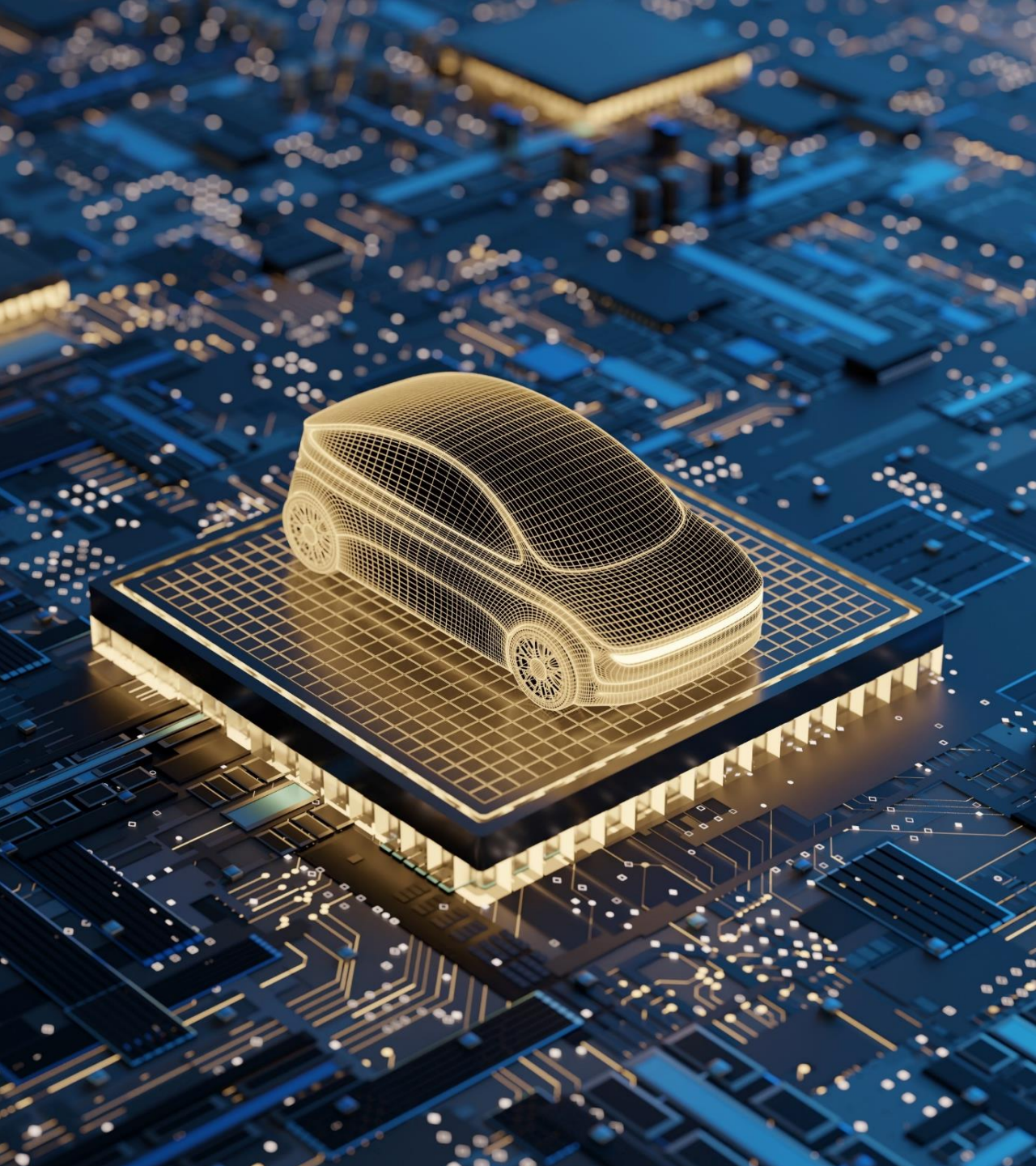




# ECU Consolidation with S32Z2/E2 使用S32Z/E实现车载 ECU集成

**Tracy Yu**

Senior Vehicle Electronic Architecture Manager  
September 2024



# Agenda

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Consolidation & why it matters

NXP's role in consolidation

- Hardware solutions

- Software landscape

- Using S32Z2/E2 to consolidate

Creating paths to SDV



0x1

# Consolidation & why it matters

Why is the automotive industry  
adopting consolidation now?





# History lesson

The move from ICE to EV

Without digging into the inefficiencies present within ICE solutions, the point here is to convey that size, weight and complexity reduction has been a natural progression.

As we move away from ICE we also move towards brand new architectures, providing us novel opportunities to fix problems that were not easily fixed before (due to a LOT of moving parts and system complexity).

## Internal Combustion Engine (ICE)



**Weight: 300 - 500+ lbs.**  
**Power: 180 - 400+ HP**  
**Max Speed: 6000-7000 RPM**  
**Efficiency: 30 - 35%**  
**Moving Parts: Many!**

- 1 Crankshaft
- 3 to 12 Pistons
- 3 to 12 Connecting Rods
- 6 to 48 Valves
- 6 to 48 Valve Springs
- 6 to 48 Rockers/followers
- 6 to 48 Lifters & Pushrods
- 1 to 4 Camshafts
- 1 to 4 Cam Drives & Chains/belts
- 1 Oil Pump
- 1 to 2 Balance Shafts
- 1 Flywheel

**Maintenance Required:**  
**Oil & Filter Changes 5 to 12K Miles**  
**Spark Plugs at 100k Miles**  
**Timing Belts & Drive Belts 100K Miles**  
**Coolant Changes 50-100K Miles**  
**Emission Inspections 1 to 2 years**

## Electric Vehicle Motor (EV)



**Weight: 100 - 200 lbs.**  
**Power: 180 - 400+ HP**  
**Max Speed: 15,000-21,000 RPM**  
**Efficiency: 90 - 95%**  
**Moving Parts: One**

1 Rotor

**Maintenance Required: Minimal**  
**No Oil & Filter Changes**  
**No Spark Plugs**  
**No Timing Belts & Drive Belts**  
**Coolant Changes maybe 50k+ Miles**  
**No Emission Inspections**

**VS**

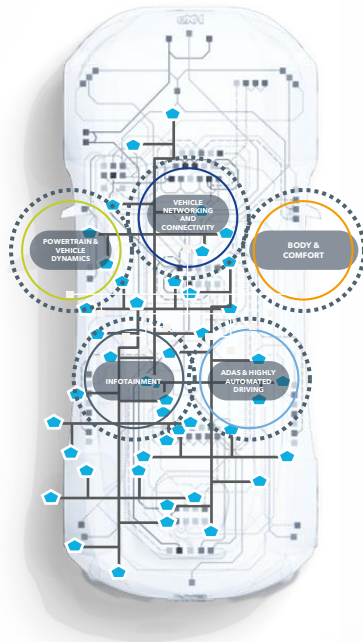
# E/E architecture evolution: consolidation of ECUs = more focus on software

Flat



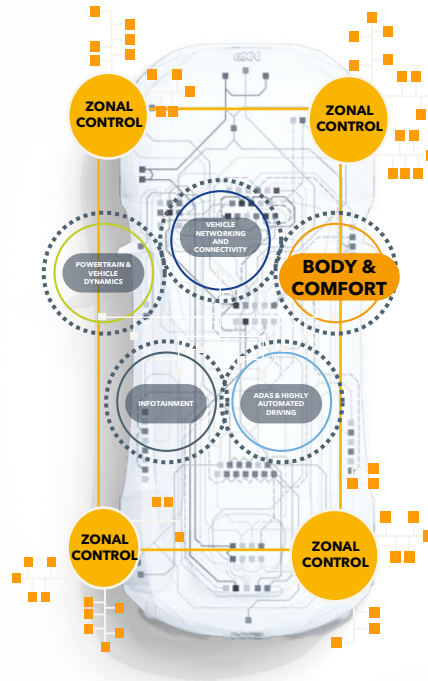
**LEGACY ARCHITECTURE  
ORGANICALLY GROWN**

Domain



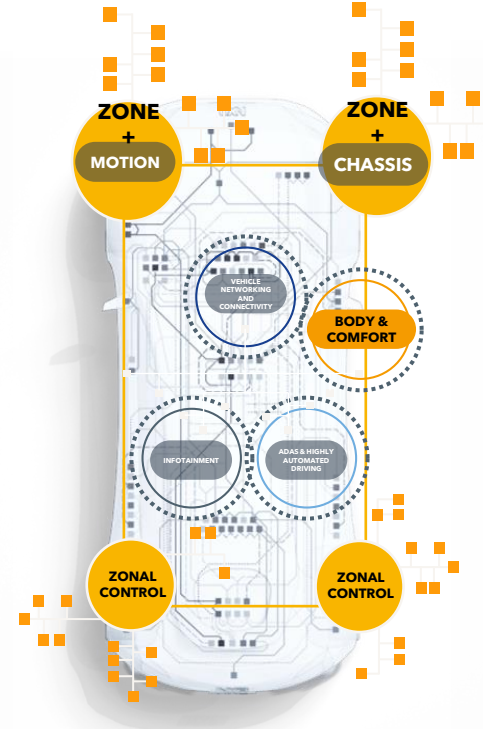
**SCALABLE AND CENTRALIZED  
SOFTWARE DEVELOPMENT**

Domain + Body Zonal



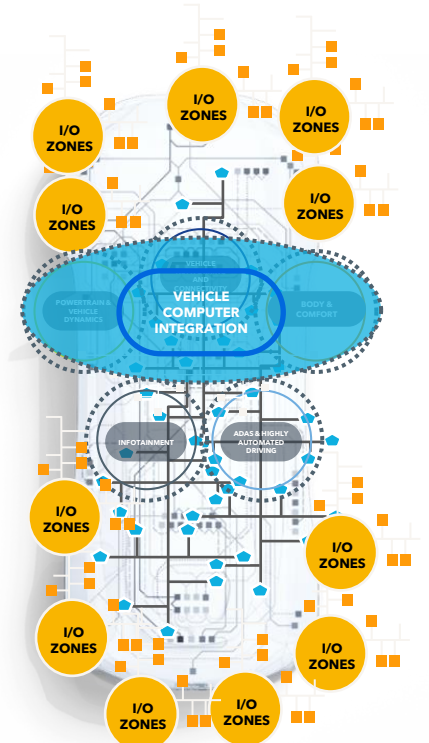
**DOMAIN SW BENEFIT +  
SIMPLIFIED WIRING AND  
VEHICLE NETWORK**

Cross-Domain Zonal



**LOWER HW COST  
VS MORE COMPLEX SW**

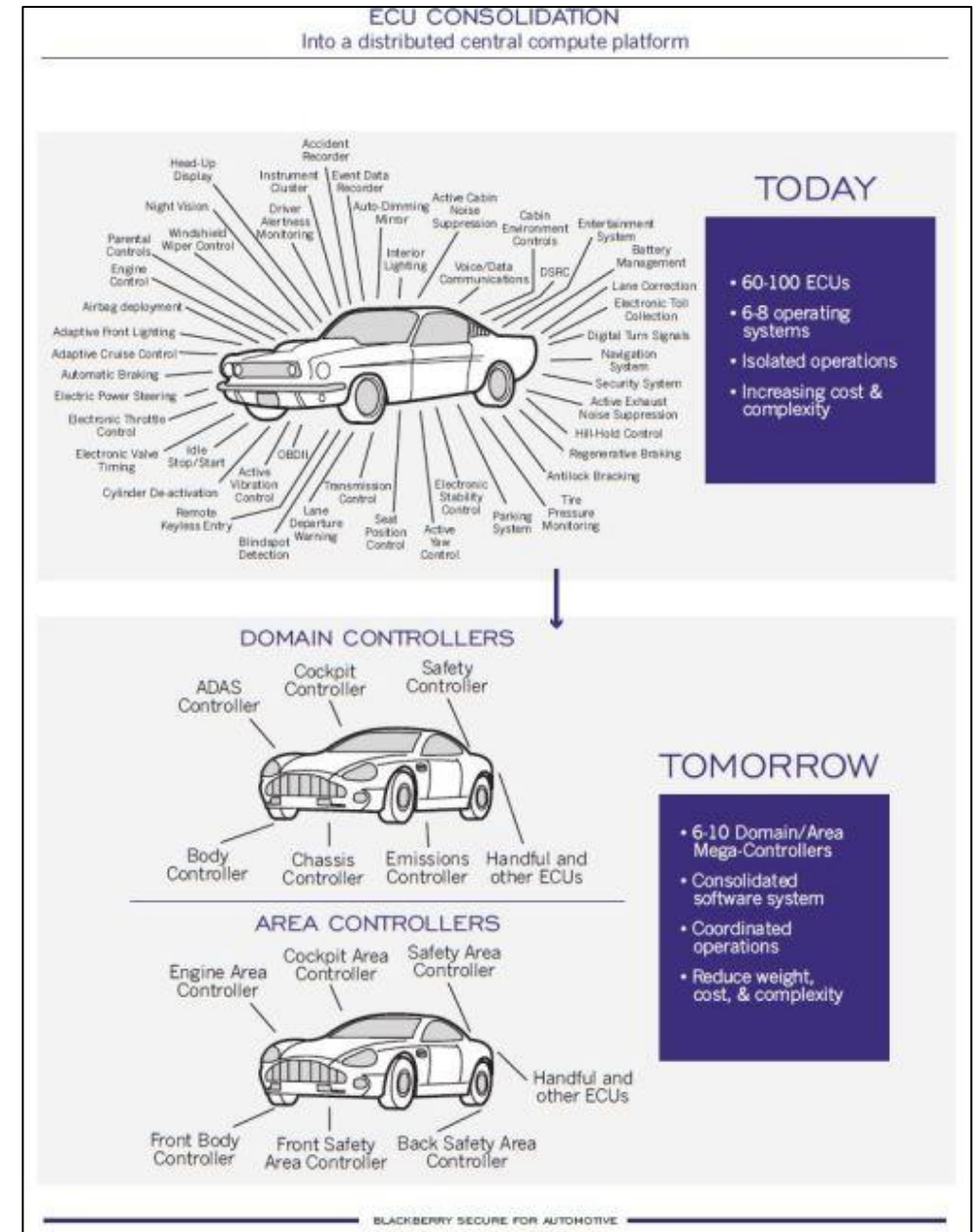
Consolidated Compute



**SIGNIFICANTLY REDUCES SW  
DEVELOPMENT COST,  
VS HIGHER HW COST FOR  
FUTURE-PROOFING**

# Benefits of ECU consolidation for the OEMs

- Lighter
- Less wiring, loom and power connections
- More compact
- Less assembly steps
- Cost reduction
- Easier reuse across product portfolio
- Simplified supply chain
- Improved reliability
- Potentially better in terms of functional safety and OTA update management

