SMART HEADLIGHT

Coaxial RADAR, Lidar and Light Integration in Smart Headlights

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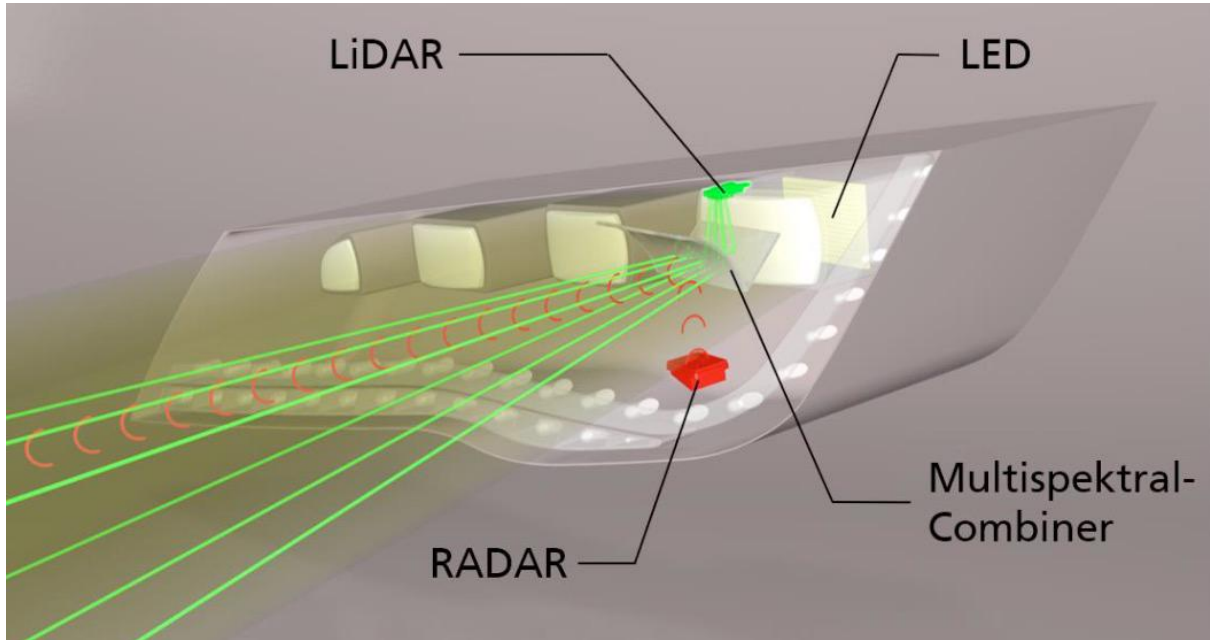

FHI FÜR LASERTECHNIK **ILT**

FHI FÜR OPTIK UND FEINMECHANIK **IOF**

FHI FÜR HOCHFREQUENZPHYS IK UND RADARTECHNIK **FHR**

FHI FÜR MIKROELEKTRONISCHE SCHALTUNGEN UND SYSTEME **IMS**

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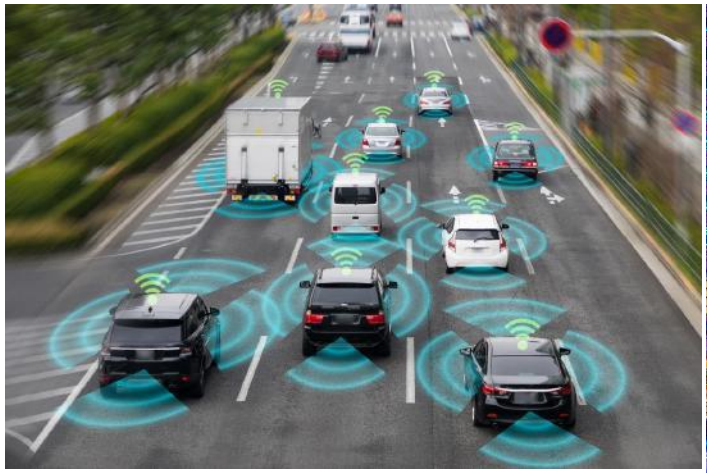
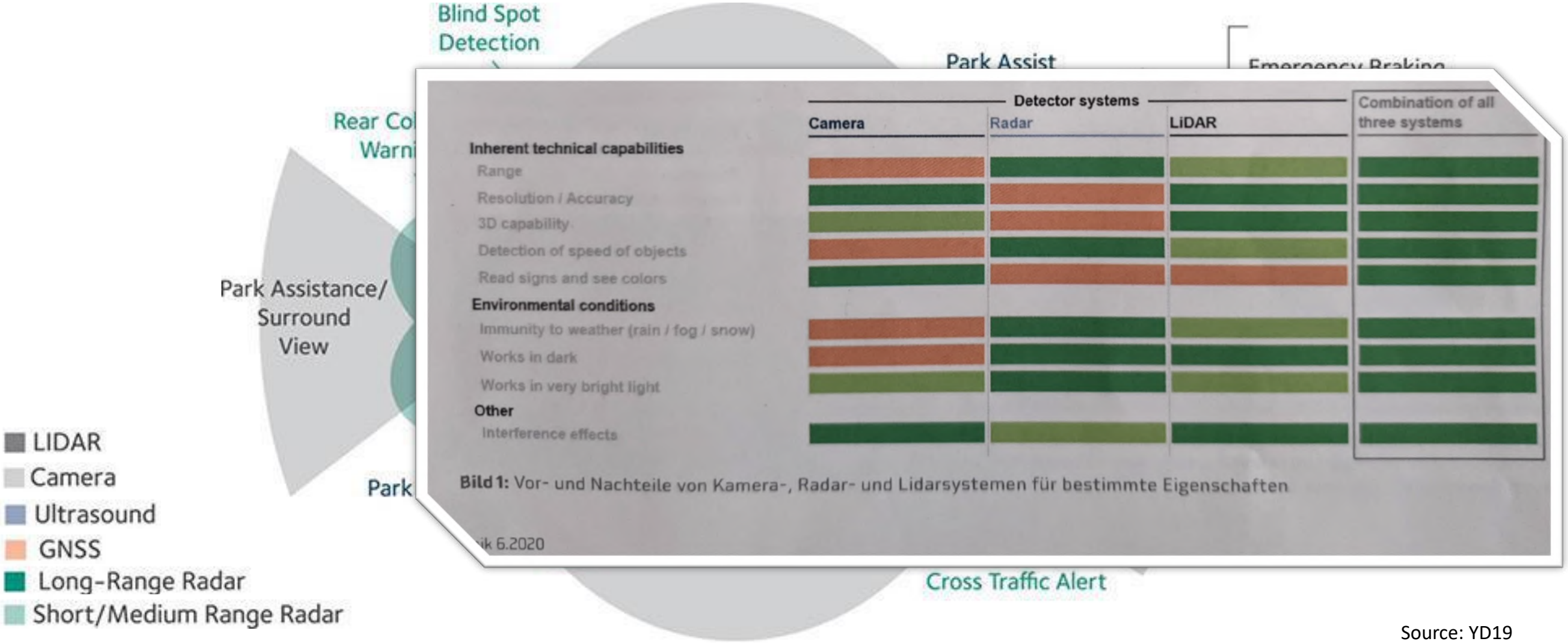
The future of digital and autonomous driving



