RENESAS ELECTRONICS
INDUSTRIAL BUSINESS

INDUSTRIAL SOLUTION BUSINESS UNIT

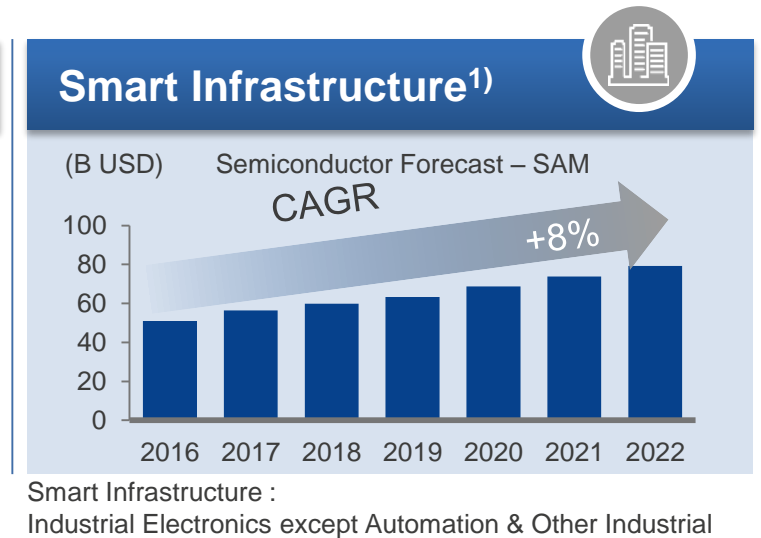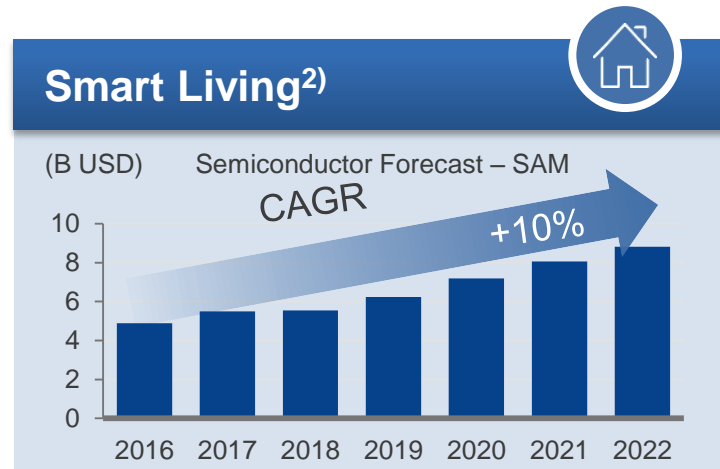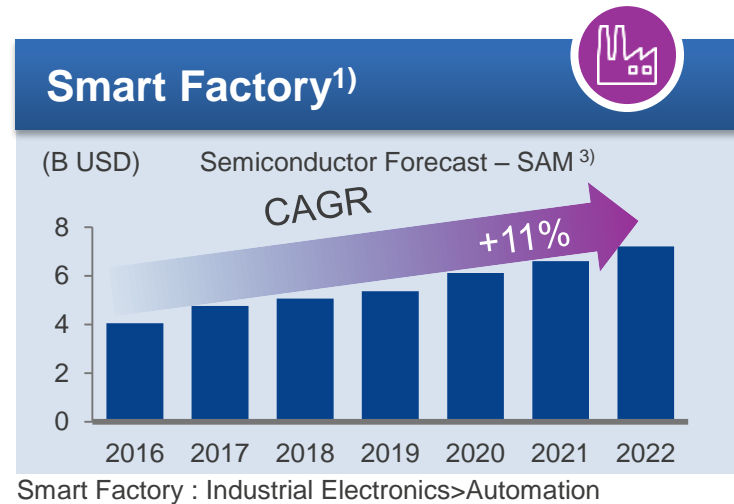BIG IDEAS FOR EVERY SPACE **RENESAS**

AGENDA

- Industrial Business

  – Focus Market and Position

  – Business Direction - Endpoint Intelligence

    – By Artificial Intelligence

    – By Extreme Low Power

- Summary & Take Away

 BIG IDEAS FOR EVERY SPACE

INDUSTRIAL BUSINESS

BIG IDEAS FOR EVERY SPACE
RENESAS

SEMICONDUCTOR MARKET FORECAST
RENESAS FOCAL SEGMENT

Smart Factory[1]

(B USD) Semiconductor Forecast – SAM [3]

CAGR +11%

| 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |

(Y-axis: 0, 2, 4, 6, 8)

Smart Factory : Industrial Electronics>Automation

Smart Living[2]

(B USD) Semiconductor Forecast – SAM

CAGR +10%

| 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |

(Y-axis: 0, 2, 4, 6, 8, 10)

Smart Infrastructure[1]

(B USD) Semiconductor Forecast – SAM

CAGR +8%

| 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |

(Y-axis: 0, 20, 40, 60, 80, 100)

Smart Infrastructure :
Industrial Electronics except Automation & Other Industrial

▶ **Overall CAGR in focus markets is 8,3%**
(estimated by Renesas)

1)Graph created by RENESAS based on Gartner Research, Source Gartner Forecast: : "Gartner Semi-conductor Forecast Database, Worldwide, 2Q18 Update". All statements in this report attributable to Gartner represent Renesas Electronics interpretation of data, research opinion or viewpoints published as part of a syndicated subscription service by Gartner, Inc., and have not been reviewed by Gartner. Each Gartner publication speaks as of its original publication date (and not as of the date of this [presentation/report]). The opinions expressed in Gartner publications are not representations of fact and are subject to change without notice.

