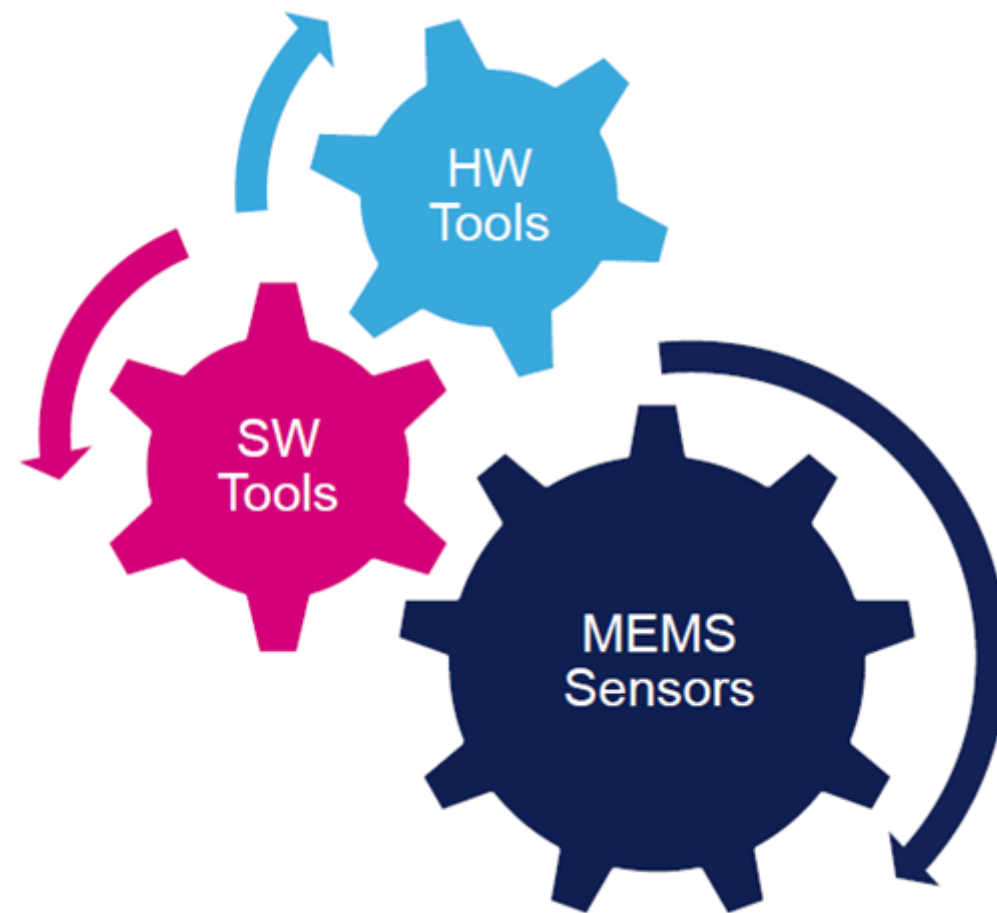
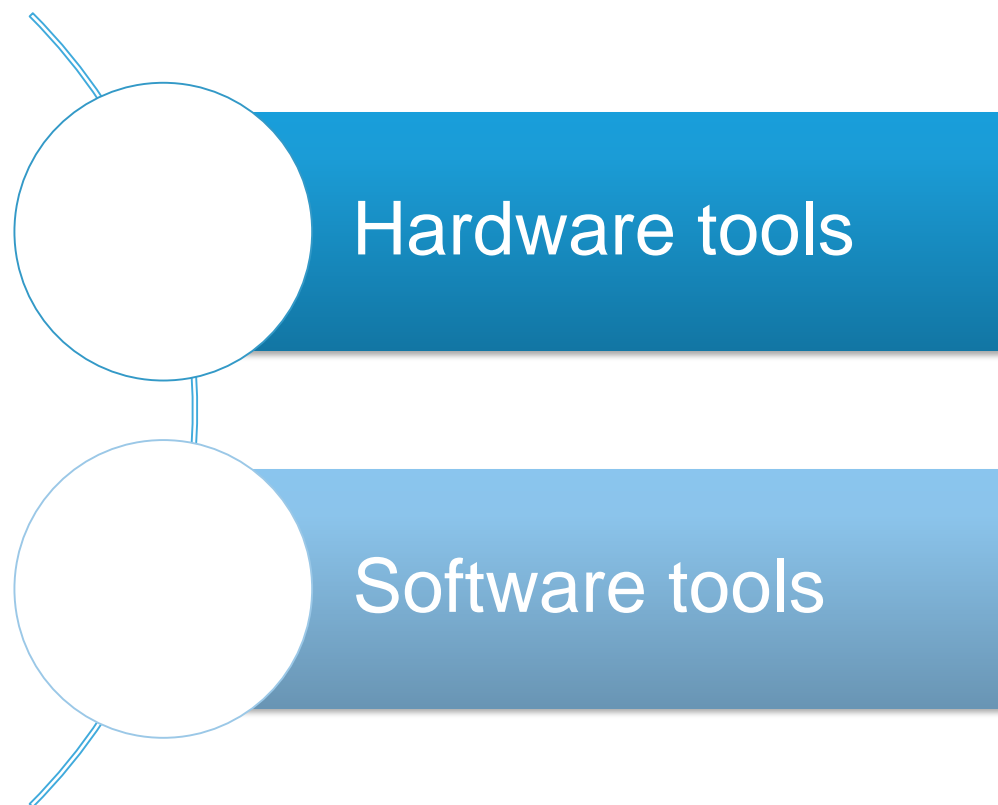


