

Fault Prediction with Vibration Sensing

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Presentation Abstract

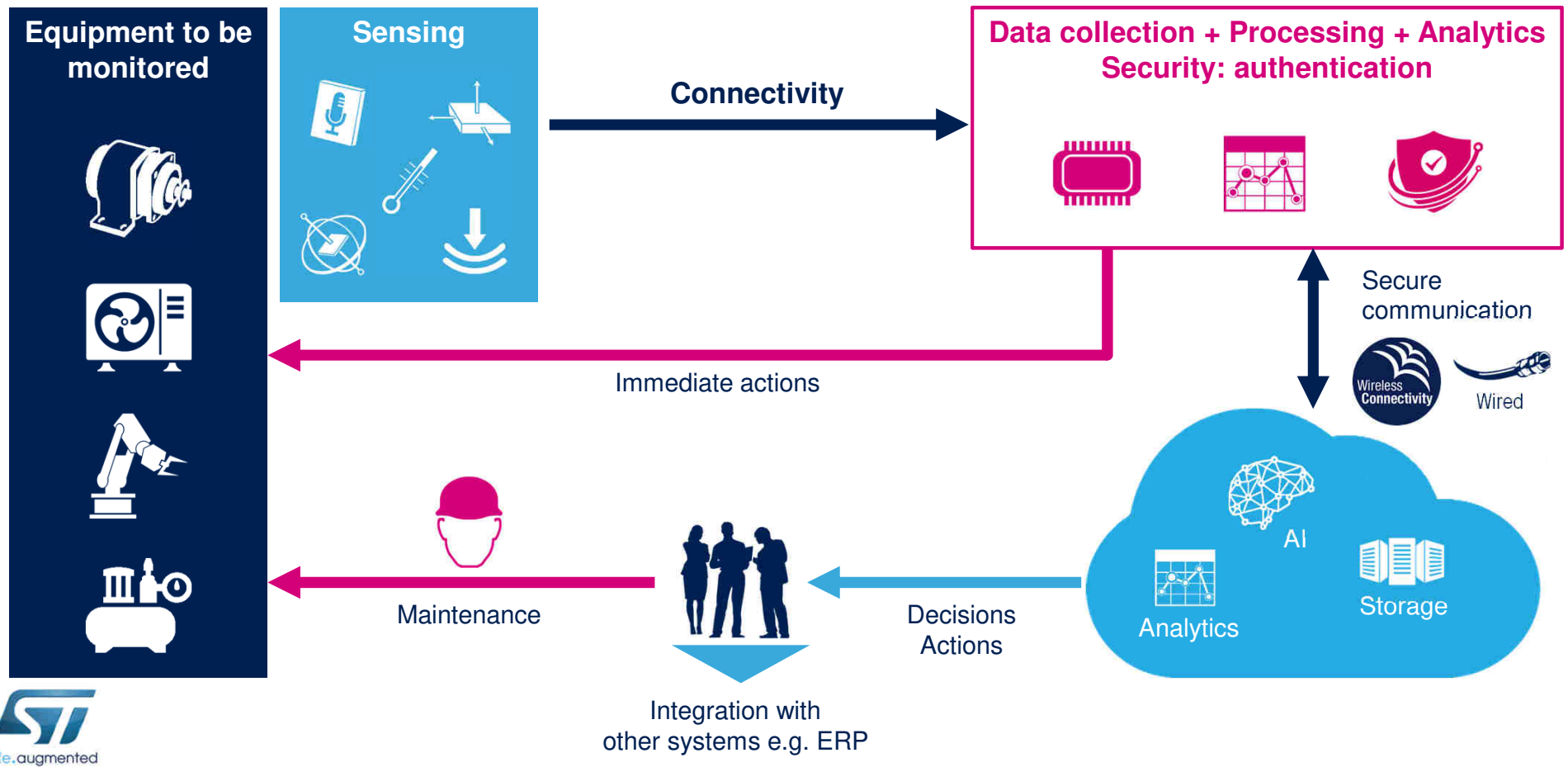
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Fault Prediction (or Predictive Maintenance) reduces down time and maintenance costs; increases safety and monitors equipment health. Discussion will include:

