SMART SENSORS TECHNOLOGY AS THE FOUNDATION OF THE IOT

OPTICAL MICROSYSTEMS ENABLE INTERACTIVE LASER PROJECTION

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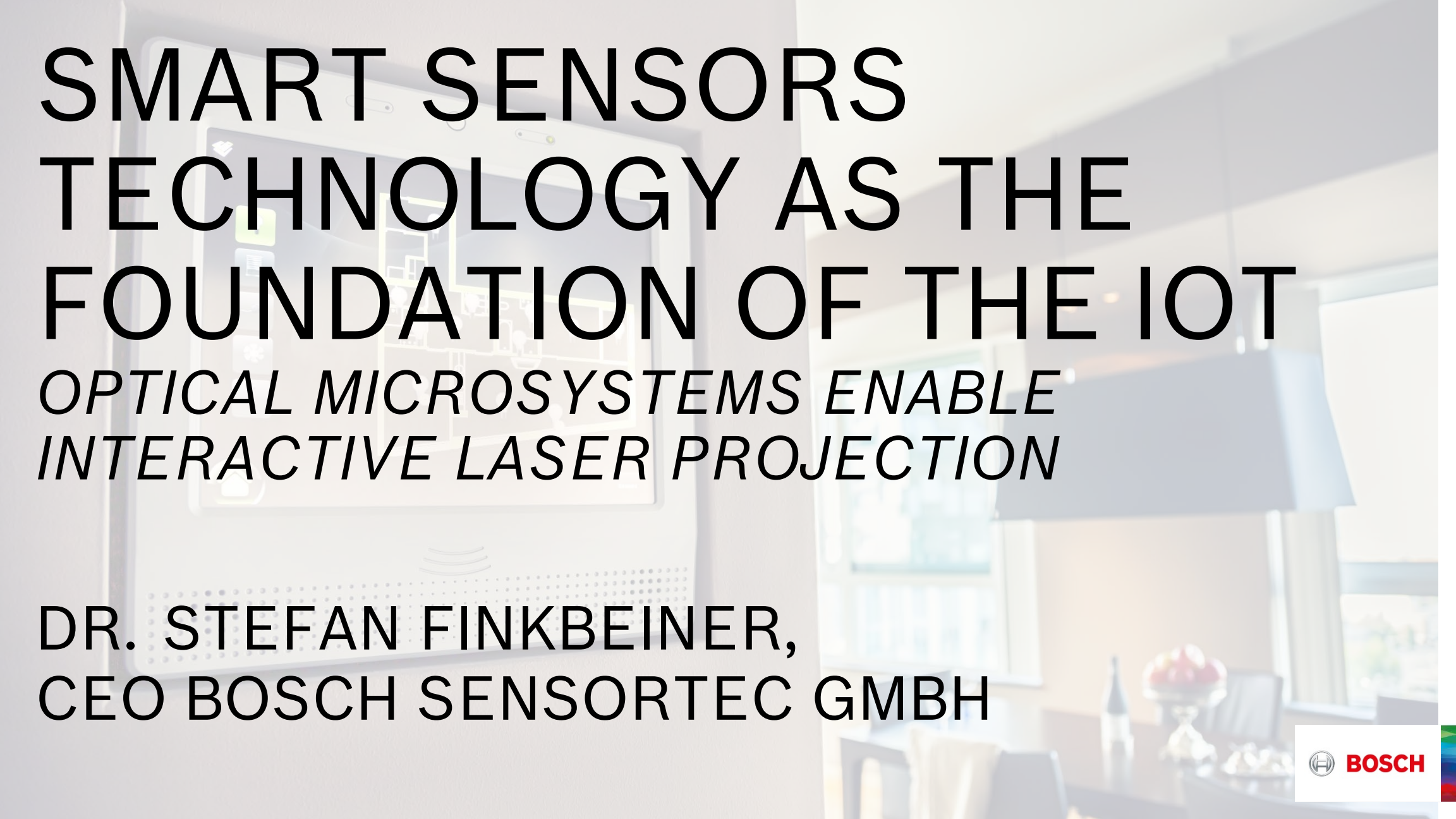
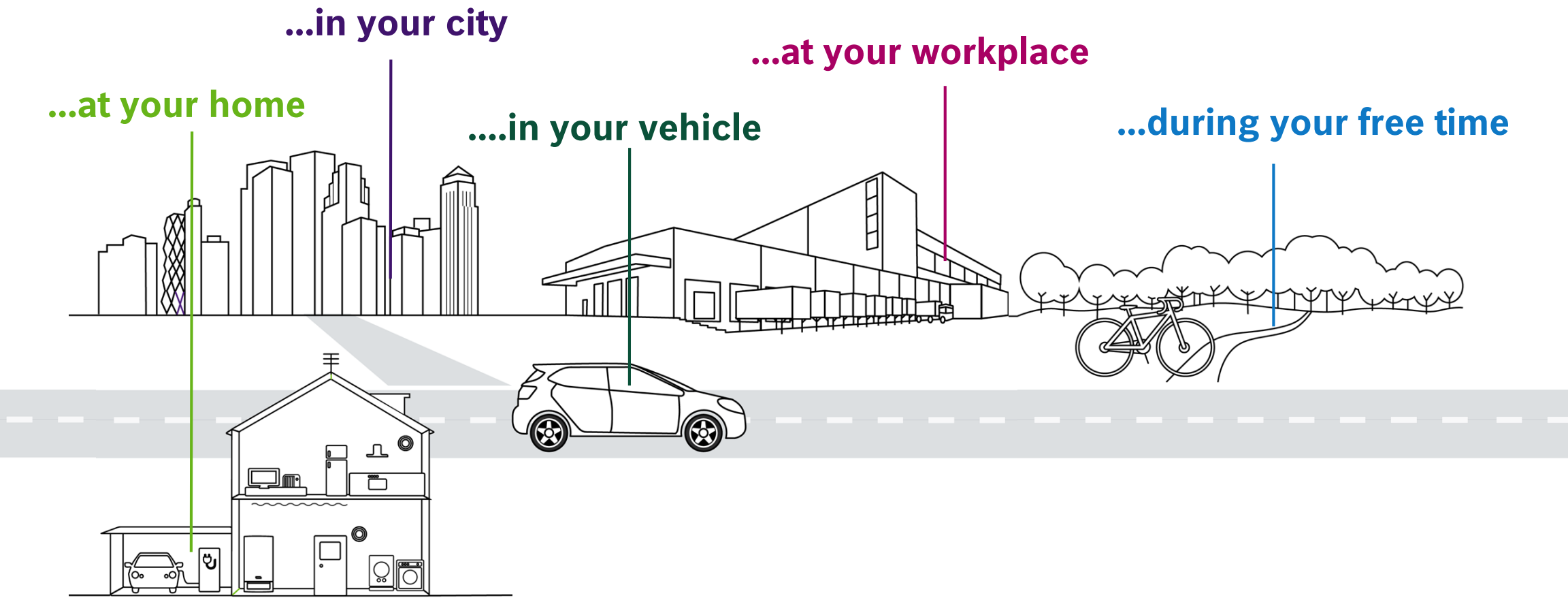
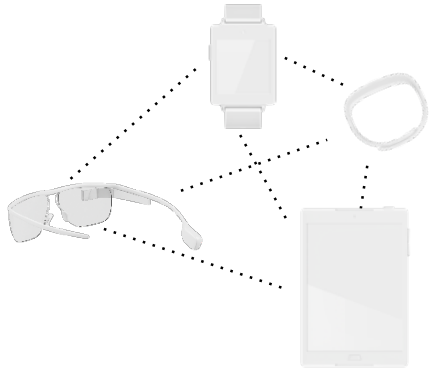


