Peeking into the Car of the Future

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Sep 25, 2019

NXP

SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC

Agenda

Cost of Automotive Electronics

Architecting the Car of the Future

Domain Based Architecture

- Connectivity
- ADAS & Highly Automated Driving
- Powertrain & Vehicle Dynamics
- Body & Comfort
- Infotainment & In-Vehicle Experience

Safety & Security

Some terms use in automotive electronics

- CAN bus – Controller Area Network
- DSRC – Dedicated short range communication (802.11p)
- V2X – V2V, V2I, V2X (vehicle-vehicle, infrastructure)
- ADAS – Advanced Driver Assist System
- ASIL – Automotive Safety Integrity Level
- LIDAR – Light Detection and Ranging
- EPS – electronic power steering
- ESP – electronic stability program
- ISO -26262 Functional Safety Standard

Autonomy

Electrification

Connectivity

Safe and Secure Mobility

More than tripling the semi value per car – today's standard car at $380

Autonomy

+$700	**Full** Automation	⑤
+$600	**High** Automation	④
+$400	**Conditional** Automation	③
+$100	**Partial** Automation	②
+$50	**Driver Assistance**	①
	No Automation	⓪

Level **3-5**
Automated Driving System
Performs entire dynamic driving task
Monitors environment

Level **0-2**
Human Driver
Performs part of dynamic driving task
Monitors environment

Electrification

+$450	**Pure** Electric Vehicle	E5
+$425	**Range Extended** Electric Vehicle	E4
+$400	**Plug-in** Hybrid	E3
+$350	**Full** Hybrid	E2
+$200	**Mild** Hybrid	E1
	Combustion Engine	E0

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

Vehicle Electrification: Diversity of Approaches

Electrification Levels	E0	E1	E2	E3	E4	E5
Common Name	Combustion Engine (ICE)	Mild Hybrid (M-HV)	Full Hybrid (F-HV)	Plug-in Hybrid (PHEV)	Range Extended EV	Pure Electric Vehicle
Example	Ford Mustang	Honda Insight	Toyota Prius	FCA Pacifica	BMW i3	Nissan Leaf
Combustion Engine	●●●●	●●●●	●●●	●●●	●●	
Battery System	12V	12V, 48V	LV, HV	LV, HV	LV, HV	LV, HV
Mains Charging	-	-	-	🔌	🔌	🔌
Electric Traction	-	(motor) 10 – 20kW	(motor) 15 – 60kW	(motor) 40 – 80kW	(motor) 40 – 80kW	(motor) > 80kW

Connectivity

+$100	**Fully Connected Car**	**5G** 🔒 / **AM/FM Digital** | **WiFi BT NFC** 📍 **C5**
+$80	**+ 4G-LTE Advanced, V2X Security**	**4G-LTE / AM/FM Digital** | **WiFi BT** 🔒 **C4**
+$50	**+ Digital Radio, 4G**	**4G / AM/FM Digital** | **WiFi BT** **C3**
+$30	**+ Connectivity**	**2G/3G / AM/FM** | **WiFi BT** **C2**
+$10	**Analog Radio**	**AM/FM** | **WiFi BT** **C1**
	No Connectivity	**C0**

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

Architecting the Car of The Future

Mega Trends Force Vehicle Architecture Transformation

TODAY: FLAT

Flat to hierarchical
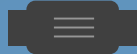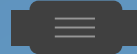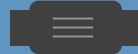
TOMORROW: DOMAINS

Connectivity

Powertrain & Vehicle Dynamics

Infotainment & In-Vehicle Experience

Domain Controller

Gateway

Domain Controller

Domain Controller

Domain Controller

Domain Controller

Body & Comfort

ADAS & Highly Automated Driving

Wires go virtual

AFTER TOMORROW: ZONES

Zonal Gateway

Zonal Gateway

Central Brain

Zonal Gateway

Zonal Gateway

- Low bandwidth, flat network
- One MCU per application

Unfit to future Mobility

- High bandwidth network
- Gateway key to communication between domains

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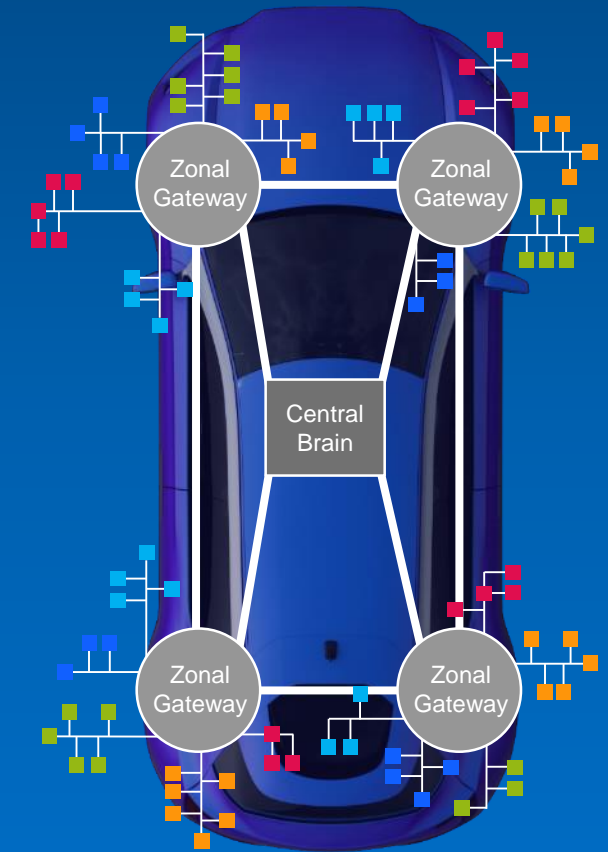
- Domains virtualized by SW – enabling high flexibility
- Easy enable/disable or update functions

Step to User-Defined Car

Domain Architecture
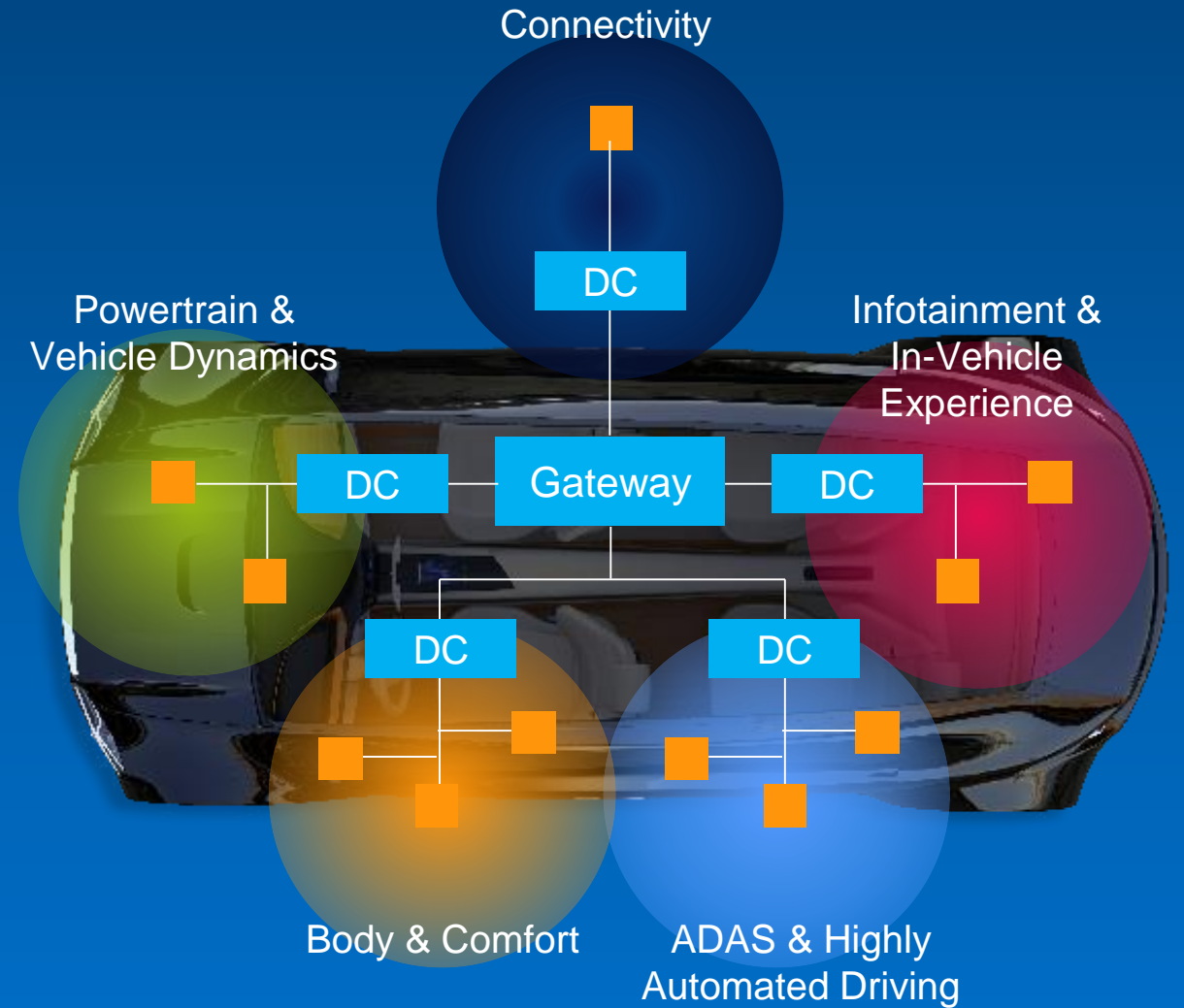
SENSE   THINK   ACT

Domain MPUs

Edge Nodes & Sensors

High Bandwidth

Gateway

Safety & Security

Connectivity
- V2X 🔒
- Cellular 🔒
- WiFi, BT, GNSS, NFC 🔒
- Smart Car Access 🔒
- Radio Reception