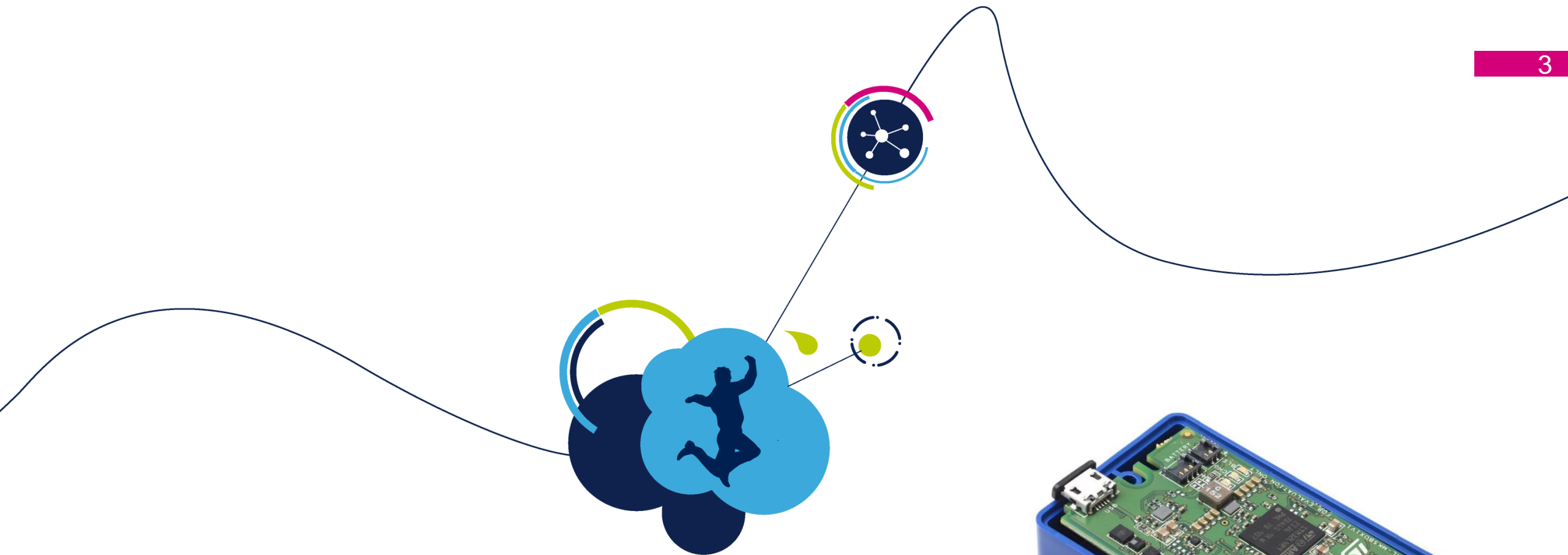
# Development tools

ST MEMS workshop, Italy

November 2019







# Hardware tools



# Sensors Evaluation boards

## STM32Nucleo expansion **X-NUCLEO-IKS01A3**

STM32CubeMX  
Easy debugging



CONSUMER

## Profi MEMS tool **STEVAL-MKI109V3**



Evaluate All ST  
sensors through  
DIL24 adapter

AUTOMOTIVE

INDUSTRIAL

CONSUMER

## BlueTile **STEVAL-BCN002V1B**



Focus on BLE  
communication

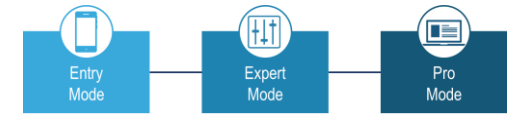
CONSUMER

## SensorTile.Box **STEVAL-MKSBOX1V1**



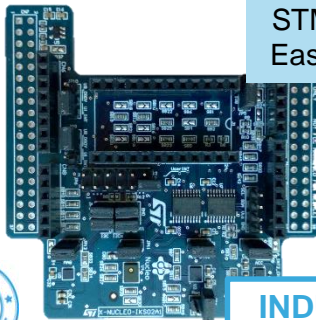
Play with ST  
Sensors

CONSUMER



## STM32Nucleo expansion **X-NUCLEO-IKS02A1**

STM32CubeMX  
Easy debugging



INDUSTRIAL

MP: Q1 2020

## STWIN: Wireless Industrial Node **STEVAL-STWINKT1**

50mm

Vibrometer  
IIS3DWB

50mm



INDUSTRIAL

MP: Q1 2020



# X-NUCLEO-IKS01A3

5

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

- The X-NUCLEO-IKS01A3 is the NEW motion MEMS and environmental sensor evaluation board system with consumer products

### Key products on board:

**LSM6DSO:** MEMS 3D accelerometer ( $\pm 2/\pm 4/\pm 8/\pm 16$  g) + 3D gyroscope ( $\pm 245/\pm 500/\pm 2000$  dps)

**LIS2MDL:** MEMS 3D magnetometer ( $\pm 50$  gauss)

**LIS2DW12:** MEMS 3D accelerometer ( $\pm 2/\pm 4/\pm 8/\pm 16$  g)

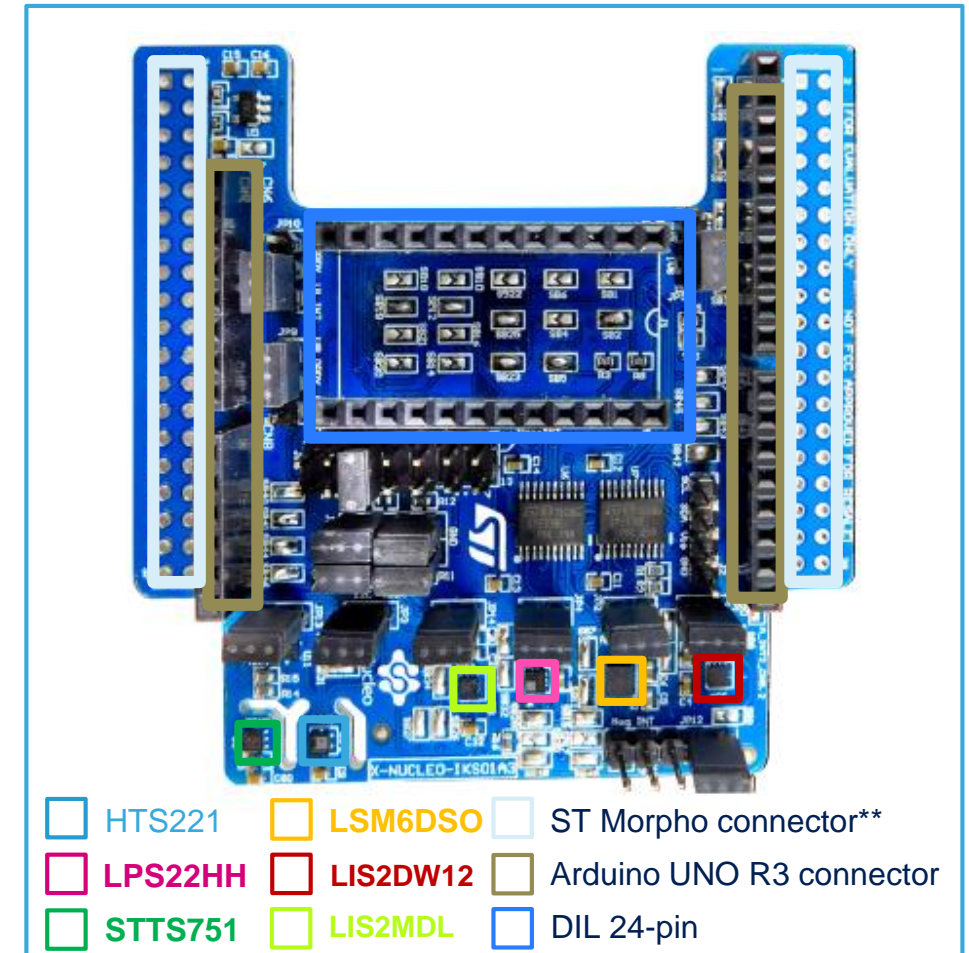
**LPS22HH:** MEMS pressure sensor (260-1260 hPa)

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

**STTS751:** digital temperature sensor ( $-40$  °C to  $+125$  °C)

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

I<sup>2</sup>C, SPI support



\*\* Connector for the STM32 Nucleo Board



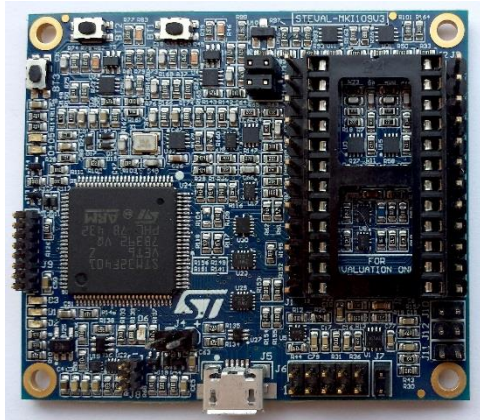


# STEVAL-MKI109V3

6

## Professional MEMS tool

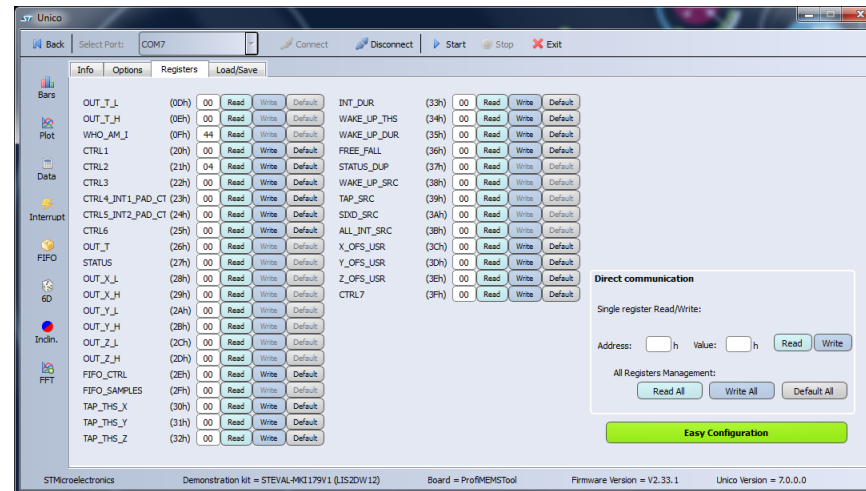
- Professional MEMS tool (STEVAL-MKI109V3) motherboard is a complete, ready-to-use platform for the evaluation of STMicroelectronics MEMS products.
- It includes a high-performance 32-bit microcontroller which functions as a bridge between the sensors and a PC, on which you can download and run the graphical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



