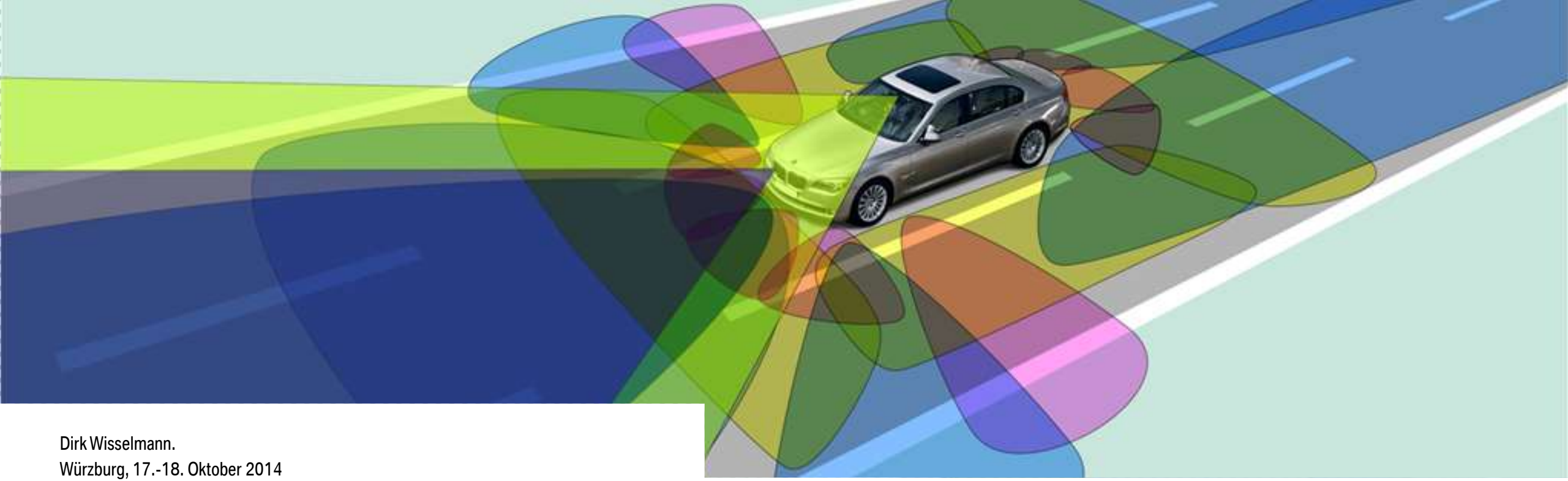


Dirk Wisselmann.
Würzburg, 17.-18. Oktober 2014

TECHNISCHE FAHRZEUGENTWICKLUNG – AUTOMATISIERTES FAHREN AB 2020?

BMW GROUP

Rolls-Royce Motor Cars Limited

TECHNISCHE FAHRZEUGENTWICKLUNG – AUTOMATISIERTES FAHREN AB 2020?

1	Motivation.
2	Automation and Customer Acceptance.
3	Roadmap.
4	Challenges.
5	Future Steps.

AUTOMATED DRIVING WILL INCREASE SAFETY, COMFORT AND EFFICIENCY BOTH FOR THE DRIVER AND THE TRAFFIC SYSTEM.

IMPROVED TRAFFIC AND DRIVING SAFETY.

Always safe (also without automation by an optimized perception).

INCREASED DRIVING COMFORT.

Gaining valuable time by delegation.

IMPROVED DRIVING EFFICIENCY.

Time and fuel savings through optimized driving strategy.

AUTOMATED DRIVING ENABLES THE DRIVER TO DELEGATE DRIVING TASKS. THE ENVIRONMENT PERCEPTION INCREASES HIS COMPETENCE AND THE ACTIVE SAFETY PROTECTS HIM.