Connectivity Domain Controller 🔒

ADAS & Highly Automated Driving
- Radar 🔒
- Camera 🔒
- Lidar 🔒

Safe Central Compute & Planning Domain Controller 🔒

Powertrain & Vehicle Dynamics
- Motion & Pressure 🔒
- Speed 🔒
- Ultrasonic 🔒

Powertrain Domain Controller 🔒

🔒 Vehicle Networks

🔒 Engine Steering
Transmission Airbag
Brake Suspension
Battery Cell Management

Body & Comfort
- Temp, Light, Humidity 🔒
- Switch Panels 🔒

Body Domain Controller 🔒

🔒 HVAC, Interior Lighting

🔒 Doors, seats, steering wheel, mirrors, wipers, sunroof

Infotainment & In-Vehicle Experience
- Touch Displays & Gesture 🔒
- Voice Recognition & Audio 🔒

eCockpit Domain Controller 🔒

🔒 eCockpit

🔒 Audio & Amplifiers

Auto Processors Tomorrow – NXP's Unique S32 Platform

Body & General Purpose

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Network Processing

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Radar

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Vision

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Safety & Powertrain

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Common Chassis

Safety	Peripherals
Security	Debug

Autonomy – Safety

Arm Cortex	Memory
Interconnect	
Common Chassis	

Application Specific IP

Reduces SW R&D[1] by 35%
Unified HW with identical SW environment

10x the Performance[2]
Multiple real time OS
ADAS AI accelerators

Safe and Secure
4 independent ASIL D paths
HW security engine
Ready for OTA

The World's First Fully Scalable Safe Auto Compute Platform

Unprecedented Design Win Pipeline ➔ 1.5x of Previous Generations

1. Based on analysis of existing NXP Software code in existing customers' applications
2. Based on publicly available competitor roadmap performance statements versus today's best safe auto platform

Connectivity

A Look Inside the Connectivity Domain – All in a single ECU

Broadcast Reception

- Analog Radio
- Digital Radio
- Satellite Radio

Modem

- 2G / 3G / 4G / 5G

V2X / DSRC

- IEEE 802.11p

Car Access – Base Station

- Long Range
- Passive Keyless Entry

Security

- Crypto µC

Consumer Connectivity

- Bluetooth
- Wifi
- GPS / GNSS
- NFC & WPC
- Connectivity Stack

Secure **V2X** Sensors
Seeing around Corners

Sees objects up to 1km, around corners
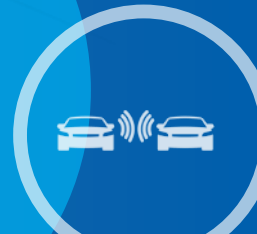
Proven IEEE 802.11p standards

Highest security

Scalable architecture

NXP RoadLINK
In volume production
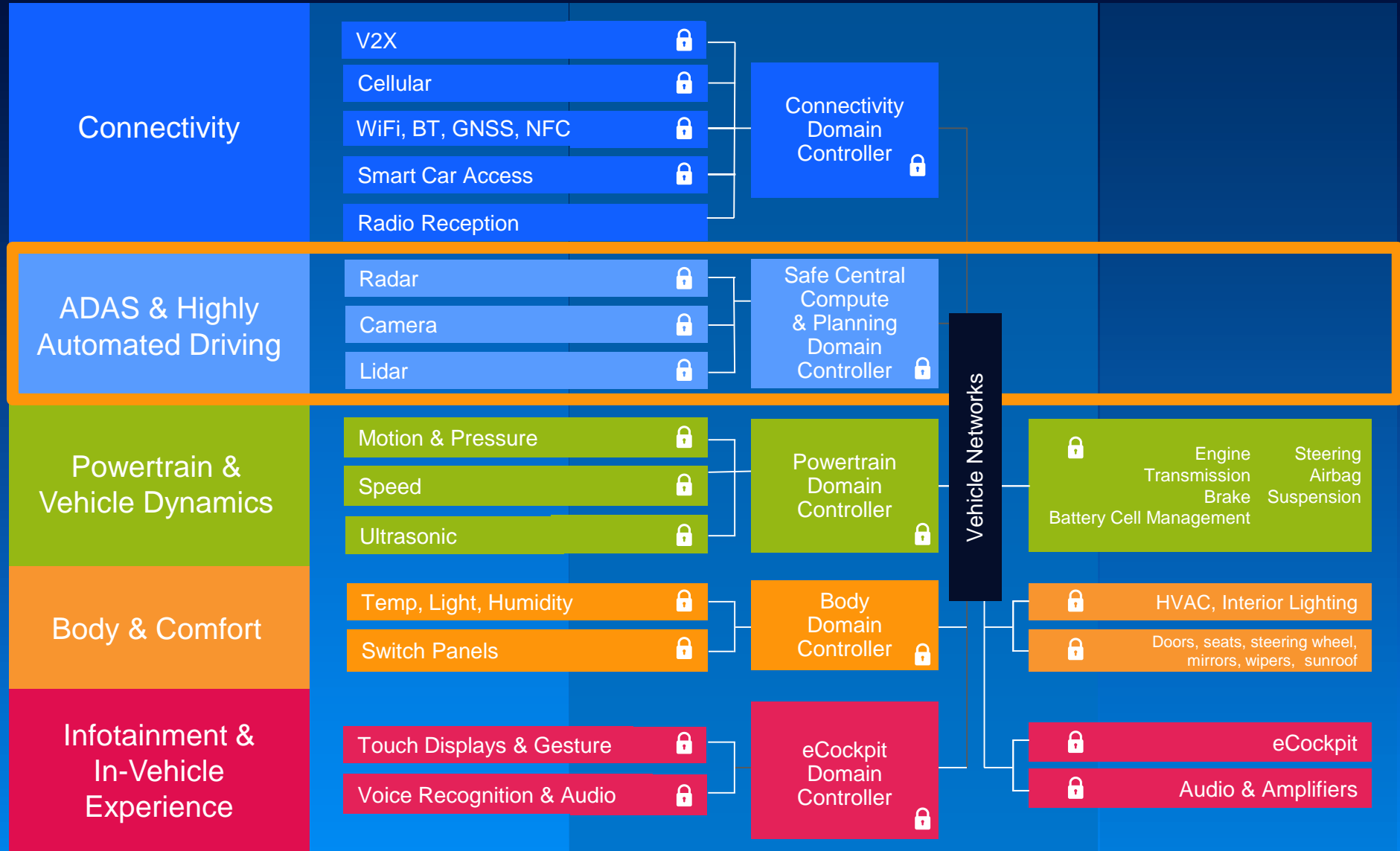1st to market with secure 1-chip modem
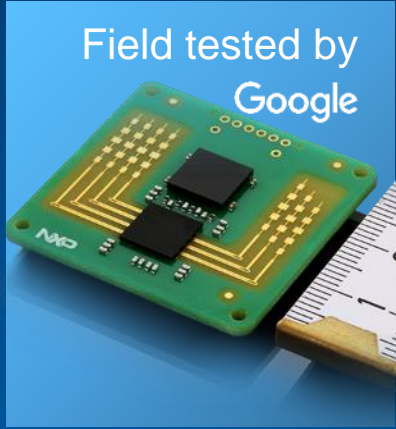
ADAS & Highly Automated Driving

SENSE   THINK   ACT

Connectivity
- V2X 🔒
- Cellular 🔒
- WiFi, BT, GNSS, NFC 🔒
- Smart Car Access 🔒
- Radio Reception

Connectivity Domain Controller 🔒

ADAS & Highly Automated Driving
- Radar 🔒
- Camera 🔒
- Lidar 🔒

Safe Central Compute & Planning Domain Controller 🔒

Powertrain & Vehicle Dynamics
- Motion & Pressure 🔒
- Speed 🔒
- Ultrasonic 🔒

Powertrain Domain Controller 🔒

Vehicle Networks

🔒 Engine   Steering
Transmission   Airbag
Brake   Suspension
Battery Cell Management

