AGENDA

- Industrial Business
  - Focus Market and Position
  - Business Direction - Endpoint Intelligence
    - By Artificial Intelligence
    - By Extreme Low Power

- Summary & Take Away
Overall CAGR in focus markets is 8.3% (estimated by Renesas)

1) Graph created by RENESAS based on Gartner Research. Source Gartner Forecast: “Gartner Semiconductor 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.


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

## Major Players
- **Smart Factory**
  - FANUC
  - MITSUBISHI ELECTRIC
  - SIEMENS
  - YASKAWA

- **Smart Living**
  - DAIKIN
  - PHC
  - Midea
  - OMRON
  - Haier
  - Whirlpool

- **Smart Infrastructure**
  - Landis+Gyr
  - Johnson controls
  - HPL
  - United Technologies
  - Itron
  - Honeywell

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ENDPOINT INTELLIGENCE

Enhance Endpoint Intelligence by e-AI
Extreme Low Power creates new markets
“ENDPOINT INTELLIGENCE” REALIZES INNOVATION IN OT CONSISTS OF THREE TECHNOLOGIES

**Enhanced by AI**

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

**IT**
- Information Technology

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

**Enhanced Intelligenc**

**Enhanced Market**

**Proven**

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

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e-AI: Embedded Artificial Intelligence
TWO TYPES OF AI APPLICATIONS

REQUIREMENTS FOR OT INFERENCE

OT Inference Requirements
- Absolute Power Consumption
- Flexibility in Field
- Real Time Operation
- Direct Actuation, Control
- Safety and Robustness
e-AI CAPABILITY ENHANCED BY DRP

e-AI Capability

Class-4
Realtime Image Processing by DRP

Class-3
Realtime Cognition by DRP-AI

Class-2

Class-1
Endpoint Inference e-AI on MCU / MPU

 Endpoint Incremental Learning by DRP-AI 2

Product release October 2018

Paper reported VLSI symp. 2018

Solution released July 2017

1.5 years ahead of competition

DRP: Dynamically Reconfigurable Processor
ESTABLISHED e-AI FLOW
TOOLCHAIN WILL EVOLVE WITH AI ACCELERATOR “DRP”

Open Source Software
AI Frameworks

Learning

Caffe
ONNX

e-AI Class-1
- Small program size 1/1000

e-AI Class-2
- Image Processing
  Performance x10
- Power consumption 1/10

e-AI Class-3
- NN pruning & quantization
  → Reduce Mem Size 1/16

e-AI Class-4
- Incremental Learning
  → Enable Autonomous System

IDE Tools
Integrated Design Environment
all MCU / MPU

Inference

IDE Tools
Integrated Design Environment

Inference

IDE Tools
Integrated Design Environment

Inference

IDE Tools
Integrated Design Environment

Inference

IDE Tools
Integrated Design Environment

Inference

IDE Tools
Integrated Design Environment

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

Power Allowance for Embedded Solutions

Performance (OPS)

100T
10T
1T
100G
10G
1G

Power (W)

(10 TOPS / W)
(100 GOPS / W)
(10 GOPS / W)
(1 GOPS / W)

Class-4
Class-3
Class-2

CPU
DSP
GPU
FPGA
TPU
# POSITIONING OF AI ACCELERATOR

<table>
<thead>
<tr>
<th>Hardware SoC</th>
<th>Imaging specialized</th>
<th>Absolute Power Consumption</th>
<th>Flexibility In Field</th>
<th>Real Time Operation</th>
<th>Direct Actuation, Control</th>
<th>Safety and Robustness</th>
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<tbody>
<tr>
<td>VPU</td>
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<td>SoC</td>
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<tr>
<td>DRP / ASSP</td>
<td>Renesas</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>SoC</td>
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<td>TPU</td>
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<td>GPGPU</td>
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<td>FPGA</td>
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<tr>
<td>CPU</td>
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</tr>
</tbody>
</table>

| Power Efficiency |
|------------------|-------------------|
| high             | low               |
USE CASE CLASS-1:  e-AI ANOMALY DETECTION 
FOR HUNDREDS MILLION MOTORS

Benefits:
- Improve service quality
- Avoid downtimes
- Reduce maintenance cost

Renesas is shipping 200M+ motor control MCU per year. New MCU series will enable e-AI Anomaly Detection.
USE CASE CLASS-2 / 3: MULTIMODAL E-AI BIOMETRICS AUTHENTICATION

Smart cognitive system without cloud service. New MPU release in October.

- Biometrics Information
  - match
  - match
  - match
  - detect

- Authentication Data

- Airport
  - Passport

- Cashless
  - ID Card

- Office Entry Systems
  - ID Card

- Mobile Systems, Body-worn
  - Criminal Photo
e-AI MARKET FORECAST

Smart Factory

Smart Living

Smart Infrastructure

e-AI MARKET GROWTH

“Integrated AI Semiconductor Revenue Forecast for IoT”

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.

