units.

## Architecture - Development process and roles





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## Driver Assistance – towards the seeing car Conclusions – the future of driving?

Autonomous Racing Golf GTI

- DGPS Trajectory



## **Driver Assistance – Towards the seeing car**

### **Conclusions - Theses**

- **Driver Assistance becomes mature**
  - **Sensor costs drop – volume class cars are reachable**
  - **All big players try to take part – alliances are necessary**
  - **Severe technical issues remain – innovation is essential**
- **Exploding Functionality**
  - **Safety is critical – Modularization is essential**
  - **Complexity leads to new roles of OEMs and supplier**
  - **Human-Machine-Interaction is critical**
- **Ultimate goal automatic driving?**
  - **Relaxed accident free driving: „New manual driving“**