“Do you know how often you encounter MEMS sensors in your daily life?”

MEMS sensors – key technology for the connected world



How did MEMS develop?
Waves of MEMS sensor proliferation



3rd wave

Internet of Things (IoT)

2nd wave

Consumer Electronics

1st wave

Automotive

1990 2000 2010 2020

Bosch Sensortec
More than 50 MEMS sensors in 1 car

Engine Management *e.g. Diesel*

10 Sensors

1 Mass flow sensor
1 Pressure sensor [Barometric air pressure]
2 Pressure sensors [Manifold air pressure, oil]
1 High pressure sensor [Common Rail]
1 Pressure sensor [Tank pressure]
1 Pressure sensor [Start/stop function]
2 Acceleration sensors [Active engine mounting]
1 Pressure sensor [Diesel particulate filter]

Safety

27 Sensors

2 High-g acceleration sensors [Airbag]
1 Angular rate sensor, 1 Low-g acceleration sensor [Roll-over sensing],
1 Acceleration sensor (Structure-borne sound sensor) [Airbag]
4 Acceleration sensors, 2 Pressure sensors [Peripheral airbag sensors]
2 Pressure sensors [Pedestrian safety]
1 Angular rate sensor, 1 Low-g acceleration sensor, 1 High pressure sensor [ESP (incl. ACC)]
1 Angular rate sensor [Active steering]
1 Acceleration sensor [eCall]
4 Pressure sensors, 4 acceleration sensors [TPMS]
1 Pressure sensor [Occupant detection]

Comfort

17 Sensors

2 Pressure sensors [Automatic transmission]
5 Acceleration sensors [Active suspension]
1 Pressure sensor, 1 Humidity sensor,
2 Gas sensors [Air conditioning, air quality]
1 Angular rate sensor, 1 Acceleration sensor [Navigation]
3 Microphones [telephone]
1 Bolometer Array [Night vision]
1 Acceleration sensor [Car alarm]
(Seldom: 16 Pressure sensors (up to 8 pressure sensors per seat)

