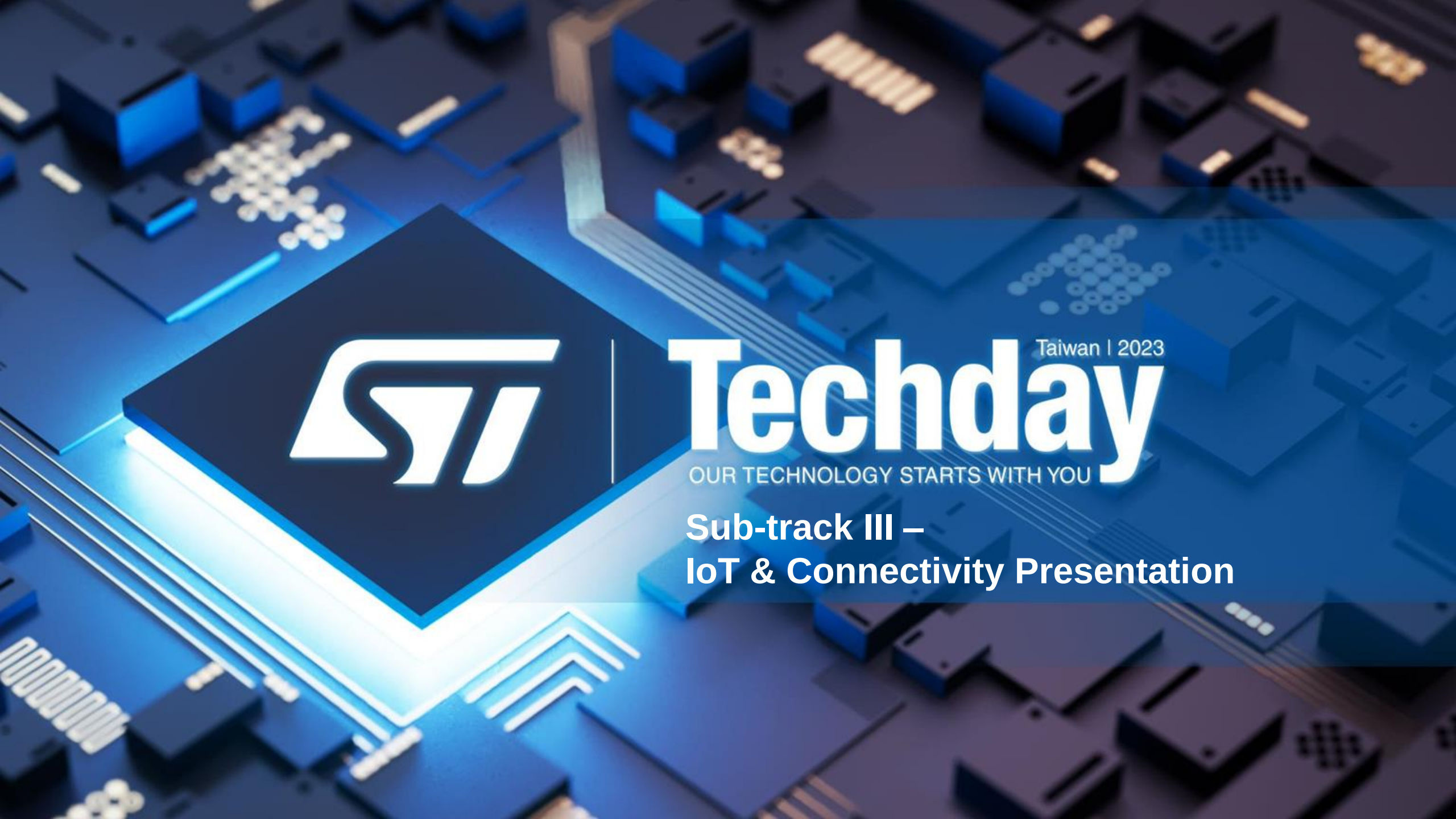
