

CAREER TALK

AUTOMATED DRIVING @ ROBERT BOSCH GMBH

Marco Meißner

B-Physics Workshop, Neckarzimmern 07.04.2022



Agenda

1. Who Am I?
2. Who is „Bosch“? What do we do?
3. What is Automated Driving?
4. What is an AD System?
5. What is Systems Engineering?
6. How do we work?
7. Our Project „Automated Driving“



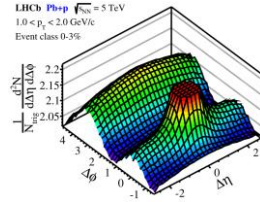
01

Who Am I?

Who Am I

Marco Meißner

- ▶ Born in Mannheim, Germany
- ▶ Studies Physics at Heidelberg University
 - ▶ Diploma in 2009
 - ▶ PhD in 2015, with U. Uwer
 - Thesis title: "Measurements of particle production and particle correlations in proton-proton and proton-ion collisions with LHCb"*
- ▶ Joined Robert Bosch GmbH in 2016 in Abstatt (near Heilbronn)
 - ▶ As Systems Engineer for Automated Driving in a pre-development project
 - ▶ Product Owner for Systems Engineering team
 - ▶ Acquisition support for the Bosch+CARIAD cooperation
 - ▶ TechLead / Product Owner for an End-2-End Feature team (Stuttgart-Feuerbach)



02

Who is “Bosch”?

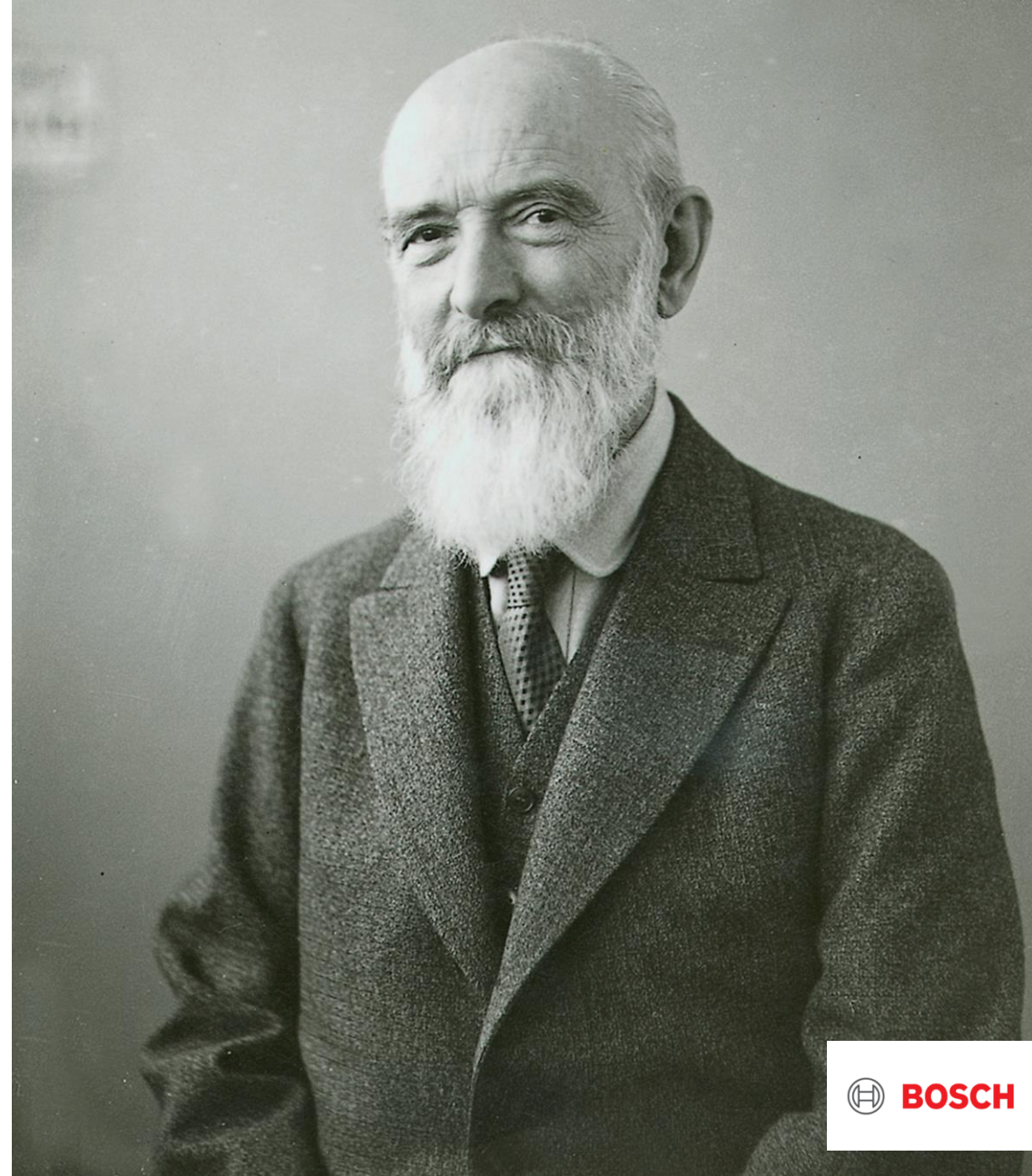


Where we come from

Our founder Robert Bosch

“We should all strive to improve on the status quo: none of us should ever be satisfied with what has been achieved but should always endeavor to do better.”

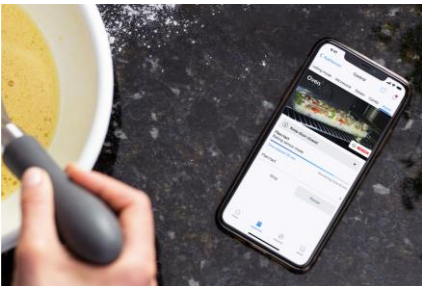
Robert Bosch, 1861–1942



We want our products and solutions to spark enthusiasm, enhance the quality of people's lives, and help conserve natural resources.

In short, we aim to create technology

Invented for life



Future in work

Mobility Solutions



We are one of the world's leading suppliers to the automotive industry. Our offering: Hardware, electronics, system solutions, software and services for almost every type of vehicle and powertrain. Our goal is to make mobility safer, smarter and more sustainable.





Around **395,000**
Bosch-Employees worldwide



Around **440** Subsidiaries
and regional companies in 60
countries

71,5 Billion Euro
revenue in 2020



129 Engineering
locations worldwide



1,7 Billion
Euro EBIT
in 2020



03

What is Automated Driving?



What is Automated Driving?