CE MEMS sensors in mobile devices

Inertial Measurement Unit
Integrates accelerometer and gyroscope

Accelerometer
Detects acceleration and orientation

eCompass
Combines accelerometer and geomagnetic sensor

Gyroscope
Measures yaw rates

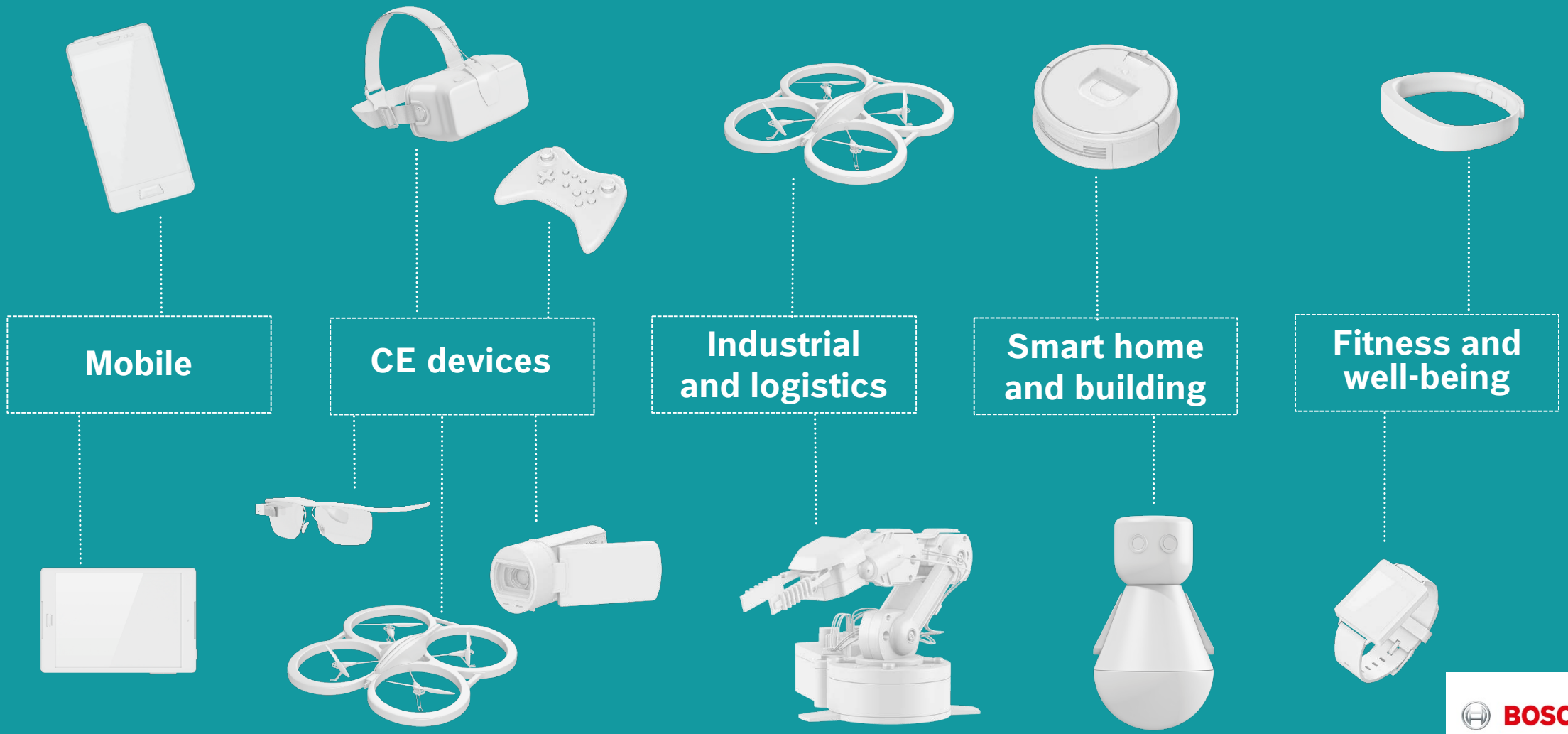
Software
Intelligently fuses raw data from multiple sensors

Microphone
Highly integrated MEMS-based microphone solution

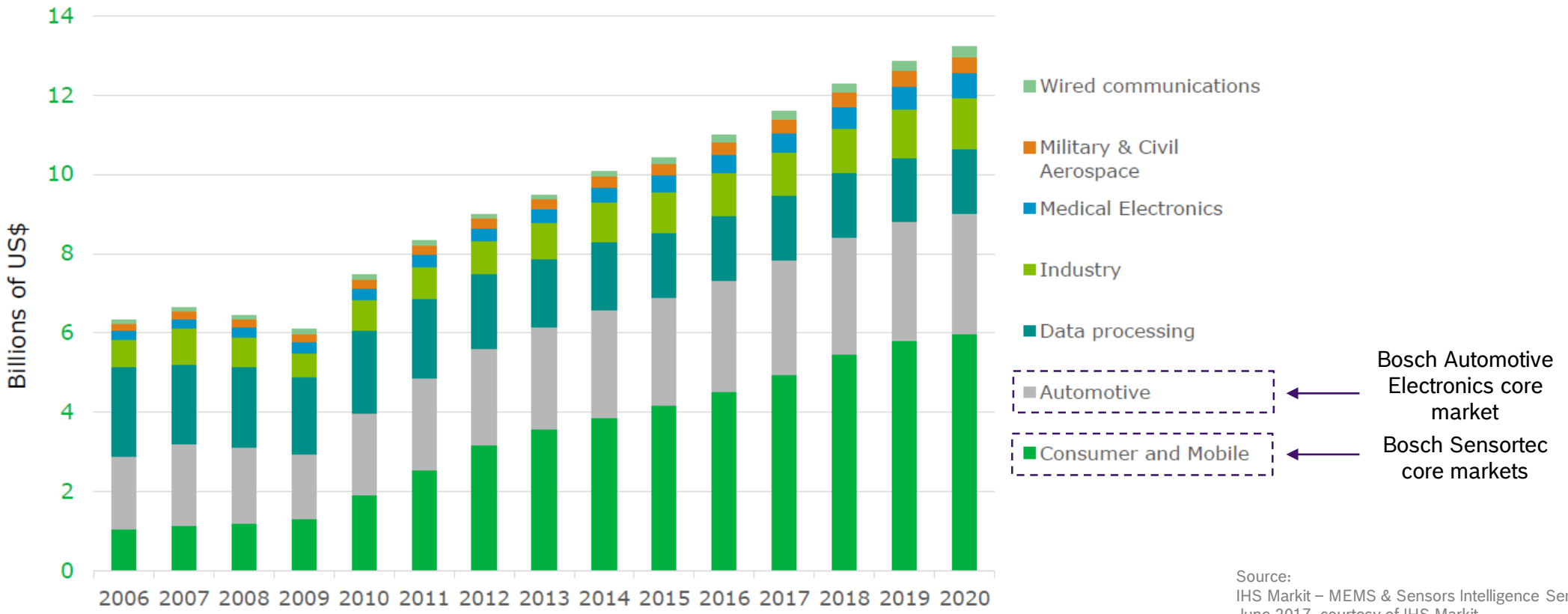
Environmental Unit
Measures pressure, humidity and temperature

