

Core Exterior Lighting

## Exterior Lighting evolution - need for revolution

DVN Workshop Rochester 2019



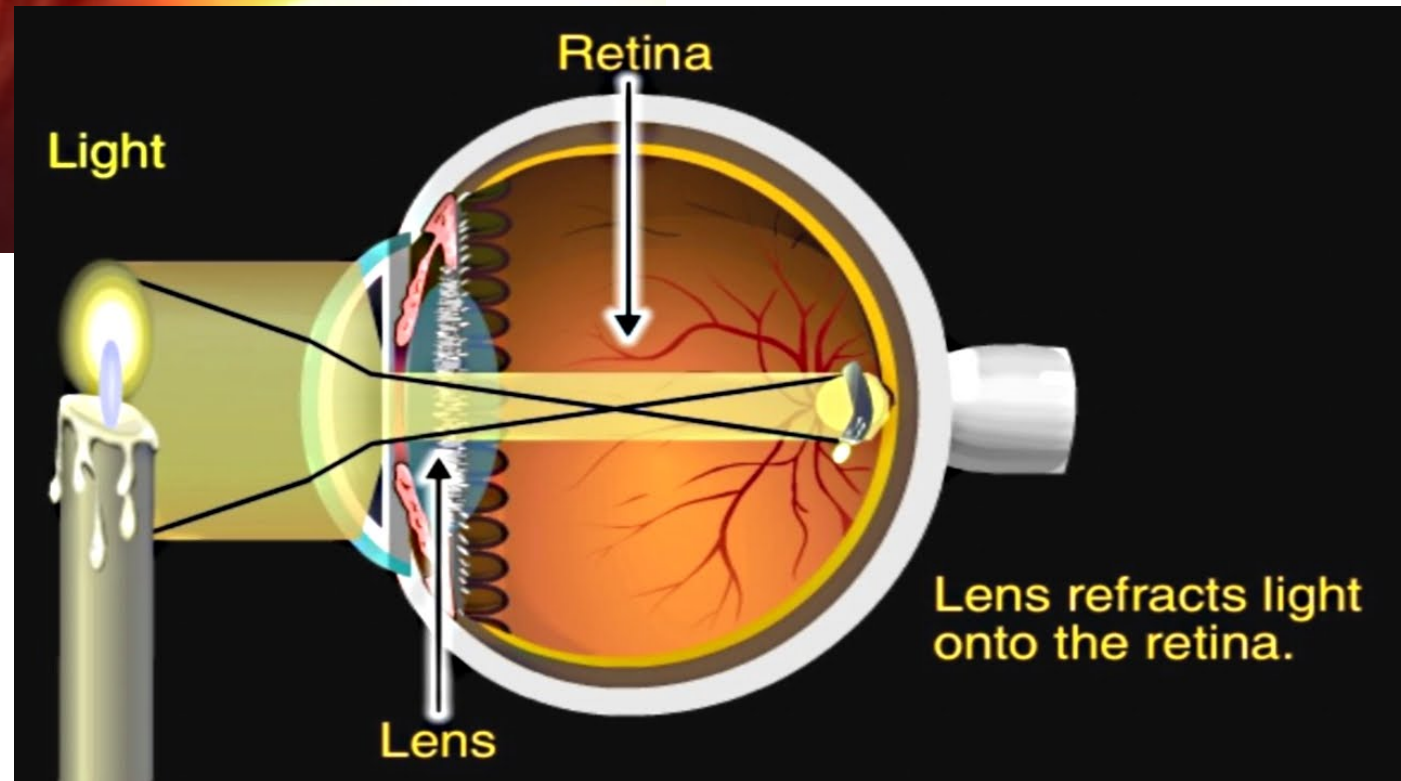
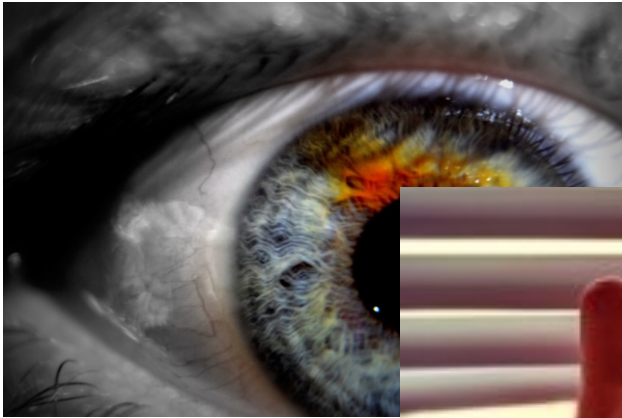
Go Further