- 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

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Architecture Optimization

Constraints of Centralized Data Processing

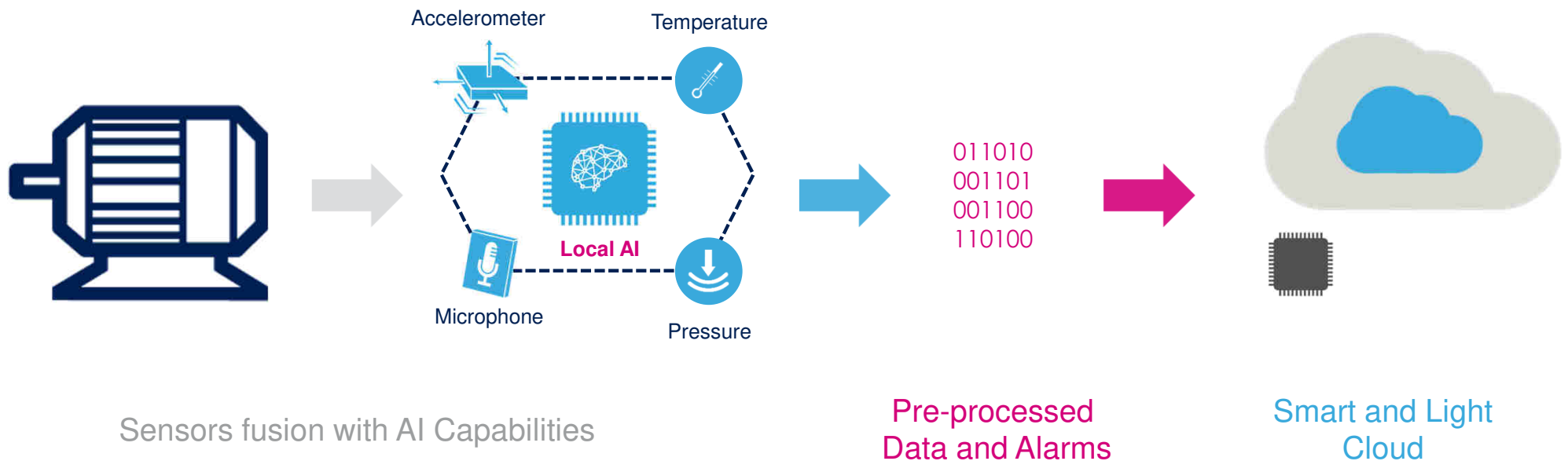


Current approach

Architecture Optimization

Moving the Intelligence to the Node

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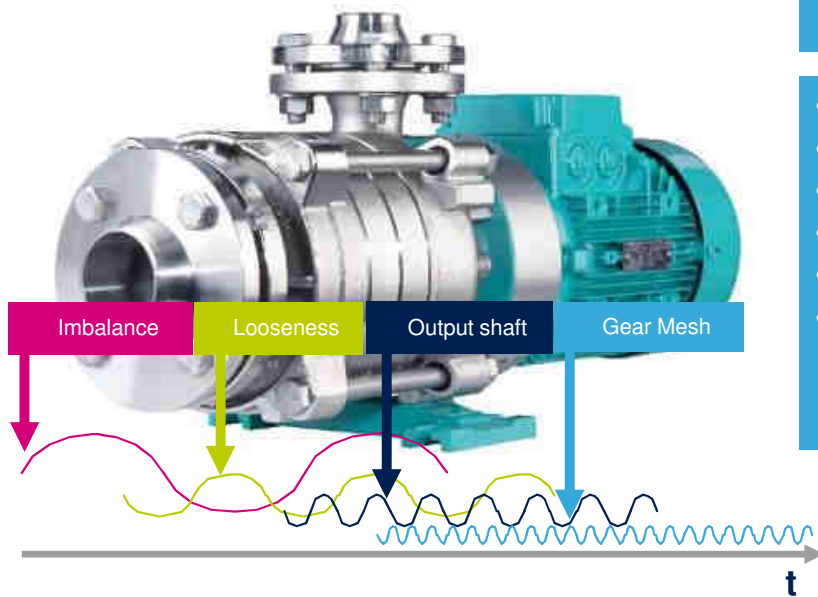
Local AI processing capabilities enable new approaches

Monitoring of an Industrial Motor

Typical Use Case

6

Any parameters deviation is an indicator of potential failure



Mechanical vibration

- Displacement
- Speed
- Acceleration
- Acoustic noise
- Angular speed
- Torque

Thermal

- Winding temperature
- Bearing temperature


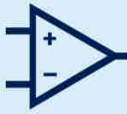
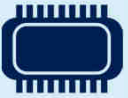



Electromagnetic

- Current
- Voltage
- Electrostatic discharge
- Magnetic flux – internal
- Magnetic flux – external

Monitoring of an Industrial Motor

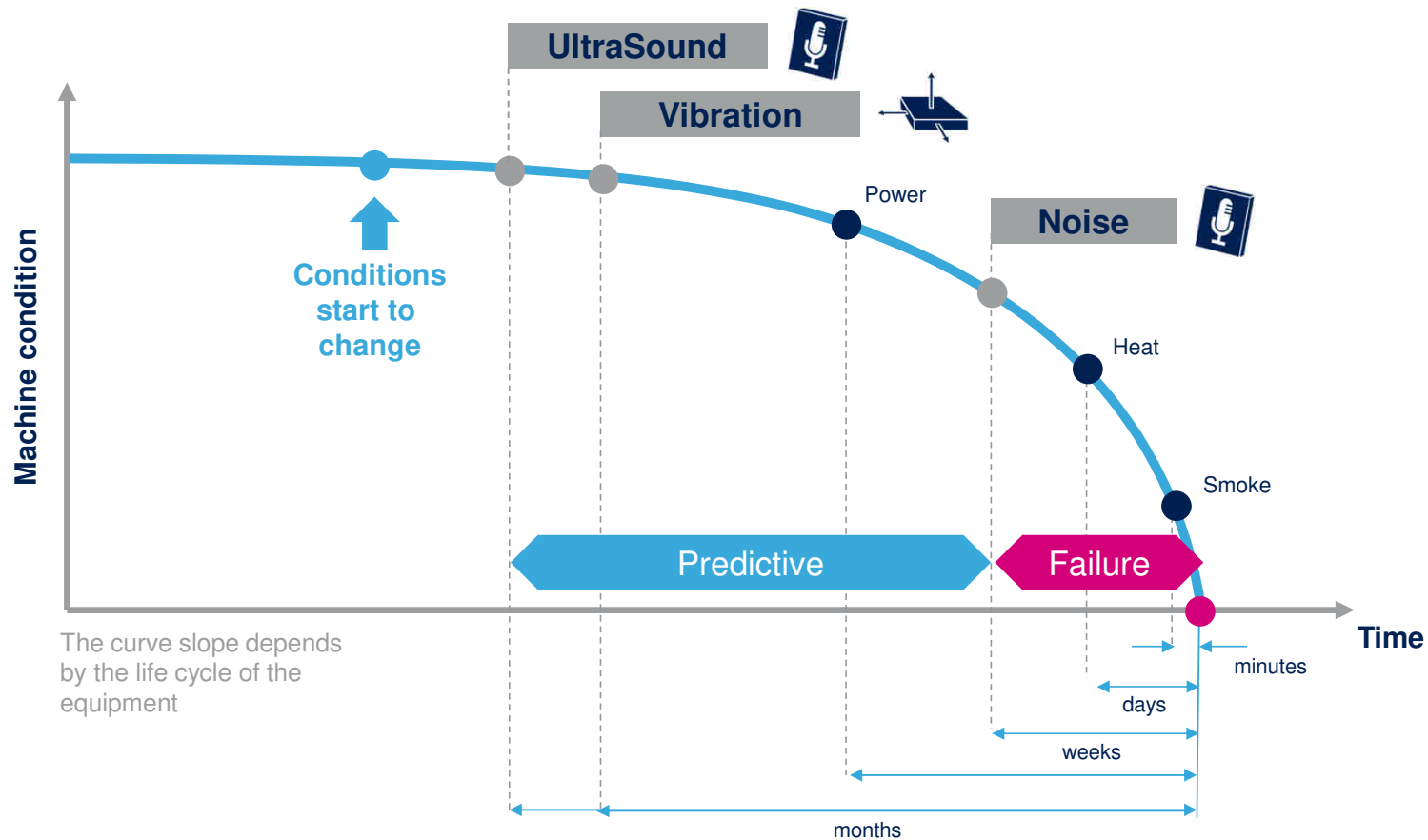
Typical Use Case

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Functional needs	Capture vibrations	Signal conditioning	Processing	Power Management	Connectivity	Secure Connections
ST solutions	<p>MEMS Sensors</p> 	<p>Op Amps Comparators</p> 	<p>MCU</p> 	<p>Power ICs & Power Discrete</p> 	<p>Bluetooth Sub-1 GHz IO-Link</p> 	<p>Secure MCU</p> 

