Integration and Control for Tomorrow's Intelligent Electrified Solutions

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SECURE CONNECTIONS FOR A SMARTER WORLD

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Based in Austin, Texas, USA, responsible for high end Automotive Microcontroller products, specifically focusing on HeV/eV Control and Safety for the latest automotive systems.

Background in both engineering and business. Originally joining NXP in the United Kingdom, (Formerly Freescale/Motorola Semiconductors).

Agenda

- Automotive Mega Trends Driving Development
- Vehicle Architectural Developments
- New Control Requirements for MCU/MPU's
- New MCU/MPU Architectures and Solutions
- NXP GreenBox Hybrid/EV Platform how to get started.

Automotive Global Megatrends

Driving the need for next generation silicon capabilities

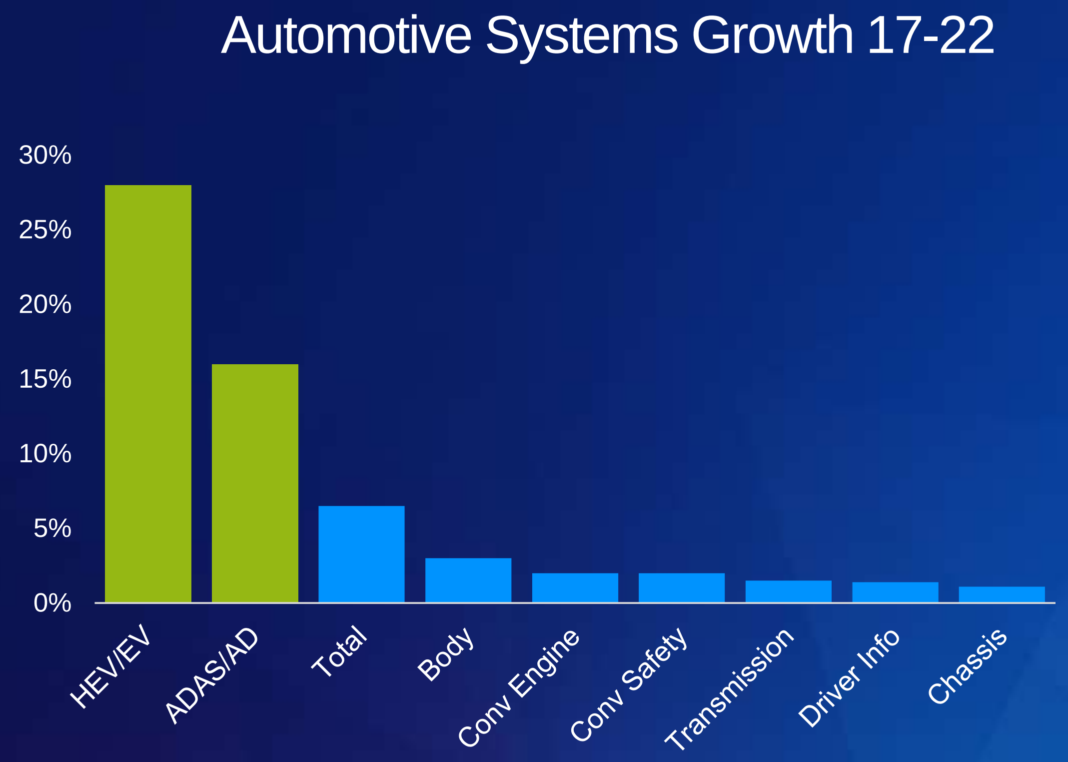
Autonomy

Electrification

Connectivity

Safe and Secure Mobility – An Exciting Market

Key Growth Areas of Automotive Electronic Systems

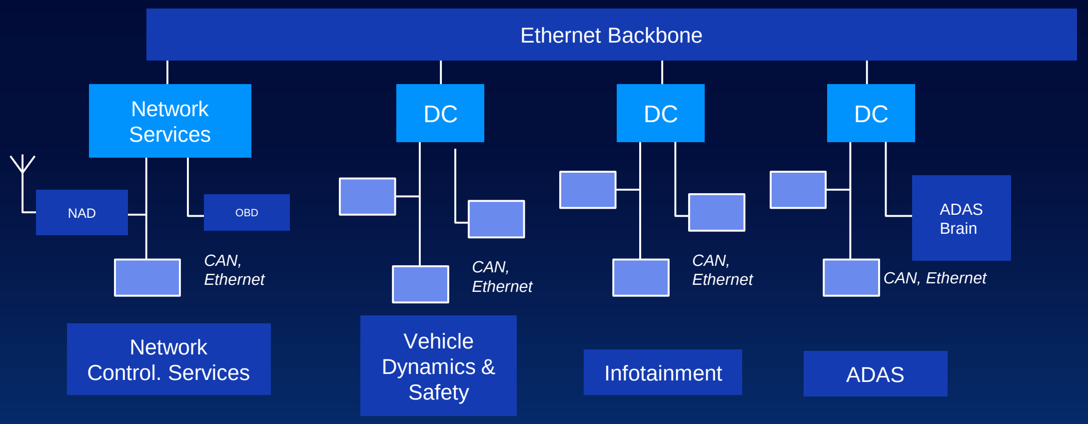


Vehicle Electrical Architectures and their Evolution

What’s on the Horizon ?

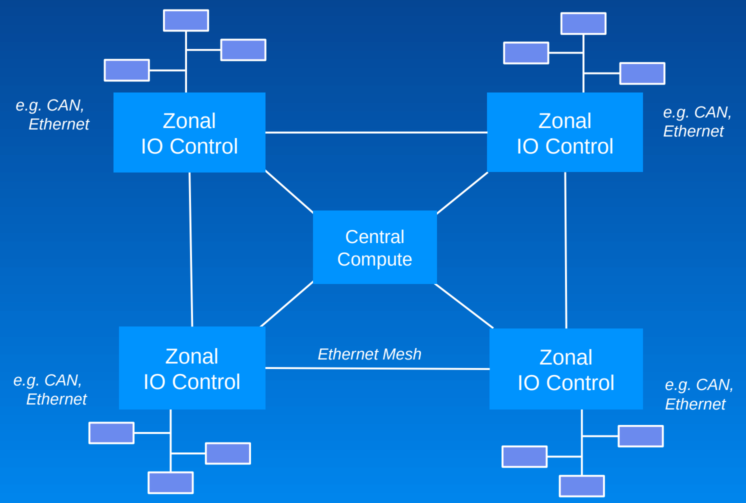
In Development

Domain Architecture

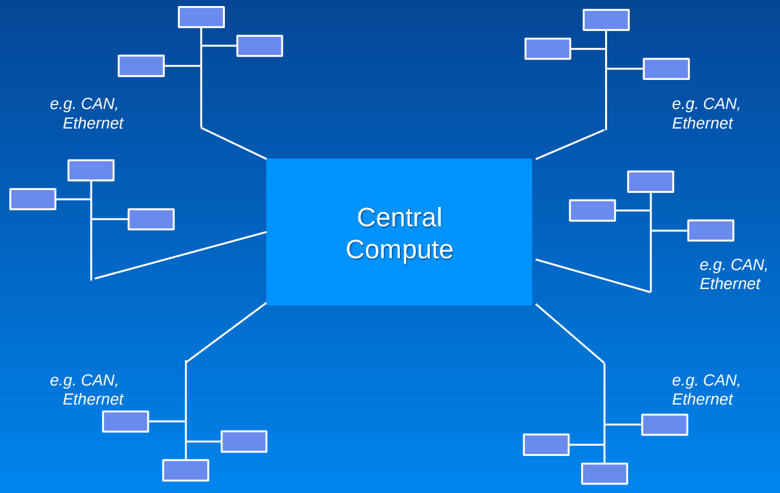


In Concept

Zonal Architecture

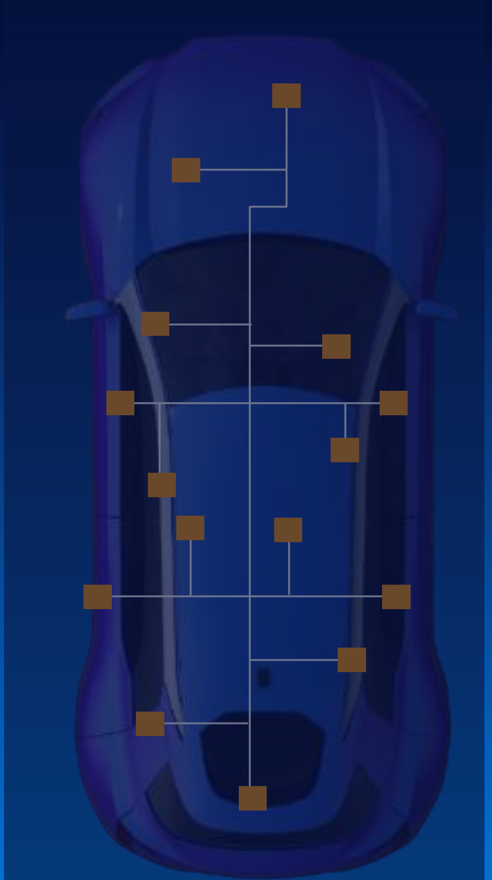


Central Compute - Star



The focus of today's discussion.

