Toward Fully Automated Driving

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Future Mobility – Automated, Connected, E

Automated mobility

Connected mobility

Electric mobility

Parking management

Integration of CE world

Multimodal mobility

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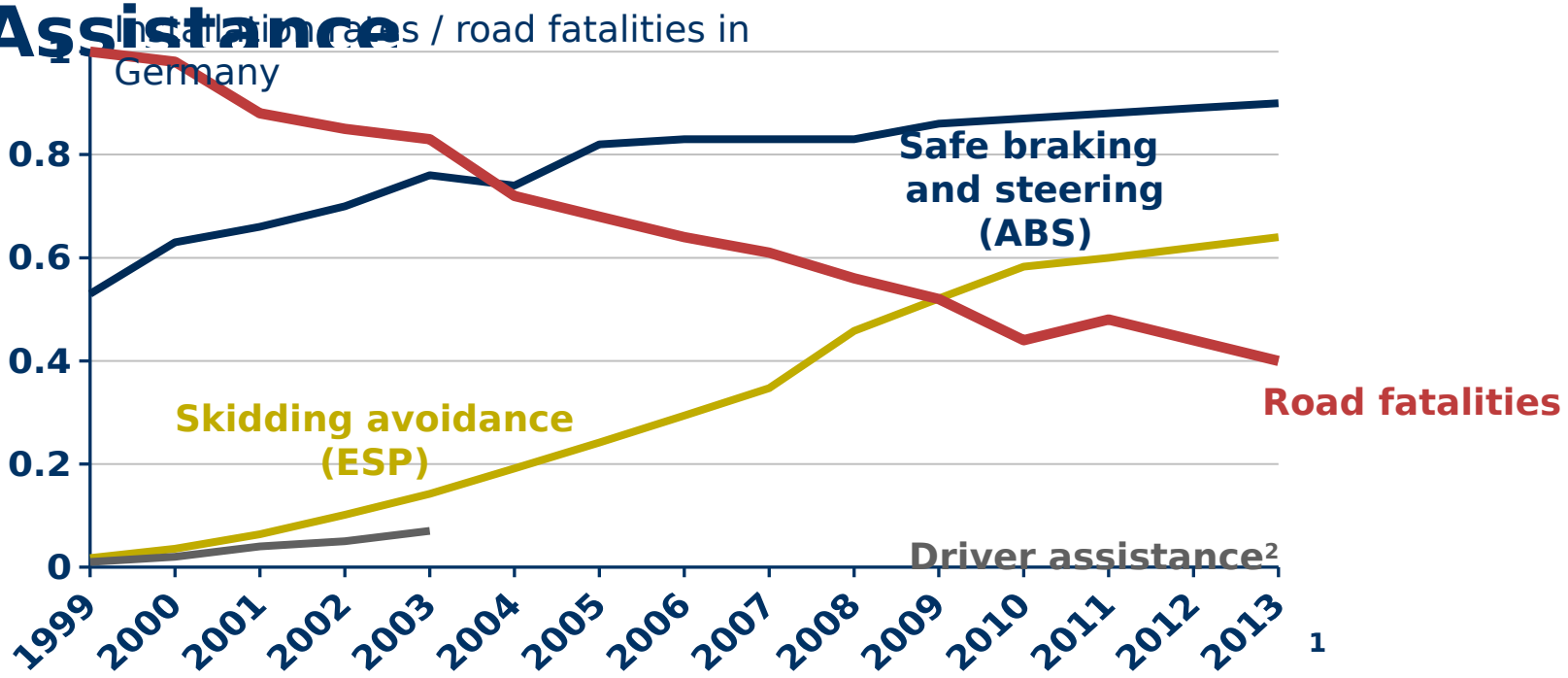
Automated and Connected – Social

Safety	Technologies for an intelligent and forward-thinking vehicle **Injury and accident-free driving**
Traffic Management	Reduced traffic jams and waiting time at intersections and lights **Relaxed driving even in dense traffic**
Demographics	Reduced driver burden **Allow a variety of age ranges to be mobile**
Networked Society	Vehicle as part of the driver's connected life **Time on the road becomes more productive**
Clean Technology	Synchronizes traffic flow → **Improved fuel economy**

Road Safety – Influence of Driver Assistance



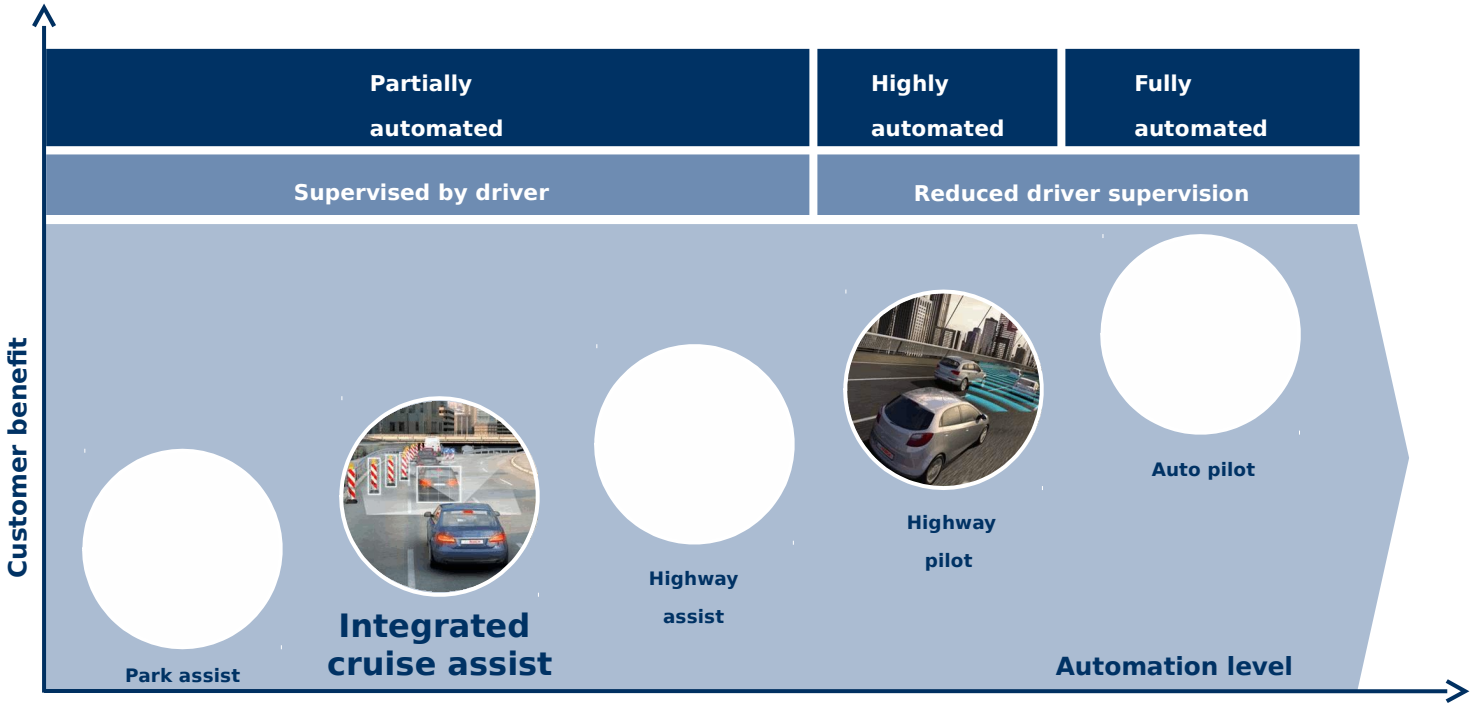
Number of road fatalities reduced by 60% within last 14 years

