

The Next Wave of Sensors – Smart and Connected

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GRENOBLE,
FRANCE

EUROPEAN
**MEMS
& SENSORS**
SUMMIT

EUROPEAN
**IMAGING
& SENSORS**
SUMMIT

Who We are

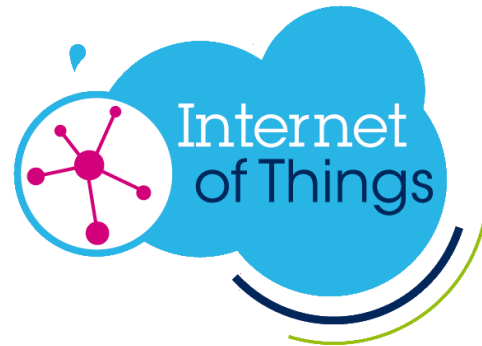
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- A global semiconductor leader
- 2016 revenues of **\$6.97B**
- **\$1336 M R&D** expenses in 2016
- Listed: NYSE, Euronext Paris and Borsa Italiana, Milan

- Research & Development
- Main Sales & Marketing
- Front-End
- Back-End

- Approximately **43,500** employees worldwide
- Approximately **7,500** people working in R&D
- ~ **16,000** patents; ~ **500** new filings (in 2016)
- **11** manufacturing sites, Over **80** sales & marketing offices

Application Strategic Focus



Smart Things



Smart Home & City



Smart Industry

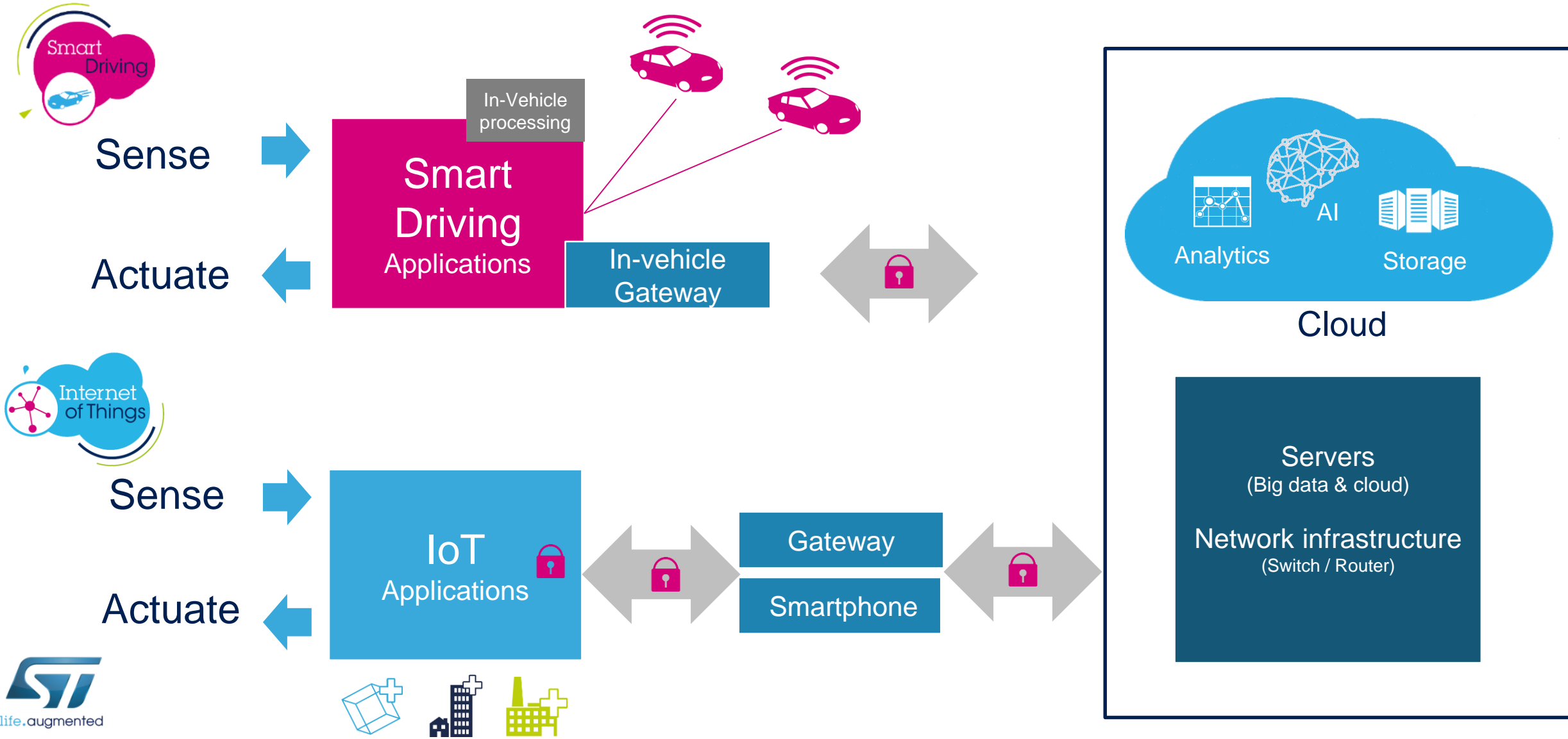


Smart Driving



Connected Sensing

A key part of the Internet of Things & Smart Driving



Enabled by Connected Sensors



Smart Things



Smart Home & City



Smart Industry



Smart Things

- Sensing to understand the environment around an IoT device
- Bio-information capture for wearable device
- Micromirrors for multimedia projection and scanning



