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SBD's Car IT Team comprehensively profile the modern infotainment ecosystems from the ground up: system on chip (SoC) & silicon vendors, automotive tier 1s, operating systems, and the various ecosystems surrounding infotainment supporting digitally-oriented consumer experiences.

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The Intelligent Cockpits report assesses the key attributes of intelligent, continuously interactive vehicle cockpits to create a picture of how technologies, with a broad range of primary uses, can be joined to enable these new vehicle-focused user experiences.

CAR IT

Car IT

#636

The Software-Defined Vehicle

Enabling the Updatable Car

Business, technology, and supply chain

As OEMs integrate more software-defined solutions into their vehicles, there is the potential for future vehicle architecture to be defined by the software it uses, and the platforms adopted from its ecosystem. The end goal is a **Software-Defined Vehicle** - a car that leverages software to reduce the cost of development, boost performance, and enhance the in-vehicle user experience.

SBD Automotive's Car IT Team has created **The Software-Defined Vehicle** report to support OEMs and suppliers. It identifies the Software-Defined Vehicle and outlines how OEMs can utilize platforms and services to build cars that can be continually updated, and progressively maintained, by cross-platform software.

COVERAGE	FREQUENCY	PUBLICATION FORMAT	PAGES
GLOBAL, NA, CHINA, EUROPE	ANNUALLY, QUARTERLY, ONE-OFF	PDF, POWERPOINT, EXCEL, ONLINE	170+

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Key features & benefits

- **Defines the SDV:** Understand the Software-Defined Vehicle, the KPIs, high-level architecture and patterns, and the key technology domains.
- **Core technologies:** Go in-depth on the hardware and software powering the Software-Defined Vehicle.
- **Global OEM activities & impacts:** How Software-Defined Vehicles are changing OEM businesses, as well as their partnerships, investments, platforms and organizations.
- **Supply chain activities and impacts:** How tier 1s, tier 2s and service providers support the Software-Defined Vehicle.

This research supports

- PRODUCT PLANNERS
- C-SUITE
- MARKETING
- ENGINEERS

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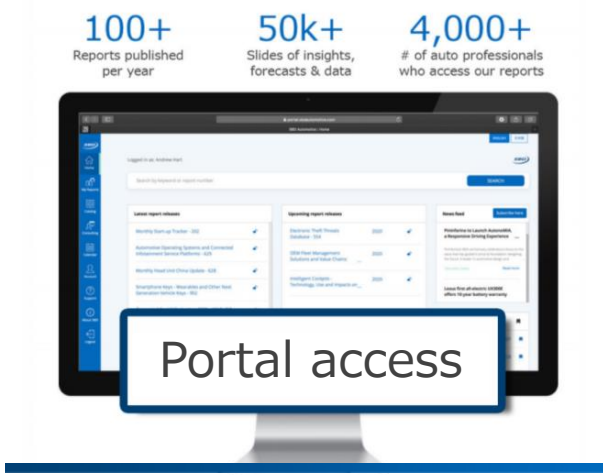

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The Software-Defined Vehicle

