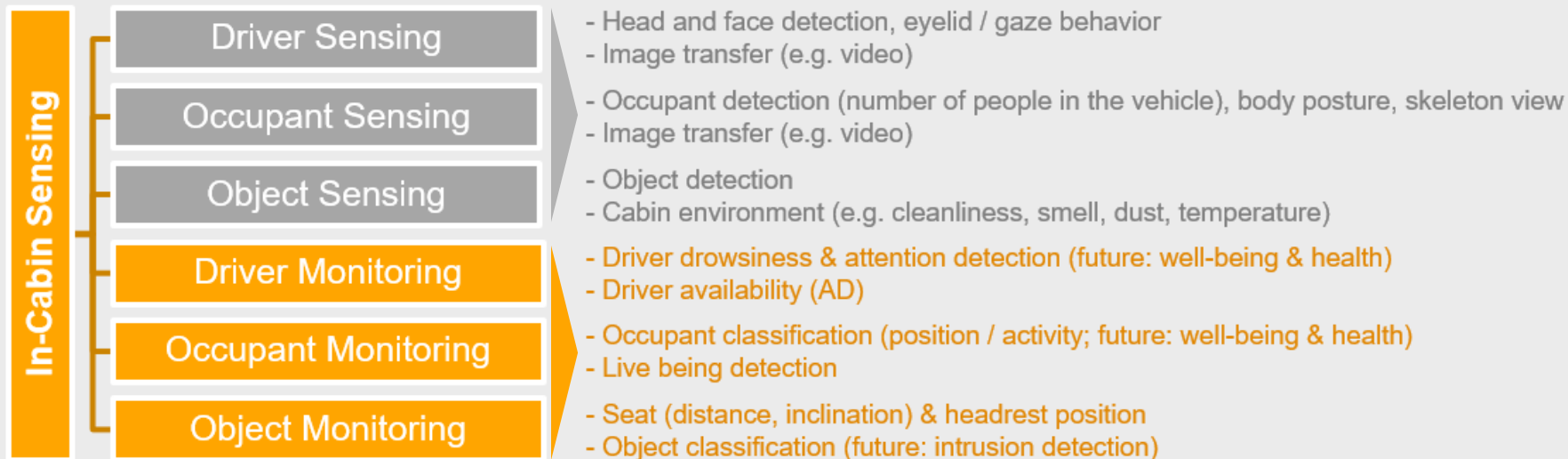


IN-CABIN SENSING - FUTURE VIEW FOR PASSENGER VEHICLE APPLICATIONS

In-Cabin Sensing @ Continental

Overview & Scope



- › **Sensing:** One of the 5 natural powers of sight, hearing, feeling, taste, and smell, that provides us information about the things around us
- › **Monitoring:** To carefully watch and check a situation in order to see how it changes over a period of time



EuroNCAP Regulations Requirements



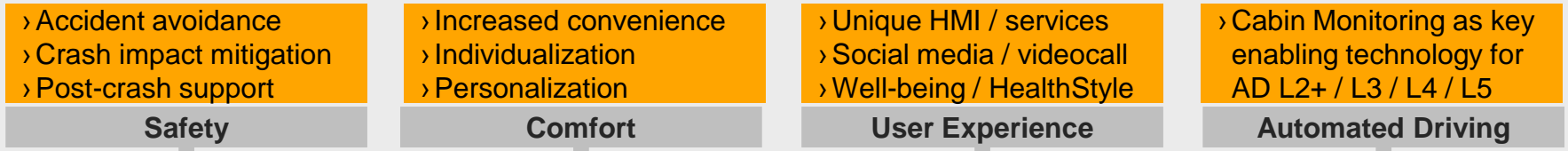
Regulations:

- › Driver drowsiness
- › Driver availability
- › Driver attentiveness
- › Driver visual distraction
- › Child presence detection
- › And further



