

INFRA, INDUSTRIAL AND IOT STRATEGY UPDATE: CONTENT EXPANSION

MARCH 3, 2021
SAILESH CHITTIPEDDI
EVP AND GENERAL MANAGER
IOT AND INFRASTRUCTURE BUSINESS UNIT
RENESAS ELECTRONICS CORPORATION

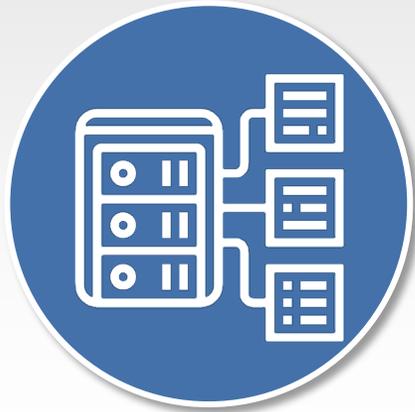
AGENDA

- Update on our major growth drivers, post COVID & distribution trends
- Recap of previously highlighted content expansion opportunities:
 - MCU& MPU, Memory interface, 5G,O-RAN,Satcom, Industrial power
 - New Content Growth Opportunities
 - Industry 4.0
 - Emerging AI & Voice
 - Wireless power
 - Digital power & Higher-power densities in Data center
- Examples of Winning Combos
- Summary

MEGA TRENDS CONTINUE TO BE INTACT

DRIVING GROWTH FOR INDUSTRIAL, IOT AND INFRA BU

Strategy Update (August 2020)



DATA-CENTER DISAGGREGATION

- **33% cloud data CAGR**
- Optimizing underutilized resources / Power / thermal inefficiencies
- Rise of data-centric computing
- Bandwidth constraints driving growth



5G RAMP

- **~0% penetration in 2019 → ~20% in 2023**
- ~40% content expansion from 4G to 5G
- Sub-6GHz / mmWave
- SatCom market growth



INTELLIGENCE MOVING TO ENDPOINT

- **1T connected devices**
- Industry 4.0 / 150MM industrial edge devices enabled with AI shipped annually by 2022
- ~34% IoT sensors long-term growth forecast

MEGA TRENDS CONTINUE TO BE INTACT

DRIVING GROWTH FOR INDUSTRIAL, IOT AND INFRA BU

Strategy Update (August 2020)

Memory Interface Products
Core Power and Power Stages
Timing & Standard Products
Optical (CDR, LD, TIA)

RF
Timing & Standard Products
Power
Optical & MIP (O-RAN)

MCU & MPU
Connectivity
Low-Power/ Wireless Power
Sensors, OIS and Actuation

DATA-CENTER DISAGGREGATION

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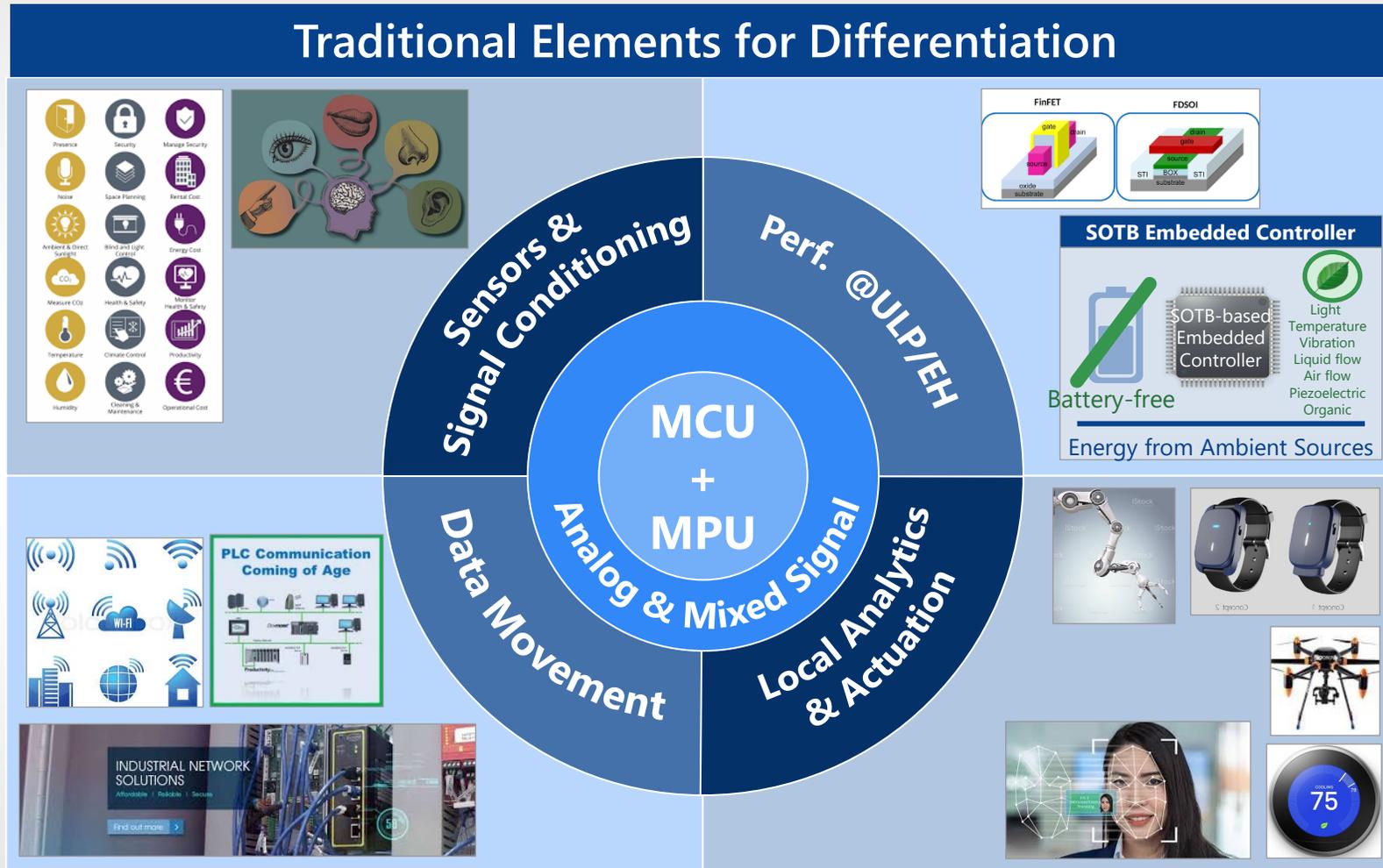
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MICROCONTROLLER + ANALOG/POWER SOLUTIONS-DIVERSIFIED PRODUCTS FOR OUR CUSTOMERS



System Differentiation

Interfaces & e-AI

Renesas RX65N Cloud Kit & Amazon FreeRTOS Make Quick Cloud Connections Easy

Software Tool Chain Ecosystem

New Arm® Cortex®-M33-based RA6M4 MCUs with Superior Performance & Advanced Security

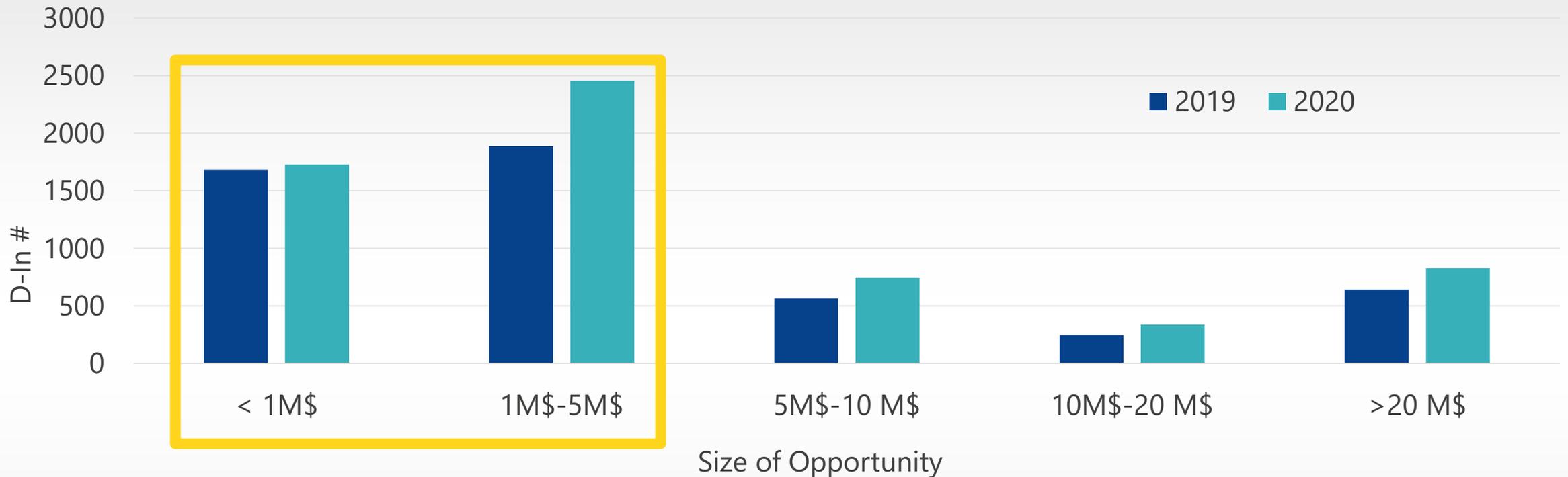
Security

Hardware Attack Methods	Tamper-Resistant Technology
<ul style="list-style-type: none"> Physical Attacks Malfunction-Based Attacks Information Leak Attacks (Side Channel Attacks) 	<ul style="list-style-type: none"> Physical Security Technology Fault Detection Circuit Technology Security Logic Circuit Technology

MAJOR POST COVID-19 TRENDS (A RECAP INTO 2021)