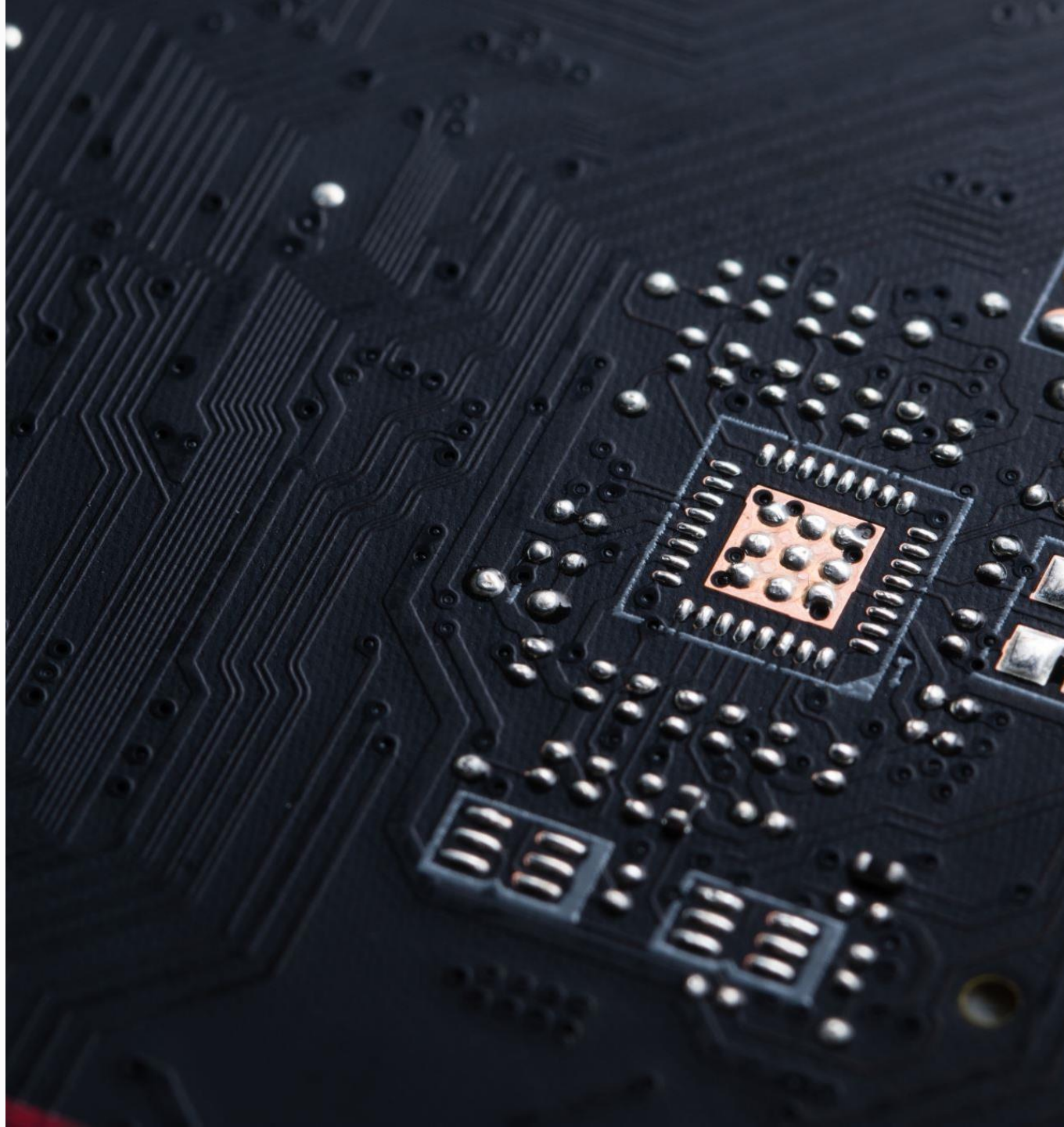




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# What is NXP's role?

How are we advising and serving customers to meet their needs?



i.

# Hardware solutions





# Electrification semiconductor content



1. Semi Content per Car increase (TAM) vs Level 0  
2. Source: Strategy Analytics; IHS; Evercore; ABI Research; NXP

# NXP platform play in evolving vehicle electronics architecture

## Vehicle Computer

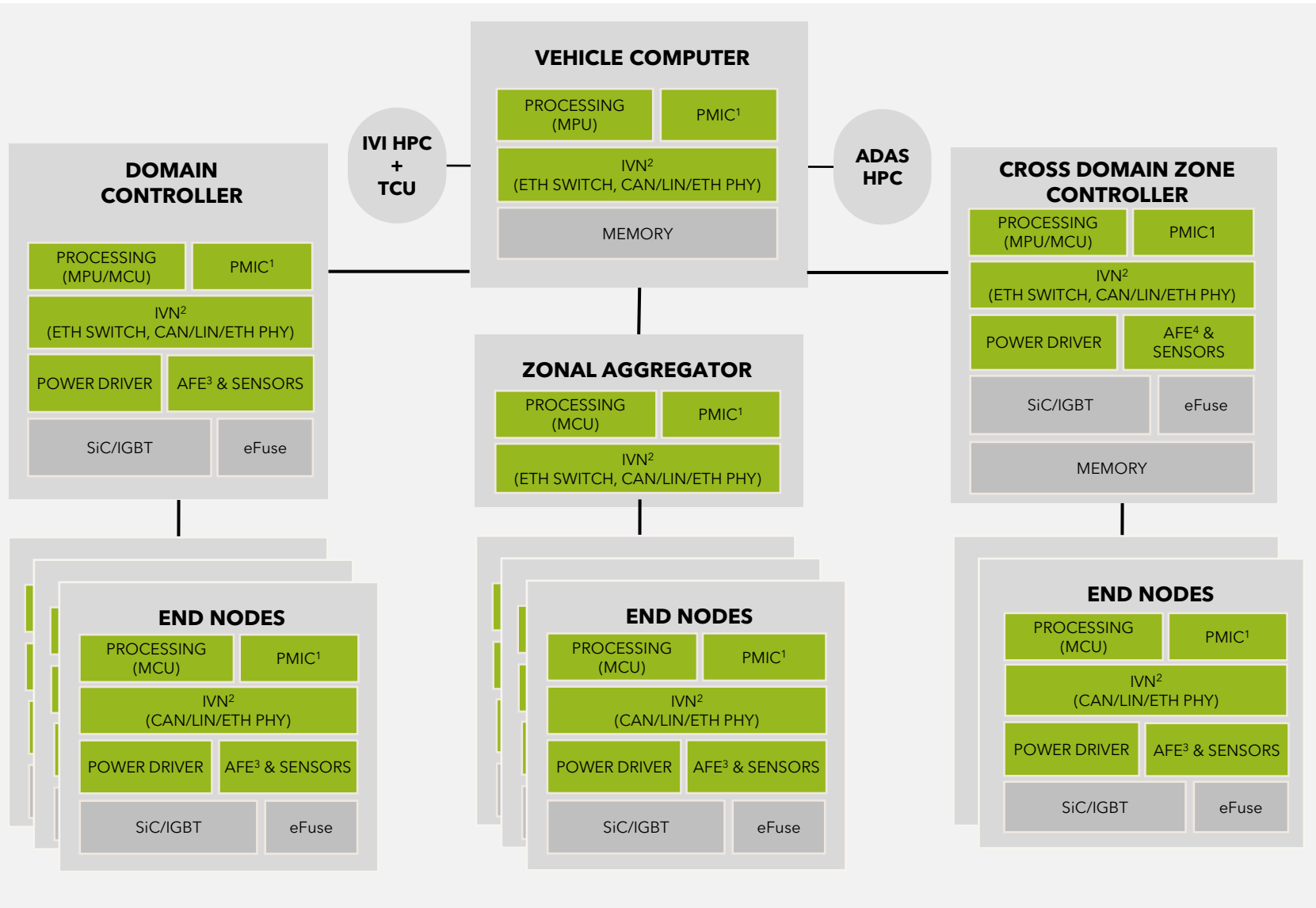
- **Arm-based safe and secure processors** with industry's highest application and real-time ASIL-D performance, highest security, Multi-Gb ETH networking interfaces and accelerators and AI/ML capabilities
- **PMICs/SBCs** for safety and power management
- Robust, reliable and secure **ETH/CAN/LIN** solutions

## Zonal, Domain, Cross-Domain Modules

- **Arm-based safe and secure MCUs and processors** with industry's highest ASIL-D performance, highest security, high-end networking interfaces and accelerators and AI/ML capabilities
- **PMICs/SBCs** for safety and power management
- Robust, reliable and secure **ETH/CAN/LIN** solutions
- **Power drivers** for motors, lighting and relays
- **AFE and sensors** for powertrain and motor control

## Edge Nodes

- **Arm-based safe and secure MCUs** with industry's highest ASIL-D performance, highest security, low-power, high-end networking interfaces and accelerators
- **PMICs/SBCs** for safety and power management
- Robust, reliable and secure **ETH/CAN/LIN** solutions
- **Power drivers** for motors, lighting and relays
- **AFE and sensors** for powertrain and motor control





# Introducing the NXP S32Z/E real-time processors



## S32Z/E

NXP Extends S32 Automotive Platform with its S32Z/E Real-Time Processors for New Vehicle Architectures



- The new S32Z/E Real-Time high-performance processors accelerate and consolidate real-time applications for safety, domain and zonal architectures
- Creates new class of processors offering real-time behavior of microcontrollers with unparalleled gigahertz performance and integration
- Offers scalable, 16nm S32Z and S32E families with roadmap to 5nm solutions

## S32Z/E: key system design principles

Architecture supports  
partitioning /  
virtualisation from  
processor core-to-pin

- Minimise para-virtualisation
- Integrate partitioning with safety and security features
- Optimise QoS when allocating partitions
- Provide virtualization-aware and dedicate modules to partitions

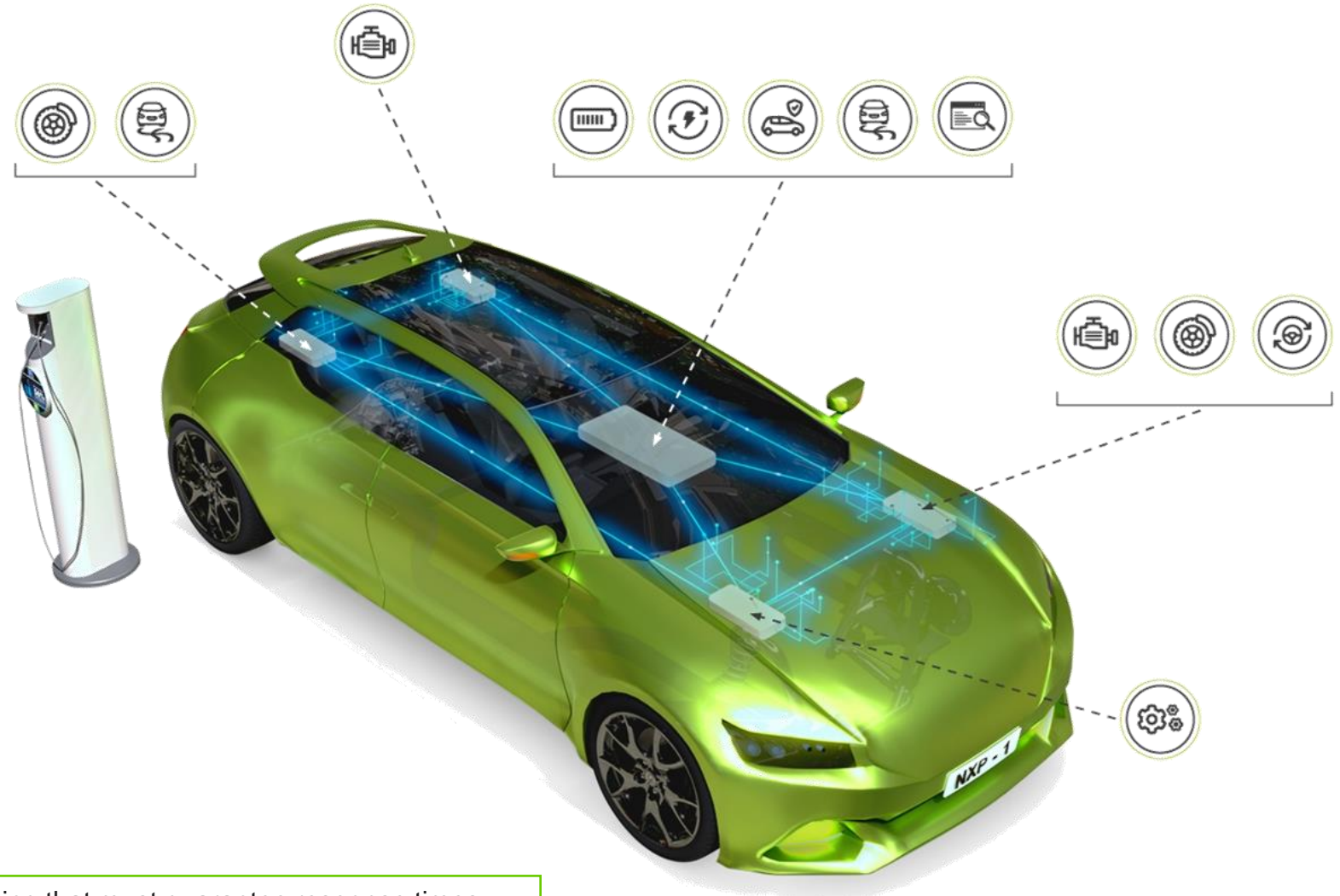
Optimise the architecture  
for best performance in  
16 nm technology

