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Silicon to Software™

Evolution and Trends driving the Automotive Architecture and Ecosystems of the future

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Agenda

- Introduction
- Macro Trends in the Automotive Market and implications
- Zonal Architecture – a preview
- Next Gen SOC Architecture & Design paradigms
- Software Defined Vehicle
- Conclusion

5 Biggest Automotive Industry Challenges

Supply Chain Disruption

- Worldwide chip shortage compressing the supply chain
- OEMs, Tier 1s, New Entrants are changing SOC sourcing strategy

Overhaul of E/E Architectures

- Demand for new HAD/ADAS features, electrified powertrain, infotainment
- New zonal architectures

Complex Software Development & Deployment

- Platform as a Service Infrastructure
- Millions lines of code
- Software updates over the air

Increasing Security Challenges

- New vulnerabilities from OTA software updates, self-driving cars, 5G connectivity
- Additional focus on security + safety

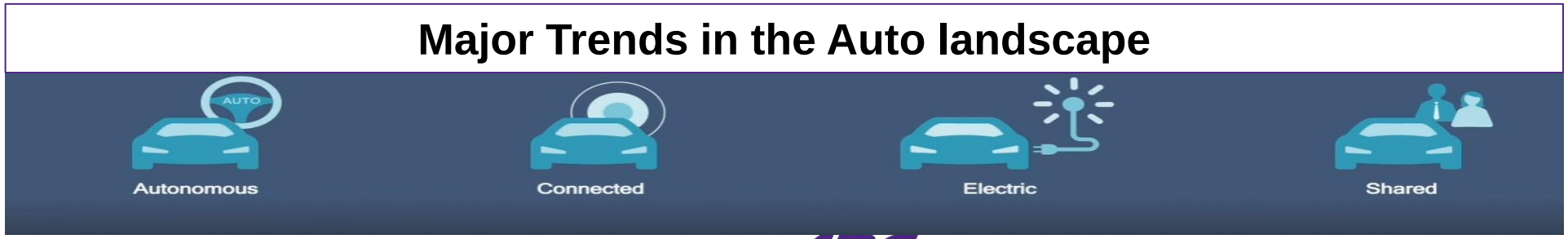
Accelerating Time-to-Market

- New automotive entrants challenging traditional processes

Macro Trends in the Car Landscape

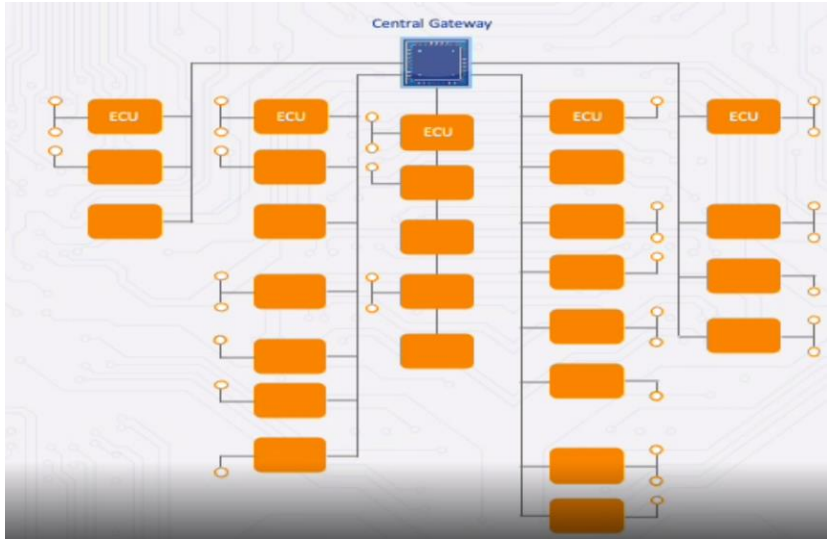
Major Macro trends changing the architectural landscape

- **Electrification**: EV architecture/chassis has changed Electrical and Mechanical architectures – Skateboard vs Mechanical Chassis
- **Autonomous Driving**: The road to full autonomy is underway – increasing compute and communication complexity
- **Maas & evolving business models**: OEMs pushing new biz models along with new players – Uber/Lyft etc.

