Condition monitoring and predictive maintenance

Introduction

Industrial motor monitoring example

Component details including IIS3DWB

Development tools including STWIN

life.augmented

Predictive maintenance

Predictive Maintenance (PdM) enables **cost savings** over time-based preventive maintenance.

The maintenance tasks are performed while machine is running using:
- condition based monitoring with sensors
- local processing
- cloud analytics

ST provides solutions that will help you create Predictive Maintenance applications.

For more information, visit our pages on Condition Monitoring and Predictive Maintenance

- Rotating equipment and related parts (i.e. motors, fans, pumps, bearings, spindles)
- Elevators, escalators, ...
- Electric equipment (i.e. circuit breakers)
- Chemical industry
- Structural monitoring (i.e. bridges, railways)
- Automotive (i.e. electrical motors and parts - bearings, battery management)
- Consumer Industrial (i.e. HVAC)

Focus on

Vibration monitoring
Temperature and Environmental
Ultrasound detection

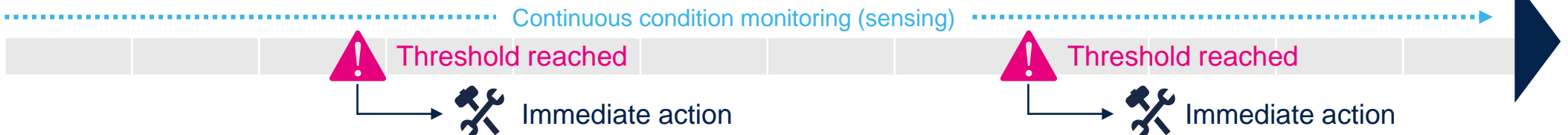# Preventive, condition monitoring and predictive what's different
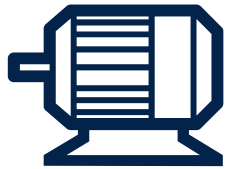
Preventive Maintenance
(scheduled)

Q1   Q2   Q3   Q4

Condition Based Maintenance (CBM)
(performed at the exact moment when measured parameters reach unacceptable levels)

Continuous condition monitoring (sensing)

Threshold reached   Threshold reached

Immediate action   Immediate action

Predictive Maintenance (PdM)
(scheduled in the future based on analysis of sensor measurements and formulas)

Continuous condition monitoring (sensing)
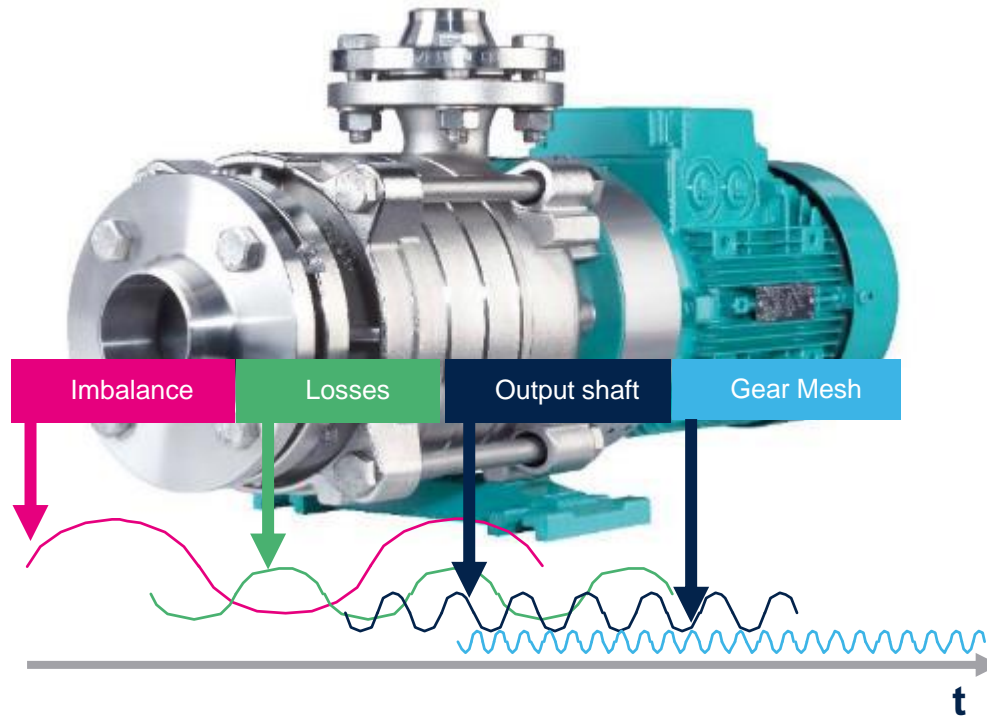
Continuous data collection and analysis

