Fault Prediction with Vibration Sensing

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Technology Tour 2019

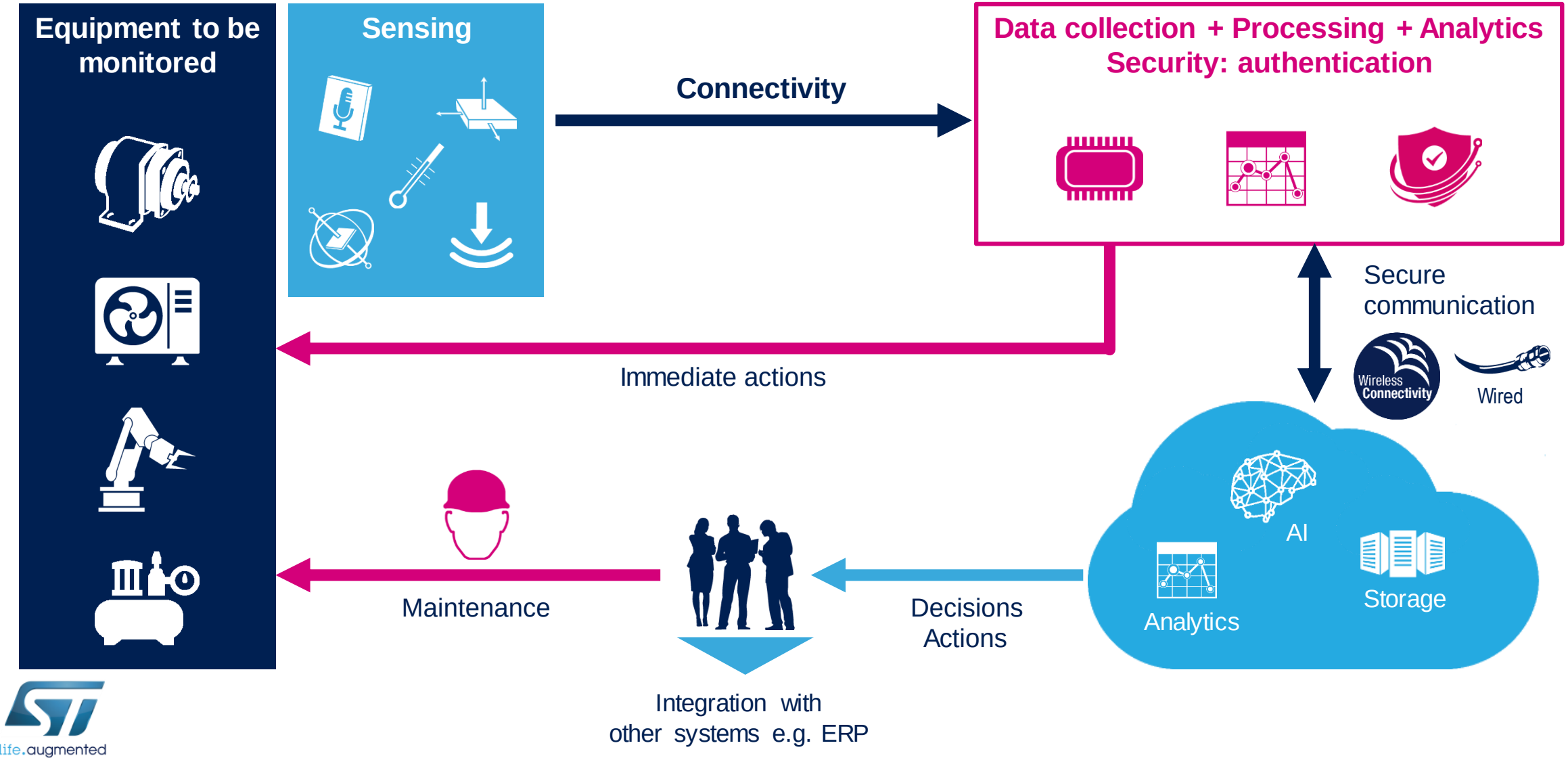
Dallas-Richardson, TX | March 7

Presentation Abstract

Fault Prediction (or Predictive Maintenance) reduces down time and maintenance costs; increases safety and monitors equipment health. Discussion will include:

- Solutions for sensing, processing, connectivity and Security
- HW/SW for evaluation boards, low level drivers, middle ware libraries, SW functional packs
- Latest developments in MEMS based sensors, Arm Cortex based STM32s and connectivity.