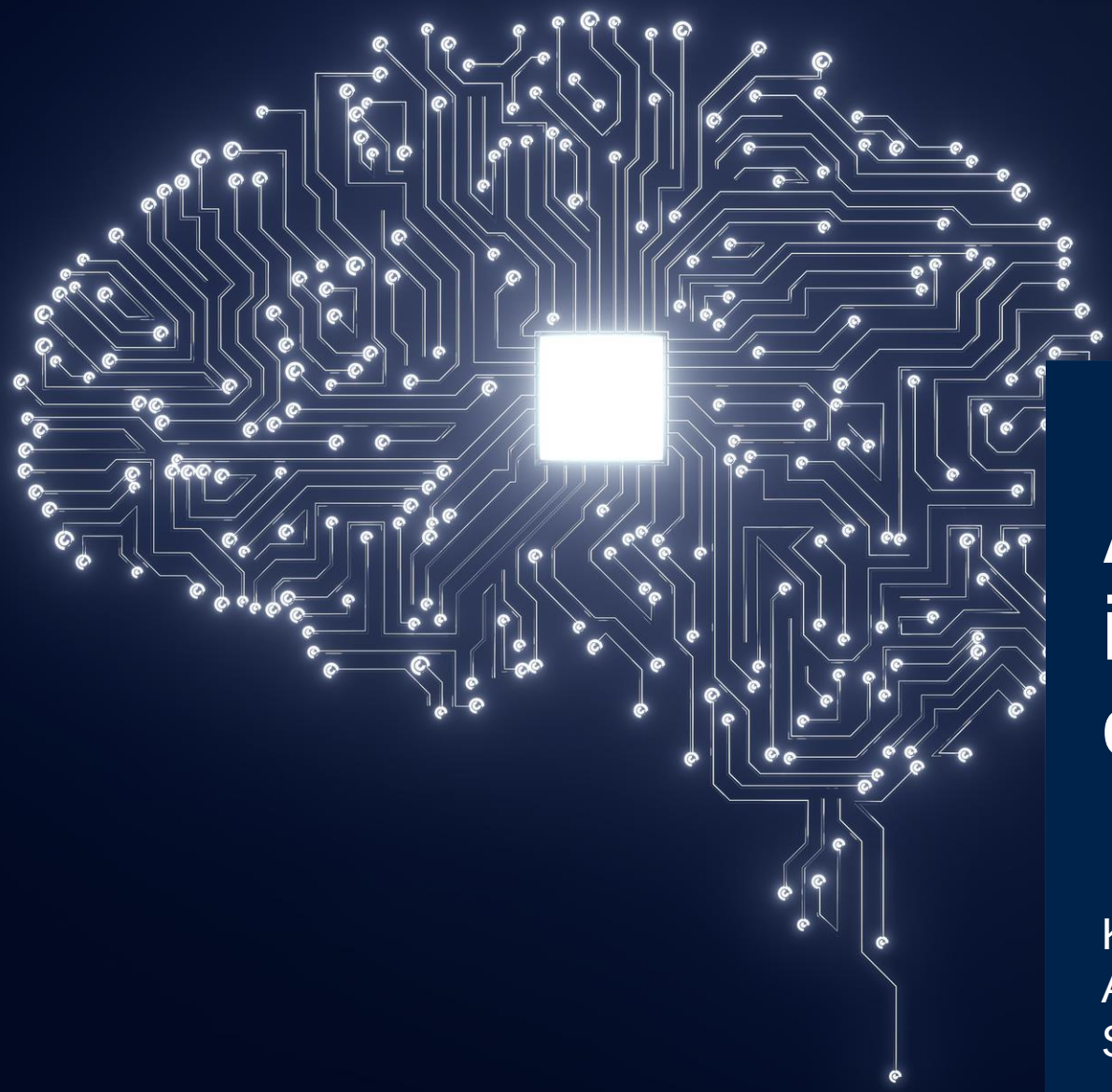