Smart City

- Remote monitoring, activation and dimming control for street lighting
- Connected monitoring stations for air quality, security and traffic
- Empty space detection for Smart parking



Smart Home

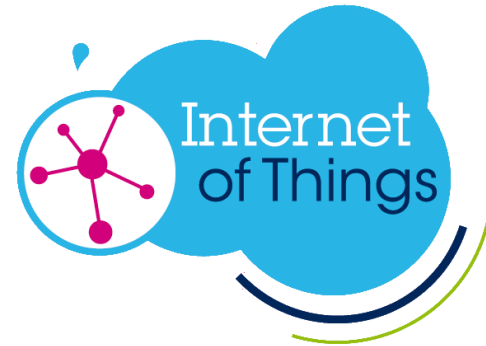
- Smart control of heating, air-con, appliances, locks & alarms
- Voice-controlled home environment
- Smart Meters for electricity, gas and water



Smart Industry

- More efficient factories
- More flexibility and customization
- Safer working environments
- Better man-machine cooperation

Sensors for Smart Industry



Smart Industry



What Will Smart Industry Bring?

And What Role Will Sensors Play?



Sensors for Industrial Applications



Temperature sensors

Analog and digital contact temperature sensors



Local Temperature Monitoring



Humidity sensors

Combo humidity and temperature sensor



Environment Humidity Monitoring



Pressure sensors

With water proof solutions



Environment Pressure Monitoring



MEMS Microphones

Analog, digital, top and bottom port solutions



Acoustic Monitoring