Predictive Maintenance Principles



Architecture Optimization

Constraints of Centralized Data Processing

Raw Data Collection

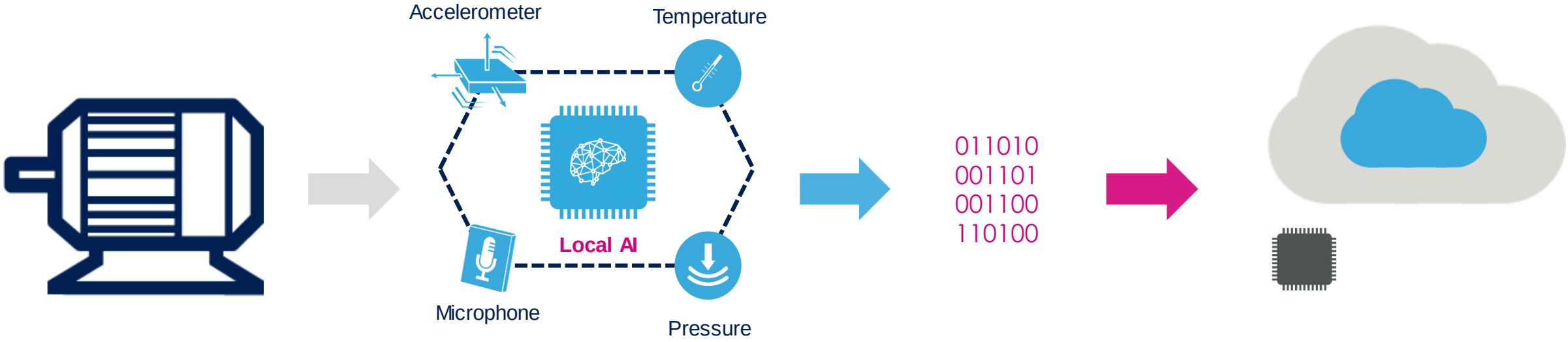
Huge Amount of Data

Large Storage and Data Processing

Current approach

Architecture Optimization

Moving the Intelligence to the Node



Sensors fusion with AI Capabilities

Pre-processed Data and Alarms

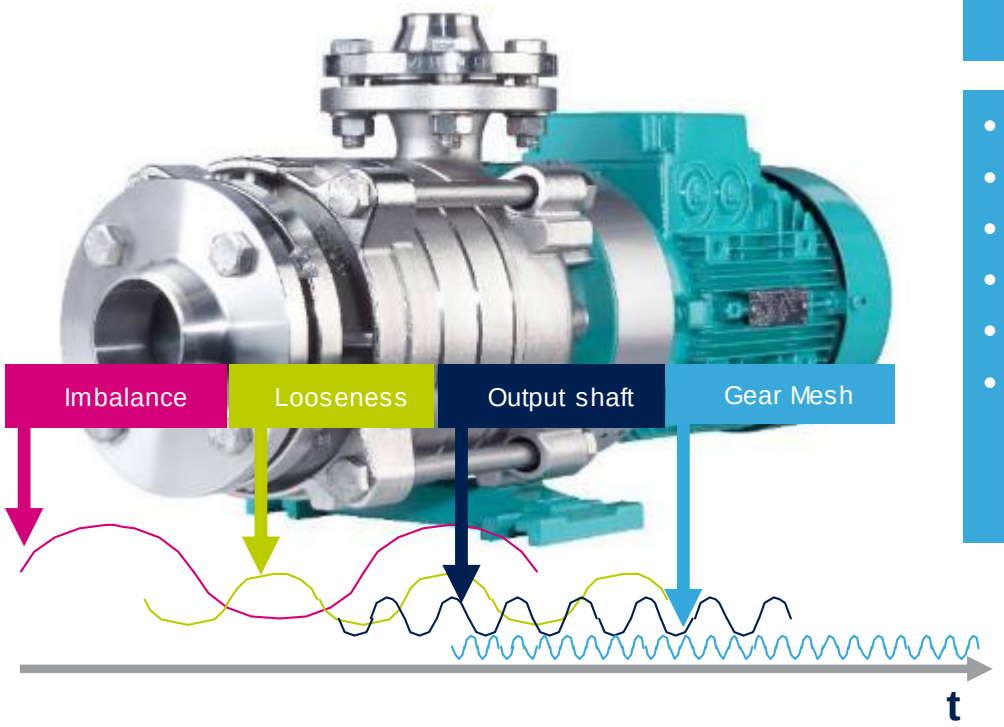
Smart and Light Cloud

Local AI processing capabilities enable new approaches

Monitoring of an Industrial Motor

Typical Use Case

Any parameters deviation is an indicator of potential failure



Mechanical vibration	Thermal	Electromagnetic
• Displacement • Speed • Acceleration • Acoustic noise • Angular speed • Torque	• Winding temperature • Bearing temperature	• Current • Voltage • Electrostatic discharge • Magnetic flux – internal • Magnetic flux – external

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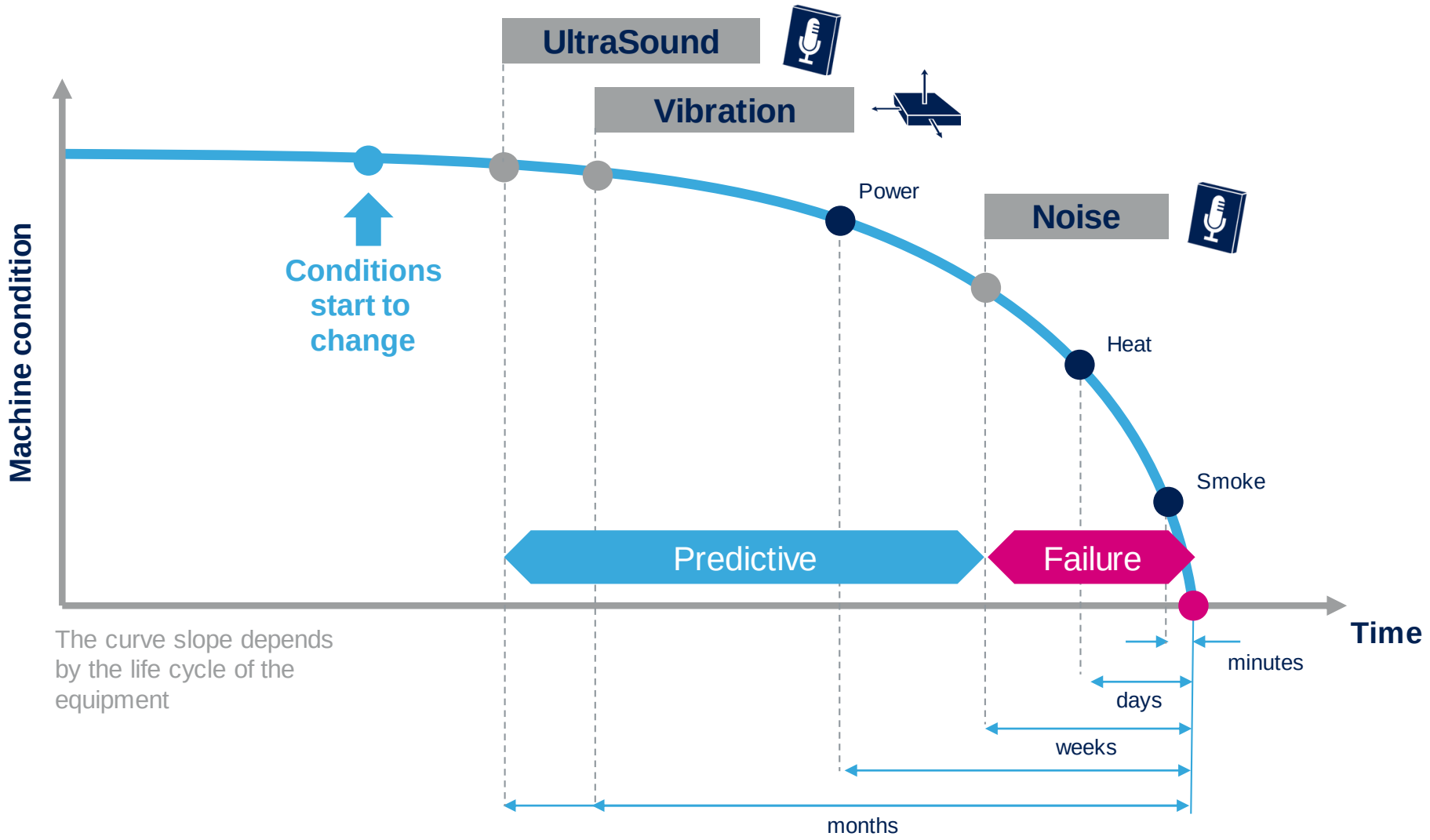
Accelerometer & Microphone

