



BRIGHT MINDS,
BRIGHT LIGHTS.

**ZKW Project Dragonfly
360-Degree Multiple Sensors &
Digital Lighting Fusion**



Agenda Project Dragonfly

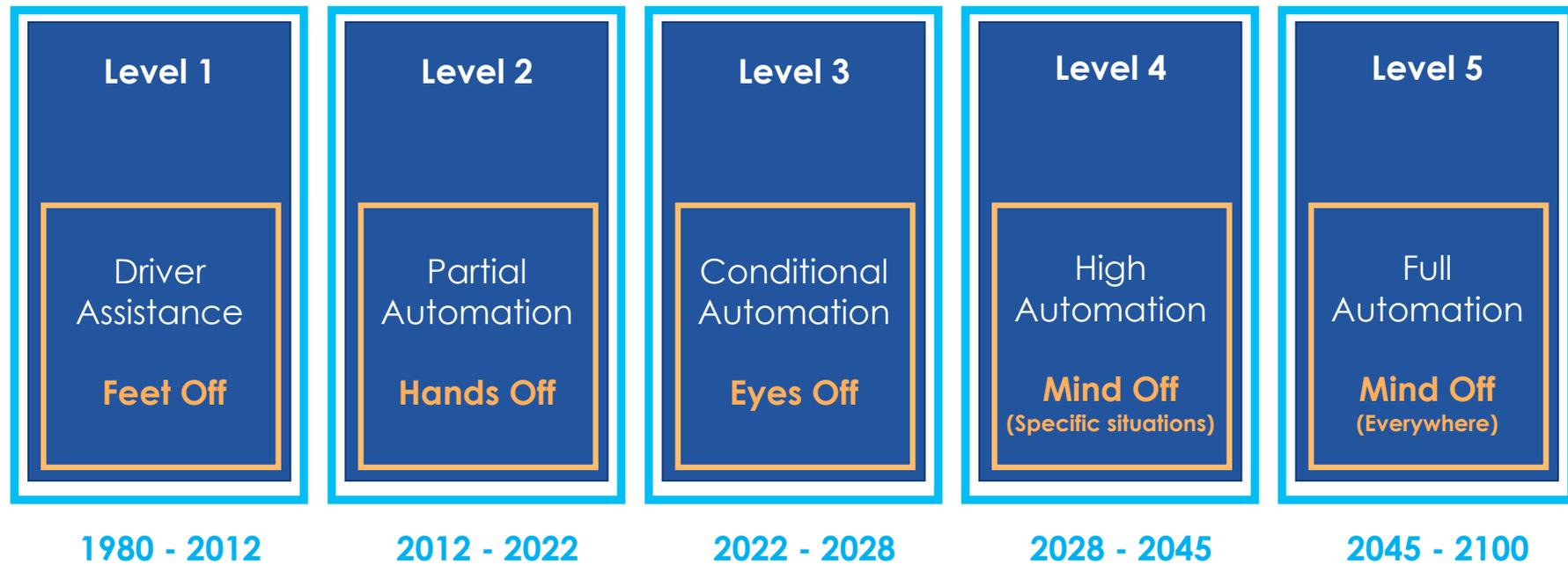
- > Reasons for Sensor Integration in the Headlamp
 - > Trends – more functionality
 - > Positioning – without blind spots
 - > Bad light conditions

- > Project Dragonfly
 - > Setup
 - > HMI
 - > Use Cases

- > Outlook future topics
 - > Next steps project dragonfly
 - > Climate wind tunnel result evaluation
 - > LiDAR & Camera Fusion