Levels of Automation



SAE J3016™ LEVELS OF DRIVING AUTOMATION™

Learn more here: [sae.org/standards/content/j3016_202104](https://www.sae.org/standards/content/j3016_202104)

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	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	

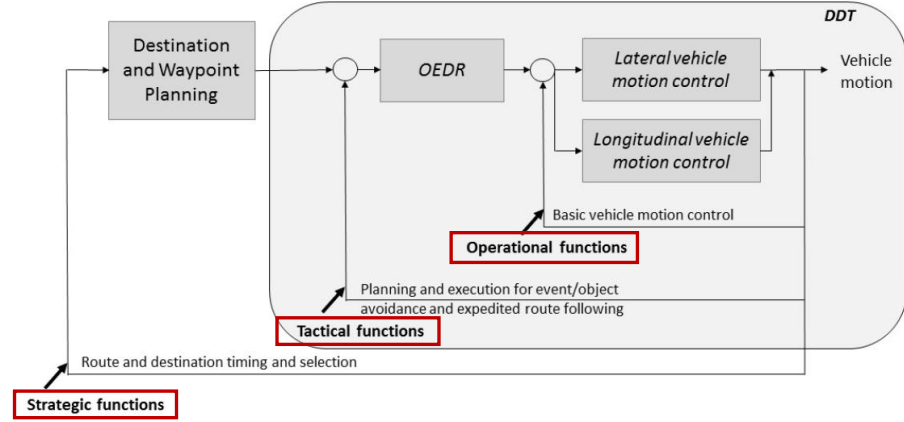
Copyright © 2021 SAE International.

	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	<ul style="list-style-type: none"> • automatic emergency braking • blind spot warning • lane departure warning 	<ul style="list-style-type: none"> • lane centering OR • adaptive cruise control 	<ul style="list-style-type: none"> • lane centering AND • adaptive cruise control at the same time 	<ul style="list-style-type: none"> • traffic jam chauffeur 	<ul style="list-style-type: none"> • local driverless taxi • pedals/steering wheel may or may not be installed 	<ul style="list-style-type: none"> • same as level 4, but feature can drive everywhere in all conditions

SAE = Society of Automotive Engineers

<https://www.sae.org/blog/sae-j3016-update>

The “driving task”:



► Dynamic Driving Task (DDT)

includes operational workload (e.g. steering, braking, accelerating...) and tactical workload (responding to events, merge into a lane, etc.), but not strategic workload (destination/waypoint planning)

► Operational Design Domain (ODD)

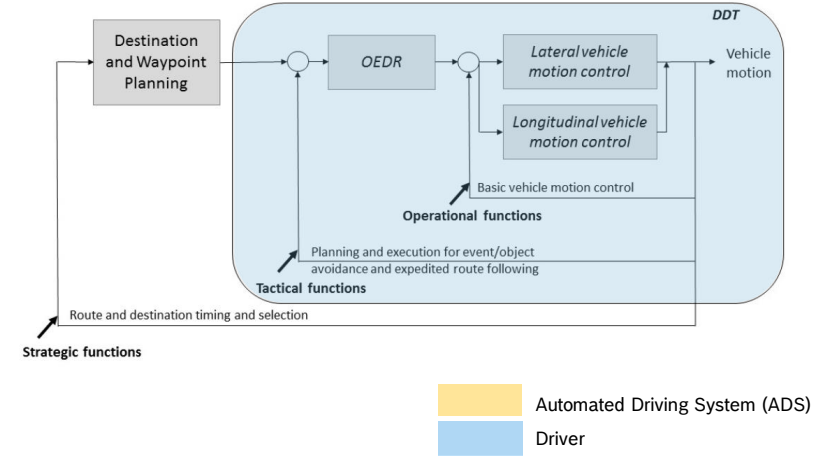
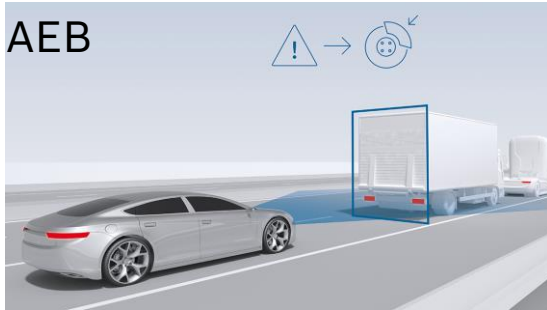
defines conditions under which an automated driving system (ADS) is designed to function: geographic, roadway, environmental, traffic, speed, and/or temporal limitations, ...

OEDR = Object and Event Detection and Response

What is Automated Driving? Levels of Automation

Level 0 – No Automation

- ▶ “Manual driving”, full-time performance by the driver of the entire dynamic driving task, even when enhanced by active safety systems (e.g., ESP), or an automated emergency brake (AEB)

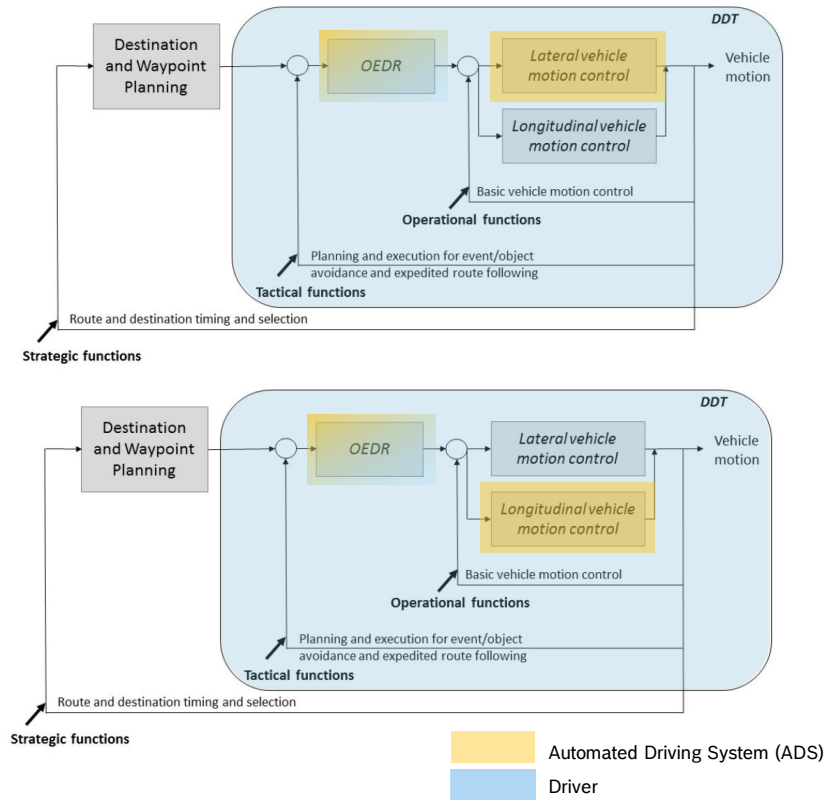


What is Automated Driving?