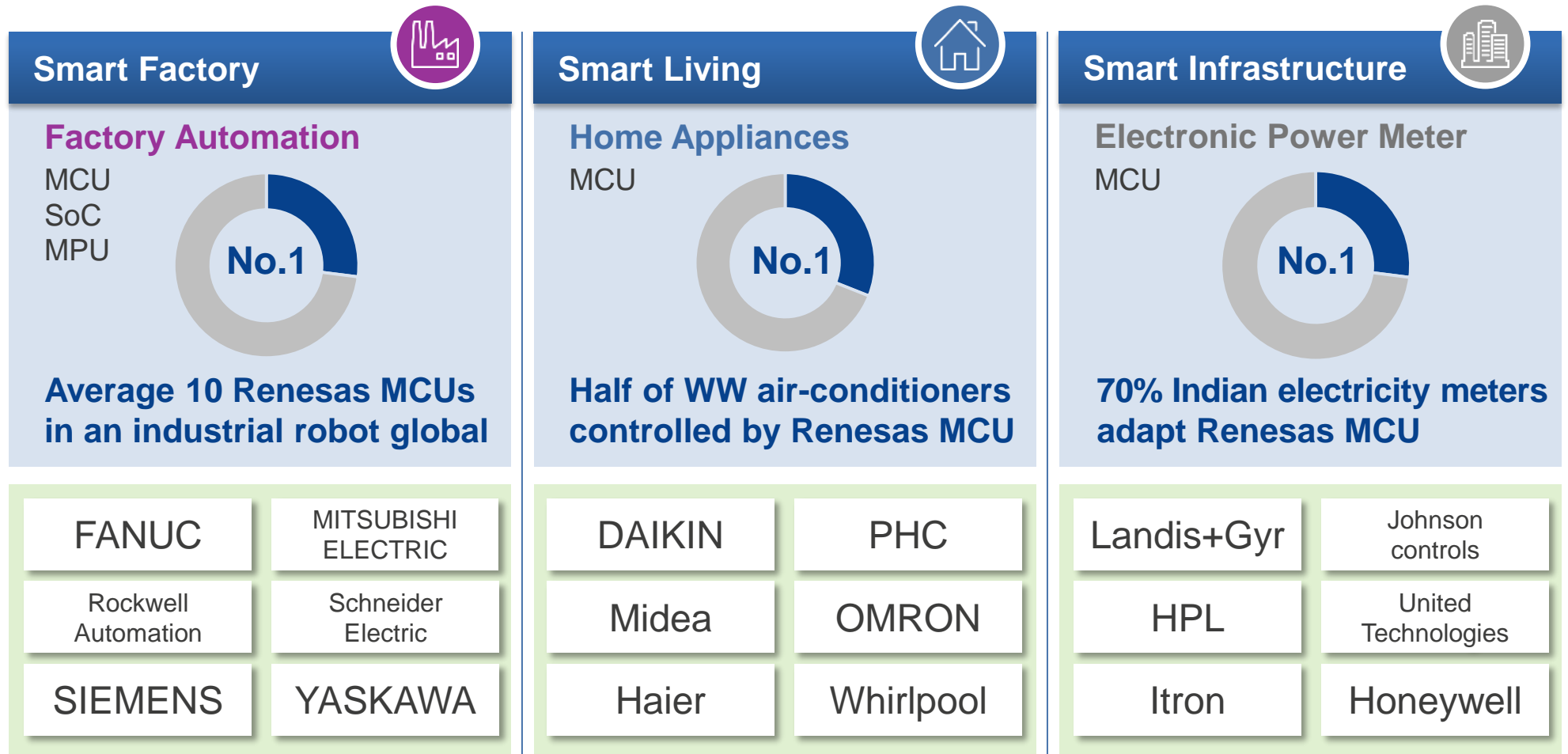2) Fuji-Keizai "Global Home Appliance Market 2018 – Comprehensive Survey", home appliance and healthcare.

3) SAM: Total market minus DRAM, Flash, MPU and Non-optical sensor

BIG IDEAS FOR EVERY SPACE RENESAS

RENESAS POSITIONING
STRONG RESULTS BY CORE COMPETENCE

Smart Factory

Factory Automation

MCU
SoC
MPU

No.1

Average 10 Renesas MCUs in an industrial robot global

Smart Living

Home Appliances

MCU

No.1

Half of WW air-conditioners controlled by Renesas MCU

Smart Infrastructure

Electronic Power Meter

MCU

No.1

70% Indian electricity meters adapt Renesas MCU

RENESAS Position

estimated by Renesas

Major Players

Smart Factory		Smart Living		Smart Infrastructure	
FANUC	MITSUBISHI ELECTRIC	DAIKIN	PHC	Landis+Gyr	Johnson controls
Rockwell Automation	Schneider Electric	Midea	OMRON	HPL	United Technologies
SIEMENS	YASKAWA	Haier	Whirlpool	Itron	Honeywell

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ENDPOINT INTELLIGENCE

Enhance Endpoint Intelligence by e-AI
Extreme Low Power creates new markets

BIG IDEAS FOR EVERY SPACE

"ENDPOINT INTELLIGENCE"
REALIZES INNOVATION IN OT CONSISTS OF THREE TECHNOLOGIES

Operational Technology
- Realtime system
- Control technology
- Safety and robustness

e-AI
- Endpoint real-time inference
- Cognition
- Endpoint learning

Extreme Low Power
- Battery-less system
- Maintenance free
- New energy source

IT
Information Technology

OT
Operational Technology

Enhanced by AI

Proven

Enhance Intelligence

Enhance Market

e-AI: Embedded Artificial Intelligence

TWO TYPES OF AI APPLICATIONS
REQUIREMENTS FOR OT INFERENCE

Cloud

Endpoint

IT
Information Technology

OT
Operational Technology

Statistical Application

Continuing

Learning **Inference**

Continuing

Realtime Application

Learning

Pre or
1 time
Training

Inference

OT Inference Requirements
- Absolute Power Consumption
- Flexibility in Field
- Real Time Operation
- Direct Actuation, Control
- Safety and Robustness

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e-AI CAPABILITY ENHANCED BY DRP

e-AI Capability

Class-4				x10	**Endpoint Incremental Learning** by DRP-AI 2
Class-3			x10	**Realtime Cognition** by DRP-AI	Paper reported VLSI symp. 2018
Class-2		x10	**Realtime Image Processing** by DRP		Product release October 2018
Class-1	**Endpoint Inference** e-AI on MCU / MPU				Solution released July 2017