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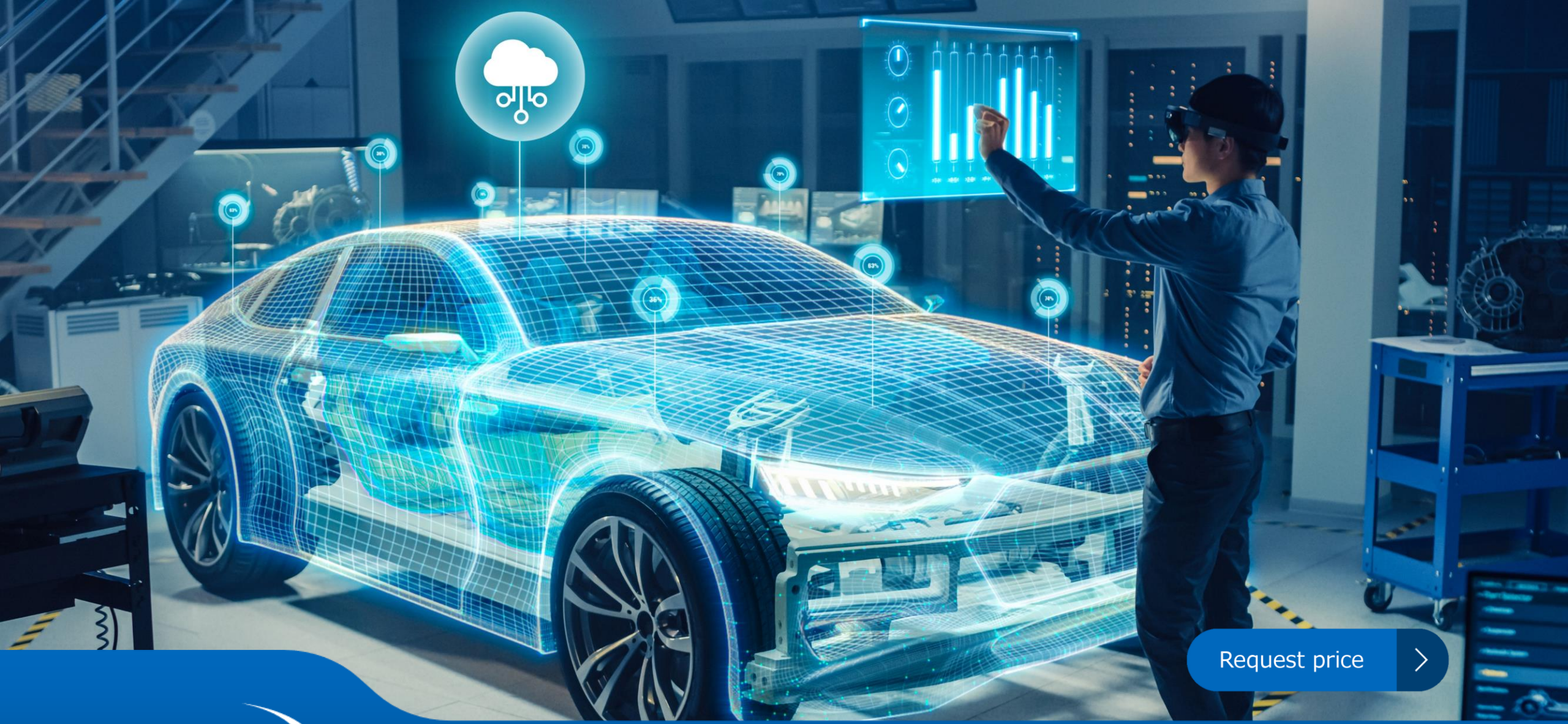

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July 2021

CON636-21

THE SOFTWARE-DEFINED VEHICLE

Enabling the updatable Car - Business, technology, & supply chain

Contents Page

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Introduction

SDV Levels to Principles

	E/E Patterns	User Experience	Updatability	Connectivity	S/W Architecture
Vehicle 1.0 Functional	Zonal Functional Domains Functional Bandwidth Multi-CAN	Personalized Connected IVI Smartphone Integration Static IVI	Vehicle Software Updates Firmware Updates Phone App Updates No Updates	5G with Edge Multi-Channel 4G None or eCall Only	Edge Container Runtime Service-Oriented Architecture Cockpit S/W Apps Tightly Coupled
Vehicle 2.0 Digital	Zonal Functional Domains Functional Bandwidth Multi-CAN	Personalized Connected IVI Smartphone Integration Static IVI	Vehicle Software Updates Firmware Updates Phone App Updates No Updates	5G with Edge Multi-Channel 4G None or eCall Only	Edge Container Runtime Service-Oriented Architecture Cockpit S/W Apps Tightly Coupled
Vehicle 3.0 Updateable	Zonal Functional Domains Functional Bandwidth Multi-CAN	Personalized Connected IVI Smartphone Projection Static IVI	Vehicle Software Updates Firmware Updates Phone App Updates No Updates	5G with Edge Multi-Channel 4G None or eCall Only	Edge Container Runtime Service-Oriented Architecture Cockpit S/W Apps Tightly Coupled
Vehicle 4.0 Software-Defined	Zonal Functional Domains Functional Bandwidth Multi-CAN	Personalized Connected IVI Smartphone Projection Static IVI	Vehicle Software Updates Firmware Updates Phone App Updates No Updates	5G with Edge Multi-Channel 4G None or eCall Only	Edge Container Runtime Service-Oriented Architecture Cockpit S/W Apps Tightly Coupled