End Market		Products	Pre-CoVID-19	Post-CoVID-19	Current and Long-term Trend
Data Center		Memory Interface, Timing, Core Power	+	++	++
Smart Phone		Wireless Power, OIS	++	+	+
Laptop & Tablet		Display Power, FGIC	+	++	++
Healthcare & Environment		Sensor Signal Conditioning IC, flow sensors, power	+	++	++ Environmental focus
Surveillance, VUI		MPUs and MCUs	neutral	+	++
Rad Hard / Satellite Technology		Rad Hard Analog, RF, Power & MCUs	neutral	+	Focus shifted to LEO satellites

DISTRIBUTION: GROWTH IN DESIGN-IN BY OPPORTUNITY \$



- 17% growth in the < 5 M\$ Design-In funnel shows strong trajectory for mass market strategy
- Growth in mass market achieved as we continued consolidating our TYT distribution from 16 to 6 for IoT and Infrastructure (8 including automotive)

RE-CAP AND STATUS UPDATE OF LAST ANALYST DAY

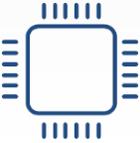
- MCU & MPU ROADMAP UPDATE
- MEMORY INTERFACE
- INDUSTRIAL POWER
- 5G, O-RAN & SATCOM



MCU & MPU ROADMAP UPDATE

- MCU roadmap with RISC-V and e-AI products
- MPU roadmap with deployed DRP

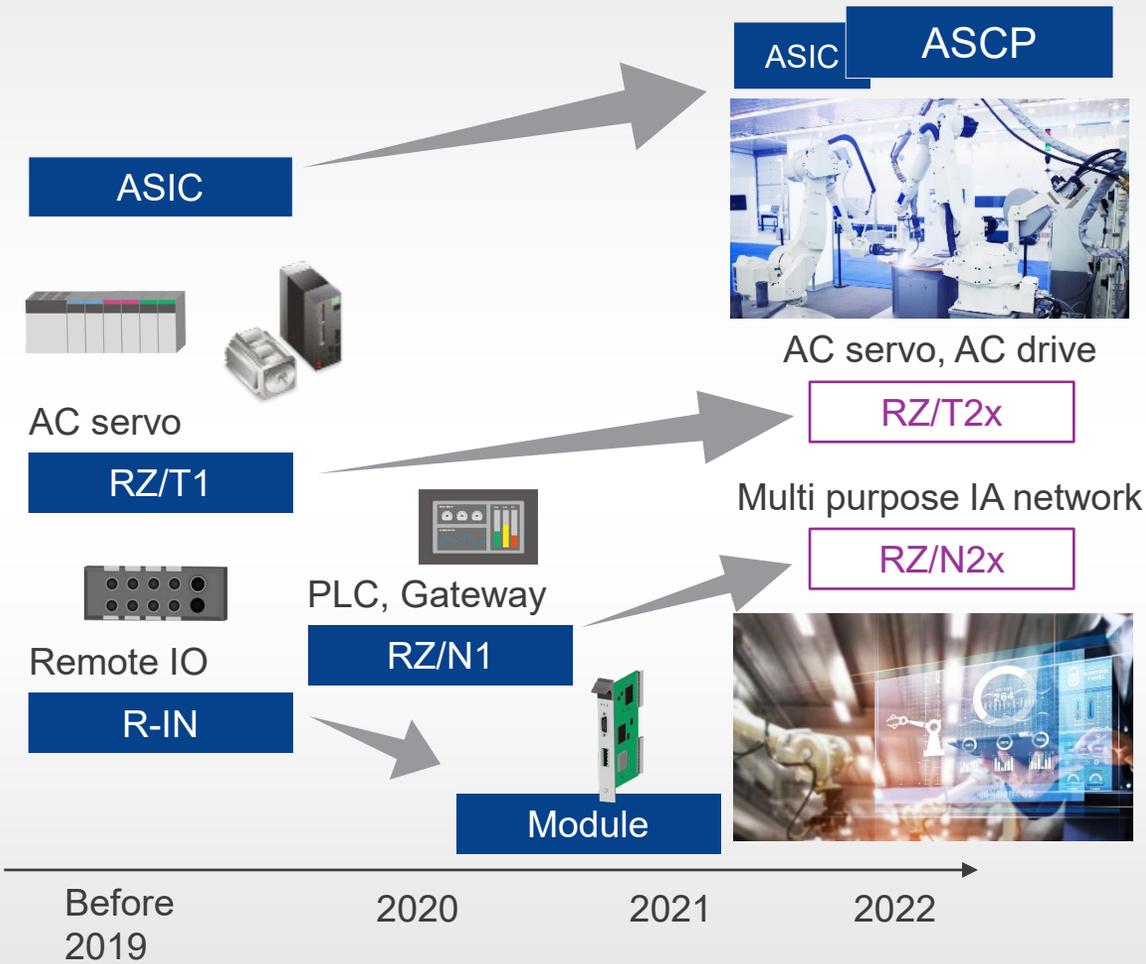
MCU LEADERSHIP...

RENESAS RL78	RENESAS RX	RENESAS RA	Renesas Synergy™ ARM POWERED	RISC-V®
Low Power	Performance	Security	Platform	ASSP
 Low Cost	 Industry Leading Performance	 Top Security Implementation	 Complete SW & HW Solution	 Optimized Motor Control
 Tiny Footprint	 Motor control	 Flexible SW Packages & Ecosystem	 Cloud-Integrated	 All-in-one Voice Recognition
 Broadest Portfolio	 Industrial Interfaces and FuSa support	 Enhanced Cap-Touch	 Short Time to market	 Complete Toolchain & Solution

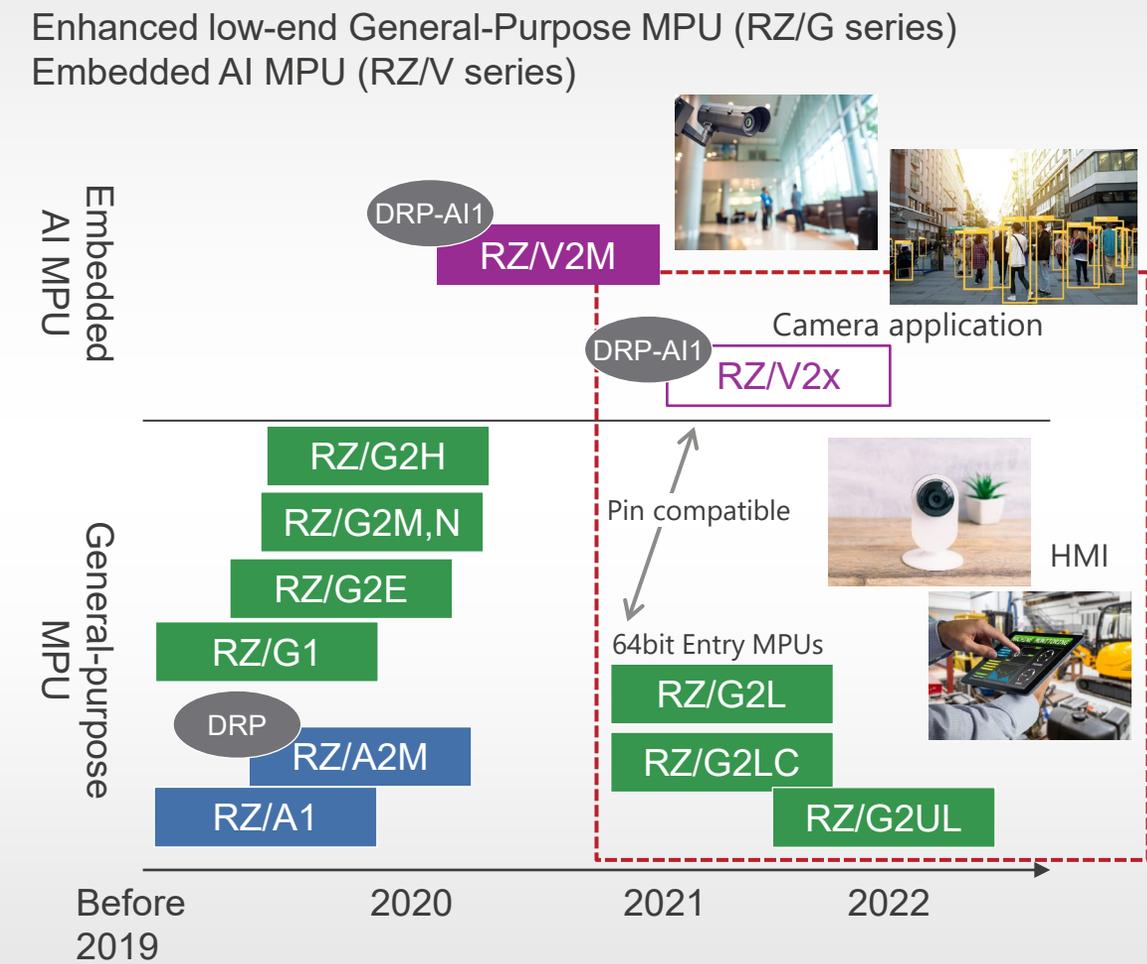
 Consumer	 Smart Home	 Industrial	 IoT	 Robotics	 e-AI
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RENESAS MPU ROADMAP ENHANCEMENT