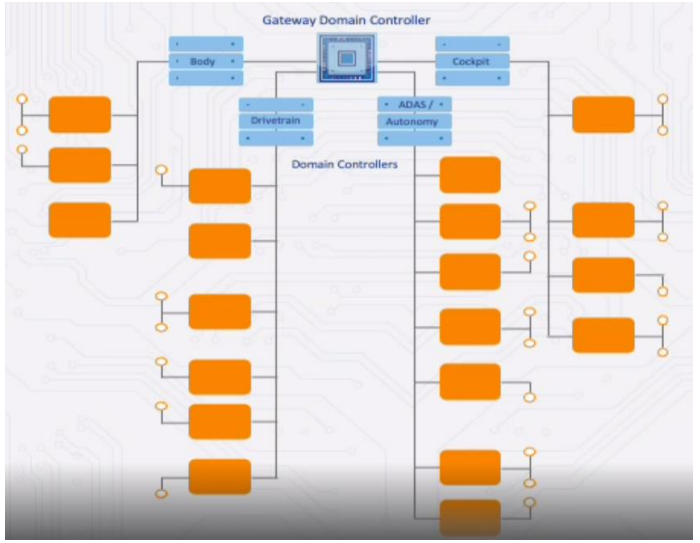


Architectural Evolution – A changing landscape

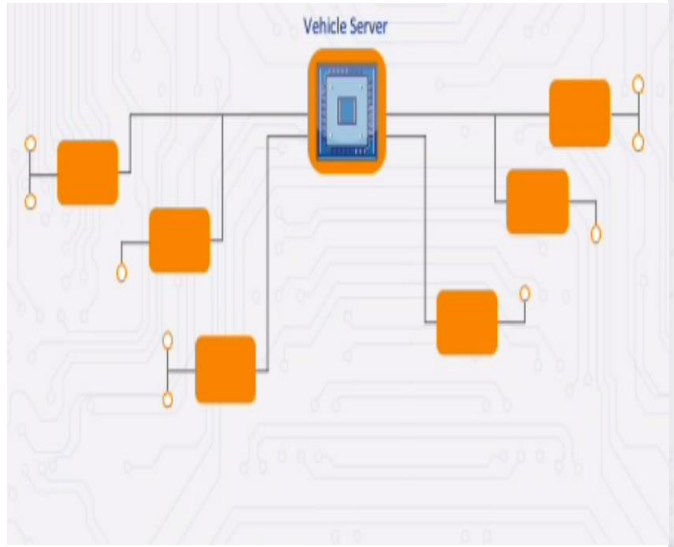
A walk along the path of ECU Evolution



In Production



2020+



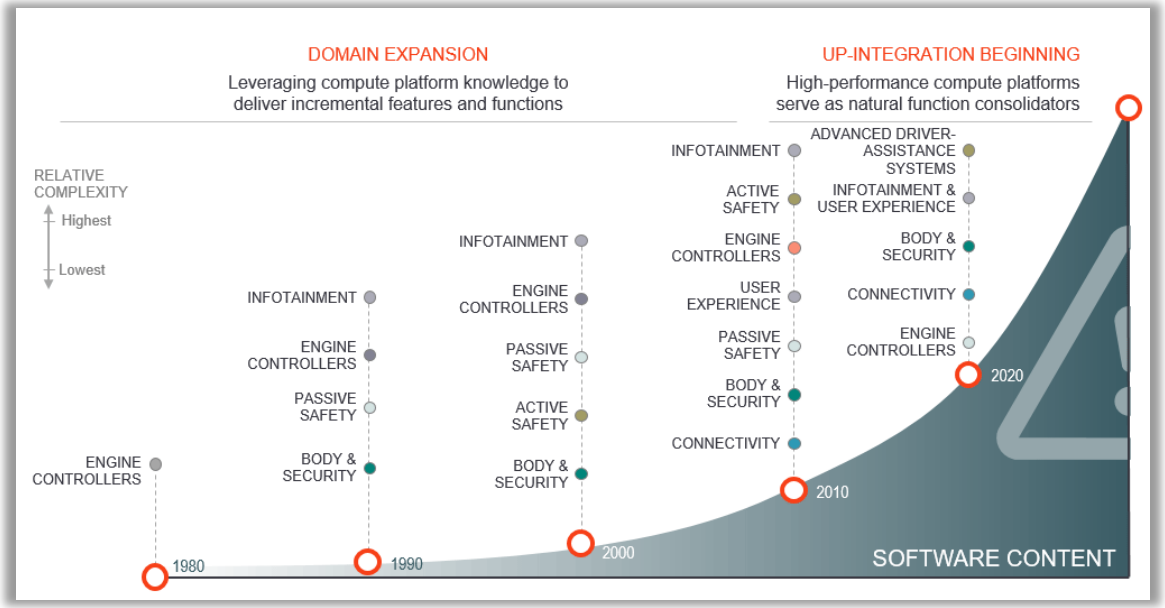
2025+

Evolving Computational needs driving the acceleration of a Zonal/Vehicle Server Architecture

Accelerating adoption of S/W First architectures

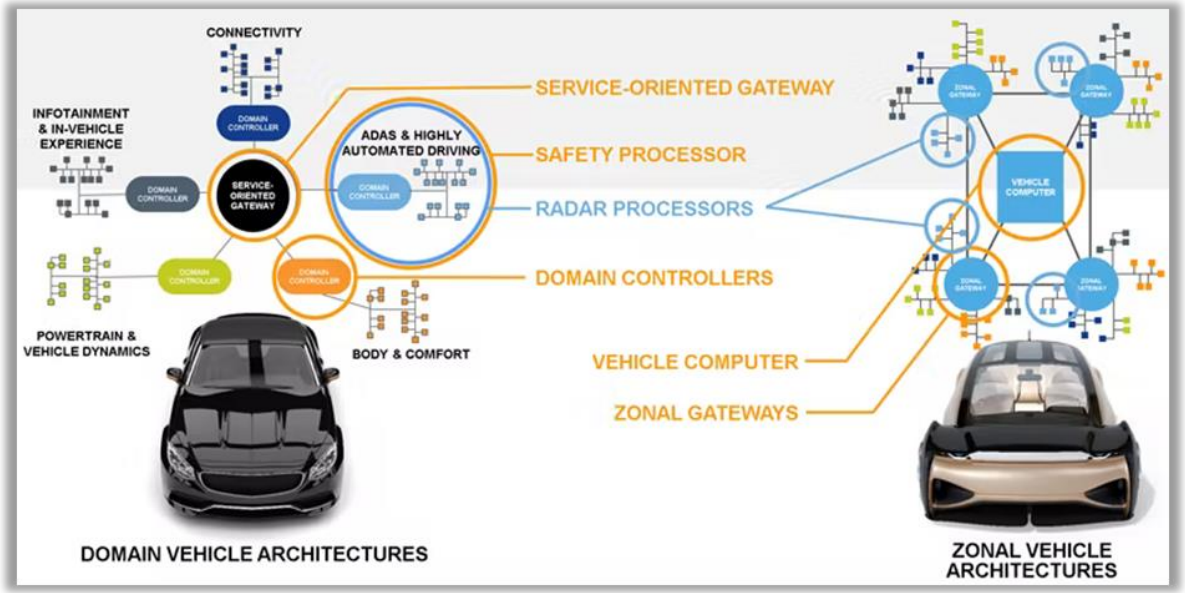
Shift to software-defined vehicles (SDV)

