



## Smart Sensor Systems – Enabling the Internet of Things

Dr. Udo-Martin Gómez, CTO, Bosch Sensortec

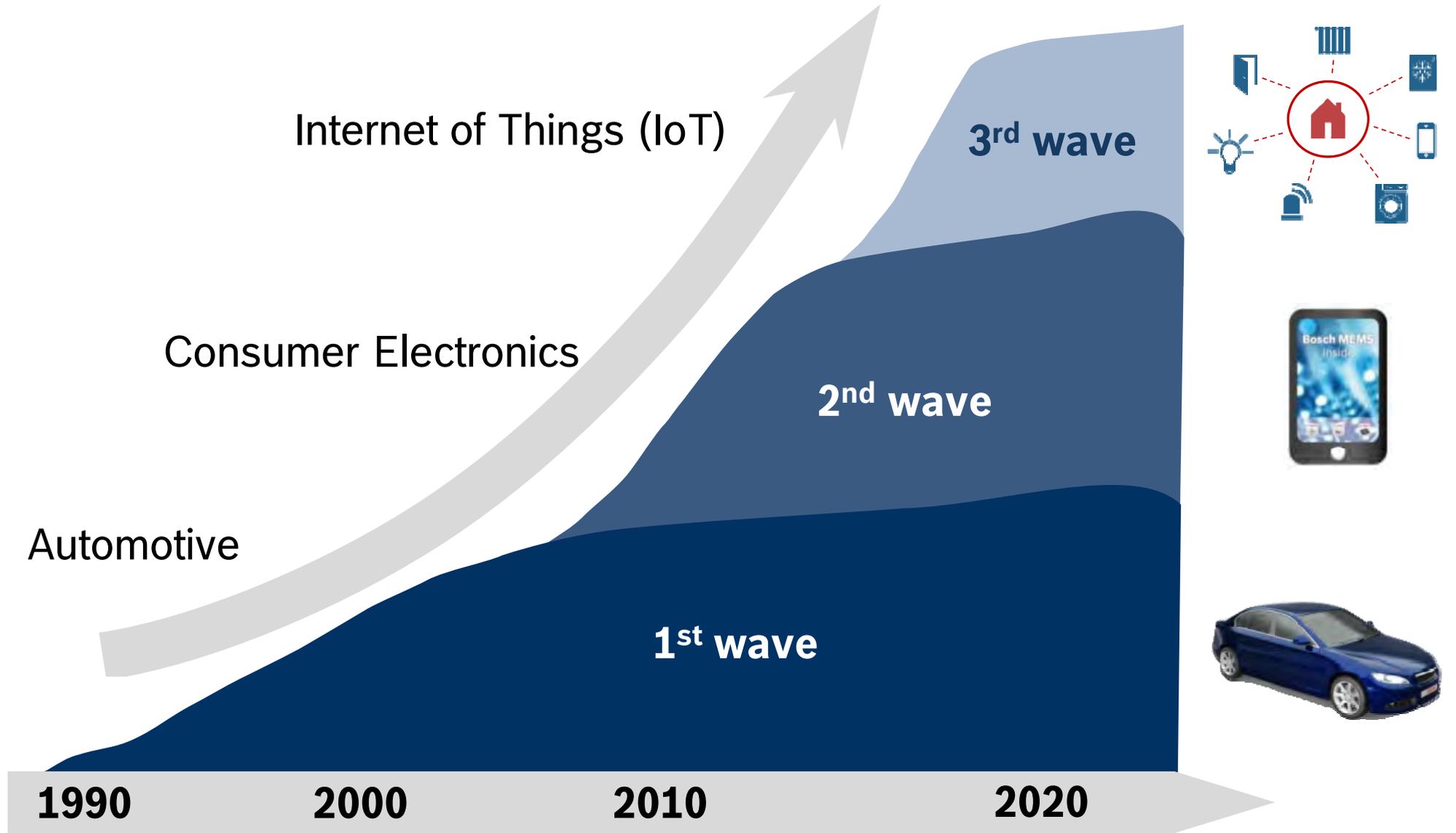
Bosch Sensortec

Udo Gómez | 21.04.2015 | © Bosch Sensortec GmbH 2015. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