Body & Comfort
- Temp, Light, Humidity 🔒
- Switch Panels 🔒

Body Domain Controller 🔒

🔒 HVAC, Interior Lighting

🔒 Doors, seats, steering wheel, mirrors, wipers, sunroof

Infotainment & In-Vehicle Experience
- Touch Displays & Gesture 🔒
- Voice Recognition & Audio 🔒

eCockpit Domain Controller 🔒

🔒 eCockpit

🔒 Audio & Amplifiers

Radar

Evolves to 360° view with high-performance integration

Field tested by Google

Short range/ Medium range RADAR
Park Assist
Cross-Traffic Alert
Junction Assist

Medium Range RADAR
Blind Side Detection

Long Range RADAR
Adaptive Cruise Control
Automatic Emergency Braking
Forward Collision Warning

Higher Resolution

TOMORROW
TODAY
TOMORROW
TODAY
TOMORROW
TODAY
TOMORROW
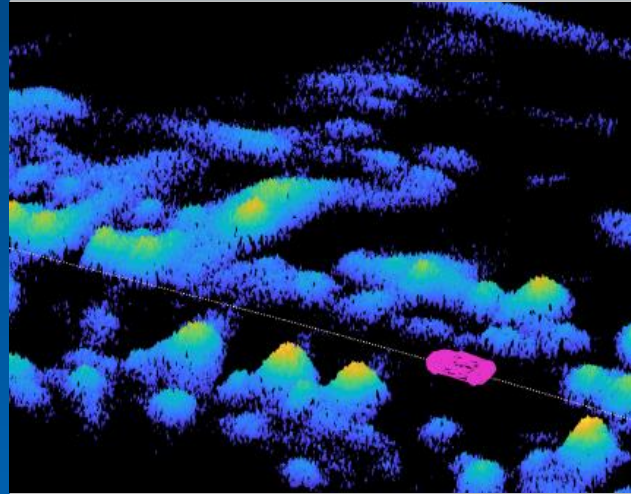TODAY
TOMORROW

NXP
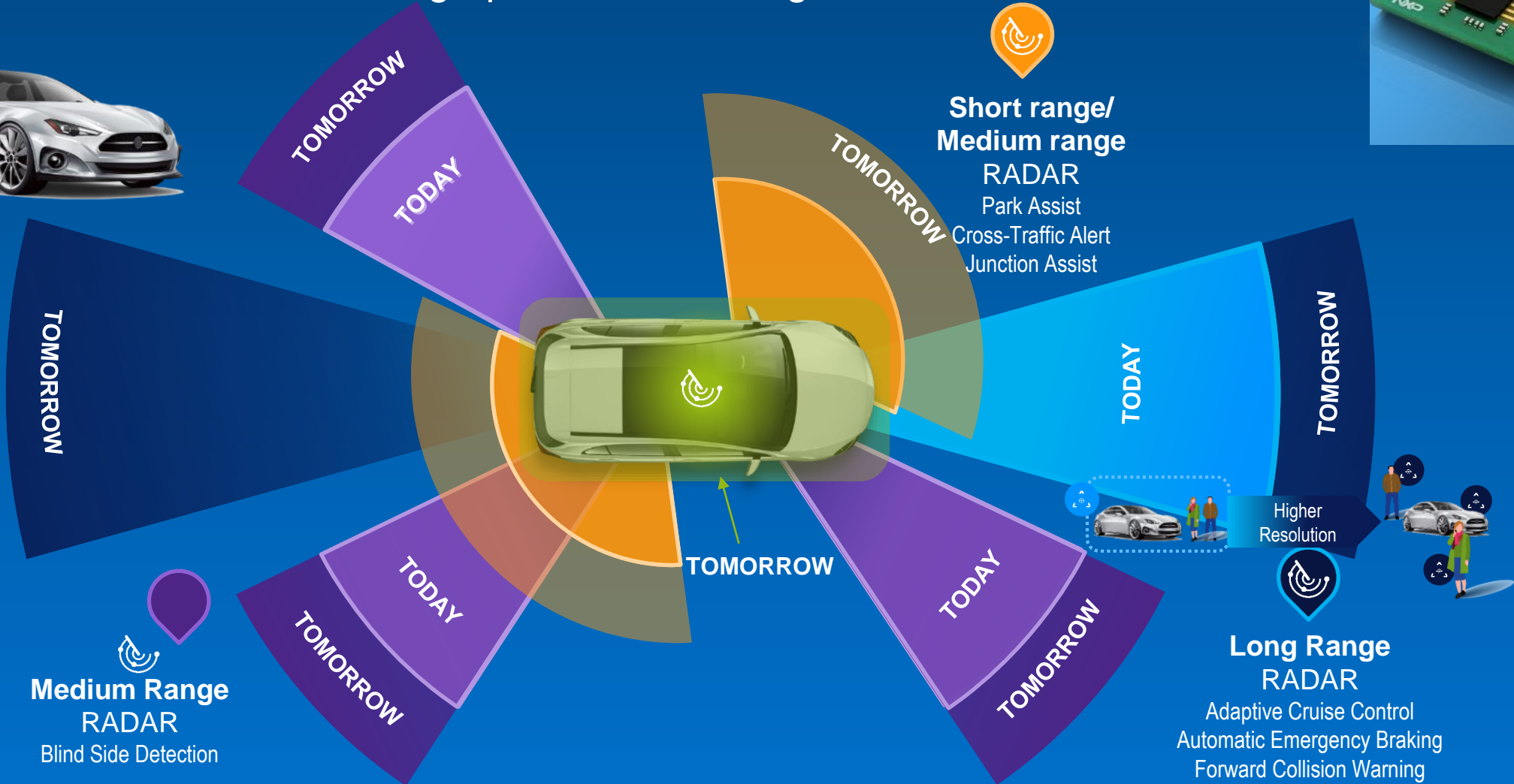
Enabling A/D Perception & Sensing Requirements in Radar

Detection & Tracking

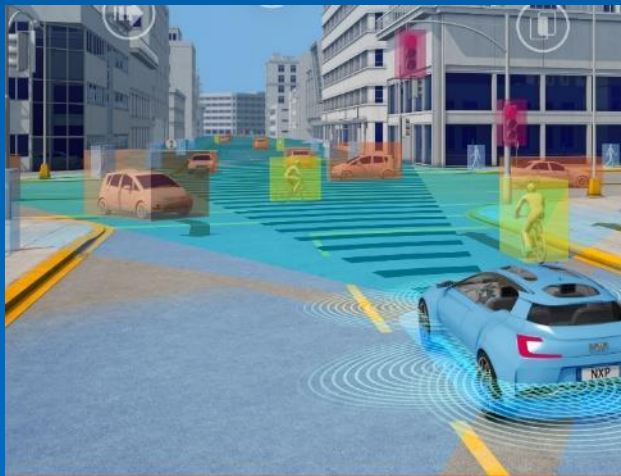Resolve cluttered, hidden objects & track directionality

Classification & Segmentation

Pedestrians, Cars, Trucks, Motorcycles

Mapping

Static and Dynamic Object & Free Space detection (L4 functions)

3D Shapes (images) with classification (Deep Learning)

