R-CAR GEN3: COMPUTING PLATFORM FOR AUTONOMOUS DRIVING ERA

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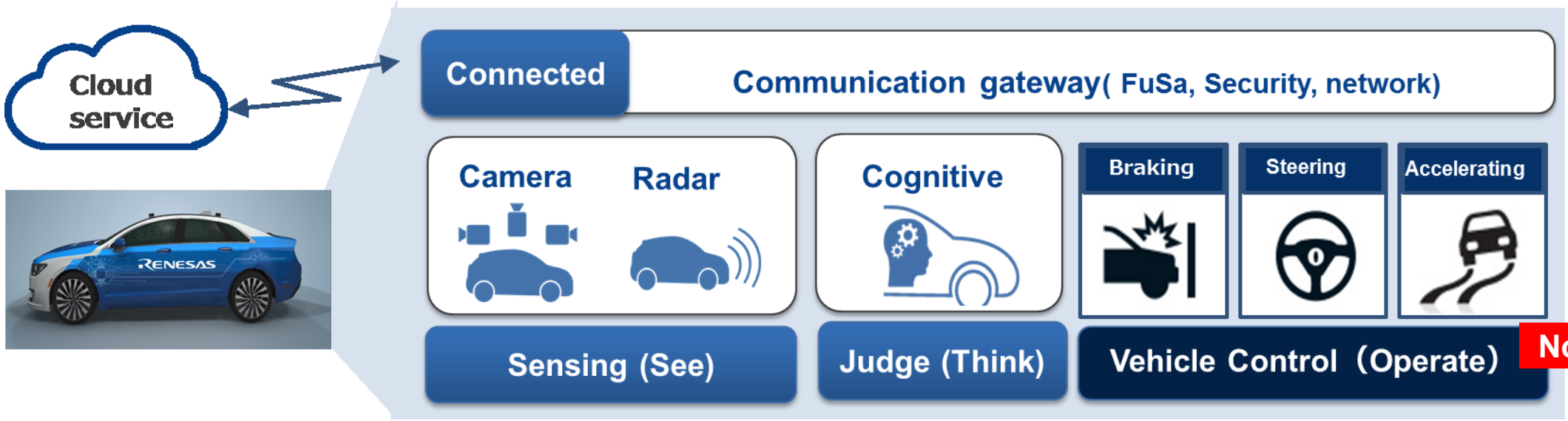
Outline

- Renesas Autonomy : ADAS/Autonomous Driving Platform
- Autonomous Driving Challenges and Feature of R-Car H3
- Level 4 Autonomous driving Concept Car
- Concept of Reliability Management for future auto. driving usage

NEW RENESAS CONCEPT FOR AUTONOMOUS DRIVING

Renesas autonomy

END TO END SOLUTION FROM CLOUD SERVICE TO SENSING AND VEHICLE CONTROL
CONTRIBUTE TO NEXT AUTONOMOUS DRIVING SOCIETY

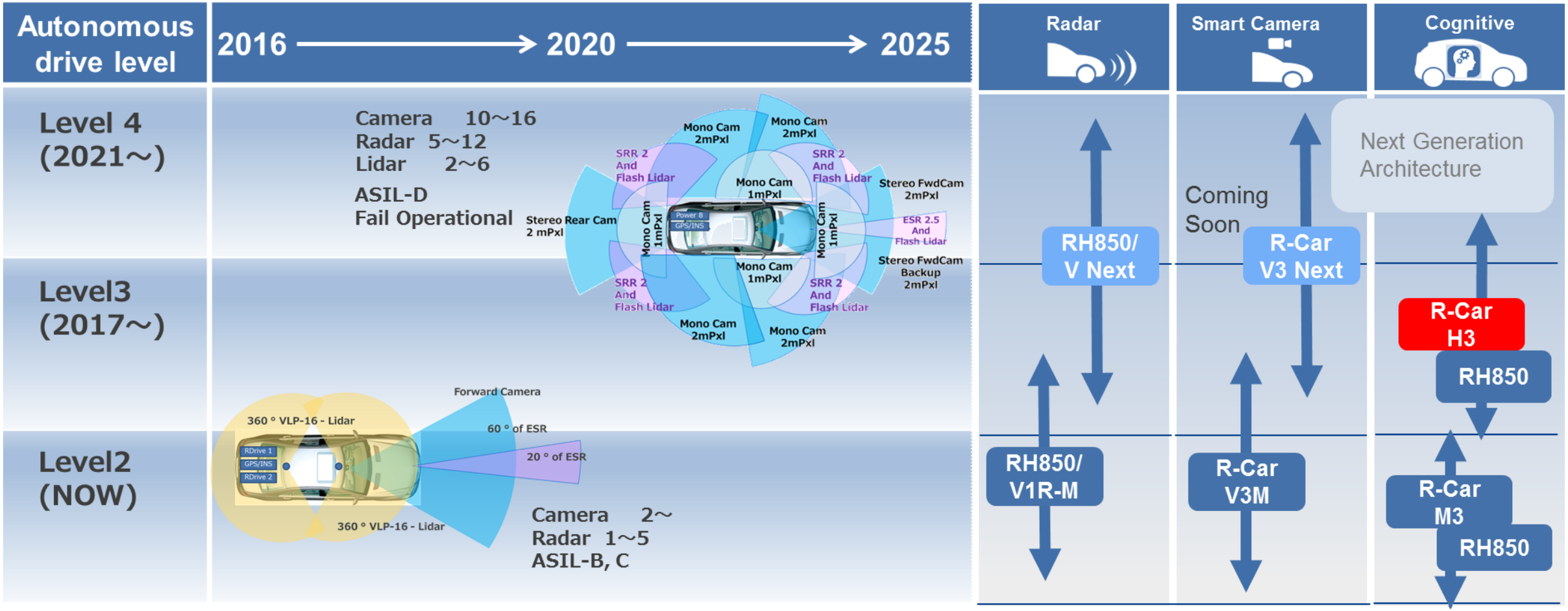


Global No.1 share in vehicle MCU

Promote end to end solution in collaboration with many global partners

SENSING &COGNITIVE SOLUTION FOR AUTONOMOUS DRIVING

Scalable solution for sensing (Camera/Rader) and Cognitive from Level2/3 to Level 4/5



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Autonomous Driving Challenges for LSI