- Increasing interaction and data exchange in transportation (pedestrians, vehicles, traffic lights, interactive traffic signs)
- Networking and digitization as a prerequisite for autonomous driving
- Fusion of sensors to create redundancies for safe, holistic sensing of the environment

Connectivity and sensor technology on passenger cars

Requirements profile and state of the art



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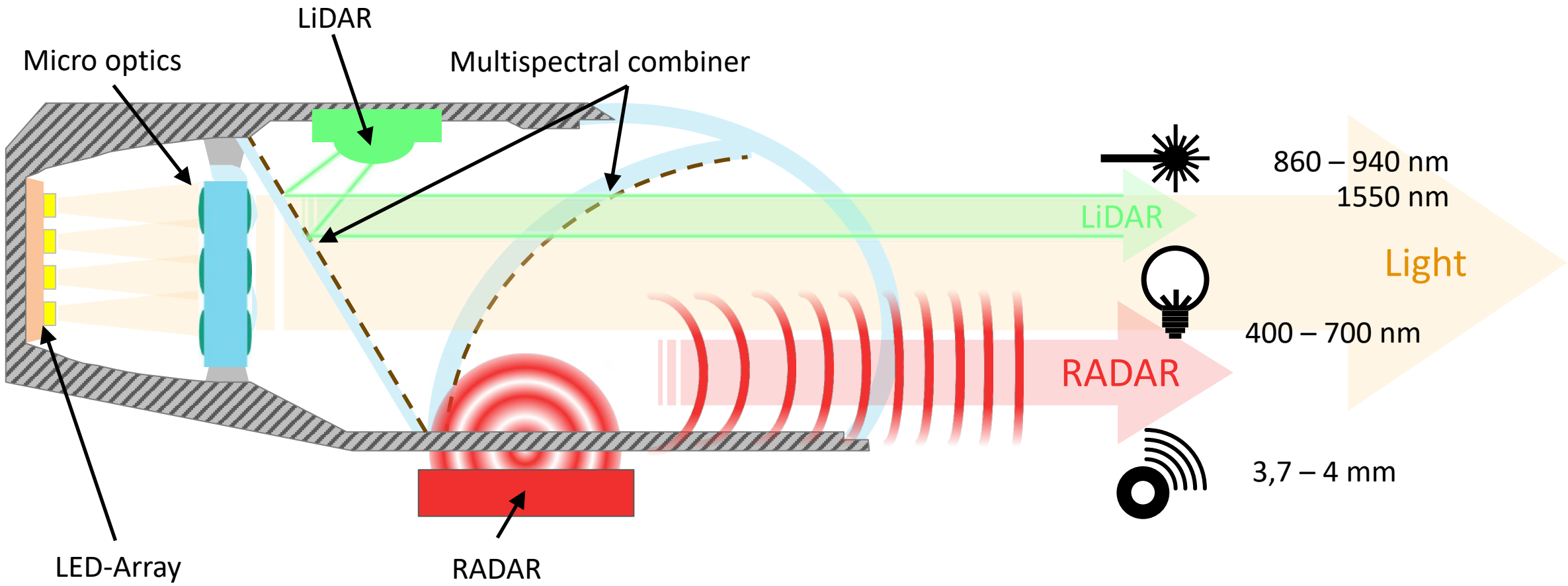
Multi-Sensor-integrierter adaptiver Scheinwerfer