Distinctive Sensor Parameters for Predictive Maintenance



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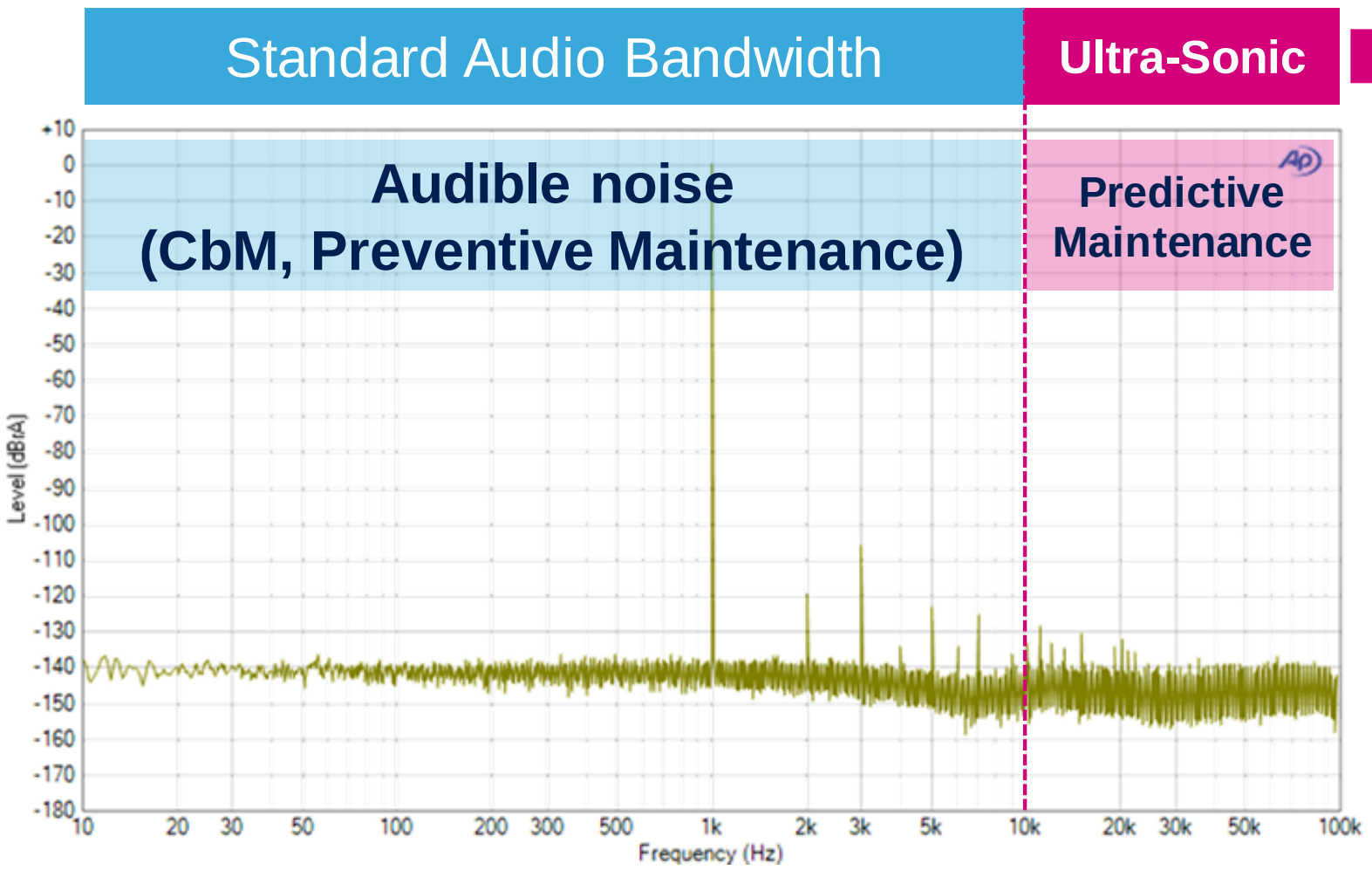
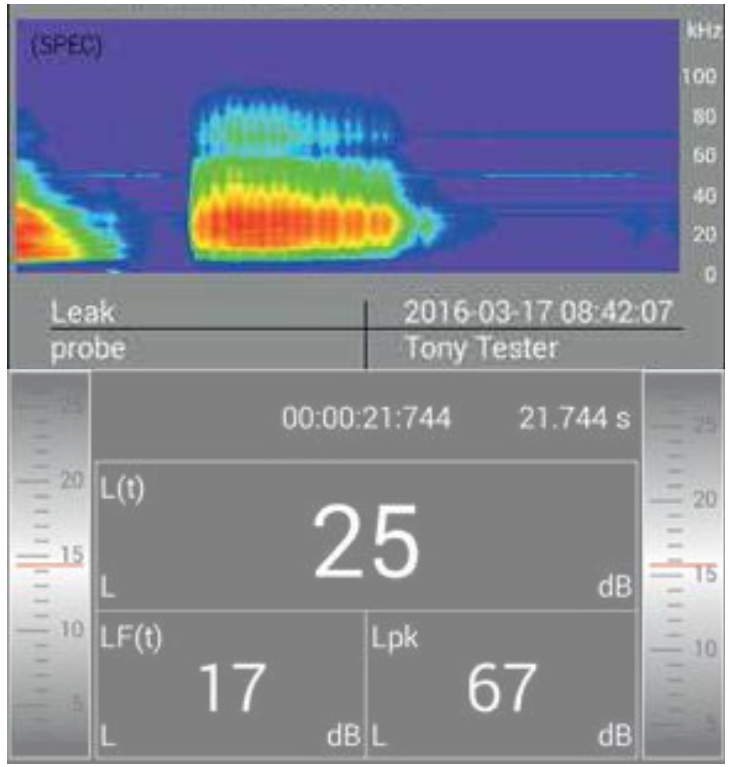
Symptoms According to Audio Frequency

Standard Audio vs Ultrasonic



Post processing analysis
Ultrasonic frequencies
to **detect** and **classify** leaks



ST Enablers for Vibration Analysis

Products & Solutions

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End-to-end Approach
from Sensors to Cloud

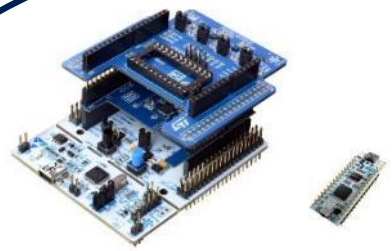
Products	Solutions and fast prototyping	Long lifetime support

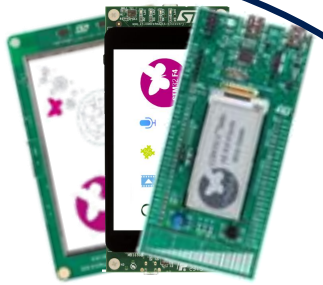
Sensing

Connectivity

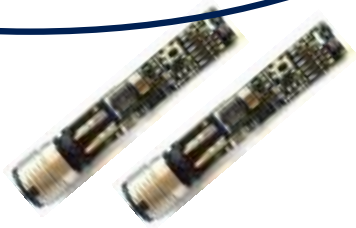
Security

Processing





Fast Prototyping and
Development Kits



Reference Design

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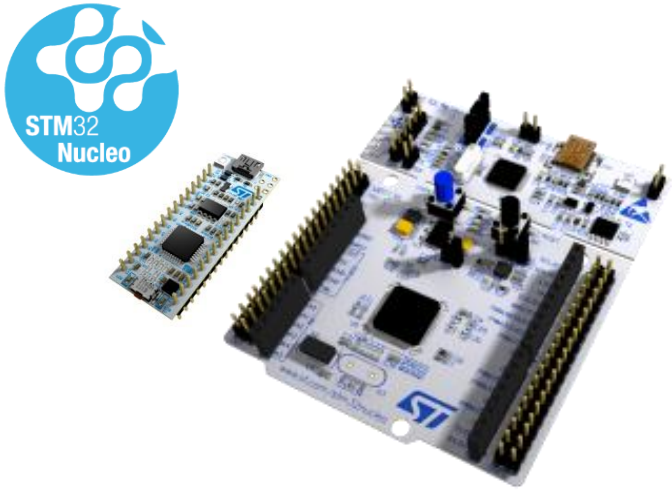
Partner Program