1.5 years ahead of competition

| 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
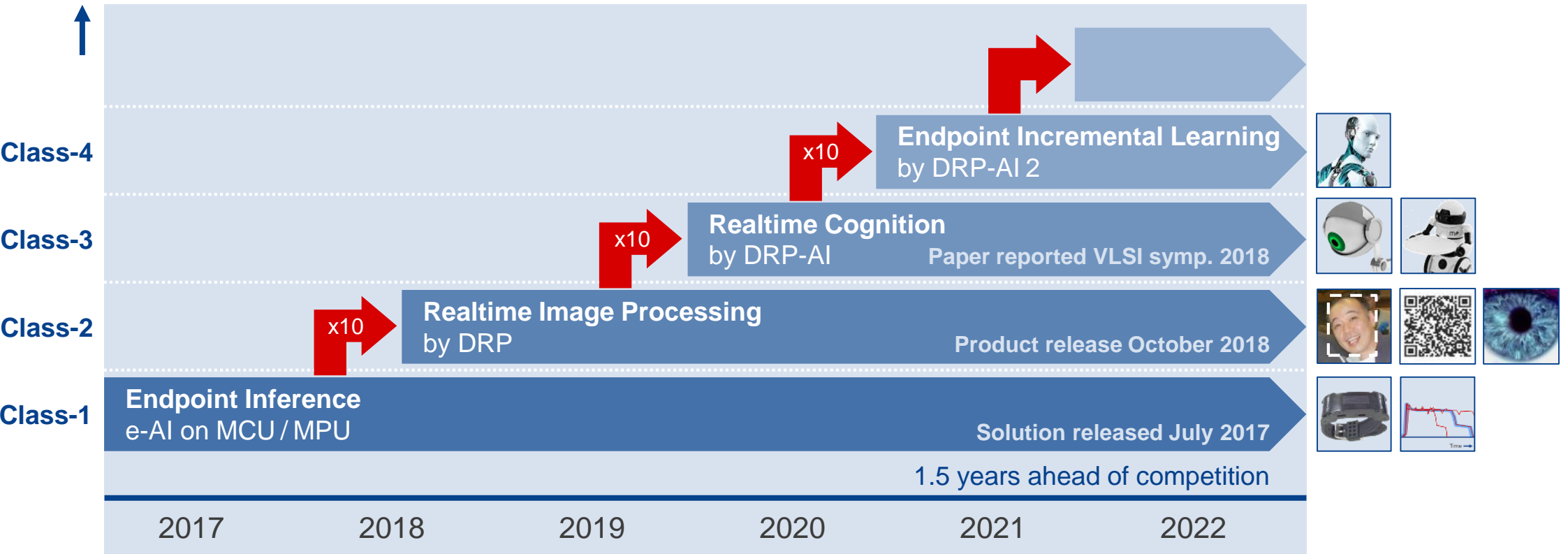
DRP: Dynamically Reconfigurable Processor

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ESTABLISHED e-AI FLOW
TOOLCHAIN WILL EVOLVE WITH AI ACCELERATOR "DRP"

**Open Source Software
AI Frameworks**

TensorFlow   Caffe   ONNX

Learning

e-AI Tools

e-AI Class-1	e-AI Class-2	e-AI Class-3	e-AI Class-4
e-AI Translator	**e-AI Translator for DRP**	**e-AI Translator for DRP-AI**	**e-AI Translator for DRP-AI 2**
- Small program size 1/1000	- Image Processing Performance x10 - Power consumption 1/10	- NN pruning & quantization → Reduce Mem Size 1/16	- Incremental Learning → Enable Autonomous System

Inference   **Inference**   **Inference**   **Inference**

IDE Tools

Integrated Design Environment   all MCU / MPU   DRP   DRP-AI   DRP-AI 2   Incremental Learning

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UNIQUE POSITIONING OF RENESAS' e-AI
EXCELLENT PERFORMANCE AT LOWEST POWER

Power Allowance for Embedded Solutions

Performance (OPS)

(10 TOPS / W)

(1 TOPS / W)
TPU

(100 GOPS / W)
GPU

100T

10T — Class-4

(10 GOPS / W)

1T — Class-3

FPGA

(1 GOPS / W)

100G
DSP

Class-2

10G
CPU

1G

1   10   100   Power (W)