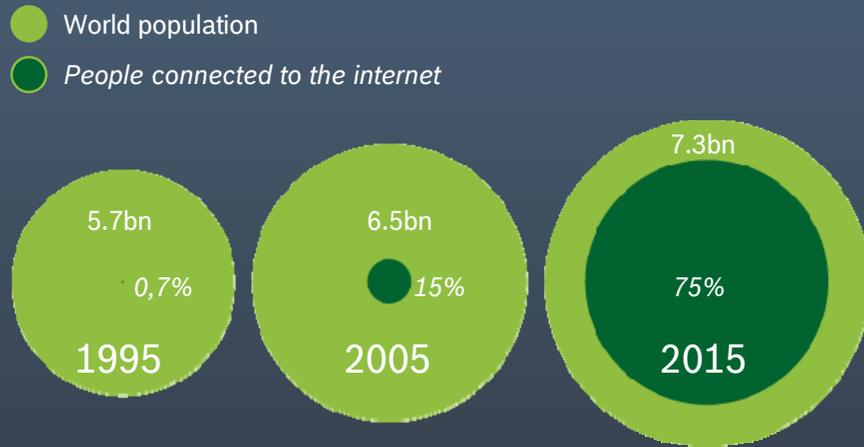
**BOSCH**

# Waves of MEMS sensor proliferation

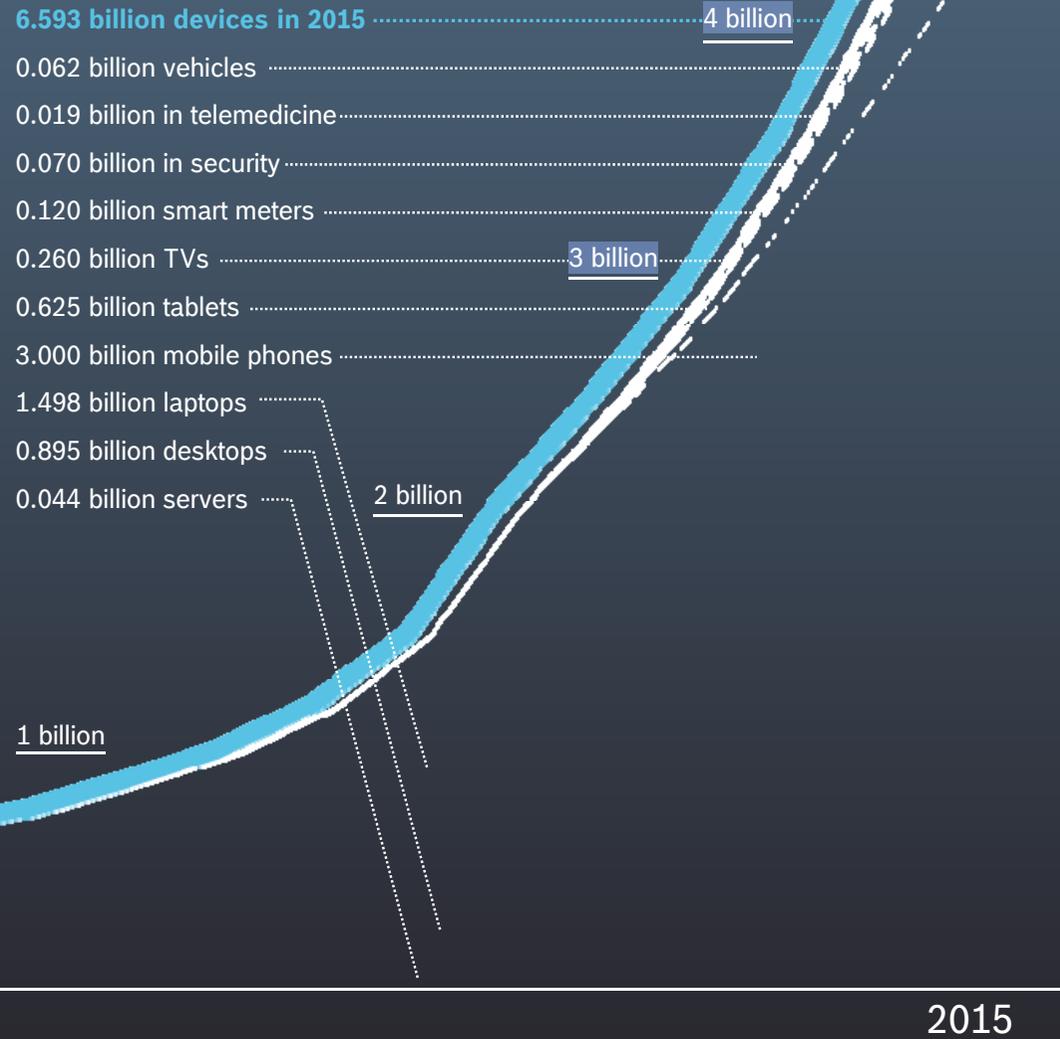


## Everyone & everything connected

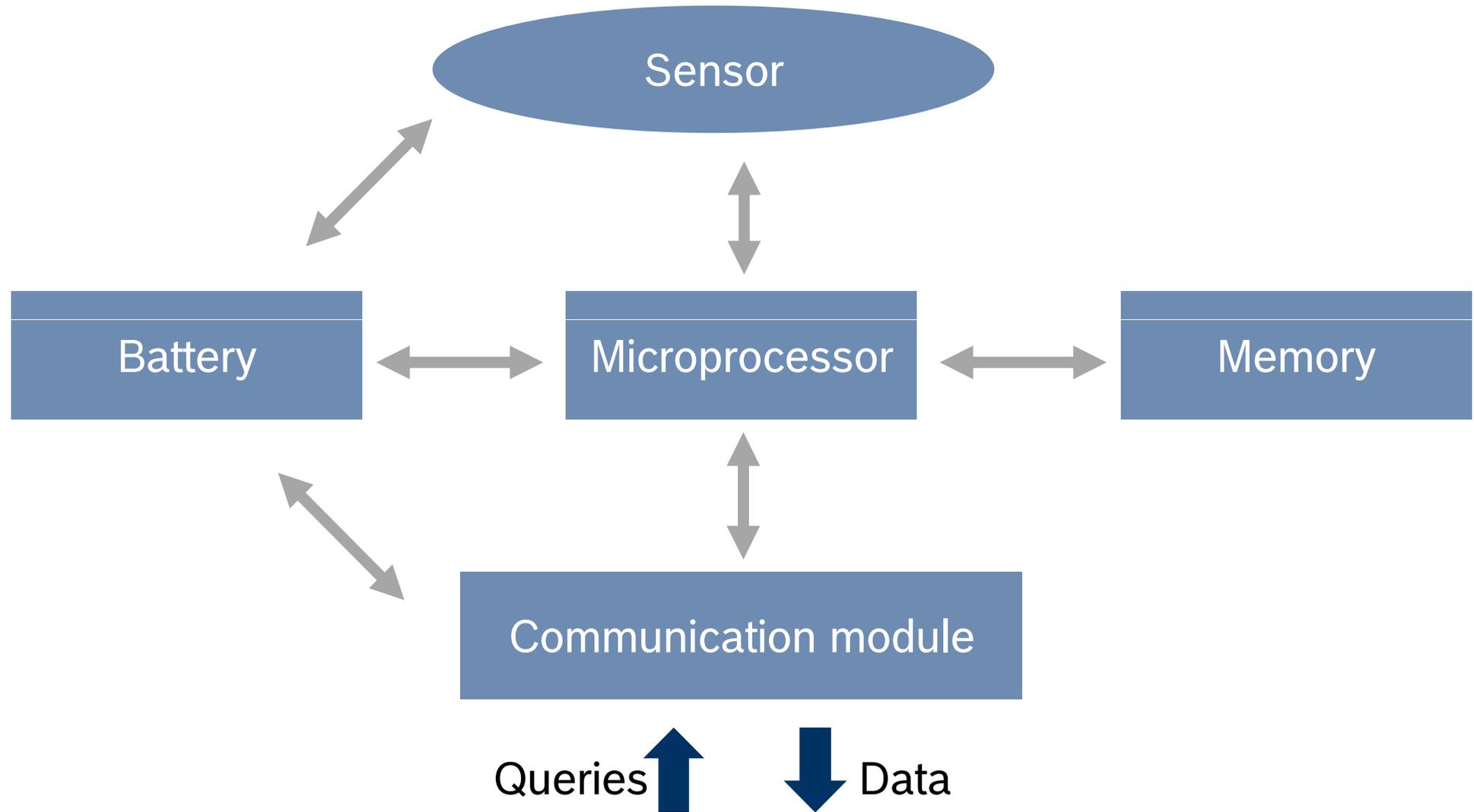
### People connected



### Devices connected



## Definition smart system



## From sensors to smart systems

### 3-axis sensors



- Accelerometer
- Gyroscope
- Magnetometer



### 6-axis sensors



- eCompass
- Inertial Measurement Unit



### 9-axis sensors



- Absolute Orientation Sensor
- Application Specific Sensor Nodes (ASSNs, incl.  $\mu$ C)