Sub-track III –
IoT & Connectivity Presentation



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Advanced MEMS sensors in the sustainable onlife era

Kay LIN
APeC, AMS, MEMS Sub-Group
STMicroelectronics

Smart sensors making our world a better place

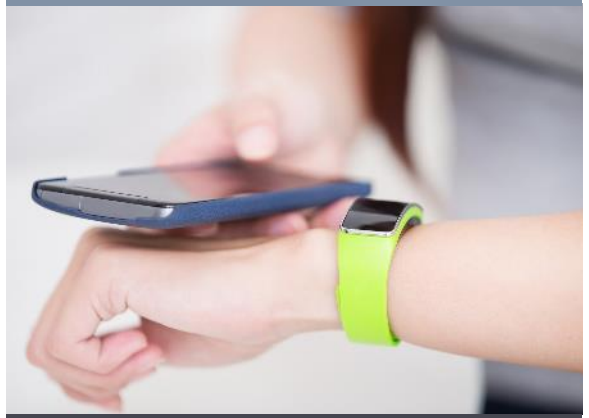
Offline Era

2000

A paradigm change in the man-machine interface

MEMS technology: from a concept to a product.

Online Era



2010

Sensor proliferation and connections to the Cloud

Performance improvement and technology fusion.

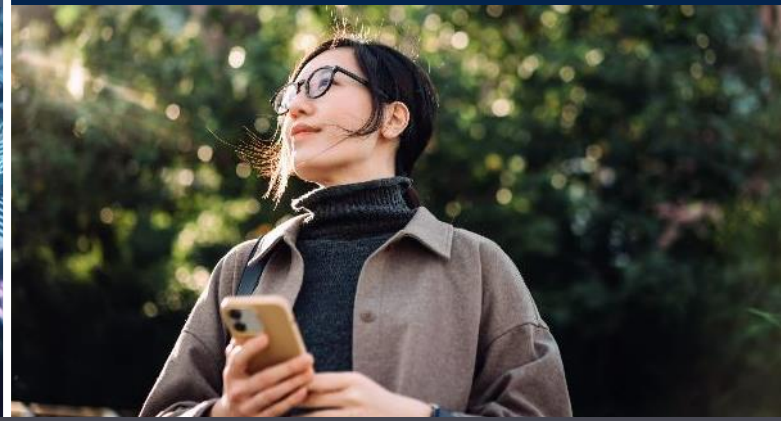
Onlife Era

2020

The fusion of technology and life

MEMS sensors able to sense, process, and act.

Sustainable Onlife



Sustainable sensorization of the world

MEMS sensors sending only the **meaningful data** to the cloud

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Sensors at the heart of our interactions with the digital world

Human centered

Sensors are the key components to **bridge** the **physical** and the **digital worlds**

Sustainable

Sensors becoming **smart** answer **human expectations** while ensuring a **sustainable future**

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Sensor Fusion

Orientation

Track and monitor orientation in 3D space

Static accuracy(1): 0.5, 1.5, 1.5 deg
Low dynamic accuracy(1): 0.7, 0.5, 0.5 deg
Calibration time(2):0.8 s
Orientation stabilization time: 0.7 s
Extra power: 30 µA @ 120 MHz