Action scheduled ahead of time

Any parameter deviation is an indicator of potential failure

Mechanical vibration

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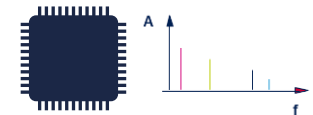- Acceleration
- Acoustic noise
- Angular speed
- Torque

Imbalance | Losses | Output shaft | Gear Mesh

t

Functions to enable monitoring

Vibration Capture

Connectivity
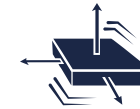
Wireless Connectivity

Processing

Secure Connections

life.augmented

Processing at the edge
from FFT to machine learning

While FFT thresholds are widely used,
Machine Learning and AI can enable new scenarios

- **Embedded FFT** analysis at the sensor can **isolate vibration**
- **Thresholds** are based on human based features extraction
- **Alarm** can be set according to specific threshold to detect potential defects.

- **Machine and Deep Learning can be used to automatically extract features** with several benefits
- Machine and Deep Learning techniques and acquisition strategies can be differentiated according to the use case
- Both can now run in a MCU

life.augmented
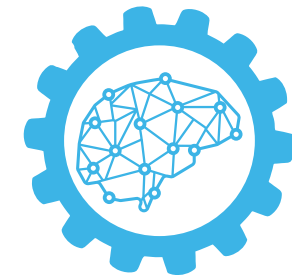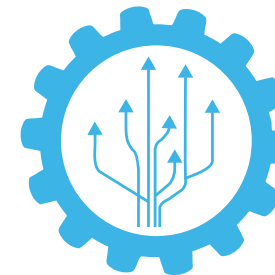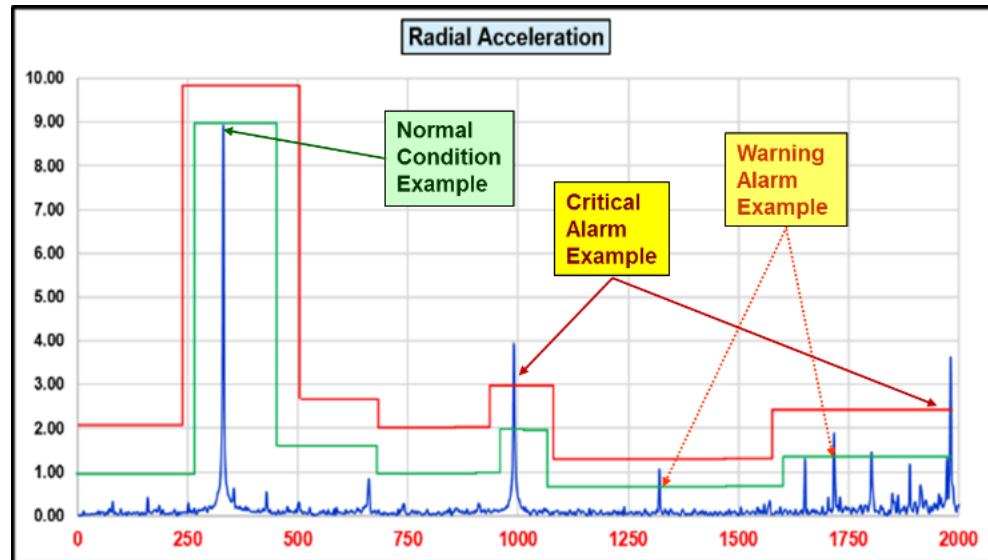
Industrial sensors for vibration analysis sensors and defects over bandwidth
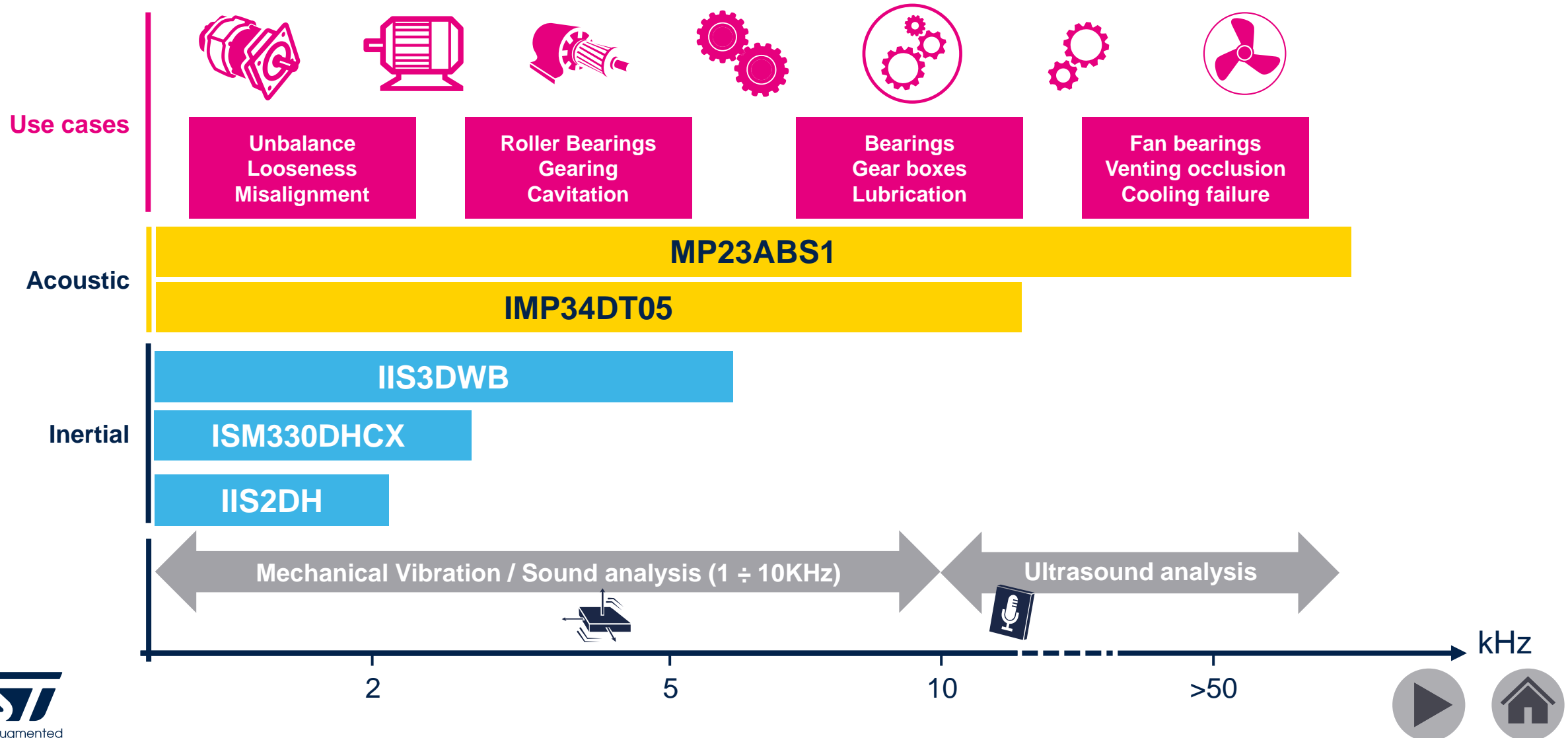
IIS3DWB 3-axis digital vibration sensor ultra-wide bandwidth and low-noise