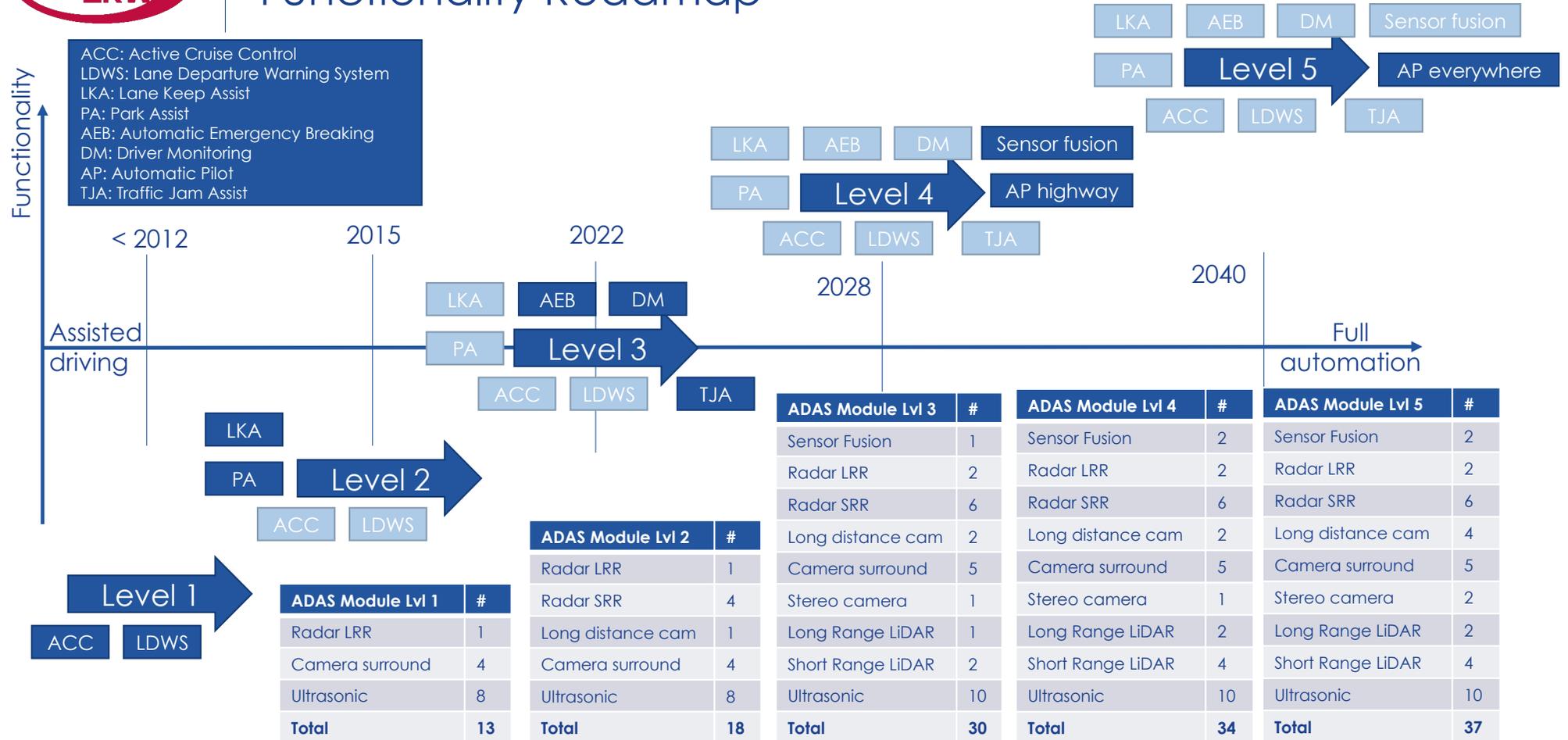


Different Levels towards fully Autonomous Cars





Functionality Roadmap

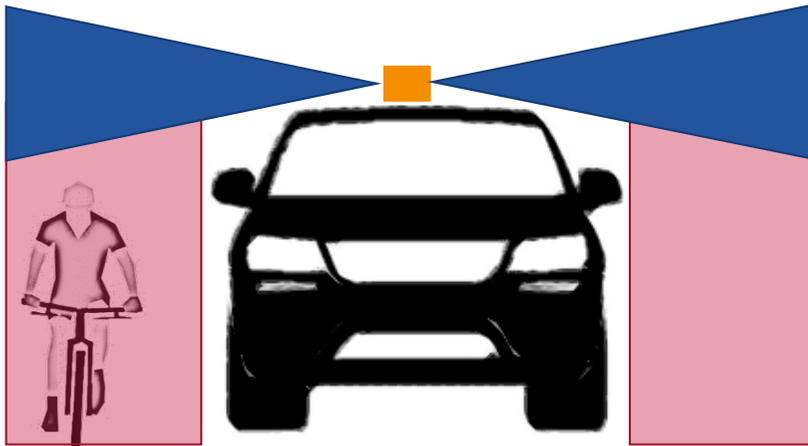


Source: http://soiconsortium.eu/wp-content/uploads/2017/02/IHS-Markit-Technology_Auto-Trends_Public.pdf