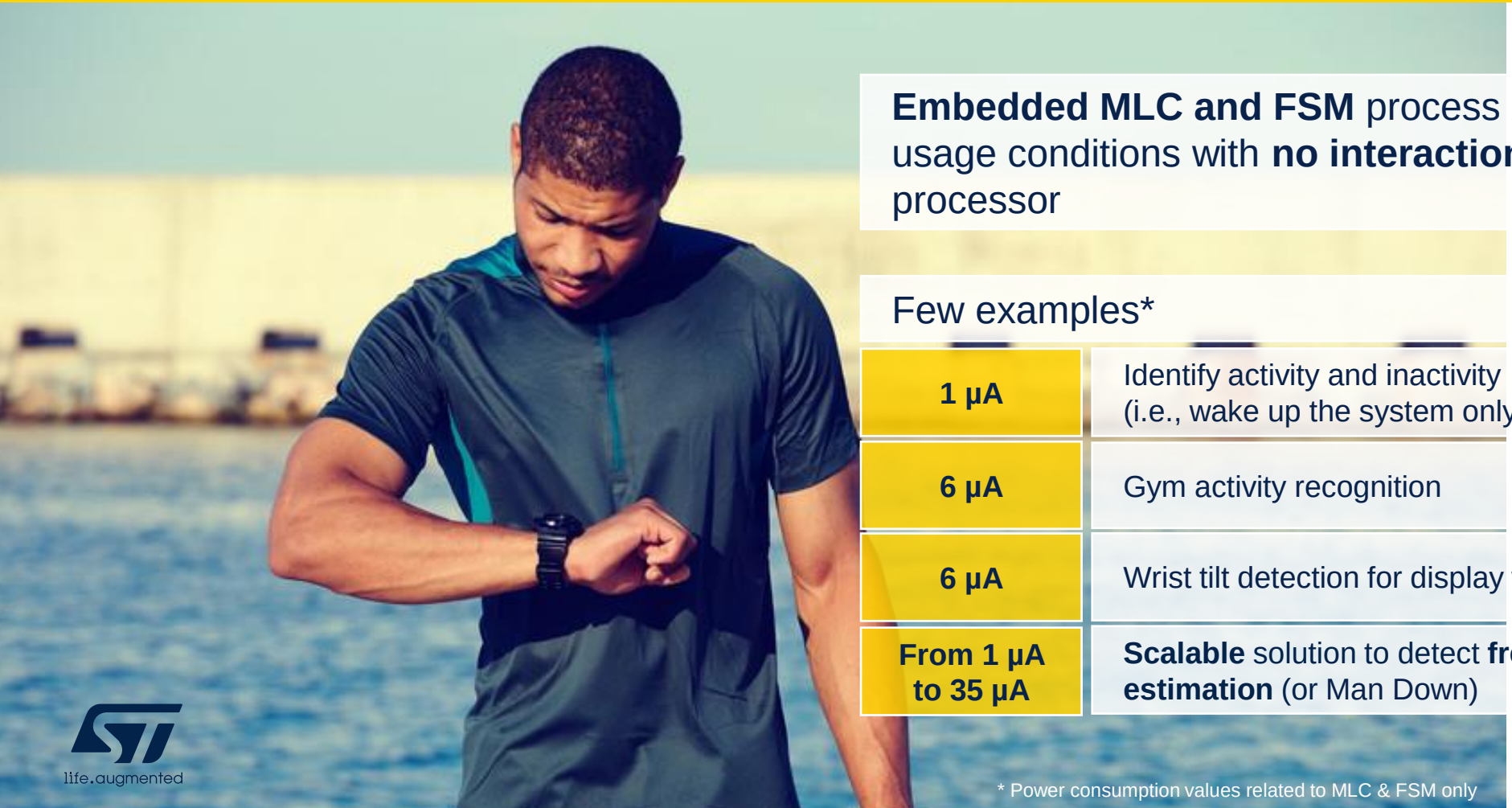
Detect and track device orientation with the **embedded low power sensor fusion** algorithm with **30 µA**

Plug and play solution that provided **6x game rotation vector** (accelerometer + gyroscope) & **Gyro-bias calibration**

Ultra-low power operation
50% power reduction vs. external MCU(3) processing

Context awareness detection

Adding intelligence in the edge with MLC and FSM



Embedded MLC and FSM process XL & Gyro data to detect usage conditions with **no interaction required** with external processor

Few examples*

1 µA	Identify activity and inactivity (i.e., wake up the system only when needed)
6 µA	Gym activity recognition
6 µA	Wrist tilt detection for display wake up
From 1 µA to 35 µA	**Scalable** solution to detect **free fall, shock** and fall **height estimation** (or Man Down)

* Power consumption values related to MLC & FSM only

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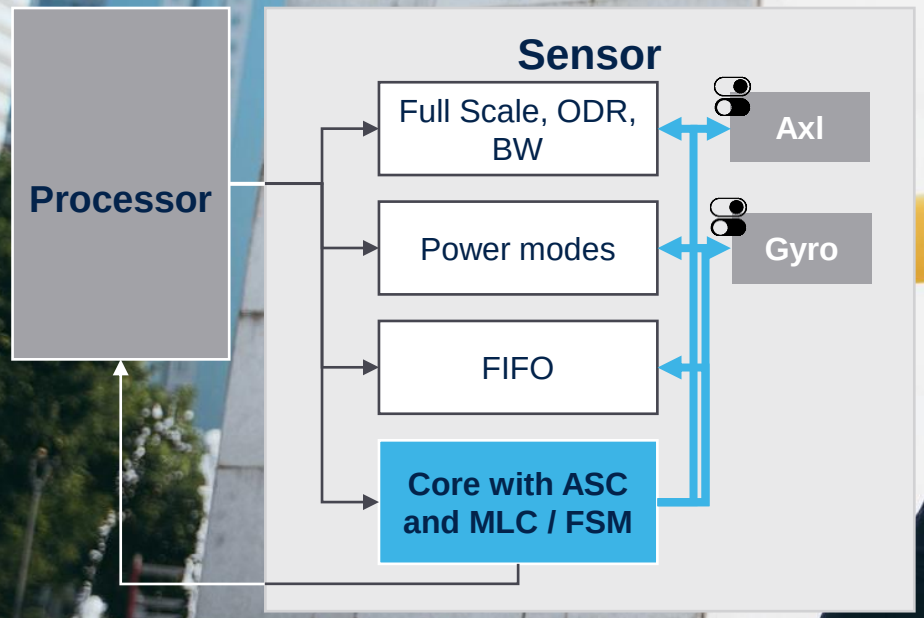
Adaptive self configuration (ASC)

