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AKTIENGESELLSCHAFT

Transilvania
University
of Brasov
FACULTY OF
MECHANICAL ENGINEERING

Development of automated and connected driving

Prof. Dr.-Ing Heinrich Petra

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Agenda

1. **Difference between electric and gasoline combustion engines**
2. **Development of automated and connected driving**

1. Difference between electric and gasoline combustion engines

Design of electrical drive systems :
The perfect interplay of components.

1	Analogy of the electric / conventional drive system
2	Major differences in electric drives, system dependencies and sensitivities
3	Summary

Design of electrical drive systems :
The perfect interplay of components.

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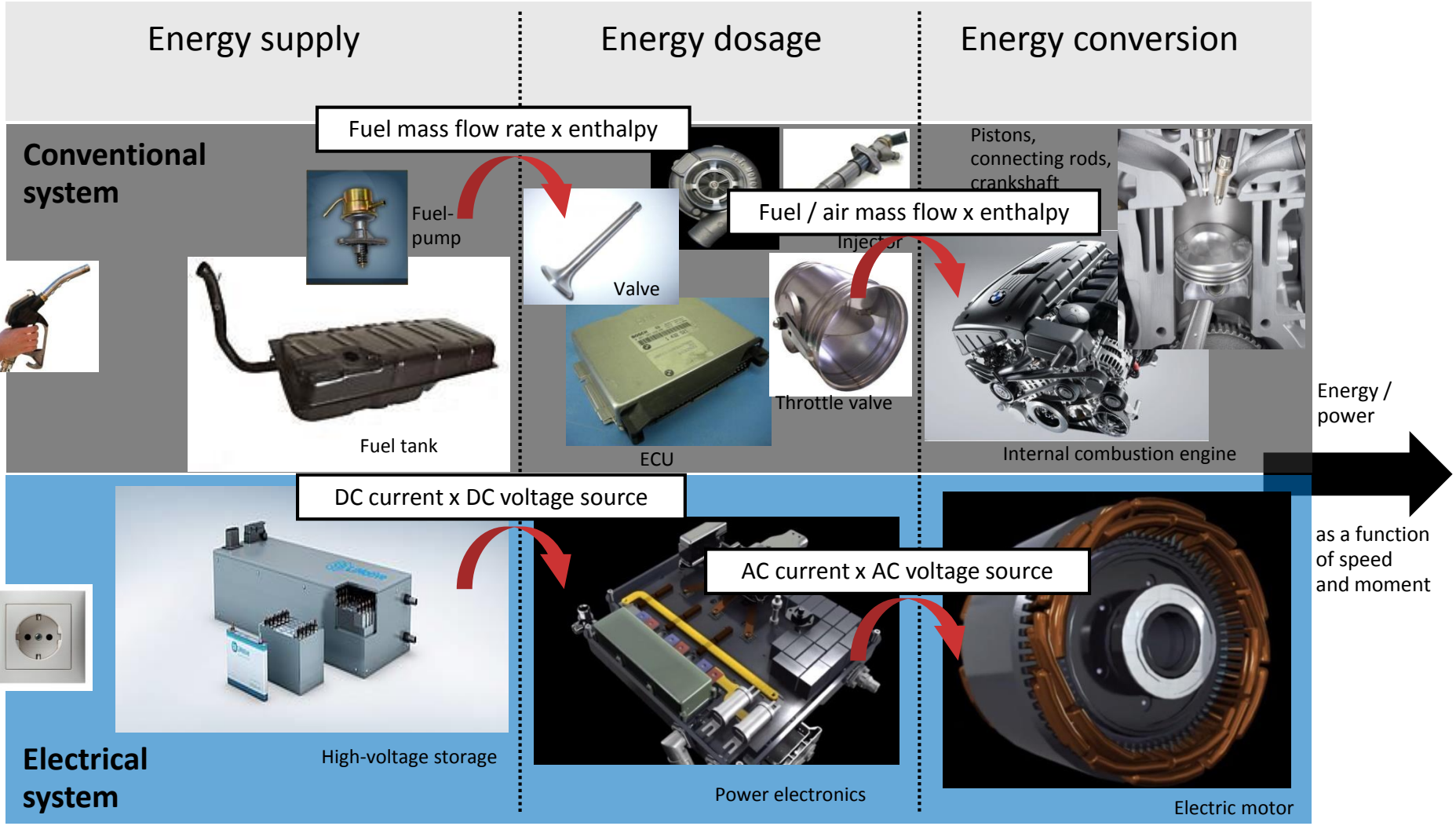
3	Summary

Analogy of the electric / conventional drive system.



Design of electrical drive systems :
The perfect interplay of components.

1	Analogy of the electric / conventional drive system
2	Major differences in electric drives, system dependencies and sensitivities
3	Summary

Electric vs. conventional drive system.

Energy supply component comparison.

Task: Supply of energy and power

Conventional system

Usable energy E depends on:

- Type of fuel / fuel density ρ (Benzin / Diesel/H_2)
- Tank volume (Liter)
- Tank fill level

predetermined

Power P depends on:

- Fuel mass flow rate
- Fuel enthalpy

E dimensionable independently of P.

Electrical system

Usable energy E Is depending on:

- Electrochemistry / cell layout
  - → Voltage U_{cell}
  - → Capacity C_{cell}
- Number N_{Zelle}
- SoC (State of Charge)

variable

Power P is depending on :

- Electrochemistry / cell layout
  - → Voltage U_{cell}
  - → Current I_{cell}
- Number N_{cell}

Mutual influencing of P and E.

Electric vs. conventional drive system.

Load dosing component comparison.

Conventional system

Dosing the performance through :

- Air boost pressure
- Air throttling
- Valve control
- Fuel injection duration
- Ignition point

Dosing primarily through mechatronics / mechanics

Electrical system

Dosing the performance through :

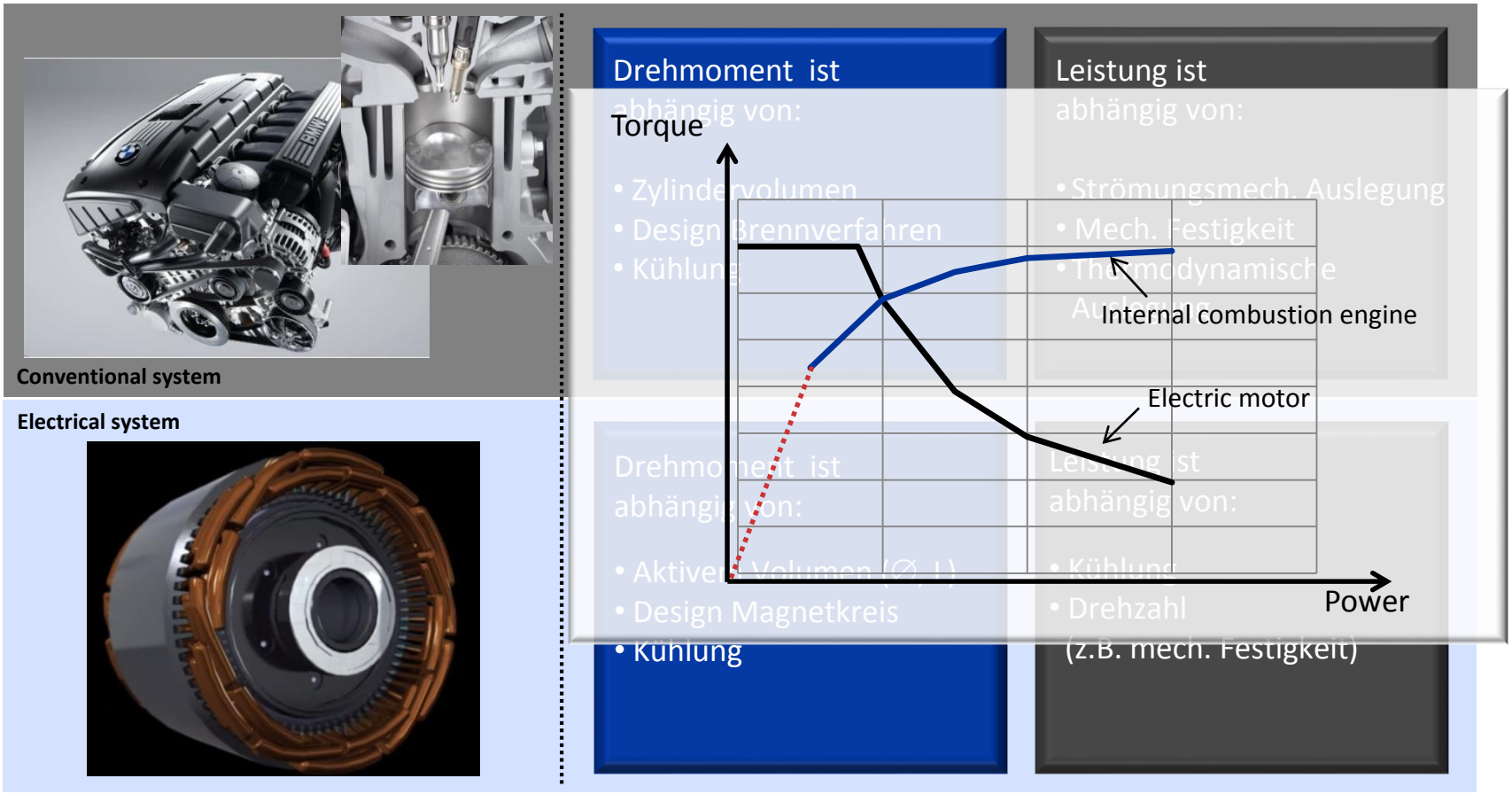
- Output current I_{AC}
- Output voltage U_{AC}
- Output frequency
- Power factor cos(phi)
- Duty cycle
- Signal quality

Dosing primarily by electronics / control

Electric vs. conventional drive system.

Energy conversion component comparison.

Task : Conversion of electrical power into the torque and speed mechanical parameters

