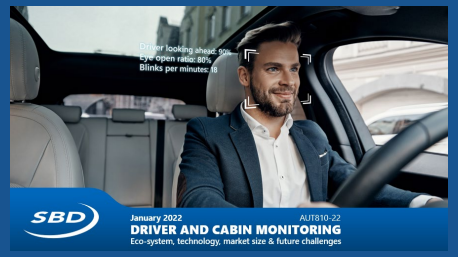

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Driver and Cabin Monitoring

Eco-system, technology, market size & future challenges

The topic of Driver Monitoring has gained significant momentum, especially due to European homologation requirements from 2022. Up until now, OEMs did not need to deploy such systems and the vast majority of them either ignored this feature or only introduced very basic systems. However, this is about to change, not just because of new regulations but also with the advent of more advanced levels of vehicle automation.
This report, new for 2022, provides:

- The key influencing factors for the introduction of driver monitoring in USA, EU & China.
- Detailed list of different technologies with their pros and cons are explained along with recent OEM initiatives and R&D demonstrations.
- A comprehensive view of the ecosystem by profiling Tier-1 & Tier-2s active in this space.
- Driver monitoring forecast in terms of unit sales and Tier-1 revenue is also provided from the understanding of the different dynamics in each global region as well as their current and future drivers.

This report explores the problem of monitoring the driver both physically and cognitively to ensure a safe interaction between human and machine. It also outlines how more competent driver monitoring solutions are an enabler to more robust SAE L2, and are a requirement for SAE L3.

COVERAGE: GLOBAL, NA, CHINA, EUROPE

FREQUENCY: ANNUALLY, QUARTERLY, ONE-OFF

PUBLICATION FORMAT: PDF, POWERPOINT, EXCEL, ONLINE

PAGES: 130+

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Key questions answered

- What are the key influencing factors for the introduction of driver monitoring?
- What are the long-term needs for implementing driver monitoring systems?
- Who are the key players currently exploring driver monitoring systems?
- What is the potential revenue created from implementing driver monitoring systems?

This research supports

- PRODUCT PLANNERS
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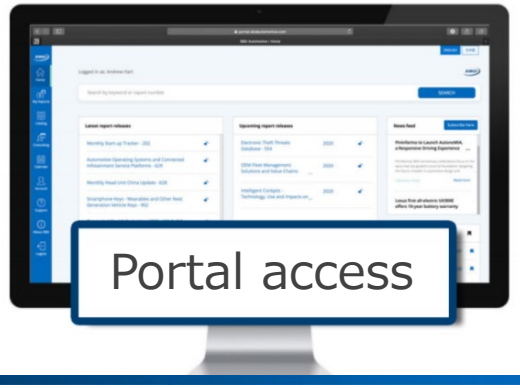