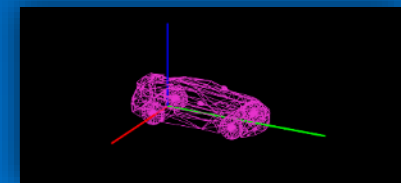
Localization

Ego motion and pin-point position via map correlation or SLAM

SOP 2021

for L3-4 vehicles

High-performance **Vision** Sensors

Improve Safety on the Road

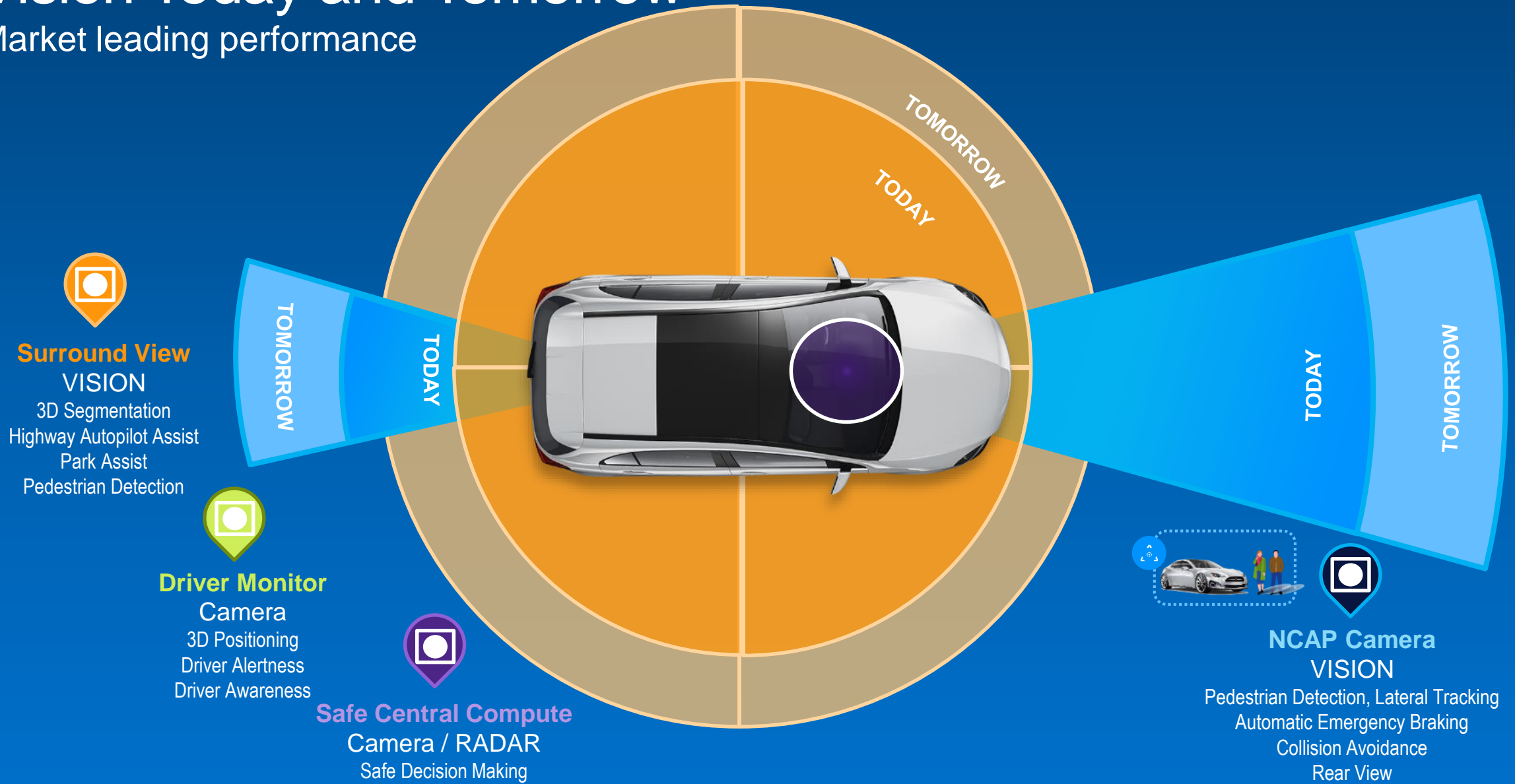Front View   Surround View   Driver Monitor   Perception

NXP S32V

Supports demand for
open, safe, scalable solutions, and AI

S32V

Vision Today and Tomorrow
Market leading performance

Surround View
VISION
3D Segmentation
Highway Autopilot Assist
Park Assist
Pedestrian Detection

Driver Monitor
Camera
3D Positioning
Driver Alertness
Driver Awareness

Safe Central Compute
Camera / RADAR
Safe Decision Making

NCAP Camera
VISION
Pedestrian Detection, Lateral Tracking
Automatic Emergency Braking
Collision Avoidance
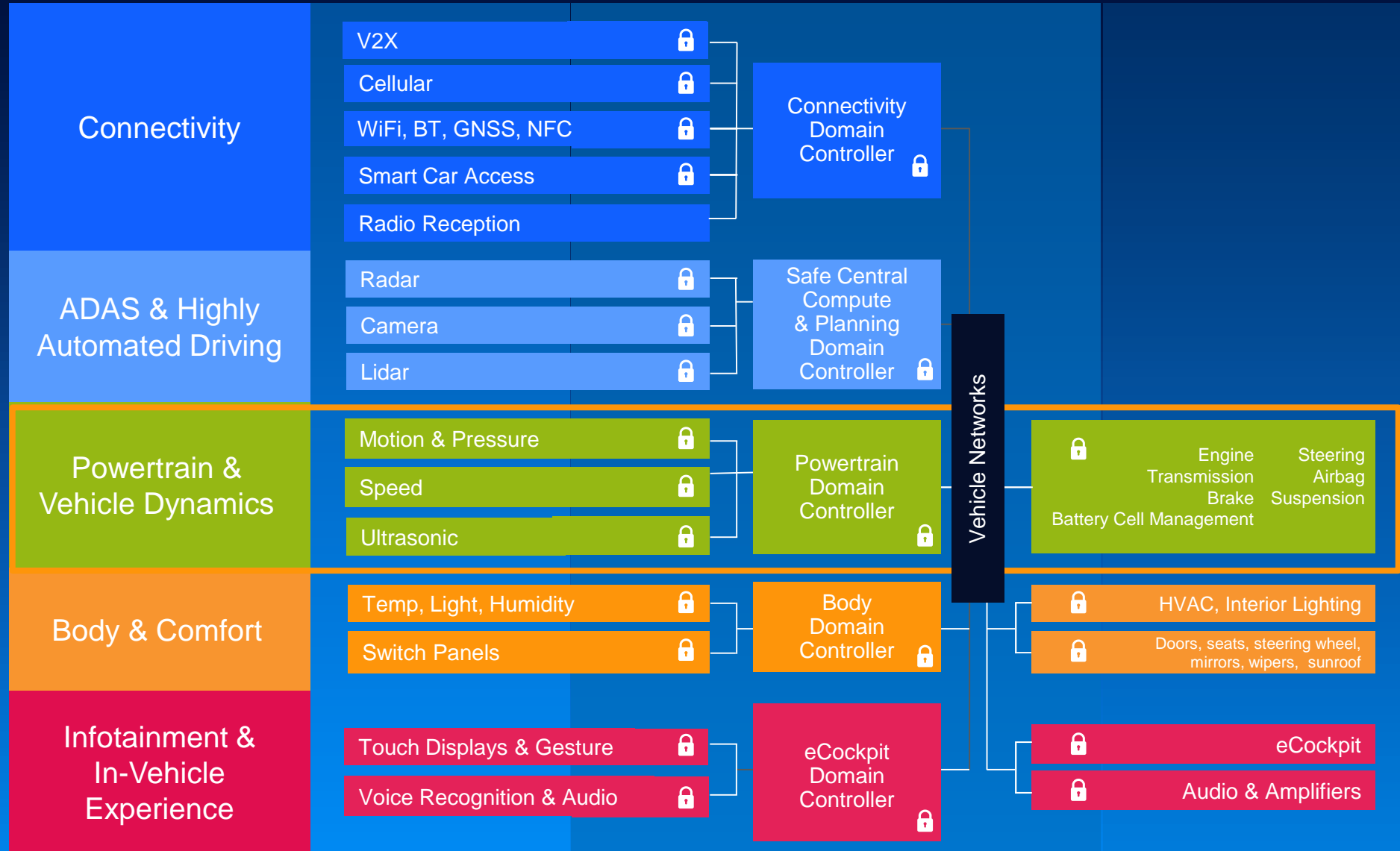Rear View

TOMORROW
TODAY

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Powertrain & Vehicle Dynamics

NXP Provides Leading Powertrain Control Solutions
System optimized, scalable, secure and safe