Example slides from the report

Please note: *These slides are taken from the pre-release report and may be updated before the final release*

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The Software-Defined Vehicle abstracts hardware from software

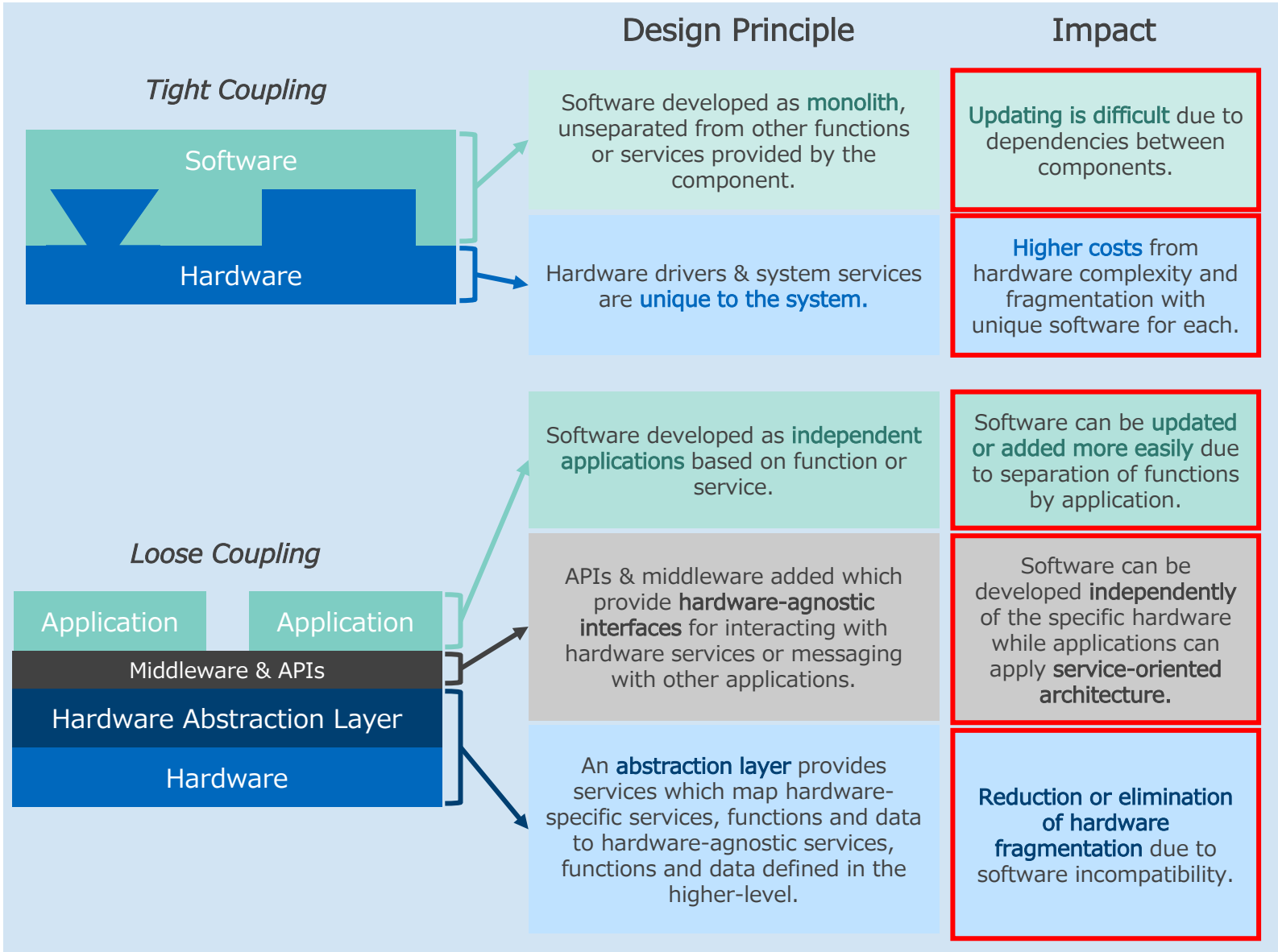
Automakers do not manufacture their own silicon. For any given computing module in a vehicle, a hardware platform is sourced from a vendor that specializes in system-on-chip components.