TODAY:
FLAT

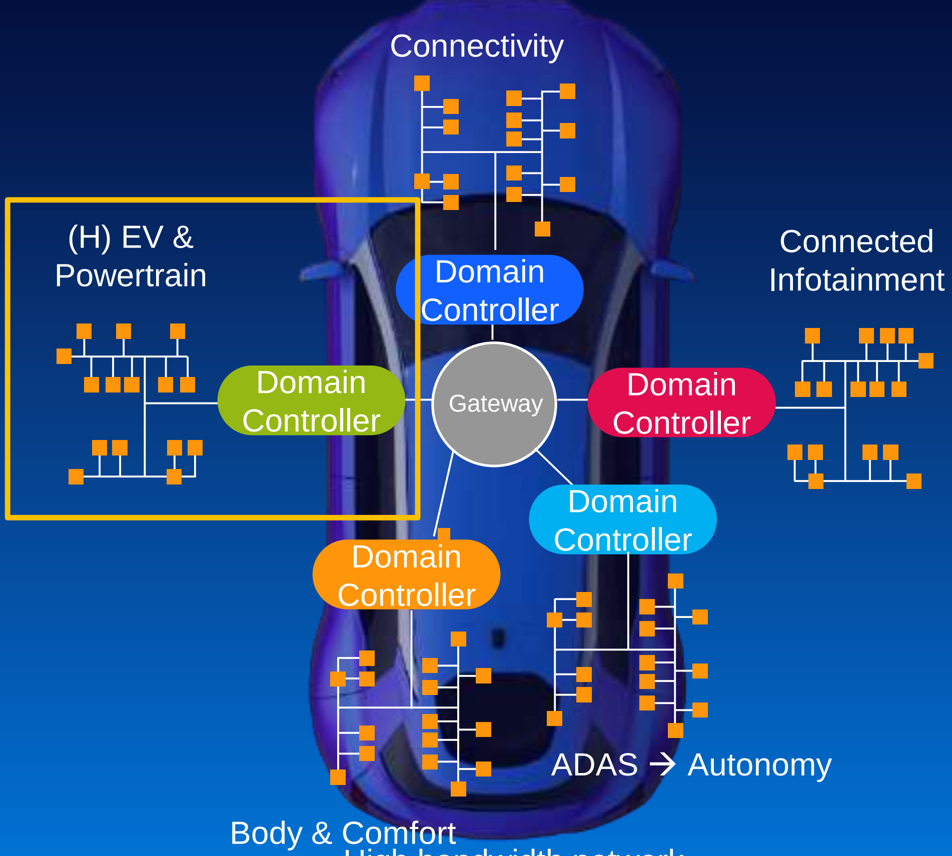


- Low bandwidth, flat network
- One MCU per application

Unfit for future Mobility

Flat to hierarchical

TOMORROW:
DOMAINS

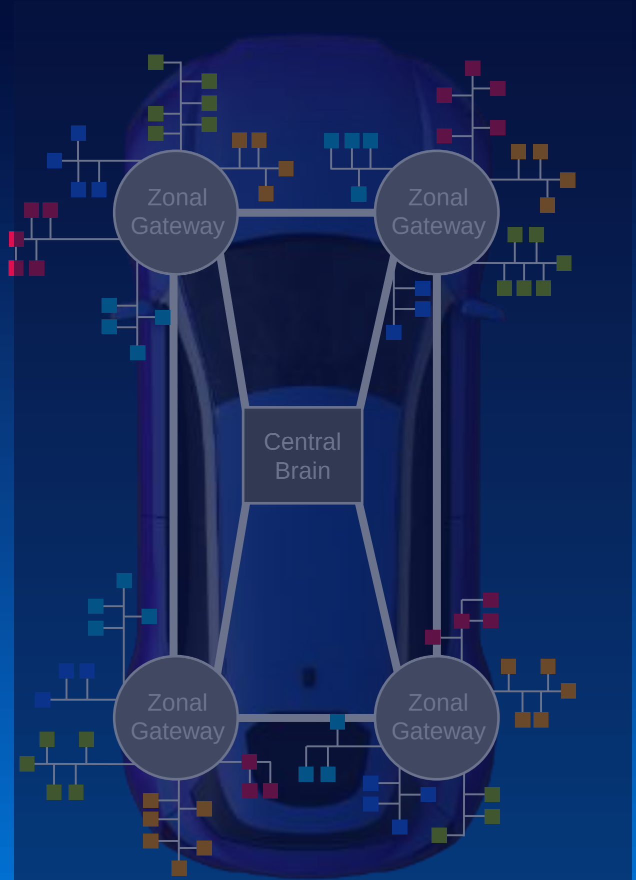


- High bandwidth network
- Gateway key to communication between domains

Step to Autonomous Car

Wires go virtual

AFTER TOMORROW:
ZONES



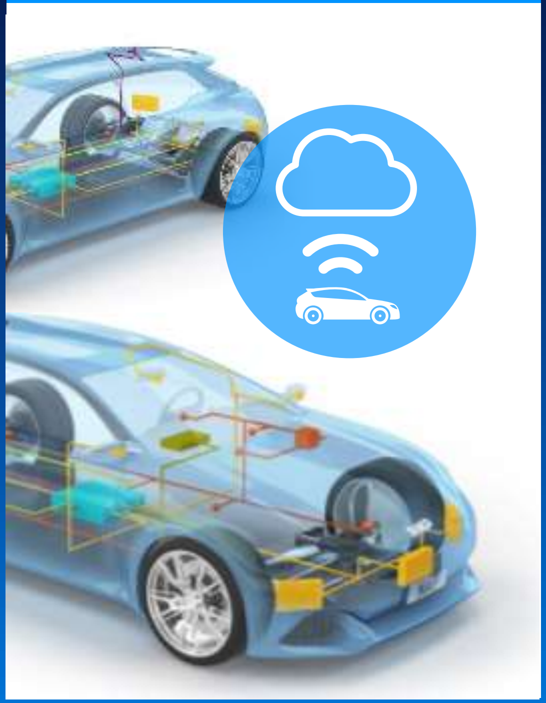
- Domains virtualized by SW – enabling high flexibility
- Easy enable/disable or update functions

Step to User-Defined Car

New Control Requirements

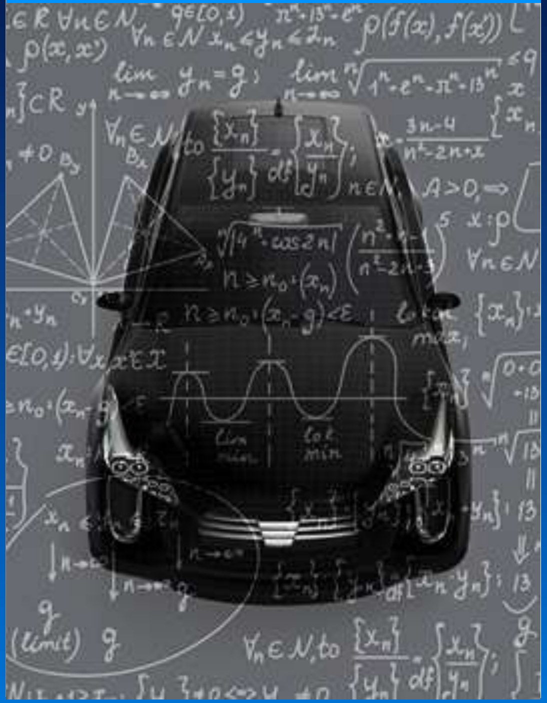
What's Changing in Vehicle Dynamics Control?