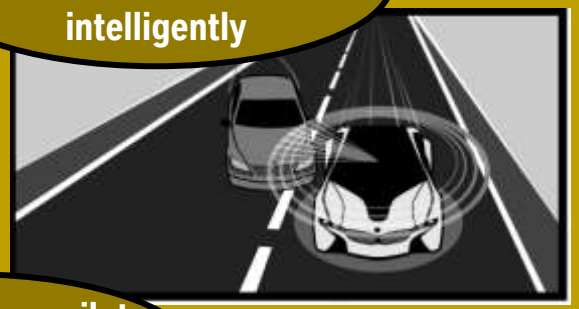
Delegation

My car drives and parks itself

My car drives me when I want it

Competence

My car has a 360° view and reacts intelligently



My car is my co-pilot and knows more than I

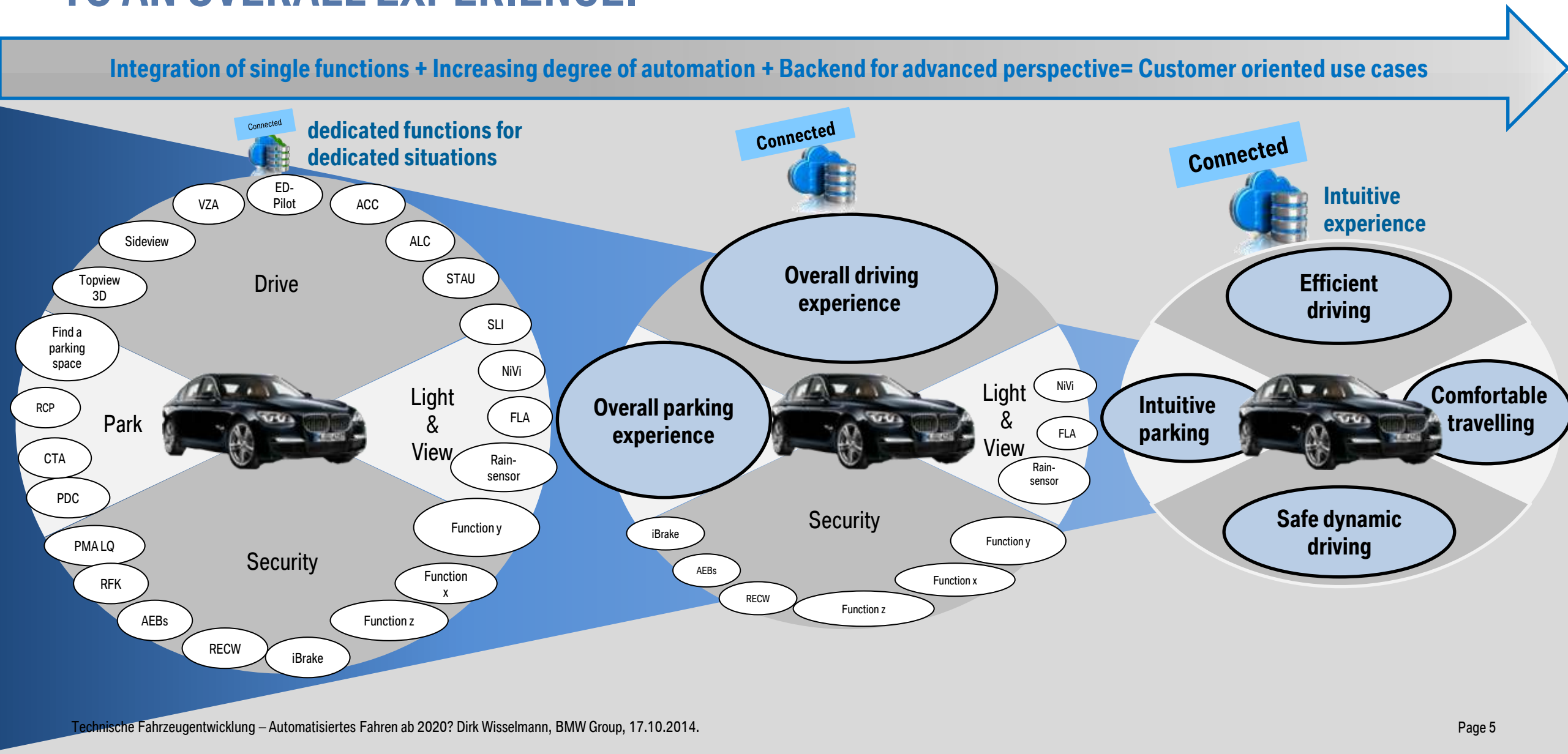
Protection

My car protects me (and others) and avoids accidents

My car protects itself, no more dents and scratches

AUTOMATED DRIVING IS THE BASIS TO INTEGRATE SINGLE FUNCTIONS TO AN OVERALL EXPERIENCE.

Integration of single functions + Increasing degree of automation + Backend for advanced perspective= Customer oriented use cases



BMW ACTIVE ASSIST – THE ROADMAP TO AUTOMATED DRIVING.