Many system-on-chip components have system services, platforms, or APIs which are unique to that component or manufacturer. When software is written on these services, that software becomes **"tightly coupled"** with the hardware – that is, the software will only run on that specific hardware platform.

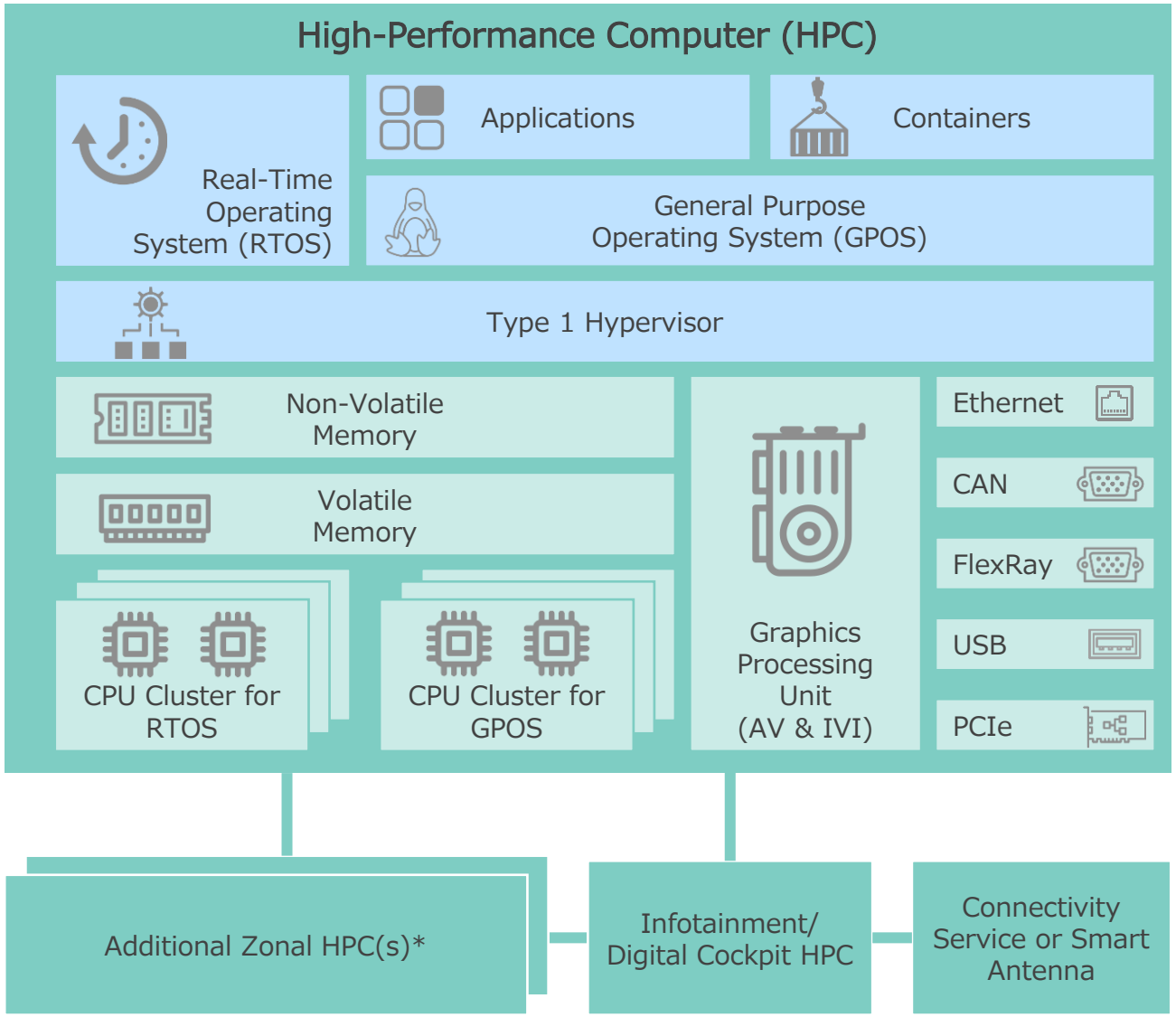
As automotive computing platforms become more capable, the introduction of **hardware abstraction layers** provides, on one side, support for hardware-specific system services, while on the other side, these services are exposed as homogenous interfaces.

Software developers can then **"loosely couple"** their software as applications, leveraging the abstraction layer and other services to isolate functionality as services while being portable to any hardware which supports the same abstraction layer.

