MEMS Sensors as enablers for IoTS

Shanghai, 17th of March 2014

百里博 / Leopold Beer Regional President Asia Pacific

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Sensing | our World

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Agenda

→ Brief company introduction

→ State of the art sensor portfolio today and future projection

→ Sensor Requirements for IoTS applications

Bosch Sensortec − The MEMS technology leader

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Bosch Sensortec - The MEMS Technology Leader

→ **Bosch is one of the world's most innovative technology companies.**

→ **Bosch has invested more than 35 billion Euros in research and development over the past ten years.**

→ **For innovations that make life safer, more comfortable, and more environmentally friendly – Invented for life.**
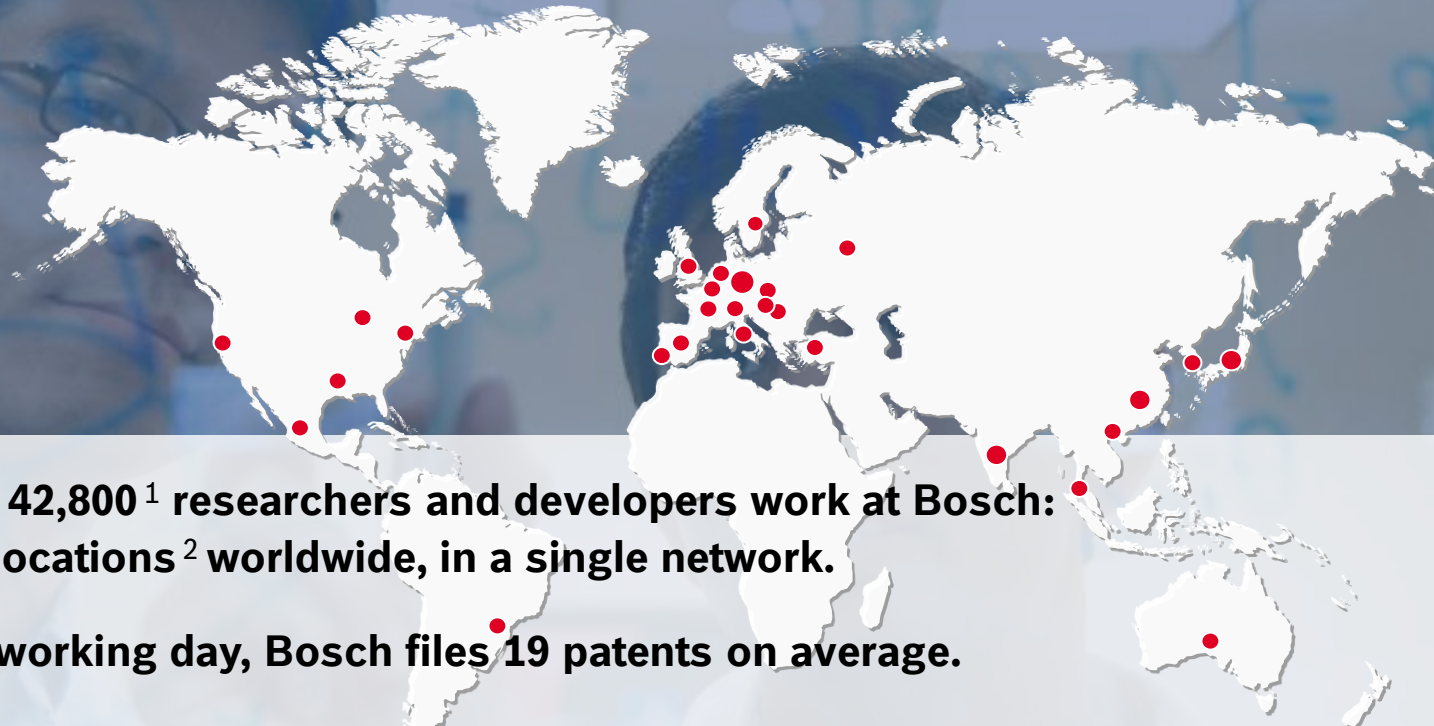
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➔ **Some 42,800[1] researchers and developers work at Bosch: at 89 locations[2] worldwide, in a single network.**

➔ **Each working day, Bosch files 19 patents on average.**

➔ **This makes Bosch one of the world's leading companies for patent applications, and puts it in first place in Germany.**
– Invented for life.

[1] as of 01/2013 [2] R&D locations with >50 associates, as of 01/2013

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Four Business Sectors

Automotive Technology

Industrial Technology

Energy and Building Technology

Consumer Goods

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2013 Key Figures [1]

Bosch Group	→ 46,4 billion euros in sales → 281,000 associates	
Automotive Technology	→ World's largest supplier of cutting-edge automotive technology	66 % share of sales
Industrial Technology	→ Leading in drive and control technology, packaging, and process technology	
Energy and Building Technology	→ Leading manufacturer of thermo- and building security technology → World's largest supplier of heat pumps	34 % share of sales
Consumer Goods	→ World's largest power tool manufacturer → Leading the field in household appliances	

