Université de Liège - Seminar

Advanced Driver Assistance Systems for increased Traffic Safety

Liège, 13.05.2011

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Agenda

- Introduction
  - Traffic Safety
  - Classification of ADAS
- Sensors for environment perception
- Examples of ADAS
  - Current automotive applications
  - Current off-road applications
  - Future automotive applications

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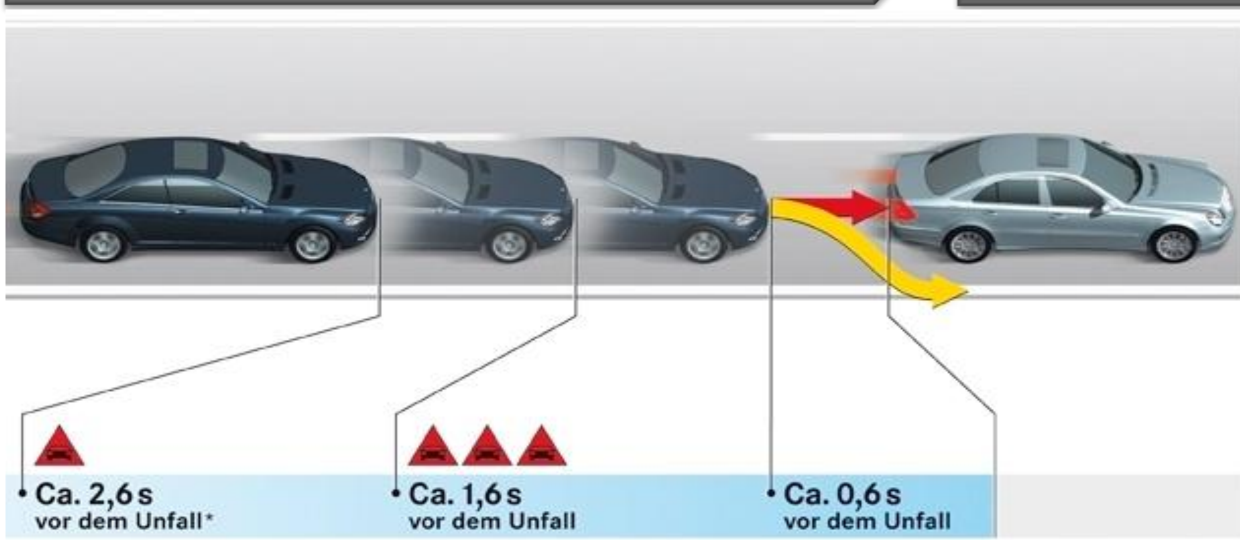
Traffic Safety
Terminology

Information | Warning | Assistance | Intervention | **Accident** | Protection Systems „soft level“ | Protection Systems „hard level“ | Protection Systems after Accident

Normal | Accident Avoidance | Pre-Crash | In-Crash | Post-Crash

Active Safety | **Passive Safety** | **Rescue**



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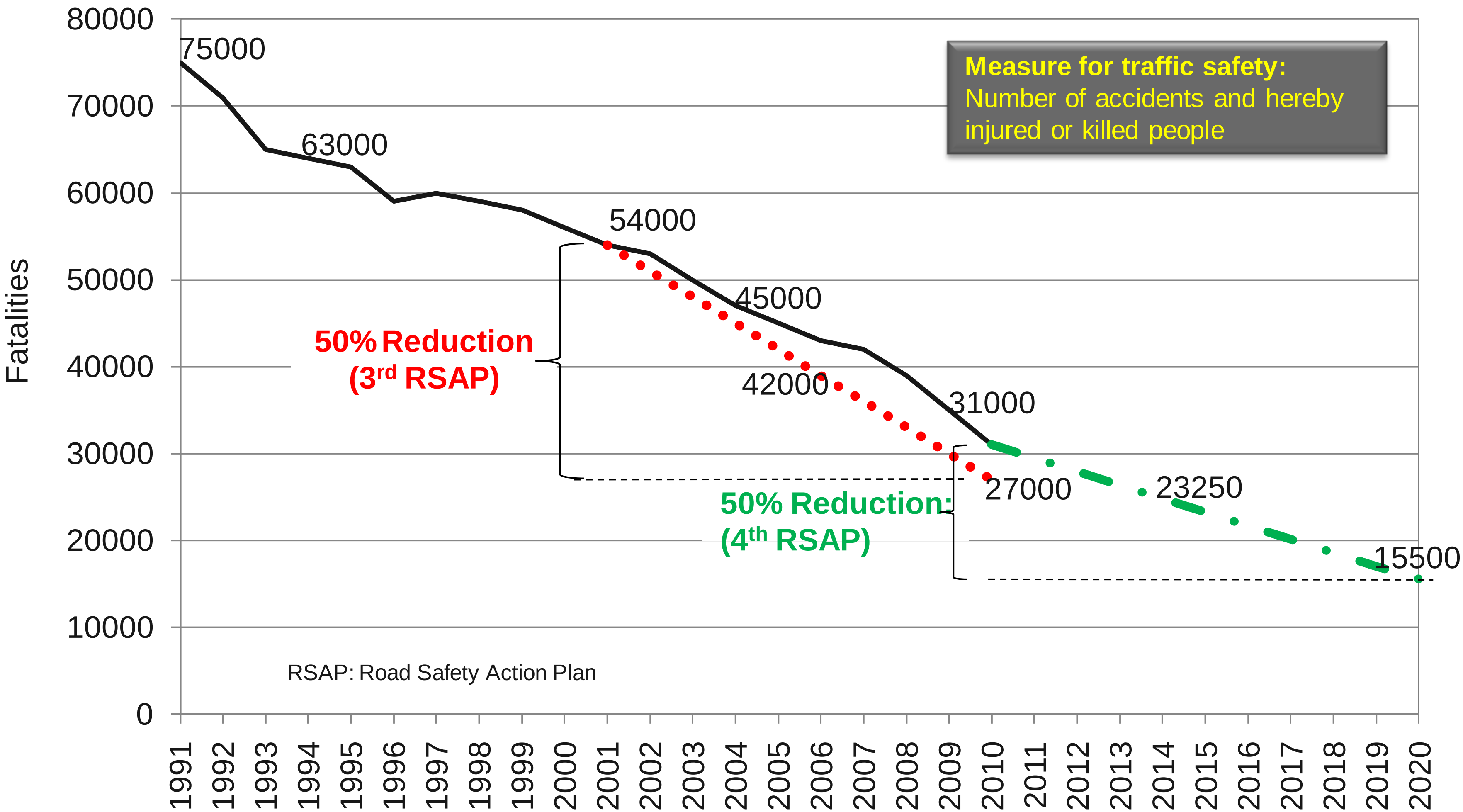
Traffic Safety

Accident Statistic vs. Target of European Commission



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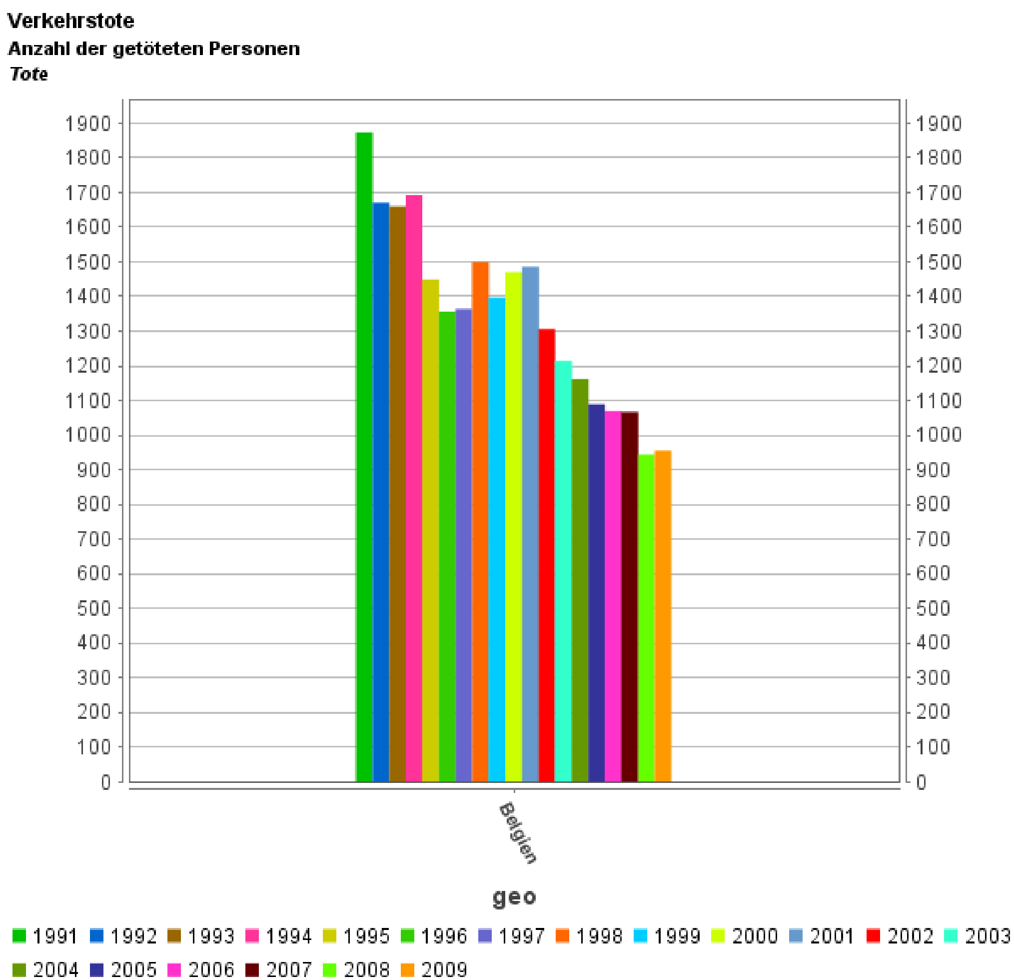

Traffic Safety

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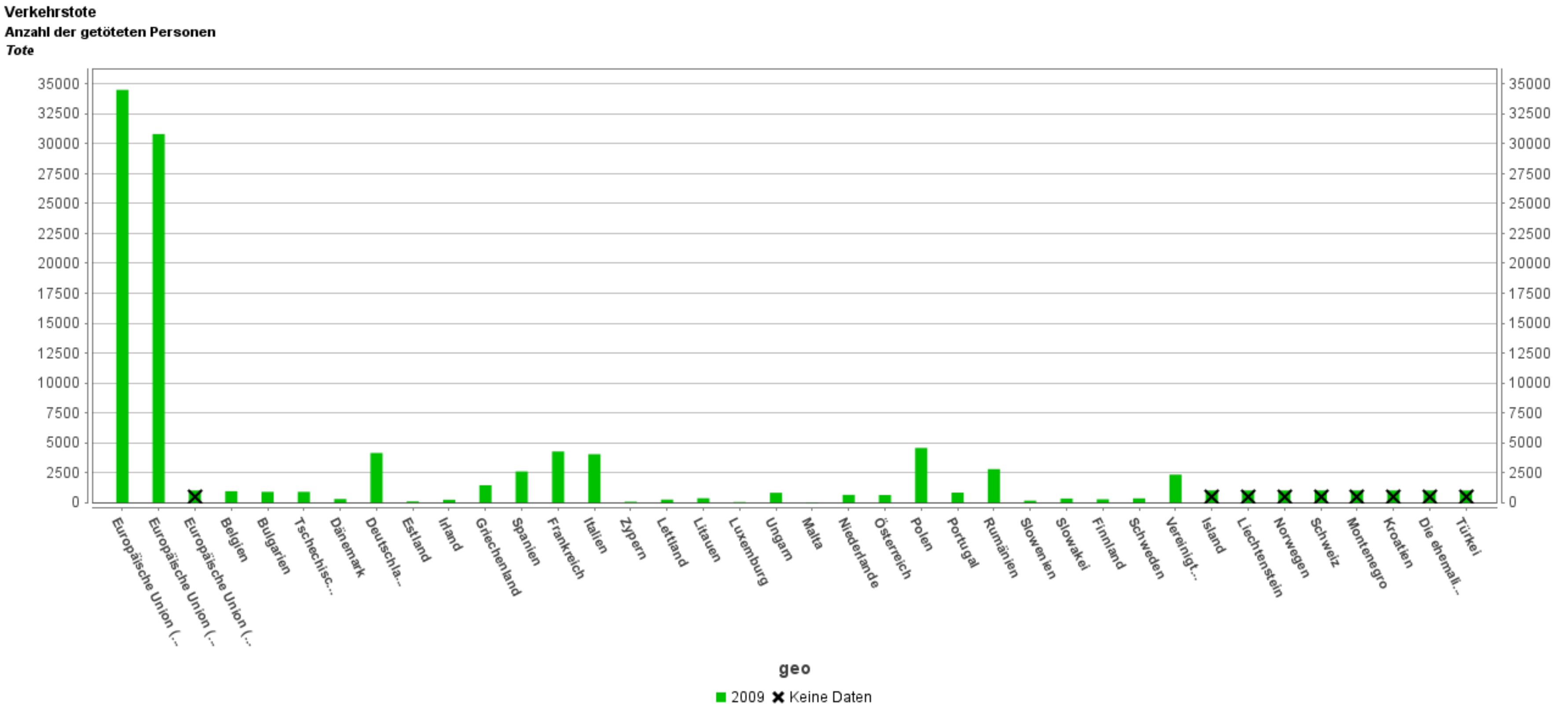

Traffic Safety

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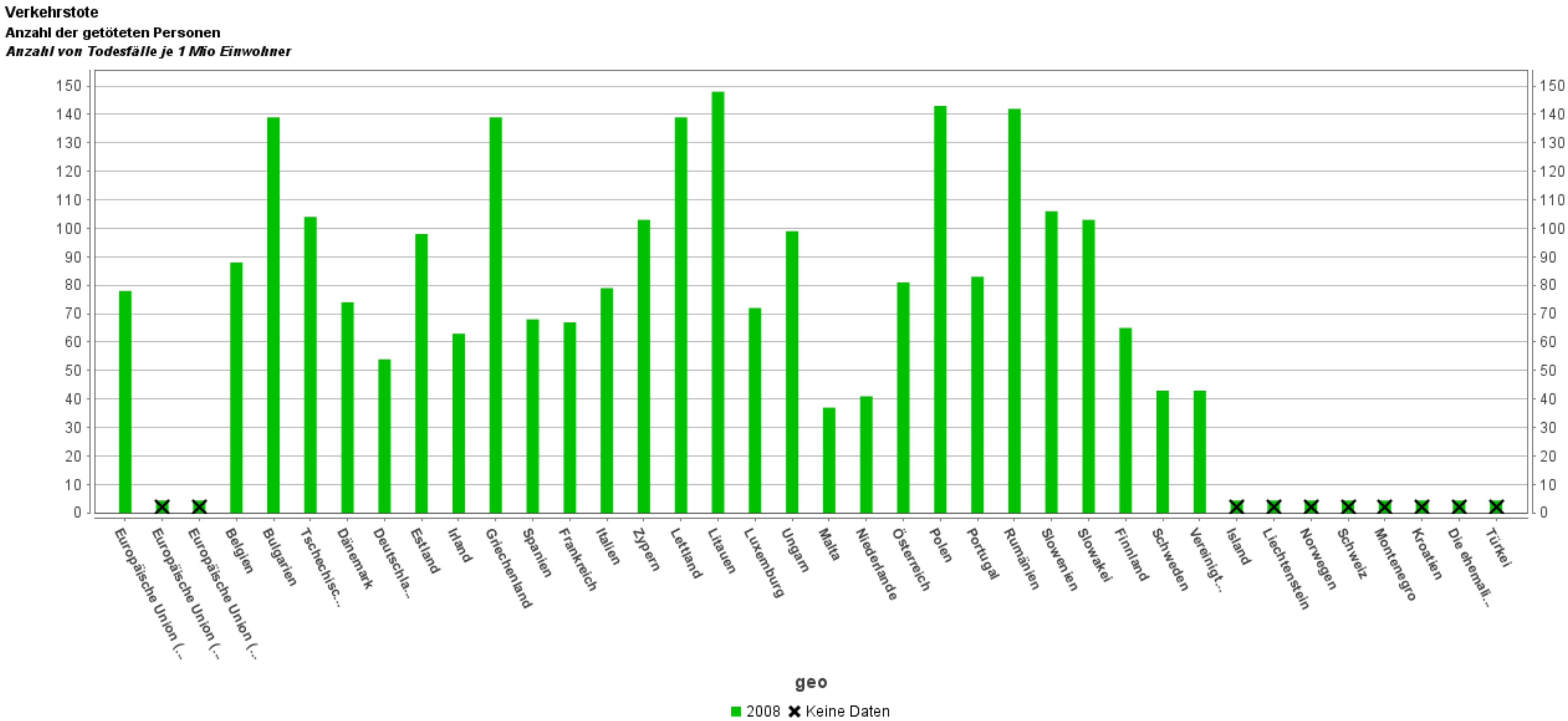