The transition from tight coupling to loose coupling is the ethos of the software-defined vehicle.



High-performance computers are the key to abstraction



* In zonally configured E/E architectures

- **Applications & containers leverage services on the GPOS** to run portable software integrated with the hardware abstraction services offered by the GPOS or other middleware.
- **Multiple CPU clusters alongside sizable memory availability allows for simultaneous execution of real-time and general purpose operating systems.** The RTOS provides deterministic computing for safety-critical functions, while the GPOS allows deployment of more general services, features, and data processing applications.
- **Type 1 hypervisor provides hardware-optimized virtualization services**, ensuring safe operation of the RTOS alongside GPOS guest OS(es).

- **HPCs provide a variety of physical interfaces** to integrate both with CAN, LIN, and FlexRay sub-networks whilst allowing for high-bandwidth communication with other components via Ethernet, USB, and PCIe.
- **GPUs power the processing of camera & radar data** for ADAS/AV applications as well as power **rendering for digital cockpit** interfaces.
- **CPU clusters ensure redundant processing** for both RTOS and GPOS applications with separate contexts for deterministic and non-deterministic operations.
- Multiple HPCs may be deployed to provide **high availability, optimized, redundant AV services** and/or specialized digital cockpit applications.

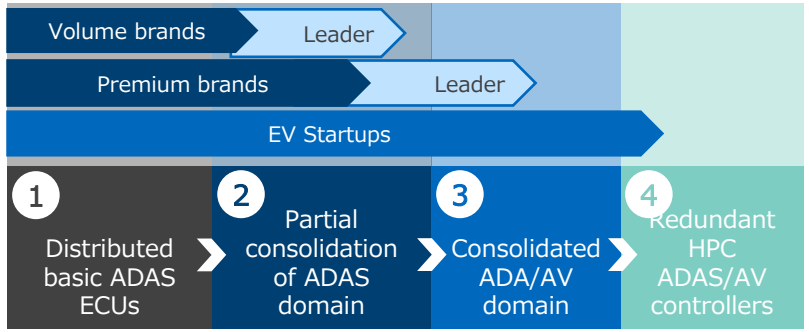
SDVs create long-term scalability for ADAS & AV functionality

- Higher levels of automation create significant new hardware and software requirements for vehicles, requiring cutting edge technologies to provide the relevant input, quickly and reliably process input data, and improve the performance of the system over time through integration with the cloud & other autonomous vehicles
- The operational requirements of higher levels of autonomy mandates the need to move from a strict fail-safe to a more fail-operational strategy: fault detection and reaction needs to be controlled by independent hardware, resulting in unique AV software architecture requirements
- The goal of the implemented redundancies is to allow the driver (for SAE L3) to take over the driving task when required but also be able to implement a minimum risk manoeuvre if absolutely necessary
- Dedicated high-performance computer systems are required to deliver real-time sensor data processing, sensor fusion and trajectory planning with the broader numbers & types of sensors in highly autonomous vehicles, and this software requires significant integration with the cloud to be able to improve & update over time

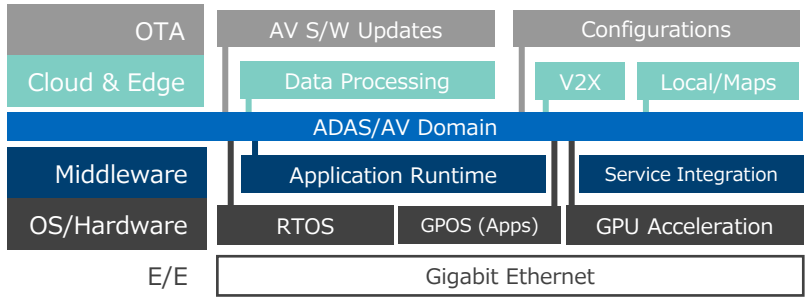
ADAS Domain Requirements for Software-Defined Vehicles