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THE DUALISM OF AUTOMATION: INCREASE OF COMFORT, SAFETY AND EFFICIENCY VERSUS LOSS OF COMPETENCE?

Manual Driving „only“

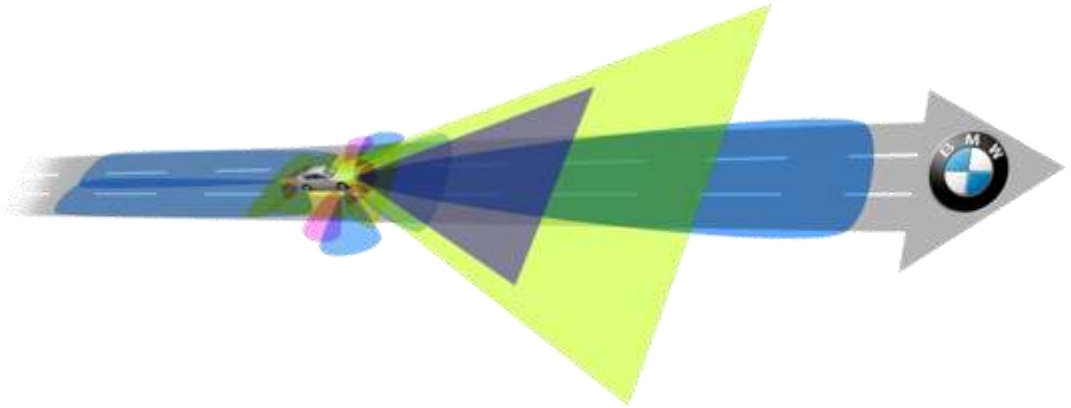
Automated Driving

Comfort,
Safety,
Efficiency
(& Pleasure)

Manual Driving

Joy,
Competence
(& Comfort,
Safety,
Efficiency)

WITH THE AUTOMATION THE CUSTOMER HAS TO DEVELOP AND ACCEPT A NEW ROLE MODEL.



Self driving:
Well experienced.
Underdemanding in longlasting, boring situations.

Delegation

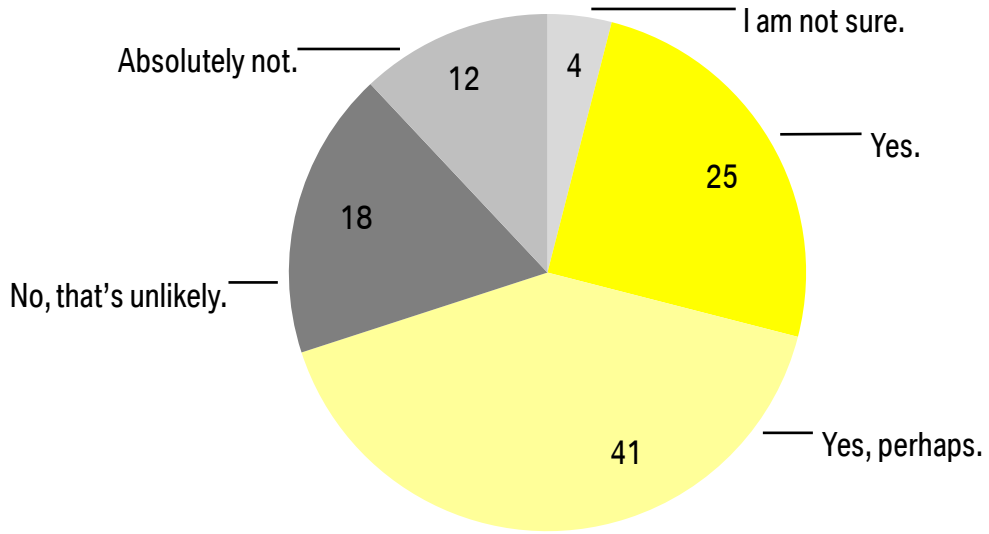
Re-Delegation

Automated Driving:
New experience of relaxation in boring situations.

FIRST STUDIES SHOW THAT HIGHLY AUTOMATED DRIVING WILL BE ACCEPTED BY THE CUSTOMER BUT WE HAVE TO CONVINCE THE SOCIETY, TOO.

"The industry is developing autonomous vehicles. Could you imagine driving such a car if you were able to intervene in the case of an emergency?"

Results of a survey of 1,000 customers with a German driver's license:



>> For two thirds of the drivers an autonomous car would be an option.