Traffic Safety

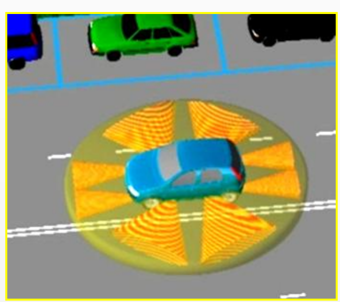
Basics for the Deduction of Measures

- Accident research and analysis
  - When, where, why and under which circumstances do accidents happen?
  - Type, severity, frequency, reconstruction, … of accidents

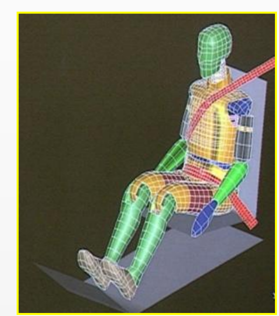
- Biomechanics
  - How do these accidents affect the human body?
  - Type, severity, frequency, … of injuries

Deduction of measures

- Active Safety
  - Reduce the number of accidents

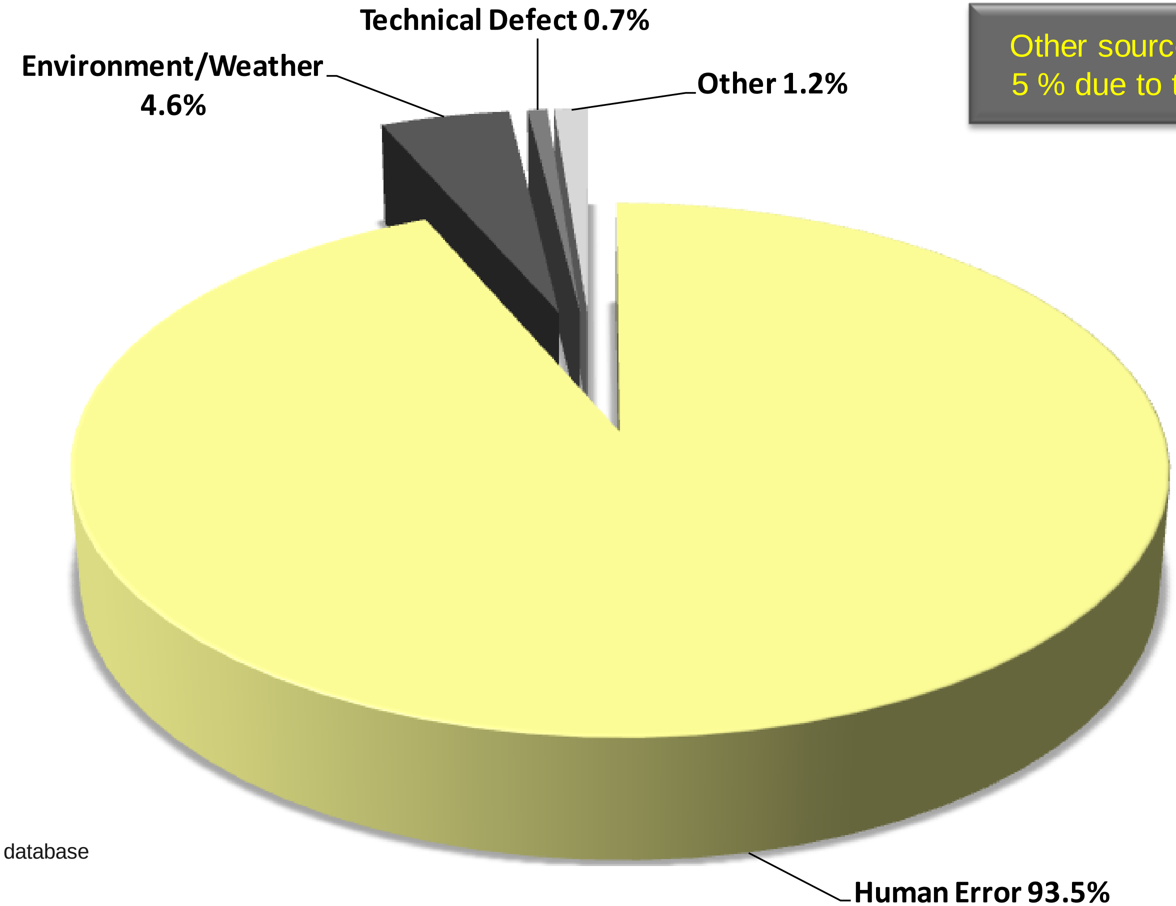


- Passive Safety
  - Minimise the effects of accidents



Traffic Safety
Accident Research and Analysis

- Accident reasons



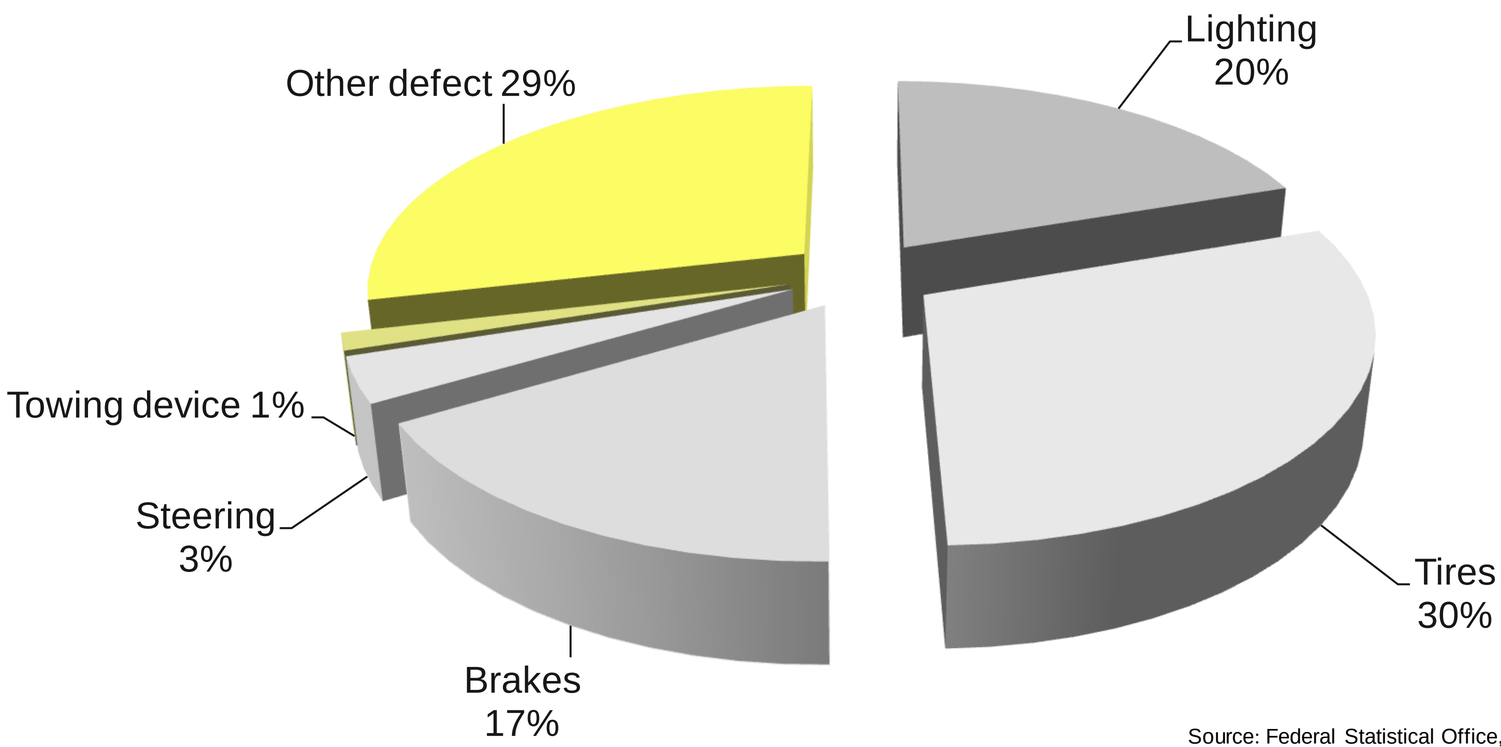
Other sources mention up to 5 % due to technical defects

Source: Volkswagen GIDAS database
Analysis of 16.544 accidents

Traffic Safety

Accident Research and Analysis

- Distribution of 3966 technical defects in 2009 (Germany)



Source: Federal Statistical Office, Series 8, Volume 7, 2009

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Traffic Safety
Deduction of Measures

- Passive safety in former times

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Traffic Safety

Deduction of Measures

- Passive Safety Protection of Passengers in the Past and Today

aggressive form of steering wheel

square-edged instrument panel

displacement of steering wheel

floor room intrusion

knee protector pads

side airbag

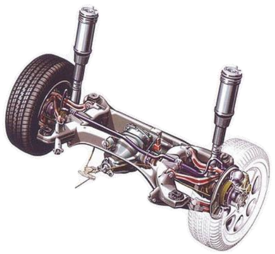
telescopic steering column

front airbag

Traffic Safety

Deduction of Measures ⇨ Accident Risk Reduction

- Vehicle
  - Vehicle design (chassis concept, quality of safety relevant parts, etc.)
  - Vehicle concept (control panel, climatisation, lighting, viewing angle, seat position)



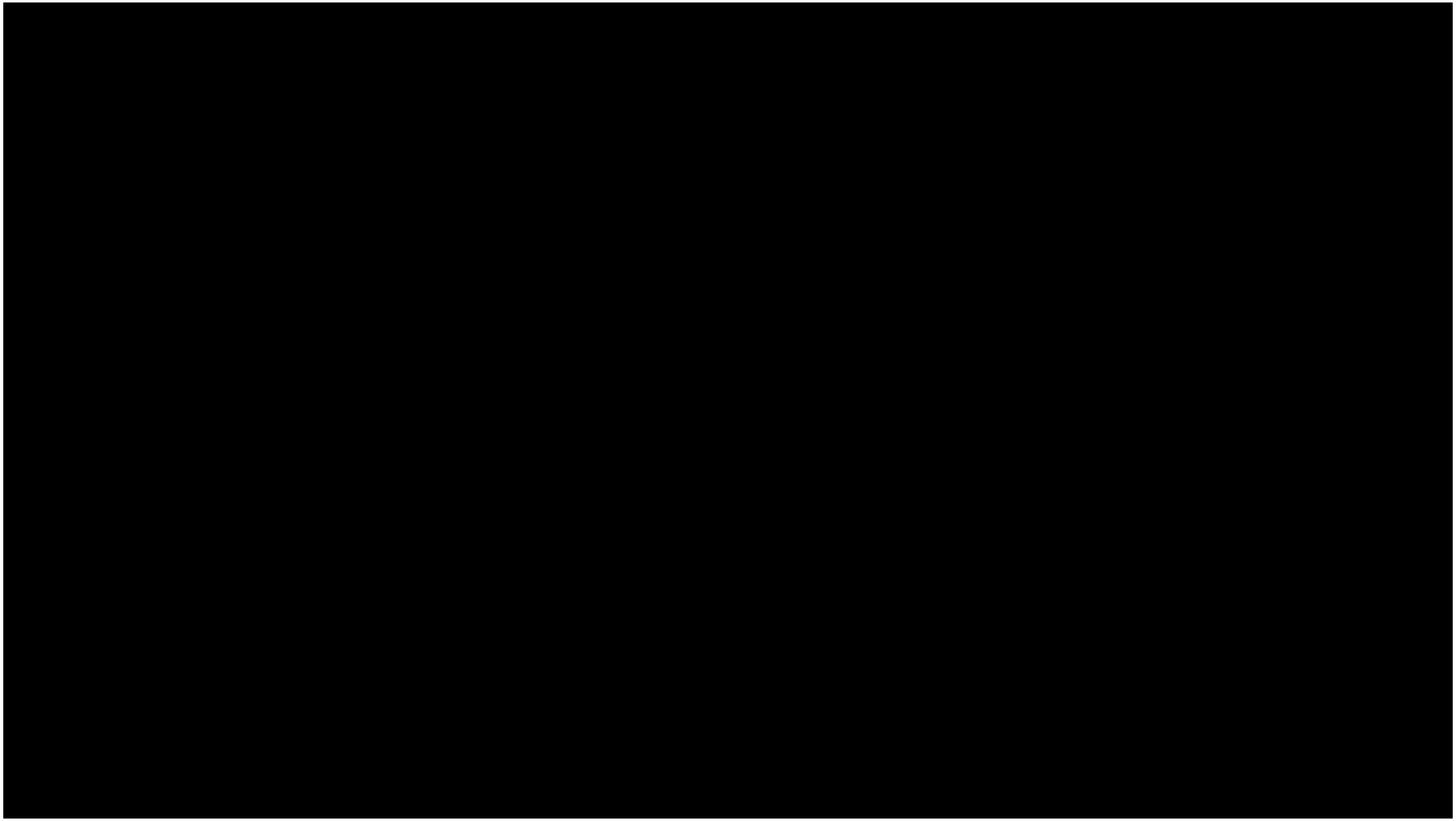
- Driver
  - Driver condition (stress, exhaustion, driver attention etc.)
  - Driver behaviour (choice of speed for cornering, choice of distance for following, etc.)