From “Always-On” to “Smart, Always-Aware”



The device automatically **reconfigures itself**, based on the actual context, maximizing the **system efficiency**.

MLC and FSM detect the context without the need of additional data processing

ASC allows to independently configure Gyro and XL channels.
No tradeoff required!

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User interfaces

Qvar electrodes to improve UI: Touch and Swipe

- Sensor fusion between Qvar and 6x IMU improves the user experience accuracy reducing false positives
- Support for single/long and multiple touch and swipe

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Free fall height estimation

Beware: LSM6DSV16X can track your shock!

Scalable solution to detect **shock**, **free fall**, and estimate **height of the free fall**

Embedded processing and **FSM** detect the context without the need of additional data processing at system level

From free fall **height exceedance** detection, to the **accurate height** estimation, from **1 µA** to **35 µA**, always the right algorithm

* Power consumption values are related to the embedded processing

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ISPU

Moving the intelligence at the edge

Sensor + MCU

Microcontroller

MCU standalone or hosted in the sensor package

Standard
MCU runs the algorithms

Runs any kind of SW
provided it matches the MCU specs

MLC

reconfigurable Processing Unit (rPU)

rPU integrated in the sensor ASIC

Optimized
reconfigured through register setting

Constrained
runs same model/mapping (MLC, FSM)

ISPU

Intelligent Sensor Processing Unit

ISPU integrated in the sensor ASIC

Programmable
ANSI-C plus AI dedicated instruction set

Runs several AI algorithms
full precision to 1-bit NN

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ISPU

ISPU
intelligent sensor processing unit

Highly specialized DSP* for machine learning and processing

Super tiny silicon

Unique solution for **TinyML** with **machine learning** (ML), **binary neural network** (BNN), and **processing** capabilities

Lowest power consumption IoT node in the market with AI in the edge

Productivity: empowers 10M+ C language developers
Complement STM32 MCU portfolio for AI