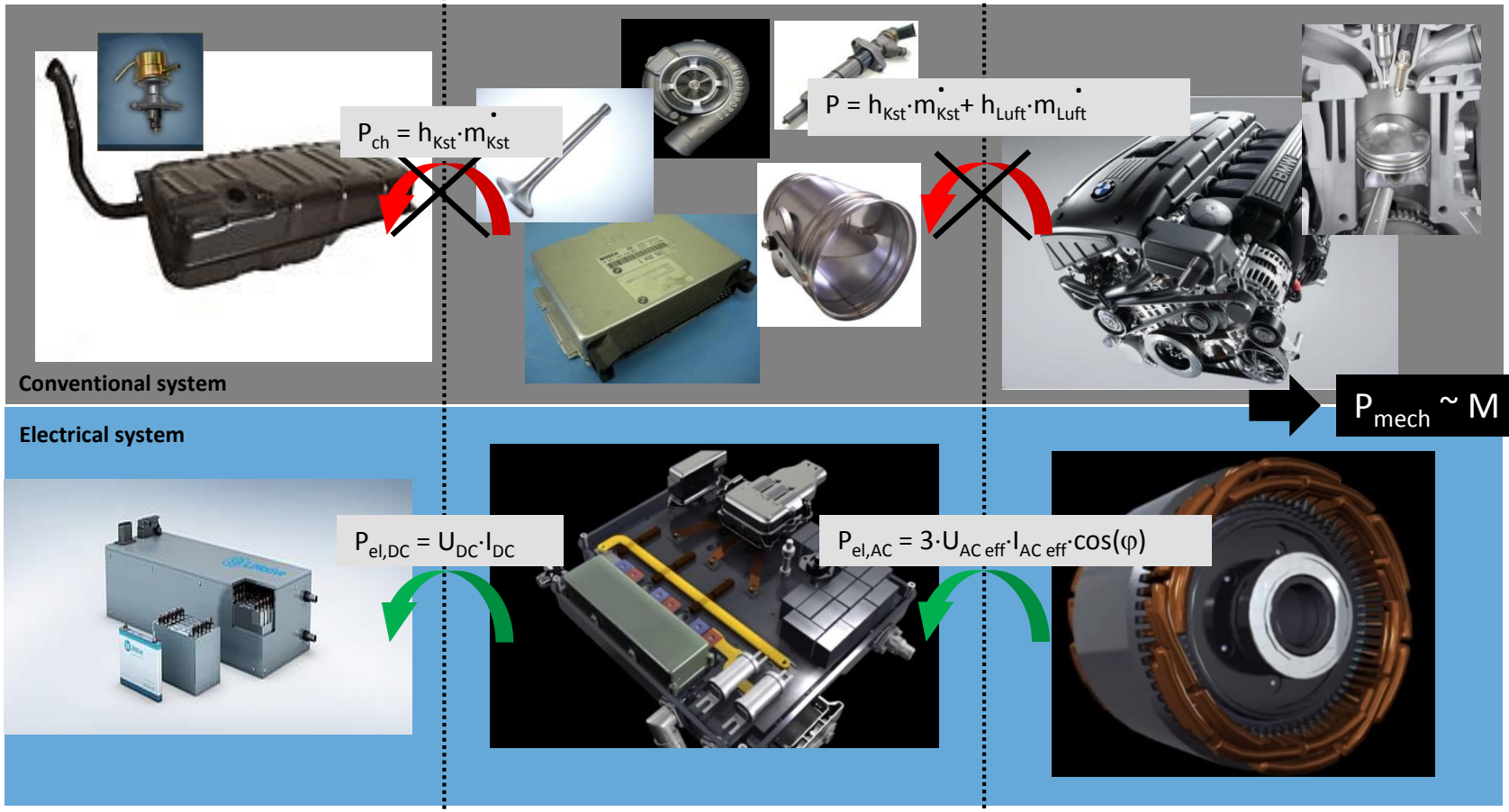


- Changed torque availability with electric motor drive
- Different acceleration potential, e.g. by bridging turbo lag.

Electric vs. conventional drive system.

Significant system differences.

Recuperation capacity,
i.e. braking energy recovery is possible



- Interaction between traction and recuperation through the same system components.
- Energy consumption in the city is reduced compared to long-distance travel.

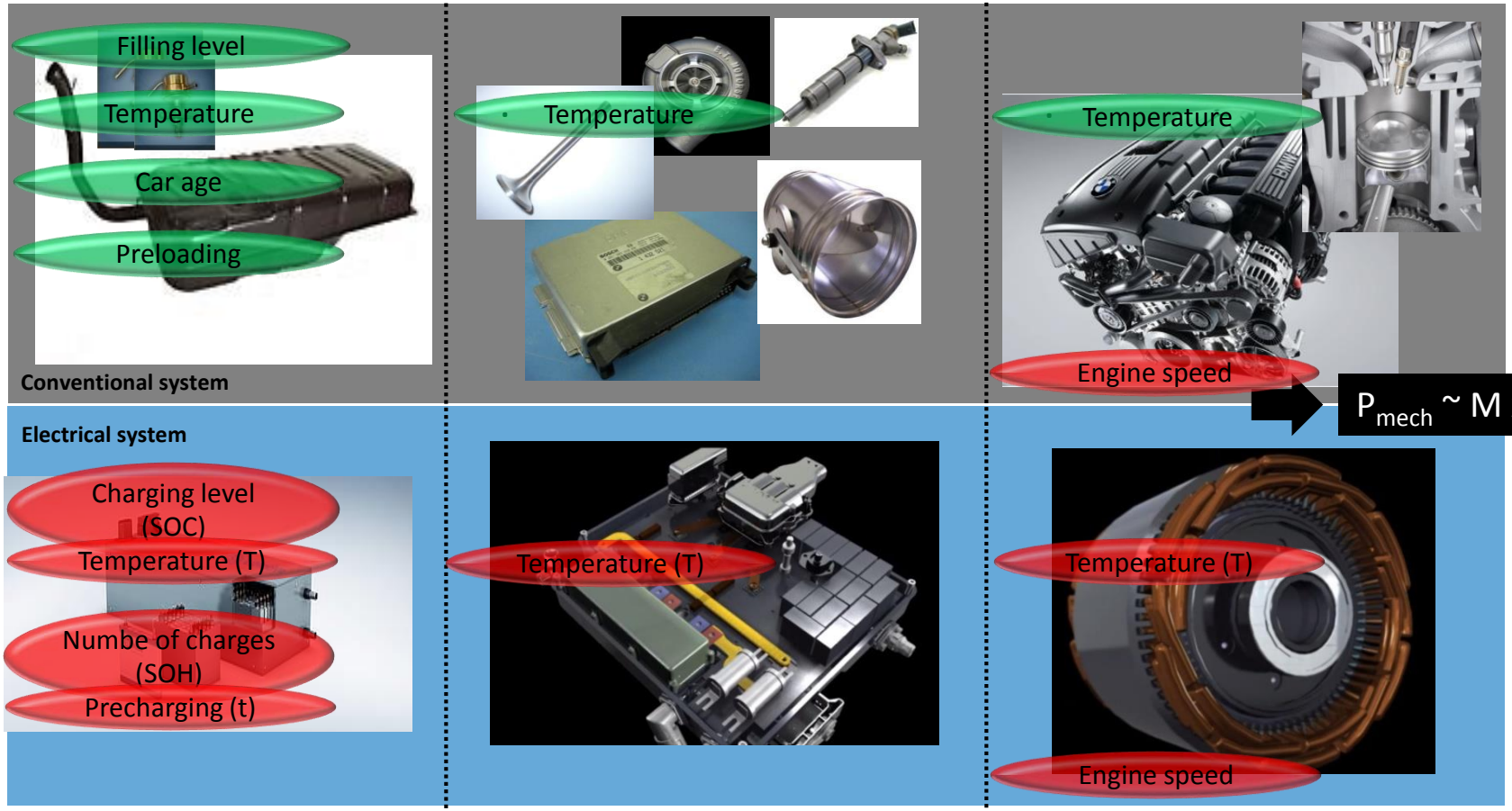
Electric vs. conventional drive system.

Significant system differences.

Dependency of the performance on boundary conditions

No / little dependency

Relevant dependency



Significantly more complex dependency of the performance on boundary conditions, especially through storage

Design of electrical drive systems:
The perfect interplay of components.

1	Analogy of the electric / conventional drive system
2	Major differences in electric drives, system dependencies and sensitivities
3	Summary

Electric drive system.

Summary

Most important consequence :

- **The potential for differentiation lies in a well-founded understanding system and component levels**

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2. Development of automated and connected driving

What are the main areas of interest?

1. **Economy**

   The development of this technology costs billions, how can the industry successfully earn back the investment?

2. **Automatic / autonomous driving**

   „Technical complexity similar to a manned Mars mission“ Thomas Sedran, Manager-Magazin, 3/2019

3. **Safety**

   There are no perfect technical systems. How safe is safe enough and how can be proved?

4. **Traffic impact**

   Is automatic driving the solution to all traffic problems ?

5. **Connected driving and infrastructure**

Challenges

BUSINESS MODEL

Content- Provider

Mobility-Provider

Fleet-Service-Provider

Vehicle Manufacturer

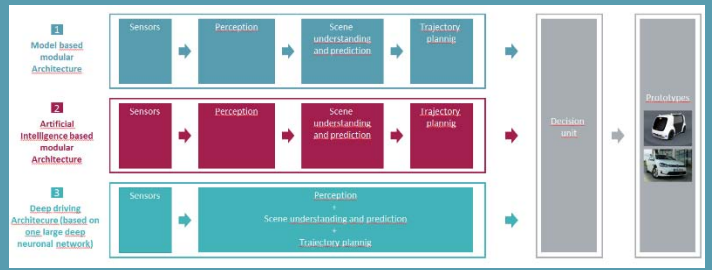
Self-Driving-System

TECHNOLOGY

Redundancy

Robustness

Computing Power



VERIFICATION/VALIDATION

How good is good enough,

and how to prove it?

Bundesministerium für Wirtschaft und Energie

PEGASUS

1. Economy

BUSINESS MODEL

Content- Provider

Mobility-Provider

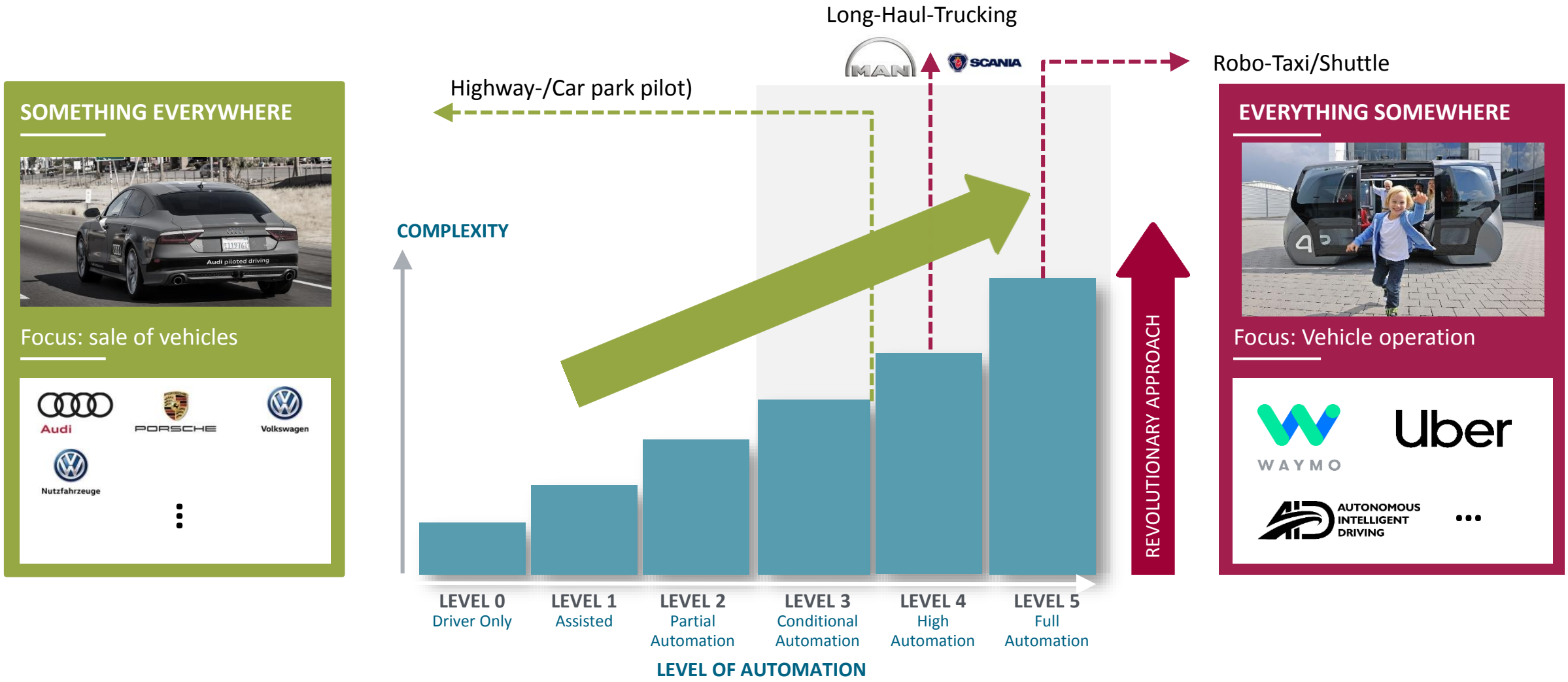
Fleet-Service-Provider

Vehicle Manufacturer

Self-Driving-System

1. Economy

Different business models address different functional characteristics



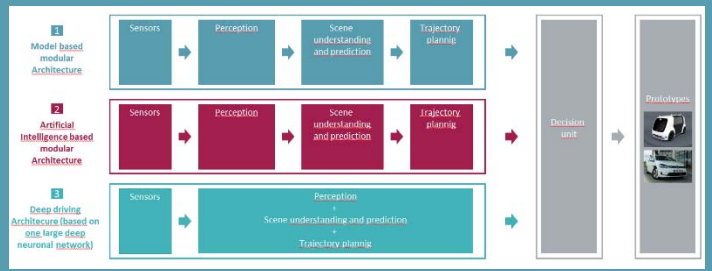
2. Automatic / autonomous driving technology