· 90% of all car accidents involving injury are caused by human error

· Introduction of further driver assistance systems will amplify positive trend

Source: Bosch, DAT, BASt. Based on total vehicle fleet. 1 Figures estimated 2 ACC and lane keeping support only

Roadmap to Fully Automated Driving



Automated driving starts with highway driving and parking functions

· Step-by-step approach – for technological and psychological reasons

· Survey: 59% in favor of automated driving as long as it can be switched off[1]

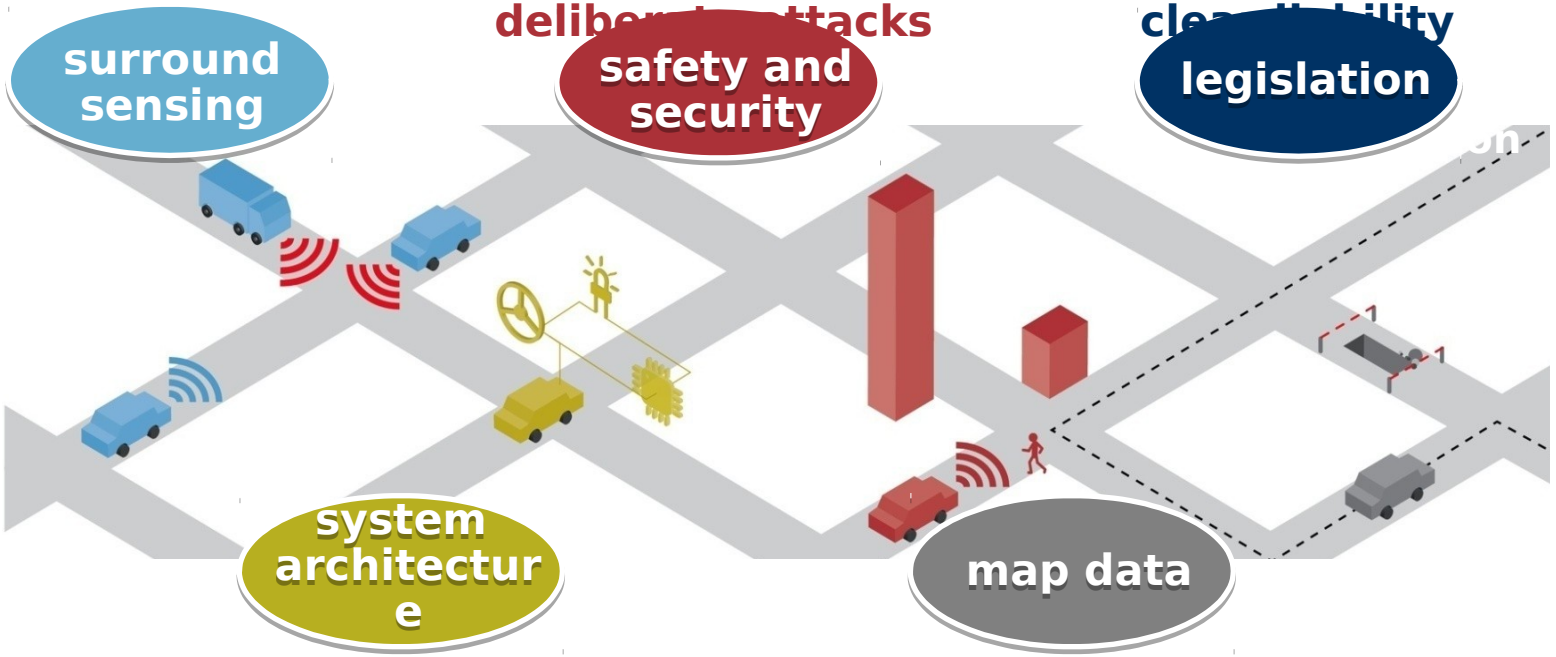
1 Source: Bosch survey 2012 (CC)