Focus on Products: STM32 and Hardware Tools

STM32 Nucleo Boards



Discovery Kits

Evaluation Boards

Fast agile prototyping

Feature highlight, prototyping

Full features evaluation

Sensing

Connectivity

Security

Processing

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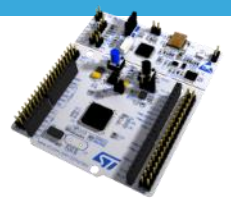
Modular Hardware for Vibration Analysis

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



Covering all STM32 microcontroller families and different development needs

32 expansion boards and growing… covering all the key functions

Sense (5)	Connect (9)	Power Drive (3)	Move Actuate (12)	Translate (3)
Motion & environmental sensors	BLE	Power management	Motor drive	Audio amplifier
Proximity sensor	Wi-Fi	LED boost	Actuator	Op-Amp
Microphone	Sub-GHz			
	NFC			

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End-to-end Approach
from Sensors to Cloud

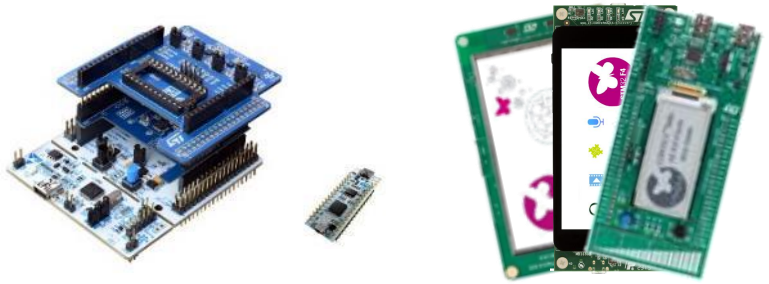
Products	Solutions and fast prototyping	Long lifetime support

Sensing

Connectivity

Security

Processing



Fast Prototyping and
Development Kits

Reference Design

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Partner Program

Condition Monitoring Through IO-Link

Reference Platform

Sensing

Vibration and Environmental

- **ISM330DLC** 6-Axis digital MEMS axel and gyro
- **MP34DT05-A** Microphone
- **LPS22HB** MEMS Pressure sensor
- **HTS221** Humidity & Temperature Sensor
- **STTS751** Digital temperature sensor

Connectivity

Wired

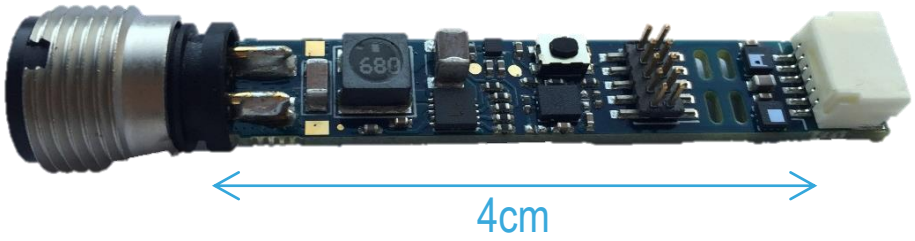
- L6362A IO-Link communication transceiver device IC

Processing

Local Processing

- **STM32F469AI** 32-bit ARM Cortex-M4 microcontroller

STEVAL-IDP005V1



Main Features

- Optimized form factor for industrial M12 connector
- Embedded algorithm for sensors data analysis, detecting anomalies like unbalance, misalignment, or bad equipment condition
- Logging of worst working condition events

Equipment with vibration up to 2KHz

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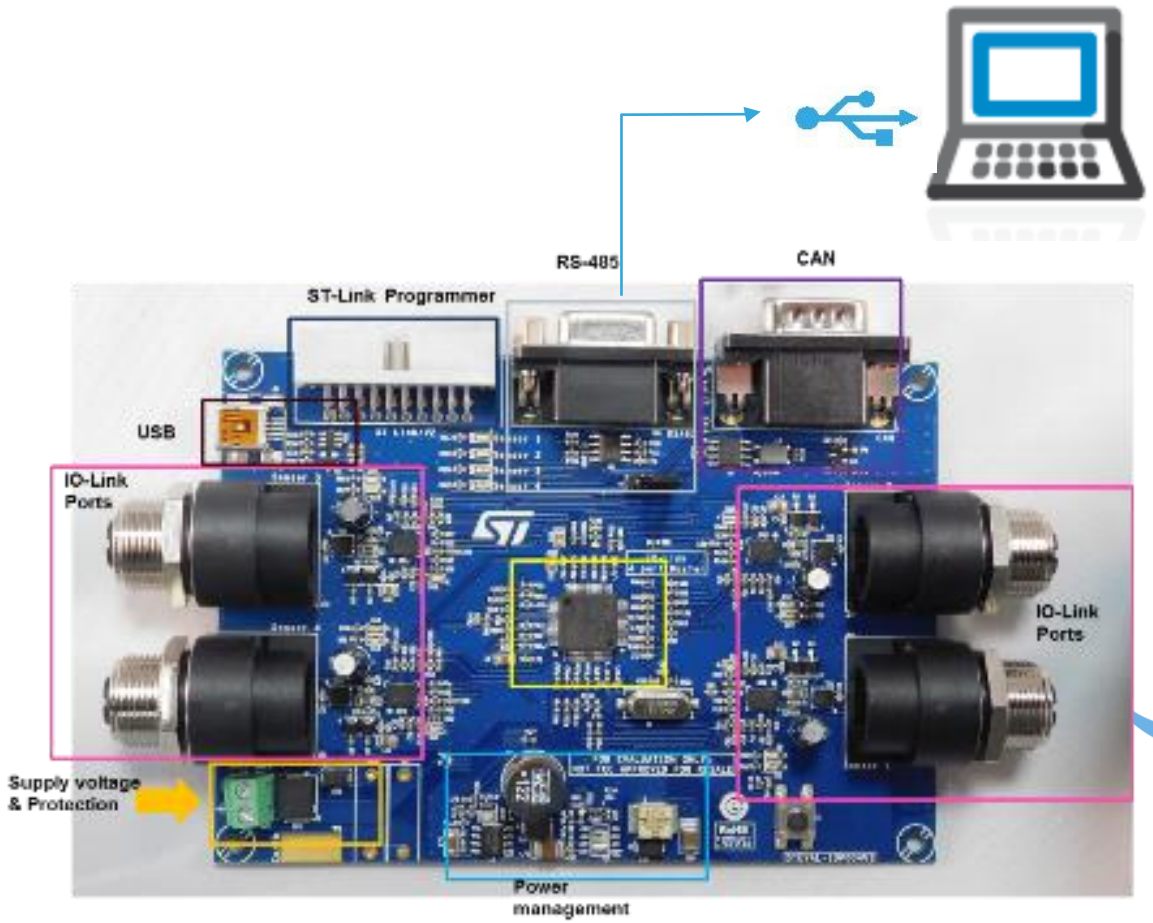
STEVAL-IDP005V1