TECHNOLOGY

Redundancy

Robustness

Computing Power



2. Automatic / autonomous driving

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DEFINITIONS - LEVELS OF AUTOMATIC / AUTONOMOUS DRIVING

Automation ↔ Driver

Level 0 *Driver Only*	Level 1 *Assisted*	Level 2 *Partial Automation*	Level 3 *Conditional Automation*	Level 4 *High Automation*	Level 5 *Full Automation*
Driver continuously performs the **longitudinal and lateral driving task**	**Driver** continuously performs the **longitudinal or lateral driving task**	**Driver must monitor the driving task** and the driving environment **at all times**	**Driver does not need to monitor the driving task** nor the driving environment; must always be in a position to resume control	**Driver is not required** during defined use case	**System** performs the lateral and longitudinal driving task in all situations encountered **during the entire journey. No driver required.**
No intervening vehicle **system** active	**The other** driving task is performed **by the system**	**System** performs **longitudinal and lateral driving task** in a defined use case	**System** performs longitudinal and lateral driving task in a defined use case. **Recognizes its performance limits** & requests driver to resume the dynamic driving task with **sufficient time margin**.	**System** performs the lateral and longitudinal driving task **in all situations in a defined use case.**	

Robo-Taxi

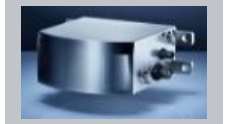
Auto-Pilot

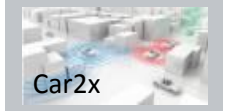
Level of automation (Terms according to SAE J3016)

2. Automatic / autonomous driving technology

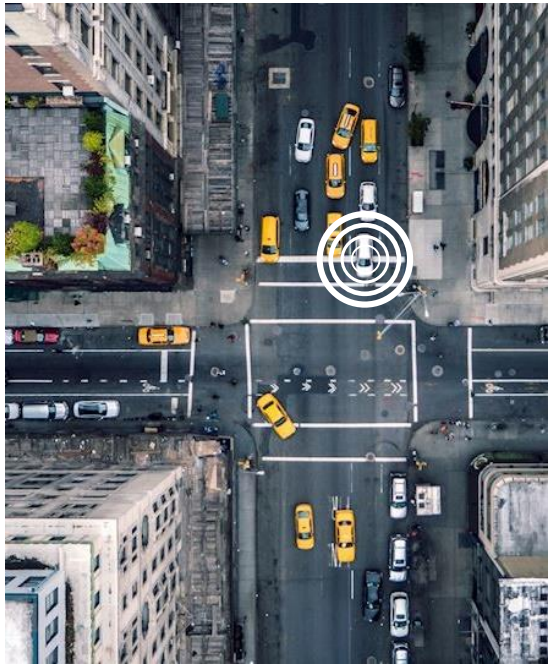
Complexity of the functional architecture

Sensors

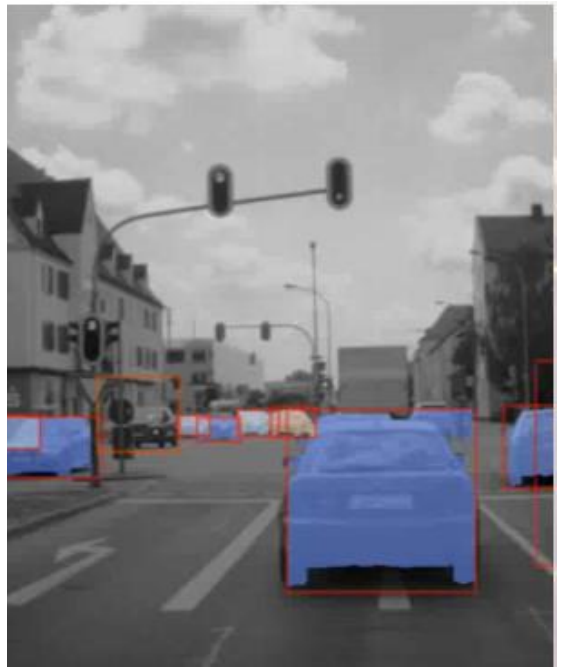




Recognize, Localize



Understand, Predict



Planing

Vehicle

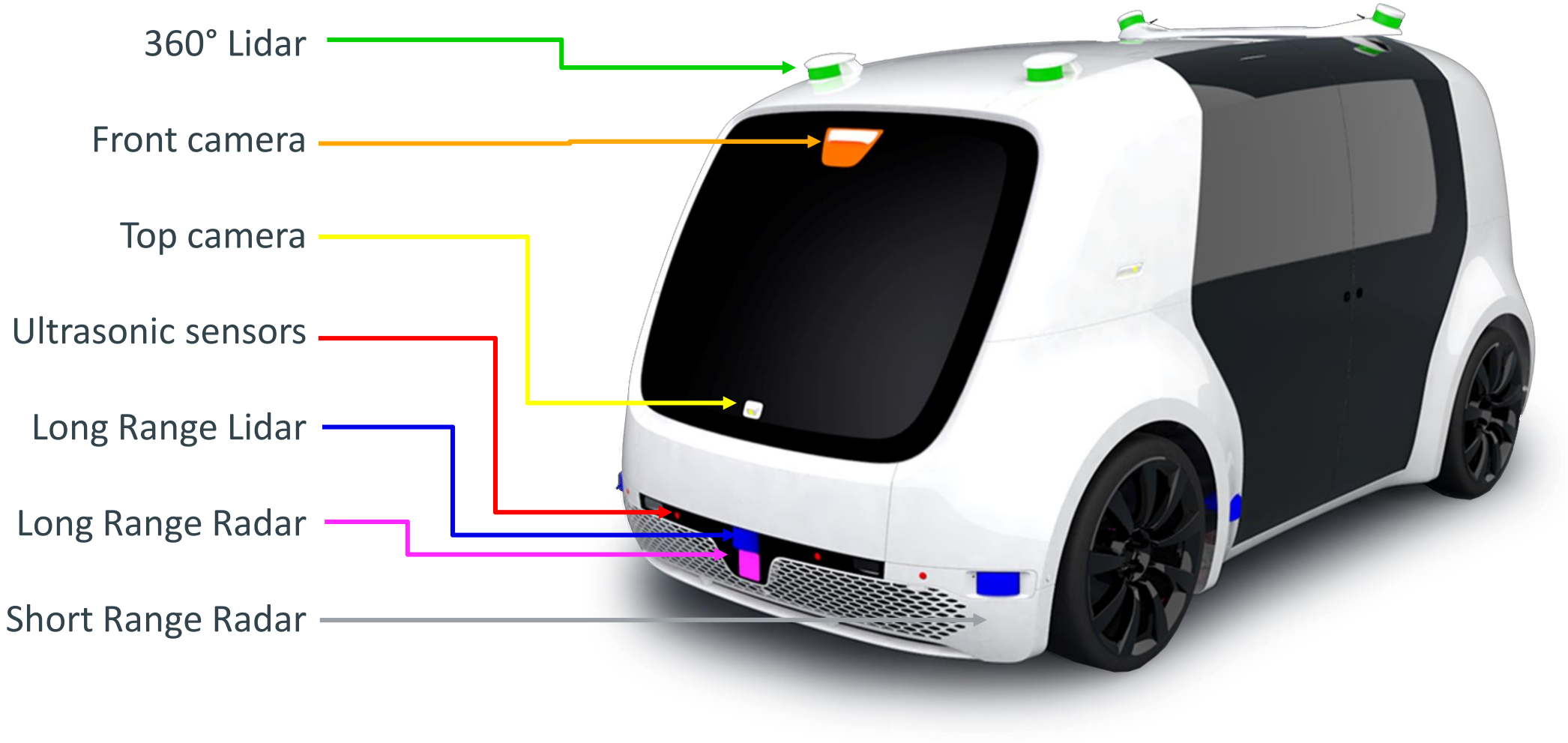
Steering & Actuators

Not considered: Functional safety requires redundancy in all function blocks !

2. Automatic / autonomous driving sensors

SEEING LIKE AN OBSERVANT PERSON

AUTONOMOUS DRIVING REQUIRES A LARGE NUMBER OF DIFFERENT SENSORS

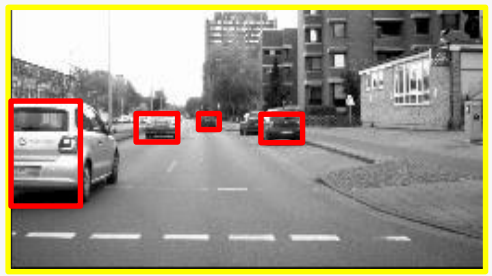


2. Automatic / autonomous driving sensors

SEEING LIKE AN OBSERVANT PERSON

WHY ARE DIFFERENT SENSOR TECHNOLOGIES REQUIRED ?

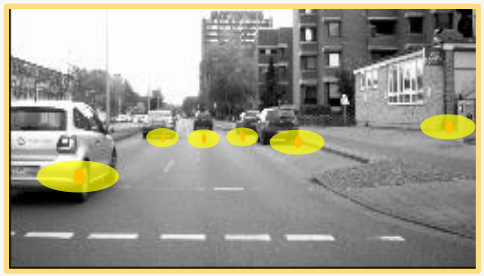
Mono Camera



e.g. Object classification

- Recognition
- Classification
- Resolution
- Range
- Speed

Radar



e.g. Velocity measurement

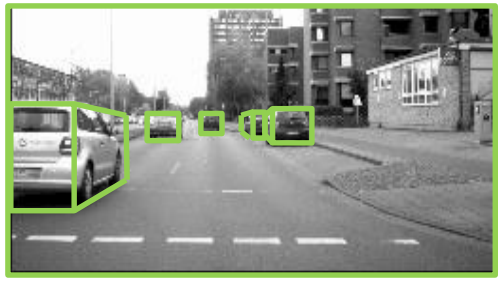
- Recognition
- Classification
- Resolution
- Range
- Speed

