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RELATED SBD REPORTS

636 – The Software-Defined Vehicle

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.

CASE

Enabling CASE

#213

Advanced Computing

How AI, Edge & Cloud Computing Will Transform the Car

The continued development of connected & autonomous vehicles is enabling more technically advanced user experiences. As it develops, understanding the technologies influencing the eco-system that enables these experiences will benefit OEMs in the short and long-term. The increasing abstraction of hardware and software enables new thoughts about how to advance automotive computing.

Likewise, the presence of these technologies is not limited to one sector, segment, or system. The shift towards software-defined vehicles will require the evolution of advanced in-vehicle computers, each with a different set of technologies and partnerships behind them. Vehicle autonomy already has a similarly expansive ecosystem, consisting of its own variety of technologies that depend on a growing partnership network. As this landscape develops, understanding the technologies at the center of it will benefit OEMs in the short and long-term.

The Advanced Computing report identifies and analyzes impactful advanced computing technologies being applied in automotive, applicable use cases, and companies developing them. Further analysis is conducted into the trends of advanced computing, including an outlook of enabling stages.

COVERAGE	FREQUENCY	PUBLICATION FORMAT	PAGES
GLOBAL, NA, CHINA, EUROPE	ANNUALLY, QUARTERLY, 1 ONE-OFF	PDF, POWERPOINT, EXCEL, ONLINE	86

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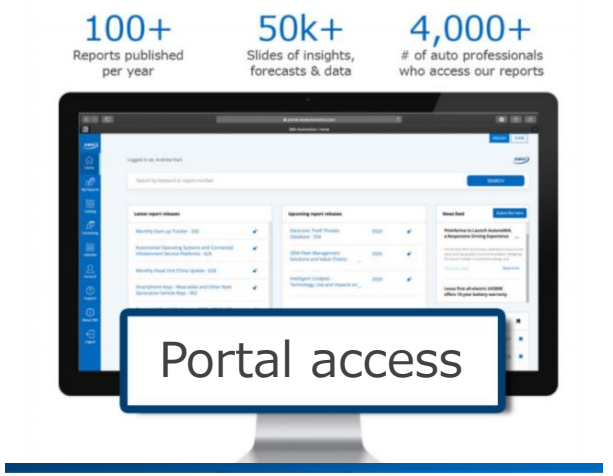
Key questions answered

- How will advanced computing enable vehicles to become more automated and immersive?
- What technologies and systems will provide the highest impact to OEMs and suppliers?
- Who are the leading players deploying advanced computing in Automotive?
- How can OEMs work with tech partners while maintaining control over the overall stack?

This research supports

- PRODUCT PLANNERS
- IT
- MARKETING
- ENGINEERING

Do I have access?



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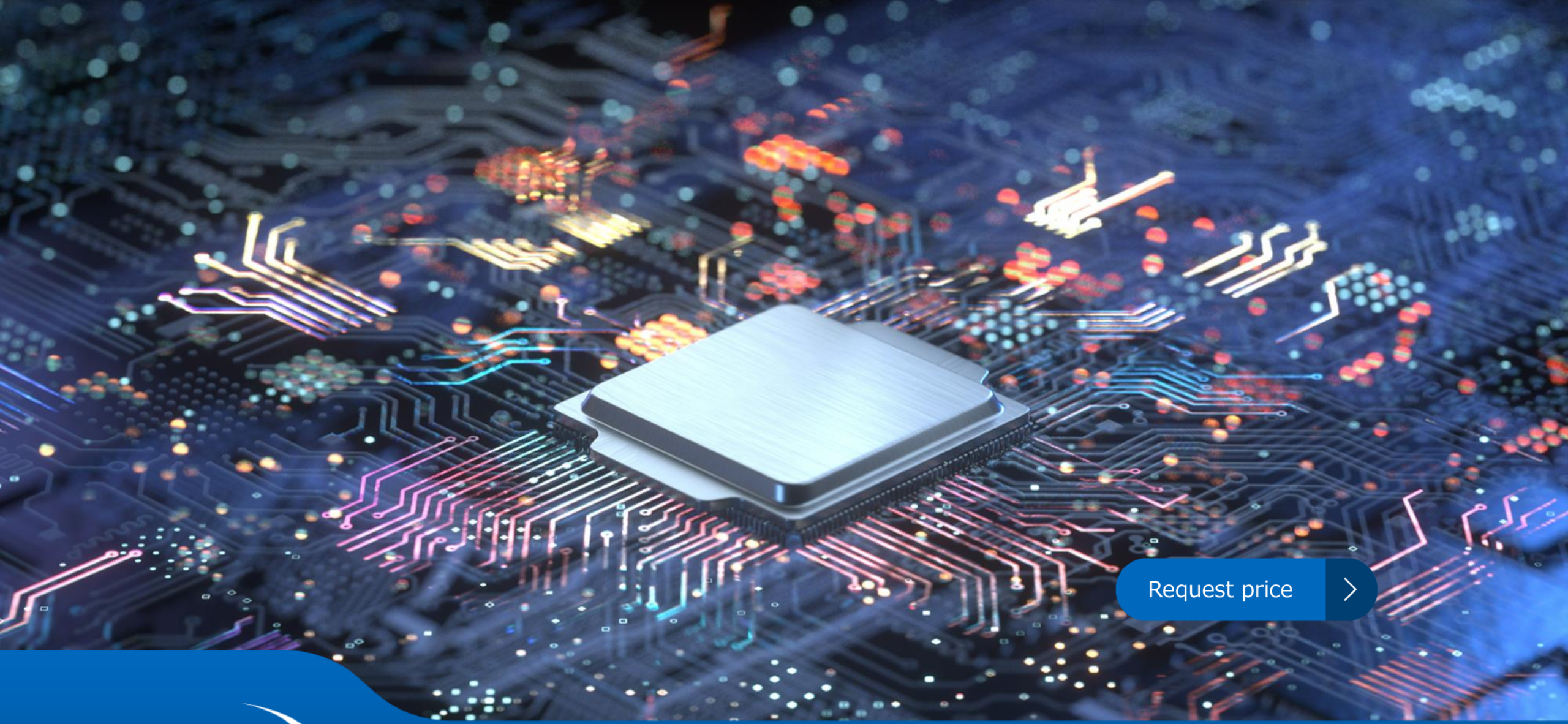