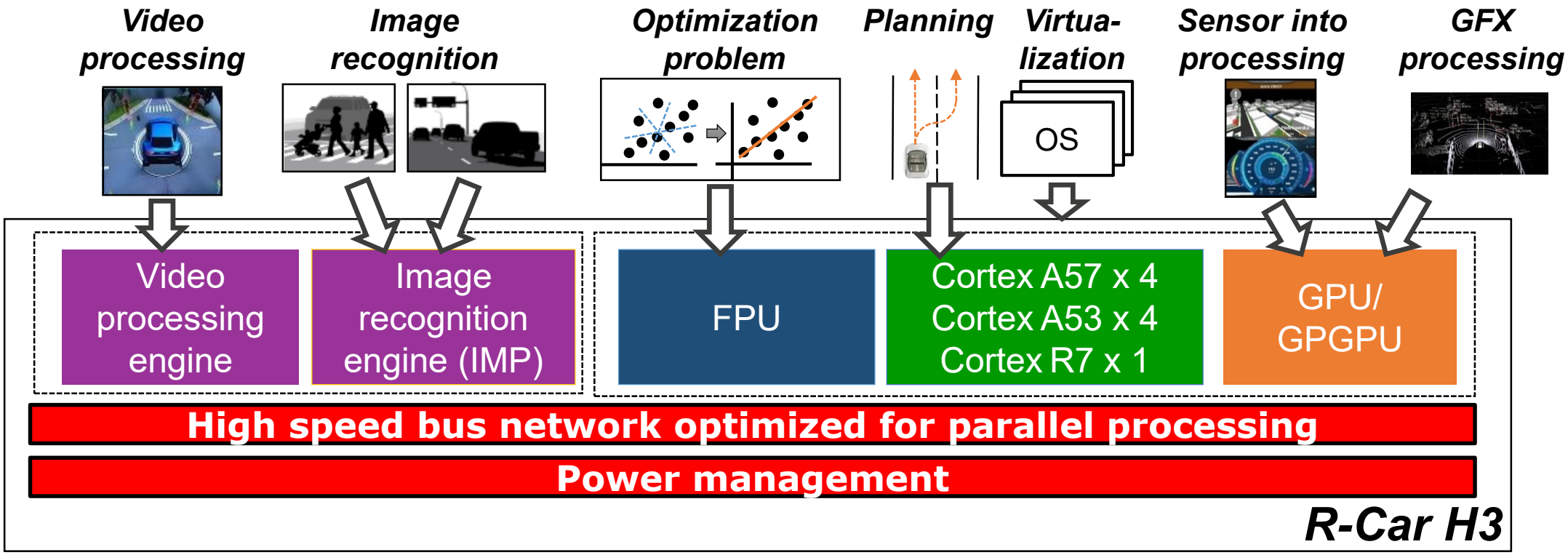
Automotive
High Reliability

Hardware
Performance @ Low power

Functional Safety
Availability & Fail Operational

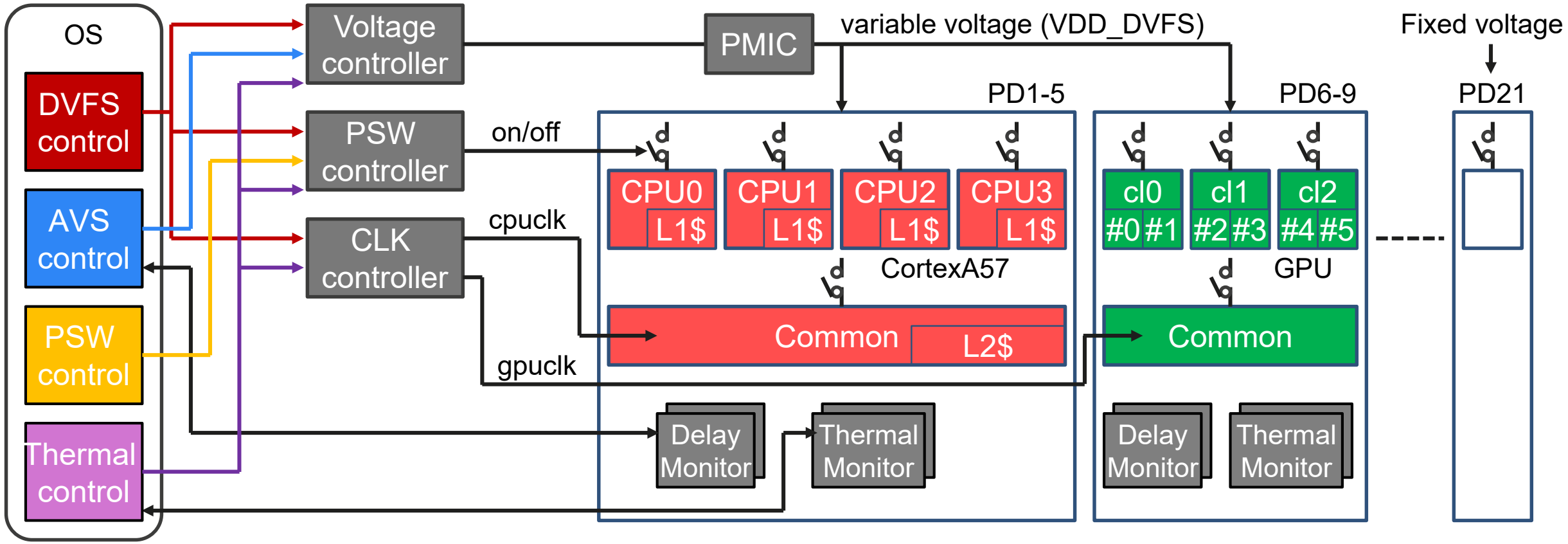
Solutions for Performance and Low Power by R-Car

- Performance at Low power
  - ✓ Allocate each process to suitable automotive engines/processors
  - ✓ Several power management techniques
- Real time operation : Parallel processing preferred bus network / HW assist virtualization



Several Power Management Techniques for Low Power

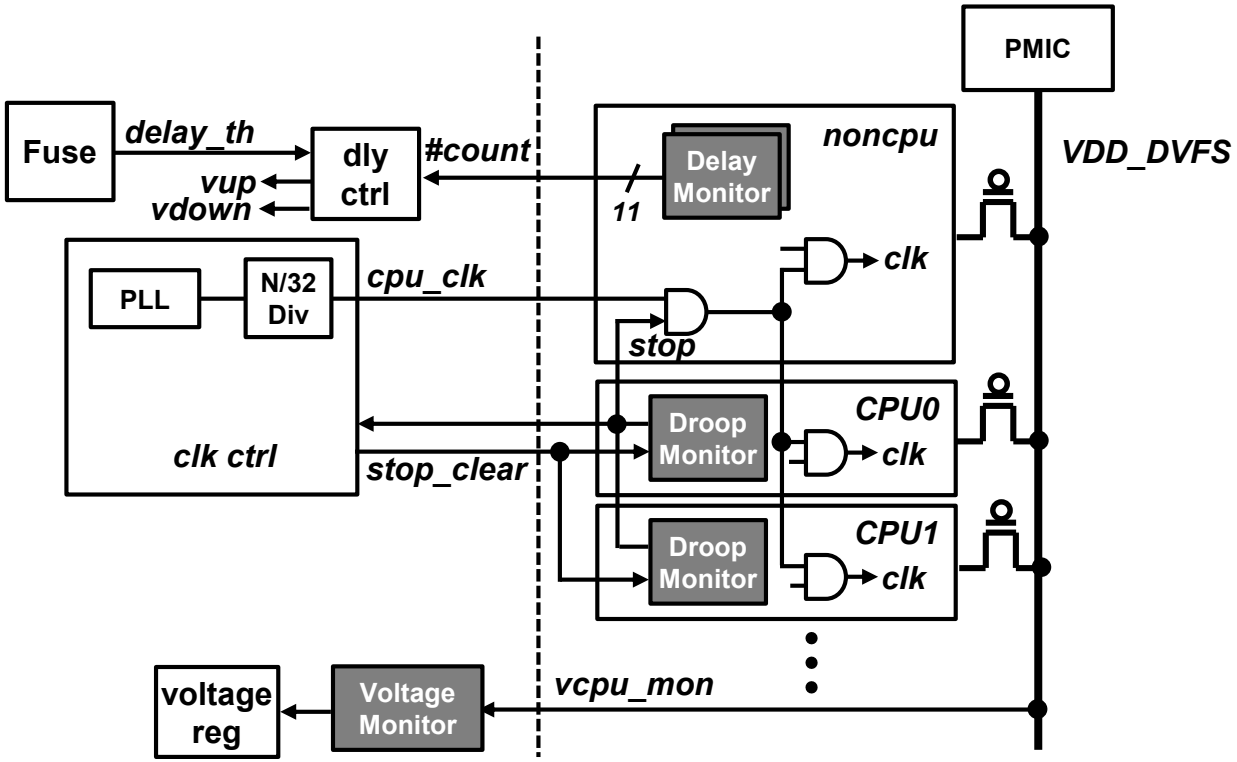
- Power gating : 21 power gated domains control, introduce each cluster shutdown for GPU
- Dynamic Voltage Frequency Scaling / Adaptive Voltage Scaling to CPU and GPU



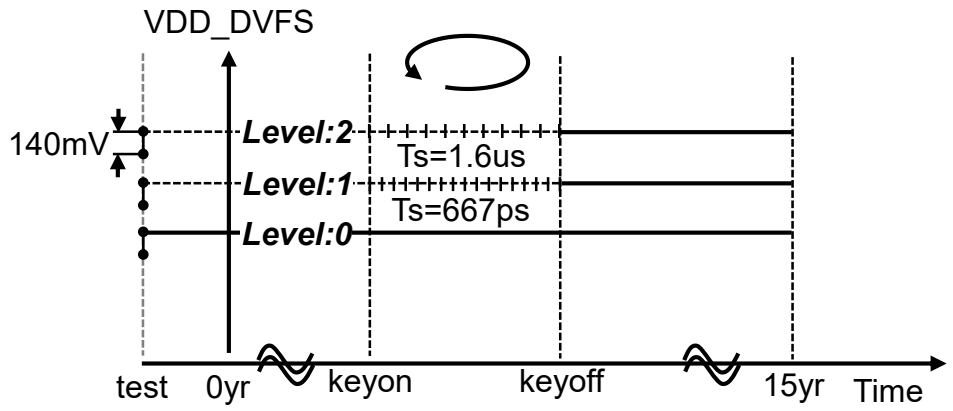
PSW : Power Switch

Power Management for Functional Safety

- Power management with several on chip monitor for several time scale events
- Introduce voltage droop prediction and recovery technique with droop monitor [1]



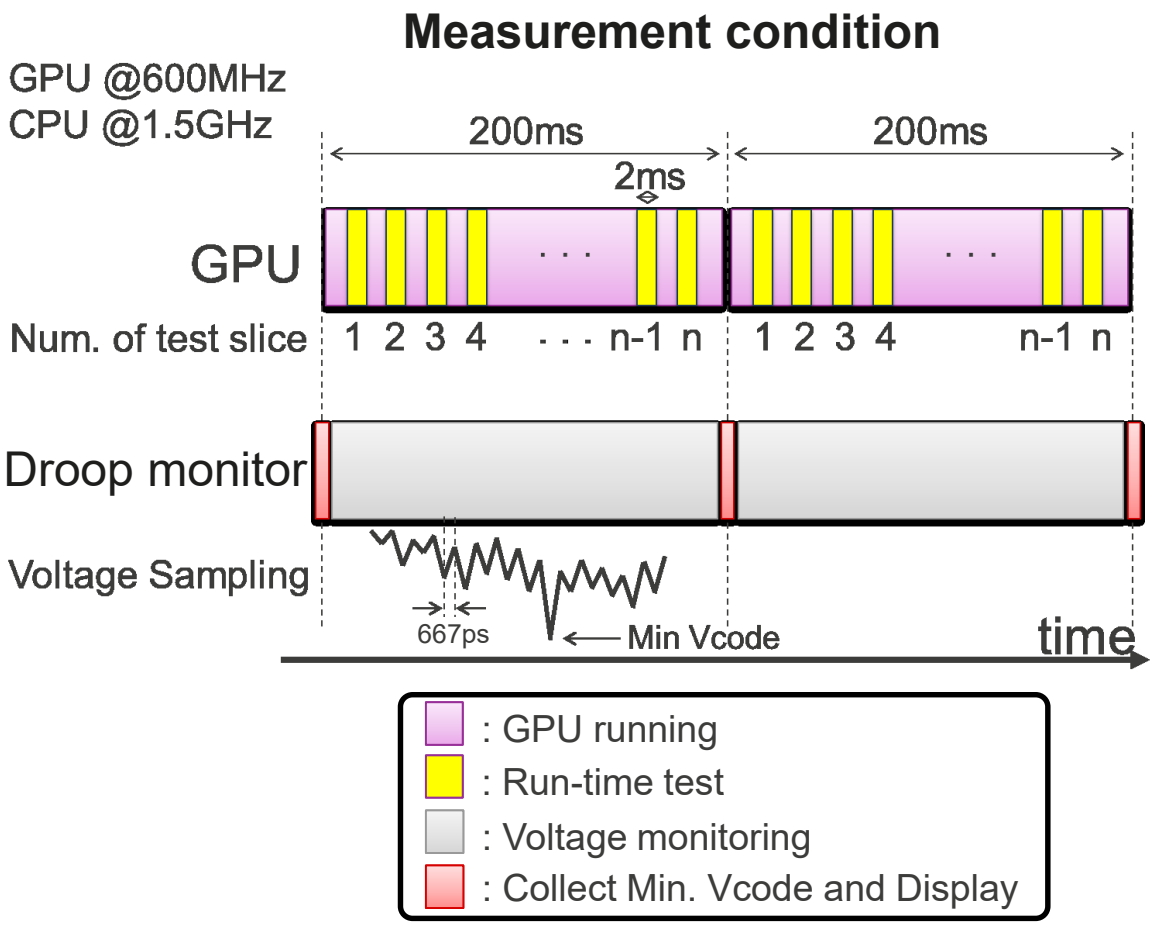
Level	Target Vmin	Used monitor	Control
2	DC operation	Delay monitor	voltage up
1	AC(>1MHz) operation	Droop monitor	Clock stop & restart
0	Monitor Vmin	Voltage monitor	System shutdown