Multispectral Headlamp



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Smart Headlight – Solutions

LiDAR IMS

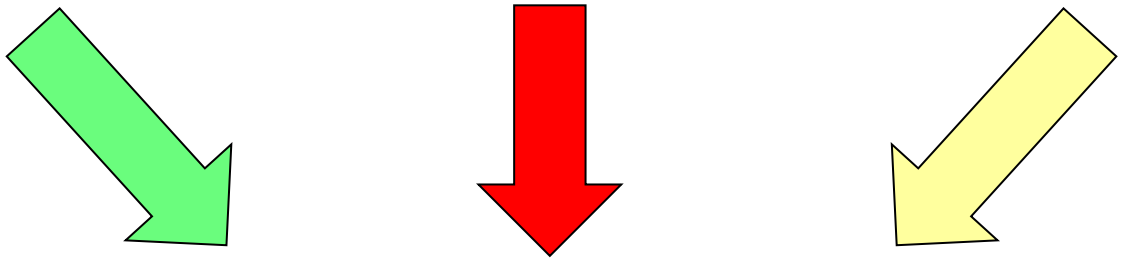
- Patterned LiDAR
- Signals with coded signature

RADAR FHR

- High resolution RADAR
- Extended Field of View (FoV)

Lighting IOF

- Segmented light source
- Apertureless micro optics



Multispectral combiner FEP, ILT

- Multispectral merging over 4 orders of magnitude (400 nm - 4 mm)
- Integral beam guiding and shaping

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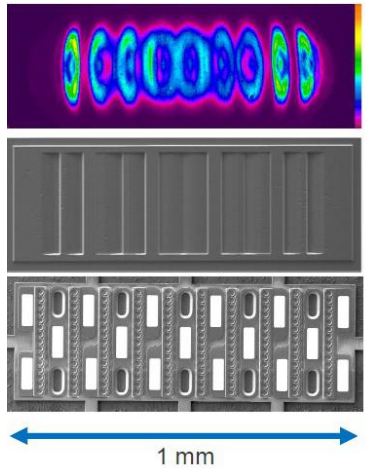
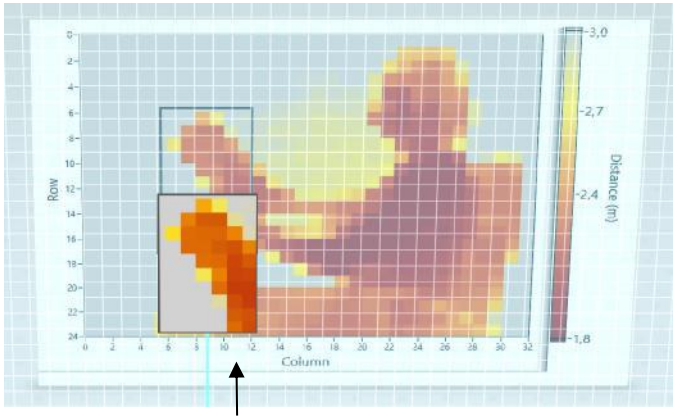
LiDAR

Far-field light distribution

Integrated optics

VCSEL-Array

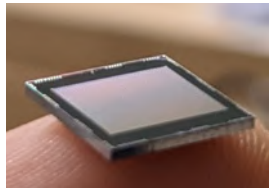




Selection of a segment

Coded LiDAR for reduced susceptibility to interference

External LiDAR



SPAD Arrays

Patterned LiDAR

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Signals with coded signatur

- Adaptive illumination of segmented scene areas
- Robust against interference / interactions with other LiDARs

- Demonstrate efficiency in real-time measurements
- Converting random numbers into signal code in real-time

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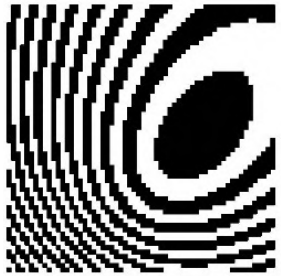
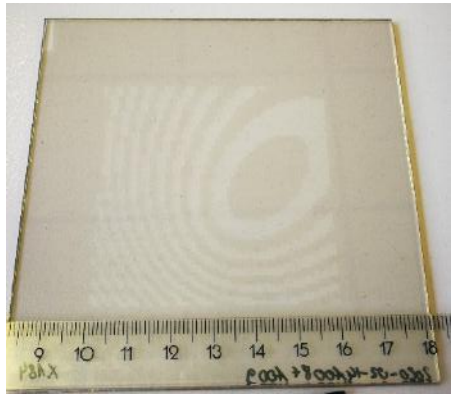
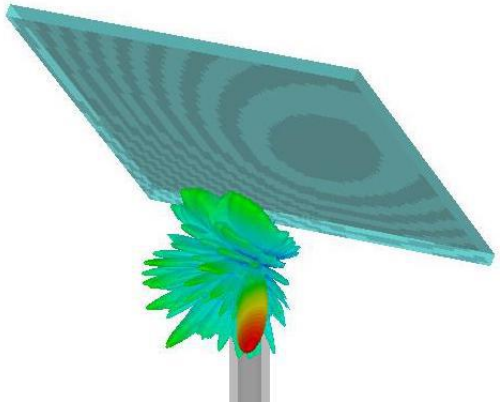
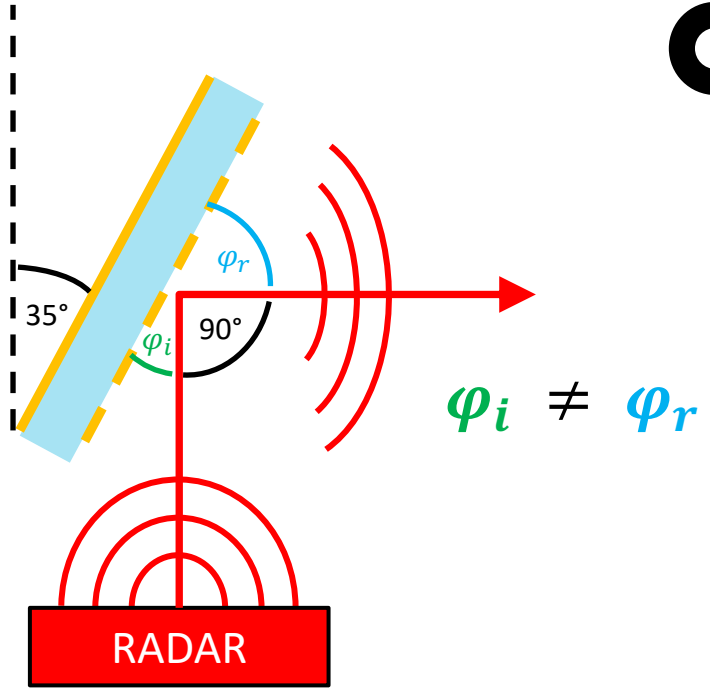
RADAR