In-Cabin Sensing

Market Influencing Factors



In-Cabin Sensing

Legislation and assessment programs

Driver drowsiness

Visual distraction

Driver availability

Driver attentiveness



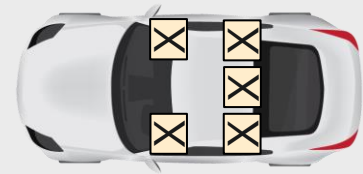
*GB-T (China) under discussion

In-Cabin Sensing

Example: Use-Cases versus required Sensorics



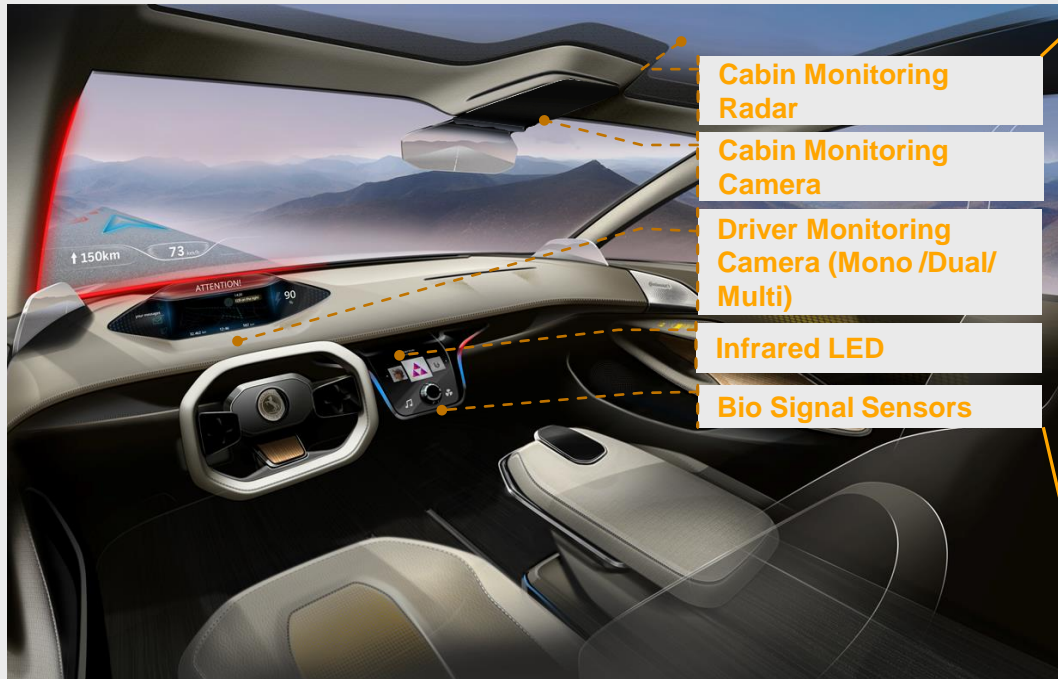
Use-Case	Passengers involved	Sensorics needed
<ul style="list-style-type: none">Hands on Wheel DetectionAttentiveness, distraction and drowsiness detection	Only Driver	Driver Camera (NIR)
<ul style="list-style-type: none">Child presence detection (child left behind)Child presence detection for restraint deploymentSeat Occupant for seat belt reminder	All In-Cabin passenger are involved	In-Cabin Radar (60GHz)



*NIR= Near Infrared, GHz= Gigahertz

In-Cabin Sensing

Sensing Devices & Mounting Positions



- › **Cabin Monitoring Camera & Radar**
 - › Hands-on wheel detection / Free-air gestures
 - › Body / pose tracking / Child presence detection
 - › Occupant (presence) detection & classification
 - › Activity classification / context information
 - › Live in-vehicle view / Intrusion detection
- › **Driver Monitoring Camera**
 - › Presence detection
 - › Head- / eye-tracking incl. gaze direction
 - › Sleepiness / drowsiness detection
 - › Distraction detection
 - › Identification (personalization / authentication)
 - › Facial expression (e.g. emotions)
 - › Video calling / social media
- › **Infrared LED Proximity Detection**
 - › Proximity & gesture detection
- › **Bio Signal Sensors**
 - › Heart rate / breathe rate
 - › Temperature / air quality
 - › Intoxication

In-Cabin Sensing

Applications Based on Camera & Radar

Occupant Detection

- › Child presence detection (CPD)
- › Seat occupant detection
- › Number of passengers

Vital Sign Detection

- › Respiration rate (RR)
- › Heart rate (HR)
- › Heart rate variability (HRV)



In-Cabin Sensing

Use Case - Child Presence Detection (CPD)



Sensing technology

- › Radar sensor with a carrier frequency of 60 GHz (mm-wave radar)
- › Reflected by the human body and its internal organs
- › Body functions such as the heartbeat and the breathing modify the radar signal when it is reflected back to the receiver (Doppler effect)
- › This modulated signal provides the information from which heart rate (HR) and breath rate (BR) of an occupant/child or pet animal can be calculated.

