As more new vehicles integrate a growing number of hardware and software technologies, E/E architectures are set to play an important role across the vehicle lifecycle. This role will be especially important as software-defined vehicles emerge and place new technologies at the core of this lifecycle—from development and throughout the user experience, to the SDV-specific features and services that help extend it.

The significance of E/E architectures in SDVs, as well as today’s vehicles, makes it crucial for OEMs to carefully plan and map out a holistic approach to them. Doing so will allow automakers to create cost-effective vehicles that are safer, more secure, and provide enhanced system usability.

This Guide includes everything automotive planners and engineers need to understand around the state of the art of E/E architectures, and the journey to enable a software defined vehicle. Here, it provides insight into the decisions that enable year-on-year delivery with optimal utility and costs while highlighting relevant trends and profiling key technologies. An accompanying Excel version offers the latest data to encourage strong decision-making, with thousands of data points presented with every release.
Key questions answered

> How are companies making architectural decisions that allow them to deliver year-on-year, without carrying inefficient utility and cost to every vehicle made?

> Which companies are implementing zonal architectures?

This research supports

- Product Planners
- C-Suite
- IT
- Engineering

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Software-Defined Vehicle: E/E Architecture Guide

Annual Report for 2023

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Introduction
Introduction

The automobiles have come all the way from Karl Benz’s first working prototype, “the Benz Patent Motor Car Model No.1” which had a few spark plugs and a battery to a modern electric vehicle that is literally a ‘smartphone on wheels’. The vehicles have evolved and now fit more in terms of comfort, safety, entertainment, security, automation, and more.

To service all these, modern cars require a high number of electrical and electronic components like ECUs, sensors, actuators, and communication buses connecting all of them – together forming the E/E architecture of the vehicle. As cars become even more feature-rich, the constantly evolving E/E architecture continues to get more and more sophisticated.

A holistic approach to E/E architectures will increase vehicle safety, security, and system usability, while also reducing costs to the manufacturer. Decisions made now will be a vital part of meeting the autonomous, connected, and mobility expectations of a consumer 5 years from now. There are solutions, such as hypervisors, Ethernet domain controllers, and service-orientated architecture, which are great options for flexibility, but only if they deliver your specific and unique customer requirements at the right price point.

The key questions from an OEM standpoint are:

**How do I make architectural decisions that allow me to deliver great experiences that can be added to year-on-year, without carrying inefficient utility and cost to every vehicle made?**

**How does my electrical architecture, with its multi-year development and life, keep up with consumer expectations set by the far shorter consumer electronics lifecycle?**

SBD Automotive’s SDV: E/E Architecture Guide highlights the state-of-the-art E/E designs and discusses where and how that puts them on the broader software-defined vehicle (SDV) roadmap.
This report is one of four 2023 reports that look at different layers and enablers of the Software Defined Vehicle. In September 2023, and again in December 2023, the report shall be updated on the SBD Automotive Portal with an additional ‘Bird Eye View’ chapter which pulls out the key points from across the layers of the Software Defined Vehicle.
Example slides from the report
The industry is promising big on SDVs, but no one’s just there yet

**Vehicle 4.0**

**The Software-Defined Vehicle**

*The functionalities are encapsulated as discreet "services" with defined interfaces APIs* and can be adapted with simple code changes (rather than being tied to monolithic hardware or drivers). Theoretically, any service can be added, standardized and reused independently of the ‘neighboring service’ increasing the overall resiliency and extensibility of the system.

**Vehicle 3.0**

**The Updateable Vehicle**

Master controllers are added for each domain or services are centralized. Each domain controller, often a High-Performance Computer, is connected on a high bandwidth backbone allowing a stronger inter-domain communication with minimal latency.

**Vehicle 2.0**

**The Connected Vehicle**

ECUs with high dependencies that are serving specific ‘domains’ like body control/ADAS/power train are grouped together. A gateway module then provides for the bridging of signal flows between these domains. Sometimes, high bandwidth technologies are added as ‘overlays’ to provide specific functions.

**Vehicle 1.0**

**The Digital Vehicle**

Each ECU is function centric and has a 1:1 relation with the specific function it is serving. These ECUs require communication, so they are connected by networks. The grouping of network is usually based upon a functional requirement e.g., the speed of the network.
Kia launches EV9 with on-demand features and expanded OTA software update capability

The EV9’s E/E architecture allows for OTA software updates, giving customers the added flexibility to select the features they want to upgrade.

Renault and Valeo to co-develop next generation E/E architecture

The partnership will help to reduce development times and costs for the E/E architecture while focusing on high performance, compatibility, and safety.

Hyundai Motor and Kia form Model-Based Development (MBD) consortium for SDVs

17 companies including Hyundai Motor Group affiliates and software development companies, to form the MBD consortium

Continental and Infineon develop new E/E architecture for SDVs

Continental will use Infineon’s Aurix TC4 microcontroller for its zonal consolidation platform and central high-performance computers (HPC)

MediaTek and NVIDIA to develop automotive SoC and HPCs for SDVs

MediaTek will develop automotive SoCs and integrate the NVIDIA GPU chiplet, featuring NVIDIA AI and graphics intellectual property, into the design architecture.

HL Klemove and Sonatus collaborate on E/E architecture for SDVs

A new Automotive Gateway Reference Design, aimed at accelerating the development and production of conventional gateways to zonal architectures.

Latest OEM announcements in the SDV space
Body and power control shifting zonally without Ethernet backbone

Centralized Architecture

- 8 separate CAN buses, with the three major ones being Vehicle, Powertrain and Chassis. The body electronics power architecture is separated between left, right and front to minimize harness and complexity.

- Ethernet is used to allow high bandwidth data transfer between Machine Control Unit (Gateway module) and Autopilot Control Unit. This is used for software updates. Virtualization of software from hardware means that sensors or actuators can be attached to a suitable network but used by other notes ‘as if directly connected’, therefore reducing wiring harness size and complexity.

Gateway Architype

Previous generation E/E architectures for Tesla models had separate CAN buses for different vehicle attributes, with a varying number of channels on each bus.

Autonomy (up to SAE 2 ADAS) is delivered with the interaction between the Autopilot Control Unit and various modules (including the gateway module).
BMW Group

Key Takeaways

- **BMW Group** has a clear theme within its model range; providing a Basic Ethernet architecture for their lower-priced models and an Ethernet bus architecture for their more expensive models. Functional domain controller architecture is the natural progression to reduce the complexity of the system.

- BMW iX and 8-Series get a similar E/E architecture design based on a high-bandwidth Ethernet bus connecting several ECUs and a dedicated FlexRay bus for ADAS.

- BMW iX scores the best in terms of capability ratings of all models included in the database (with Ethernet Bus architype).

Summary Table

<table>
<thead>
<tr>
<th>Architype</th>
<th>OEM Model</th>
<th>CAN Buses</th>
<th>MOST</th>
<th>FlexRay</th>
<th>Ethernet</th>
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<tr>
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</tbody>
</table>

![Diagram of 8-Series Architecture](image)
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Do you have any questions?

If you have any questions or feedback about this research report or SBD Automotive’s consulting services, you can email us at info@sbdautomotive.com or discuss with your local account manager below.

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