

Smart IIoT Solutions

RF GaN PA Module for 5G Base Station

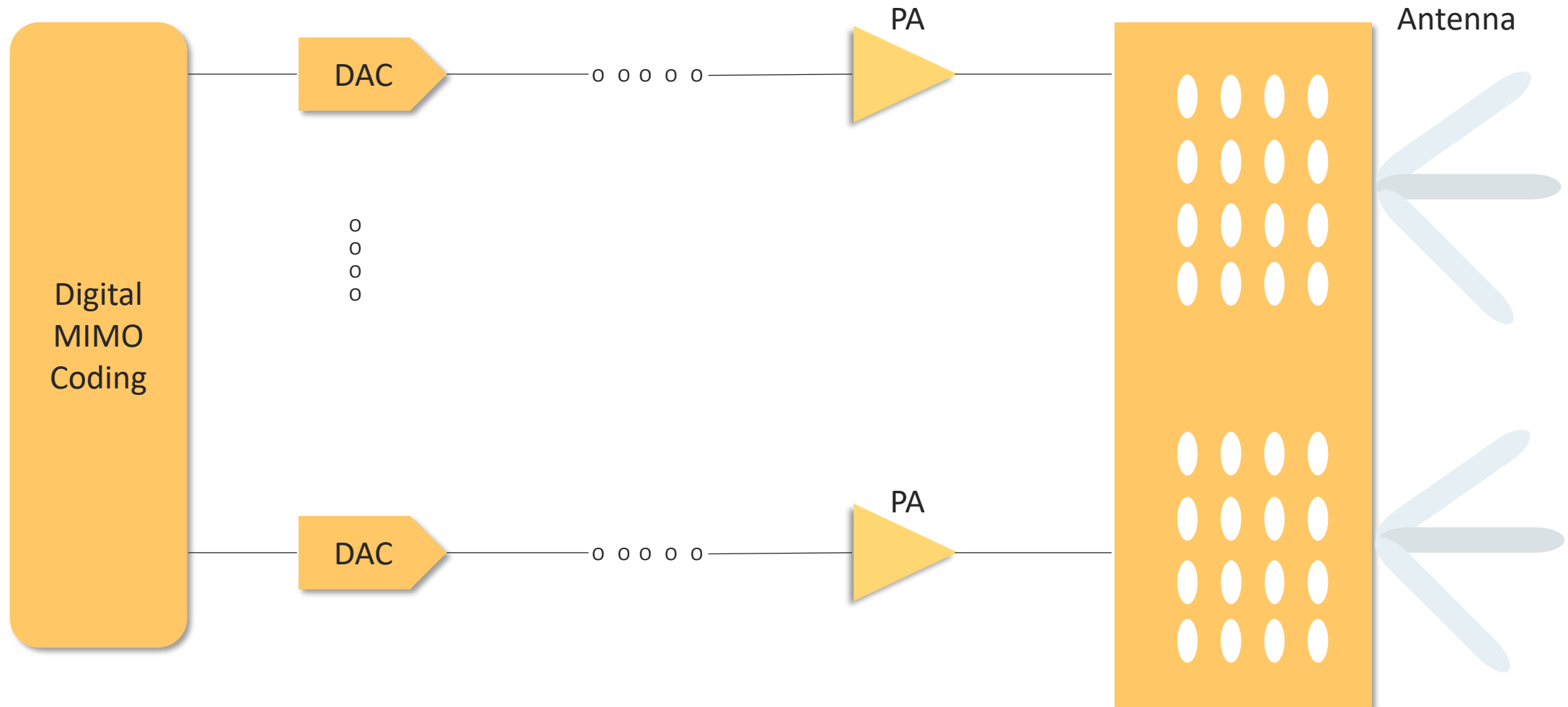
楊良吉 Jim Yang

Marketing and Application Division

Senior Technology Manager

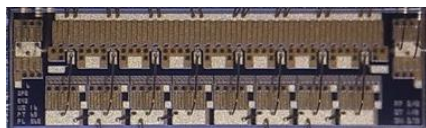


| 5G RF PA (Power Amplifier)



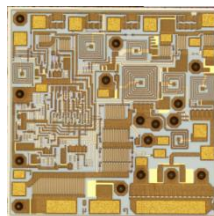
| Nuvoton RF-GaN PA Module

GaN



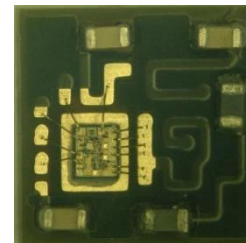
GaN HEMT on Si

GaAs



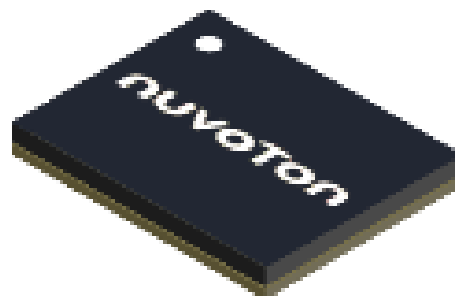
BiFET (HBT+HEMT)

Module



Multilayer plastic PKG

5G_{sub6} PA Module



Market Activity

First 5G PA Module in Japan

(Deployed for subscription service in Q2 / 2020)

- **2019 RUGBY WORLD CUP**
- **2020 TOKYO**



UN0HD-SERIES

UN0HD374 - 3.6 to 3.8GHz

UN0HD464 - 4.5 to 4.6GHz

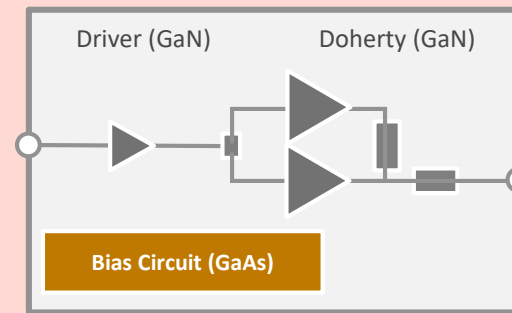
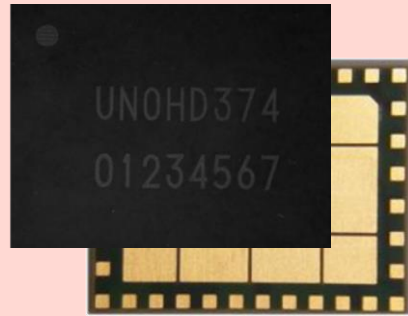
3-stage GaN Power Amplifier.
with bias circuit for GaN.



International Stadium, Yokohama, Japan

| Nuvoton PA Module for RAN

Sub-6GHz highly integrated PA module



- ✓ Driver and Doherty Amp.
- ✓ 50 ohm matching circuit
- ✓ Bias circuit (optional)
- ✓ 4.9GHz Band support

1 Capacity

5G NR Sub-6GHz

Wide band, High efficiency

2 Compact

Highly integrated

Doherty, Driver & Bias circuit

3 Coverage

High Power

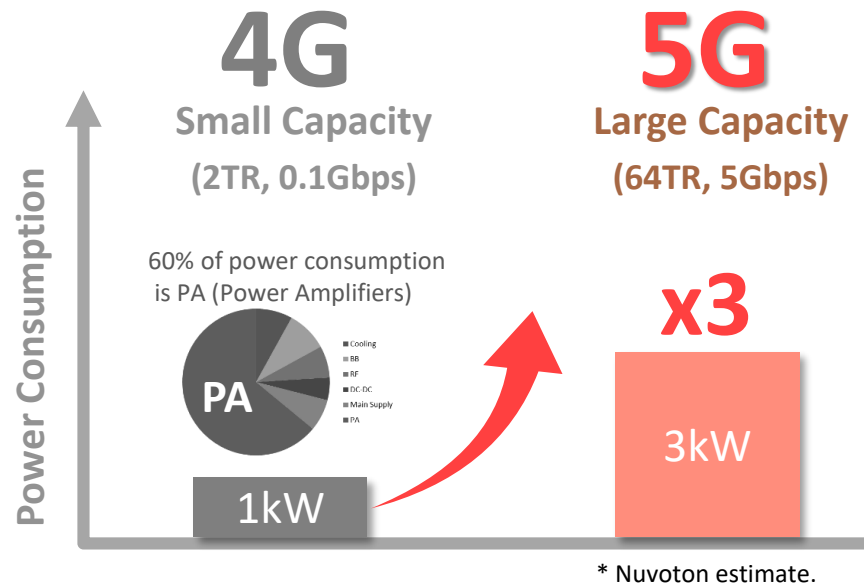
16W to cover suburb

| Proposal – ① Capacity

✓ 5G RAN issue

Large capacity requires
high power consumption

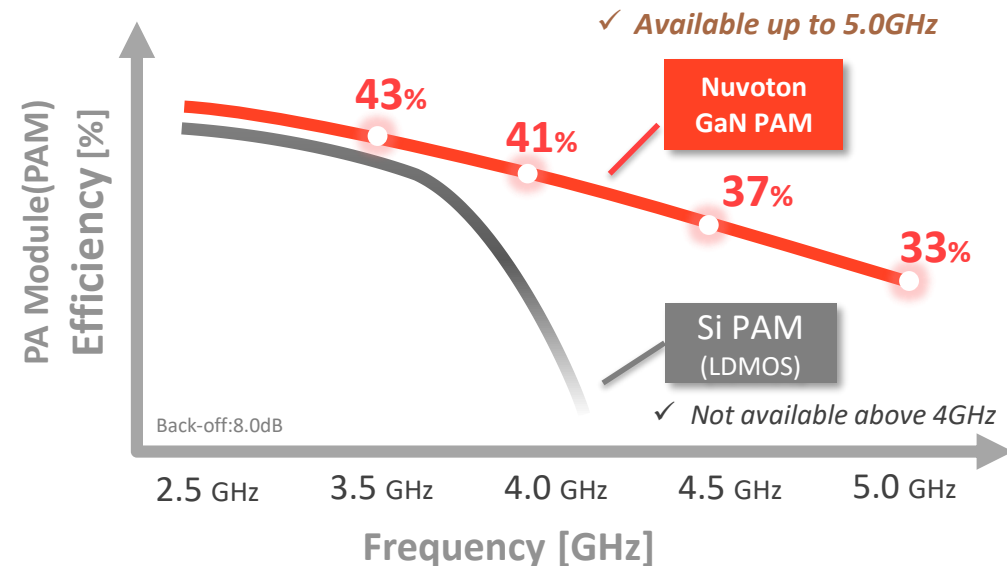
3x power consumption



✓ Nuvoton Proposal

Reduce power consumption

Helps reduce power consumption



I Proposal – 2 Compact

✓ 5G RAN issue

Requires compact radio units

Small Cells
to be installed anywhere.



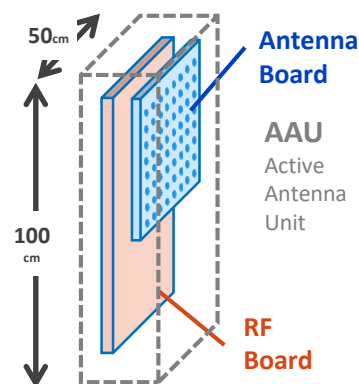
✓ Nuvoton Proposal

Compact unit size

Helps make radio unit smaller

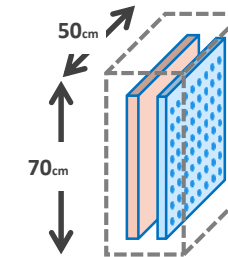
with Discrete PA

- ✓ Only Doherty Amp.
- ✓ Without matching circuit
- ✓ Without bias circuit



with Nuvoton PA Module

- ✓ Driver and Doherty Amp.
- ✓ 50 ohm matching circuit
- ✓ **Bias circuit**



30% Reduction

* Nuvoton estimate.