Domain Management



Electrification

Mathematization



Autonomous Control

Automotive Control Trends

- New Functions and Applications
- Lots More Software
- More ECUs
- More Safety and Security

- More Computing Power
- New Architectures
- ECU Integration
- Fail Safe to Fault Tolerant
- OTA Upgradable inc. Security

Energy Optimization : Extend the Driving Range of xEV

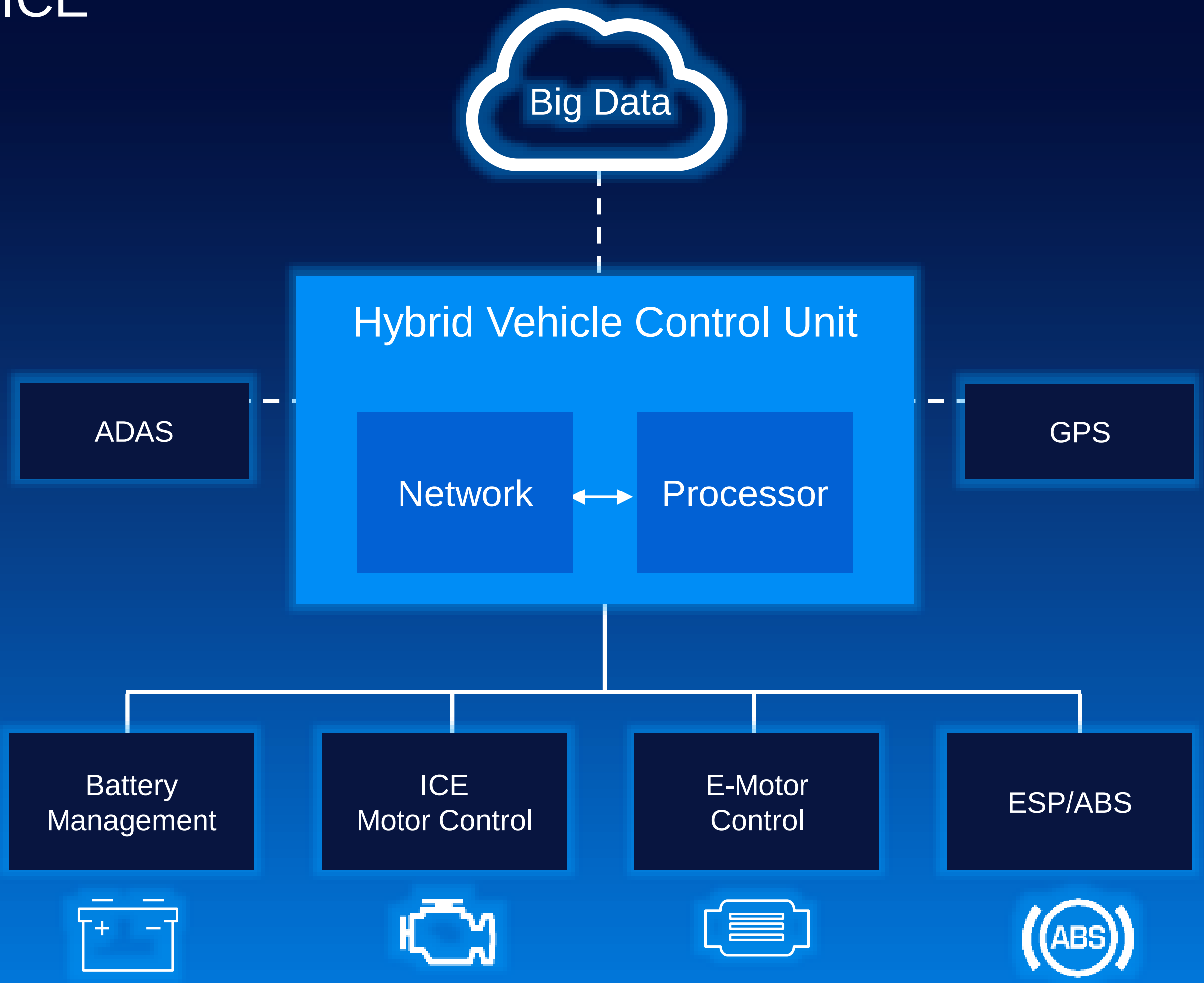
xHEV are more complex than BEV and traditional ICE

- Traditional ICE + eMotors

HCU (Hybrid Control Unit)

Energy management:

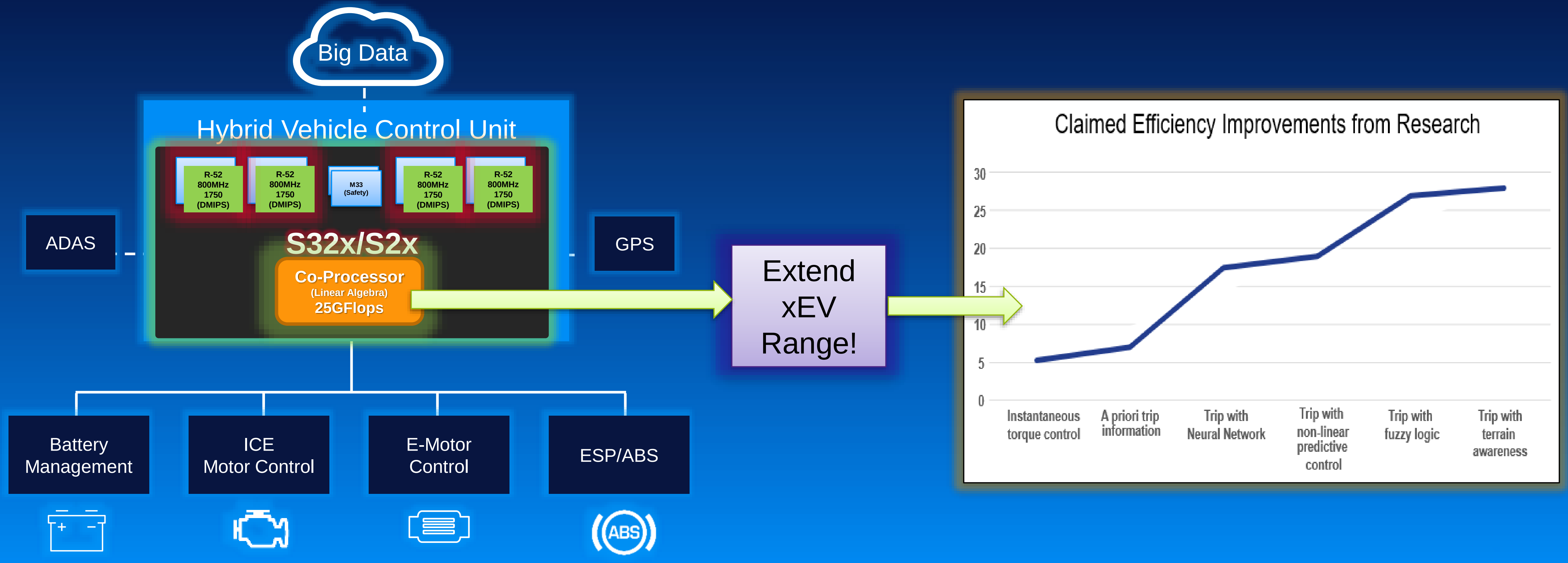
- *Torque Selection (ICE or eMotor?)*
- *Braking usage (regen. or friction?)*
- *Torque Vectoring*
- *Communication with other modules*
- ….



Energy and Torque Optimization : Extend the Driving Range of xEV

The Issue: Today's MCUs have insufficient computational power for model predictive control algorithms

The Solution: 25GFlops Math Co-processor to enable **Advanced predictive control algorithms** able to extend the xEV range up to 30%