**Sensor data-fusion software ties everything together**

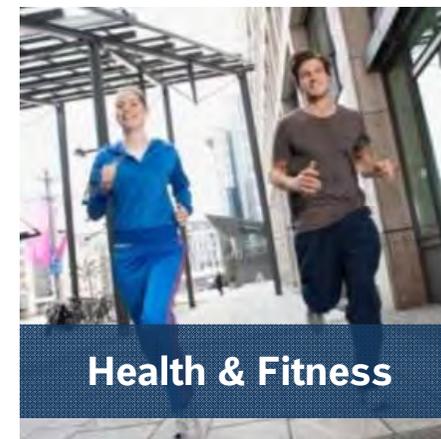
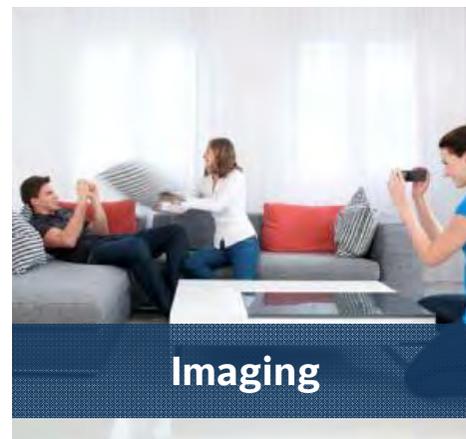
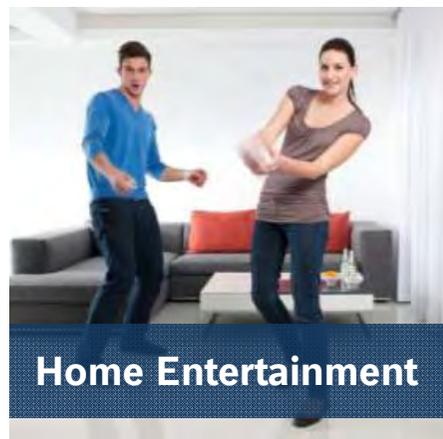


## Internet of Things – connected smart systems



**Wireless connected smart sensors and actuators: enabler for IoT**

## MEMS sensors – a multitude of markets



## Connected smart home

**Smart home**  
How intelligently connected household appliances communicate with each other

Heating, ventilation, and air-conditioning are automatically adjusted to changing weather conditions

The charge spot for the electric car checks with the utility company for the best electricity price

A central home gateway takes care of data reception and transmission between appliances and the internet

Recording your favorite TV program, starting the washing machine – all this can be done remotely

Partners: **ABB** **BOSCH** **CISCO** **LG**  
Invented for life



## Example smart home - intrusion sensor



### Sensors & Functions



Acceleration



Gyroscope



Geomagnetic sensor



Buzzer



Battery life time: up to two years (10.000 closing cycles assumed)

Wireless data transmission

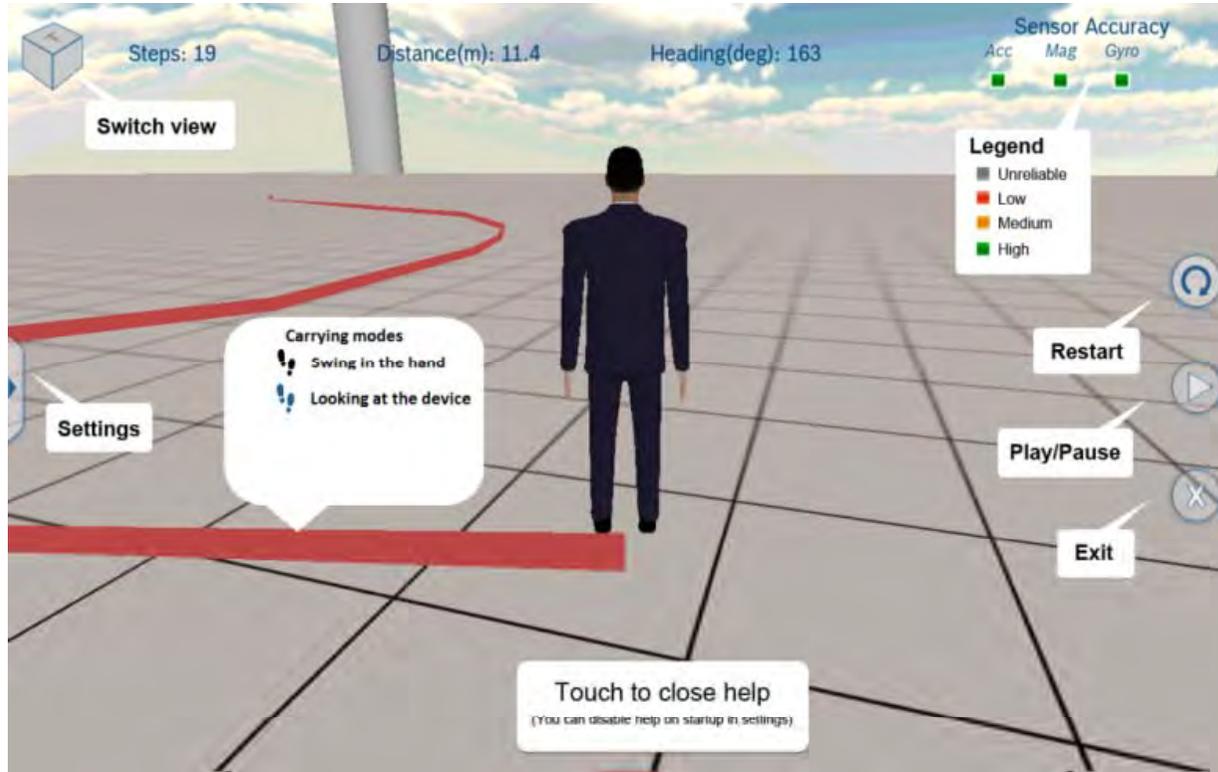
### Applications

- Home safety monitoring
- Energy efficiency management
- Ambient Assisted Living