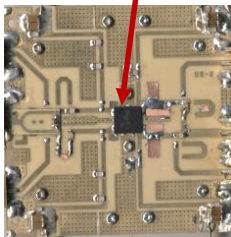
Proposal – 2 Compact

✓ 5G RAN issue

RF design complexity

Requires RF circuit &
tuning for Power supply

with Discrete PAs



RF Board of radio unit

- ✓ Only Doherty Amp.
- ✓ Without matching circuit
- ✓ Without bias circuit

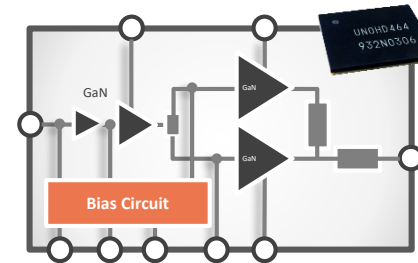
- ✓ Requires matching circuit
- ✓ Power supply tuning

✓ Nuvoton Proposal

Compact & simple RF design

Available without tuning

with Nuvoton PAM



- ✓ Driver and Doherty Amp.
- ✓ 50 ohm matching circuit
- ✓ Bias circuit

Tuning Free

Simply connect with a 50Ω line

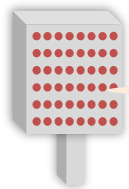
I Proposal – ③ Coverage

✓ 5G RAN issue

Narrow coverage
with high band

5G bands difficult to reach

4G



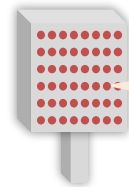
2.5GHz

Easier to reach



5G

bands difficult to reach



3.5GHz

Range shortened by 30%

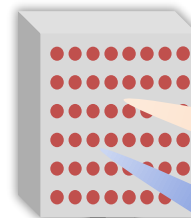


✓ Nuvoton Proposal

Wide coverage
with high power PAM

16W PAM for suburban area
that requires wide coverage

mMIMO



with 16W PAM

With 8W PAM



| Target Application

- Focus on “Massive MIMO” and “Small Cell, Local 5G”

Massive MIMO Base station



Area : 0.5 to 1.0 km

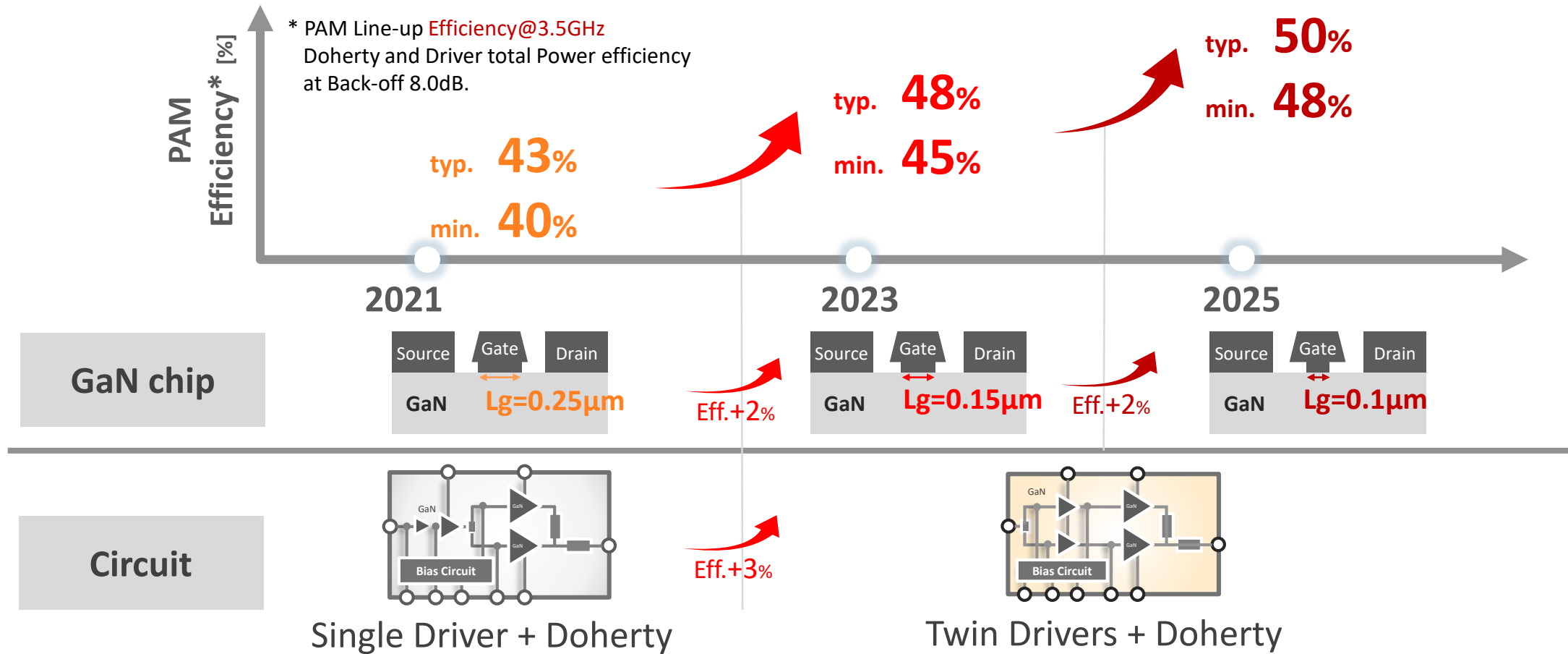
Small Cell, Local 5G Base station








Area : 0.2 km

Technology Roadmap

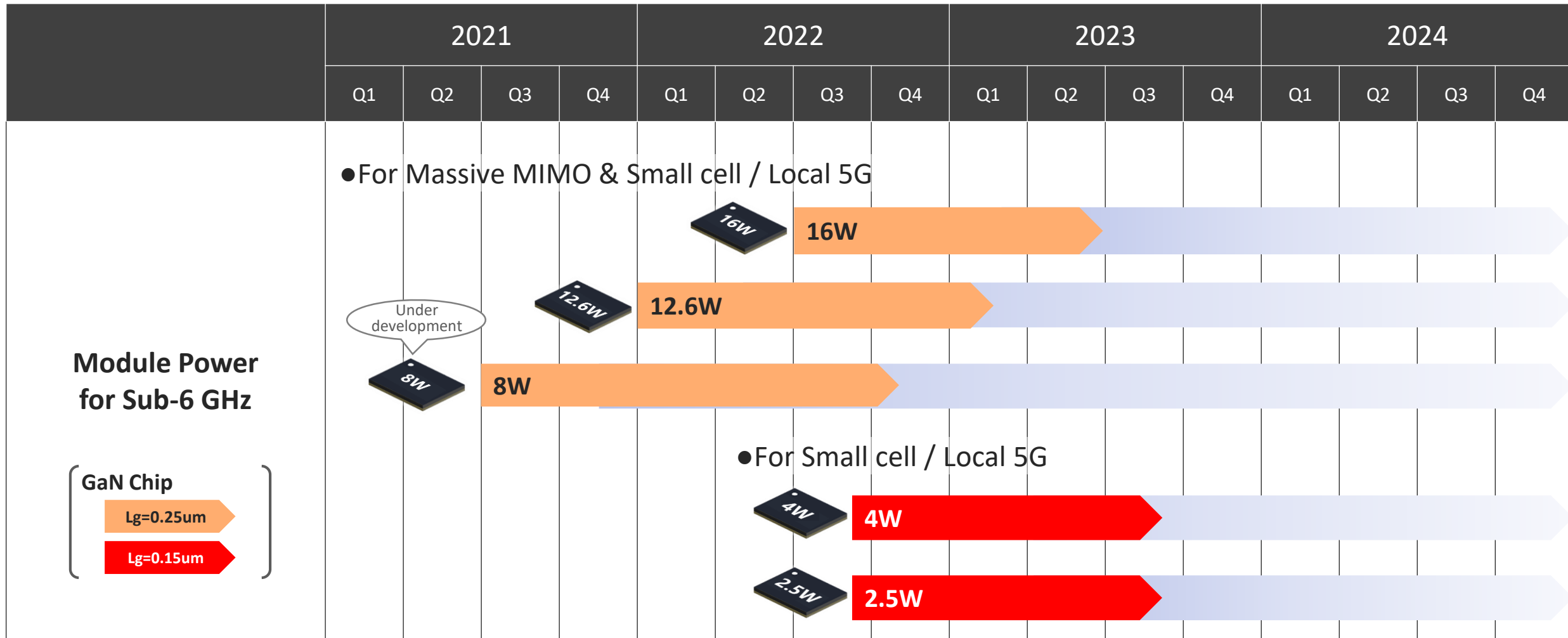
- High efficiency by GaN with finer gate and Twin drivers



Development Schedule

		2022												2023		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
 KU0HC358 3.3-3.8GHz	Previous			▼ WS	▼ ES				▼ CS		▼ MP					
	Latest					▼ ES					▼ CS		▼ MP			
NEW  KU0HC388 3.7-3.98GHz	Latest						▼ WS	▼ ES				▼ CS		▼ MP		
 KU0HC478 4.5-4.9GHz	Previous			▼ WS	▼ ES				▼ CS		▼ MP					
	Latest					▼ ES					▼ CS		▼ MP			
 KU0HC35C 3.3-3.8GHz	Previous			▼ WS		▼ ES					▼ CS		▼ MP			
	Latest								▼ ES					▼ CS		▼ MP
 KU0HC47C 4.5-4.9GHz	Previous					▼ WS		▼ ES			▼ CS		▼ MP			
	Latest								▼ ES					▼ CS		▼ MP

Product Roadmap



Note)
 Left edge = First Sample  Right edge = Mass Production

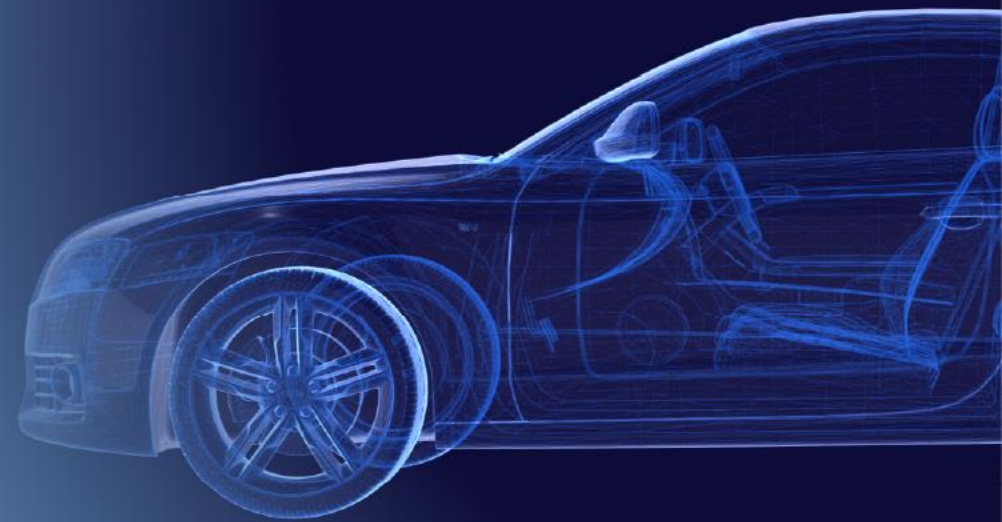
Automotive Solutions

- **Human Machine Interface Display LSIs (Gerda[®] Series)**
- **3D ToF**

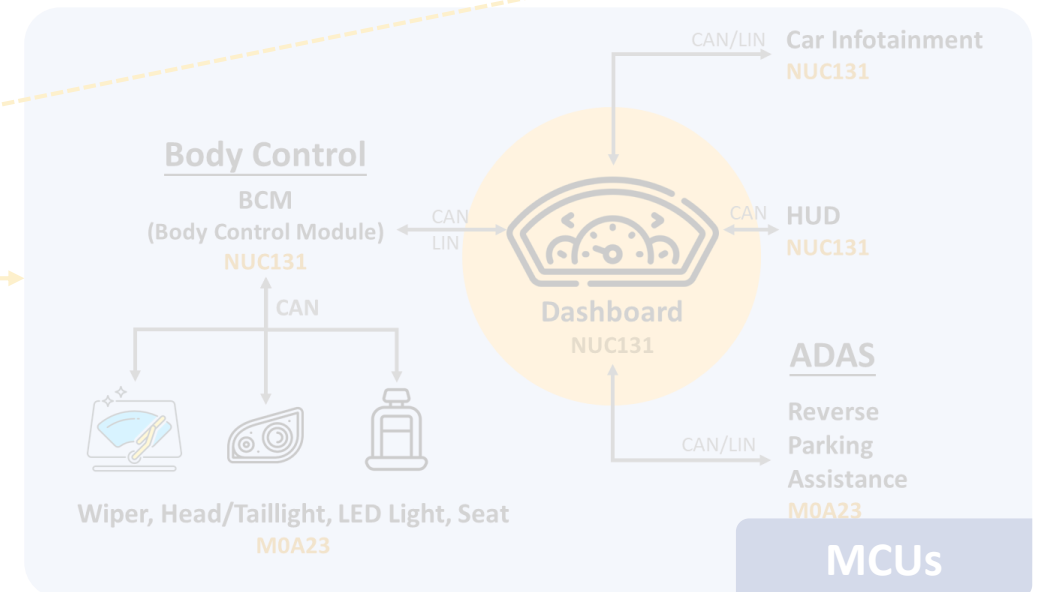
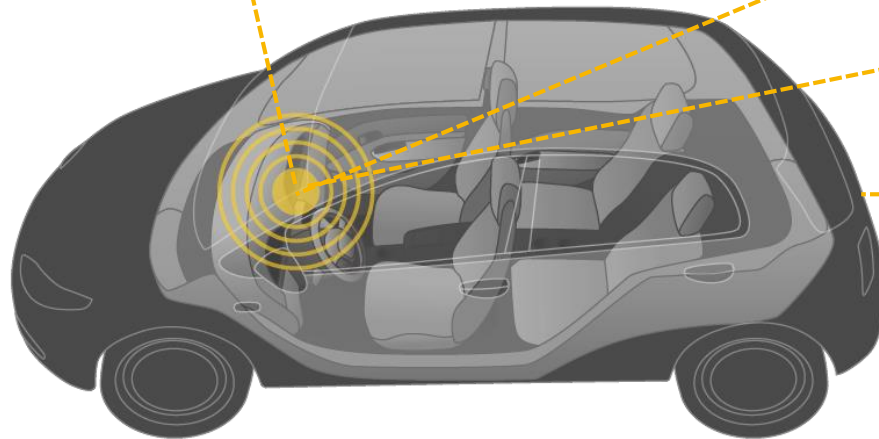
楊良吉 Jim Yang