- Gather co-operating hardware modules in autonomous blocks
- Provide multiple copies of commonly used modules
- Optimise QoS for “general purpose” features



# Example: real-time applications

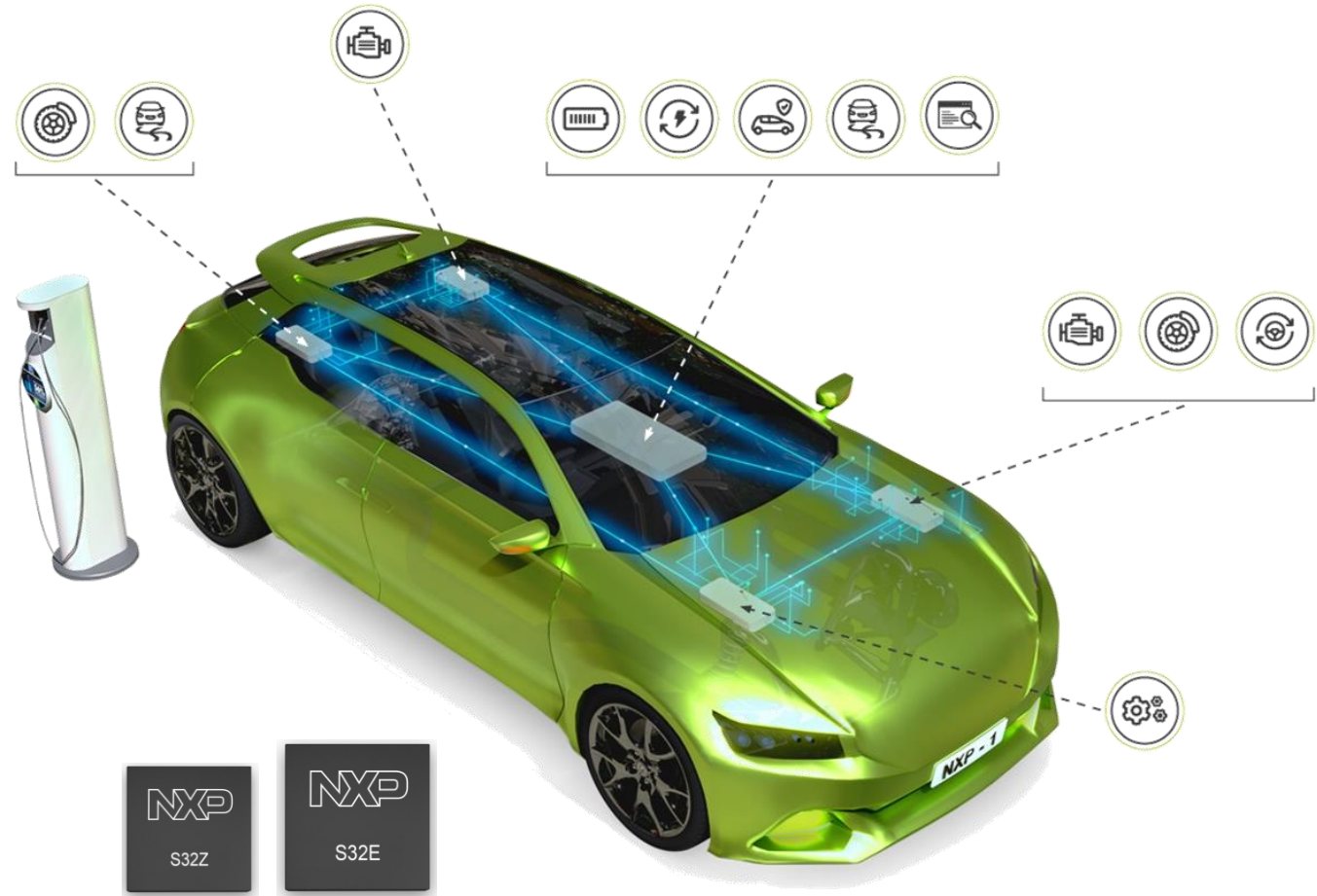
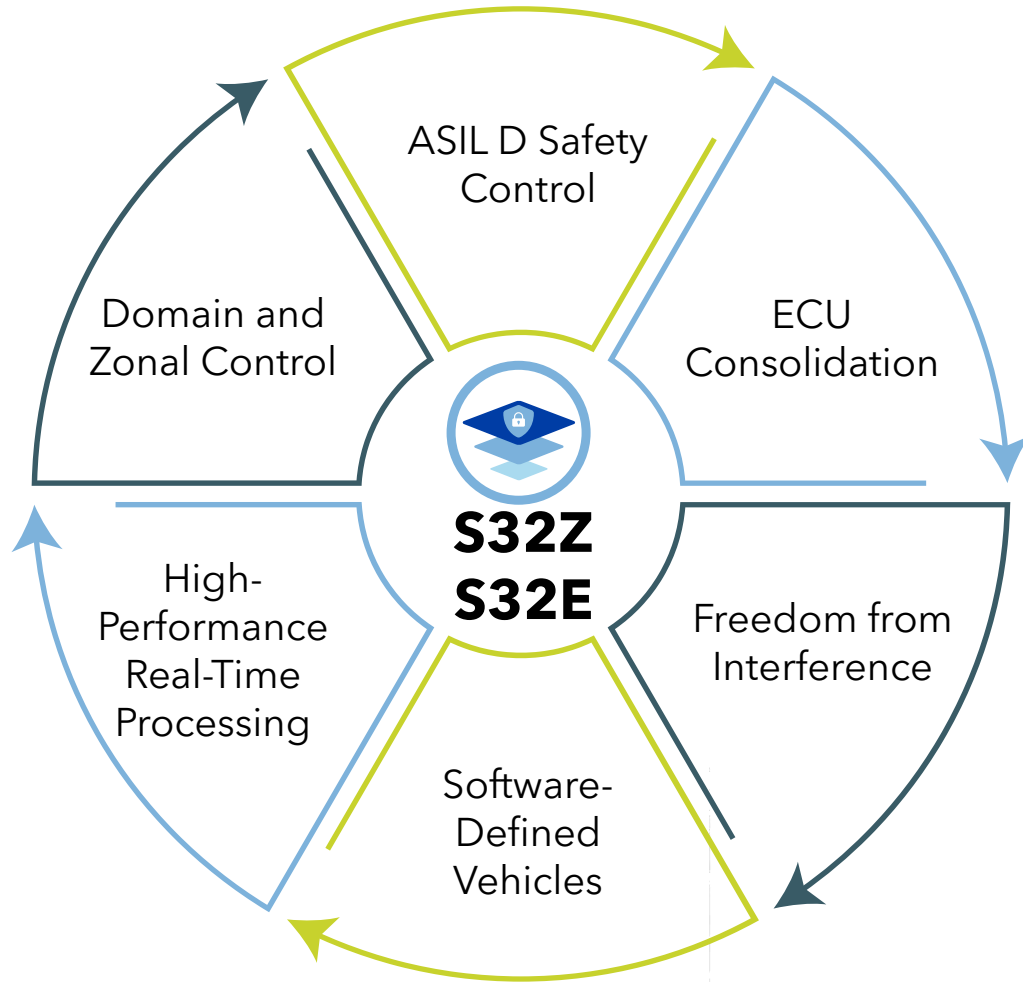
- Domain Control
- Zonal Control
- Safety Processing
- Braking
- Steering
- Electronic Stability Control
- Traction Motor Control
- Torque Control
- Battery Management
- Energy Optimization
- Power Conversion
- On-Board Charging
- Real-time Data Analytics



**Real-time** describes various operations in computing that must guarantee response times within a specified time (deadline), usually a relatively short time. - Wikipedia