max. radiation at
$\varphi = 30°$





Structured, arbitrarily shaped surfaces for deflecting RADAR radiation

- Arbitrary surface shape creates additional degree of freedom for beam guiding LiDAR/ illumination
- No co-design of surface and RADAR required - use of any sensor by OEM

- Identification of suitable phase-controlling elements and optimization of their arrangement
- Suppression of unwanted radiation directions and edge effects

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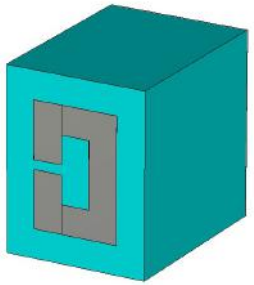
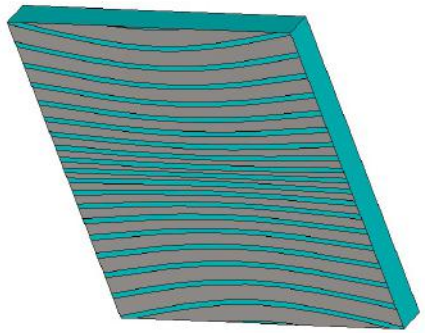
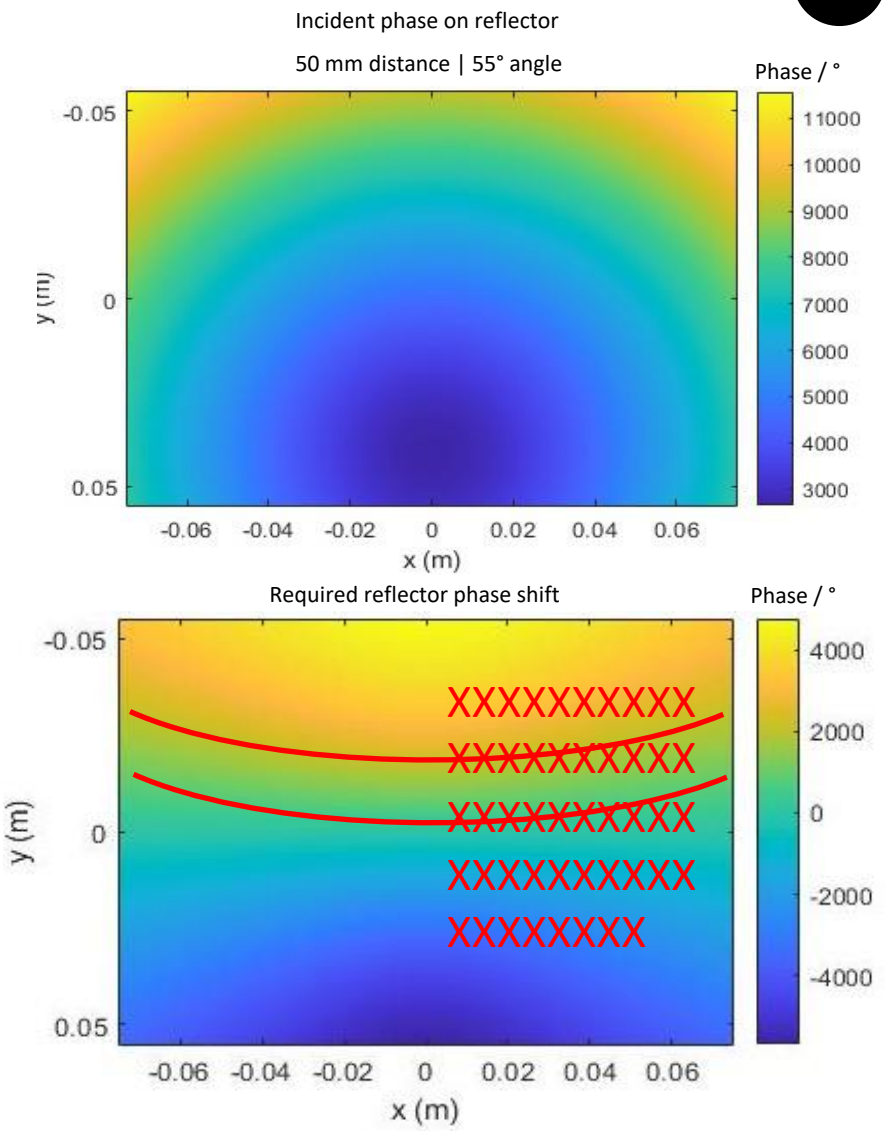
Phase on RADAR reflector and demanded phase shift