Time-of-Flight Sensors

Ranging, Multi-zone detection

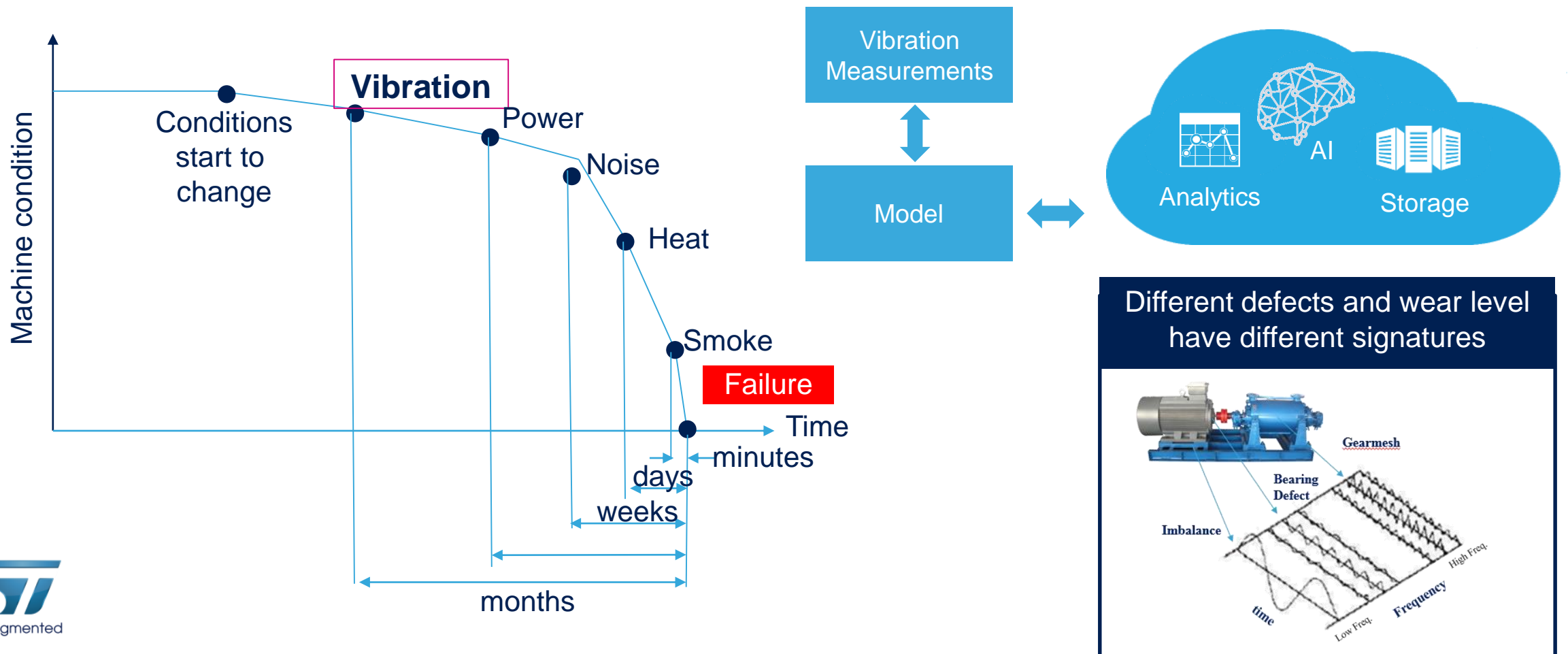


Proximity, Position, Presence Detection



Monitoring and Predictive Maintenance with Motion Sensors

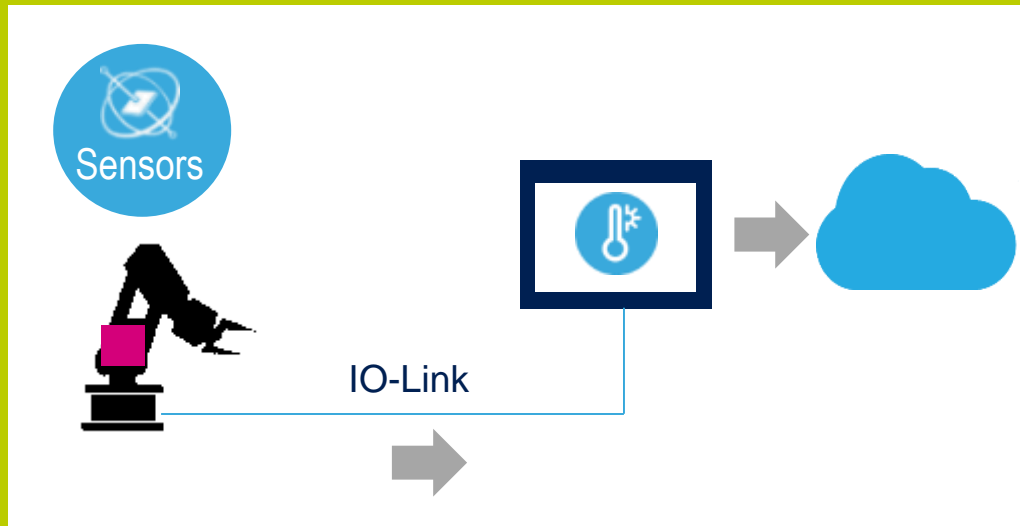
Condition monitoring enables a predictive maintenance strategy



Connectivity Options for Sensors

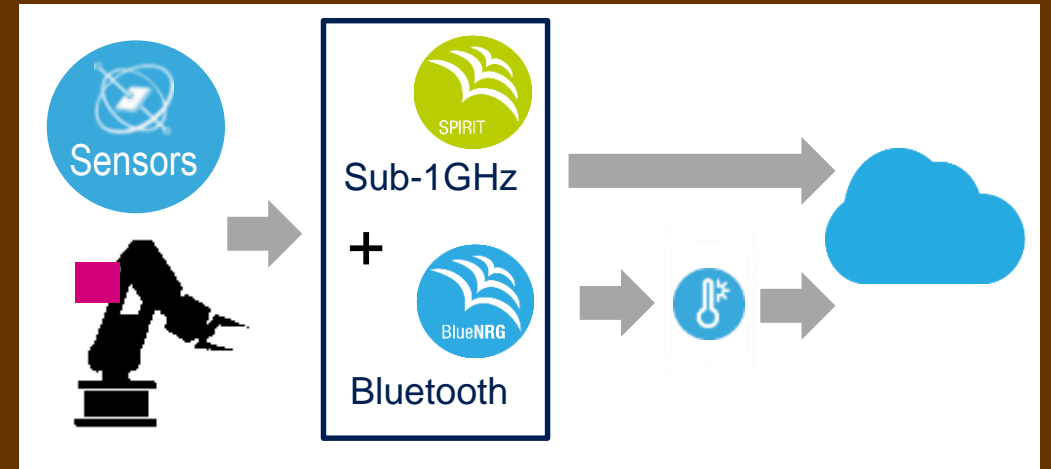
New Manufacturing Installation

- Smart Sensors pre-installed in new equipment
- Connection via wired (IO-Link) or wireless connections



Existing Manufacturing Installation

- Smart Sensor add-on to existing equipment
- Wireless connections for local and cloud connectivity



Motion Sensors for Smart Industry

- Ultra-low power and high performance context sensing solutions
- Dedicated products family for Industrial with 10 year committed availability
- Accelerometer, Gyroscope and 6-axis IMU offer with high accuracy, flexibility, and ultra-low power in tiny packages
- Wide range of sensors drivers and free software libraries from ST's Open.MEMS SW environment and STM32 Open Development Environment