Levels of Automation

Level 1 – Driver Assistance

- ▶ The ADS (automated/assisted driving system) executes either the **lateral** or the **longitudinal** vehicle motion control
- ▶ The ODD is limited
- ▶ Level 1 is a support feature, the driver remains in control and must **permanently supervise** the ADS
- ▶ Some examples:
 - ▶ ACC (“active cruise control”)
 - ▶ LKS (“lane keeping system”)



DDT	DDT Fallback	ODD
Driver & System	Driver	Limited

What is Automated Driving?

Levels of Automation

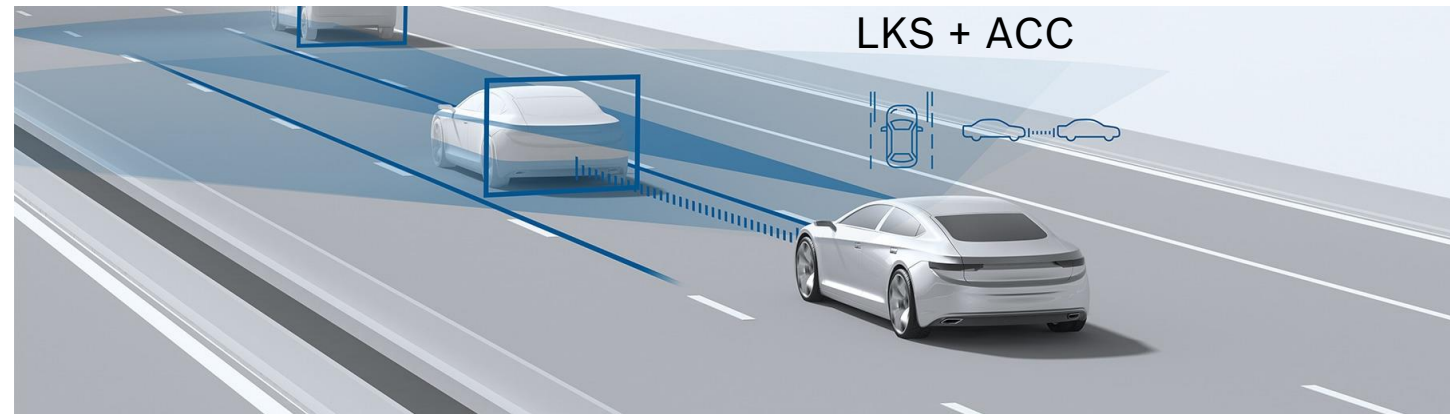
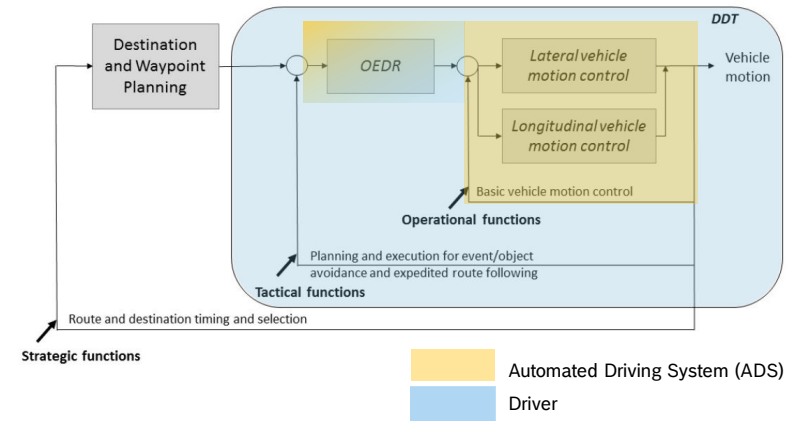
Level 2 – Partial Driving Automation

- ▶ The ADS (automated/assisted driving system) executes **both the lateral and longitudinal** vehicle motion control
- ▶ The ODD remains limited
- ▶ Still a support feature, the driver completes the OEDR subtask and must **permanently supervises** the driving automation system.

▶ Examples:

- ▶ Driving Assist (ACC + LKS)
- ▶ Lane Change Assist
- ▶ Level 2 “Hands-free driving”

DDT	DDT Fallback	ODD
Driver & System	Driver	Limited

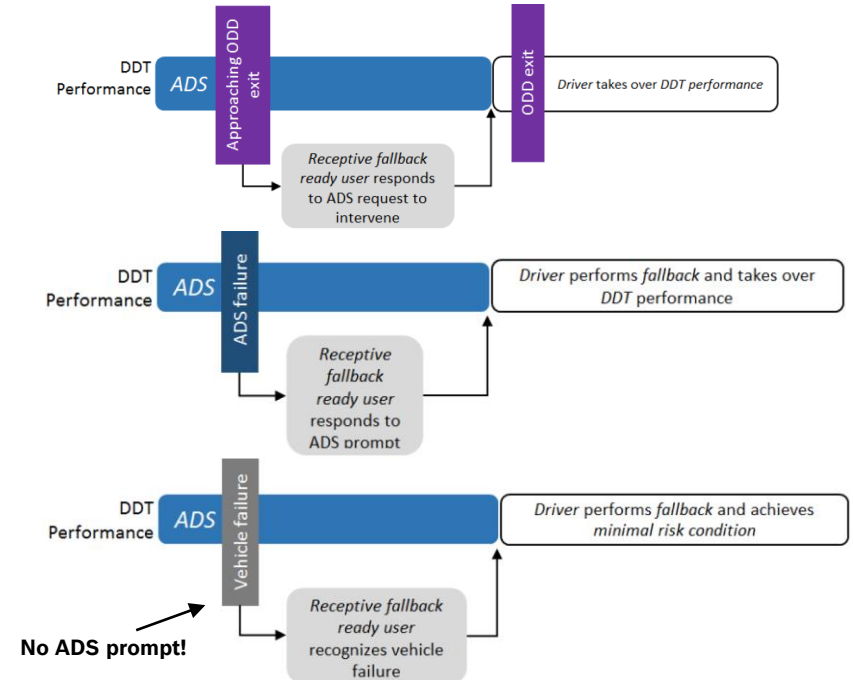
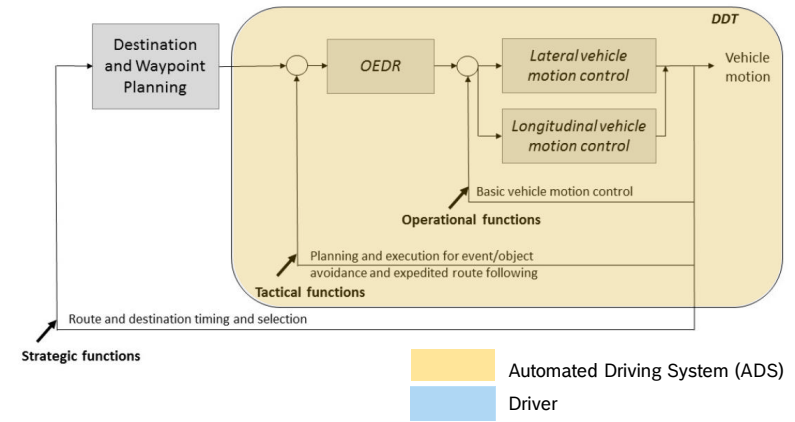