SAM: ~ $2B

Excellent growth potential in Renesas’ core competence area

CAGR 2018 – 2022: +83%
EXTREME LOW POWER – BY SOTB

SOTB – SILICON ON THIN BURIED OXIDE
EXTREME LOW POWER – BY SOTB TECHNOLOGY

<table>
<thead>
<tr>
<th>Standby Current (µA)</th>
<th>Active Current (µA/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10, 28/22nmFDSol</td>
</tr>
<tr>
<td>1</td>
<td>90~40nm</td>
</tr>
<tr>
<td>0.1</td>
<td>130~90nm</td>
</tr>
</tbody>
</table>

- Conventional Battery System (>200µA)
- Long Battery Life
- Battery Less (<10µW)
- Conventional MCU
- Target of SOTB

SOTB: Silicon on Thin Buried Oxide
Disruptive Extreme Low Power Performance of SOTB

Conventional Circuit

- Normal MCU
- Battery
- Power Supply = Battery

SOTB

- Normal MCU
- Battery-free
- Operated by Environment Power

SOTB realizes
Operating Current
x 0.1
Standby Current
x 0.01

- Light (Solar)
- Temperature
- Vibration
- Water flow
- Wind
- …
## Application Capability

<table>
<thead>
<tr>
<th>Phase 1: Extreme Low Power</th>
<th>Phase 2: Fusion EH + RF</th>
<th>Phase 3: Fusion EH + RF + e-Al</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing Application</strong></td>
<td><strong>Smart Home, Building, Healthcare</strong></td>
<td><strong>Infrastructure, City</strong></td>
</tr>
<tr>
<td>Battery free systems</td>
<td>Combine BLE RF with EH</td>
<td>Integrate e-Al / DRP</td>
</tr>
<tr>
<td>Maintenance free systems</td>
<td>Expand sensor options</td>
<td>Combine Low Power Wide area RF</td>
</tr>
<tr>
<td>Single Energy Harvesting source</td>
<td>Multiple Energy Harvesting source</td>
<td>EH solutions by advanced PMIC</td>
</tr>
</tbody>
</table>

### Phase 1: Extreme Low Power
- Battery free systems
- Maintenance free systems
- Single Energy Harvesting source

### Phase 2: Fusion EH + RF
- Combine BLE RF with EH
- Expand sensor options
- Multiple Energy Harvesting source

### Phase 3: Fusion EH + RF + e-Al
- Integrate e-Al / DRP
- Combine Low Power Wide area RF
- EH solutions by advanced PMIC

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

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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.

Public launch at electronica 2018 November 2018 in Munich.
NEW SOLUTION

Use Case Phase 1: Intelligent Faucet Control

Detect object and condition

Infrared Sensor
Capacitance Sensor

Generator
Capacitor
Solenoid valve

Control
ON / OFF
Temperature
Water Flow

Extreme Low-power with SOTB enables Endpoint Intelligence.
## APPLICATION USE CASE EXAMPLES
**EXTREME LOW POWER – MARKET GROWTH POTENTIAL**

### ELP Applications

<table>
<thead>
<tr>
<th>Medical / Healthcare</th>
<th>City</th>
<th>Infrastructure</th>
<th>Industrial Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitness Wearable</td>
<td>Smart Agriculture</td>
<td>Urban Environment Monitoring</td>
<td>Equipment Monitor</td>
</tr>
<tr>
<td>Capsule Device</td>
<td>Transportation</td>
<td>Natural Environment Monitoring</td>
<td>Worker Monitor</td>
</tr>
<tr>
<td>Portable Device</td>
<td>Commercial and Public Facility</td>
<td>Home/Office Security</td>
<td>Smart Tags</td>
</tr>
<tr>
<td>Smart Watch</td>
<td>Aquatic Product</td>
<td>Stockbreeding</td>
<td></td>
</tr>
<tr>
<td>Implantable Device</td>
<td>Stockbreeding</td>
<td>Stockbreeding</td>
<td></td>
</tr>
<tr>
<td>Equipped Device</td>
<td>Stockbreeding</td>
<td>Stockbreeding</td>
<td></td>
</tr>
</tbody>
</table>

### Energy Management

- Controller
- Lighting
- Meter

### Gadget / Home Devices /…

- Gadget
- Home Device

- Other Prototype
- Sports & Outdoor Device
INDUSTRIAL BUSINESS
OUTLOOK

Sustainable Outlook until 2022 in Focus Markets

IBU Gross Margin Target

CAGR >10%

60%
Gross Margin

FY16 (Act)
FY18 (Est)
FY22 (Target)
TAKE AWAY

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