Accelerometer & Microphone

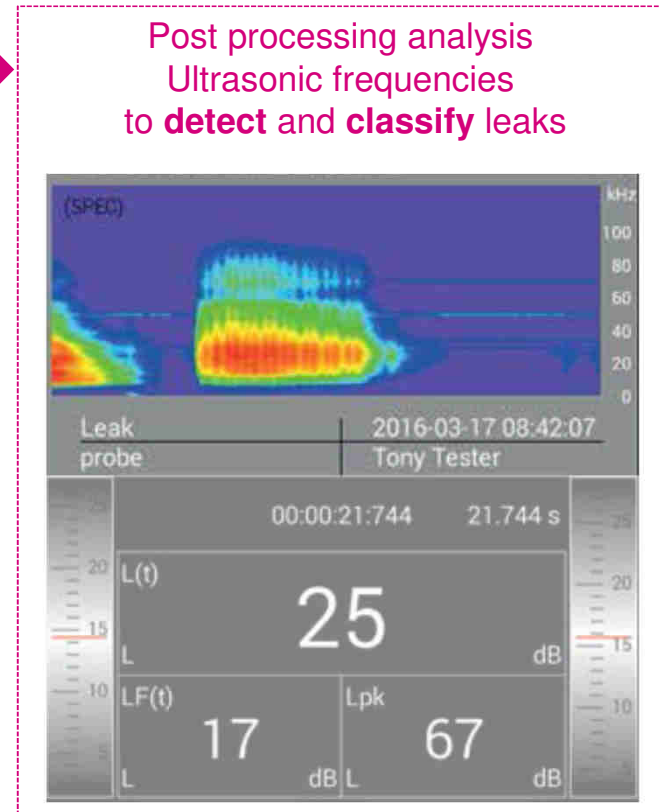
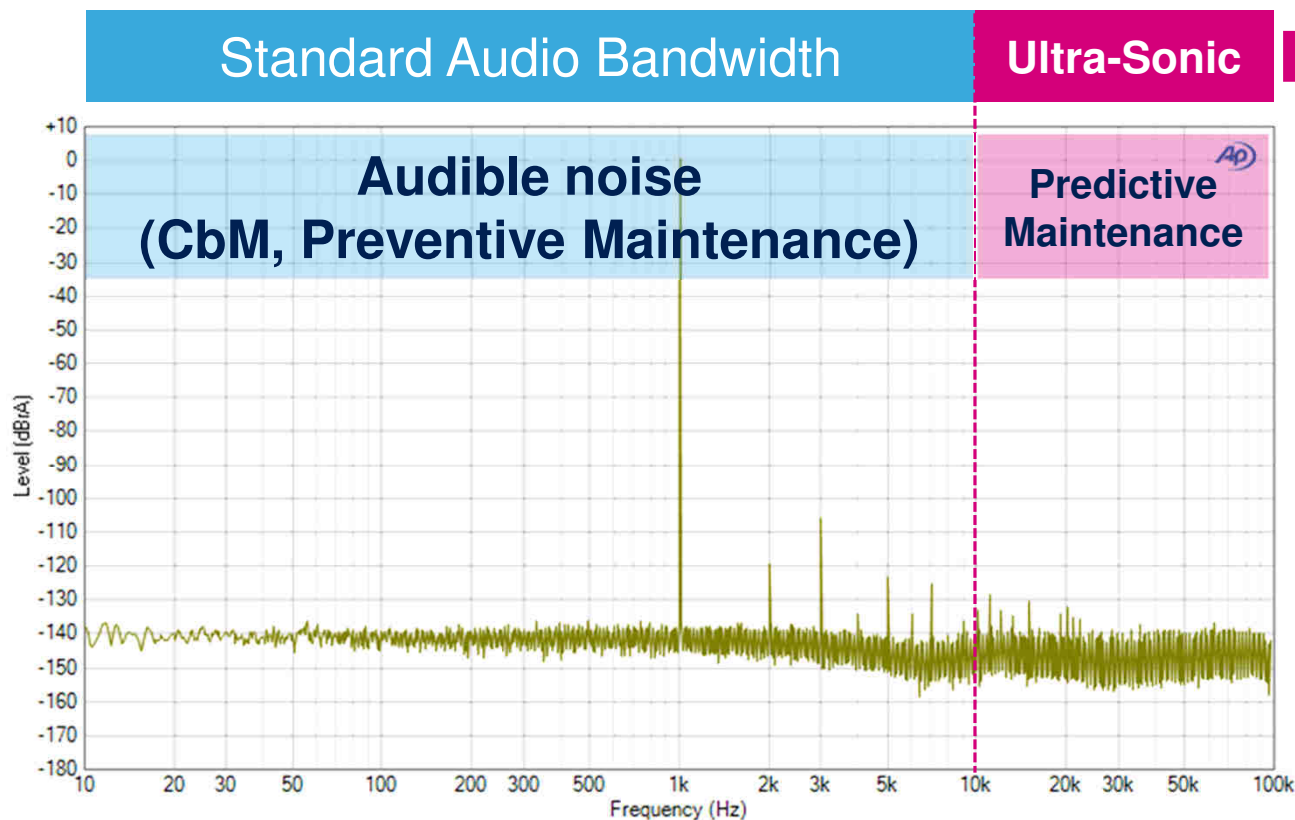
Distinctive Sensor Parameters for Predictive Maintenance



Symptoms According to Audio Frequency

Standard Audio vs Ultrasonic

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Monitoring and Predictive Maintenance with Environmental Sensors

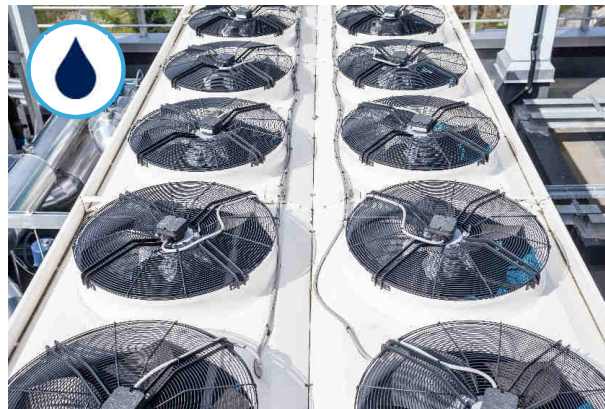
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Key components for process and quality control in industrial applications

Pressure measurements for **"air management" systems**, which monitor the performance indicators and the different stages of the air compressors connected to the compressed-air supply grid

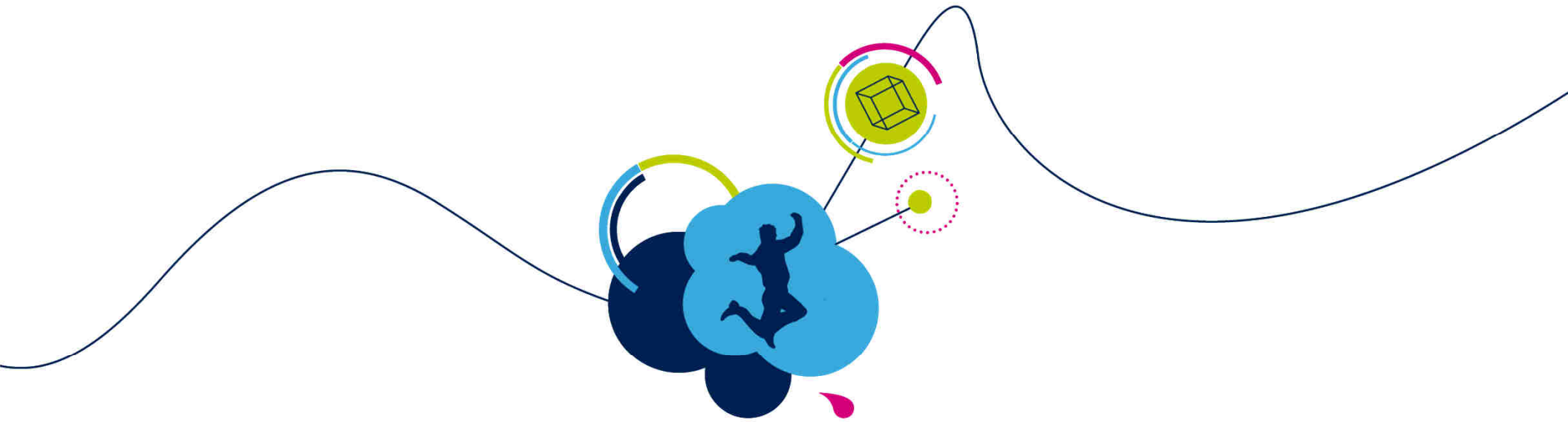


Largely adopted in **HVAC system** control water vapor level or to help in regulating parameters such as air temperature and blowing speed