Laser

e.g. Object dimensions

- Recognition
- Classification
- Resolution
- Range
- Speed

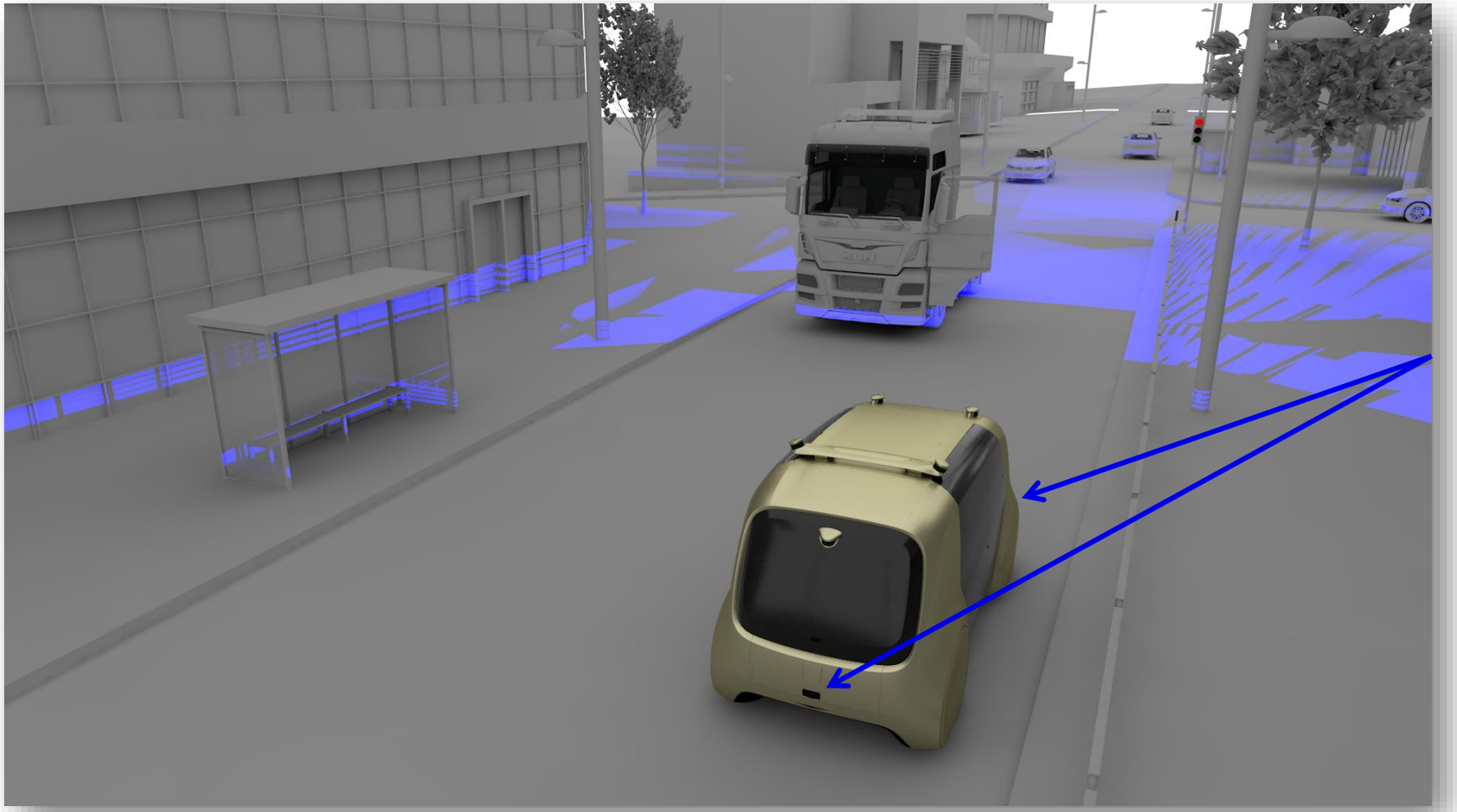
Sensor fusion



- Recognition
- Classification
- Resolution
- Range
- Speed

2. Automatic / autonomous driving sensors

PERCEPTION IN URBAN ENVIRONMENT



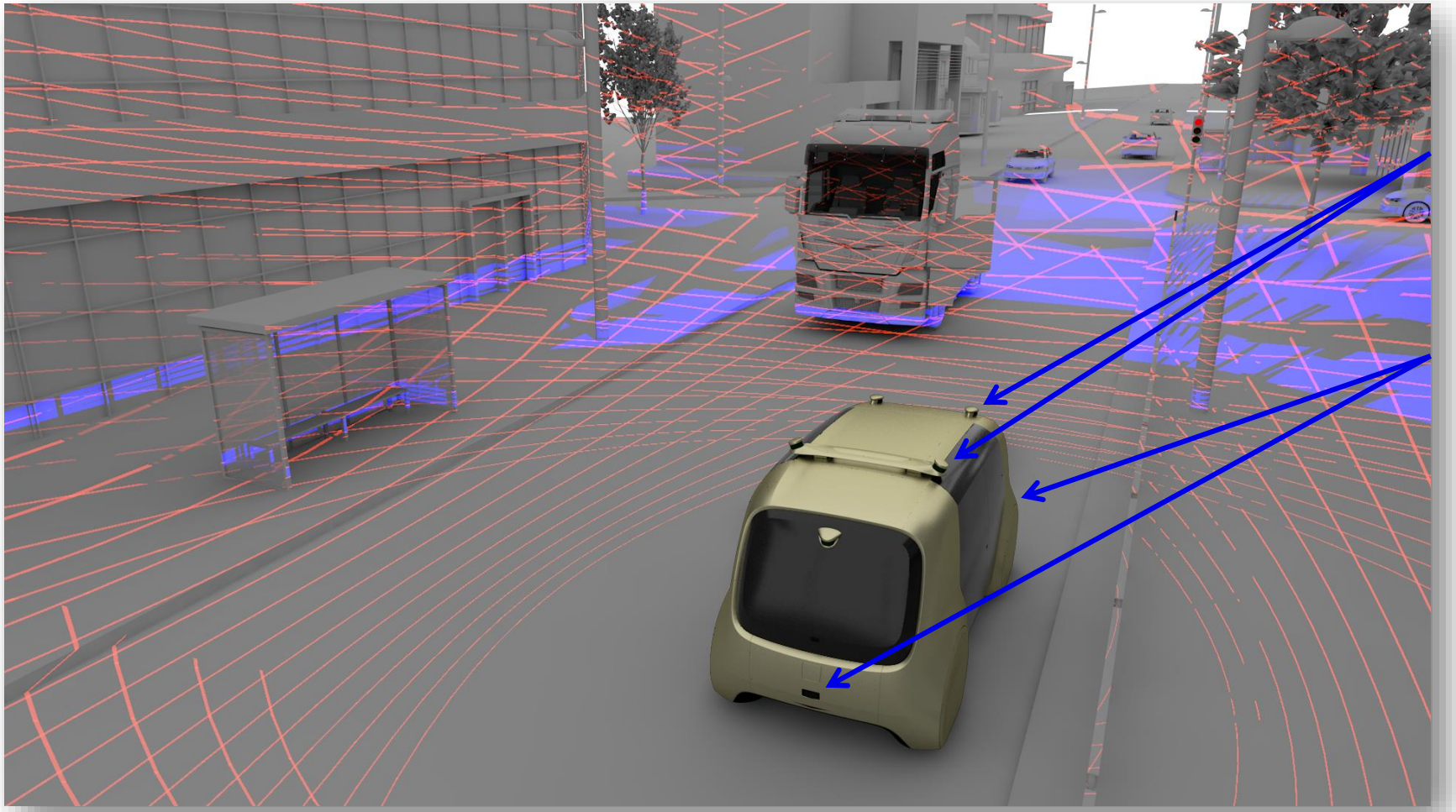
Detection of obstacles at large distances with six high-precision long range lidars:

→ Dynamic objects

→ Static objects

2. Automatic / autonomous driving sensors

PERCEPTION OF URBAN ENVIRONMENT



Detection of near obstacles by five overlapping 360° lidars:

→ High precision volumetric detection of obstacles at different elevation levels (e.g. open truck door)

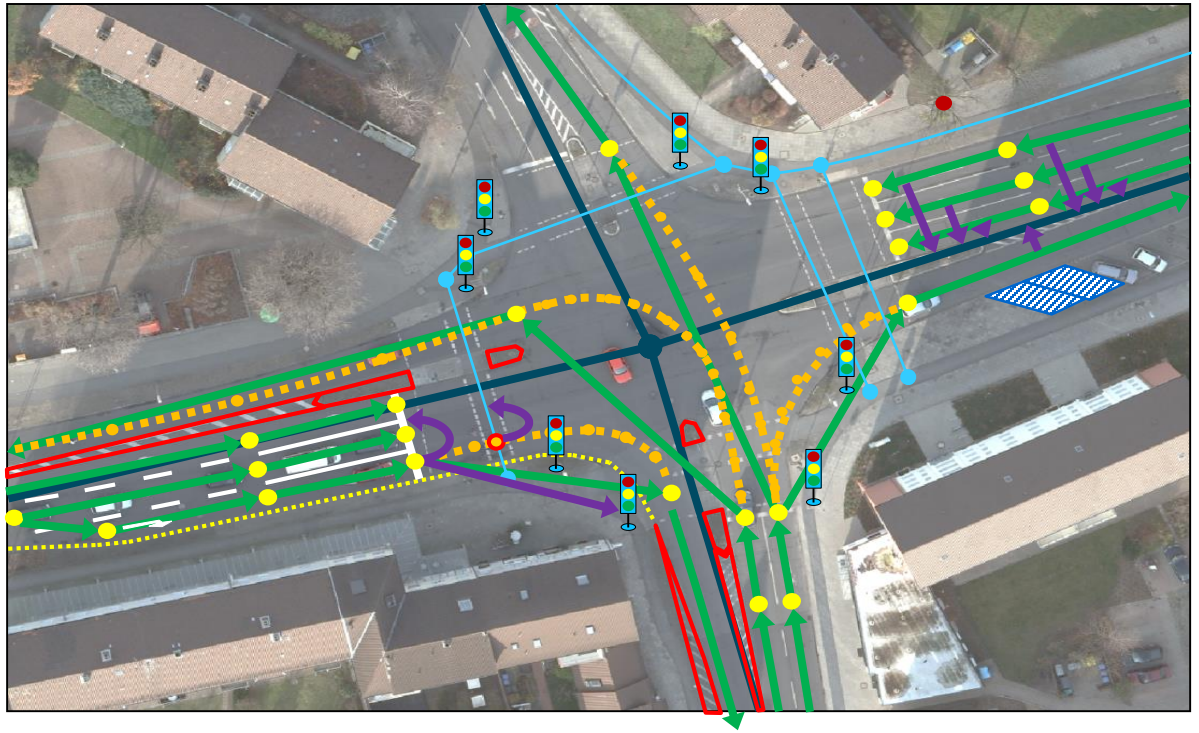
2. Automatic / autonomous driving maps

MAPS

NEED TO BE ACCURATE AND DETAILED

Standard Map according to Navigation Data Standard (NDS)

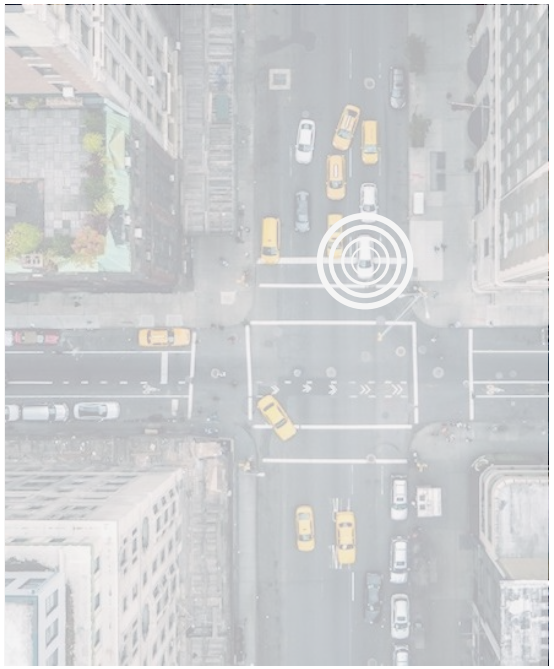
High Quality Map according to Detailed Lane Model (DLM)



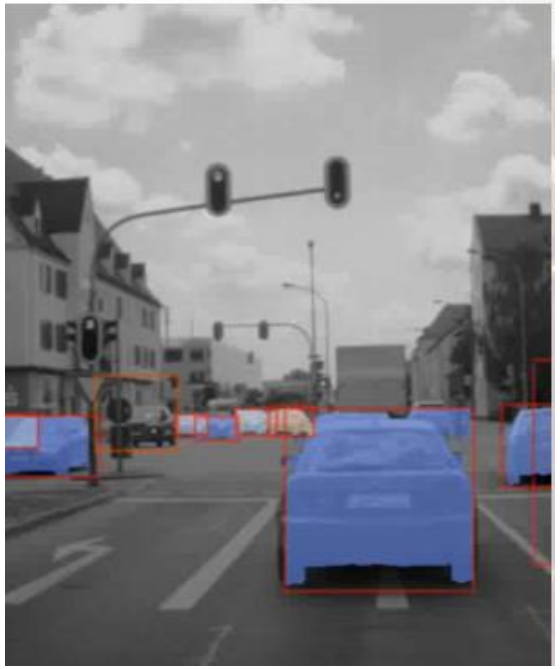
2. Automatic / autonomous driving technology