Professional MEMS tool  
(STEVAL-MKI109V3)



DIL 24  
adapter



Unico – GUI for Windows PC  
(STSW-MKI109W)

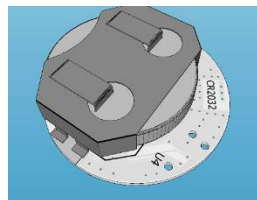
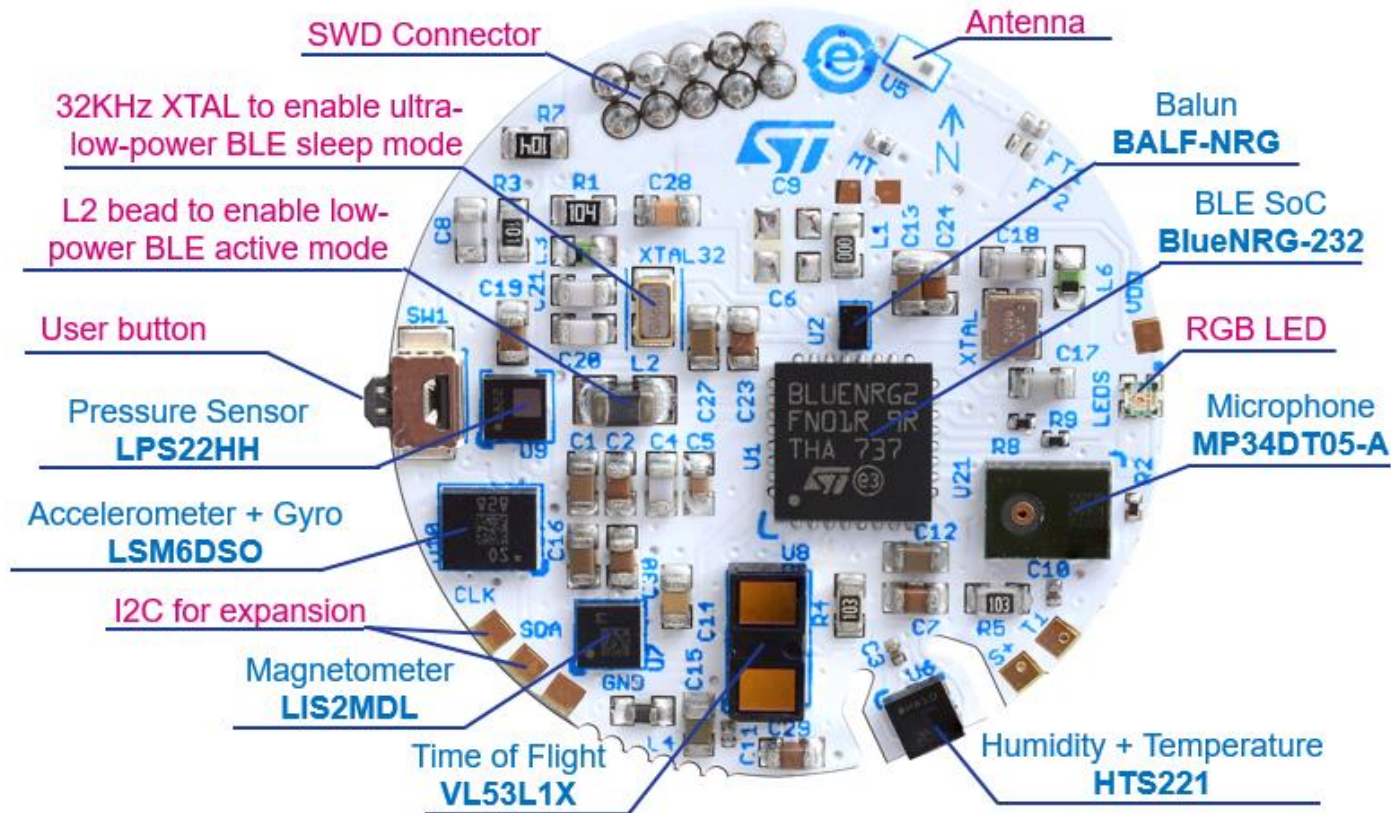
Part Number	Manufacturer	Description
STEVAL-MKI105V1	ST	LIS3DH adapter board for standard DIL 24 socket
STEVAL-MKI106V1		LSM303DLHC adapter board designed to be plugged into a standard DIL24 socket
STEVAL-MKI107V2		L3GD20 adapter board for a standard DIL 24 socket
STEVAL-MKI122V1		LSM303DLC adapter board 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	L2GD20IS adapter board for a standard DIL 24 socket
STEVAL-MKI192V1	ST	LPS22HH adapter board for a standard DIL24 socket



# BlueTile

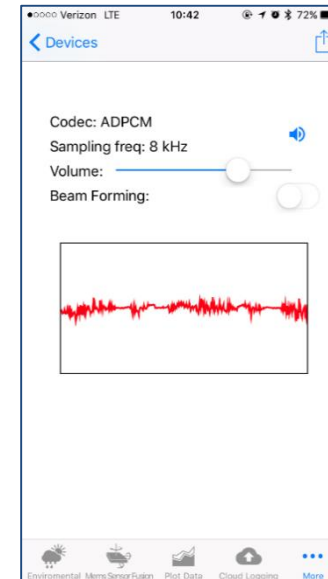
## STEVAL-BCN002V1B

7

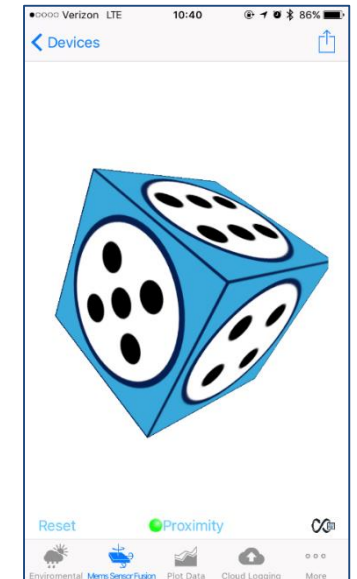


Bottom view

Available soon:  
STEVAL-BCN002V1B



BlueVoice  
library

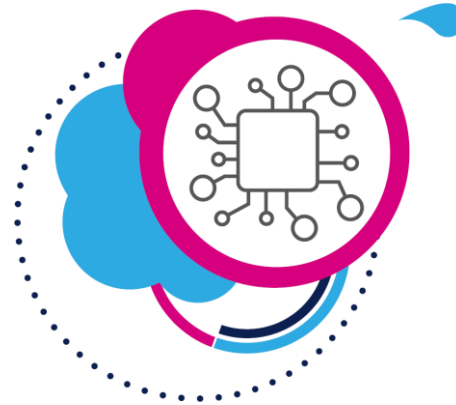


MotionFX  
library



# SensorTile.box

## Play with ST sensors



**A ready-to-go IoT Node**

Built into a compact IP54 casing

Bundled with app for Smartphone







# X-NUCLEO-IKS02A1

## with Industrial products

9

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

- This is the NEW motion MEMS and environmental sensor evaluation board system with INDUSTRIAL products