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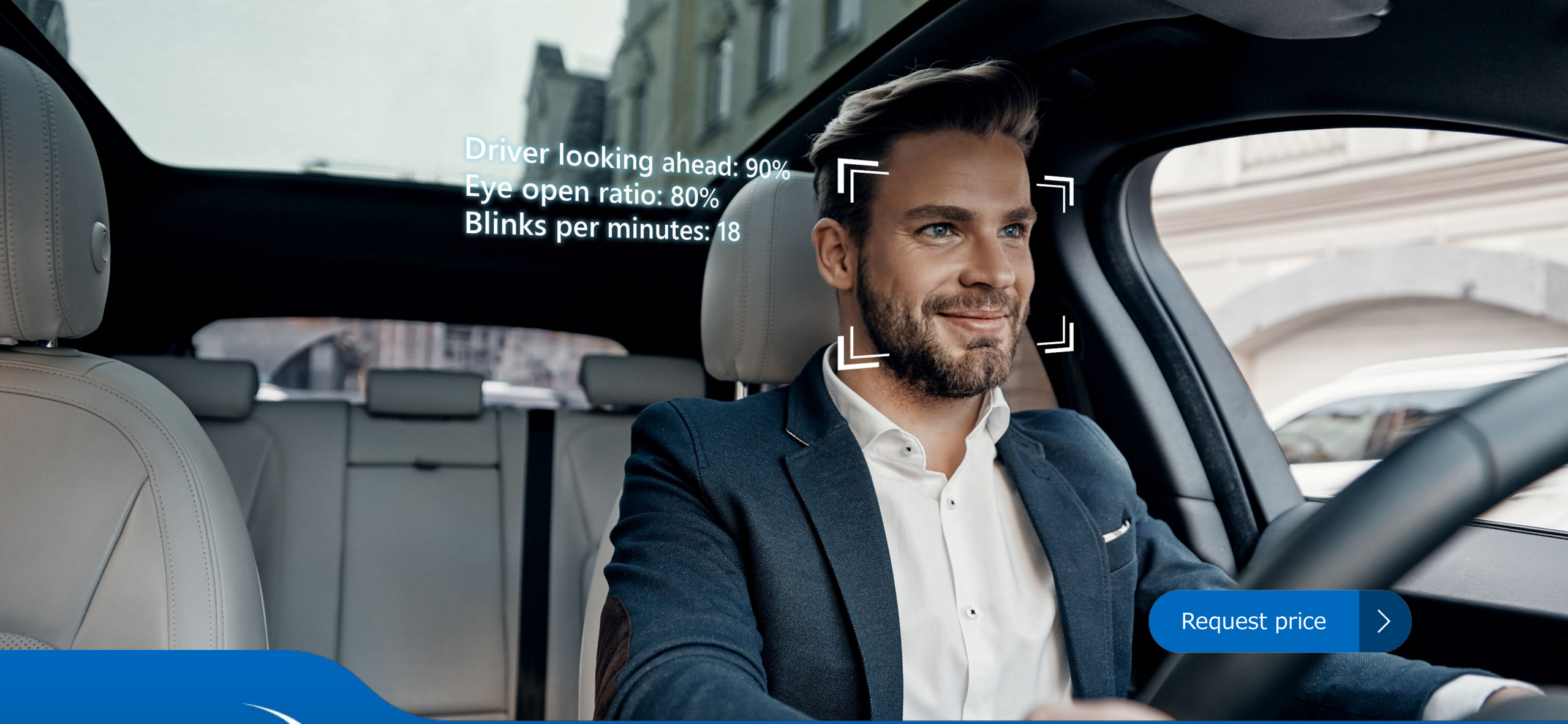

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January 2022

AUT810-22

DRIVER AND CABIN MONITORING

Eco-system, technology, market size & future challenges

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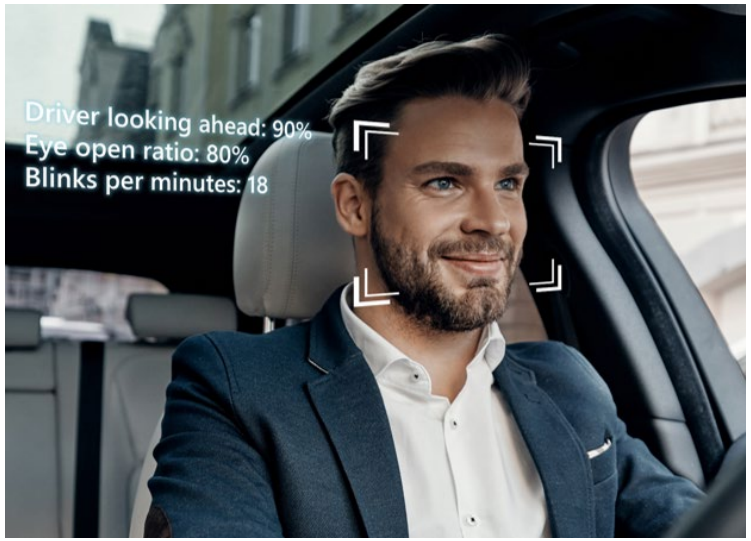
Introduction

Introduction

The topic of **Driver Monitoring** has gained significant momentum, especially due to European homologation requirements from **2022**. Up until now OEMs did not need to deploy such systems and the vast majority of them either ignored this feature or only introduced some very basic systems.

This is however about to **change**, not just because of new regulations but also with the advent of more advanced levels of **vehicle automation**. More competent driver monitoring solutions are an **enabler** to more **robust SAE L2** and are a **requirement** for **SAE L3**. The problematic of monitoring the driver both physically and cognitively becomes critical to ensure a **safe interaction** between **human** and **machine**.