Requirement	Design Impact
AV/ADAS controllers must be able to support the highest levels of safety assurance at any level of autonomy	Hardware & software redundancy, e.g. multiple sensing modalities, independent power supplies, lockstep mechanisms, consensus-driven AI, etc.
AV/ADAS controllers must provide the highest levels of cybersecurity protection in the vehicle to prevent threats to driver/passenger safety	Both the hardware & software of the AV operational domain must be secured by design, leveraging best-in-class countermeasures to both defend and react to security and safety threats
AV/ADAS controllers must be able to support new and enhanced functionality over its lifetime through software & configuration updates	The vehicle should integrate reliable access to high-speed, low-latency, low-cost data networks for OTA, and the domain hardware should be considered with a multi-year lifespan (or mid-cycle upgrade) strategy
AV/ADAS controllers must be able to support dynamic, localized applications to support data processing & functional validation	ADAS/AV high-performance computers should allow for edge-oriented application runtimes which can be used to rapidly develop & deploy data cost-efficient functions
AV/ADAS controllers must be capable of ingesting & processing high-bandwidth camera inputs in real-time	High-performance computers used for AV/ADAS systems should be equipped with specialized graphics processing and artificial intelligence capabilities

Trend



Relationship with other layers



Hardware | E/E Architecture | Operating System | Middleware and Communications | **ADAS** | Connectivity & Infotainment | Cloud & Edge Computing | DevOps & OTA

Ford has jumped from laggard to near-leader in software in 5 years

Key Messages

- Ford has completely overhauled its infotainment and E/E platforms as it shifts its portfolio to include a high EV mix
- Ford is the first manufacturer to offer over-the-air software updates for almost all ECUs in its F-150 truck series
- Ford's cloud strategy, centered around Ford Smart Mobility, pairs with its new FNV E/E to create a strong volume OEM technology stack, which also includes co-investments with Volkswagen

SDV Maturity Index

1.0	2.0	3.0	4.0
Key Achievements:	➢ Most ECUs updateable ➢ In-house cloud s/w ➢ Google data partnership	Roadmap:	➢ Android Automotive ➢ Adaptive AUTOSAR ➢ Some level of ECU consolidation
Functional	Digital	Updateable	Software-Defined

Business Model/Supply Chain Insights

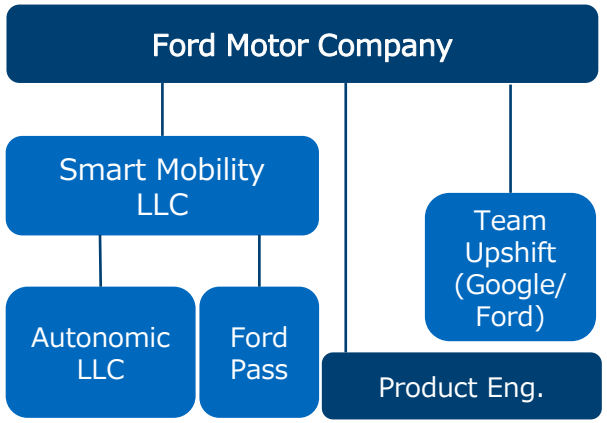
EV shift underpins tech strategy

As Ford targets 40% of its sales by 2030 to be EVs, it has rapidly evolved its technology development strategy to offer significant in-house capability.

Ford Smart Mobility manages cloud & MaaS development, while product engineering manages in-vehicle software development

Organization Insights

OEM | Subsidiary | Supplier



- ✓ Ford Smart Mobility acts as a subsidiary and manages its cloud portfolio
- ✓ Team Upshift is a co-staffed team from Ford & Google using Google's cloud platform for data analytics & services
- ✓ Ford's in-vehicle software engineering is primarily managed in-house via product engineering

Technology & Platform Insights

In Market | *Announced* | *R&D*

Connectivity	OTA Updates via Embedded 4G	"Power Up" OTA Software Updates for Full Vehicle
Infotainment	SYNC 4: OTA; Live Mapping; BlackBerry QNX	SYNC (2023): Google Services; Android Automotive OS
ADAS	Driver Assist: Mobileye; AUTOSAR Classic	DAT 2.X: Adaptive AUTOSAR*; ArgoAI
OS & Middleware	*No Middleware*: Classic AUTOSAR; BlackBerry QNX	Adaptive AUTOSAR (projected); Classic AUTOSAR; Android OS
E/E	Single Gateway: Multi-CAN, ADAS Flexray	Fully Networked Vehicle (FNV-2): TBD
Hardware	SYNC 4 IVI Controller (2x power of SYNC 3); Microcontroller ECUs	*No Data Available*

** Based on analysis of open job postings*

The biggest suppliers are adopting the Tier 0.5 model

While other, specialized companies have existed throughout the automotive hardware & software supply chain, Tier 1s have traditionally acted as the central hub for aggregating supplied products and technologies into a usable component. Some of the biggest Tier 1s are now evolving their business model to act more like a "partner" to OEMs – a Tier 0.5 – while other specialized suppliers and OEMs themselves replace or augment services traditionally provided by Tier 1s for highly differentiating components and associated software.