Software content increasing rapidly



Source: Aptiv

Hardware architecture optimized for the software-centric view



Source: NXP

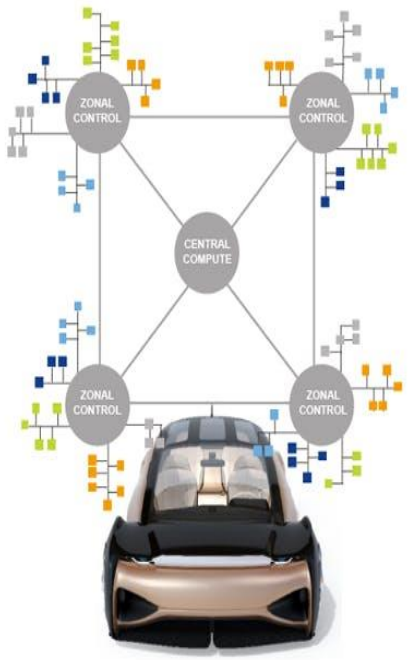
The desire of the OEMs: Commercially available, general purpose HPC HW
The realization: H/W Designed to reduce power and cost for specific SW Algorithms

From Silicon to System – Driving changes

Changing Landscape of Wants and Needs

System-on-Chip	Multi-die SoC	E/E System-of-Systems
• Ever increasing Performance • Power matters – Every Watt affects EV Range • H/W & S/W – Co-design for less problems downstream	• Scalability – different OEMs have different vehicle needs • Upgradability – EV lifecycle is different from ICE.	• Dealing with S/W Complexity – Agile and CI/CD is the need of the hour. • Early S/W analysis – reduces system bottlenecks • Cloud Native – seamless integration and new Monetization opportunities.

Zonal Architecture & Implications to Central Compute SOCs & Zone Controllers

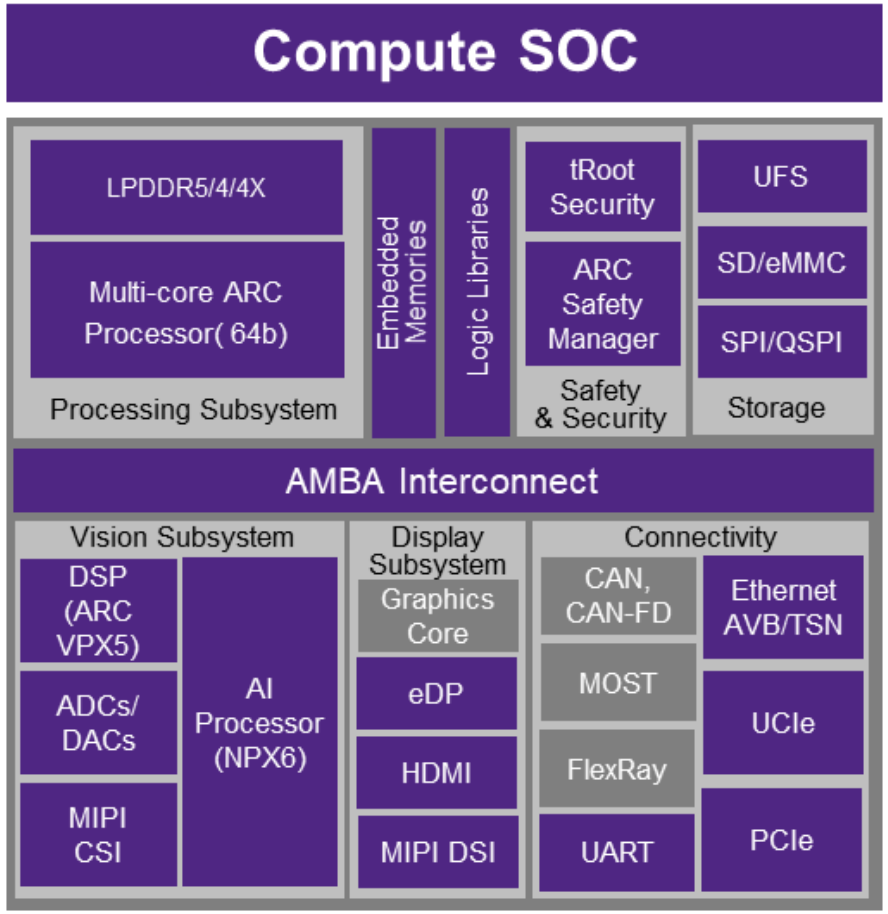


Category	Function	Consolidation	Connectivity	Main Characteristic
Central Compute /Server	Mixed criticality – Application Host	Physical ECUs	High-Speed and some low speed	Computational Power – 1000s of TOPS
Zonal Gateway/Hub	Local Connectivity Hub with some processing	Wiring and Harnesses	Few High Speed, Low Speed and Some Legacy	Connectivity (I/O) & Speed (Latency)

Co-existence of different functions pushing the need for mixed criticality in the central hub

SOCs for the E/E Architecture

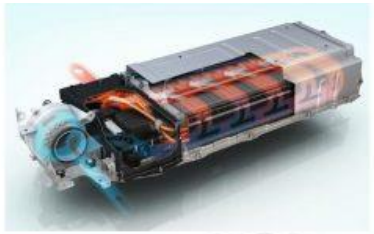
Building Blocks with a view on Safety and performance