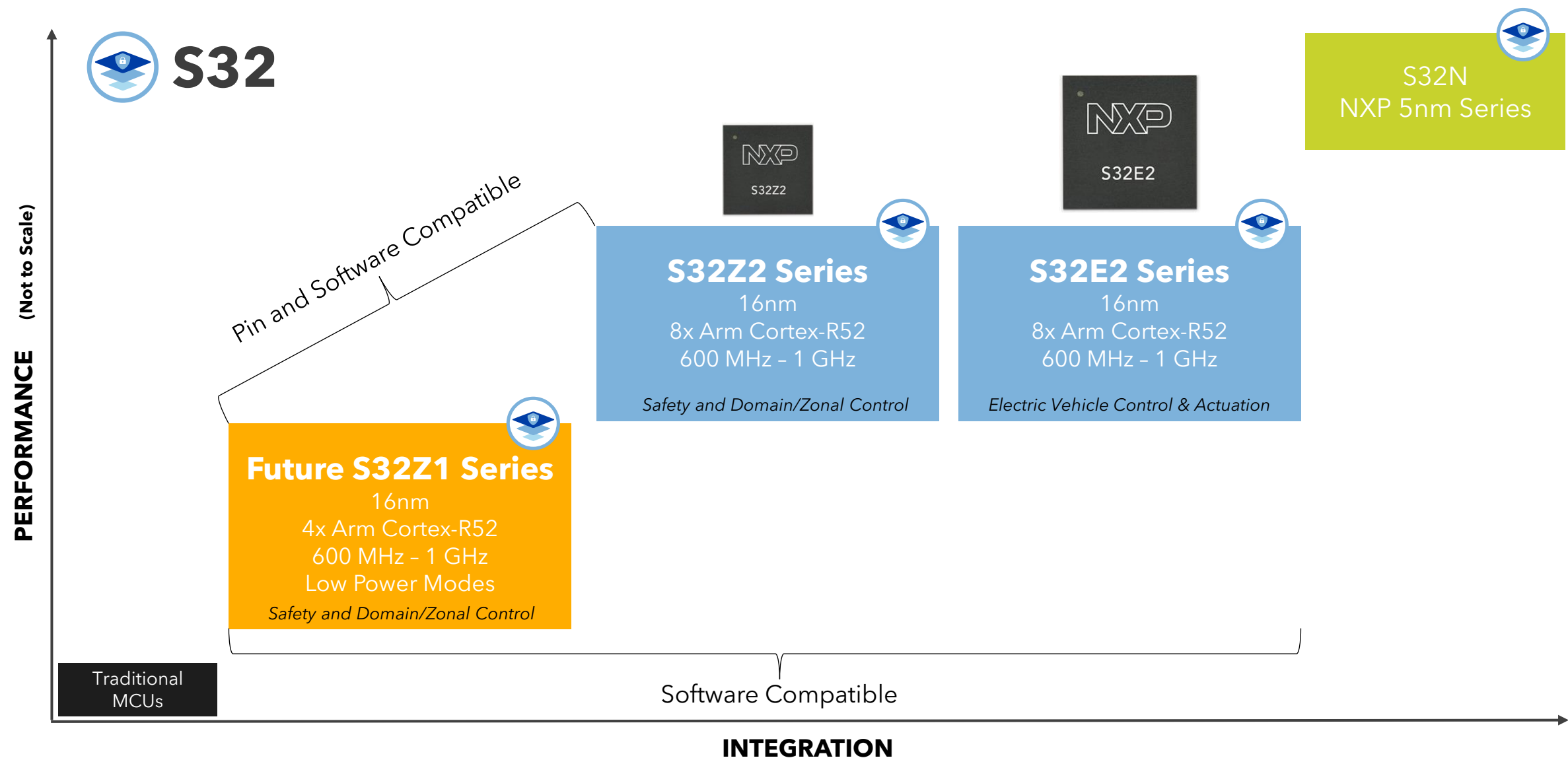
# S32 real-time processors

New class of processors addressing key market trends

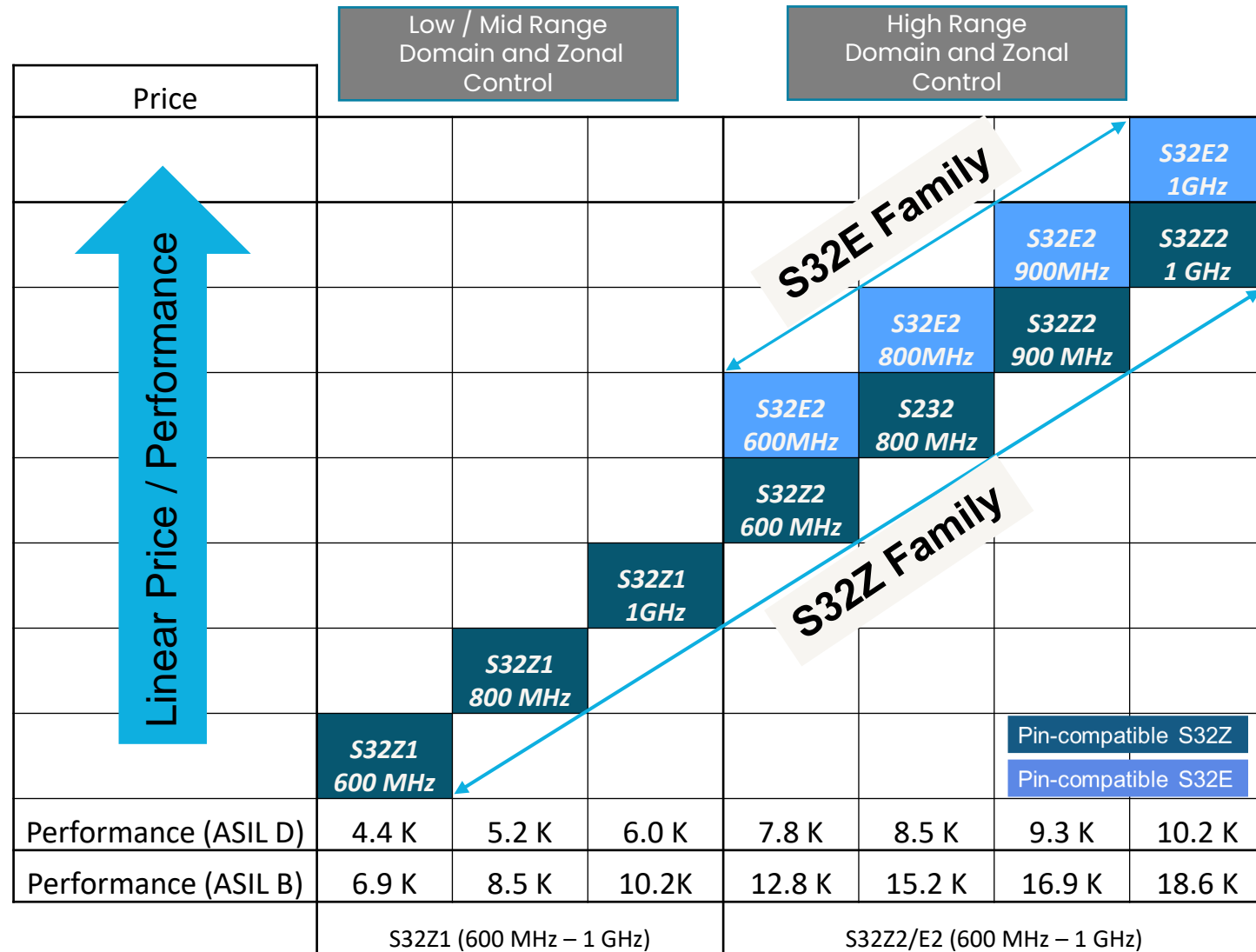




# S32 real-time processors roadmap



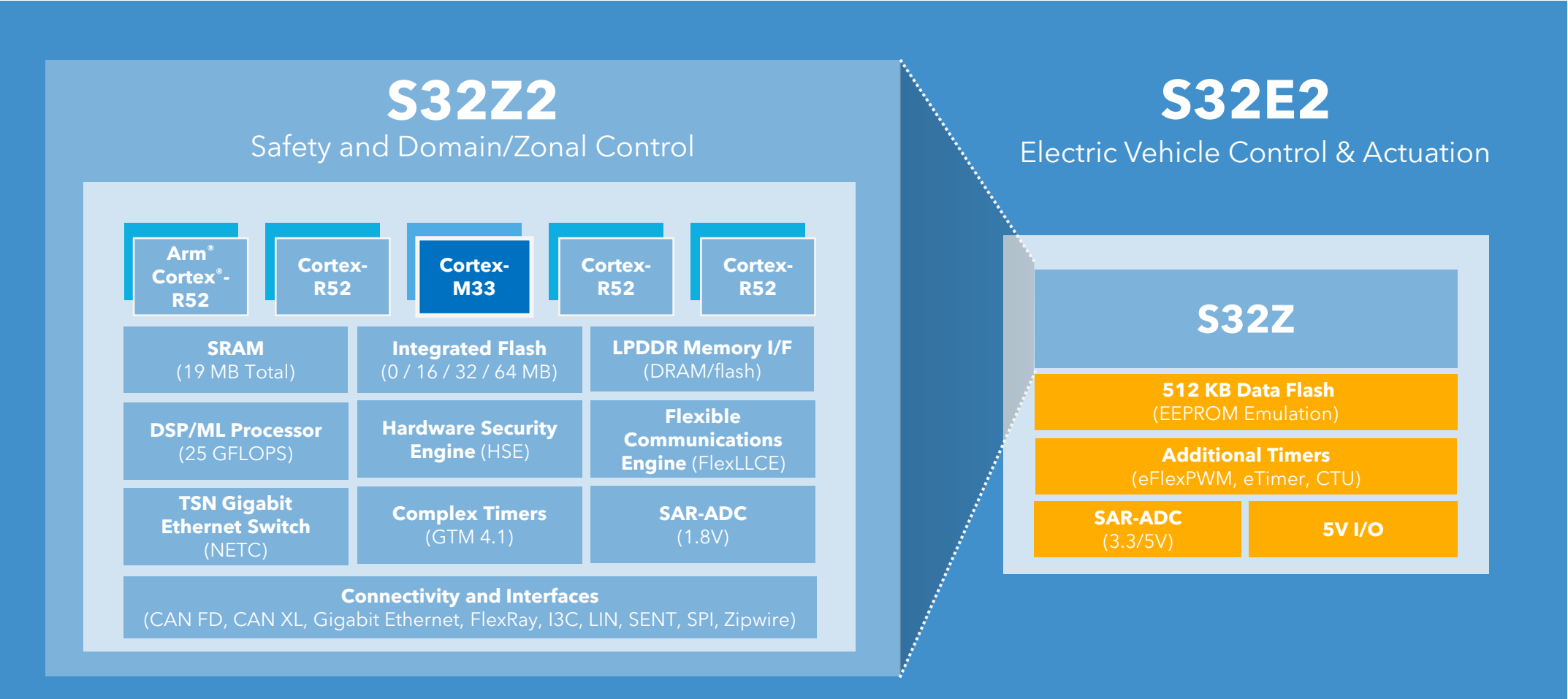
# S32Z and S32E real-time processor families – price and performance scalability

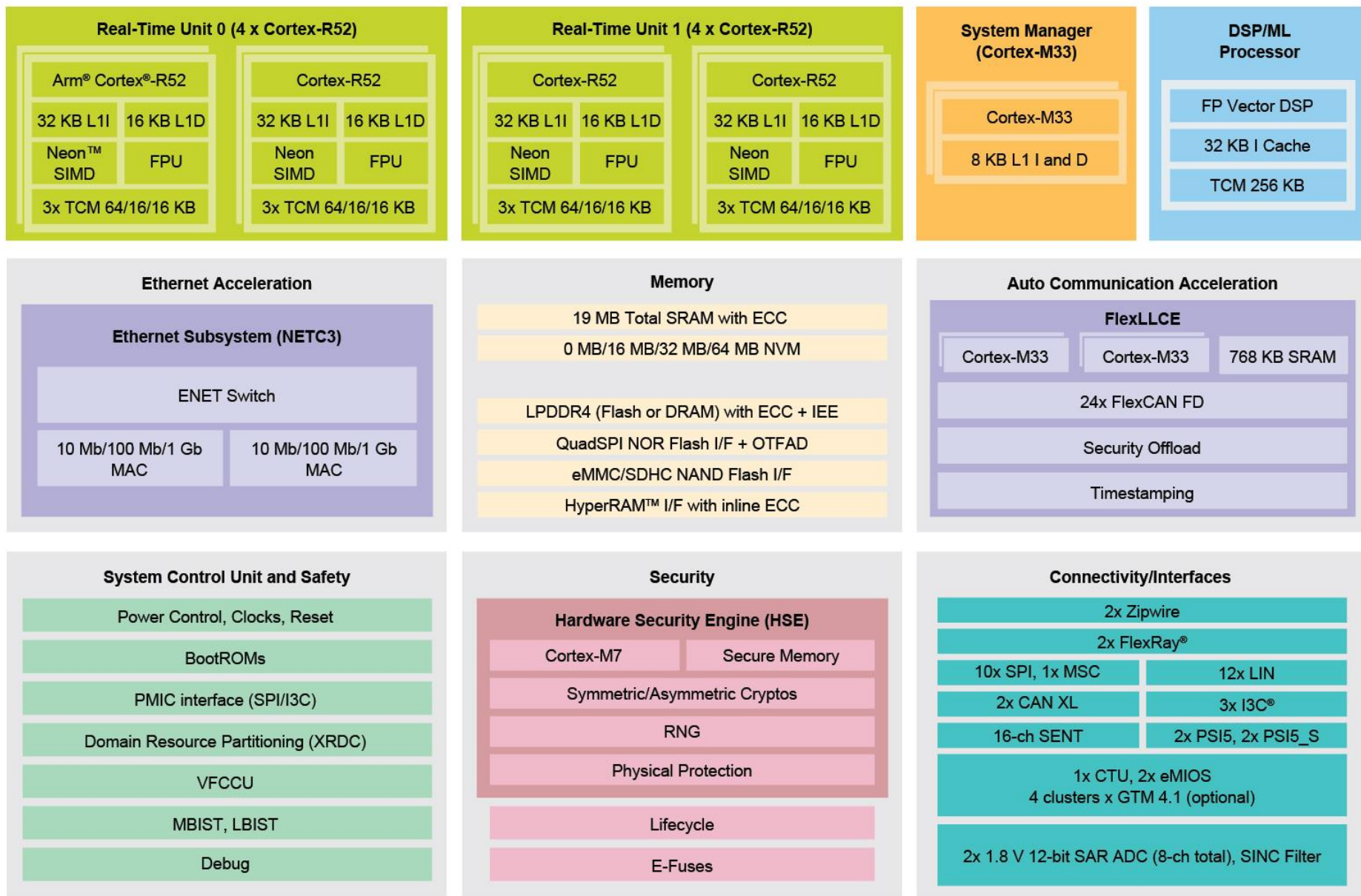


- **Wide range of real-time performance solutions for domain and zonal control**
  - Pin and SW-compatible families
  - Support for single ECU design
  - Scalable performance
    - 4K – 10K ASIL D DMIPS
    - 6K – 18K ASIL B DMIPS
  - Integrated Actuation with S32E
    - Complex timers and 5V support
- **Addressing needs for multi-application integration (domain, zonal)**
  - Real-time control
  - Safety processing
  - Scalable across vehicle fleet