(Source: Ernst & Young GmbH, Study „Autonomous Driving", 2013, provided by research partner Continental AG)

The society's hopes and concerns:

(Source: BMW Group Research and Technology, Online-Media Analysis „Social perception of highly automated driving")

THE STEPWISE INCREASE OF AUTOMATION HELPS CUSTOMERS AND SOCIETY TO UNDERSTAND AND TO ACCEPT THE NEW FUNCTIONALITY.

<table>
<tr><th></th><th>Level 0</th><th>Level 1</th><th>Level 2</th><th>Level 3</th><th>Level 4</th><th>Level 5</th></tr>
<tr><th></th><th>Driver only</th><th>Assisted</th><th>Partial Automation</th><th>Conditional Automation</th><th>High Automation</th><th>Full Automation</th></tr>
<tr><td>Vehicle guidance</td><td>System cannot assume neither longitudinal nor lateral control; control remains with the driver.</td><td>System assumes either longitudinal or lateral control</td><td colspan="4">System accomplishes both longitudinal and lateral control</td></tr>
<tr><td>Monitoring task</td><td>Not applicable</td><td colspan="2">Driver must monitor the system at all times. Activities not related to driving are not permitted.</td><td>Driver does not have to monitor the system at all times. Activities not related to driving are possible to a limited degree</td><td>Driver is not required to monitor the system. Driver may perform activities not related to driving at all times.</td><td>No driver required.</td></tr>
<tr><td rowspan="4">Performance limits</td><td rowspan="4">Not applicable</td><td rowspan="4">System is not capable of recognizing all of its performance limits. This lies in the responsibility of the driver.</td><td rowspan="4">Whenever the system recognizes its performance limits, driver will be requested to resume control.</td><td colspan="3">System recognizes its performance limits. Emergency situations can be accomplished by the system, provided that they can be managed similarly by a human driver …</td></tr>
<tr><td colspan="2">… during defined use case</td><td>… during the whole journey</td></tr>
<tr><td rowspan="2">System is not capable of transferring to the minimum risk condition out of each situation. Therefore it requests the driver to resume vehicle control with sufficient time margin.</td><td colspan="2">System can cope with all situations automatically.</td></tr>
<tr><td>… during defined use case</td><td>… during the whole journey</td></tr>
<tr><td colspan="2">At the end of the use case the driver is requested to resume vehicle control.</td><td></td></tr>
</table>

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FIRST FUNCTIONS OF PARTIAL AUTOMATION ARE AVAILABLE. SPECIFIC SEGMENT SOLUTIONS ARE FEASIBLE BY SCALING.

Low ← **Scaling** → High 

Delegation

Protection

Active Cruise Control

– Mono camera
– Up to140 km/h
– First ACC system in UKL1

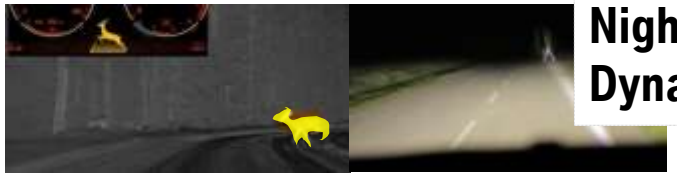
– Radar and Mono camera
– Up to 210 km/h
– Emergency Braking

Traffic Jam Assistant

– Traffic Jam Assistant up to 60 km/h
– Mono camera

– Traffic Jam Assistant up to 60 km/h
– Data fusion of radar sensor and mono camera

Night Vision mit Dynamic Light Spot



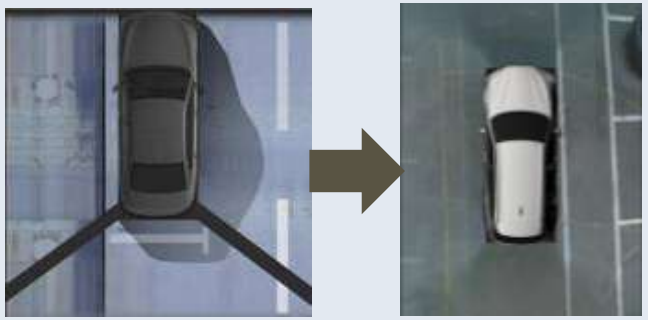
– FIR camera
– Recognition of pedestrians and animals
– Lightspot on critical objects