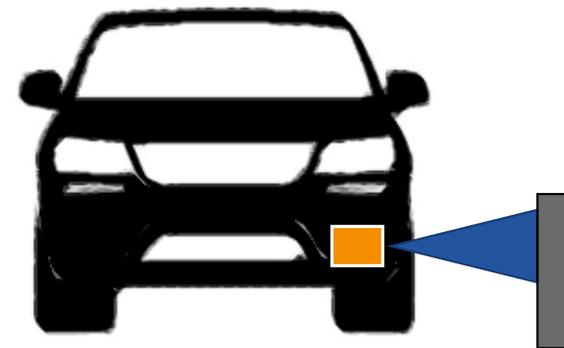
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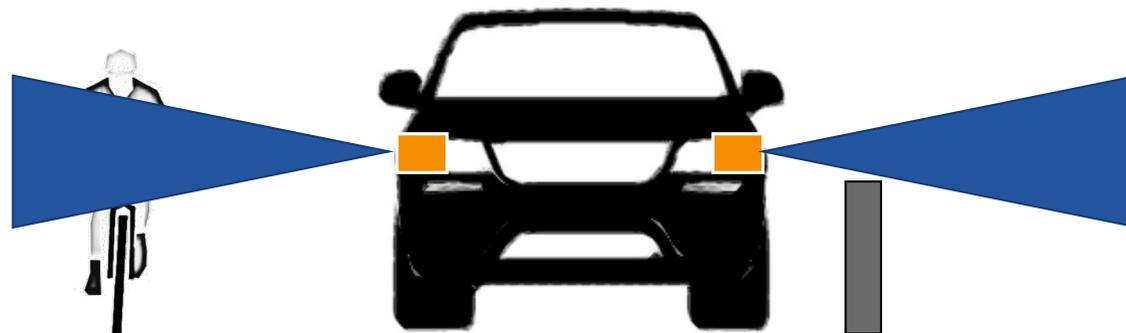
Sensor Positioning – Roof/Bumper/Headlamp



