tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

"The Future of Personalized Connected Healthcare"

Andrew Baker - Maxim Integrated

January 5, 2021

www.tinyML.org

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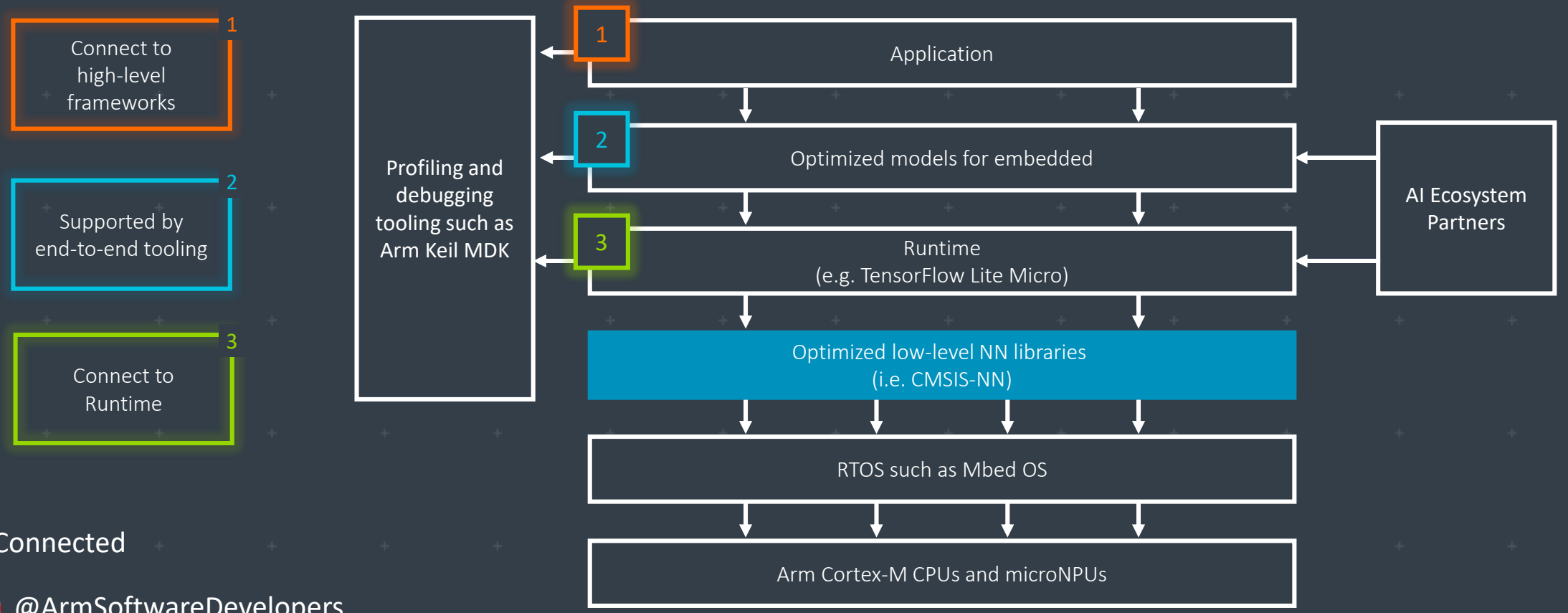
tinyML Strategic Partner

Additional Sponsorships available – contact Bette@tinyML.org for info

Arm: The Software and Hardware Foundation for tinyML



Stay Connected

@ArmSoftwareDevelopers

@ArmSoftwareDev

Resources: developer.arm.com/solutions/machine-learning-on-arm

arm

Deeplite

WE USE AI TO MAKE OTHER AI FASTER, SMALLER AND MORE POWER EFFICIENT

Automatically compress SOTA models like MobileNet to <200KB with **little to no drop in accuracy** for inference on resource-limited MCUs

Reduce model optimization trial & error from weeks to days using Deeplite's **design space exploration**

Deploy more models to your device without sacrificing performance or battery life with our **easy-to-use software**

BECOME BETA USER **bit.ly/testdeeplite**

mobilityXlab arm AI 100 CBINSIGHTS

TinyML for all developers

C++ library

Arduino library

WebAssembly

Dataset

Acquire valuable training data securely

Enrich data and train ML algorithms

Edge Device

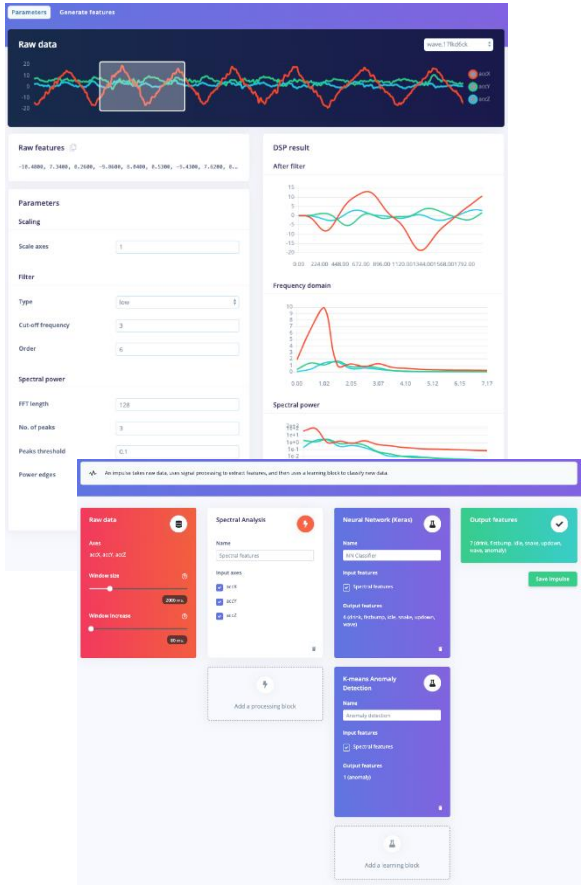
Real sensors in real time
Open source SDK