Sensors

Recognize, Localize



Understand, Predict



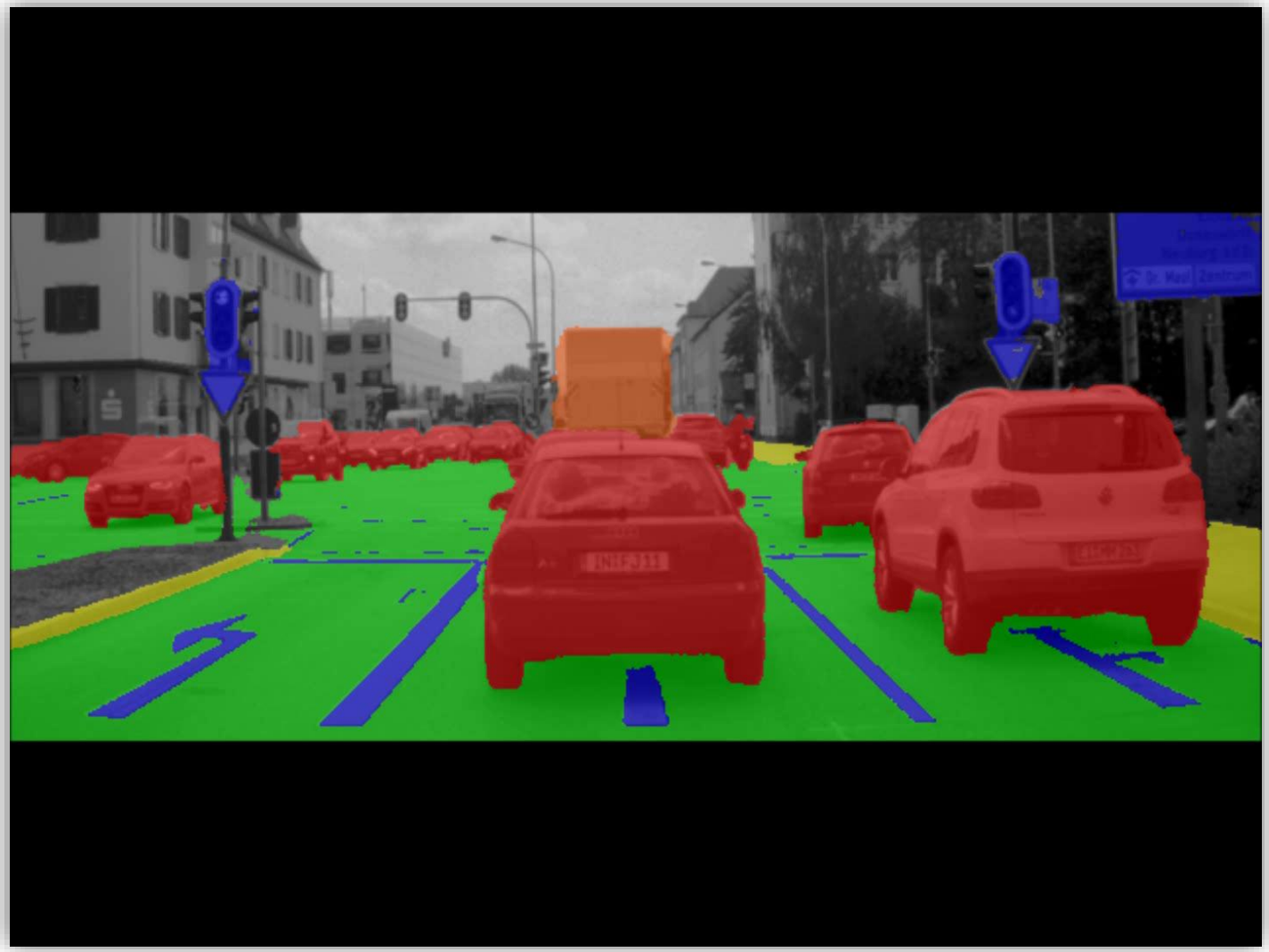
Planing

Vehicle

Steering & Actuators

2. Automatic / autonomous driving technology

SCENE UNDERSTANDING



- Complete environment perception using several cameras
- Object and free space classification by image segmentation with artificial neural networks
- Image processing on specialized, high capacity GPUs

2. Automatic / autonomous driving

BLIND SPOT HANDLING

Challenges:

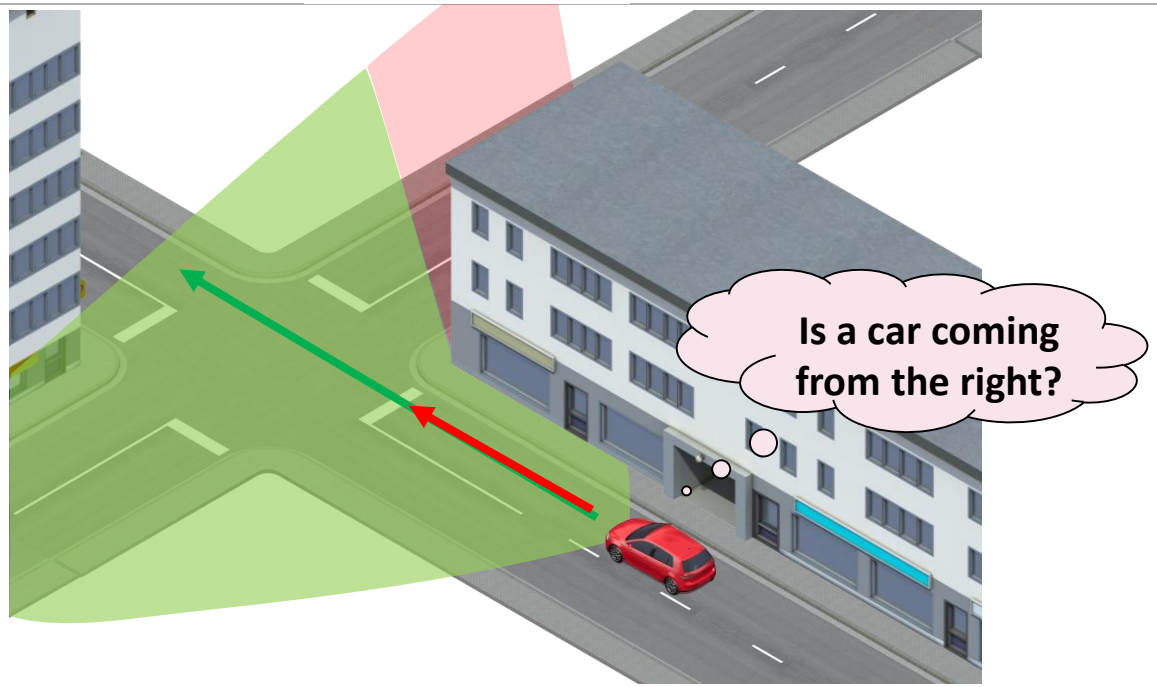
- Static or dynamic obstacles often occlude parts of the scene.
- Sensor limitations due to e.g. viewing range, weather, and lighting conditions.

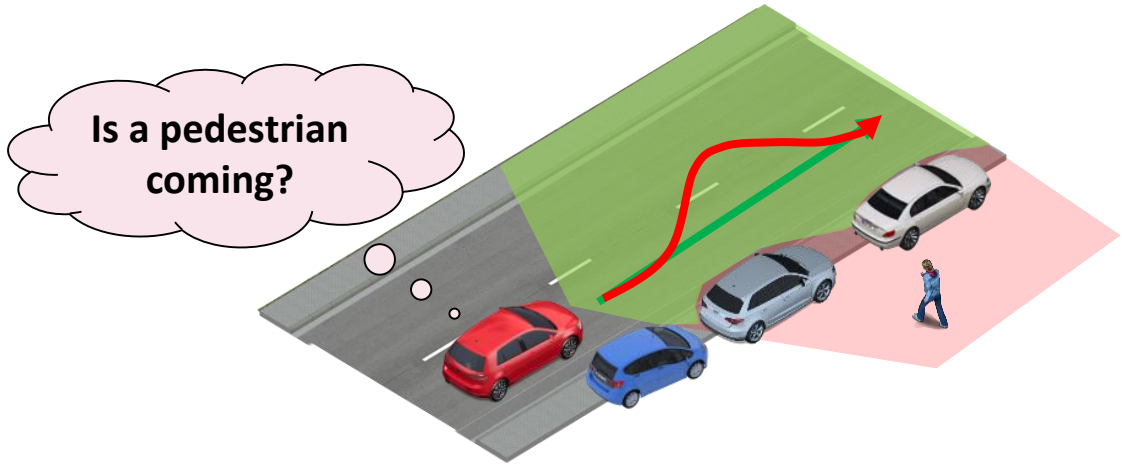
Tasks:

- Consider sensors' fields of view.
- Model potential threads from occluded areas.

Approach:

- Set up *phantom* objects in unknown areas.
- Result: Automated car will slow down and/or keep safety distance to unknown areas.





2. Automatic / autonomous driving technology

OBJECT ACTION RECOGNITION / INTENTION ESTIMATION

Challenges

- In order to provide a good prediction of object movement, is needed to know what that object is going to do :
  - make (action)
  - will do (intent)

Task

- Interpretation of traffic participants
- Use the learned behavior

The vehicle is moving.

Will it keep going or will it stop?

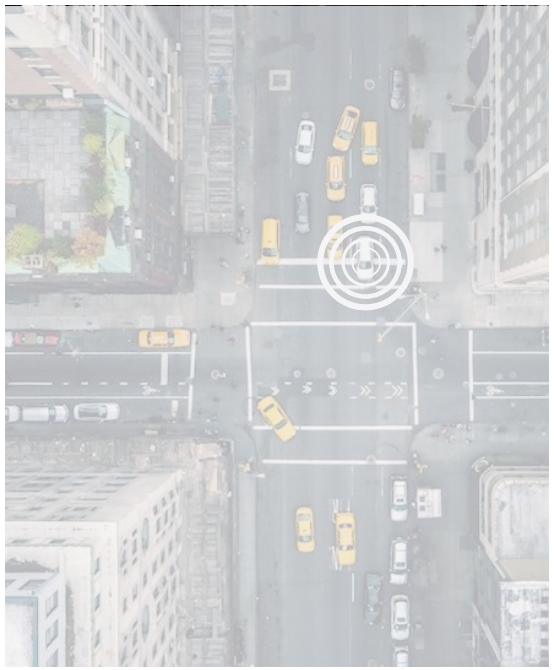
The pedestrian is walking.

Will he cross the street?