[1] Preliminary figures as of 01/2014

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Bosch − the MEMS supplier

Out of one hand MEMS sensors, actuators and solutions

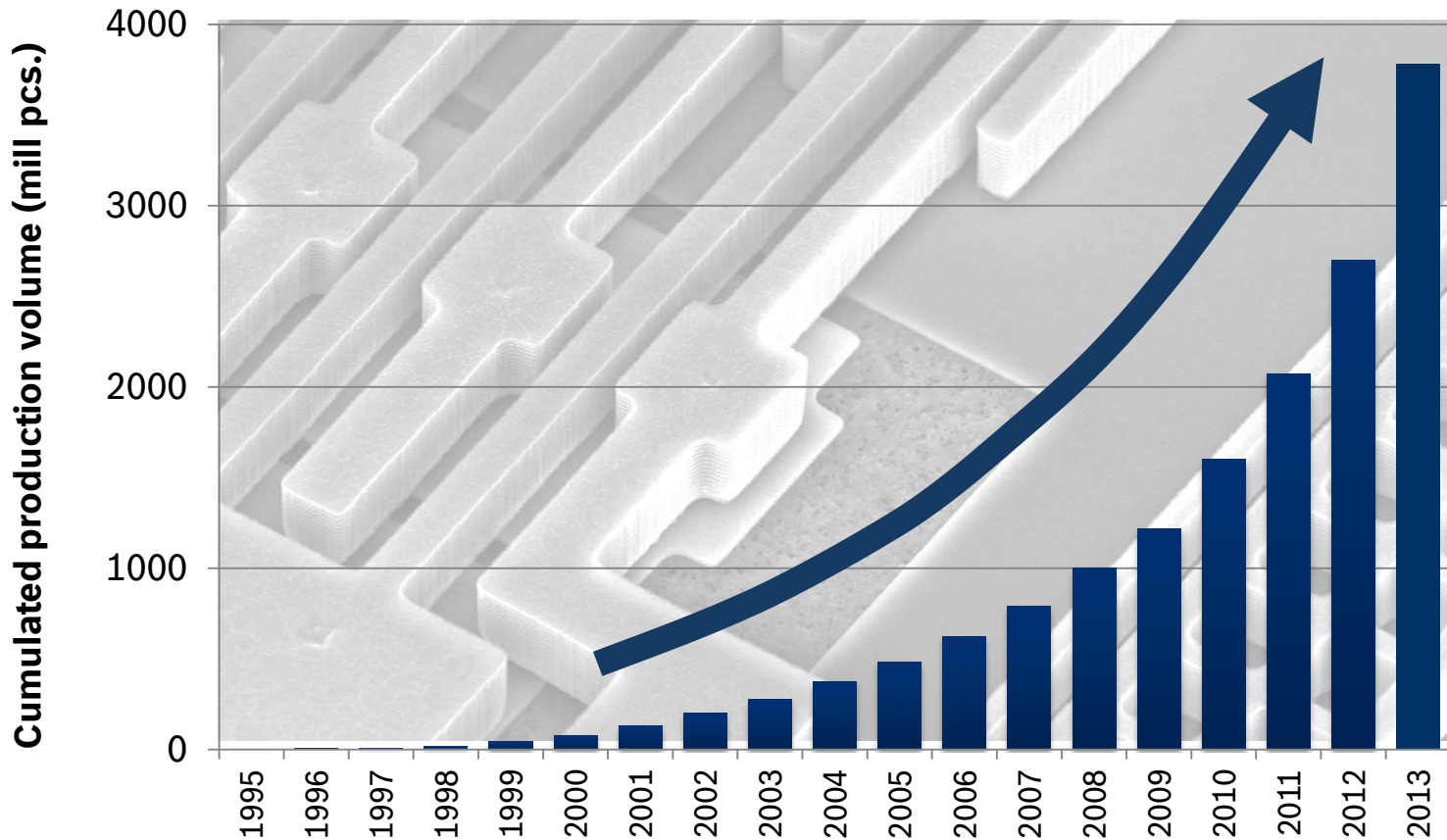| Bosch Sensortec	Akustica	Bosch Connected Devices & Solutions	Automotive Electronics
CE	CE	CE & Industrial	Automotive
→ Accelerometers → Geomagnetic sensors → Gyroscopes → Pressure sensors → Humidity sensors → Combo sensors → ASSNs	→ MEMS microphones	→ Smart sensor/ actuator nodes → Embedded SW & algorithms → Customized IoTS sensor & actuator solutions	→ Accelerometers → Angular rate → Pressure sensors → Mass flow sensors

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MEMS is microscopic fascination

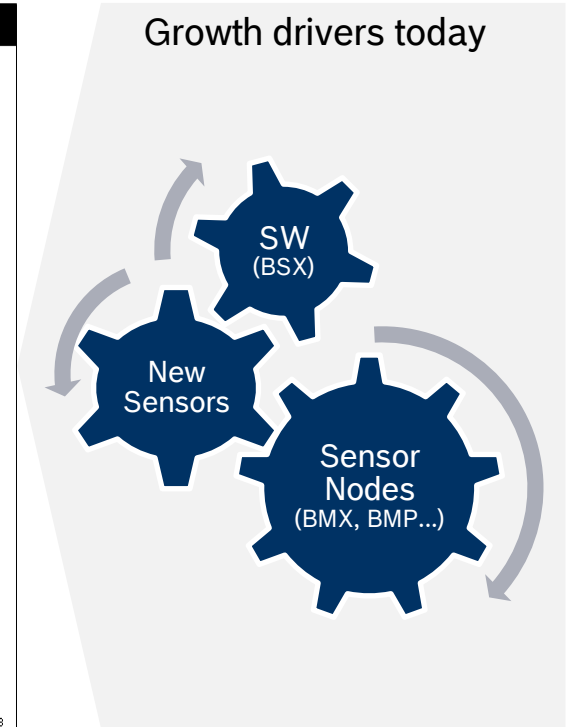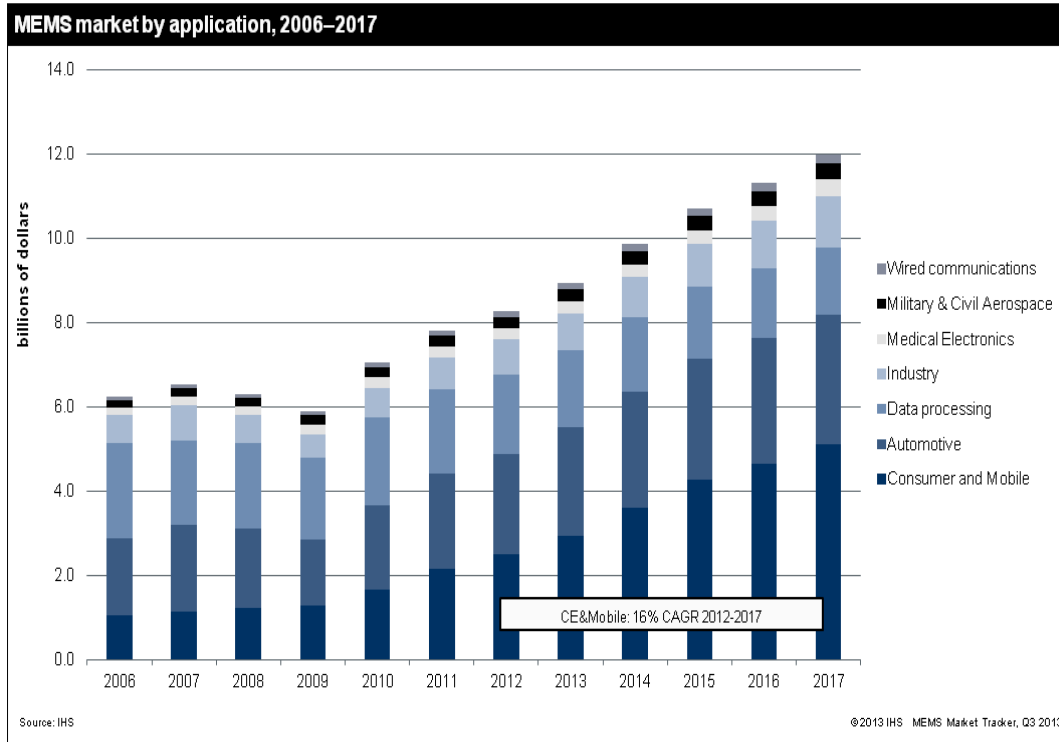**"MEMS"** = **"M**icro-**E**lectro-**M**echanical **S**ystem"