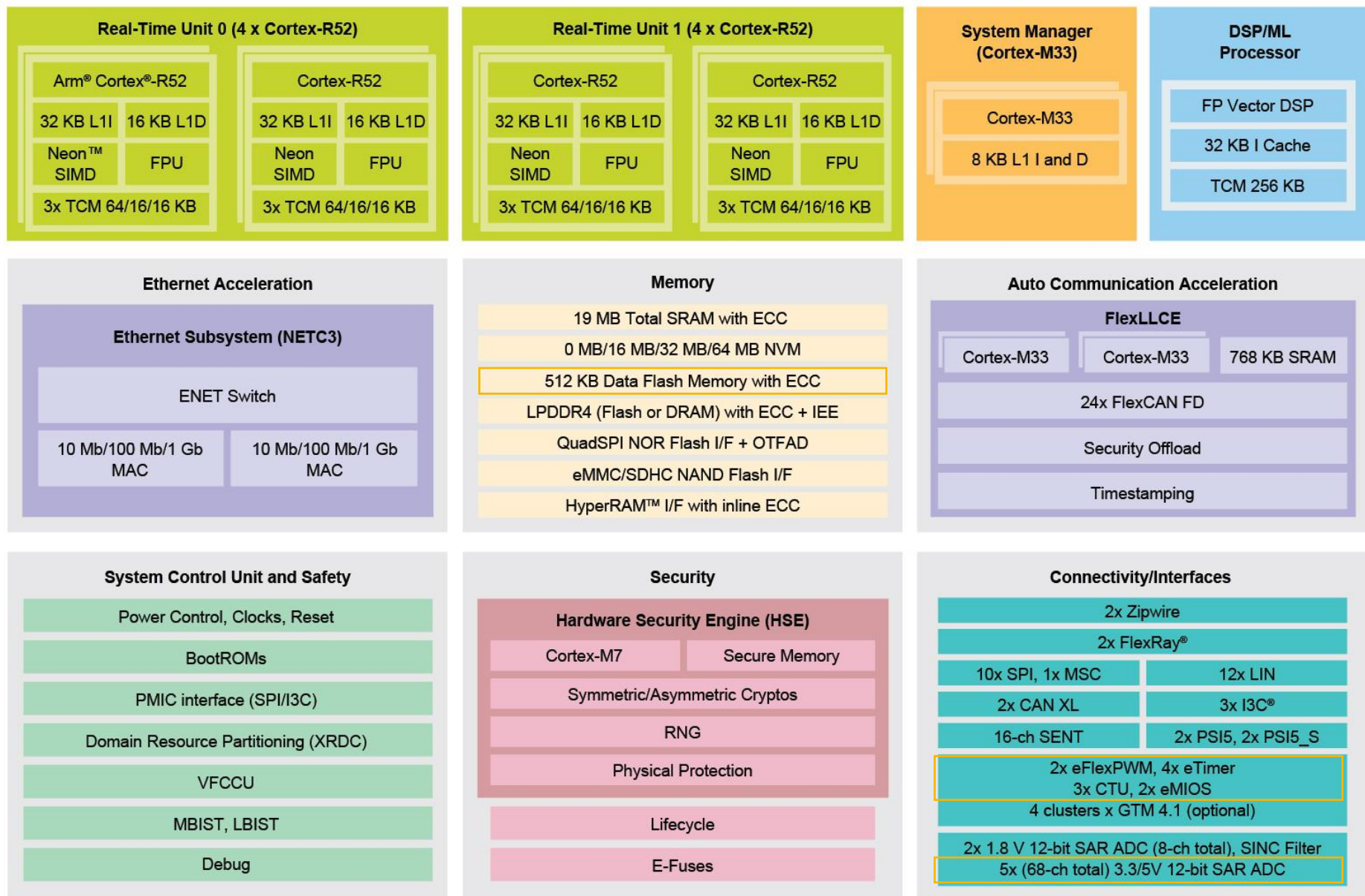


# S32Z2 and S32E2 real-time processors relationship





## S32E2 PROCESSOR BLOCK DIAGRAM

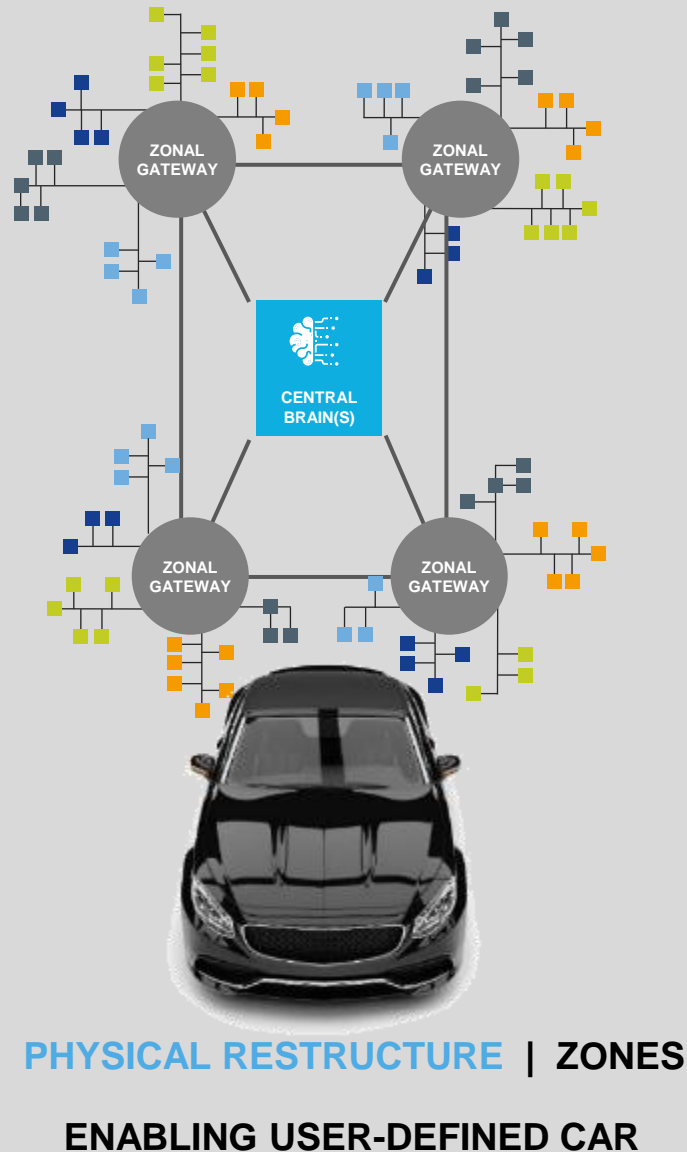




ii.

# Software landscape





# Software challenges with new vehicle architectures

Future means the software-defined vehicle with full SoA architecture, virtualization and shared compute resources

1

## Complexity increasing

Growing integration of functions with ECU consolidation

High-performance real-time, and applications-style compute. Dual OS.

2

## Integration of many SW partners in one SoC

While maintaining security and isolation and offering in-field upgradability

3

## Networking demand

Increasing performance – bandwidth and latency

Increasing flexibility – zone arch, multiple protocols

4

## Advanced future proof security

Tamper-resistant, crypto-agile, IDPS

5

## Built on automotive safety and quality standards and reputation

# Manage complexity – ECU consolidation with mixed-criticality applications

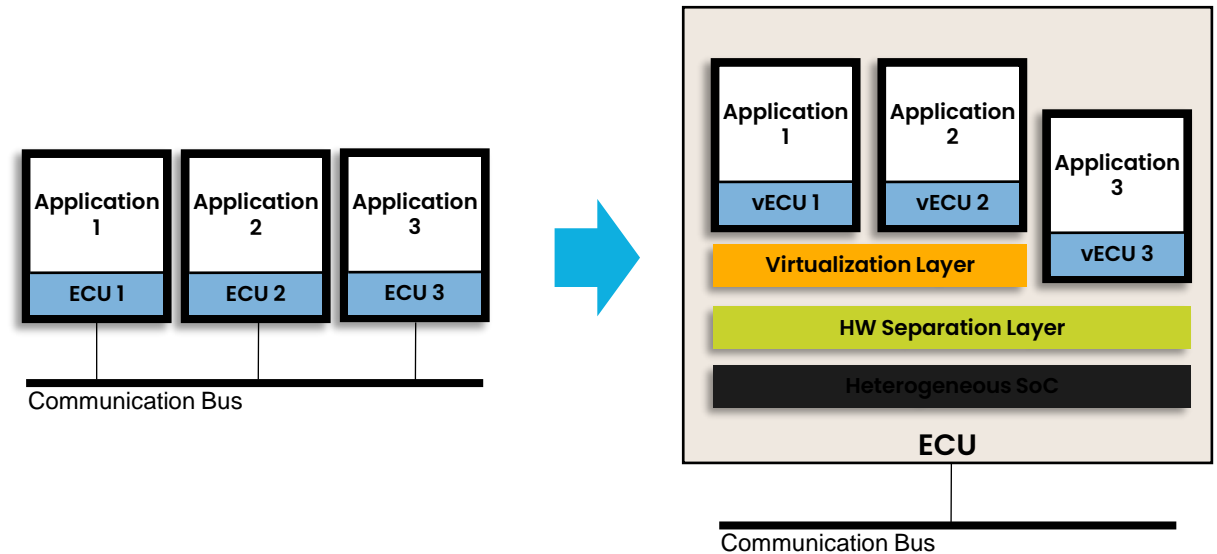
- Benefits:

- Lower cost and fast time-to-market
  - Reduce the number of wiring harnesses
  - Reduce the number of ECUs
  - Reduce SW complexity
  - Reduce test and validation effort
  - Simplified SW upgradability

- Challenges:

- Ensuring deterministic behavior of the application
  - Ensuring isolation of and precise resource allocation for safety-critical functions
  - Virtualizing various peripherals/devices across domains
  - Inter vECU communication

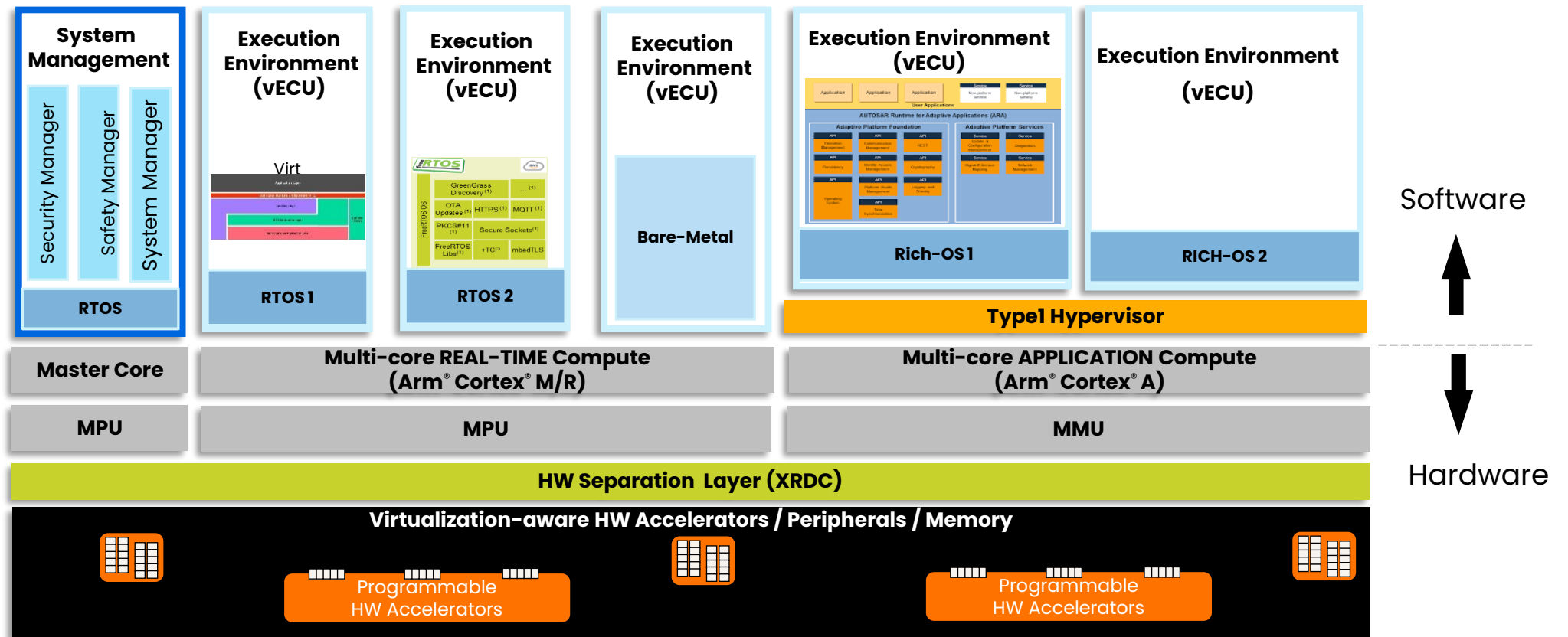
*ECU Consolidation via Virtualization and Separation*