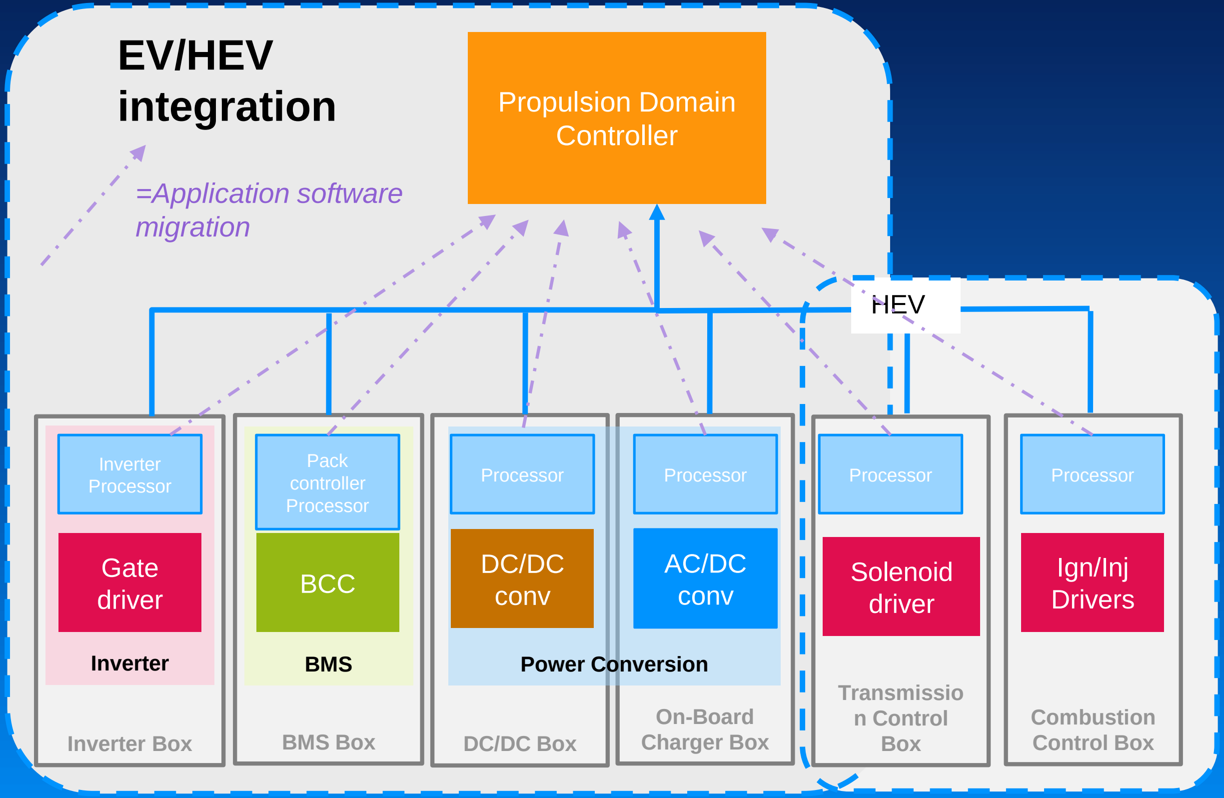


HEV/EV Future Domain Management Architectures

Today's Hybrid and EV control systems are low integration solutions coupling many historically separate modules. The critical **E**nergy and **T**orque **M**anagement function (ETM) is a virtual task and is normal resident in one of the larger control modules (INV, BMS, ICE).

First Generation

- Leading OEM's and Tier 1's view **up-integration** into a more powerful and centralized architecture as a key business strategy.
  - **OEM's** view it as a way to simplify and centralize software plus supporting future advanced energy management computing tasks that are critical to range and efficiency.
  - **The Tier1's** view it as an area where they can support all the hardware while offering the OEM simplified software integration and sourcing opportunities.



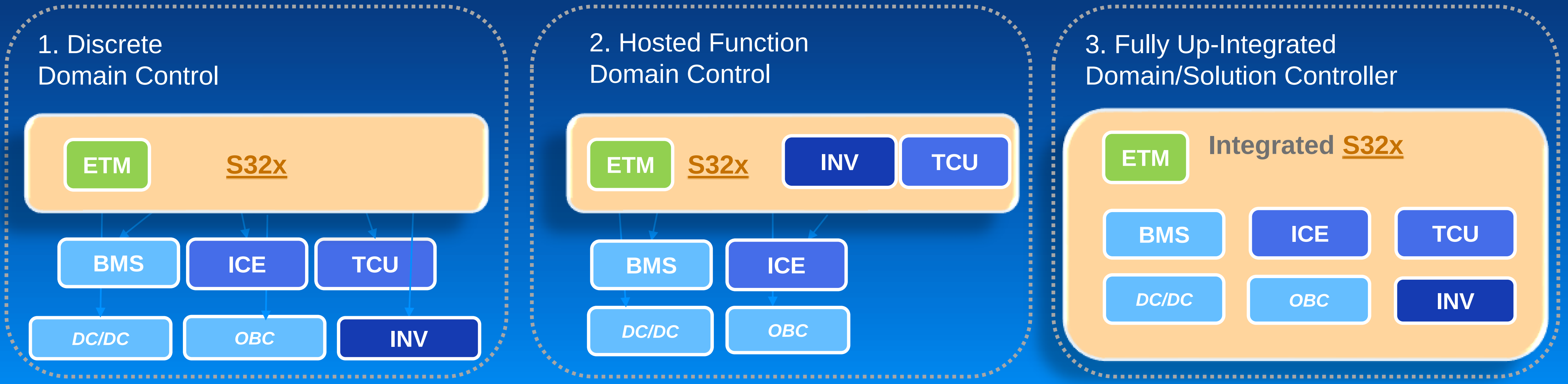
HEV Future Management Architectural Alternatives

- To up-integrate the software base to allow this level of functionality **key new architectural** features are required.

  - A modern **Real Time CPU** architecture providing **5-10 X** today's high end MCU performance.
  - Expandable memory to support combination of previously separate software plus supporting **OTA capability of 32M-64MByte.**
  - An advanced **Hypervisor** based architecture supporting multiple VM's* with guaranteed FOI* and hardware virtualized I/O.
  - **Modular I/O options** for alternative physical hardware solutions based on OEM preference.

Future Integration Options:

❖ FOI = Freedom of Interference
❖ VM = Virtual Machine



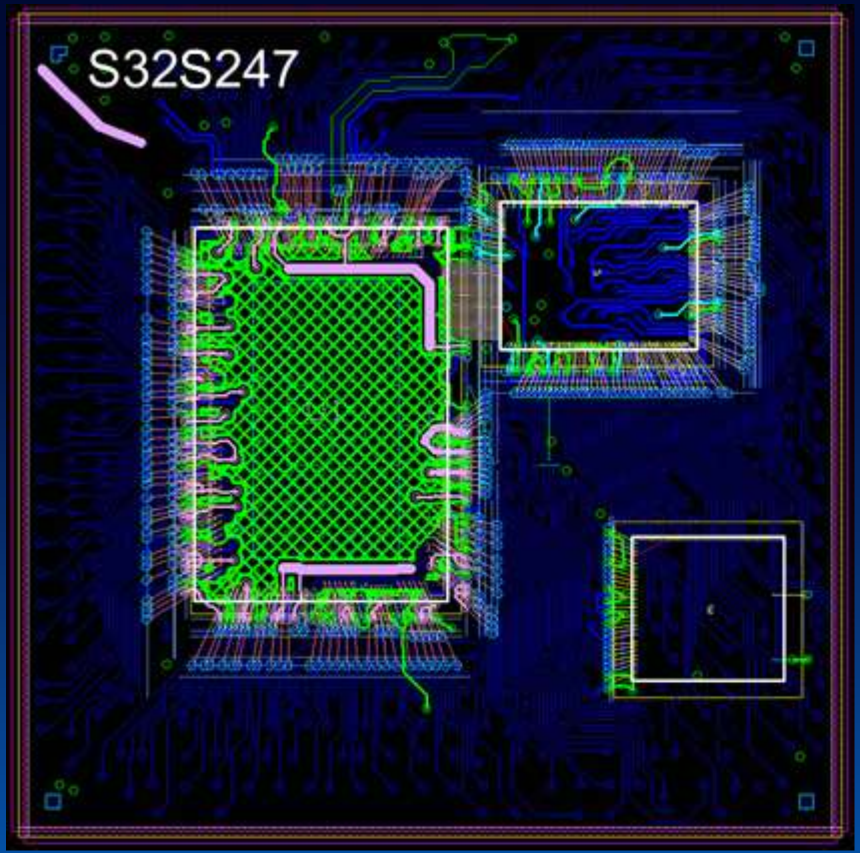
New MCU Architectures

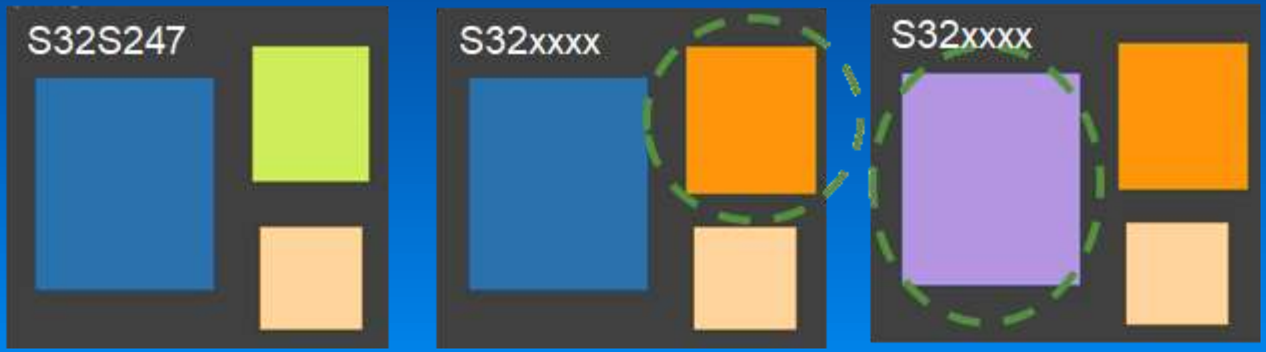
System in Package (SiP) MCU

- A new Automotive SiP MCU containing multiple die in standard Automotive form factors.