What is Automated Driving? Level of Automation

Level 3 – Conditional Driving Automation

- ▶ The **ADS controls and is responsible** for the entire DDT in a **specific ODD**
- ▶ The driver remains the **fallback-ready user** who must take back control of the DDT after ADS-issued requests. Typical granted time for a take-over is ~10 – 30 s.
- ▶ Relies (at least sometimes) on the driver to achieve minimal risk condition
- ▶ Example: L3 Bosch Driving Pilot / “Autobahn Pilot”

DDT	DDT Fallback	ODD
System	Fallback ready user	Limited



What is Automated Driving?

Level of Automation

Level 4 – High Driving Automation

▶ The ADS controls and is responsible of the entire DDT in a specific ODD

▶ The **ADS replaces the driver as fallback**

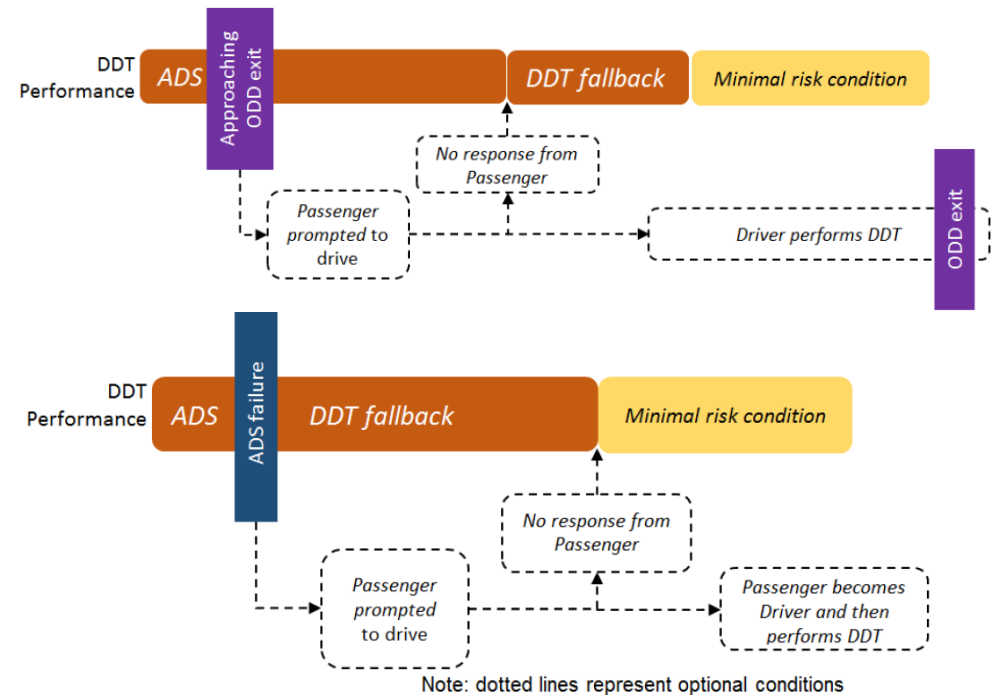
▶ **No expectation that a user will respond to a request to intervene.**

In case of a failure, the vehicle is automatically removed from the active lane of traffic before coming to a stop

▶ Examples:

- ▶ L4 Bosch Driving Pilot / “Autobahn Pilot”
- ▶ Robotaxis (driver-less)
- ▶ Automated Valet Parking

DDT	DDT Fallback	ODD
System	System	Limited



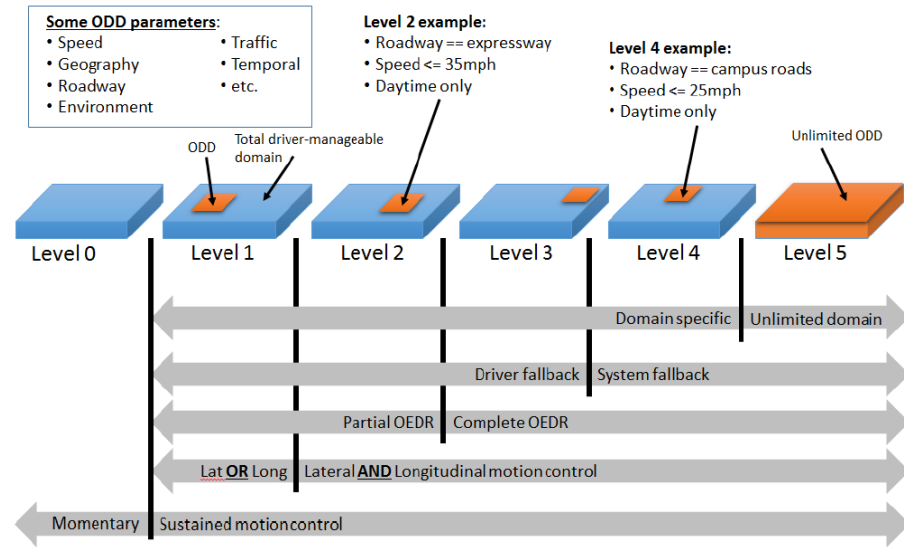
What is Automated Driving?

Level of Automation

Level 5 – Full Driving Automation

- ▶ The ADS controls the entire DDT
- ▶ The **ODD is unlimited**, the ADS can operate on all roads and under all conditions like a skilled human driver
- ▶ No expectation that a user will respond to a request to intervene – the driver becomes a passenger
- ▶ If conditions are unmanageable by a driver, e.g. during a white-out snow storm the vehicle may pull over to the side of the road to wait for conditions to change

DDT	DDT Fallback	ODD
System	System	Unlimited



What is Automated Driving?

The way to Automated Driving



	Partial Automation	High Automation
Decision Making	System	System
Responsibility	Driver	System
Insufficient Actuation	Driver take over	Not permissible
Covered situations	Selected use cases	All situations
System failure	Fail safe / fail silent	Fail operational

High Automation requires...

...redundancy for Sensors, ECUs, Communication and Actuation

...new methods for Data fusion and Decision making

What is Automated Driving?