- Infrastructure / environment
  - Road conditions
  - Road lighting
  - Crossroad concept
  - Signing (speed limit/ ban on overtaking)

- Legislation
  - Speed controls
  - Minimum distance between two vehicles

Traffic Safety

Deduction of Measures ➩ Accident Risk Reduction



Traffic Safety
Deduction of Measures ⇨ Accident Risk Reduction

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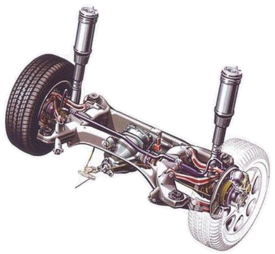

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- Legislation
  - Speed limits
  - Minimum distance between two vehicles

Traffic Safety
Deduction of Measures

- Human errors and possible technical solution
  - Driver has to realise (detect) the situation (viewing angle, i.e. vehicle in blind spot?) ⇨ Lane Change Assist
  - Driver has to assess the situation in the right way (risk of collision, critical situation) ⇨ Collision Warning
  - Driver has to judge the situation in the right way („It will be close, but I will go through“) ⇨ Emergency Braking
  - Driver has to react in the right way (full brake power, evasion manoeuvre)
  - Vehicle has to convert driver‘s reaction (sufficient high deceleration/lateral acceleration) ⇨ ABS
  - Street condition has to realize the deceleration/lateral acceleration (friction factor, unevenness) ⇨ Road Friction Tester

Traffic Safety

... is not the only target of ADAS

- **Comfort**
  - Increase of driving comfort
  - Relieve the drivers from monotone tasks
- **Traffic efficiency**
  - Improved utilisation of the road capacity
  - Avoidance or faster dissolution of traffic jams
- **Effects on the environment**
  - Decrease of fuel consumption
  - Decrease of emissions (e.g. CO_2, CO, NO_x, Particles)
  - Reduction of traffic noise

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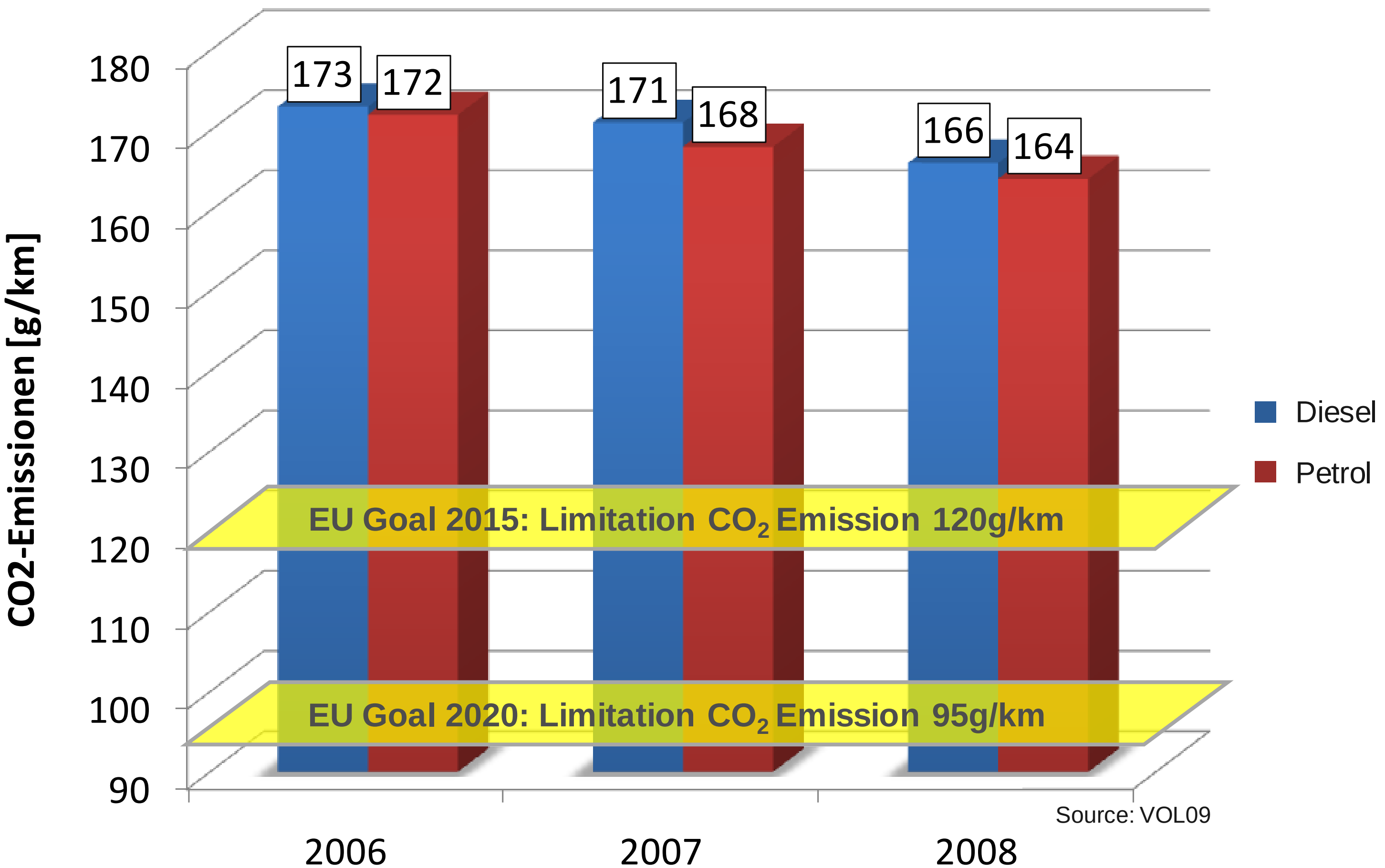
Traffic Safety

... is not the only target of ADAS

- CO_2 emission of new licensed passenger cars



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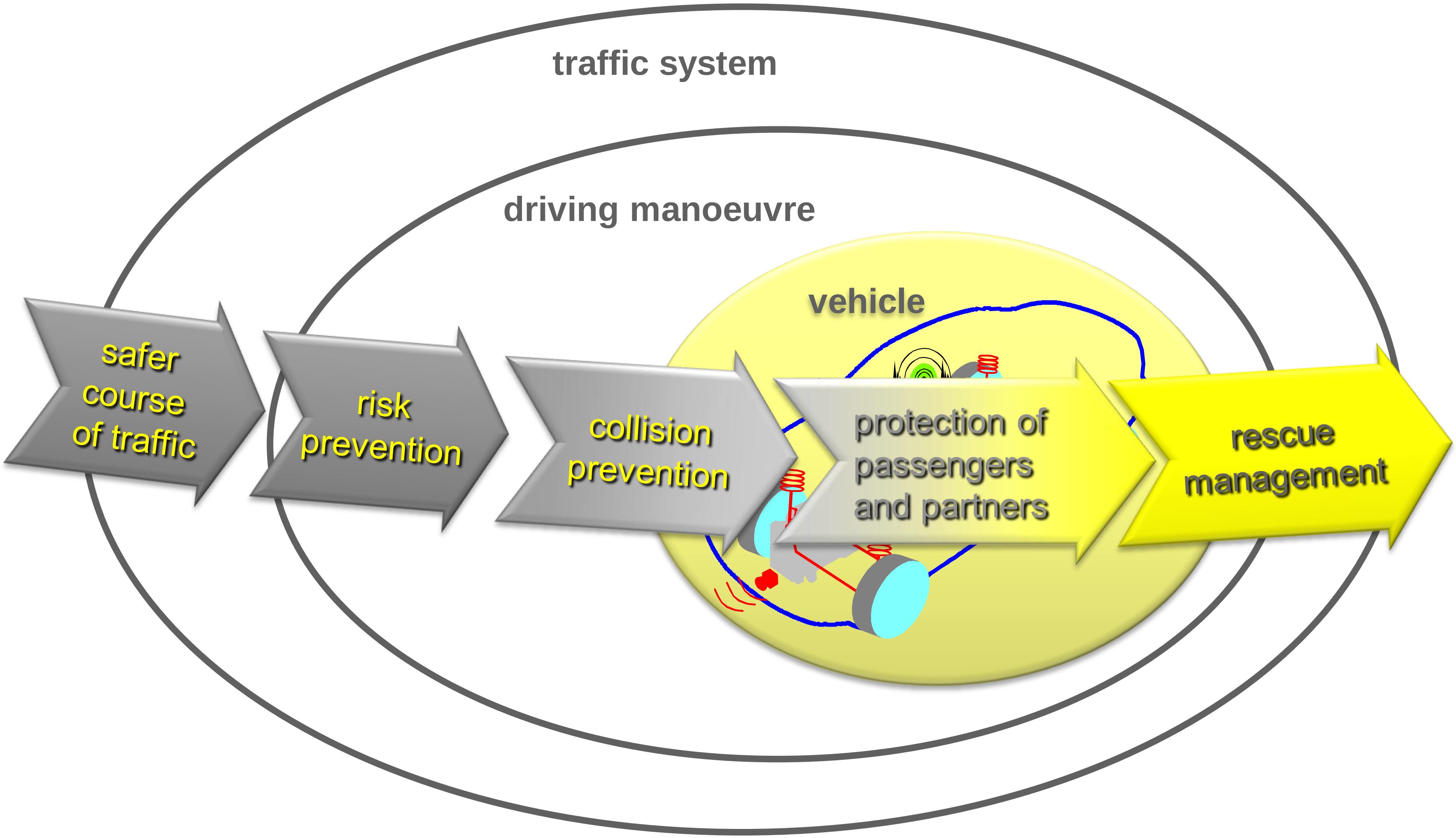
Classification of ADAS

... according to the course of traffic



Classification of ADAS

... according to the type of assistance

information	warning	intervention/takeover of the driving task
acoustic	acoustic	accelerator/ brake pedal
visual	visual	steering
haptic	haptic	transmission

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Classification of ADAS

... according to the driving task

Driving Task

Navigation level
t = 10 s … x h

The driver decides the route inside an existing road network. During the drive the navigation engages itself to the perception of the necessary information for keeping the route and if necessary to an adjustment of the route due to changed boundary conditions.

Guidance level
t = 1 s - 10 s

The driver adjusts the driving manner to the road situation perceived by him and the surrounding traffic. The guidance level contains subtasks e.g. the lane-keeping, the following, the overtaking and the reaction to traffic signs. The tasks of this level can be divided into lateral and longitudinal guidance.

Stabilisation level
t = 0 s - 1 s

The driver converts the chosen driving strategy into vehicle-specific control variables, e.g. steering action, position of accelerator, brake und gear. A permanent adjustment of the actual value to the desired value of the velocity and the lane takes place. For the driver „stabilisation“ means the avoidance of uncontrolled internal dynamic of the vehicle.

Time demand

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Classification of ADAS
... according to the driving task

Level of driving task	Asisstance System	Analogy
Navigation (route choice)	**Navigation System**	**3rd Commu-nicate**
Guidance (course and speed choice)	**ADAS** (e.g. ACC, LDW)	**2nd See**
Stabilisation (actuation of steering wheel, throttle and brake pedal)	**Chassis Control Systems** (e.g. ABS, DSC)	**1st Feel**

3rd Commu-nicate

C2X, GNSS
≡
Ear & Mouth

2nd See

Radar, Camera
≡
Eyes

1st Feel

Inertial sensors
≡
Equilibrium organ

Needed Sensors

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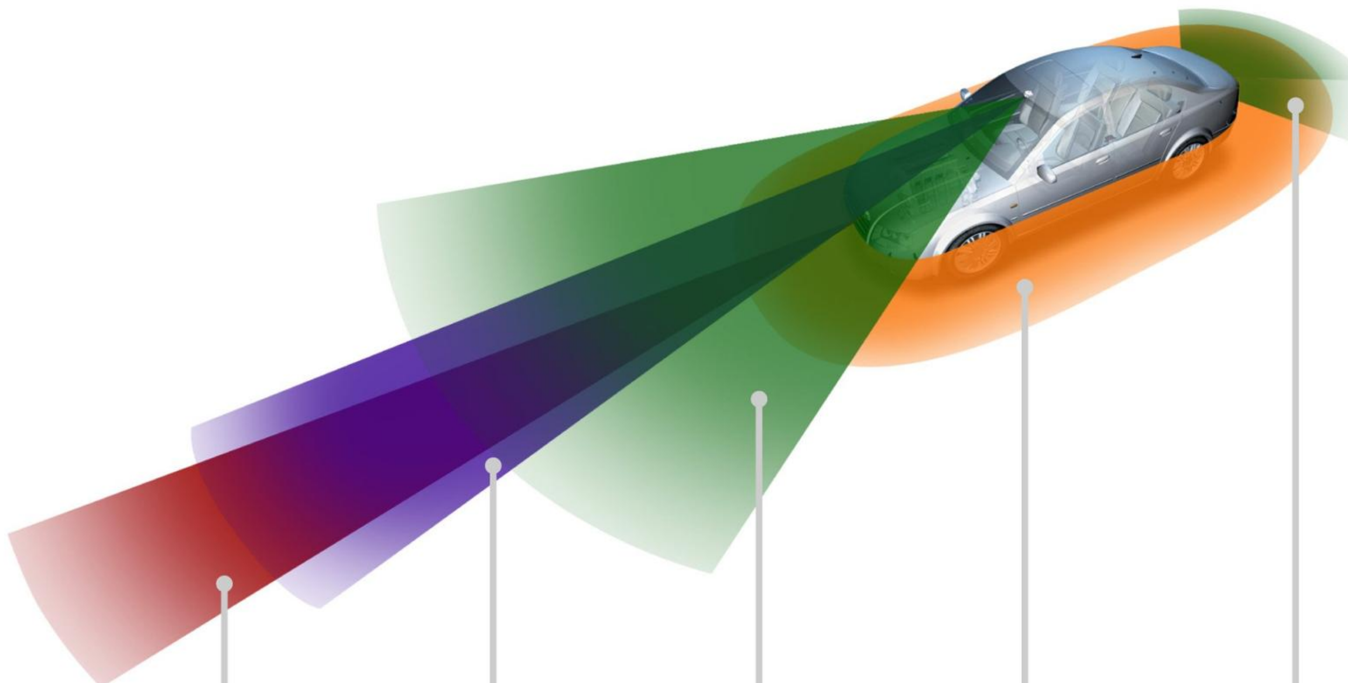
Sensors for environment perception

Overview



Long-Range Radar

Far field
≤200m

Infrared

Night View

Video

Middel field
≤80m

Ultrasonic

Ultranear field
≤4m

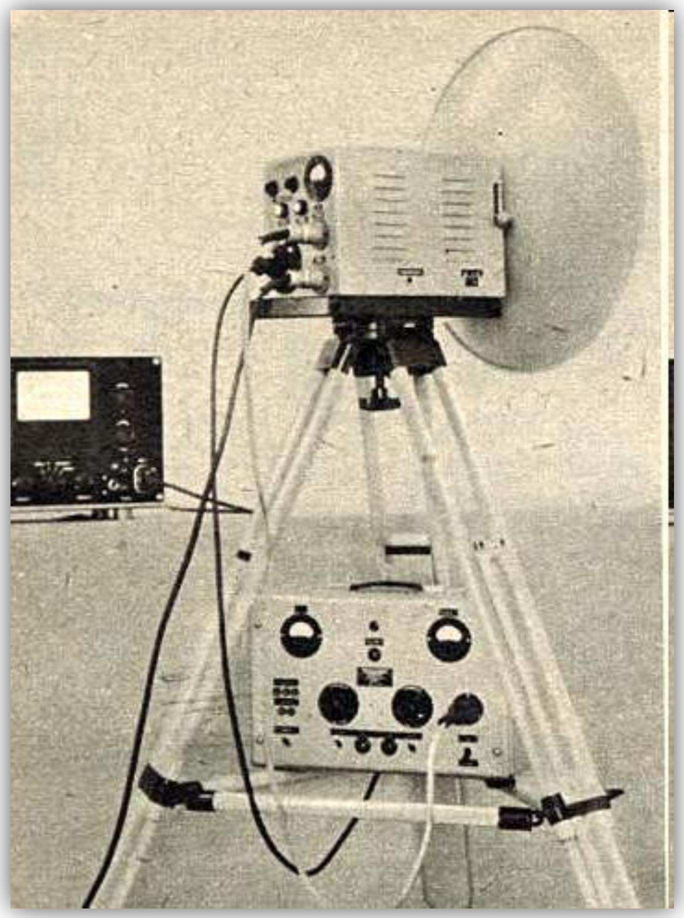
Video

Rear range

source: Bosch

Sensors for environment perception
History of Radar Technology

- Traffic radar equipment in Dresden 1961
- Display unit is integrated in vehicle



source: German Traffic 07/1961

Sensors for environment perception

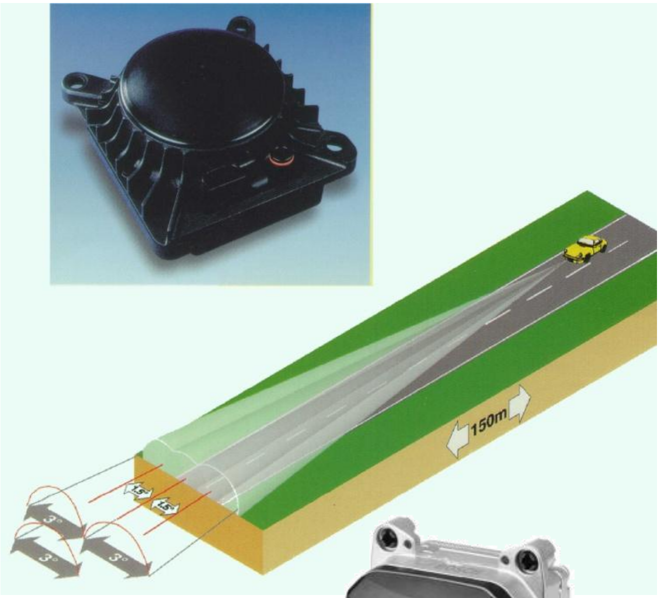
Long Range Radar

- RADAR = **<u>Ra</u>**dio **<u>D</u>**etection **<u>A</u>**nd **<u>R</u>**anging
- Example: Bosch 3rd generation