Prerequisites for Automated Driving – Overview

highly robust in all use cases

protection against technical failure and deliber[illegible]ttacks

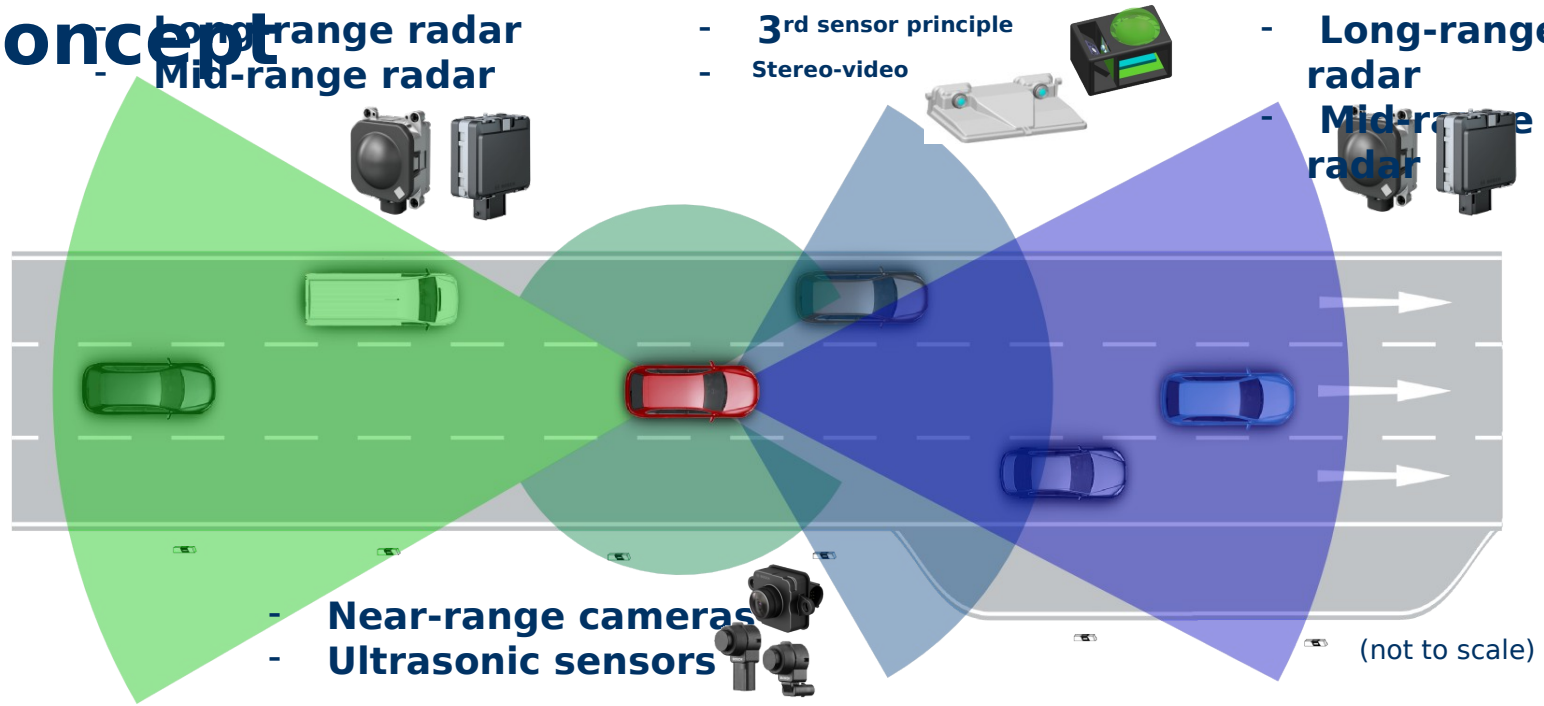
global standards and cle[illegible]bility



redundancies for sensing, ECUs, and actuation required (fail operational)

always precise and up-to-date

Surround sensing – vehicle sensor concept

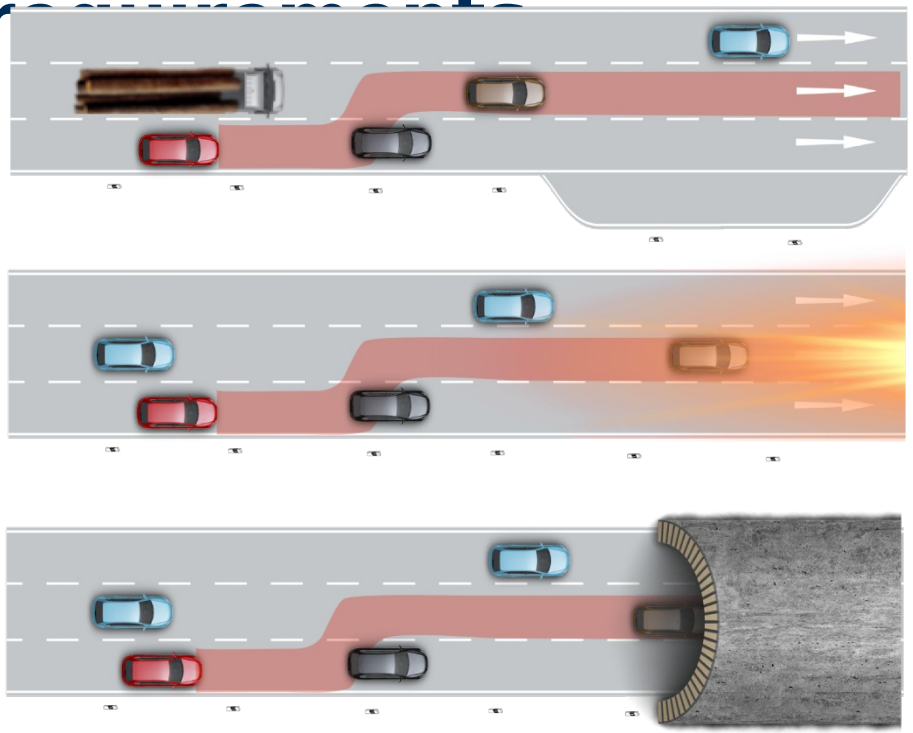


360° surround sensing by combination of different sensors

· Long- and mid-range radar prerequisite for driving at higher speed

· Satisfy reliability requirements by using multiple sensors for each area

Surround sensing – reliability requirements



Timber transport may not be detected reliably by radar sensor

Low standing sun can fade the video sensor

Tunnel entrances can affect the radar and video sensors

Highly automated driving raises new challenges for sensor concept

· Application cases show need for a third sensor principle

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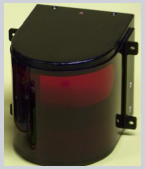
Third sensor principle – lidar strategy

Requirements 3rd sensor principle	
Range	(0.2 .. 200) m ± 0.1 m
Field of view (H) **Field of view (V)**	(50 .. 120)° ± 0.15° (9 .. 120)° ± 0.15°
Frame rate	~ 20 Hz
Eye safety	Class 1 (eye safe)