Battery Management System

| Network | Processor | Battery Cell Controller |

↔ HV

Electric Motor Control Unit

| Network | ↔ | Processor |

Inverter

Gate Driver

High Voltage IGBT Module

IGBT | IGBT

Hybrid Vehicle Control Unit

| Network | ↔ | Processor |

DC/DC Converter

| Network | ↔ | Processor |

Power MOSFET

Combustion Engine Motor Control Unit

| Network | ↔ | Processor |

| Input Signal & Sensor Interface | Output Drivers |

LV

NXP

Battery Management System

Traction Motor

Hybrid Vehicle Control Unit

Traction Motor

Traction Motor

Integrated DC/DC Converter
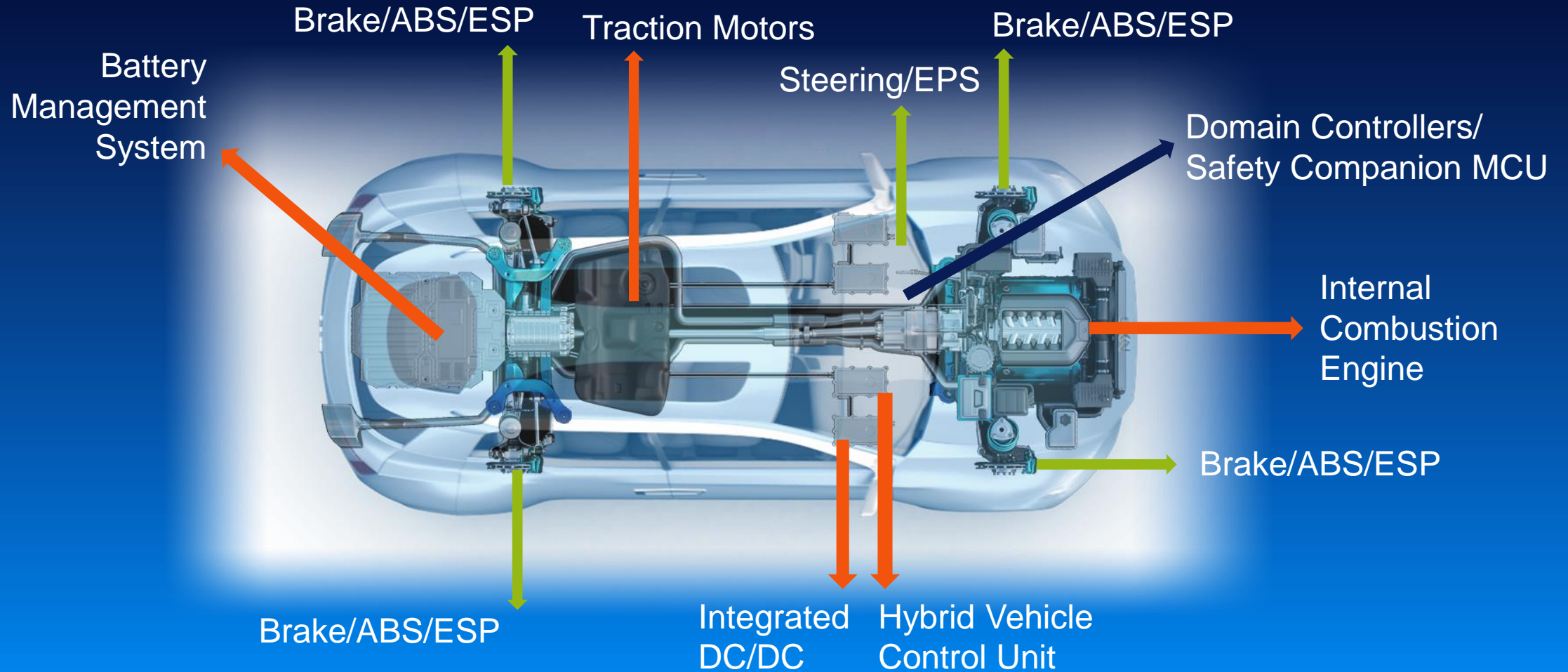
Traction Motor

Internal Combustion Engine

NXP GreenBox Development Platform Target Applications
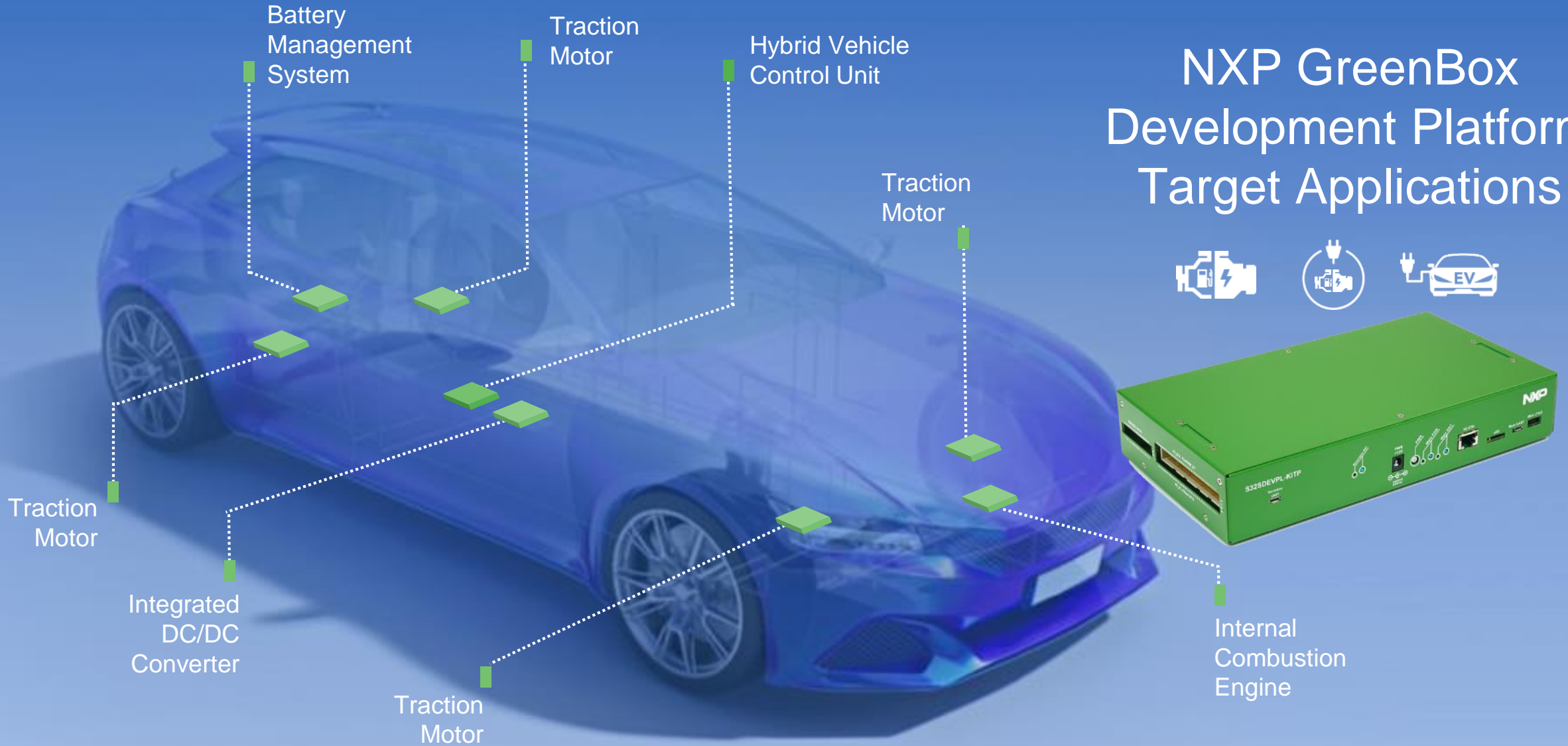
Vehicle Dynamics "Start, Stop and Steer"