Performance data	(compared to LRR2)
→ Field of View: **30°**	(16°)
→ Range: **0.5…250m**	(1.5 …200m)
→ Object separation	
• By distance: **1m**	(2m)
• By velocity: **0.6m/s**	(1.2 m/s)
• By angle: **~4°**	(none)

Technology:

- → 77 GHz Silicon Germanium MMIC **(world's first)**
- → Flexray communication **(world's first)**
- → Package advantages **(world's smallest)**
- → Lead free



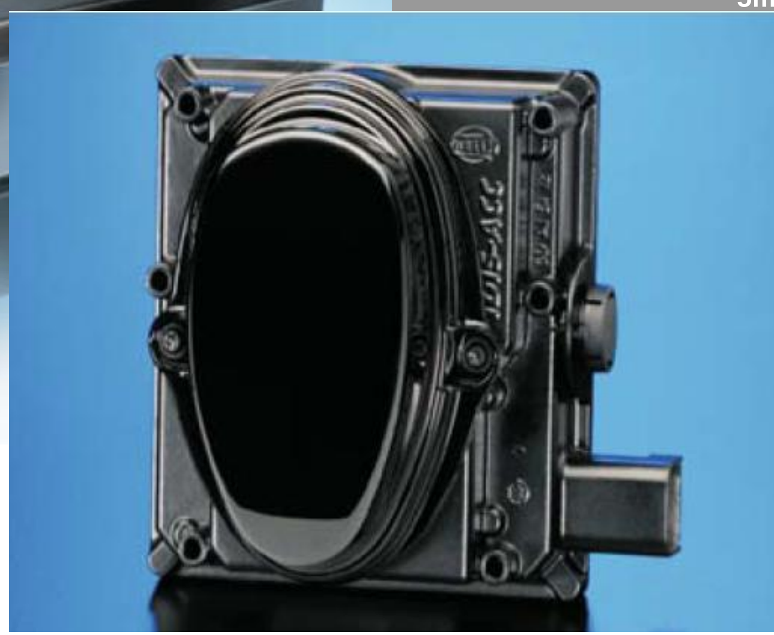
74 x 77 x 58 mm
(L x W x H)

Sensors for environment perception

Lidar

- LIDAR = **Li**ght **D**etection **A**nd **Ra**nging
- Example: Omron and Hella

Model	OMRON gen3
Wavelength	905 nm
Eye protection	Class 1 (IEC825)
Radiated power:	12W (Peak) 5mW (Average)



Model	Hella IDIS
Wavelength	905 ... 920 nm
Eye protection	Class 1 (IEC825)
Radiated power:	50W (Peak)
Coverage	±16° (Azimuth/hor.) 3° (Elevation/vert.) multiray
Number of rays	16
Min. curve radius	100 m
Range	1 … 150 m
Size LxWxH	105 x 105 x 76.5 mm²
Velocity Accuracy	1 km/h

Sensors for environment perception

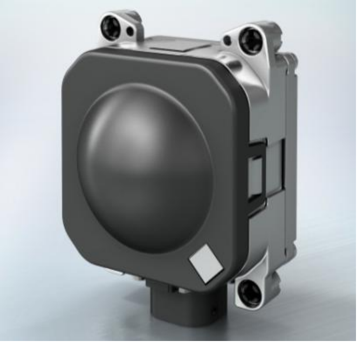
Laser Scanner

- LASER = **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation
- Example: Ibeo Lux
  - Scanning Frequency: 12,5 Hz (25 Hz)
  - Horizontal angle: 100 ° field of view
  - Range: 0,3 m to 200 m
  - Resolution: range 4 cm, angle 0.125 ° to 1 °
  - 4 parallel and simultaneous scanning layers
  - Size: H85 x W128 x D93
  - Weight: Approx. 1kg
  - Built-in processing
  - Laser class 1
  - Ethernet- and CAN-Interface

Source: IBEO

Sensors for environment perception

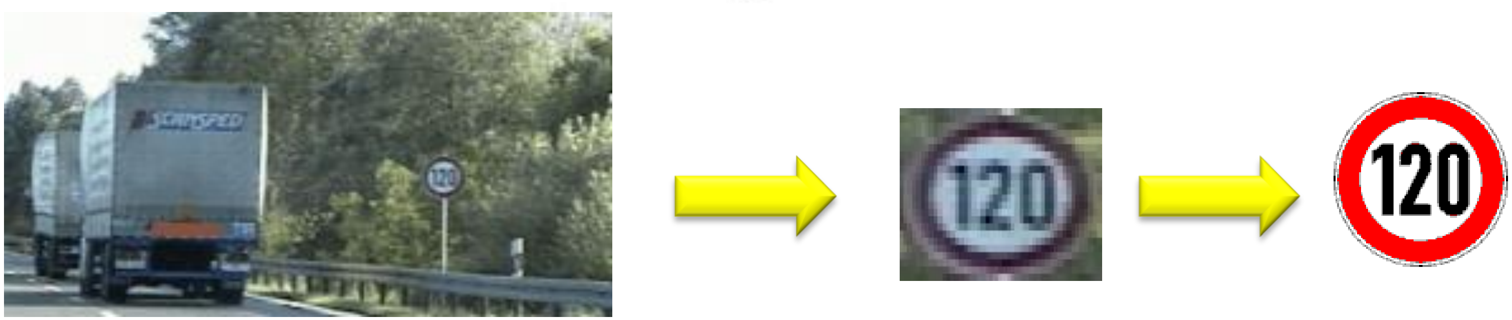
Comparison of radar with laser sensors

	Advantages	Disadvantages
Radar		
	– not sensitive to dirt – direct velocity measurement – hidden installation possible – no interferences with other sensors – low output power – small antenna because of combined emitting and receiving	– expensive – no visibility measurement – blind flight possible at bad sight
Laser		
	– low price – point of view adaptation – no interferences with other sensors – no health impairment	– sensitive to dirt – installation influences styling – indirect velocity measurement – sensitive to bad weather condition

Sensors for environment perception

Systems for image processing

- CMOS camera (Complementary Metal Oxide Semiconductor)
- CCD camera (Charge Coupled Device)
- Example Mobileye:
  - Resolution: 480×640 pixels
  - Field of View: 47 °



Sensors for environment perception
Ultrasonic

- Used in park distance control systems

Parameter	Value
Range	0.2 – 1.5 m
Position Accuracy	0.02 m
Relative Velocity	-5 m/s – +5 m/s
Velocity Resolution	0.5 m/s
Object Detection Time	100 ms

Sources: DENSO, Bosch

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Sensors for environment perception

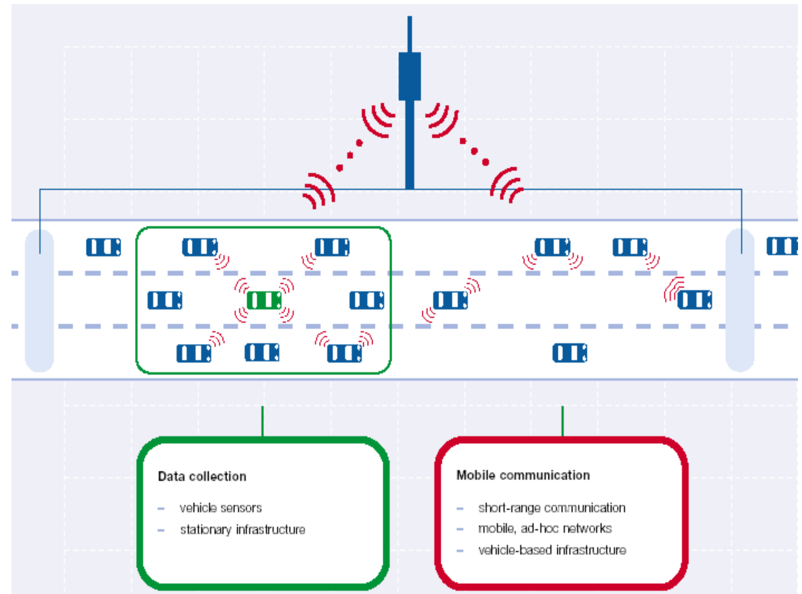
Comparison of different sensor systems

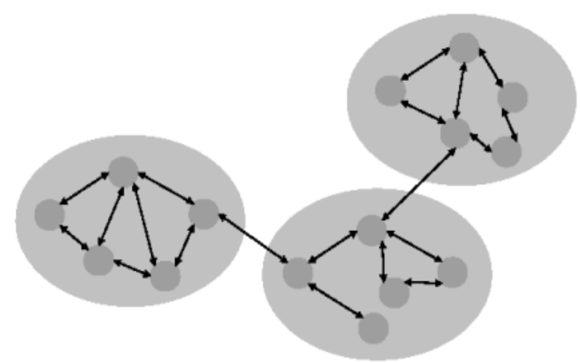
	Radar	Lidar	Laser scanner	Ultrasonic	Image processing
Range	++ (77 GHz) + (24 GHz)	++	+	-	+
Accuracy long. distance	o (77 GHz) + (24 GHz)	+	+	+	-
Lateral resolution	-		o	-	+
Multiple targets	+	o	+	-	++
Measurement process	Reflexion	Reflexion	Reflexion	Reflexion	Triangulation
Measurement at bad weather or dirty sensor	+ +	o	o	o	-
Hidden mounting	Yes	No	No	No	No

Sensors for environment perception

Vehicle-to-vehicle/infrastructure communication

- Communication technology:
  - Wireless LAN IEEE 802.11.p
  - GSM, GPRS, UMTS UTRA TDD
  - HiperLAN
  - CALM
  - Bluetooth
  - Self-contained solutions based on 434 MHz, 868 MHz, 2.4 GHz, 5.8 GHz, 24 GHz
- Abbreviations:
  - V2V (C2C)
  - V2I (C2I)
  - V2X (C2X)

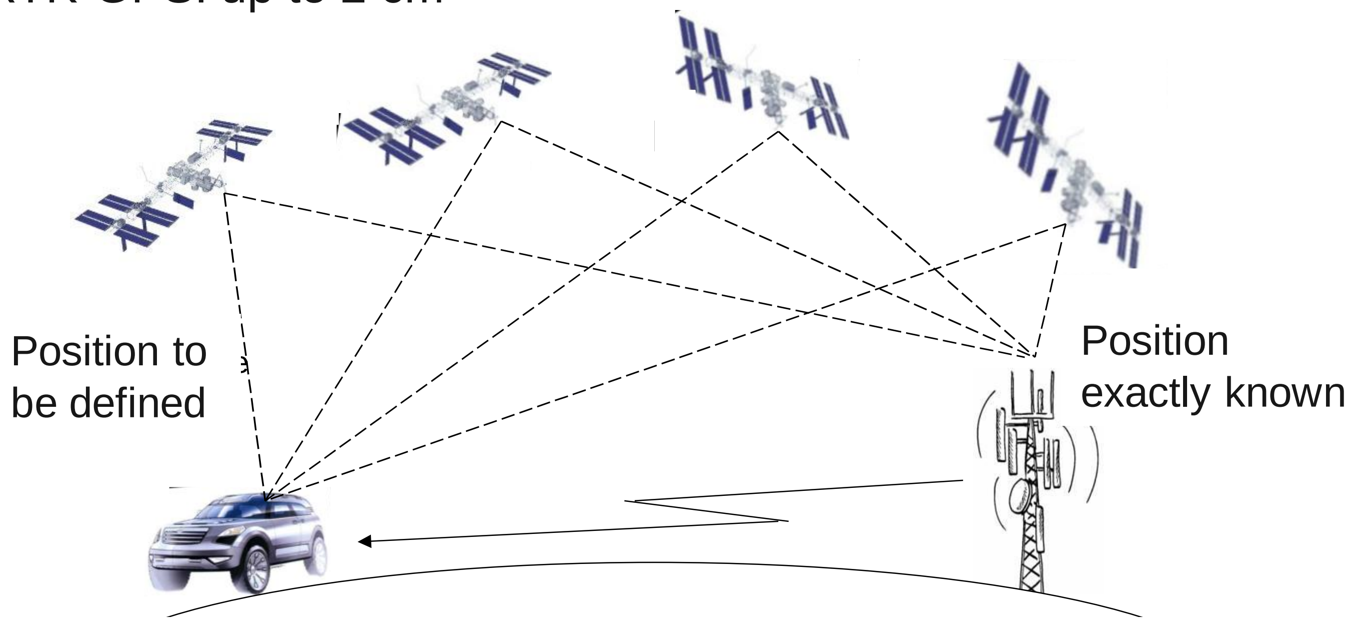




Sensors for environment perception

Global Navigation Satellite Systems

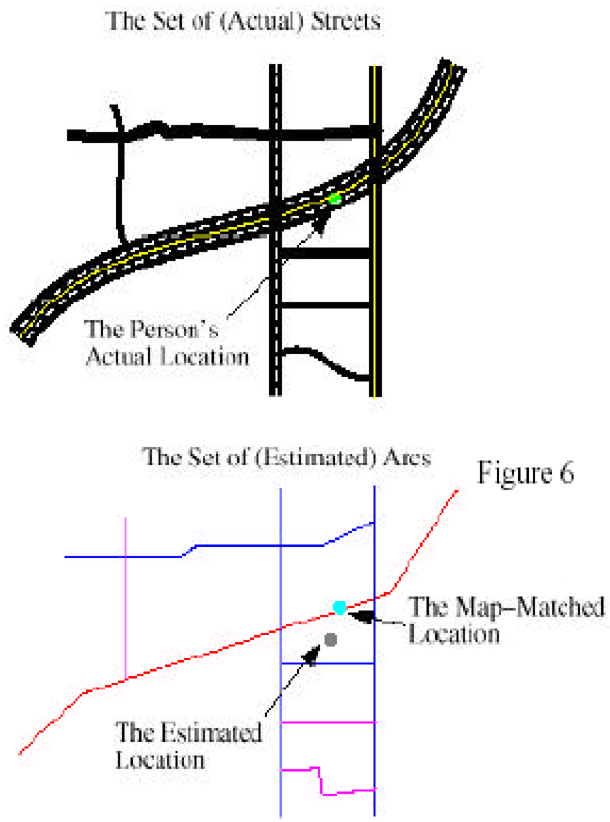
- Examples: GPS, Galileo, Glonass
  - Position Accuracy: 10 m
- Enhanced Position Accuracy:
  - DGPS: up to 0.3 – 2.5 m
  - RTK-GPS: up to 2 cm



Sensors for environment perception

Digital Map & Map Matching

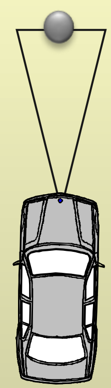
- Improve the accuracy of satellite navigation and "Dead Reckoning"
- Positioning system gives coordinates, which do not correspond exactly to those of a street on the map
- Itinerary is compared to the course of the road on the digital map
- Map Matching algorithm corrects the position
- Pseudo positioning system, because it determines the position through the coordinates of knots (junctions) or points (beginning or end of curve)



Sensors for environment perception

How does the world look like for sensor technology?