Marketing and Application Division

Senior Technology Manager



Nuvoton Automotive Solutions



| Gerda® Series Features

COCKPIT Edge Solution

Good Cost Performance

- Image compression / Memory minimization technology (4L)
- Streamlined system with built in RAM 3.5MB(ZWEI) · 5MB(4L) · 10MB(EINS)

Security

- Full support for EVITA
- Digital signature Supports **SHA256** and **RSA**
- Encryption / Decryption Compliant with **AES128**

Scalability

- Provides a broad range of optimal devices to low-price zone
- Gerda HMI common APIs (software)

Functional Safety

- Compliant with ISO26262 standards
- Supports ASIL-B safety
- Safety manual and FMEDA support (4 L/ZWEI)

Graphics/Video

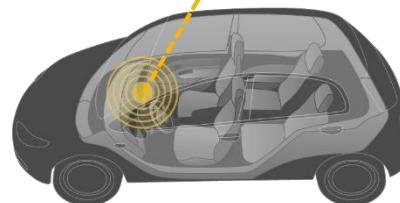
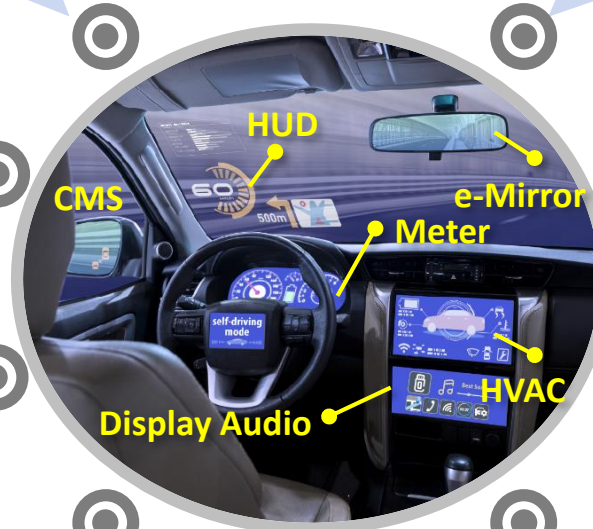
- High-end 2.5DGFx
- Super resolution technology (Clear image)

Compact Design

- QFP package
- Minimum footprint SDK (Approx. 200KB)

High Functionality

- High-definition distortion correction engine / tool (4L/EINS)
- Supports FOTA (Update Firmware in operation)

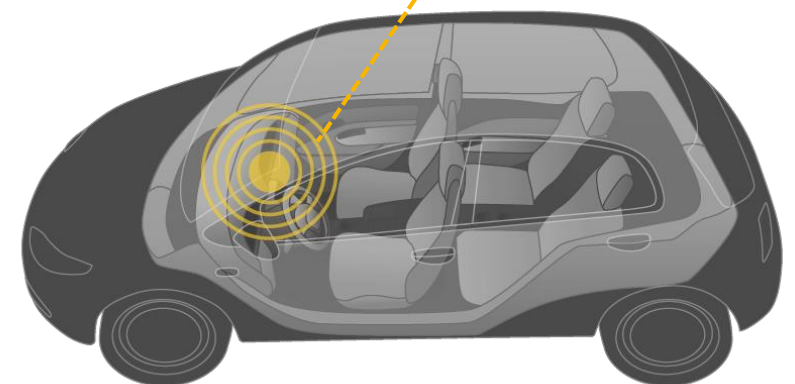
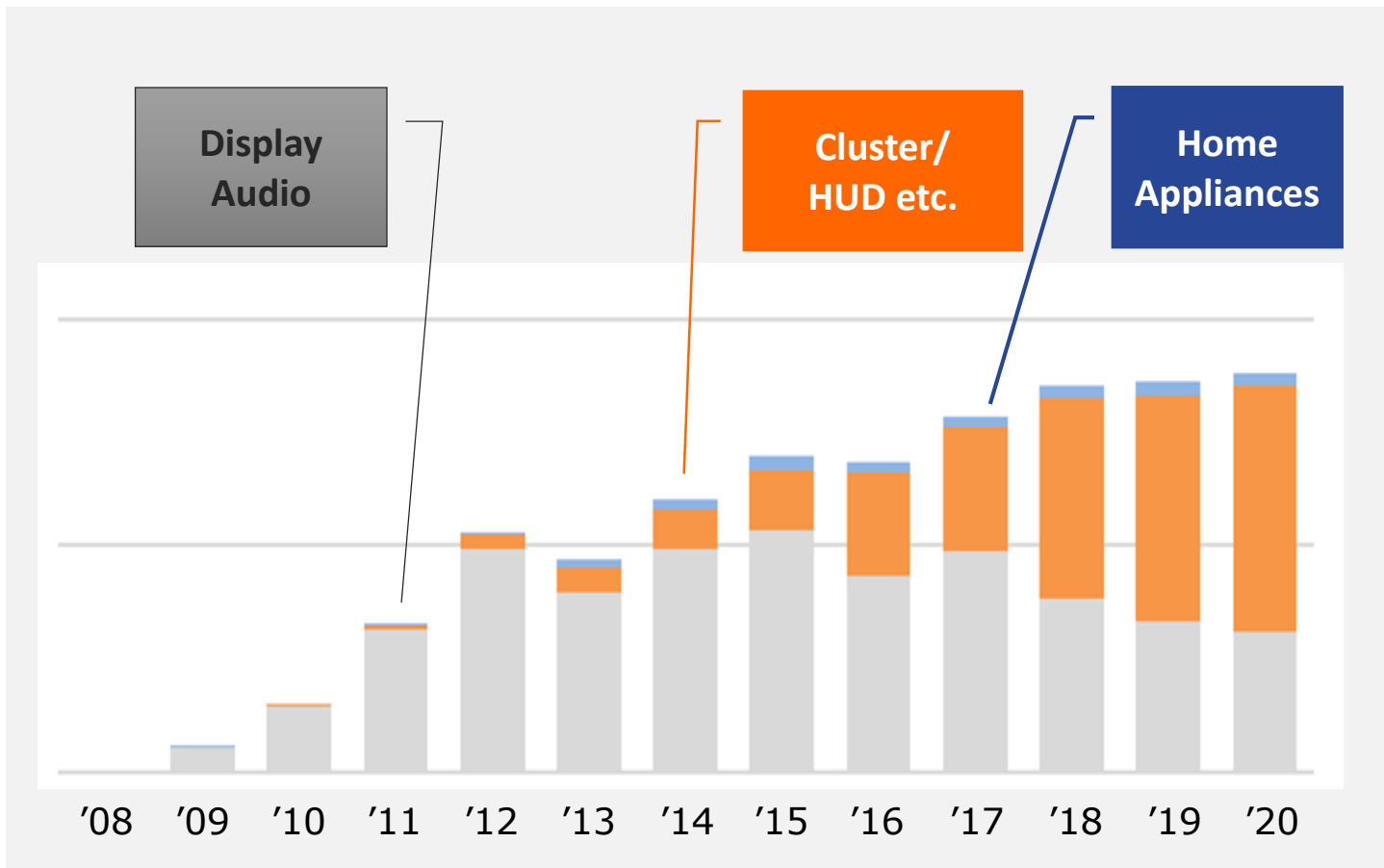


Support

- SDK Web download (Under study)
- To provide evaluation boards and HMI tools

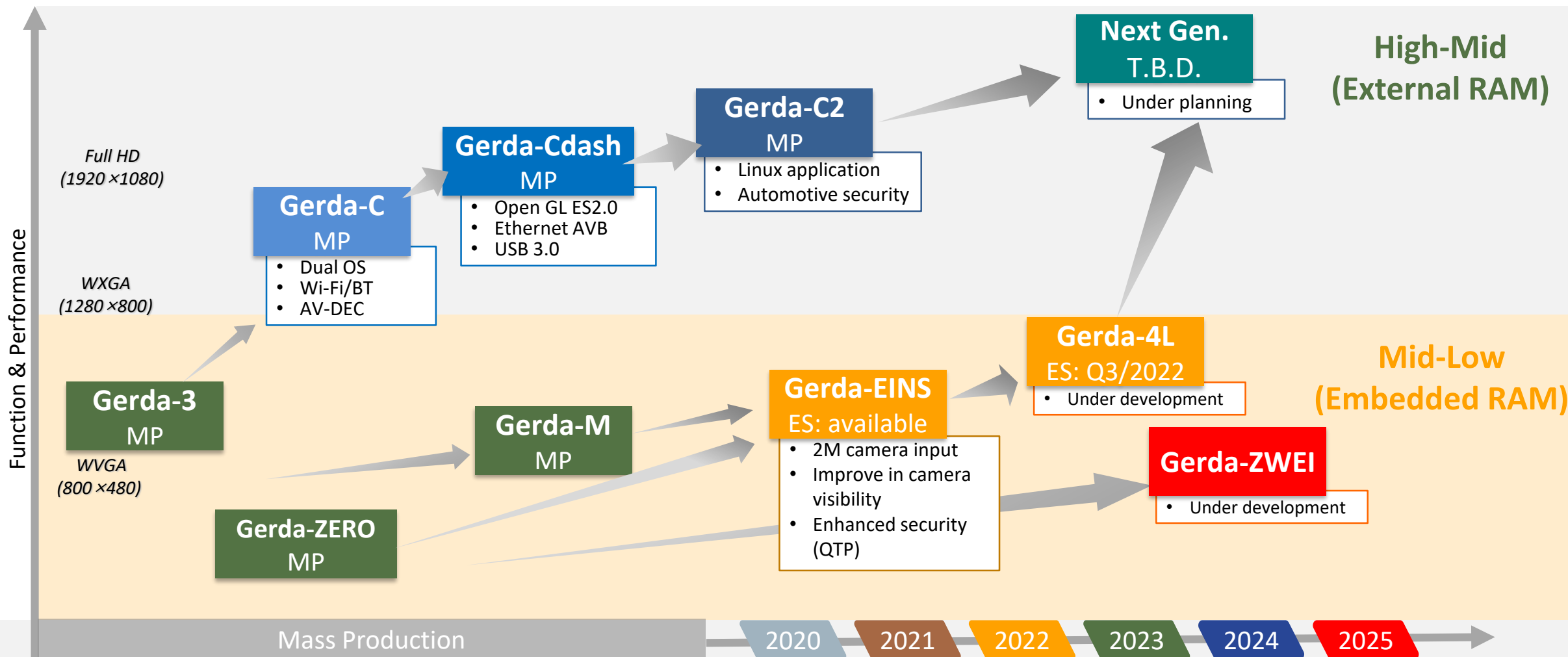
Shipment in the Market

Over 55Mil. pcs of Gerda® Series devices have been delivered since 2009.



