

# ST's Condition Monitoring Solutions



# Introduction

Condition-based Monitoring (CbM) and Predictive Maintenance (PM) are two maintenance strategies which aim at optimizing equipment efficiency and reducing service timing and costs during equipment lifecycle.

**Condition Monitoring (CM)** is the monitoring of several parameters such as equipment vibration and temperature to **identify potential issues** such as misalignments or bearing failures. Condition monitoring tools can, for instance, map equipment degradation when a vibration analysis shows a change in the harmonic frequency of rotating equipment components. Frequency analyses can be based both on vibrometer and microphone data.

Also **MCSA** (Motor Current Signal Analysis) is used as technique that is complementary with respect to Vibration Analysis. It offers benefits and works better on some specific anomalies like unbalance.

Continuous Condition Monitoring techniques can be applied on several pieces of equipment such as compressors, pumps, spindles and motors and can also be implemented to identify partial discharge on machine or vacuum leaks.

**Predictive Maintenance** is based on Condition Monitoring, abnormality detection and classification algorithms, and integrates predictive models which can **estimate the remaining machine runtime left, according to detected abnormalities**. This approach uses a wide range of tools, such as statistical analyses and Machine Learning to predict the state of the equipment.

## CONDITION BASED MONITORING TYPICAL APPLICATIONS

Factory Automation		Industrial motor vibration monitoring		Bearings ultrasound monitoring		Motor current monitoring
Power, Energy & Utilities		Pipe flow monitoring		Temperature, humidity, gas monitoring		Acoustic monitoring
Home Appliances and Building Automation		Compressor vibration monitoring		Washing machine, vacuum cleaner monitoring		Lighting monitoring
Structural Health Monitoring		Infrastructure inclination monitoring		Railways monitoring		Bridge vibration monitoring

