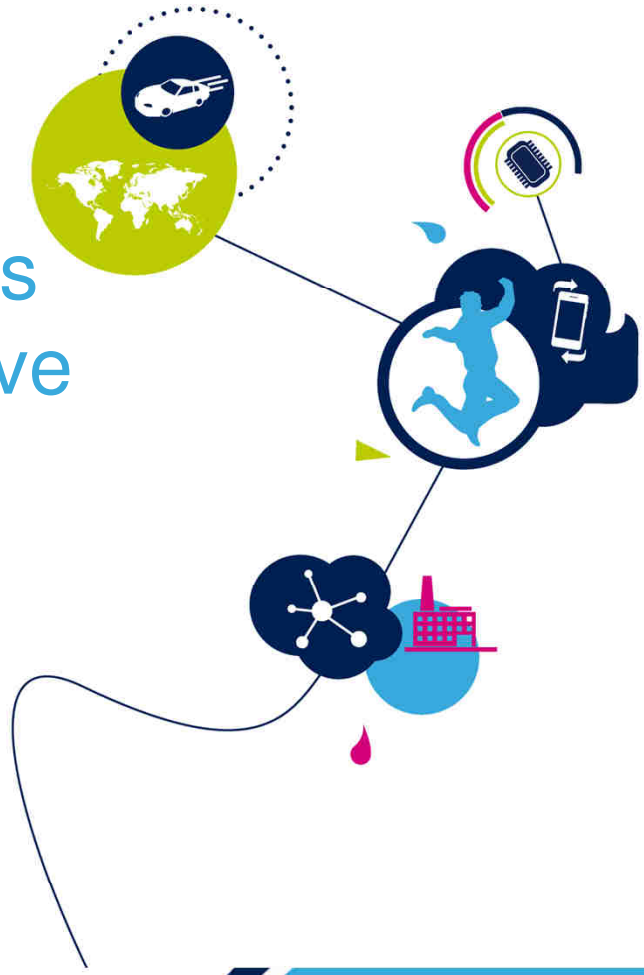
# Eval kits and Development Platforms for MEMS Sensors: A Comprehensive Environment for Fast Go-to-Market

Mauro Scandiuzzo & Thiago Reis



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Technology Tour 2019

Schaumburg, IL | April 25

# This session will explore:



- ✓ IoT Discovery Kit
- ✓ SensorTile Development Kit
- ✓ BlueNRG-Tile: Bluetooth LE-enabled sensor node development kit
- ✓ STM32 Nucleo Expansion boards
- ✓ Professional MEMS tool: ST MEMS adapter motherboard

# ST: Products & Ecosystem
## to Match IoT Market Trends



**Market Trends**

| Smart Things | Smart Home | Smart City | Smart Industry |
|---|---|---|---|
| | | | |
| Ultra-low power, Form Factor, Sensors Performance… | Wifi, BTLE, sub-GHz, Sensors, Audio, Touch, Graphics… | LTE, Sub-GHz, Motion Sensors | Longevity, Certification, motion sensors… |

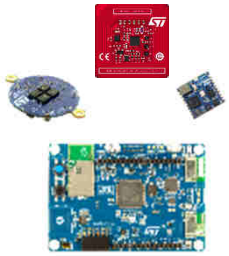
**ST Offering**

### Broad Technology Offer

### Ecosystem for application development

STM32 Nucleo development kits

STM32 Nucleo expansion boards for connectivity, sensing, actuating



Starter Kits and Form Factor Boards

STM32 Cube

STM32 Open Development Environment

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Partner Program

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# …but Their Needs are the Same



| | Processing & Security | Sensing & Actuating | Connectivity | Signal Conditioning & Protection | Power & Energy Management |
|---|---|---|---|---|---|
| Smart Things<br>Smart Home<br>Smart City<br>Smart Industry | Ultra-Low Power<br>to<br>High Performance<br><br>Scalable Security solutions | Full range of sensors and actuators | 10 cm<br>to<br>10 km | Nano Amps<br>to<br>Kilo Amps | Nano Watt<br>to<br>Mega Watt |

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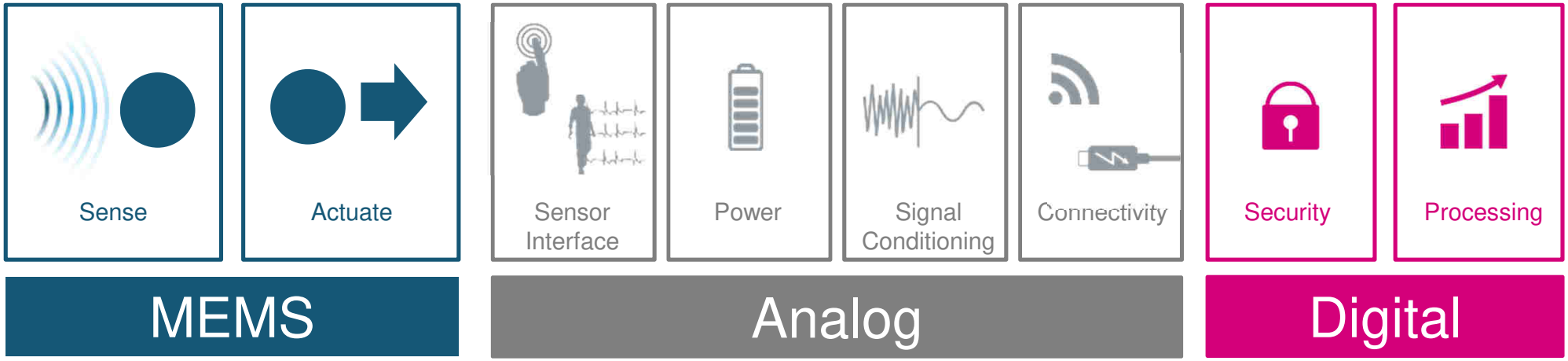
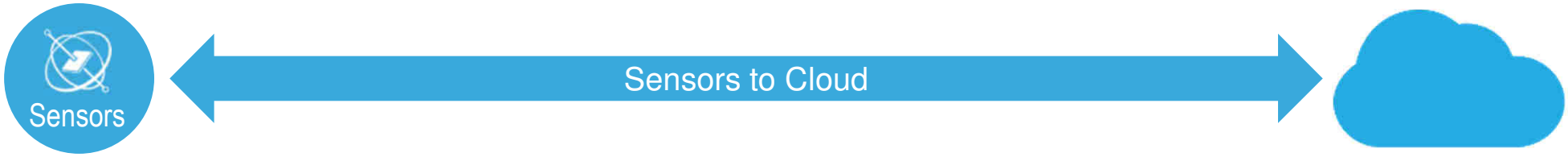
# MEMS and Analog Empower the IoT






Today only a tiny portion of the sensory data that would be useful is captured, stored and analyzed
…and even smaller part of that is used to carry out actions through actuators

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# Supporting the IoT Movement



Connect

Translate

Move
Actuate

Power

Secure

Process

Sense



SensorTile

BlueNRG-Tile

ProfiMEMS

Discovery Kit IoT Node

STM32 Nucleo Development
& Expansion boards

## Pre-integrated SW for vertical applications

Smart Things

Smart Home

Smart City

Smart Industry

## Development Ecosystem

Code generators

Prototyping software

IDE
Development environments

Debug solutions

Simulation and analysis tools

On-line design tools

ST Community

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Partner Program

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# >150 Partners… and Counting

Cloud | Components and Modules | Embedded Software | Engineering Services | Hardware Development Tools | Software Development Tools | Training

# IoT Discovery Kit

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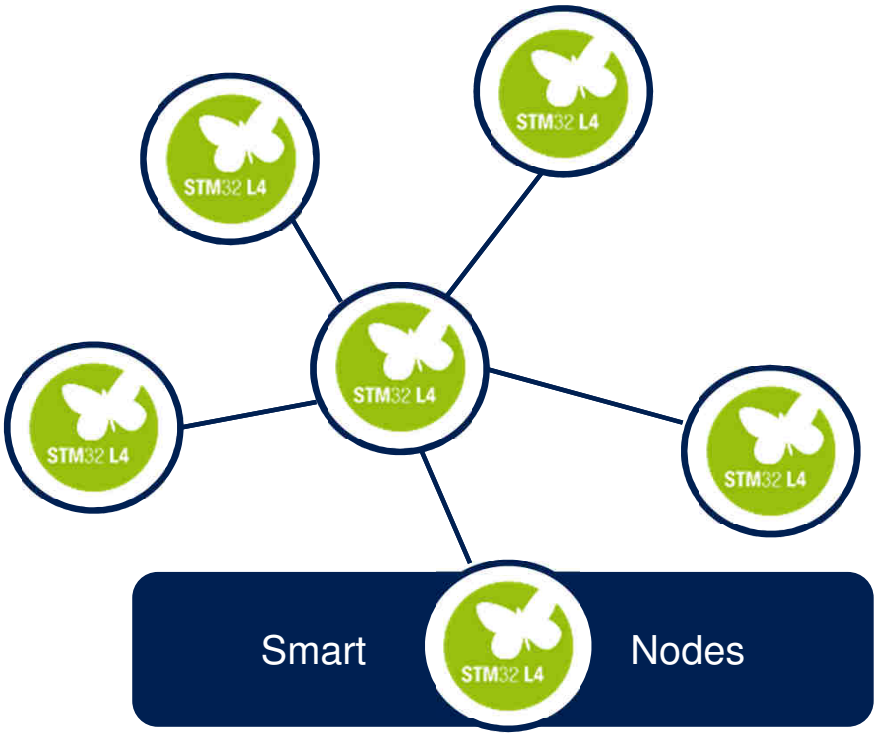
# STM32L4 Discovery Kit IoT Node



Get connected seamlessly!