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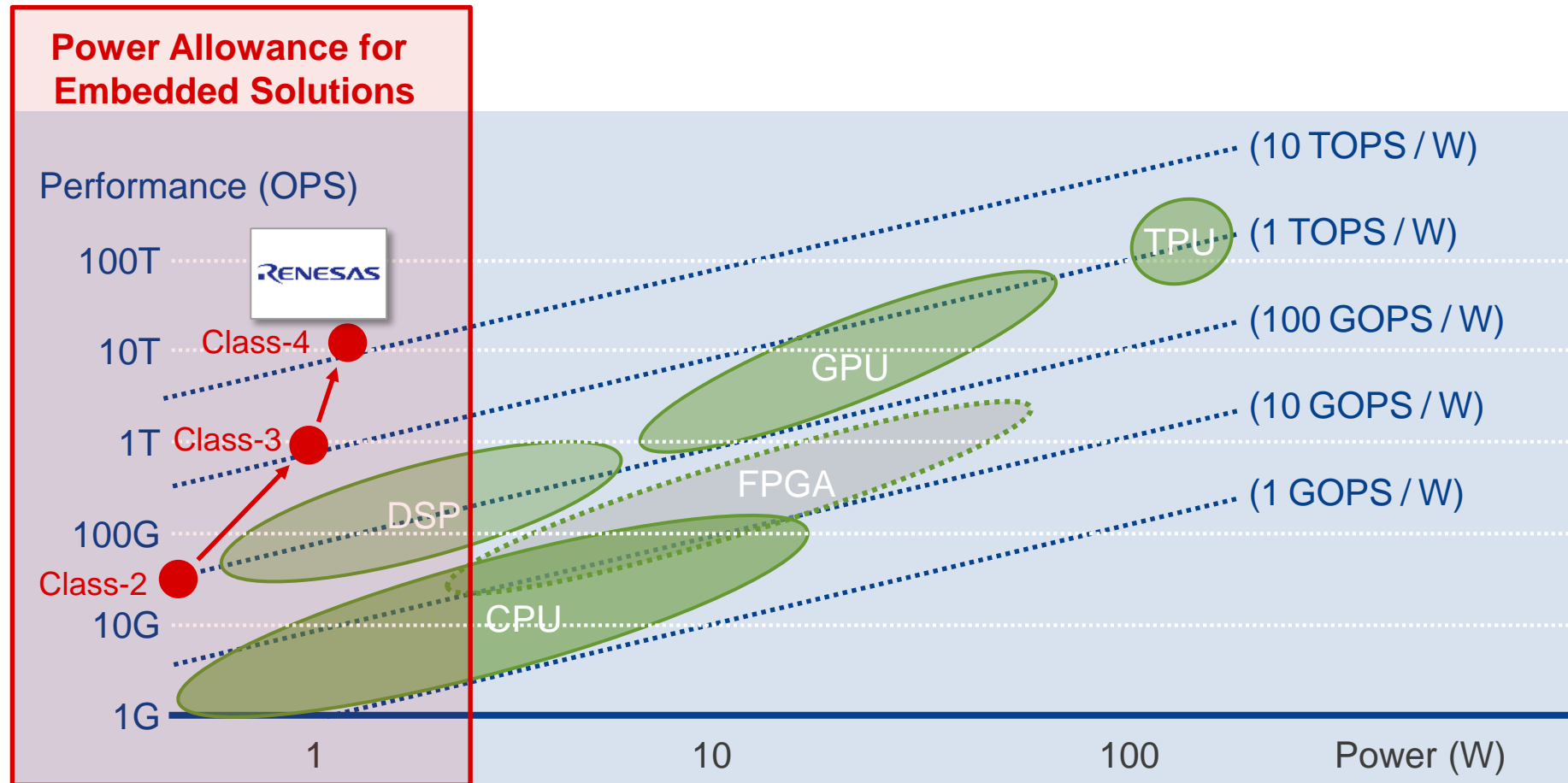
POSITIONING OF AI ACCELERATOR

Power Efficiency (high → low)

		Absolute Power Consumption	Flexibility in Field	Real Time Operation	Direct Actuation, Control	Safety and Robustness
Hardware SoC	Imaging specialized		❌			
VPU			❌		❌	❌
SoC				❌		
DRP / ASSP	RENESAS	✅	✅	✅	✅	✅
SoC				❌		
TPU		❌		❌	❌	❌
GPGPU		❌		❌	❌	❌
FPGA		❌	❌			
DSP		❌				
CPU		❌				

BIG IDEAS FOR EVERY SPACE   RENESAS
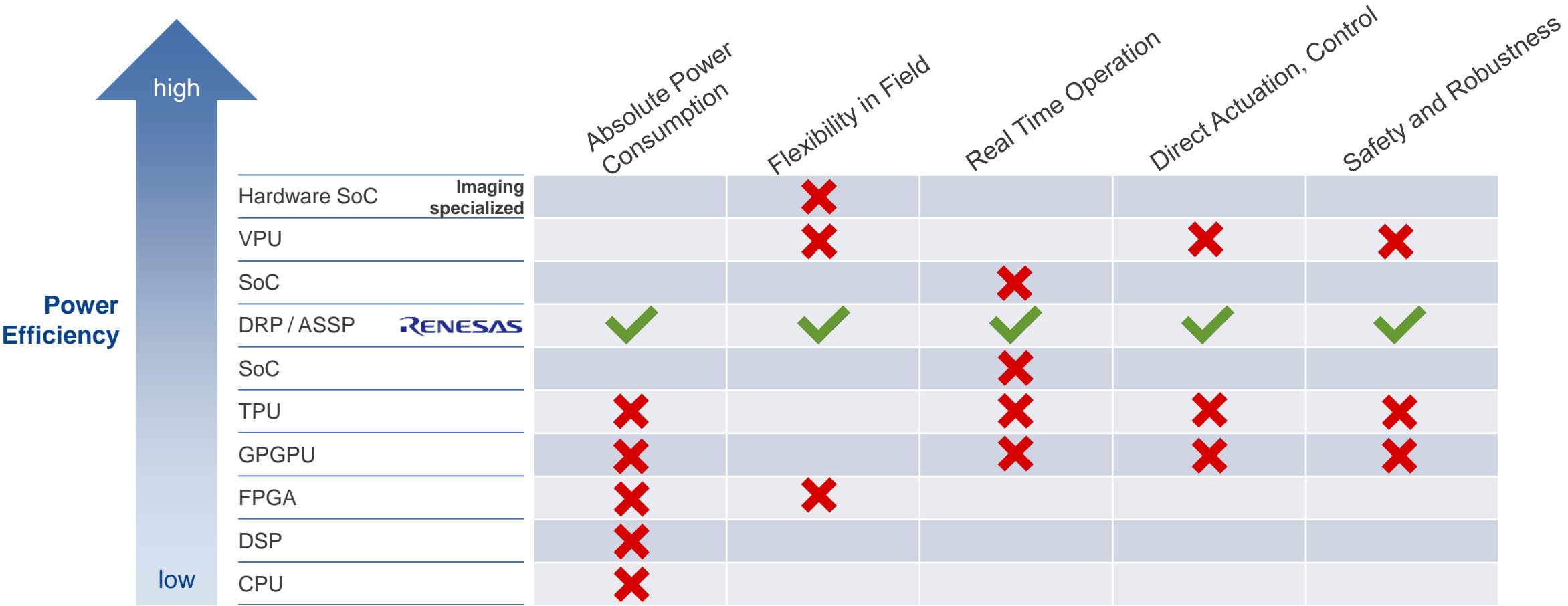
USE CASE CLASS-1:   e-AI ANOMALY DETECTION
FOR HUNDREDS MILLION MOTORS