## ST'S PORTFOLIO FOR CONDITION MONITORING AND PREDICTIVE MAINTENANCE IN INDUSTRY 4.0

### Factory Automation



### Processing



### Sensing & Actuating



### Security



### Power, Energy & Utilities



### Connectivity



### Power & Energy Management



### Signal Conditioning & Protection



### Home Appliances and Building Automation



### Structural Health Monitoring



Multiple applications, one platform, one vendor

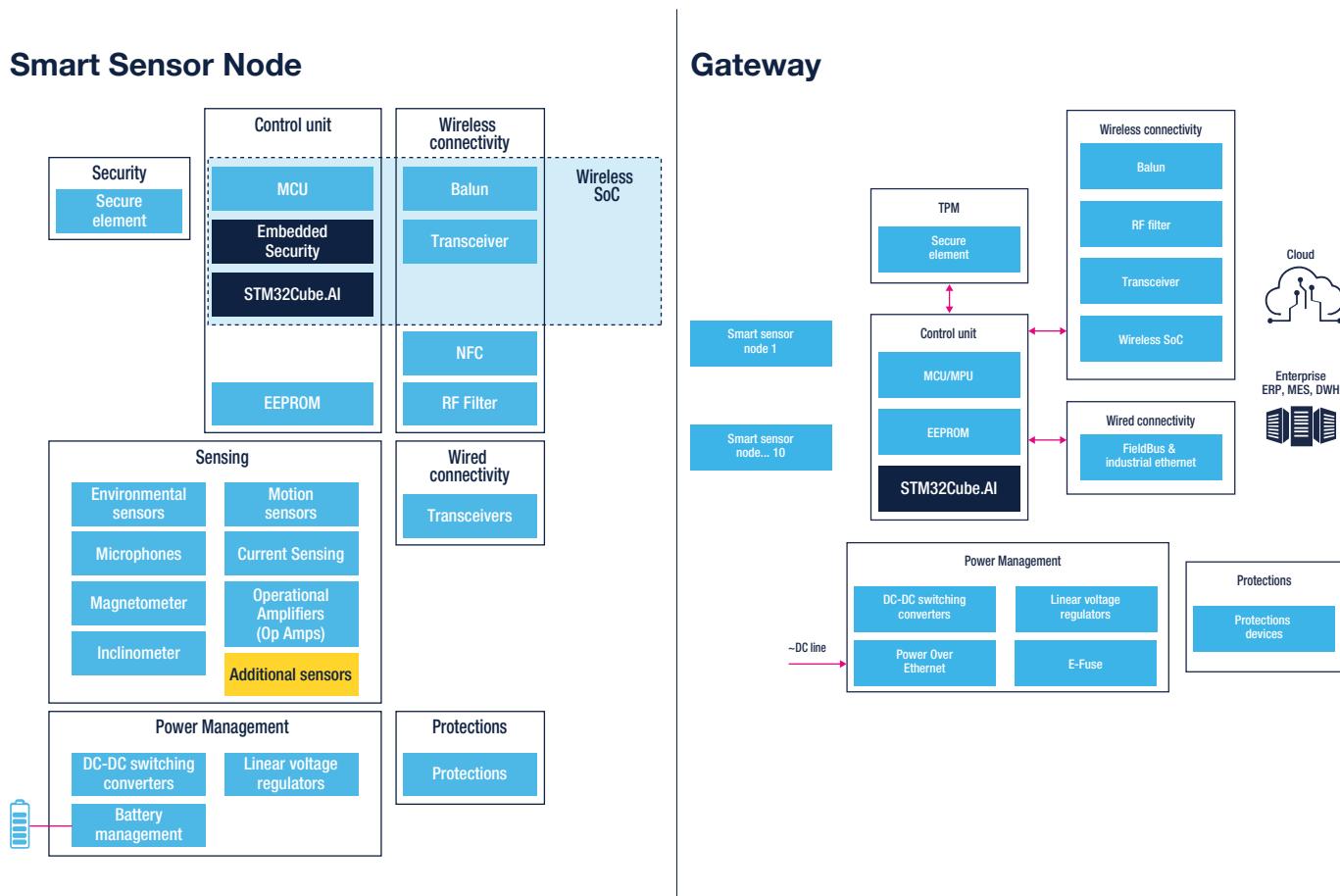
Condition Monitoring and Predictive Maintenance are value-added yet challenging applications in Industry 4.0. ST has therefore deployed advanced ICs and an ecosystem of evaluation tools, software, documentation and online dashboards for remote monitoring, which are continuously updated to be in keeping with industrial needs.

## ARCHITECTURE AND MAIN ELEMENTS: SMART SENSOR NODES AND GATEWAY

From designing smart sensor nodes and configuring embedded software running in sensor nodes and the gateway, to developing software to be integrated in the Cloud or company Enterprise Resource Planning (ERP) system, Predictive Maintenance requires a variety of skills and competencies. **Machine Learning** and **Artificial Intelligence** algorithms can be implemented to ensure technical abnormalities are detected early and equipment uptime is maximized

Today market is mainly segmented in:

- New equipment (greenfield): Integration possible with power supply and existing sensors
- In-field maintenance (retrofit): Battery-powered simplifies installation



**Smart sensor** nodes are key enablers of predictive analysis. They gather and log pre-processed, secure data to be displayed in visualization tools and used in other processing algorithms. Smart sensor nodes can also process data and detect anomalies by reducing computational latency. For example, smart sensor nodes can detect a small rise or a sudden increase in temperature indicating a probable device issue and future reliability problems.

**Gateways** are either implemented to collect and process data from several smart sensor nodes or to act as a connectivity bridge to enable secure connection to the cloud using ethernet, Wi-Fi, cellular or LPWAN technologies.

**Edge processing** combines and distributes processing power among smart sensor nodes and gateways with the aim of sending the right data at the right time to enterprise-level systems where more advanced analyses can be performed. Processing at the Edge can also use Machine Learning and Artificial Intelligence (AI) algorithms to enhance smart sensor node and gateway mission profiles and to broaden the scope of anomaly detection and classification.

# Key Products

## ST SENSORS FOR INDUSTRY 4.0 - A COMPLETE PORTFOLIO

ST offers high-performance, cost-competitive sensors and Inertial Measurement Units (IMUs) with 10-Year Product Longevity Commitment, including Vibration Sensors and ultra-sound analog microphones enabling vibration analysis from simple Pass/Fail monitoring to high-accuracy, frequency-based data analysis. Our portfolio also includes a wide range of environmental sensors for temperature, humidity and pressure sensing and advanced MEMS Sensors with advanced programmable digital features such as Finite State Machine and the Machine Learning Core, allowing the use of the sensors not only to capture data but also to identify patterns implementing a local classification engine. This offloads computation from the main controller, allowing it to focus on high level processing and enables the possibility to explore more power efficient architectures, bringing unprecedented value also in terms of overall system cost.