Measure **operating temperatures**, It's useful for detecting loose or improperly terminated electrical connections, overloading, defective contacts, phase imbalances and other electrical problems





ST Enablers for Vibration Analysis

Products & Solutions

End-to-end Approach

from Sensors to Cloud

12

Products

Solutions and fast prototyping

Long lifetime support

Sensing



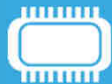
Connectivity



Security



Processing



Fast Prototyping and
Development Kits



Reference Design



ST Enablers

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Focus on Products: STM32 and Hardware Tools

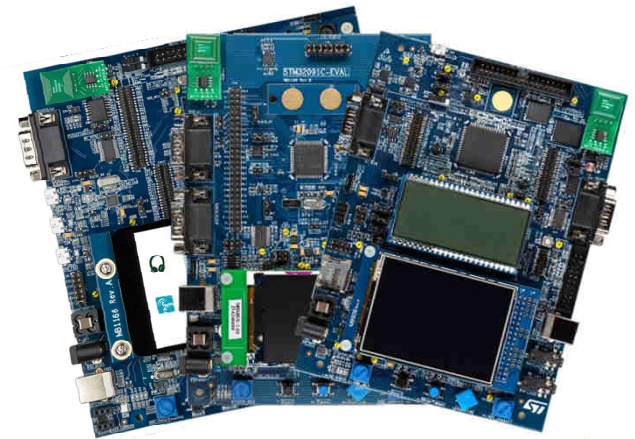
STM32 Nucleo Boards



Discovery Kits



Evaluation Boards



Fast agile prototyping

Feature highlight, prototyping

Full features evaluation

Sensing



Connectivity



Security



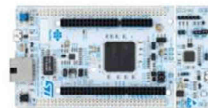
Processing



Modular Hardware for Vibration Analysis

14

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



Motion & environmental
sensors

Proximity sensor

Microphone



BLE

Wi-Fi

Sub-GHz

NFC



Power management

LED boost



Motor drive

Actuator



Audio amplifier

Op-Amp

End-to-end Approach

from Sensors to Cloud

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Products

Solutions and fast prototyping

Long lifetime support

Sensing



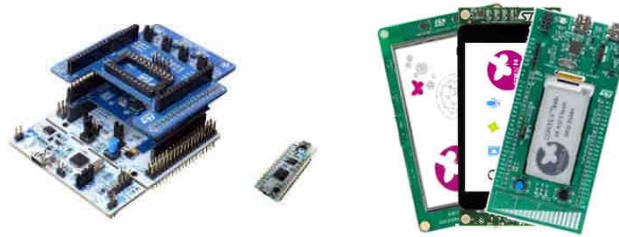
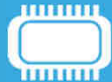
Connectivity



Security



Processing



Fast Prototyping and
Development Kits



Reference Design



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

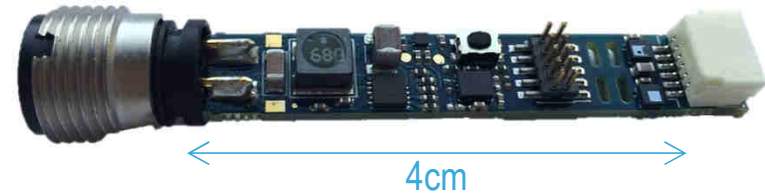


Local Processing

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



STEVAL-IDP005V1



Main Features

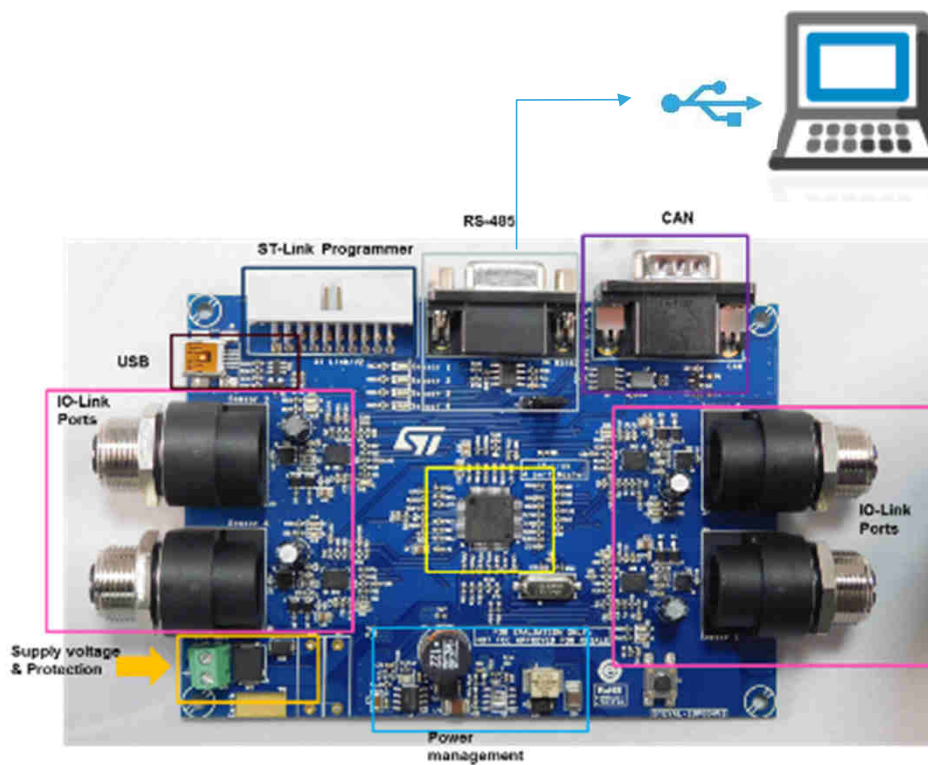
- Optimized form factor for industrial M12 connector
- Embedded algorithm for sensors data analysis, detecting anomalies like unbalance, misalignment, or bad equipment condition
- Logging of worst working condition events