Cyclist passing by – or children near the car



Low obstacle besides car

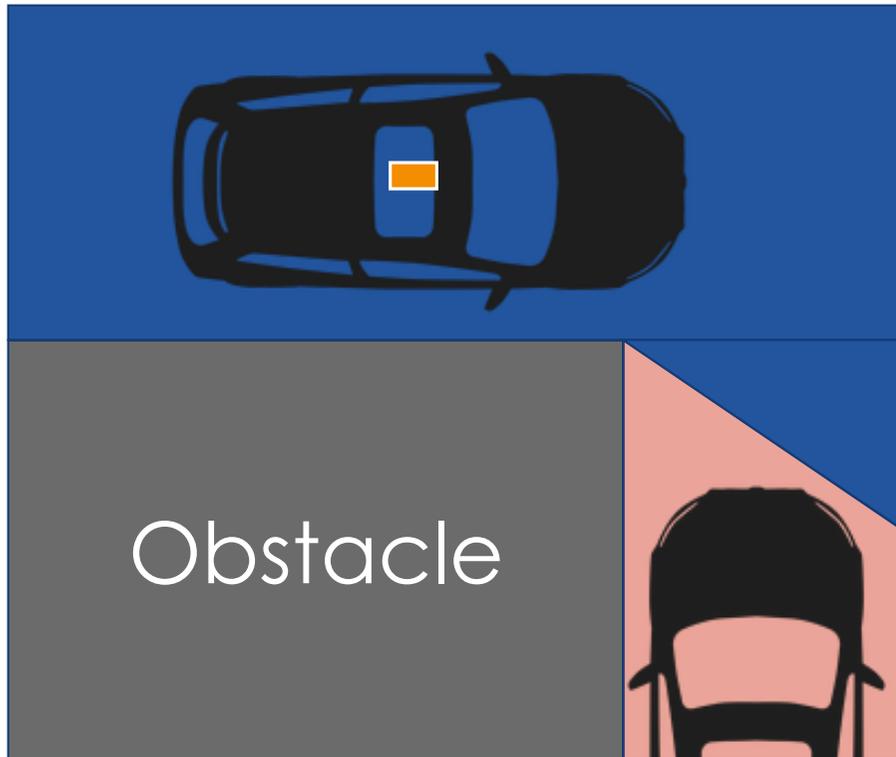


Headlamp position



Look around the Corner

■ Sensor FOV
■ Blindspot





Automatic Emergency Braking with Pedestrian Detection



A vehicle turning right onto an adjacent road with an adult crossing at the same time.



Automatic Emergency Braking with Pedestrian Detection



At night, none of the systems detected or reacted to the adult pedestrian.



Motivation for Sensor Integration into Head / Rear Lamps

Sensor Integration

 Motivation	<ul style="list-style-type: none">> AD SAE Level 4 & Level 5 vehicles require among others a light / sensor integration at the 4 strategic corners> Position of headlamps and rear lamps are seen as strategic corners for sensor integration> Intelligent illumination to support sensors for object and scene classification
 Function Concept	<ul style="list-style-type: none">> Integration of sensors<ul style="list-style-type: none">> Camera> LiDAR & radar> IR/MS camera> Integration of deep learning algorithms<ul style="list-style-type: none">> for object detection> for scene classification> Sensor data fusion for AD functionalities
 Facts for Sensors at 4 Strategic Corners	<ul style="list-style-type: none">> Leveling system; dynamic compensation> Interfaces – power, data bus CAN/Ethernet,...> Protection against UV-light / weathering, Protection against road stone, notch test> FOV > 120° feasible – 260°> Lighting support for sensors> Existing defogging & deicing solutions> Re-use of cleaning system> Redundancy of sensor systems

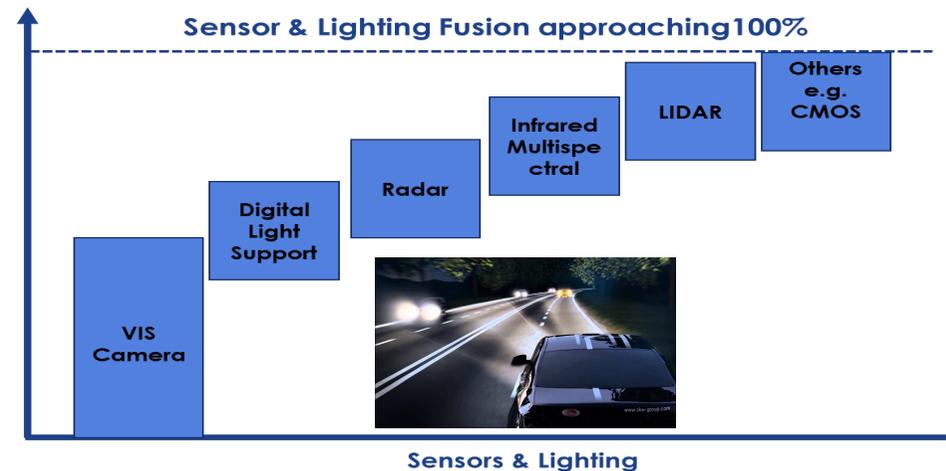


Current sensor setup for urban Level 5



Upcoming sensor integration

Object Classification Probability





Project Dragonfly – AD & ADAS Solutions by ZKW & LG



Project Dragonfly



Project Dragonfly



- > Demonstration vehicle to present integration of sensors in the headlamp for different use cases





Project Dragonfly



-  Camera
 -  Radar
 -  LiDAR
 -  IR/MS camera
 -  USS
-  Additional
-  Standard


Sensor Setup

- 4 front cameras + 2 LiDAR systems + 2 back cameras + 2 front MS cameras + 2 back LiDAR + 2 back cameras for side view + 2 back RADAR
- Enhanced robustness of camera view (data fusion)
- Further improved lane change by additional back LiDAR systems
- Enables corner view for backwards maneuvers
- Enables ENCAP 2025 compliant sensor setup