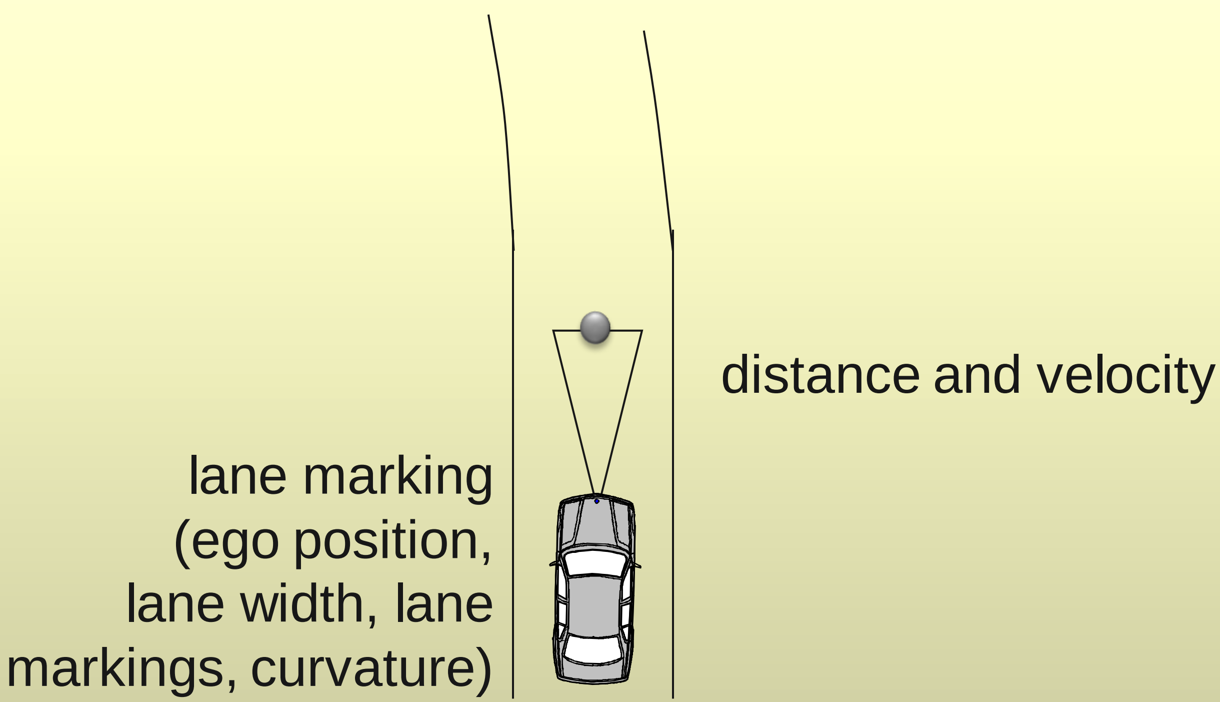
- Distance sensors



Sensors for environment perception

How does the world look like for sensor technology?

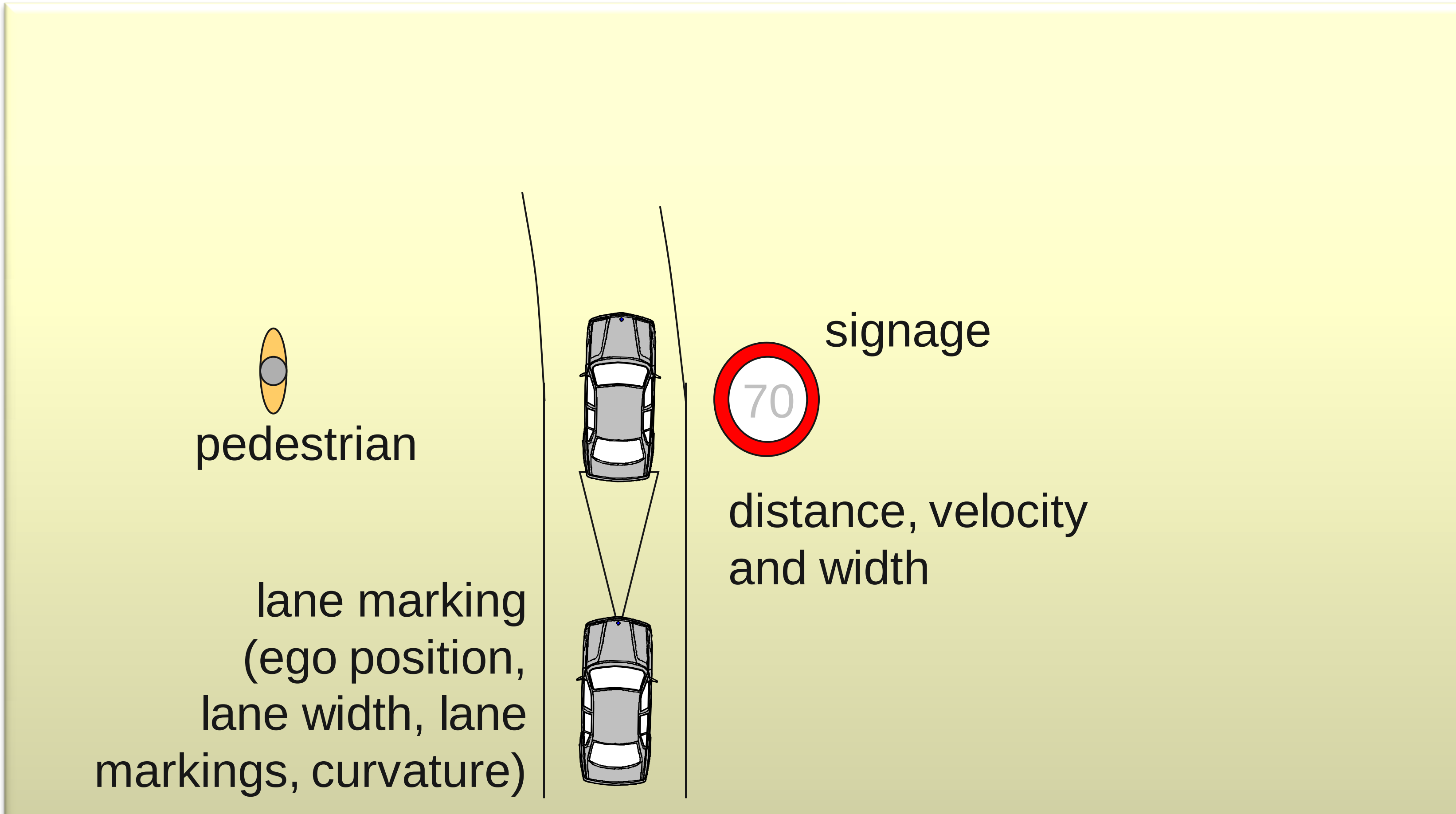
- Distance sensors + image processing “1G”



Sensors for environment perception

How does the world look like for sensor technology?

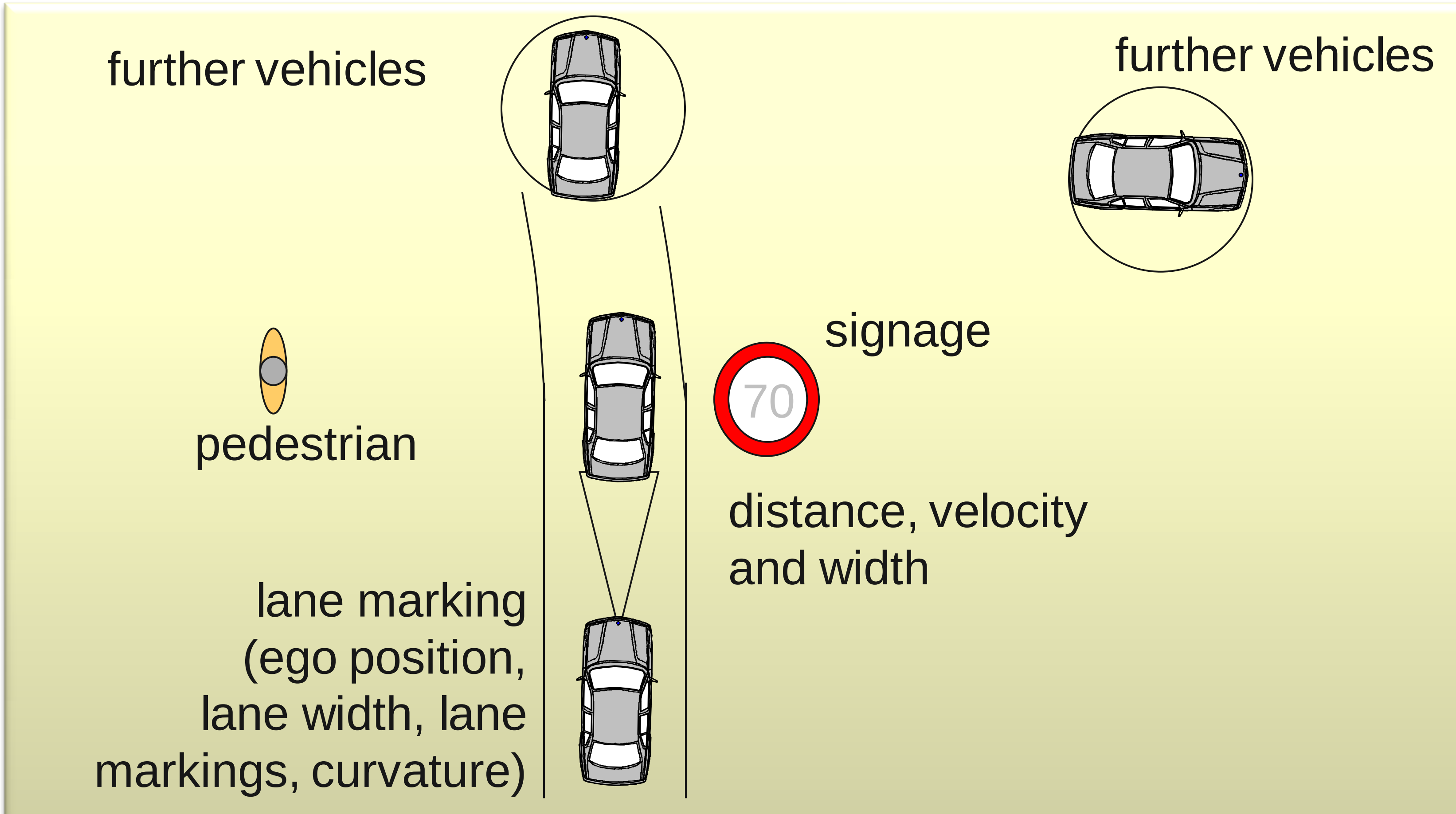
- Distance sensors + image processing “2G”



Sensors for environment perception

How does the world look like for sensor technology?

- Distance sensors + image processing “2G” + C2C



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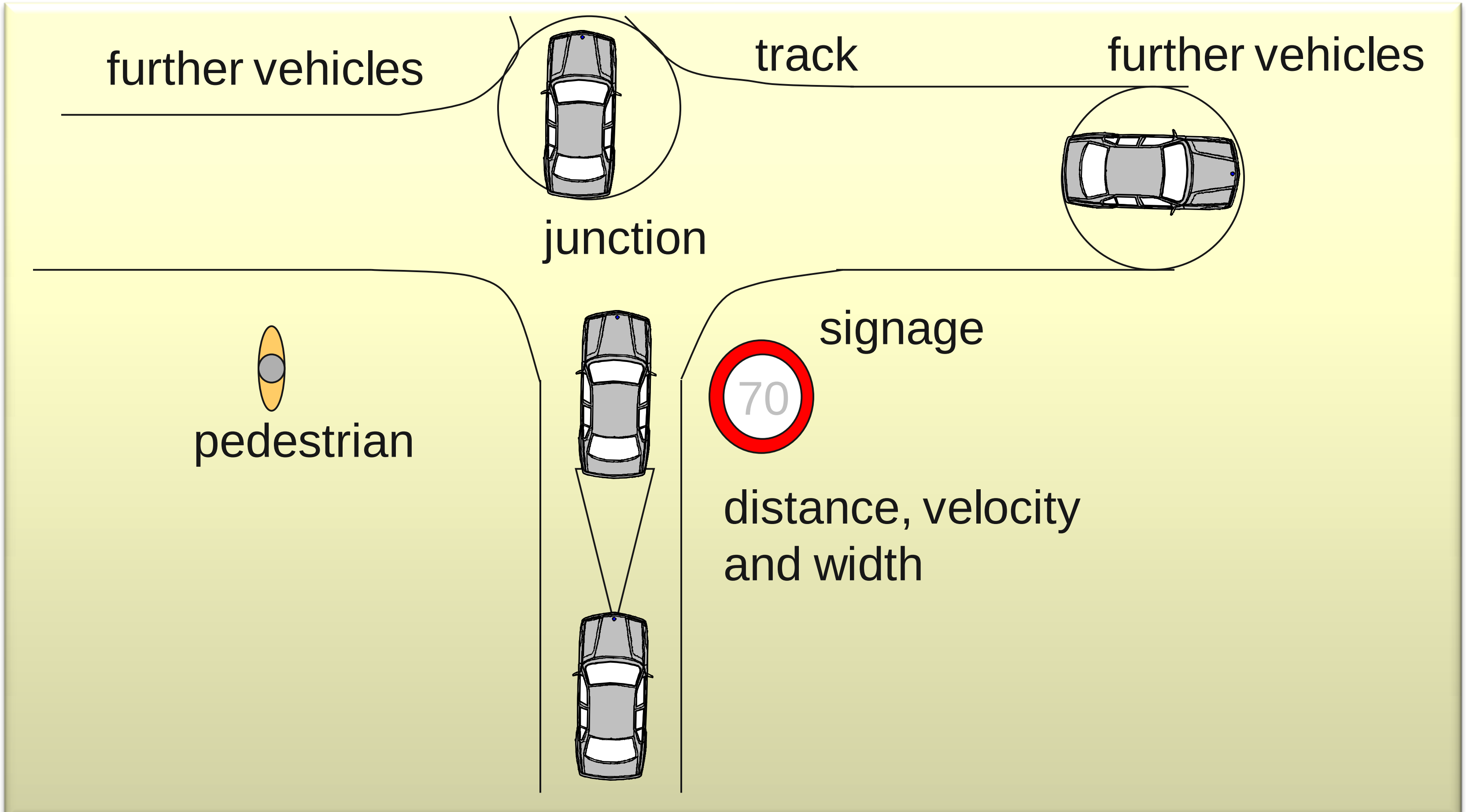
Sensors for environment perception

How does the world look like for sensor technology?

- Distance sensors + image processing “2G” + C2C + digital map



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Current automotive applications

First developments in the 1950th's

the first field test of a radar-based distance measurement in the 50th's

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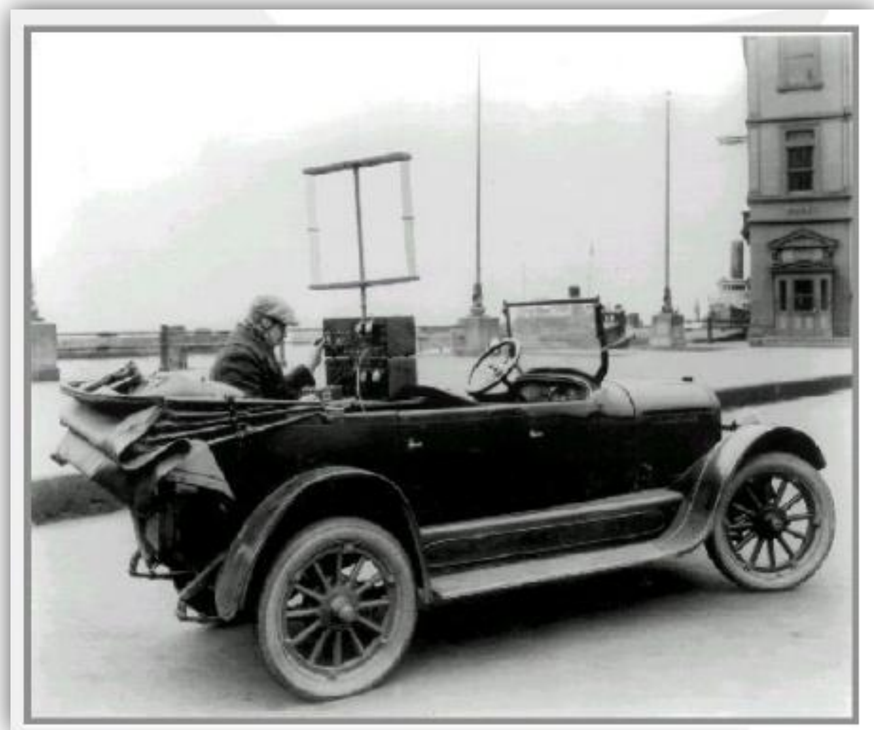
Current automotive applications
First C2C



Source: ADASE 2 AIDER CARTALK WORKSHOP

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Current automotive applications
Automatic tunnel drive

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Current automotive applications
First lateral guidance system


Driving on a guide wire

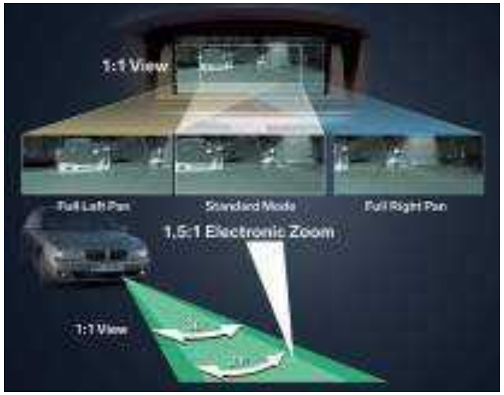
Current automotive applications
Example: BMW 7 series