Safe Dynamic Control Using S32S MCUs and MPUs

Domain Controller

Brake / ABS / ESP
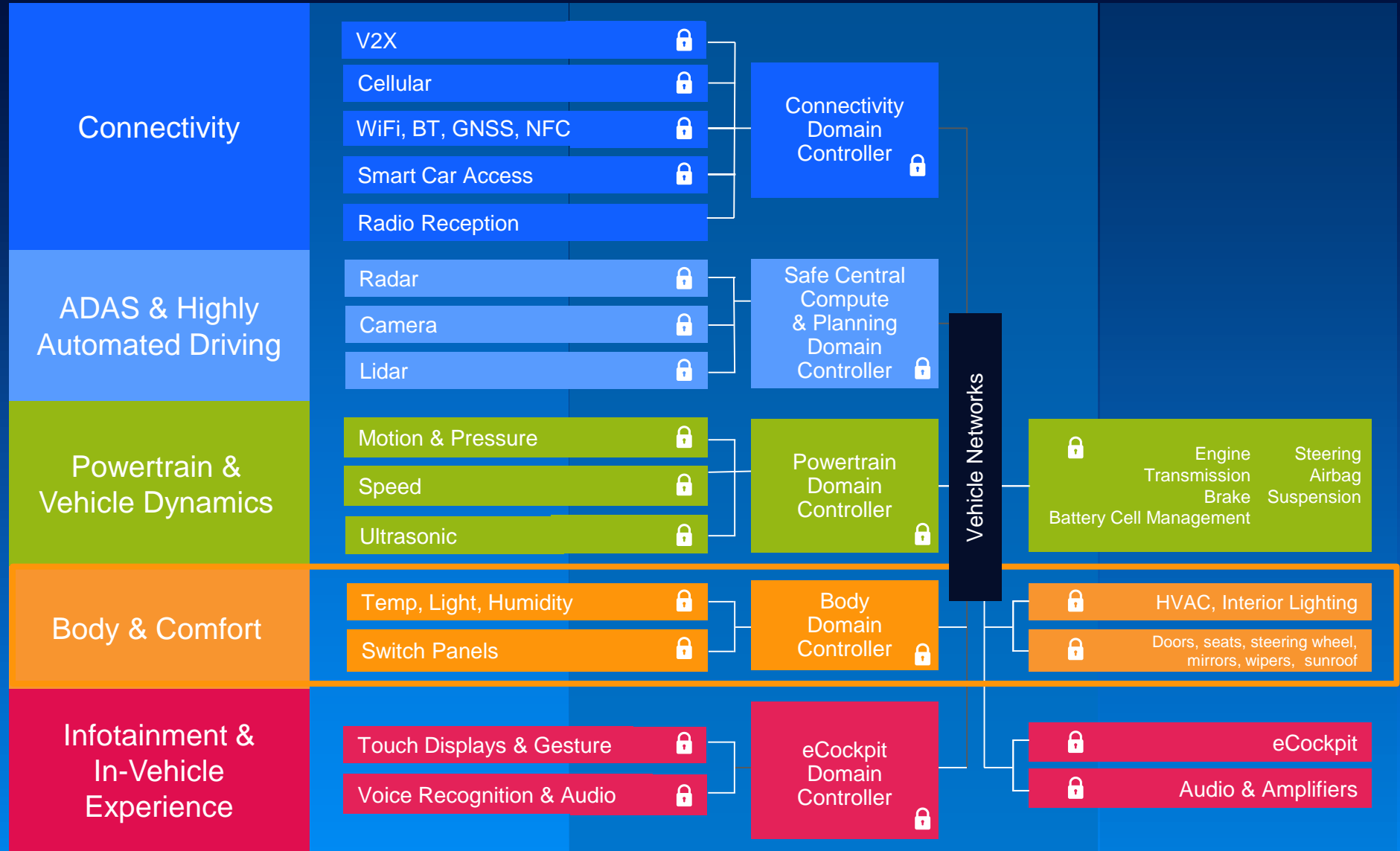
Safety Companion MCU

Steering / EPS

Brake / ABS / ESP

Battery Management System

Brake / ABS / ESP

Integrated DC/DC Converter

Brake / ABS / ESP

Traction Motor Energy Management

Internal Combustion Engine Energy Management
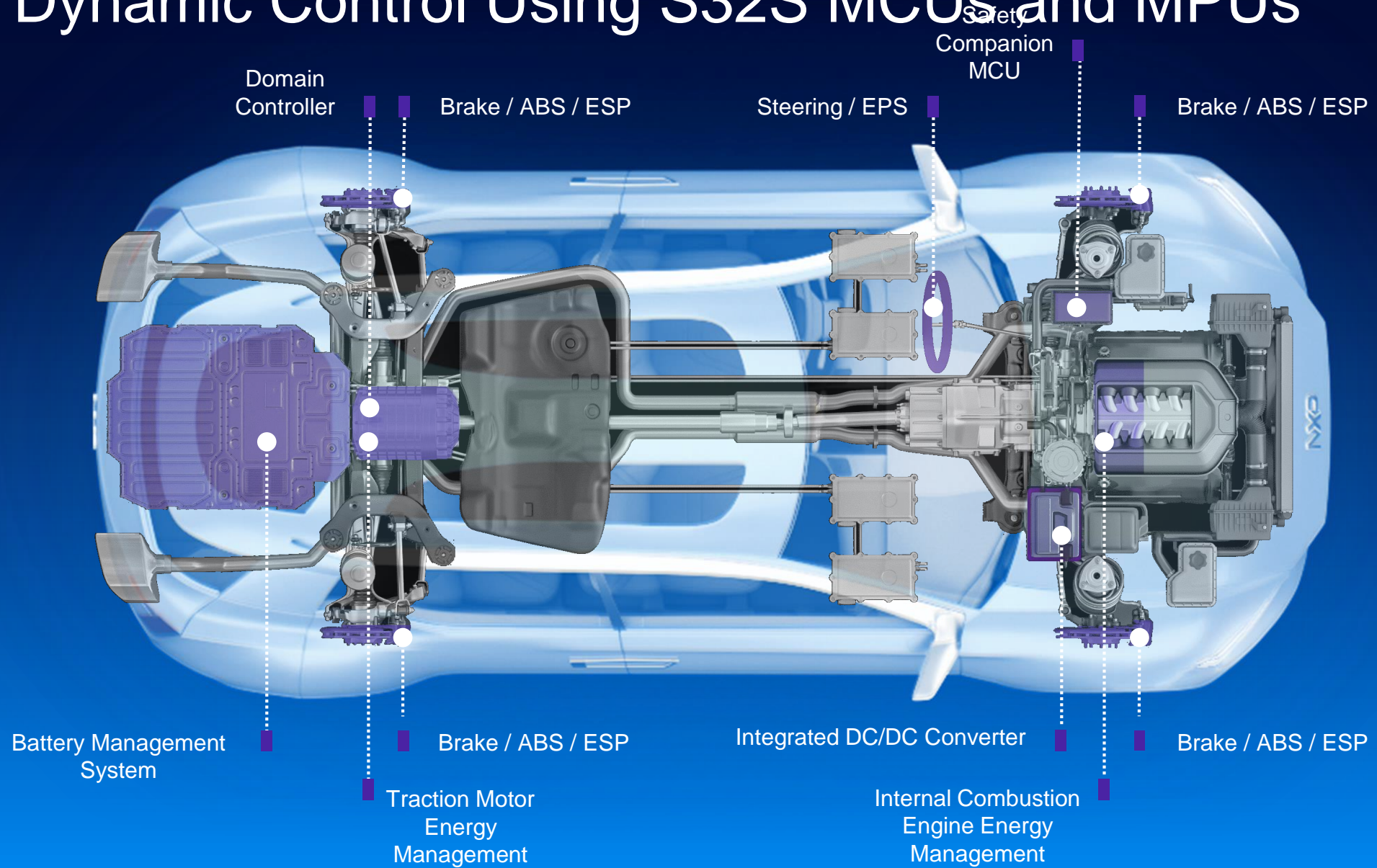
Sensors in Automotive Applications

Navigation
Dead Reckoning

Roll Over
detection

Vehicle movement
Tracking Unit 6DOF

Electric Parking Brake
Hill start control

Airbag Central
Crash sensor

Night Vision
Infrared
sensing

Electronic
Stability
Control
sensors

Radar beam
orientation & stabilization

Engine Mgt -
Air Pressure,Turbo
CNG/LPG Gas
pressure

Tire Monitoring Sensor

Suspension
monitors

Engine Mgt -
Electronic Throttle
Exhaust Gas
Recirculation

Comfort seat
Air Bladder Sensor

Airbag Pressure
Satellite Sensor

Car Alarm

Brake booster
vacuum pressure

Airbag Inertial
Satellite Sensor

Steering
Angle,
Torque
Sensor

Pedal Position Sensor

Wheel Speed Sensor (ABS)

Pedestrian Impact
protection PSAT
and /or Low g

Keyfob motion
detection

Body & Comfort

SENSE | THINK | ACT

Connectivity
- V2X 🔒
- Cellular 🔒
- WiFi, BT, GNSS, NFC 🔒
- Smart Car Access 🔒
- Radio Reception

Connectivity Domain Controller 🔒

ADAS & Highly Automated Driving
- Radar 🔒
- Camera 🔒
- Lidar 🔒

Safe Central Compute & Planning Domain Controller 🔒

Powertrain & Vehicle Dynamics
- Motion & Pressure 🔒
- Speed 🔒
- Ultrasonic 🔒

Powertrain Domain Controller 🔒

Vehicle Networks

🔒 Engine   Steering
Transmission   Airbag
Brake   Suspension
Battery Cell Management

Body & Comfort
- Temp, Light, Humidity 🔒
- Switch Panels 🔒

Body Domain Controller 🔒

🔒 HVAC, Interior Lighting

🔒 Doors, seats, steering wheel, mirrors, wipers, sunroof

Infotainment & In-Vehicle Experience
- Touch Displays & Gesture 🔒
- Voice Recognition & Audio 🔒

eCockpit Domain Controller 🔒

🔒 eCockpit

🔒 Audio & Amplifiers
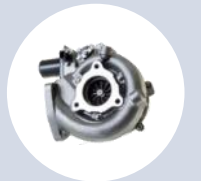
Infotainment & In-Vehicle Experience