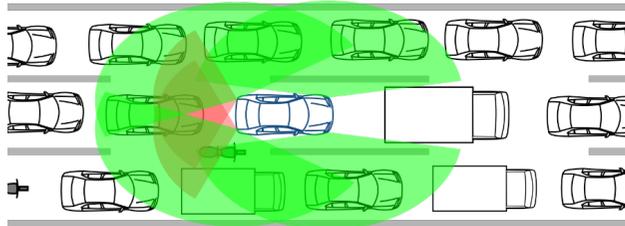


Project Dragonfly – HMI Stage 1

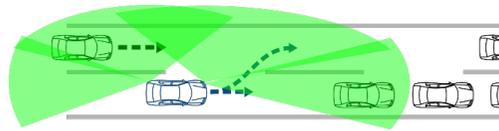




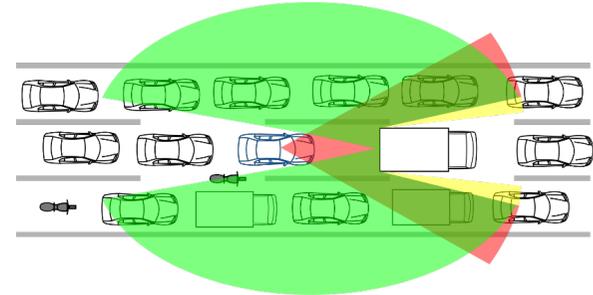
Use Case – Highway Chauffeur



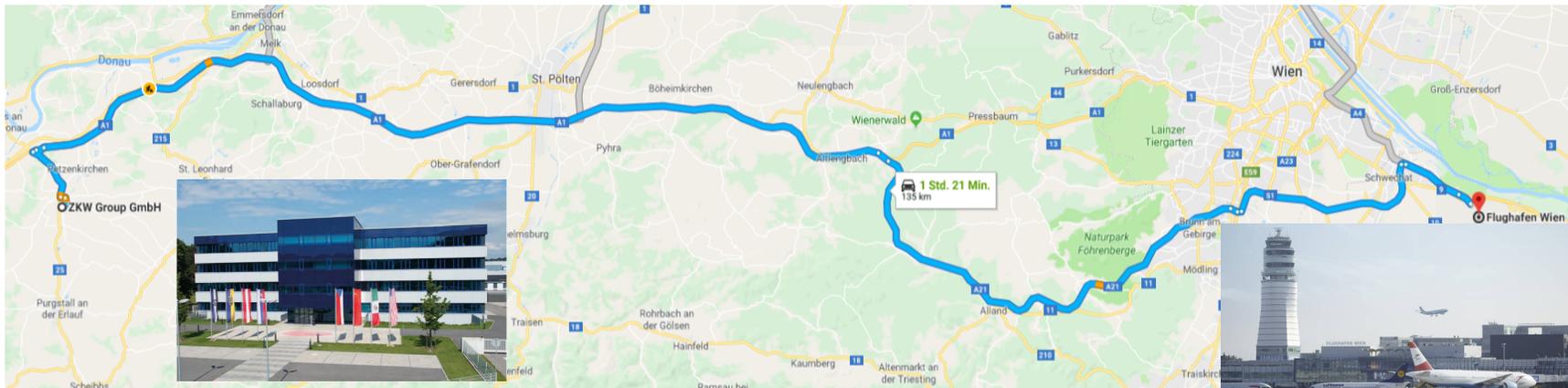
Schematic back and side view



Passing Maneuver



Schematic front and side view





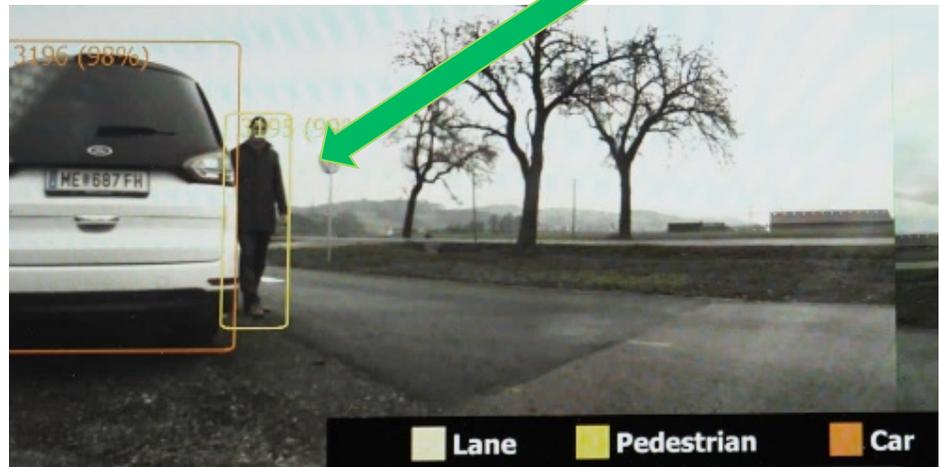
Use Case - Look around the Corner



AAA - Test



Side facing Sensor





Use Case – Night Situations



AAA - Test



LiDAR Data at Night Situations



Without Digital Light: **only 50% confidence level**



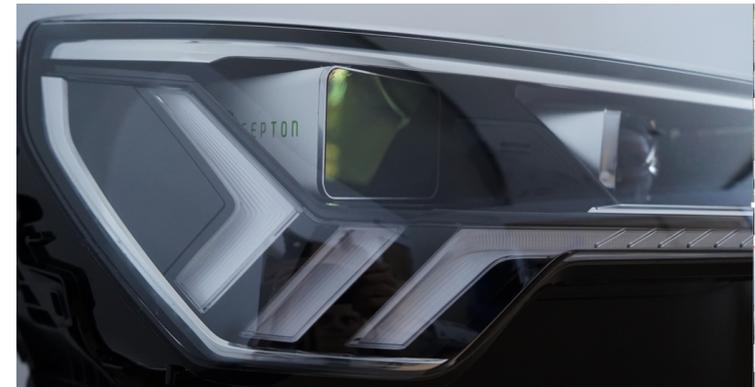
With Digital Light: **96% confidence level**