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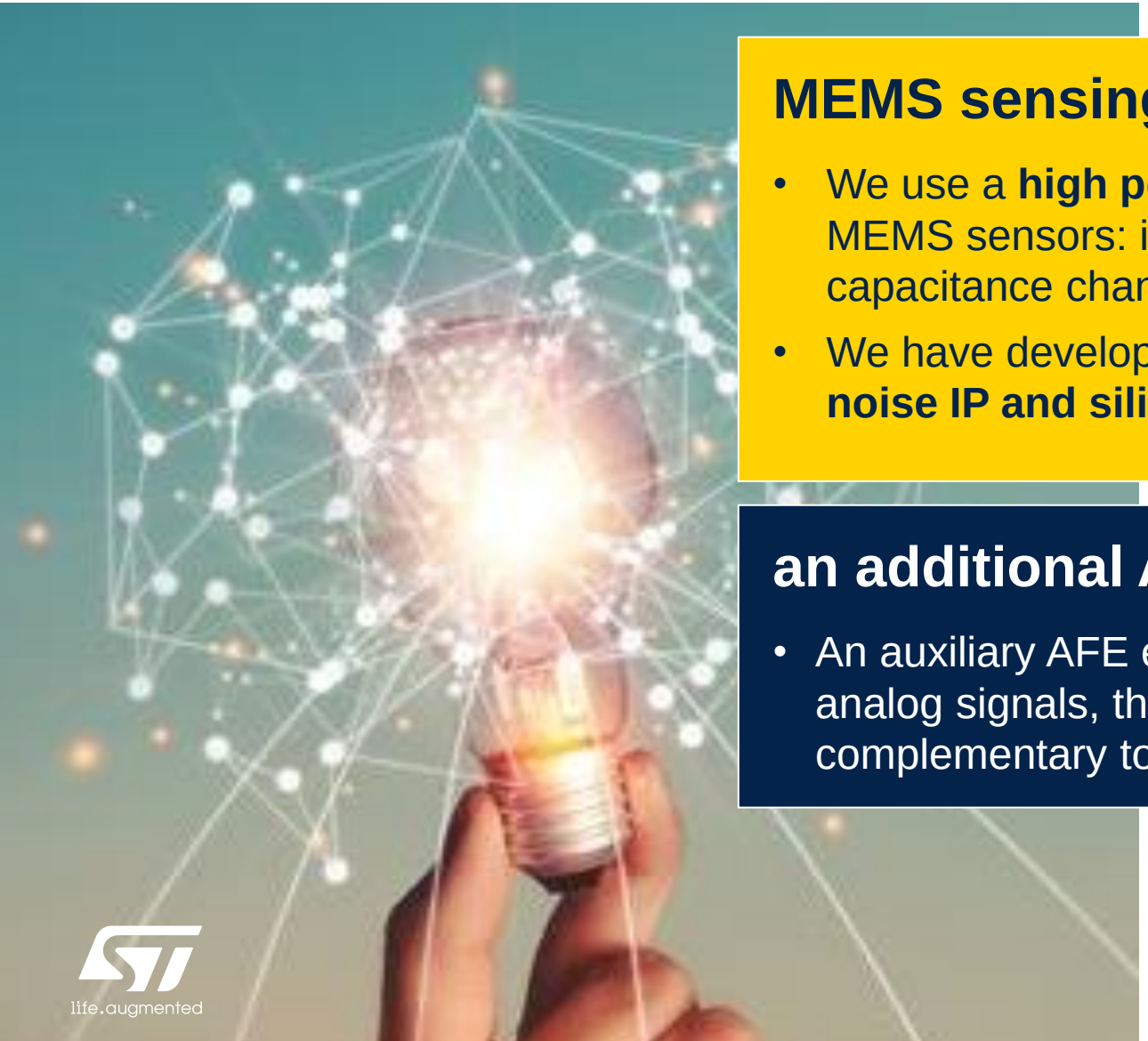
*DSP: Digital Signal Processing

vAFE

vAFE, because the world is analog



MEMS sensing

- We use a **high performance AFE** in MEMS sensors: it reads and converts capacitance change ~ 0.1aF*
- We have developed **specific low noise IP and silicon technologies**

an additional AFE: vAFE

- An auxiliary AFE enables reading of analog signals, that are complementary to motion signal

vertical **AFE**

vAFE and Motion signals are intrinsically **synchronous**.

The result is a unique **context aware analysis** done in-the-edge, thus low power and with the minimum possible latency.

And we do it in standard package dimensions.

* 1aF = 10^{-18}F

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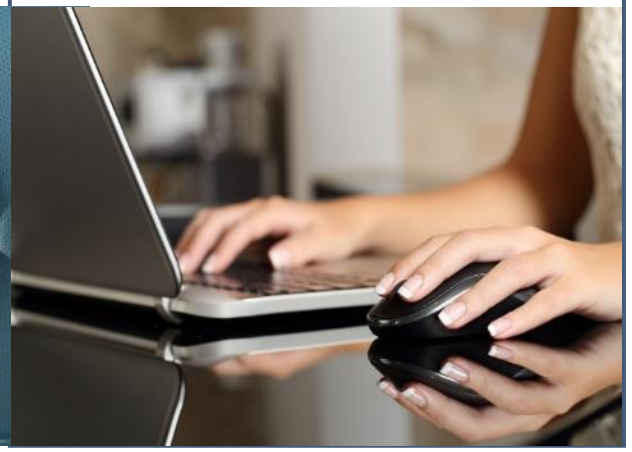
vAFE

vAFE: opening new application frontiers

Smartphone & Camera	TWS	Wearable	IoT
Presence detection Activity tracking	In-Ear detection Touch-Multiple Touches Long press	Presence detection Enhanced activity tracking Biometric data	Presence detection Energy Saving



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Smart Ring: the 2023 trend runs ST sensors