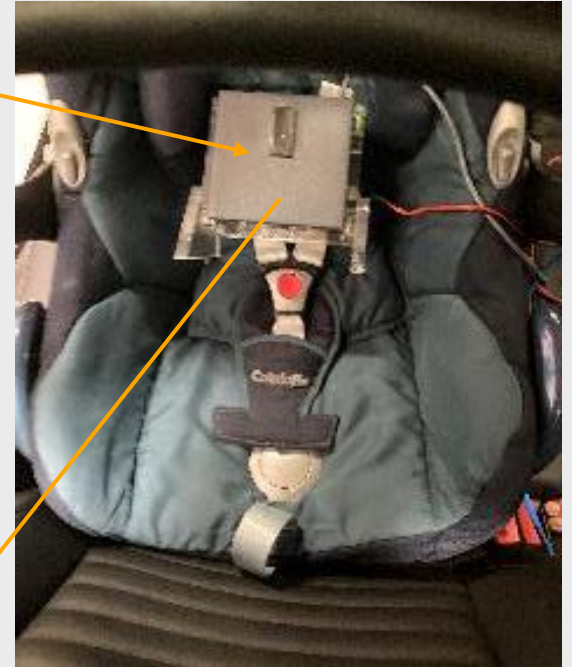
In-Cabin Sensing: Radar Technology

Baby & Child Surrogate for CPD Study

Configuration parameters:

BRA [0-10]	BRF [5-120]	HRA [0-10]	HRF [40-200]	RBMA [0-10]
0-3	5-120	0-10	40-200	0-10
4-5	5-79	0-10	40-200	0-10
6-10	5-50	0-10	40-200	0-10

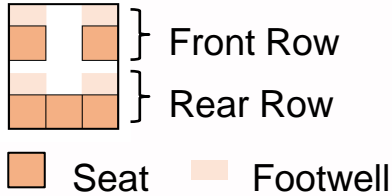
Emulator bio signal settings for **breath rate (BR/bpm)**, **heart rate (HR/bpm)** quantified by **amplitude (A/mm)** and **frequency (F/bpm)** plus **random noise (RBMA)**