Impulse

Embedded and edge compute deployment options

Test impulse with real-time device data flows

Test



Get your free account at http://edgeimpulse.com

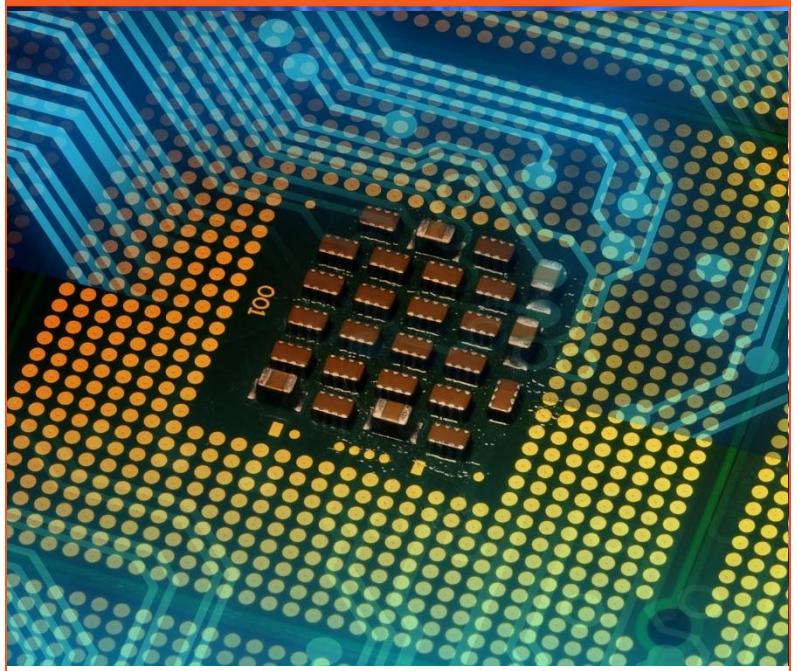
Maxim Integrated: Enabling Edge Intelligence

www.maximintegrated.com/ai

Sensors and Signal Conditioning

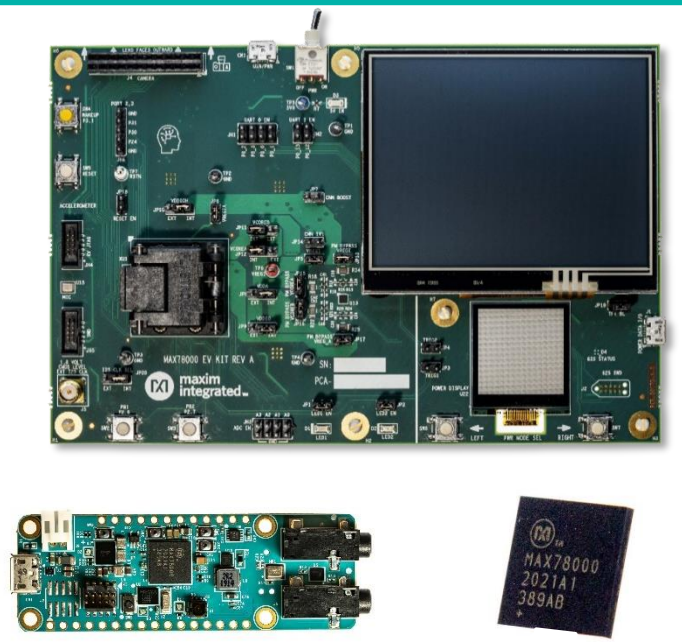
Health sensors measure PPG and ECG signals critical to understanding vital signs. Signal chain products enable measuring even the most sensitive signals.

Low Power Cortex M4 Micros



The biggest (3MB flash and 1MB SRAM) and the smallest (256KB flash and 96KB SRAM) Cortex M4 microcontrollers enable algorithms and neural networks to run at wearable power levels

Advanced AI Acceleration



The new MAX78000 implements AI inferences at over 100x lower energy than other embedded options. Now the edge can see and hear like never before.

Qeexo AutoML for Embedded AI

Automated Machine Learning Platform that builds tinyML solutions for the Edge using sensor data