Benefits:

- Improve service quality

- Avoid downtimes

- Reduce maintenance cost
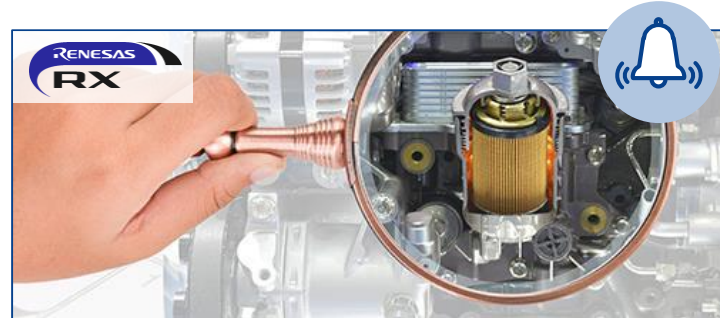
e-AI detects and pre-warns anomalies everywhere every time

Smart Factory	Smart Living	Smart Infrastructure

▶ Renesas is shipping 200M+ motor control MCU per year.
New MCU series will enable e-AI Anomaly Detection.

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USE CASE CLASS-2 / 3: MULTIMODAL E-AI BIOMETRICS AUTHENTICATION
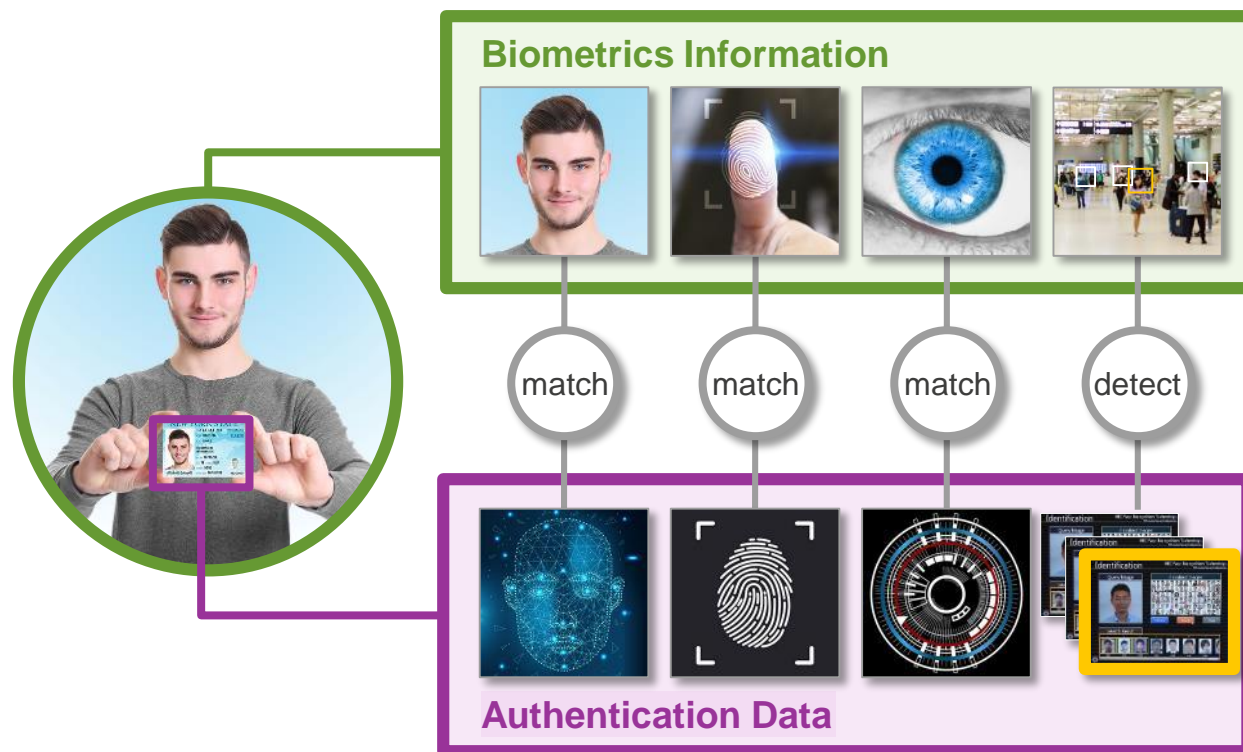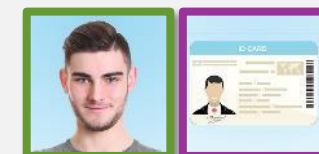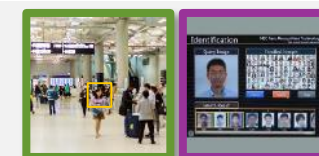
Smart cognitive system without cloud service.
New MPU release in October.

BIG IDEAS FOR EVERY SPACE

e-AI MARKET FORECAST

Smart Factory

Smart Living

Smart Infrastructure

e-AI MARKET GROWTH

(M USD)

CAGR 2018 – 2022: +83%

"Integrated AI Semiconductor Revenue Forecast for IoT"

SAM: ~ $2B

Excellent growth potential in Renesas' core competence area

Graph created by RENESAS based on Gartner Research, Source Gartner Forecast: AI Neural Network Processing Semiconductor Revenue, Worldwide 2018, 11 January 2018 All statements in this report attributable to Gartner represent Renesas Electronics interpretation of data, research opinion or viewpoints published as part of a syndicated subscription service by Gartner, Inc., and have not been reviewed by Gartner. Each Gartner publication speaks as of its original publication date (and not as of the date of this [presentation/report]). The opinions expressed in Gartner publications are not representations of fact and are subject to change without notice.