Part	Description	Idd (mA)	Parameters	Package
IIS2DH	3-axis accelerometer with digital output	0.011 HPF 50Hz ODR	6µA consumption in Low-power mode @ 50Hz ODR	LGA-12L 2.0 x 2.0 x 1mm
IIS328DQ	3-axis digital output accelerometer	0.250	Automotive grade derivative	QFN-24L 4 x 4 x 1.8mm
I3G4250D	3-axis digital output gyroscope	6.1	Automotive grade derivative	LGA-16L 4 x 4 x 1.1mm
ISM330DLC	iNEMO Inertial Module: 3D accelerometer and 3D gyroscope	0.75 Combo HPM	Noise density in HPM Gyroscope: 3.5mdps/√Hz. Accelerometer: 90µg/√Hz	LGA-14L 2.5x 3.0 x 0.83mm

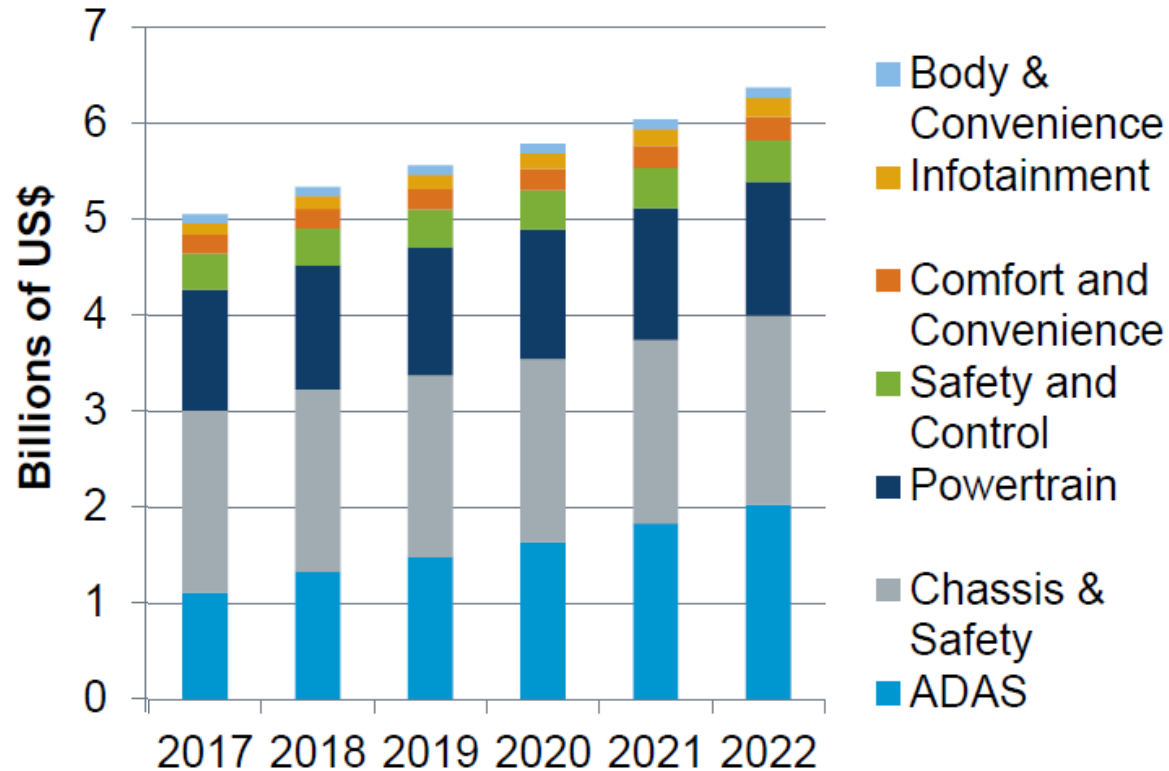
Sensors for Smart Driving



Smart Driving



Market for Sensors for Smart Driving



- Autonomous Driving (ADAS) is a key growth driver requiring multiple high-value sensing elements
- Sensors for Chassis and Safety applications also continue to grow strongly