### Key products on board:

**ISM330DHCX** MEMS – 6-axis IMU - accelerometer / gyroscope

**IIS2DLPC** MEMS 3D accelerometer

**IIS2DMC** MEMS 3D Magnetometer

**IMP34DT05** MEMS microphone

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

**I<sup>2</sup>C, SPI support**





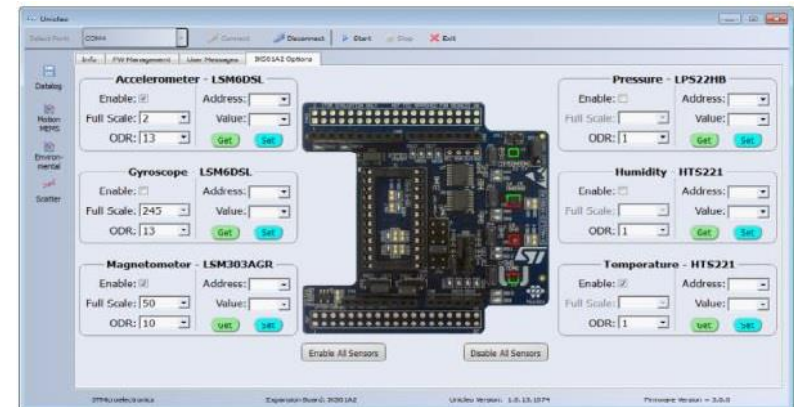
## Key features:

- Multi-sensing wireless platform implementing vibration monitoring and ultrasound detection
- Built around STWIN core system board with processing, sensing, connectivity and expansion capabilities
- **Micro SD Card slot** for standalone data logging applications
- **Wireless BLE4.2** (on-board) and **Wi-Fi** (with STEVAL-STWINWV1 expansion board), and wired **RS485** and **USB OTG** connectivity

## Industrial IoT sensors:

- **IIS3DWB** - ultra-wide bandwidth MEMS vibrometer up to 5 kHz
- **ISM330DHCX** - 3D accelerometer + 3D Gyro iNEMO inertial measurement unit with machine learning core
- **IIS2DH** - ultra-low-power high performance MEMS motion sensor
- **IIS2MDC** - ultra-low-power 3-axis magnetometer
- **LPS22HH** - digital absolute pressure sensor
- **HTS221** - relative humidity and temperature sensor
- **STTS751** - low-voltage digital local temperature sensor
- **IMP34DT05** - industrial grade digital MEMS microphone
- **MP23ABS1** - wideband analog MEMS microphone

# Software tools



# Sensors Software

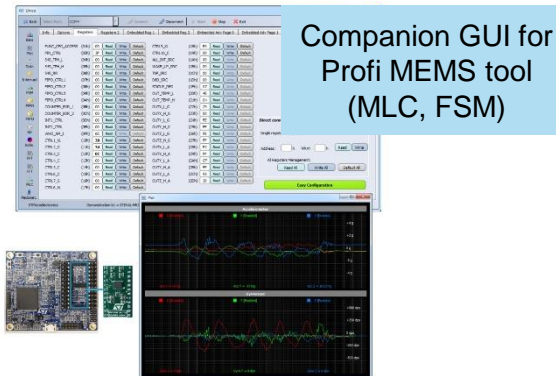
## PC software Unicleo-GUI



Companion GUI  
for X-NUCLEO,  
SensorTile.box, ...

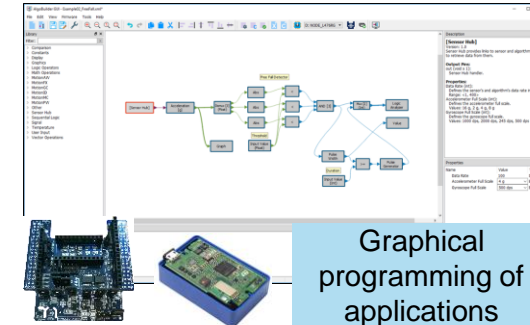


## PC software UNICO GUI



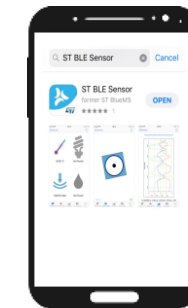
Companion GUI for  
Profi MEMS tool  
(MLC, FSM)

## PC software Algobuilder



Graphical  
programming of  
applications

## Phone App ST BLE Sensor



Display, program  
and sensor data  
push to Clouds

## Embedded software X-CUBE-MEMS1, Libraries, Function packs

Application	Applications
Middleware	MotionAC
	MotionAR
	MotionAT
	MotionAV
	MotionCP
	MotionEC
	MotionFA
	MotionFD
	MotionFX
	MotionGC
	MotionGR
	MotionID
	MotionIC
	MotionPE
	MotionPM
	MotionPV
	MotionSD
	MotionSM
	MotionSP
	MotionTL
Hardware Abstraction	STM32Cube Hardware Abstraction Layer (HAL)
Hardware	STM32 Nucleo expansion boards X-NUCLEO-WK31A3 (Sensor) X-NUCLEO-WK31A3 (Sensor)
	STM32 Nucleo development board



## Low level drivers & Examples (incl. MLC/FSM) [github.com/STMicroelectronics/](https://github.com/STMicroelectronics/)

### STMems\_Standard\_C\_drivers

Platform-independent drivers source code for  
and environmental sensors, based on C stan