Absolute Orientation
Integrates accelerometer, gyroscope and magnetometer

MEMS sensors – a multitude of devices

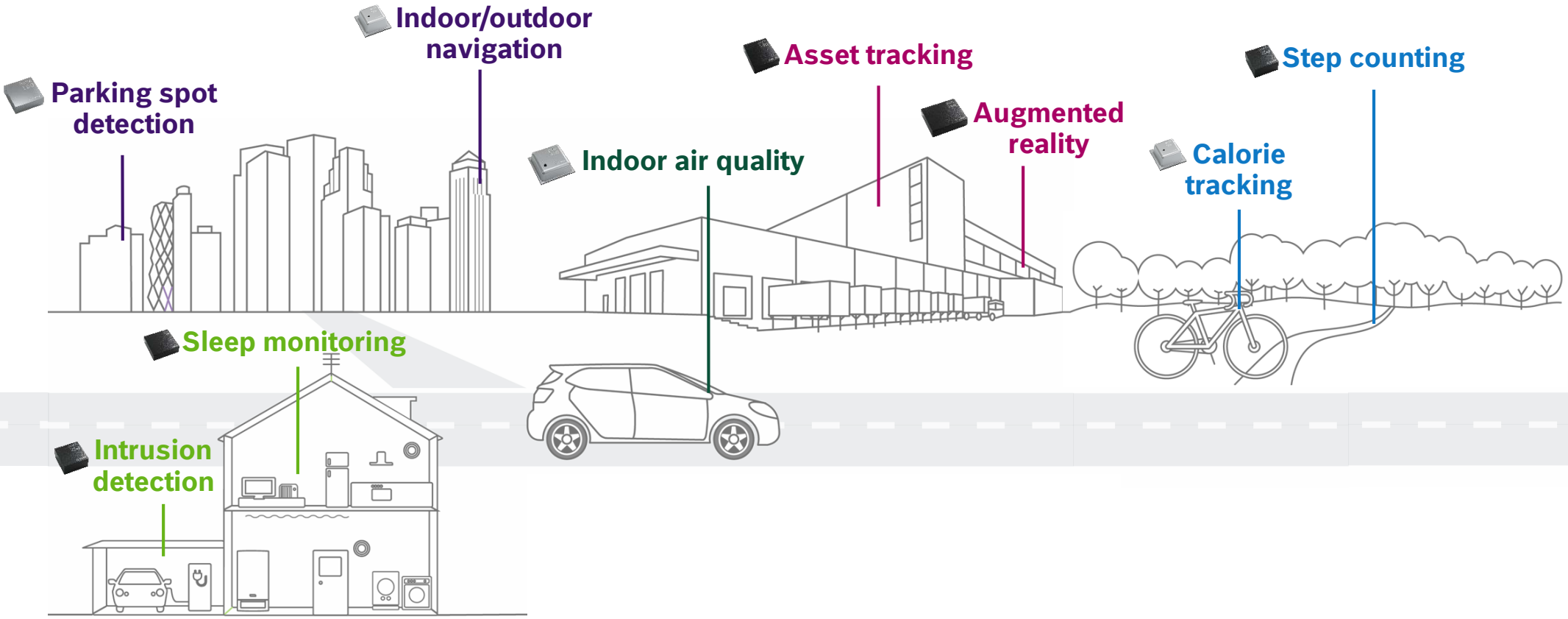


Overview / MEMS markets by application



Source:
IHS Markit – MEMS & Sensors Intelligence Service
June 2017, courtesy of IHS Markit

MEMS sensors – enablers for the Internet of Things



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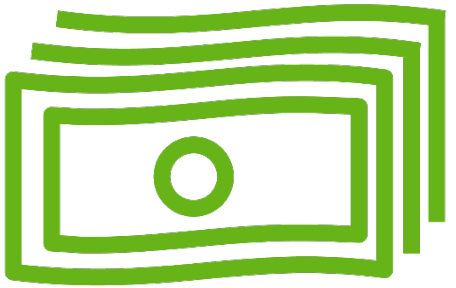
Role of smart sensors in the IoT

Everything will be connected

Today, about **6bn*** devices are connected worldwide.

By 2020, about **21bn*** devices will be connected.



By 2020, the global market for IoT solutions is expected to be worth some **250bn** USD.

Source: *Gartner

IoT is about making life simpler and more exciting.

Everything should be “Simply. Connected“ for the user.

But sensing everything in **multiple and complex environments** bears a lot of **challenges**…

Role of smart sensors in the IoT
Challenges and barriers

IoT is…

… technologically demanding

CE sensor technology

- Many technologies available…
- …but not always adapted for IoT
- Power (always-on applications), size, scalability, cost

Role of smart sensors in the IoT
Challenges and barriers

IoT is... **...fragmented**

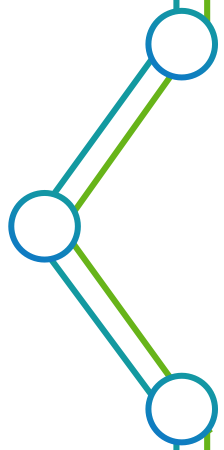
System/application customization

- Different applications: home, vehicle, city, industry, entertainment
- Deep application know-how needed
- Small volume customers
- Lack of synergies & standardization

Role of smart sensors in the IoT
Challenges and barriers

Cooperation and collaboration

- Value is in end-to-end solution
- Large and diverse eco-system
- Business models not yet established
- Fast time to market (fast prototyping)