Network Servers

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# STM32L4 Discovery Kit IoT Node



## Open the door to remote services

- Direct connection to cloud servers
- Low-power long-range communication
- Environmental awareness: humidity, pressure, temp
- Detection hub: motion, proximity, audio

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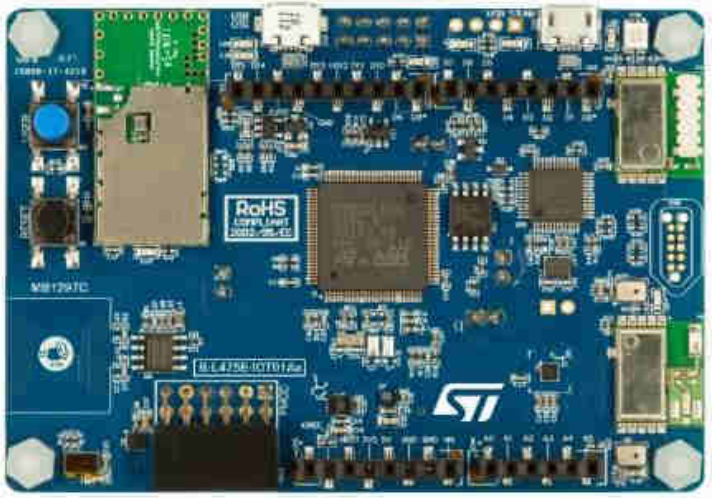
# IoT Discovery Kit



## All-in-One IoT Development Platform

- Motion sensors
- Environmental sensors
- MEMS Microphones
- Proximity sensor
- Dynamic NFC Tag
- Low Power MCU
- Sensors Fusion
- Bluetooth Low Energy
- Sub 1GHz
- Wi-Fi



**B-L475E-IOT01A**

STM32 L4

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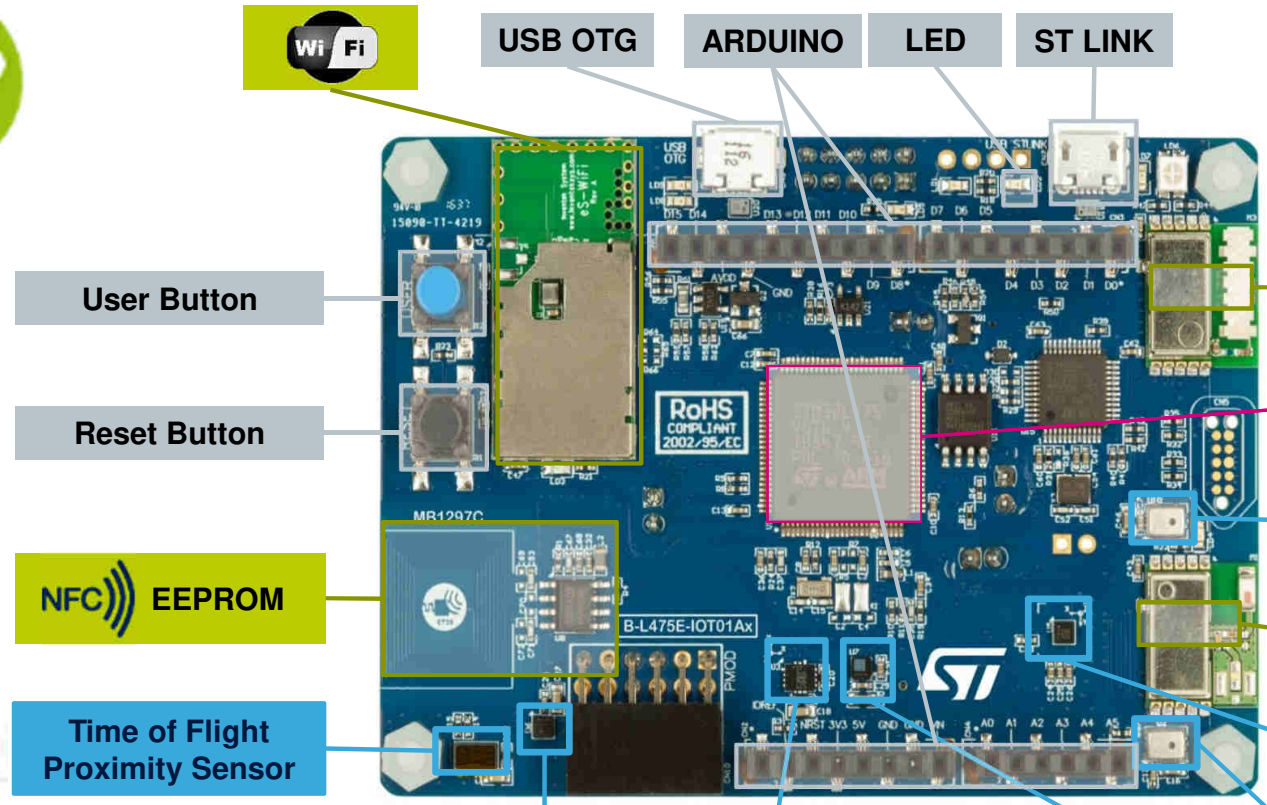
# STM32L475 Discovery Kit IoT Node

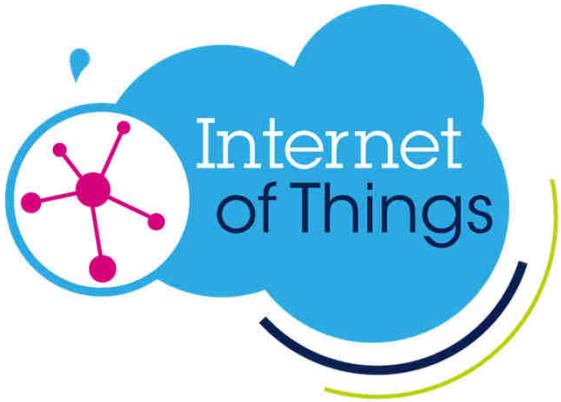




# Cloud Connected IoT Sensor Nodes



- Amazon AWS IoT
  - X-CUBE-AWS
  - FP-CLD-AWS and Web Dashboard
  - Amazon FreeRTOS
- Microsoft Azure IoT
  - FP-CLD-AZURE1
  - STM32ODE IoT Web Dashboard
  - X-CUBE-AZURE
- Google Cloud IoT Platform
  - X-CUBE-GCP
- IBM Watson IoT
  - X-CUBE-WATSON
  - FP-CLD-WATSON1




ST provides device kit and FW packages to connect to the major Cloud providers

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aws

Microsoft

Google

IBM

# SensorTile

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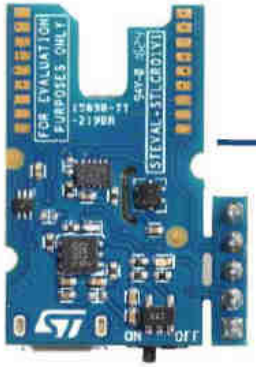
# SensorTile Kit