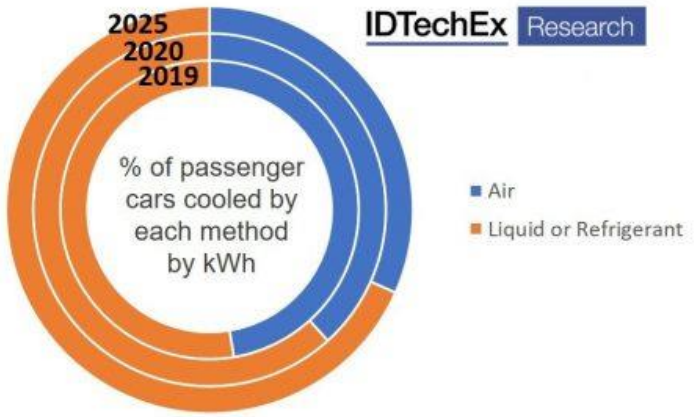


- Performance matters
  - Many CPU cores – support for virtualization and domain separation
  - Specifically defined accelerators – NPUs/Vision accelerators
- Integration of High Speed I/Os and Memory
  - Increased Bandwidth needs → HBM like data-rates
  - Multi-Gb ethernet – upto 112g (no compression)
  - Coherent Interconnects – UCIe/CXL
- Mixed criticality of cores
  - ASIL-D for safety applications
  - ASIL-B/QM for non-ADAS applications

Range Anxiety – Watt really matters!

Why custom accelerators is the way to go?

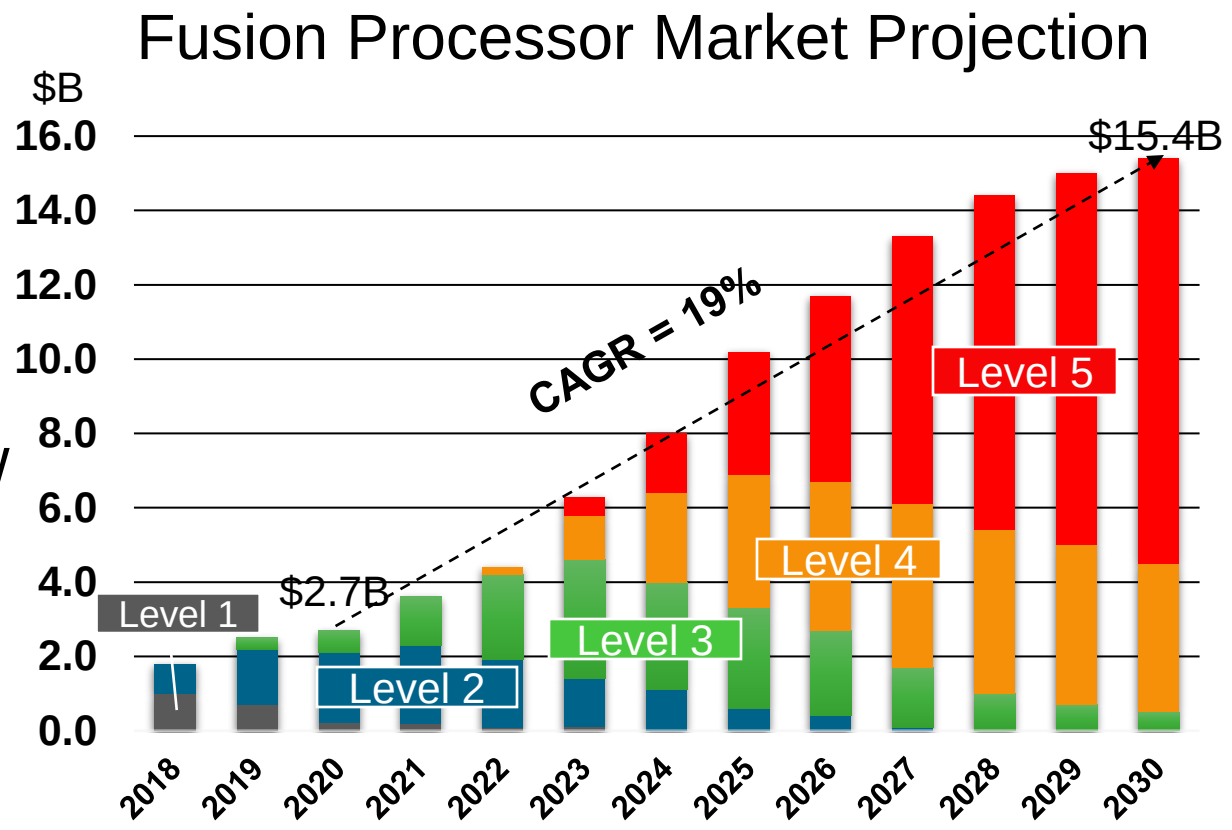




- Software defined custom SoCs are needed to continue performance scaling at acceptable power
  - **For EVs: higher TOPS with low efficiency affects range!**
  - Custom SOCs with specific custom-built accelerators can reduce power footprint by an order of magnitude!
- TOPS is key but TOPS/Watt really matters
- Cost of Cooling is also higher! Every Kwh of battery ~ $125
- Near-memory architectures support lower power consumption
  - Synopsys NPX family built with tiled architecture – most efficient NPU design