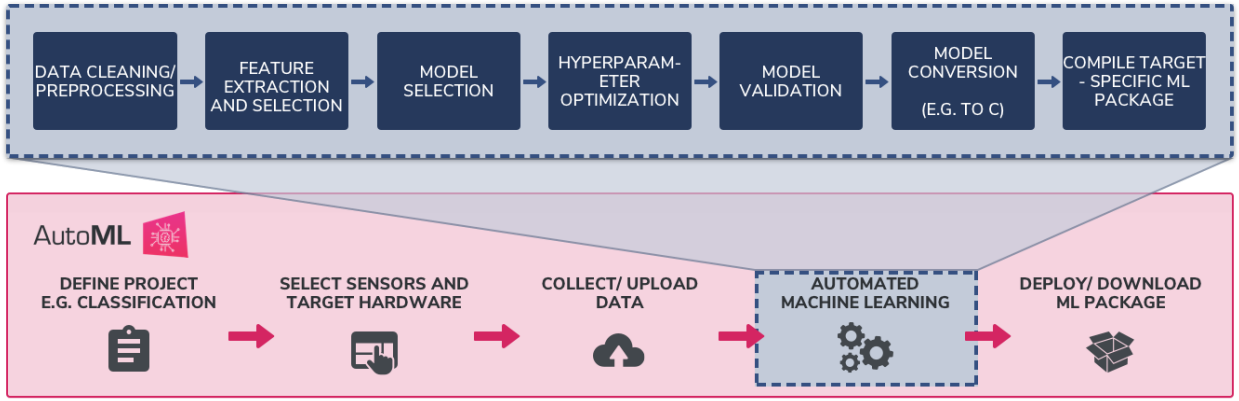
Key Features

- Wide range of ML methods: GBM, XGBoost, Random Forest, Logistic Regression, Decision Tree, SVM, CNN, RNN, CRNN, ANN, Local Outlier Factor, and Isolation Forest
- Easy-to-use interface for labeling, recording, validating, and visualizing time-series sensor data
- On-device inference optimized for low latency, low power consumption, and a small memory footprint
- Supports Arm® Cortex™- M0 to M4 class MCUs
- Automates complex and labor-intensive processes of a typical ML workflow – no coding or ML expertise required!

Target Markets/Applications

- Industrial Predictive Maintenance
- Smart Home
- Wearables
- Automotive
- Mobile
- IoT

QEEXO AUTOML: END-TO-END MACHINE LEARNING PLATFORM



For a limited time, sign up to use Qeexo AutoML at automl.qeexo.com for FREE to bring intelligence to your devices!

Reality AI®

is for building products

https://reality.ai info@reality.ai @SensorAI Reality AI

Reality AI Tools® software

- Automated Feature Exploration and Model Generation
- Bill-of-Materials Optimization
- Automated Data Assessment
- Edge AI / TinyML code for the smallest MCUs

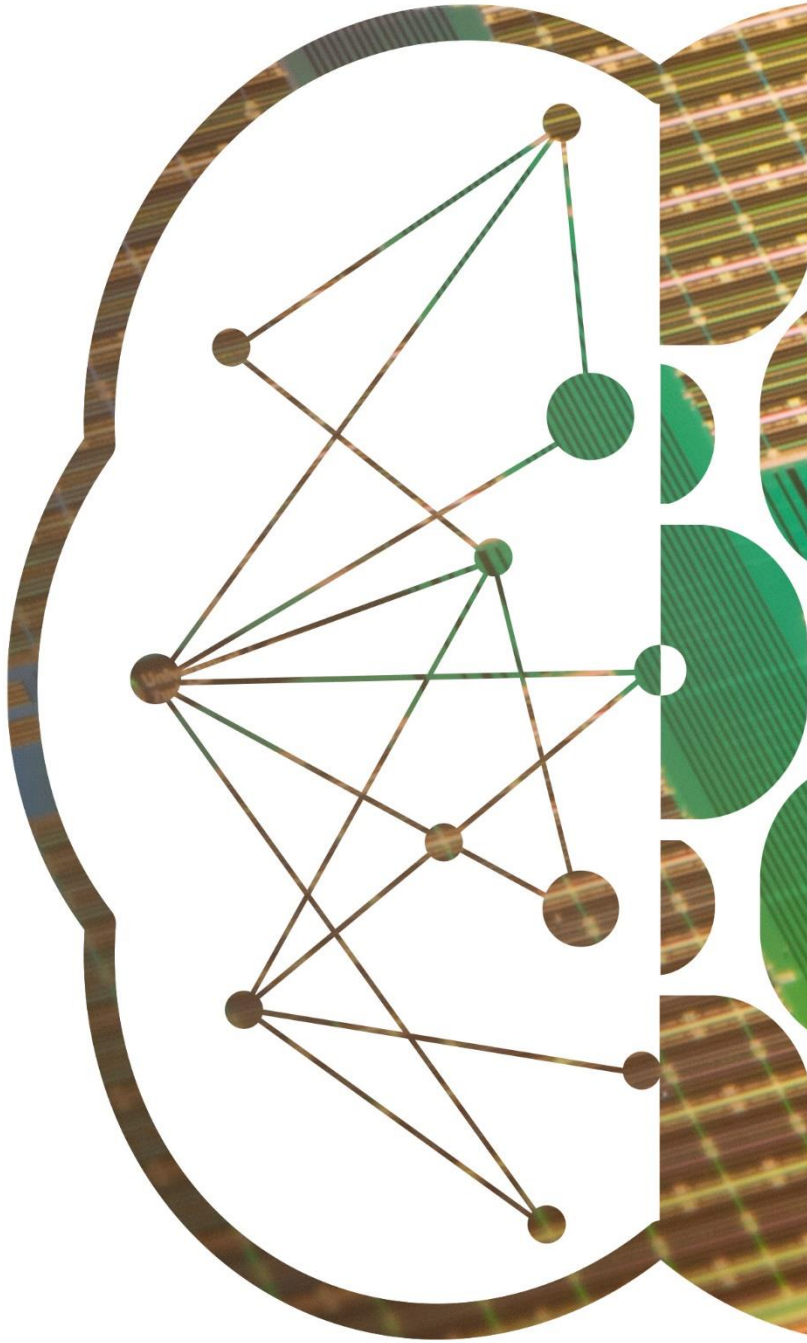
Reality AI solutions

- Automotive sound recognition & localization
- Indoor/outdoor sound event recognition
- RealityCheck™ voice anti-spoofing