Vibration	
<b>IIS3DWB *</b>	Ultra-wide bandwidth (up to 6kHz), low-noise 3-axis digital Vibration sensor
<b>ISM330DHGX *</b>	Wide Bandwidth Accelerometer + Gyroscope with Machine Learning Core
<b>IIS2ICLX *</b>	High-accuracy, high-resolution, low-power, 2-axis digital inclinometer with Machine learning core
<b>IIS2MDC *</b>	Low-Noise, Low Power Magnetometer
<b>ISM330DLC *</b>	iNEMO inertial measurement unit (IMU): 3D accelerometer and 3D gyroscope with digital output

Acoustic	
<b>IMP23ABSU *</b>	Analog bottom port microphone with frequency response up to 80kHz for Ultrasound analysis
<b>IMP34DT05</b>	Digital Top Port Microphone

Environmental	
<b>LPS22HH</b>	High Accuracy – Compact Size Absolute Pressure Sensor
<b>LPS27HHW</b> <b>LPS27HTW</b> <b>LPS33W</b>	Water Resistant Absolute Pressure Sensor
<b>STTS22H *</b>	Digital Temperature Sensor
<b>STLM20</b>	Analog Temperature Sensor
<b>HTS221</b>	Relative humidity and temperature Sensor

Note: \* 10 years longevity



# STM32: 32-BIT MCUS AND MPUS

ST offers a large portfolio of STM32 Arm® Cortex® from M0 to M7-based microcontrollers addressing many different markets. The STM32 products can be effectively used to develop embedded AI solutions, thanks to the **STM32Cube.AI** framework, and thanks to a broad ecosystem of Partners to ease the implementation of Predictive Maintenance algorithms on MCU and MPU edge devices. STM32Cube.AI is supporting several deep learning frameworks and includes optimized libraries which can be used to map and run pre-trained Artificial Neural Networks on the broad STM32 microcontroller portfolio.

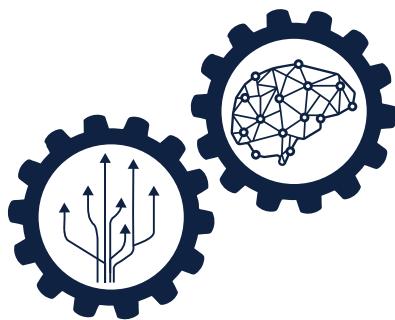


## THE BENEFIT OF EDGE PROCESSING AND THE ROLE OF AI

Collecting actionable data from machines provides an insight into their condition, but this only really becomes useful when the data are analyzed. Looking at one sensor node's data in isolation may not tell the entire story. It is only when all of the data are analyzed together that real insights emerge. This will become simpler as Artificial Intelligence (AI) in the sensor can be relied on to provide the analysis. Moving from understanding what a machine is doing, to predicting how it will behave in the future is what AI will deliver, by enabling even rudimentary sensors to provide greater value in a condition monitoring environment.

Edge processing occurs exactly when the computation of data is carried out directly in the smart sensor node or at the gateway, in order to save power consumption and ensure data is kept confidential, allowing companies to analyze critical information at the node level and to reduce anomaly detection time.

Processing at the Edge can also use **Artificial Intelligence (AI)** such as **Machine Learning (ML)** algorithms to enhance smart sensor node and gateway mission profiles and to broaden the scope of anomaly detection and classification.



STMicroelectronics offers machine learning algorithms based on decision tree classifiers in motion sensors and AI extension for STM32CubeMX to **map pre-trained Neural Networks**



Software examples for Quick prototyping  
Audio, Motion and Vision Function packs on ST development Hardware



STM32 Community with dedicated Neural Networks topic



Trainings, hands on, MOOCs and partners videos



ST Partner Program with dedicated AI Partners

## CONNECTIVITY SOLUTIONS

Connectivity is an increasingly important aspect of condition monitoring, as data is only useful if it can be actioned. Wireless connectivity technologies have developed enormously in recent years, spurred on by the IoT and, now, the Industrial IoT (IIoT) which is primarily where condition monitoring resides. A range of wired and wireless communication solutions complement our offer: IO-Link-compatible devices for industrial wired connectivity, and a portfolio of wireless technology such as Bluetooth Low Energy SoCs and network processors, as well as LPWAN SoCs and transceivers supporting LoRa, Sigfox and license-free ISM and SRD frequency bands.