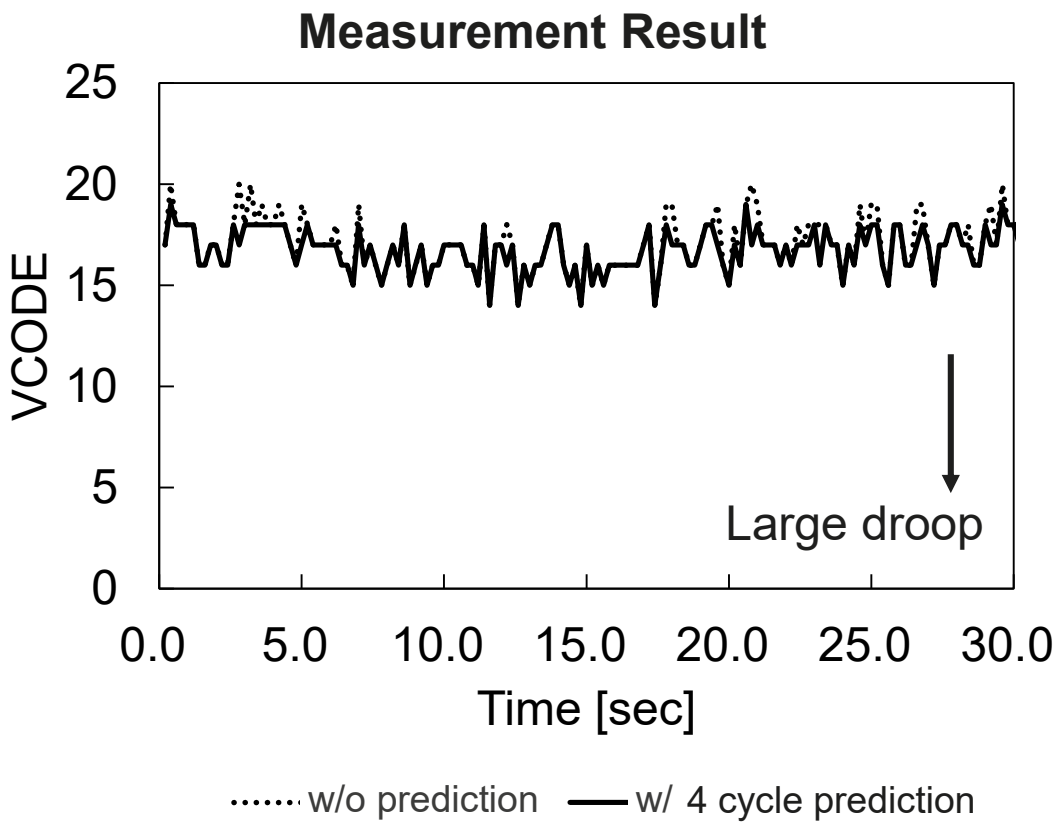


[1] C. Takahashi et al., ISSCC, 2016

Power Management for Functional Safety and Run-time Test

- Droop prediction technique can prevent the failure caused by voltage droop
- Wear-out faults detection by run-time test

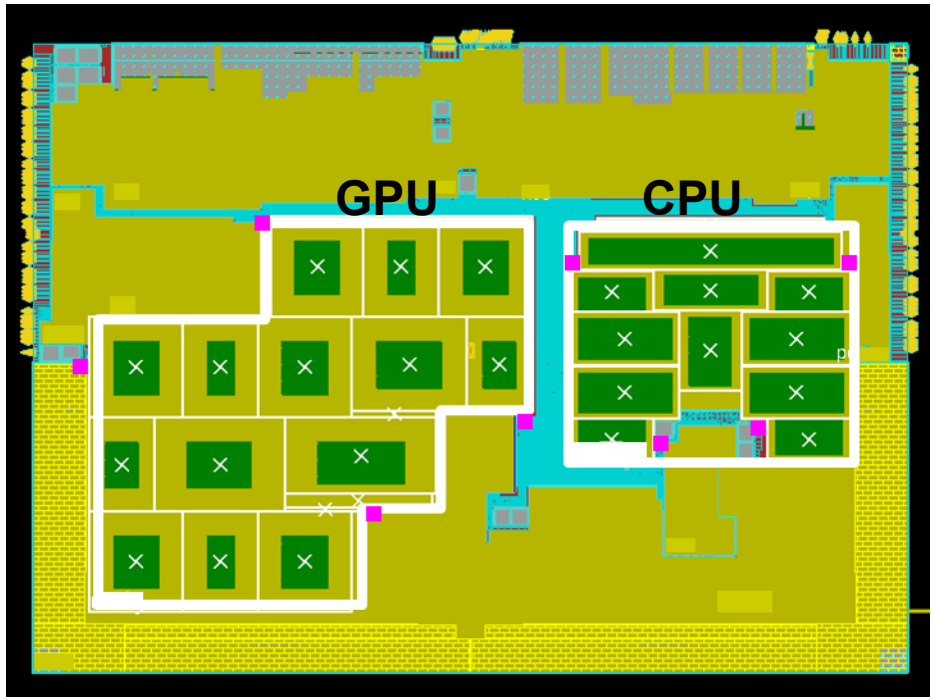


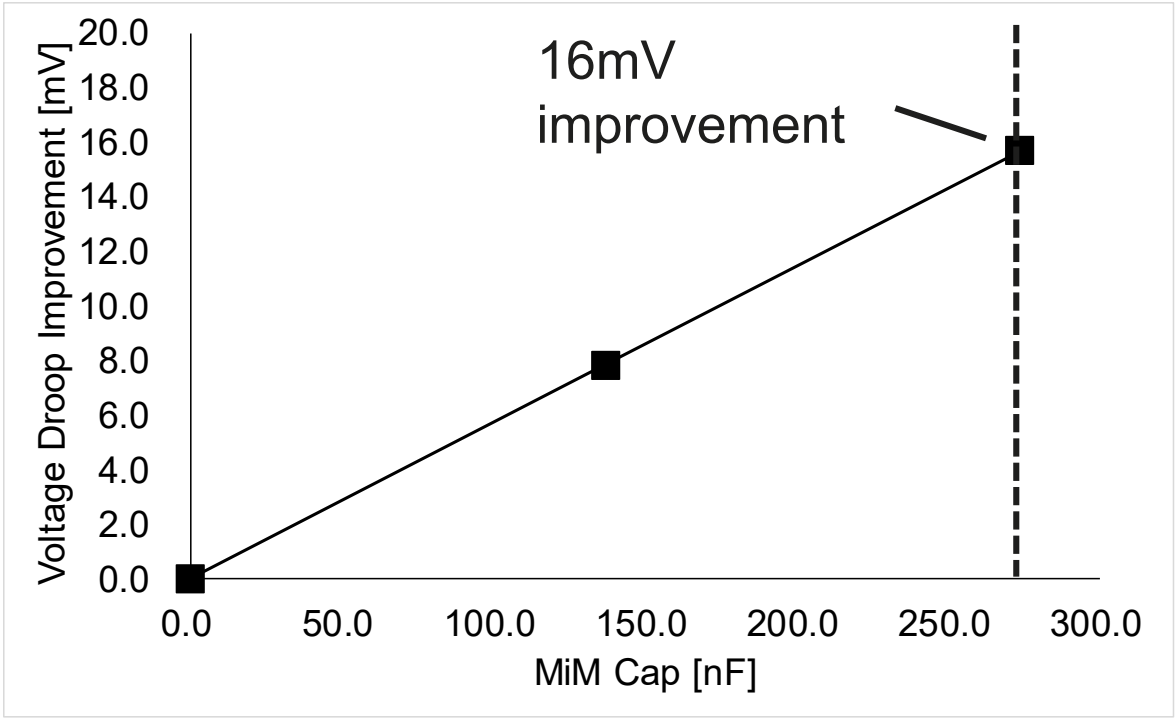


Reliability Aware Droop Mitigation with MIM

- Satisfy both voltage droop reduction with MIM and automotive reliability grade by
  - ✓ Dedicated ESD protection for MIM (AEC-Q100 capable)
  - ✓ MIM area optimization of CPU and GPU