- Discrete phase shift (X):
  - Resonant elements: Set phase between 0° - 360°
  - Distance between elements < $\frac{\lambda}{2}$ (resulting from antenna array theory)
  - Challenge: Many cells difficult to model (>1000 different on reflector 100x100mm)



- Continuously phase shift (-): Diffractive structure
  - Easy to model
  - Challenge: Avoid radiation through reflector and energy losses



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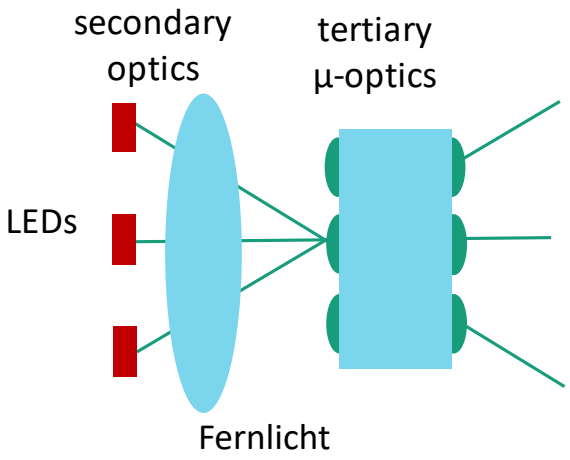
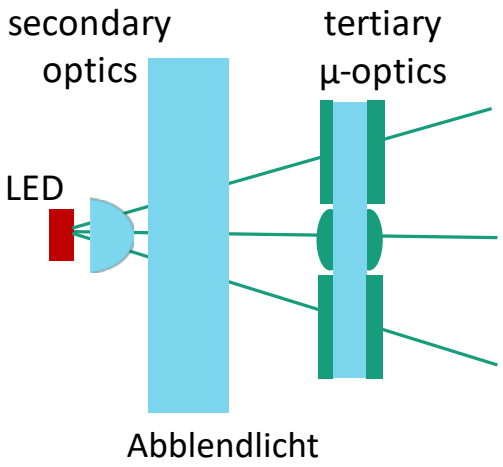
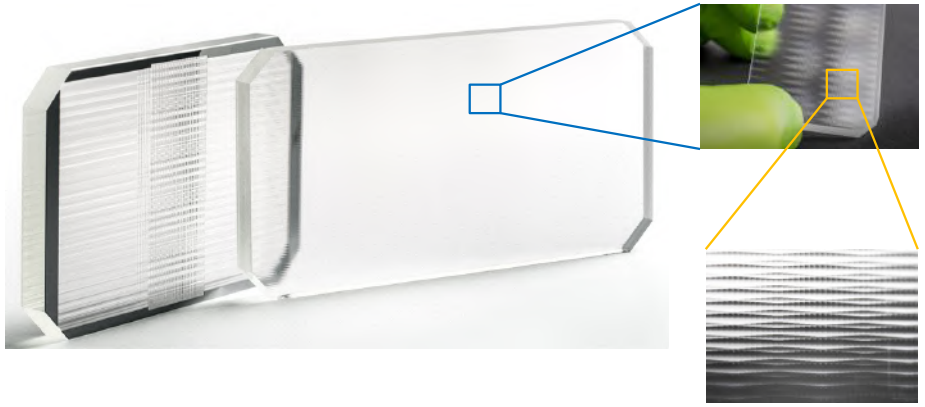
Lighting







Segmented light source

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Apertureless micro optics

- Switchable LED arrays for beam control
- Mask-free, irregular micro-lens arrays for beam shaping

- Suppression of segment artifacts and scattered light for compliance with ECE standards
- Transmission >65%, thus low heat input

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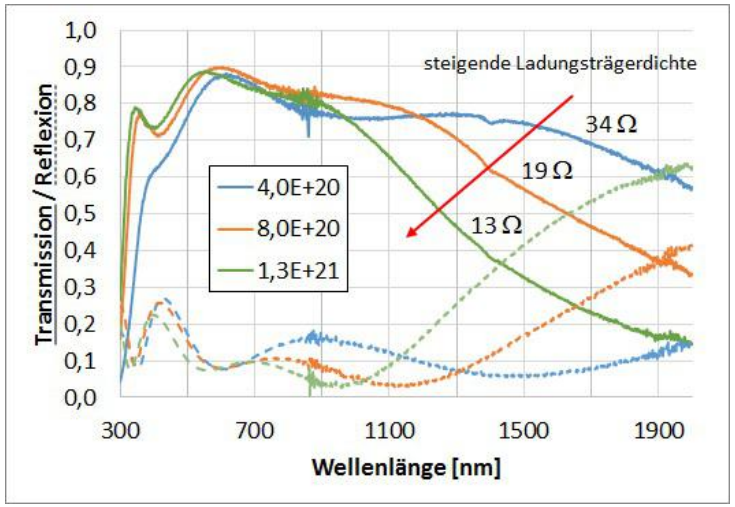
Multispectral combiner