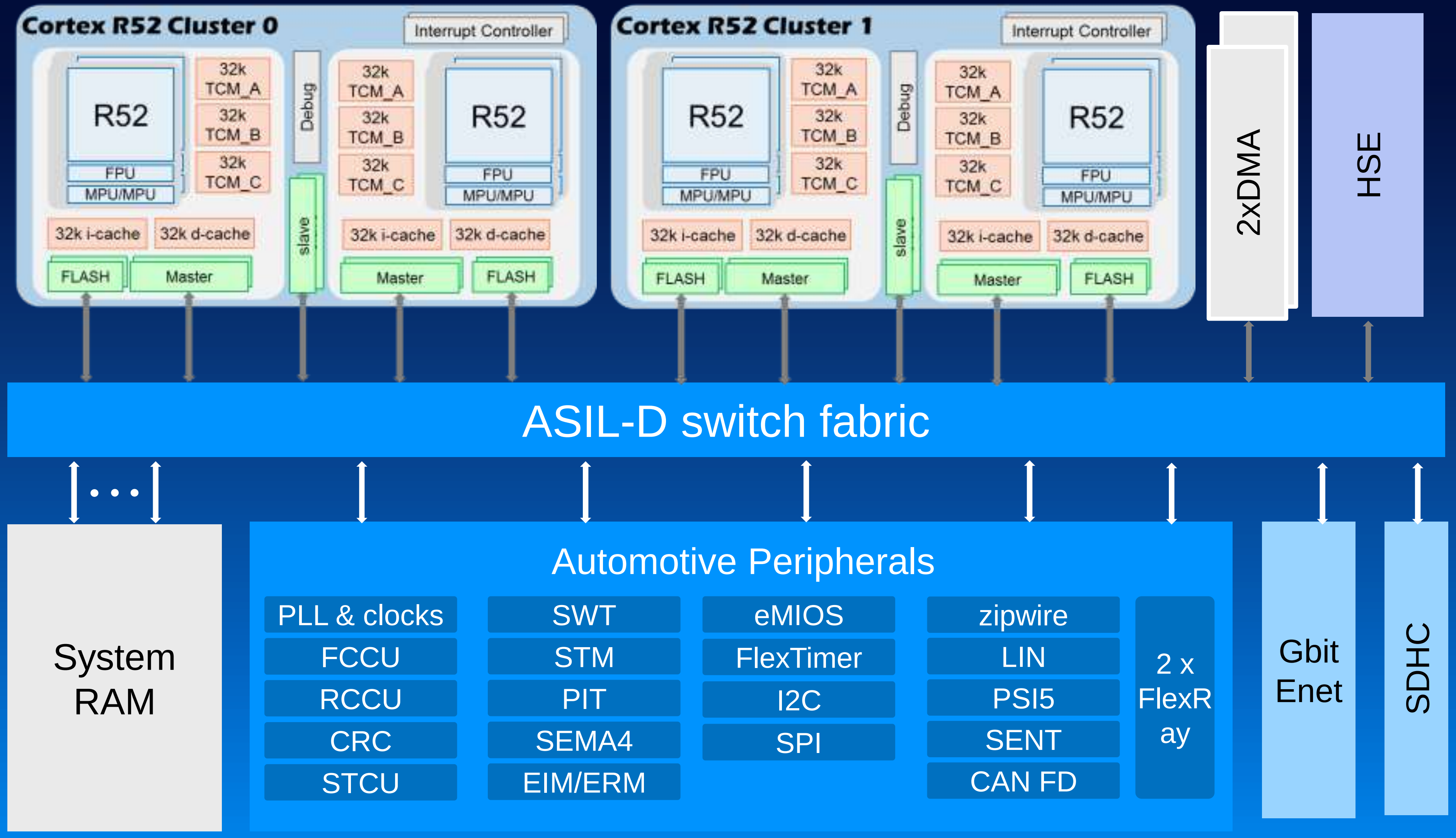
- Allows best technology to be used for each feature without comprise

- NXP has developed new interface technology enabling efficient Automotive SiP devices