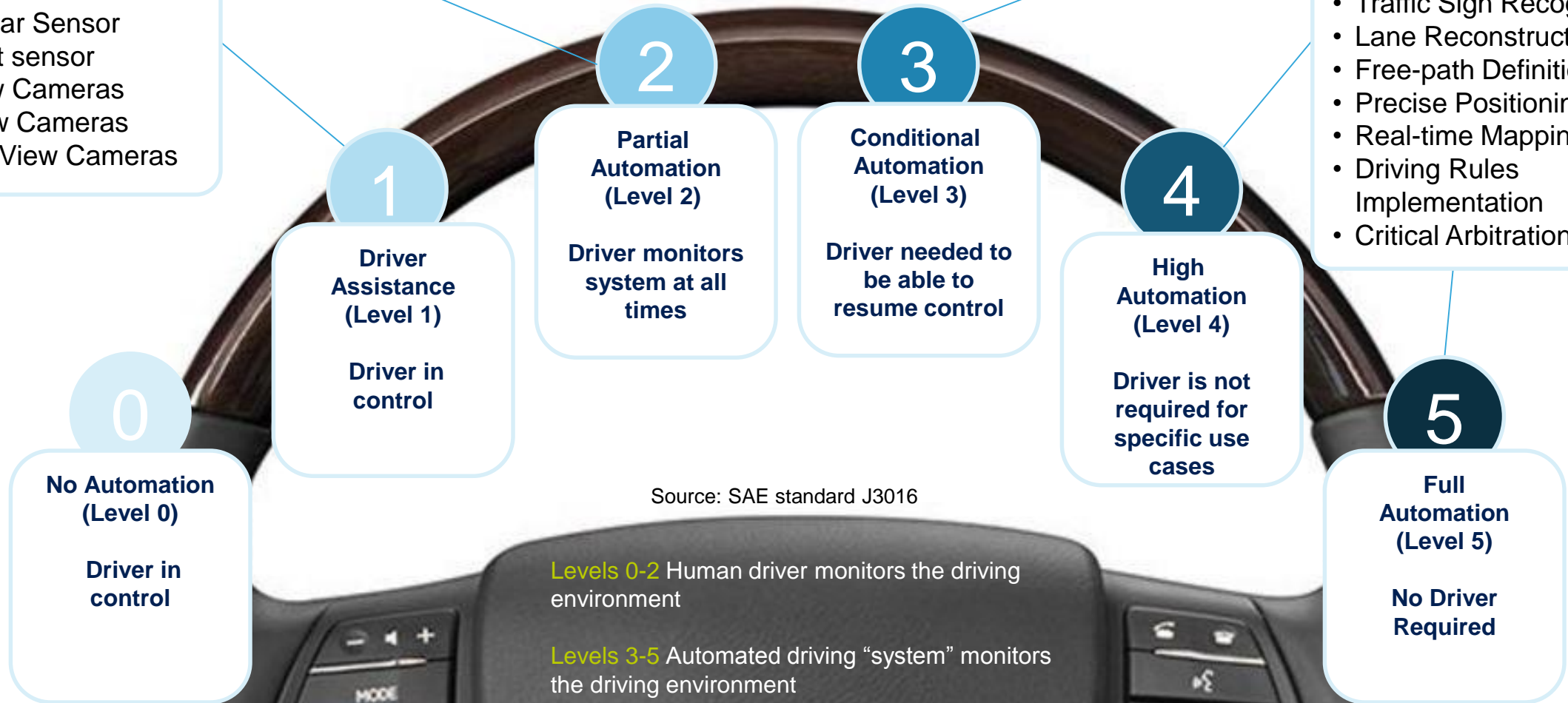
The 5 Levels of Vehicle Automation

Adding Senses

- Accelerometers and Gyro
- Steering Wheel Angle
- Ultrasonic sensors
- Front Radar Sensor
- Blind Spot sensor
- Rear View Cameras
- Front View Cameras
- Surround View Cameras

Learning to Drive

- Systems Networking
- Sensor Fusion
- Distance Measurement
- Traffic Sign Recognition
- Lane Reconstruction
- Free-path Definition
- Precise Positioning
- Real-time Mapping
- Driving Rules Implementation
- Critical Arbitration