Industrial Automation ASSP



General-Purpose MPU

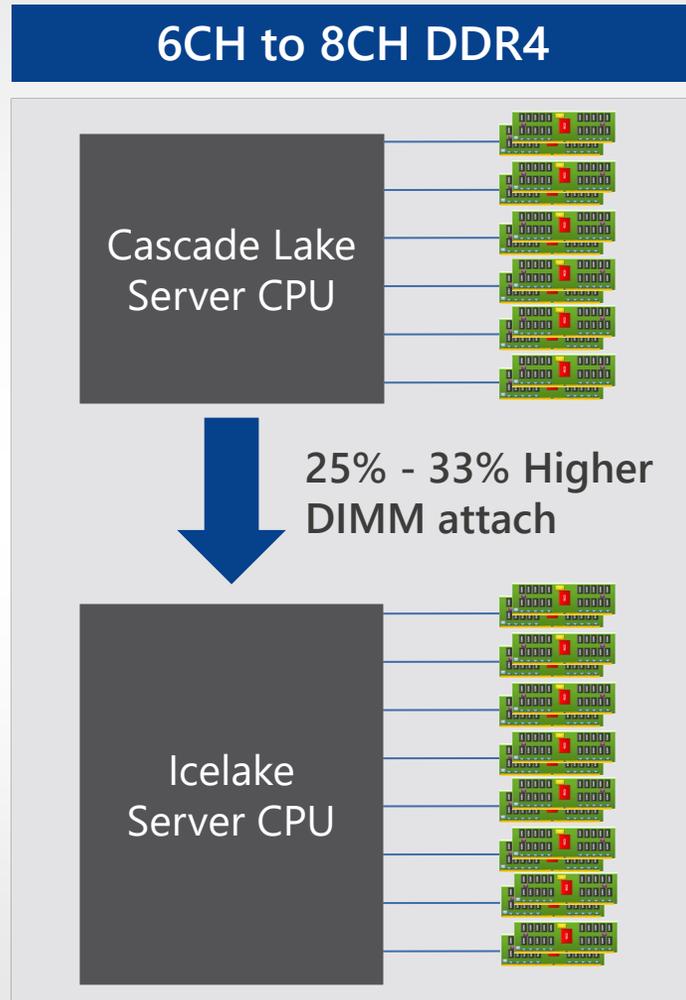


MEMORY INTERFACE UPDATE

- Transition to Icelake the new CPU platform
- DDR5 Update

DDR4-- CONTENT GROWTH WITH NEW CPU PLATFORM

● Qualified



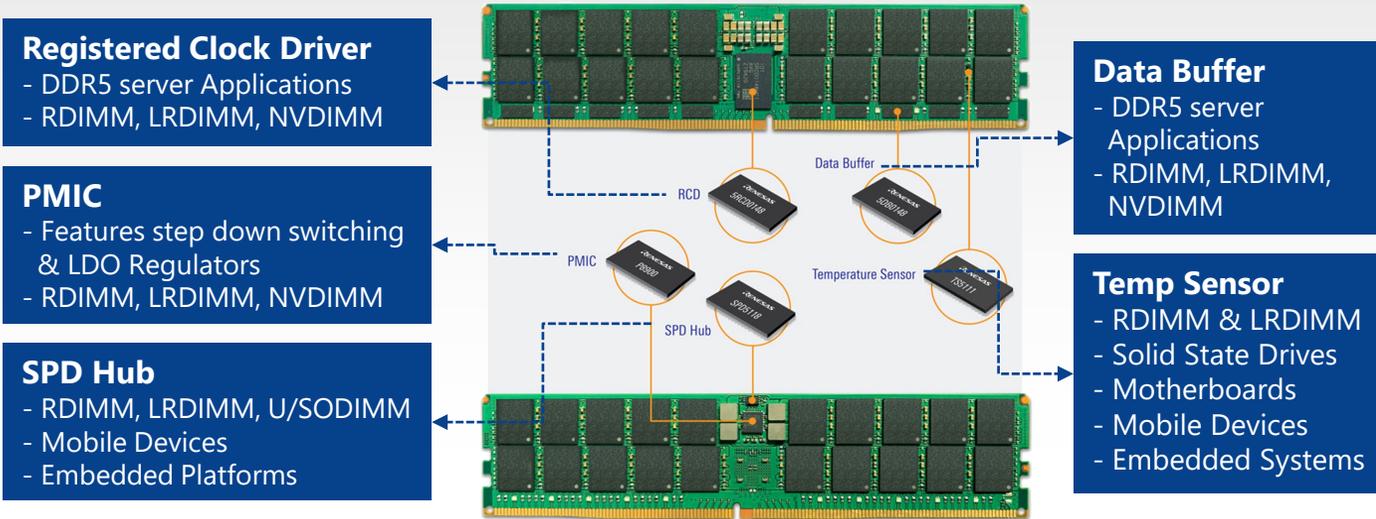
						China CPU #1
Icelake	Milan	Power 9	Thunder X	Emag	Graviton	
●	●	●	●	●	●	●



- Gen 2.5 RCD: + 24% (13Mu) on Icelake in 2021
- Gen 2.5 DB: + 45% (7 Mu) on Icelake in 2021

DDR5 -- CONTENT GROWTH WITH NEW MEMORY

● In Qualification ● Planned



			China CPU #1
Sapphire Rapids	Genoa	Graviton 3	
●	●	●	●

- DDR5 Gen 1 RCD
- DDR5 Gen 1 PMIC (server and client)
- DDR5 Gen 1 SPD Hub (server and client)
- DDR5 Gen 1 Temp sensor
- DDR5 Gen 1 Data buffer