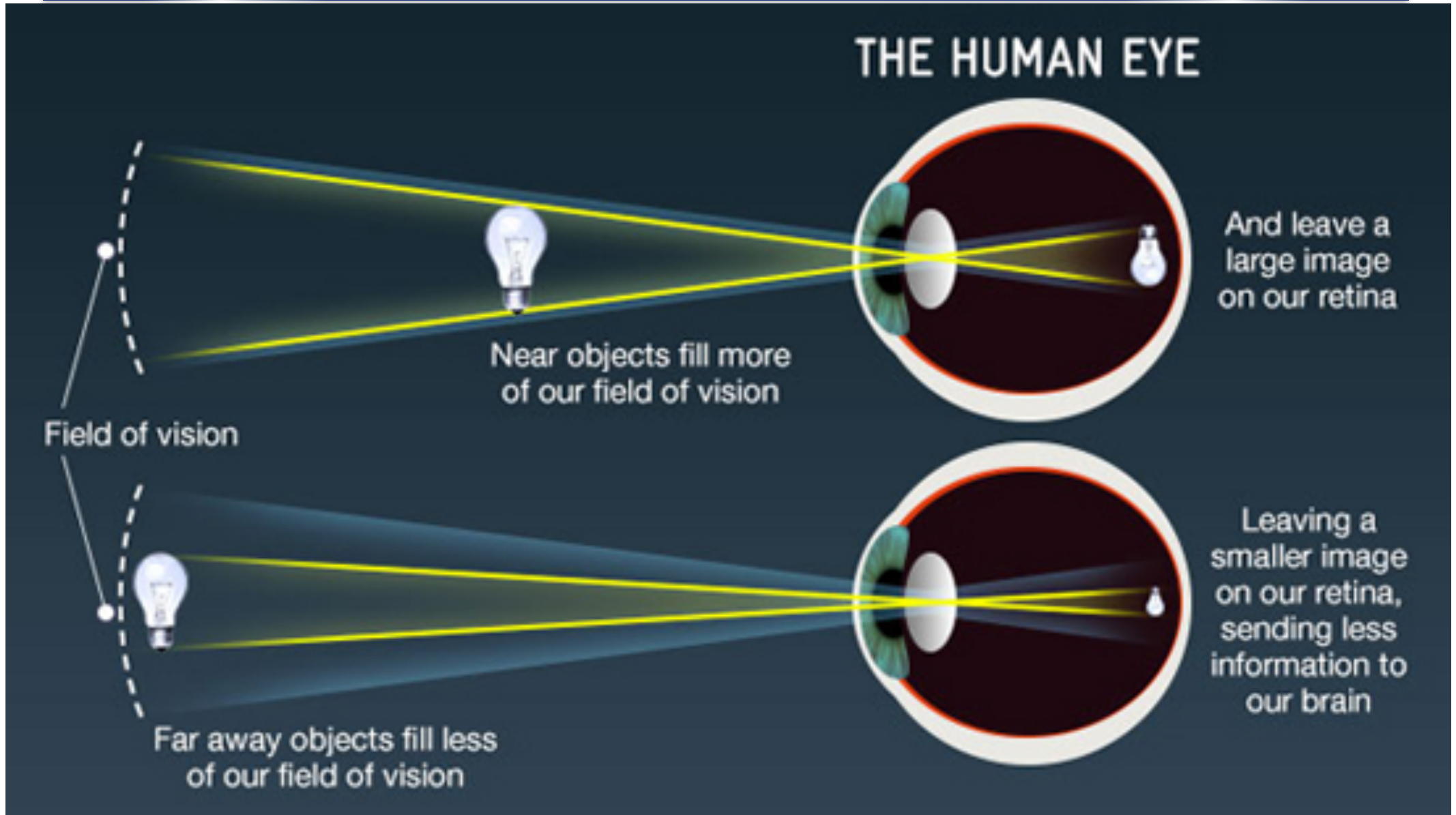
Thorsten Warwel  
twarwel1@ford.com

# Light for humans – the original need



# Light for humans – the eye

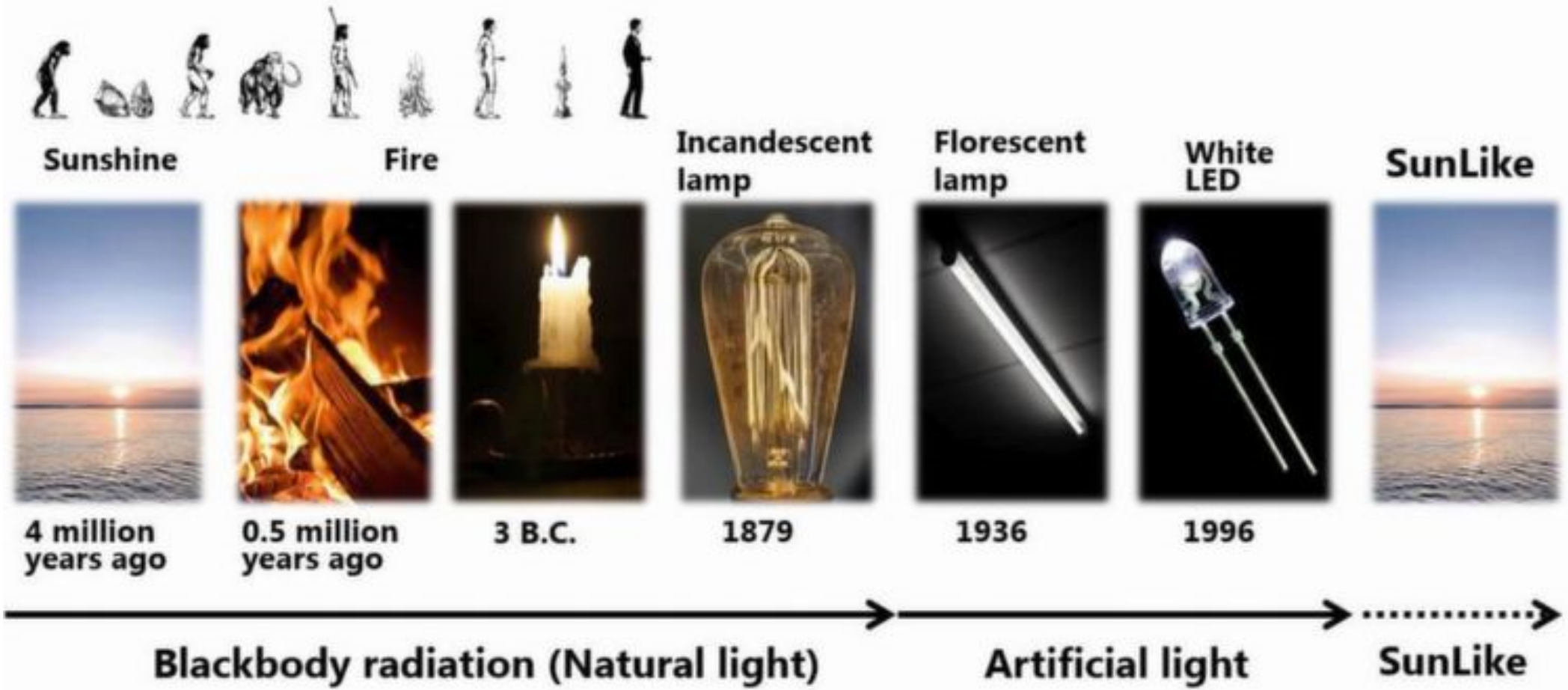




Source: BBC

More distance requires more light

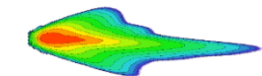
# Light source evolution



1st vehicles

Source: Elektronikpraxis

# First cars – 20<sup>th</sup> century

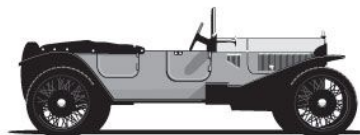


Core Exterior Lighting

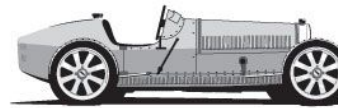
1900 - 1935



**Ford Model T**  
1912



**Lancia Lambda**  
1922



**Bugatti Type 35**  
1922



**Chrysler Airflow**  
1934

1905  
**SAE Formed**  
*USA*

1906  
**First Grand Prix**  
*France*

1912  
**Starter Motor**  
*Delco - USA*

1912  
**Peak of Electric Car Sales**  
*USA*

1914  
**Automatic Transmission**  
*Mercedes - Germany*

1912  
**First Unibody Car**  
*Lancia - Italy*

1922  
**First Car to Reach 200mph**  
*Sunbeam - UK*

1927  
**First Car Radio**  
*Galvin Corp - USA*

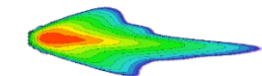
1928  
**Synchromesh Gears**  
*Cadillac - USA*