Communication Based on Master Board



STEVAL-IDP004V1

STEVAL-IDP005V1

- Axel spectrum
- Axel Peak
- RMS
- P, T, H parameters

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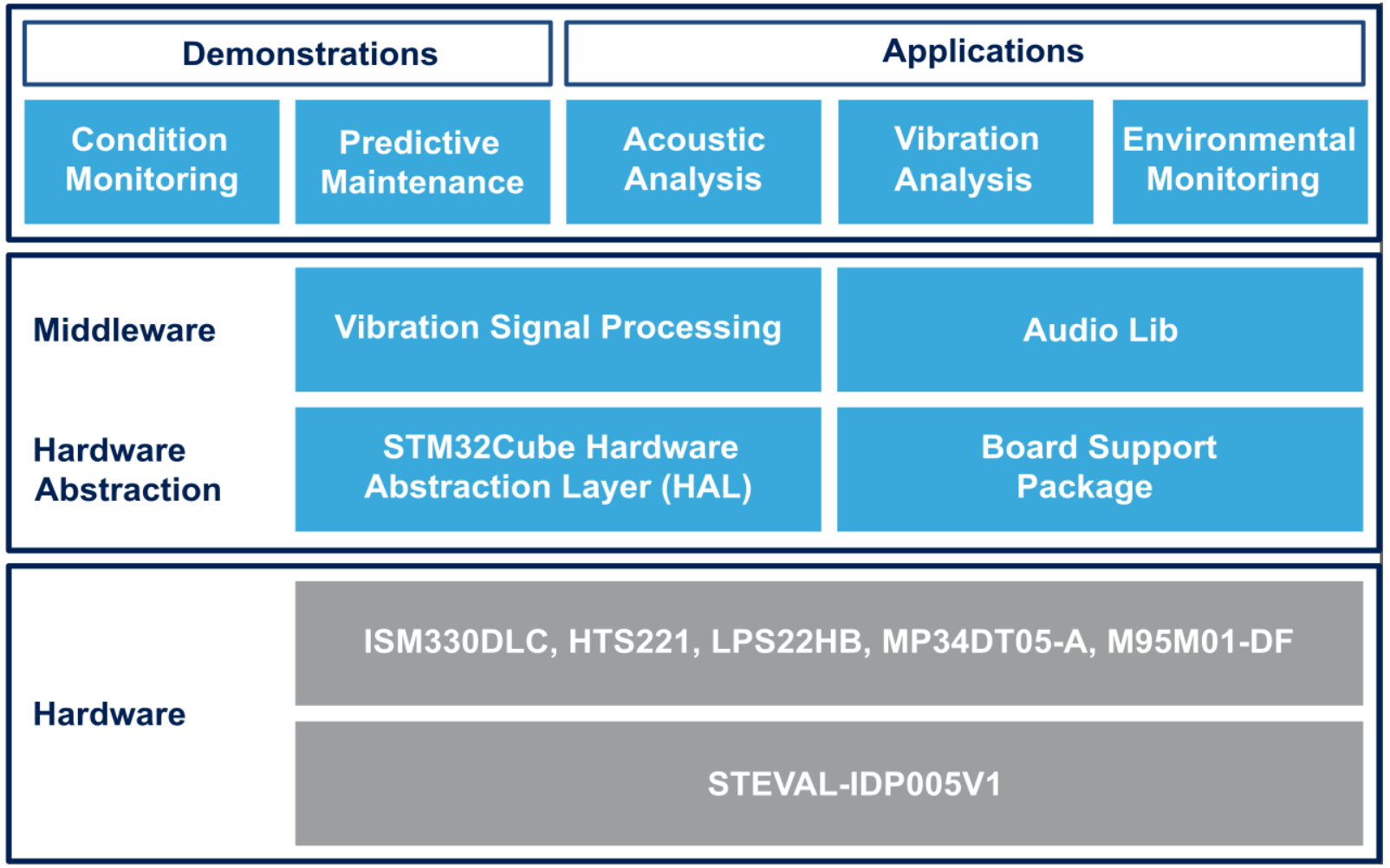
STEVAL-IDP005V1

Firmware Architecture



Download
STSW-BFA001V1

The firmware package is designed to help you develop industrial predictive maintenance solutions based on condition monitoring.

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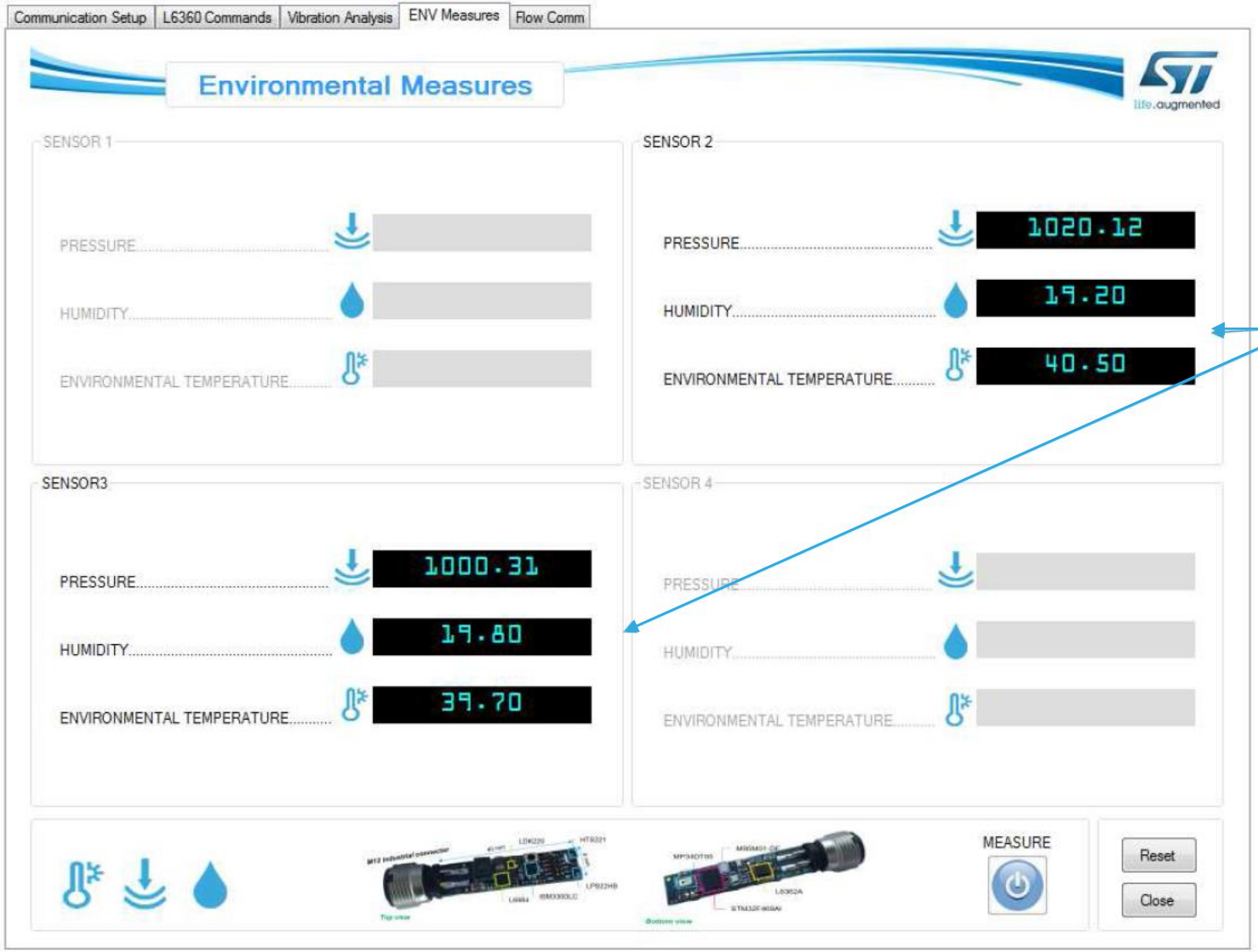
Environmental Measures