Solution: "time of flight" method

Requirements design elements	
Lighting	Scanner or flash
Detector	Single photon avalanche photo diodes (SPAD) / Imager
Laser	Wavelength ~ 850 – 1500 nm Pulse length ~ 10^{-9} s

Sensor principles	Design elements	Available
Macro scanner 	• Edge emitter 905 nm • Motor driven rotor • Avalanche photo diode	2016 to 2018
MEMS scanner 	• Vertical emitter ~1 µm • MEMS mirror • InGaAs / new Si-technology	2020
Flash lidar 	• Solid-state laser ~1.5 µm • InGaAs time-of-flight imager	2020

Lidar sensor is key for automated driving: three different possibilities

· Development of innovative semiconductor technologies is essential

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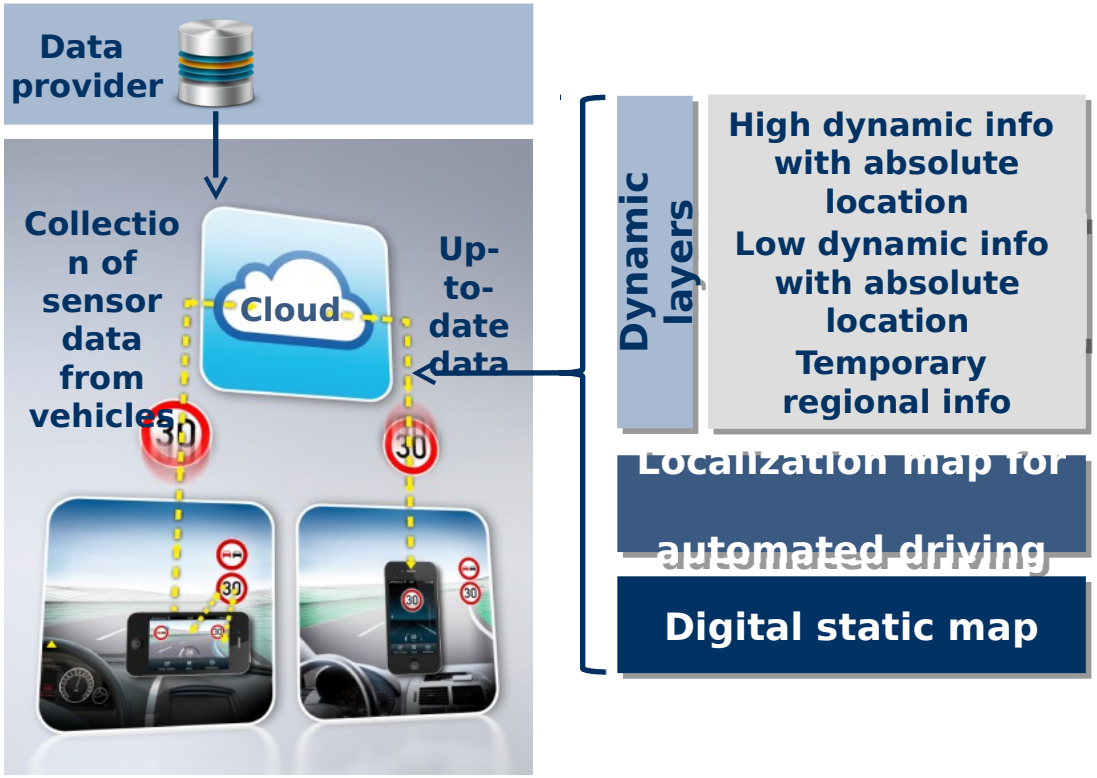
Dynamic map data – layered approach



Highly automated driving requires latest high-precision map data

· Aggregated information processing and delivery via the cloud

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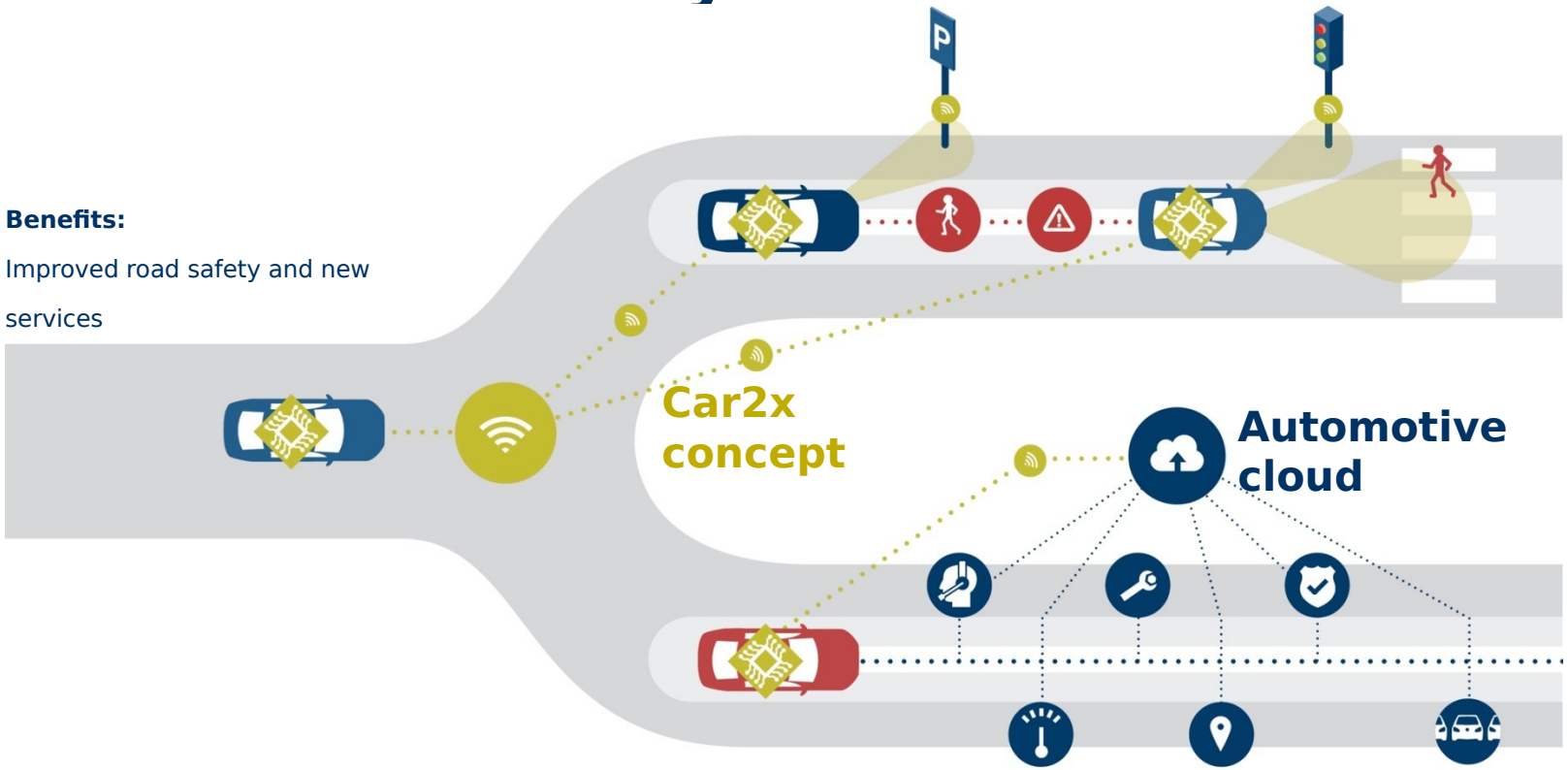
Connected mobility – cloud and car2x