High-beam assistant

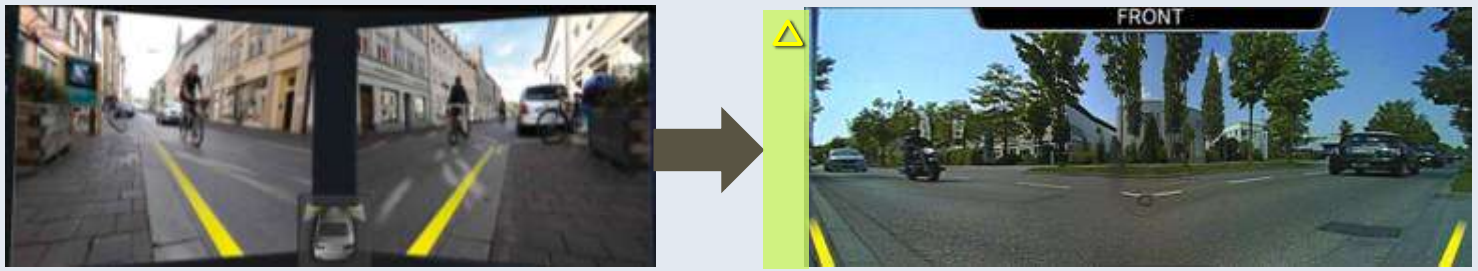
– Enlighting the whole road without dazzling other vehicles

PARKING SYSTEM ARE FURTHER DEVELOPED TO AN INTUITIVE OVERALL EXPERIENCE.

Parking maneuver assistant with longitudinal and lateral guidance



Surround View from four cameras



Panorama sideview with front camera

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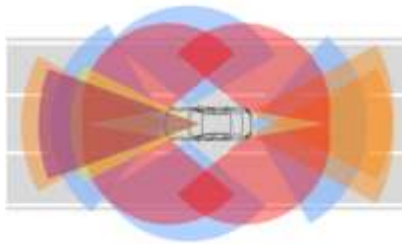
MASTERING THE BASIC TECHNOLOGIES IS THE FIRST STEP FOR HIGHLY AUTOMATED DRIVING.