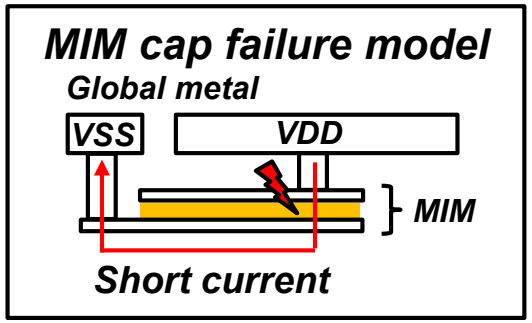
MIM cap
Dedicated ESD protection

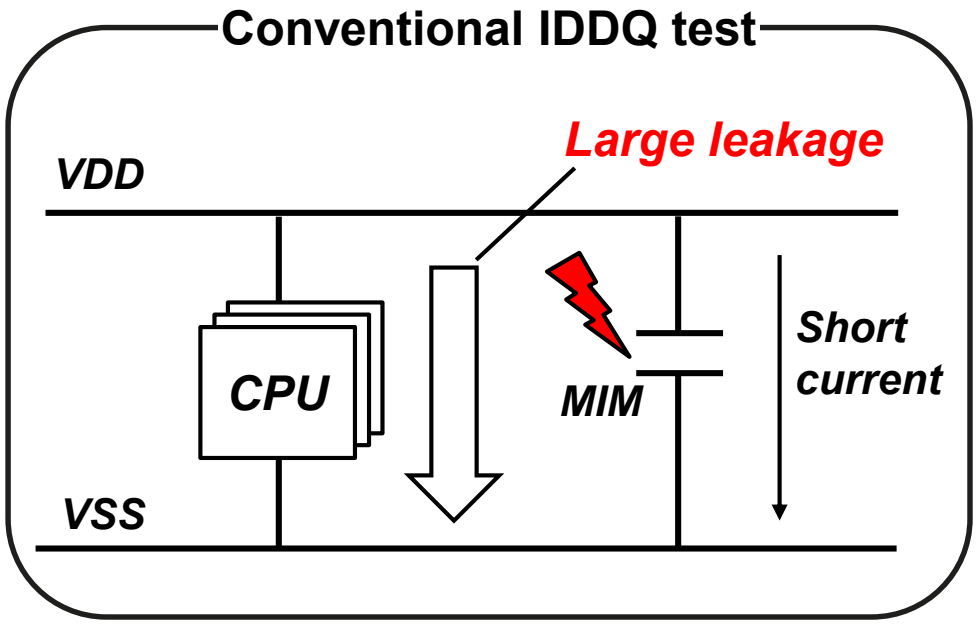


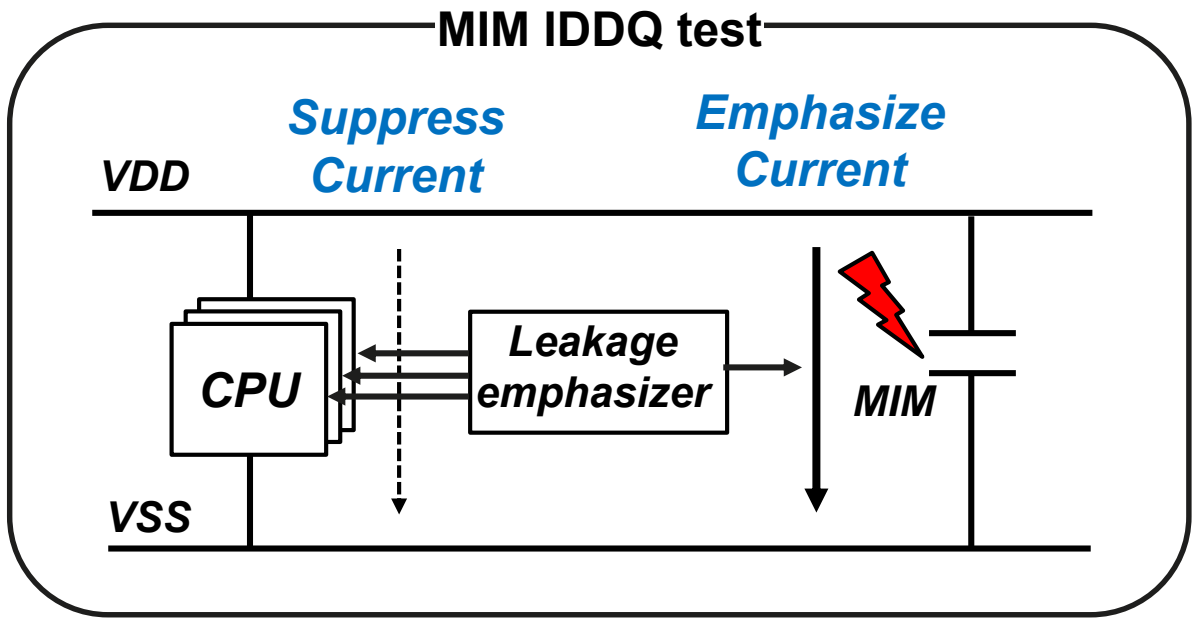


Reliability Aware Droop Mitigation with MIM

- Introducing MIM IDDQ testing enable early failure rejection of MIM
- Emphasize only MIM short current







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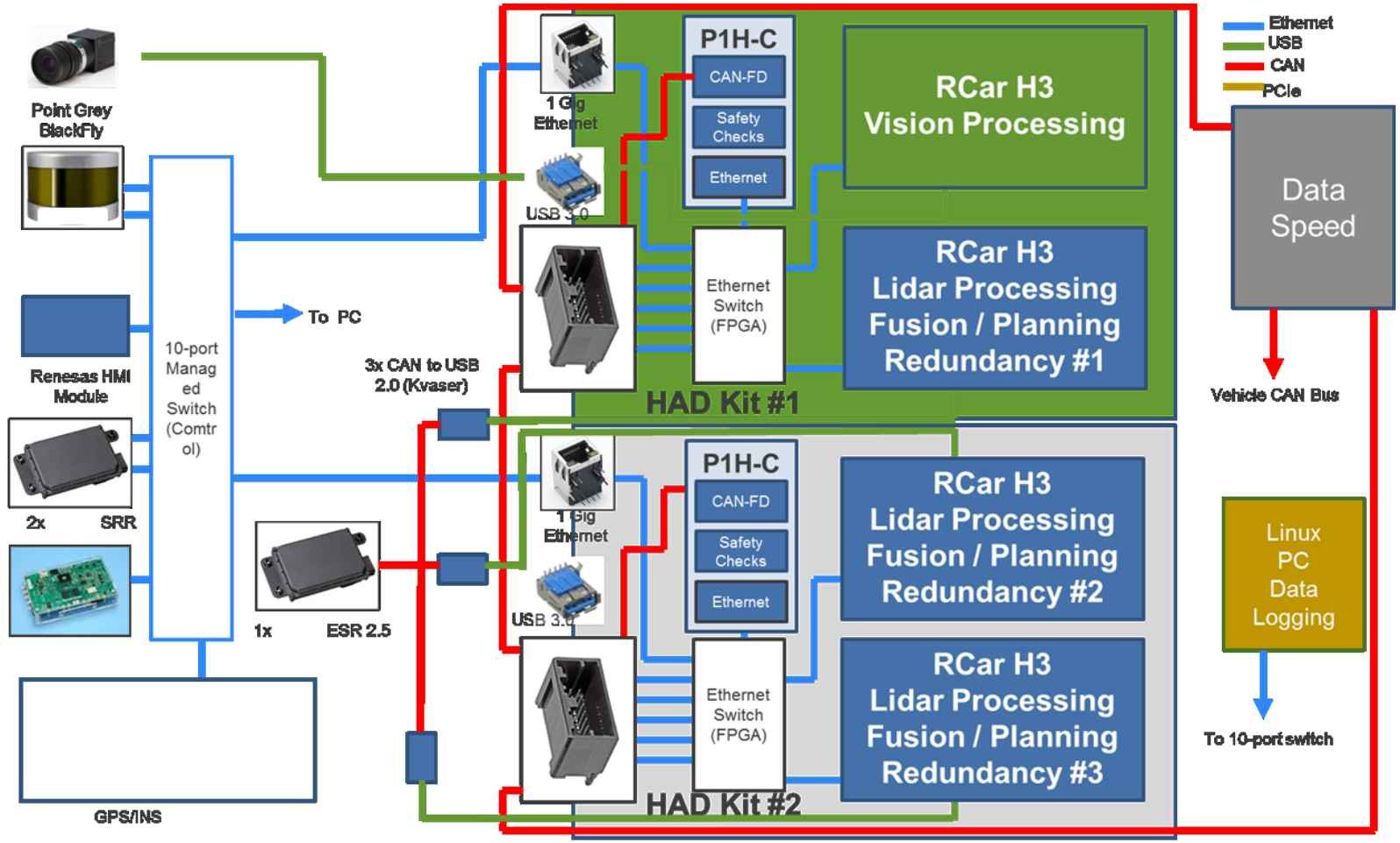
Renesas Concept Car for Level 4 Autonomous Driving