Infotainment & In-vehicle Experience

- Cockpit
- Multimedia
- Media Source
- Radio
- Audio

Connected Infotainment:
Key Differentiator & Sales Driver for OEMs

Cockpit ▶▶▶ Full digital eCockpit

Multimedia ▶▶ Multiple high resolution displays

Media Source ▶▶ Smartphone content, apps & services

Radio ▶▶ Digital radio & regional standards
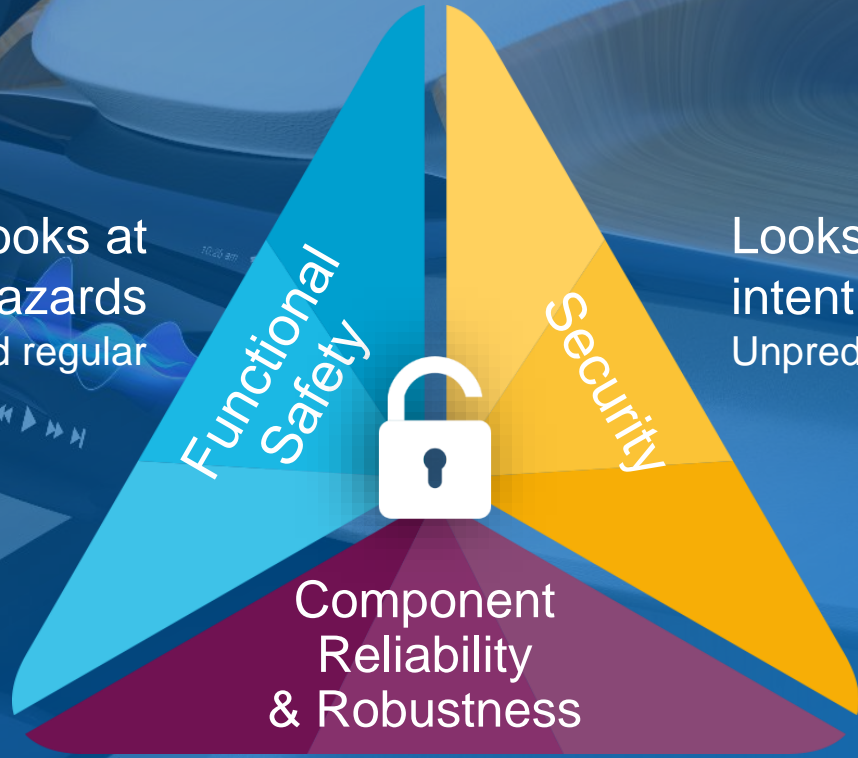
Audio ▶▶ Noise cancellation, engine sound …

Safety & Security

System Development Unlocks NXP's Value Propositions
Functional Safety and Security

Looks at unintentional hazards
Predictable and regular

Functional Safety

Security

Looks at intentional hazards
Unpredictable and irregular

Component Reliability & Robustness

Maximum quality of components is mandatory for high-value system

PUBLIC

Safety & Security Go Together
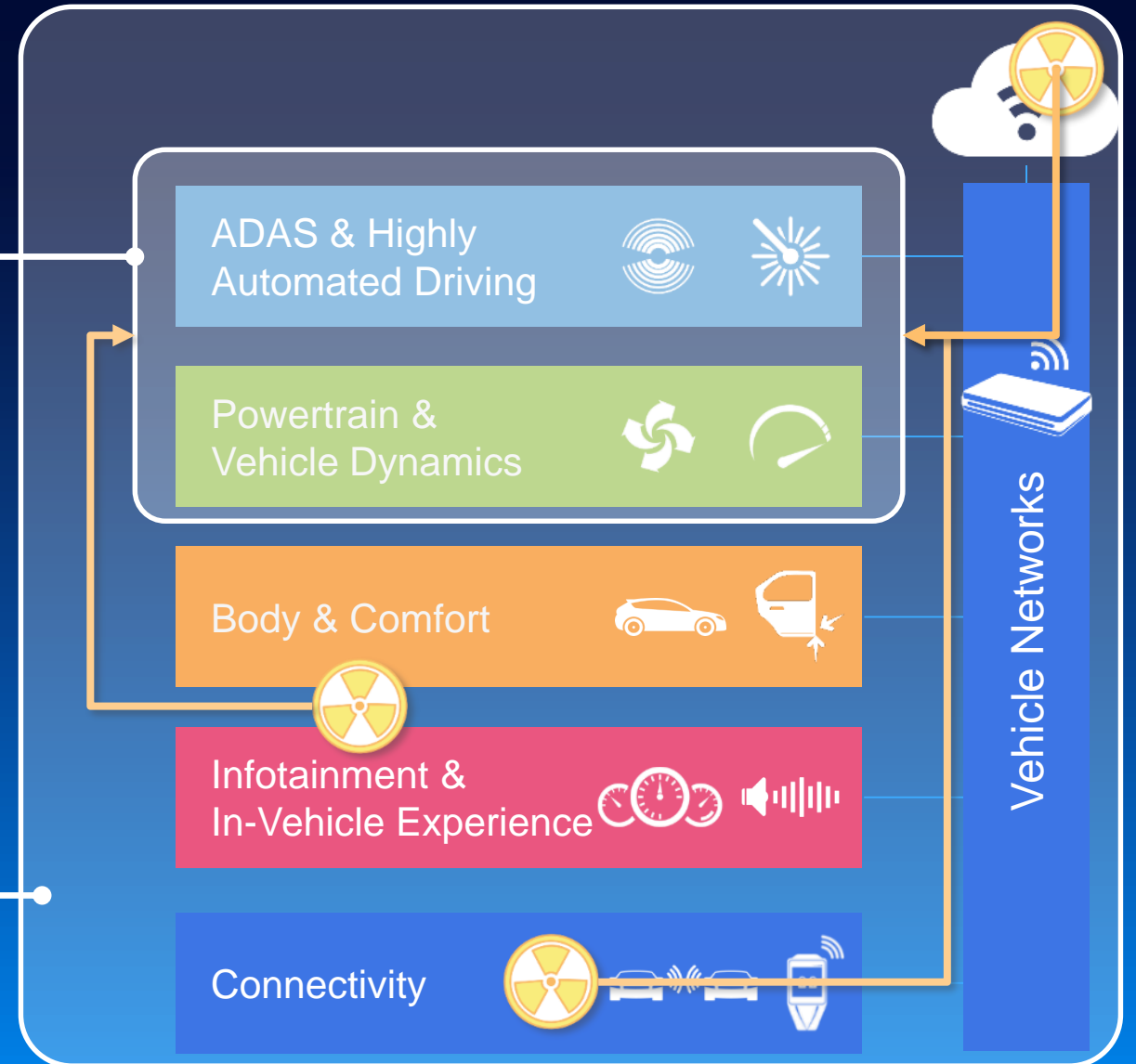
#1 Objective: no functional hazards
on mission-critical ECUs

Only possible, if:
System availability ensured
Information received / processed trustworthy

Cyber-security is a prerequisite for
availability and trust in the system

ADAS & Highly
Automated Driving

Powertrain &
Vehicle Dynamics

Body & Comfort

Infotainment &
In-Vehicle Experience

Connectivity

Vehicle Networks

Functional Safety & Security – System-Level Concerns

IC-LEVEL SAFETY & SECURITY SOLUTIONS + **SAFE & SECURE DOMAIN ARCHITECTURES** = **SAFE AND SECURE MOBILITY**

Connectivity	ADAS & Highly Automated Driving	Powertrain & Vehicle Dynamics	Body & Comfort	Infotainment & In-Vehicle Experience

Vehicle Networks
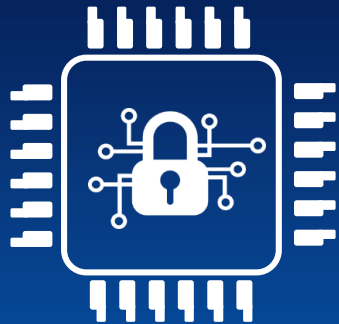
- Resource isolation
- On-die monitoring
- Integrity & authenticity checks

- Domain isolation
- Firewalls
- Network intrusion detection

- Fail operational
- Resilient against cyber attacks

ISO 26262 : 2018 Part 11 – What's New and Already Applicable

ISO 26262 Deliverables

		2018 Edition 2		Applicability
Impact Analysis		Reinforced	Applicable	
IP Management		New	Applicable	
Safety Analysis- FTA		Reinforced	Applicable	
Safety Analysis- DFA		Improved	Applicable	
Safety Anlysis- FMEDA		Improved	Applicable	
Fault Injection		Reinforced	Applicable (or not)	
Confirmation Measures		Improved	Yes and No	

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ASIL Level Examples For Different Solutions

Domain	Application	Hazardous Event (example)	ASIL
Active safety	Central Fusion	Inadvertent hard braking during driving	D
Passive Safety	AIRBAG	Inadvertent deployment during driving	D
Chassis	EPS	Self steer during driving	D
	Stability control	One wheel lock during driving	D
	ABS	One wheel lock during hard braking	C
HEV/EV	Motor control	Sudden Torque Up/Down	C
Power Train	Transmission	Speed down on express way	C
	Engine control	Decreasing of engine torque	B
Body	Brake Lamp	No brake lighting during braking	B

VERIFIED SafeAssure

D ADAS/ RADAR: SAFE CENTRAL COMPUTE

B SECURE CAR ACCESS

B INFOTAINMENT

D POWERTRAIN ELECTRIFICATION

D SAFETY

B VEHICLE NETWORKING

B BODY

D CHASSIS

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Examples Of a System Dreaded Event and ASIL Levels

ADAS Sensor	Battery Management	Power Steering
Phantom detection	Fire	Auto steering, lock, loss
ASIL B	ASIL C	ASIL D

NXP's Safe Assure Program

Simplify Customer Experience
ISO26262 system compliance process

Optimize Customer R&D Efficiency
Reduces time and complexity required to develop
ISO26262 safety systems