1928  
**Run Flat Tires**  
*Michelin - France*

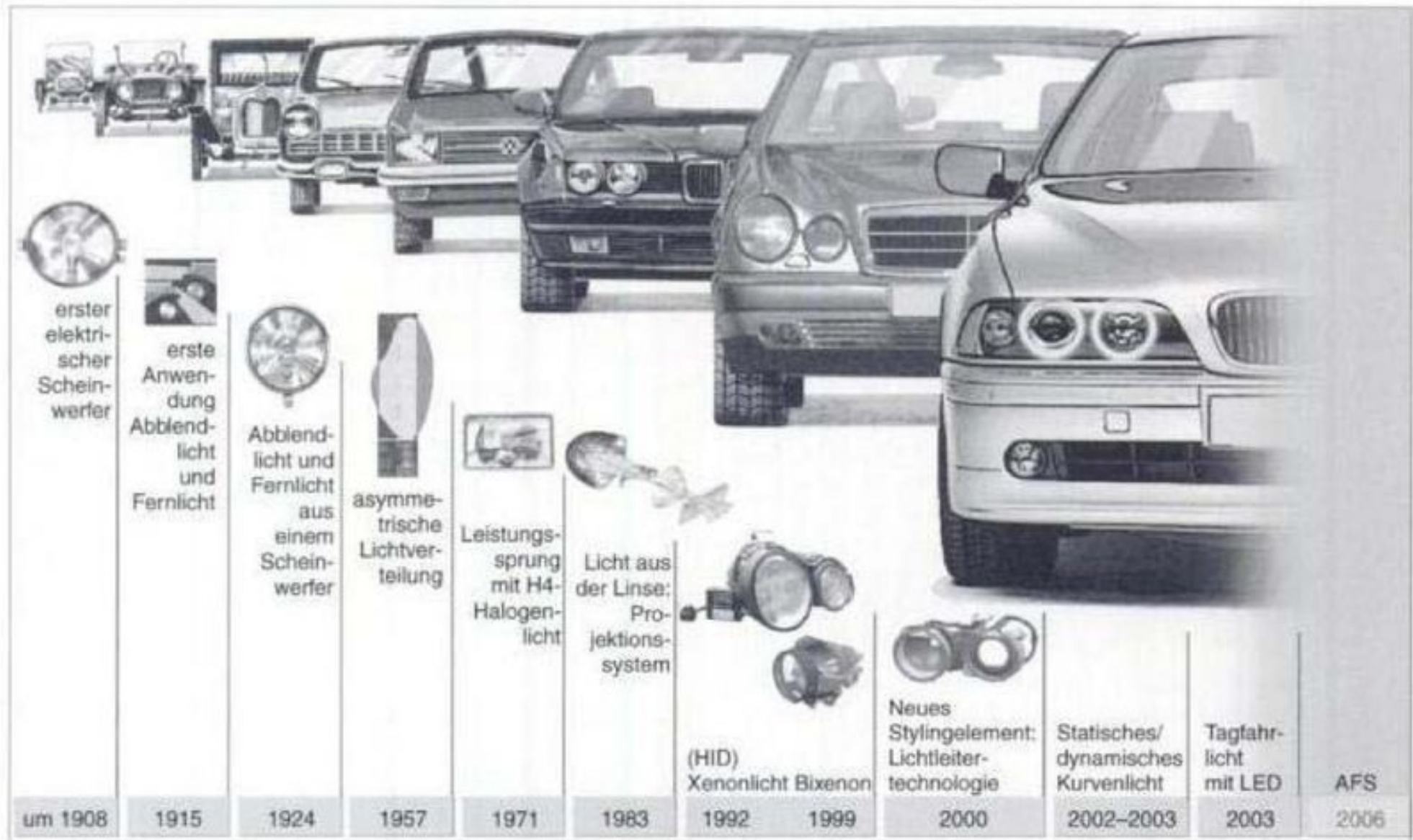
H-POINT | History



# History of automotive light sources



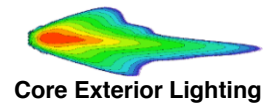
Core Exterior Lighting



Source: University of Münster Germany



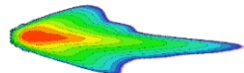
# At the beginning – Model T



Ford Model T 1920s



# A few decades later – Model T & Mustang



Core Exterior Lighting



# FORD ESCORT 1968

# FORD FOCUS 2003

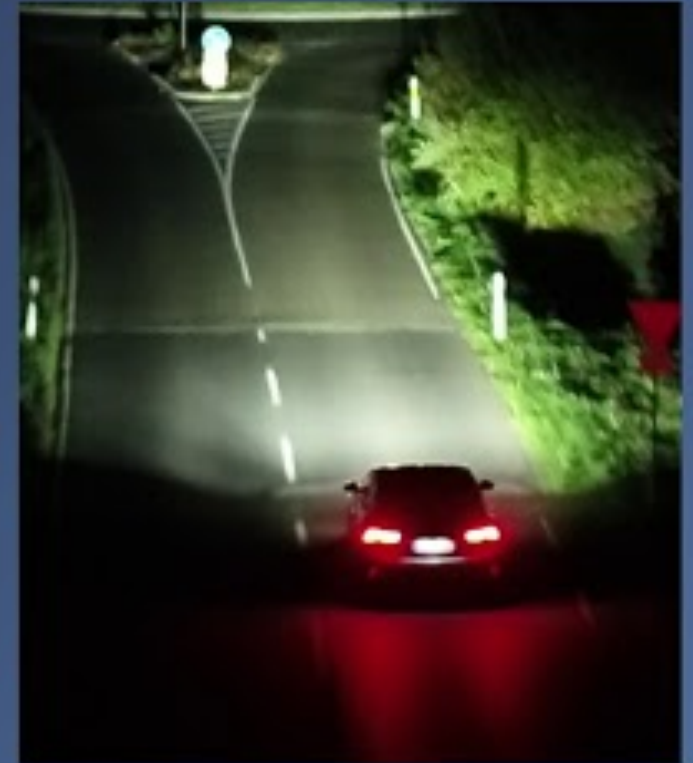
# FORD FOCUS 2018



LIGHT DISTANCE  
**250 METRES**

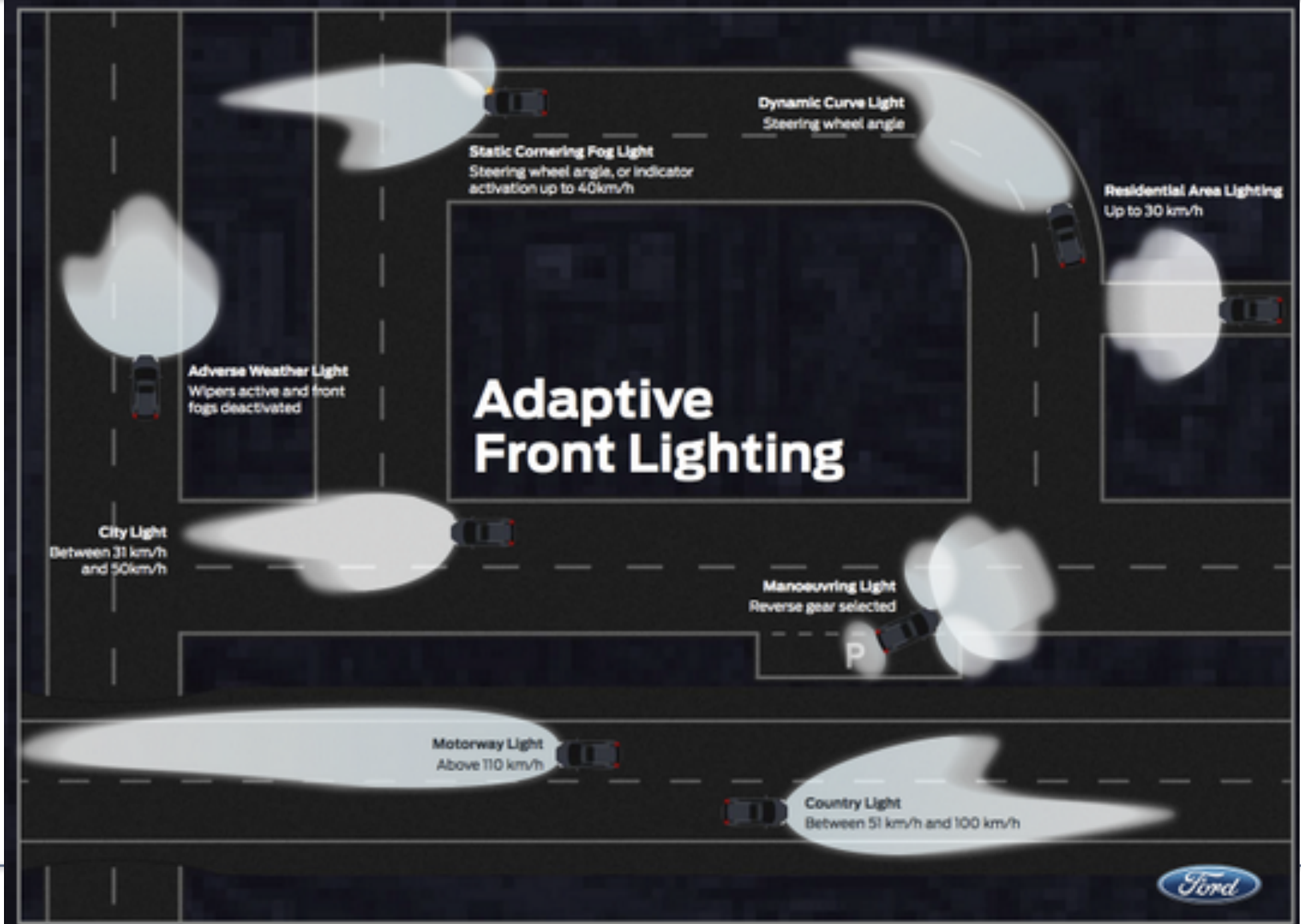
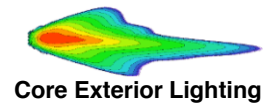