Project Dragonfly – Next Steps



- > First test run in Austria in June 2019 completed
- > Next integration steps are already ongoing
 - > LiDAR Integration for ZKW-Demo Car
 - > Use of headlamp sensor data fusion for light control



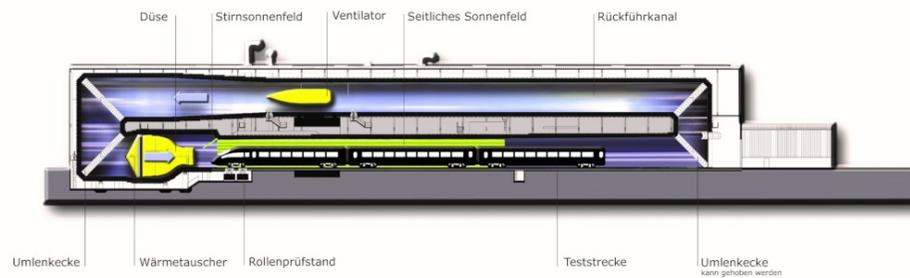


Climate Wind Tunnel Result Evaluation

Tested Technologies

- > LiDAR (905 and 1550 nm)
 - > MEMS
 - > Rotating
 - > Oscillating
 - > Flash LiDAR
- > Cameras (VIS, Thermal)

22 Sensors total and simultaneously





Climate Wind Tunnel Result Evaluation

> Tested-Targets

- > Lane markings
- > Traffic signs
- > Dummy
- > Whole Car
- > License plates
- > Traffic cones
- > Tire
- > NIST Targets (10% and 80%)