● C ● BSD-3-Clause 155 ★ 142

### STMems\_Android\_Sensor\_HAL\_IIO

This repository contains ST Android sensor Hardware &  
MEMS Linux IIO drivers

● C++ ● Apache-2.0 6 ★ 16 0 0 1

Regularly  
updated

### STMems\_Machine\_Learning\_Core

● C++ ● BSD-3-Clause 3 ★ 5 0 0 1

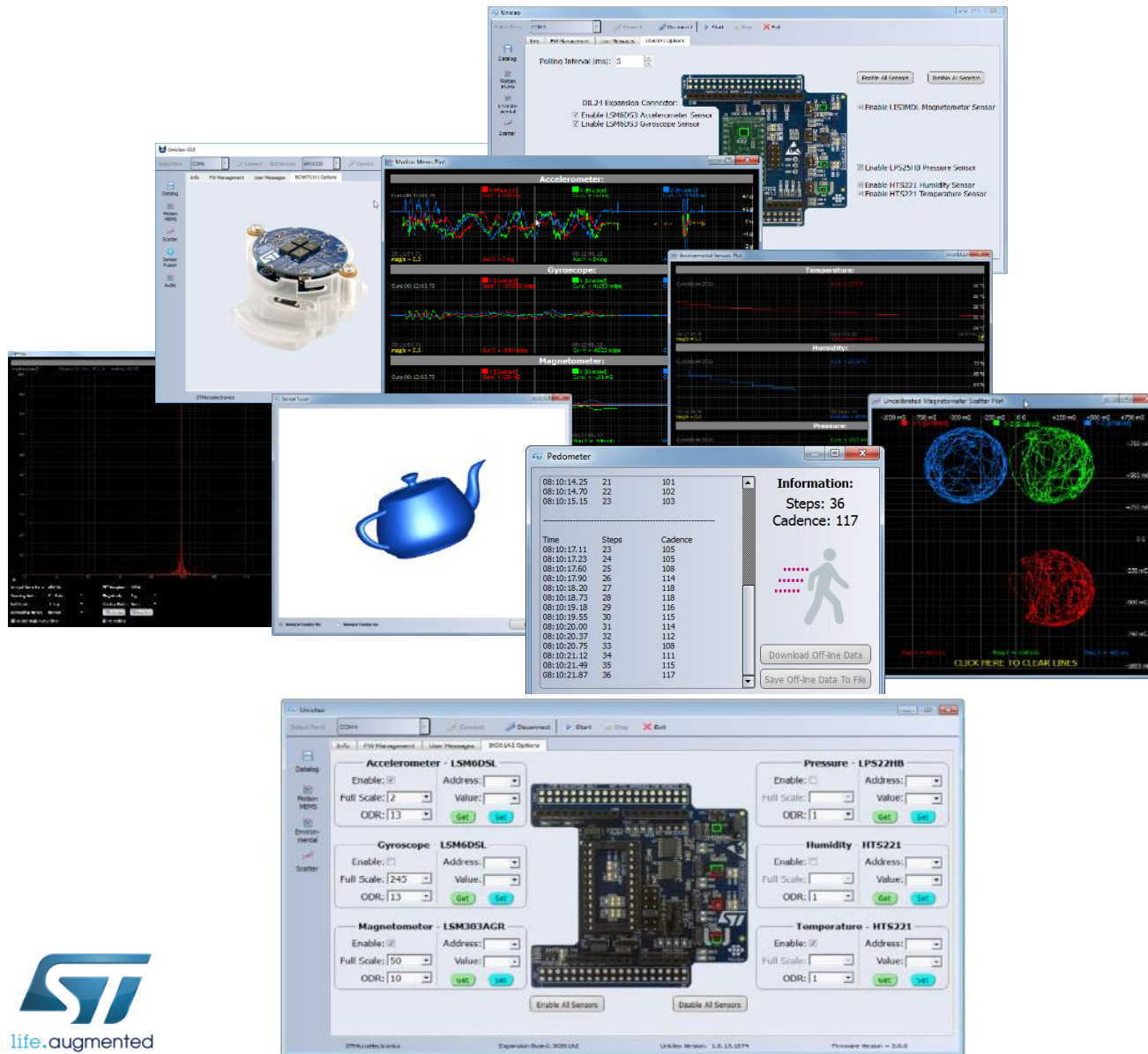






# Unicleo-GUI

13



- **Unicleo-GUI** is a graphical user interface (GUI) for the X-CUBE-MEMS1 / XT1

- **Demonstrates** the functionality of ST sensor devices and SW libraries

- The key features of this application:

- Displays data from connected sensors in various views (time plot, scatter plot, 3D plot)
- Saves data to tab separated (TSV) or comma separated (CSV) files
- Directly reads from and writes to sensor registers

- Supports **wireless communication over Bluetooth-LE** – Windows 8.1 or 10 needed!

- Needs to be installed in addition to Nucleo packages.

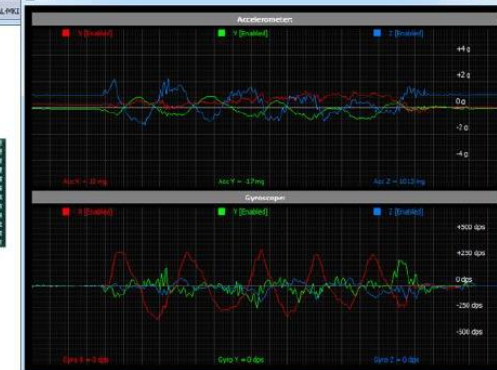
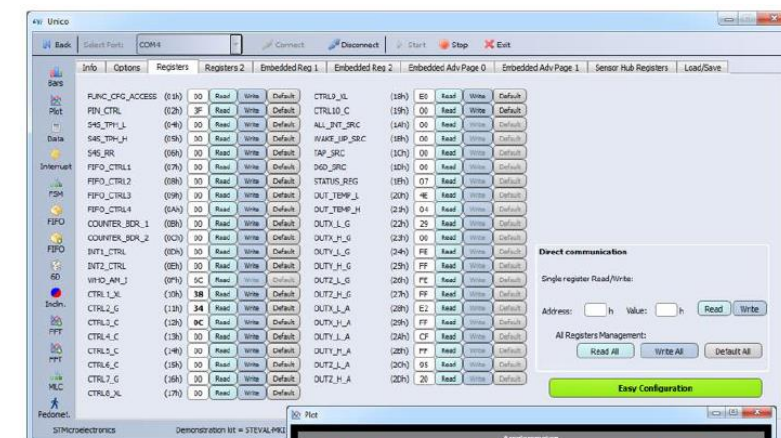
Available for download at  
[Unicleo-GUI](#)



- All **Motion/ Environmental MEMS** adapter boards (STEVAL-MKIxxx) supported
  - Compatible with Profi MEMS tool (STEVAL-MKI109V3)
- Cross-platform GUI for **Windows, Linux and MacOS X**
  - STSW-MKI109W for Windows OS
  - STSW-MKI109L for Linux OS
  - STSW-MKI109M for Mac OS

## Features:

- Device registers configuration, Data logging
- Configuration file (.ucf) creation & C code generation
- FSM / MLC development support
- Current measurement & Power supply management
- H/W interrupts visualization and logging
- Demonstration tools (FIFO, 6D, Inclinometer, FFT, etc...)



Device Configuration

Runtime verification

CONFIGURATION  
.UCF file



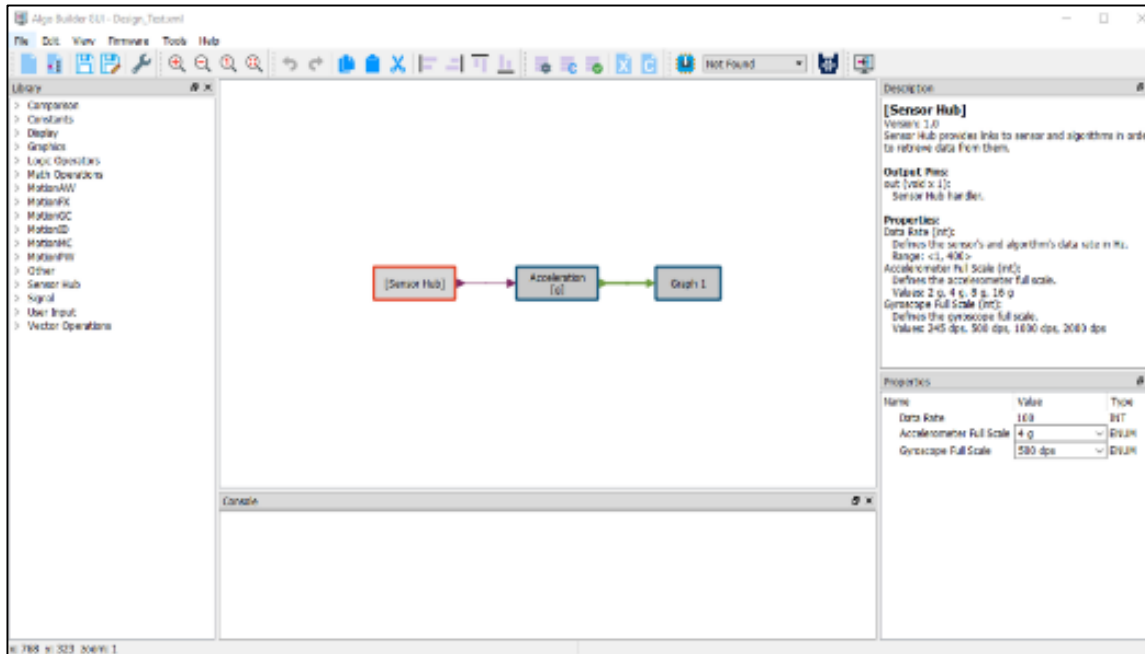
Available for download at  
[Unico GUI](#)