SensorTile
Core System
**STLCS01V1**

SensorTile
Cradle Board
**STLCR01V1**



SensorTile
Cradle eXpansion
**STLCX01V1**

**STEVAL-STLKT01V1**

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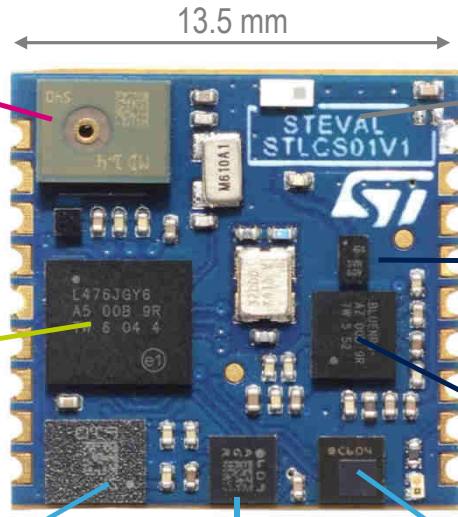
# SensorTile

## Sensors, MCU, Connectivity



## SensorTile Development Kit: STEVAL-STLKT01V1




MEMS Microphone

STM32 Low power MCU

Accelerometer & Gyroscope
**LSM6DSL**

Accelerometer + Magnetometer
**LSM303AGR**

Antenna Clearance Area

Balun Filter

Bluetooth Low Energy processor

Barometer
**LPS22HB**

*Bottom View*

BlueNRG

Bluetooth SMART

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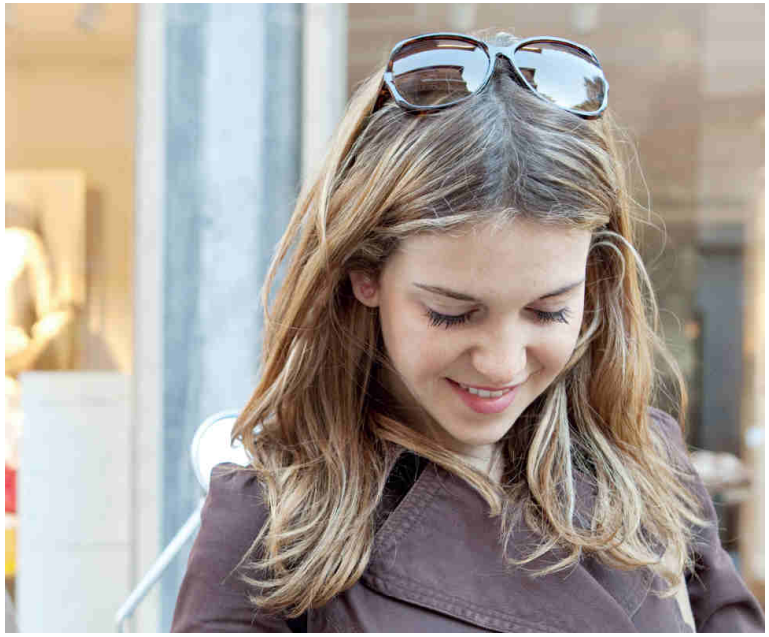
Sense

# LSM6DSL / LSM6DSM



## High performance 6-axis IMUs



- 3D accelerometer and 3D gyroscope
- “Always-on” experience with <0.7mA
- Smart features: FIFO, Sensor hub, Pedometer, Motion detection etc.

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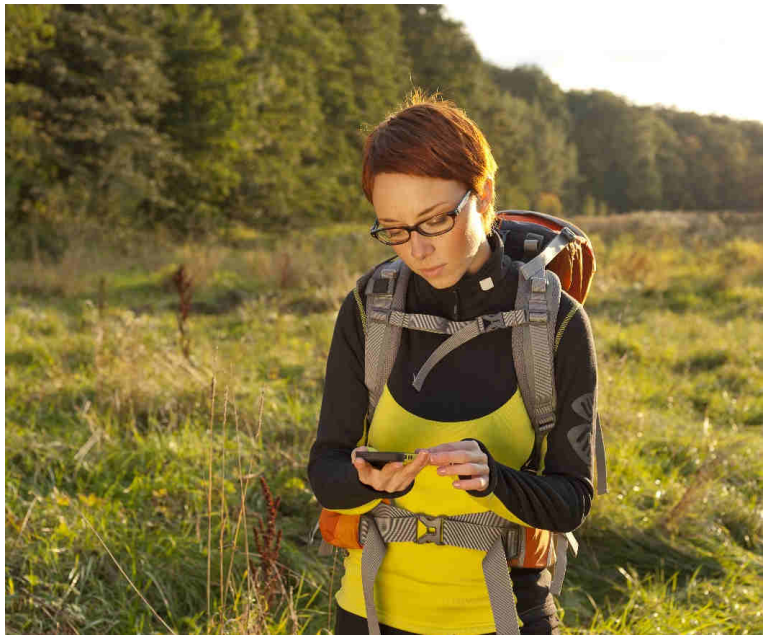
**LSM6DSL and LSM6DSM enabling always-on low-power features for an optimal motion experience for the user.**
It is a system-in-package featuring 3D accelerometer and 3D gyroscope performing at 0.65 mA in high-performance mode.

Sense

# LSM303AGR / LIS2MDL



## Ultra-high accurate e-compass / magnetometer



- Extended dynamic range: 50Gauss
- Low power: 200µa @20hz
- Very low noise: 2.5mGauss

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**LSM303AGR and LIS2MDL enabling high performance Magnetic field measurement** by offering High Full Scale Magnetometer, Flexibility resolution vs. power consumption, Magnetic offset cancellation embedded in a standard pinout 2 x 2 mm package

# LPS22HB



## High accuracy barometric sensor

- Low noise: down to 20µbar & 7.5µbar (LPF)
- High accuracy: 6cm with OPC
- Reduced current consumption: 12µA (low noise) to 3µA (low power) @1Hz
- High stability vs Temperature: Embedded Quadratic Temperature compensation

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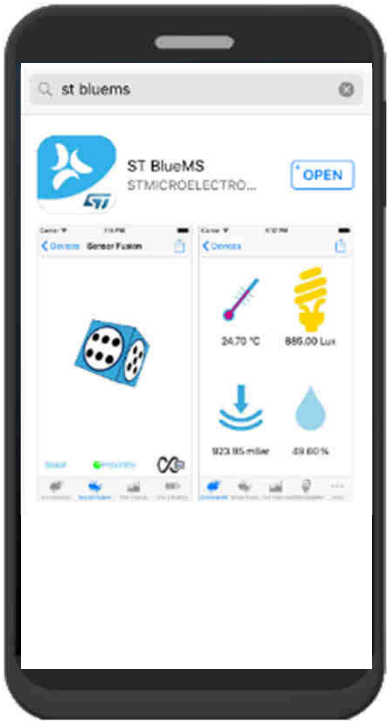
**LPS22HB enabling high performance pressure measurement** by offering Low noise, High accuracy, Reduced current consumption & High stability vs Temperature in a 2 x 2 x 0.76mm package