SynSense

SynSense builds **ultra-low-power** (sub-mW) **sensing and inference** hardware for **embedded, mobile and edge** devices. We design systems for **real-time always-on smart sensing**, for audio, vision, IMUs, bio-signals and more.

https://SynSense.ai



Next tinyML Talks

Date	Presenter	Topic / Title
Tuesday, January 19	**Lukas Geiger** Deep Learning Researcher, Plumerai	Running Binarized Neural Networks on Microcontrollers

Webcast start time is 8 am Pacific time

Please contact talks@tinyml.org if you are interested in presenting

TINY ML TALKS webcast

Reminders

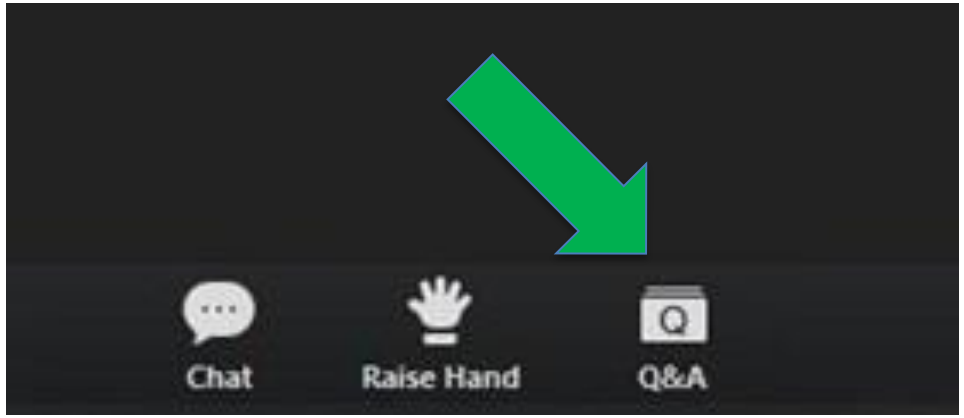
Slides & Videos will be posted tomorrow

PDF

tinyml.org/forums

youtube.com/tinyml

Please use the Q&A window for your questions



TINY ML TALKS webcast

Andrew Baker

Andrew Baker joined Maxim Integrated in 2009. He has 25 years of experience in the electronics industry in roles ranging from development engineering to sales as well as business/product management. In his current role, he is responsible for leading Maxim's wearable solutions initiatives for sensors and power management, as well as multiple other product lines. Andrew holds a Bachelor's degree with honors in electronic engineering from the University of Portsmouth, UK.

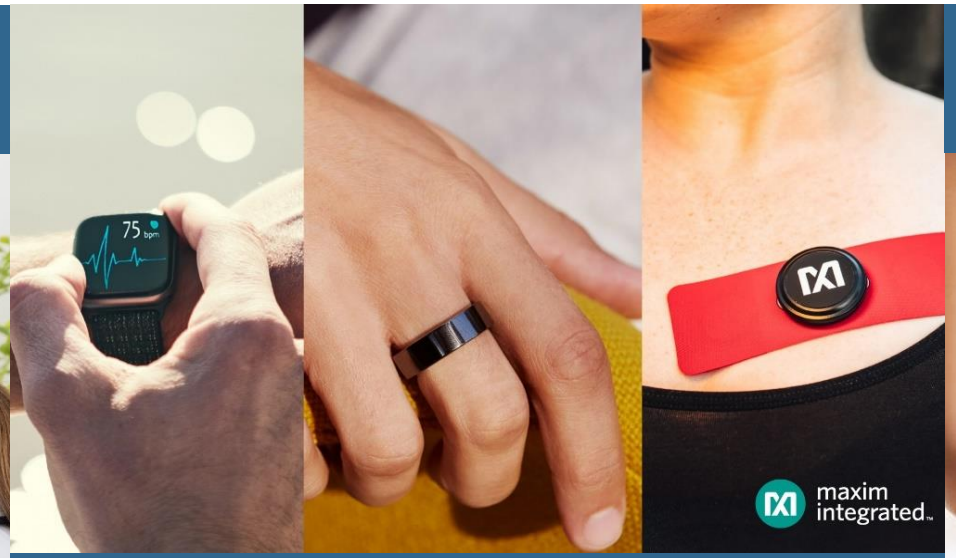
The Future of Personalized Connected Healthcare

Andrew Baker, Managing Director of Industrial & Healthcare Business Unit

Transitioning to a New Model for Healthcare Delivery

Global healthcare costs growing – Currently ~$9T or 10% of global GDP

Remote monitoring with analytics



Preventive monitoring

Chronic disease management

maxim integrated™

Healthcare is Becoming More Personalized

- Medical/healthcare wearable devices totaled 640M in 2019
- Total device shipments forecasted to top 1B in 2023
- Target device types* set to grow at 22% CAGR (2019 to 2023)

Source: Omdia Healthcare Equipment Database, December 2019

*Select wearables include smartwatches, activity & fitness monitors, hearing aids, HRMs, disposable CGMs, infusion pumps and pregnancy test kits
Results are not an endorsement of Maxim Integrated. Any reliance on these results is at the third-party's own risk.