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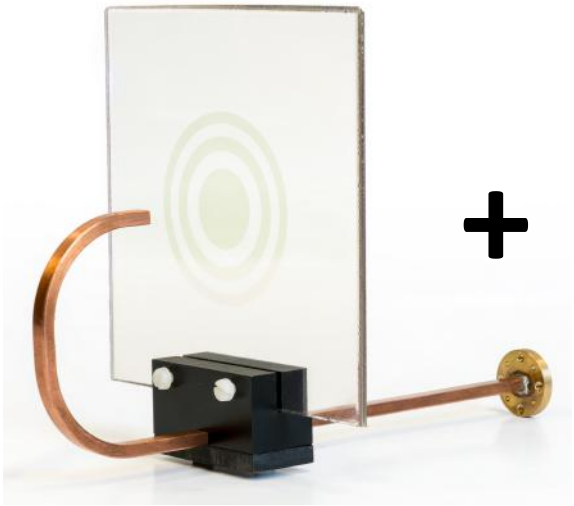

Transparent radar lense

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Large scale industrial coating process

Superposition of LiDAR, RADAR and light

- Multi-wavelength beam guiding and shaping
- Transfer of the individual technologies into an overall concept

- Thin-film technology for high transmission in the wavelength range 400 nm to 4 mm
- Selective surface functionalization by precision laser ablation

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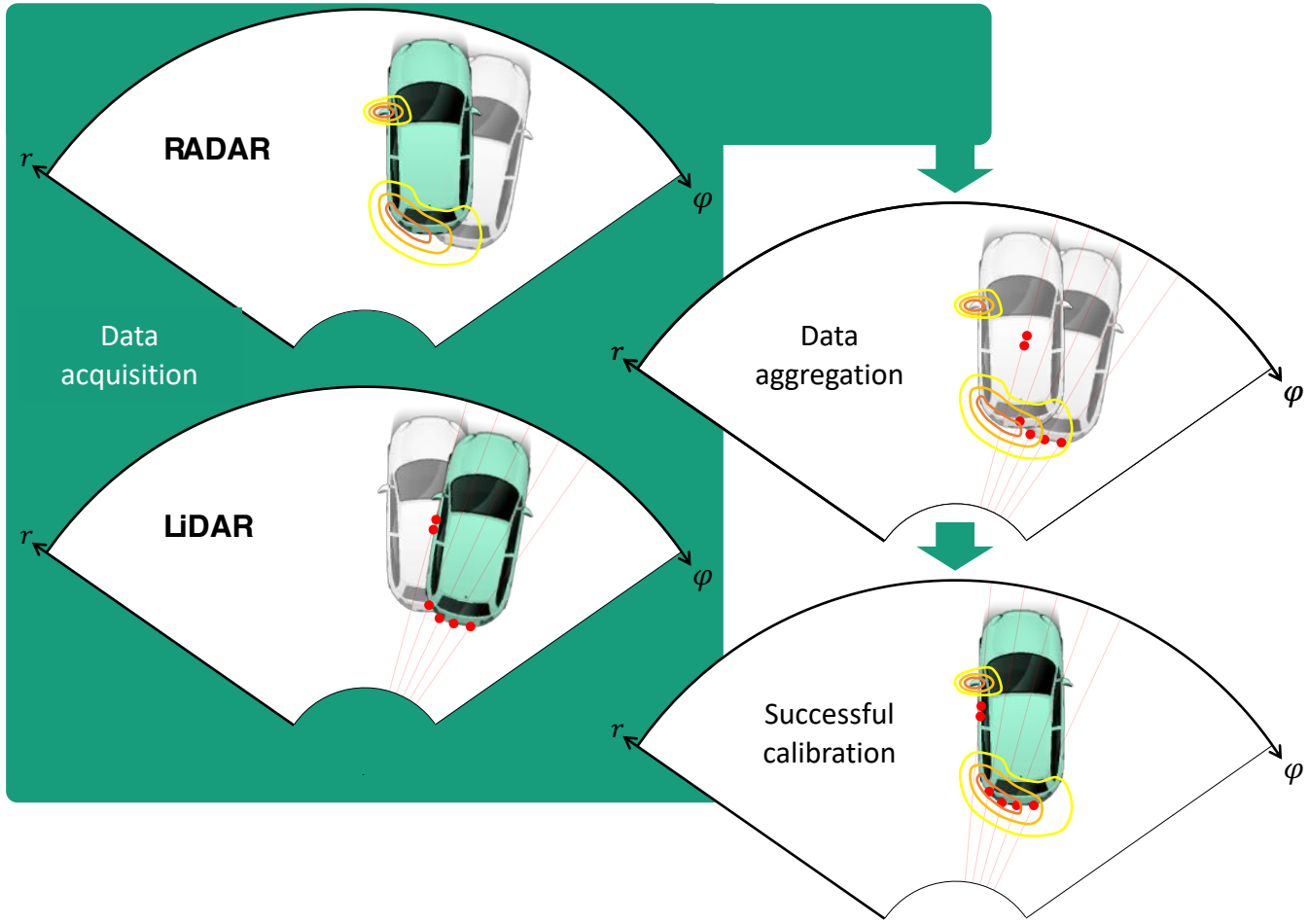
Data merging in Smart Headlight