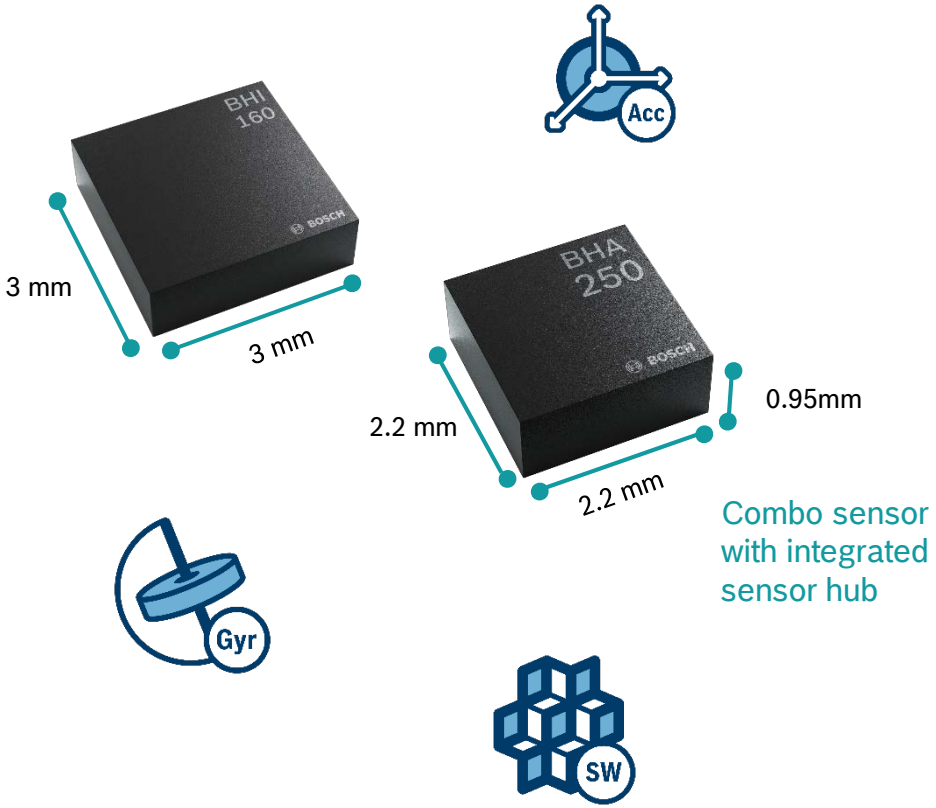


IoT is...

... complex

Role of smart sensors in the IoT

Smart sensor hubs



Combo sensor with integrated sensor hub

Integrated sensor hubs BHI160 and BHA250

SmartHub solutions combine Bosch Sensortec's…

- lowest power sensors (IMU < 1mA)
- best-in-class sensor data fusion software
- optimized microcontroller, "FUSER Core"
- … to provide the lowest power solution without compromising features or performance.

Role of smart sensors in the IoT

Driving innovation and cooperation: Smart sensor hubs

Innovation: Development of smart sensor solutions

- **Overcoming the challenge of TECHNOLOGY**
  - Leverage CORE MEMS- and system know-how
  - Size, power, performance, embedded intelligence
- **Overcoming the challenge of FRAGMENTATION**
  - Platform solution with hardware and software
  - APPLICATION know-how in the Bosch Group
  - Application-specific software, e.g. AR/VR/PDR
- **Overcoming the challenge of COMPLEXITY**
  - From components to systems and solutions
  - Simple design and TURN-KEY solution
  - COOPERATION with third parties, reference designs

Role of smart sensors

Smart sensors are sensing our world in multiple and complex environments, allow things to be “Simply.Connected” and act as the enablers of the IoT.

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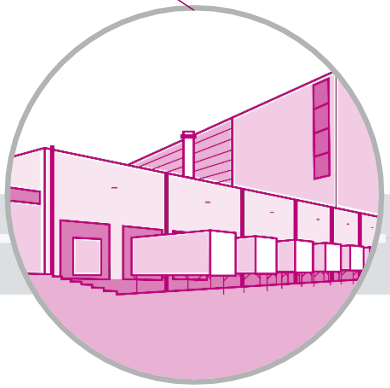
Invented for life