LIGHT DISTANCE  
**350 METRES**

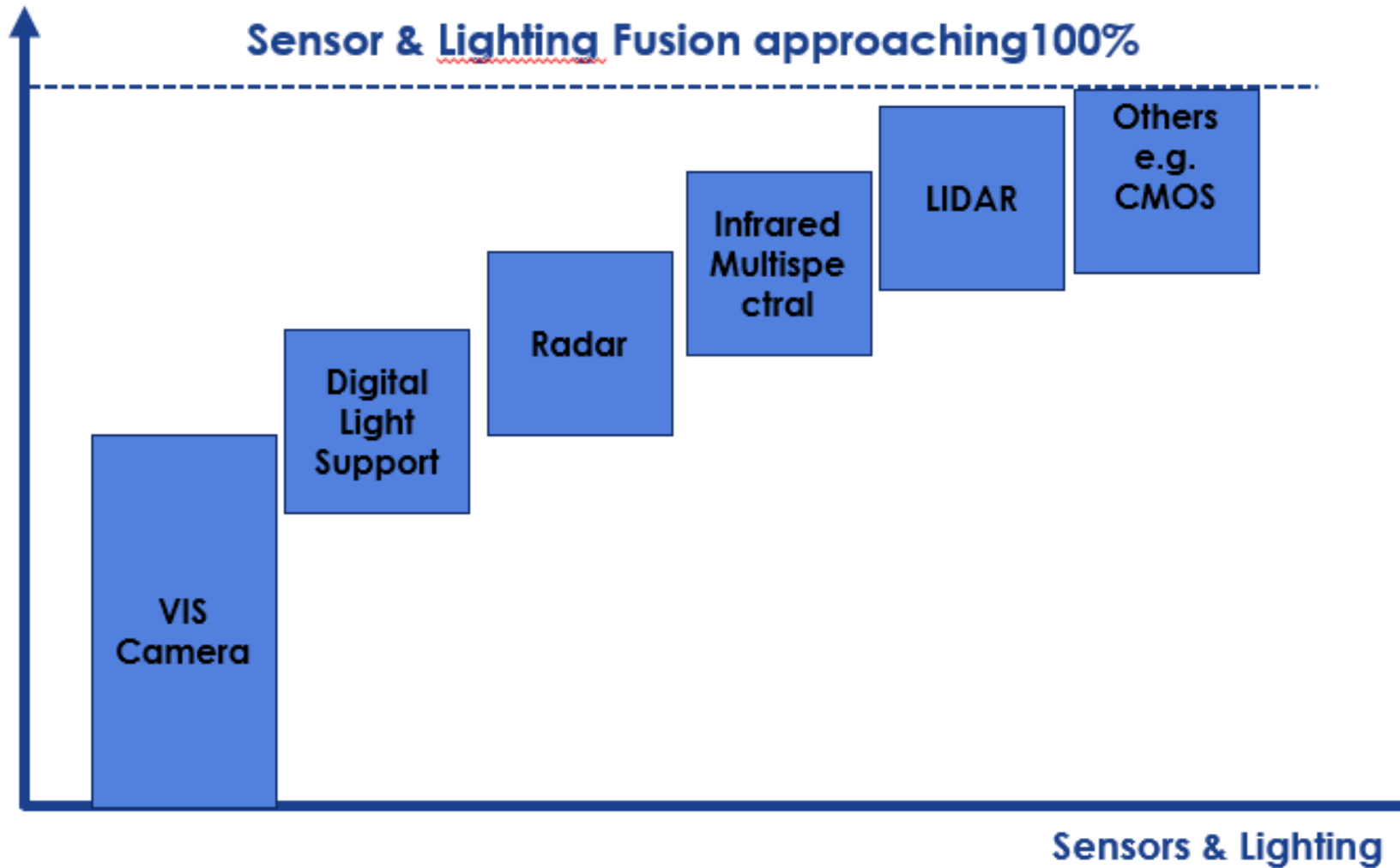


LIGHT DISTANCE  
**500 METRES**

# Light for humans– utilizing vehicle data (CAN/LIN connect)

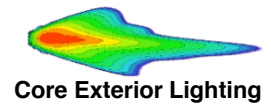


## Object Classification Probability

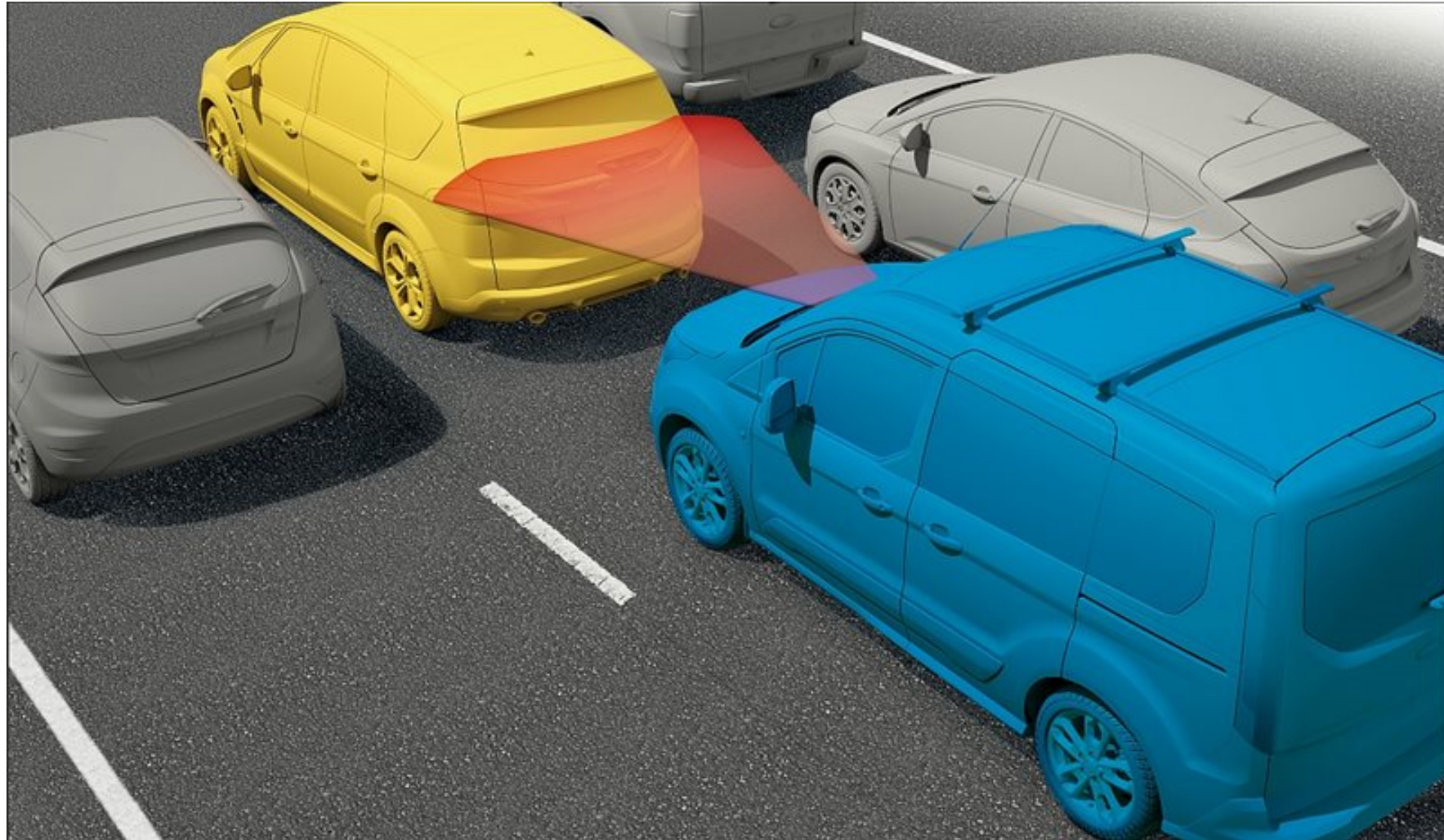


Quelle: DVN Lidar Congress 2018

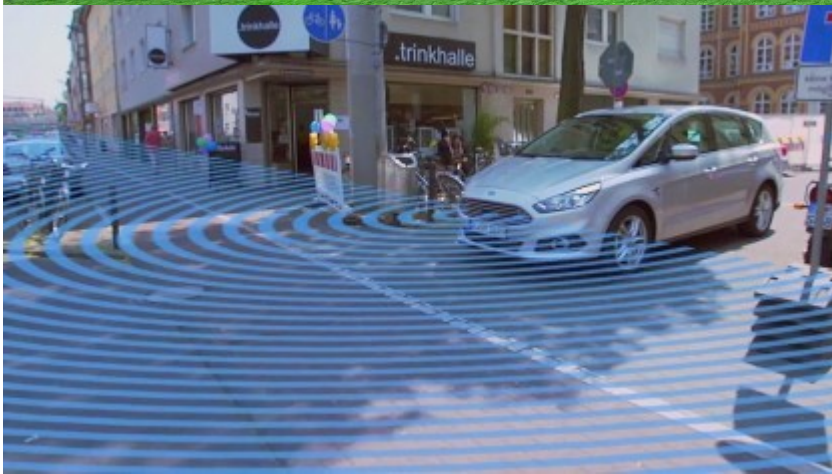
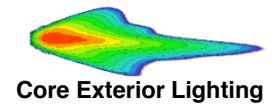
# Light for humans and Sensors – a symbiosis utilizing cameras



# Light for humans and Sensors – a symbiosis



# Cameras – helps the driver where needed

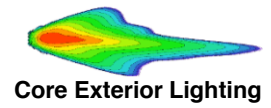


Thorsten Warwel  
twarwel1@ford.com

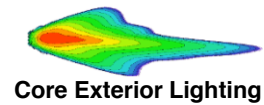


Go Further

# Camera– enable ADB functionality and more visibility at night



# LiDAR integration – the beginning at FORD



## HISTORY OF AUTONOMY

**2004** Ford's Jim McBride volunteers at the original DARPA autonomous vehicle challenge, which leads Ford to compete the following year



**2008** Ford Motor Company debuts driver-assist technology features – Blind Spot Information System, lane-keeping system and active park assist

**2006** Ford Motor Company introduces adaptive cruise control



**2013** Ford launches fleet of 10 Fusion Hybrid autonomous research vehicles for testing and development



**2015** Ford transitions from the research phase of fully autonomous vehicle development to the advanced engineering phase