Temperature
Pressure &
Humidity

End-to-end Approach
from Sensors to Cloud

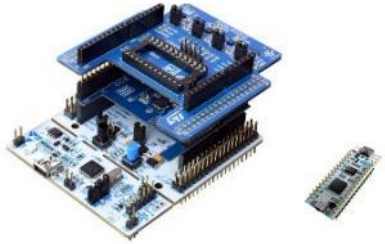
Products | **Solutions and fast prototyping** | **Long lifetime support**

Sensing

Connectivity

Security

Processing



Fast Prototyping and
Development Kits

Reference Design

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Partner Program

ST's Solutions for Cloud

INTEGRATION

Common SW platform

4 Cloud provider SDKs supported, enabling sensor-to-cloud platforms

131 SW packages from drivers to full application examples and mobile applications

STM32 Cube

Smart Things | Smart Home | Smart City | Smart Industry

STM32 Open Development Environment

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

>30 STM32 Nucleo expansion boards (X-NUCLEO)
Offering peripheral functions

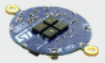
STM32 Nucleo

Modular hardware

ST & 3rd-party form-factor boards

SensiBLE

Bluecoin



SensorTile

Discovery Kit IoT Node

SmarTAG

Form factor boards

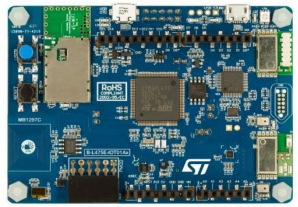
End-to-End Tools
from Sensor to Cloud

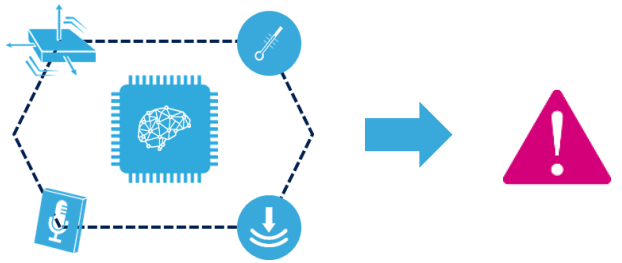
Ultrasound, Vibration, Noise & Environmental data processing at the Node

Modular Reference Designs
for **Wired** and **Wireless** Sensor Nodes

Processing at the edge of Ultrasound, Vibration, Noise and Environmental sensor data for detection and alert

"Ready to use" secure framework communication between Sensors and Cloud





Secure
Communication

Starter kit available

Predictive Maintenance Node to Cloud

Ultrasound, Vibration, Environmental sensing

Sensor Nodes

Edge Computing Gateway

Cloud Sample Application

STEVEAL-IDP004V1

STEVAL-BFA001V1B **STEVAL-BFA001V1B**

Serial Connectivity

Hand Shaking – Upstream Data

Downstream – Set up of Streaming Time

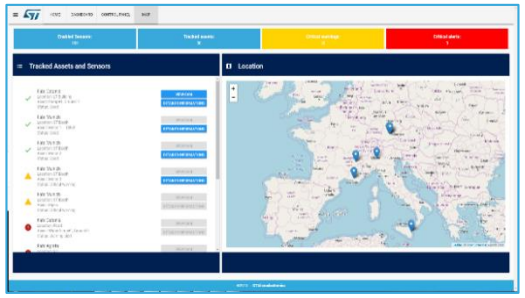
Amazon FreeRTOS

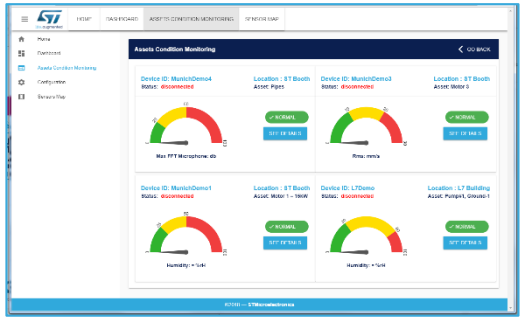
B-L475E-IOT01A

Wi-Fi Connectivity

Hand Shaking – Upstream Data

Downstream





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End-to-end Approach
from Sensors to Cloud

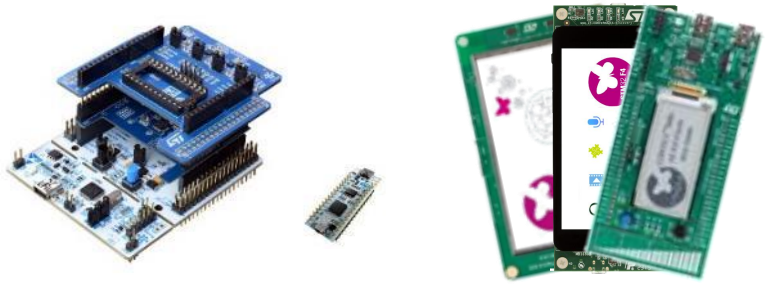
Products | **Solutions and fast prototyping** | **Long lifetime support**

Sensing

Connectivity

Security

Processing



Fast Prototyping and
Development Kits

Reference Design

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STM32L475 Discovery Kit IoT Node

(B-L475E-IOT01A)

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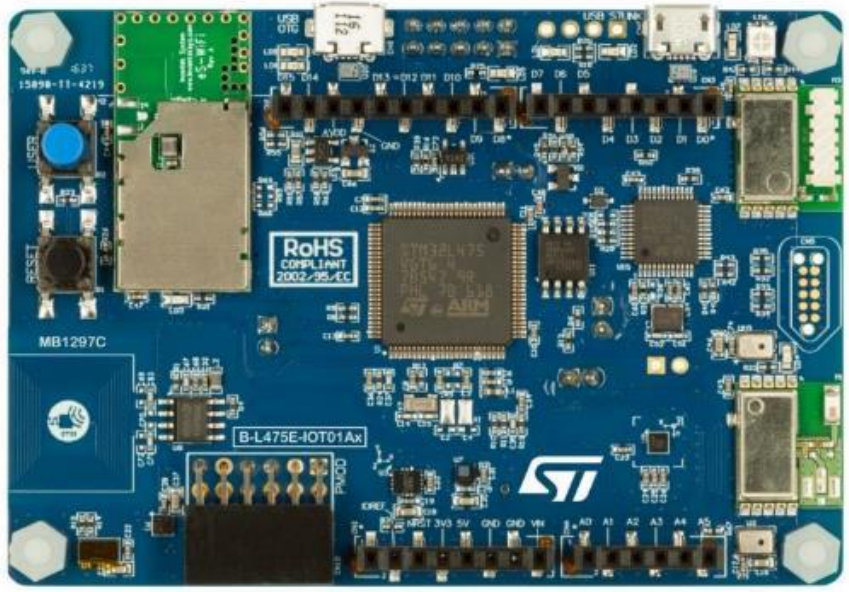
aws partner network

Standard Technology Partner

- Ultra-Low-Power ARM Cortex-M4 MCU
- Wi-Fi Connectivity
- Motion MEMS and Environmental Sensor

