SHIFT LEFT: ELECTRONICS ARCHITECTURES FOR THE NEW SOFTWARE-DEFINED VEHICLE AND S32K MICROCONTROLLERS

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OVERVIEW

• Software-Defined Vehicle
• Electrical and Electronic Architecture
• Re-Architect Software
• Embrace Virtualization
• Software and Partner
• S32K Microcontrollers
• Q & A
Software-Defined Vehicle
SECURE CONNECTIONS FOR A SMARTER WORLD

OUR DIGITALLY ENHANCED WORLD IS EVOLVING TO ANTICIPATE AND AUTOMATE

NXP Semiconductors N.V. (NASDAQ: NXPI) enables a smarter, safer and more sustainable world through innovation. As the world leader in secure connectivity solutions for embedded applications, NXP is pushing boundaries in the automotive, industrial & IoT, mobile, and communication infrastructure markets.
THREE FUTURE CAR MISSIONS → ONE CLEAR PATH TOWARDS SOFTWARE-DEFINED VEHICLE

Autonomous
New sensing, thinking

Connected & Service Oriented
New E/E architecture

Electric
New energy management
WHAT IS A SOFTWARE-DEFINED VEHICLE?

**Software** …
defines the customer experience
becomes the differentiator
is the focus point for innovation
brings OEMs new revenue streams

**Hardware** …
is a stable, scalable future-proof platform

**New features include** …
car & cloud integration
over-the-air updates
flexibility to continuously evolve
service-oriented architectures
virtualization and containerization

**New processes are** …
DevOps: continuously integrate, test
and deployment of software
Agile and lean methods
digital twin virtual modelling
WHAT DOES A SOFTWARE-DEFINED VEHICLE OFFER?

**LEGACY**
SINGLE HARDWARE AND SOFTWARE DEVELOPMENT

- FUNCTION DEVELOPMENT
- HARDWARE DEVELOPMENT
- HARDWARE PRODUCTION
- VEHICLE PRODUCTION

Limits frequency of updates

**NEW DECOUPLED HARDWARE AND SOFTWARE DEVELOPMENT**

- FUNCTIONS AS A SERVICE
- SOFTWARE PLATFORM
- HARDWARE DEVELOPMENT
- FUTURE-PROOF HARDWARE CAPABILITIES
- HW REVISION
- VEHICLE PRODUCTION
- NEXT GEN VEHICLE PRODUCTION

Allows for multiple software updates and code re-use across hardware
Electrical and Electronic Architecture
E/E ARCHITECTURE EVOLUTION

LEGACY ARCHITECTURE ORGANICALLY GROWN
SCALABLE AND CENTRALIZED SOFTWARE DEVELOPMENT
DOMAIN SW BENEFIT + SIMPLIFIED WIRING AND VEHICLE NETWORK
LOWER HW COST VS MORE COMPLEX SW
SIGNIFICANTLY REDUCES SW DEVELOPMENT COST, VS HIGHER HW COST FOR FUTURE-PROOFING

I/O ZONES
I/O ZONES
I/O ZONES
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LOGICAL AND PHYSICAL TRANSITIONS

TWO PARALLEL ARCHITECTURAL CHANGES

1. CENTRAL DOMAIN FOCUS: SCALABLE AND CENTRALIZED SOFTWARE DEVELOPMENT
   1. Flexible & scalable software environment
   2. Efficiently supports the user defined vehicle
   3. Centralized OTA, easily upgradable Software

2. ZONAL FOCUS: SIMPLIFIED WIRING AND CONNECTIVITY
   1. Dramatically reduced wire routing and cable costs
   2. Flexible data monetization
   3. Easily upgradable Hardware
IMPLICATIONS OF E/E ARCHITECTURE CHANGES

- Communications – transition to high bandwidth Ethernet
- Function distribution – dedicated controller at the edge, to hierarchical setup
- ECU consolidation – one vehicle function = one ECU is history
**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
NXP VEA SOLUTIONS LANDSCAPE

**Body Zonal**
- Three-chip solution (plus PHYs)
- High port and I/O processing scalability
- Smart power distribution, fast wake up
- Strong safety + security

**Cross-Domain Zonal**
- Three-chip solution (plus PHYs)
- Strong on-chip isolation & recovery
- High port and CAN scalability
- Powerful network, smart power distribution
- Strong safety + security