Benefits:

Improved road safety and new services



The automotive cloud will be an integral part of the vehicle architecture

· Car2x concepts include local danger warning and driver assistance functions

Driver Monitoring

Distraction detection

... because 80% of accidents caused by inattentive drivers[1]

Drowsiness detection

... because 30% of drivers have experienced microsleep events[2]

Health monitoring

... because 10% of fatal accidents caused by medical conditions[3]

Identification

... because it enables the vehicle to adapt to the person driving

Adaptive assistance

... because it enables the vehicle to react according to the driver's state

Driver monitoring will be a key element for automated driving functions

· System has to be able to return control to the driver at any time

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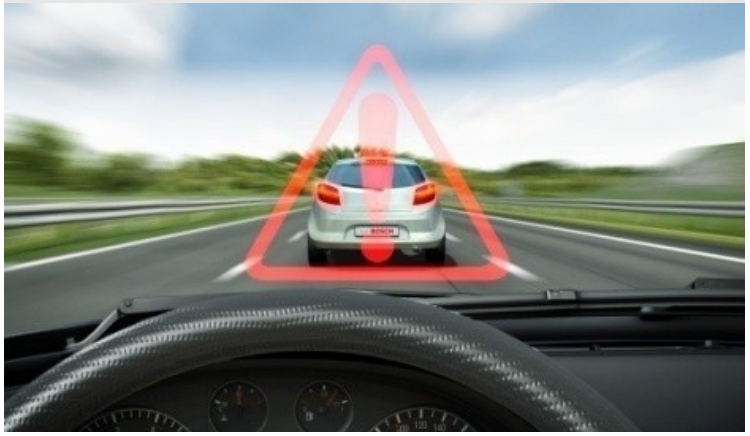
Safety and security - distinction

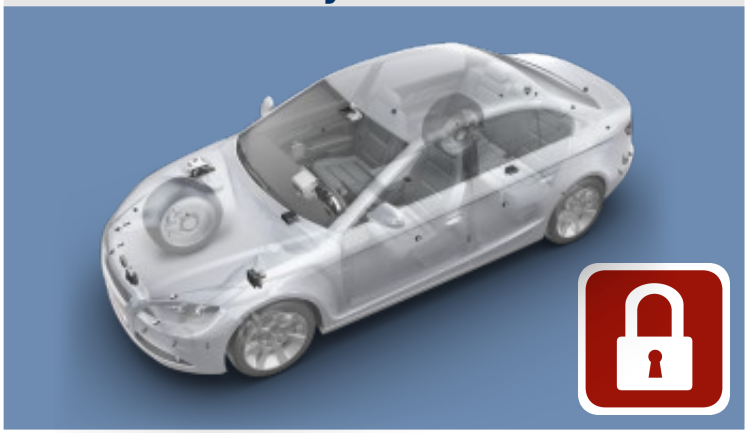
Safety

- Protection against technical failures
- Covers malfunction aspects



Security

- Blocking of deliberate attacks
- Confidentiality, integrity, availability



Safety (malfunction) differs in scope from security (deliberate attack)