- Out of the box support for Amazon FreeRTOS
- Firmware available on Amazon FreeRTOS Console and GitHub
- AWS IoT Tester Certified
- Enables variety of applications
- Multiway Sensing



ST Partner Program

Building Greater Solutions Together

www.st.com/partners

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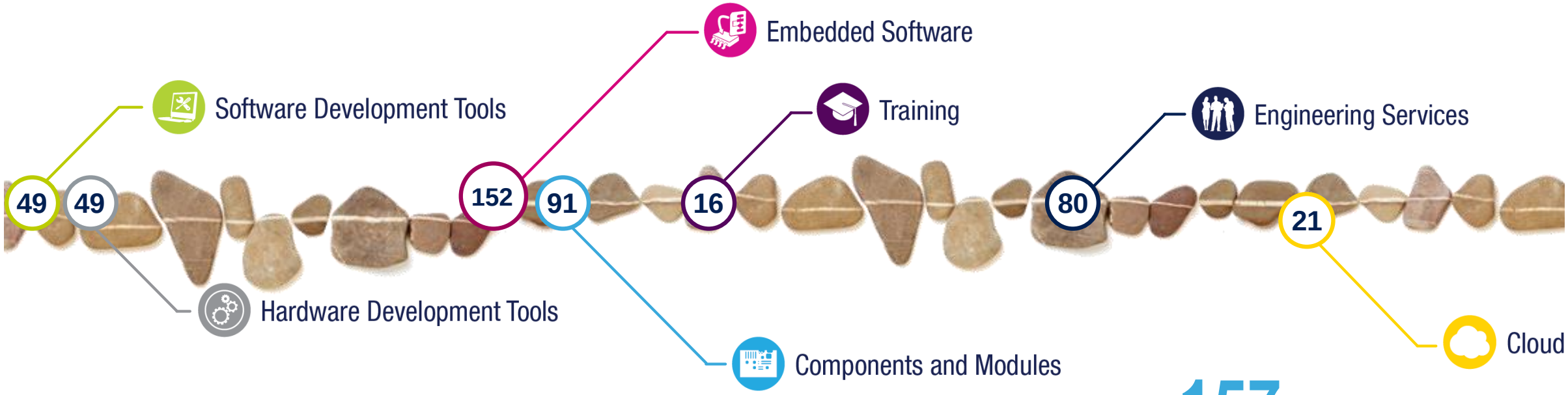
Partner Program

Partner Program

STPartner Program enable customers to quickly industrialize ST concepts for Industrial use cases



- Allow customers to identify "**certified**" **third party companies**
- **Define a selection and validation process** to qualify Partners
- **Increase ST visibility**, presence online and **Brand awareness**
- Support **New Business Models** with Partners

157 Partners

458 Products

106 Videos

*** 1st July 2018**

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>150 Partners… and Counting

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

End-to-end Approach

from Sensors to Cloud

Products

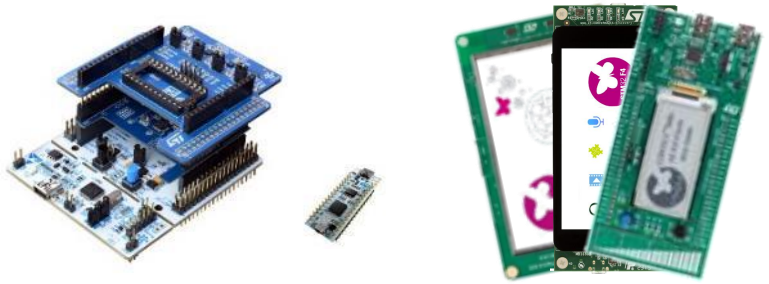
Sensing

Connectivity

Security

Processing

Solutions and fast prototyping



Fast Prototyping and
Development Kits

Reference Design

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Long lifetime support

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Industrial Sensors

Environment

Temperature sensors
Analog and digital contact temperature sensors

Humidity sensors
Combo humidity and temperature sensor

Pressure sensors
With water proof solutions

Motion

Accelerometer
Ultra Wide Bandwidth, Ultra low power

Gyroscope
Wide Bandwidth and Smart Features

Magnetometer
Low-Noise, Low Power

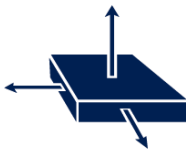
Acoustic

Microphones
Analog, digital, top and bottom port solutions

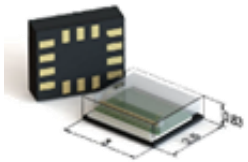
Optical

Time of Flight
High precision, surface agnostic distance measure

Motion MEMS Sensors for Smart Industry



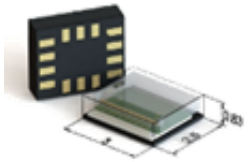
IIS3DWB
Accelerometer - Ultra Wide Bandwidth



LGA-14 2.5x3mm2

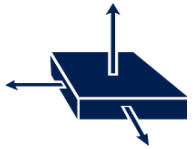
- 3D Accelerometer – 16g Full Scale
- Digital Output
- Ultra Wide Bandwidth (Min 5 kHz)
- Ultra Low Noise
- Up to 105°C Operating Temp

ISM330DLC
Combo accelerometer & Gyroscope & - Wide Bandwidth



LGA-14 2.5x3mm2

- 3D Accelerometer + 3D Gyro - Digital Output
- Accelerometer with Wide Bandwidth (up to 3 kHz)
- Ultra Low Power and Smart Features



IIS2DH
Accelerometer - Wide Bandwidth, Ultra-low-power

LGA-12 2x2mm2

- 3D Accelerometer – Digital Output
- Wide Bandwidth (up to 2.3 kHz)
- Ultra Low Power – Ultra Compact

IIS2MDC
Magnetometer Low-Noise, Low Power

LGA-12 2x2mm2

- 3D Magnetometer – Digital Output
- AMR Technology - up to 50 Gauss Full Scale
- Ultra Low Noise, Low Power

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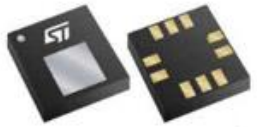
Environmental Sensors for Smart Industry

LPS22HB
Pressure Sensor – High Accuracy – Compact Size



HLGA-10L 2x2x0.76 mm

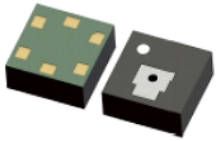
- Absolute Pressure Sensor
- 260 to 1260 hPa Range - Digital Output
- High Accuracy (±1 hPa)
- Low noise (0.75 Pa RMS)
- Ultra Compact full molded package

LPS33HW
Pressure Sensor – Water Resistant

3.3x3.3x2.9 mm

- Absolute Pressure Sensor
- 260 to 1260 hPa Range - Digital Output
- High Accuracy (±2.5 hPa)
- Low noise (0.8 Pa RMS)
- Water resistant up to 10 ATM

HTS2E
Humidity and Temp Sensor – High Accuracy



HLGA-6 2x2x0.9mm2

ES Q3'18

- Humidity and Temperature Sensor
- Digital Output
- High Accuracy:
  - Humidity: ±3.5 %RH
  - Temperature: ±0.5 deg
- Low Power