Battery constrained solutions require **low power, in-the-edge processing**

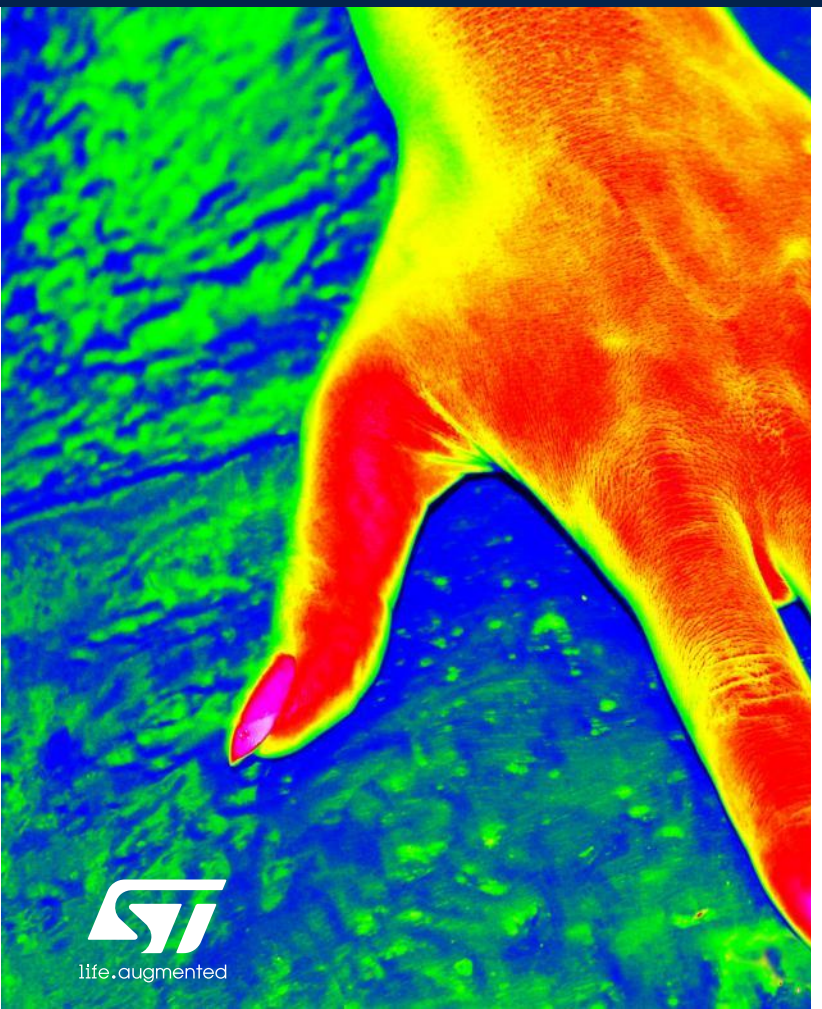
LIS2DUX features single-digit µA power consumption with embedded AI (MLC, FSM, ASC)

LIS2DUXS also features a vAFE
LSM6DSV16X includes a gyro for more functionalities

TMOS

IR sensor STHS34PF80, ready to go

STHS34PF80 IR Sensor based TMOS technology starts finally in Mass Production, we are ready to go market.



ST IR sensing element
Sensor measures in the wavelength range from 5 to 20 um

Human body
radiation is ~9.8 um, at in the center of the sensor’s range

Biometric
Presence detection and temperature measurement

MEMS sensors roadmap

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New generation MEMS sensors

	Features	Products	Applications
iNEMO® Inertial Module	Embedded **ISPU** **N** version for **NEAI**	**LSM6DSO16IS** **ISM330IS/N**	
	MLC, **FSM**, **ASC**, **SFLP**, **Qvar**, **Audio AXL, BC**	**LSM6DSV16X** **LSM6DSV32X** **LSM6DSV16BX**	
Accelerometers	ULP, 12b resolution, AAF, 128 samples FIFO ;(i.e. 0.47µA @6Hz ODR) **FSM, MLC**, Pedometer, Qvar™	**LIS2DU12** **LIS2DUX12** **LIS2DUXS12**	
Pressure Sensors	Water resistant & WP, better accuracy, lower power consumption, Dual FS Qvar™	**LPS22DF** **LPS28DFW** **ILPS22QS** **ILPS28QSW**	
IR Sensor	**Presence** Detection up to 4 meter 80° Field Of View TMOS sensor	**STHS34PF80**	