### Benefits

- Easy and fast installation
- Multiple event detection
- Flexible usage for doors and windows
- Extendibility to many different use cases

## Example indoor navigation - inertial sensor



### Sensors & Functions

-  Low power consumption
-  Acceleration
-  Gyroscope
-  Geomagnetic sensor

### Applications

- Step counter & dynamic orientation sensor indoor
- Path integration
- Pedestrian dead reckoning

### Benefits

- Navigation in shopping malls, public areas, parking decks, etc.

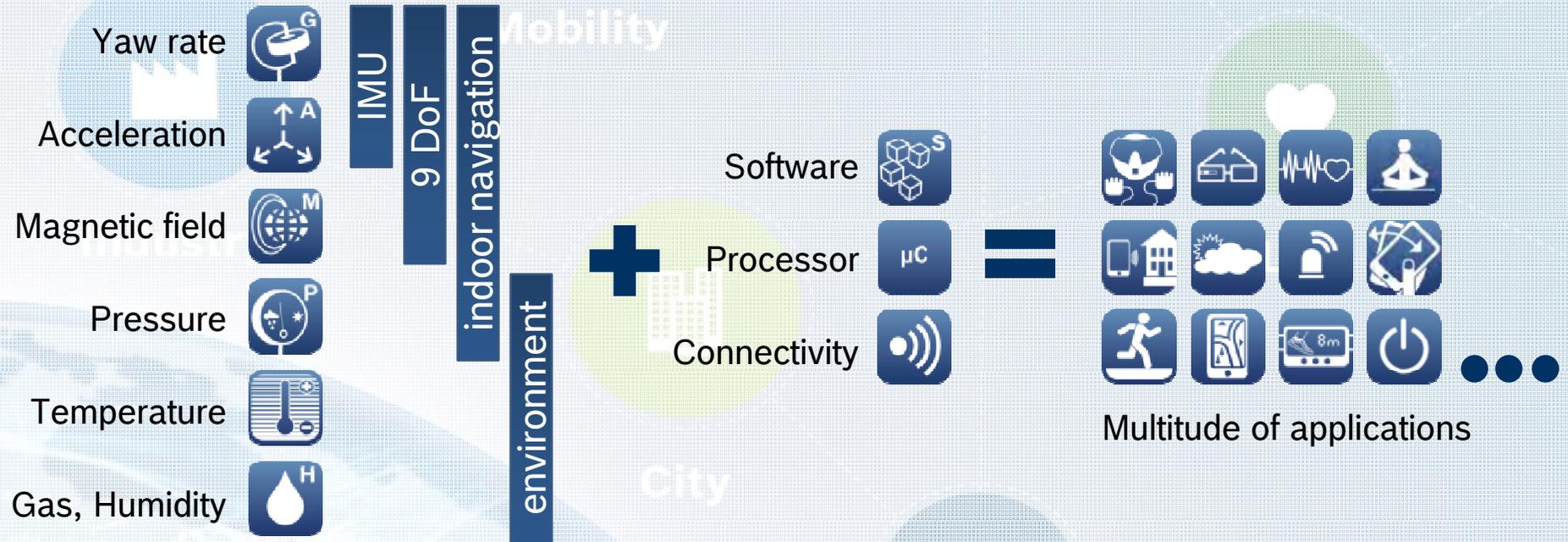
## Smart systems require new competences



Software and advanced packaging are gaining weight, “SW is the new ASIC”