- Common field of view of the 3D sensors LiDAR and RADAR when using the multispectral combiner
- Aggregation and merging of measurement data
- Angular calibration of both systems
  - ➢ Calibration method for future systems
- Detection via redundant and technologically different sensors
  - ➢ Increase of reliability and robustness



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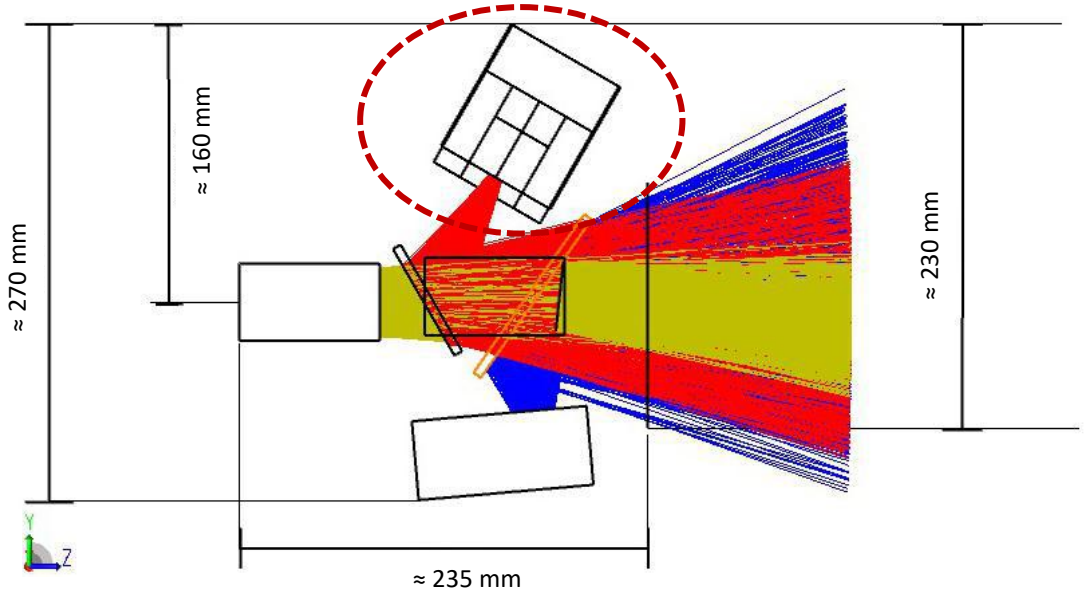
Smart Headlight System Design

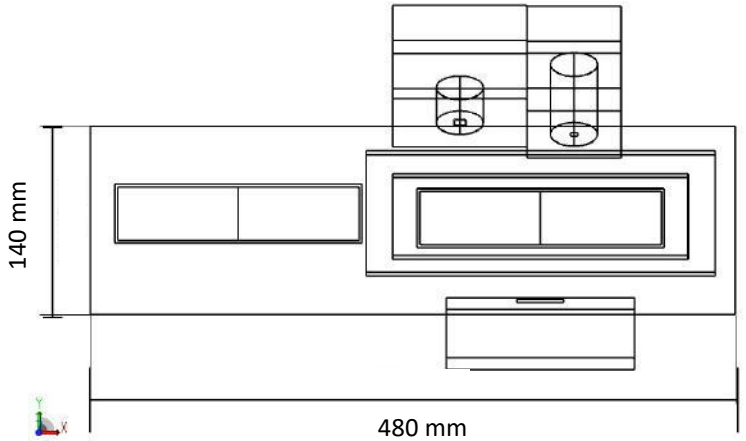
CONFIG. 1 – “ABOVE (LIDAR) – BELOW (RADAR)“

SIDE VIEW



System length:	235 mm
System height:	270 mm
LiDAR combiner size (W x H):	220 x 70 mm²
RADAR combiner size (W x H):	260 x 110 mm²
Exit window size (W x H):	480 x 140 mm²