**Consolidated Compute**
- Multi-chip full-function HPC solution
- Can be built as single box (connected by PCIe and/or Ethernet) or multiple boxes
- Strong safety + security

**COMMON CONFIGURATION & SOFTWARE**
Re-Architect Software
RE-ARCHITECTING SOFTWARE

RT COMPUTE
Function

First Step:
Identify how to split existing application software into RT compute vs I/O control

I/O CONTROL
Function

GOAL
Not bound by strict functional or geographical constraints
Maximum flexibility to co-locate these functions, less HW dependent, quicker to update & deploy

GOAL
I/O interface is application agnostic
Multi-consumers of sensors via an API call or service subscription (e.g. Video stream, temp sensor, …)

I/O Interfaces
Networked (CAN, Eth)
Loosely Coupled

Control Loops
Network
Higher

Direct
Lower

Raw I/O (ADC, Timer, Pixel)
Tightly Coupled

Networked
Loosely Coupled

First Step:
Identify how to split existing application software into RT compute vs I/O control
SW PARTITIONING – ARCHITECTURAL CHOICES

Architectures focused on vehicle infrastructure – exclude ADAS and Infotainment

- **Legacy ECUs**
  - Features enabled with new hardware

- **Body Zonal**
  - **Body Zonalization**
    - Wiring harness reduction, modularity introduced
    - Primary / secondary body controllers

- **Domain + Body Zonal**
  - **Domain Controller / Vehicle Computer**
    - Higher level of control
    - New features in software
  - **Body Zonalization**
    - Wiring harness reduction, modularity introduced
    - Primary / secondary body controllers

- **Cross-Domain Zonal**
  - **Vehicle Computer**
    - Consolidation, ECU reduction
    - New features in software
  - **X-Domain Zonalization**
    - Multi-tenancy, more ECU consolidation
    - Compute local to zone
  - **Persistent ECUs**
    - Limited value to migrate (e.g. too complex, lifespan)

- **Consolidated Compute**
  - **Vehicle Computer**
    - Hosts “All decision making”
    - Fully flexible platform for SDV
  - **I/O Aggregators**
    - Generic sensor / actuator control
    - Available to multi-applications
Embrace Virtualization
New E/E architecture approaches aim to consolidate independent applications into a single SoC.

But software desires:
- Virtual ECU = Physical ECU
- Each SW environment believes it ‘owns’ the hardware

Ownership of existing software a critical topic for ECU consolidation

Evolving ecosystem between OEM, SW integrators and tier-one suppliers

Virtualization on a single SoC provides protected, dedicated sandboxes for each vendor to contribute software.
MIGRATION TO CONSOLIDATED ECU

Full Chip Hardware Virtualization with Safe/Secure Resource Domain Partitioning

**HW Access Control**
- System-level firewall for all authorized accesses
- vECU software ‘sees’ dedicated resource, HW manages virtualization

**HW Virtualized Peripherals**
- Ethernet Controller (NETC)
- Single MAC

**System Manager**
- Partitioning and management of vECUs

**HW Virtualized QoS**
- QoS mechanisms for shared resources

- Tier1 A (HW/SW) ECU0
- Tier1 B (HW/SW) ECU1
- Tier1 C (HW/SW) ECU2
- Tier1 D (HW/SW) ECU3

- vECU0
- vECU1
- vECU2
- vECU3

- Application 0
- Application 1
- Application 2
- Application 3

- ASAR BSW (ASIL-B)
- ASAR BSW (ASIL-B)
- ASAR BSW (ASIL-B)
- ASAR BSW (ASIL-B)

- CPU0
- CPU0
- CPU0
- CPU0

- HSE
- HSE
- HSE
- HSE

- MCU1
- MCU1
- MCU1
- MCU1

- Eth
- Eth
- Eth
- Eth

- CAN
- CAN
- CAN
- CAN

- OEM (SW)
- Tier1 C (SW) ECU2
- Tier1 D (SW) ECU3

- OEM (Integration & HW)

- OEM (SW)
- Tier1 C (SW) ECU2
- Tier1 D (SW) ECU3

- OEM (Integration & HW)
Software and Partner
NXP SOFTWARE OFFERING

**VISION:** Accelerate adoption of transformational automotive architectures using S32x SoCs by providing leading class software tools, integrated frameworks and broad ecosystem of solutions within a common software architecture platform