➜ MEMS are miniature systems which usually combine tiny mechanical structures with electronic circuits. Typical individual structures have a size of a few μm

➜ Bosch Engineers invented the DRIE process that is the basis for all MEMS manufacturing today

BMA 355

1.5mm

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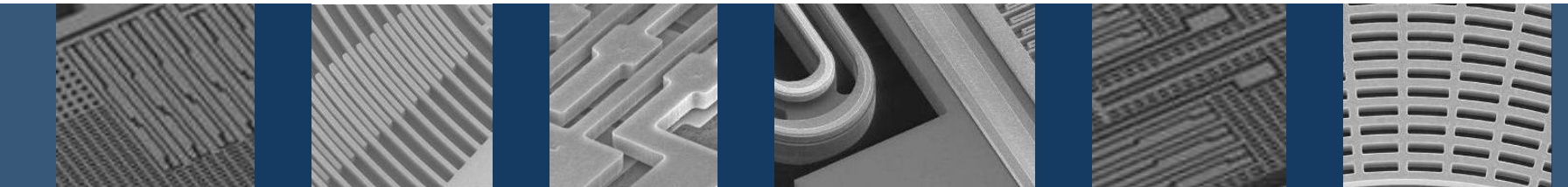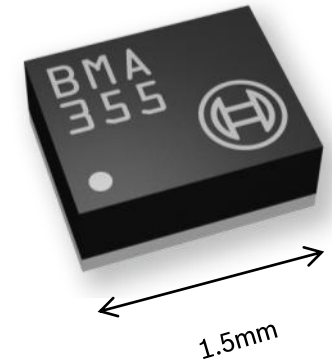
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Bosch MEMS sensor shipments

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Market evolution based on actual technologies

MEMS market by application, 2006–2017

Growth drivers today

SW (BSX)

New Sensors

Sensor Nodes (BMX, BMP...)

CE&Mobile: 16% CAGR 2012-2017

Source: IHS

©2013 IHS MEMS Market Tracker, Q3 2013

- Wired communications
- Military & Civil Aerospace
- Medical Electronics
- Industry
- Data processing
- Automotive
- Consumer and Mobile

Smartphone's are today's CE MEMS growth and technology drivers

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Industry Evolution Stages(Ex. Bosch Sensortec)