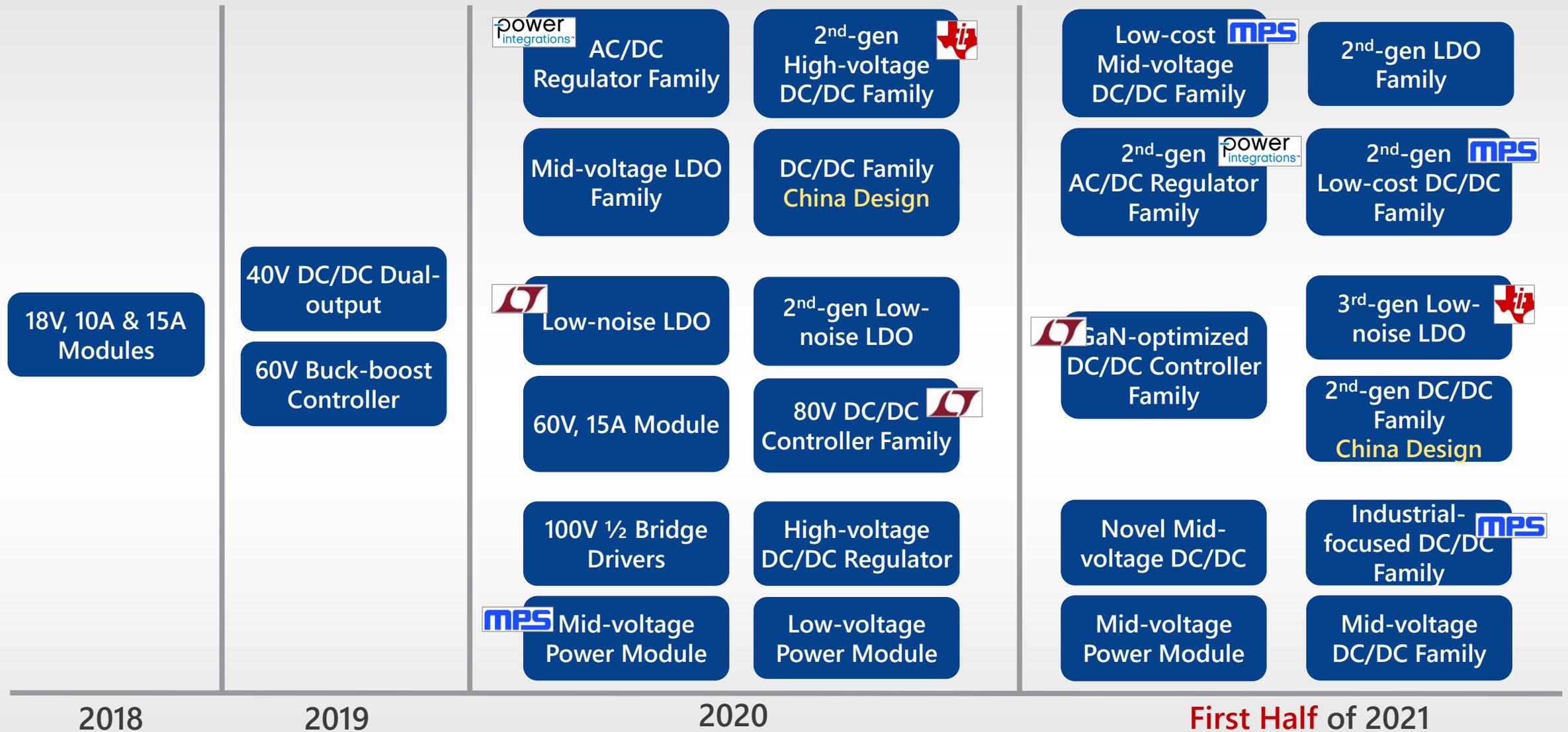


Project Renesas content in 5M+ DDR5 DIMMs in 2021

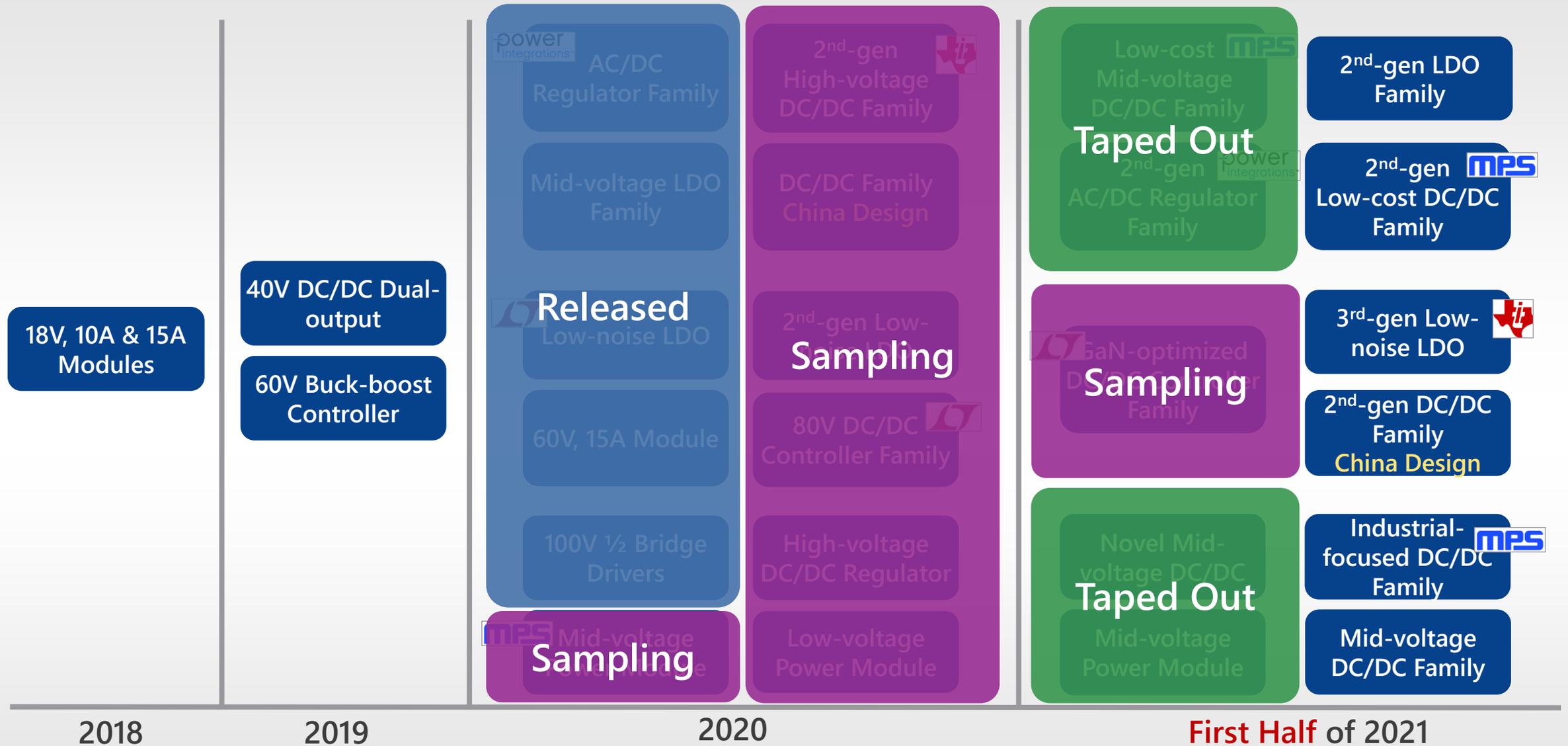
INDUSTRIAL POWER UPDATE

- PROGRAMS ON TRACK

INDUSTRIAL POWER ROADMAP HIGHLIGHTS – \$3B SAM EXPANSION!

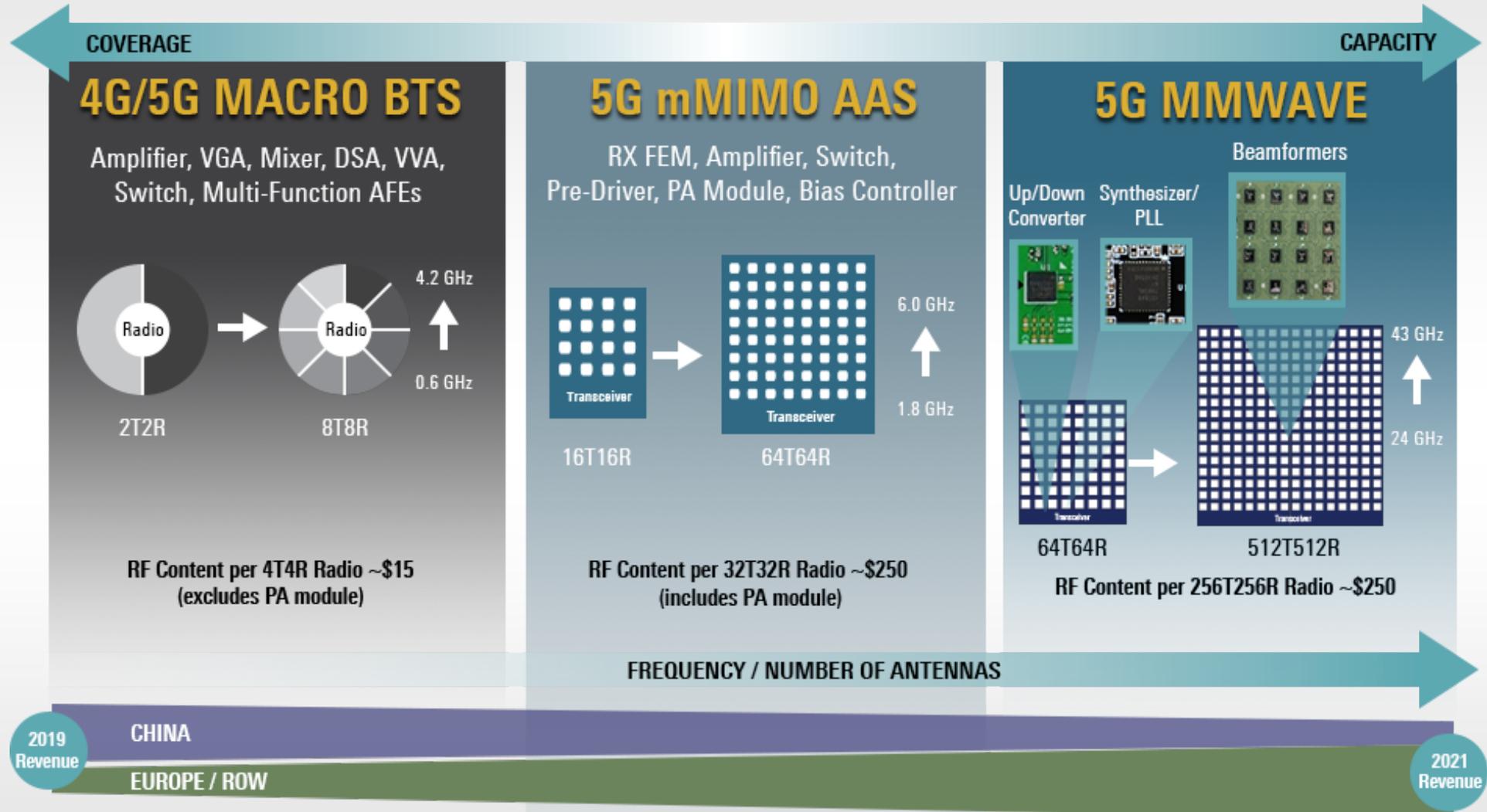


INDUSTRIAL POWER ROADMAP – EXECUTING TO PLAN!



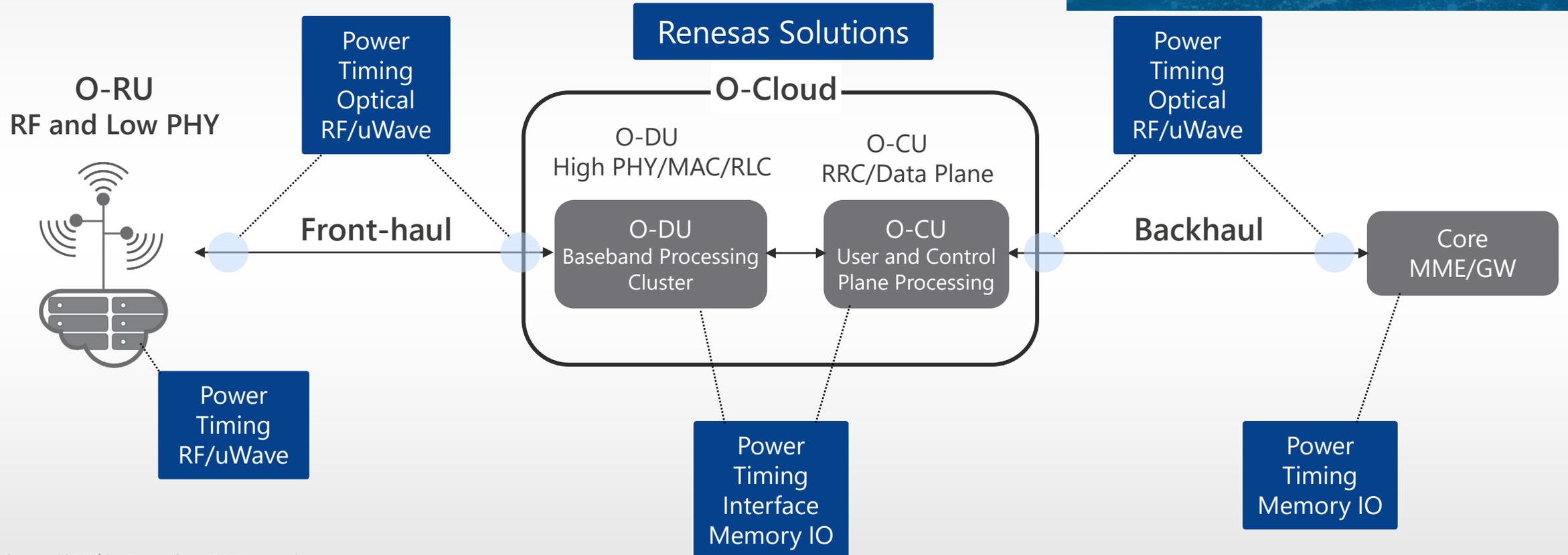
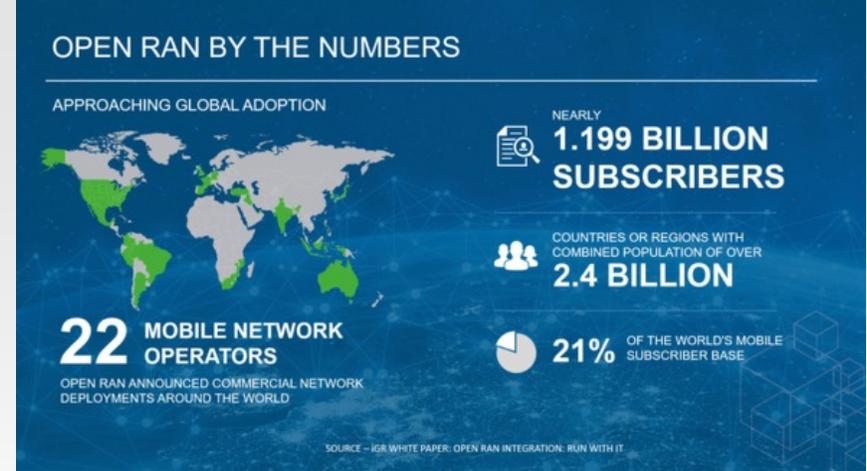
5G, O-RAN AND SATCOM UPDATE