· Leaks in security can put safety at risk

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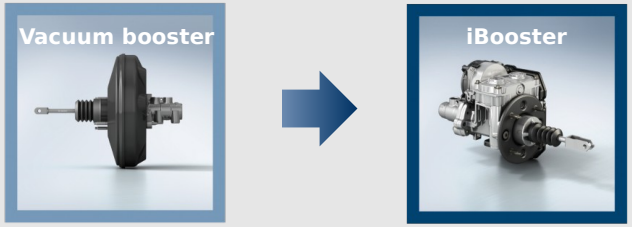
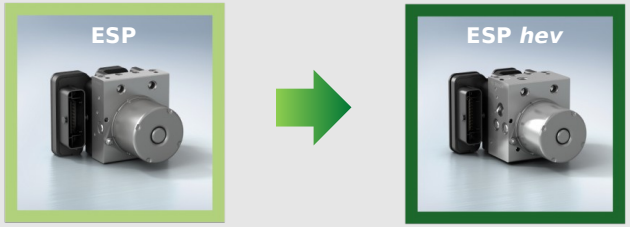
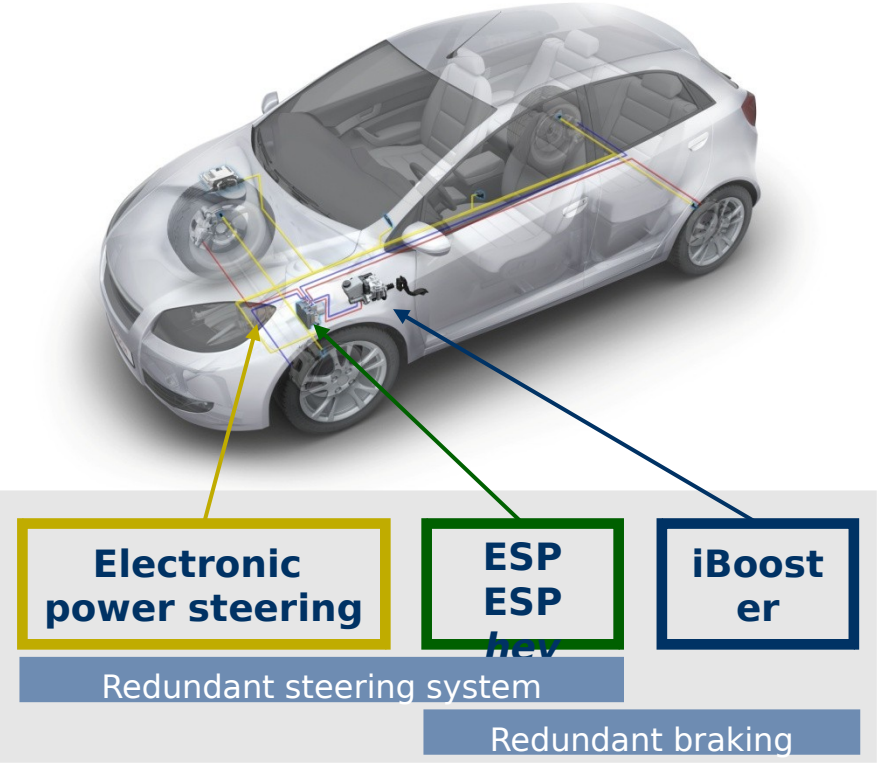
Safety – reliable actuation elements

Brake boost → **Vacuum-free boost & autonomous braking**



Modulation → **Recuperation**





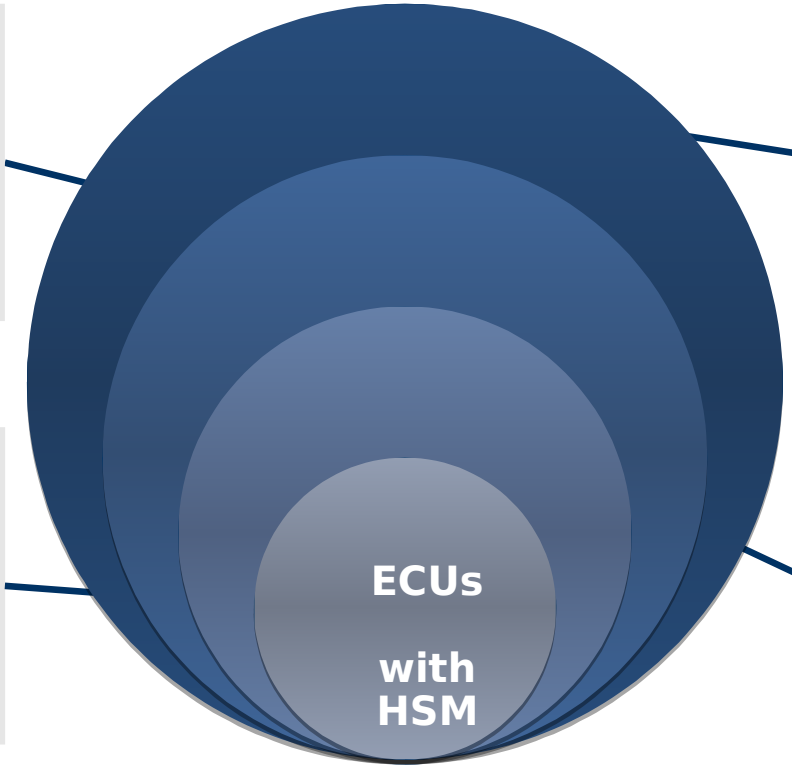
Redundant steering, braking, and stabilization systems required

· Modular actuation concept offers a perfect solution for automated driving

Security – layered automotive approach

E/E architecture
- Protect and separate domains
- Secure E/E architectures, and security gateways

Individual ECU
- Protect integrity of ECU SW & data
- Bosch hardware security module (HSM) in µC



Connected vehicle
- Protect safety & integrity of vehicle and privacy of driver
- Vehicle firewalls and security standards

In-vehicle network
- Protect integrity of critical in-vehicle signals
- Truncated message authentication codes (MAC)