# AlgoBuilder

15

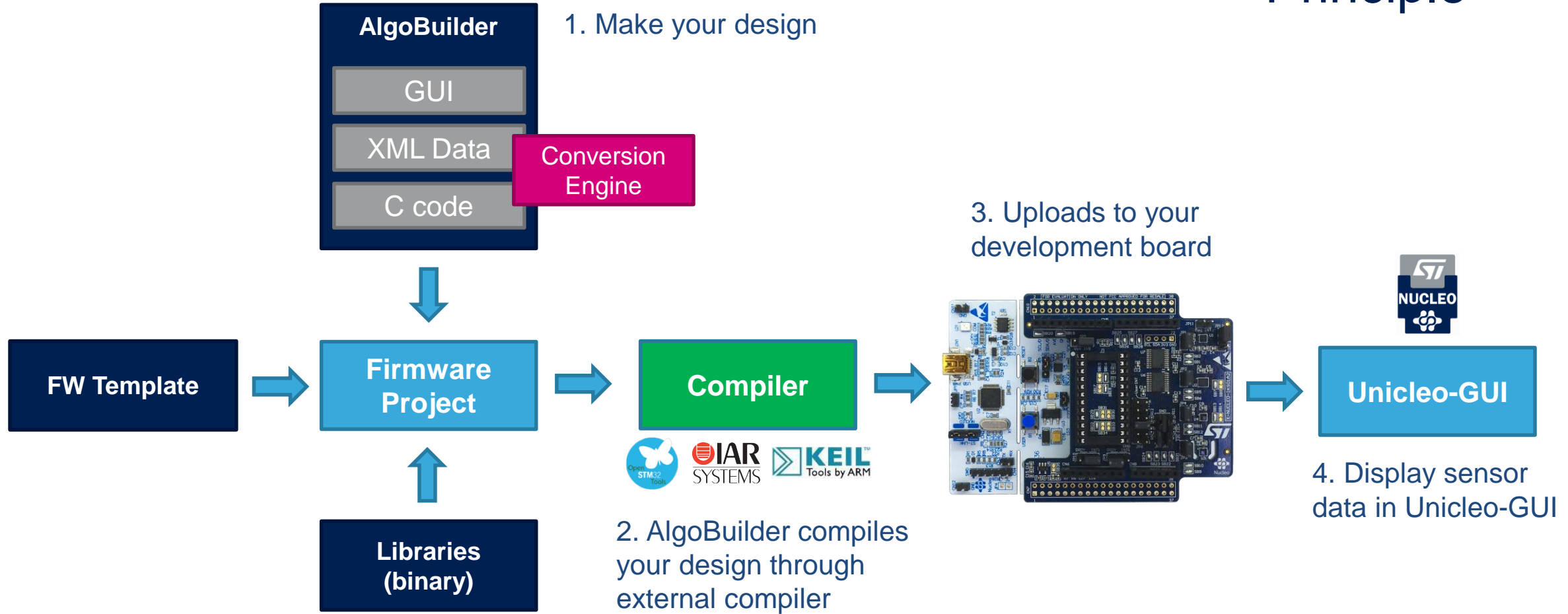


- PC application for **graphical design of algorithms using ST MEMS sensors**
- Simple graphical design (drag and drop, connect, set properties)
- Wide range of function blocks including motion sense algorithms (e.g. Sensor fusion, gyroscope and magnetometer calibration or pedometer)
- **C code is generated** from the graphical design
- Outputs from generated firmware can be **displayed in Unicleo-GUI** application

Available for download at  
[AlgoBuilder](#)



## Principle



Support for STM32 NUCLEO-F401RE or NUCLEO-L476RG with connected X-NUCLEO-IKS01A2 expansion board and SensorTile STEVAL-STLKT01V1

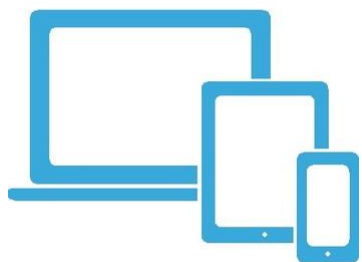






## ST Sensors Finder

### Mobile Application



### ST Sensors Finder

Free application for smartphones and tablets

- Explore ST MEMS and Sensors portfolio
- Evaluation tools and applications overview
- Parametric and part number search engine
- Quick sharing by e-mail or social media in a click
- Technical documentation easily accessible
- Samples ordering

### Download Now !





# ST BLE Sensor for Android and iOS

18

ST BLE Sensor

23% 01:37

ST BLE Sensor



CONNECT TO A DEVICE



CREATE A NEW APP



ABOUT

ST BLE Sensor

Version:4.5.2

© 2019 STMicroelectronics



life.augmented

SensorTile.Box



Sensor data reception over BLE  
Data plot and log, publish to cloud

Application for SensorTile.box  
creation & upload

SensorTile



BlueTile



WESU1



BlueCoin



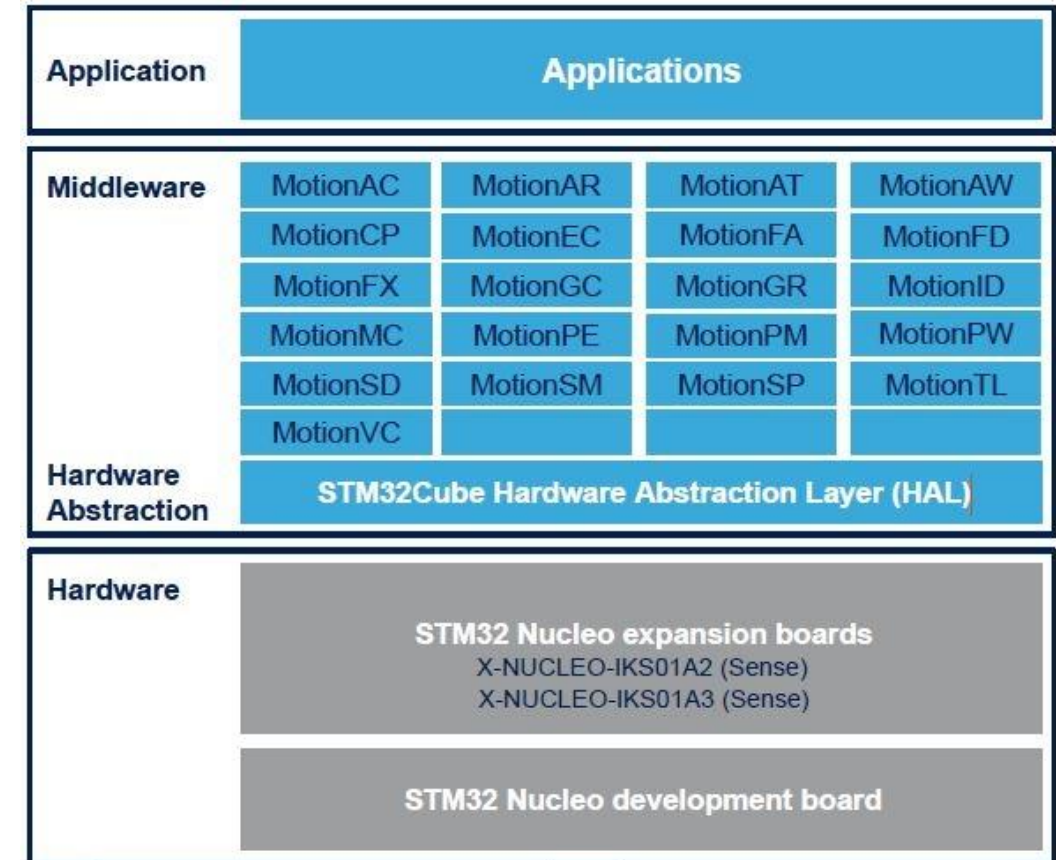
Support multiple platforms and  
STM32Cube Function Packs  
through **BlueST-SDK** protocol



# X-CUBE-MEMS1 Firmware Package

19

- Low level drivers + Example projects
- Middleware
  - Libraries and demo applications dedicated to utilization of sensor data – see next slide
  - Free, user-friendly license terms
- Supported HW tools
  - MEMS expansion: X-NUCLEO-IKS01A2 / A3
  - Industrial MEMS expansion: X-NUCLEO-IKS02A1
  - STM32 Nucleo boards: NUCLEO-F401 or NUCLEO-L073 or NUCLEO-L152 or NUCLEO-L476
- Development Toolchains and Compilers
  - IAR Embedded Workbench for ARM (EWARM)
  - Keil RealView MDK-ARM
  - System Workbench for STM32



Available for download at  
[X-CUBE-MEMS1](#)