Source: SAE standard J3016

Levels 0-2 Human driver monitors the driving environment

Levels 3-5 Automated driving “system” monitors the driving environment

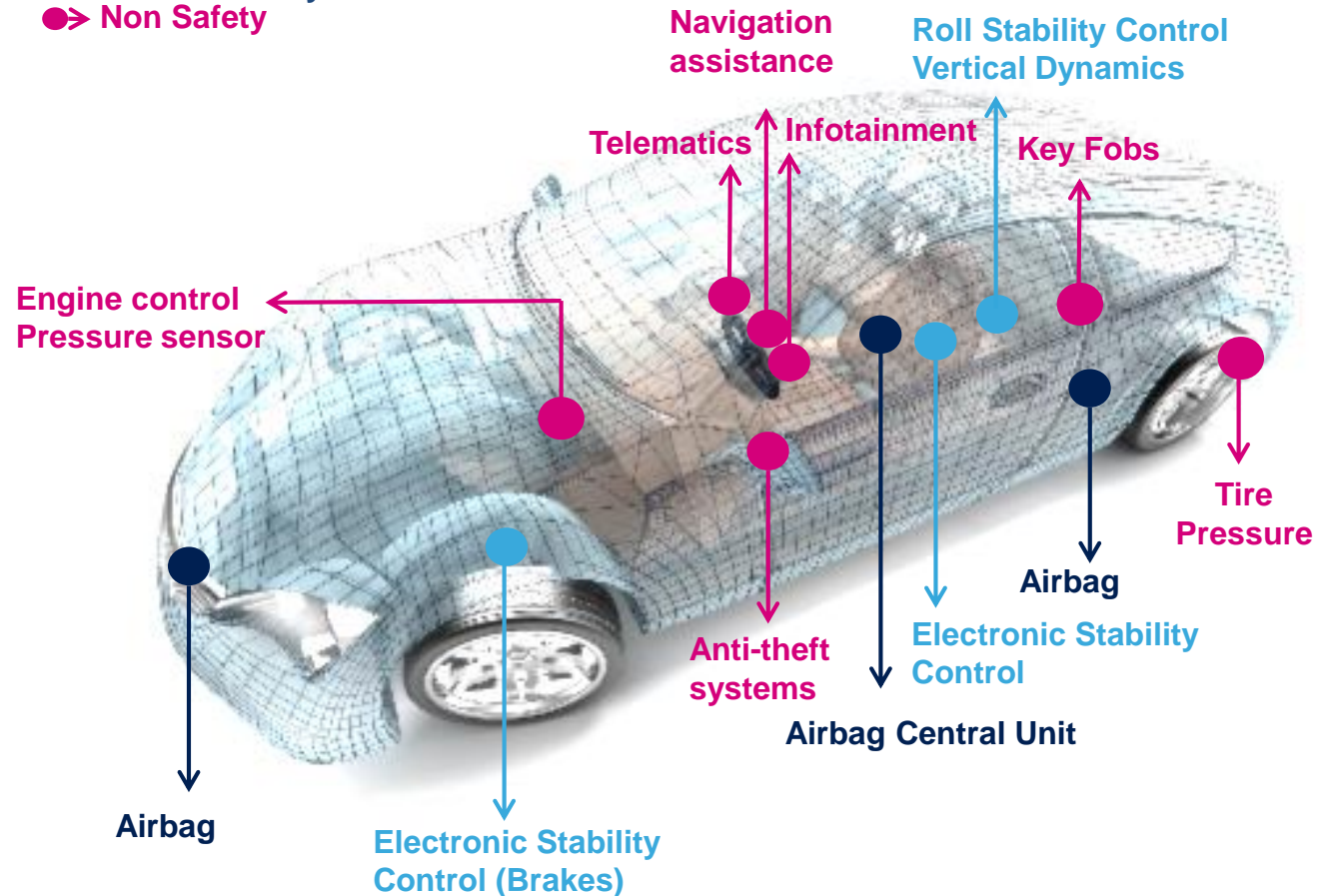
MEMS Sensor Technologies for Smart Driving

SENSORS

Acoustic/ Video	Motion	Environmental
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 Voice process.	 Accelerometer	 Humidity
 Microphone array	 Gyroscope	 Temperature
 Digital microphone	 Magnetometer	 Pressure
 Camera/ Stabilization	 6, 9-axis Inertial	