Different Business Use Cases... different approaches



Privately Owned Automated Cars Highway

Low system usage
Medium system complexity
Low vehicle utilization

Price driven
Consumer Grade System

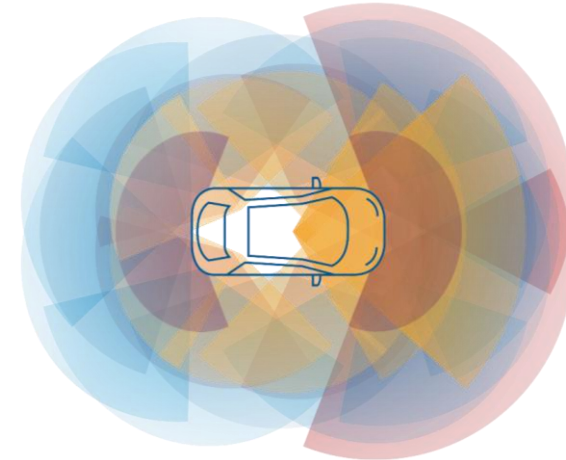
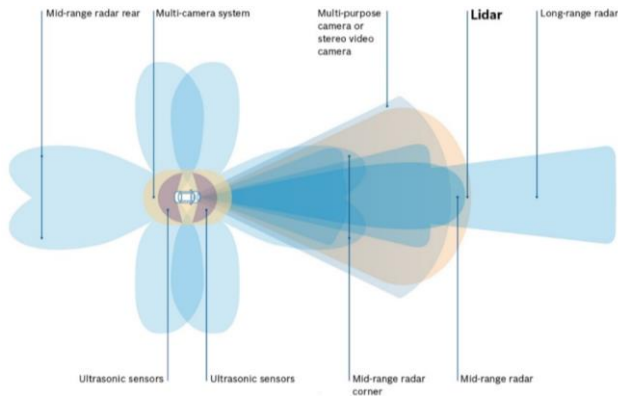


Urban Automated Taxi (UAT) - Robotaxi

High system usage
High system complexity
High vehicle utilization

Function Driven
Industrial Grade System

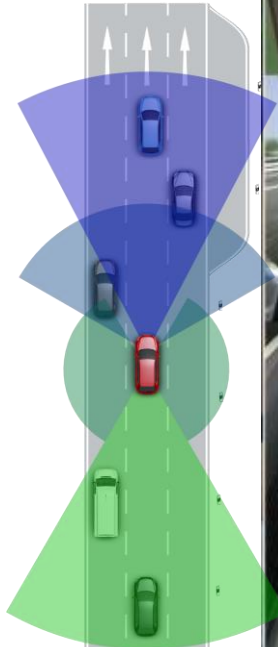
Example:
→ Sensor Set



What is Automated Driving?

Product Vision Bosch Driving Pilot (BDP)

Exemplary function



illustrative



SAE Level 3 Automated Driving function

- Speed range: 0 – 130 kph
- Automatic lane changes & merges
- The driver can relax while system is active and consume, e.g., onboard entertainment
- ~20 s take-over time for driver when requested by system
- Emergency stop: in lane
- System is available:
 - on German highways
 - good weather conditions
 - ...
- System not available:
 - in construction zones
 - ...

04

**What is an
“AD System”?**

Sensor Perception



Sensor Fusion

Environment Model

Behavior Planning
(strategic, tactical reactive)