BIG IDEAS FOR EVERY SPACE

EXTREME LOW POWER – BY SOTB

SOTB – SILICON ON THIN BURIED OXIDE

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EXTREME LOW POWER – BY SOTB TECHNOLOGY

SOTB: Silicon on Thin Buried Oxide

BIG IDEAS FOR EVERY SPACE
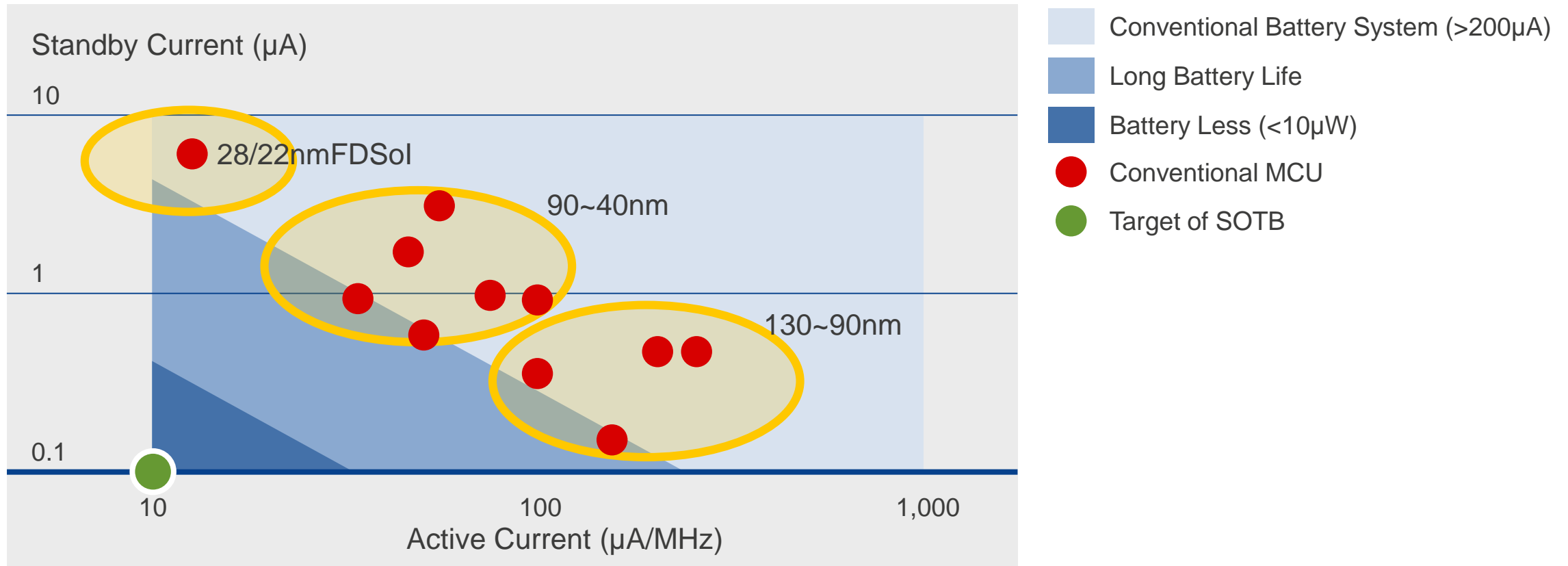
EXTREME LOW POWER
CREATE ENERGY HARVESTING MARKET

Disruptive Extreme Low Power Performance of SOTB

Conventional Circuit		SOTB
Normal MCU	**SOTB realizes**	SOTB
Battery	Operating Current **x 0.1**	Battery-free
	Standby Current **x 0.01**	• Light (Solar) • Temperature • Vibration • Water flow • Wind • …
Power Supply = Battery		**Operated by Environment Power**