Industry broad-liner
- Broad application portfolio
- Broad technology portfolio

Technology broad-liner
- Application focus
- Broad technology portfolio

Technology Focus
- Application focus
- Technology focus

2006   2011   2014   2016

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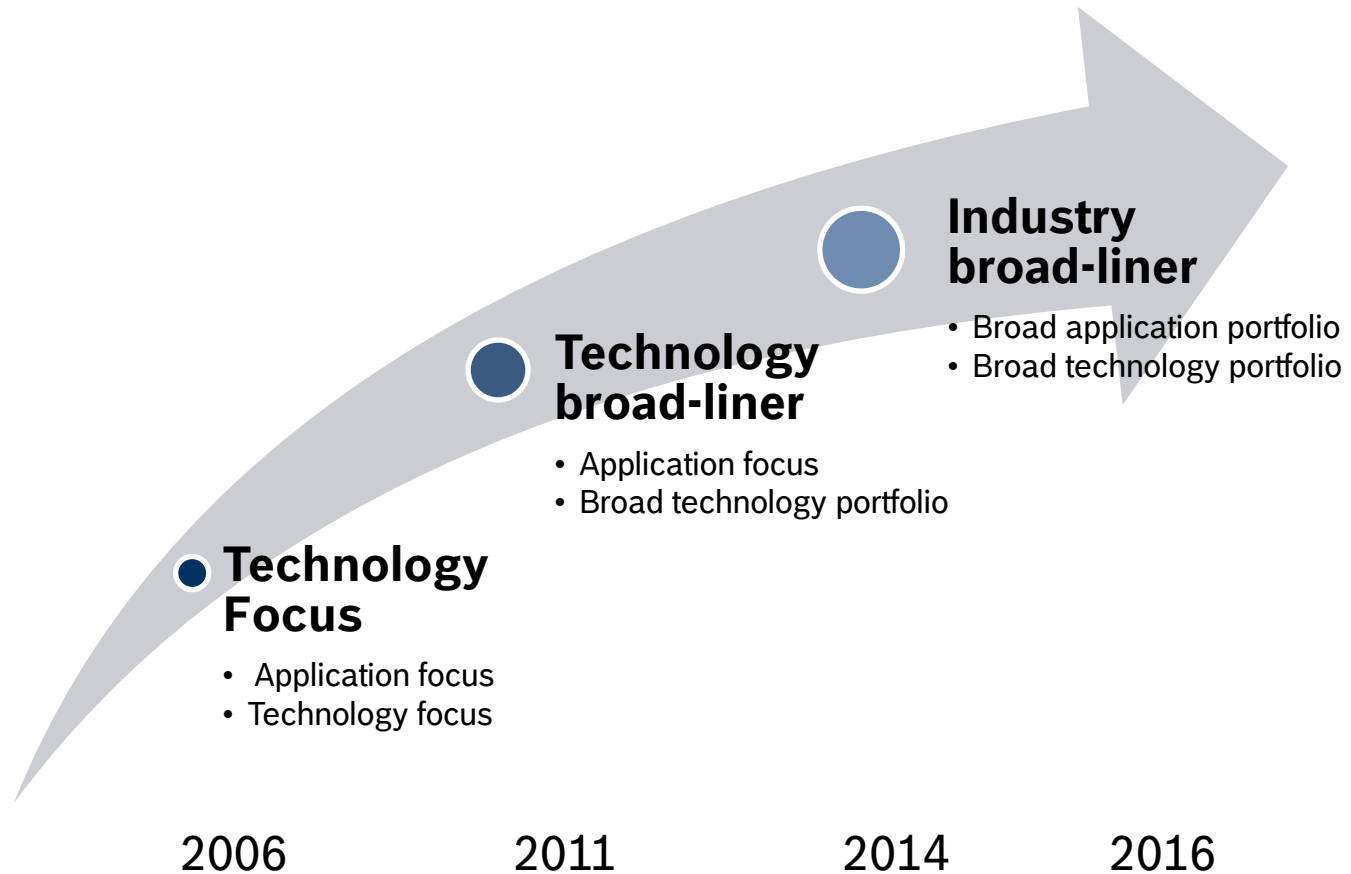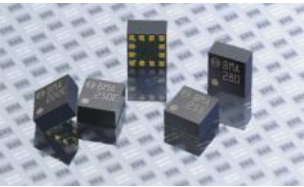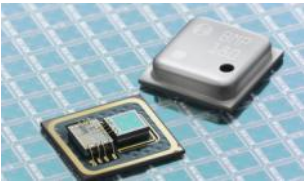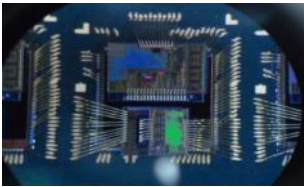
New applications...with new technologies

➜ Multitude of **Technologies** (Inertial, GeoMagnetic, Environmental, Acoustic...)

➜ Implement **Application Specific** (Smartphone, Wearable, Tablets...)

➜ **Solutions** (Integrating sensors, µC and application specific software)

Broad Technology Foundation   Broad Application Know-How

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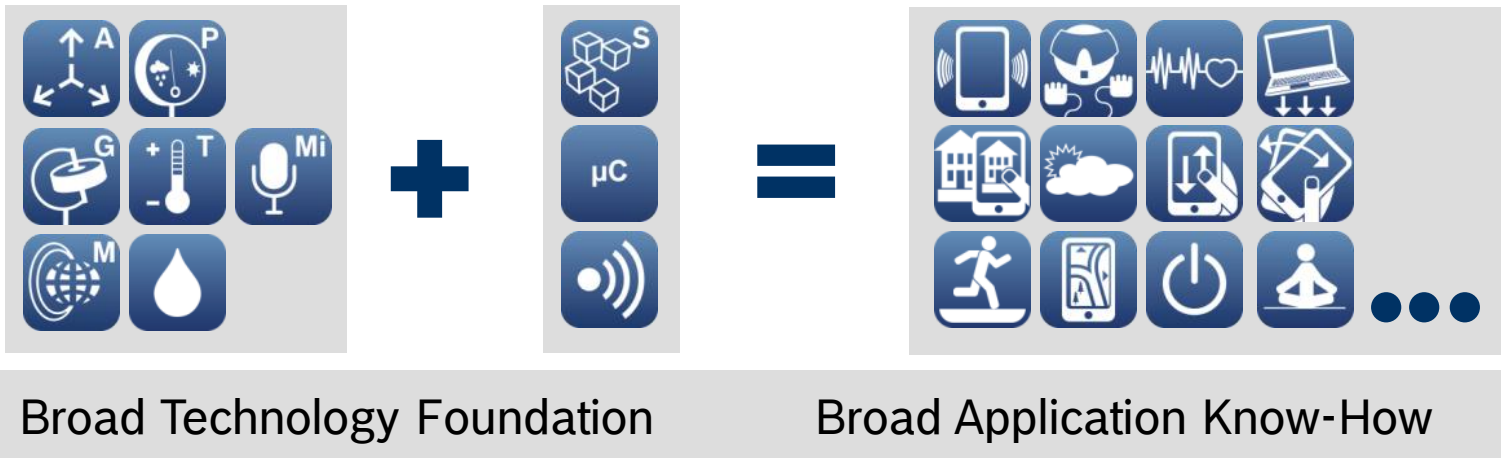
State of the art technology portfolio

Inertial	Geomagnetic	Environmental	Sensor Clusters	Microphones
- Accelerometer - Gyroscope - IMU - 9 Axes	- eCompass - GeoMag - Magnetic Gyro	- Barometric Pressure - Integrated Environmental Unit	- Sensor Hubs - ASSN Application Specific sensor nodes	- Analog and digital MEMS microphones (Akustica) - High quality voice input for mobile devices