Decision Making

Motion planning

Sense



Video

Radar

Lidar

Ultrasonics

Locate



Video/Radar

GNSS

inertia

MAP

Think

Perceive + plan



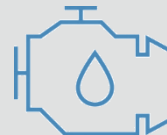
Sensor data fusion

SW redundancy



Safe and legal driving

Act



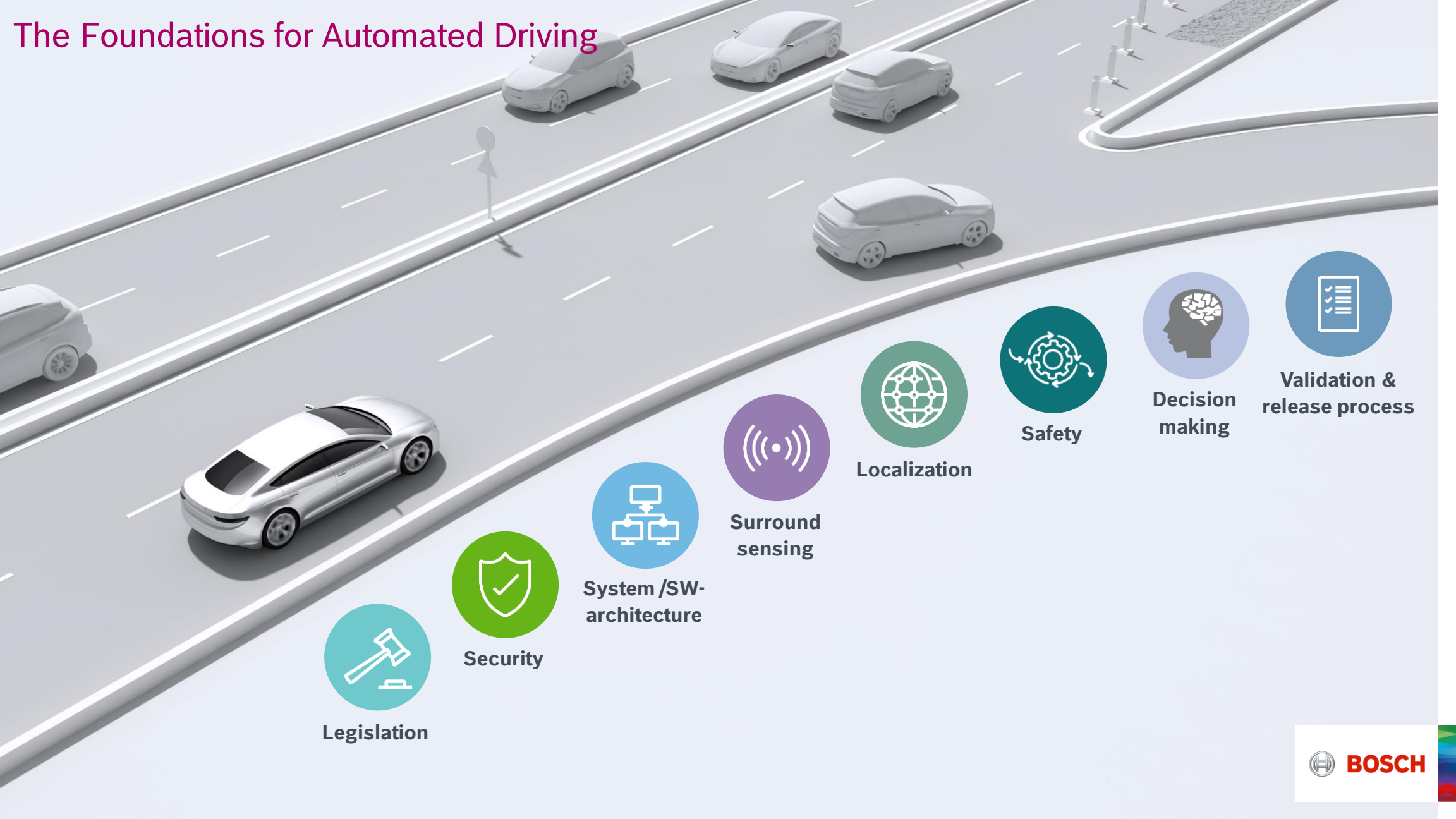
Redundant steering and braking systems

Redundancy is crucial throughout sensing, thinking and acting

A woman with long dark hair is driving a car, seen from the side. She is holding the steering wheel. The car's interior, including the dashboard, air vents, and rearview mirror, is visible. The scene is brightly lit, suggesting a sunny day.

Technik Video:
Robert_Bosch_GmbH_XC_Technik_Video_short_cut_v2.mp4

The Foundations for Automated Driving



Legislation



Security



System /SW-
architecture



Surround
sensing



Localization



Safety



Decision
making



Validation &
release process

05

What is Systems Engineering?

What is Systems Engineering?

Systems Engineering

- ▶ Interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a solution and to support that solution throughout its life

(ISO/IEC/IEEE, 2010)

- ▶ An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem

(INCOSE, 2012)

Main Objectives

Main objectives of Systems Engineering at BOSCH:

Focus engineering on customer value.



Transform stakeholder needs into technical solutions.



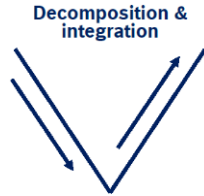
Master multidisciplinary system development.



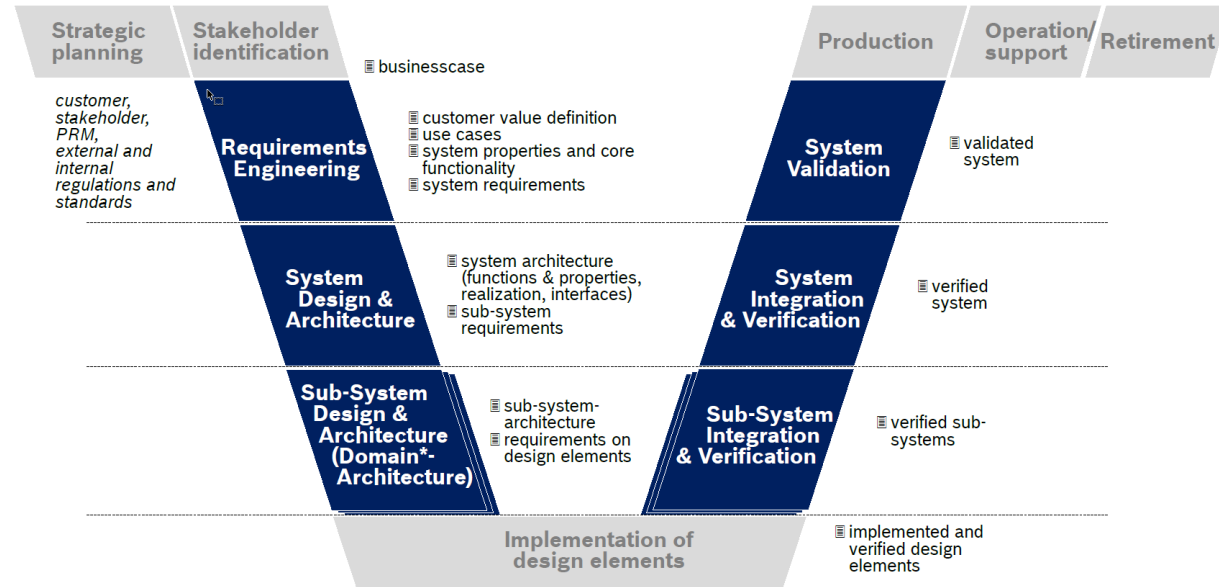
What is Systems Engineering?

The V-model for development

- ▶ The **V-Model** separates **decomposition** (breaking down a system into smaller parts) from **integration** (building up a whole from lower-level elements)



- ▶ **Verification** is carried out on different levels
- ▶ Verification and **validation** should be done from the beginning of a project



*) Domain, i.e. software, services, electrics, electronics, mechanics, hydraulics, pneumatics,...

What is Systems Engineering?

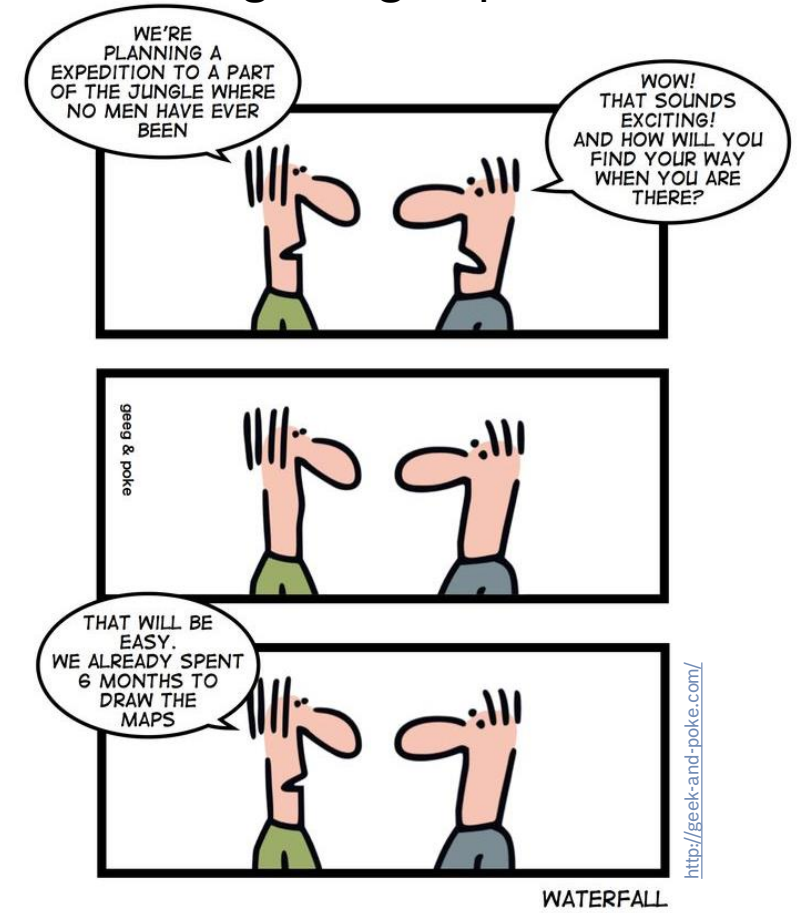
The V-model for development

- ▶ Big Design Upfront not suited for Automated Driving
 - ▶ Unknown, evolving or incomplete use-cases, requirements & architecture
 - ▶ Changing requirements, e.g., legislation
- ▶ Systems engineering must be iterative & incremental!