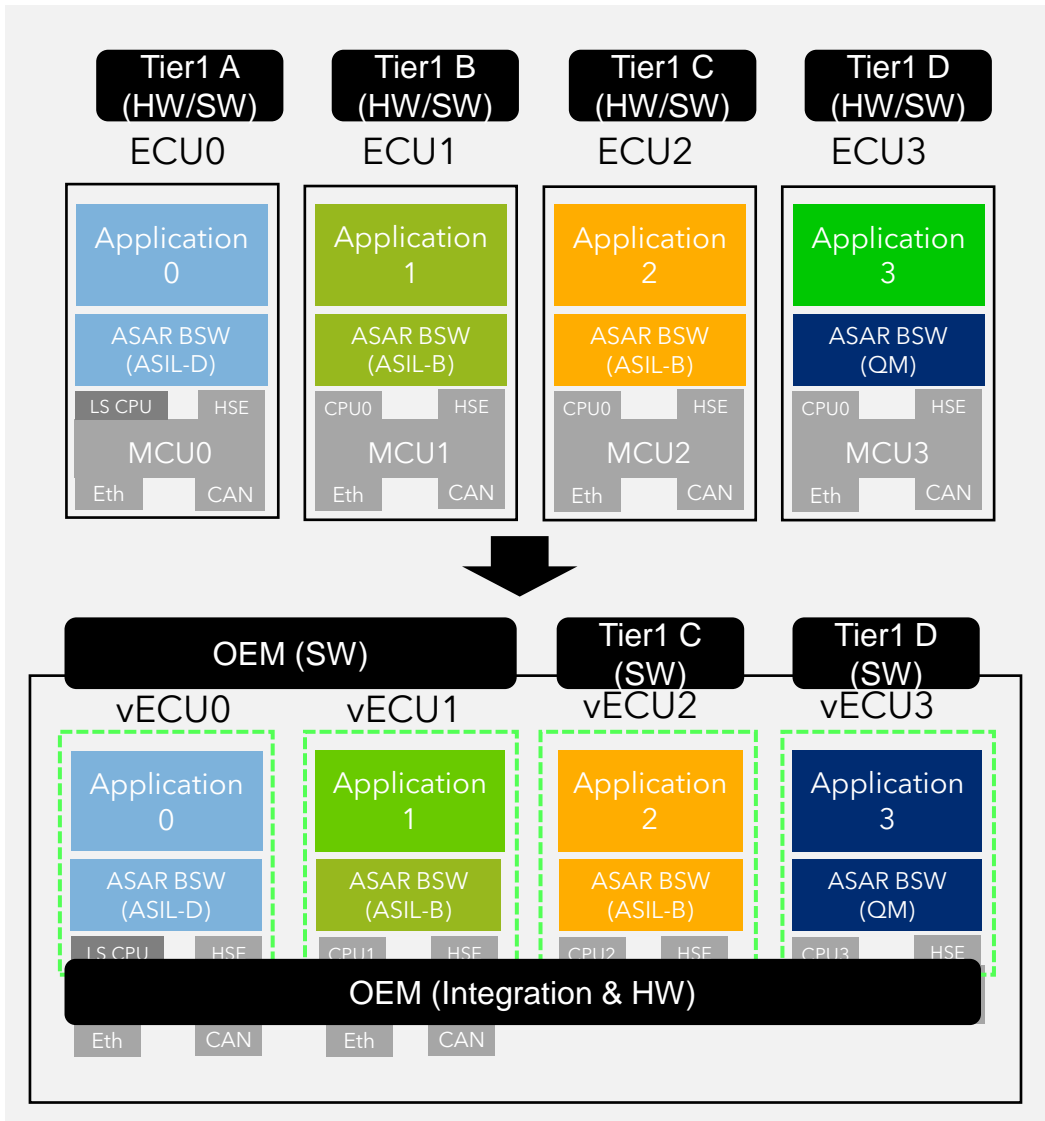


# Manage complexity – ECU consolidation with mixed-criticality applications

- **NXP's approach: SoCs with hardware-assisted virtualization support**

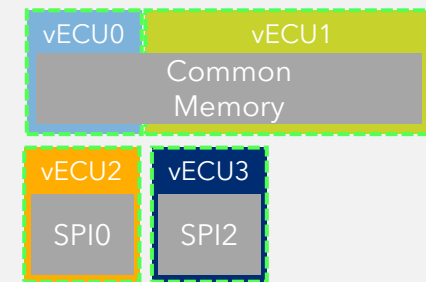


# Migration to consolidated ECU



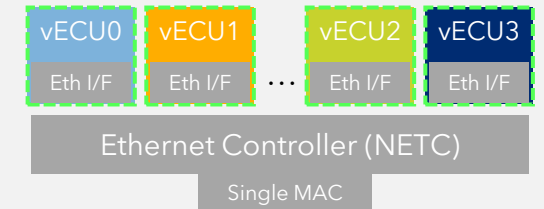
## Virtualization -> Full Chip Hardware Isolation with Safe/Secure Resource Domain Partitioning

### HW Access Control



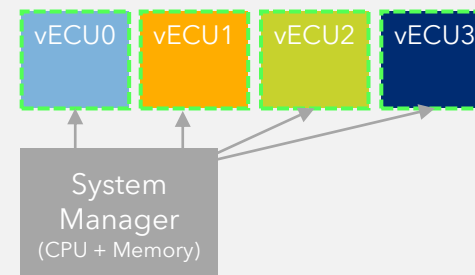
System-level Firewall for all Authorized Accesses

### HW Virtualized Peripherals



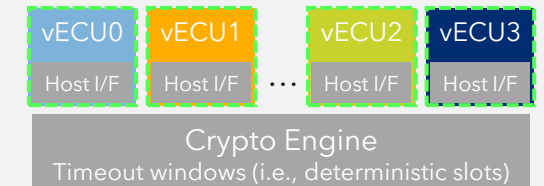
vECU Software 'sees' dedicated Resource, HW manages Virtualization

### System Manager



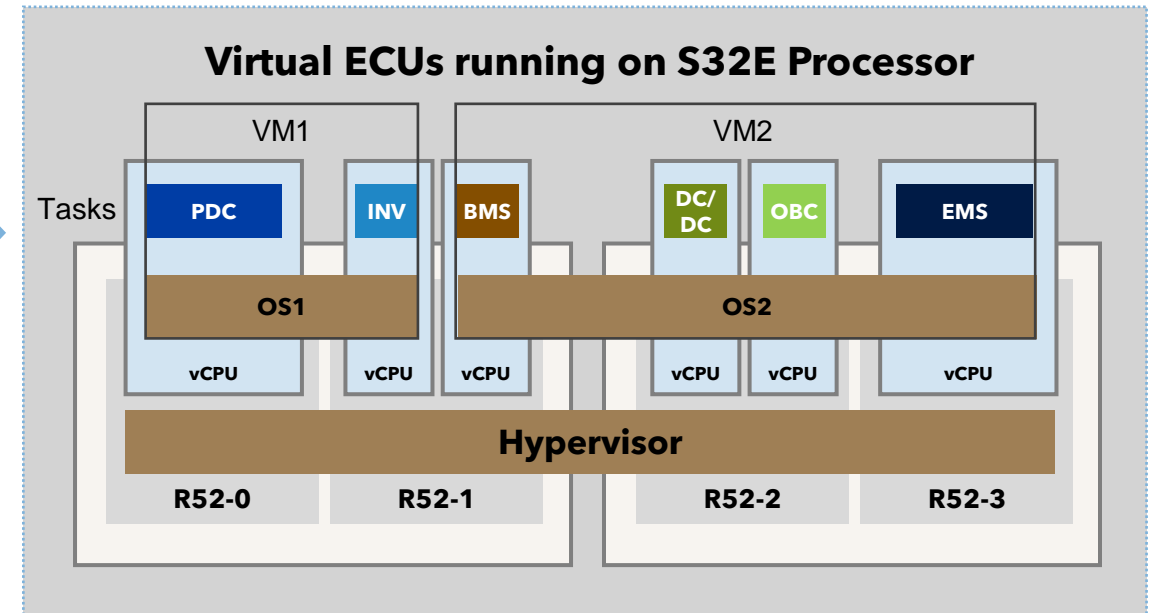
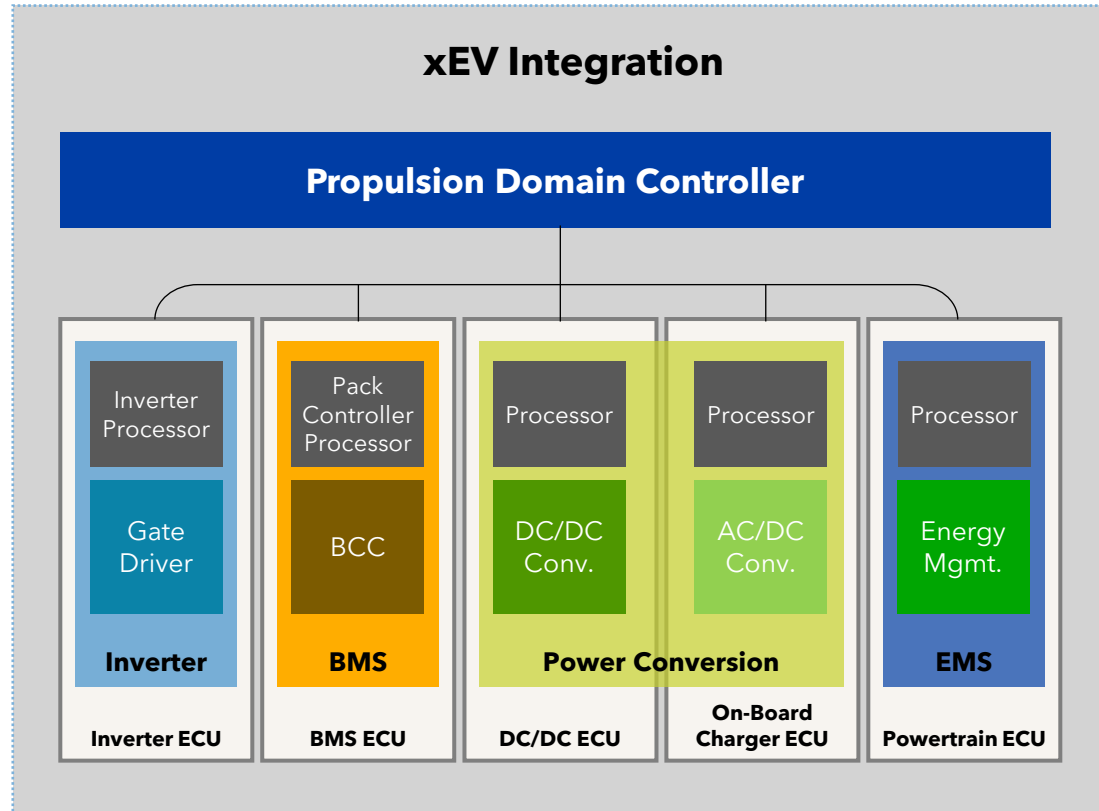
Partitioning and Management of vECUs

### HW Virtualized QoS



QoS Mechanisms for Shared Resources

# Example of multi-ECU integration – propulsion domain controller



S32Z and S32E processors support multiple, isolated virtual machines (VMs) with “core-to-pin” hardware virtualization

ECU boxes evolve to Virtual ECU tasks

Multi-tenancy with hardware isolation for freedom from interference

Moving from a hardware-centric world to a **software-defined world**



# s32z / s32e multi-application integration example

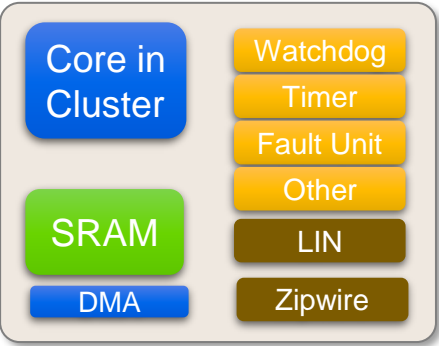


Memories and peripherals can be logically partitioned for each real-time application's needs

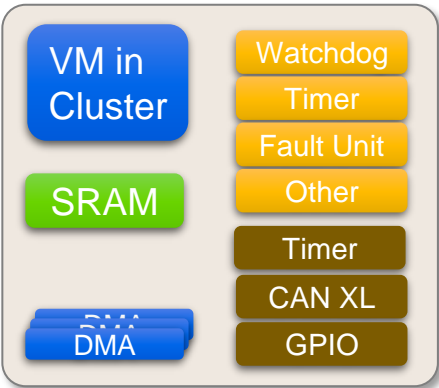
Partition provides **hardware protection, fault handling** and execute-in-place (XiP) **NVM bandwidth**

Resource	Grouped by
Processor Core(s)	Virtual machine
Memory	Regions configured by size and access policy (16 for every block)
Simple peripherals (LIN/SPI/Timers etc)	Whole peripheral
DMA	Individual channel
GPI	Individual pin
Ethernet	8 independent ports
CAN	Whole module or offload to FlexLLCE
GTM	Individual cluster
LPDDR	Individual access slot

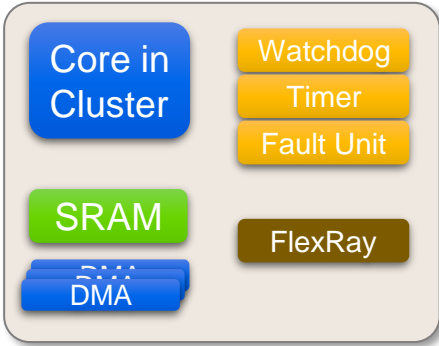
## Virtual ECU\_A



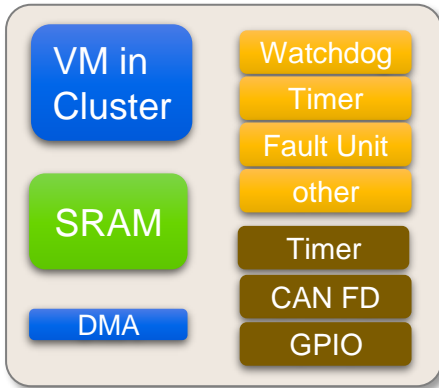
## Virtual ECU\_B




## Virtual ECU\_C



## Virtual ECU\_D





## 高效的多ECU集成：基于恩智浦S32 实时处理器和虚拟机的多应用开发

### 高效的多ECU集成：基于恩智浦S32实时处理器和虚拟机的多应用开发

🕒 活动时间：2022年8月

📍 活动地址：在线会议

基于域控制器和区域控制器的电子电器架构已被众多主机厂所接受，如何有效合理地将多个传统分布式ECU的功能集成在一个控制器中不仅需要具备硬件虚拟化机制的处理器芯片，同时支持多应用协同开发的虚拟机框架也不可或缺。本次培训将介绍恩智浦最新一代ASIL-D实时处理器S32Z/E及其虚拟化特性和应用范例。