Driver Monitoring

- This report explains the **key influencing factors** (legislation, consumer group testing and higher levels of vehicle autonomy) for the introduction of driver monitoring in **USA, EU & China**. The **long term needs** are explained, drawing some parallel with the aviation industry and reviewing the academic literature.
- The **different technologies** with their **pros and cons** are explained. A **comprehensive** view of the **ecosystems** is provided by profiling Tier 1 & Tier 2 active in this space. **OEMs** recent **initiatives** and **R&D demonstrations** are also documented.
- From the **understanding** of the **different dynamics** in each regions (USA, EU & China) and the current and future drivers, a **driver monitoring forecast** in terms of unit sales and Tier 1 revenue is provided.

Child presence detection

- Within the vehicle cabin, child presence detection is an **emerging functionality**. Solutions so far have been quite basic but with the possible introduction of **NCAP testing in 2023**, Tier 1s are under pressure for providing solutions. An **overview** of the possible options and main players is provided.

Example slides from the report

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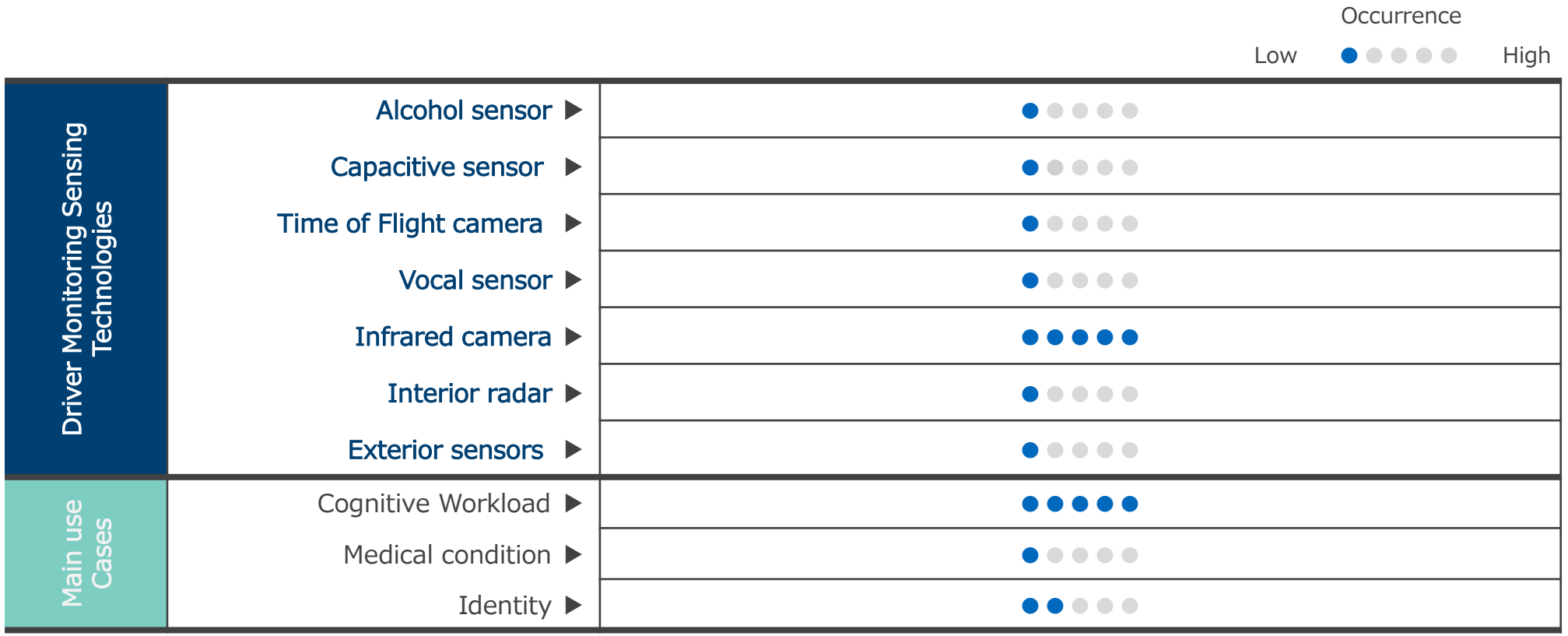
Vision Based Solutions are Becoming the Norm

Traditionally driver monitoring systems have been **quite primitive** in their ability to measure driver's state in real-time. However, OEM's and Tier 1 suppliers have started to introduce **more sophisticated** methods using direct measurement.