Equipment with vibration up to 2KHz

STEVAL-IDP005V1

Communication Based on Master Board

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STEVAL-IDP004V1



Axel spectrum
Axel Peak
RMS
P, T, H parameters



STEVAL-IDP005V1

Firmware Architecture

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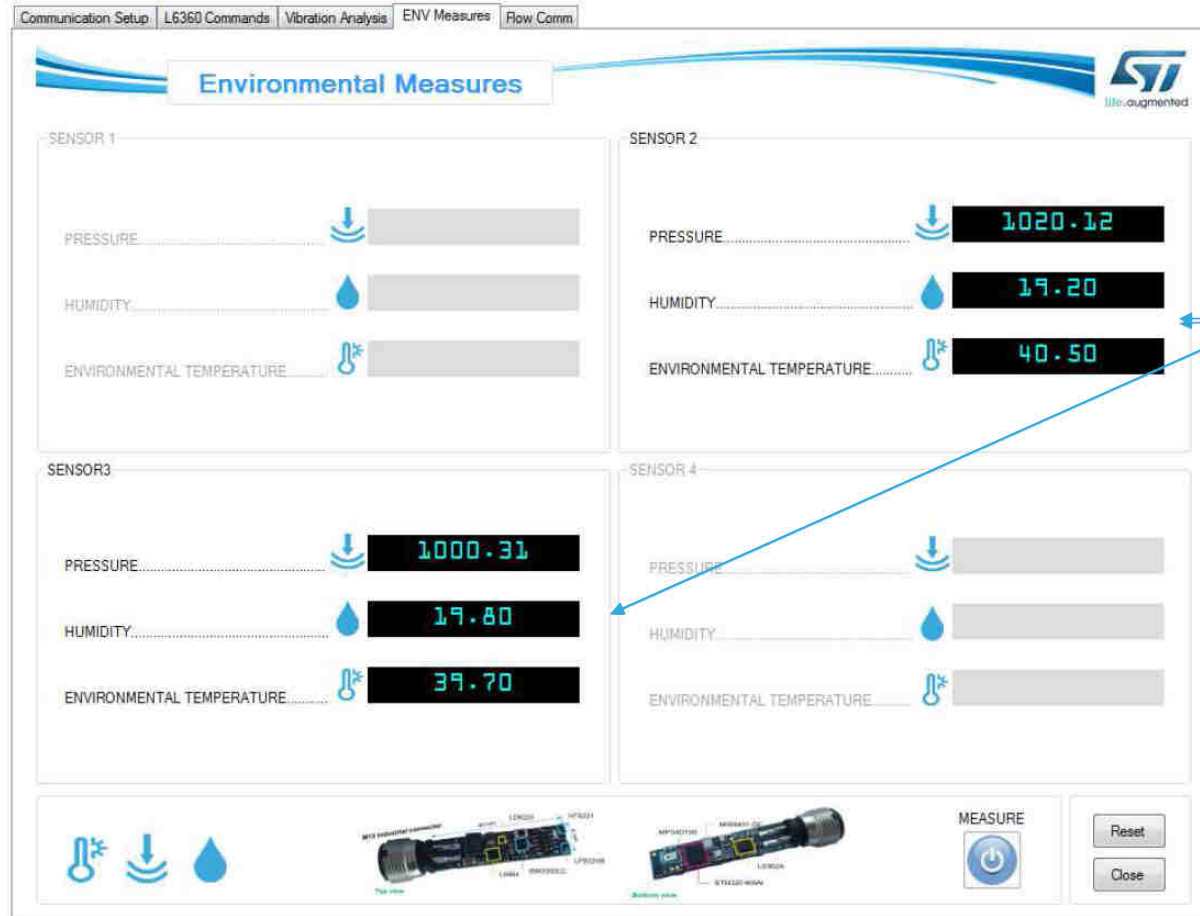
Demonstrations		Applications		
Condition Monitoring	Predictive Maintenance	Acoustic Analysis	Vibration Analysis	Environmental Monitoring
Middleware	Vibration Signal Processing		Audio Lib	
	STM32Cube Hardware Abstraction Layer (HAL)		Board Support Package	
Hardware Abstraction				
Hardware	ISM330DLC, HTS221, LPS22HB, MP34DT05-A, M95M01-DF			
	STEVAL-IDP005V1			

Download
[STSW-BFA001V1](#)

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

Environmental Measures

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Temperature
Pressure &
Humidity

End-to-end Approach

from Sensors to Cloud

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Products

Solutions and fast prototyping

Long lifetime support

Sensing



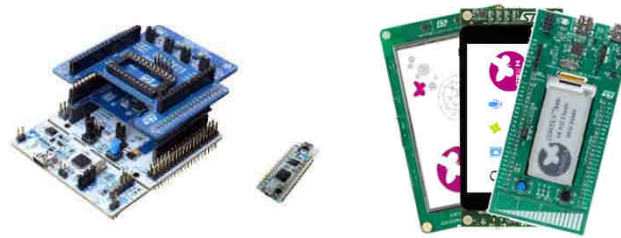
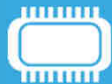
Connectivity



Security



Processing



Fast Prototyping and
Development Kits



Reference Design



ST's Solutions for Cloud

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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



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



Modular hardware

ST & 3rd-party form-factor boards

SensiBLE



Discovery Kit IoT Node



Bluecoin



SensorTile



SmarTAG

Form factor boards

End-to-End Tools from Sensor to Cloud

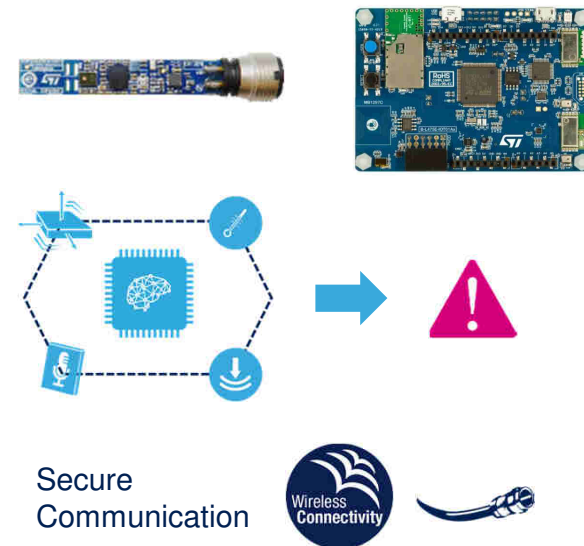
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Ultrasound, Vibration, Noise & Environmental data processing at the Node