Sensor data-fusion software ties everything together

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Bosch Sensortec solutions for all applications
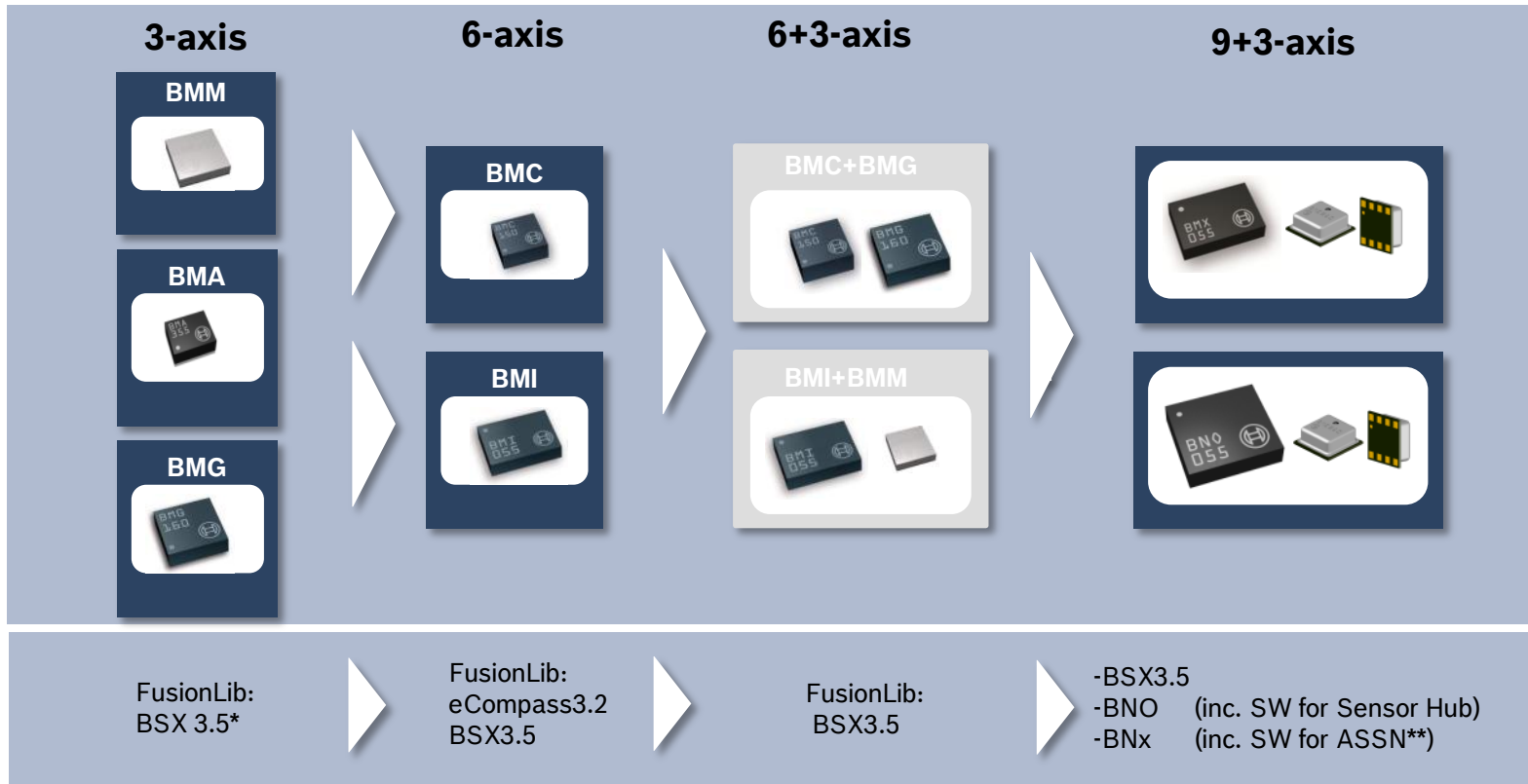
Different applications require different solutions

*Bosch Sensortec Sensor Data Fusion
**Application Specific Sensor Node

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New markets segmenting out of Smartphone

Higher Integrated Functionality

Wearable Devices
(integrating sensors)

IoT Nodes
(multiple sensors, µC and RF link)

Lower Power Budget

Higher Power Budget

Smart Switches
(event type sensors)

IoT Tags
(Sensor & RF-Link)