5G -STATUS UPDATE



RENESAS SOLUTIONS FOR O-RAN

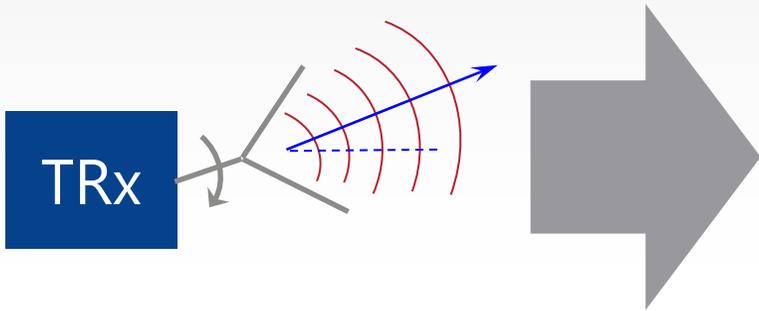
Early engagement with O-RAN solution providers on timing and mmW in US



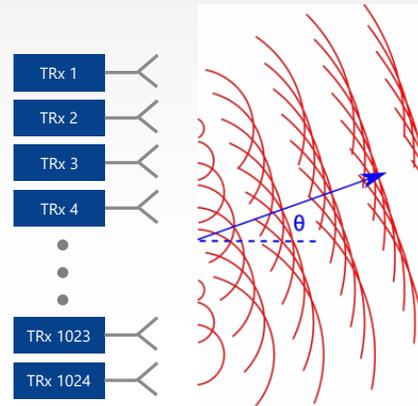
Source: IGR White Paper: Open RAN Integration

SATELLITE COMMUNICATIONS

Ku/a band user terminal
Dish Antenna for GEO



Ku/a band user terminal
Phased Array for LEO



RENESAS

- 1 high power TRx
- Mechanically Steered

**2X more
energy efficient
(bps/watt)**

RENESAS

25X \$Content

- 1024 low power TRx
- Electronically Steered

mmWave, RF, & Timing

Active Beamformers
Synthesizers, VCOs, UDCs¹, Converter
Clocks, Clock Buffers

Processing & Control

MCUs, Interface Drivers

Power Management

Power Modules, PMICs, DC-DCs, LDOs,
Gate Drivers

1- Up/Down Converters

NEW CONTENT GROWTH

- Industry 4.0: Motor Control and Robotics
- End point AI & voice activation
- Wireless power
- Digital power for the data-center