KPI for vibration monitoring

- Wide & flat measurement bandwidth
- Flat freq. response, sharp out of band roll-off, no aliasing
- Freq. response and low noise levels
- Stable thermal behavior over extended temperature range
- Power consumption suitable for wireless sensor node
- Operating temperature range
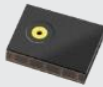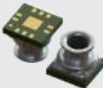
Pin2pin compatible with ISM330x/LSM6DSx devices

Parameter	Value
N. of axis	**3-axis**
Full Scale [g]	±2/±4/±8/±16
Output i/f	Digital: SPI, I2C (single axis or debug mode)
Bandwidth (-3dB) [kHz]	**6.3**
ODR [kHz]	26.7
Noise Density [µg/√Hz]	**90 (65 in single axis)**
Current Consumption [mA]	1.1
Features	FIFO (3kbyte) Programmable HP Filter Interrupts Temp. Sensor Embedded Self Test
Operating Temp [°C]	**-40 to +105**
Operating Voltage [V]	2.1 ÷ 3.6
Package [mm3]	LGA 2.5x3x0.83 14Lead

life.augmented

Industrial sensors for CBM and PdM

Function	IC	Description	Package	Features	
Vibration	IIS3DWB	**Ultra-wide bandwidth (up to 6kHz), low-noise 3-axis digital vibration sensor**	LGA-14, 2.5x3 mm	• 3D Accelerometer – 16g Full Scale • Ultra low noise + up to 105°C operating T°	• Digital Output • Ultra Wide Bandwidth (up to 6.3kHz)
	ISM330DLC ISM330DHCX	**Wide bandwidth accelerometer + gyroscope**		• 3D Accelerometer + 3D Gyro - Digital Output • 3 kHz bandwidth accelerometer	• Ultra Low Power + Smart Features
	IIS2DH	**Wide bandwidth, ultra-low-power accelerometer**	LGA-12, 2x2 mm	• 3D Accelerometer – Digital Output • Up to 2.3 kHz bandwidth	• Ultra Low Power – Ultra Compact
	IIS2MDC	**Low-noise, low power magnetometer**		• 3D Magnetometer – Digital Output • AMR Technology - Up to 50 Gauss Full Scale	• Ultra Low Noise, Low Power
Acoustic	MP23ABS1TR	**Analog differential microphone**	RHLGA metal cap 5-L, 3.5x2.65x0.98 mm	• Bottom port Microphone • Wide Acoustic Bandwidth (up to 80 kHz)	• Wide Dynamic Range (AOP up to 130 dBSPL)
	IMP34DT05-A	**Digital top port microphone**	3x4x1 mm	• Top port Microphone with Digital Output • Wide dynamic range (AOP up to 122 dBSPL)	• ESD up to ±15kVolt
Environmental	LPS22HH	**High accuracy – Compact size absolute pressure sensor**	HLGA-10-L, 2x2x0.76 mm Ultra Compact full molded	• 260 to 1260 hPa Range - Digital Output • High Accuracy (±1 hPa)	• Low noise (0.75 Pa RMS)
	LPS27HHW LPS33HW	**Water-resistant absolute pressure sensor**	2.7x2.7x1.7 mm 3.3x3.3x2.9 mm	• 260 to 1260 hPa Range - Digital Output • High Accuracy (±2.5 hPa)	• Low noise (0.8 Pa RMS) • Water resistant up to 10 atm
	STTS22H	**Digital temperature sensor**	2 x 2 x 0.50 mm 6-lead UDFN	• Operating temperature -40 °C to +125 °C • Accuracy: ±0.5 °C max (-10 °C to +60 °C)	• Programmable threshold, One-shot mode
	STLM20	**Analog temperature sensor**	SOT323-5L, UDFN-4L	• Accuracy ±0.5 °C (typ.)	• Operating Temp –55 °C to +130 °C