# The right SW for your Sensor

20

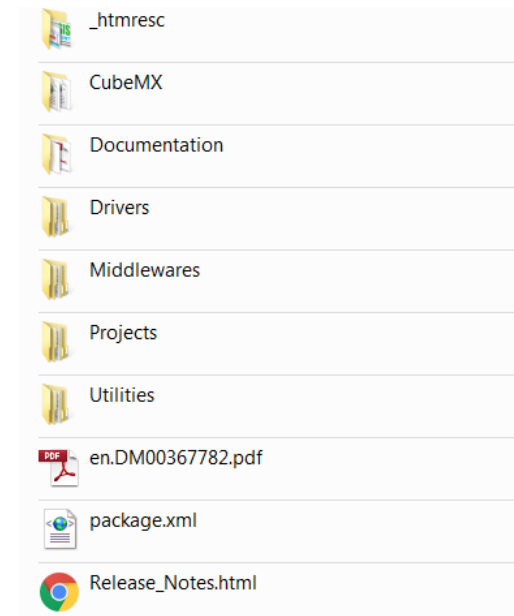




# Example projects

21

- Standard examples – fundamental utilization of sensors and their features
  - DataLog examples
    - allow to display user data in the Unicleo-GUI or serial terminal
    - sensor configuration
    - support of sensors in DIL24 socket
  - FIFO modes examples, Self-test utilization examples, interrupt event examples
  - LSM6DSO embedded features examples
    - detection of 6D orientation, free fall, single tap, tilt, wake up
    - how to handle multiple HW events
    - advanced features: pedometer, self-test
- Middleware application examples – utilization of SW libraries
  - With each SW library there is associated application
    - e.g. MotionSP library is demonstrated in Vibration Monitoring application
  - Application reads sensor data, calls the SW library and acquires output values
  - Results are sent to Unicleo-GUI over USB port



# Conditions to use ST SW libraries

(binary provided)

22

## STM32 is used:

- Simplified process for SW library usage
- No paperwork
- License provided by server
- (if Software License Agreement accepted)

I  
M  
D  
I  
A  
T  
E

Delivery

## No STM32 used:

- Request to sent to ST (me)
- LUA\* preparation
- LUA\* signature from customer
- SW reception

3  
W  
E  
E  
K  
S

Delivery

**Free of Charge!**

Valid for:

X-CUBE-BLE1, X-CUBE-MEMS1, X-CUBE-MEMSMIC1, X-CUBE-SUBG1, FP-SNS-MOTENV1,  
FP-SNS-ALLMEMS1, FP-SNS-FLIGHT1, FP-AUD-BVLINK1, FP-SNS-SMARTMIC1



# FP-SNS-STBOX1

23

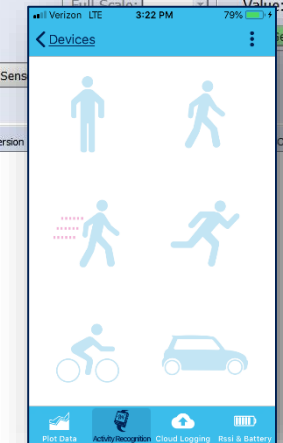
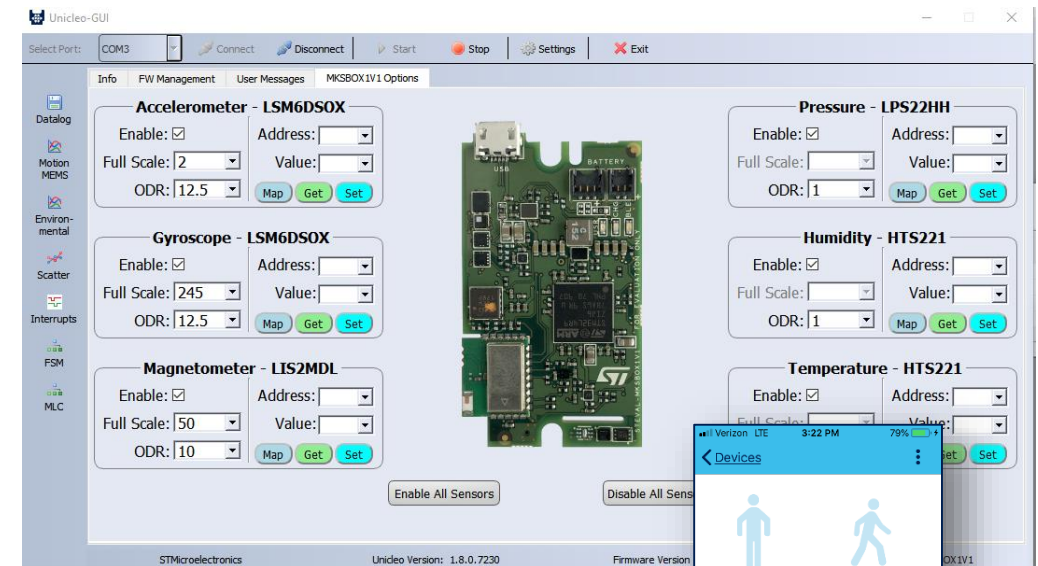
## SW function pack for SensorTile.box

- Applications

- **DataLog** save to SD card at max speed w/RTOS
- **BLE Sensors** stream to ST BLE Sensor app
- **BLE LowPower** stream to ST BLE Sensor app w/RTOS
- **BLEMLC** Machine Learning Core demo (DecTree by **Unico GUI**) – activity recognition or vibration monitoring
- **BLEFOTA** Firmware Over-The-Air-Update

- Examples

- **Bootloader** at 0x0800 000 with BLEFOTA at 0x0800 4000
- **DataLogExtended** stream to **Unicleo GUI** via USB Virtual COM port

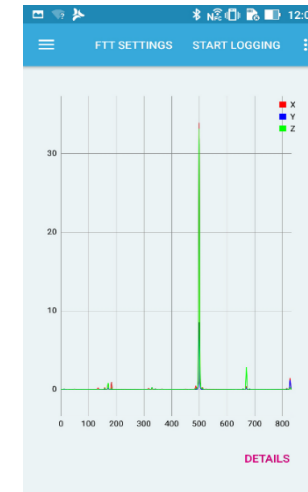


# FP-IND-PREDMNT1

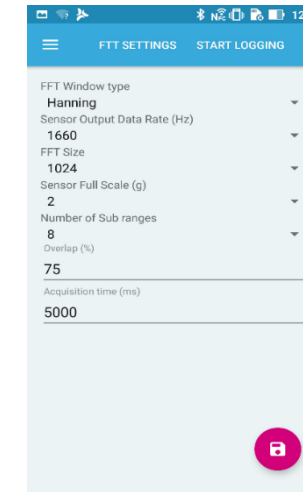
24

## SW function pack for predictive maintenance

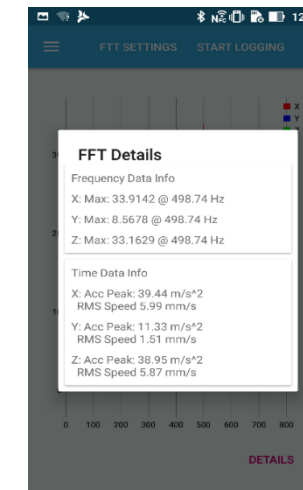
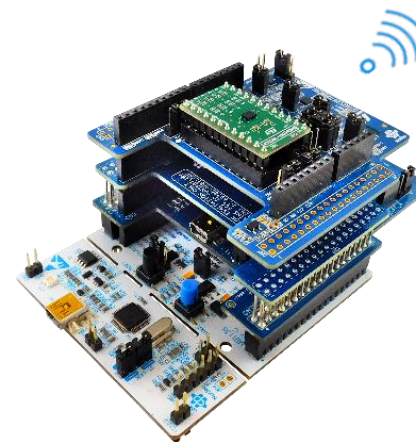
- Advanced **time and frequency domain** signal processing for predictive maintenance
- **Audio** algorithms for acoustic emission (AE) monitoring
- **Mobile device connection via BLE** and use a suitable Android™ or iOS™ application, the ST BLE Sensor app.
- **Connection to cloud (ST Dashboard ) via Wifi**