The Tier 1 Model

The traditional supplier model relies on Tier 1 suppliers to manage the entire lifecycle of the high tech component which it is manufacturing for the OEM.

Trend

The Tier 0.5 Model

When designing and building highly differentiating components, OEMs will source partners – Tier 0.5s – rather that just "suppliers" to facilitate co-creation.

The Tier 0.5 model also gives rise to specialists along the supply chain, provided either by the supplier or selected by the OEM to work in cooperation.

Specialized Suppliers	Description	Example
White-Label OEM	Complete vehicle design, development & manufacturing	MAGNA
Engineering Management Services	Custom design & manufacturing for specialized hardware	JABIL
Low-Cost Supplier	Commodity hardware manufacturing	DESAY 德赛
Vertically Integrated Supplier	Suppler builds both automotive components & underlying silicon/SoC	SAMSUNG, HARMAN
Software Engineering Services	Contract development & engineering resources	Luxoft A DXC Technology Company
Software Products & Platforms	Non-differentiating software that accelerates time to market	Elektrobit

Bosch is well-positioned as full-stack SDV technology supplier

Key Messages

BOSCH

Bosch is a titan in the race for the software-defined vehicle, offering both products and services in the vehicle and in the cloud to enable development & integration of new E/E and software

While Bosch offers a wide variety of automotive solutions, its strategic direction is clearly aligned to CASE and SDV, as evidenced by the consolidation of its 17,000 in-vehicle software and platform experts into its Cross-Domain Computing Solutions organization

News & Insights

Headline	Insight
Bosch/Microsoft SDV Platform	Bosch's integration of its OTA & in-vehicle software solutions with Microsoft's suite of Azure development, hosting, and deployment tools foreshadows the future of software deployment for SDVs
Bosch wins orders worth billions for vehicle computers	Bosch is establishing itself as a leader in software-defined vehicle computing technology through multiple orders for billions of euros worth of vehicle computers which underscores Bosch's vertically integrated SDV value proposition to OEMs

SDV Strengths & Weaknesses

Strengths

Consolidated Organization – Mirroring its customers, Bosch has consolidated its in-vehicle computing and software expertise into a single organization – Cross-Domain Computing Solutions – which gives Bosch a global, scalable organizational platform from which to build SDV-oriented products and services

Embedded Security – Bosch's key software subsidiaries (ETAS and Escrypt) offer an embedded development and cybersecurity pedigree that enhances the Bosch's credibility in providing "automotive-grade" SDV-oriented services

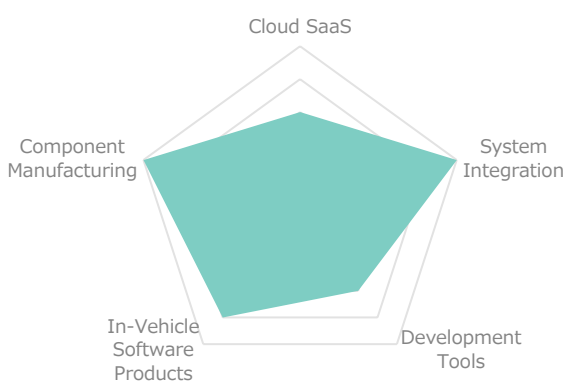
Weaknesses

Automotive Insider – Bosch is a stalwart of the automotive industry, but this can work against them in the SDV domain, where many OEMs are looking to the semiconductor and consumer electronics industries to help modernize and accelerate their processes and platforms