# SensorTile & ST BLE Sensor App

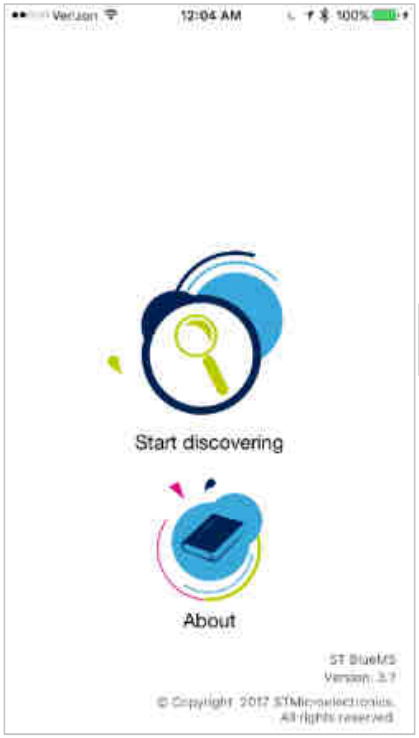


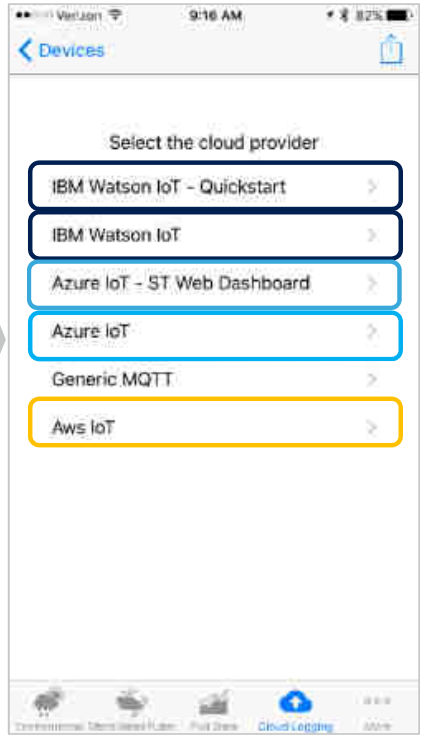



Download on the App Store

GET IT ON Google Play

ST BLE Sensor
(previously ST BlueMS)
STMICROELECTRONICS INC

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# BlueNRG-Tile

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# BlueNRG-Tile

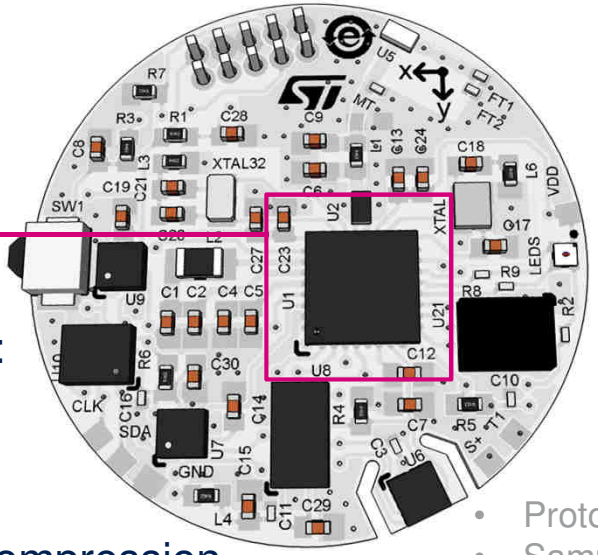
## STEVAL-BCN002V1B

BlueNRG

### BlueNRG SoC

**Sensing, processing and streaming**

2.5 cm




Ultra-low-power software libraries for:

**Motion Algorithms**:

- Gesture and Activity recognition

**Voice over BLE:**

- High quality voice capturing and compression

**BLE Mesh:**

- Range-extending networks with duplex communication

- Prototypes available
- Samples in Q3 2018
- Production in Q4 2018

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# BlueNRG-Tile



32KHz XTAL to enable ultra-low-power BLE sleep mode

L2 bead to enable low-power BLE active mode

Wake-up button

**Pressure Sensor**
LPS22HH

**Accelerometer + Gyroscope**
LSM6DSO

I²C for expansion

**Magnetometer**
LIS2MDL

Debug & Program Interface

**High efficiency**
Chip Antenna

**Balun**
BALF-NRG-02D3

**Bluetooth Low Energy SoC**
BlueNRG-232

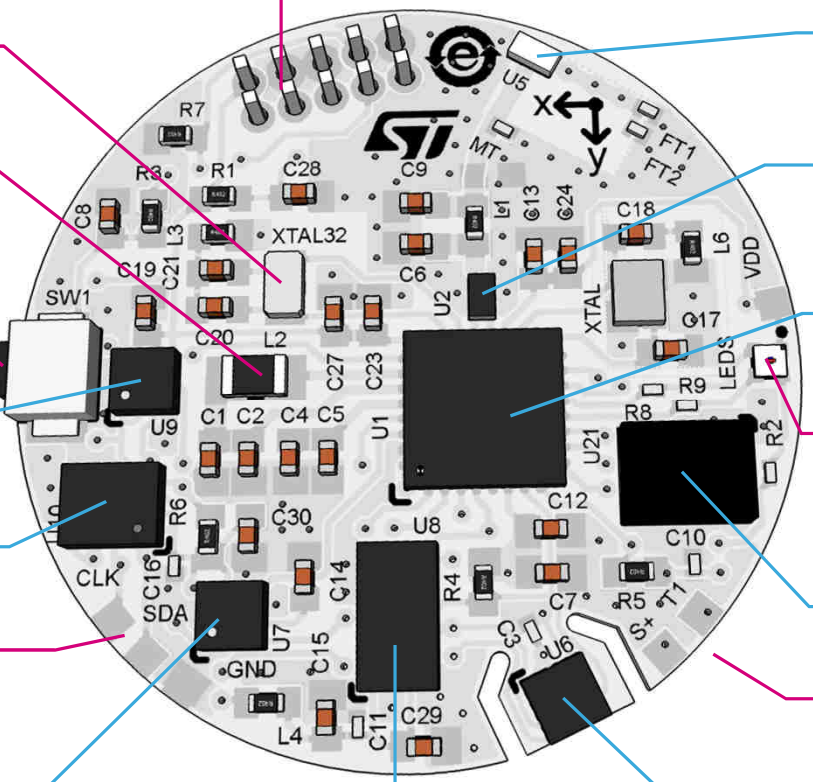
RGB LED

**Microphone**
MP34DT05-A

CR2032 battery holder (Bottom)

**Humidity + Temperature**
HTS221

**Time of Flight**
VL53L1X

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# BlueNRG-2 and MEMS Sensors



## Ready-to-go Software Libraries for Voice and Motion

Mic

VOICE CAPTURE

### Voice over BLE

High quality voice capturing and compression (ADPCM)
More codec supported through external host
(Speex, Opus, …)

Sensors

MOTION CAPTURE

### Motion Algorithms

Lightweight 6 or 9 axis sensor fusion (up to 50Hz ODR)
and gesture recognition algorithms

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# STM32 Nucleo Expansion

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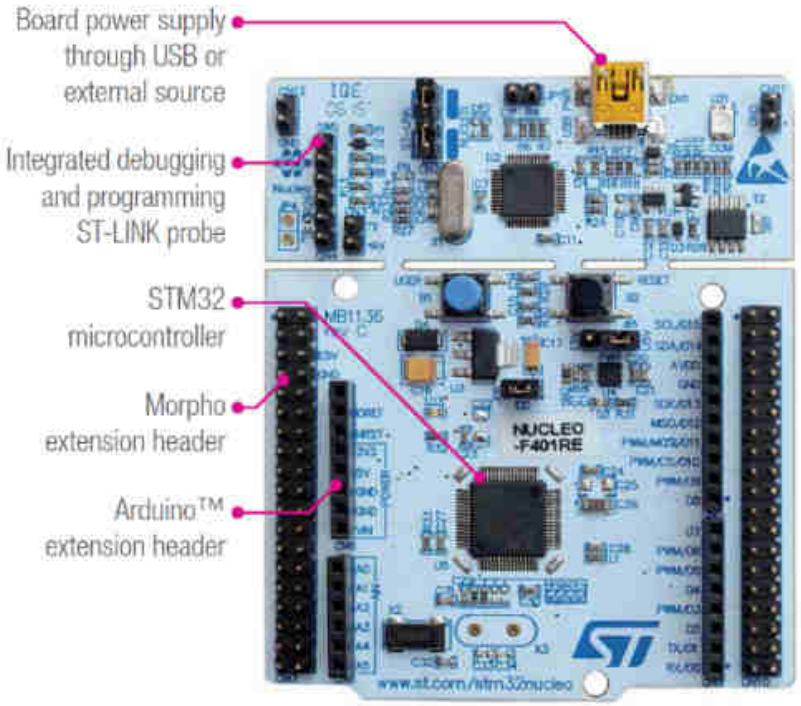
# STM32 Nucleo Development Boards



27 development boards and growing… in two flavors (Processing & Security)




STM32 Nucleo

STM32 complete product range
from ultra-low power to high performance

STM32 F0 STM32 F1 STM32 F2 STM32 F3 STM32 F4 STM32 F7

STM32 L0 STM32 L1 STM32 L4 STM32 H7

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# STM32 Nucleo Expansion Boards



**38** expansion boards and growing… covering all the key functions

| Sense (5) | Connect (10) | Power Drive (3) | Move Actuate (16) | Translate (4) |
|---|---|---|---|---|
| Motion & environmental sensors | BLE | Power management | Motor drive | Audio amplifier |
| Proximity sensor | Sub-GHz | LED boost | Actuator | OpAmp |
| Microphone | NFC | | | |

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# An Application-Oriented Approach



## Your need

- Sensors
- Connectivity
- Translate
- Motor drivers
- Power
- Processing

## The building blocks

**Processor boards (Nucleo 64)**
**Expansion boards (X-NUCLEO)**

- Motion
- Environmental
- Bluetooth LE
- Sub-1GHz
- NFC
- Op Amp
- Motor controller
- Power manager
- Microcontroller