**2015** Ford performs the first demonstrated autonomy test in snow



**2016** Ford announces it will triple its autonomous test fleet

2004

2005

2006

2007

2008

2009

2013

2015

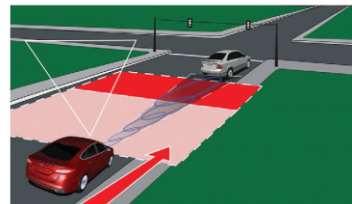
2016

2021

**2005 & 2007** Using a self-driving Ford F-250 Super Duty, Ford is one of only six teams to qualify as a finalist at the DARPA Desert Classic and Urban Finals, supported by engineers still with the company

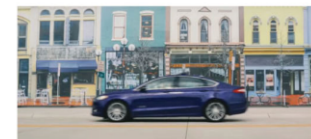


**2009** Ford sends a car on a 25-state journey, nicknamed the "Mother of All Road Trips," to test collision warning with brake support and other systems



**2015** Ford secures a license to test autonomous vehicles in California and opens its Palo Alto research center

**2015** Ford becomes the first automaker to test a fully autonomous vehicle at Mcity



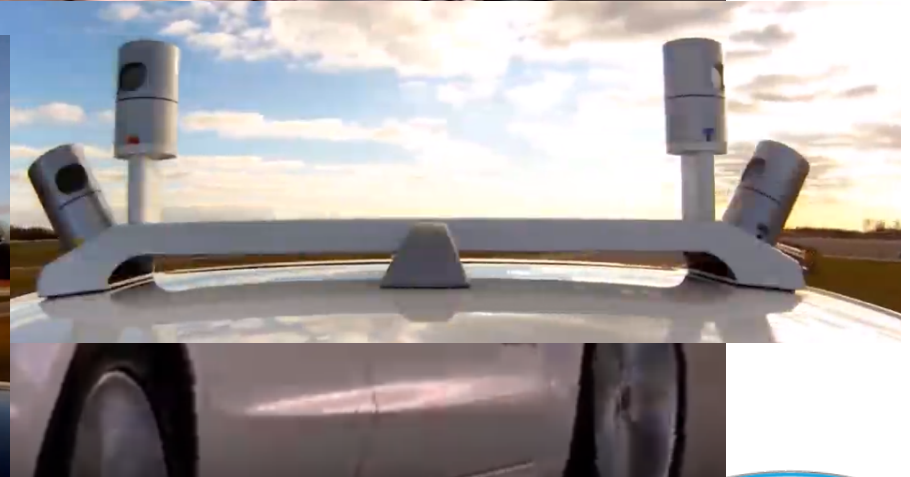
**2021** Ford intends to mass-produce a high-volume, fully autonomous, SAE level 4-capable vehicle for ride-hailing or ride-sharing services

Source: HybridCars

# LiDAR integration – the beginning at FORD



## 2nd Generation





Velodyne LiDAR on Ford Fusion/Mondeo demo

2.232 Aufrufe



nwradu

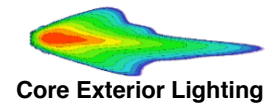
Am 06.03.2014 veröffentlicht

Four HDL-32 LiDAR units mounted on a new Ford Mondeo demonstrate the technology for detecting nearby objects with a good resolution.