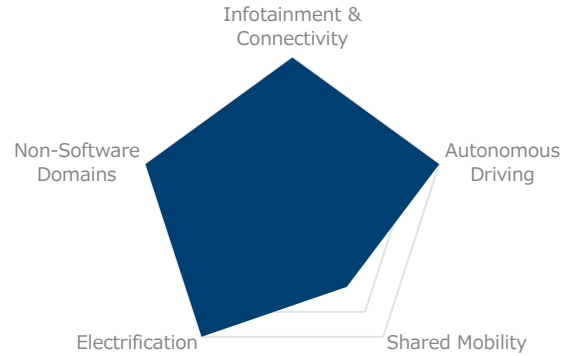
Too Big? – Bosch's significant engineering footprint and experience define its SDV value proposition, but this can also lead to a more expensive portfolio of products and services which may not be as competitive as modular, "slimmer" solutions from specialists

Strategic Direction

Products & Services



Technology Domains



Cloud SaaS	IoT Cloud offers cross-vertical device management services; plus partnership with Microsoft	Infotainment & Connectivity	Bosch offers full-stack infotainment & connectivity hardware & software solutions
System Integration	The foundation of Bosch's overall automotive footprint & offering	Autonomous Driving	Extensive components, platforms, and investments for AV/ADAS
Development Tools	ETAS, Escrypt, and Bosch all offer a fragmented portfolio of tools, but not specifically SDV-oriented	Shared Mobility	Bosch Connected Mobility offers some MaaS-centric solutions, but not core focus
In-Vehicle Software Products	Bosch's portfolio is less product-centric, but some AUTOSAR-related products	Electrification	Bosch provides solutions in all powertrain sectors, as well as BEV drive systems
Component Manufacturing	Offered for all major software-driven components, including digital cockpit, HPCs and E/E, zonal controllers, ADAS, etc.	Non-Software Domains	Bosch offers a wide variety of vehicle components throughout almost every domain in the vehicle

AUTOSAR Adaptive Platform early leader for SOA, ADAS software

Key Messages

- AUTOSAR is a long-standing industry alliance focused on the development of open standards for ECUs and in-vehicle software applications, from which suppliers can develop software which implements the standard, and OEMs (or suppliers) can develop application software which is guaranteed to run on AUTOSAR-compliant solutions
- AUTOSAR Classic is a full RTOS specification for microcontroller ECUs, while AUTOSAR's other main output – Adaptive Platform – is a novel application middleware standard intended for high-performance computers

News & Insights

Headline	Insight
AUTOSAR release R20-11 published	AUTOSAR continues to iterate on both Classic and Adaptive standards to ensure viability in modern vehicle software architectures. Adaptive is still relatively young but sufficiently mature for usage in production

Members/Contributors

Core Partners	BMW, Daimler, Bosch, Ford, Continental, PSA Groupe, Toyota, VW
Strategic Partners	DENSO
Premium Partners	60 companies, including Aptiv, BlackBerry, Baidu, Honda, Hyundai and others
Development Partners	59 companies, including TTTech, OpenSynergy, Excelfore, Airbiquity and others
Associate Partners	147 companies, including other OEMs, suppliers and service providers

Maturity

Exploratory | Incubation | First Output | Limited Adoption | **Widespread Adoption**

Organization Type

Alliance | Consortium | Foundation | Undefined

Output(s)

Name	Type	Description
Classic Platform	Standard	Standard for Classic, including basic software (BSW) and runtime environment (RTE)
Adaptive Platform	Standard	Standard for implementing the Adaptive Runtime for Applications (ARA), which contains a variety of components for managing embedded software applications
Foundation	Standard	Standard for shared components between Classic and Adaptive to ensure interoperability between the platforms
Acceptance Tests for Classic Platform	Specification	Specification of tests which verify compliance with AUTOSAR Classic standards
Application Interfaces	Specification	Specification of domain-specific interfaces i.e. powertrain, body and comfort, chassis, etc.

Strengths

- **Uniqueness:** Adaptive platform is not only first-to-market for a much-needed capability, it is also the most mature solution, enjoying implementation by many suppliers & OEMs
- **Heritage:** AUTOSAR Classic is nearly ubiquitous in traditional ECU development; this builds the support framework & credibility of Adaptive, with many of the OEMs who would need such a solution already supporting the Alliance

Weaknesses

- **Emerging Applications:** The industry is still working out the best way to implement hardware abstraction in HPCs, and Adaptive may not end up failing to meet many OEM requirements
- **Cloud Integration:** Adaptive platform supports connectivity, but there is no specific standard or platform for holistic management of software and configuration – a key area of R&D for cloud vendors, OTA solution providers, and OEMs

Request the price

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