Gerda® Roadmap

Name
Schedule
• Features / Status



User Experience

Graphics

2.5D / 3D graphics

- 7 inch WVGA



- 12 inch Full-HD

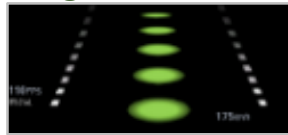


Superimpose graphics on input video

Various Enhancement

Distortion correction

- Original

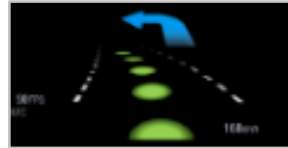


HUD navigation



Back Monitor

- After



Low latency



Safety

Abnormal image detection

- Tell-tales check



- Diagnost



- Color check



Correct



Wrong

Notify attention

Better Visibility

Super resolution

- Before



- After



Clearer image

Anti-glare

Local contrast correction

- Before



- After



Better night vision

| Gerda[®] Meter Cluster Features

- High Quality Meter Cluster Provided by Gerda original Graphics Engine
- Colorful Display Available by Texture Material(ROM) and Image Compression Technology (RAM)

Translucent

Add Strength with Translucent processing for icons like Alert

High Quality Display

Smooth Gradation Color with Dithering

Display High Quality

Anti-Aliasing Function to smoothen the outline of meter needle pointer

Colorful Display

By 3D Icon Texture, Colorful Expression Available with 2.5D Engine

Efficient Flash Memory Design

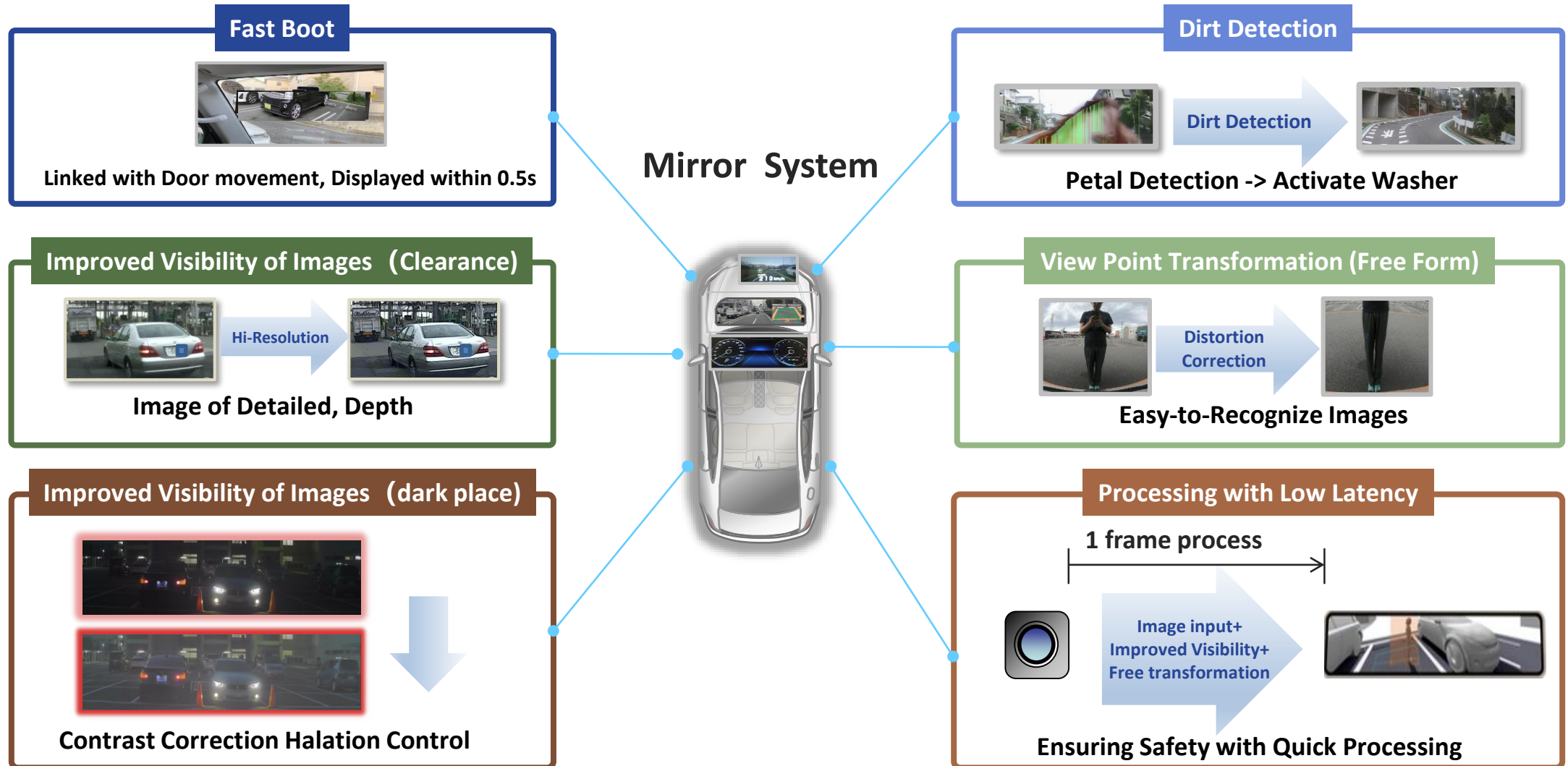
Various Expression like Animation or Multi-language
By Texture Material Compression Technology (Compressibility : approx. 25-50%)

Efficient Image Memory (RAM) Design

High Resolution and Clear Image
By Frame Memory Compression Technology

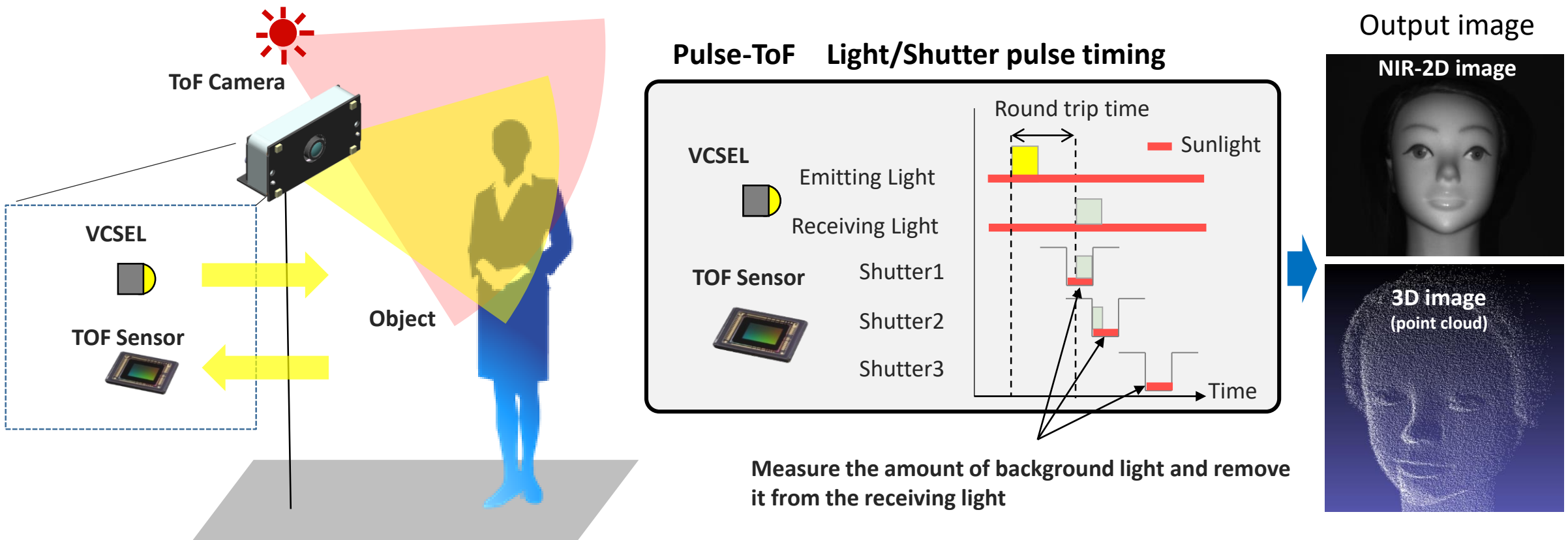


Gerda[®] E-Mirror Features

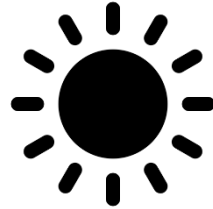


Measurable Under Sunlight (iTOF with Pulse-ToF)

- Calculating distance to objects by measuring the round-trip time of pulsed NIR by ToF sensor
- This system can output NIR-2D image & 3D image without background light

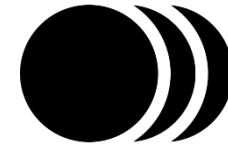


| Characteristics of Nuvoton ToF Sensor



Sunlight Resistance

- ✓ You can measure even in the dark or under sunlight

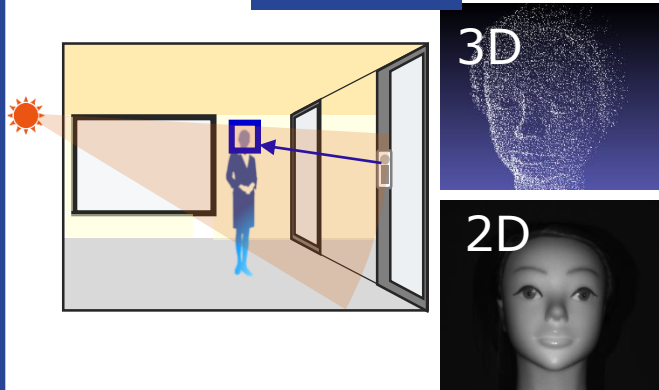


Low Motion Blur

Major Applications

ToF Sensor is used at outdoor (0.1~150k lux) and Long range (~13m)

Smart Lock



Face authentication

Driver monitoring



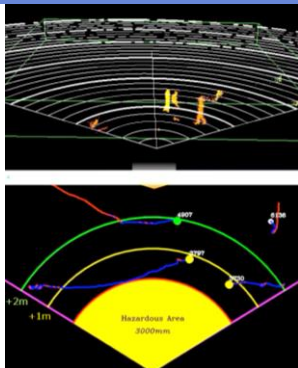
Inattention, drowsiness and driving posture detection

XR (VR/AR)



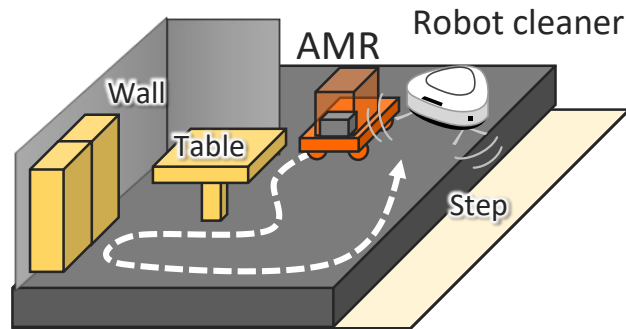
Gesture & Spatial recognition

Marketing for Retail



People flow detection

AMR (Indoor)



Obstacle detection, SLAM

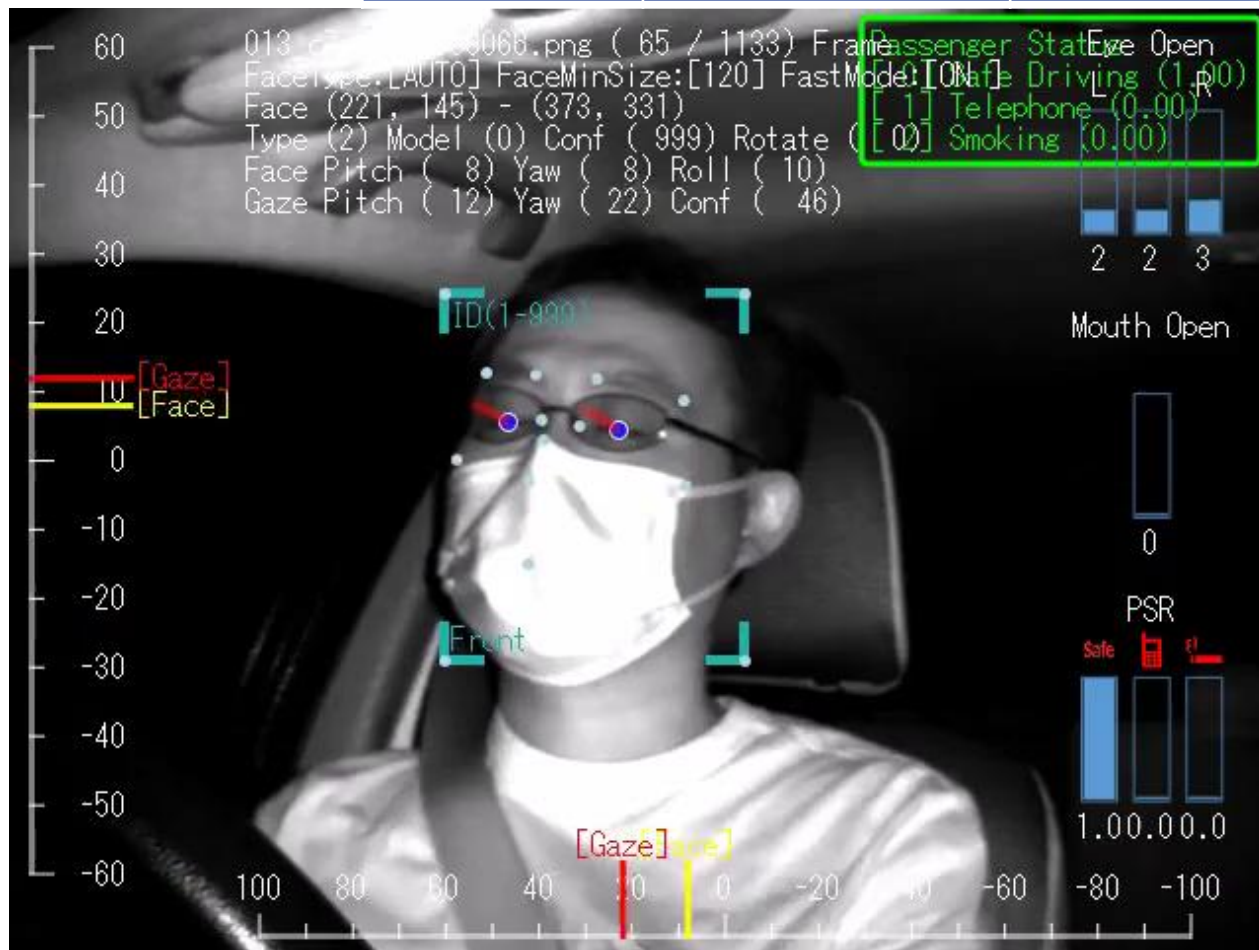
AMR (Outdoor)