FRONT VIEW



Main drawback → Doesn’t fit for the average car headlamp geometry

Real sizes of the modules are considered

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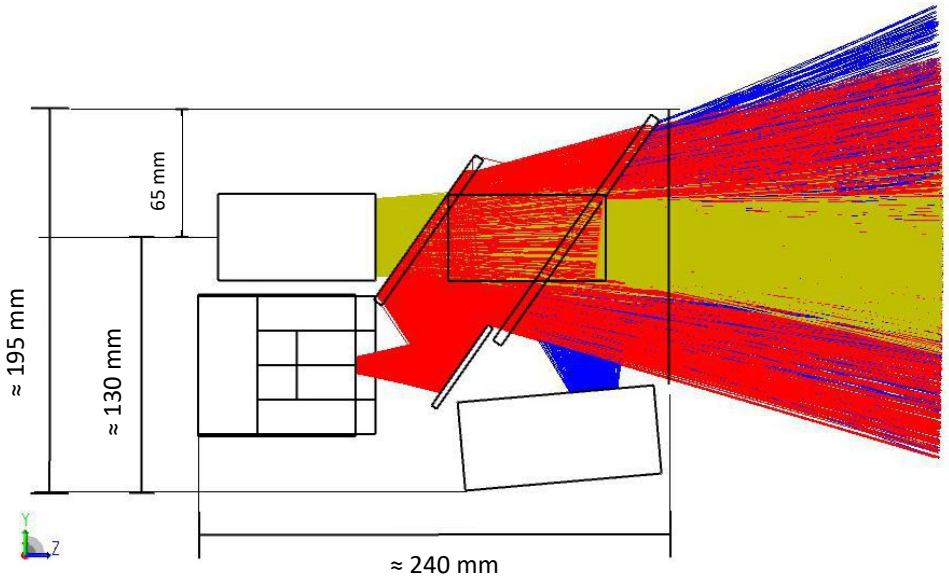
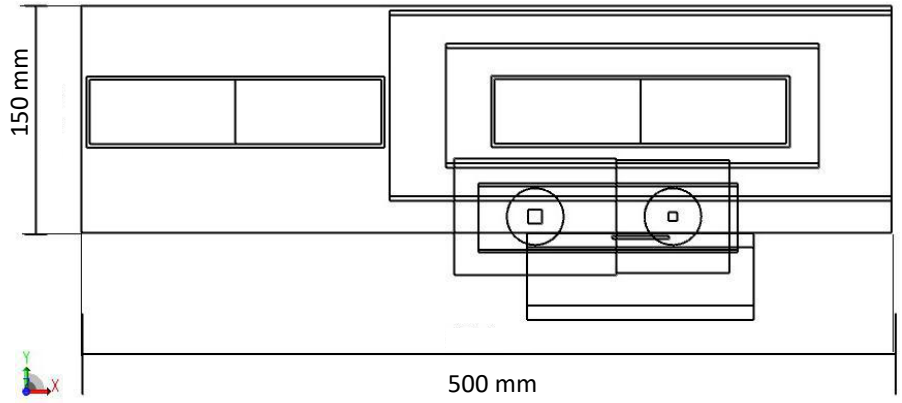
Smart Headlight System Design

CONFIG. 2 – “BELOW (LIDAR) – BELOW (RADAR) FOLDED“

SIDE VIEW



FRONT VIEW



System length:	240 mm
System height:	195 mm
LiDAR combiner size (W x H):	230 x 90 mm²
RADAR combiner size (W x H):	310 x 140 mm²
Exit window size (W x H):	500 x 150 mm²

Real sizes of the modules are considered

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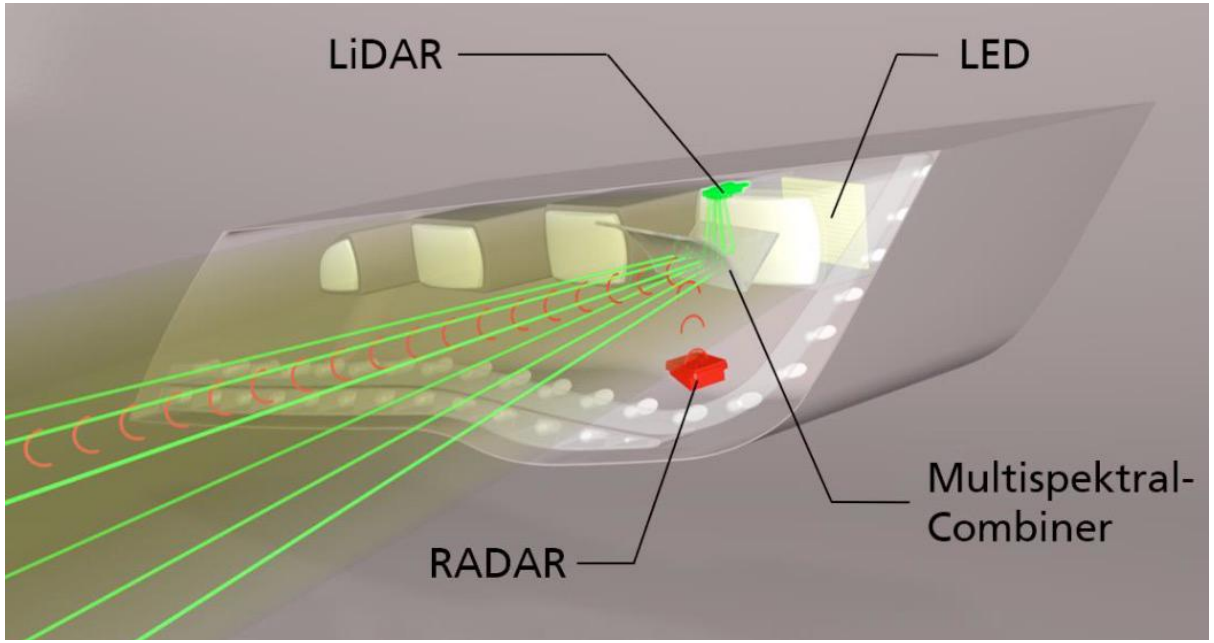
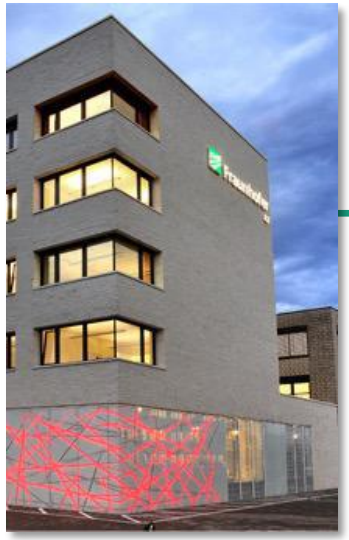
THANK YOU VERY MUCH FOR YOUR ATTENTION!





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