Child Presence Detection

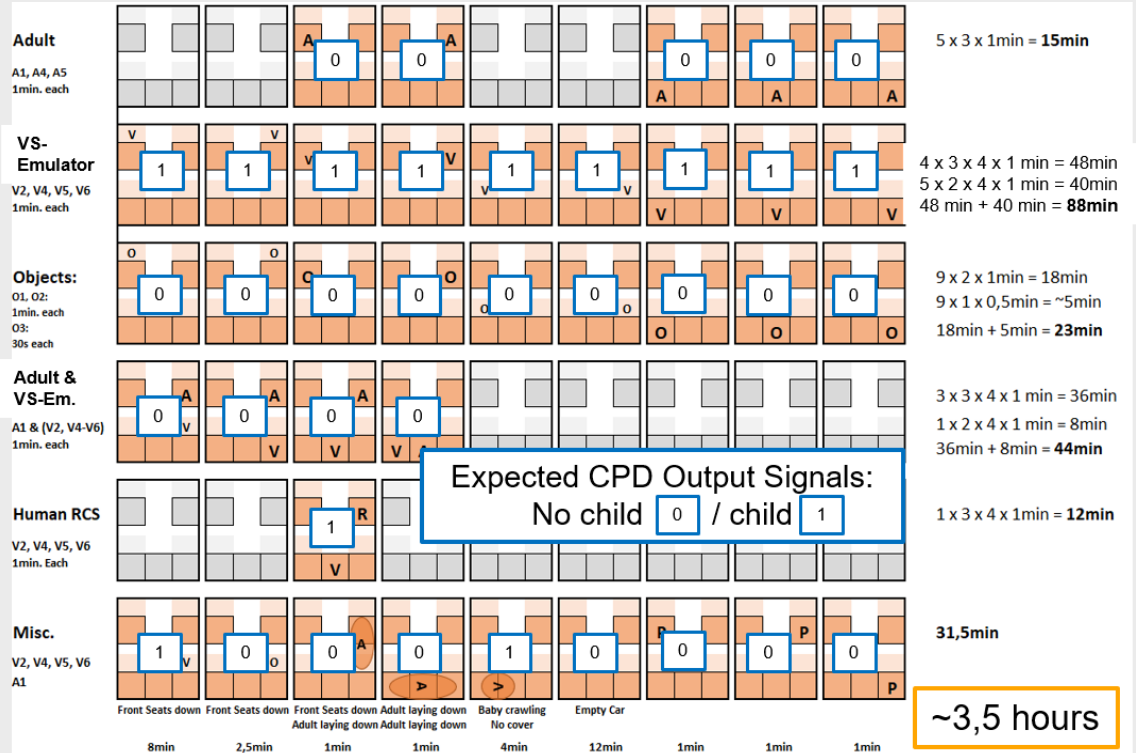
Validation for Different Positions

Vehicle Seat Map



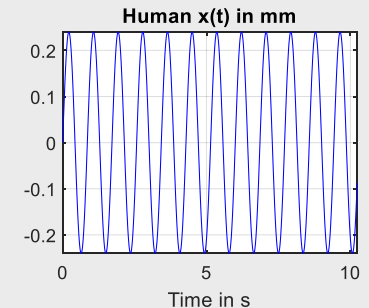
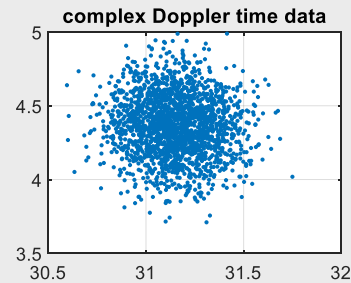
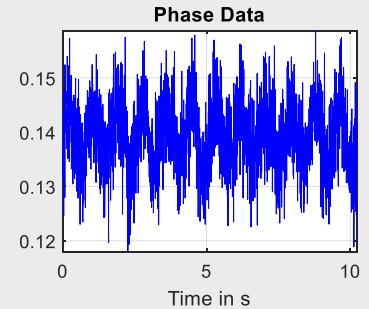
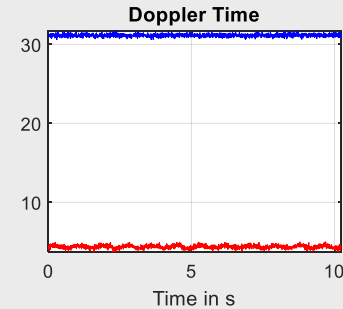
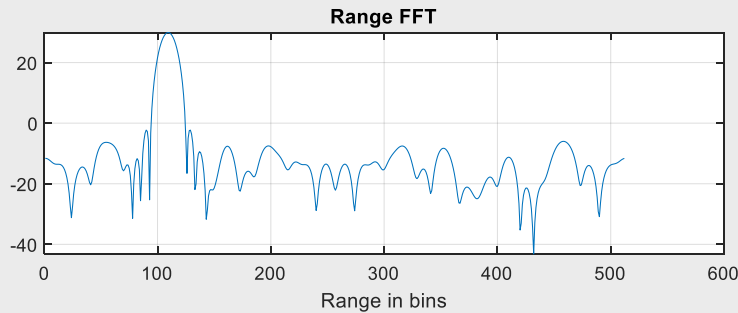
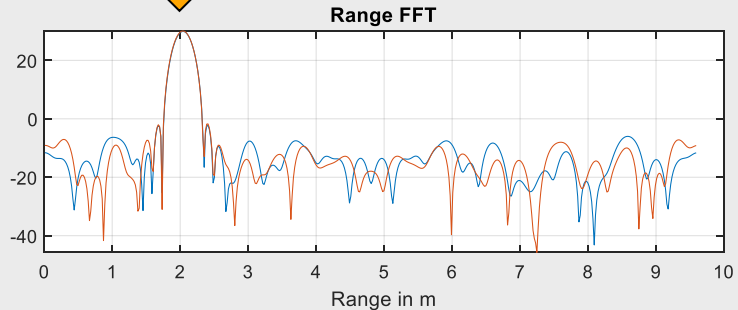
Legend

- A1-A5: Adult 1 to 5
- V: VS-Emulator=Surrogate
- S: With Suncover
- B: With Blanket
- 1 to 6: Vital Sign Settings
- O: Object
- 1: Vibrating Water Bottle
- 2: Clock
- 3: Ringing Phone
- R: Human Reflector
- P: Pet