点击页面右下角 **【查看回顾】**  
观看本讲座视频

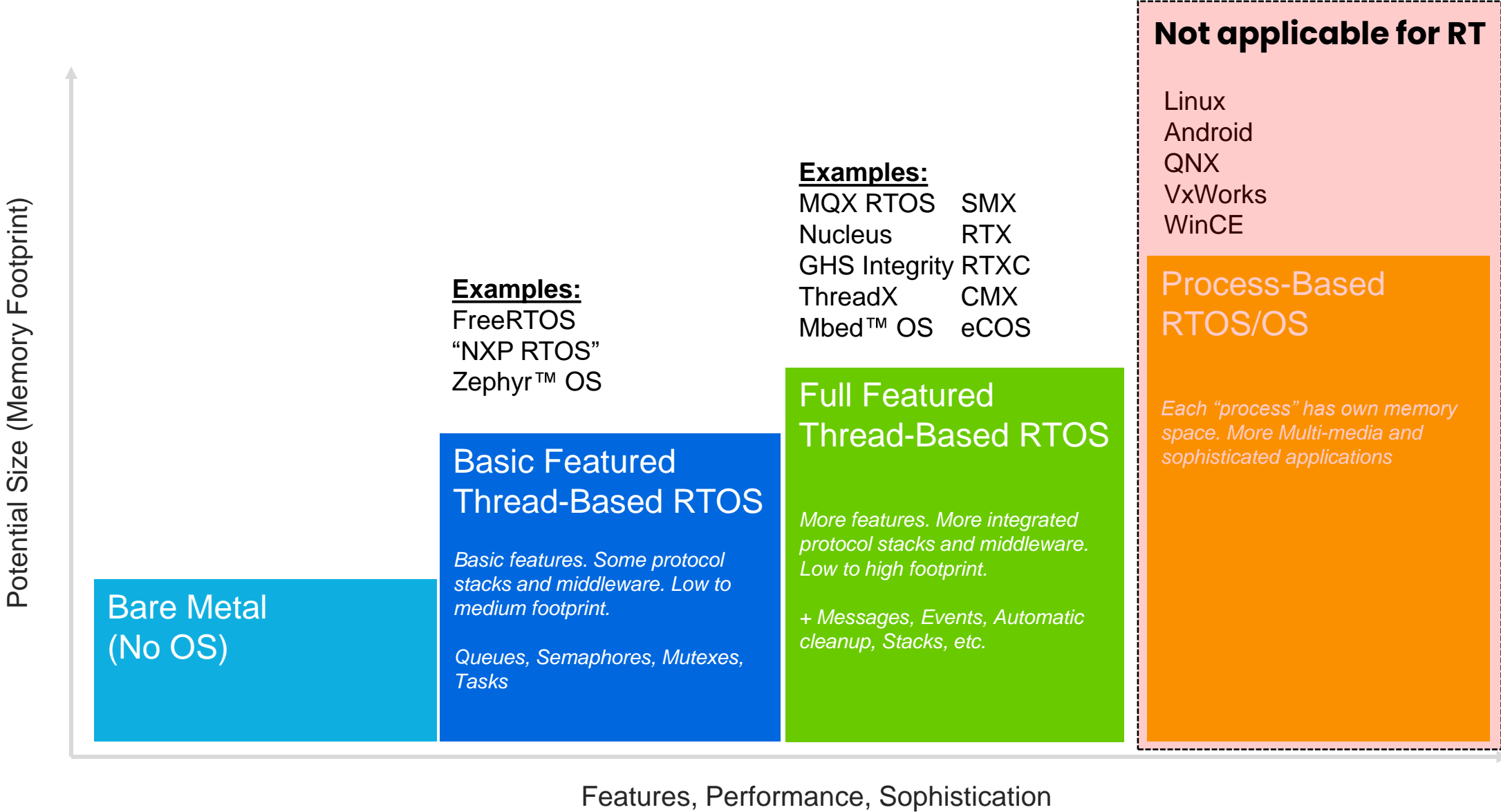
#### 主讲嘉宾

- 余辰杰 恩智浦车载处理器资深市场经理
- 包明飞 Arm中国资深技术市场经理

查看回顾

🔗 分享给好友

# High-level operating system landscape





# S32Z and S32E processors vehicle integration platform: GreenVIP



Consolidation of in-vehicle software applications from multiple vendors



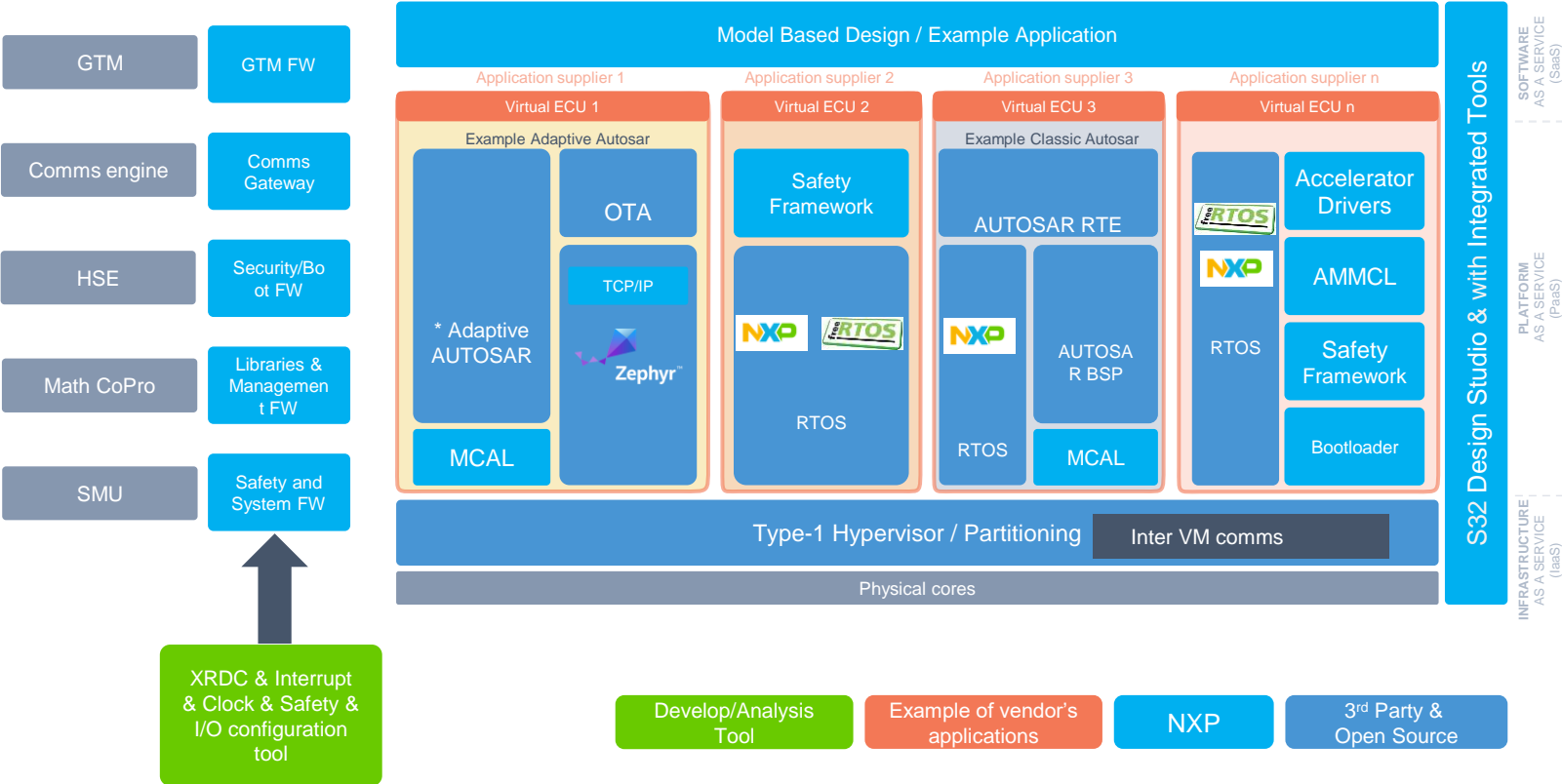
**Enables integration** of 3rd party applications from different vendors with NXP SW on S32Z/E



Demonstrates S32Z/E's capability to **execute multiple applications (vECUs)** in separated boxes, **free-from-interference** in safety point of view

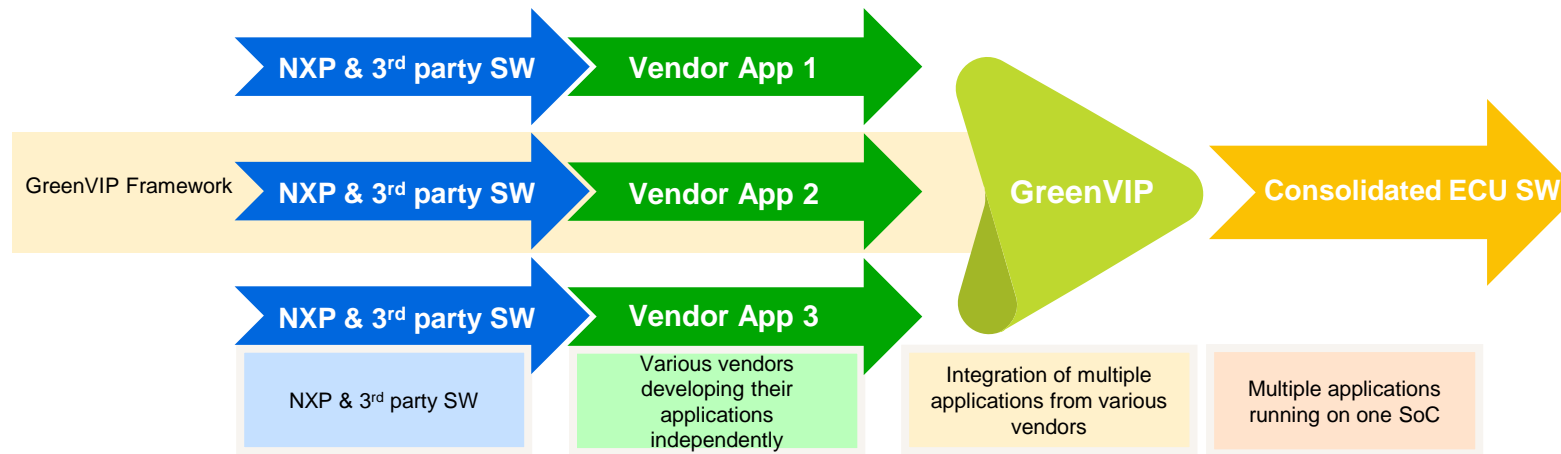


**Abstraction of HW complexity enables fast Time-To-Market** to reduce your investment



# S32Z/E vehicle integration platform: GreenVIP

- Abstract SW from HW (the SW in a vehicle should be able to update more frequently than the HW)
- Enable development of SW independently of the underlying hardware
- The S32Z/E processors can execute multiple of applications (vECUs) in separated boxes, free-from-interference in safety point of view  
Each of those applications (vECUs) can be provided by a different vendor

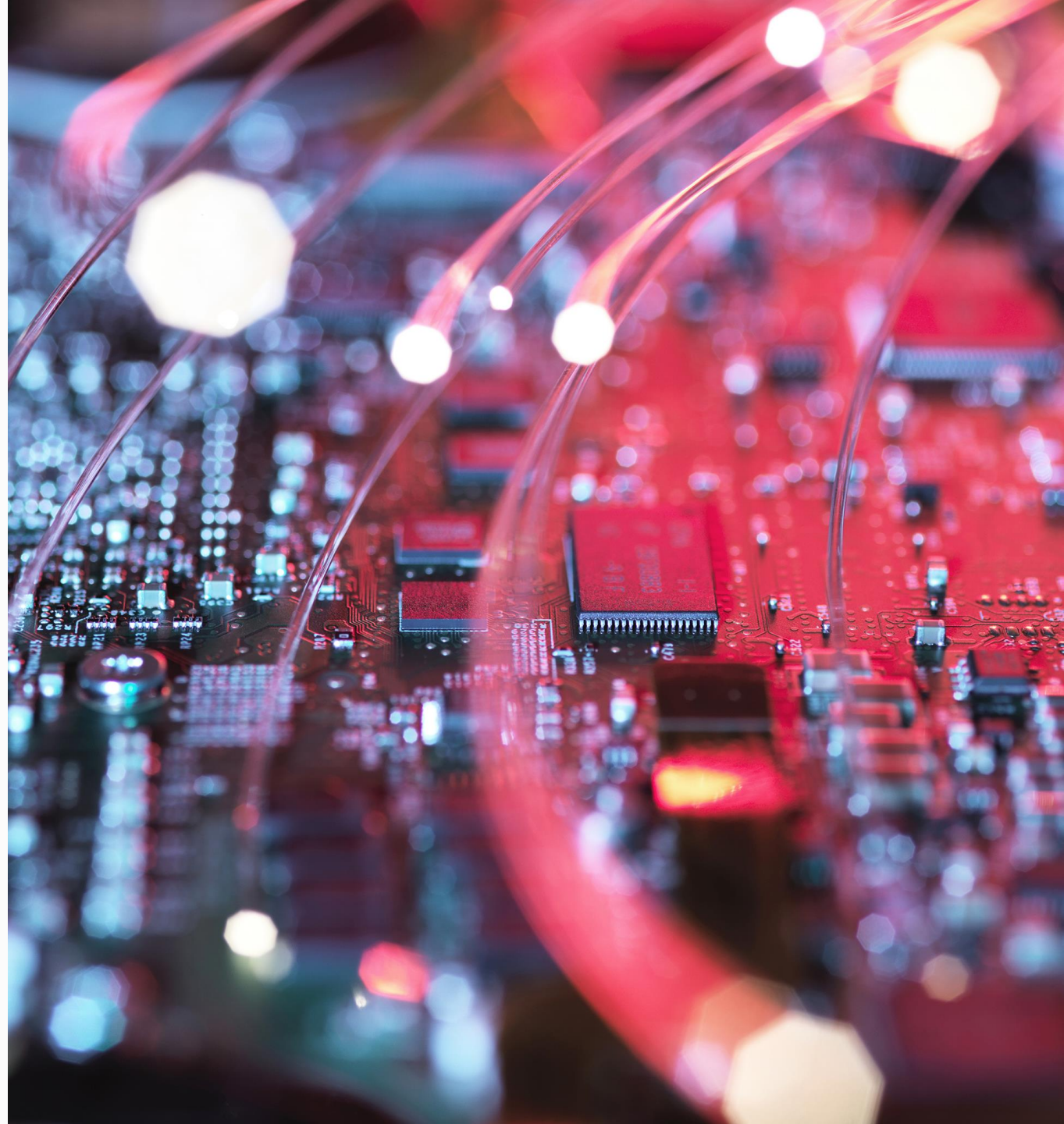


- **GreenVIP** is intended to provide a functional software platform that **allows customers to begin developing an application** on the S32ESZ family **with minimal effort**
- **GreenVIP** enables **standalone development of each single application** (vECU), and their integration. For that, **GreenVIP** offers:
  - Definition of separated execution environments (EENV) and virtual machines (VM)
  - Configuring all common SoC items, ensuring the separation, freedom from interference
  - Virtualization of some shared modules