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

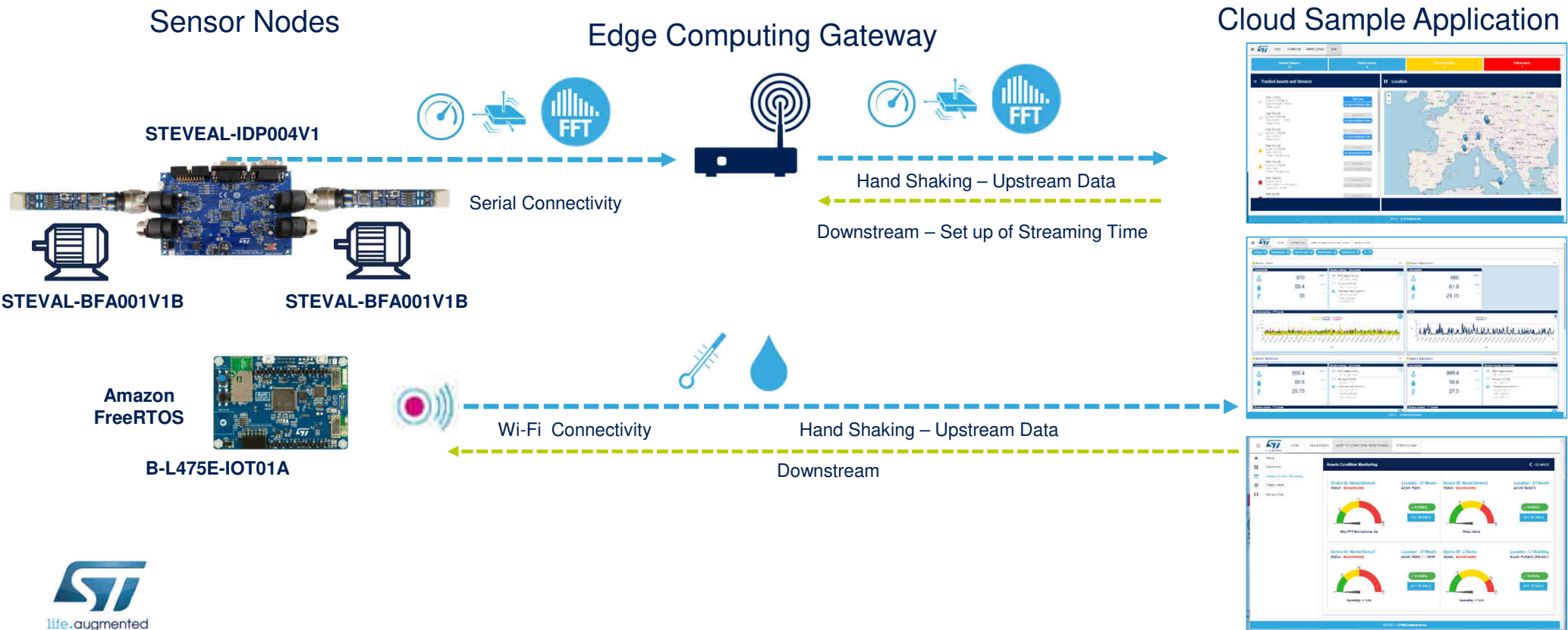


Starter kit available

Predictive Maintenance Node to Cloud

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Ultrasound, Vibration, Environmental sensing



End-to-end Approach

from Sensors to Cloud

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Products

Solutions and fast prototyping

Long lifetime support

Sensing



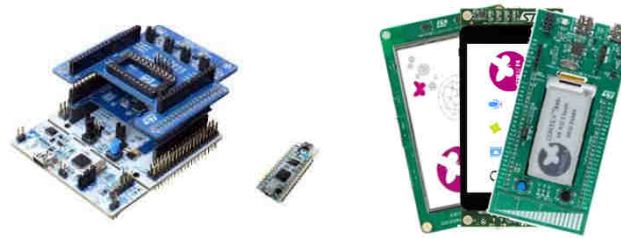
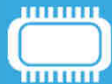
Connectivity



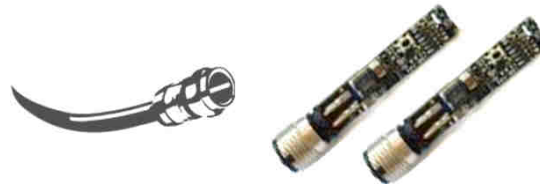
Security



Processing



Fast Prototyping and
Development Kits



Reference Design



STM32L475 Discovery Kit IoT Node

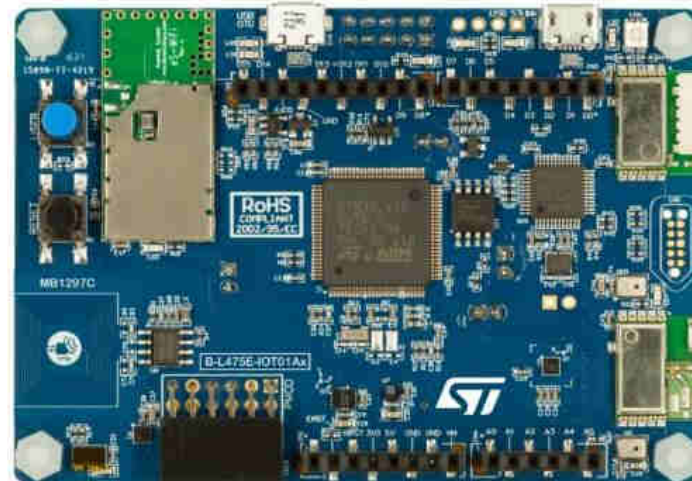
(B-L475E-IOT01A)

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- 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

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



ST Partner Program

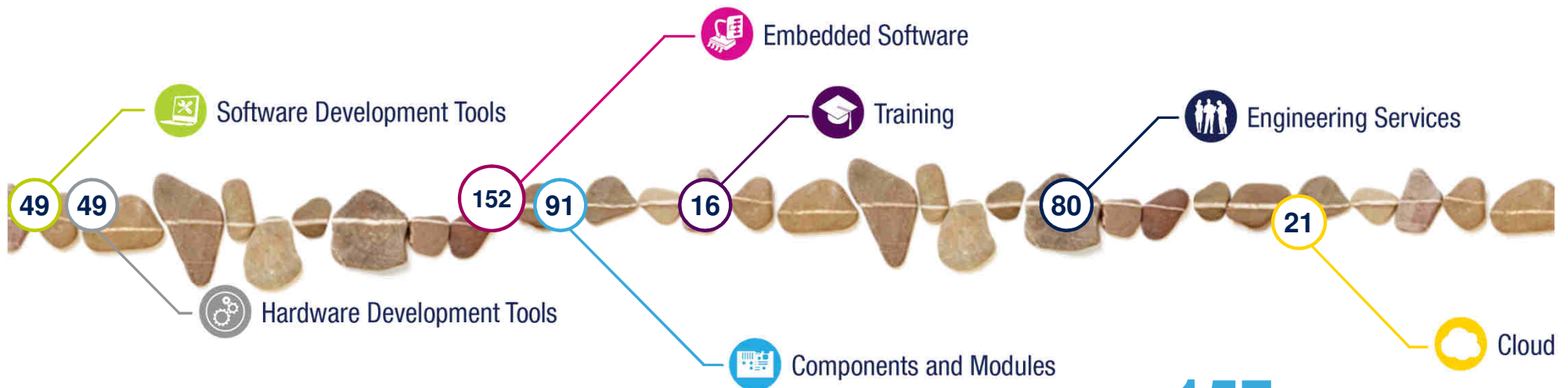
Building Greater Solutions Together

www.st.com/partners



Partner Program 27

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

>150 Partners... and Counting

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End-to-end Approach from Sensors to Cloud