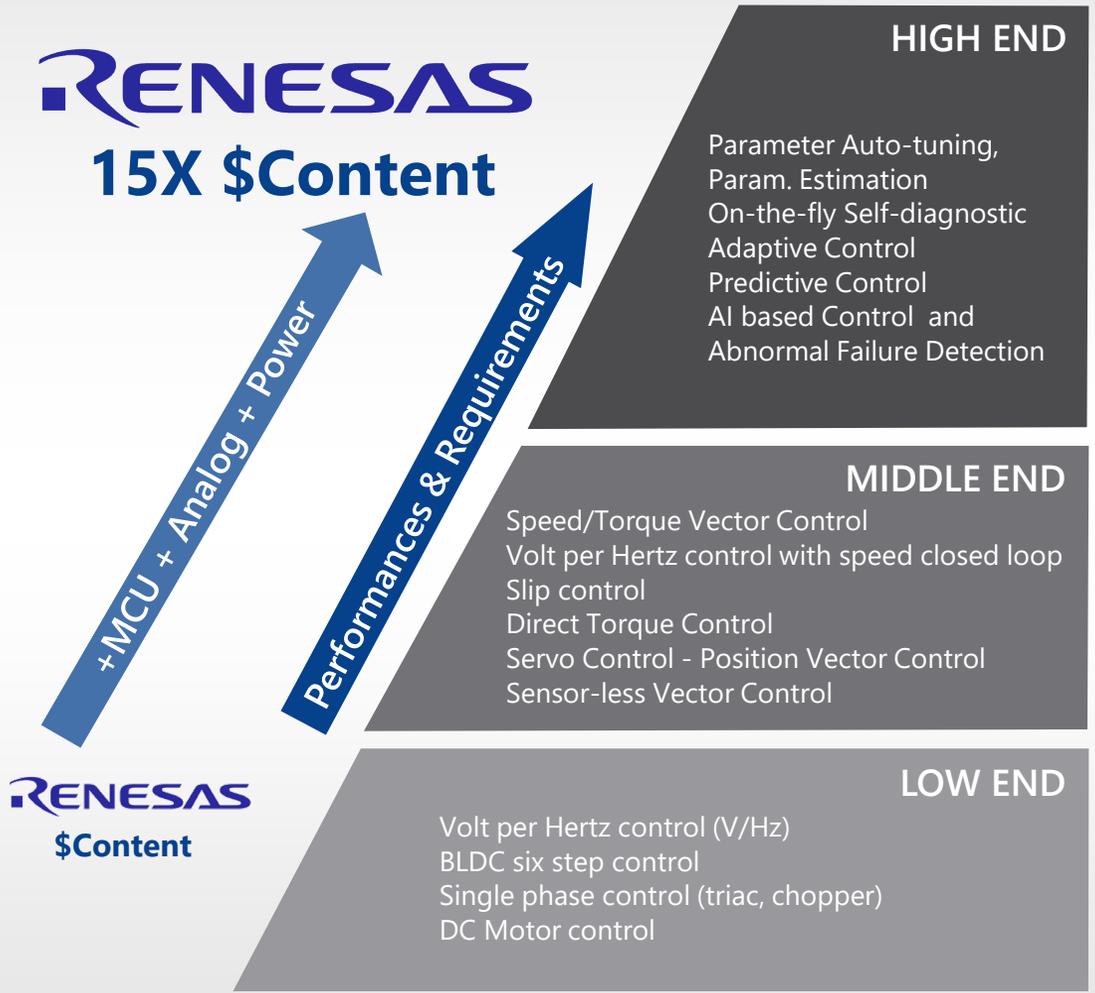


NEW CONTENT GROWTH : INDUSTRY 4.0

MOTOR CONTROL

DIVERSITY OF MOTORS TYPES AND PERFORMANCE RANGES

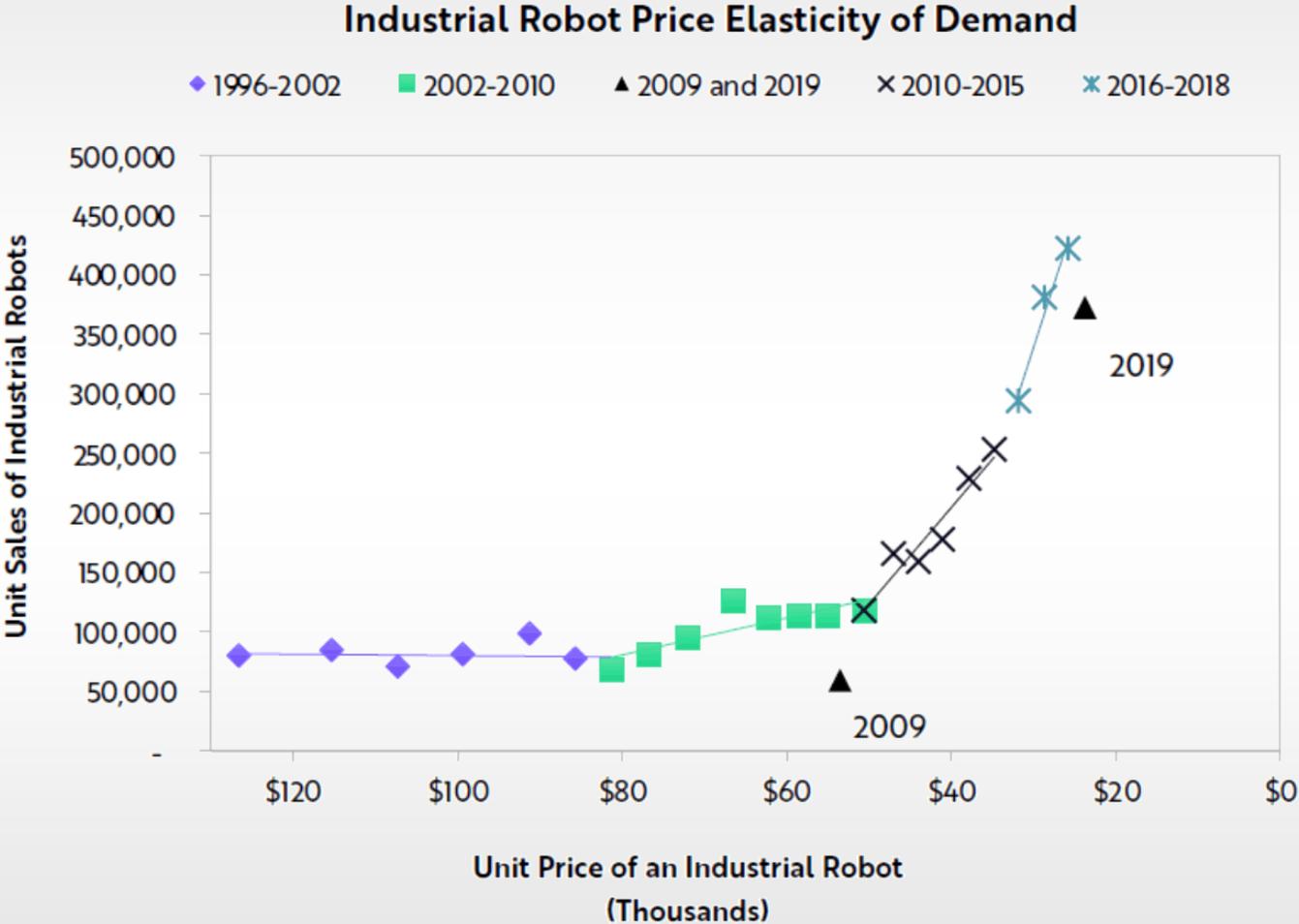
FULL LINE-UP MICROCONTROLLERS AND MICROPROCESSORS WITH ANALOG & POWER



<p>HIGH</p> <p>600MHz AC Servo, EtherCAT RZ/T</p> <p>160MHz RX72T</p> <p>200MHz RA6T2 Cortex M33</p> <p>200MHz RX66T-L/H RXv3 Core Context save Trigonometric function Accelerator</p> <p>120MHz RA6T1 Cortex M4</p> <p>120MHz S5D9 2MB Flash 640KB SRAM</p> <p>120MHz S5D5 120MHz S5D3 Cortex M4</p> <p>RXv2 Core Built-in HOCO Voltage 2.7 ~ 5.5V</p> <p>80MHz RX24U 100 to 144 Pin Up to 512KB Flash 2.7 to 5.5V</p> <p>80MHz RX24T(L/H) 64 Pin Up to 256KB Flash 2.7 to 5.5V</p> <p>Up to 3 x Inverter Control Capability</p>			
<p>MIDDLE</p> <p>48/64/80MHz RA2T1 Cortex M23/33</p> <p>80MHz RX24T 80 to 100 Pin Up to 256KB Flash 2.7 to 5.5V</p> <p>Up to 2 x Inverter Control Capability</p>			
<p>LOW</p> <p>32 and 48 Pin Up to 256KB Flash 2.7 to 5.5V RX23T</p> <p>32MHz RX13T 48 to 64 Pin Up to 128KB Flash 2.7 to 5.5V</p> <p>1 x Inverter Control Capability</p> <p>RL78</p>			
<p>Amplifiers & Buffers</p> <p>Data Converters</p> <p>Smart Analog</p> <p>Other Analog ICs</p> <p>Analog Devices</p>	<p>IGBTs</p> <p>Power Diodes</p> <p>MOSFETs</p> <p>Thyristors</p> <p>Triacs</p> <p>Discrete & Power Device</p>	<p>RS485</p> <p>RS422</p> <p>RS232</p> <p>USB ASSP</p> <p>Communication I/Fs</p>	<p>Battery Management</p> <p>Digital Power</p> <p>LDO</p> <p>MOSFET Drivers</p> <p>Buck, Boost & Buck Boost Converters</p> <p>Switching Regulators</p> <p>Switching Controller</p> <p>PWM Controller ICs</p> <p>Power Supply Support</p> <p>Power Modules</p> <p>Switch Mode Isolated Power Supply</p> <p>Power Management</p>
<p>SoC Motor Driver</p> <p>Smart Pre-driver IC</p> <p>ICs for Motor Driver</p>	<p>Resolver</p> <p>Induction Position Detection</p> <p>ToF - Proximity Sensor</p> <p>Gas Sensor</p> <p>Flow Sensor</p> <p>Humidity Sensor</p> <p>Sensor Signal Conditioners</p> <p>Sensors</p>	<p>Photocouplers/Optocouplers Motor Drive</p> <p>Photocouplers/Optocouplers IC Output</p> <p>Photocouplers/Optocouplers Transistor Output</p> <p>Optoelectronics</p>	

- Support Capabilities – Value Chain**
- Sensored / Sensor-less Solutions
 - E-AI Capable Predictive Maintenance
 - Adaptive Observer / Control
 - FO – Control (Vector Control)
 - Block (BEMF) Control

ROBOTICS & INDUSTRIAL AUTOMATION



Source: ARK Investment Management

ROBOTICS & INDUSTRIAL AUTOMATION

Industry 4.0

Assembly Line
w/Conveyor Belt



Throughput
& efficiency
increased

7 Axis Collaboration
Robot (Cobot)



Throughput
& efficiency
increased

30X \$Content

Next Generation
Cobot



6X \$Content

Machine Vision

Embedded AI MPU,
OIS¹, TOF² Sensors, CIS³

Processing & Control

Advanced MCUs and
MPUs, Safety, Clocks,
Clock Buffers, Interface ICs

Precision Motor Drive

Motor Driver AFEs & SIPs⁴
MCUs, MOSFET Drivers, MOSFETs
Op Amps, I&V Sensors, Temp Sensors,
RDCs, IPS

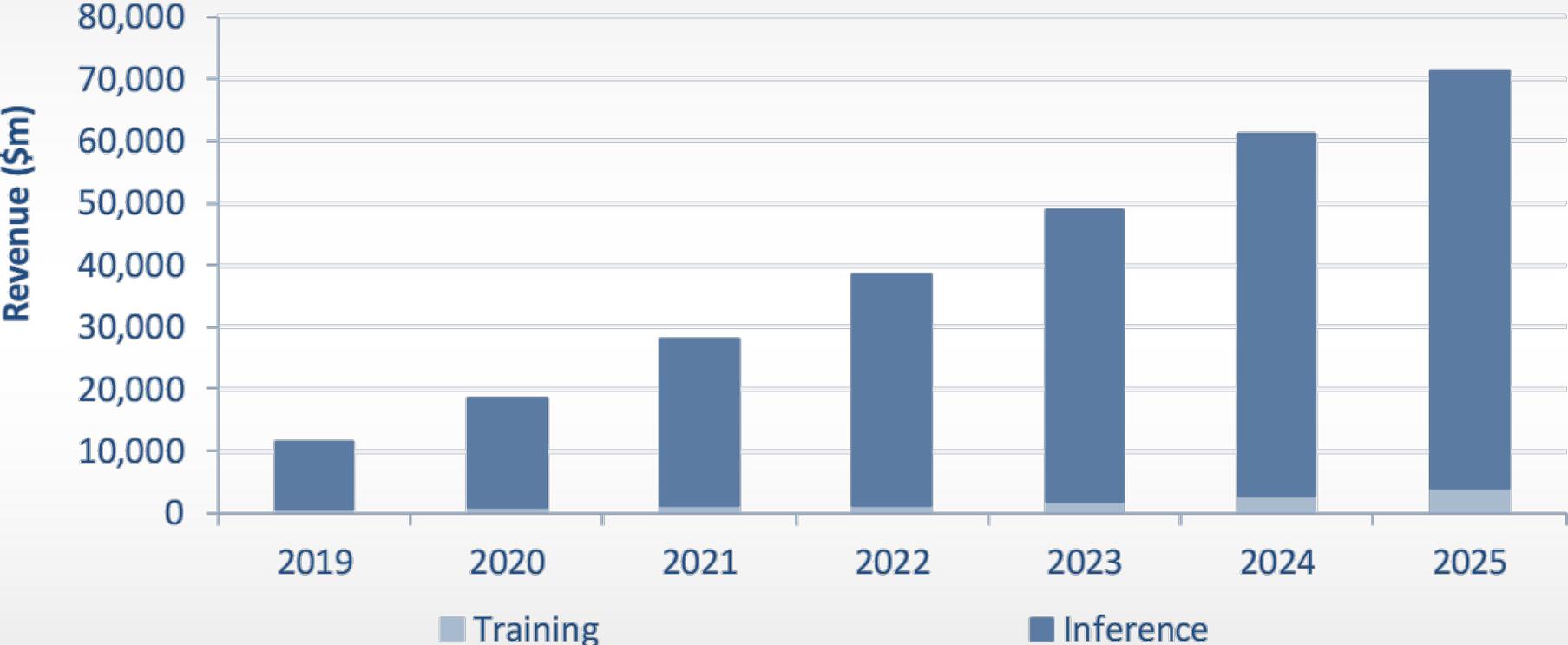
Power Management

DC-DC Buck, PMICs,
Photocouplers, Gate
Drivers, LDOs

NEW CONTENT GROWTH: END POINT AI & VOICE ACTIVATION

POWERING THE ARTIFICIAL INTELLIGENCE OF THINGS (AIOT)!

Deep learning chipset revenue, inference vs. training, world markets: 2019–25



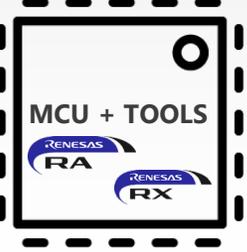
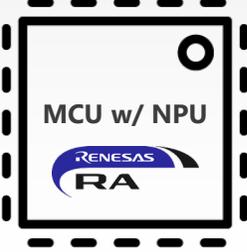
Source: Omdia

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POWERING THE ARTIFICIAL INTELLIGENCE OF THINGS (AIOT)!