BIG IDEAS FOR EVERY SPACE
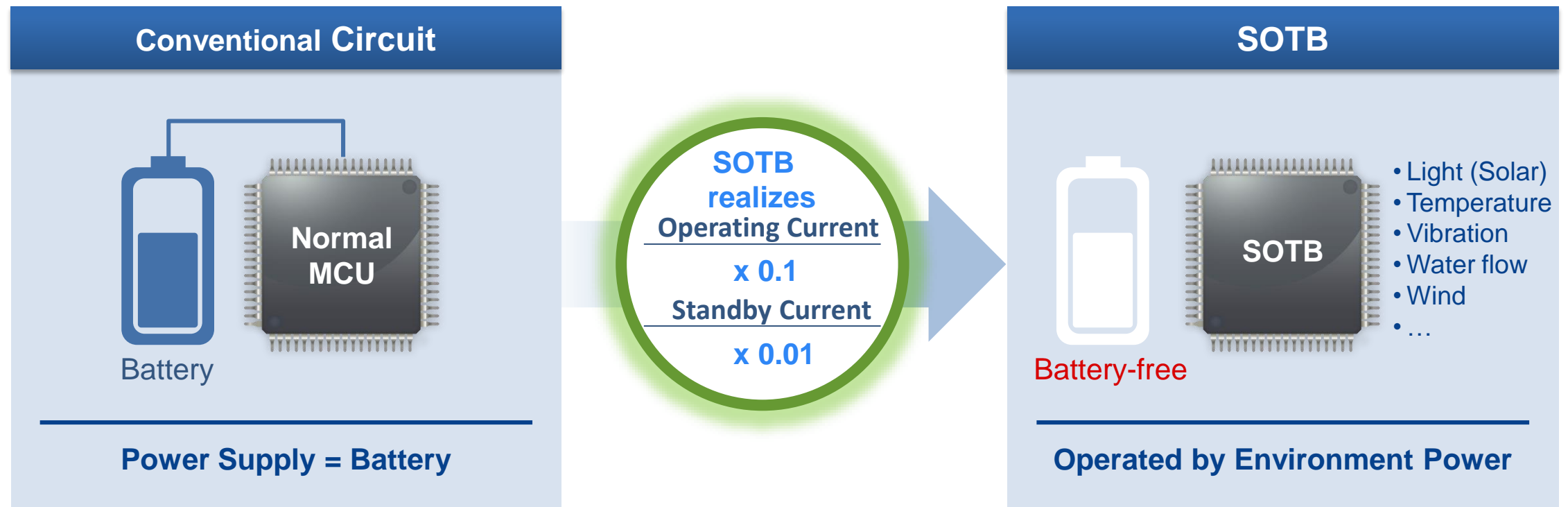
RENESAS

EXTREME LOW POWER CREATES NEW MARKET
CONNECT TO EVERYWHERE – BY SOTB TECHNOLOGY

Application Capability

| Phase 2 EH sources | Δ Temp., Bacteria |

| Phase 1 EH sources | Vibration |

Phase 3: Fusion EH + RF + e-AI

| Solar | Water | Pressure |

Phase 2: Fusion EH + RF

Phase 1: Extreme Low Power

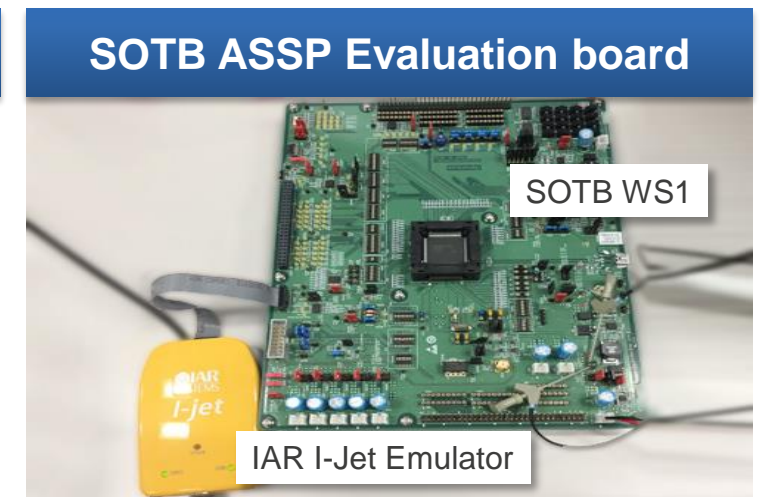| Existing Application	Smart Home, Building, Healthcare	Infrastructure, City
▪ Battery free systems ▪ Maintenance free systems ▪ Single Energy Harvesting source	▪ Combine BLE RF with EH ▪ Expand sensor options ▪ Multiple Energy Harvesting source	▪ Integrate e-AI / DRP ▪ Combine Low Power Wide area RF ▪ EH solutions by advanced PMIC
2019	**2021**	**2023**

EH = Energy Harvesting   RF = Radio Frequency   BLE = Bluetooth Low Energy   PMIC = Power Management IC

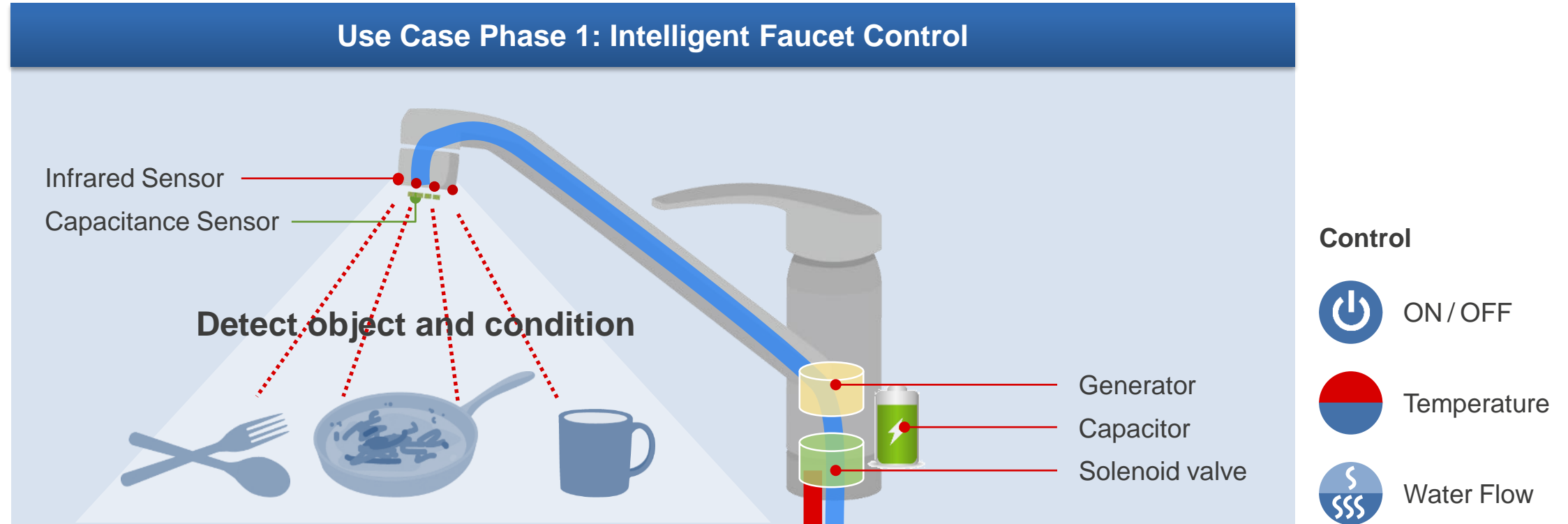BIG IDEAS FOR EVERY SPACE   RENESAS

PROGRESS OF RENESAS ACTIVITIES

- Last spring, we got first Silicon of SOTB ASSP

- Active power and standby power are just less than the target. Continue to improve.