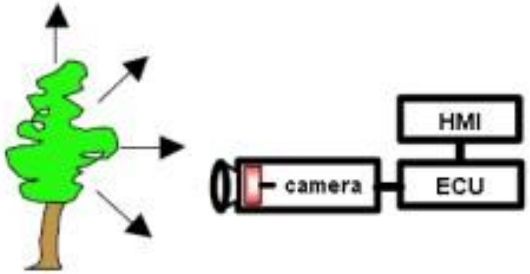
- BMW Night Vision
- Adaptive curve light
- Front light assistant
- ACC S&G
- Head-Up Display
- Lane Departure Warning
- Speed-Limit Display
- Lane Change Warning
- Side View, Rear View Camera
- Park Distance Control (PDC)
- BMW Assist
- Dynamische Stabilitäts Control (DSC), Brake assistant
- Rain sensor including drive light and wiper control
- Adaptive Brake light
- Active steering

Source: BMW

Current automotive applications
Night Vision - Far Infrared Radiation (FIR)

- Passiv Night Vision System
- Infrarotsensitive camera in vehiclefront
- Thermal radiation (7-12 µm) of objects are detected
- Warm objects are indicated as black-white picture
- Especially pedestrians and bikers are detected in cold environment
- Range up to 300 m
- No additional receptor/ transmitter required





Quelle: BMW

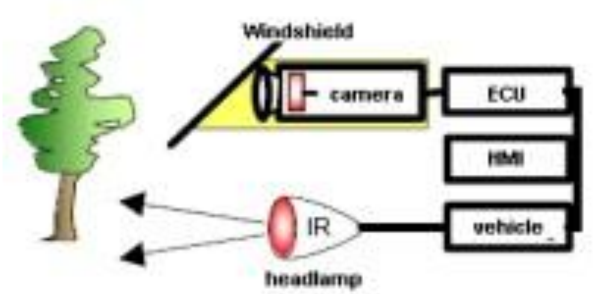
Current automotive applications

Night Vision - Near Infrared Radiation (NIR)

- Active Night Vision System
- Infrarotradiator in vehiclefront, acceptor camera can be integrated in vehiclefront in any order
- Wavelength in the range of 780-1000 nm (near infrared radiation)
- Infrarotradiation is reflected on objects
- Important objects (road markings, traffic signs etc.) are dedicated definitly
- Further applications are possible (pedestrian detection)
- IR-emitter is halogen bulb with optical filter (future: IR-LDEs)

Camera picture only with Xenon Light

Camera picture with additional IR Radiator



source: VDI Electronic Systems for Vehicles

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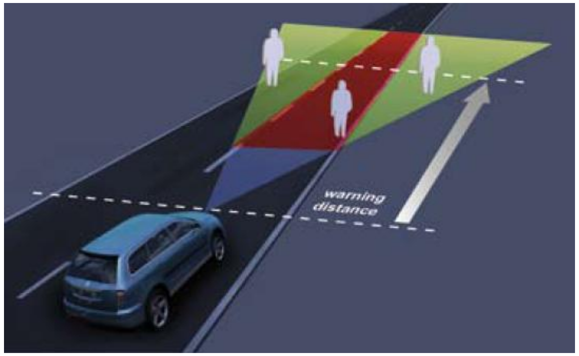
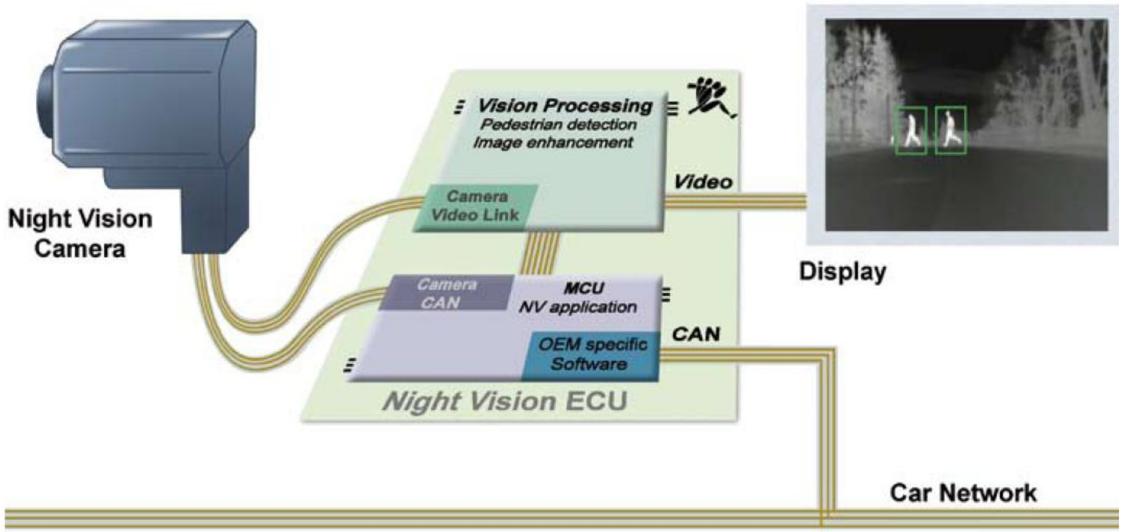
Current automotive applications
Night Vision 2

- Based on FIR Technology with additional detection of pedestrian and bikers
- Objects are classificated
- Driver is warned in case of positiv detection
- Detectionfield depends on vehicle velocity





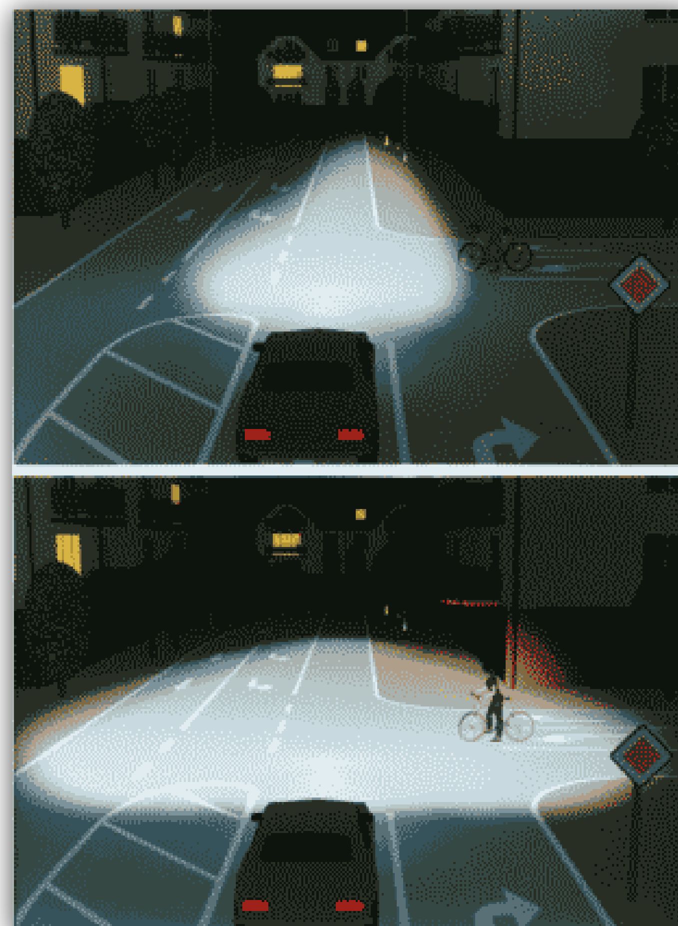
Quelle: BMW, Autoliv, ATZ

Current automotive applications

Adaptive light (Variable light dissipation at intersections)

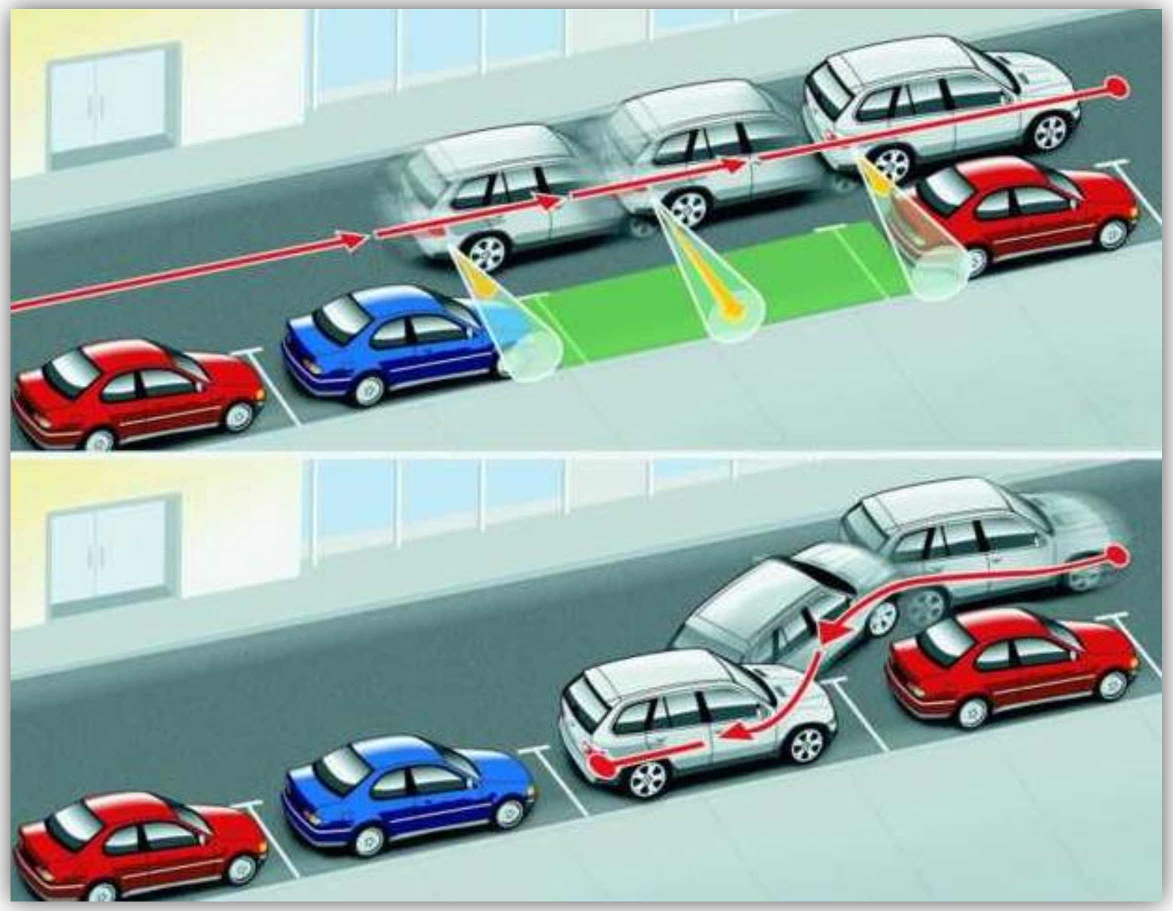
standard

new



Source: Hella

Current automotive applications
Semi-autonomous parking



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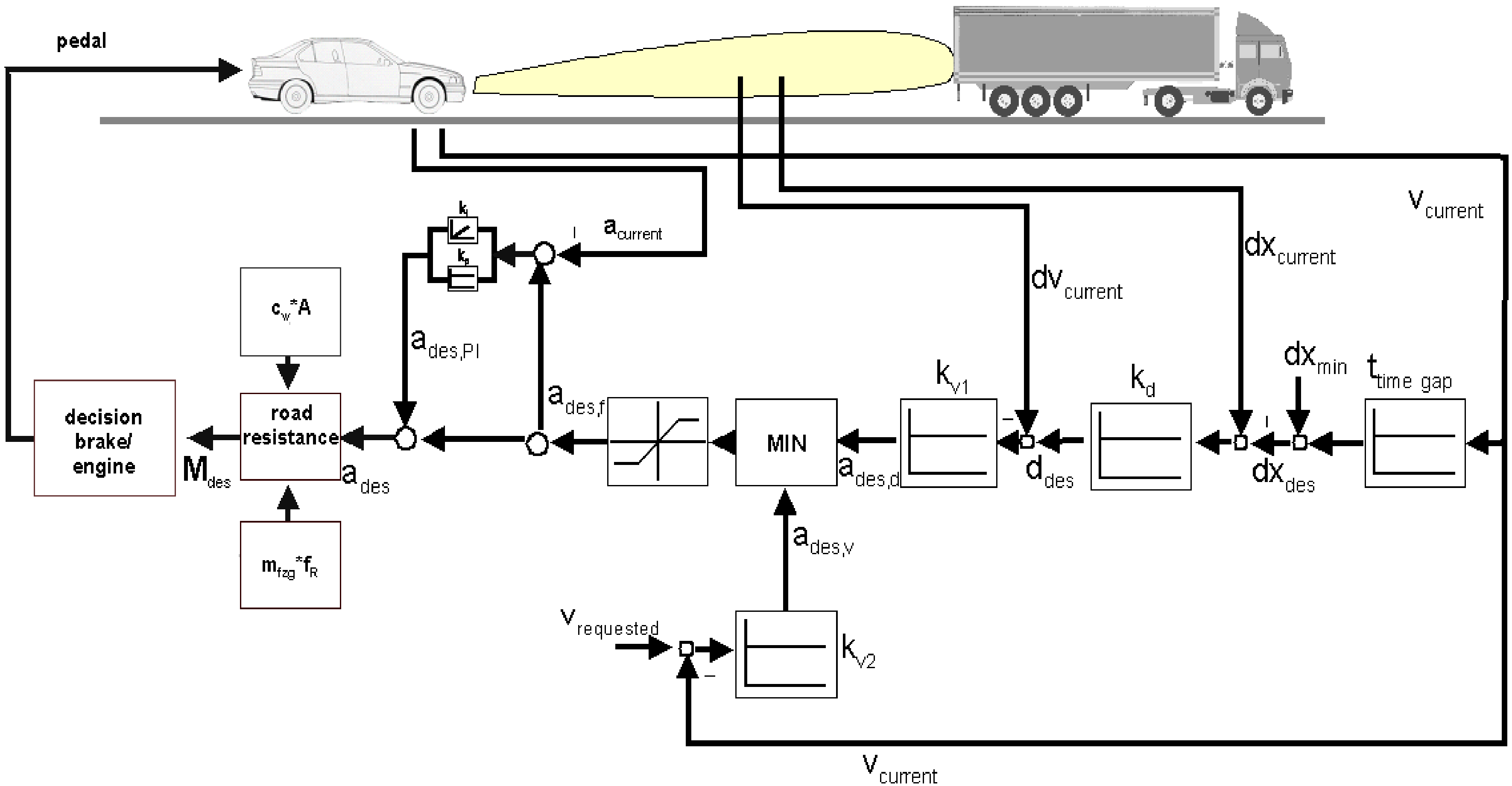
Current automotive applications
Adaptive Cruise Control (ACC)

- Facts and figures:
  - First use 1995 in Japan
  - Introduced in Europe 1999 in Mercedes vehicles
  - In 2002 integration of ACC systems in heavy duty vehicles
  - Radar with 76-77 GHZ or Lidar
  - Today available at over 20 vehicle manufactures

Current automotive applications
Adaptive Cruise Control (ACC)



Current automotive applications
ACC Stop&Go

- Facts and figures:
  - Introduced in Europa 2005 by Daimler in S-Class
  - Other OEMs bring ACC S&G to the market (e.g. BMW 5 and 7)
  - Detection of surrounding using 24 GHz Radar Sensors
  - Maximum deceleration of up to 4 m/s^2
  - Automaic acceleration after standstill if front vehicle accelerates within 3 seconds