TODAY

NEXT

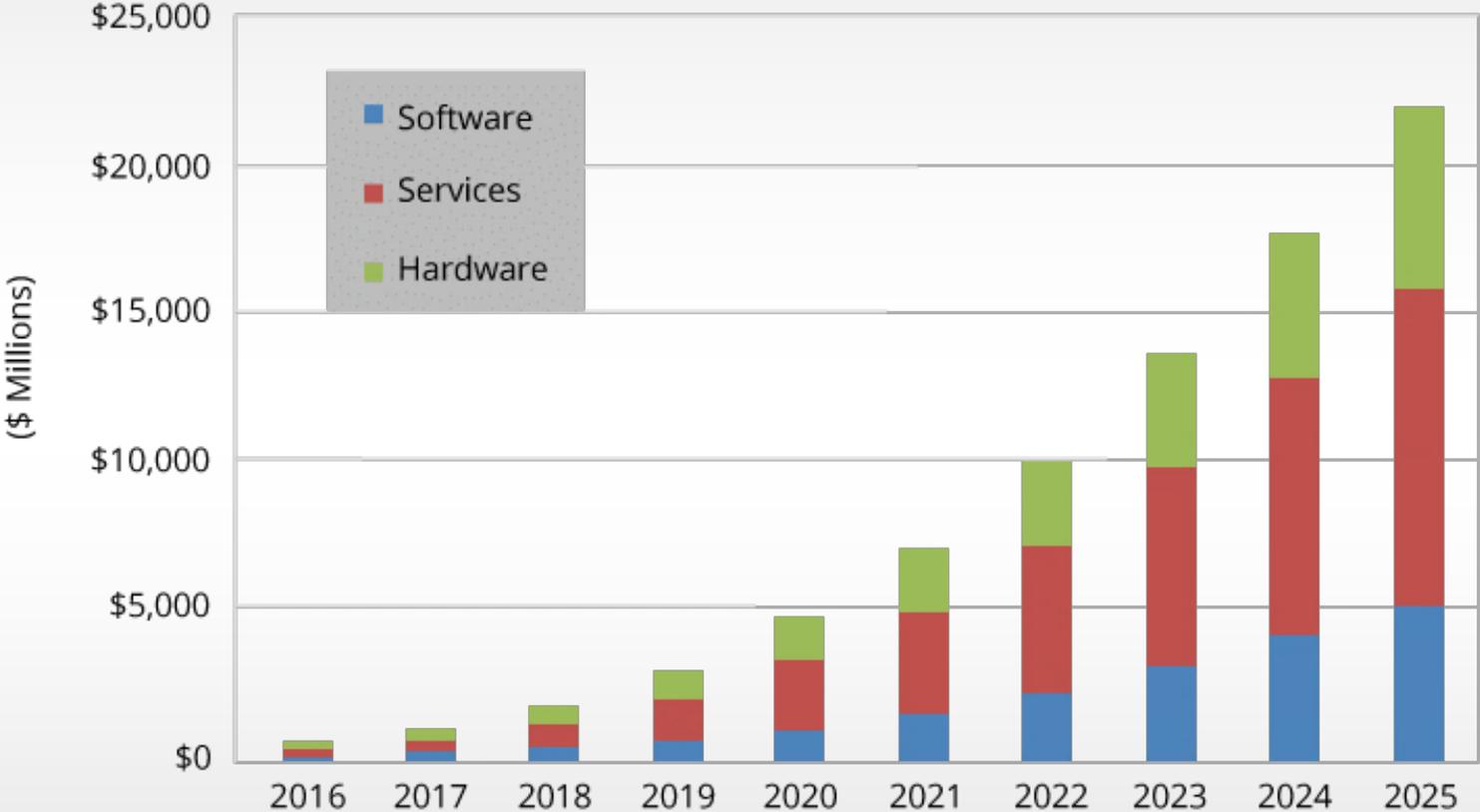
EMBEDDED AI @ ENDPOINTS	<h3>CPU INFERENCE</h3>  <p>RENESAS e-AI TOOL-SUITE PARTNER M/W + TOOLS</p>	<h3>HW ACCELERATION</h3>  <p>NEURAL PROCESSING UNIT (NPU) PARTNER M/W + TOOLS</p>
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AI @ the EDGE	<h3>ENTRY CLASS AI</h3> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid gray; padding: 5px;"> <p>Existing Apps. AI by CPU</p>  <p>RZ/Gx: AI by CPU Cortex® -A55</p> </div> <div style="border: 1px solid gray; padding: 5px;"> <p>Existing Apps. DRP</p>  <p>RZ/A2M Cortex® -A9</p> </div> </div>	<h3>HIGH PERFORMANCE AI</h3> <div style="border: 1px solid gray; padding: 5px;"> <p>Existing Apps. DRP-AI</p>  <p>AI ACCELERATOR DRP-AI</p> </div>
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AI ECOSYSTEM	      
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VOICE RECOGNITION

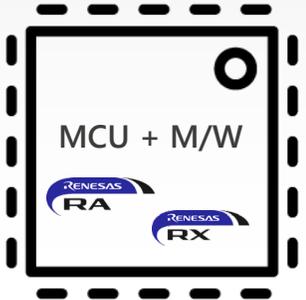
Natural Language Processing Total Revenue by Segment, World Markets: 2016-2025



Source: Tractica

VOICE RECOGNITION

VOICE now preferred USER INTERFACE as COMPUTING & INTELLIGENCE @ the EDGE explodes!

TODAY	2+ YEARS	5+ YEARS
 <p>MCU + M/W</p> <p>SPEECH RECOGNITION</p> <p>MCU VOICE PERIPHERALS + AI M/W</p> <p>30+ LANGUAGES & ACCENTS</p>	 <p>VOICE ASSP</p> <p>SPEECH RECOGNITION</p> <p>PURPOSE-BUILT PROCESSOR</p> <p>CONCURRENT MULTI-LANGUAGE SUPPORT</p>	 <p>AI MCU</p> <p>CONVERSATIONAL AI</p> <p>PROCESSOR W/ AI ACCELERATION</p> <p>INTENT + LANGUAGES</p>

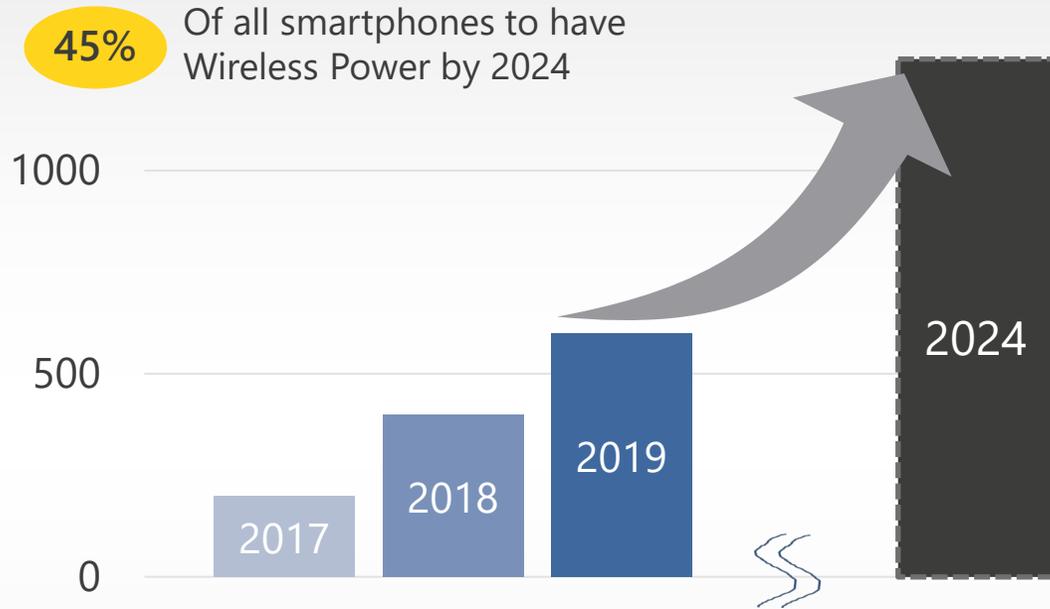
VOICE ECOSYSTEM



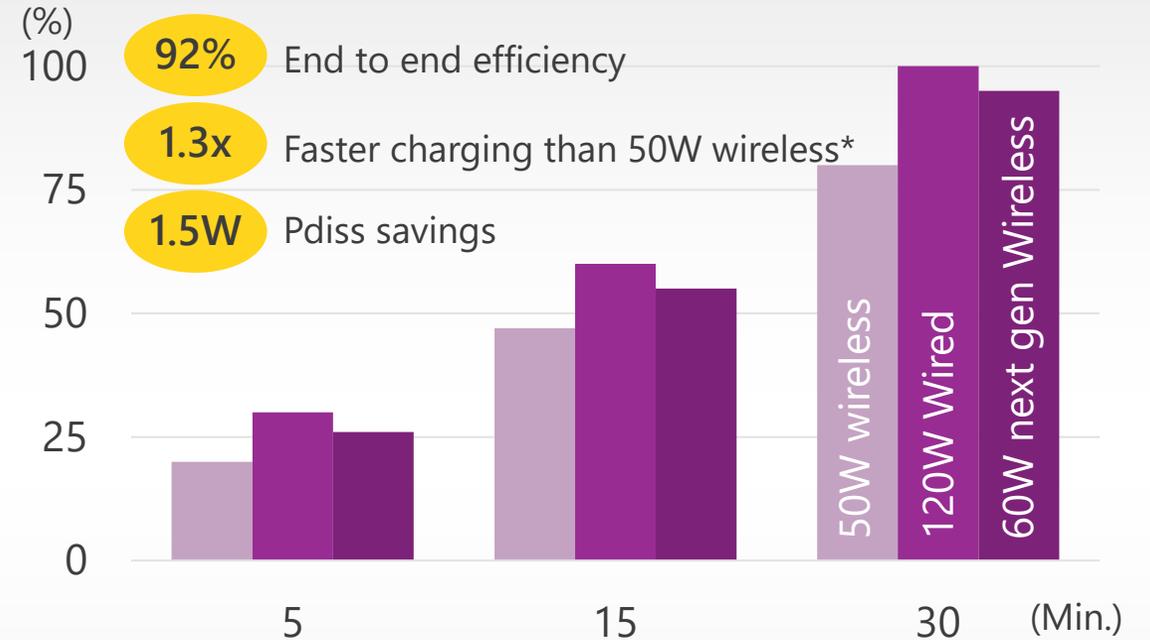
NEW CONTENT GROWTH: WIRELESS POWER

WIRELESS POWER – PROLIFERATION VIA FAST CHARGING

Global Qi RX+TX shipments,
Wholesale unit volumes, Mu†



Charging time vs Battery %
Wired vs Wireless



Penetrating New Attractive Markets - End to End solution for broad range of applications