- Level 4 driving with redundancy at **25 Watts**

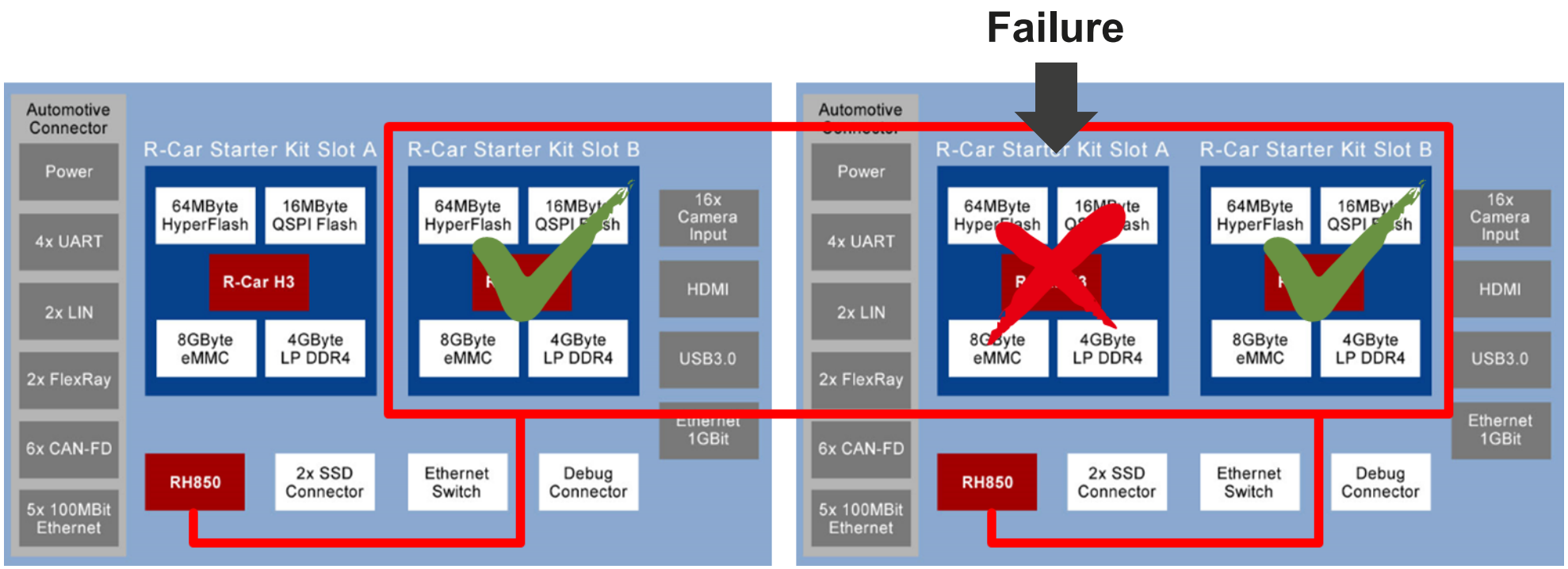
Renesas	NVIDIA	NXP
HAD x **2** (H3 x 4 + MCU x 2)	Drive PX2 (Parker x 2 + Pascal GPU x 2)	BlueBox (QorIQ LS2088A)
25 W	250 W *1	40 W *2



*1 http://www.eetimes.com/author.asp?doc_id=1328609
*2 http://www.nxp.com/jp/products/microcontrollers-and-processors/arm-processors/s32-arm-processors-microcontrollers/bluebox-autonomous-driving-platform-s32vls2-rdb:S32VLS2-RDB

Renesas Concept Car : Fail Operation

- Fail operation tolerant by ASIL-D MCU (RH850) and triple redundant H3 system
- Control the car to move to the safety zone when the failure is detected



https://www.youtube.com/watch?v=r59vYREilHY

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Big Waves in the Future Automotive

Owner Driven Car

Level2/3 (Level4)

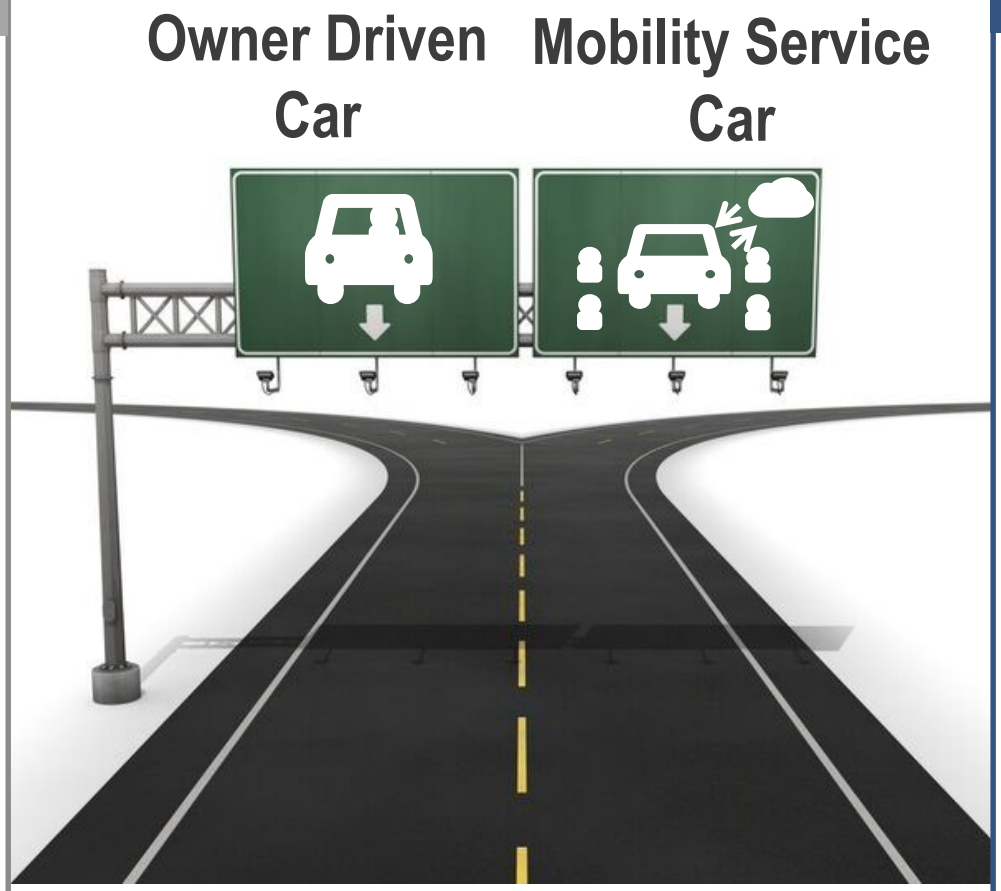
Reduce Car Accident

Driving pleasure

Convenience for Driver

Economic efficiency

(EV Range, Function vs cost)



Mobility Service Car

Level4/5 (Driverless)

Complete Safety

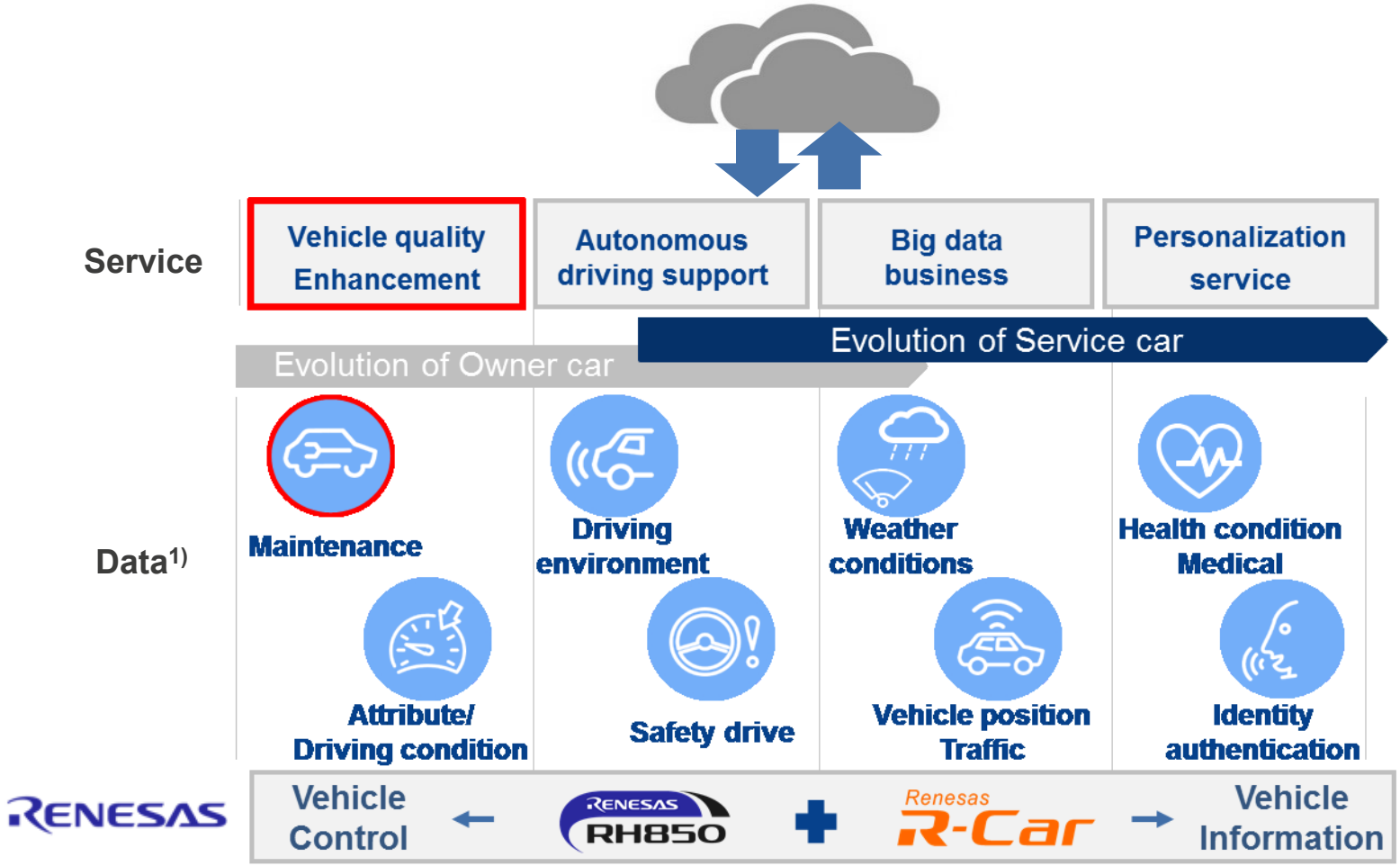
Service pleasure

Mobility convenience

Cloud Service model

Connected Car Solution with Cloud Service

Renesas can link all information to Cloud from control (RH850) to car information (R-Car).
One of important Service is "**Vehicle quality Enhancement**" for Service Car