FS: Full Scale
FSM: Finite State Machine
ASC: Adaptive Self Configuration
AAF: Anti-Aliasing Filter
ISPU: Intelligent Sensor Proc Unit
WP: WaterProof

ULP: Ultra Low Power Mode
MLC: Machine Learning Core
SFLP: Sensor Fusion Low Power
Qvar: Electrostatic Charge Variation
NEAI: Nano Edge AI
TDM: Time Density Modulation

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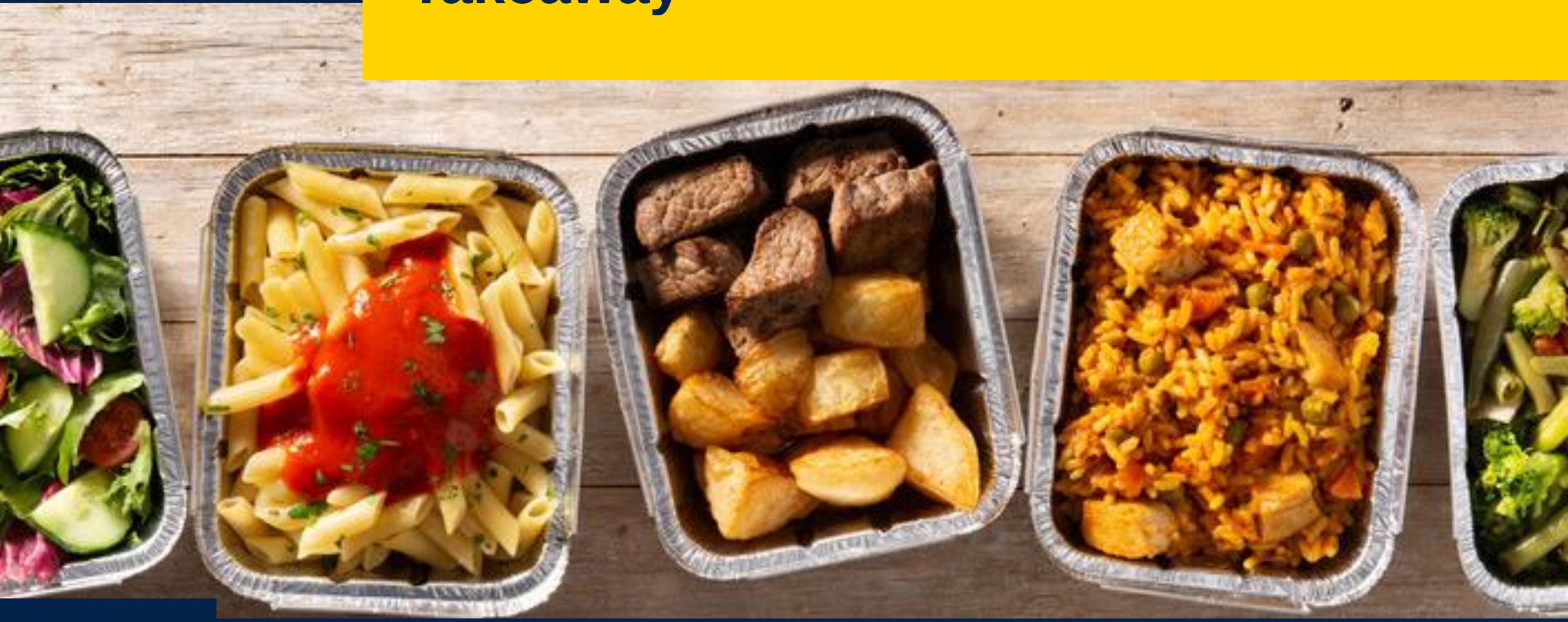
Takeaway



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Takeaways

1	LSM6DSV16X, LSM6DSV16BX, LIS2DUXS12 and ILPS28QSW are innovative sensing solutions with unique IP
2	Qvar is a new sensing capability that opens the door to many new functions such as in ear detection, user interface, water leakage detection without the need of additional sensors
3	Machine learning core, finite state machine, embedded sensor fusion low power move the processing at the edge, in the sensor, allowing great system optimization and performance improvement

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Our technology starts with You

Find out more at www.st.com/MEMS

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