2. Automatic / autonomous driving technology

Sensors

Recognize, Localize



Understand, Predict

Planing

Vehicle

Steering & Actuators

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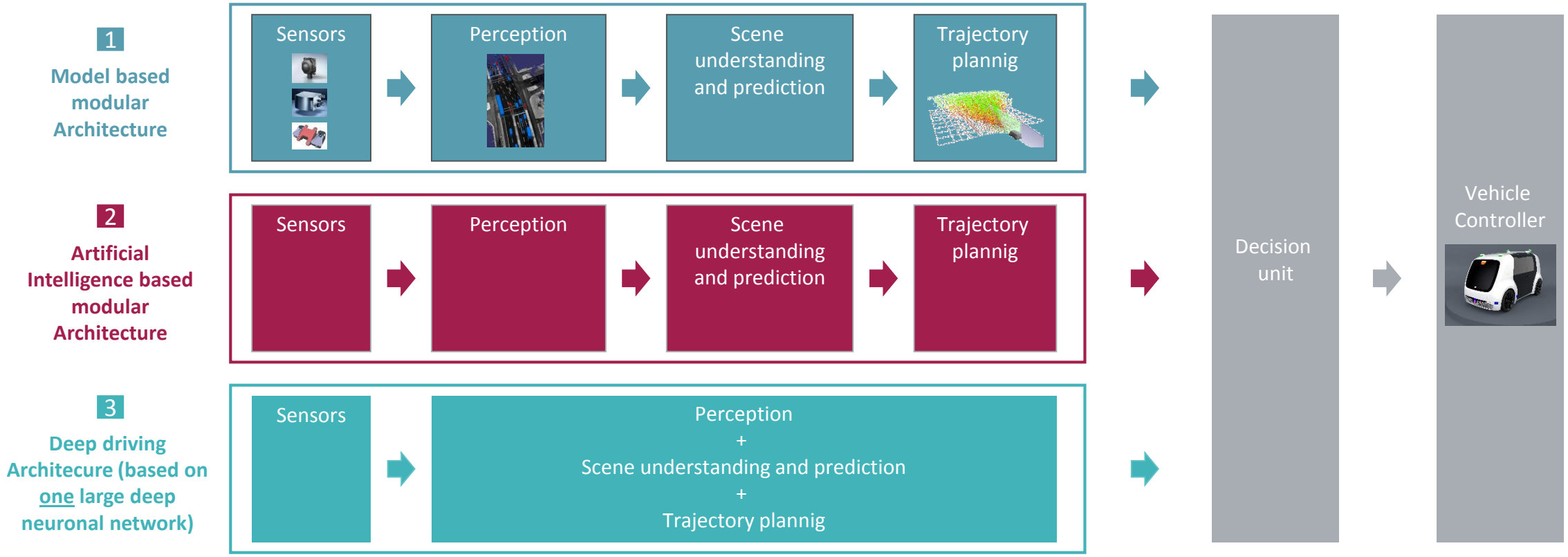
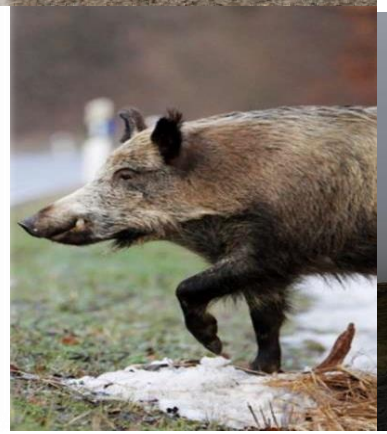
2. Automatic / autonomous driving function - the challenge of redundancy

Functional safety requires at least double redundancy in function blocks



2. Automatic / autonomous driving technology

Operation on public roads requires safe handling of all borderline cases



2. Automatic / autonomous driving tchnology

VERIFICATION/VALIDATION

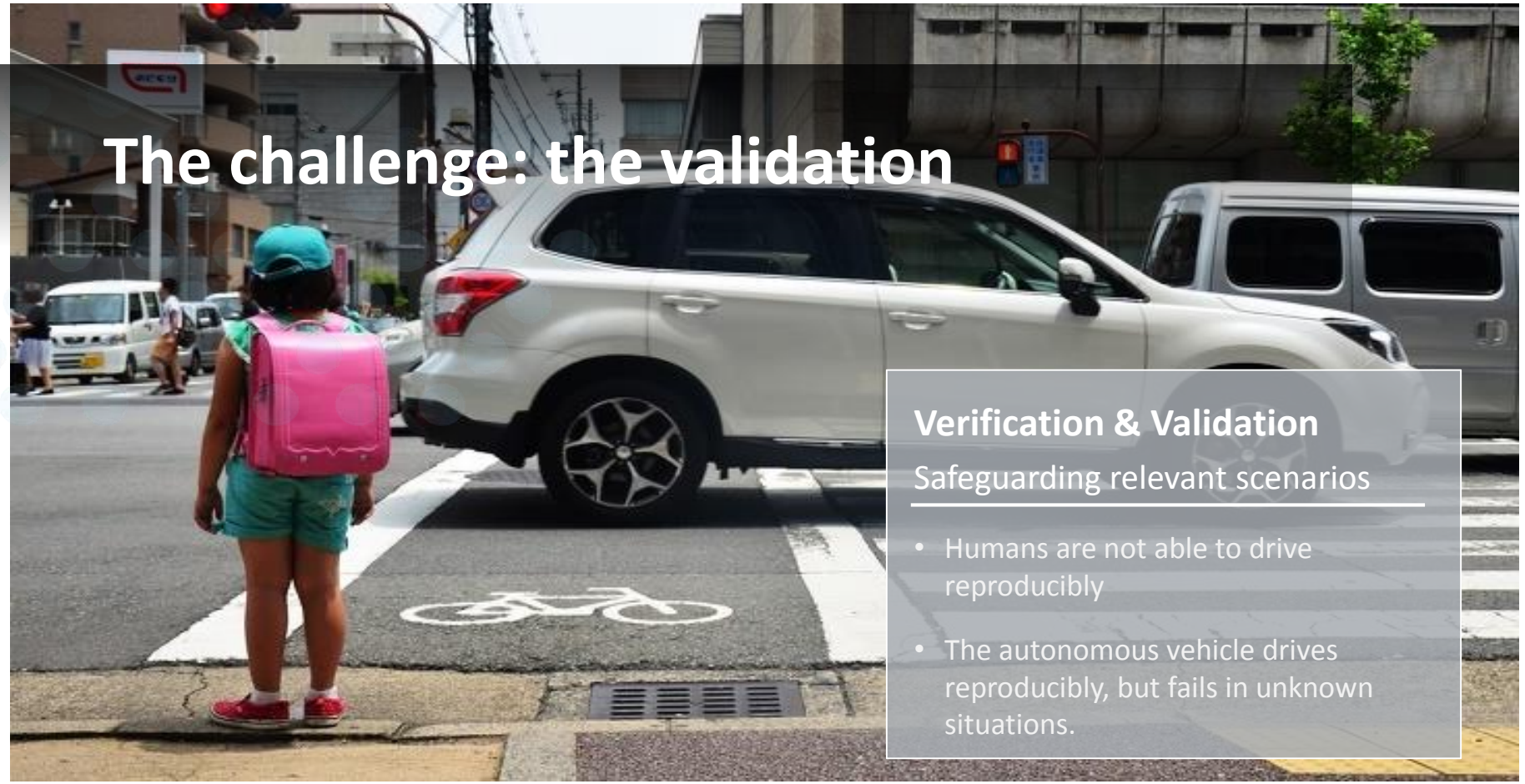
How good is good enough,

and how to prove it?

2. Automatic / autonomous driving verification & validation

TEST KILOMETERS FOR AUTONOMOUS VEHICLES ?

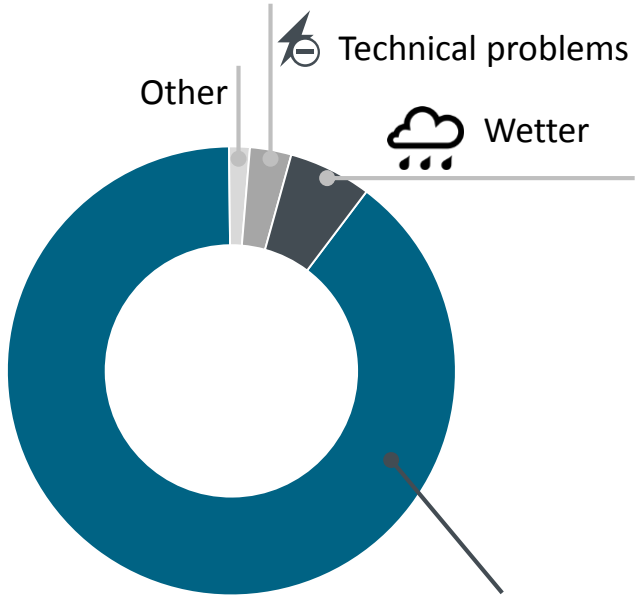
HOW TO COVER ALL RELEVANT SCENARIOS



3. Safety - How well does an autonomous vehicle have to drive?

What is expected, what can be expected?

Statistics
Causes of accidents



More than 90% of all accidents

based on

human error

Mileage statistics

on a German highway

Human driver

on average

12 Mil. km

between two accidents **with injured,**

614 Mil. km

between two accidents **with dead.**

3. Safety

TEST KILOMETERS FOR AUTONOMOUS VEHICLE

HOW TO COVER ALL RELEVANT SCENARIOS

The Human

is not able to drive without failure repeatably.

The autonomous vehicle

may repeatably fail in specific but unknown situations

3. Safety - How do I prove security

Dilemma of the virtually infinite test space

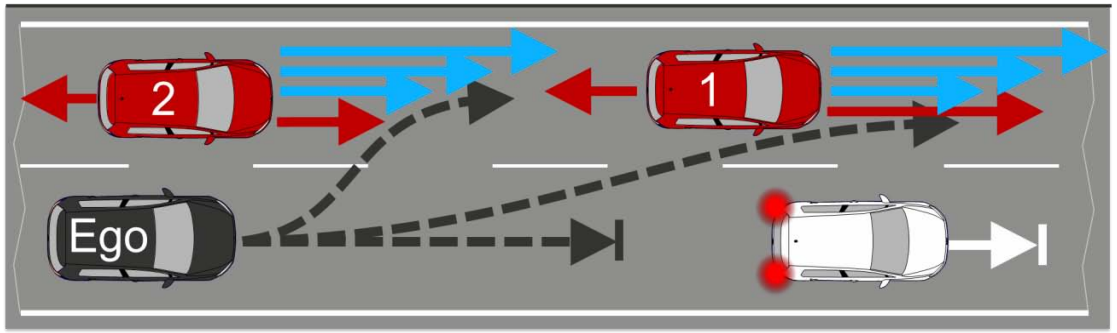
Optimization

- Use Optimization Algorithms to iteratively create relevant scenarios

Evaluation

- Evaluate and interpret Scenario results with Metrics

Example Scenario with 4 Parameters:



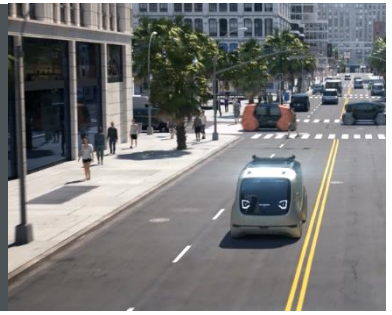
Parameter		Steps	Test Cases
Object 1	Velocity	100	**100.000.000**
	Position	100	
Object 2	Velocity	100	
	Position	100	

Research Question:

How do we find the relevant and critical test cases?

4. Traffic impact

Robotaxi + shared Mobility – the solution to our traffic problems ?

Current status		New mobility services
High parking fees		Drive around until you need the vehicle again 
Current behavior		New ways of behaving

-/+ ?