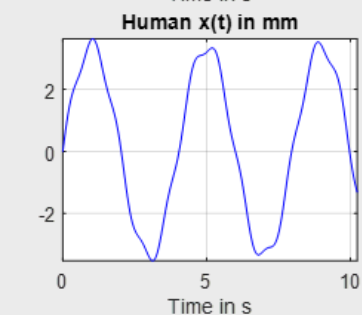
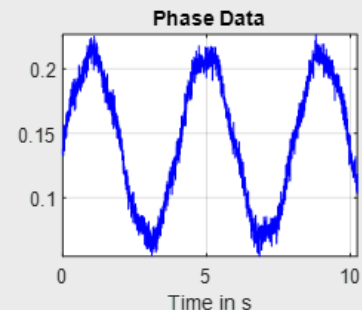
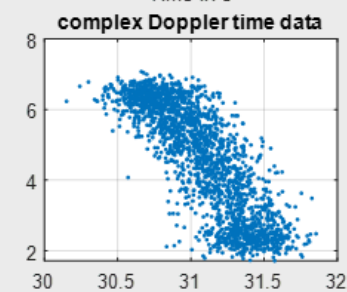
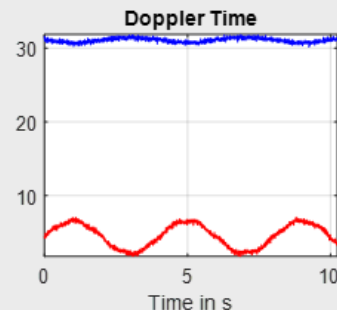
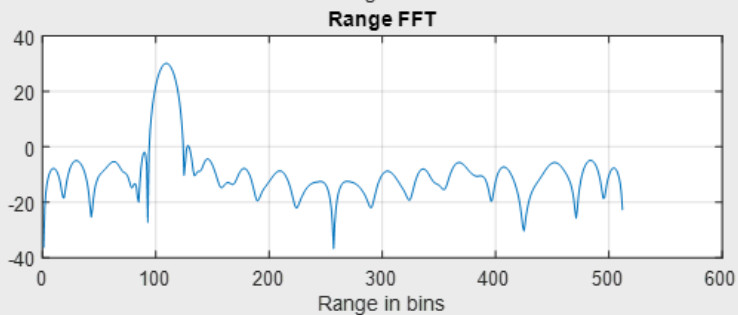
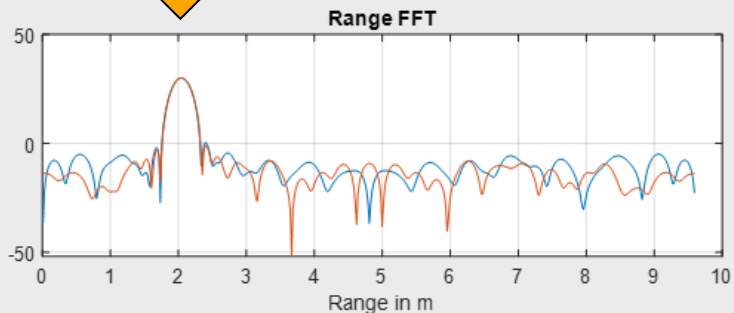
In-Cabin Sensing: Vital Signs

Human Detection - Heart Rate (70bpm)