**ENABLING APPLICATIONS & ARCHITECTURES**
- Application and Reference Middleware
  - Integrated PMIC/analog drivers
  - Communications stacks: TCP/IP, AVB/TSN
- Reference SW for future vehicle architectures
  - Vehicle integration platform for cloud platforms
  - FOTA, data analytics
  - Domain and zonal middleware framework

**EASE OF USE**
- Complete & robust enablement speeds development
  - Real Time Drivers (RTD): AUTOSAR & non-AUTOSAR
  - Security firmware standard
  - Complex drivers for IP accelerators
  - Support for RTOS and application OS’s across Arm cores

**NXP Software Ecosystem**
- Services / Application Software
- Middleware
- OS / Drivers / Safety
- Hypervisor (if available)
- Arm® Cortex® Cores(S)
- Firmware / HW Accelerators

**ACCELERATING CUSTOMER TIME TO MARKET**
- Full suite of tools for project integration:
  - S32DS IDE & Config tool
  - Premium Safety Software Framework (SAF)
  - eIQ Auto AI/ML inference engine

**S32x Platform Compatibility**
- S32K
- S32Z
- S32G
- S32 Next
BROAD PARTNER NETWORK WITH STRONG AUTOMOTIVE EXPERTISE

The **Automotive Processing Partner Program** comprises a global network of independent companies that offer the vital tools, software, technology, engineering services and training to accelerate customer designs based on NXP components.

**Engineering ecosystem:**
software and hardware engineering services, consultancy and training on products, safety and security and more.

**Application ecosystem:**
application software and networking stacks.

**Enablement ecosystem:**
OS & hypervisors, development tools, virtualization and modelling tools.

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Logos shown in this page belong to companies that are members of the NXP Partner Program or are in process at the date of its publishing.

Rev. Sept 2023
NXP DELIVERS APPLICATION EXPERTISE IN E/E ARCHITECTURES THROUGH MULTIPLE DEVELOPMENT AND DEMONSTRATION PLATFORMS

<table>
<thead>
<tr>
<th>VIP reference designs</th>
<th>Zone POC platform</th>
<th>Ethernet TSN</th>
<th>Digital twin (BMS) demo</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Box reference design</td>
<td>Smart data access demo</td>
<td>Motor control over network</td>
<td>Virtual development</td>
</tr>
</tbody>
</table>
BUILDING AN SDV

1. Select optimal E/E architecture
2. Re-architect vehicle software
3. Determine scope of vehicle platform
4. Adopt new Ethernet TSN technology
5. Embrace virtualization
6. Build in future-proofing
7. Architect vehicle-to-cloud software
8. Use virtual modelling
9. Select the right ecosystem partner(s)
S32K Microcontrollers
S32K3 AUTOMOTIVE MCU

TACKLING SOFTWARE COST AND COMPLEXITY

• Security firmware and software streamlines development
• Safety hardware and software simplify ASIL certification
• Free AUTOSAR® drivers accelerate development and quality compliance
• Smart memory design enables fast and reliable over-the-air updates
• Breakthrough HDQFP package minimizes footprint
**NXP S32 AUTOMOTIVE PROCESSING PORTFOLIO**

**BODY & COMFORT**

Safety Everywhere
Increasing Security
#1 General Purpose 32-bit
#1 Integrated Solutions
Leader in MC, body, BMS

- S32K1, S32K3
- MagniV® → Next Gen.

**VEHICLE CONTROL**

xEV, ENERGY Management
Chassis & safety
Leader in xEV control
Highest performance real-time
Domain BMS, DPC, Inverters

- MPC57xxx
- S32E/Z, S32x

**VEHICLE NETWORKING**

Exponential Data Growth
Secure OTA UPDATES
#1 in Vehicle Network Processors
High-throughput networking, network security, service gateways, OTA updates

- S32G2, S32G3
- S32x

Scalable, Safe and Secure with Software, Tools and Compatible Analogue Products
FUNCTIONAL SAFETY, SECURITY AND LONGEVITY

**SAFETY**

- Compliance with ISO 26262 / IEC 61508
- Reduced development complexity
- Safety hardware, software & documentation
- SafeAssure on-line community & direct safety expert support

**SECURITY**

- Compliance with ISO 21434
- Hardware accelerators with free software driver and firmware
- Security documentation & support – see ‘Secure Files’ option in NXP.com account (DocStore replacement)