Remote Patient Monitoring Use Cases – Virus Pandemic Model

Predictive Screening

Temp & SpO_2

Onset Monitoring (Hi Risk)

Temp, SpO_2, HR/ECG & Respiration

Periodic Telemetry

FDA

Post Hospital Monitoring

Temp, SpO_2, Heart Rate/ECG, Respiration

24/7 Telemetry

FDA

Deteriorating Condition

Body Temperature, SpO_2, Heart Rate/ECG, Respiration

24/7 Telemetry

FDA

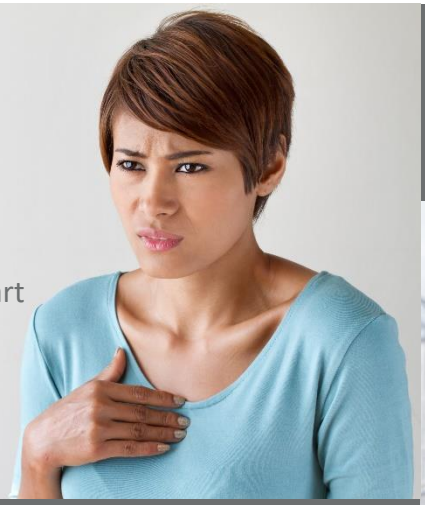
ECG: Electrocardiogram
SpO_2 : Blood oxygen saturation

Preventive Monitoring - AFib Detection

Atrial fibrillation (AFib) increases risk of stroke by 5x

Common symptoms of AFib

Source: American Heart Association



Racing heart, fluttering or palpitations
Shortness of breath
Lightheadedness

Or no noticeable symptoms at all

People with no symptoms may be diagnosed by an exam and an ECG

Chronic Disease Management - Continuous SpO_2 Monitoring

Identify onset of critical conditions to mitigate risk of hospitalization

251 million
COPD cases globally; 5% of global deaths

Source: World Health Organization

$$$

936 million
30-69yrs adults with Obstructive Sleep Apnea

Source: THE LANCET

300 million
Affected by Asthma globally

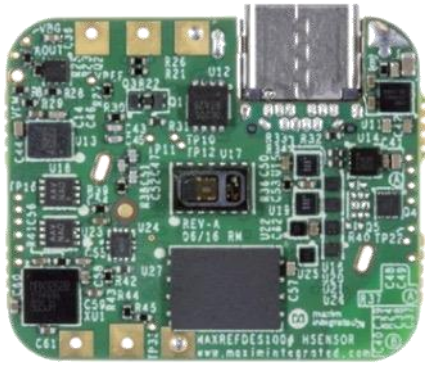
Source: PubMed.gov

48 million
Infected with COVID-19 globally

Source: BBC News

Proven Track Record of Accelerating Time to Market for Customers

Integrating several sensors for new functionality



Health Sensor Platform 2.0 (HSP 2.0)
MAXREFDES101#

2016 | 2018 | 2020

Health Sensor Platform
MAXREFDES100#
System Board

Health Sensor Platform 3.0 (HSP 3.0)
MAXREFDES104#

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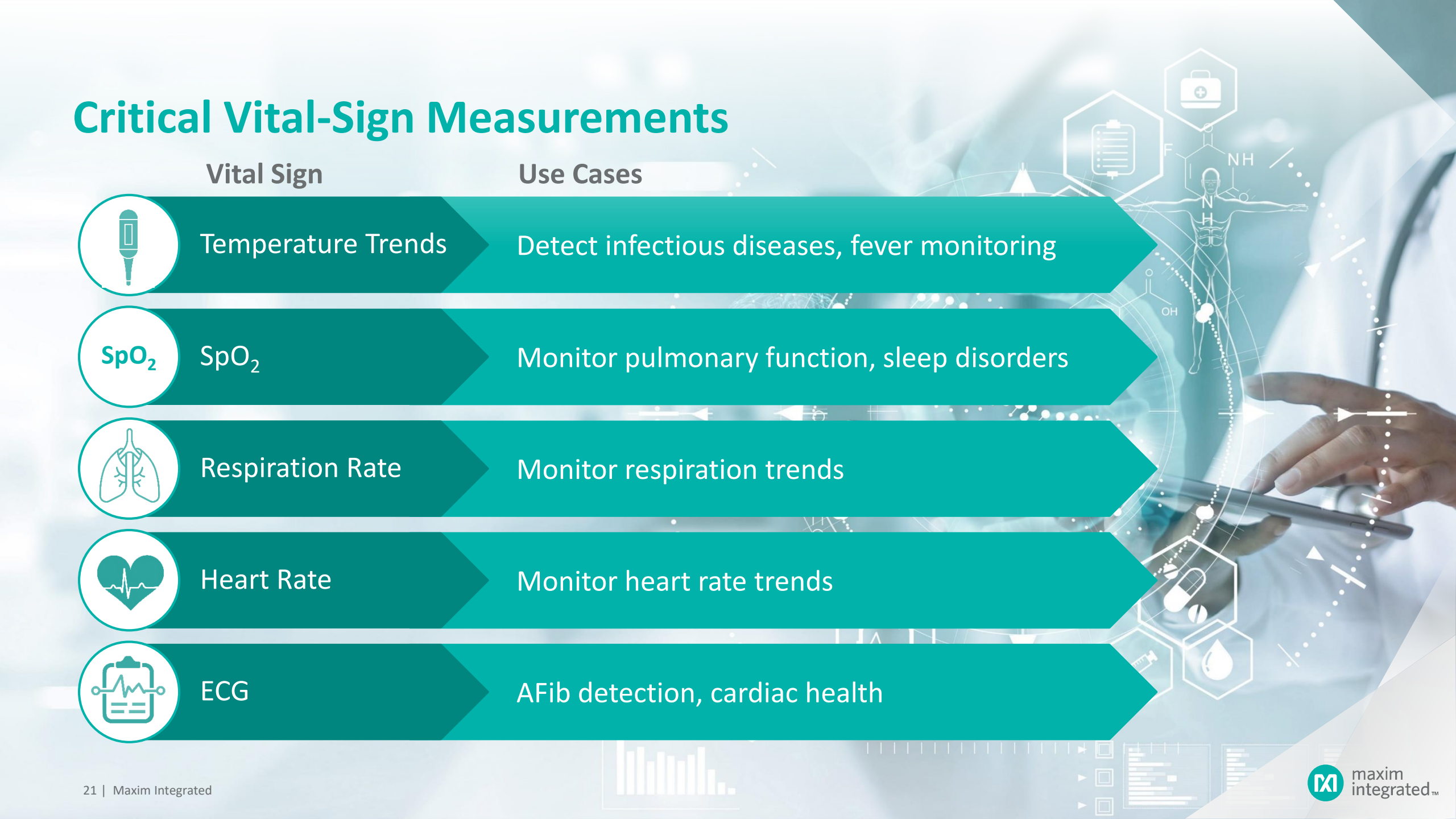
Health Sensor Platform 3.0 (HSP 3.0)