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Products

Sensing



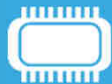
Connectivity



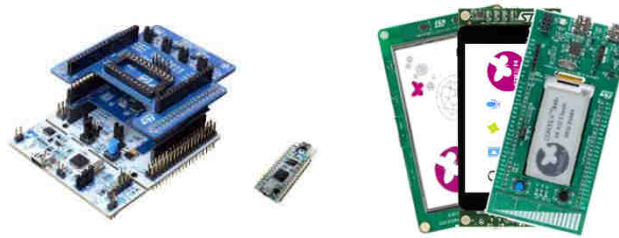
Security



Processing



Solutions and fast prototyping



Fast Prototyping and
Development Kits



Reference Design

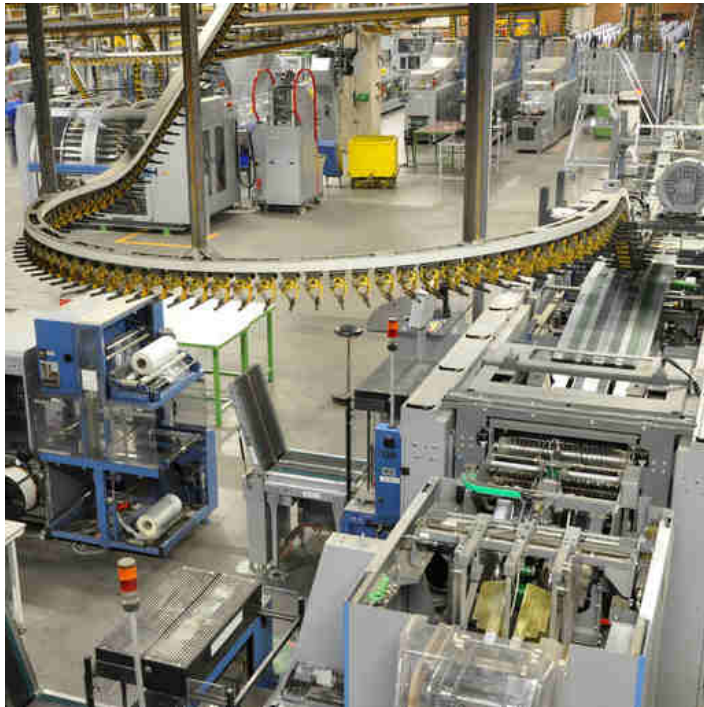


Long lifetime support



Industrial Sensors

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Environment



Temperature sensors

Analog and digital contact temperature sensors



Humidity sensors

Combo humidity and temperature sensor



Pressure sensors

With water proof solutions



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



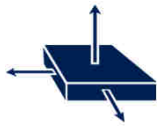
Time of Flight

High precision, surface agnostic distance measure



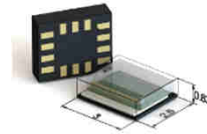
Motion MEMS Sensors for Smart Industry

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IIS3DWB

Accelerometer - Ultra Wide Bandwidth



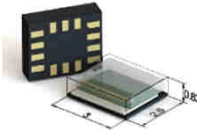
LGA-14 2.5x3mm2

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

Environmental Sensors for Smart Industry

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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



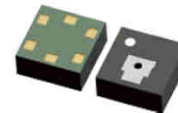
3.3x3.3x2.9 mm

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



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 °C ; Programmable resolution

LM23

Analog Temperature Sensor

TO92/SO8

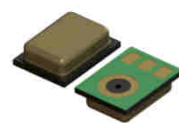
Accuracy ± 1.0 °C ; Op. Temp up to 150 °C

MEMS Microphones for Smart Industry

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MP23AB01DH
Analog Differential Microphone

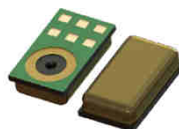


3.35x2.5x0.98
mm

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



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 dB SPL)

Integrated Temperature Sensor
With High Accuracy ($\pm 0.5^{\circ}\text{C}$)



IMP34DT05
Digital Top Port Microphone



3x4x1 mm

Top Port Microphone
Digital Output
Wide dynamic range (AOP up to 122 dB SPL)
 $-26\text{dBFS} \pm 3\text{ dB}$ sensitivity

FlightSense™ Mass-Market Products

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VL6180X



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

VL53L0X



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

VL53L1X



- 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...

Endless New Applications

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Drones



PC & Tablet



Vacuum cleaners



Sanitary



Smart home



Printers



Medical



Service Robots



White Goods



AR/VR

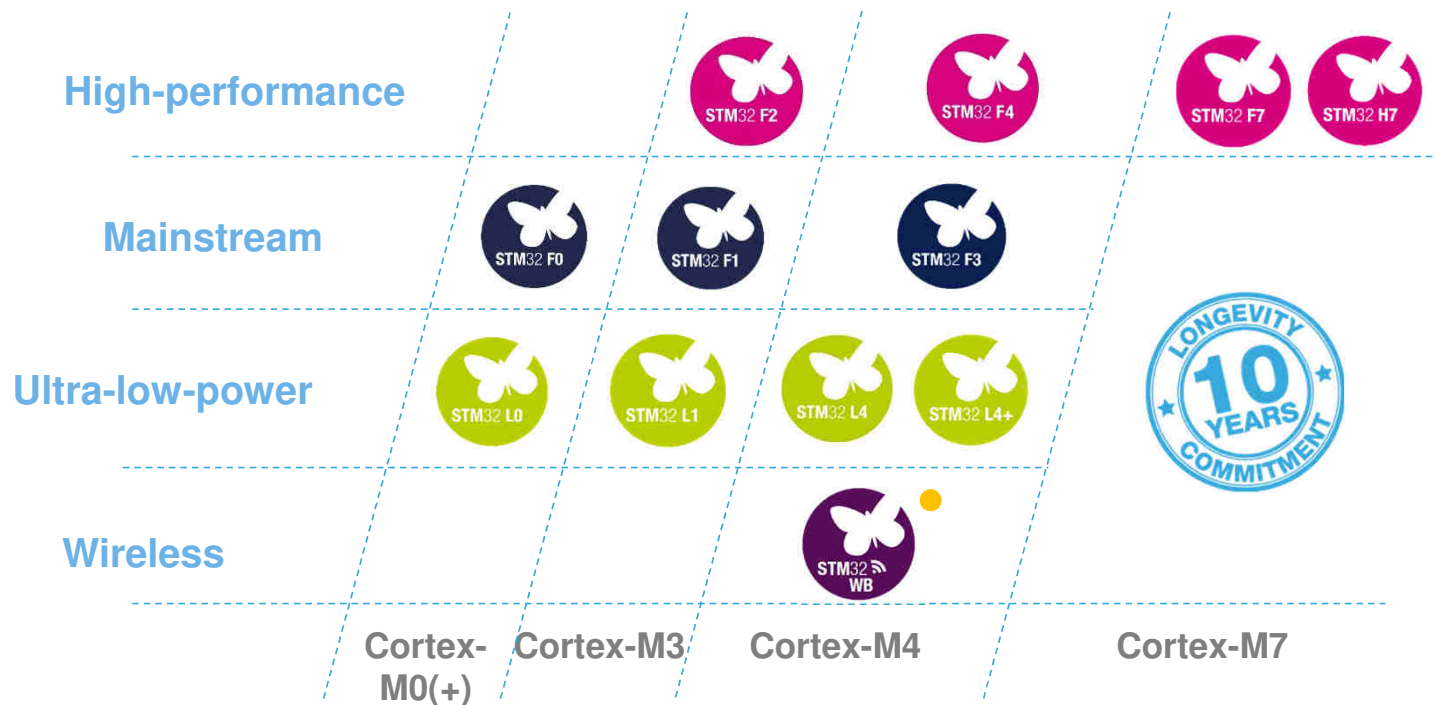


Industrial



Wearable & IoT

12 product series / More than 50 product lines



More than
40,000 customers

Connectivity Options

to Match the Needs of Industrial Environments



Wired Connectivity

P2p, Industrial Fieldbus, Industrial Ethernet



And more ..