## Our answer

**Function Packs (FP)**

Application software and development tools

Integrated Development Environment and middleware

Ready-to-use application-oriented package

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# All the Software Needed

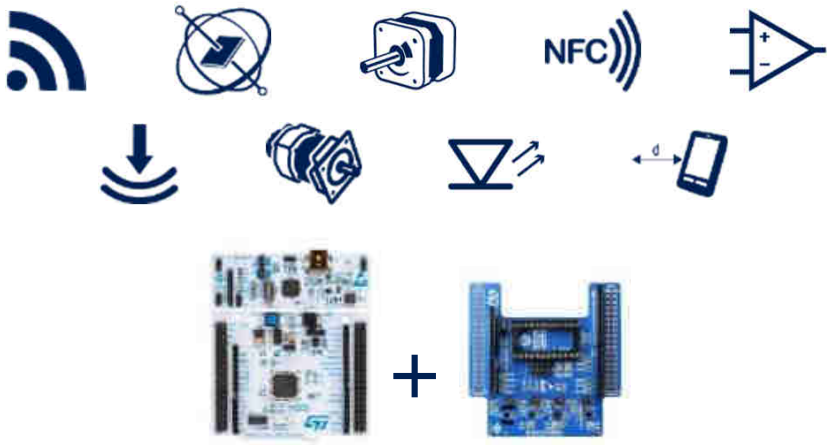
## to Start Application Coding from Day One



### STM32Cube Expansion SW

- Prototype with a single expansion board

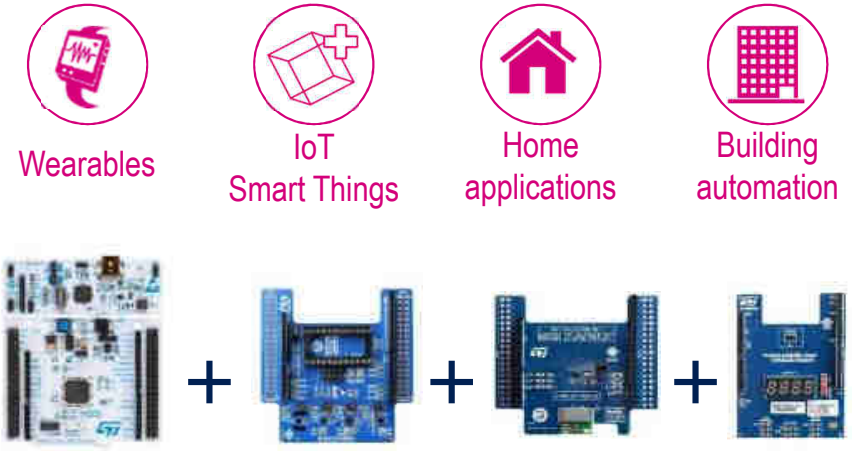
**Sample applications**




### STM32 ODE Function Pack

- Create advanced use cases based on multiple expansion boards

**Pre-integrated application example**

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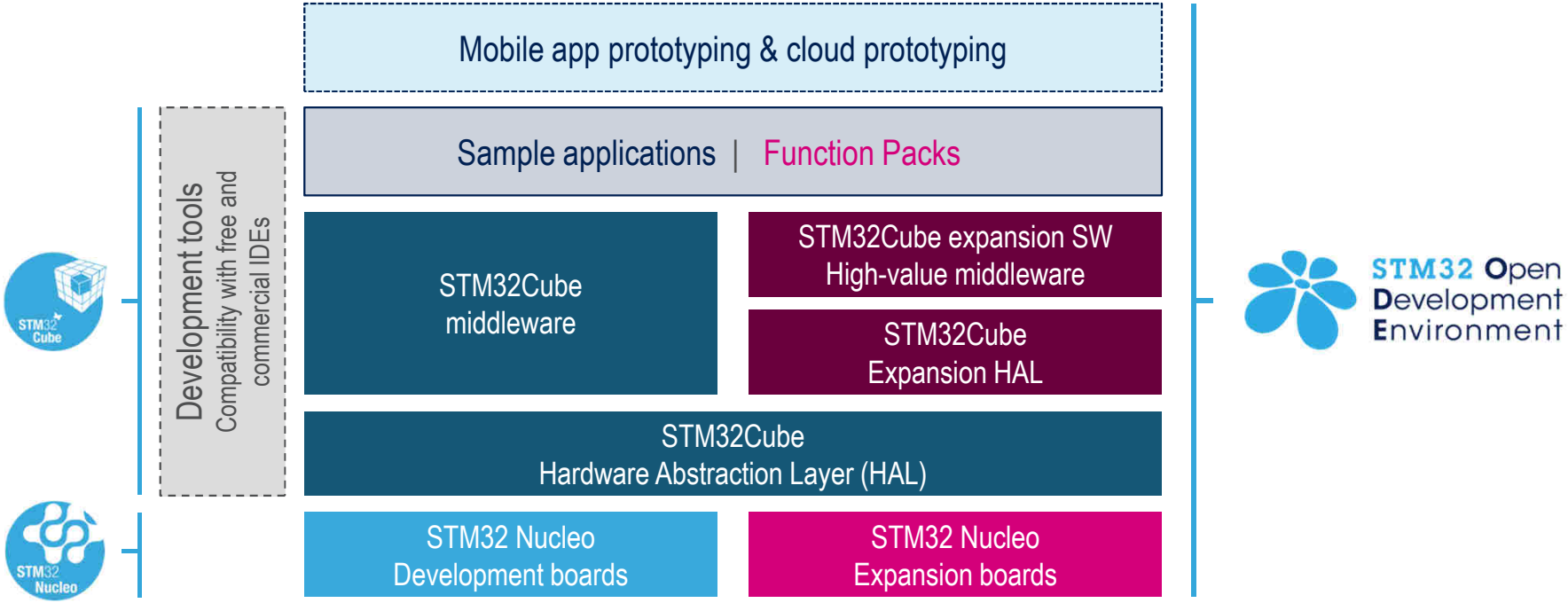
# Development Software Architecture





# X-NUCLEO-IKS01A2



## Motion MEMS and environmental sensor expansion board for STM32 Nucleo

- It is compatible with the Arduino UNO R3 connector layout

**Key products on board:**

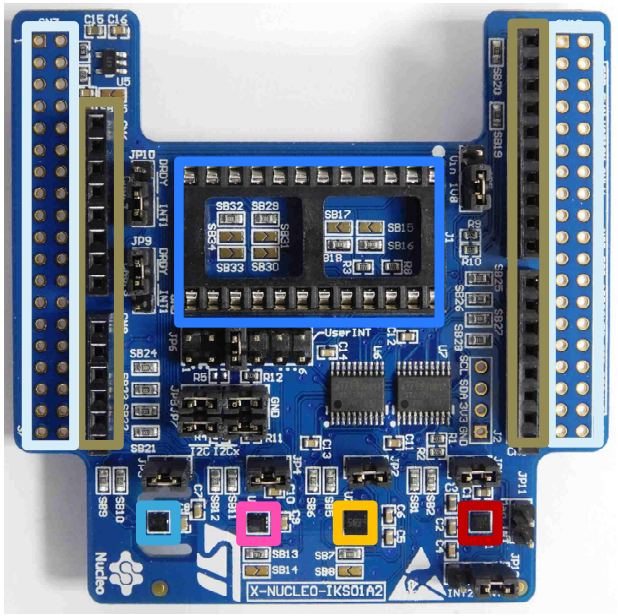
**LSM6DSL:** MEMS 3D accelerometer (±2/±4/±8/±16 g) + 3D gyroscope (±245/±500/±2000 dps)

**LSM303AGR:** MEMS 3D magnetometer (±50 gauss) + 3D accelerometer (±2/±4/±8 g /±16 g)

**LPS22HB:** MEMS pressure sensor, 260-1260 hPa absolute digital output barometer

**HTS221:** Capacitive digital relative humidity and temperature

**DIL 24-pin:** Socket available for additional MEMS adapters and other sensors




HTS221 LSM6DSL ST Morpho connector**

LPS22HB LSM303AGR Arduino UNO R3 connector

DIL 24-pin

** Connector for the STM32 Nucleo Board

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**Info available at**
X-NUCLEO-IKS01A2