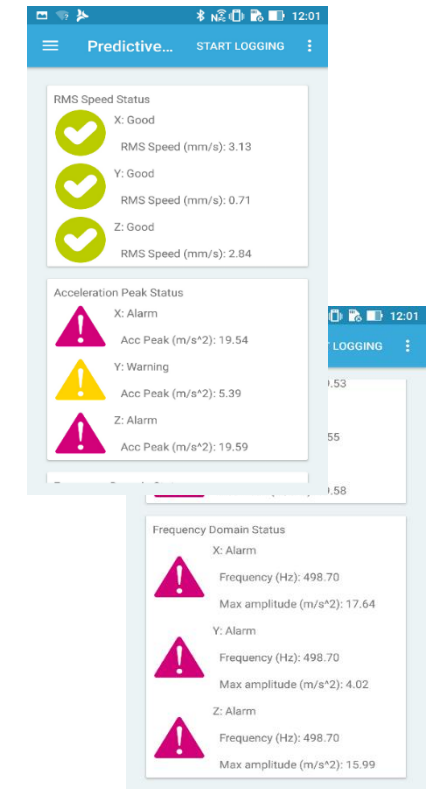
ST BLE Sensor: FFT Amplitude



ST BLE Sensor: FFT Settings



ST BLE Sensor: FFT Details



ST BLE Sensor: Predictive Maintenance

Available for download at  
[FP-IND-PREDMNT1](#)





# Low level drivers & Examples

25

- Standard C platform-independent drivers
- Linux Device Drivers (LDD)
  - Input framework
  - IIO framework
- Android Hardware Abstraction Layer (HAL)
- Database of example configurations for
  - Machine Learning Core
  - Finite State Machine

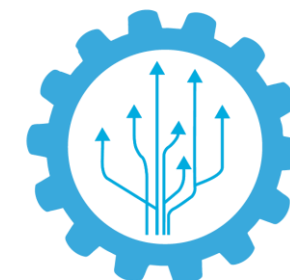
C / C++



Linux



ANDROID



Available for download at

[st.com](http://st.com) or [github.com/STMicroelectronics](https://github.com/STMicroelectronics)



# Resources

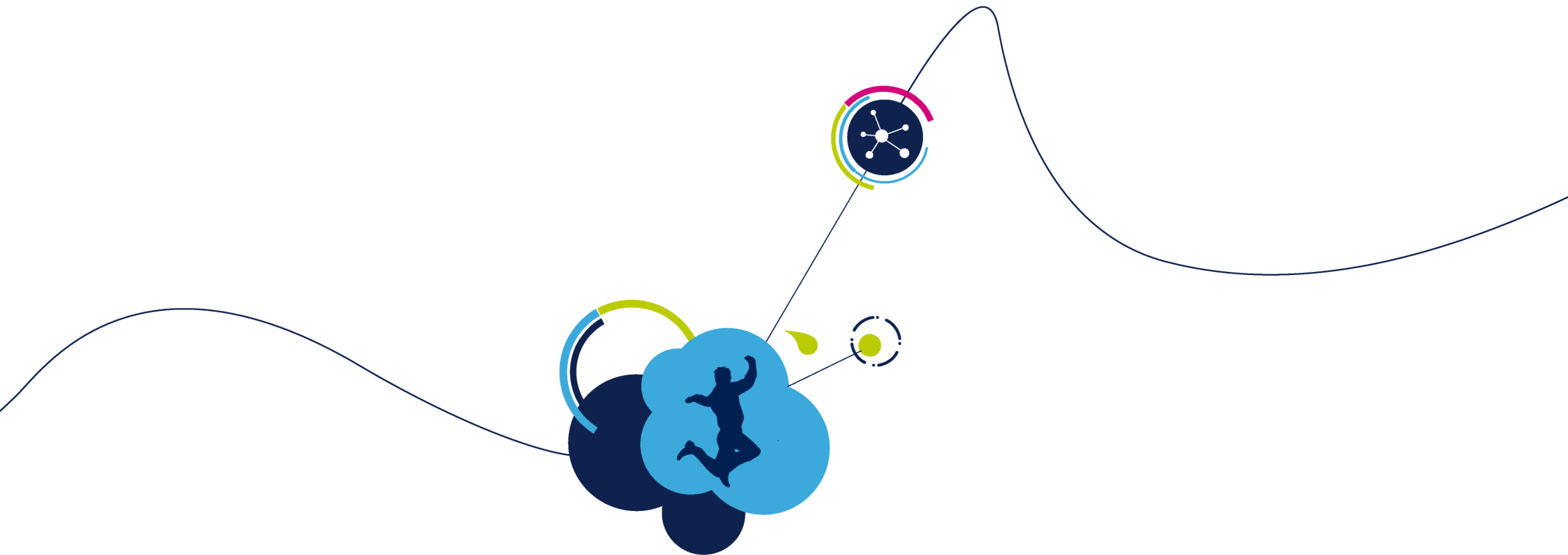
[www.st.com/sensors](http://www.st.com/sensors)

The screenshot displays the ST Microelectronics website's MEMS and Sensors section. At the top, there's a search bar and navigation links for 'Product Catalog', 'English', and 'Login'. Below this, the 'MEMS and Sensors' header is followed by a brief overview of ST's offerings. A sidebar on the right contains links for 'Product Tree', 'Tools & Software', 'Resources', and 'Support & Community'. The main content area features a grid of product categories, each with an icon, a title, a short description, and a 'View products' link. The categories include Accelerometers, Automotive sensors, Gyroscopes, e-Compasses, Humidity sensors, Industrial sensors, iMEMS inertial modules, iMEMS microphones, Pressure sensors, Proximity sensors, Temperature sensors, and Touch sensors. A '10 Years longevity industrial sensors' badge is also visible on the right.

ST MEMS workshop, Italy, November 2019



Product documentation		
Product features	Datasheet, application note(s)	See corresponding product page on st.com
Technical notes		
PCB layout and soldering guidelines	LGA packages	<a href="#">TN0018</a>
	QFN packages	<a href="#">TN0019</a>
	HLGA packages	<a href="#">TN1198</a>
Design tips		
Embedded features of ST accelerometer's	6D orientation	<a href="#">DT0097</a>
	Free-fall recognition	<a href="#">DT0100</a>
	Single-tap and Double-tap recognition	<a href="#">DT0101</a>
	Wake-up recognition	<a href="#">DT0098</a>
	Single data conversion mode	<a href="#">DT0102</a>
	Benefits of using FIFO	<a href="#">DT0011</a>
Sensor calibration	1-point or 3-point tumble sensor calibration	<a href="#">DT0105</a>
	6-point tumble sensor calibration	<a href="#">DT0053</a>
	Ellipsoid or sphere fitting for sensor calibration	<a href="#">DT0059</a>
Magnetometer calibration and compass	Computing tilt measurement and tilt-compensated e-compass	<a href="#">DT0058</a>
	Compensating for magnetometer installation error and hard-iron effects using accelerometer-assisted 2D calibration	<a href="#">DT0103</a>
	Digital magnetometer and e-Compass: efficient design tips	<a href="#">DT0131</a>
	Noise analysis and identification in MEMS sensors, Allan, Time, Hadamard, Overlapping, Modified, Total variance	<a href="#">DT0064</a>
	Exploiting the magnetometer as a virtual gyroscope at low and ultra-high spin rates	<a href="#">DT0104</a>
	Residual linear acceleration by gravity subtraction to enable dead-reckoning	<a href="#">DT0106</a>
White paper	Capacitive MEMS accelerometer for Condition Monitoring	<a href="#">link</a>



# Thank You!