**LONGEVITY**

- Minimum 15 years supply for all Automotive processors
- Lifecycle starts from product launch
- Strong historical commitment with recent extensions for key legacy processors

- AUTOMOTIVE ISO 26262
- INDUSTRIAL IEC 61508

NXP QUALITY FOUNDATION

www.nxp.com/productlongevity
### GPIS: BROAD SCALABLE PORTFOLIO AND APPLICATION RANGE

<table>
<thead>
<tr>
<th>NVM</th>
<th>128KB</th>
<th>256KB</th>
<th>512KB</th>
<th>1MB</th>
<th>2MB</th>
<th>4MB</th>
<th>6MB</th>
<th>8MB</th>
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<tbody>
<tr>
<td><strong>K3E</strong></td>
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<td><strong>K3</strong></td>
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</tr>
<tr>
<td><strong>K1</strong></td>
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<table>
<thead>
<tr>
<th><strong>Typical Application</strong></th>
<th><strong>Arm CPU Core</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASIL D</strong></td>
<td><strong>4 x M7</strong> (2 x LS) 320MHz</td>
</tr>
<tr>
<td><strong>Powertrain, OBC, Inverter, BMS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K38</strong> (1LS*+3)</td>
<td><strong>5 x M7</strong> (2 x LS) 320MHz</td>
</tr>
<tr>
<td><strong>Zonal Aggregator</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K35</strong> (1LS+1)</td>
<td><strong>3 x M7</strong> (1 x LS) 240MHz</td>
</tr>
<tr>
<td><strong>BMS, Electrification</strong></td>
<td></td>
</tr>
<tr>
<td><em><em>K34 (LS</em> core)</em>*</td>
<td><strong>2 x M7</strong> (1 x LS) 160MHz</td>
</tr>
<tr>
<td><strong>Body, Electrification</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K32 (Dual-core)</strong></td>
<td><strong>1 x M7</strong> 120MHz</td>
</tr>
<tr>
<td><strong>High perf body, Zone &amp; IO, Info/Audio</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K31 (Single-core)</strong></td>
<td><strong>1 x M4</strong> 112MHz</td>
</tr>
<tr>
<td><strong>“K1 extension”, Security 2022+, OTA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K14 (Single-core)</strong></td>
<td><strong>1 x M0+</strong> 48MHz</td>
</tr>
<tr>
<td><strong>CAN FD and Ethernet nodes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K11</strong></td>
<td></td>
</tr>
</tbody>
</table>

*S32K388 SPEC IS PRELIMINARY AND SUBJECT TO CHANGE, LS = lock step
## S32K1 VS. S32K3

<table>
<thead>
<tr>
<th>Feature</th>
<th>S32K1</th>
<th>S32K3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance</strong></td>
<td>M0+ @ 48MHz Or M4F @ 80-112MHz Single-core</td>
<td>1-5 M7 @ 120-320 MHz Single-core, Multi-core or Lockstep core</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>128KB-2MB P-Flash 17-256KB RAM</td>
<td>512KB-8MB P-Flash 128KB-1152KB RAM</td>
</tr>
<tr>
<td><strong>Security &amp; OTA</strong></td>
<td>CSEc Sym Cipher Up to 20 keys OTA Support (RWW)</td>
<td>HSE B Sym &amp; Asym Ciphers; 100+ Keys, Side channel protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seamless OTA (RWW, Memory remapping for A/B Swap, FW rollback option)</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>ASIL B</td>
<td>ASIL B / D</td>
</tr>
<tr>
<td></td>
<td>100MbEthernet (AVB), up to 3 CAN FD Flextimer,TRGMUX,PDB for Motor control. FlexIO</td>
<td>Up to 1Gbps Ethernet (TSN, AVB), up to 8 CAN FD eMIOS, BCTU, LCU for Motor control Advanced peripherals I3C, Enhanced FlexIO</td>
</tr>
<tr>
<td><strong>Key Peripherals</strong></td>
<td>BGA LQFP QFN</td>
<td>BGA HD QFP LQFP</td>
</tr>
<tr>
<td><strong>Packaging</strong></td>
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</tbody>
</table>
**S32K3 PLATFORM – UNMATCHED SCALABILITY**