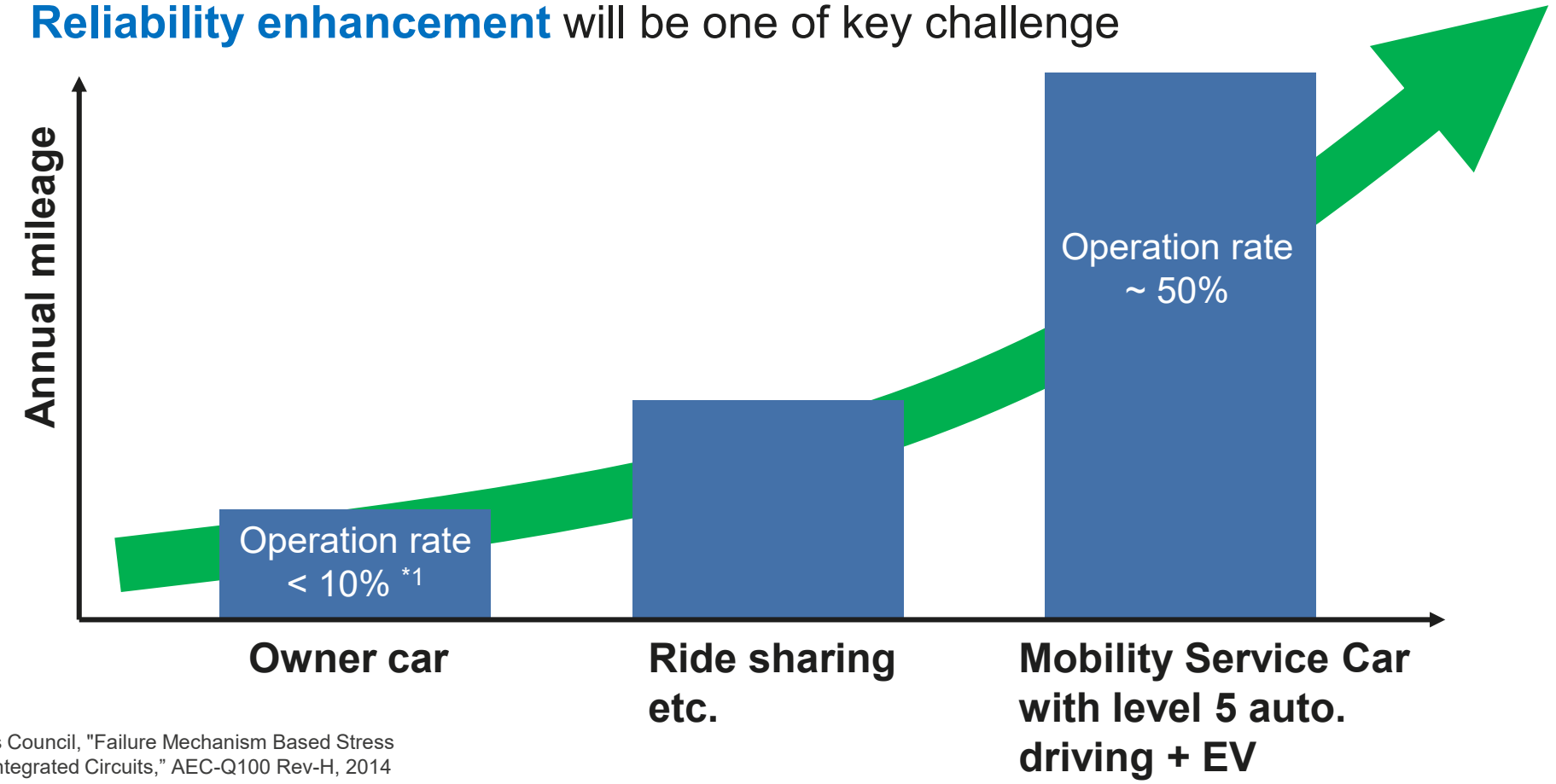


Car Usage Challenges in Future Autonomous Driving Era

What will happen at fully automated driving era?

→ Increase an annual mileage dramatically

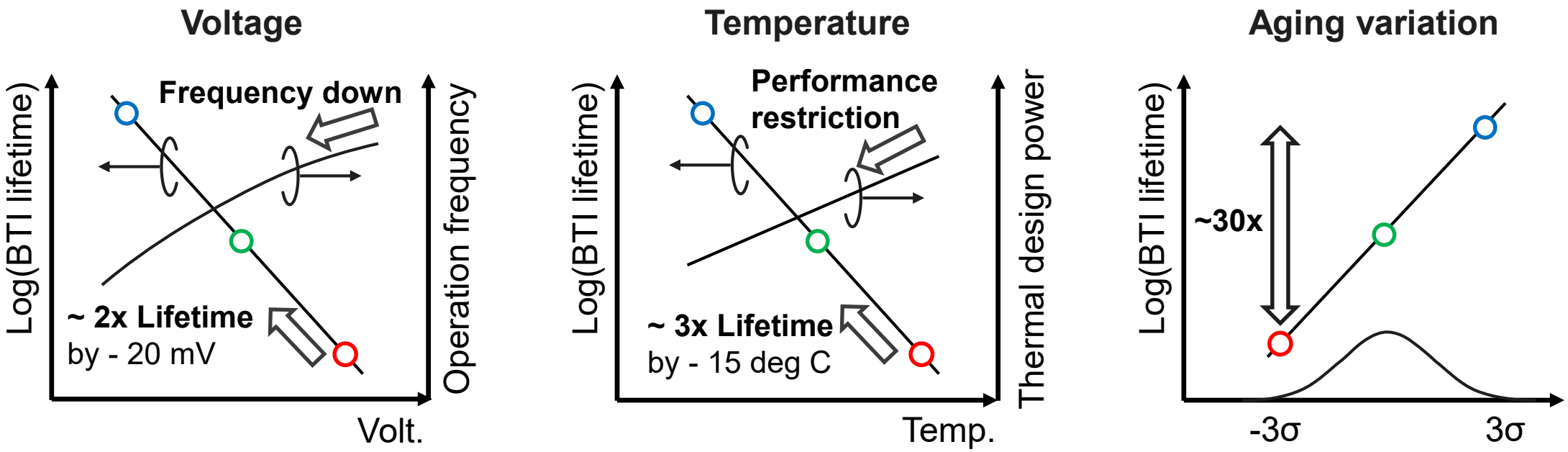
→ **Reliability enhancement** will be one of key challenge



*1 Automotive Electronics Council, "Failure Mechanism Based Stress Test Qualification for Integrated Circuits," AEC-Q100 Rev-H, 2014

Trade-off between Reliability Enhancement and Performance

- Handling of operation temperature, voltage and aging variation further optimize reliability
- Low temp. limitation and low volt. operation may restrict the performance
  → Propose concept of reliability management for further LSI reliability enhancement

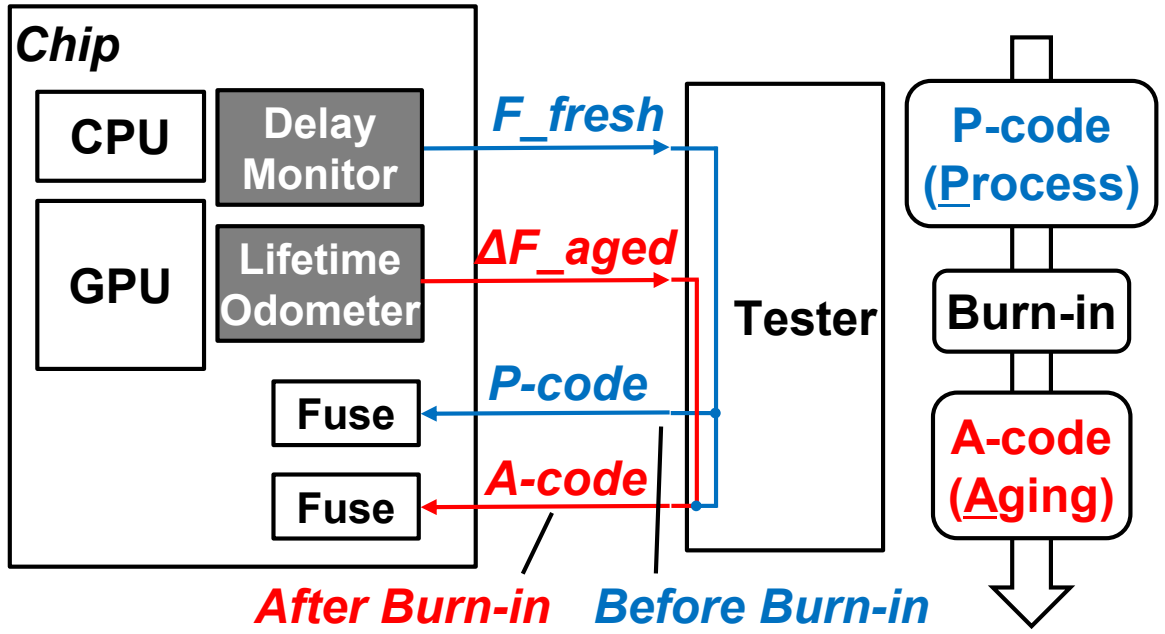


BTI : Bias Temperature Instability

Reliability Management Concept ~ Static AVGS

- One of key reliability item is BTI/HCI degradation
- Lifetime odometer (LTO) monitors BTI/HCI degradation per chip
- Delay monitor and LTO detect Process variation and **Aging variation** at testing