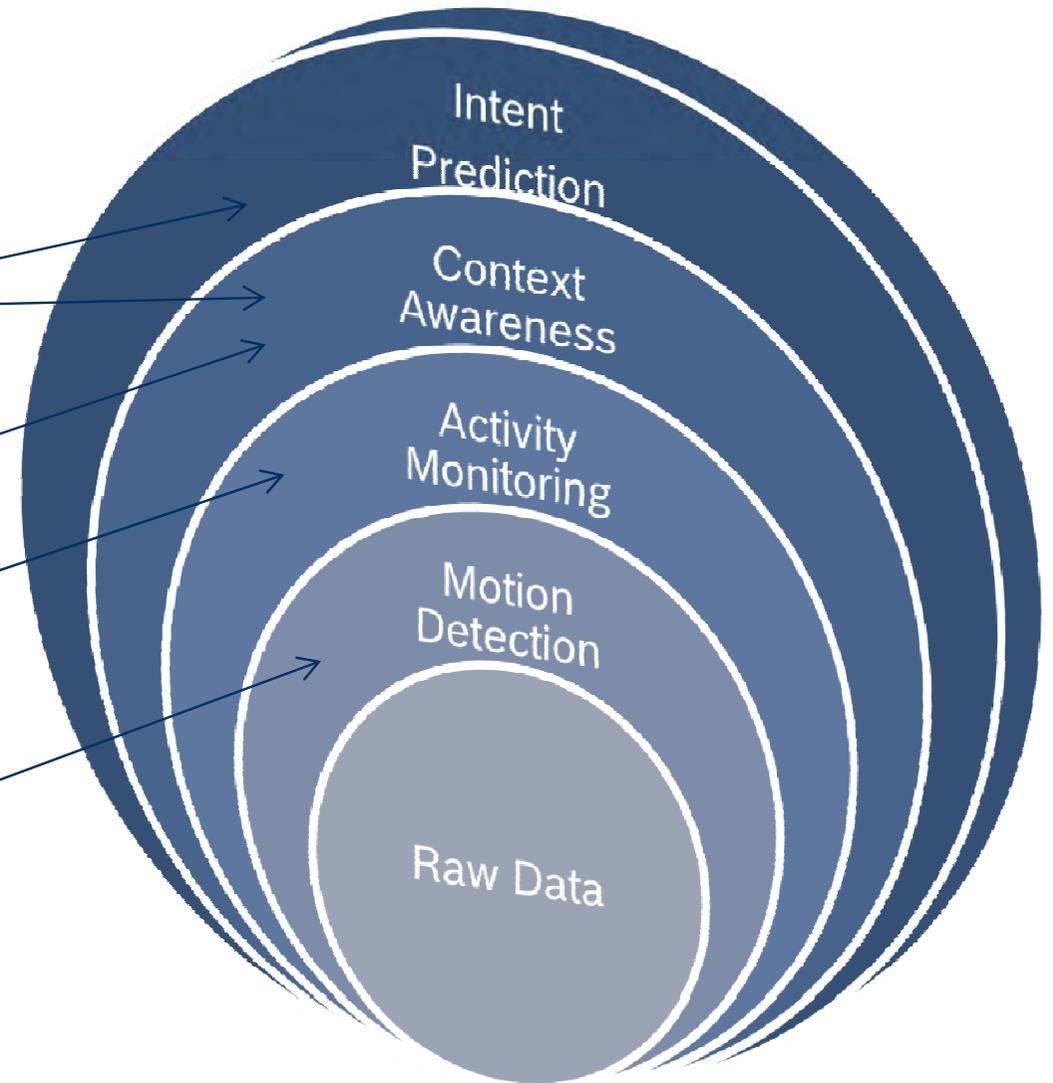
## Sensor data fusion

Multitude of technologies combined with intelligent processing for application specific solutions



## Enables use-cases...

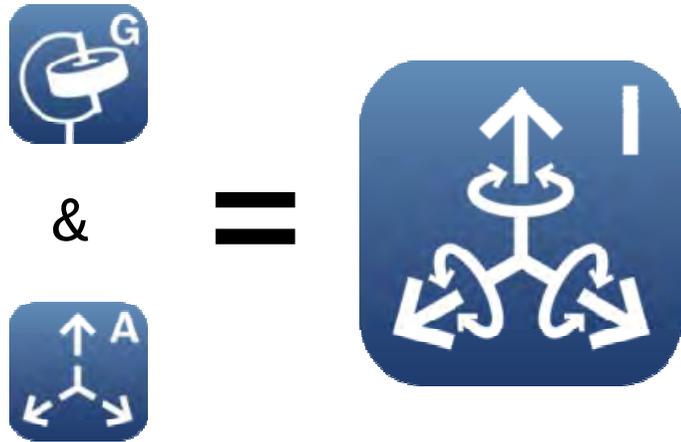
- Location-based services
- Well-being recommendations
- Indoor navigation
- Augmented reality
- Activity monitoring
- User interface
- Gaming
- Image stabilization



**Advanced use cases are enabled by smart systems**

## BMI160 inertial measurement unit

- The 6-axis sensor integrates a 3-axis accelerometer and an ultra-low power 3-axis gyroscope into a single package



- Developed specifically to support the demands of next generation applications such as indoor navigation, augmented reality and immersive gaming

Average market performance



Sub 1mA in full operation mode  
**BMI160 – World's first IMU**  
for true always-on applications



Bosch Sensortec



## New: Integrated sensor hub BHI160 & BHA250

→ SmartHub solutions combine Bosch Sensortec's ...

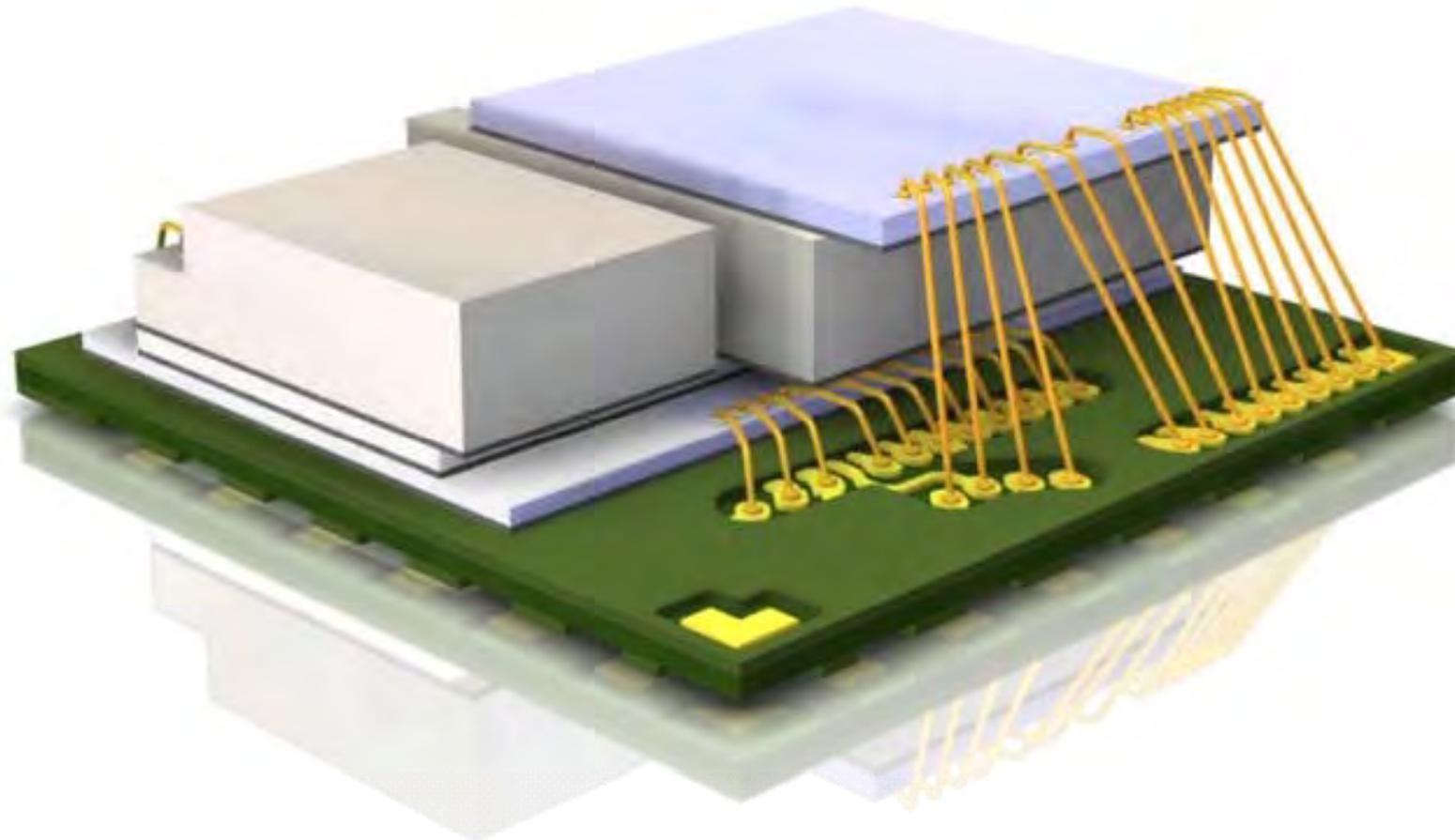
- **lowest power** sensors (IMU < 1mA)
- **best-in-class** sensor fusion software
- optimized sensor **FUSER Core**