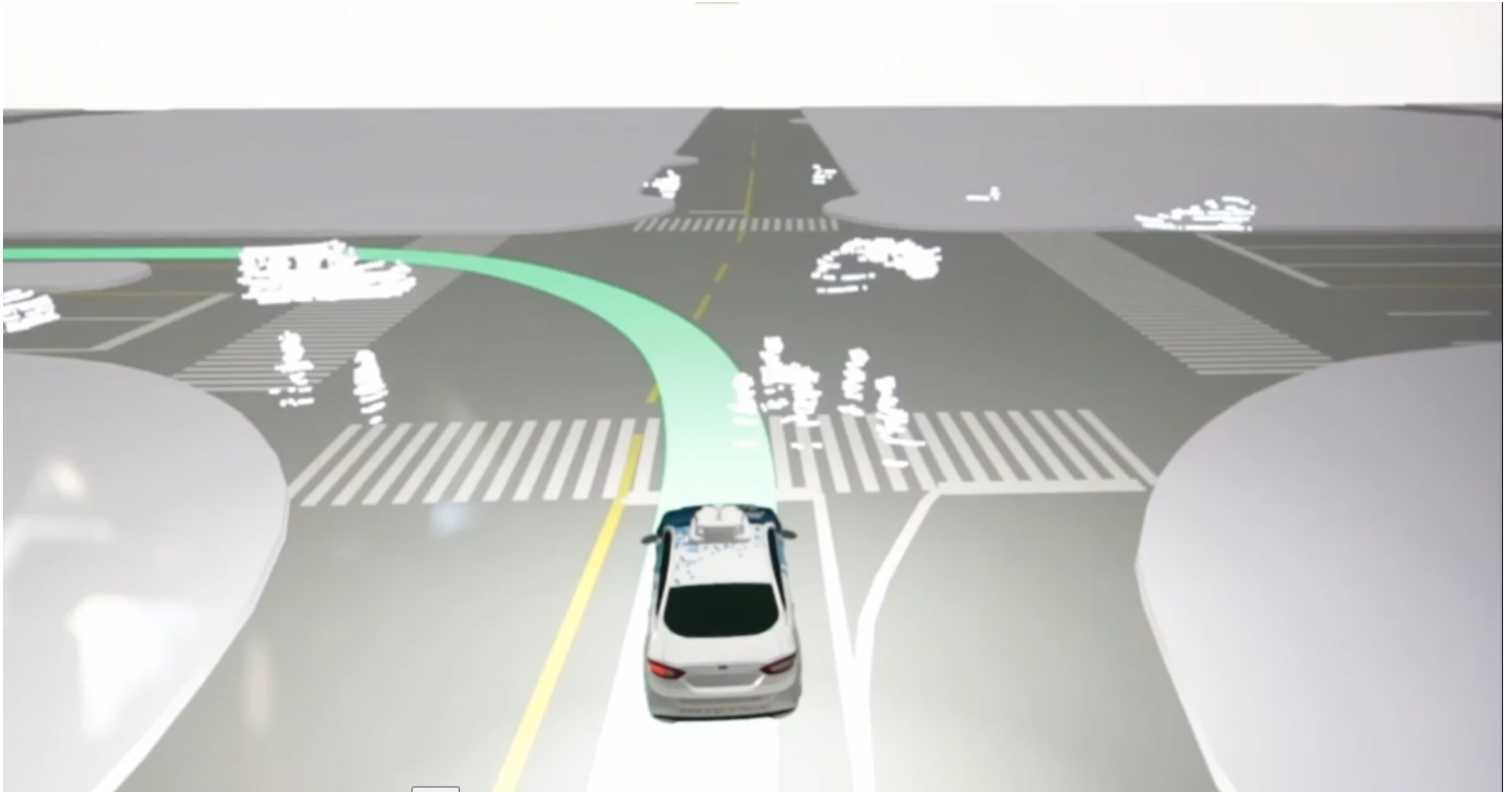




# LiDAR integration – evolution





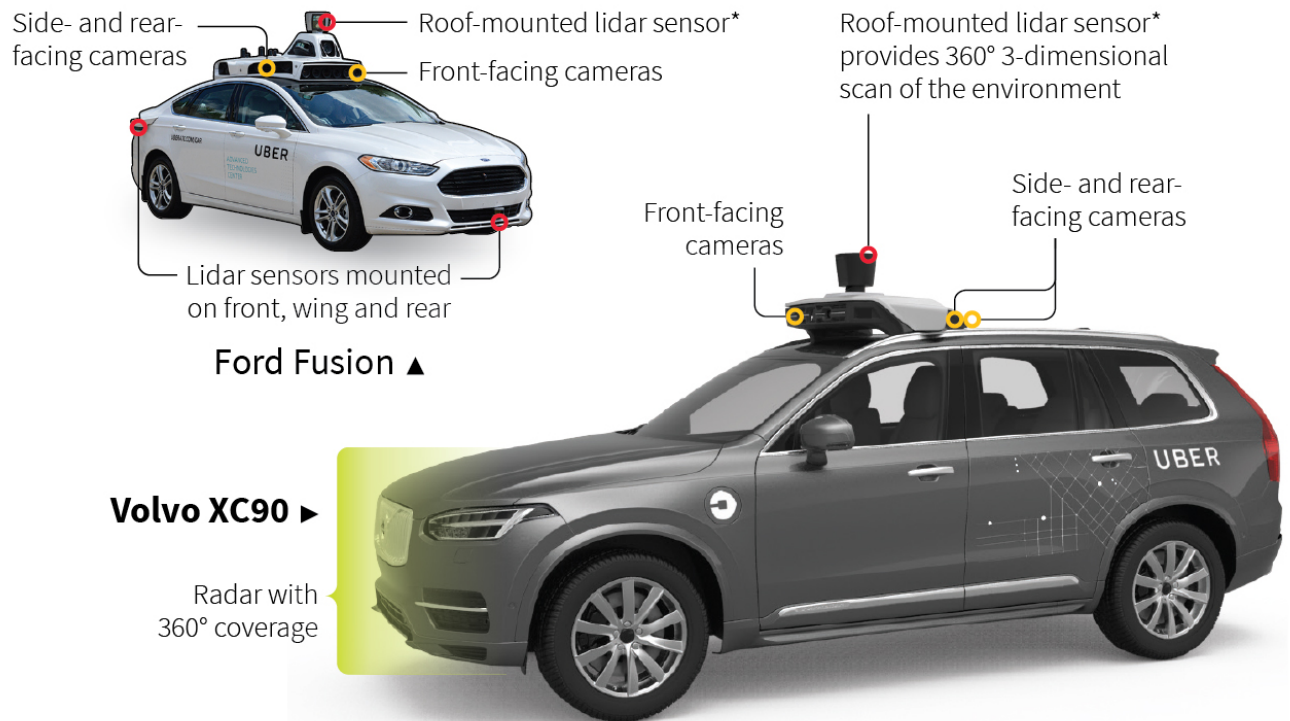


## How Uber altered safety sensors on newest test cars

Uber's self-driving Volvo SUV that struck and killed a pedestrian last week in Tempe, Arizona, used fewer safety sensors than the self-driving Ford Fusions that Uber phased out of its test fleet last year.

### UBER SELF-DRIVING VEHICLE SAFETY SENSOR SUITE

	LIDAR	RADAR	CAMERA
<b>Volvo XC90</b>	● 1	●●●●●●●●●● 10	●●●●●●●● 7
<b>Ford Fusion</b>	●●●●●●●● 7	●●●●●●●● 7	●●●●●●●●●●●●●●●●●● 20

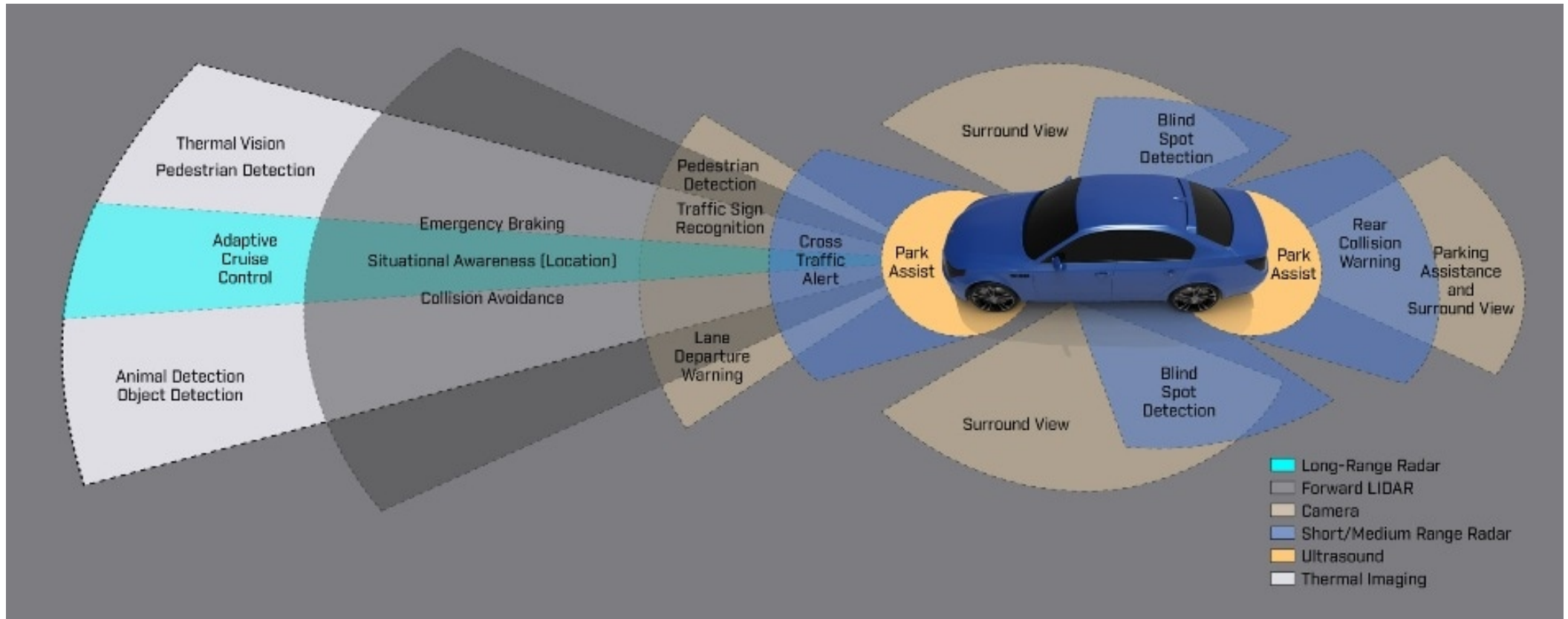
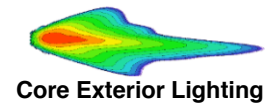


Source: Uber Images: Uber  
W. Foo, 28/03/2018

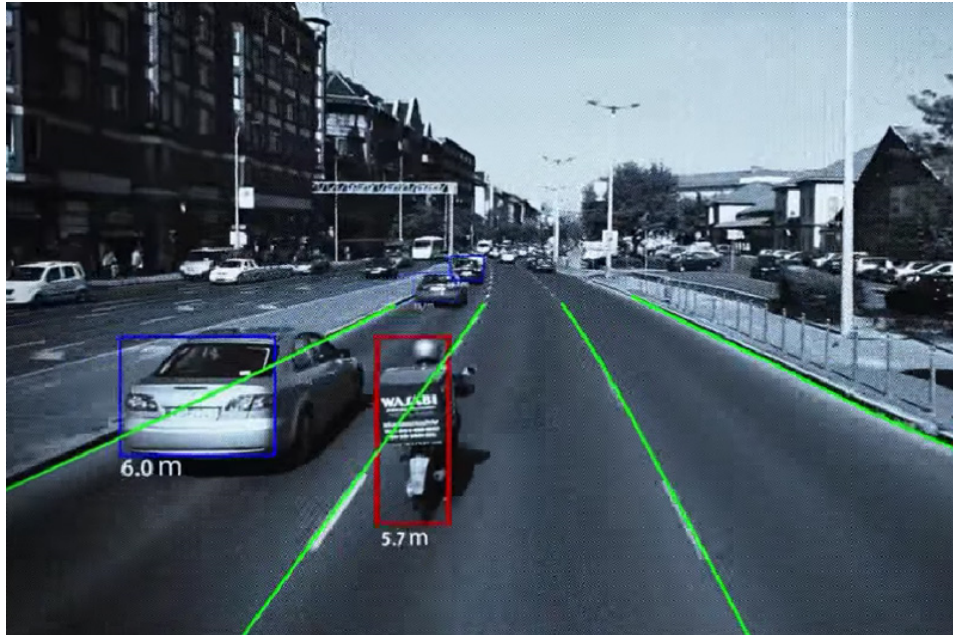
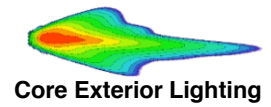
\* Lidar uses laser light pulses to detect obstacles