MAXREFDES104#: A wrist form-factor reference design

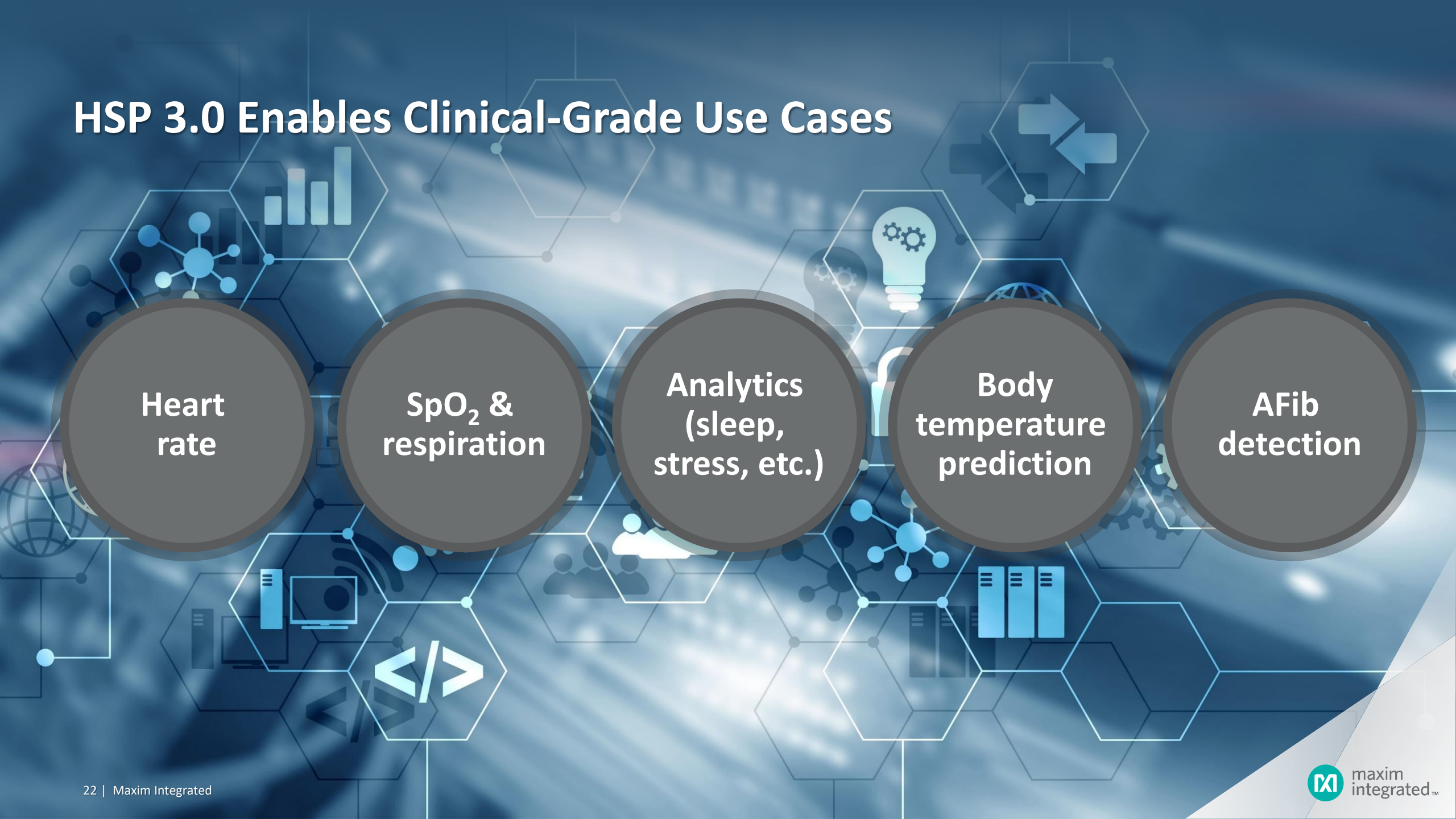
Faster time to market	Clinical-grade	Complete reference design	Covers key vital signs
Saves at least six months in development time	Accuracy meets regulatory requirements for SpO_2 & ambulatory ECG (IEC 60601-2-47)	Source code and design files to accelerate designs	Addresses needs of advanced health wearables with SpO_2 , ECG, HR, HRV, RR, body temp & motion