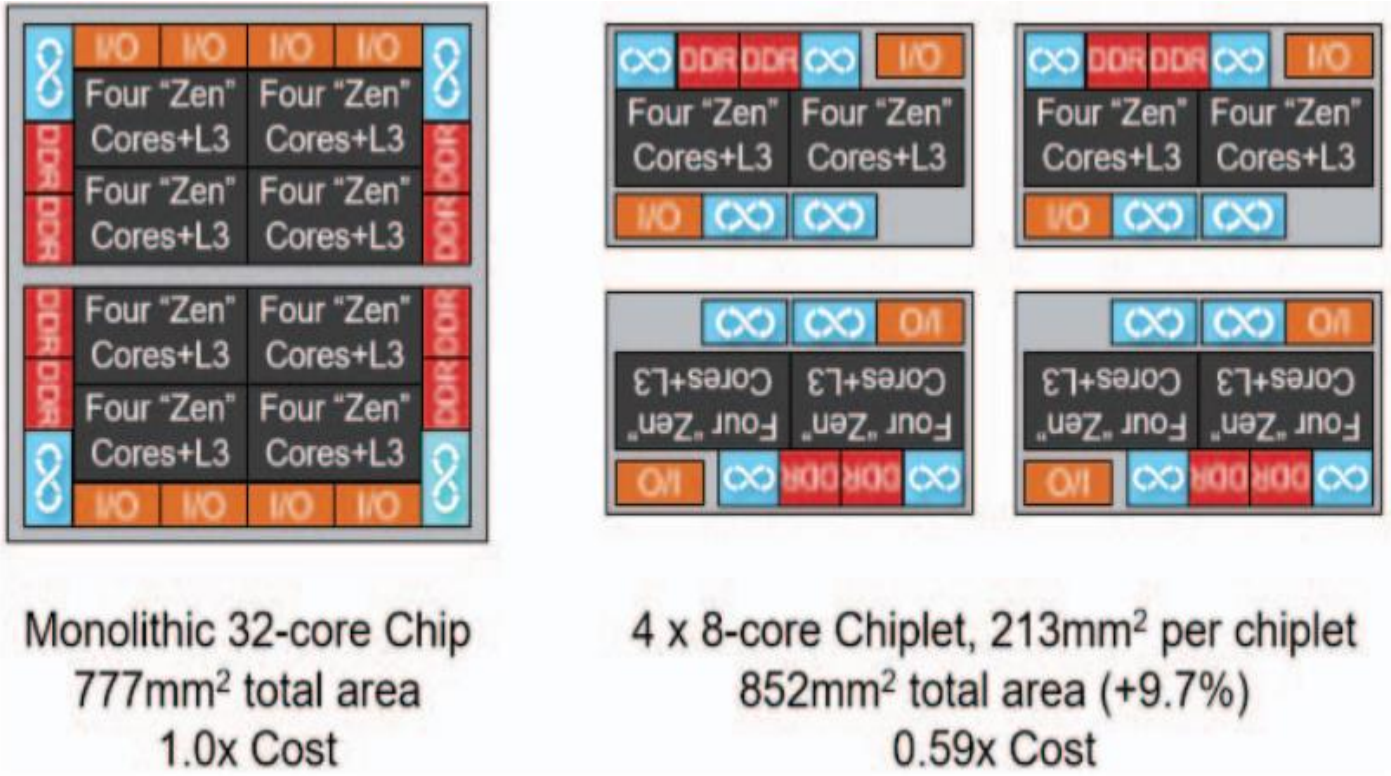
Custom SOCs – What is the road ahead?

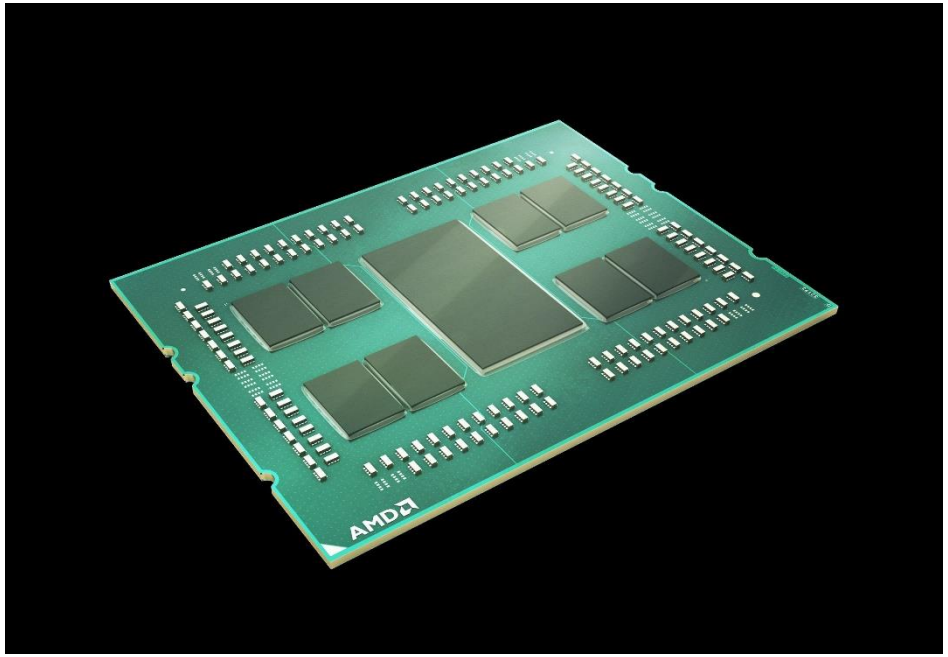
- Monolithic Socs can meet performance needs up to L3 solutions
- Level 4/5 requires performance levels that exceed Moore's Law's single Chip scaling potential
- Chiplets based multi-die packages allow beyond Moore's Law scaling efficiently:
  - Performance
  - Power
  - Cost