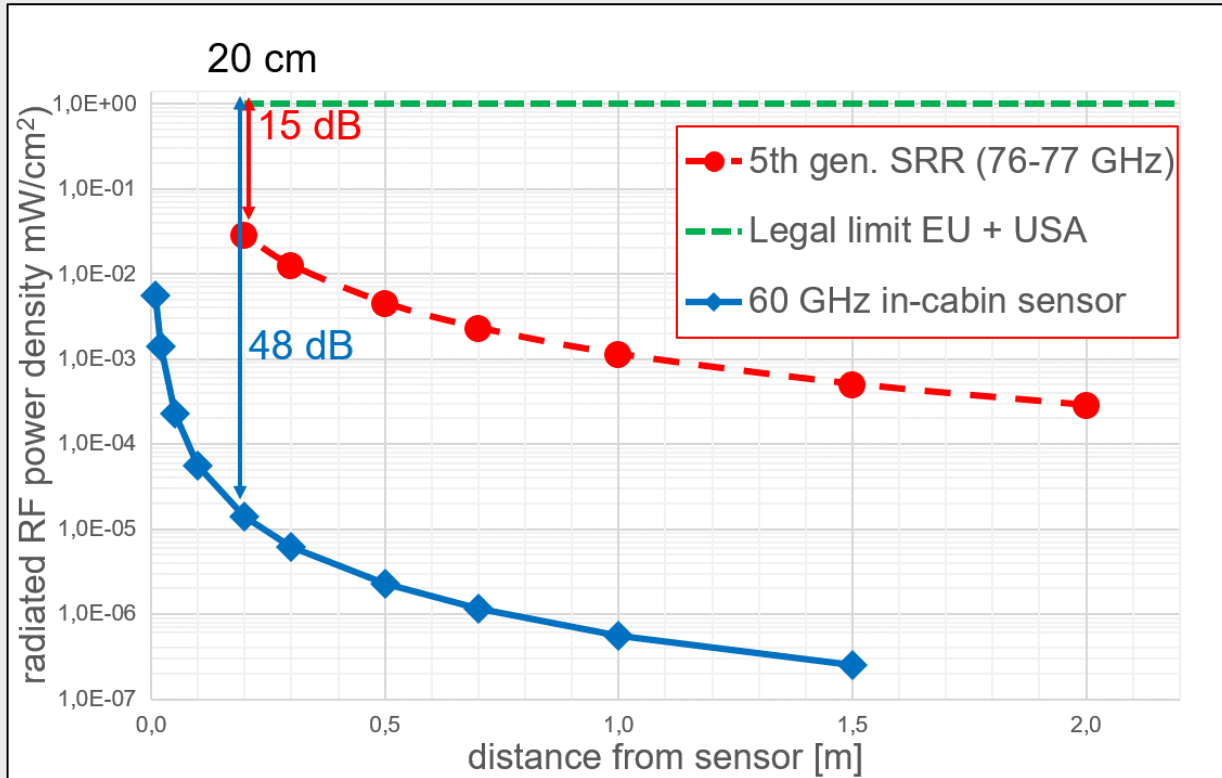


In-Cabin Sensing: Vital Signs

Human Detection – Respiration Rate (15bpm)



Radiation Measurements Overview



- Limit for human health is 1mW/cm² above 20 cm
- Measured values @ 20 cm distance
 - 76 GHz: margin "x 35" (15 dB), ACC appl.
 - 60 GHz: margin "x 71.000" (48 dB)

In-Cabin Sensing

Child Presence Detection: How to Inform the Driver?

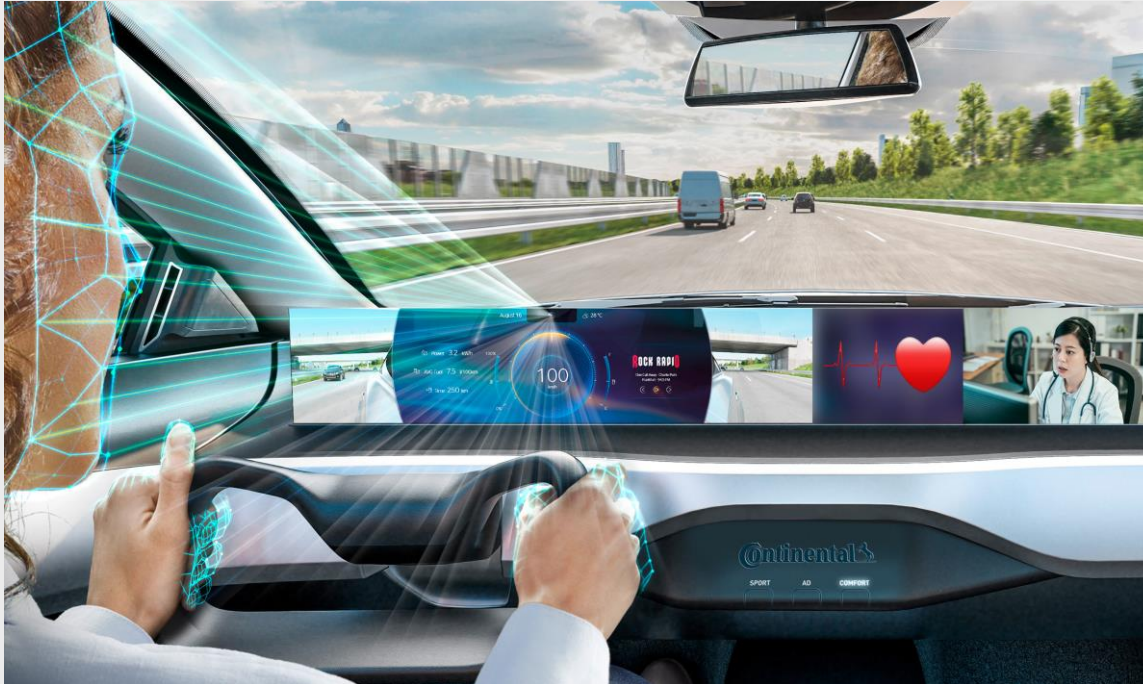


Warning output elements options:

- › **Activation of the horn** after driver has left the vehicle
- › **Activation of vehicle lighting system** (front & rear)
- › **Submit a message to driver's cellphone**
- › **Show message** within "window displays"

In-Cabin Sensing

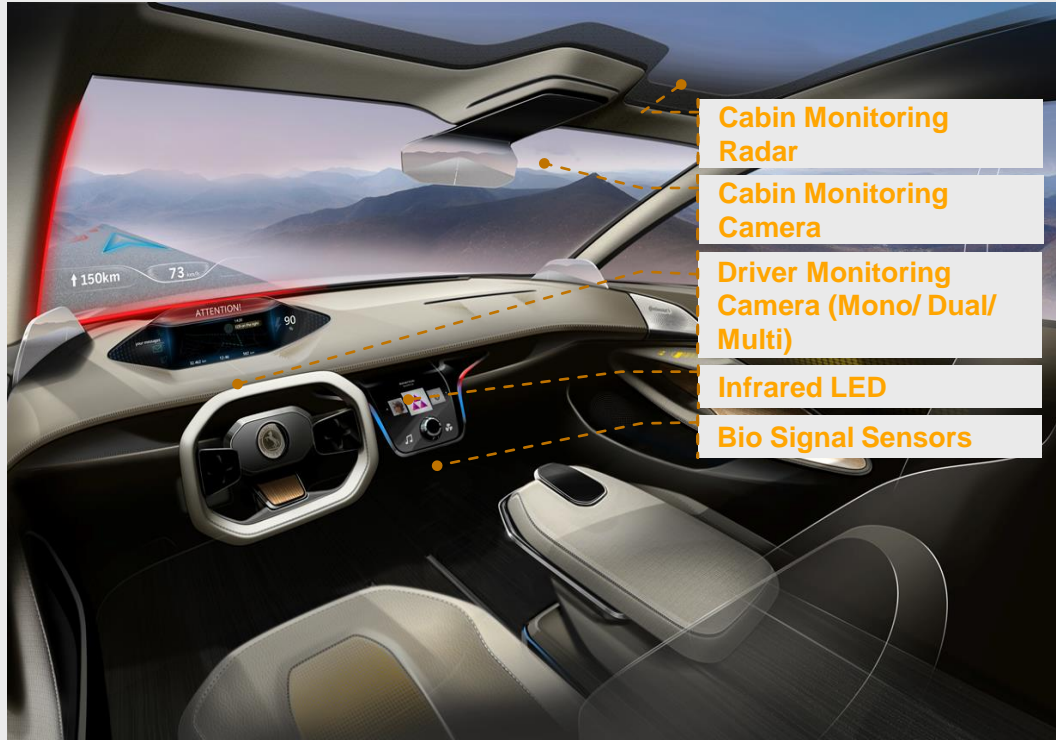
Visualization of Health Status



Health support:

- › Visualization of health status within cockpit display
- › Audio information or warning
- › Vehicle activates support call with health professional
- › If driver is incapacitated:
 - › Automated emergency call
 - › Automated vehicle minimal risk maneuver

In-Cabin Sensing Summary & Conclusion



- › **In-Cabin Sensing** solutions opens new applications in the future, e.g. **child presence detection (CPD)**, **seat occupant detection**, **number of passengers**
- › **Global NCAP regulations** are driving the market to take new products
- › **Radar technology (60GHz)** for child presence detection (CPD) was successfully evaluated and tested
- › Analyzing **radio homologation** for 60 GHz solutions shows positive results for **global market deployment**
- › First **biometrics health solutions** have been investigated in order to **identify driver's capabilities & driver availability**
- › There is wide range of **HMI solutions** to communicate In-Cabin Sensing data to vehicle driver

THANK YOU!