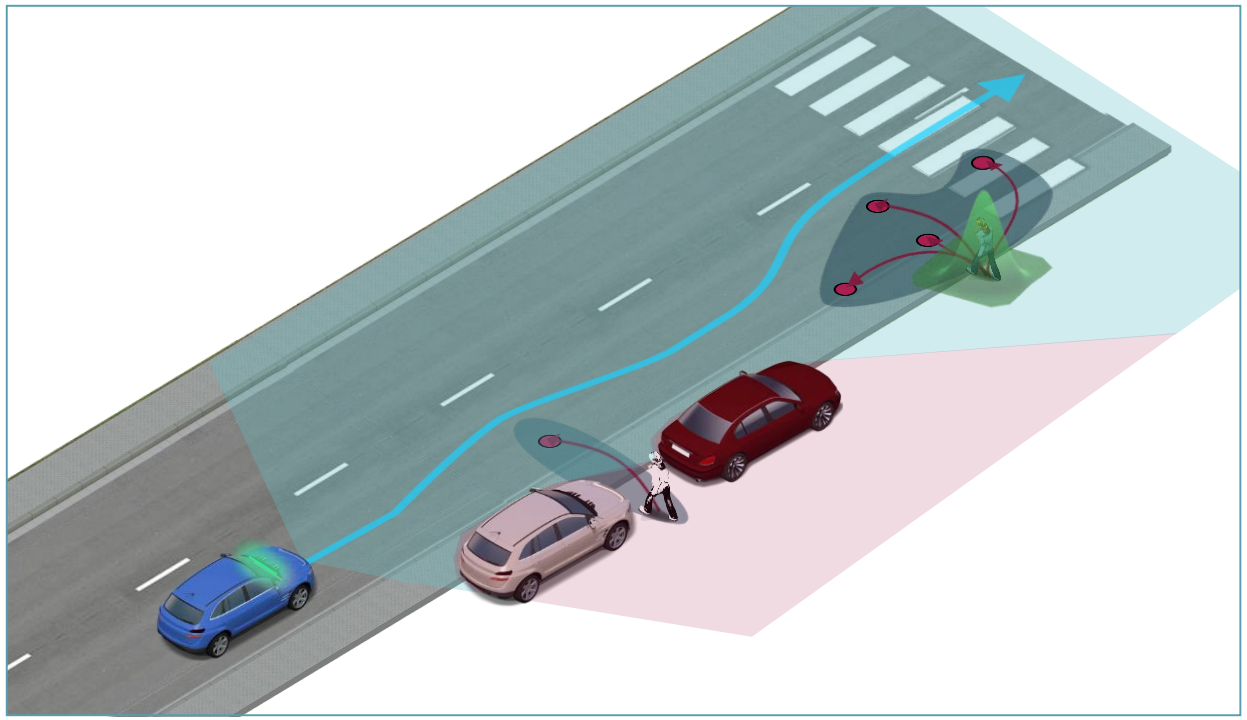
- Number of vehicles
- Number of journeys
- Traffic flow

Images: www.istockphoto.com

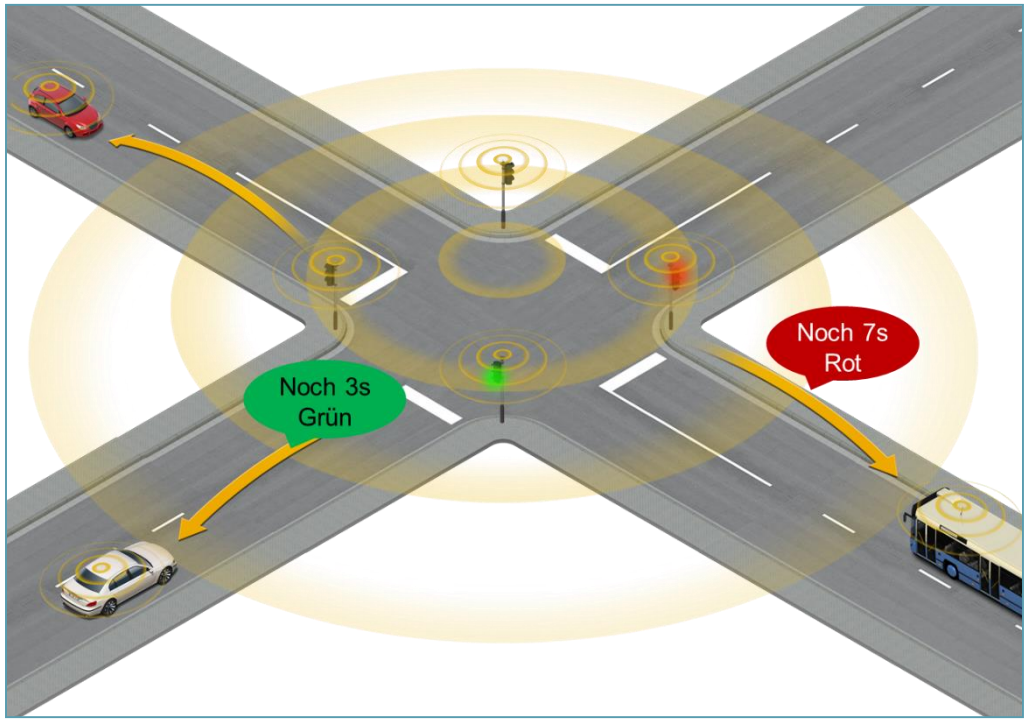
5. Connected driving and infrastructure

VEHICLE SENSORS & INTELLIGENCE VS. CONNECTIVITY

Safety has to be guaranteed by each vehicle on its own

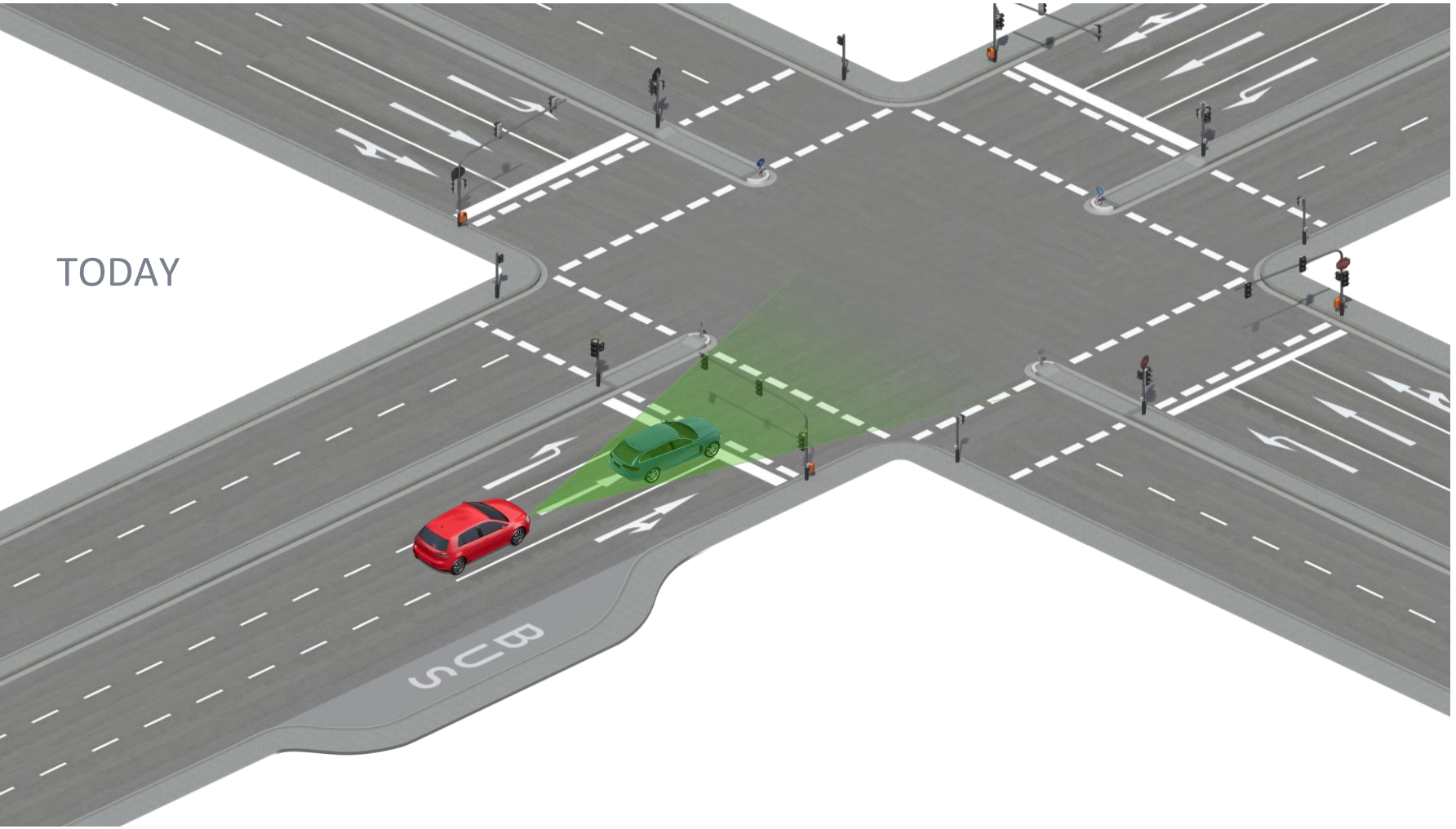


Connectivity (C2X) provides more comfort & efficiency



5. Connected driving and infrastructure

HOW VEHICLE CONNECTIVITY HELPS FOR PLANNING AHEAD

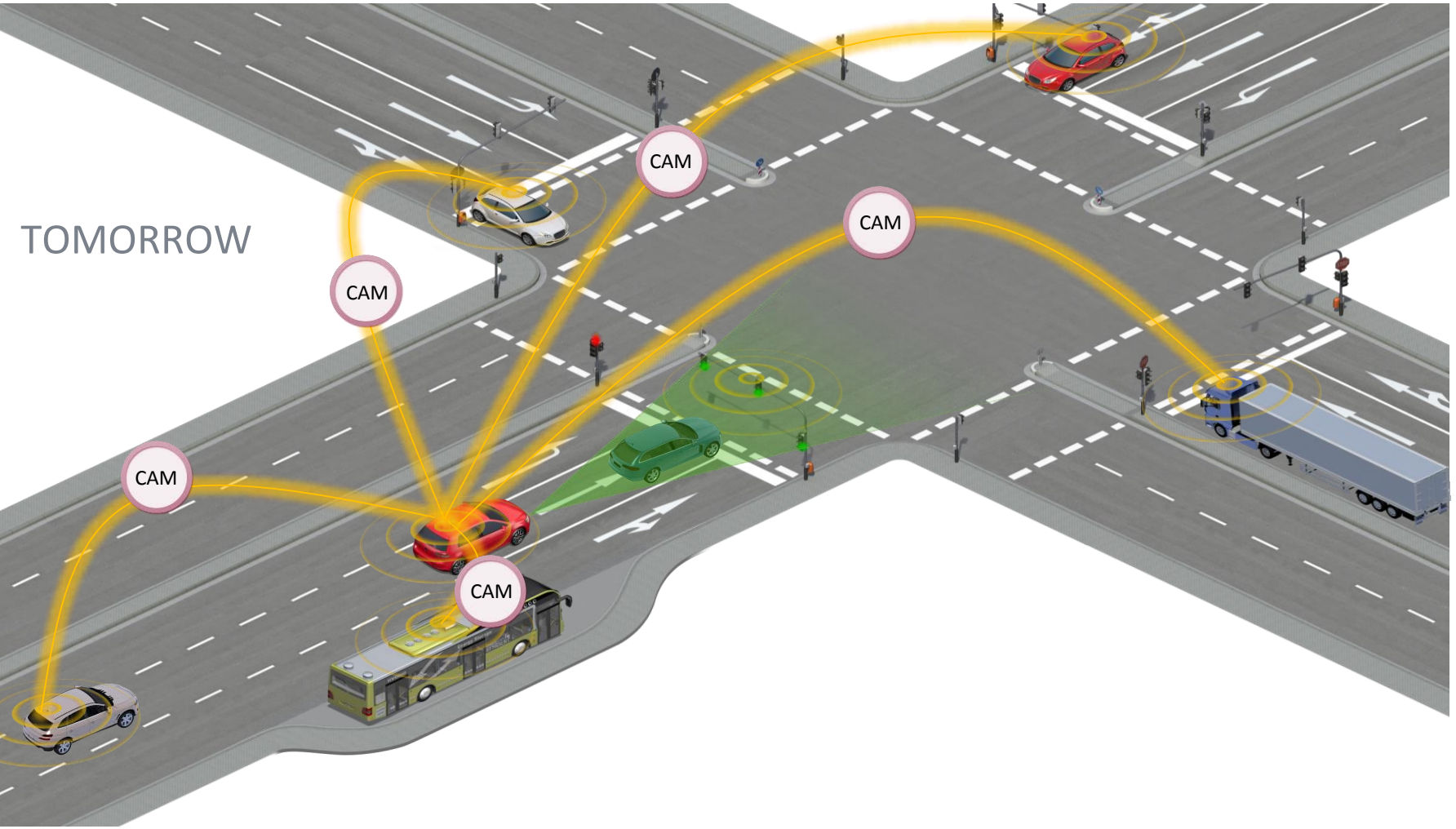


Local Perception Sensors

Red ego-vehicle knows about objects detected by its local perception sensors

5. Connected driving and infrastructure

HOW VEHICLE CONNECTIVITY HELPS FOR PLANNING AHEAD



Day 0

Local Perception Sensors

Day 1

V2X Communication

Red ego-vehicle additionally knows about V2X vehicles within the communication range