# Graphical User Interface

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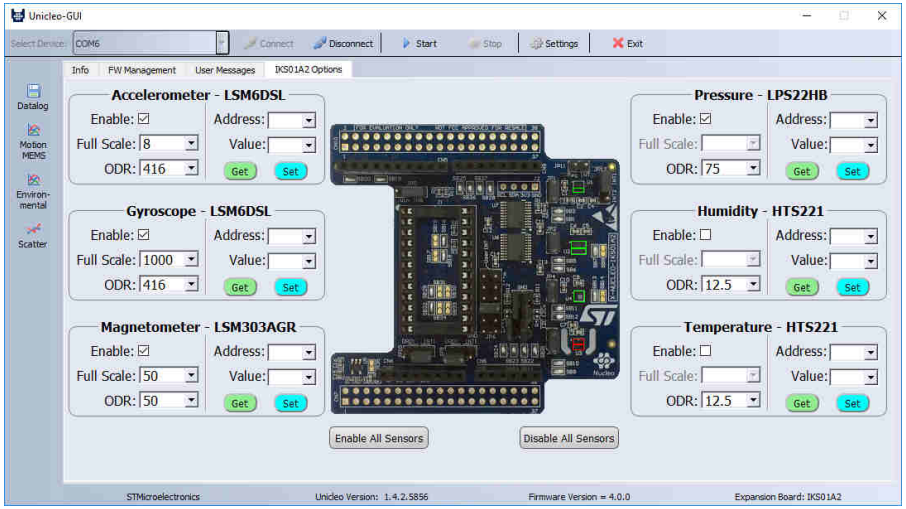
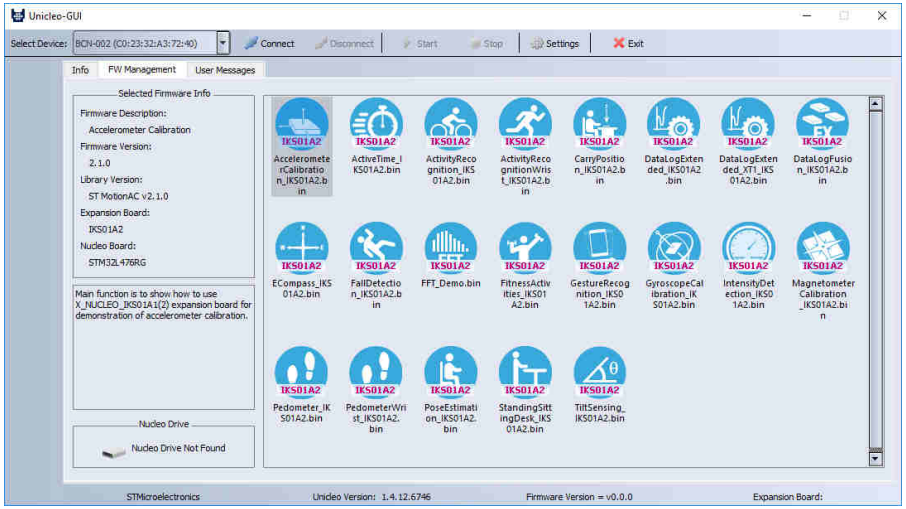
# Unicleo-GUI

## X-CUBE-MEMS1

**Key features:**

- Display output data from connected sensors in various views (**X-NUCLEO-IKS01A1**, **X-NUCLEO-IKS01A2**)
- Display outputs from algorithms
- Save data to comma separated (CSV) or tab separated (TSV) files
- Configure sensor output data rate and full scale
- Direct read from and writes to sensor registers
- Program NUCLEO board with selected FW
- Available also for Sensor Tile & Blue Tile

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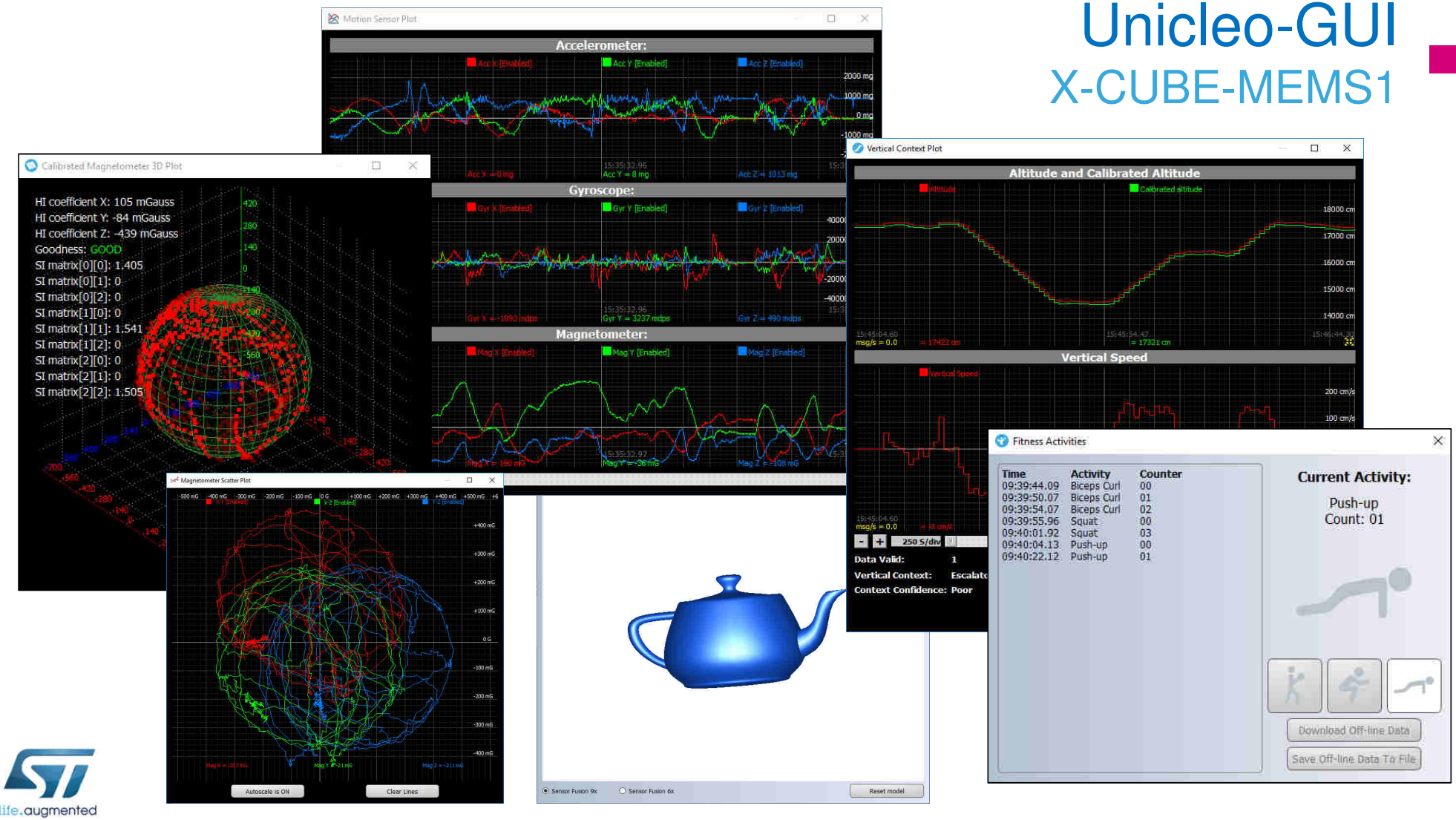
# Unicleo-GUI

## X-CUBE-MEMS1



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# Vibration monitoring tools



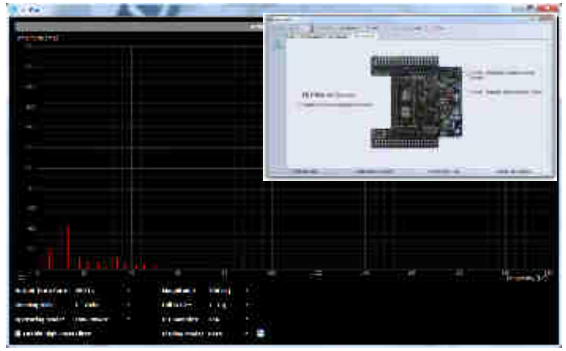
- Hardware

STM32 Nucleo + X-NUCLEO-IKS01A2

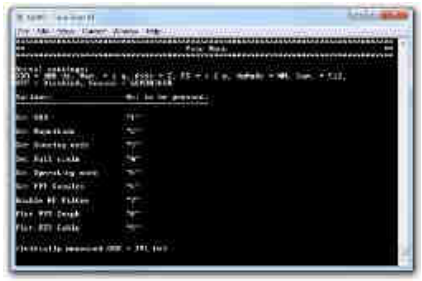
(optional DIL24 adapter)

- Software
  - X-CUBE-MEMS-XT1 package
    - MotionSP middleware – including both time and frequency analysis
    - FFT Demo example

- Windows application: Unicleo-GUI



- Serial terminal



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# Tilt measurement tools



- Hardware

STM32 Nucleo + X-NUCLEO-IKS01A2

(optional DIL24 adapter)

- Software
  - X-CUBE-MEMS-1 package
    - MotionTL middleware – including both tilt calculation and 6-point calibration