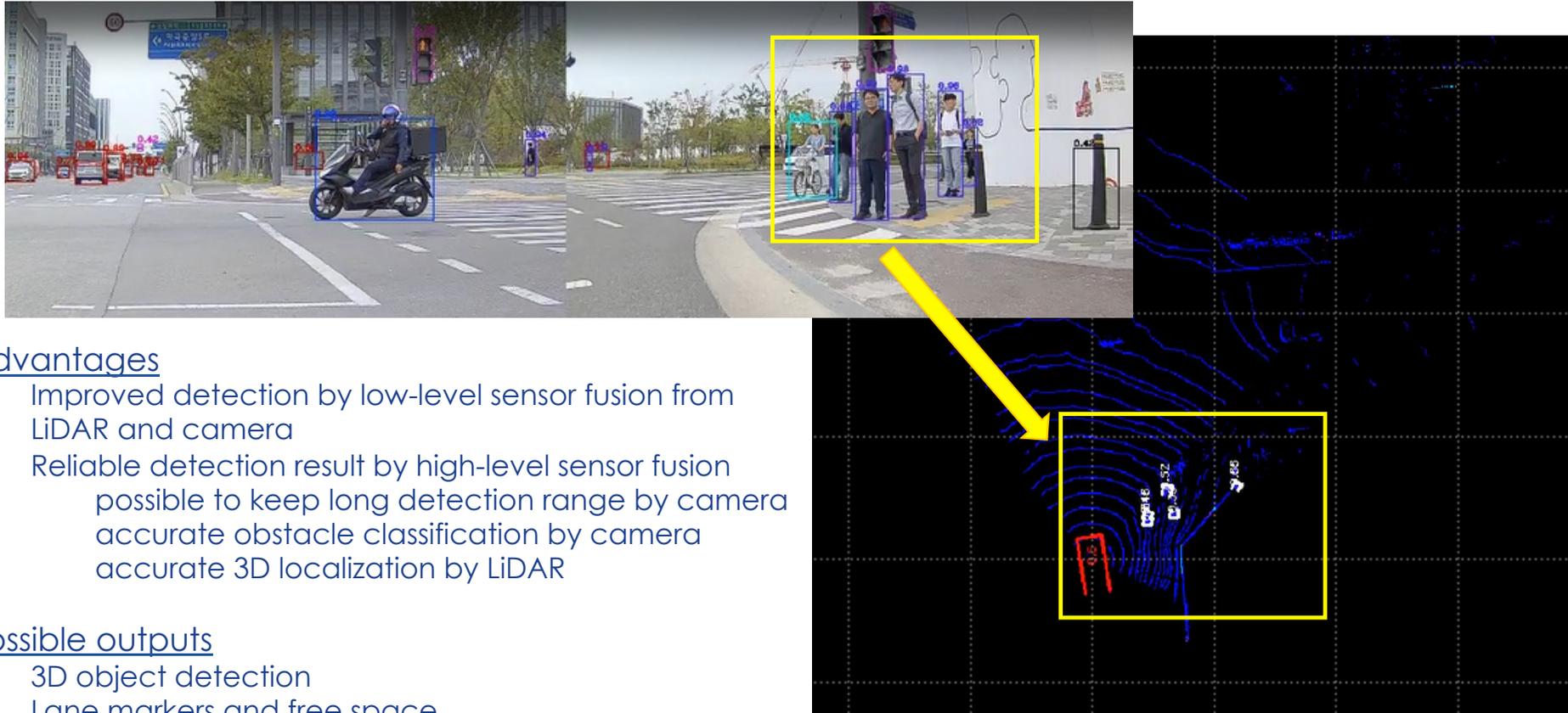
> Environmental Conditions

- > Fog conditions (calibrated particle size, 0.16 -19 g/m³)
- > Rain conditions (0-80 l/h)
- > Wind (0-60 km/h)
- > Cover glass influence
- > Jammer (Flash LiDAR, Headlamp)





LiDAR & Camera Fusion - Integrated in Headlamp



Advantages

- Improved detection by low-level sensor fusion from LiDAR and camera
- Reliable detection result by high-level sensor fusion
 - possible to keep long detection range by camera
 - accurate obstacle classification by camera
 - accurate 3D localization by LiDAR

Possible outputs

- 3D object detection
- Lane markers and free space



Take Home Message

The first step of sensor integration shows, that the “headlamp” not only provides optimal light, but also additional value as “information component”. A new functionality, located in the field of ADAS.