Vehicles broadcast Cooperative Awareness Messages **(CAMs)**

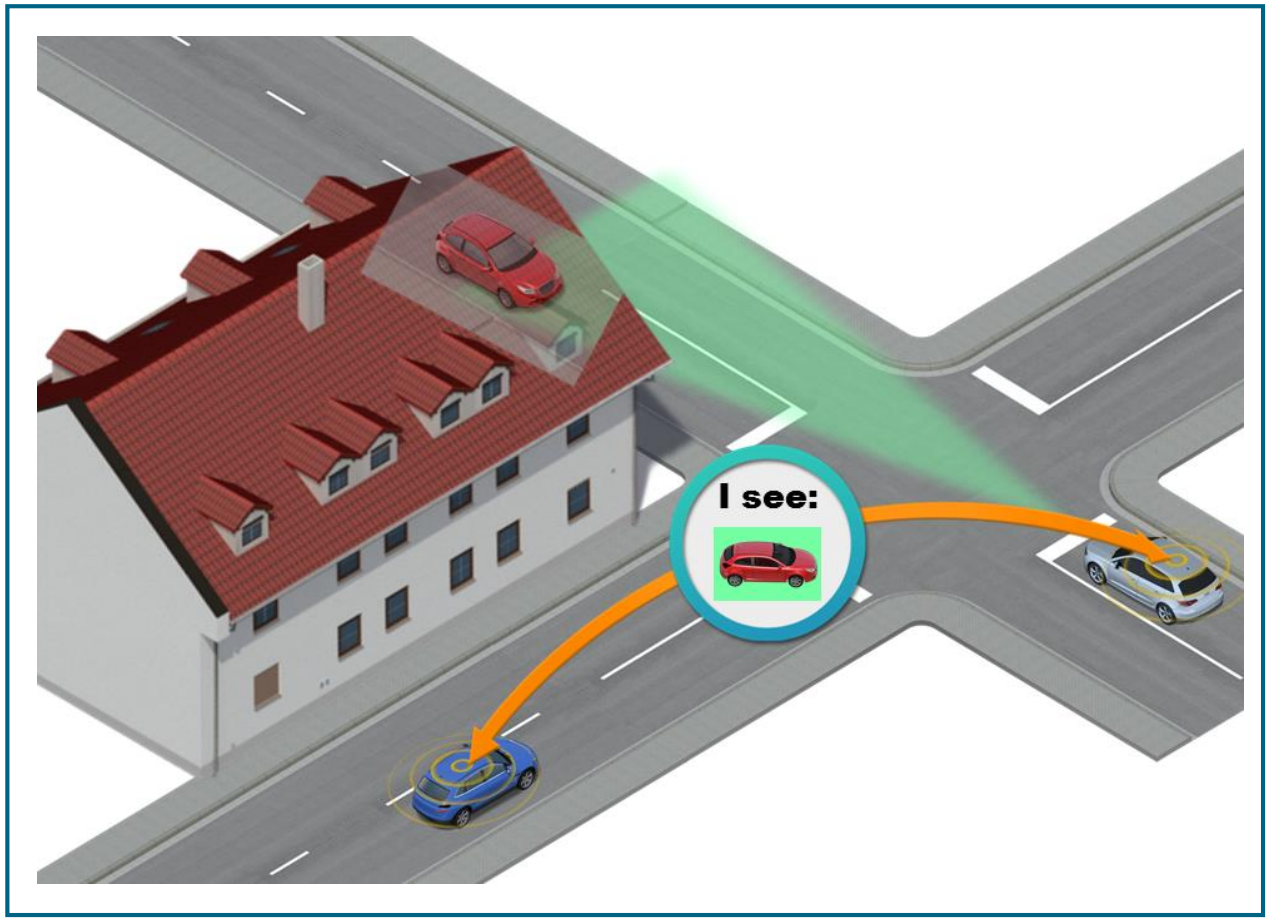
5. Connected driving and infrastructure

COLLECTIVE PERCEPTION

USE THE SENSORS OF OTHER ROAD USERS / INFRASTRUCTURE

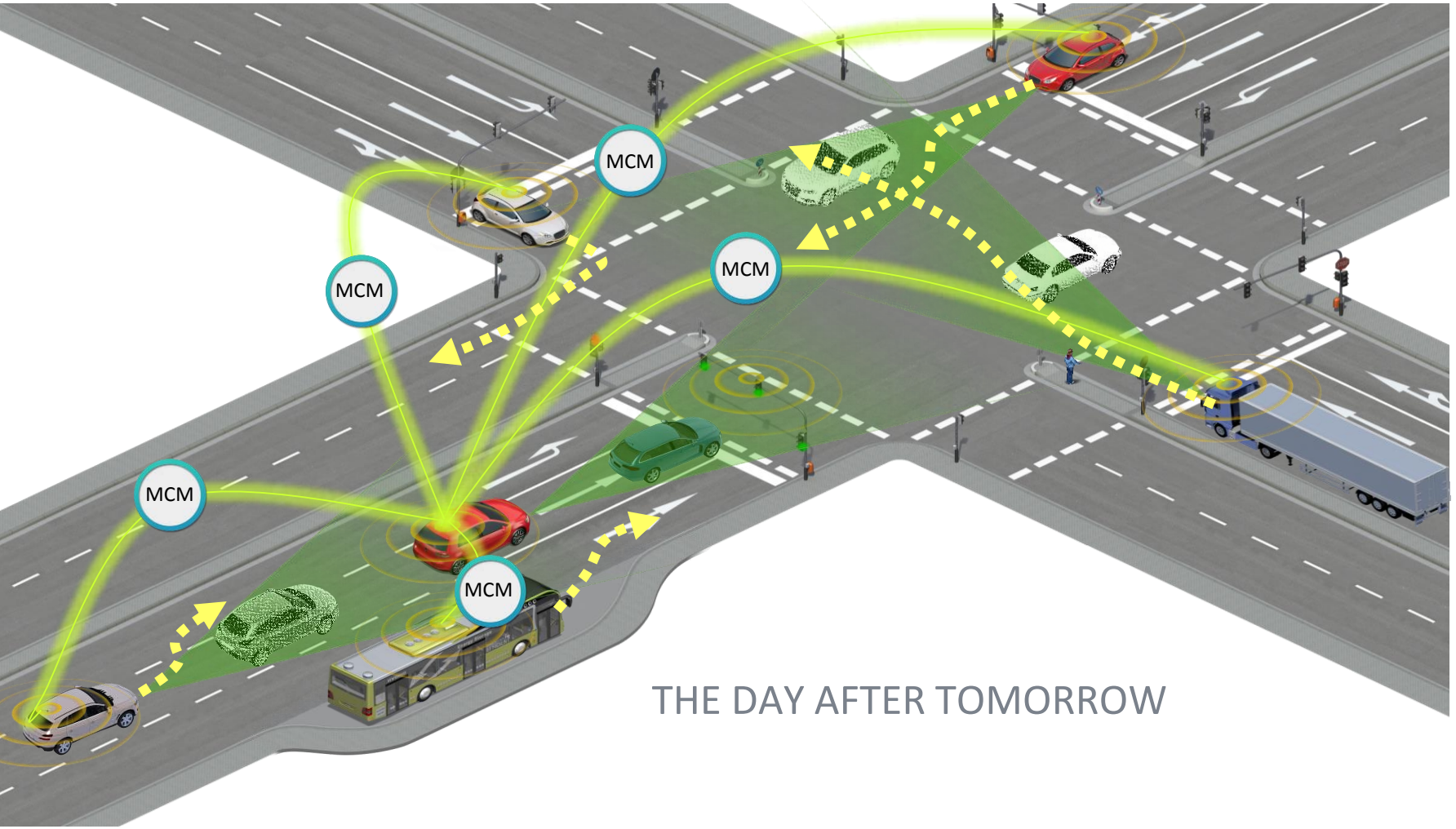
Day 2

V2V and V2X exchange of sensor information to expand the common knowledge about the environment



5. Connected driving and infrastructure

HOW VEHICLE CONNECTIVITY HELPS FOR PLANNING AHEAD



THE DAY AFTER TOMORROW

Day 0 — Local Perception Sensors

Day 1 — V2X Communication

Day 2 — Collective Perception

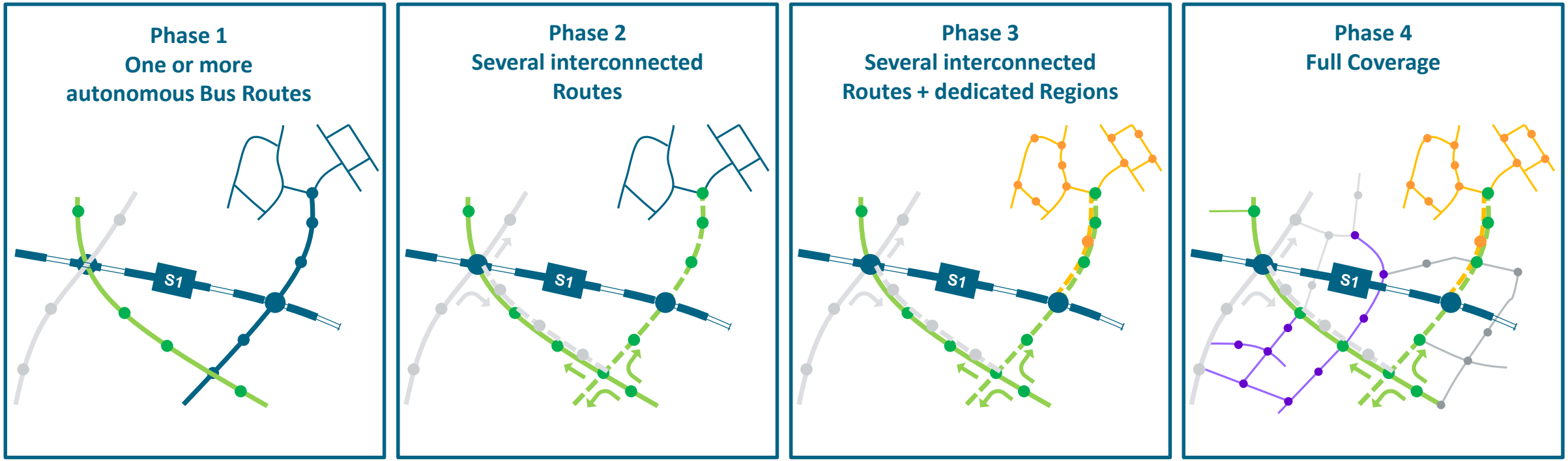
Day 3 — Intentions

V2X Vehicles broadcast their planned trajectories.
Maneuver Coordination Message **(MCM)**

5. Connected driving and infrastructure

Introduction Scenarios for Autonomous Intermodal Mobility-as-a-Services

•Phases for evolving Geographic Coverage and Services



: Manual driven conventional Bus Routes

: Autonomous driven Taxi/Shuttle/Bus Routes or Regions

5. Automatic driving - infrastructure and connected driving

Dependencies and derived premises

→ **The safety of an automatic driving function must be able to be ensured by the vehicle in every situation, either by driving safely or by returning fast to a safe state.**

→ **The availability of an infrastructure or external information can therefore not be a prerequisite for safe automatic driving, but can serve to increase traffic efficiency and driving comfort.**

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Thank you!
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