...at your home

....in your vehicle

...in your city



...at your workplace

...during your free time

SMART SENSOR technology is the foundation of the IoT

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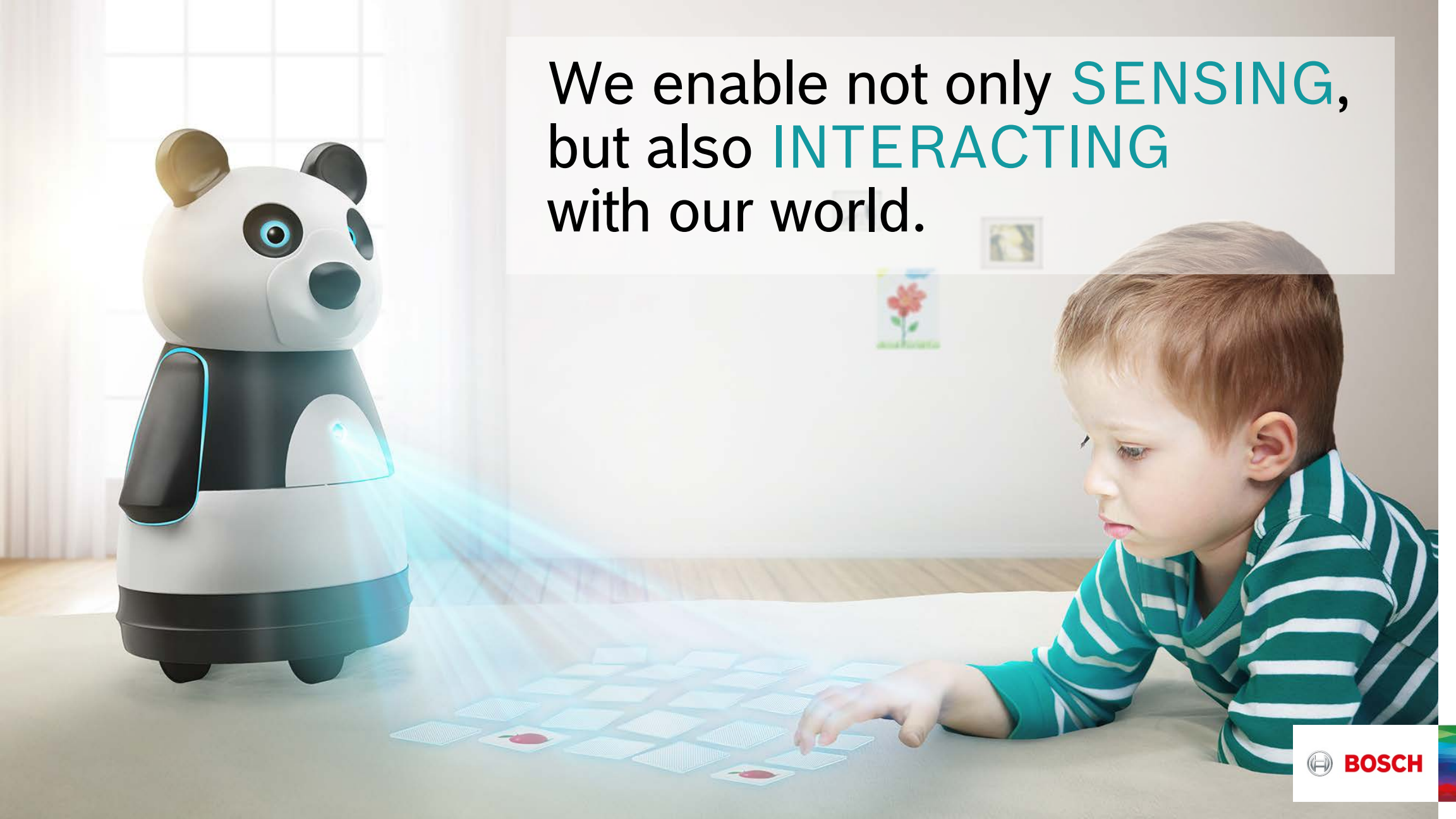
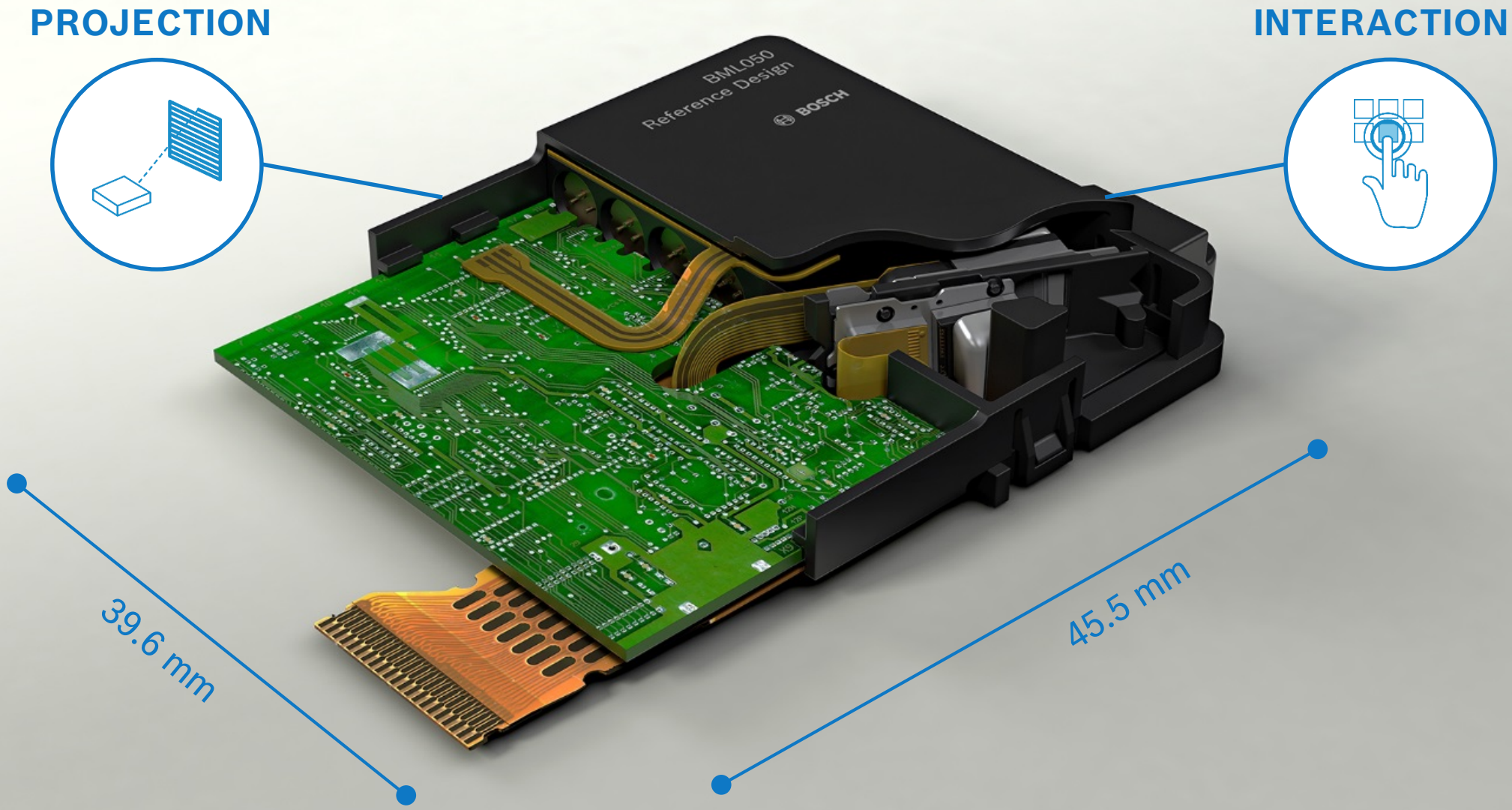
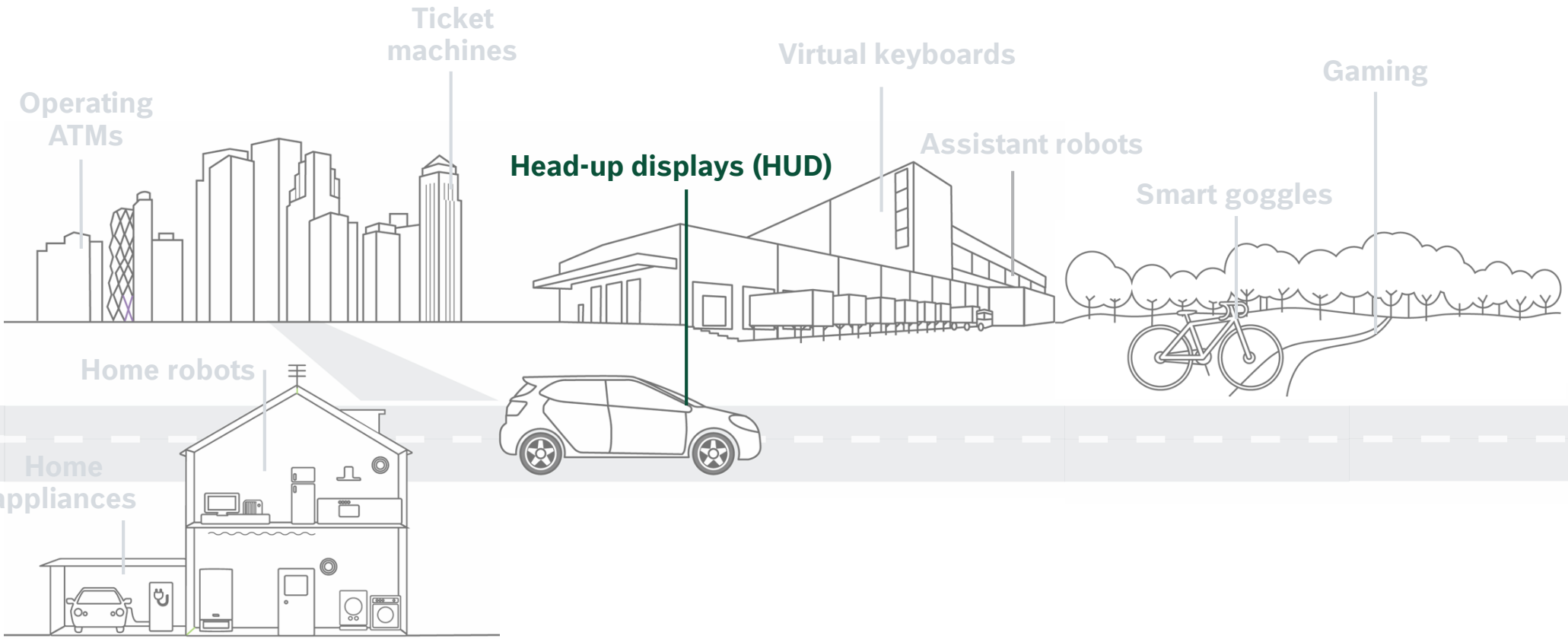