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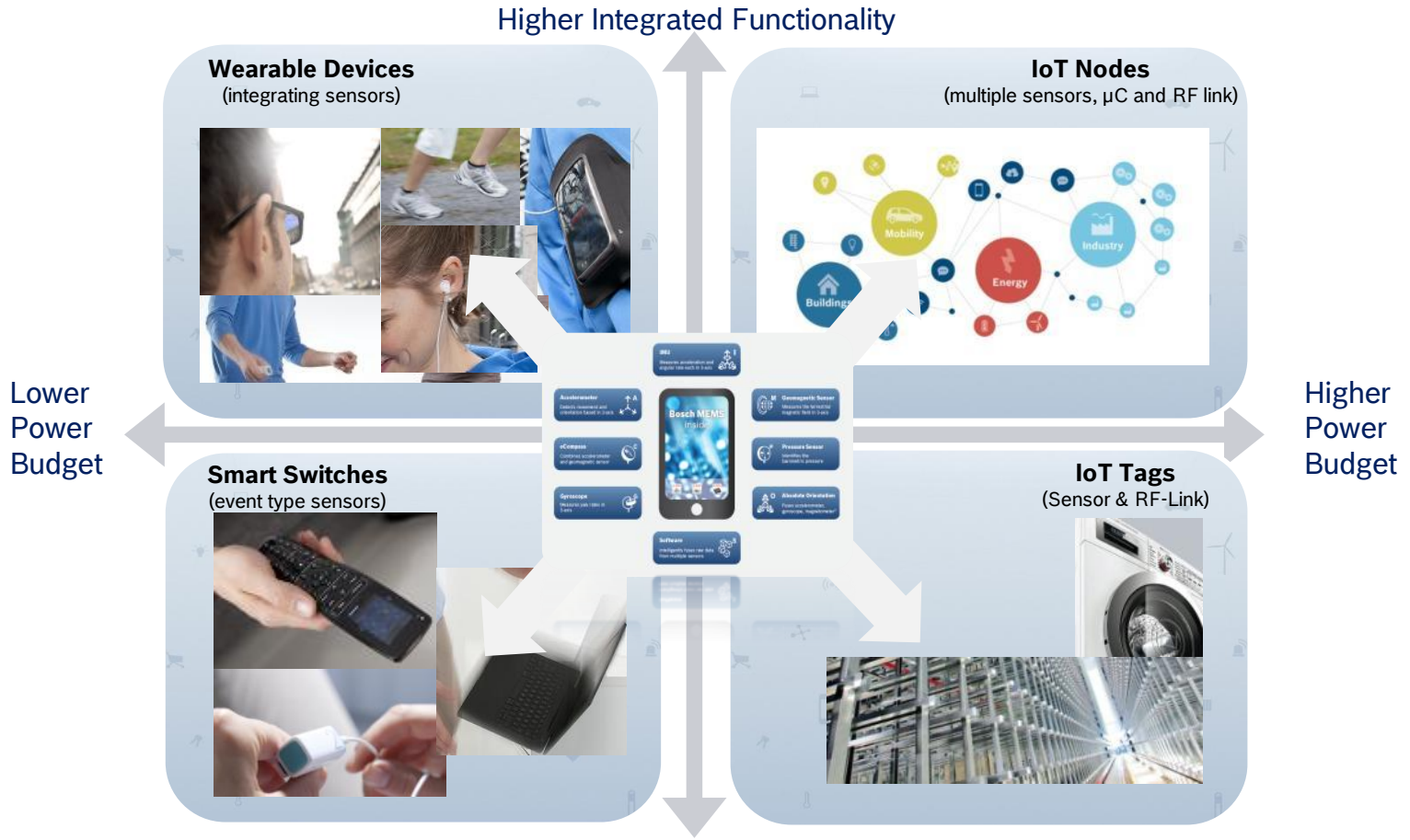
New Applications are Enabled

Higher Integrated Functionality

Wearable Devices

IoT Nodes

Lower Power Budget

Higher Power Budget

Smart Switches

IoT Tags

Lower Integrated Functionality

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Evolving New Solutions...