iterative & incremental



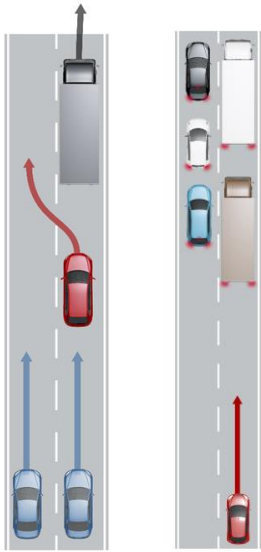
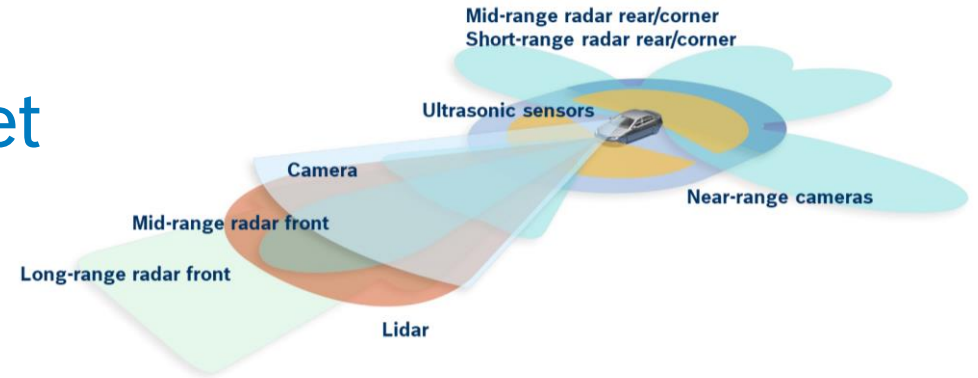
Big Design Upfront



What is an “AD System”

Example: Derivation of a Sensor Set

- ▶ Describe the world with (relevant) „Use cases“
- ▶ Derive qualitative and quantitative requirements



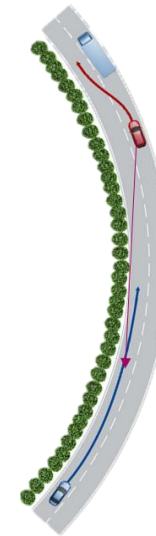
High range



High resolution



Small latency



Field-of-view



Special situations

06

How do we
work?



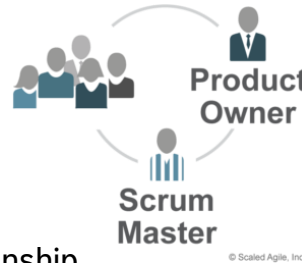
How Do We Work?

Agile Development Teams

- ▶ “Agile teams” or “Scrum teams” typically consists of 7-8 team members with different roles:

Developers:

- Devs create the value
- Cross-functional / full-stack teams
- Engineering expertise and SW craftsmanship



Product Owner:

- Defines the product vision, product roadmap and priority of work packages
- Ownership and accountability of business outcome
- Owns the “backlog” and defines the “Definition of Done”

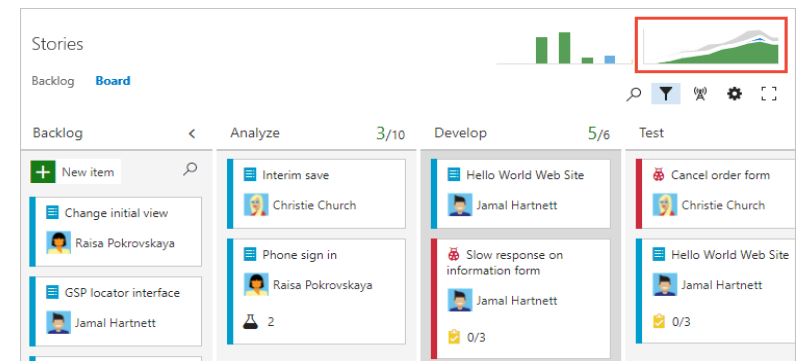
Scrum Master:

- Coaches for team
- Facilitator of team meetings
- Removes impediments from the team

- ▶ Work is aligned in “sprints” of ~2 weeks
- ▶ “Daily” scrum meetings



- ▶ Team commitment to deliver a working product after every sprint
- ▶ The developer can individually pull a stories
- ▶ After sprint there are “Sprint Reviews” and “Retrospectives”



How do we work?

Agile Developmement



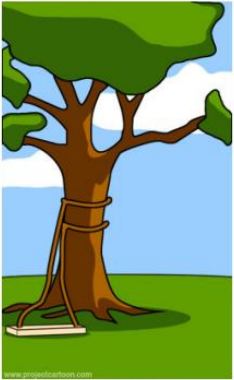
How the customer explained it



How the project leader understood it



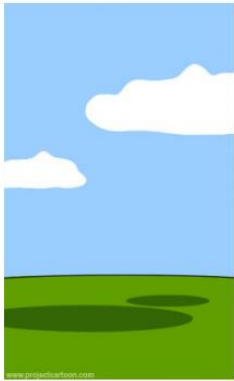
How the analyst designed it



How the programmer wrote it



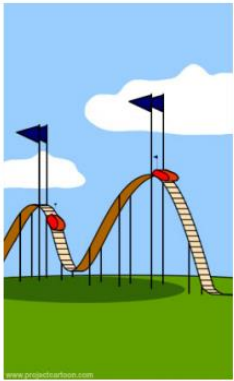
How the business consultant described it