NFC & RFID	
ST25DV-I2C	Dynamic NFC / RFID tags

Bluetooth Low Energy	
BlueNRG-LP	Programmable Bluetooth® LE 5.2 Wireless SoC
BlueNRG-2	Highly energy-efficient Bluetooth 5.2 Wireless SoC
STM32WB	Multi-protocol (Bluetooth 5.0 / 802.15.4) Wireless SOC with integrated balun
BALF-NRG-02D3 MLPF-WB55-0xE3	Balun & Filter
BlueNRG-M2	Wireless SoC module for Bluetooth 5.2

Sub-1 GHz	
BALF-SPI2-01D3	Balun for S2-LP
STM32WL	STM32 Sub-1 GHz SOC LoRa/Sigfox compatibility
S2-LP	Ultra-low power, high performance, sub-1GHz transceiver
S2-LPTX	Ultra-low power, high performance, sub-1GHz transmitter

Wired Connectivity	
L6364	IO-LINK Dual Device transceiver
STR485	low power differential line transceiver for data transmission standard RS485 applications in half-duplex mode



WPAN	
STM32WB	Bluetooth LE 5, Zigbee, Thread, proprietary Wireless SOC (integrated balun)

Cellular	
Cellular connectivity	



## POWER MANAGEMENT

ST is a leading supplier in power management and mixed-signal ICs for mobile applications, offering a wide range of products from simple power management ICs up to highly-integrated devices that mix power management blocks with advanced analog and digital functionalities.

DC/DC converters		Low Dropout (LDO) Linear Regulators
<b>ST1PS0X</b>	400 mA Nano-Quiescent™ Synchronous step-down converters	<b>STLQ020</b> 200 mA ultra-low quiescent current LDO
<b>L7983</b>	60 V 300 mA Synchronous step-down switching regulator with 10 $\mu$ A quiescent current	<b>LDLN030</b> 300 mA ultra-low noise LDO with power good and soft start
<b>L6983</b>	38 V 3 A Synchronous step-down converter with 17 $\mu$ A quiescent current	<b>LDLN025</b> 250 mA ultra-low noise LDO
<b>L6981</b>	38 V 1.5 A synchronous step-down converter with low quiescent current	<b>LD59030</b> 300 mA very low dropout current linear regulator IC
		<b>LD39130S</b> 300 mA very low quiescent current, with green mode linear regulator IC
		<b>LD57100</b> 1A ultra low drop, with bias, linear regulator IC

## CURRENT SENSE

ST's current sense amplifier IC portfolio offers a large variety of high-performance devices. Current sensing solutions add valuable safety and protection features to system designs. They provide information to control current in power systems and avoid overheating and short circuits, enabling Motor Current Signal Analysis with specific processing like FFT Advantages are complementary respect to Vibration Analysis.

### High-side

- if ground line cannot be cut (return to neutral by chassis)
- if multiple outputs power supply (all currents are combined in Gnd line)
- if application is sensitive to RF disturbances and requires Gnd line continuity

### ST solution

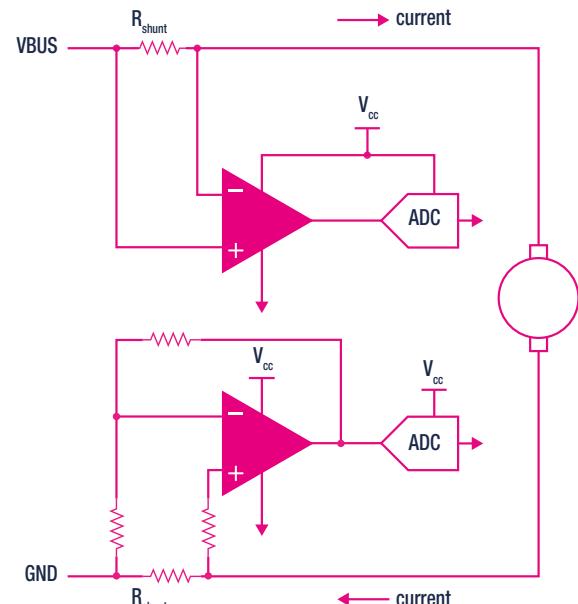
TSC series  
STEVAL-AETKT1V2 : Evaluation kit for high voltage bidirectional current sense amplifiers