We enable not only SENSING,
but also INTERACTING
with our world.
BOSCH

Bosch microscanner BML050 for interactive laser projection

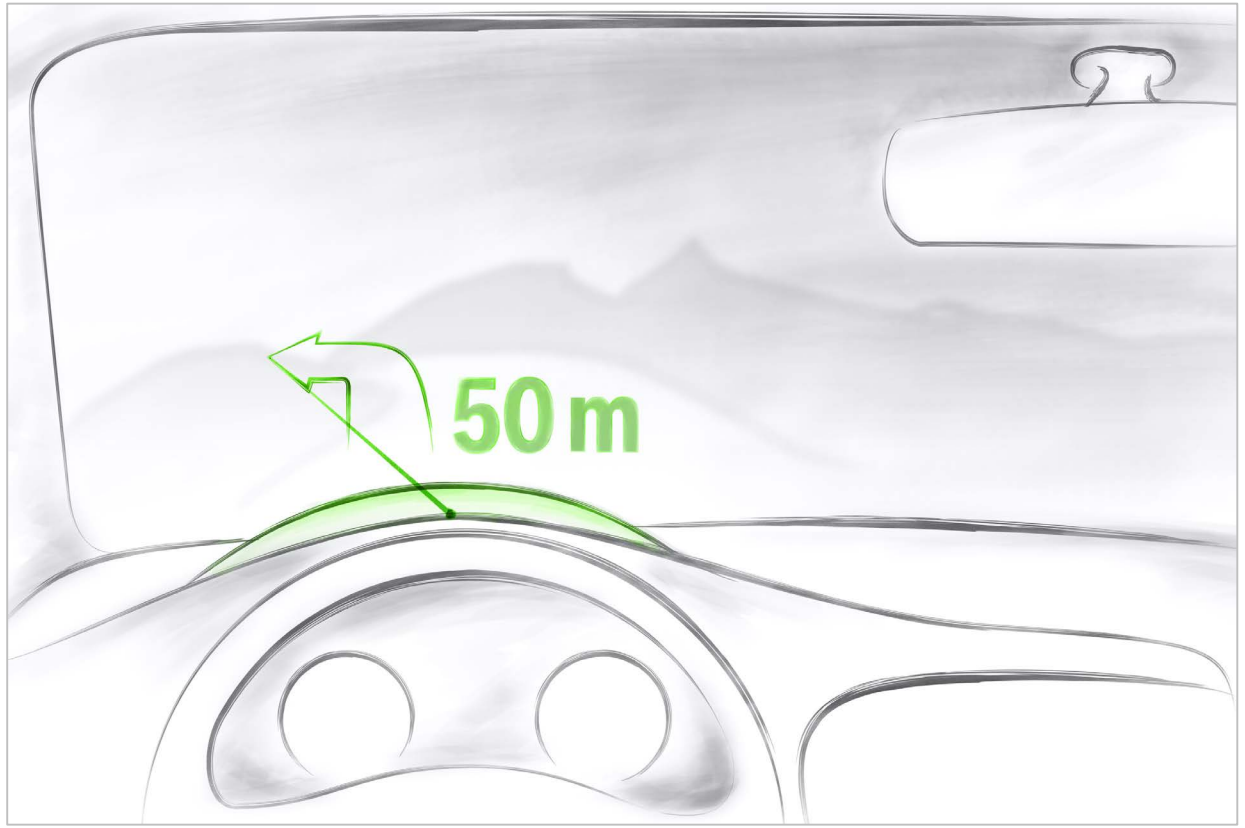
Transforming any surface into a virtual user interface


PROJECTION
INTERACTION
BML050
Reference Design
BOSCH
39.6 mm
45.5 mm

MEMS scanner – interactive projection for the automotive industry



Joint research project PICOLO



Bundesministerium
für Bildung
und Forschung

OSRAM

BOSCH
Invented for life

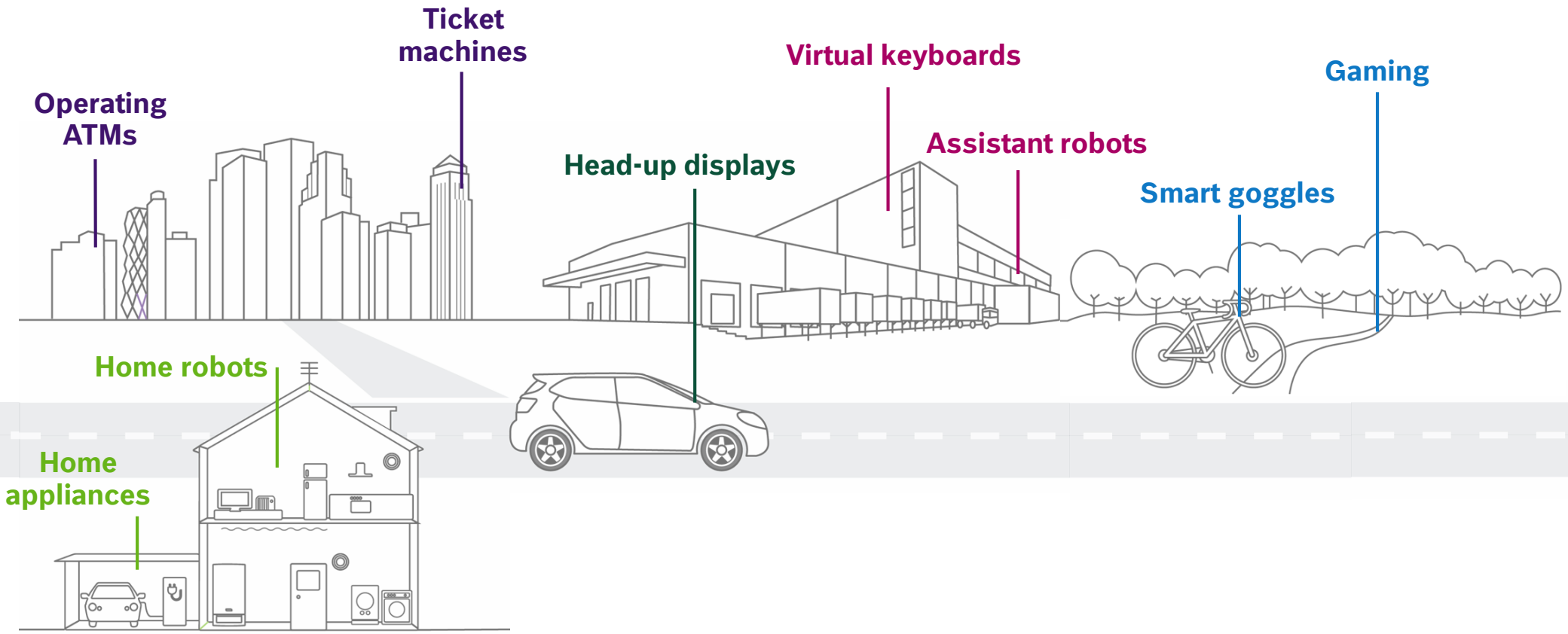
Fraunhofer
ISIT

VDI Technologiezentrum

Laser projection in low-cost, building space reduced HUD modules

BOSCH

MEMS scanner – virtual user interfaces in your everyday life



THANK YOU!