†Source: Strategy Analytics, Renesas Electronics

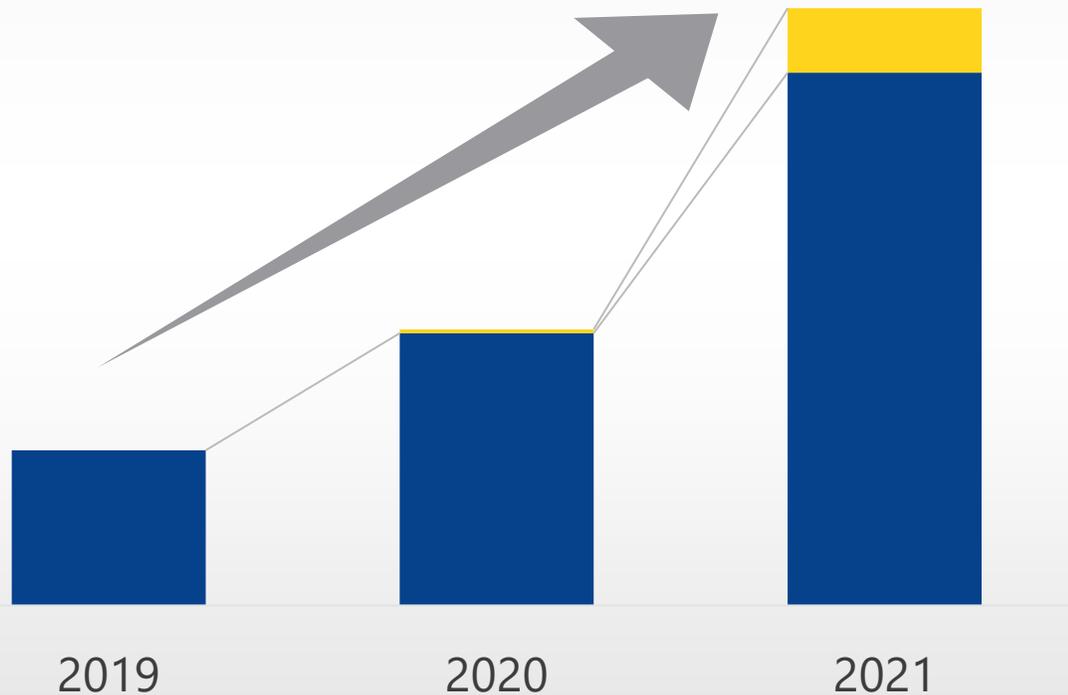
50W wireless and 120W wired charging based on commercially available phones and published reports for 4500mAh battery
*projected with 60W wireless charging vs 50W wireless.

NEW CONTENT GROWTH: DIGITAL POWER FOR THE DATA-CENTER

MAINLINE SERVER POWER REVENUE GROWTH

Power Revenue

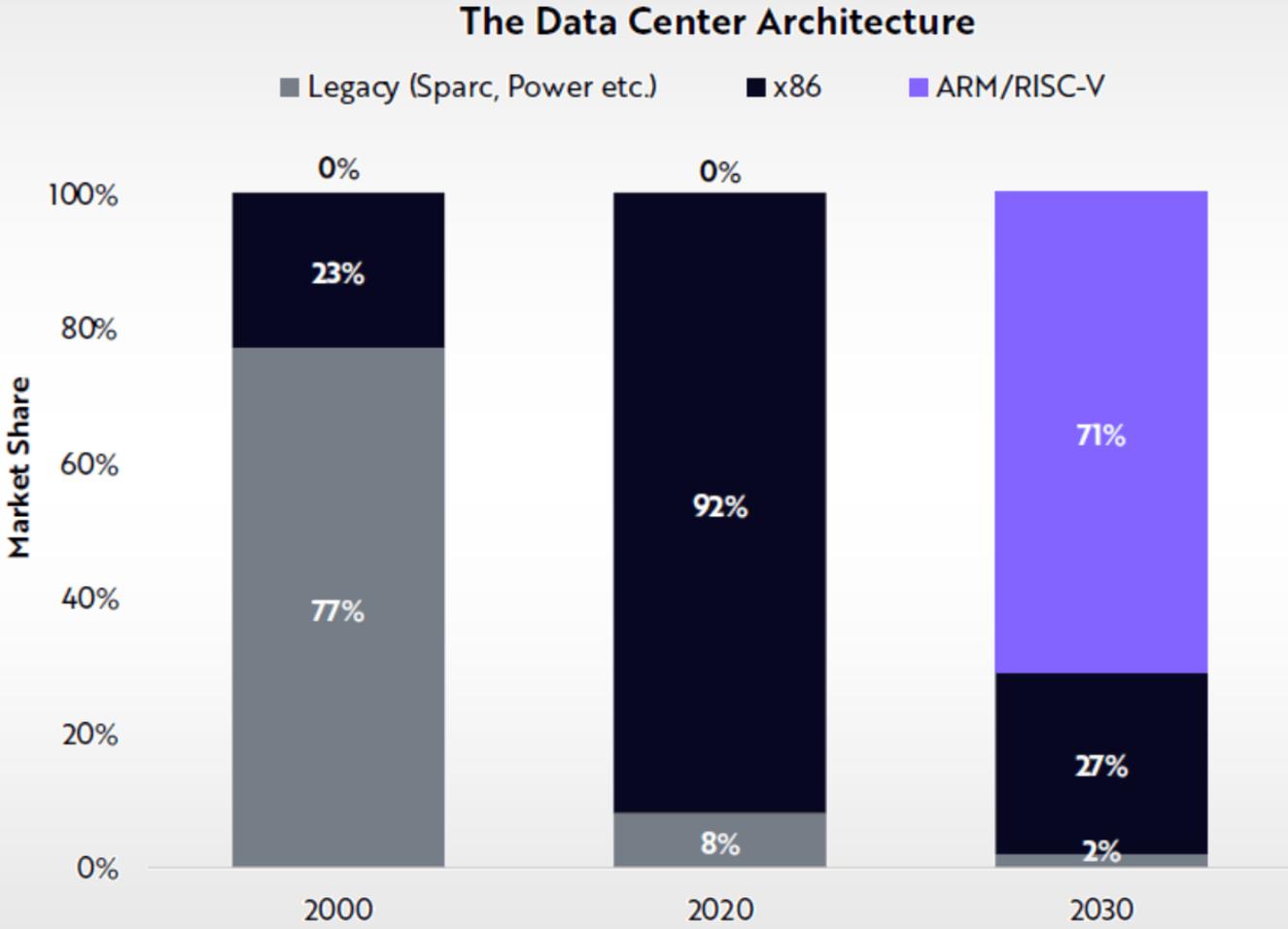
■ Core Power ■ DDR5 PMIC



96% CAGR in server power revenue

Server Power TAM 10% CAGR

MAINLINE SERVER POWER CONTENT GROWTH POTENTIAL



Source: ARK Investment Management

MAINLINE SERVER POWER CONTENT GROWTH POTENTIAL

 BOM Opportunity	Current Generation (e.g. VR13.HC)	NEXT Generation (e.g. VR14)
	38x Digital Controllers and Power Stages > \$52.00	48x Digital Controllers and Power Stages 48V Front end controllers + drivers > \$68.00
	46x Digital Controllers and Power Stages > \$60.00	48x Digital Controllers and Power Stages 48V Front end controllers + drivers > \$68.00
 ARM-based and workload optimized CPUs	38x Digital Controllers and Power Stages > \$50.00	44x Digital Controllers and Power Stages > \$56.00

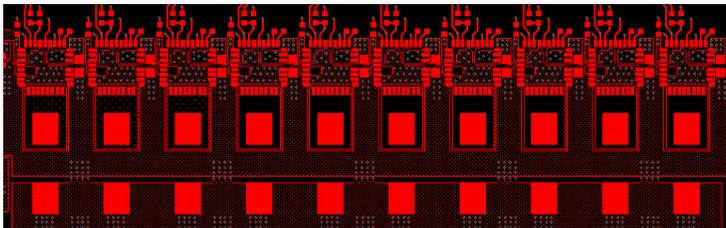
- Next Generation CPUs across all OEMs pushing current and power envelope >20%
- Exponential growth in AI accelerator cards and ARM-based/workload optimized CPUs adds significant power content
- Dramatic increase in power density leading to increased usage in conversion content 48V/54V → POL

Renesas offers full 'end to end' solution for datacenter

SOLVING DATACENTER POWER DENSITY CHALLENGES

Next-gen datacenter processors can draw more than 1000 amps, and are increasingly power supply constrained

Digital multiphase + power module technology = Next-gen high-density power solutions



Renesas multiphase power stage
23 amps per cm²



2022 target:
66 amps per cm²

3x datacenter power stage SAM expansion!

A 1% efficiency difference would equate to nearly a Terrawatt of global power savings

WINNING COMBOS TWO EXAMPLES

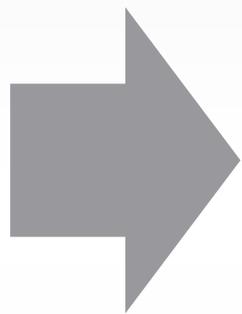


VACUUM APPLIANCES

Vacuum Cleaner
AC Motor 1800W



Vacuum Cleaner
BLDC Motor 650W



RENESAS

RENESAS

15X \$Content

Same airflow for 1/3
the electrical power!

Motor Drive

Motor Drive SIP *
MCU, MOSFET Drivers, MOSFETs
Op Amps, Photocouplers

Battery Pack

Battery Management System
(Fuel Gauge & Cell Balancing)

Battery Charging

DC-DC Buck, DC-DC Boost, LDOs
Wireless Charging Tx/Rx

* System in Package (Argos)

MOBILITY SOLUTION

Electric Scooter
24V BLDC Motor 100W



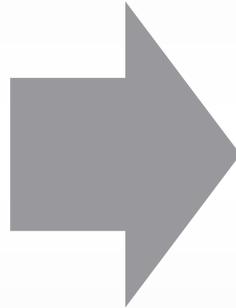
RENESAS

E-Scooter
48V BLDC Motor 1600W



RENESAS

7X \$Content



Motor Drive

Motor Drive IC
MCU, MOSFET Drivers
Op Amps, Power Management

Wireless Control

Bluetooth Low Energy

Battery Pack

Battery Management System

Battery Charging

Power Management,
Wireless Charging Transmitter / Receiver

SUMMARY

- Our growth drivers across our business remain solid
- The post COVID trends observed in 2020 are largely intact for 1H/2021
- We continue to drive content expansion in multiple areas
- Our Winning Combos continue to fuel growth opportunities
- We are on track with plans shared at our earlier strategy reviews
- Objective is to continue to outpace market growth rate in areas of investment

[Renesas.com](https://www.renesas.com)