No automotive security standardization or agreement available yet

· Bosch offers a broad spectrum of solutions for automotive security

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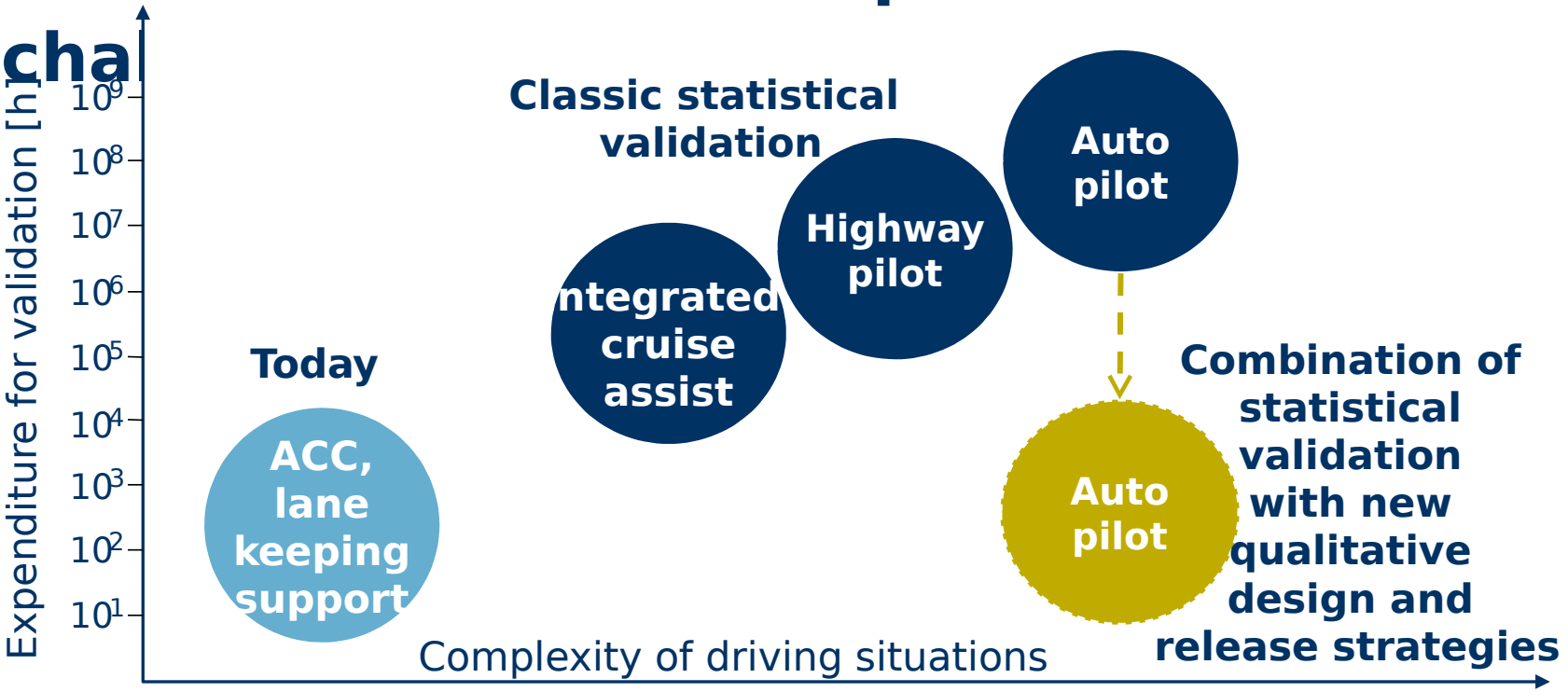
Validation and release process – cha



Expenditure for validation will increase by a factor of $10^{6 \text{ to } 107}$

- Traditional statistical validation not suitable for higher degree of automation
- Highly automated systems require completely new release strategies

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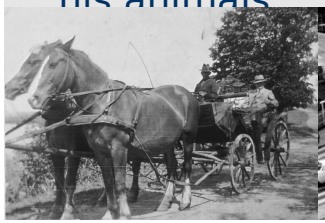
Legislation frameworks – need for a

Current legal framework

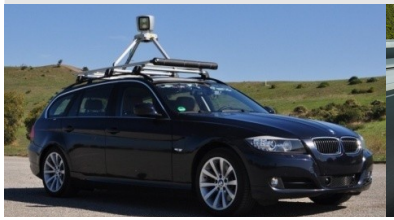
- National laws
- Geneva convention (1949)
- Vienna convention on road traffic (1968):

Article 8 (5):
„Every driver shall at all times be able to control his vehicle or to guide his animals“



Ongoing activities

- Legislation and regulation of automated driving decided in individual U.S. states
- Initiative in Europe by VDA
- Japan (MLIT) is exploring different possibilities (e. g. special lanes)



Legislation framework no longer reflects technical progress

· Need for adaptation to take account of highly automated driving

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Development steps – automated parking

Degree of automation

- Ultrasonic sensors
- Ultrasonic sensors + cameras
- Ultrasonic sensors + cameras + map

Park steering control

Automated steering, driver applies gas and brake

Park maneuver control

Steering and braking partly automated

Driver applies gas

Automatic / remote park assist

Partially automated longitudinal and lateral guidance

Driver supervises (from outside vehicle)

Robust environment recognition (possibly camera)

Auto park pilot

Highly automated longitudinal and lateral guidance

No supervision by driver

Robust environment recognition necessary

Strict safety requirements

Valet parking

Connected vehicle drives autonomously into parking space

Robust environment recognition + maps necessary

Strictest safety requirements

C2x communication

Series production | 2015 | 2018 | > 2018

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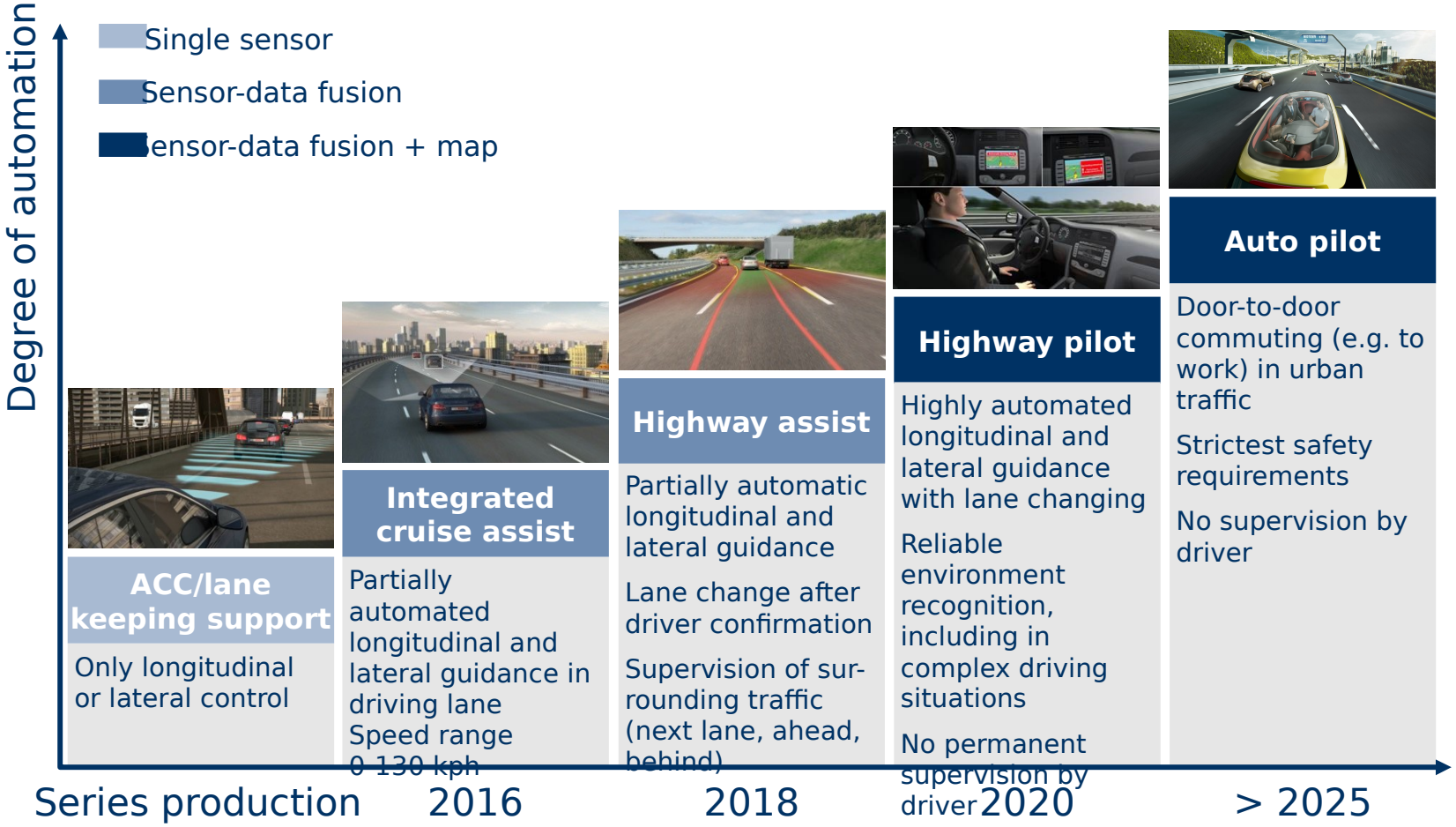
Development steps – automated driving