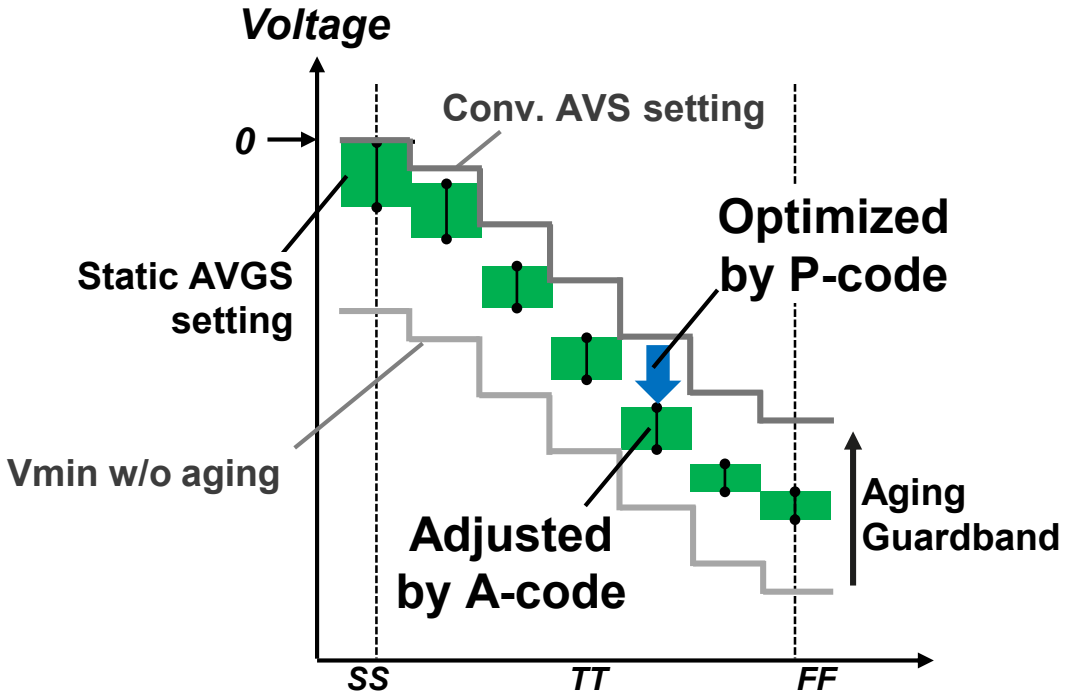
Static Adaptive Voltage Guardband Scaling (AVGS)



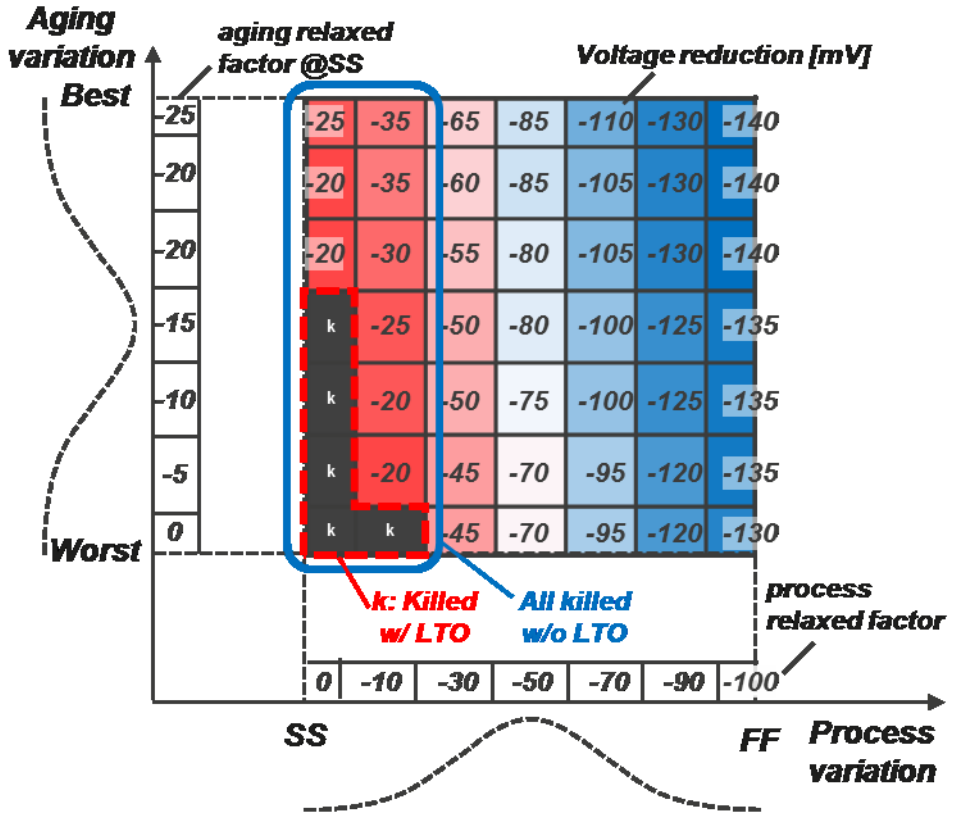
BTI : Bias Temperature Instability
HCI : Hot Carrier Injection

Reliability Management Concept ~ Static AVGS

- Static AVGS optimize Voltage Guardband (VGB) chip by chip with reflecting
  - ✓ Operation Voltage difference (by P-code)
  - ✓ Aging variation difference (by A-code)
- 20 mV lower operation extend lifetime at SS chip with negligible yield loss by LTO



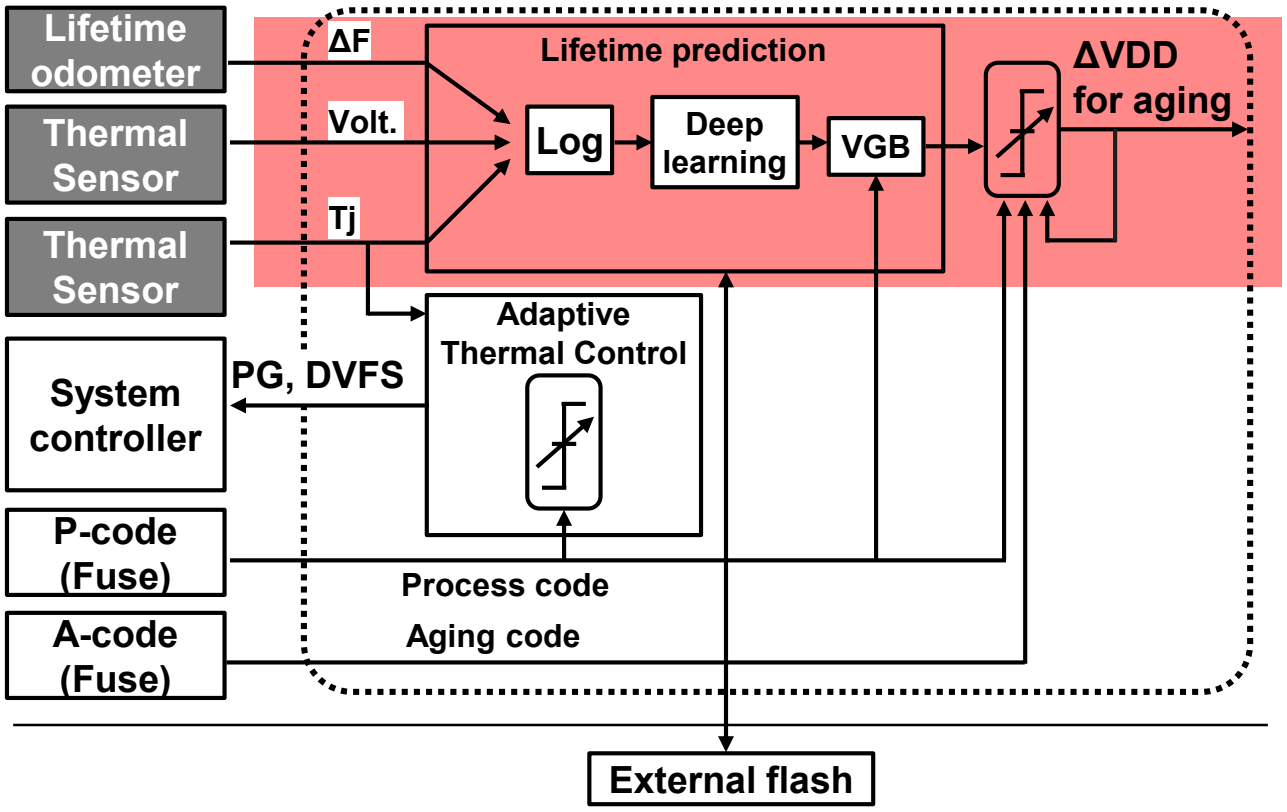
SS/TT/FF : Slow/Typical/Fast Chip



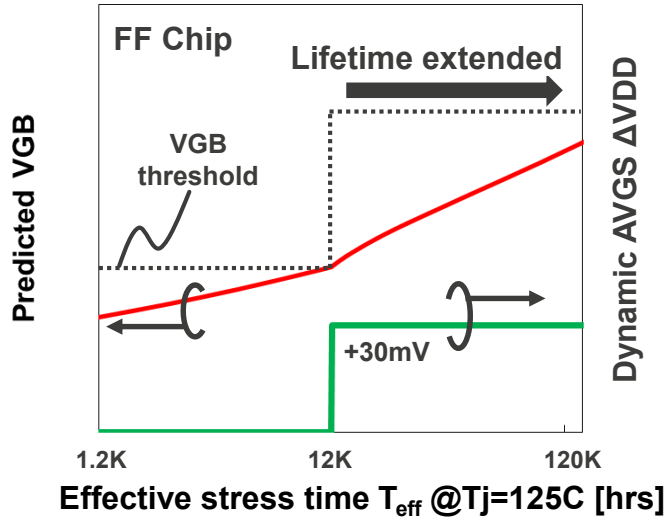
Reliability Management Concept ~ Dynamic AVGS

- Dynamic voltage control based on P&A-code and lifetime prediction extend lifetime of chip with initial low volt. (TT~FF chip)