Source: IBS, Inc., Automotive Electronics Report, August 2020

Chiplets – Stretching Moore's law to the next Decade





Scaling Moore's Law for the performance needs of the future

The Software-Defined Vehicle

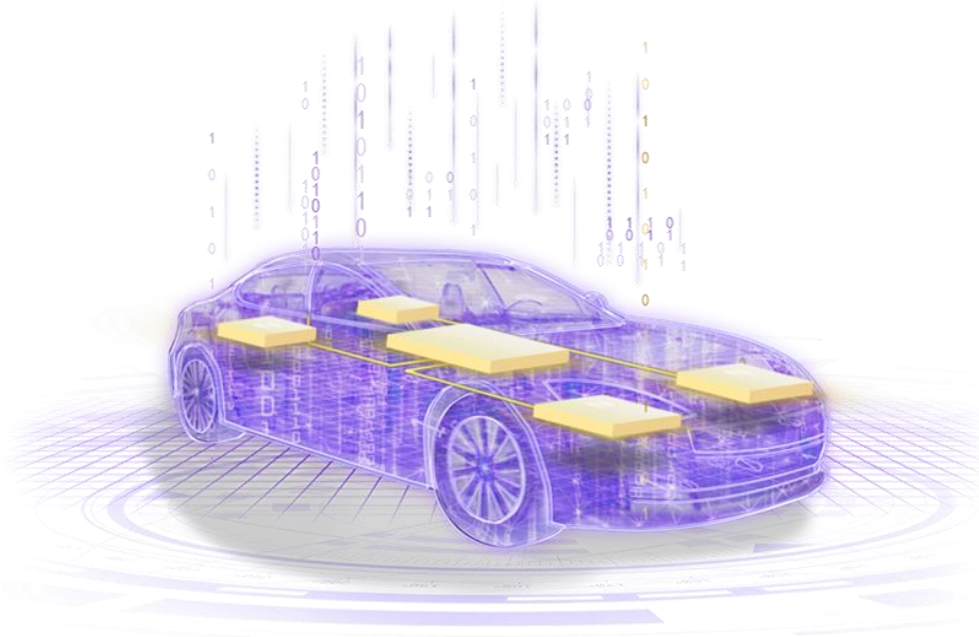
A vehicle defined by software running on highly-optimized hardware

Benefits to the OEM

- Eliminates static nature of today's vehicle
- Flexibility, programmability, scalability
- Real-time capabilities and cost efficiencies
- New Monetization opportunities

Benefits to the user

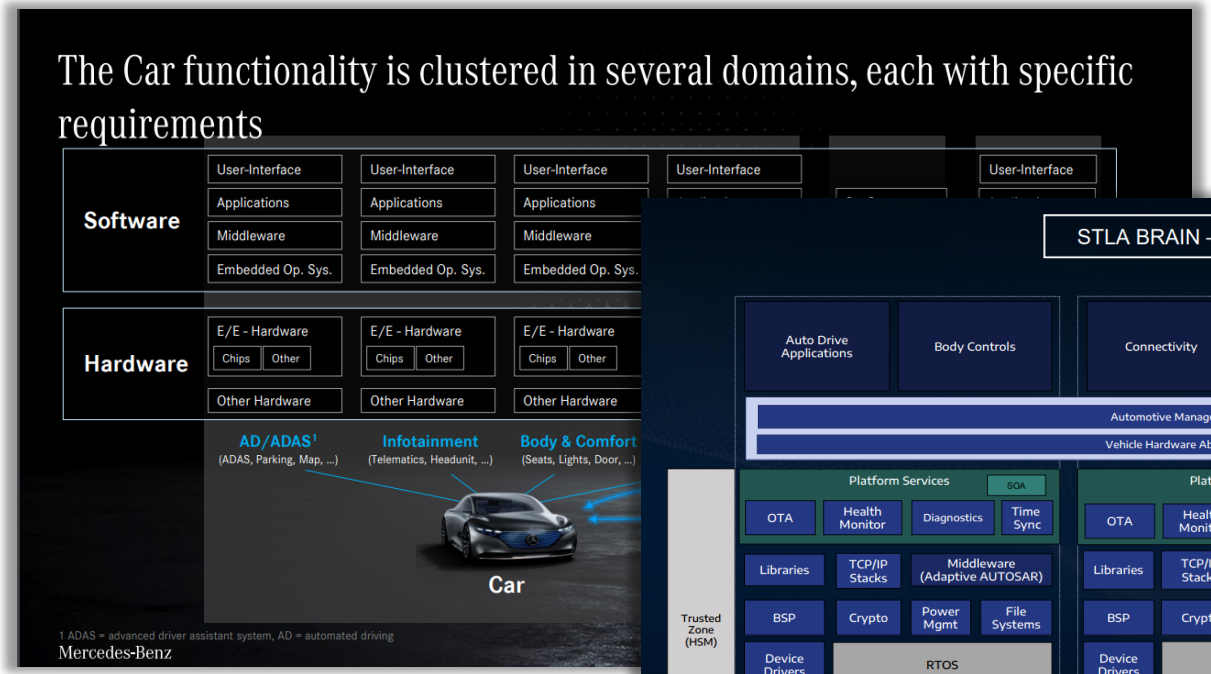
- Unlock safety, comfort, convenience features
- Fix issues and avoid service center visits
- Improve pricing and resale value