REUTERS

# Why 4 different Sensors

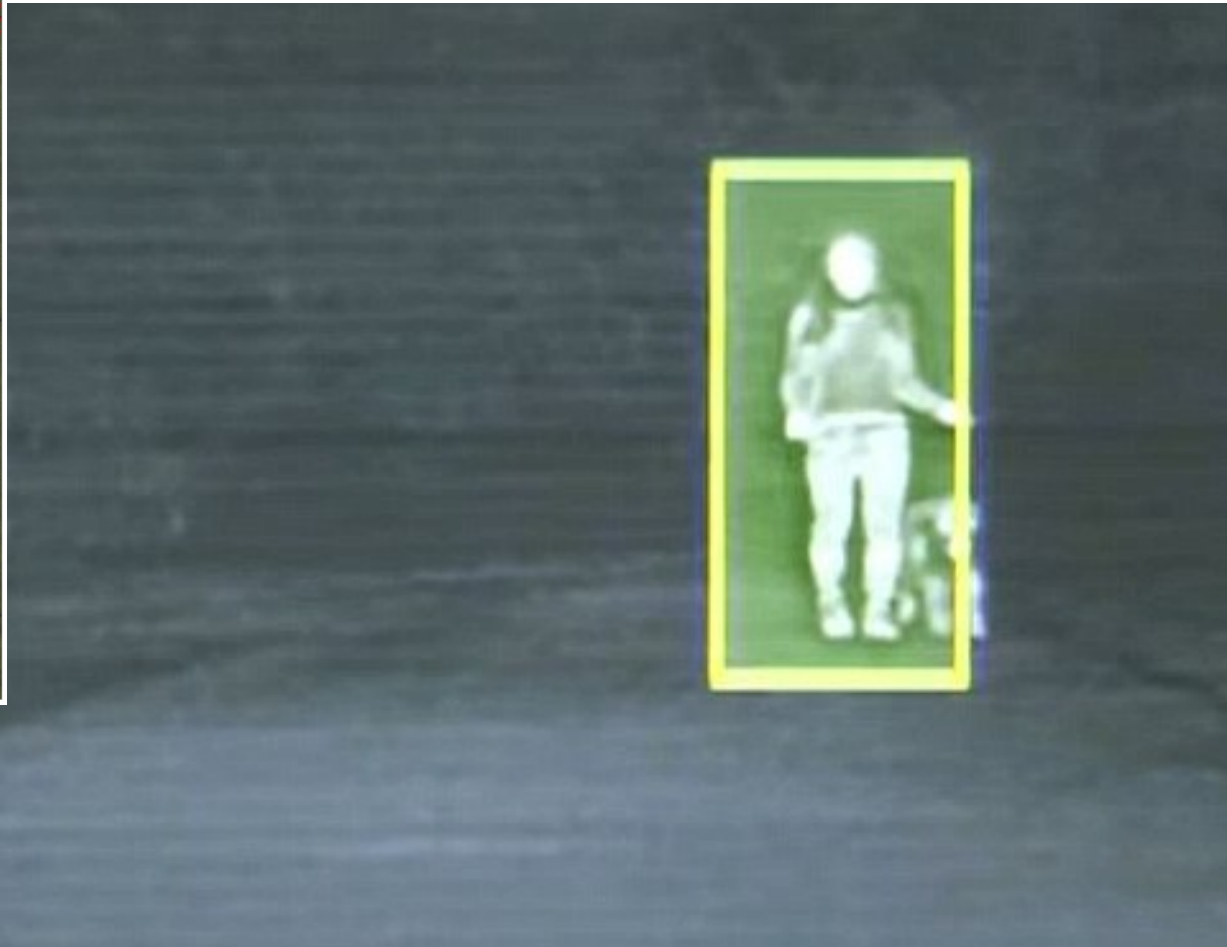
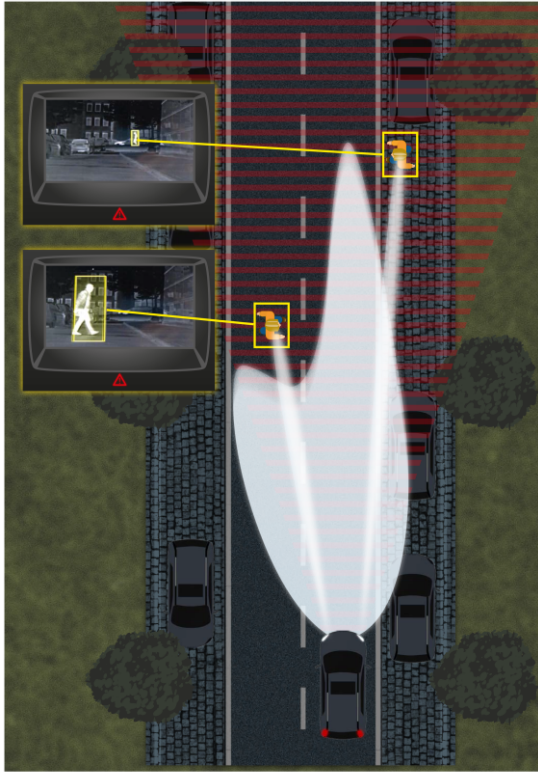


# Camera opportunities



- Cameras arrived long time in car industry. Cost efficient
- Precise in color and geometrie detections
- Needs light!

# IR Camera opportunities

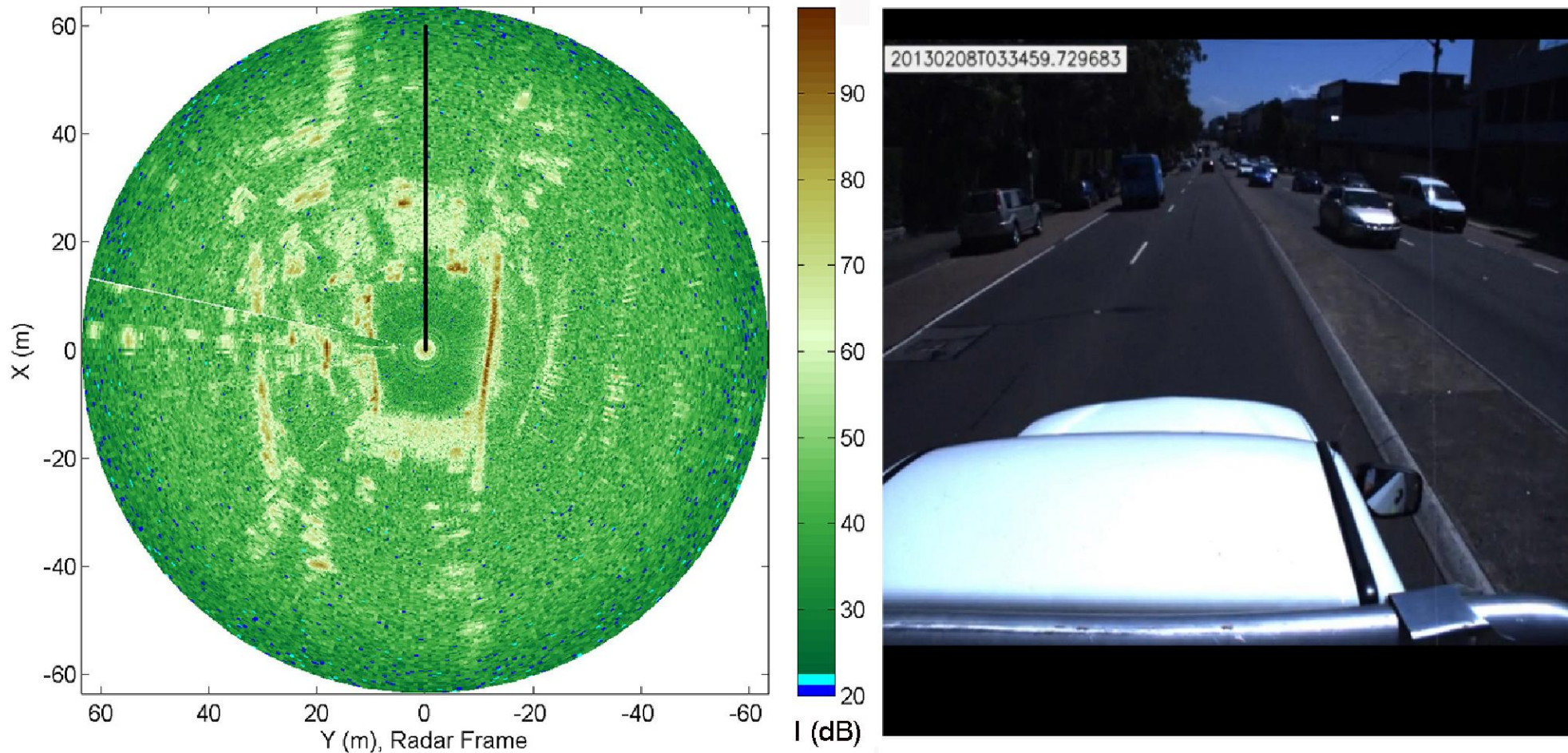


- Costly, detects warm bodies (living bodies or heated bodies)
- Does require IR emitter for dead geometrie