Any Industrial protocol for any STM32



Wireless Connectivity















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



Wireless Connectivity

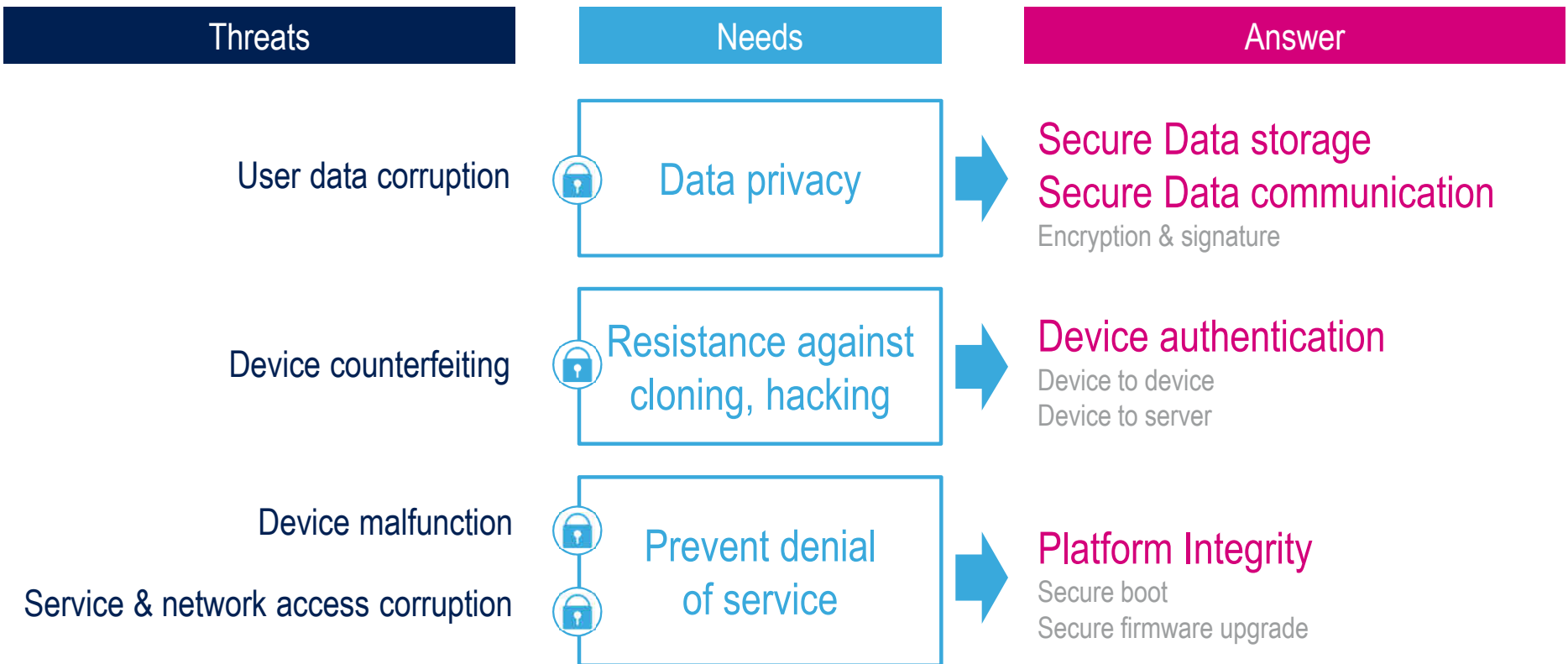
a Range of Solutions for Industrial Use Cases

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	  Bluetooth <small>SMART</small>	  IEEE 802.15.4	  THREAD	  Wi-Fi <small>IEEE 802.11a/b/g/n/ac</small>	  sigfox	  LoRa	  lte <small>NB-IoT-Cat-M1</small>
Range	<30m Short-range Area Network			<200m Local Area Network	<25Km Low-Power Wide Area Network		
Bandwidth	2 MHz	600 kHz, 2MHz and 5 MHz	5 MHz	20, 21, 22, 23, 24, 40, 80, 160 MHz	Base station listening bandwidth: 200 kHz, 100 Hz UL channels; 600 Hz DL channels	125 kHz, 500 kHz (DL) 125, 250, 500 kHz (UL)	DL and UL (Multitone): 180 kHz (15 kHz sub-carrier spacing) Single-tone: 180 kHz (3.75 /15 kHz spacing) // 1.4 MHz
PHY Data Rate	Up to 1 Mbps (BT 4.2) Up to 2 Mbps (BT 5.0)	20 kbps, 40 kbps, 250 kbps	40 kbps to 250 kbps	b: 11 Mbps a/g/h/j: 54 Mbps n: 600 Mbps ac: 86.7 Mbps to 6.9 Gbps	100 bps up, 600 bps down	0.3 kbps - 50 kbps	DL up to 250 kbps; UL single tone up to 20 kbps, multitone up to 250 kbps // 1 Mbps
Topology	Star/Mesh	Star/Mesh	Star/Mesh	Star/Tree	Star	Star on Star	Star

Security Threats and Answers

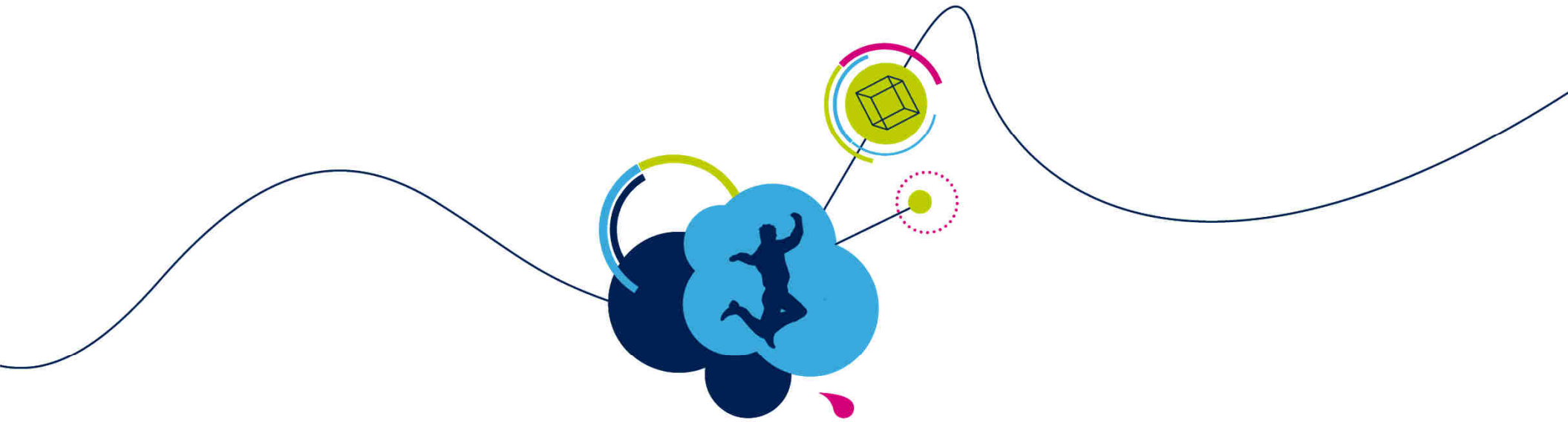
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Key Take Away

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



Thank You!