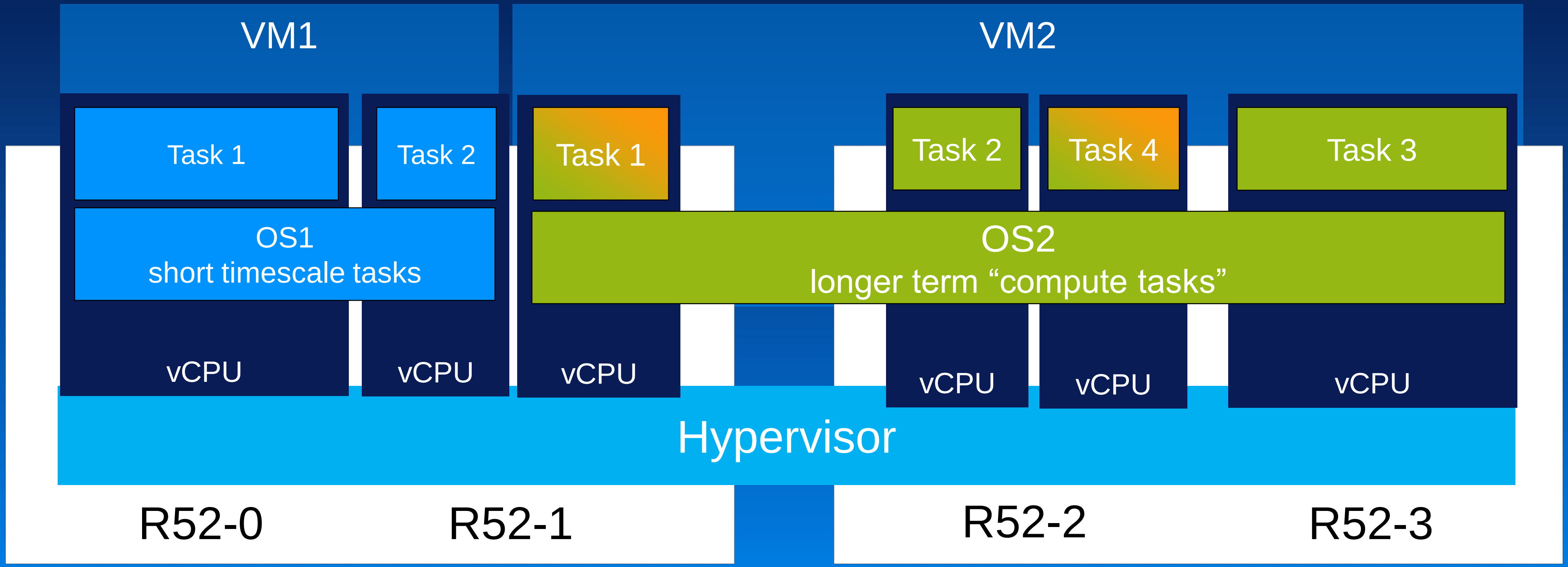


S32S Safe Fault-Tolerant Computing Platform

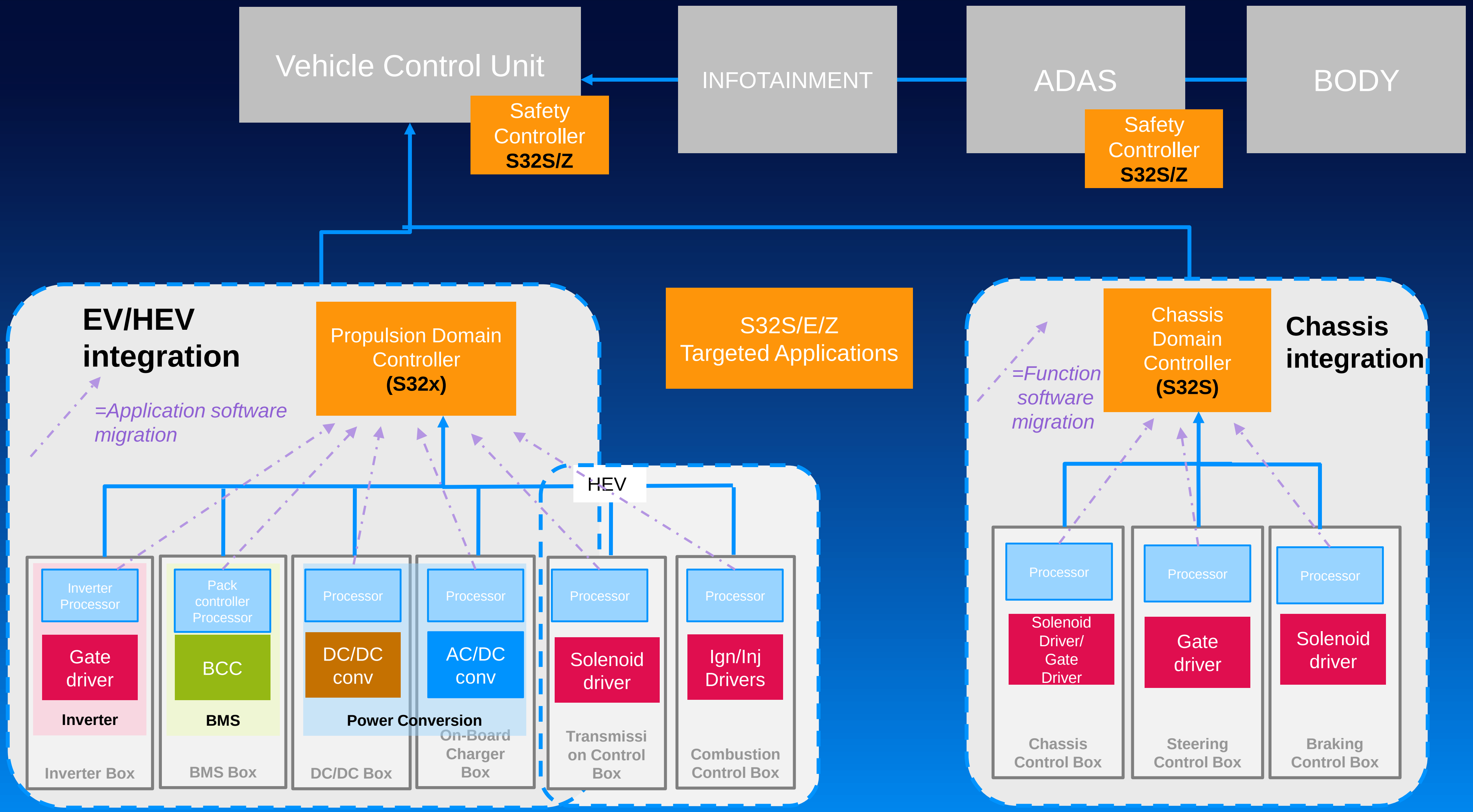


Typical Hybrid Control Unit (HCU) Software Architecture

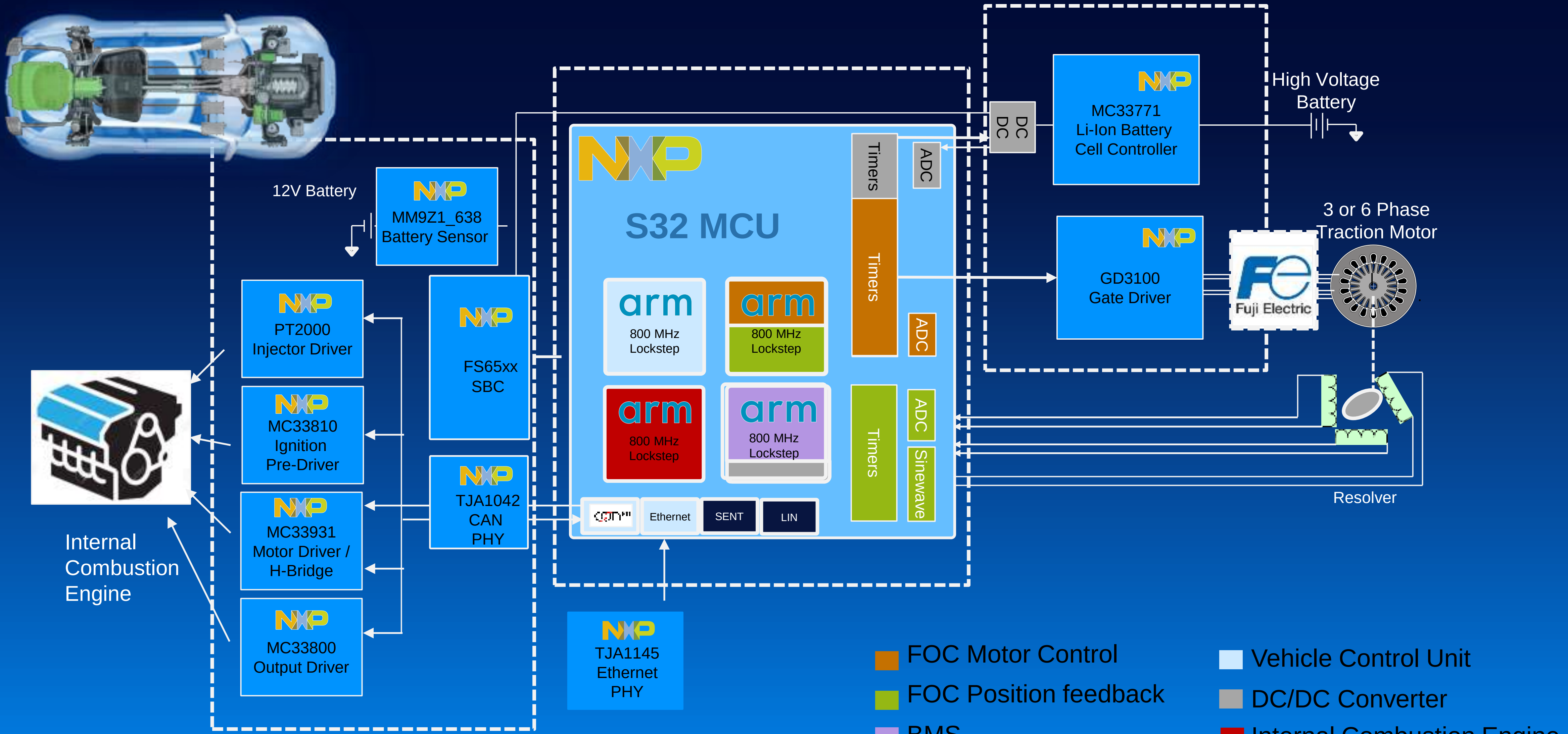
- The range of functions on the HCU map best onto a virtual machine (VM) architecture
- This simplifies integration when different suppliers provide the software functions
  - And provides a robust environment for safety-critical applications



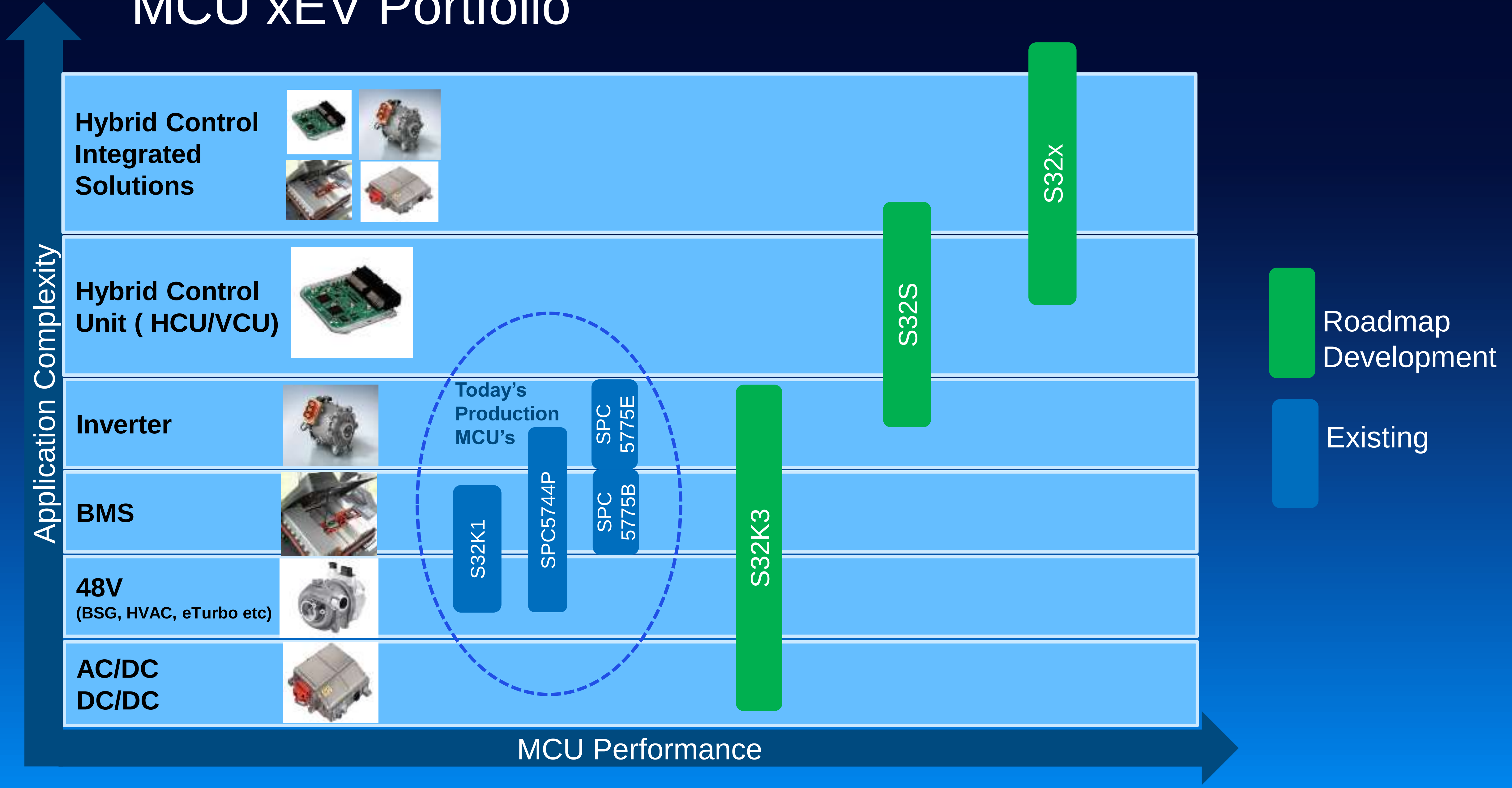
Vehicle Dynamics, Domain Control Within the total Vehicle Architecture- Not only Hybrid Control but Chassis Control Will follow the same path.