Critical Vital-Sign Measurements

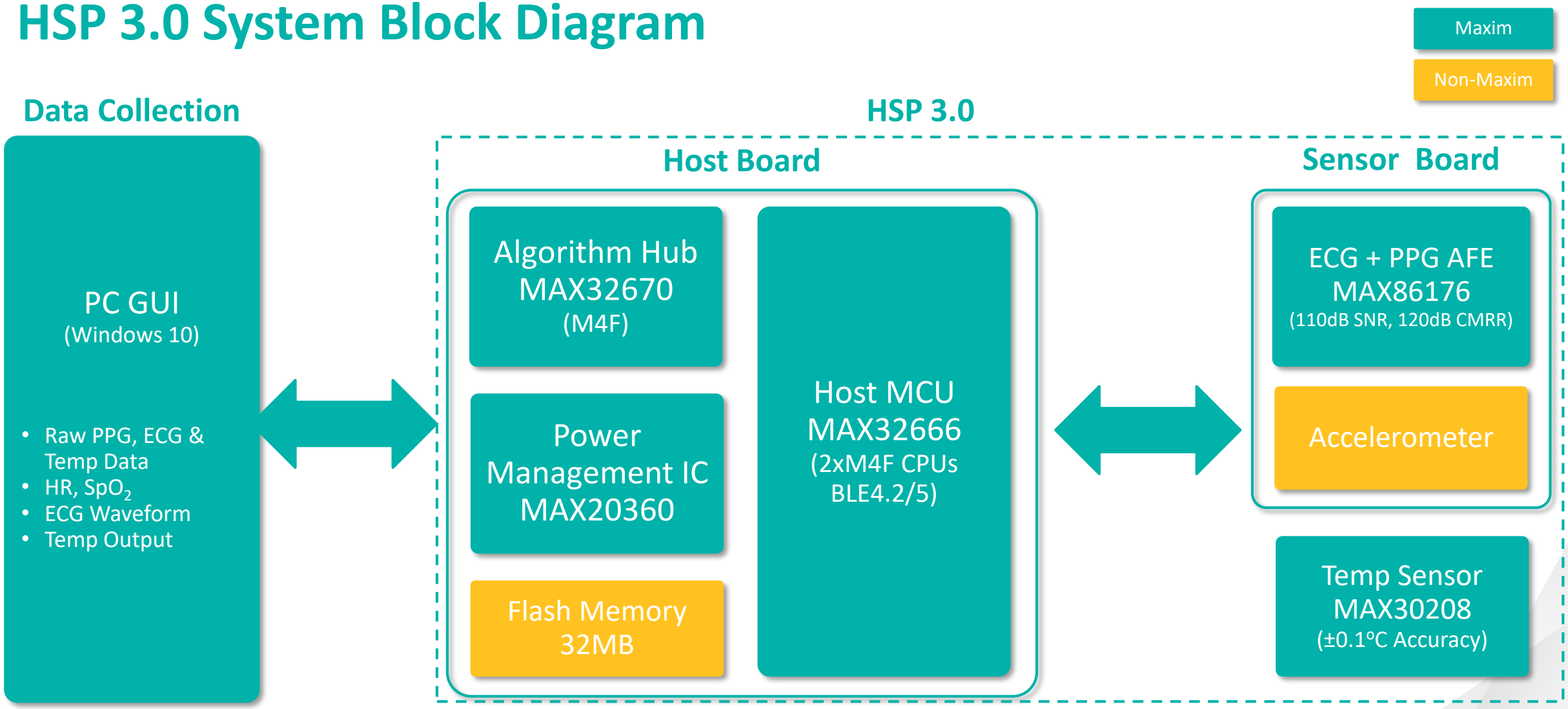
Vital Sign	Use Cases
Temperature Trends	Detect infectious diseases, fever monitoring
SpO_2	Monitor pulmonary function, sleep disorders
Respiration Rate	Monitor respiration trends
Heart Rate	Monitor heart rate trends
ECG	AFib detection, cardiac health