... to provide the lowest power solution without compromising features or performance.

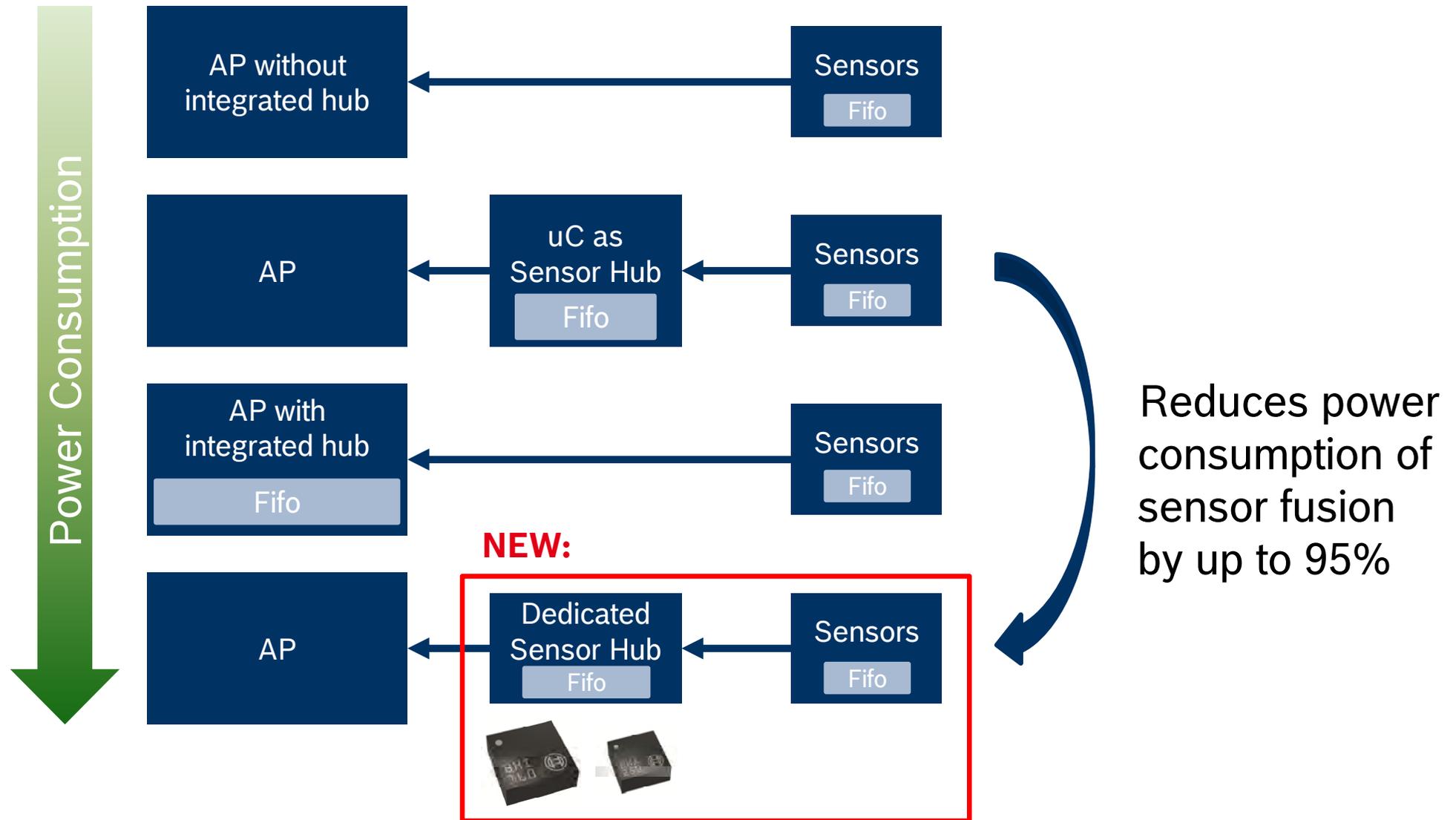


### Low Power without compromise

# New: Integrated sensor hub BHI160



## Support for multiple sensor hub solutions

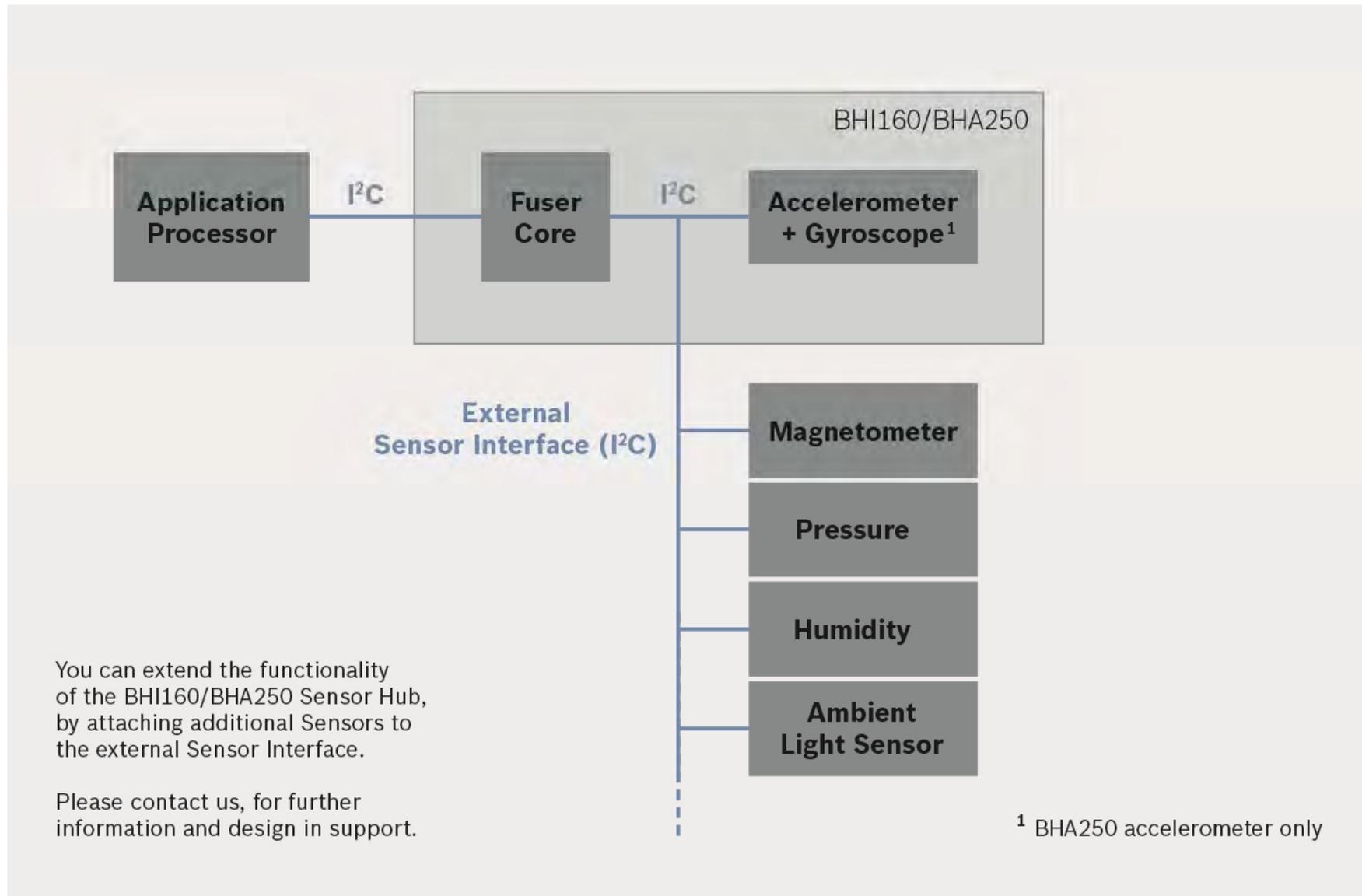


## Implements complete Android L sensor stack

### Software Features

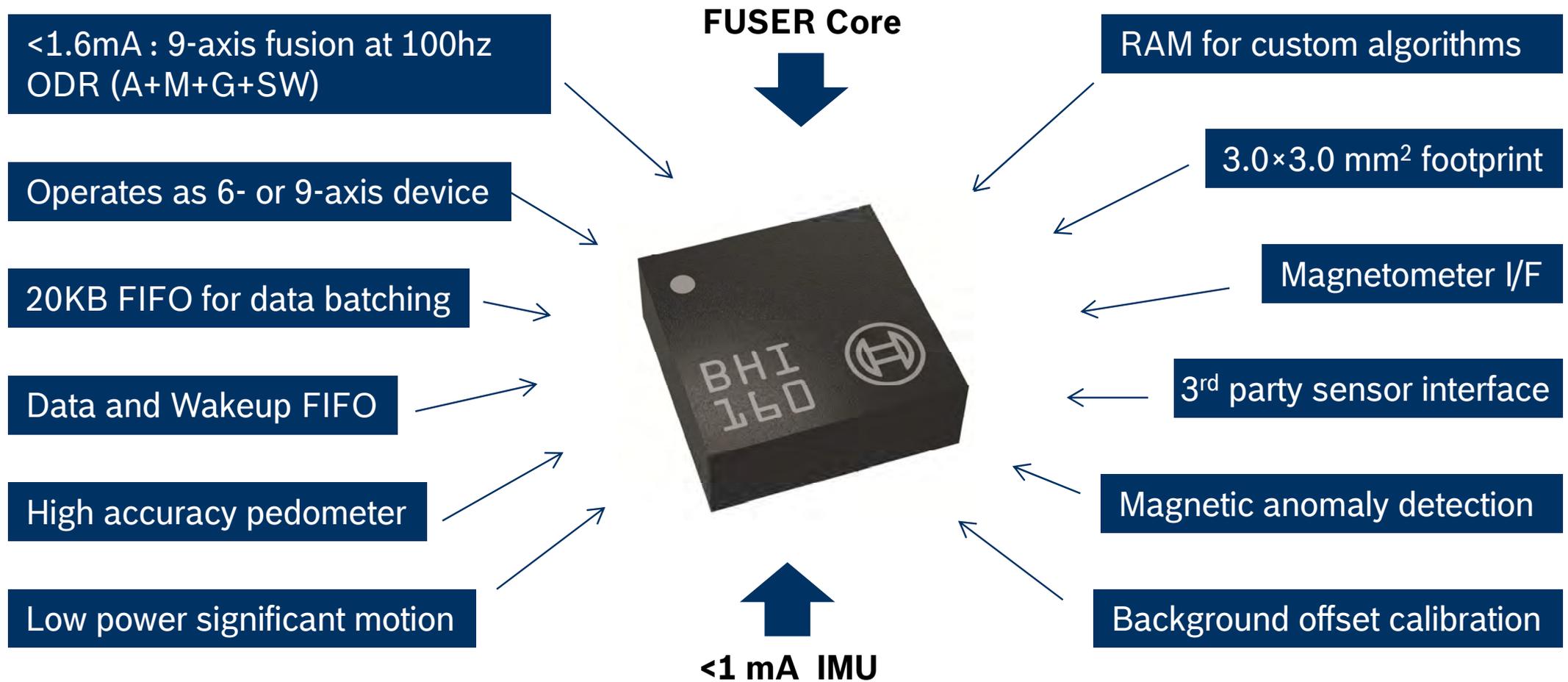
- ✓ Android L Batching with Data & Wakeup Fifo
- ✓ Gesture recognition
- ✓ Activity recognition
- ✓ Tilt / Significant motion / Step detectors
- ✓ Low power step counter
- ✓ Implements all Android Virtual Sensors
- ✓ Supports IMU and eCompass modes
- ✓ Supports Soft Gyro mode
- ✓ Advanced soft iron calibration
- ✓ Magnetic distortion detection
- ✓ Fast magnetic calibration
- ✓ Firmware updatable