BACKEND

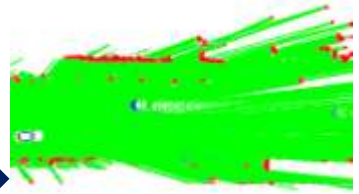


E/E ARCHITECTURE AND ECU

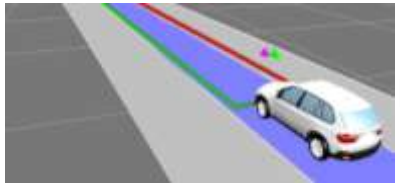
SENSORS



ENVIRONMENTAL MODEL



Represen-tations



Localization

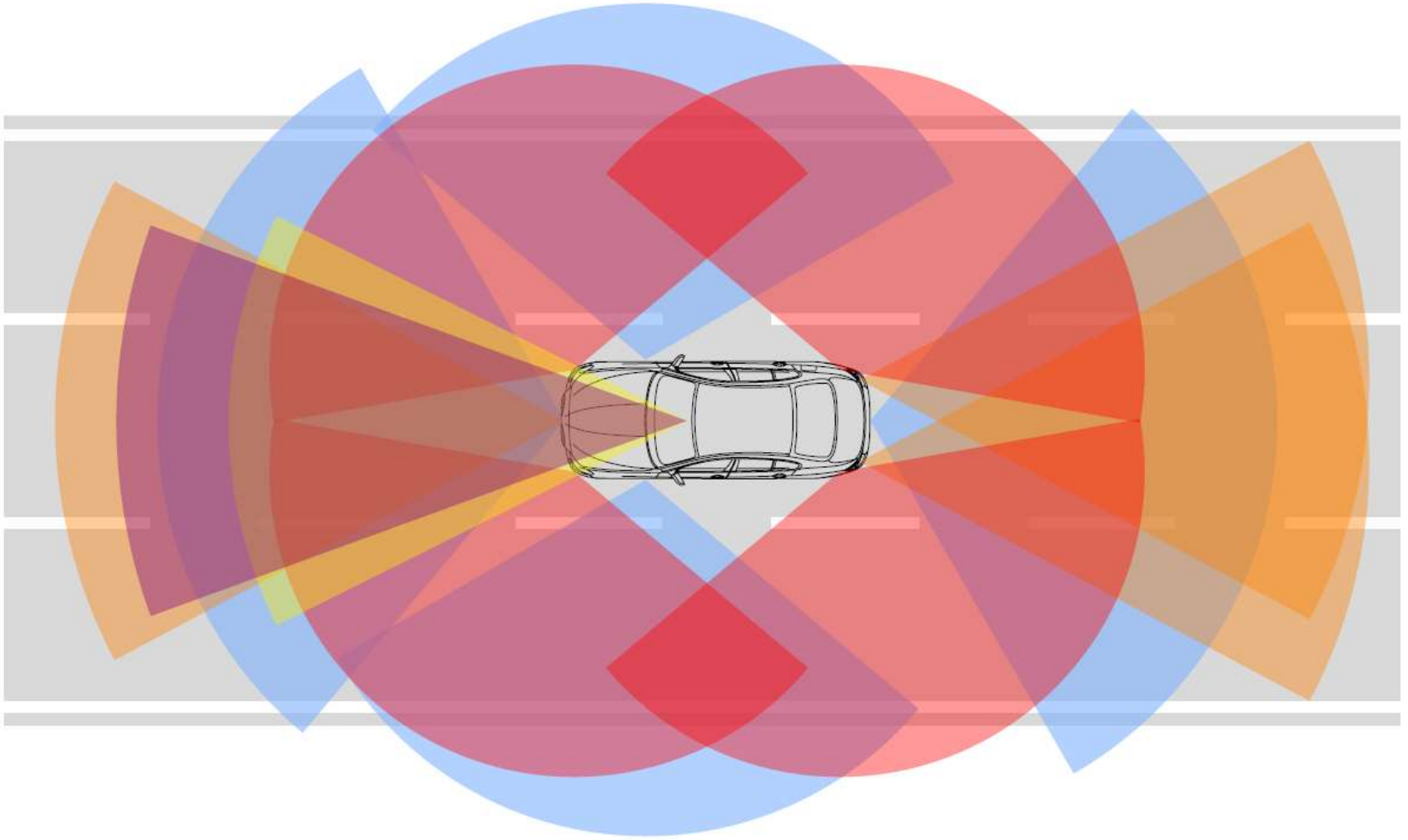
VEHICLE CONTROL

HIGHLY AUTOMATED DRIVING FUNCTION

Trajectories Planing

Driving Strategy

READY FOR THE MARKET MEANS THE AVAILABILITY OF A HIGH-QUALITY, DIVERSE AND AFFORDABLE SENSOR-SETUP.



Long-Range Radar

4-Layers Laserscanner

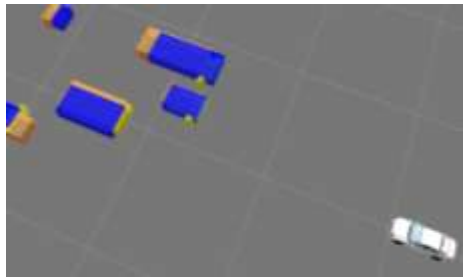
Long-Range Camera (Mono)

Stereo Camera

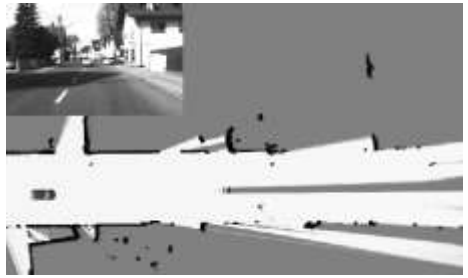
Short-Range Radar

FUSION AND SITUATION INTERPRETATION IN THE ENVIRONMENTAL MODEL REQUIRES HIGH-COMPUTING PERFORMANCE.

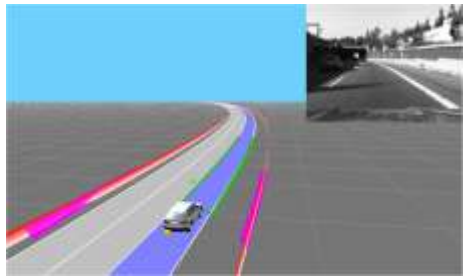
REPRESENTATION



Model based objects
- Detection and fusion of dynamic objects
- Estimation of velocity and acceleration
- Object classification
- Advanced cognitive prediction