**Reduce Risk of Harm**
Supports the most stringent Automotive Safety
Integrity Levels (ASILs)

Safety Starts with Quality
Zero defect methodology from design to manufacturing to
help ensure our products meet the stringent demands of
safety applications

Functional Safety Standards

Automotive
ISO 26262

Industrial
IEC 61508

Safety **Support**

Safety **Hardware**

Safety **Software**

Safety **Process**
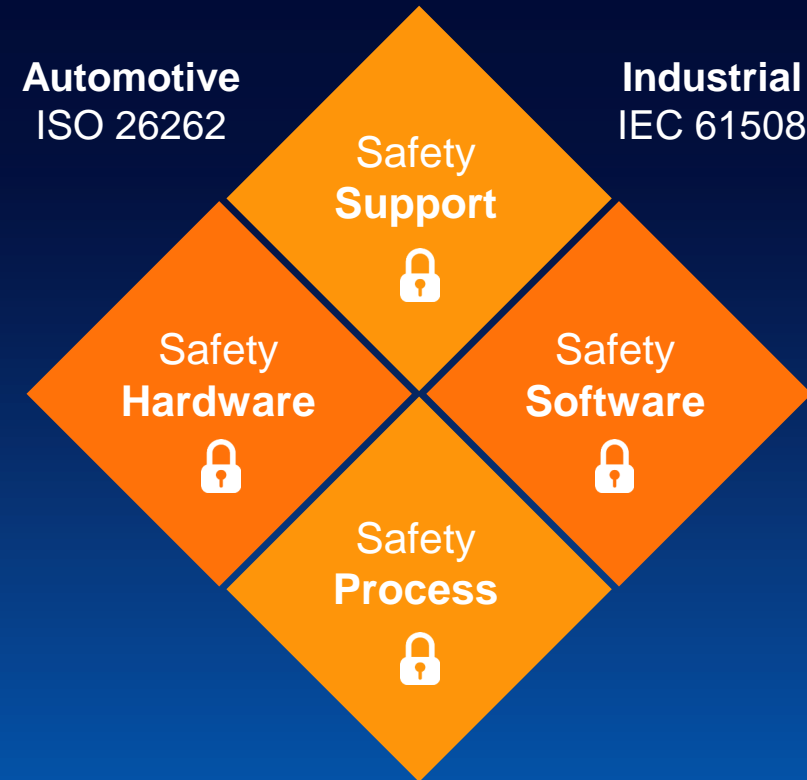
NXP Quality Foundation

SAFE ASSURE
by NXP

Proven History in Driving Security

Mid 1990s
- Censorship
- Immobilizers

Early 2000s
- Enhanced Censorship
- Remote Keyless Entry

Mid 2000s
- High Assurance Boot & Fault Detection Sensors
- Passive Keyless Entry

Late 2000s
- Crypto Services Engine (SHE), Active Shields
- Keyless Entry RF Transceivers

2010s +
- Hardware Security Module (HSM)
- Secure Elements (SE)
- Gateway, CAN security
- NFC-based Smart Access

#1 eGovernment

#1 Bank Cards

#1 Smart Mobility (MIFARE) Cards
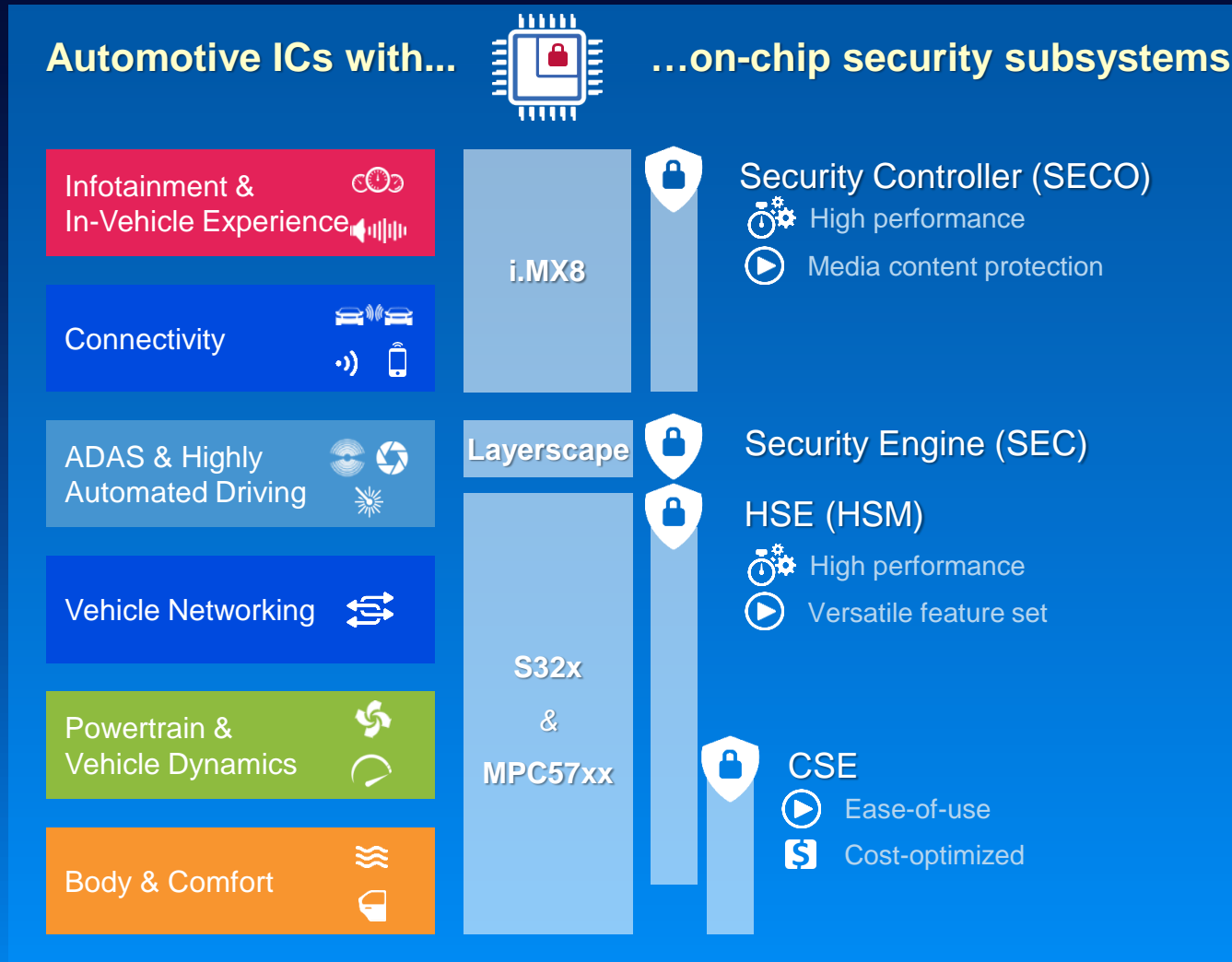
#1 Tags & Authentication

#1 Readers

#1 Mobile

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What is at Risk and who is Affected?

STAKEHOLDERS

IMPACT	Car Users	Car Owners	Insurers	OEM & Suppliers	Service Providers
Safety	Injuries	Damage	→	Claims, brand damage	
Financial		Vehicle theft →	Insurance claims	IP theft	Loss of income (fraud, DoS, …)
Privacy	Loss of personal data (PII) →			Claims, brand damage	Claims, brand damage

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NXP's Automotive Security Solutions

Automotive ICs with... ...on-chip security subsystems

Infotainment & In-Vehicle Experience

Connectivity

ADAS & Highly Automated Driving

Vehicle Networking

Powertrain & Vehicle Dynamics

Body & Comfort

i.MX8

Layerscape

S32x & MPC57xx

Security Controller (SECO)
- High performance
- Media content protection

Security Engine (SEC)

HSE (HSM)
- High performance
- Versatile feature set
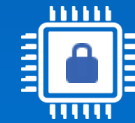
CSE
- Ease-of-use
- Cost-optimized

Security companions

Secure Element (SE)
Tamper-resistant secure system ideal for M2M authentication (e.g. V2X)

Function-specific secure ICs

Secure CAN Transceiver (TJA115x)
For enhanced IDS & IPS

Secure Ethernet Switch (SJA1110)
Network frame analysis (L2/L3/L4)

Secure Car Access ICs
For advanced RKE / PKE solutions

V2X DSRC Baseband (SAF5x00)
Ultra-fast ECDSA verifications

References

- http://www.nxp.com/automotive

- http://www.arteris.com/flexnoc-resilience-package-functional-safety

- Car Hackers Handbook, Craig Smith, No Starch Press, 2016

- Cybersecurity for Dummies, Lawrence C. Miller, 2016

- Car Hacks & Mods for Dummies, David Vespremi, 2004