life.augmented

Wireless connectivity changes the game
STEVAL-STWINKT1 is the answer

SensorTile Wireless Industrial node

STEVAL-STWINKT1 kit includes:
- Hardware Board
- Battery + plastic case for field testing
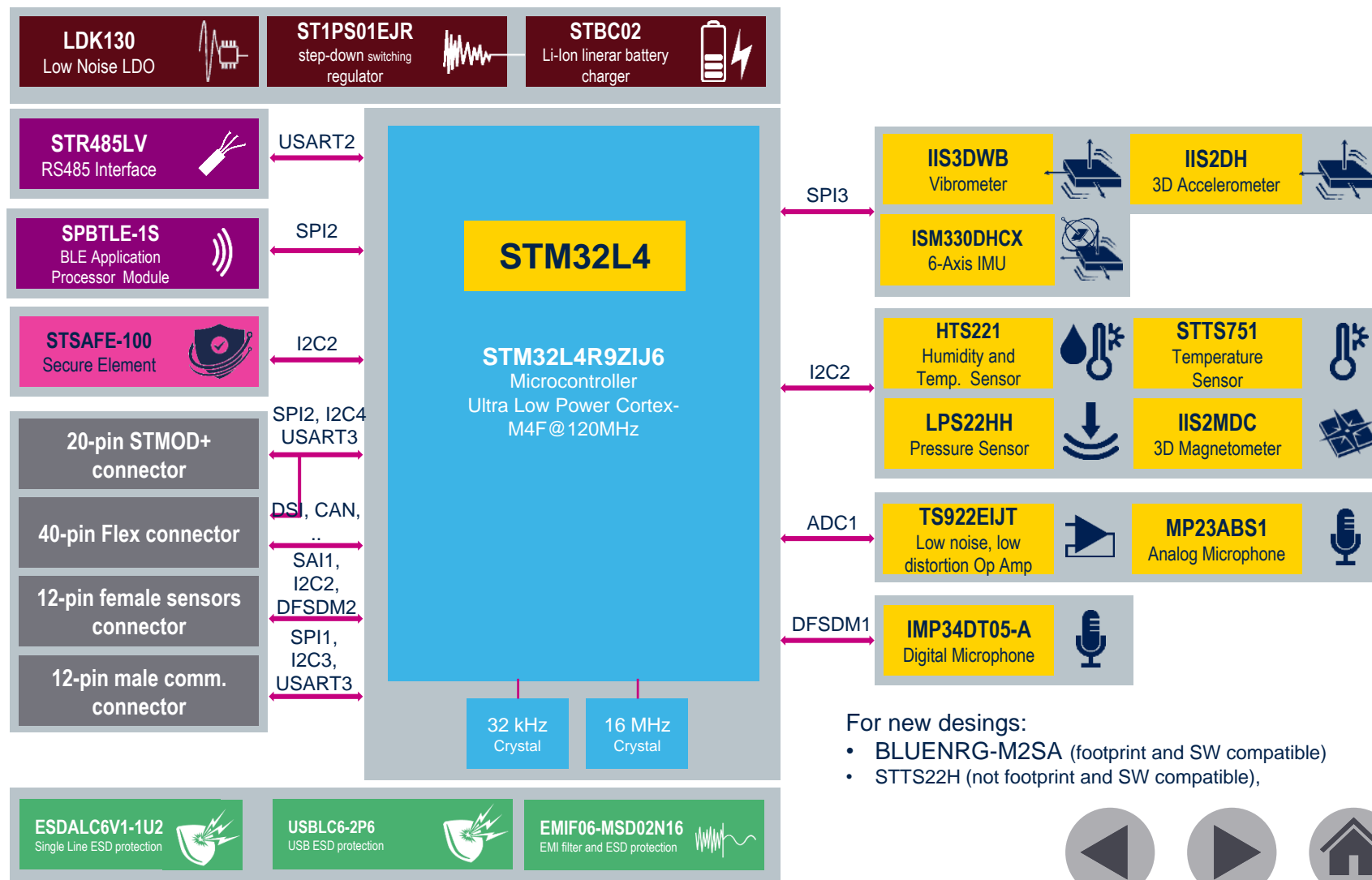- STLink-V3MINI + cable for programming

STEVAL-STWINKT1
block diagram, ICs and features in one slide

- Power supply: Li-Po battery or ext. 5 V
- Best-in-class industrial-grade sensors (i.e. ultrasound detection, to vibration analysis)
- Smart power to increase battery life
- Multiple algorithms running on the STM32L4+
- Secure connection and authentication with **STSAFE-100** (footprint)
- BLE connectivity
- Connectivity and sensor expansions support
- USB and SD-card holder

LDK130 Low Noise LDO

ST1PS01EJR step-down switching regulator

STBC02 Li-Ion linerar battery charger

STR485LV RS485 Interface — USART2

SPBTLE-1S BLE Application Processor Module — SPI2

STSAFE-100 Secure Element — I2C2

STM32L4

STM32L4R9ZIJ6
Microcontroller
Ultra Low Power Cortex-M4F@120MHz

SPI2, I2C4 USART3

20-pin STMOD+ connector

DSI, CAN, ..

40-pin Flex connector

SAI1, I2C2, DFSDM2

12-pin female sensors connector

SPI1, I2C3, USART3

12-pin male comm. connector

32 kHz Crystal

16 MHz Crystal

SPI3 — **IIS3DWB** Vibrometer — **IIS2DH** 3D Accelerometer — **ISM330DHCX** 6-Axis IMU

I2C2 — **HTS221** Humidity and Temp. Sensor — **STTS751** Temperature Sensor — **LPS22HH** Pressure Sensor — **IIS2MDC** 3D Magnetometer

ADC1 — **TS922EIJT** Low noise, low distortion Op Amp — **MP23ABS1** Analog Microphone

DFSDM1 — **IMP34DT05-A** Digital Microphone

For new desings:
- BLUENRG-M2SA (footprint and SW compatible)
- STTS22H (not footprint and SW compatible),