Obstacle detection, SLAM

Demonstration Video of Existing DMS Function

Fine	with Glasses	Mask on the mouth	Sunlight on the face
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NTCJ ToF Camera



General NIR Camera (2D)

| Detailed Comparison of Motion Blur Performance

KW33000



Low motion blur

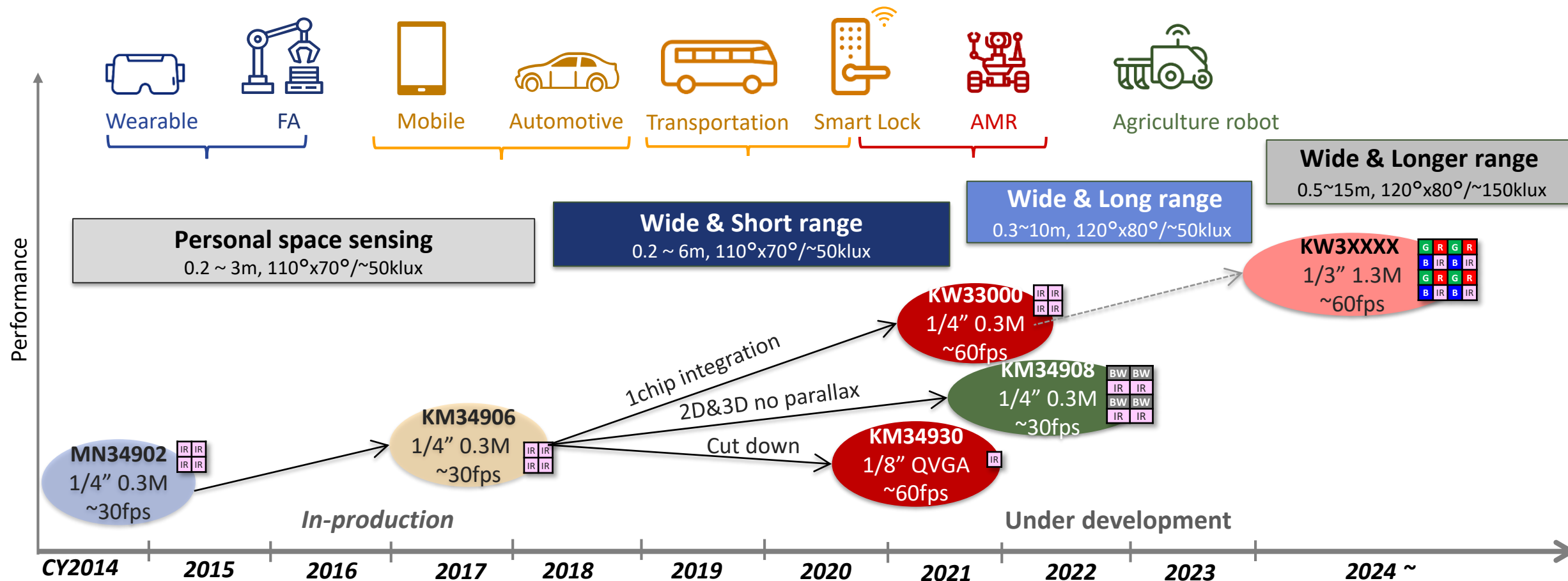
Company M's sensor
One-frequency mode



Middle motion blur

ToF Product & Solution Roadmap

- KW33000: ES available MP 2022/Q4, KM34930: ES available MP:2022/Q4



Joy of innovation
nuvoTon

谢谢

謝謝

Děkuji

Bedankt

Thank you

Kiitos

Merci

Danke

Grazie

ありがとう

감사합니다

Dziękujemy

Obrigado

Спасибо

Gracias

Teşekkür ederim

Cảm ơn

Automotive Solutions

- **Voice Prompt**
- **Body Control**

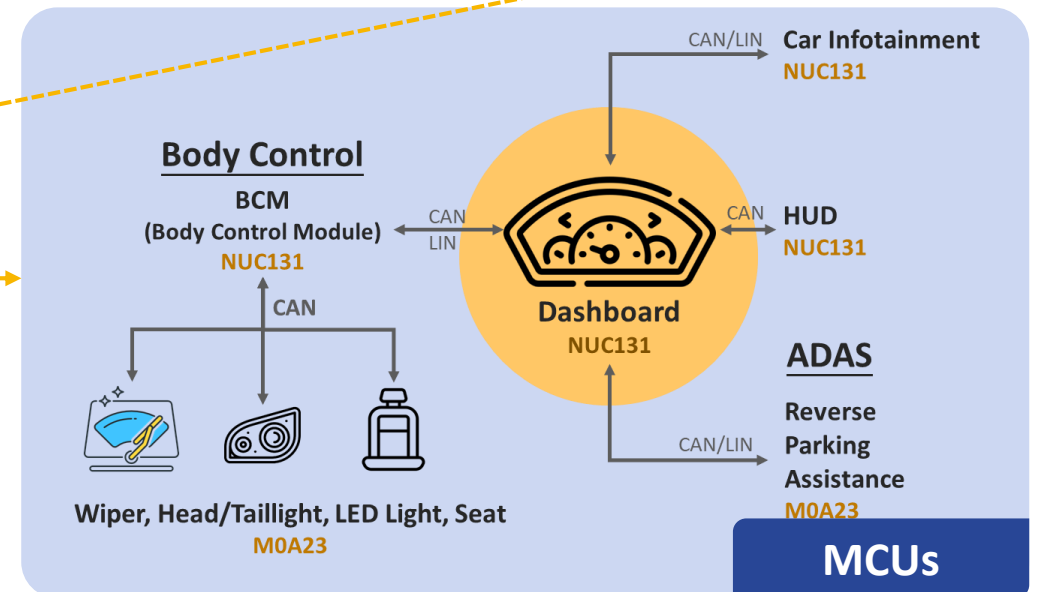
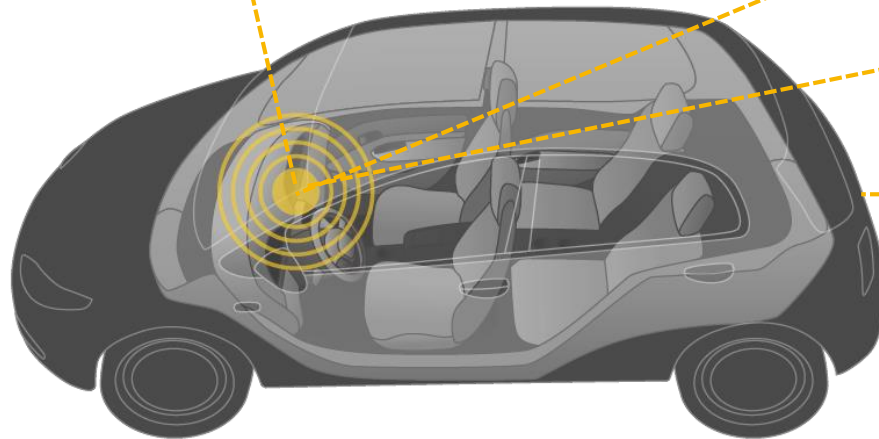
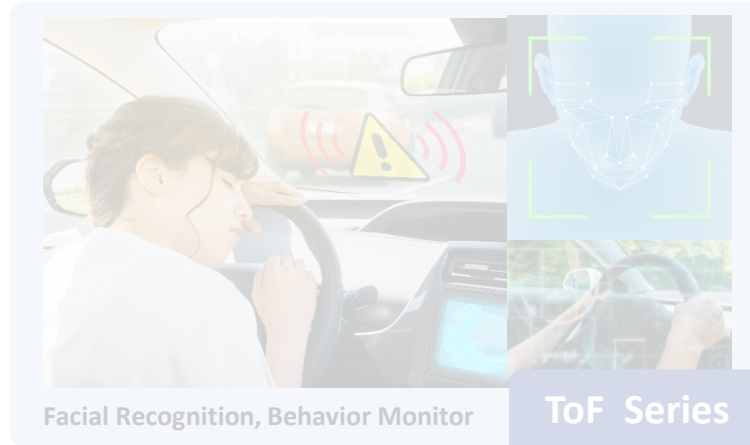
余遠欣 Benson Yu

Audio Product Marketing Division

Senior Engineer



Nuvoton Automotive Solutions



| What is the T-Box?

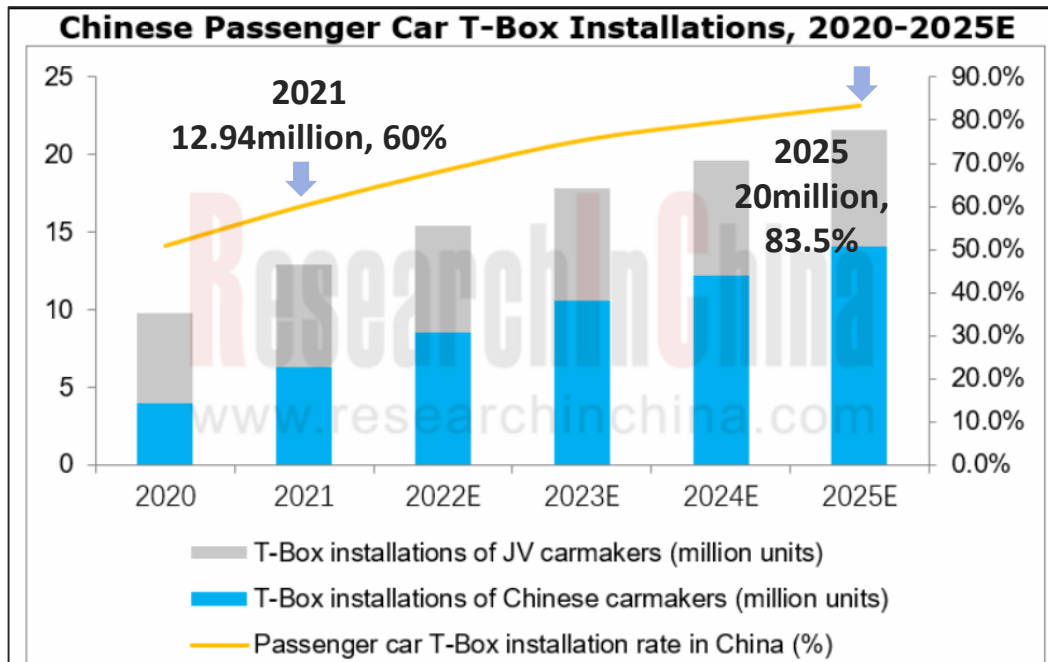
- **Telematics BOX**

A Telematics Smart Box, also known as a black box, is a small device that collects data about your driving. They've been used in emergency and commercial vehicles.