### Low side

- no need for high voltage silicon technology
- more accurate measurement

### ST solution

TSZ: very high-accuracy zero drift 5 V op amps  
TSV79: 50 MHz-bandwidth 5 V op amps

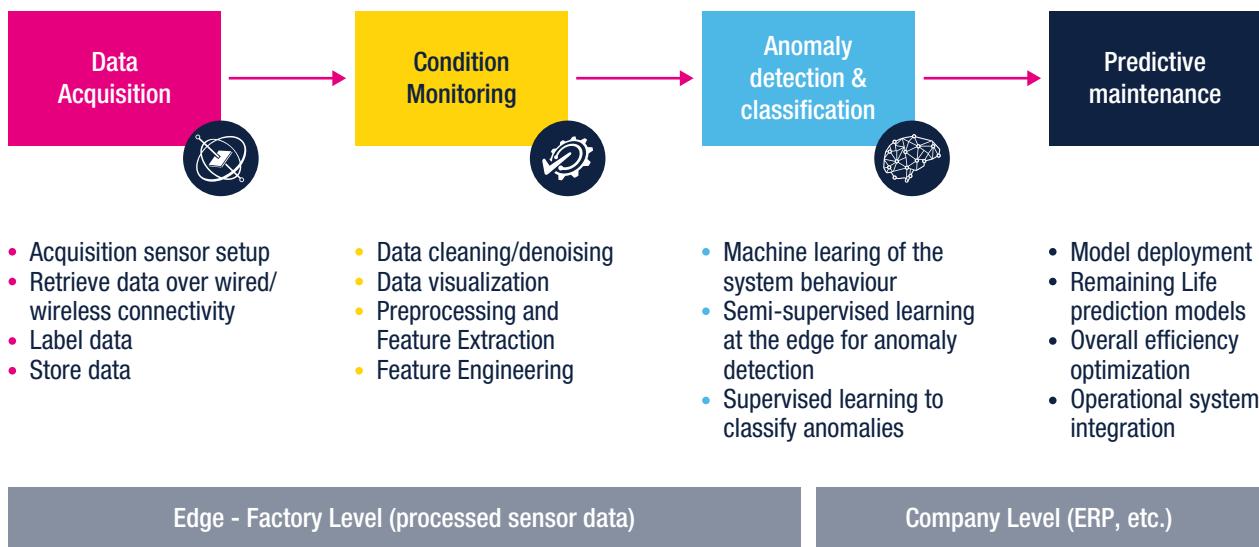


# ST Solutions

## FROM CBM TO PDM FOLLOW YOUR PATH WITH ST SOLUTIONS

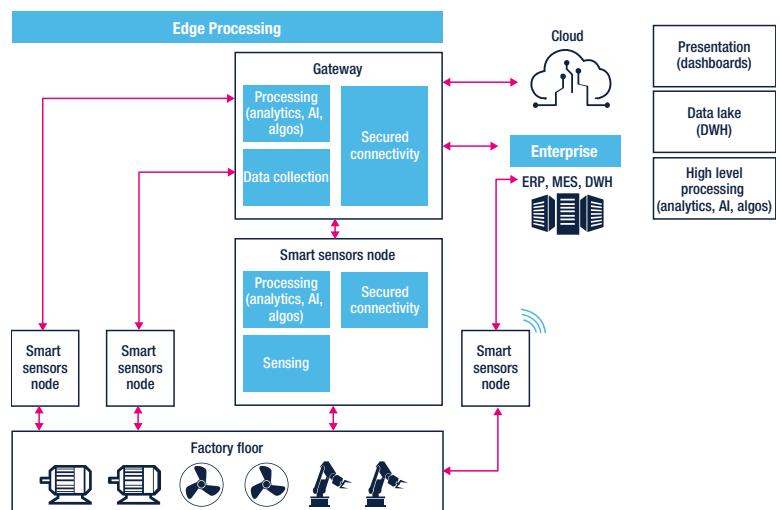
ST provides different hardware and software solutions to help designers in their job. Starting from the Product Evaluation Boards, that can be used to perform a comprehensive evaluation of ST's products, arriving to the **Solution** tailored to exploit one or more features of the application with a kit of HW and SW packages.