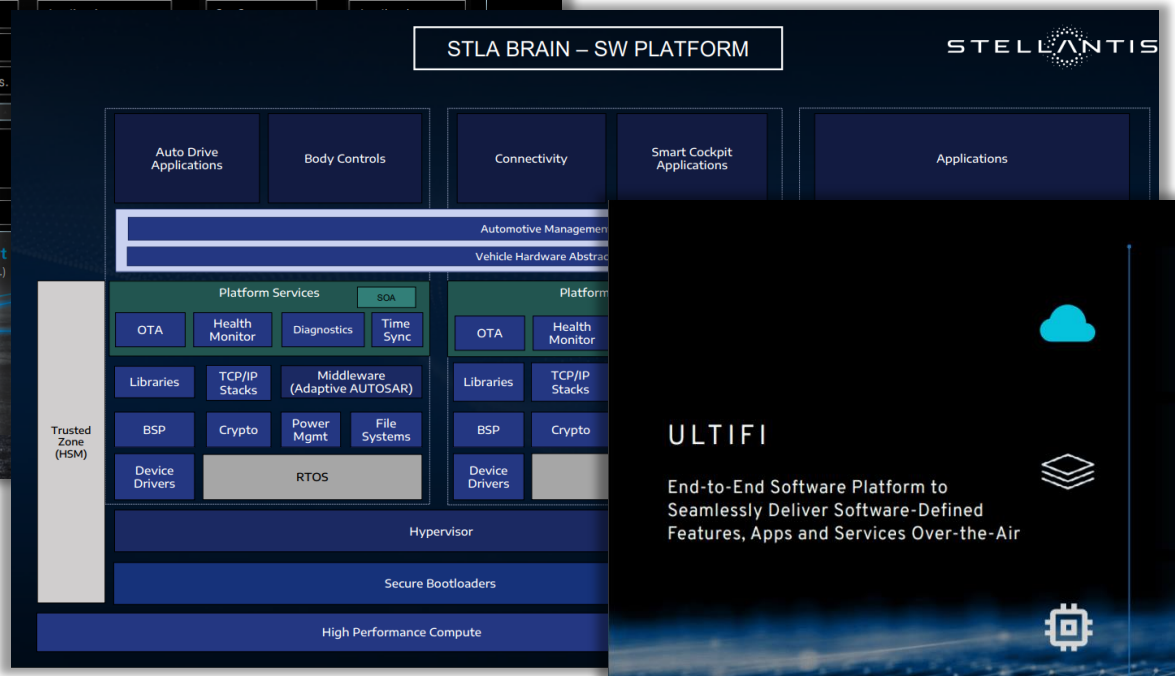
The SDV is defined by

- Service-oriented architecture (SOA)
- Agile / DevOps software development
- Consolidated hardware architecture that is scalable
- Digital Twin – virtual model of the car during vehicle lifecycle.

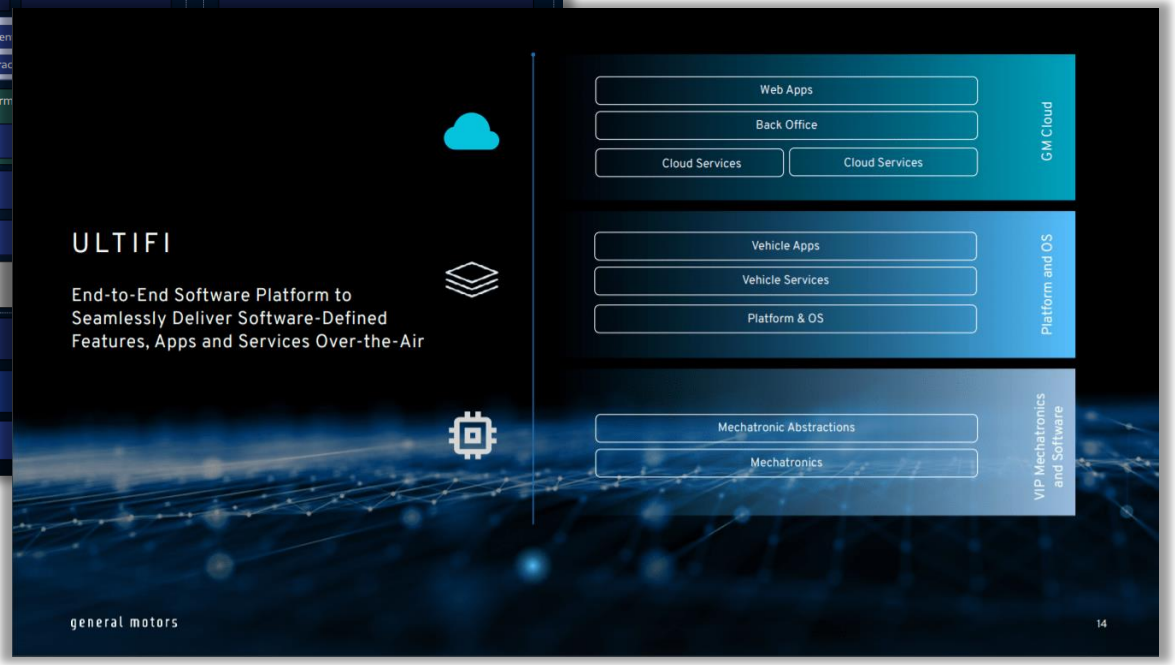
OEMs Publicly Share Their SDV Approaches