0x3

# Using S32Z2/E2 for consolidation

Specifics on how to use these devices to meet customer needs





# S32E2 HARDWARE PLATFORM - GREENBOX 3

**NAME:** GreenBox 3: Vehicle Electrification Development Platform | **PART NUMBER:** S32E2-GRNBOX3



**NXPS32E2-GRNBOX3**

**S32E2 GREENBOX 3**

## Main Function:

- Enables performance evaluation of the S32E288 silicon for various Hybrid Electric Vehicle and Motor Control use cases
- Dedicated dual motor control and battery management circuit
- Complete NXP system solution includes PMICs, Ethernet switch & transceivers, CAN transceivers

- 1 High-performance ASIL D compute with 8x Arm Cortex-R52 cores operating up to 1 GHz from the mounted S32E288 silicon
- 2 Peripheral control using complex timers, filters and analog modules
- 3 Numerous automotive communication interfaces: Ethernet, CAN FD, LIN, UART, JTAG, SDHC, PSI5, SENT
- 4 Hypervisor support for task isolation
- 5 Easy to use out of the box experience with advanced control applications including example code



# S32Z and S32E processors vehicle integration platform: GreenVIP



Consolidation of in-vehicle software applications from multiple vendors



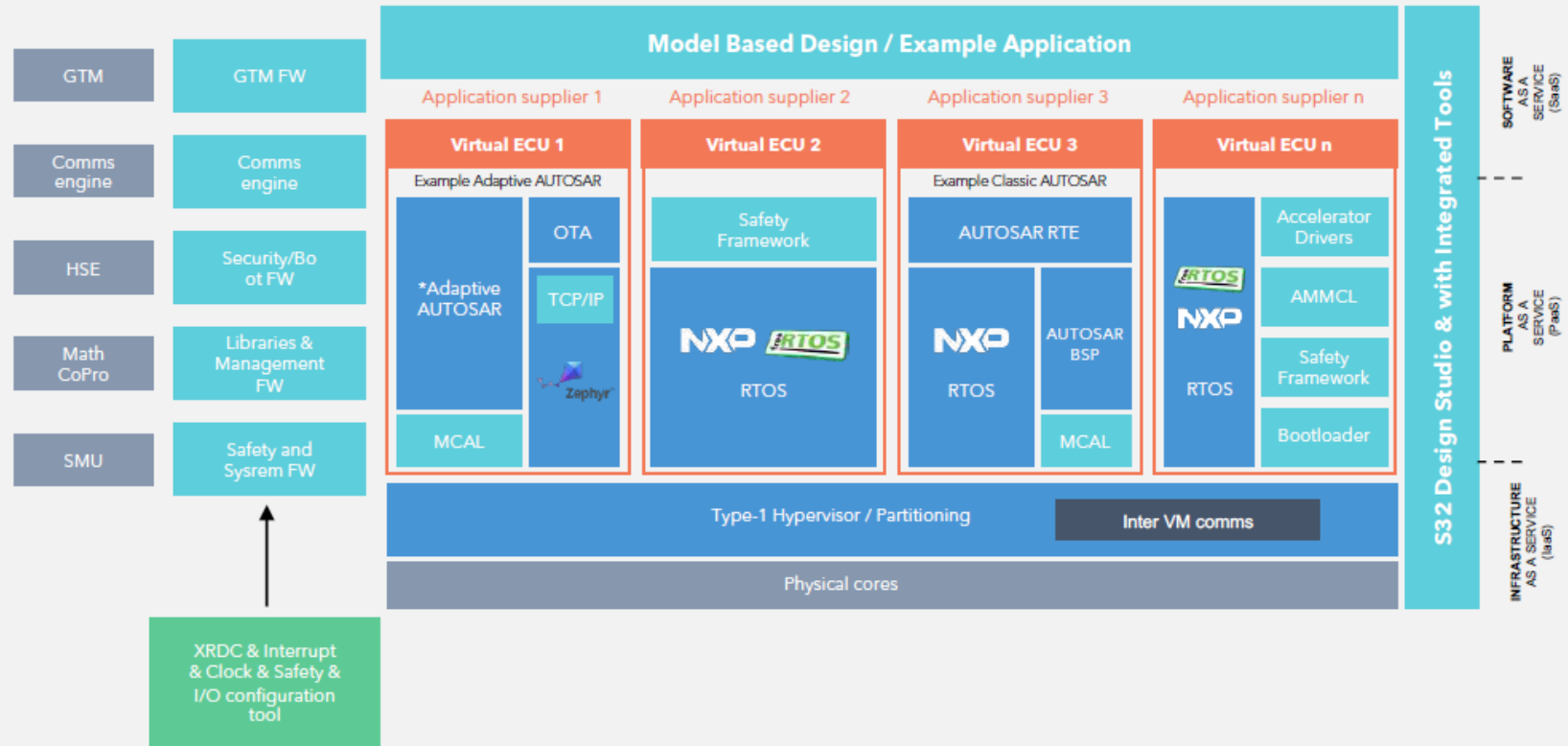
**Enables integration** of 3rd party applications from different vendors with NXP SW on S32Z/E



Demonstrates S32Z/E's capability to **execute multiple applications (vECUs)** in separated boxes, **free-from-interference** in safety point of view



**Abstraction of HW complexity enables fast Time-To-Market** to reduce your investment



Develop/Analysis Tool   Example of vendor's applications   NXP   3rd Party & Open Source

# Staircase approach: ascending features, ascending complexity

How do we get from Point A to Point B?

To enable a smooth introduction to the software offerings, we propose a **step-by-step process** starting with the basics and gradually increasing complexity when required – introducing more tools and packages with each step.

*("Walk before running")*

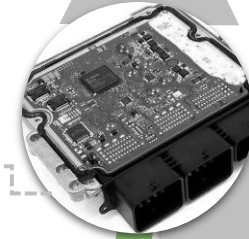
- Customer smoothly adapts into own custom application

- **Establishes familiarity with full ECU consolidation**
- Feature-heavy and comprehensive software stack
- Brings together all available software packages
- Provides an "out-of-box" isolation / partitioning example
- Multiple different OS instances running (Zephyr, NXP RTOS, EB AutoCore, etc)

- **Establishes familiarity with full application building**
- Combines multiple individual software packages
- Provides an "out-of-box" bootloader example for all cores
- Utilises Tresos and extensions

- **Establishes familiarity with configuration tools**
- Custom APIs for each module on the device
- Creates "off-the-shelf" examples for using each IP block
- Used as the *base* for building other larger packages

- **Establishes familiarity with tools & device basics**
- Custom projects built from scratch
- No reliance on other package downloads
- Extremely flexible, easy to change
- Modular, allows for low-level testing/development



Customer ECU Consolidation

5

GreenVIP

4

Integration Package

3

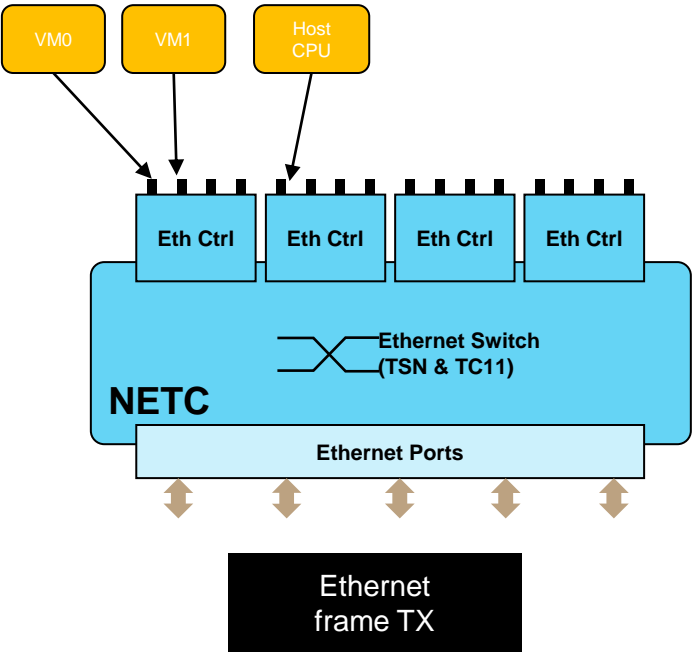
Real-Time-Drivers

2

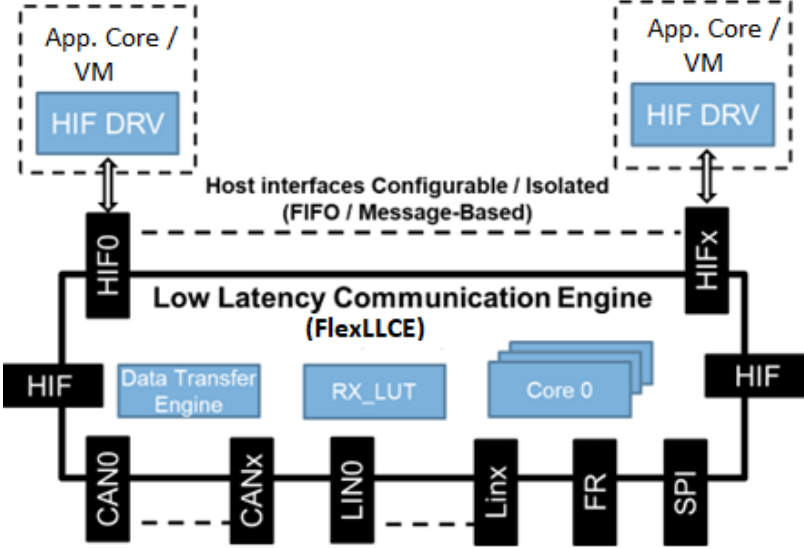
Bare-Metal

1

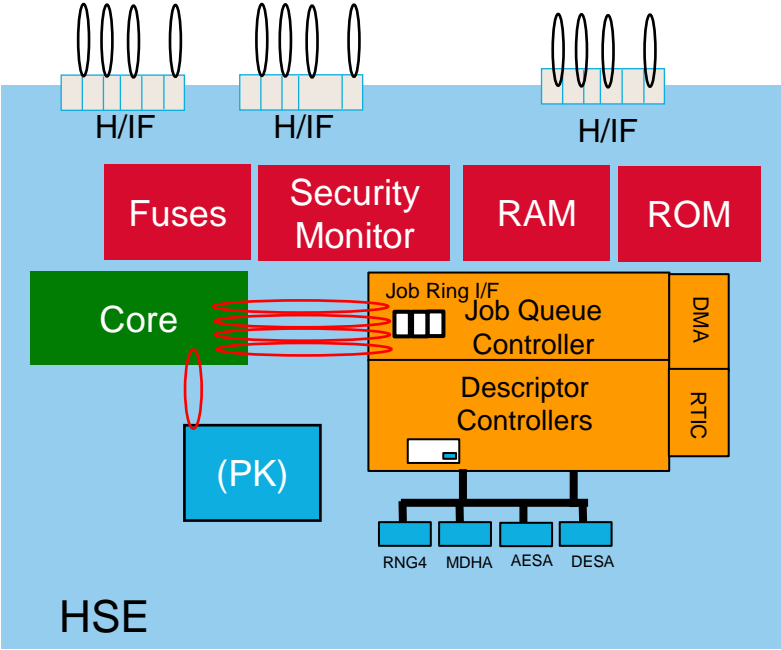
# S32Z/E – peripherals with hardware-assisted virtualization support



**Ethernet Accelerator**



**Automotive Comms Engine**



**Hardware Security Engine**



**Brighter  
Together**

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