T-Box Installation Market Survey in China

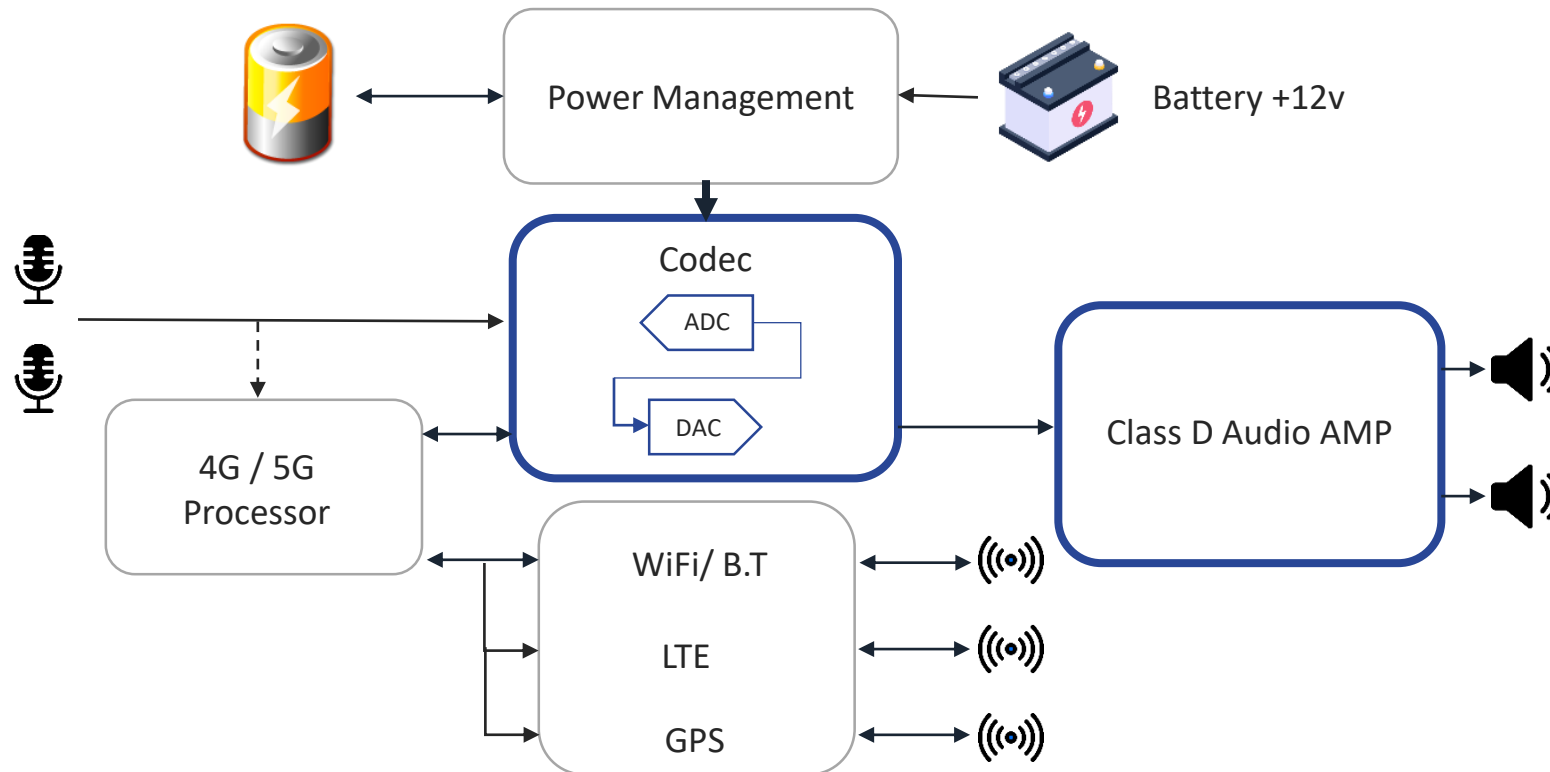
- In **2021**, **12.94 million** passenger cars were installed with T-Box by OEMs in China; the installation rate hit **60%**, up about 10 percentage points from last year.
- By **2025**, **over 20 million** passenger cars will be equipped with T-Box, and the **installation rate will climb to 83.5%**, and T-Box are growing indispensable to passenger cars.



Source: ResearchInChina

T-Box Audio Block Diagram

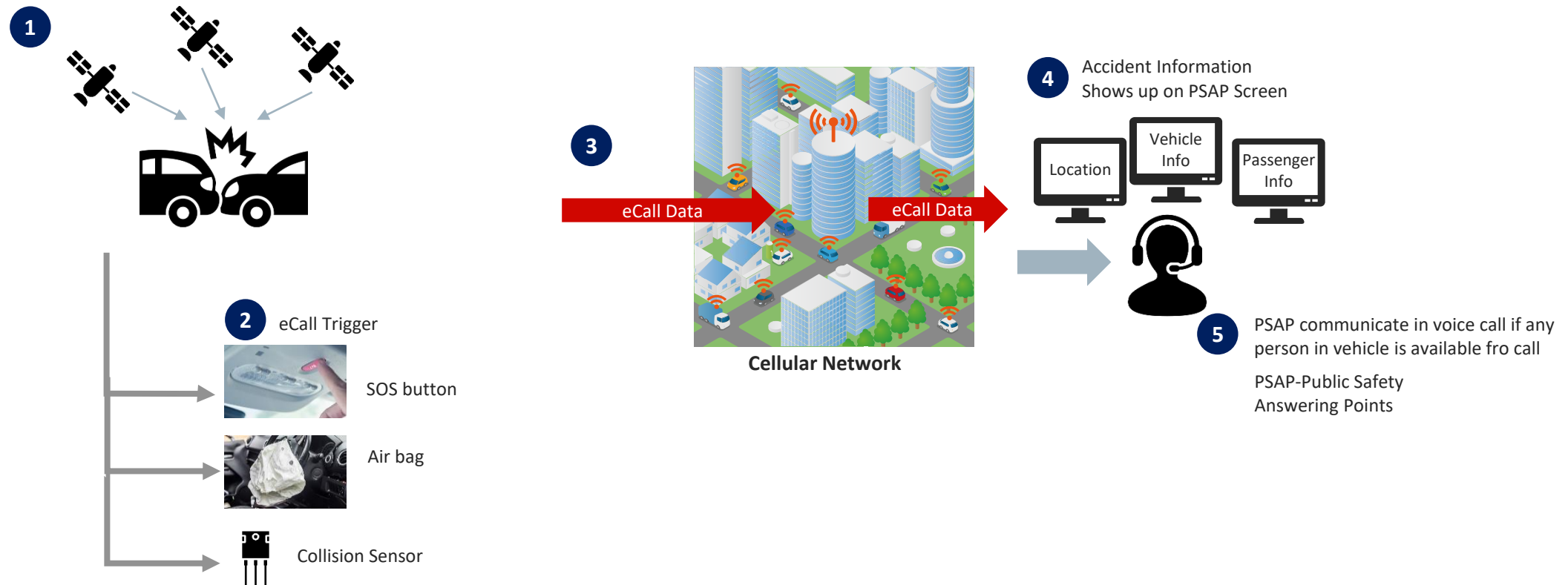
- Independent Power management system
- One to dual microphones become the main stream
- CODEC, Class D Audio Amp are also independent with the infotainment system



| What is the Emergency Call (eCall)?

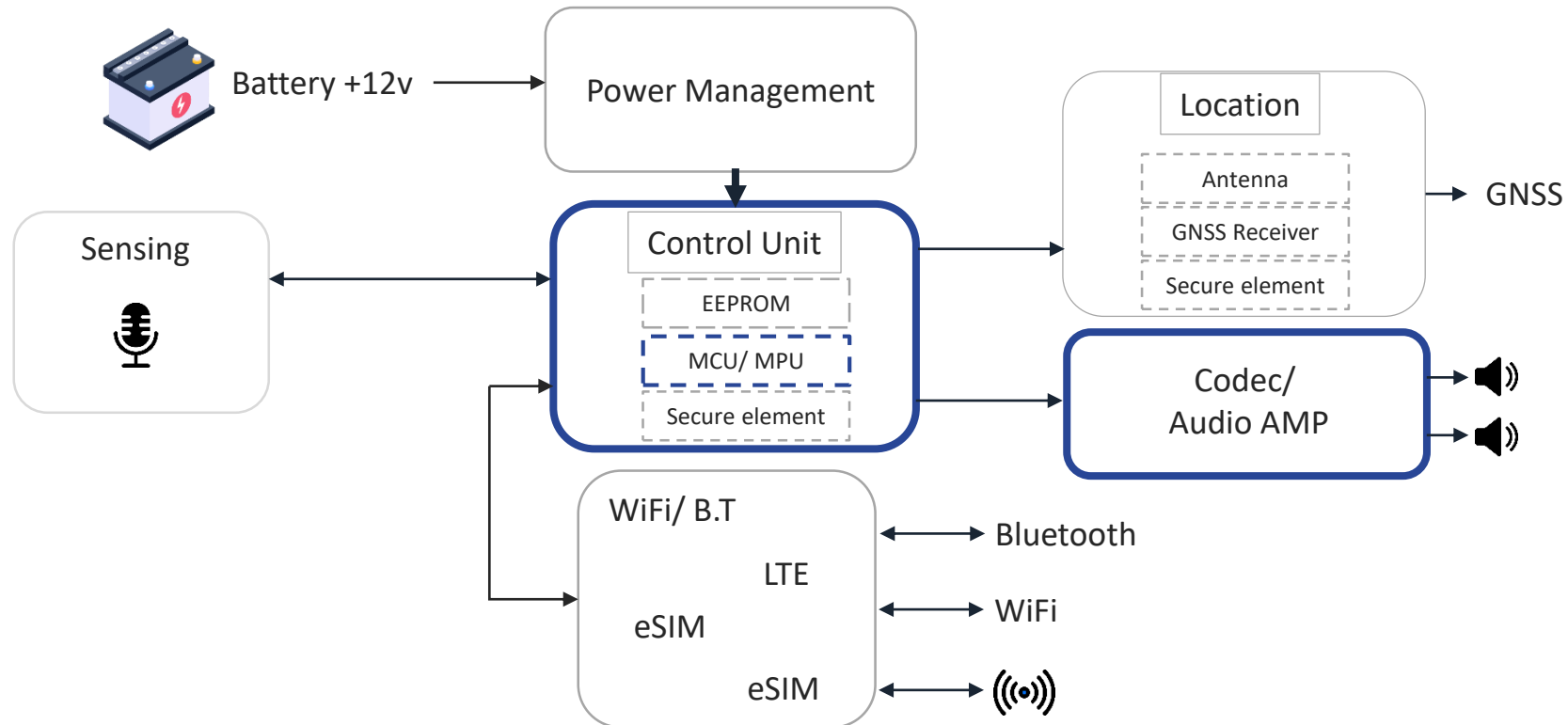
- **Emergency Call System**

E-Call is a pioneering European emergency-call system for vehicles that aims to bring rapid assistance to road traffic incidents anywhere in the European Union.



eCall Block Diagram

- Independent Power management system
- One to dual microphones become the main stream
- CODEC/ Class D Amp are also independent with the infotainment system



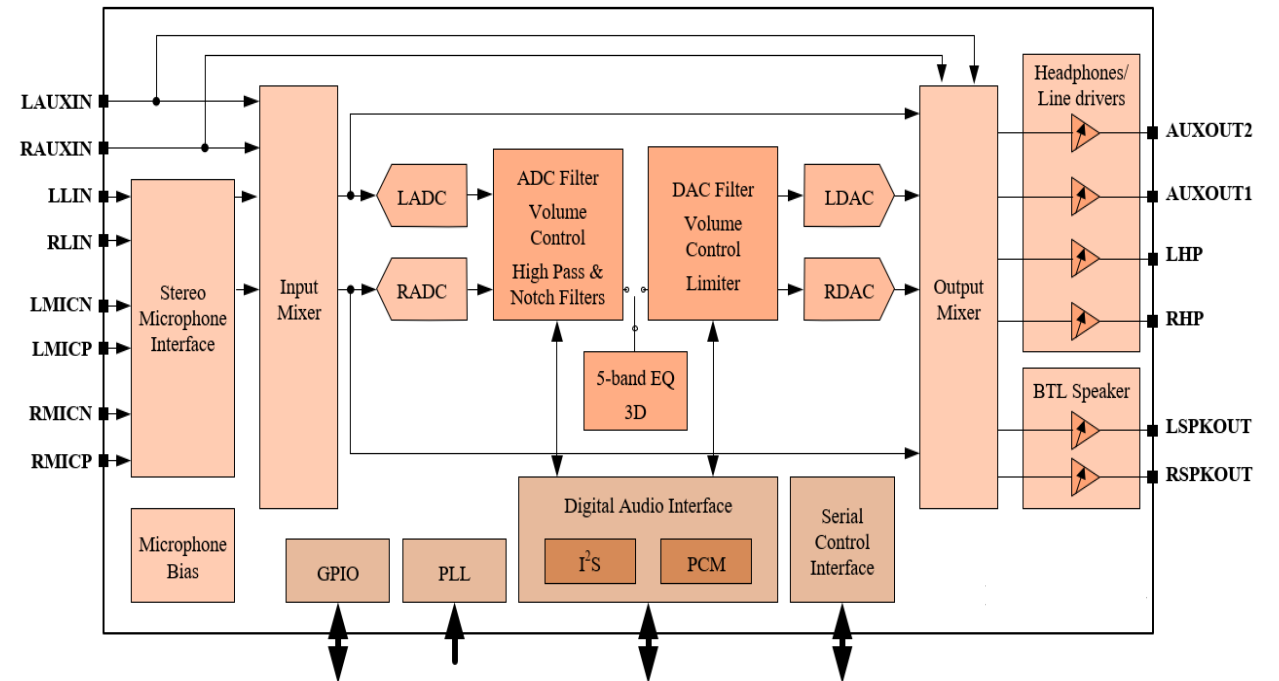
NAU88U20A

24-bit Stereo Audio Codec with Speaker Driver – Automotive Grade AEC-Q100 Qualification