Automated Driving – Already on Public

Prototypes driving on public freeways in Germany and USA

· Bosch: first vehicles on German freeways since early 2013

· Tests in real traffic conditions accelerate the development of new functions

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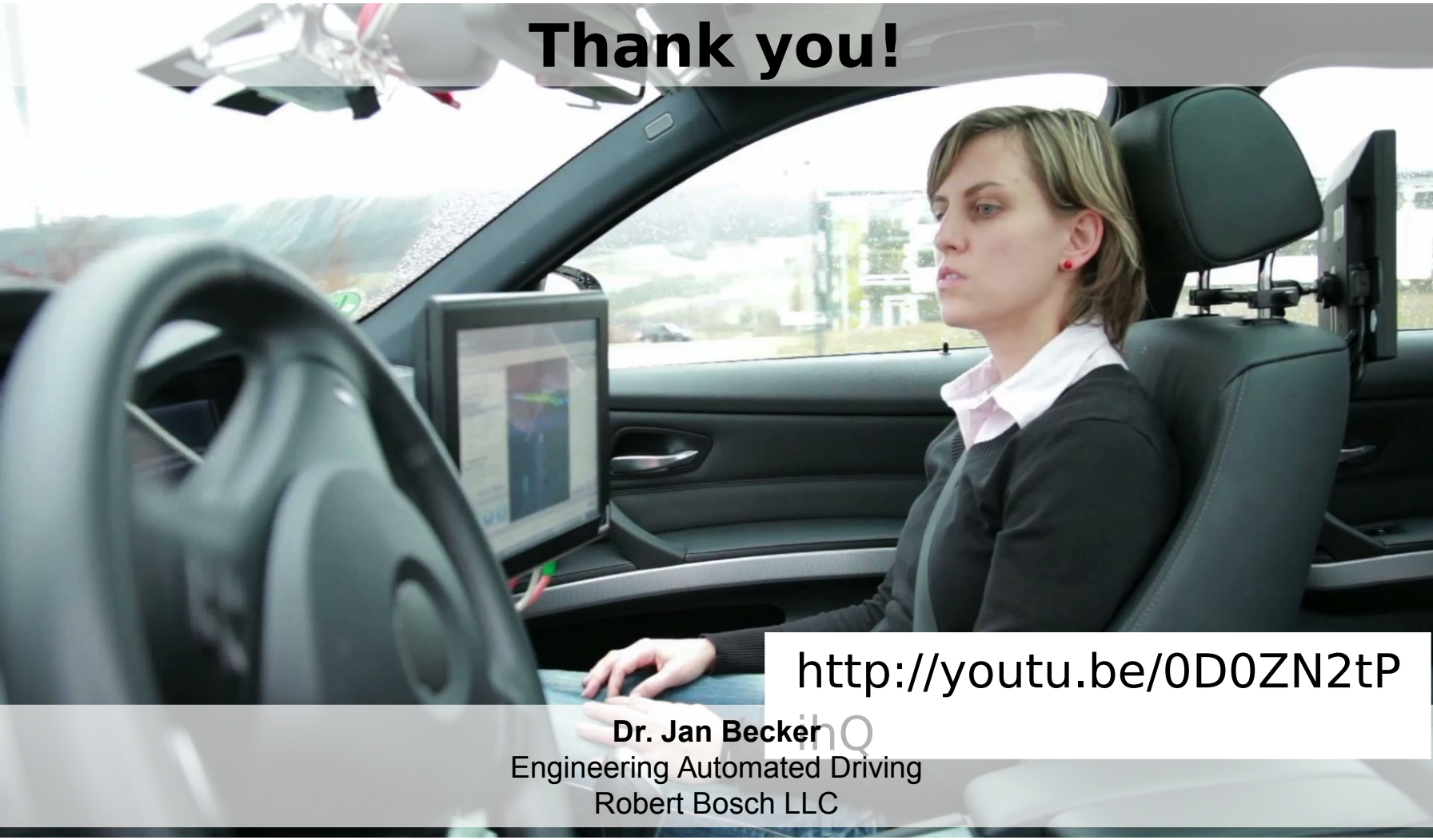
Conclusion

- Future mobility will be connected and automated
- Automated driving functions will irreversibly change vehicle architecture
- The development of automated driving functions calls for profound knowledge of all vehicle systems
  (e. g. sensors, actuation, E/E architecture, semiconductor technologies, and automotive cloud)
- Technical and legal challenges still need to be solved
- Bosch has all necessary key technologies
  available and is getting them ready for market entry

Thank you!



http://youtu.be/0D0ZN2tP

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