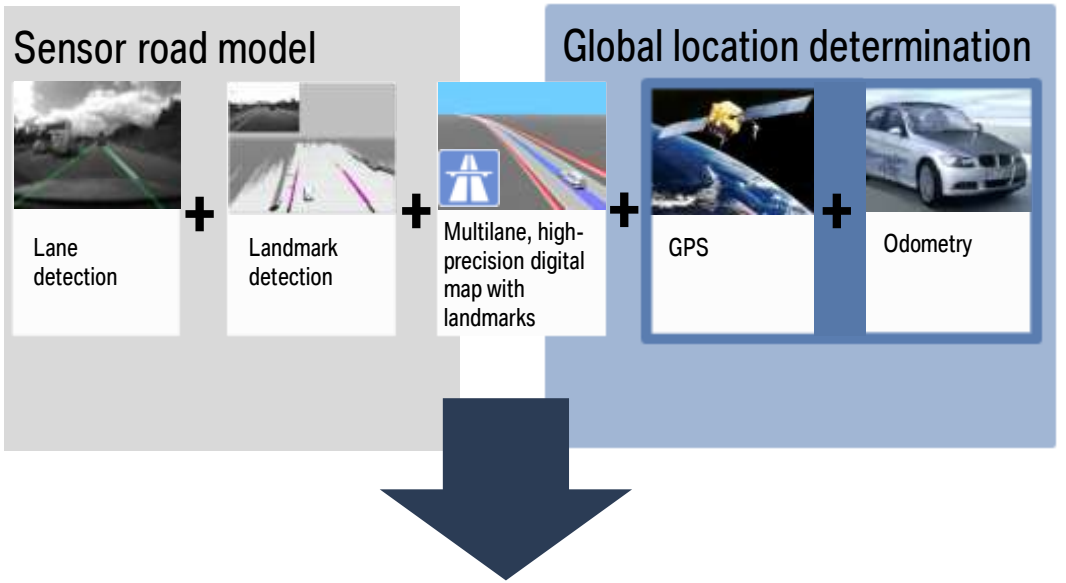
Occupancy maps / free space
- Model-free environmental representations
- Static obstacles
- Extraction of free space / road boundary



Road model
- Precise road geometry and road network
- Lane markings, road boundaries…
- Identification of possible routes

LOCALIZATION

Fusion of local and global positioning



cm-accurate, redundant and highly available localization on the motorway

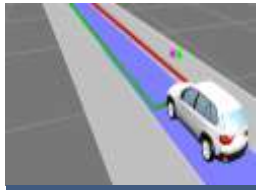
THE BACKEND IS AN ESSENTIAL PART OF OUR ARCHITECTURE.