- Core and platform: same Arm® Cortex®-M7 core across S32K3 family for SW reuse
- Security: HSE B across S32K3 family
- Safety: ASIL D and ASIL B fully compatible in S32K3 family
- Memory: 512K-8MB in S32K3, scalable down to 128KB in S32K1
- Package: BGA / HDQFP pin compatible in S32K3 family

### K3 Package

<table>
<thead>
<tr>
<th>K3 Flash</th>
<th>48 LQFP</th>
<th>100 HDQFP</th>
<th>172 HDQFP</th>
<th>257 BGA</th>
<th>289 BGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 x 7 mm</td>
<td>10 x 10 mm</td>
<td>16 x 16 mm</td>
<td>14 x 14 mm</td>
<td>14 x 14 mm</td>
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</tr>
<tr>
<td>8M</td>
<td>K358/48/38/28 &amp; Exposed Pad</td>
<td>K388/48/38/28**</td>
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<tr>
<td>6M</td>
<td>K376/K396**</td>
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</tr>
<tr>
<td>4M</td>
<td>K344/24/14</td>
<td>K344/24/14</td>
<td>K374/K394**</td>
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</tr>
<tr>
<td>2M</td>
<td>K342/22/12</td>
<td>K342/22/12</td>
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</tr>
<tr>
<td>1M</td>
<td>K311</td>
<td>K311</td>
<td>K341</td>
<td></td>
<td></td>
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<tr>
<td>512K</td>
<td>K310</td>
<td>K310</td>
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</tr>
</tbody>
</table>

* Room temperature CES only, not for production
** BGA257 is subset of BGA289

[Diagram of package offering simplification]

100 HDQFP 10x10
172 HDQFP 16x16

[Diagram of package offering simplification]

80 LQFP 12x12
64 LQFP 10x10
144 LQFP 20x20
176 LQFP 24x24
S32K3 SECURITY SOLUTION OVERVIEW

Description & Features:
- Firmware for dedicated on chip Hardware Security Engine (HSE) subsystem
- Provides extensive security services to host by offloading application processing
- Fully compatible with RTD crypto driver

Benefits:
- One stop shop solution: HSE + HSE FW + Crypto driver
- No license fees for standard HSE FW
- Covers all OEM security requirements
- Comprehensive services:
  - FAE support
  - PSIRT
  - FQE analysis

How to get it?
- Available on NXP website
- Refer business model & support section for more details
REAL-TIME DRIVERS

Description and features:
• Drivers for S32 MCU peripherals
• Two sets of APIs:
  - High Level Interface: based on MCAL. For AUTOSAR and Non-AUTOSAR Implementation
  - Low Level Interface: low level drivers. Contains IP-specific APIs. For Non-AUTOSAR implementation
• Supports AUTOSAR 4.4 and R21-11

Benefits:
• Production grade software
  - Production grade software with ASPICE and ISO-26262 compliance (up to ASIL D)
• Reduced development efforts
  - Single product covering AUTOSAR and Non-AUTOSAR environment
  - Scalable SW across S32 platform
  - Compatible with drivers of additional NXP ICs like PMIC, transceivers, etc.
• No additional charge
  - Supports multiple compilers: GCC, GHS, IAR, DIAB

How to get it?
• Available on NXP website. www.nxp.com/rtd
• Refer business model and support section for more details
## S32K3 Solution – Make Development and Production Easier

### Hardware Platform
- EVB enables access to MCU full feature, basic debug with on board OpenSDA (no extra HW debugger needed)
- System reference design board (LED, Telematics)
- MCU + SBC solution level HW design guideline

### Runtime Software
- Real-time driver (no extra cost)
- Security & OTA SW
- Safety framework + SCST SW
- Multi-core management SW
- Driver for SBC, BMS IC etc

### Software Dev Tools
- S32DS IDE and config tool
- FreeMASTER, Model-based design
- Broad 3rd party support: IAR, GHS, Lauterbach, Isystem etc
- Power consumption management tool

### Application Specific SW
- BMS
- Motor control
- Touch sensing
- LED lighting

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**Training and Support**
TECHNOLOGY SHOWROOM

JOURNEYS BY DESIRED ENGAGEMENT
Self-guided tour
Live-streaming at set times
Guided tours

JOURNEYS BY DESIRED FOCUS
Edge & AI/ML
Safety & Security
Connectivity

60+ VIRTUAL DEMOS
Focus on system solutions
Set up along NXP verticals

SHOWROOM.NXP.COM