These systems can monitor in real-time aspects of the driver including: **cognitive workload (e.g. drowsiness level, distraction level, etc.), medical conditions** and **physical posture.**

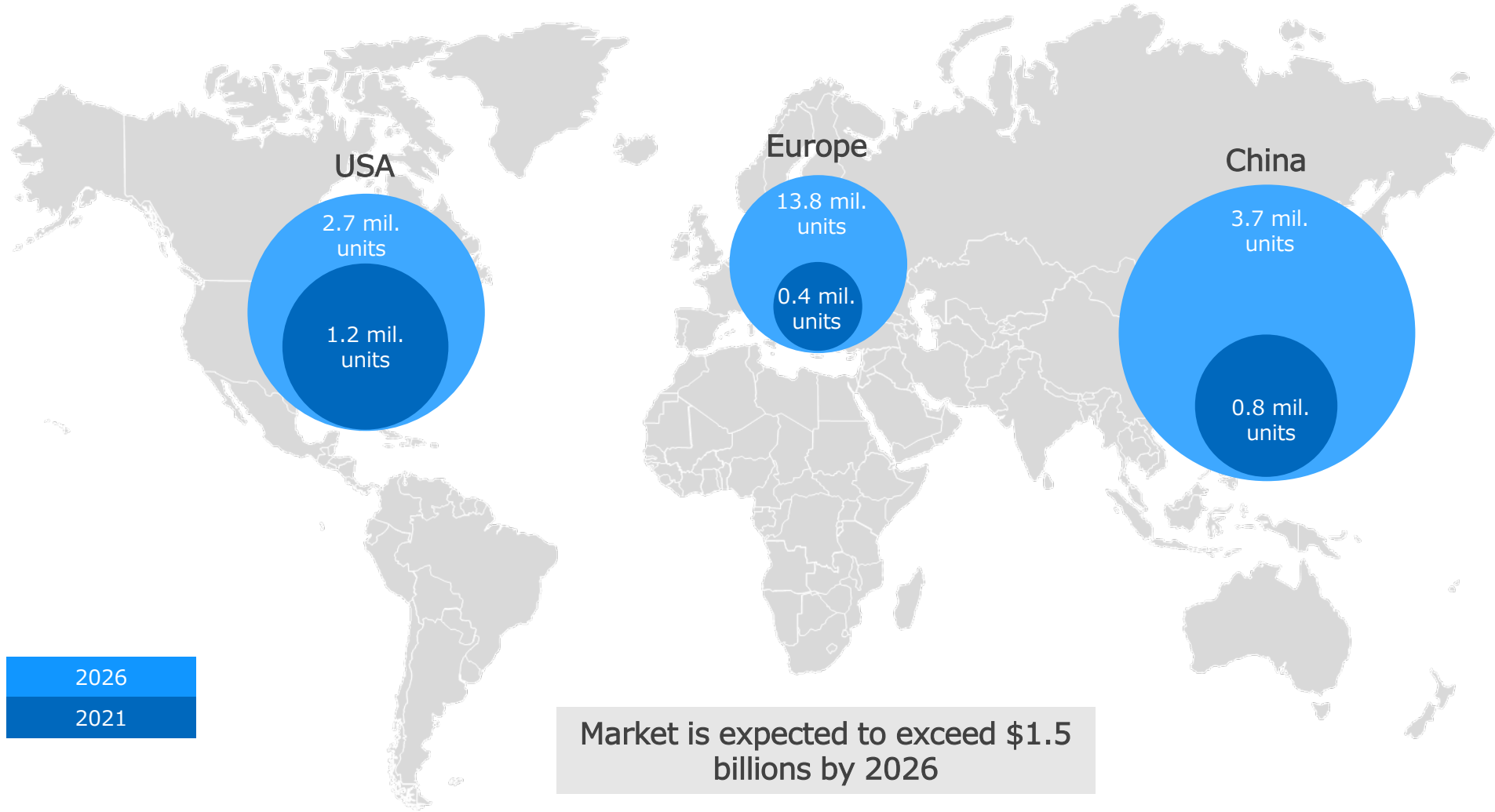
The most common sensor being used to monitor these parameters are **vision based systems such as infrared or time-of-flight cameras** due to the inherently rich data they can provide and the recent progress in artificial intelligence.



Driver Monitoring Camera Market

USA with about 1.2 million units, has got majority of the driver monitoring camera market in 2021.

By 2026, it is expected that China will be the biggest market for driver monitoring camera.