Quelle: Daimler

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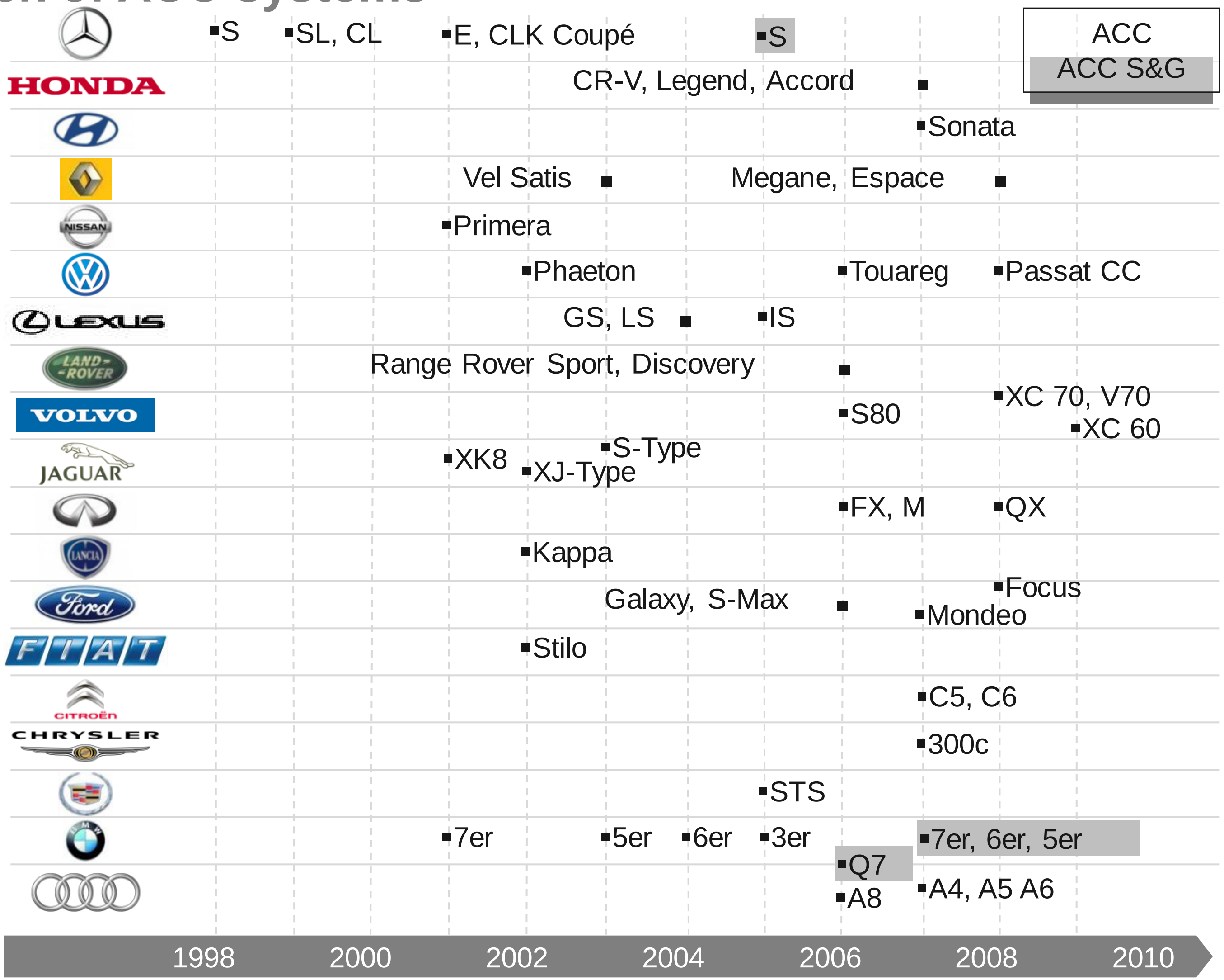
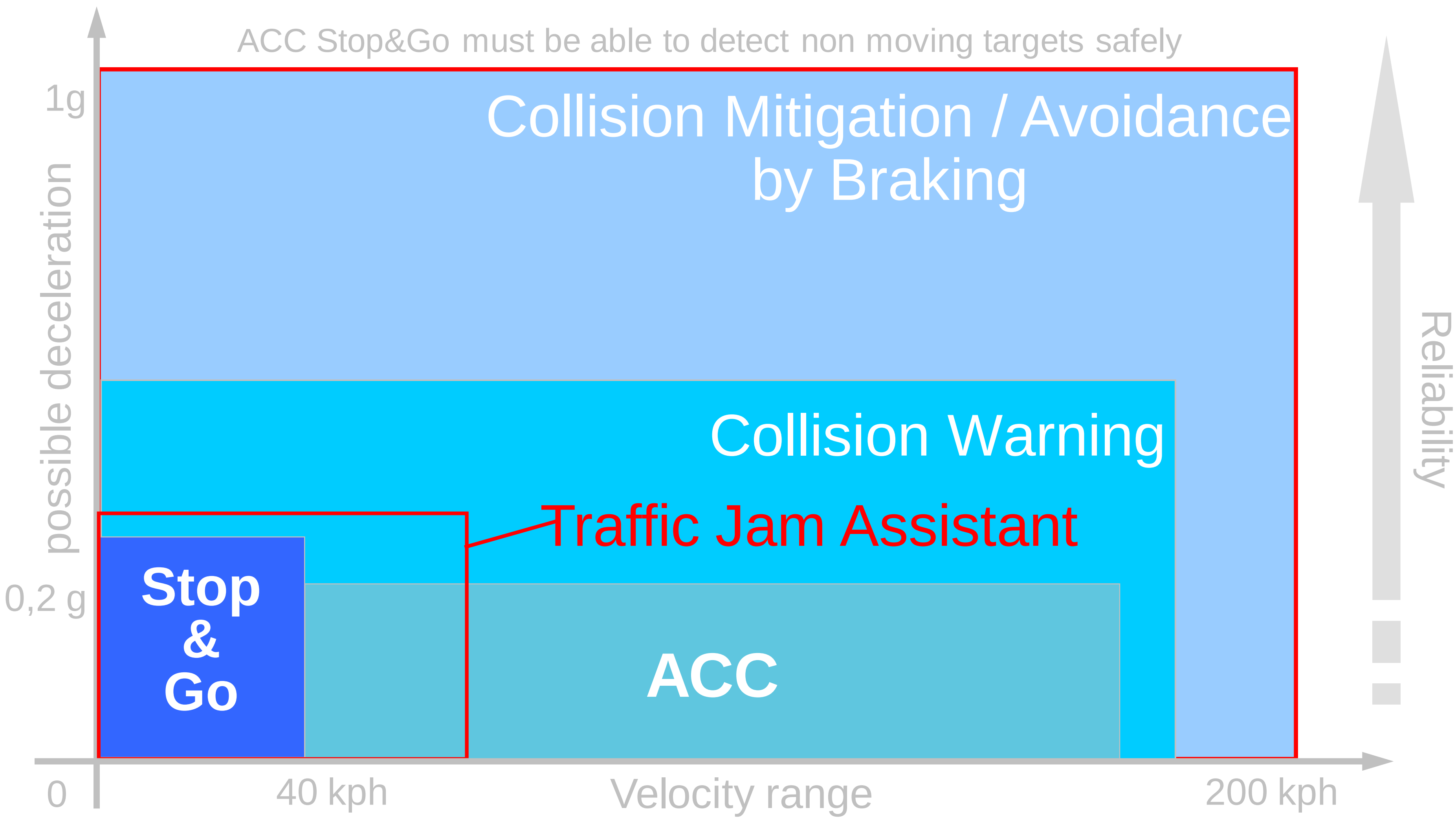
Current automotive applications

Launch of ACC systems



Current automotive applications

From *ACC to ACC Stop&Go* to *CMbB*



Current automotive applications

Euro NCAP Advanced Reward - Volvo City Safety

EURO NCAP advanced

2010 Reward for Volvo City Safety

Current automotive applications

Euro NCAP Advanced Reward - Audi Side Assist

EURO NCAP advanced

2010 Reward for Audi Side Assist

Current automotive applications

Euro NCAP Advanced Reward - Mercedes Pre-Safe Brake

EURO NCAP advanced

2010 Reward for Mercedes-Benz PRE-SAFE® Brake

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Current automotive applications

Euro NCAP Advanced Reward - Peugeot Connect SOS

EURO NCAP advanced
2010 Reward for Peugeot Connect SOS

Current automotive applications

Euro NCAP Advanced Reward - Volkswagen Lane Assist

EURO NCAP advanced

2010 Reward for Volkswagen Lane Assist

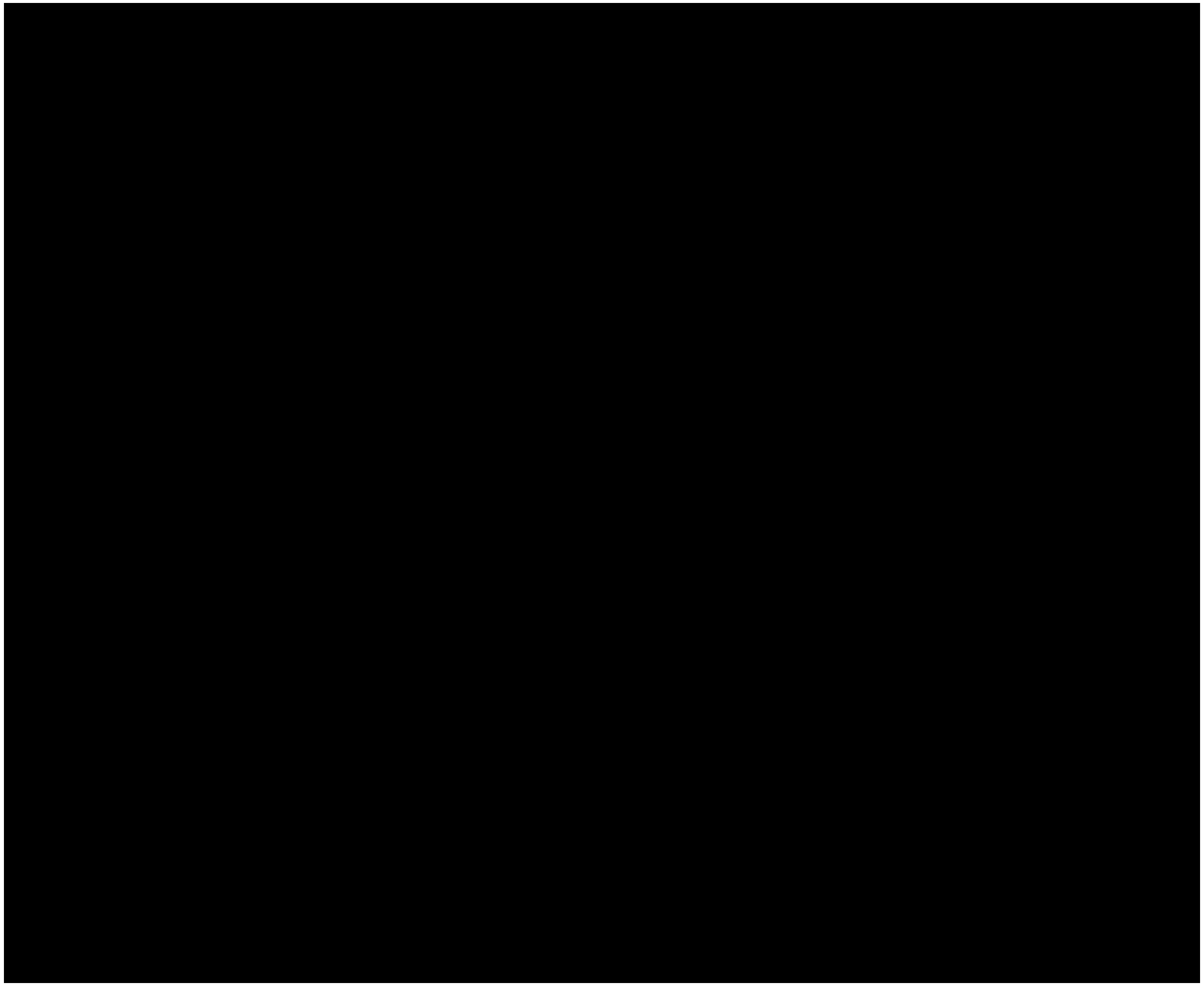
Current automotive applications
Autonomous Driving Trucks

- Introduction of autonomous driving trucks on factory premises for the transport of euro-pallets
- Realised since March 2001
- Max. driving velocity: 5 km/h

- Sensors: Laserscanner for obstacle detection
- Rubber foam bumper as emergency-off buttons
- Distance between activation of emergency-off and complete standstill of the vehicle in wet road conditions: 0,4 m
- Truck can be driven as normal vehicles by human driver

Current automotive applications

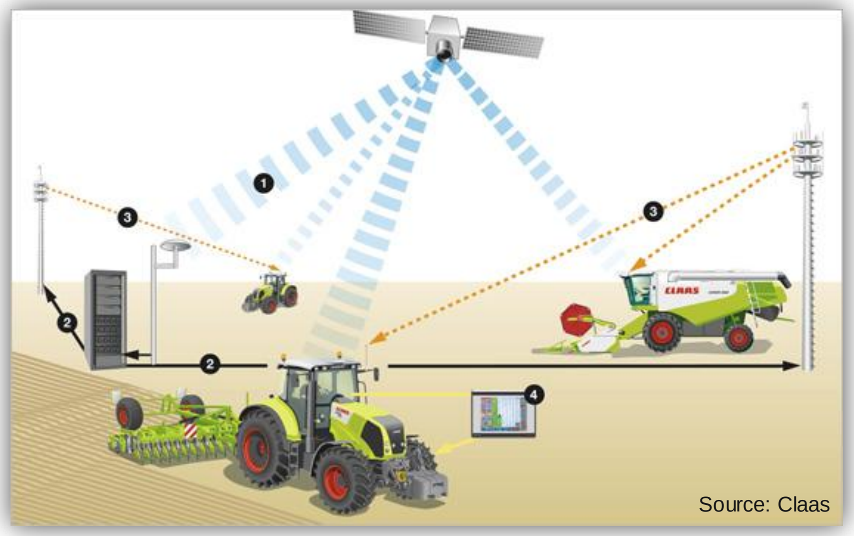
Autonomous Driving Trucks

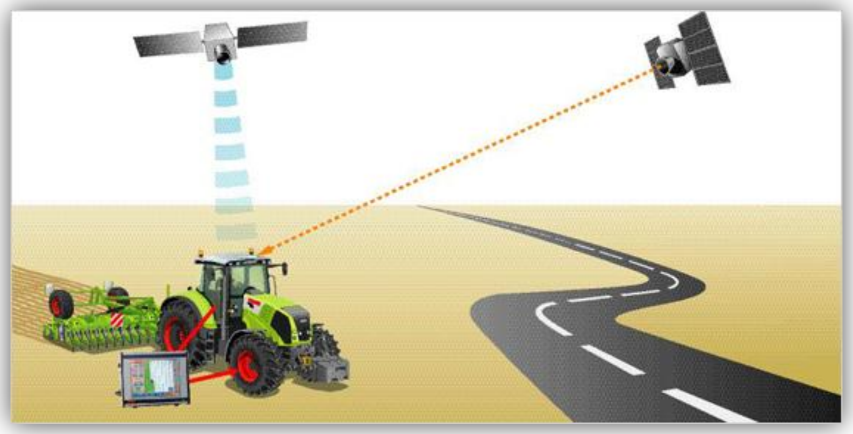


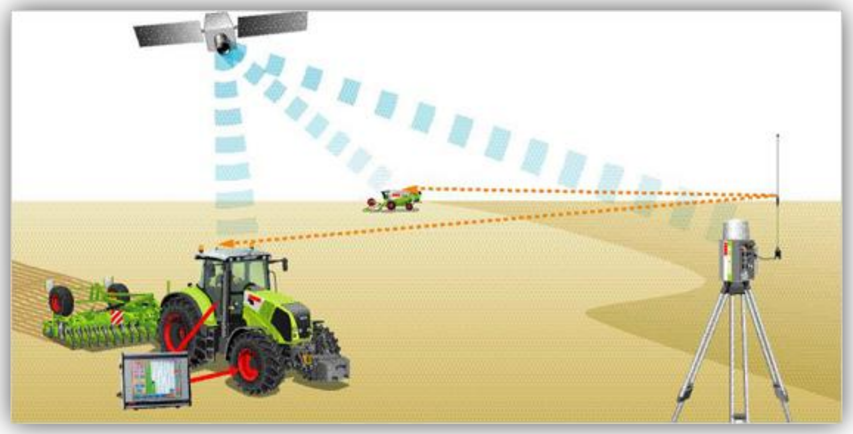
Agenda

- Introduction
  - Traffic Safety
  - Classification of ADAS
- Sensors for environment perception
- Examples of ADAS
  - Current automotive applications
  - Current off-road applications
  - Future automotive applications