NXP Integrated HEV Controller System Solution



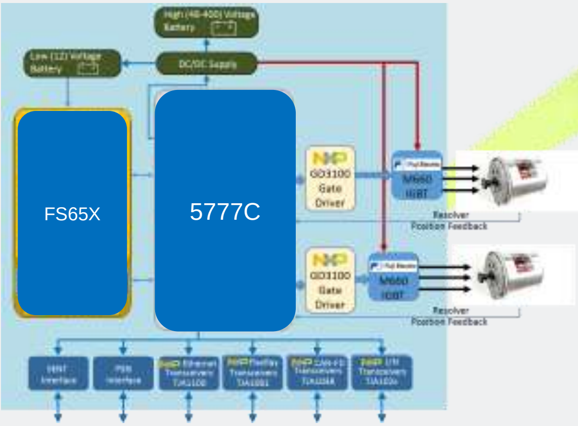
MCU xEV Portfolio

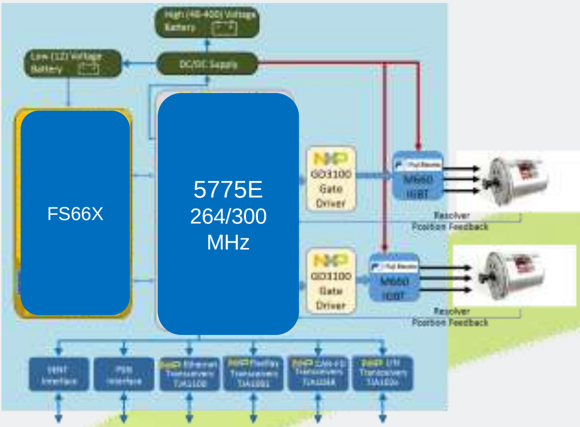


HEV/EV Inverter Solution Roadmap

Inverter Developments

2017 OEM Production





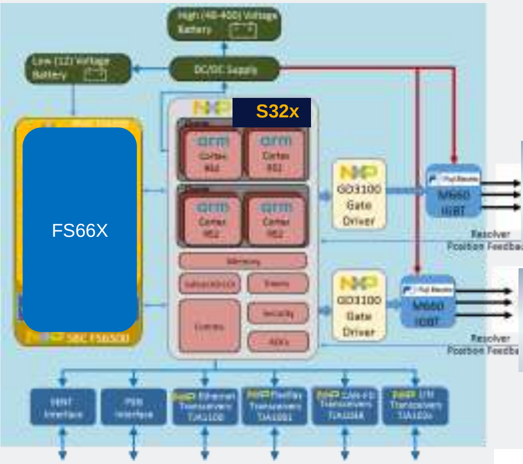
2019
Production

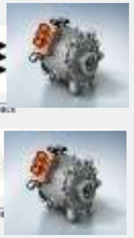
Full Reference
Inverter Design
for IGBT
Available
Q22019
(SiC Q4-2019)

GreenBox II

2022/23 Production **S32x**

HEV Domain Solutions

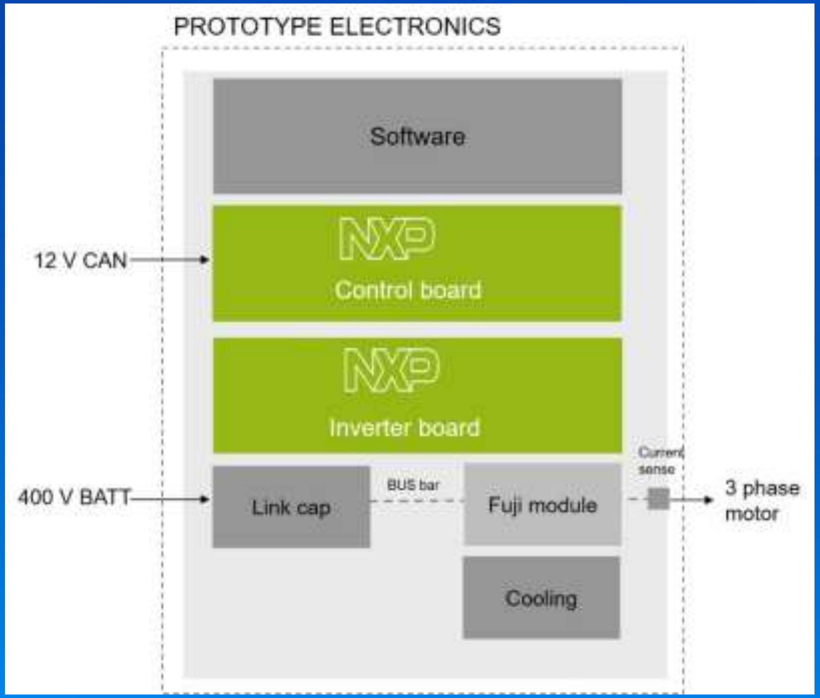




Next Gen
Demonstrator for BMS,
Inverter, ICE Integrated
Domain Control Q3 2019

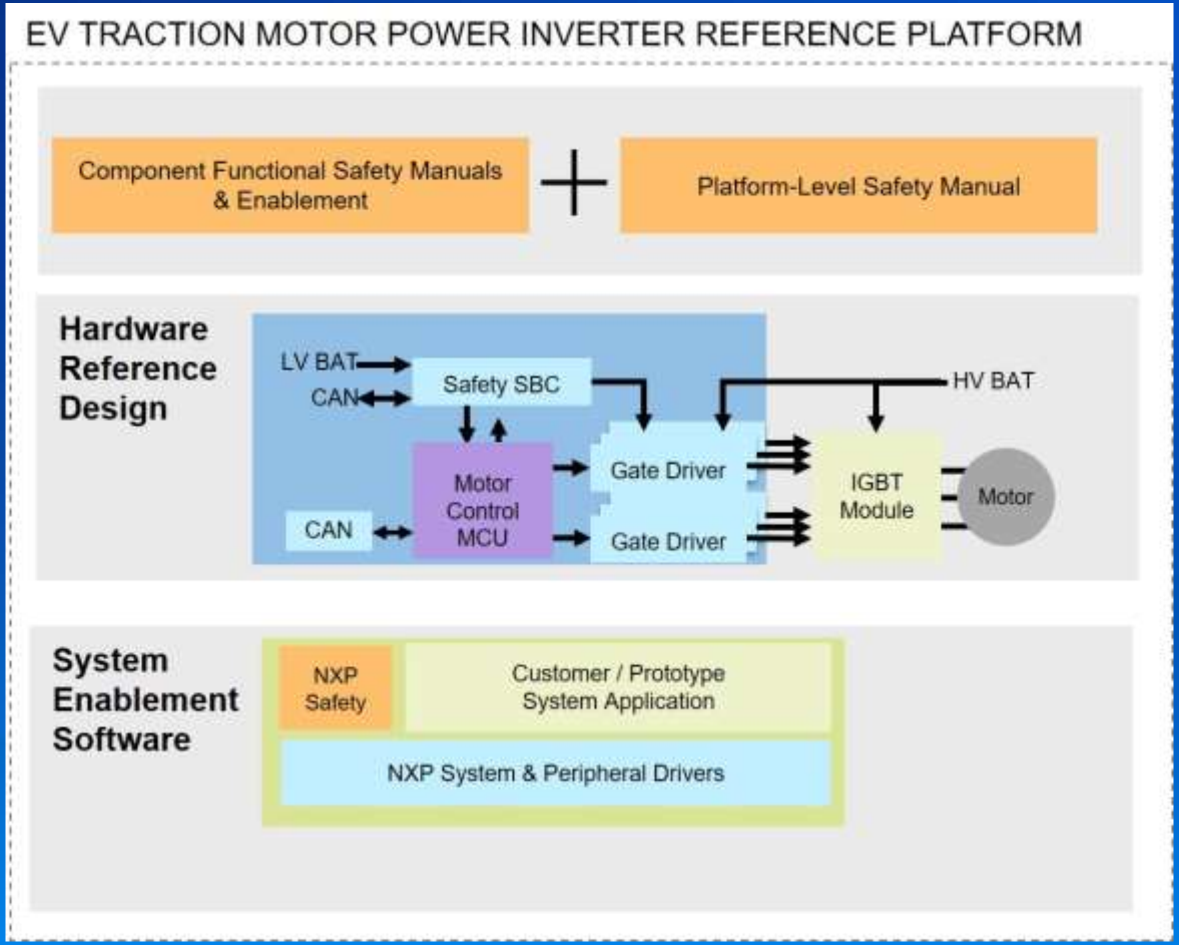
NXP Power Inverter Prototype Partnership