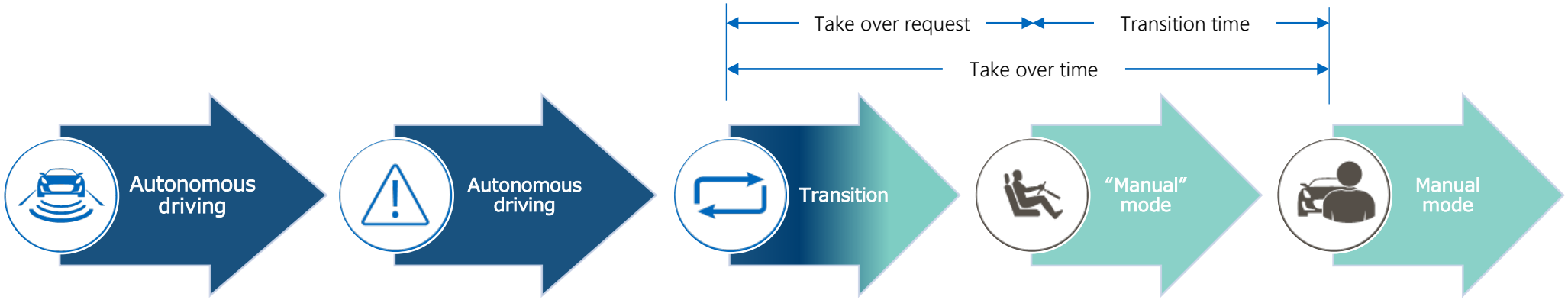


Market is expected to exceed $1.5 billions by 2026

Need for Driver Monitoring Systems at SAE L3

Sophisticated driver monitoring systems will be crucial for the safe operation of SAE L3 systems. These systems will be required to analyse the driver's ability to take control of the vehicle after a transition from automated to manual driving. This must be determined after the driver has not been engaged in the driving task for a prolonged period, which will likely cause a reduction in their alertness and attention level.

Transition from automated to manual driving for a SAE Level 3 system



Autonomous driving

Multi-stage warnings are issued to alert the driver

Take-over request issued

The driver has just taken over control of the vehicle

Driver in full control of the vehicle

The take-over request must be issued to the driver with sufficient time for them to regain alertness and understanding of the situation.

The warning time will vary depending on factors such as their cognitive load and body position. To determine a suitable warning time, a driver monitoring system must be used.

Driver monitoring will be required after the driver has taken hold of the steering wheel.
Once the driver has transitioned to manual mode, they may not be able to safely control the vehicle due to them being out of the loop for a sustained period of time. The vehicle may have to take further actions until the driver is estimated to be in full control.

Ford

Driver State	Key parameters to be monitored	
Cognitive Workload	Gaze direction	✓
	Pupillometry	
	Eyelid movement	✓
	Brain waves	
	Heart rate	
	Skin conductance	
	Respiration	
	Body temperature	
	Breath analyser	
	Blood alcohol level	
	Head posture	✓
	Facial expression	
	Monitor in-car devices	
Physical Position	Driver position	
	Seat belt/Occupancy	
	Hands on wheel	
Medical condition	Brain waves	
	Heart rate	
	Blood pressure	
	Skin conductance	
	Respiration	
Identity	Driver identification	

Key Highlights

- Ford has introduced an infrared driver-facing camera (mounted on top of steering column) as part of the Ford Co-Pilot360 technology. The driver monitoring system is able to track head position and driver eye gaze to ensure driver is paying attention to the road while it is in hands-free mode.
- If the system detects the driver is distracted, it will notify the driver to pay attention or to resume the control of the vehicle. If still there is no response from the driver, the vehicle slows down until the driver pays attention again.
- Active Drive Assist started rolling out on select 2021 model year Ford vehicles and will be available across the Mustang Mach-E line-up.
- The camera-based driver monitoring technology is based on the FOVIO system from Seeing Machines and integrated by Veoneer.

Project Partners

seeingmachines

veoneer

Interior Monitoring

Alcohol sensor

Capacitive sensor

Time of Flight (TOF) camera

Vocal sensor

Infrared (IR) camera

Interior radar

Exterior Monitoring

Exterior Sensors

Research | Concept | In Development | Production

	Low	High
Cost		✓
	Easy	Hard
Integration		✓
	Invisible	Visible
Blending in		✓

Potential Sensors

The sensing system must accurately determine if there is a child left in the car and be able to differentiate between a non-living object and a child. Presence detection of a human being is possible by using thermal, motion, pressure, carbon dioxide or distance measurement methods. To choose the right sensor it is important to be aware of the reliability, range, response time and cost implications. The following slides give an overview of the sensor types available today and which Tier 1 use them in their R&D effort.