Current off-road applications
Guidance of agricultural machinery


Source: Claas





Current off-road applications
Wheel Loader

Agenda

- Introduction
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  - Current off-road applications
  - Future automotive applications

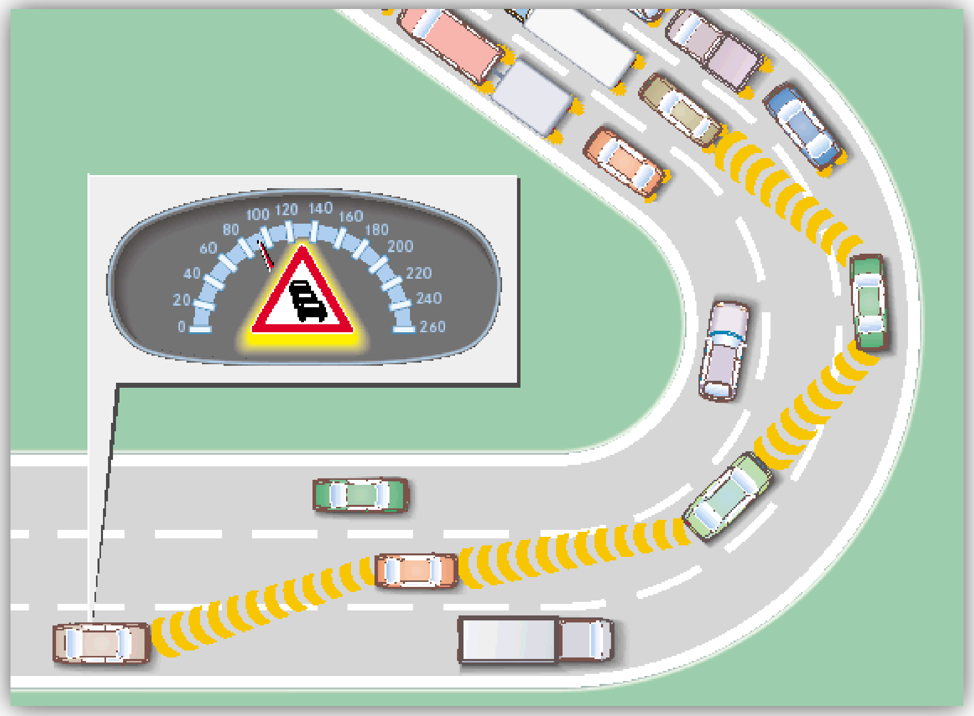
Future automotive applications
Platooning

- Electronic coupling of two or more trucks
- Distance between vehicles from 5 to 15 m
- System takes over longitudinal and lateral control
- Possible lane changes performed by the system

- Advantages:
  - Reduction of fuel consumption up to 17%
  - Reduction of occupied road space
  - Relaxed driving for the coupled drivers

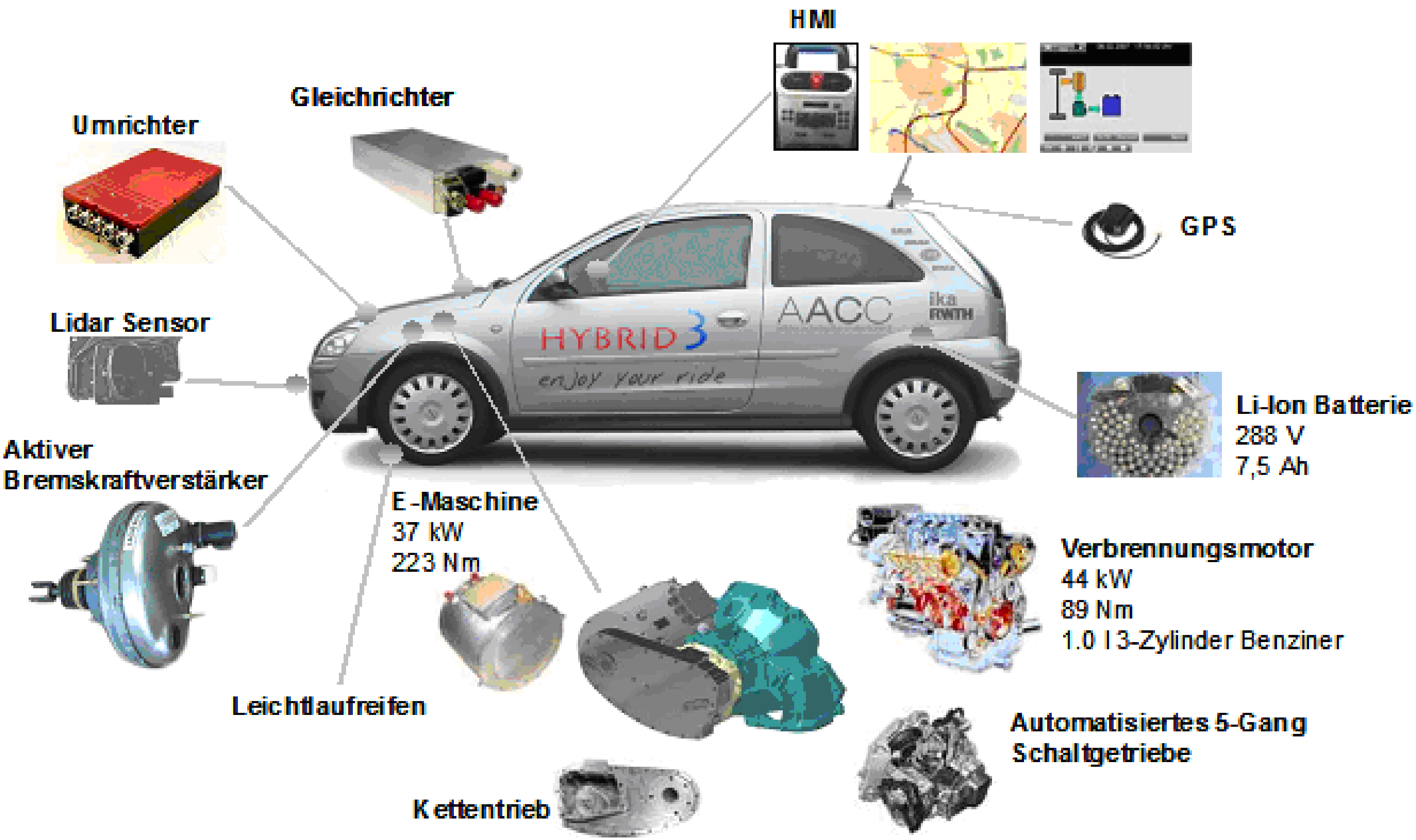
Future automotive applications
Obstacle warning

- On basis of vehicle-vehicle-communication
- Warning of traffic jam end
- Construction sites
- Accident sites
- Local dangers: icy road, oil on road
- Message is delivered from vehicle to vehicle



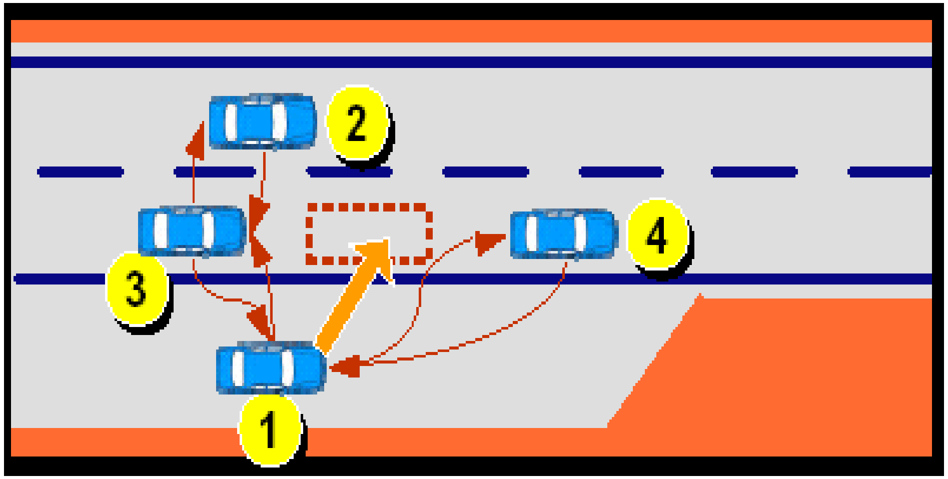
Future automotive applications

ecoACC (predictive control)



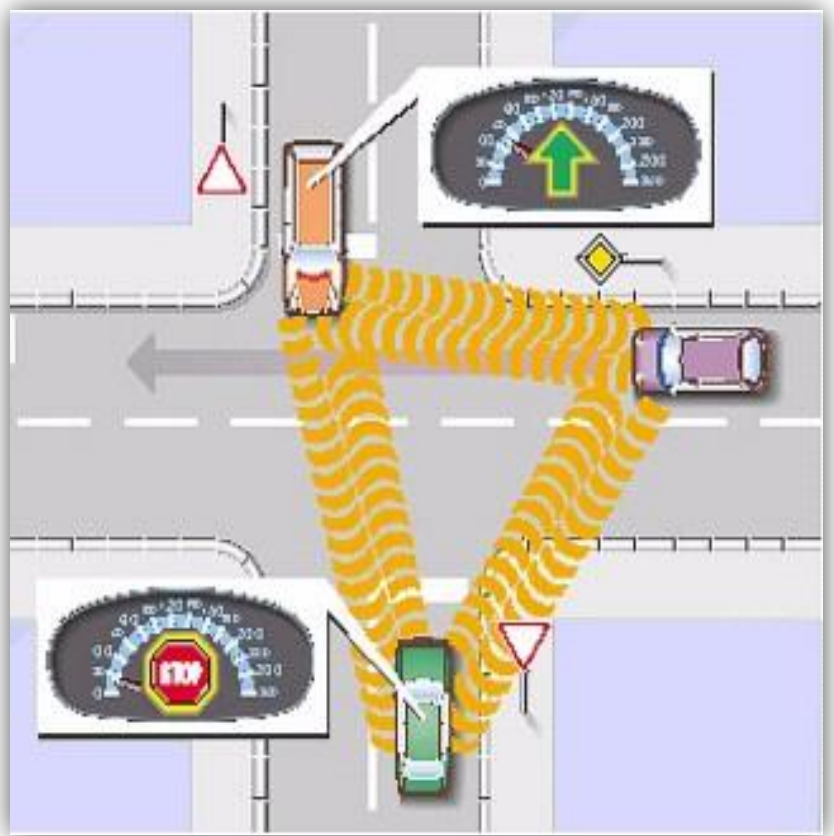
Future automotive applications
Autonomous Lane Change Assistant

- Vehicles communicate and cooperate with each other
- Vehicle 1 asks for cooperation
- Vehicle 2 keeps lane and accelerates to generate space for vehicle 3
- Vehicle 3 brakes and tries to change lane
- Vehicle 4 is not relevant in this case and keeps on the same lane



Future automotive applications
Intersection assistant

- On basis of vehicle-vehicle-communication
  - Disadvantages: no early pedestrian detection
- Realisable through image processing or laser scanner
  - Disadvantage: no detection of hidden vehicles
- ➪ Combination of systems ideal

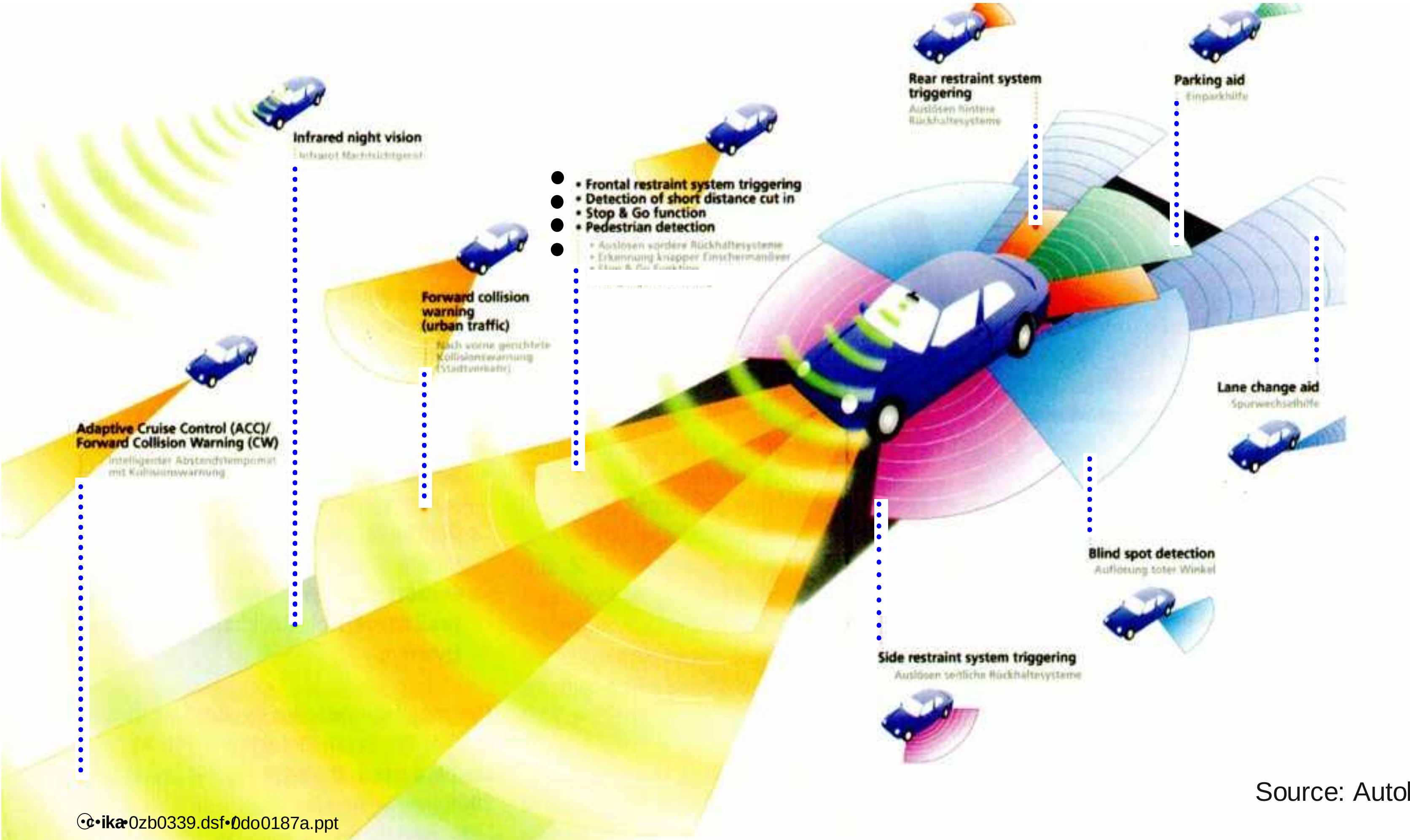


Future automotive applications

Intersection assistant ... can’t always help

Future automotive applications

"Vision Zero": Accident free road traffic



Source: Autoliv

Future automotive applications
Burden: Legal aspects

The development of ADAS has to consider the Wiener Convention from 1968:

ARTICLE 13

Speed and distance between vehicles

1. Every driver of a vehicle shall in all circumstances have his vehicle under control so as to be able to exercise due and proper care and to be at all times in a position to perform all manoeuvres required of him. He shall, when adjusting the speed of his vehicle, pay constant regard to the circumstances, in particular the lie of the land, the state of the road, the condition and load of his vehicle, the weather conditions and the density of traffic, so as to be able to stop his vehicle within his range of forward vision and short of any foreseeable obstruction. He shall slow down and if necessary stop whenever circumstances so require, and particularly when visibility is not good.

Contact

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