Source: Mercedes-Benz

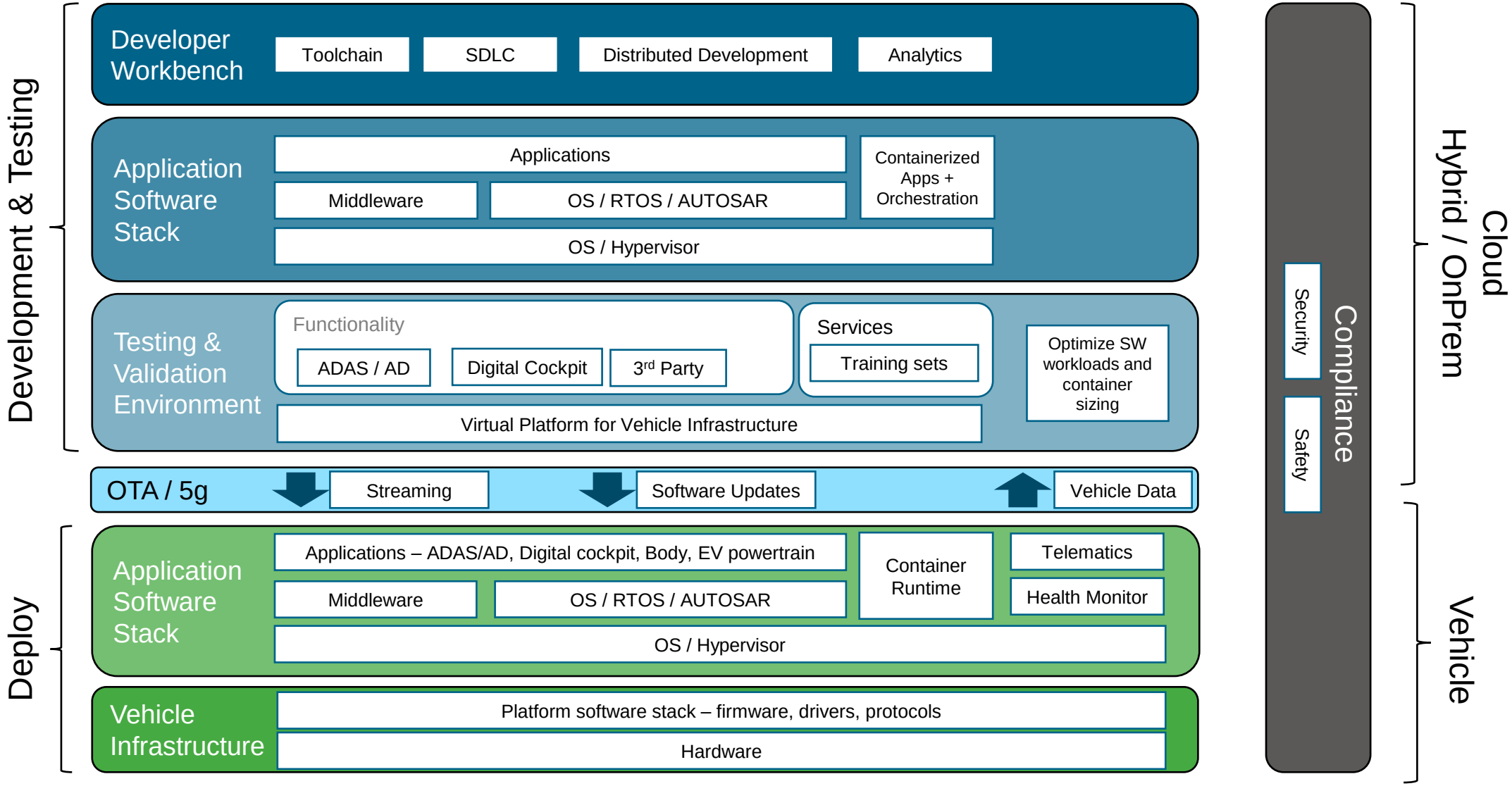


Source: Stellantis



Source: GM

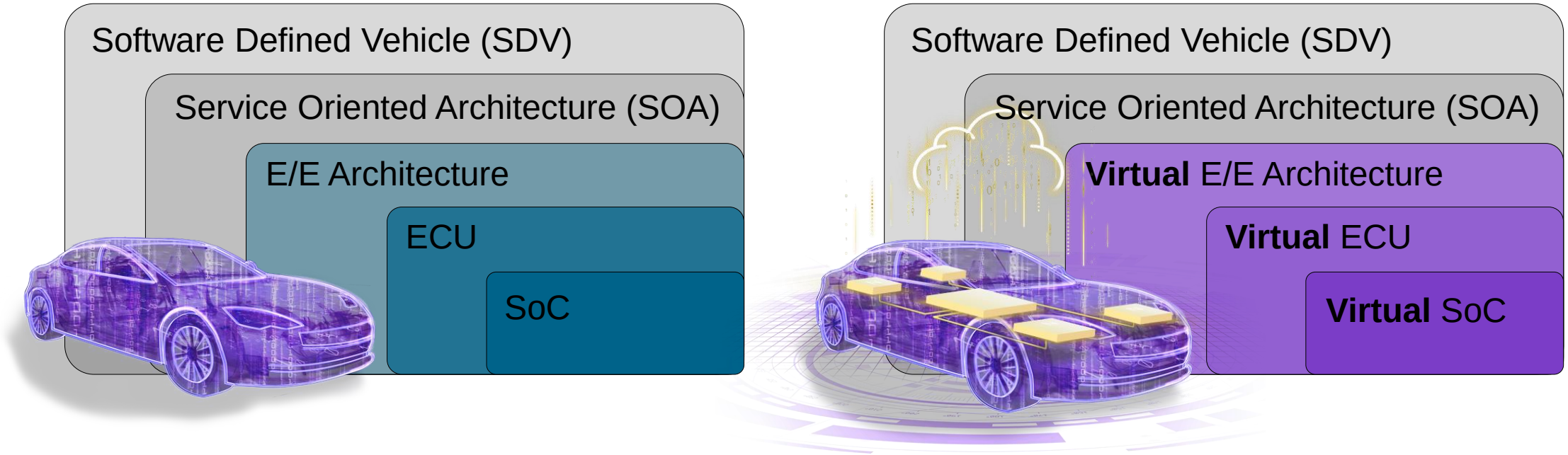
Defining Service Oriented Architecture for SDVs



Expedite Testing for SDVs with Virtual Vehicles

Transition from reliance on physical testing …

… to testing in the cloud using virtual hardware



- New features require accelerated GTM cycles and agile workflows for continuous OTA updates
- **Software first mindset**: Vehicle defined by software; hardware optimized based on software
- Physical testing is not scalable; **automated virtual testing in the cloud** enabled by a **virtual vehicle**
- Software must be **safe and secure**

Digital Twin

Creating a virtual version of the car during the entire lifecycle

- Virtual/digital replica of the car
- Aggregates all the data during the lifecycle of the car
- What it enables
  - Easier Product testing
  - Maintenance and data prediction across lifecycle of the car
  - Manufacturing process changes – testing with virtual versions to test capacity. Easing supply chain burden
  - Customer use-cases: predictive maintenance & Sales opportunities for OEMS

The Road Ahead

- Automakers and their suppliers are moving to the next generation of vehicles
  - Electrification & Autonomous cars will drive Silicon, Architecture, testing, SW Development & Deployment changes
- Roles for Synopsys and partners
  1. Provide tools and ecosystem to accelerate SOC development (IPs, new technologies/standards and architecture and modeling)
  2. Focus on S/W and H/W coupling – one solution to address the SDV
  3. Accelerate cloud native development – develop flows and tools that accelerate the adoption of SOA and cloud native application development
  4. Understand OEM pain-points in a rapidly evolving and long-life product.

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Thank You