Particularly for Condition Based Monitoring, the set of tools allow to move step by step along the development flow.



## DESIGN SUPPORT HARDWARE REFERENCE DESIGN AND DEVELOPMENT KITS

STMicroelectronics has developed smart sensor nodes and SW packages to emulate a typical architecture where smart sensor nodes can be either connected with Gateway or directly with WPAN connectivity to the data lake on premise or in Cloud application. Particularly two families of smart sensor nodes have been developed in a typical IO Link sensor to Master vertical integration (STEVAL-BFA001V2B) or wireless node with multi connectivity options from Bluetooth, to WIFI, to Cellular (STEVAL-STWINKT1B). Related SW for IO Link stack, vibration analysis, cloud application and much more complete the offer with following solutions.



## Data Acquisition

## Condition Monitoring

ST offers a broad range of solutions. Solutions are presented as a set of products that enable our customers to deliver best performance with cutting edge technology in their application domain. Our solutions are offered at many different levels, varying from basic functional elements of an application to entire subsystems where appropriate.

Each solution is accompanied by a solution evaluation kit, allowing rapid evaluation of the products, within a proven design, in order to accelerate your prototyping and development process.



### HW Component

STEVAL-BFA001V2B

### SW Component

STSW-BFA001V2

### SL-BFA001V2

Sensor node with IO-Link device stack for predictive maintenance and condition monitoring



### HW Component

STEVAL-STWINKT1B

### SW Component

FP-SNS-DATALOG1  
ST BLE SENSOR APP

### High Speed Data Logging

STWIN wireless industrial node development kit combined with High-Speed Data Logger software package, BLE Mobile APP and integrated Host Environment to greatly simplifying the acquisition process



### HW Component

STEVAL-STWINKT1B  
STEVAL-STWINWFV1

### SW Component

FP-CLD-AWS1  
FP-CLD-AZURE

### Cloud and Features Demonstration

FP-CLD-AZURE1 :Cloud Connectivity SDK and Application for fast implementations

FP-CLD-AWS1: Offer examples of Security Features

## SOLUTION END TO END

Data Acquisition

Condition Monitoring



### HW Component

STEVAL-STWINKT1B  
STEVAL-STWINWFV1  
P-L496G-CELL02

### SW Component

DSH-PREDMNT  
FP-IND-PREDMNT1  
STSW-STWINCELL

### SL-PREDMNT-S2C

A Condition monitoring sensor to cloud for vibration analysis with  
WIFI and Cellular Connection



### HW Component

STM32MP157C-DK2  
STEVAL-IDP004V2  
STEVAL-BFA001V2

### SW Component

DSH-PREDMNT  
X-LINUX-PREDMNT  
STSW-BFA001V2 /  
STSW-IPD4PREDMNT

### SL-PREDMNT-E2C

A Condition monitoring sensor to cloud for vibration analysis with  
WIFI and Cellular Connection

## SOLUTIONS FOR ANOMALY DETECTION

### Data Acquisition

### Condition Monitoring

### Anomaly detection @ the Edge



#### HW Component

STEVAL-STWINKT1B  
STM32L562E-DK

#### SW Component

FP-AI-NANOEDG1

#### Anomaly Detection with Cartesiam NanoEdge Studio

Anomaly Detection with Cartesiam Nanoedge libraries  
implemented at MCU level

## PARTNERS

Predictive Maintenance is a key challenge for the industry and the necessary skills to implement these techniques may not be easy to find or acquire. We have therefore brought together an ecosystem of trusted [Authorized Partners](#) to support our customers in the tailored design and implementation of their solution. To find out more, visit our [Partner page](#).



Order code: BPRPREDMAINT0121

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