Dynamic-AVGS and Adaptive Thermal Control

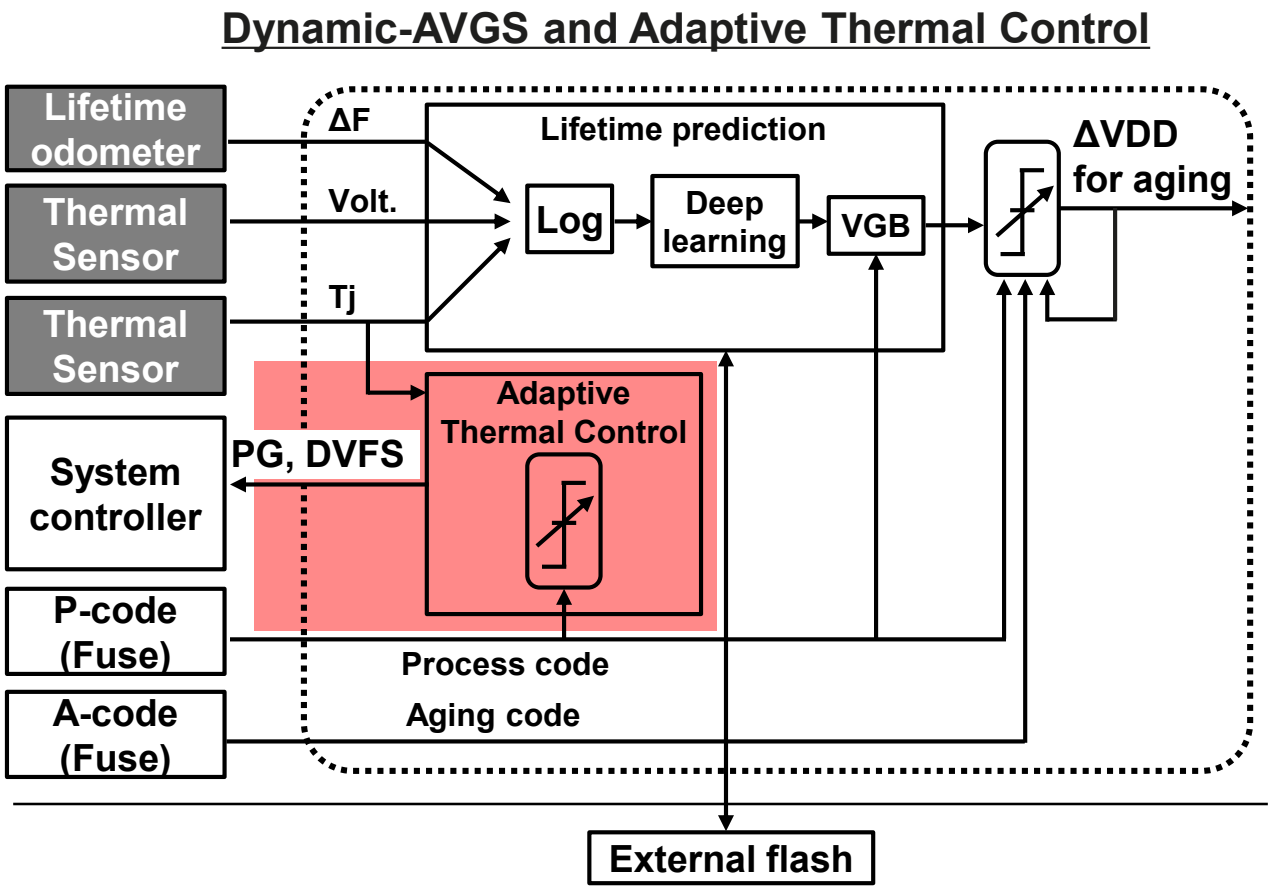


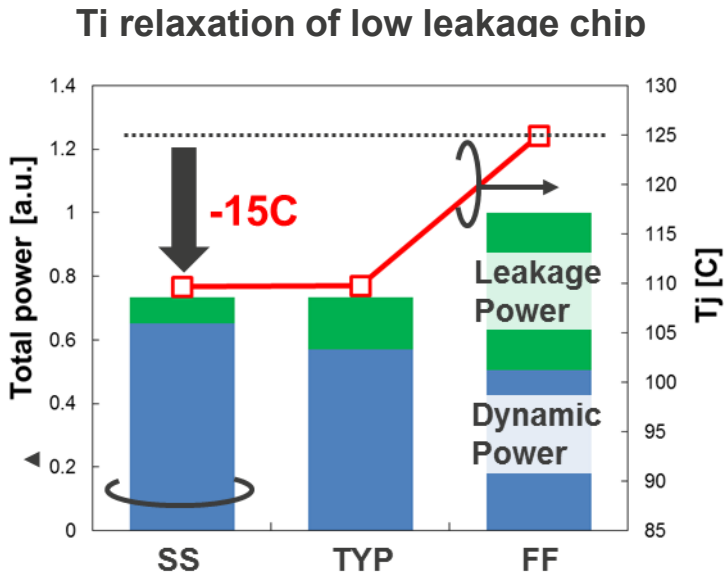
Lifetime extension with dynamic-AVGS



Reliability Management Concept ~ Dynamic AVGS

- Adaptive thermal control based on P-code extend lifetime of chip with low leakage (SS~TT)

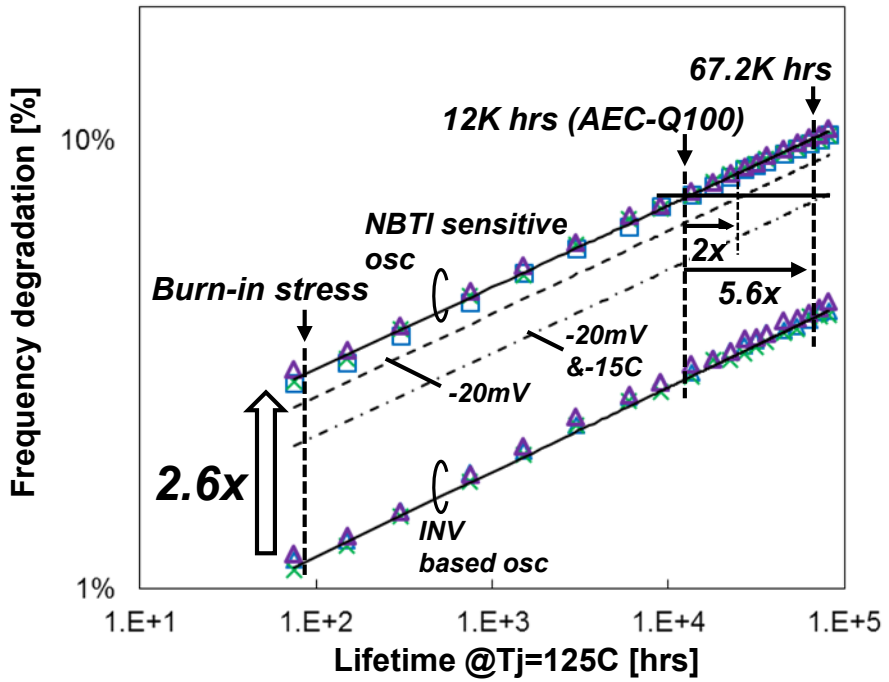




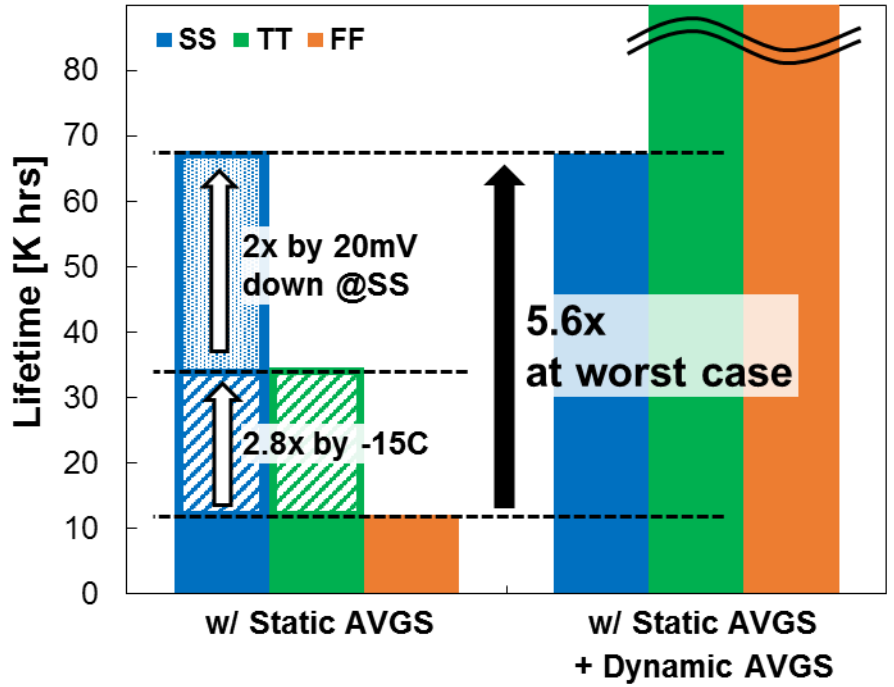
Reliability Management Concept ~ Result

- 5.6x lifetime in total without performance degradation realize ~ 50% operation rate

Measured result of Lifetime Odometer



Total lifetime extension



Power on time	Field lifetime	Duty ratio
12 K hrs	15 years	9.1%
67.2 K hrs	15 years	51.1%

Summary

- Renesas Autonomy : Total solution for auto. driving computing platform
- R-Car H3 satisfy all of Performance, Low power, Functional safety and Reliability
- Demonstrate Renesas concept car for level 4 autonomous driving
  - ✓ 25 W with triple redundant H3 and ASIL-D MCU system
- Introduce concept of reliability management for future auto. driving usage

BACKUP

Definition of Levels of Driving Automation by SAE International

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Source : SAE International J3016, Sep. 2016

BIG IDEAS FOR EVERY SPACE

Renesas.com