Partner	Responsibiity
NXP	• Power control components • Reference design platform • System enablement driver software • Safety case and software • Software development and SDK
VEPCO	• Platform system engineering and development • Prototype development • Contract system engineering services
Fuji Electric	• IGBT power module



NXP xEV Power Inverter Reference Platform
Small footprint ASIL-D 100 kW power inverter enablement

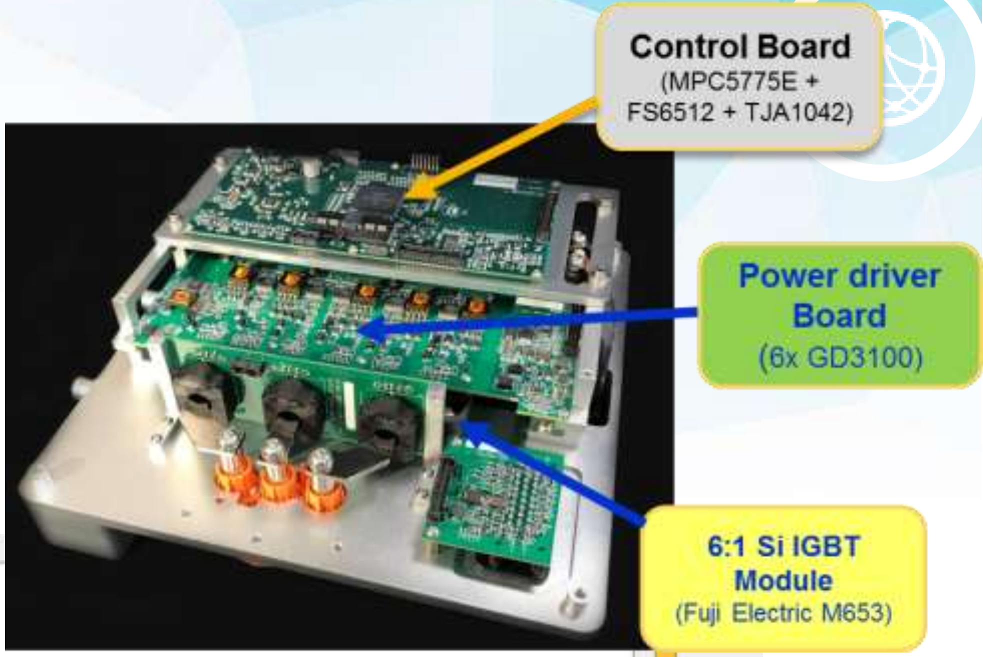
- **GD3100** isolated IGBT gate driver with <2us over-current protection
- **MPC5775E** advanced motor control ASIL-D MCU with software resolver
- **FS65** robust ASIL-D SBC with fail-silent and Grade 0 capabilities
- **TJA1042** redundant CAN bus interface with low power standby
- **System enablement software** with API and functional safety case



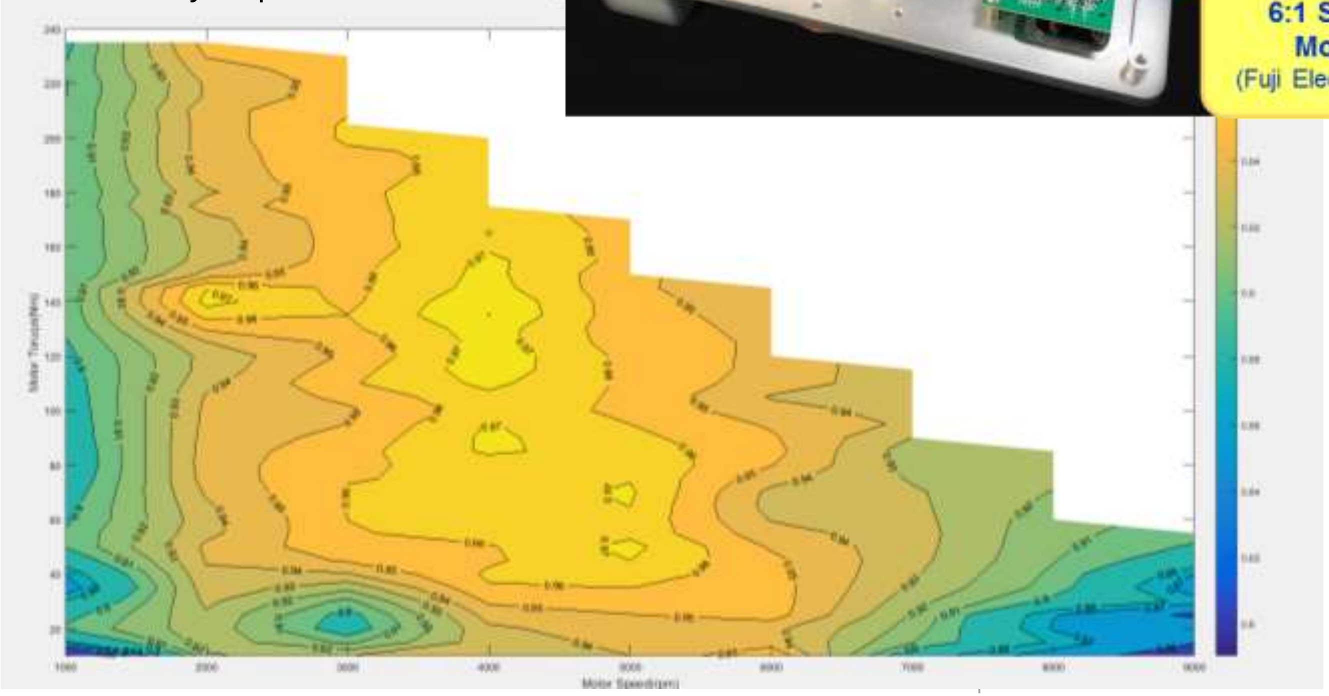
NXP / VEPCO Inverter Reference Design Performance

Parameter	Value	Units
Operating input voltage Range	200- 420	V_{DC}
Continuous output power	95	kW
Peak output power	196	kW
Nominal Voltage	320	V_{DC}
Nominal Current	300	A_{RMS}
Peak Current	470	A_{RMS}
Control input supply voltage range	8 - 18	V_{DC}
Motor Operating speed	0 - 10,000	RPM
PWM Switching Frequency	3-12	kHz
Control type	Current /Speed/Torque	
Maximum electrical Efficiency	> 96	%
Communication interface	CAN Bus	
Liquid Cooling		liters/min
Inverter mechanical envelope	28 x 28 x 14	cm x cm x cm
Inverter mass	< 10	Kg
Power Devices	Silicon IGBT (800A, 750 V)	1 module

The inverter has been tested on dyno up to 10k RPM
> 100kW of power and > 200 Nm of torque



PIM Efficiency Map



NXP GreenBox Development Platform for Hybrid and Electric Vehicles

High-performance processing platform used to design and test control algorithms and energy management tasks for next-generation electric drive vehicles

For early application development on NXP S32 Electrification MCUs and MPUs.

Demonstration in the Tech lab.

Conclusions

- Software integration will drive vehicle Architectural changes more in the next 5 years than any other factor in the last 20 years.
- Up-integration of ECUs and integration of functionality is already in progress.
- Traditional Microcontroller Solutions will not keep pace with these architectural changes
- There are new exciting solutions

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FOR A SMARTER WORLD