STTS751
Digital Temperature Sensor

UDFN-6L or SOT23-6L

- Accuracy: ±1.0 ºC ; Programmable resolution

LM23
Analog Temperature Sensor

TO92/SO8

- Accuracy ±1.0 °C ; Op. Temp up to 150 °C

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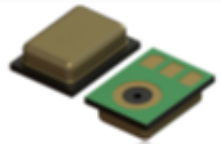
MEMS Microphones for Smart Industry

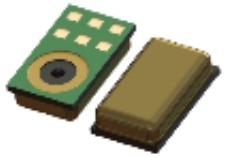
MP23AB01DH
Analog Differential Microphone



3.35x2.5x0.98 mm

- Bottom Port Microphone
- Analog Differential Output
- Wide Acoustic Bandwidth (up to 80 kHz)
- Wide Dynamic Range (AOP up to 135 dBSPL)

STTS751EM
Temperature sensor and Microphone Module

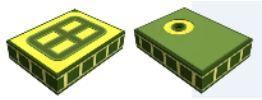


3.25x1.9x0.8 mm

- Bottom Port Microphone
- Analog Differential Output
- Wide Acoustic Bandwidth (up to 80 kHz)
- Wide Dynamic Range (AOP up to 135 dBSPL)

- Integrated Temperature Sensor
- With High Accuracy (+/-0.5 °C)

IMP34DT05
Digital Top Port Microphone



3x4x1 mm

- Top Port Microphone
- Digital Output
- Wide dynamic range (AOP up to 122 dBSPL)
- -26dBFS ± 3 dB sensitivity

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FlightSense™ Mass-Market Products

VL6180X

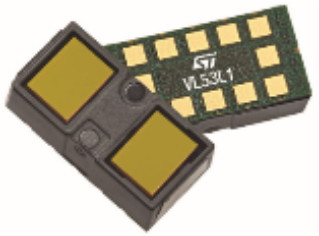
- 1st Generation ST ToF Sensor
- Proximity/ALS sensor up to **60cm**

VL53L0X

- 2nd Generation ST ToF Sensor
- Ranging sensor up to **2m**

VL53L1X

NEW



- 3rd Generation ST ToF Sensor, with lens
- Ranging sensor up to **4m**, with programmable **FoV**

Main use-cases: proximity, distance measurement, user / object detection, robotics, lighting control, basic gesture…

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Endless New Applications

Drones

PC & Tablet

Vacuum cleaners

Sanitary

Smart home

Printers

Medical

Service Robots

White Goods

AR/VR

Industrial

Wearable & IoT

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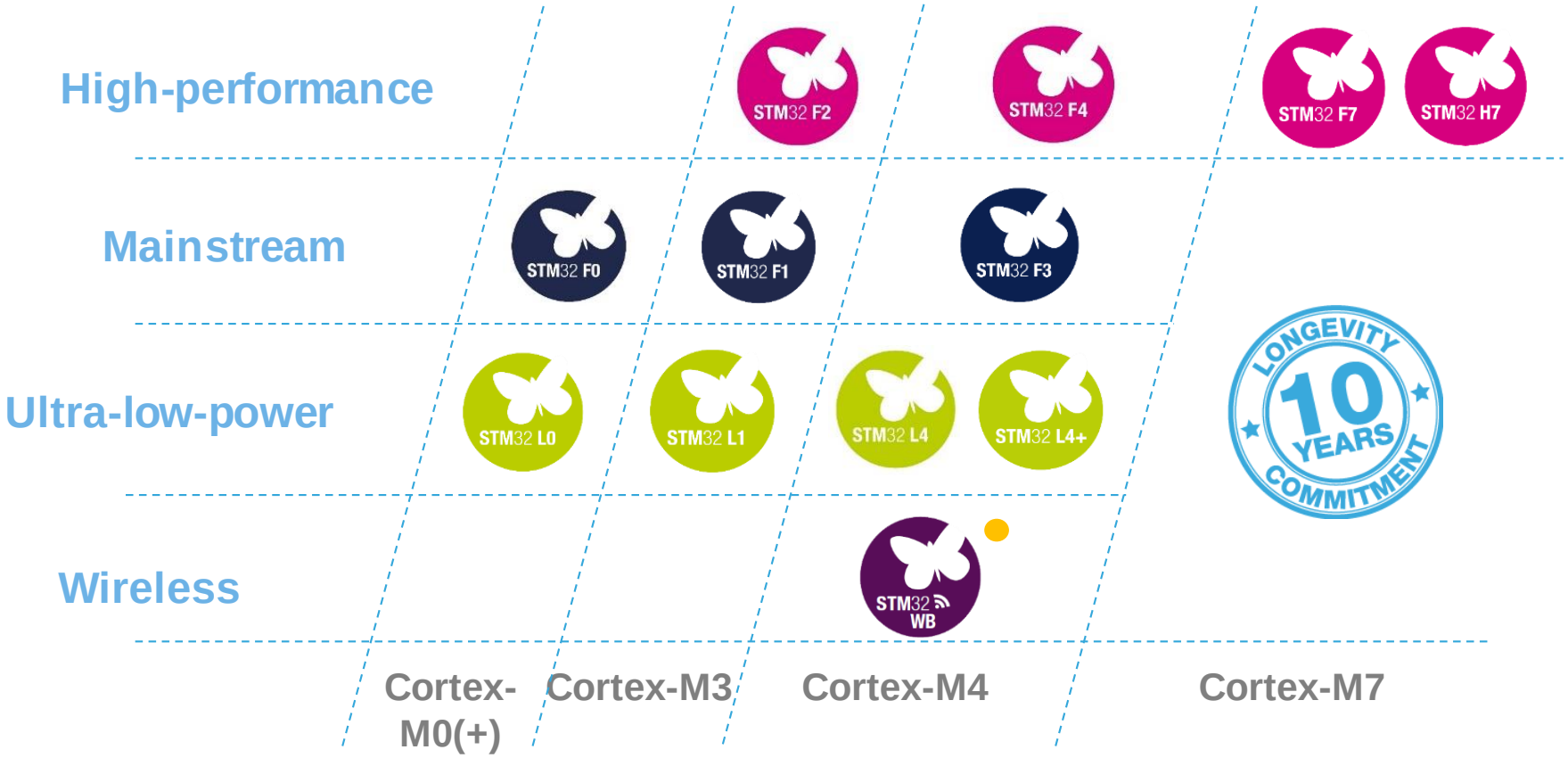
12 product series / More than 50 product lines



More than
40,000 customers

Note : Cortex-M0+ Radio Co-processor

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Connectivity Options
to Match the Needs of Industrial Environments

Wired Connectivity

P2p, Industrial Fieldbus, Industrial Ethernet

IO-Link
CANopen
PROFINET INDUSTRIAL ETHERNET
EtherCAT
sercos the automation bus
EtherNet/IP
ETHERNET POWERLINK

And more ..

Any Industrial protocol for any STM32

Wireless Connectivity

Retrofit, flexibility of technologies and protocols, interoperability with Ethernet and Cloud

Bluetooth SMART
Wi Fi
Sub 1GHz
LoRa
IEEE 802.15.4
sigfox
Lte
6LoWPAN

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Key Take Away

- ✓ Predictive Maintenance as one of the fastest growing IIoT applications
- ✓ ST Positioning
  - ✓ Modular Approach
  - ✓ Full solution
  - ✓ Cloud Integration

Thank You!

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