Higher Integrated Functionality

Wearable Devices

IoT Nodes

Lower Power Budget

Higher Power Budget

Smart Switches

IoT Tags

Lower Integrated Functionality

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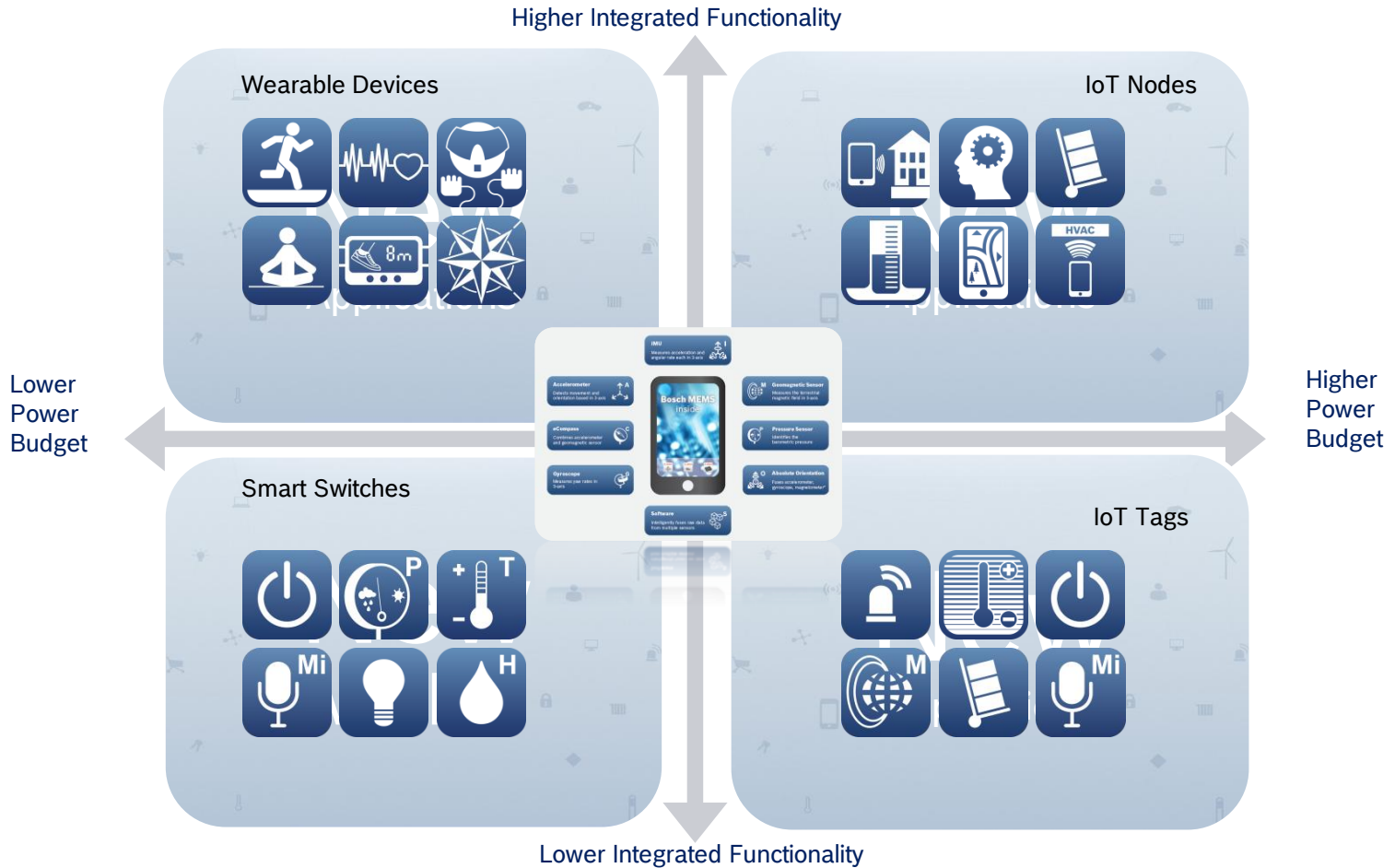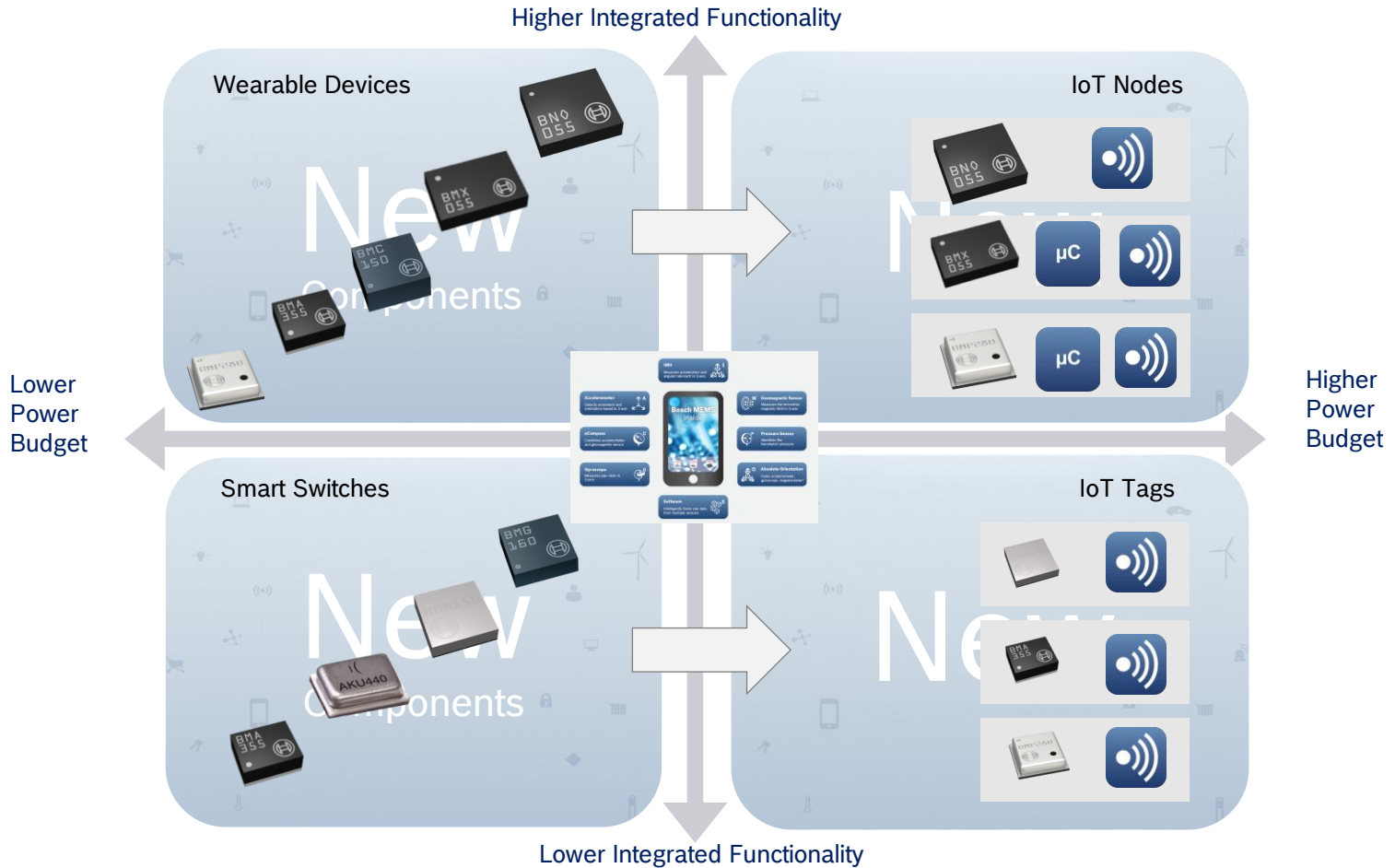
Integration Trend: 3 sensor clusters available

Inertial & Magnetic Sensor Cluster
- Integrated 9 Axes (accel., mag., gyro)
- Integrated Microcontroller
- Integrated Sensor data fusion software

Environmental Sensor Clusters
- Barometric pressure sensors
- Humidity sensors
- Temperature sensors

Acoustical Sensor Clusters
- Acoustical Microphones
- Microphone arrays control

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New Sensors: BME280 (PTH sensing)

➜ Integrated pressure, temperature and humidity sensing (PTH)

Small (2.5 x 2.5 mm²) but excellent performance

➜ Accuracy tolerance of ±3 %RH
   (typ @25 °C for humidity)

➜ Response time 1 S for humidity

➜ Absolute accuracy: typ ±1 hPa
   after soldering (950...1050 hPa, 0...+40 °C)

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New Solutions: BNO055 − ASSN* platform

Sensor HUB (including BSX)

- Smartphone
- Tablets
- Laptops

* Application specific sensor node

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Pioneering a new class of devices

Motion software powered by

hillcrestlabs.