ESDALC6V1-1U2 Single Line ESD protection

USBLC6-2P6 USB ESD protection

EMIF06-MSD02N16 EMI filter and ESD protection

STEVAL-STWINKT1 software platform for industrial IoT solution development
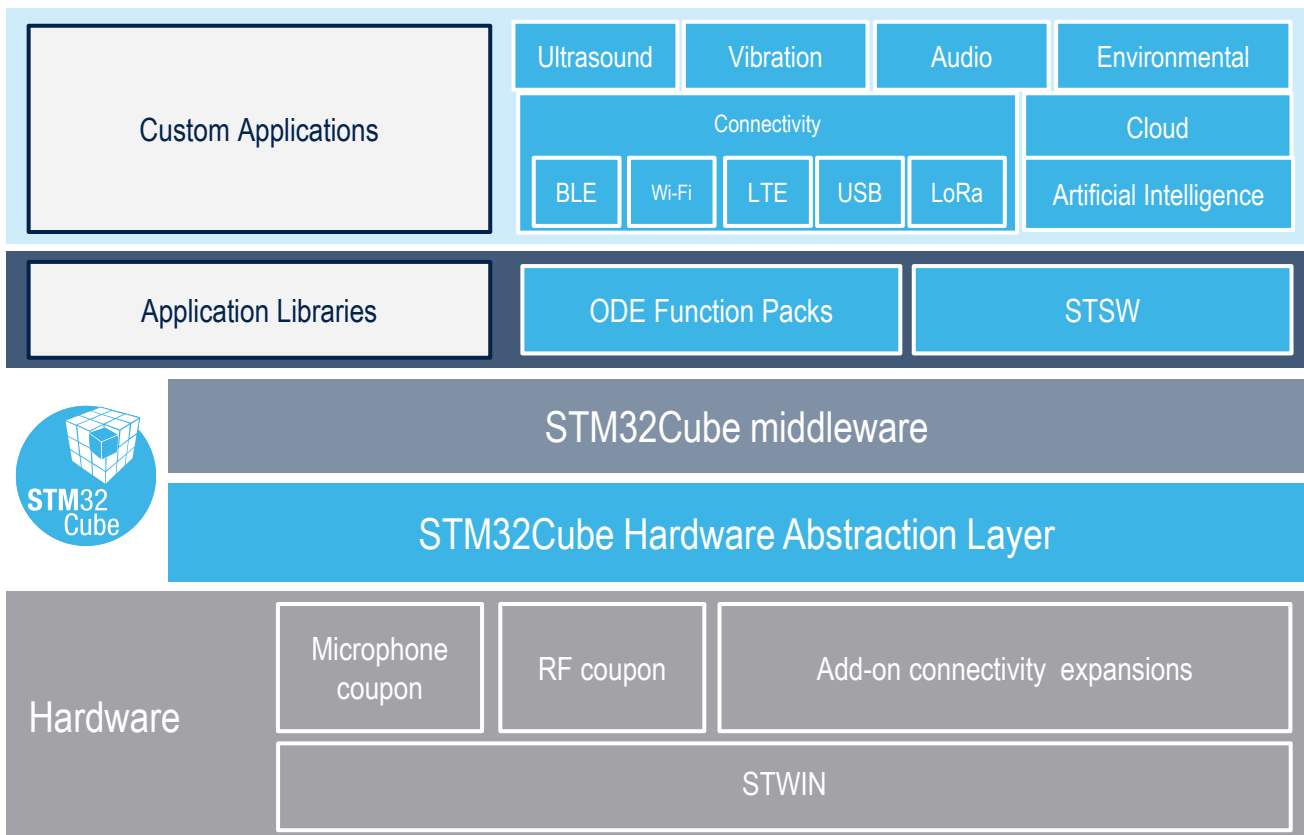
STM32 **O**pen **D**evelopment **E**nvironment

- **STSW-STWINKT01:**
  - set of source code example implementations of functionalities of the STWIN platform
- **Predictive Maintenance + AWS Dashboard:**
  - FP-IND-PREDMNT1
  - STSW-STWINCELL
- **Cloud Function Pack for IoT telemetry and device control**
  - FP-CLD-AZURE1: Microsoft Azure Cloud

Condition-based & predictive maintenance edge processing enabling end-to-end

powered by aws

Ultrasound, vibration, environmental monitoring and anomaly detection

Smart Sensor Nodes

STM32 MCU

STEVAL-IDP004V1

Serial Connectivity

STEVAL-BFA001V1B

STEVAL-STWINKT1

Wi-Fi Connectivity

Edge Processing

STM32 MPU

STM32MP157C-DK2 rev. C01

AWS Lambda   AWS IoT Greengrass

Cloud Dashboard

Events

AWS IoT Core   AWS Shield

AWS Lambda   AWS WAF

Amazon DynamoDB   Amazon Cognito

Amazon Simple Storage Service (S3)   Amazon API Gateway

life.augmented