- Active Safety
- Passive Safety
- Non Safety



Smart Automotive Camera Solutions

Transforming Driver Assistance

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Sensing & Viewing Camera

Front-Facing View
Rear & Surround View
eMirror

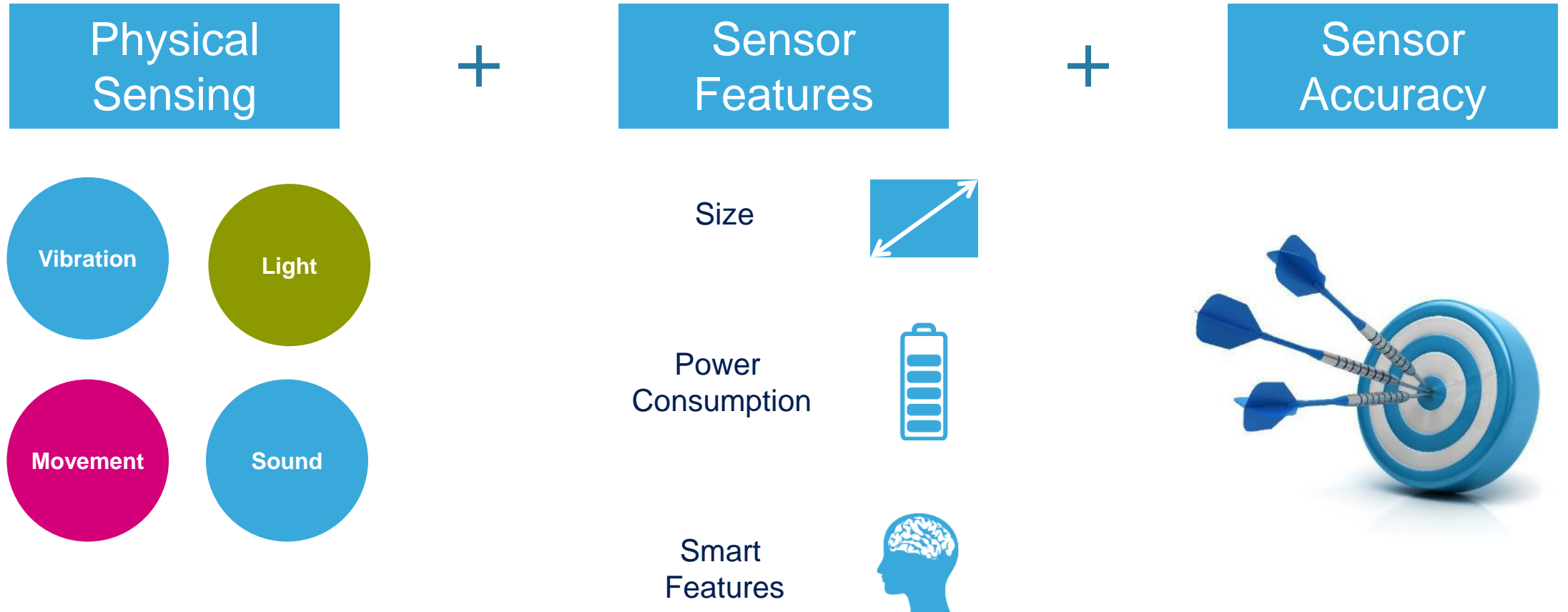


LiDAR

Autonomous Driving
through Sensor Fusion



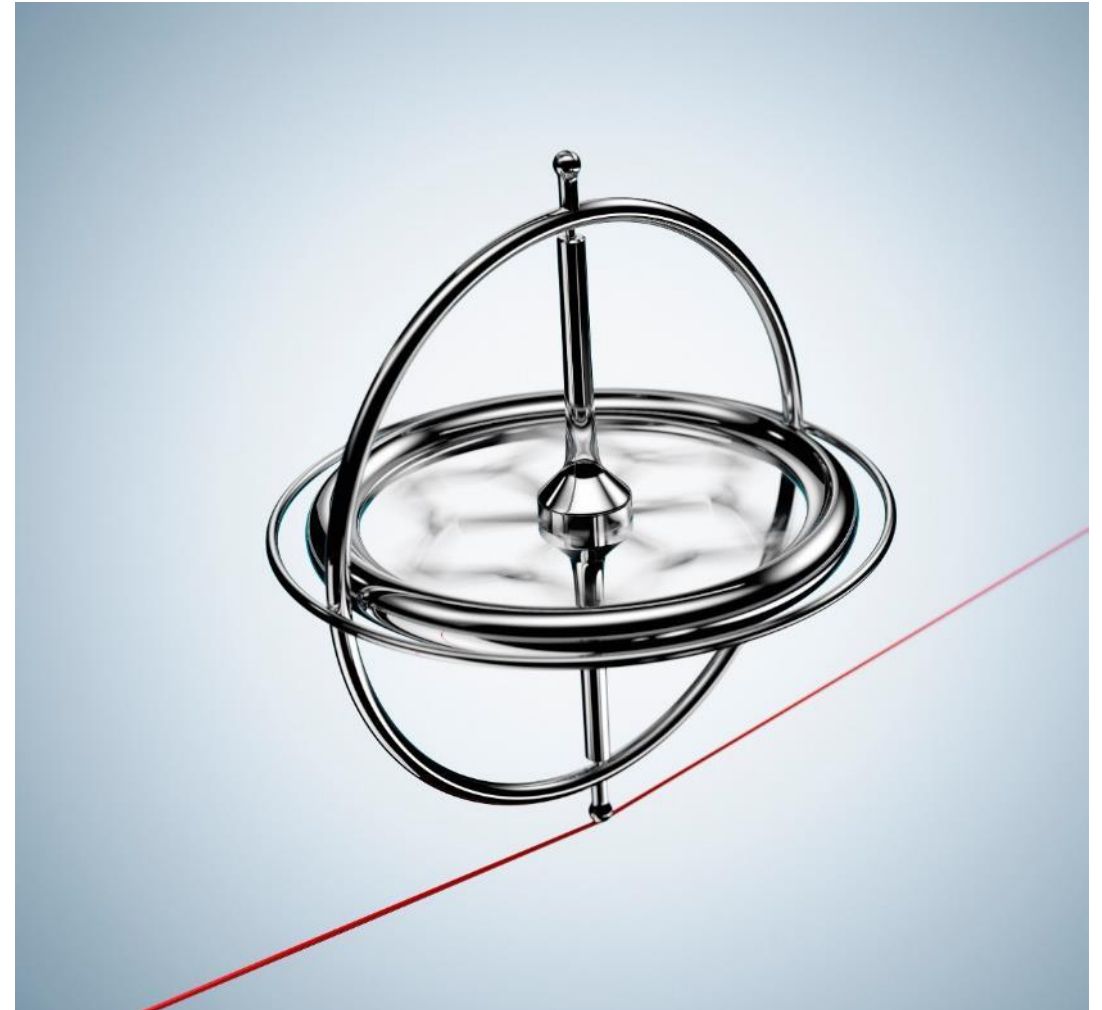
How to Make a Great Sensor



MEMS Sensor Accuracy

A key Challenge for IoT & Smart Driving Sensing

- MEMS Sensors for IoT & Automotive applications are required to become ever more accurate:
 - Precise rotation for VR and AR
 - Precise machine motion or vibration sensing
 - Highly accurate motion sensing for dead reckoning
 - Highly accurate barometric reading for altitude measurement
 - High fidelity voice and ambient noise pick-up for voice recognition & noise cancelling
- Higher accuracy generally means more power consumption so sensor makers must innovate to keep within power budgets

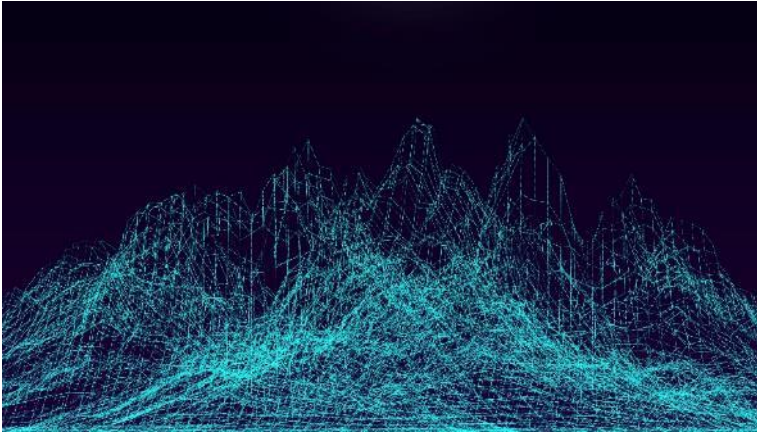


MEMS Sensor Accuracy

The Key Parameters



Sensor Accuracy



Noise

- Vibration rejection
- Flicker noise
- High frequency noise



Stability

- Stability over Time
- Stability vs temperature
- Repeatability

MEMS Sensor Accuracy In Manufacturing Technology & Equipment

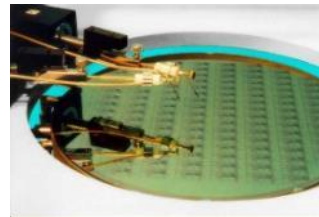


Precise geometries, etching, assembly



Enabling **sensor accuracy** at **yields** suitable for **high volume** manufacturing