En-route clearances

Variable traffic signs

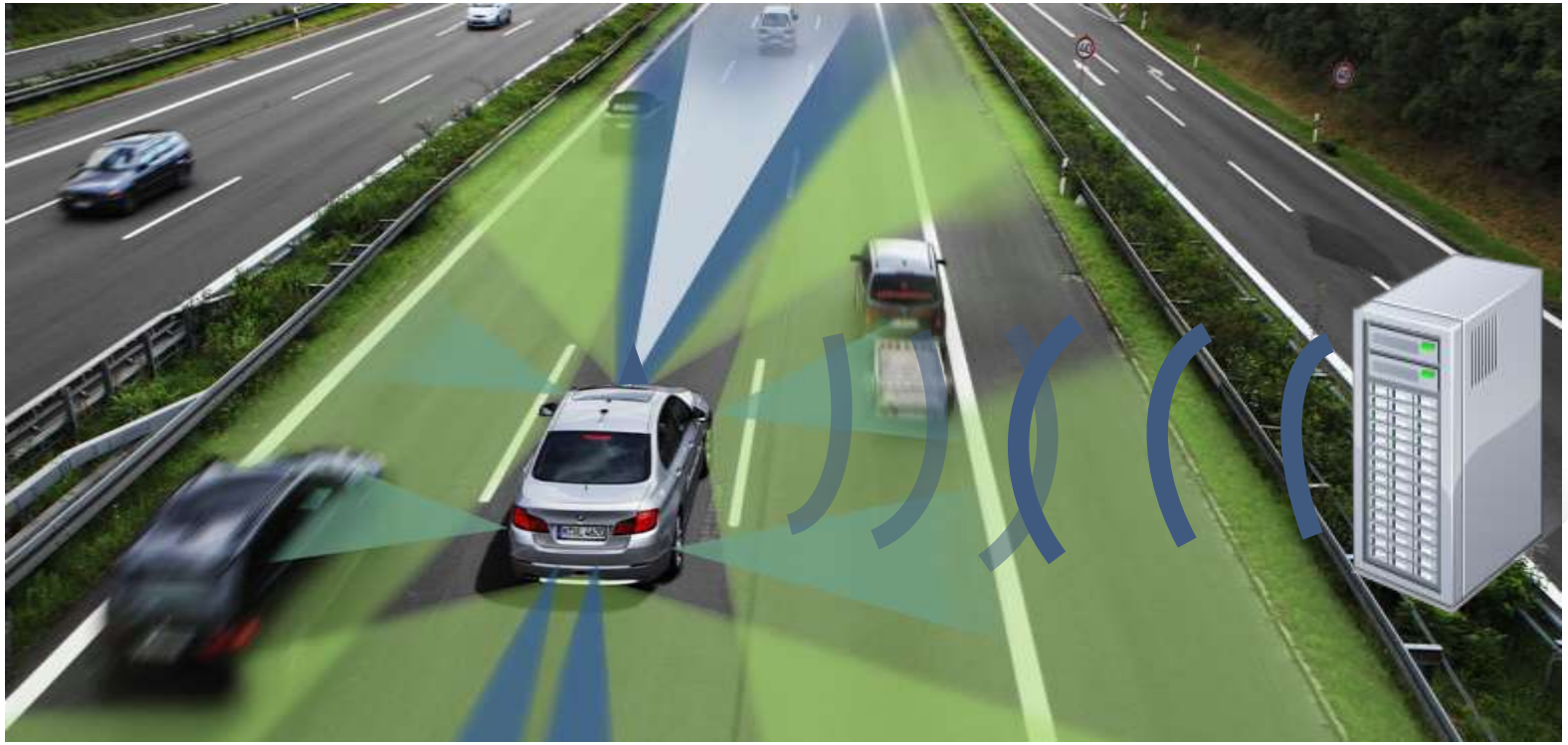
Traffic conditions

Road works



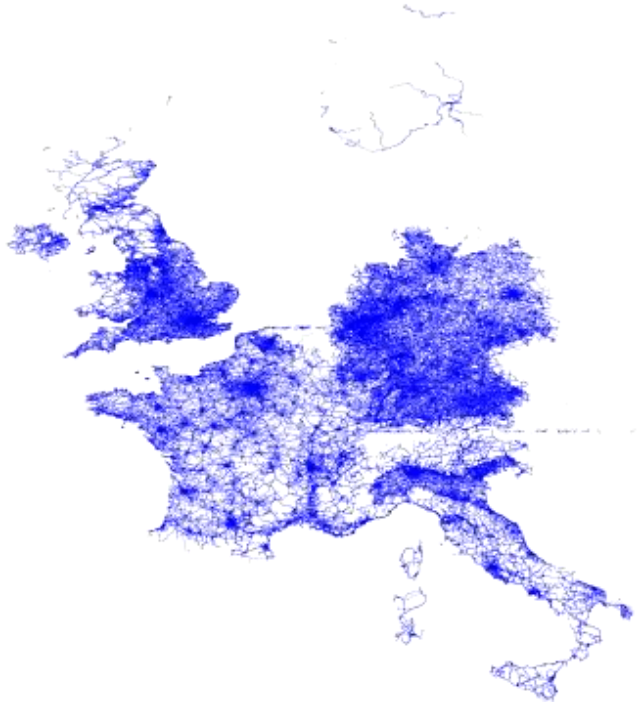
High-precision digital maps

Weather conditions



Coverage of selected countries of 100,000 selected BMW ConnectedDrive vehicles:

Roads passed by 1 - 3 vehicles within 10 days



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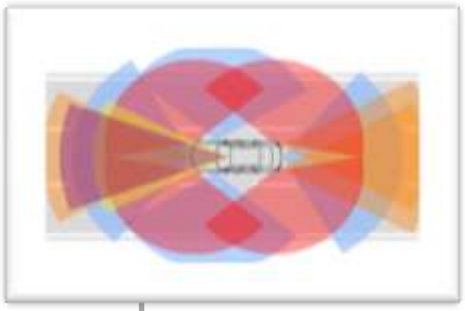
STARTING FROM 2020 FIRST HIGHLY AUTOMATED DRIVING FUNCTIONS COULD BE OFFERED TO OUR CUSTOMERS.

2013 — Development of an electronic co-pilot system with the international automotive supplier Continental.



2015 — Limited field test of highly automated driving functions in Germany and Europe (BMW Group & Continental).

2018 — Quantified benefits through large scale field operational test of highly automated driving functions (OEMs/suppliers).

… — Global rollout of highly automated driving functions.

2013 2014 2015 2016 2017 2018 2019 …

THANK YOU VERY MUCH FOR YOUR ATTENTION.