SOTB ASSP system structure

SOTB ASSP 1st sample

SOTB ASSP Evaluation board

SOTB WS1

IAR I-Jet Emulator
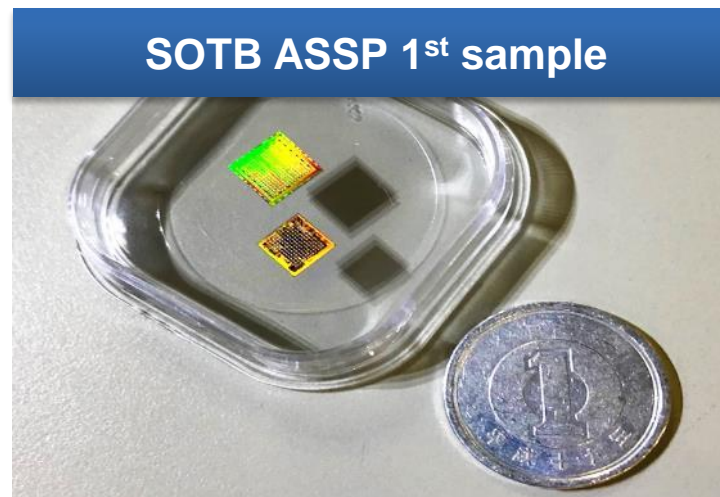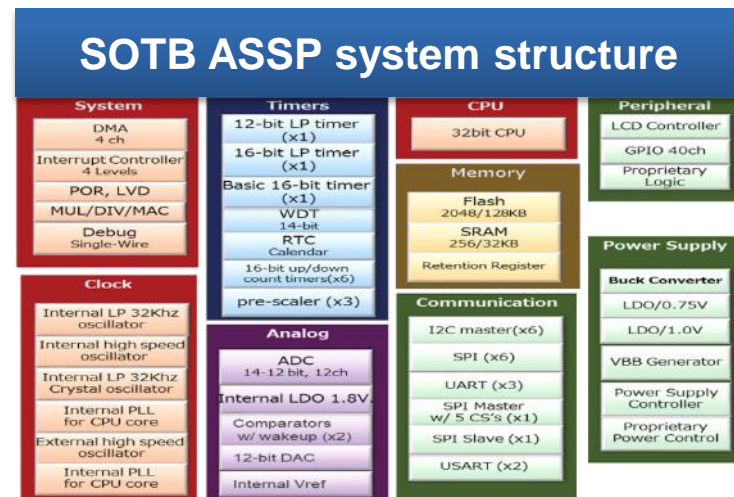
Public launch at **electronica** 2018 *inside tomorrow* November 2018 in Munich.

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NEW SOLUTION

Use Case Phase 1: Intelligent Faucet Control

Infrared Sensor

Capacitance Sensor

Detect object and condition

Generator

Capacitor

Solenoid valve

Control

ON / OFF

Temperature

Water Flow

▶ Extreme Low-power with SOTB enables Endpoint Intelligence.

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APPLICATION USE CASE EXAMPLES
EXTREME LOW POWER – MARKET GROWTH POTENTIAL

ELP Applications

Medical / Healthcare

Fitness Wearable

Capsule Device

Portable Device

Smart Watch

Implantable Device

Equipped Device

City

Smart Agriculture

Transportation

Commercial and Public Facility

Aquatic Product

Stockbreeding

Infrastructure

Urban Environment Monitoring

Natural Environment Monitoring

Home/Office Security

Infrastructure Monitoring

Industrial Automation

Equipment Monitor

Worker Monitor

Smart Tags

Energy Management

Controller

Lighting

Meter

Gadget / Home Devices /…

Gadget

Home Device

Other Prototype

Sports & Outdoor Device

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SUMMARY & TAKE AWAY

BIG IDEAS FOR EVERY SPACE

INDUSTRIAL BUSINESS
OUTLOOK

Sustainable Outlook until 2022 in Focus Markets

CAGR >10%

FY16
(Act)

FY18
(Est)

FY22
(Target)
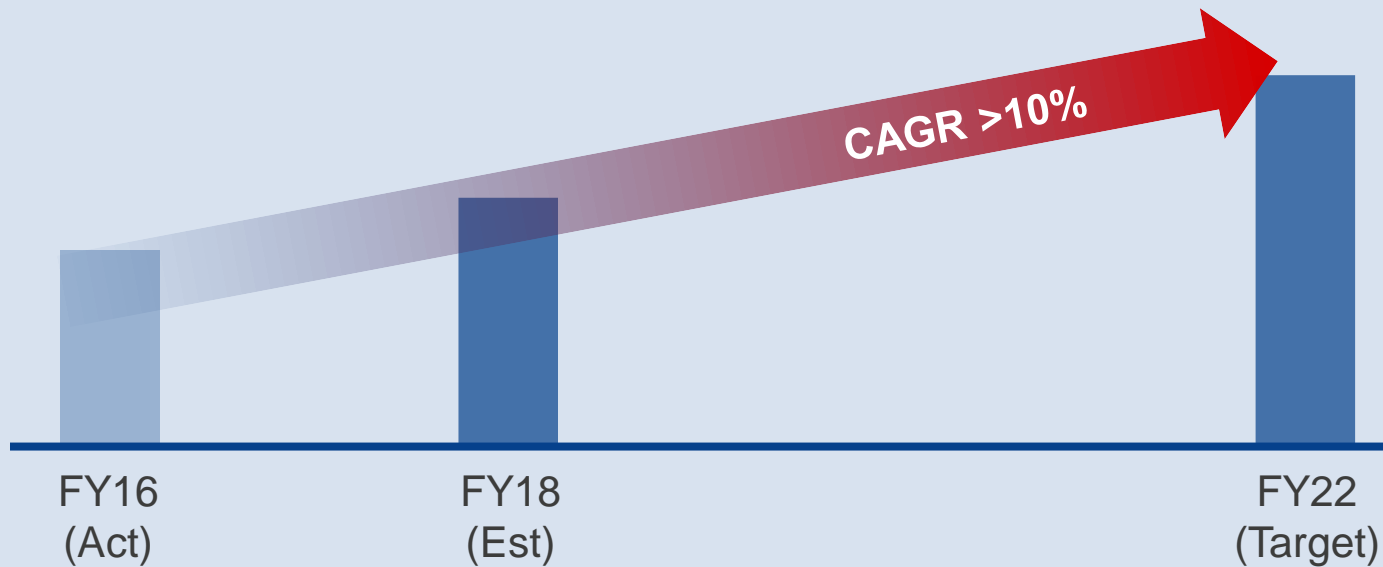
IBU Gross Margin Target

60%
Gross Margin

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TAKE AWAY

| Core Competence in OT | Differentiating Innovation by e-AI and SOTB | High Profitable Growth | Leader of Endpoint Intelligence |

Renesas – Endpoint Intelligence

BIG IDEAS FOR EVERY SPACE RENESAS