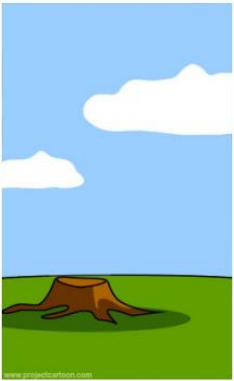
How the project was documented



What operations installed



How the customer was billed



How it was supported



What the customer really needed

www.projectcartoon.com

07

Our Project Automated Driving



Our Project Automated Driving

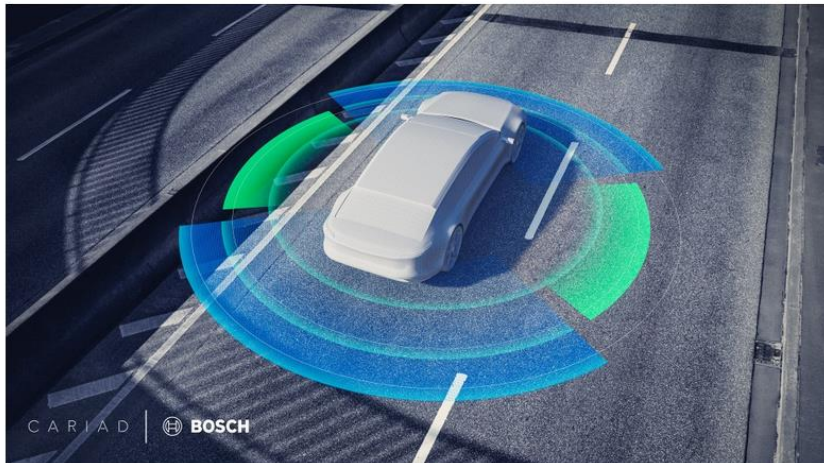
The Bosch CARIAD cooperation

25.01.2022 | Press release | #Automated mobility

share   

Automated driving: Bosch and Volkswagen Group subsidiary Cariad agree on extensive partnership

 collect  download



Engineering alliance will accelerate introduction of automated driving functions across all vehicle classes

- Safe, stress-free, and natural driving experience: hands-free driving functions to be created for one of the world's biggest vehicle fleets.
- Expertise redoubled: more than 1.000 experts from Bosch and Cariad to collaborate in engineering work.
- Solutions for today and tomorrow: engineering platform will serve as basis for automated driving up to Level 3.
- Joint development targets to be explored and evaluated for Level 4.

<https://www.bosch-presse.de/pressportal/de/en/automated-driving-bosch-and-volkswagen-group-subsi-dary-cariad-agree-on-extensive-partnership-237313.html>

Forbes
"BOSCH AND VW GROUP
TO CO-DEVELOP
HANDS-FREE DRIVING
ASSIST"

DER SPIEGEL
„VOLKSWAGEN UND
BOSCH ATTACKIEREN
TESLA - KOOPERATION
FÜR AUTONOMES
FAHREN“

REUTERS
"VOLKSWAGEN AND BOSCH
TO COLLABORATE ON
AUTOMATED DRIVING
SOFTWARE!"

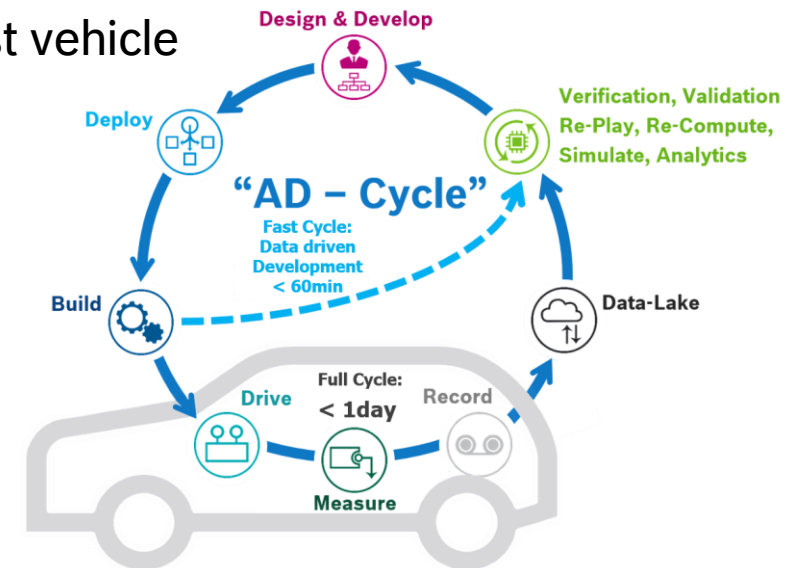
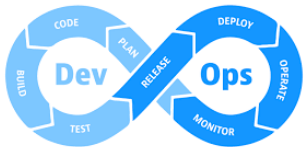
Bloomberg
"VW, BOSCH TEAM UP
ON SELF-DRIVING
SOFTWARE TO TEST
TESLA"

Our Project Automated Driving

The Bosch CARIAD cooperation

Some highlights...

- Bosch & Cariad join forces for developing of AD systems (from L2 “Hands-free” to L3/L4)
- The project is (primarily) a SW development alliance with ~1000 engineers.
We own the entire vertical stack: from the middleware to driving function, including the tooling
- Enable short cloud-based development cycles:
 - Continuous integration (CX), testing and deployment to test vehicle
 - „What works on a dev machine works in the vehicle“
 - Automated performance evaluation of each SW release



Our Project Automated Driving

A look into a develops daily business

Video:

→ Insights to daily work in the PACE project

Automated Driving

Our Project



***Sensing and perceiving** the surrounding has become one of our core competences in the field of advanced driver assistance systems. By **processing and interpreting data** we enable the system to plan its behavior appropriately. This enables the vehicle to maneuver and **steer itself independently**, swiftly, safely and precisely through traffic on highway.*



Robert Bosch GmbH is looking for **new colleagues** in the field of software development and robotics.



By developing software for **Level 2 and Level 3** we enable advanced assistance and automated driving functions in near future.



We are working closely together with our **partners**. Intensive collaboration is key for the success of the project.



Your profile:
Open minded, problem solving, **highly skilled professional** (C++, Python, DevOps, Cloud; preferable with Master degree or PhD and minimum 3-5 years of working experience).



Locations in Germany:
Baden-Württemberg (BW),
Bavaria (BY), Lower Saxony (NI).

What we have with us

Our promise as an employer

Work
#LikeABosch



Celebrate together.

Feel happy about appreciation in your job and balance in your life.

Growing together.

Grow with us in new challenges, roles and perspectives.



Inspire together.

Inspire others through strong values and vision.



What we have with us

Our company values



What we have with us

Our project benefits

#NextGenDriver Assistance



our **Workplace.**

Mac Books or multi-monitor set-ups? We offer both! You prefer to work in home office? We will find a solution!

our **Benefits.**

We offer excellent work-life-balance, flexible working hours, parental leave, above average industry salary level and sustainable facilities.



Our **Start Date.**

As soon as possible. Apply now for a full-time or part-time permanent position.



Our contact persons

Any questions? Contact us.



Robert Bosch GmbH project manager

Daniel López Caballero

+49 173 3190253

Daniel.lopezcaballero@de.bosch.com



THANK YOU!