## Sensor hub HW structure with BHI160



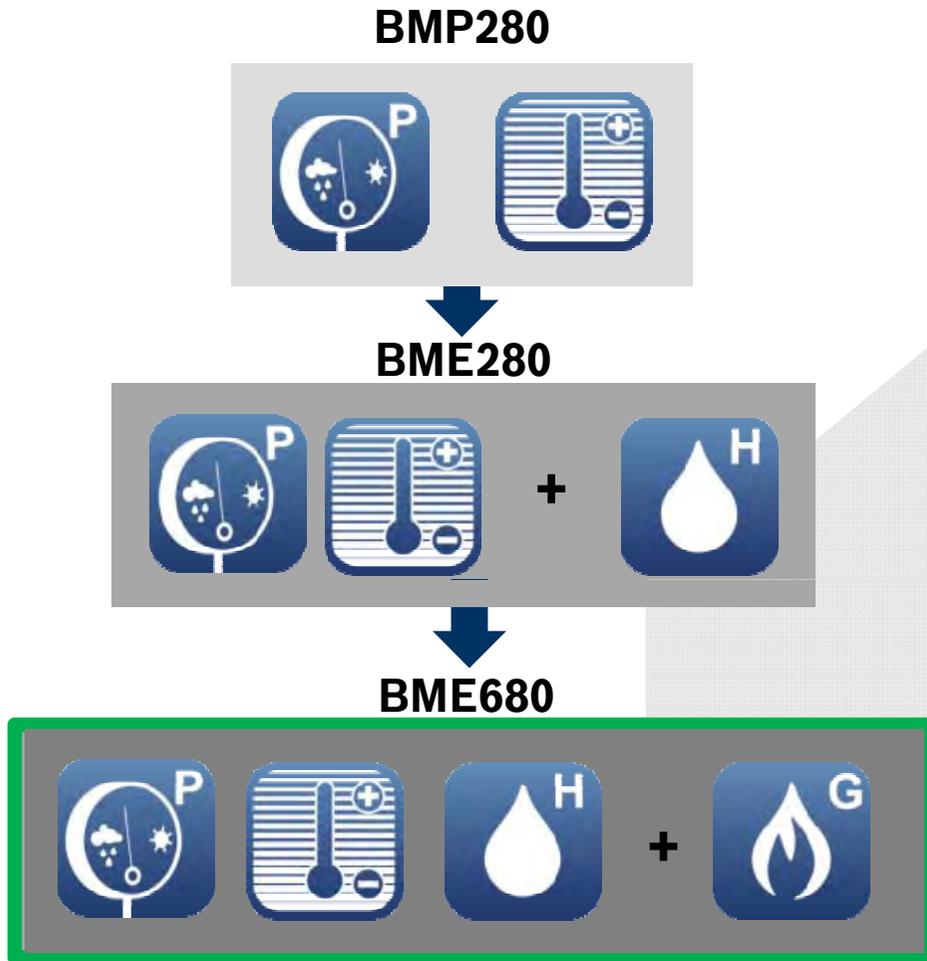
## BHI160 – IMU + FUSER Core

Power efficient 6-axis sensor with integrated smart Hub





## New: Gas sensor BME680



### Sensing our world

#### Quantify yourself

- Well-being recommendations
- Personalized environment
- Sport & fitness monitoring



#### Personalized control

- Environmental monitoring
- Personal weather forecast
- Home automation



#### Environmental measurement

- Pressure
- Humidity
- Temperature
- Gas (VOC, CO<sub>2</sub> alcohol)

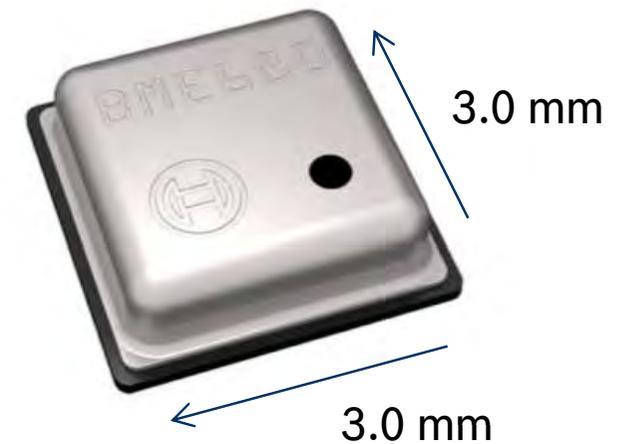


World's first environmental sensor combining pressure, humidity, temperature & indoor air quality

## New: Gas sensor BME680

### Use cases

- Home automation control for personalized HVAC management
- Manual ventilation → window open/close
- VOC detection (Volatile Organic Compounds)
- Indoor/outdoor detection to trigger GPS
- Leakage detection, e.g. gas supply in stoves
- Smoke detection
- Human recognition indoor



Equips mobile devices and wearables with indoor air quality measurement

## Summary

- Smart Systems are key enabler for IoT
- Key success factors:
  - Miniaturization
  - Reduced power consumption
  - Connectivity
- New measurants (e.g. Gas Sensor BME680)
- Bosch, the world leading supplier of MEMS sensors

Bosch sensors can be found in every  
**second**  
smart phone worldwide.

---



## Disclaimer

With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Bosch Sensortec hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights or copyrights of any third party. The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. They are provided for illustrative purposes only and no evaluation regarding infringement of intellectual property rights or copyrights or regarding functionality, performance or error has been made.

Bosch Sensortec

Udo Gómez | 21.04.2015 | © Bosch Sensortec GmbH 2015. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



**BOSCH**