Manufacturing
equipment



Accurate Stimuli, Multi-calibration points, Multi Degree of Freedom (DoF) -tests, high parallelism



Enabling accurate **sensors** at **high volume**

Test & Calibration
equipment

Optical Sense Challenges

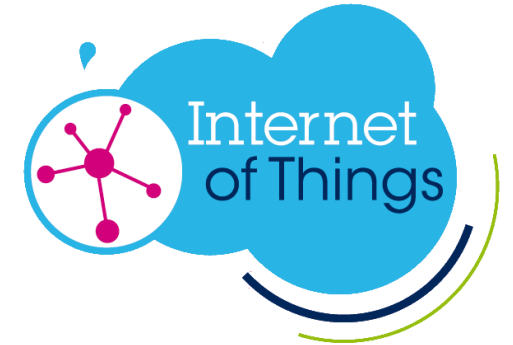
From Image Capture To Smart Sensing



Smart Driving



Robust pixel detection
Embedded safety & security
Tailoring technology
to applications



Smart Industry



MEMS Sensors, Micro-Actuators & Imaging

MEMS Sensors and Micro-actuators



MEMS Motion Sensors

- Accelerometer
- Gyroscope
- Magnetometer
- 3,6,9-Axis IMU



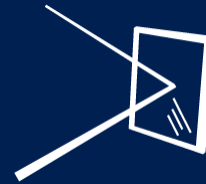
Environmental Sensors

- Pressure
- Temperature
- Humidity



MEMS Microphones

- Digital
- Analog



MEMS Micro-Actuators

- Micro-mirrors
- Fluidic micro-actuators
- Piezo-actuators

Imaging



Time-of-Flight Solutions

- Camera assist
- Ranging & Proximity
- Presence Detection
- LiDAR, AR/VR, ...



Specialized Image Sensors

- Consumer
- Automotive



Sensor Hub & Sensor Fusion

Open.MEMS libraries

- Activity Tracking
- Carry position
- Acoustic algorithms

Key Assets

- Imaging system expertise
- Innovative pixel design
- Low power architecture
- SPAD-based Time-of-Flight
- Imager silicon process
- Optical package/module



>350 Million Time-of-Flight units shipped
Billions of image sensor units

Leveraging ST proprietary manufacturing processes & world-class manufacturing capabilities