Quelle: Auto Blog

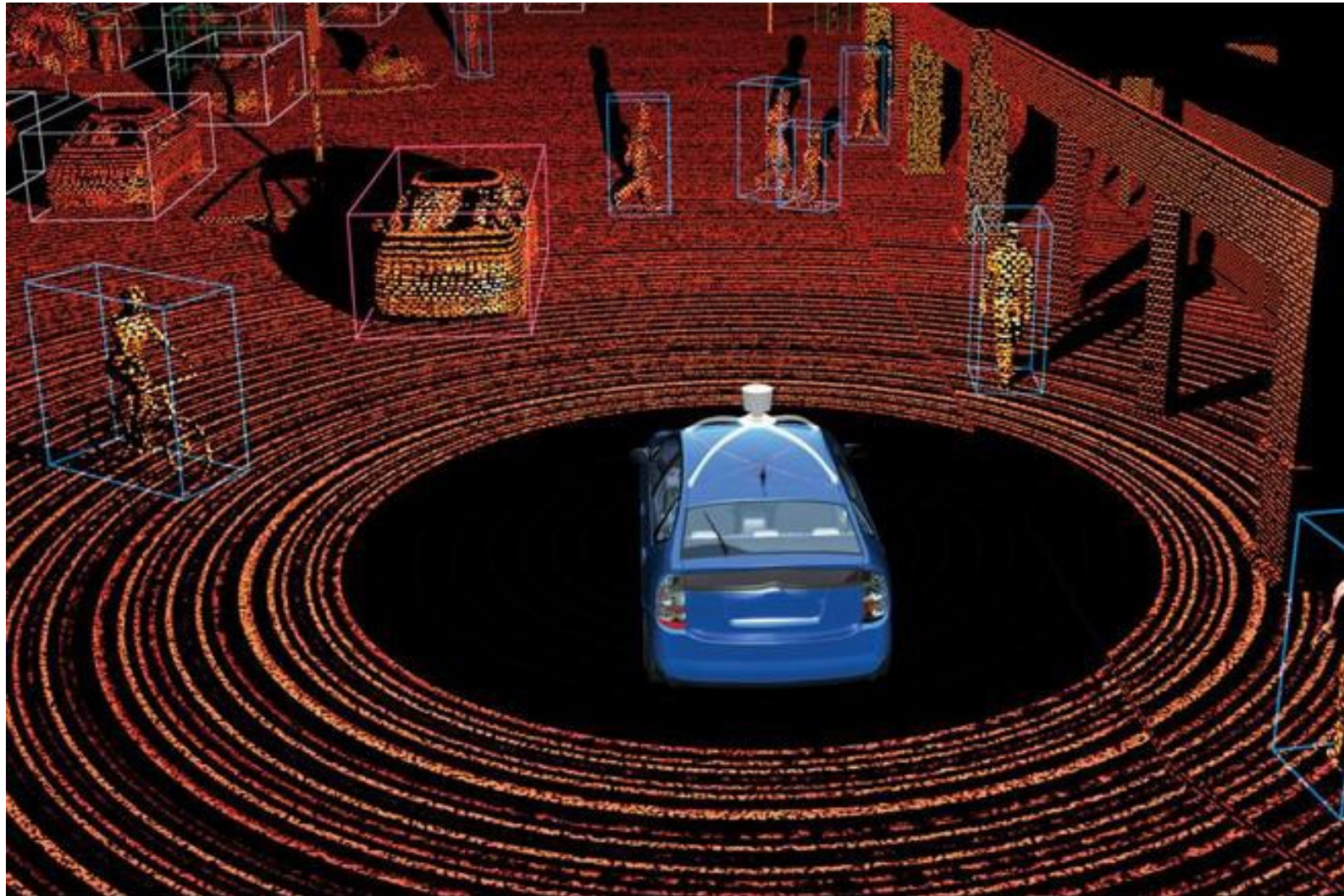




- Cost efficient, already arrived in Car industry and integrated in the lamps
- Detection with reduced resolution and accuracy

# Radars already in lamps












- Costly, size, accurate detection of geometrie
- No color or sign detecion
- Near and far far field capability

**LeddarTech**  
MASTERING LIDAR SENSOR TECHNOLOGY

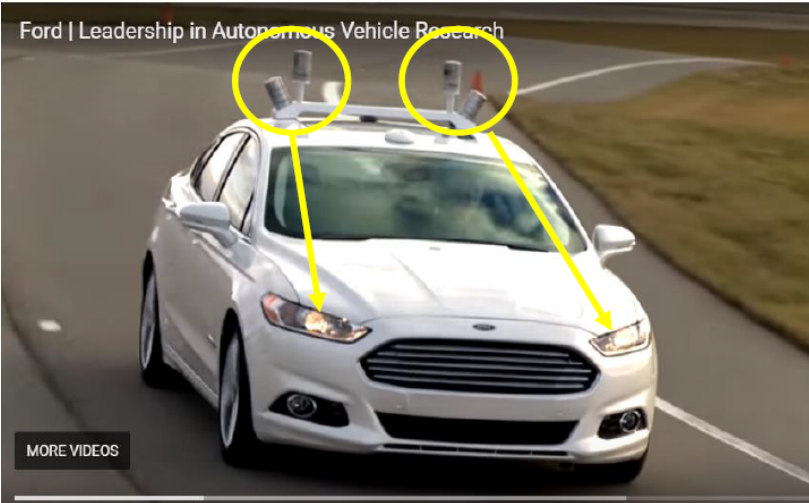
## MAJOR AUTOMOTIVE LIDAR SENSOR PROVIDERS

- Limited number of LiDAR suppliers seeking to meet automotive requirements with distinctive technologies

<p><b>Valeo</b> (LeddarTech, Ibeo)</p>  <p>Gen 1 LeddarCore</p> 	<p><b>Velodyne</b></p> 	<p><b>Quanergy</b></p> 
<p><b>Continental</b> (ASCar)</p> 	<p><b>LeddarTech</b></p>  <p>Gen 2 &amp; 3 LeddarCore</p>  <p>Gen 2 &amp; 3 Leddar Sensors</p>	<p><b>Others</b></p> <p>Photo Vision Princeton Lightwave Scanse Slamtec Innoviz Pioneer</p> <p>Subscribe</p>

Quelle:LeddarTech Internet

# Sensor integration - oportunitites



Autonomous sensors that can't be seen?  
**That's our vision.**



**SENSE WHAT'S COMING**  
with Smart Corner™ technology

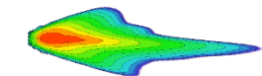
**MAGNETI MARELLI**

A close-up of a headlight assembly with a bright light source. The background is dark blue with some light trails.

Koito

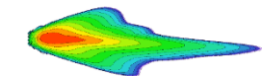


Magneti Marelli






- Light fraction at lens:  
fraction dependant on lens shape and surface quality  
design and tooling impact
- Mechanical Lidar: positioning tolerance sensitive (VS SSL)
- High data speed for recognition time needed
- Laser usage and ISO 26262 compliance
- Object detection dependant on lens cleanliness  
lens needs to be replaceable or cleaned within mili seconds
- Cleaning and service strategy

# Sensor comparison



Core Exterior Lighting

Rating: H = High, M=Medium, L = Low

	 Camera	 Radar	 LiDAR	Autonomous Requirement
Object Detection	M	H	H	H
Classification	H	M	L	H
Close-Proximity Detection	M	H	L	H
Speed Detection	L	H	M	H
Lane Detection	H	L	L	H
Traffic Sign Recognition	H	L	L	H
Range	H (200m)	H (250m)	M (120m)	Full range
Work in Rain, Fog, Snow	L	H	M	H
Work in Low Light	L	H	H	H
Work in Bright Light	M	H	H	H
Size	Small	Small	Medium	Mix
Cost	\$	\$\$	\$\$\$\$	Mix

Quelle: NXP 2017



- Lighting supplier need more sensor knowledge to improve
  - Mechanical connection
  - Optical defraction improvements
  - ISO 26262 capabilities
- Regulatory departments need to support the technology progression and enable exterior lighting to provide a maximum value add to drivers and sensors
- Sensor providers need to develop their systems to be less sensitive in:
  - Mechanical fixations and tolerances
  - Cleaningness requirements
  - Object classifications
- Sensors need to shrink and improve detection capabilities
- Avoid redundant sensing
- Improve sensor fusion.....the best wins