HSP 3.0 Enables Clinical-Grade Use Cases



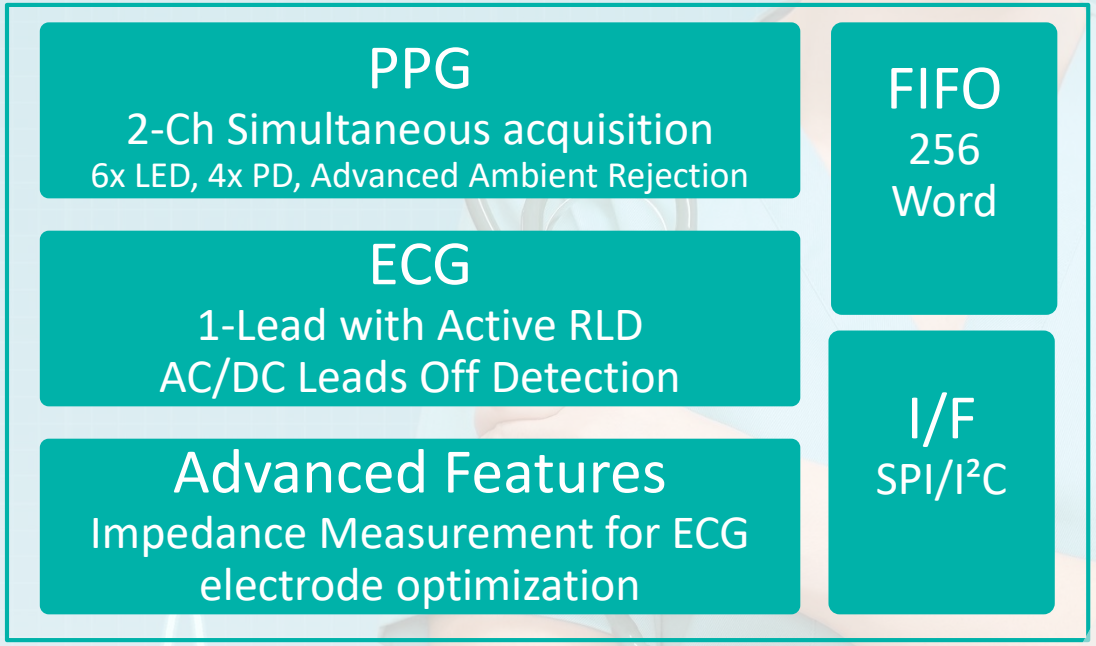
HSP 3.0 System Block Diagram



Clinical-Grade Vital Sign Measurement Using PPG + ECG AFE

MAX86176 enables the next generation of wearable healthcare use cases

- Synchronous acquisition of PPG & ECG measurements with independent sample rates
- Active Right Leg Drive (RLD) offers >110dB CMRR* for optimized ECG dry electrode performance
- Characterize ECG electrode material for system level optimization
- 110dB SNR* for highest performance SpO_2 measurements



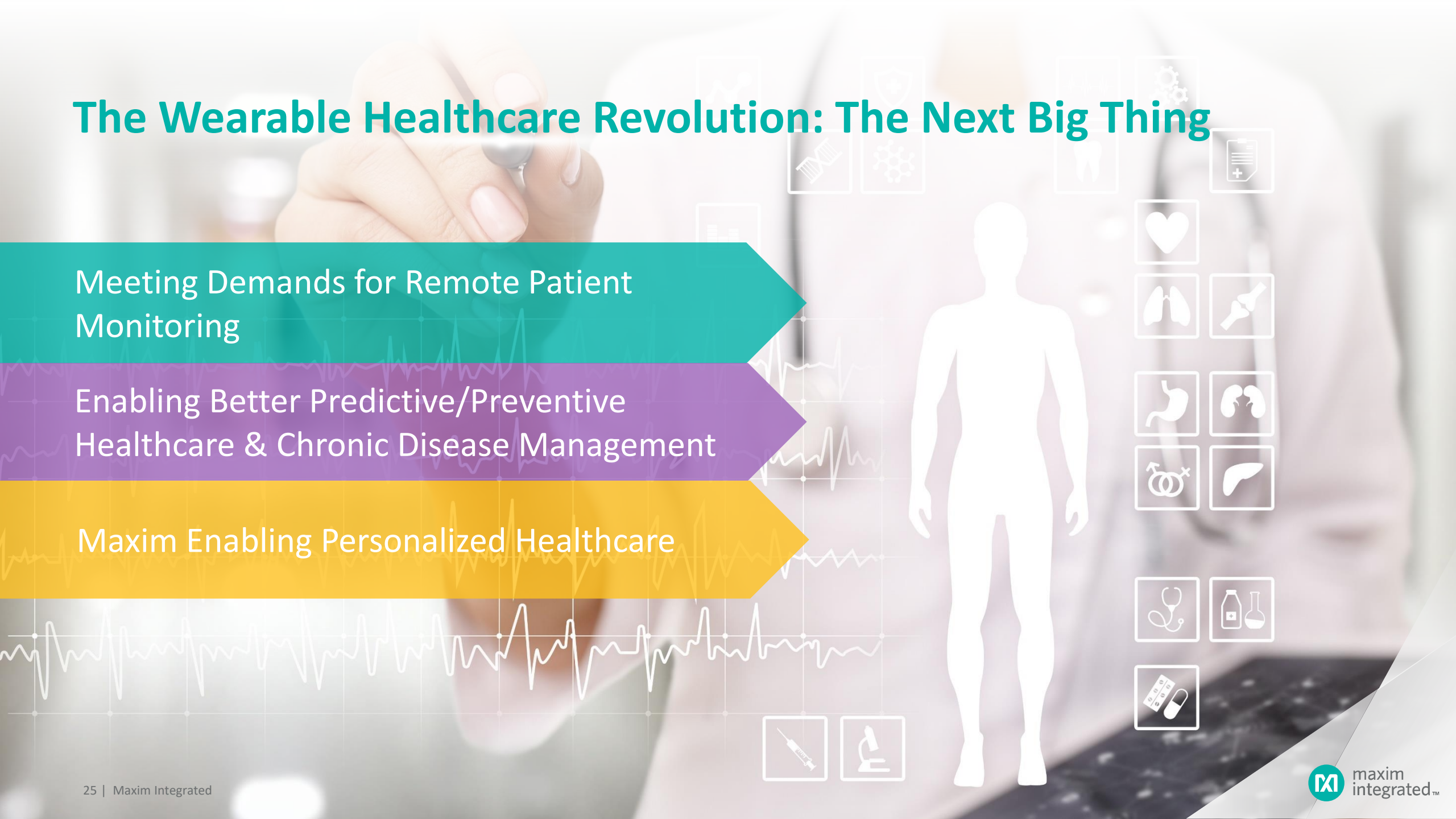
*CMRR: common mode rejection ratio; SNR: signal-to-noise ratio

The Wearable Healthcare Revolution: The Next Big Thing

Meeting Demands for Remote Patient Monitoring

Enabling Better Predictive/Preventive Healthcare & Chronic Disease Management

Maxim Enabling Personalized Healthcare



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Thank You

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