- **Applications:** IPC, Automotive eCall, T-Box

- **Features:**

- DAC: 94dB SNR, -84dB THD
- ADC: 90dB SNR, -80dB THD
- Sampling rate from 8KHz to 48KHz
- Integrated Speaker/ headphone driver
 - 1W@8Ω/ 40mW@16Ω
- On-chip PLL
- Integrated DSP:
 - Input automatic level control (ALC/AGC)/limiter
 - Output dynamic-range-compressor/limiter
 - 5-Band Equalizer
 - 3-D audio enhancement
 - Notch filter and high pass filter



| NAU8315 Mono 3W Class-D I2S AMP

Features

- **Simplified Control**
 - Pin Selectable Gain Setting
 - Pin Selectable I2S L/R Ch selection
 - Pin Selectable PCM time slot
- **Low Output Noise: 12 μ VRMS**
- **80dB PSRR @217Hz**
- **Low Current Shutdown and Standby Modes**
- **Click-and Pop Suppression: 26 μ VRMS**
- **Sampling rate from 8K to 96 KHz**
- **Powerful Mono Class-D Amplifier:**
 - 3.2W (4 Ω @ 5V, 10% THD+N)
 - 1.76W (4 Ω @ 4.2V, 1% THD+N)
 - 1.8W (8 Ω @ 5V, 10% THD+N)
 - 1.0W (8 Ω @ 4.2V, 1% THD+N)

NAU8325 Stereo 3W Class-D I2S AMP

Features

- **Low SPK_VDD Quiescent Current**
 - 2.1mA at 3.7V for 2 channels
 - 3.2mA at 5V for 2 channels
- **Gain Setting with 2 wire interface**
 - 22dB to -62dB (plus mute)
- **Low Output Noise**
 - 18 μ VRMS @0dB gain
- 80dB PSRR @217Hz
- Low Current Shutdown Mode
- Click-and Pop Suppression
- **Powerful Stereo Class-D Amplifier**
 - 2ch x 3.0W (4 Ω @ 5V, 10% THD+N)
 - 2ch x 1.32W (4 Ω @ 3.7V, 1% THD+N)
 - 2ch x 1.72W (8 Ω @ 5V, 10% THD+N)
 - 2ch x 0.75W (8 Ω @ 3.7V, 1% THD+N)

NuMicro® Automotive Product Portfolio

Memory				
1024 KB Flash				M467 Series
512 KB Flash	M487 Series	M487 Series		
256 KB Flash	M483 Series M453 Series	M483 Series M463 Series	M483 Series	
128 KB Flash	M253 Series	NUC230 NUC240 Series		
68 KB Flash	NUC131 Series			
32 KB Flash	M0A23 Series			
CAN	CAN x 1	CAN x 2	CAN x 3	CAN x 4

NuMicro® M0 Family

- **NUC230/240 Feature**
 - 72 MHz core speed
 - USB FS Device
 - CAN x2
- **M253 Feature**
 - 48 MHz core speed
 - USB FS Device
 - CAN-FD
- **NUC131 Feature**
 - 50 MHz core speed
 - CAN x1
 - AEC-Q100 Grade 2
- **M0A23 Feature**
 - 48 MHz core speed
 - CAN x1
 - AEC-Q100 Grade 1

NuMicro® M4 Family

- **M467 Feature**
 - 200 MHz core speed
 - USB 2.0 FS/HS OTG
 - 100M Ethernet MAC
 - CAN-FD x4
- **M487 Feature**
 - 192 MHz core speed
 - USB 2.0 FS/HS OTG
 - 100M Ethernet MAC
 - CAN x2
- **M463 Feature**
 - 200 MHz core speed
 - USB 2.0 HS OTG
 - CAN-FD x2
- **M483 Feature**
 - 192 MHz core speed
 - USB 2.0 FS/HS OTG
 - CAN x3
- **M453 Feature**
 - 72 MHz core speed
 - USB 2.0 FS OTG
 - CAN x1

NuMicro[®] M0A21/ M0A23 Series MCU

Flash/SRAM (Kbytes)	Package	
	SSOP20 (5.3 x 7.2 mm)	TSSOP28 (4.4 x 9.7 mm)
32 / 4	M0A23OC1ACU	M0A23EC1ACU
	M0A23OC1AC	M0A23EC1AC
16 / 4	M0A21OC1AC	M0A21EC1AC
	M0A21OB1AC	M0A21EB1AC

- Arm[®] Cortex[®]-M0 core
- Runs up to 48 MHz
- Operating temperature:
-40°C ~ +125°C
- HIRC with ± 2 % precision from -40°C to +125°C
- High immunity:
EFT 4.4 kV, ESD HBM 6 kV

Automotive AEC-Q100 Grade 1

- M0A23OC1ACU
- M0A23EC1ACU

Industrial CAN

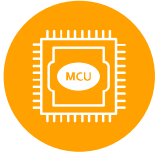
- M0A23OC1AC
- M0A23EC1AC

Industrial LIN

- M0A21OC1AC
- M0A21OB1AC
- M0A21EC1AC
- M0A21EB1AC

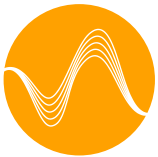
NuMicro[®] M0A23 Series Features

AEC-Q100 Grade 1 Qualified MCU



System

- Arm[®] Cortex[®]-M0
- Runs up to 48 MHz
- 32 KB Flash Memory, 4 KB SRAM
- Hardware divider
- 5-channel PDMA
- Operating voltage: 2.5 V ~ 5.5V
- **Operating temperature: -40°C ~ +125°C**



Analog

- Programmable Internal V_{REF}
- 17-channel 12-bit ADC
- Built-in temperature sensor
- Internal band-gap reference voltage
- 2 sets of rail-to-rail ACMP
- 5-bit DAC



Peripherals

- **1 set of CAN 2.0A/B**
- 2 sets of UART
- 2 sets of USCI (UART, I²C, SPI)
- 4 sets of timers
- 6 channels of PWM



Highlight

- **AEC-Q100 Grade 1**
 - M0A23OC1ACU
 - M0A23EC1ACU

NuMicro[®] NUC131 Series MCU

Flash/SRAM (Kbytes)		
68 / 8	NUC131LD2AEU	NUC131SD2AEU
	NUC131LD2AE	NUC131SD2AE
	NUC1311LD2AE	
36 / 8	NUC131LC2AE	NUC131SC2AE
	NUC1311LC2AE	
Package		
		LQFP48 (7 x 7 mm)
		LQFP64 (7 x 7 mm)

- Arm[®] Cortex[®]-M0 core
- Runs up to 50 MHz
- Operating voltage:
2.5 V ~ 5.5 V
- Operating temperature:
-40°C ~ +105°C
- 1 set of CAN, 3 sets of LIN, 6 sets of UART

Automotive AEC-Q100 Grade 2

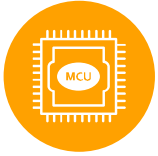
- NUC131SD2AEU
- NUC131LD2AEU

Industrial Grade

- NUC131SD2AE
- NUC131LD2AE
- NUC1311LD2AE
- NUC131SC2AE
- NUC1311LC2AE

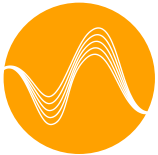
NuMicro[®] NUC131 Series Features

AEC-Q100 Grade 2 Qualified MCU



System

- Arm[®] Cortex[®]-M0 core
- Runs up to 50 MHz
- 68 KB Flash Memory, 8 KB SRAM
- Operating voltage: 2.5 V ~ 5.5 V
- **Operating temperature: -40°C ~ +105°C**
- EFT: 4.4 kV



Analog

- 8-channel 12-bit ADC
- BOD/LVR



Peripherals

- **1 set of CAN 2.0B**
- 3 sets of LIN
- 6 sets of UART, 1 set of SPI, 2 sets of I²C
- 24-channel 100 MHz PWM

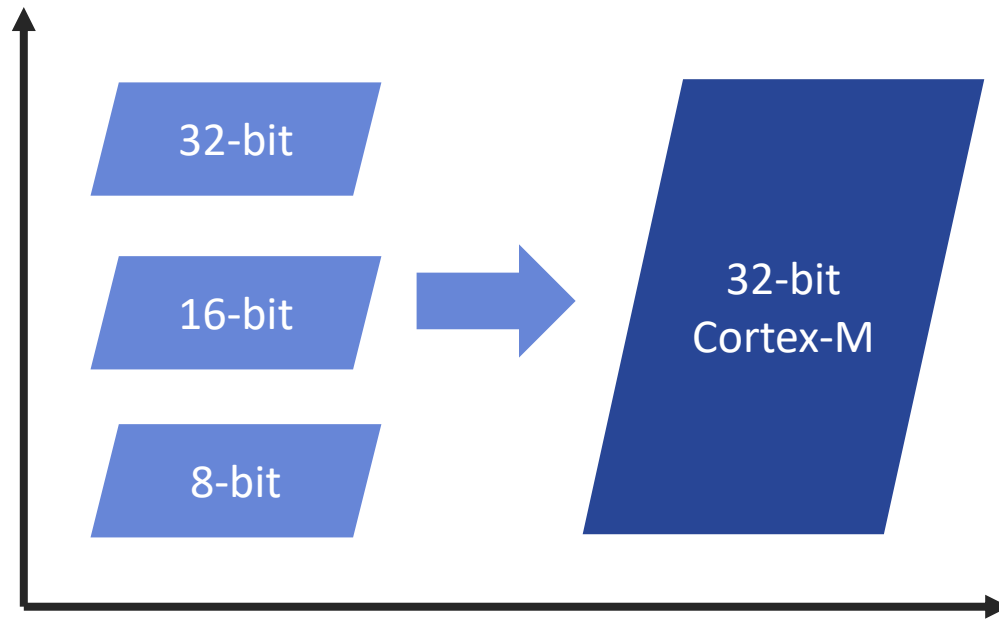


Highlight

- **AEC-Q100 Grade 2**
 - NUC131SD2AEU
 - NUC131LD2AEU

| New General Propose Automotive Platform

- Moving to the ARM Cortex-M architecture

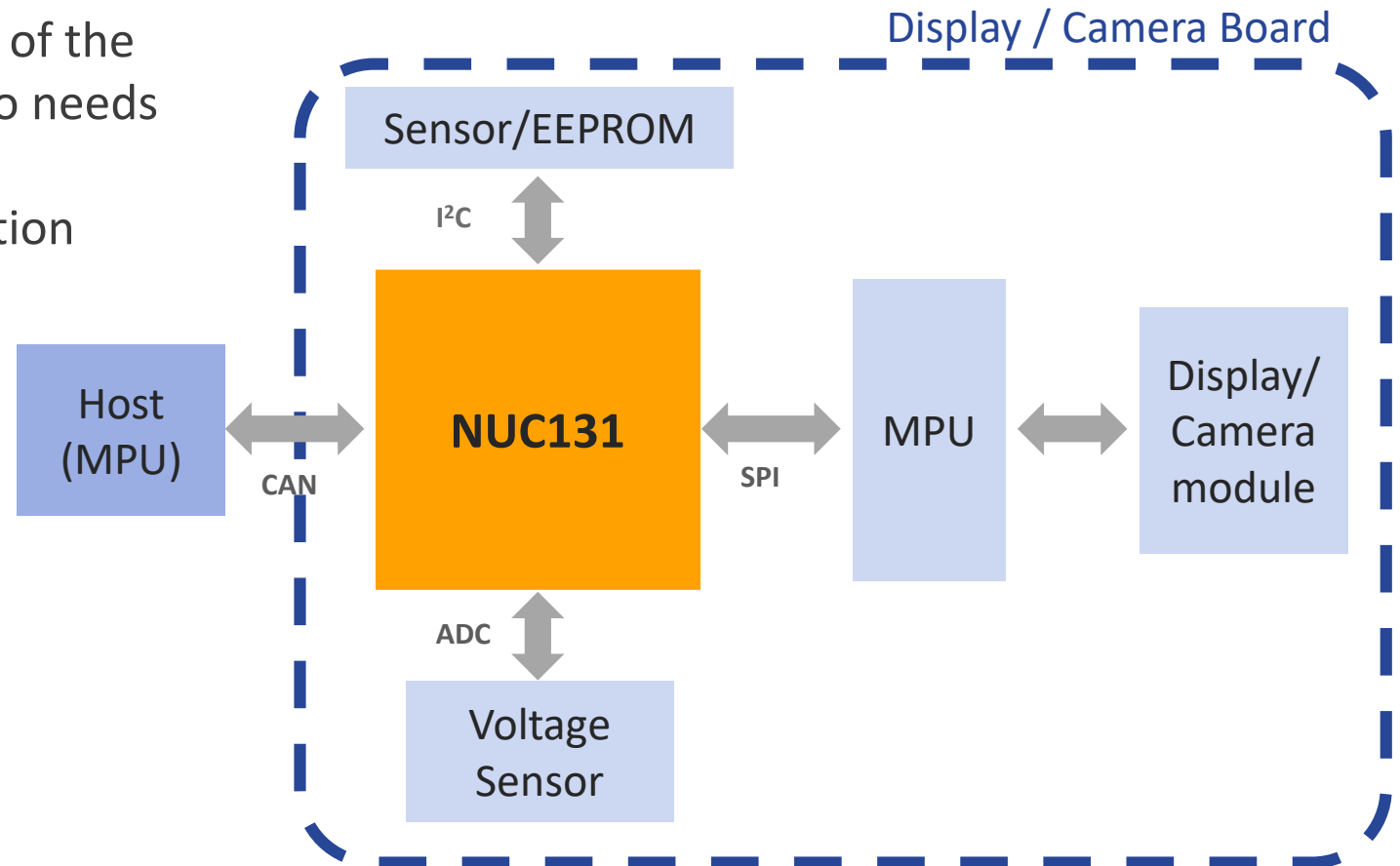


Unified Platform:

- Software development kit
- P2P
- Free IDE: Keil
- Unified ICE/SWD interface
- Bootloader (LDROM): CAN/UART/I²C/SPI
- Easy to use: Development tool
 - PIN Configure
 - PIN View
 - Clock configure

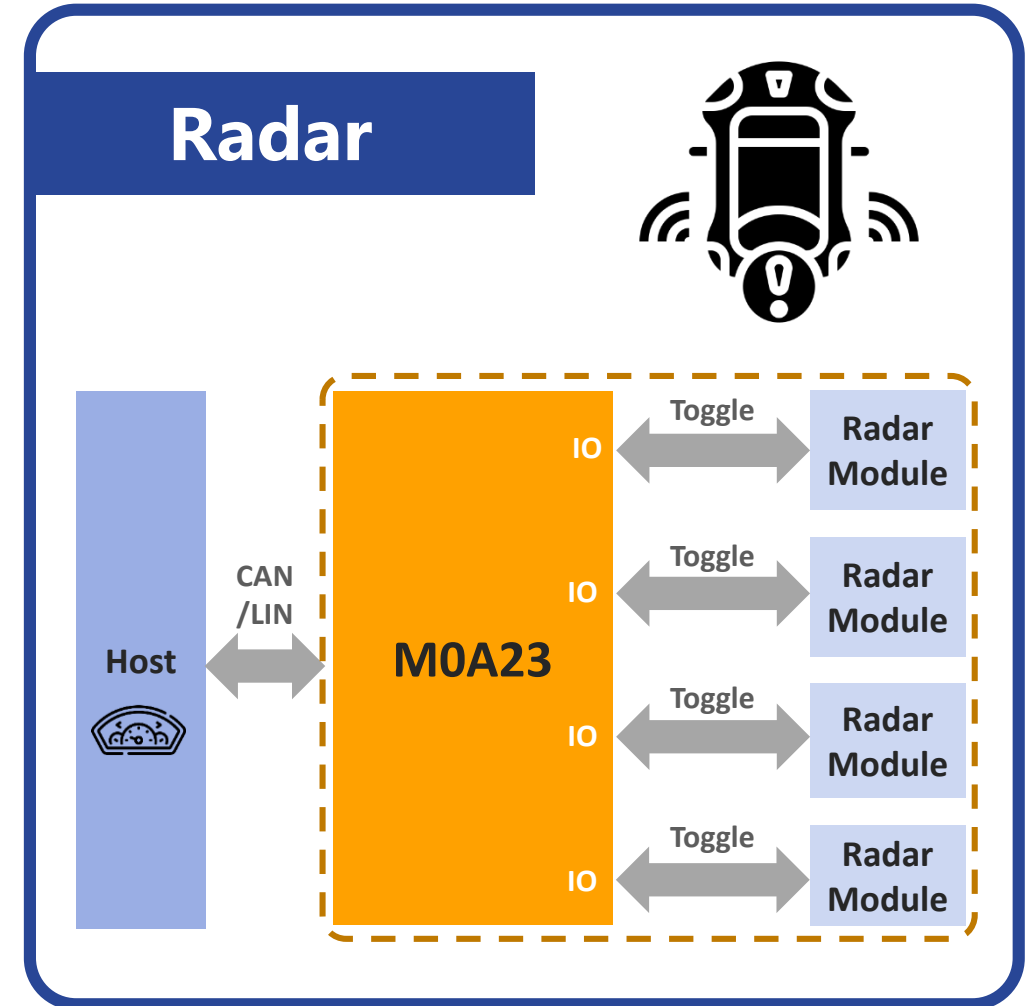
CAN Bridge – Display / Camera Module

- In addition to the graphics processing of the MPU, the Cluster/Camera module also needs an MCU. This MCU is used for power management, IO control and information transmission.
- **NUC131 Series Provides:**
 - CAN: Information transmission
 - SPI: Connect to MPU
 - I²C: Sensor, EEPROM
 - 8 sets of ADC:
 - Power management
 - Knob, Voltage sensor



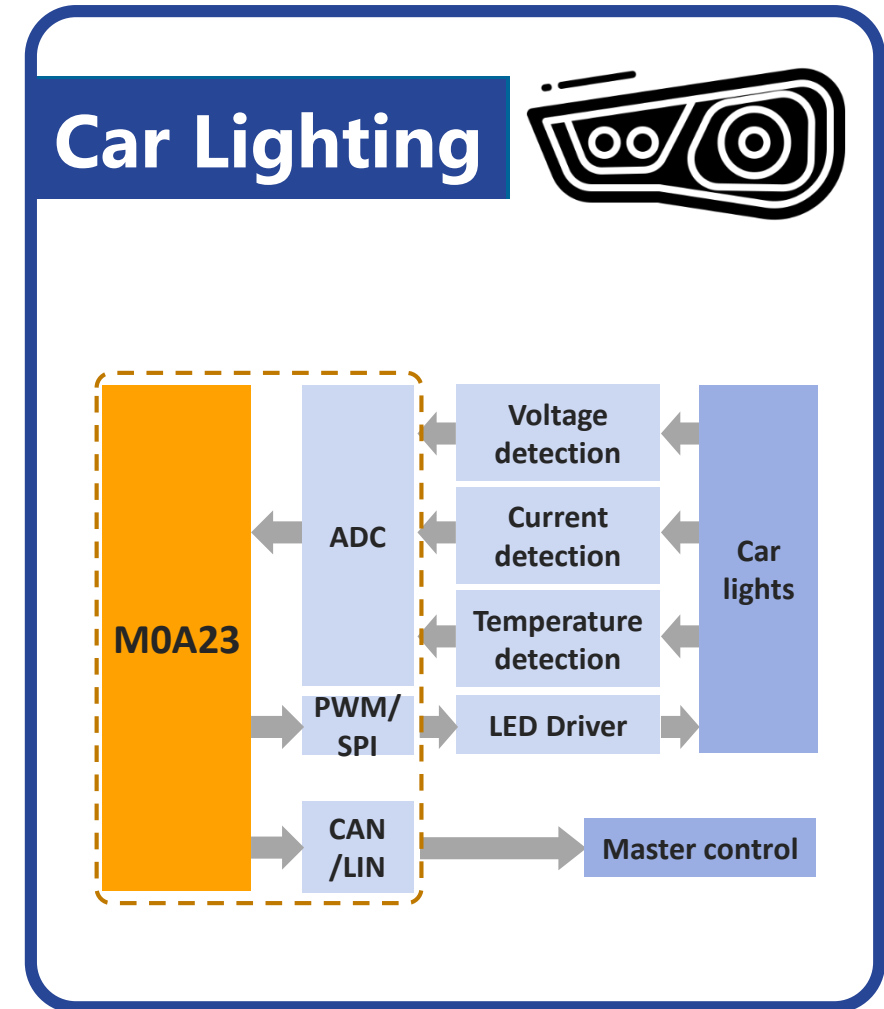
NuMicro[®] M0A23 Series Application – Radar

- **M0A23 Series Provides:**
 - AEC-Q100 Grade 1
 - Radar Sensor Communication:
 - Timer x4
 - IO x8
 - Host Communication:
 - CAN/LIN
 - Operating temperature: up to 125°C



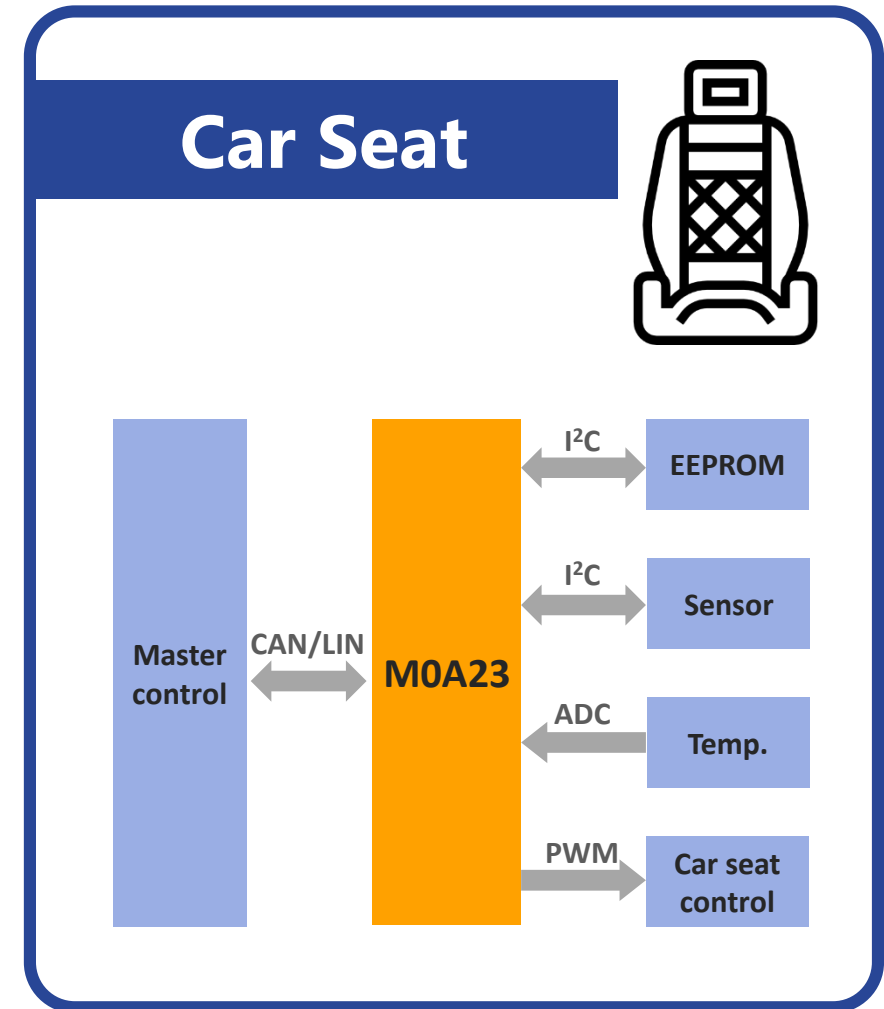
NuMicro[®] M0A23 Series Application – Car Lighting

- M0A23 Series Provides:
 - AEC-Q100 Grade 1
 - LED Driver:
 - 6-channel PWM
 - I²C / SPI
 - Voltage/Current measure: 8-channel ADC
 - Host communication: CAN / LIN



| NuMicro® M0A23 Series Application – Car Seat

- **M0A23 Series Provides:**
 - AEC-Q100 Grade 1
 - Car seat control: 6-channel PWM
 - Host communication: CAN/LIN
 - EEPROM, sensor module: I²C
 - Temp. / voltage measure: ADC



Joy of innovation
nuvoTon

谢谢

謝謝

Děkuji

Bedankt

Thank you

Kiitos

Merci

Danke

Grazie

ありがとう

감사합니다

Dziękujemy

Obrigado

Спасибо

Gracias

Teşekkür ederim

Cảm ơn