- Unicleo-GUI
  - Tilt calculation

  - 6-point accelerometer calibration

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# Sensor fusion tools



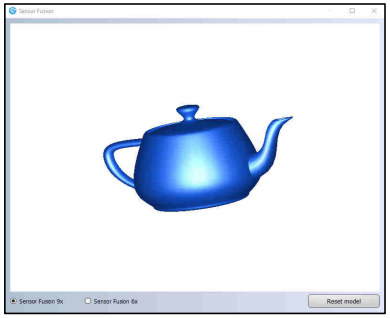
- Hardware

STM32 Nucleo + X-NUCLEO-IKS01A2

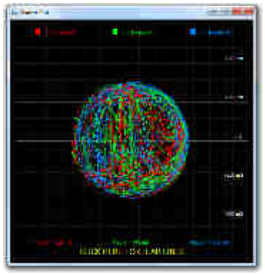
(optional DIL24 adapter)

- Software
  - X-CUBE-MEMS-1 package
    - MotionFX middleware – 6 / 9 axis sensor fusion and gyroscope and magnetometer calibration

- Unicleo-GUI
  - Orientation in 3D space



  - Magnetometer calibration



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# X-CUBE-MEMS1



## Ready-to-go Software Libraries for Voice and Motion

**Calibration Algorithms**

Magnetometer Calibration

Gyroscope Calibration

Accelerometer Calibration

**Position Tracking**

Sensor Fusion

eCompass

Tilt Sensing

**Activity Tracking for Mobile Devices**

Activity Recognition

Carry Position

Gesture Recognition

Pedometer

Fall Detection

**Activity Tracking for Wrist Devices**

Activity Recognition for Wrist

Pose Estimation

Motion Intensity Detection

Standing vs Sitting Desk Detection

Fitness Activities

Active Time

Pedometer

Sleep Monitoring

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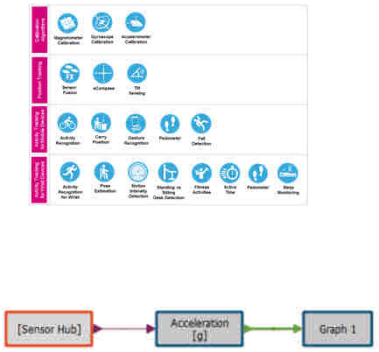
Web Page

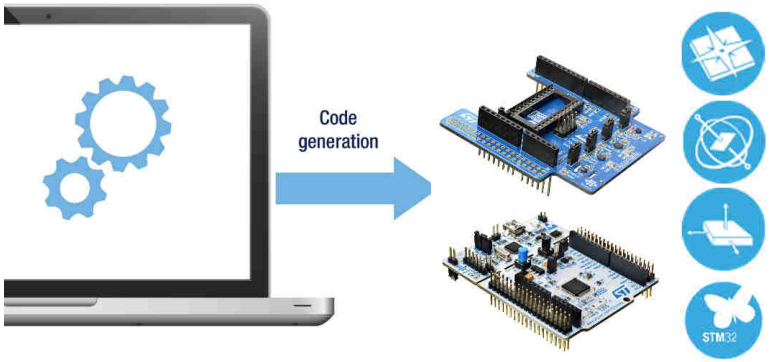
# AlgoBuilder



## An application for the graphical design and testing of algorithms




Existing algorithms
User-defined data processing blocks
Additional functionalities




GUI quickly elaborates proto applications
for
MEMS sensors
and
STM32 microcontrollers

AlgoBuilder
eases the process of
implementing
proof of concept
without writing the code

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Web Page

# Professional MEMS tool

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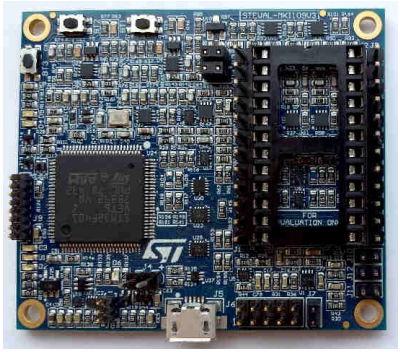
# STEVAL-MKI109V3



## Professional MEMS tool

- Professional MEMS tool (STEVAL-MKI109V3) motherboard is a complete, ready-to-use platform for the evaluation of STMicroelectronics MEMS products.
- It includes a high-performance 32-bit microcontroller which functions as a bridge between the sensors and a PC, on which you can download and run the graphical user interface (GUI) Unico or dedicated software routines for customized applications



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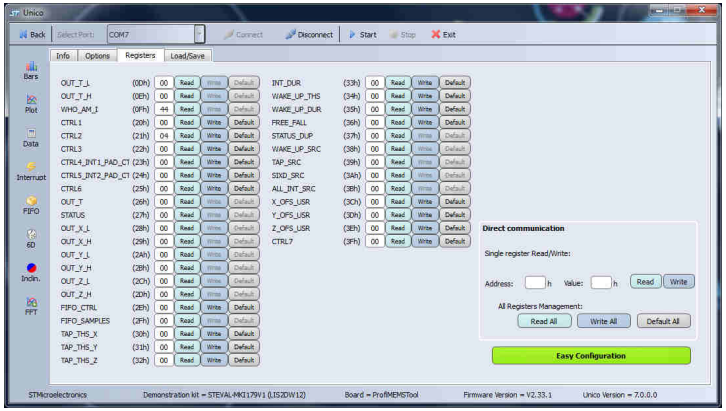
**DIL 24 adapter**

**Professional MEMS tool (STEVAL-MKI109V3)**



**Unico – GUI for Windows PC (STSW-MKI109W)**

| Part Number | Manufacturer | Description |
|---|---|---|
| STEVAL-MKI105V1 | ST | LIS3DH adapter board for standard DIL 24 socket |
| STEVAL-MKI106V1 | | LSM303DLHC adapter board designed to be plugged into a standard DIL24 socket |
| STEVAL-MKI107V2 | | L3GD20 adapter board for a standard DIL 24 socket |
| STEVAL-MKI122V1 | | LSM330DLC adapter board for standard DIL24 socket |
| STEVAL-MKI135V1 | ST | LIS2DH adapter board for standard DIL24 socket |
| STEVAL-MKI137V1 | ST | LIS3MDL adapter board for standard DIL24 socket |
| STEVAL-MKI159V1 | ST | LSM9DS1 adapter board for standard DIL24 socket |
| STEVAL-MKI160V1 | ST | LSM6DS3 adapter board for standard DIL24 socket |
| STEVAL-MKI161V1 | ST | LSM6DS0 adapter board for standard DIL24 socket |
| STEVAL-MKI163V1 | ST | LSM303C adapter board for standard DIL24 socket |
| STEVAL-MKI164V1 | ST | LIS2HH12 adapter board for a standard DIL24 socket |
| STEVAL-MKI165V1 | ST | LPS25HB adapter board for a standard DIL 24 socket |
| STEVAL-MKI172V1 | ST | LSM303AGR adapter board for a standard DIL 24 socket |
| STEVAL-MKI173V1 | ST | LSM303AH adapter board for standard DIL24 socket |
| STEVAL-MKI174V1 | ST | LIS2DS12 adapter board for standard DIL24 socket |
| STEVAL-MKI186V1 | ST | IIS3DHHC adapter board for a standard DIL 24 socket |
| STEVAL-MKI188V1 | ST | L20G20IS adapter board for a standard DIL 24 socket |
| STEVAL-MKI192V1 | ST | LPS22HH adapter board for a standard DIL24 socket |