Sensor Type	Description
Thermal	Thermal sensors are able to detect the presence of a human by picking up emitted body heat. Some advantages of thermal sensors include the ability to work through a non-contact method and robustness. However, these sensors are usually high cost and the detection capability depends on picking-up heat difference between different objects.
Radar	Radar sensors have the ability to see through clothing and can detect breathing as a mean of detecting the presence of a child. Additionally, detection times can be under 5 seconds and detection ranges can reach 10 meters. However, radar based solution may have higher power budget requirements.
Ultrasonic	Ultrasonic sensors are very common for measuring short distances to an object (e.g. parking aid). However they are quite crude and an array of them would be required together with complex algorithms to reliably detect a human presence.
CO_2	Carbon dioxide sensors can determine the presence of a child inside the car by measuring the amount of CO_2 inside the vehicle. CO_2 sensors have an advantage in that they can detect multiple occupants at the same time and are reliable even in air conditioned cabins. The drawbacks of the sensor are that they becomes unreliable if windows are opened and can need up to 5 minutes to work accurately.
Pressure	By combining multiple pressure sensors together it is possible to detect the difference between a person, a child or another object. With a specific algorithm it is also possible to detect small movements like breathing. However the algorithm needed to detect humans can be very complex in nature and reliability still to be proven.
Camera	Cameras (3D in particular) can detect occupants in real time. However, the system would require complex AI to distinguish between all possible postures and minimise false detection. The positioning of camera is also critical and multiple cameras are likely to be needed in order to cover for different car seat positions (front facing / rear facing).

Driver Monitoring Requirement per SAE Levels

L0 L1 L2

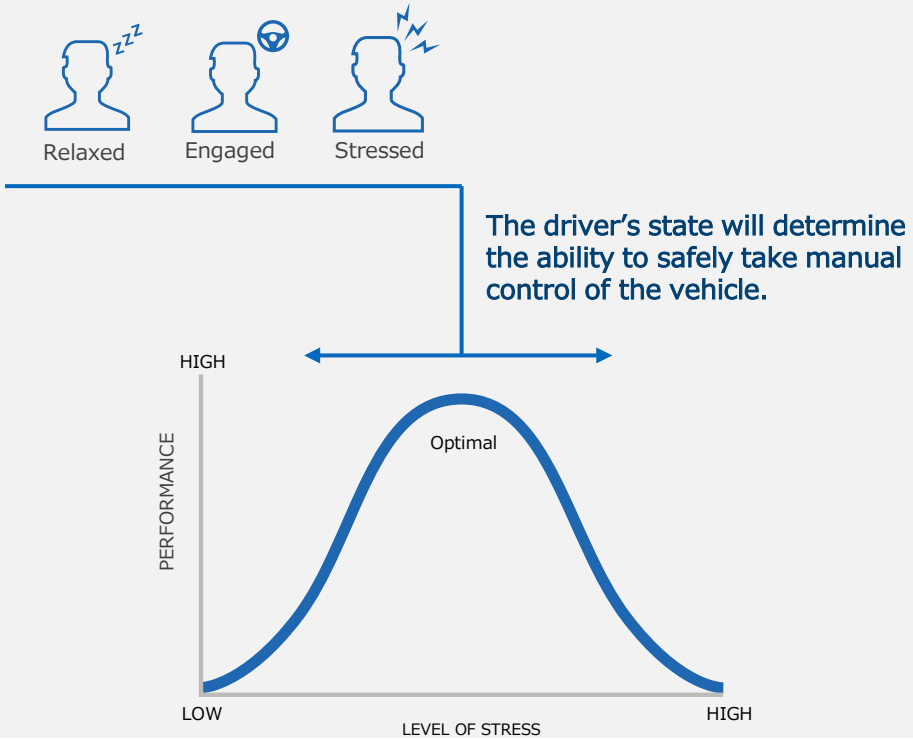
Driver in complete control

Driver monitoring can enhance vehicle safety by alerting when a break should be taken.

L3 L4

Conditional and highly automated driving

A driver monitoring system is needed to assess the drivers mental and physical status. This will enable the transition from automated to manual driving to be optimised and completed safely.



L5

Full automation

No driver monitoring system is needed

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Head of AV research

Deepa Rangarajan
Senior Specialist

Howard Abbey
Senior Specialist

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Simon Halford
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