BNO070, based on 9-axis BNO055, incorporates Hillcrest's SH-1 software optimized for head-mounted displays (HMDs)

BNO070	Technical data
Size	5.2 x 3.8 x 1.1 mm³
Update Rate	≤250Hz
Static	Accuracy: 1.5° Heading: 1.0° Non-Heading: 1.0°
Dynamic	Accuracy: 1.5° Heading: 1.0° Non-Heading: 1.0°

Absolute orientation solution for head mounted displays (HMD)

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Bosch also Acting on a Broader Scale
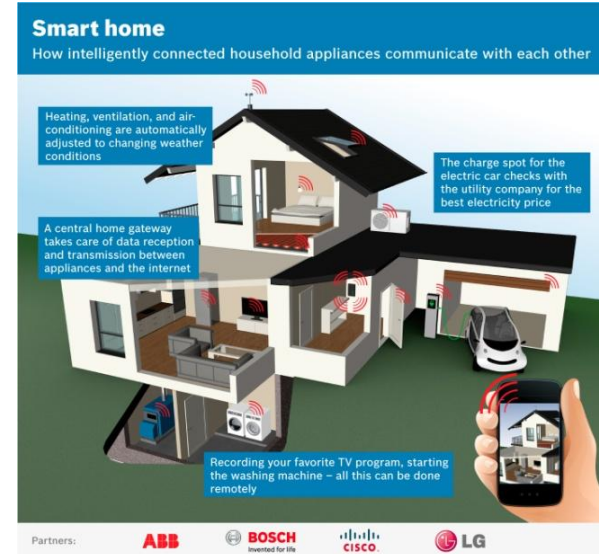
ABB, Bosch, Cisco, and LG aim to set up a consortium to provide a **software platform for smart homes.** The companies have now signed a memorandum of understanding to this effect. The plan is subject to approval by the antitrust authorities.

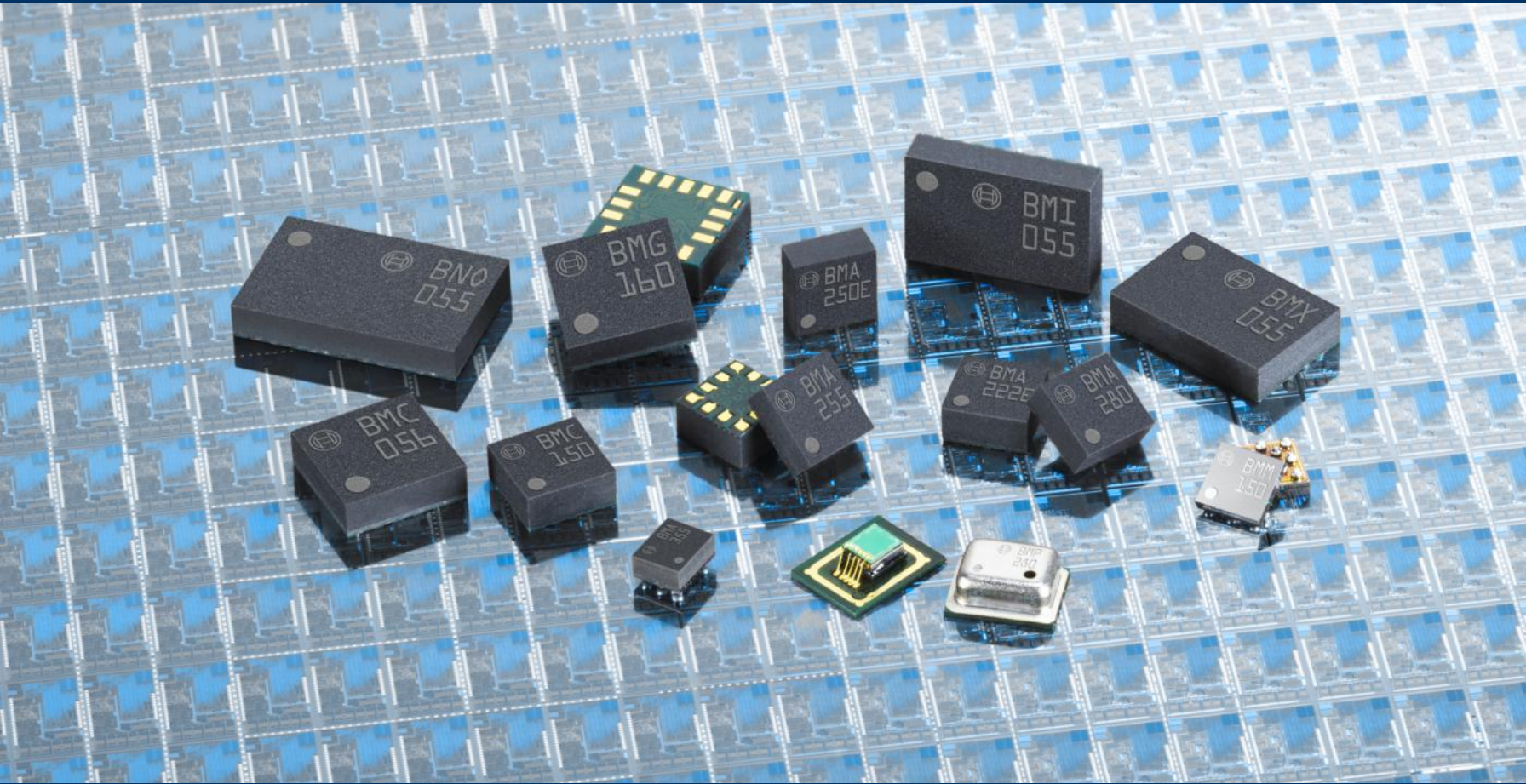**BOSCH**

Main Take-Away

Bosch Sensortec is the **driving** company **to provide** the full range of **components, integration levels & solution approaches** for consumer electronics MEMS an IoTS.

Key Success Factors

Technology Mastering -> to manage a broad technology portfolio

Application **Know-How** -> to develop the right solutions

Solution Focus   -> HW & SW Co-design capability

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Q & A Session

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Bosch sensors can be found in more then every

second

smartphone worldwide.

Detect height differences of

< 1m and tilt angles of < 1°

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