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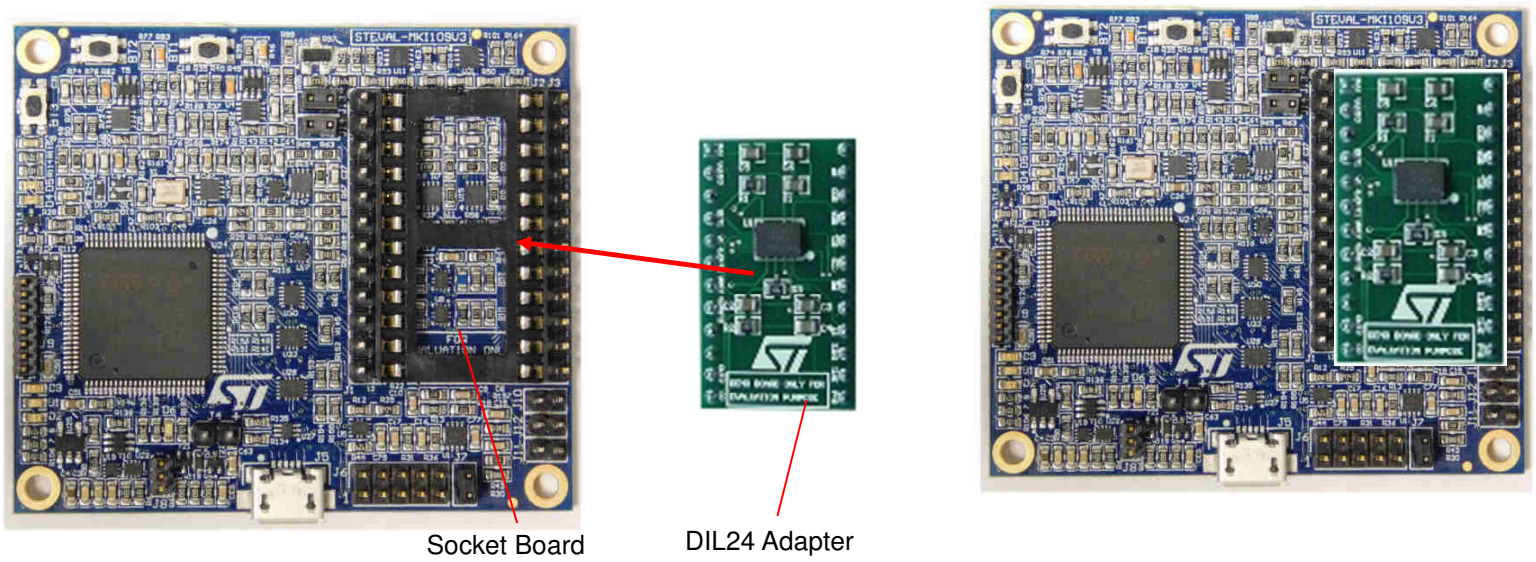
**Info available at**
STEVAL-MKI109V3
STSW-MKI109W

# Professional MEMS Tools – DIL24 Adapter






**All ST MEMS** sensors are available with DIL24 adapter support

The DIL24 Adapter can be placed on socket board

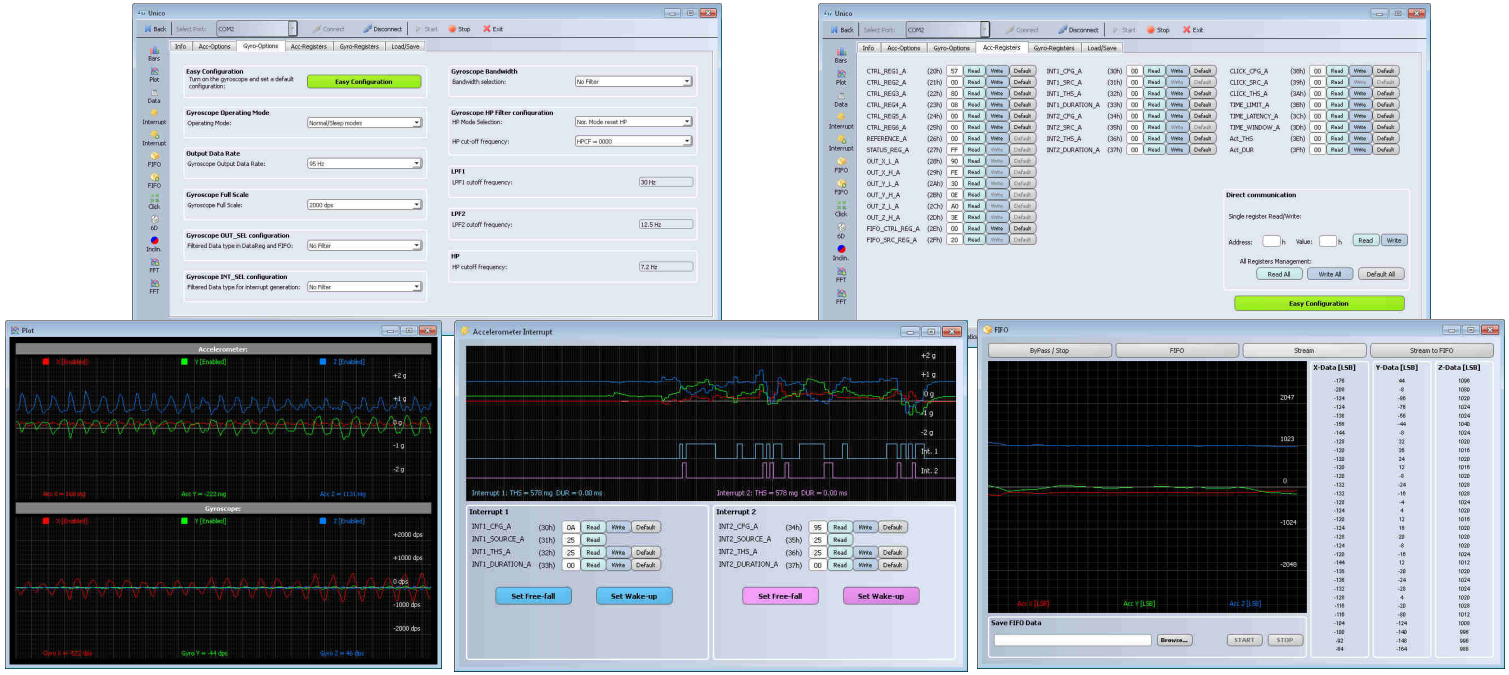
# Professional MEMS Tool – UNICO GUI SW



## Profi MEMS Tool connected with UNICO SW:

The STM32F401VE uses the STM32 microcontroller as a bridge between the sensor under test mounted on socket and the PC by USB cable.

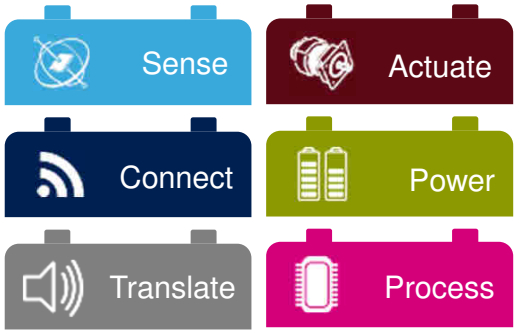
It Is possible to use the UNICO graphical user interface (GUI) or dedicated software routines for customized applications (Virtual Com Command Line Interface) to read/write all sensor registers, plot the data, manage FIFO, set and show interrupts, set easy configuration, etc.



# Takeaways

# ST Augmenting the Development

## Hardware bricks




## Software bricks

- Application Examples
- Middleware Libraries
- Board Support Package
- Hardware Abstraction Layer
- Various Dev. Environment

## Cloud services

Microsoft Azure

amazon web services™

IBM Watson

Google Cloud

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# ST's Solutions



INTEGRATION

## Common SW platform

**3** Cloud provider SDKs supported, enabling sensor-to-cloud platforms

**135** SW packages from drivers to full application examples and mobile applications

STM32 Cube

STM32 Open Development Environment

Wearable | IoT Smart Things | Smart Home | Building automation

## Modular hardware

**27** STM32 Nucleo development boards
Covering the broad portfolio of STM32 MCU families

**40** STM32 Nucleo expansion boards (X-NUCLEO)
Offering peripheral functions

STM32 Nucleo

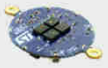
## Form factor boards

ST & 3rd-party form-factor boards

NFC Sensor TAG

SensiBLE

Bluecoin



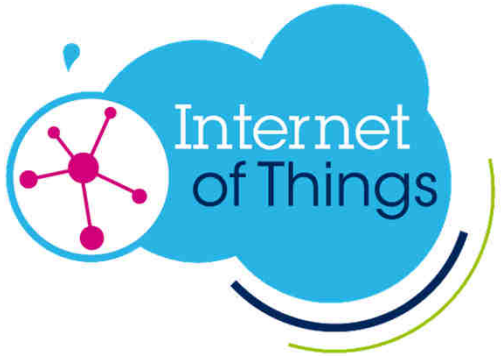
IoT Discovery

Sensor Tile

# Summary



- Internet of Things offers many opportunities for ST from Sensor to Cloud
- ST offers a wide range of development platforms such as:
  - IoT Discovery Kit
  - SensorTile Development Kit
  - BlueNRG-Tile: Bluetooth LE-enabled sensor node development kit
  - STM32 Nucleo Expansion boards
  - Professional MEMS tool: ST MEMS adapter motherboard
- Our constantly expanding development ecosystem makes design fast



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# Thank You!

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