June 2022

Advanced Computing

How AI, edge & cloud computing will transform the car

Contents

Advanced Computing

Introduction

Introducing the Advanced Computing in Automotive Report

Computing moved from the mainframe to the home personal computer and then to the family car long ago. Improvements from other information technology areas have made their way into automotive through long periods of identifying an expected in-vehicle benefit and creating automotive-grade hardened hardware capable of withstanding the harsh automotive environment.

The pace of adoption has increased as a larger portion of vehicle features become software-defined. As in-vehicle hardware reaches even higher levels, it is now reasonable to discuss providing in-vehicle software across multiple systems independently of the underlying hardware. This idea of abstraction of hardware and software enables new thoughts about how to advance automotive computing.

Cloud computing powerhouses and embedded automotive system-on-chip designers are providing advancements in how automotive computing is conceived. However, OEMs judiciously are researching their own desired path to optimum features as they seek to grow their reputation as providers of automotive tech expertise. The features taken to market, and the hardware advancements supporting them, must be focused on providing transportation value and differentiating experiences to the automotive consumer. To optimize the use of technology, each OEM and its strategic suppliers should address questions about their view of advanced computing.

What are the key questions for Advanced Computing for Automotive?

- What expected features are driving technology changes?
- What technologies and systems will provide the highest impact to OEMs and suppliers?
- How can OEMs design tech architectures to increase control of technology instead of being controlled by it?

Section	Content
Executive Summary	Introduction to the topics, technologies, and outlook considered in this report, and resulting recommendations to benefit from them. **Conclusion:** Preparation will provide flexibility for future performance and cost decisions for automotive computing.
Market Drivers	Discussion of consumer-facing features and business benefiting initiatives that are pushing software-defined vehicles and new computing architectures into reality. **Conclusion:** To meet customer expectations, the industry is seeking both computation speed and new development options.
Technology	Introduction to technologies and advancements set to change the meaning of computing for automotive. **Conclusion:** Technologies developed with faster performance are also bringing the ability to expand development past vehicle delivery dates
Company Profiles	Overview of automotive companies active in advanced computing including OEMs, Tier 1s, SoC suppliers, and Cloud services, in terms of activities, investments, and technology insights. **Conclusion:** Trends include function integration, architectural simplification, and hardware abstraction, with autonomous driving functions being the showcase applications.
Outlook and Recommendations	Discussion of the impacts of technologies, decisions that will be made, and recommendations to maximize results of future computing. **Conclusion:** Technology adoption and process changes together will allow optimization of near-term and long-term computing infrastructure.
Go Deeper	Can SBD help you with any unanswered questions?
Glossary	Expansion of abbreviations and acronyms

Example slides from the report

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Key Market Driver 2: Rich HMI for ADAS visualizations

Graphically rich and well-designed HMI improves ADAS

Collaborative driving needs easy situational awareness, which is provided by clear detailed UX visualizing the multitude of sensors and lane-specific road data

Safety
- Relevant information
- Easy to understand
- Feedback of control adjustments
- Clear warning signals through visual signals and colors

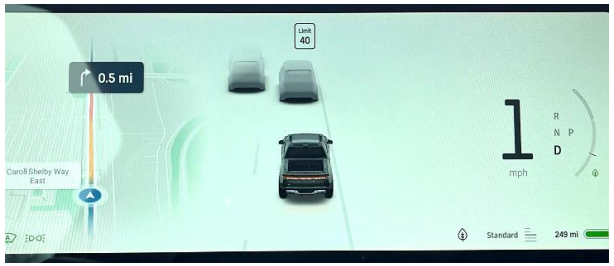
Appeal
- Match the style of the brand
- Highlights availability of features
- Uncluttered clean design
- Customizability

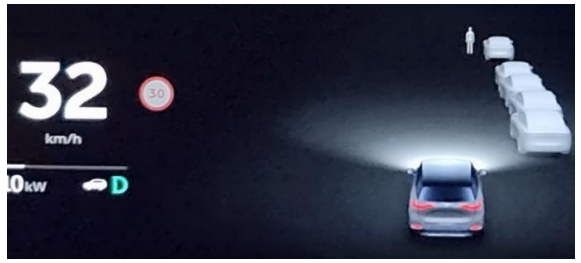
Convenience
- Communication of vehicle actions
- Functional and intuitive interface
- Communication what sensed by the vehicle
- Communication of limitations
- Ease of use

**ADAS photos taken from SBD 635 HMI Benchmarking testing for (first row) Rivian R1T, NIO ES8, (second row, 2nd photo) Mercedes-Benz S-Class, (third row) BMW iX, Lucid Air. Second row, 1st photo, Tesla Model 3 source: Whole Mars Catalog*

Vehicle systems affected by features

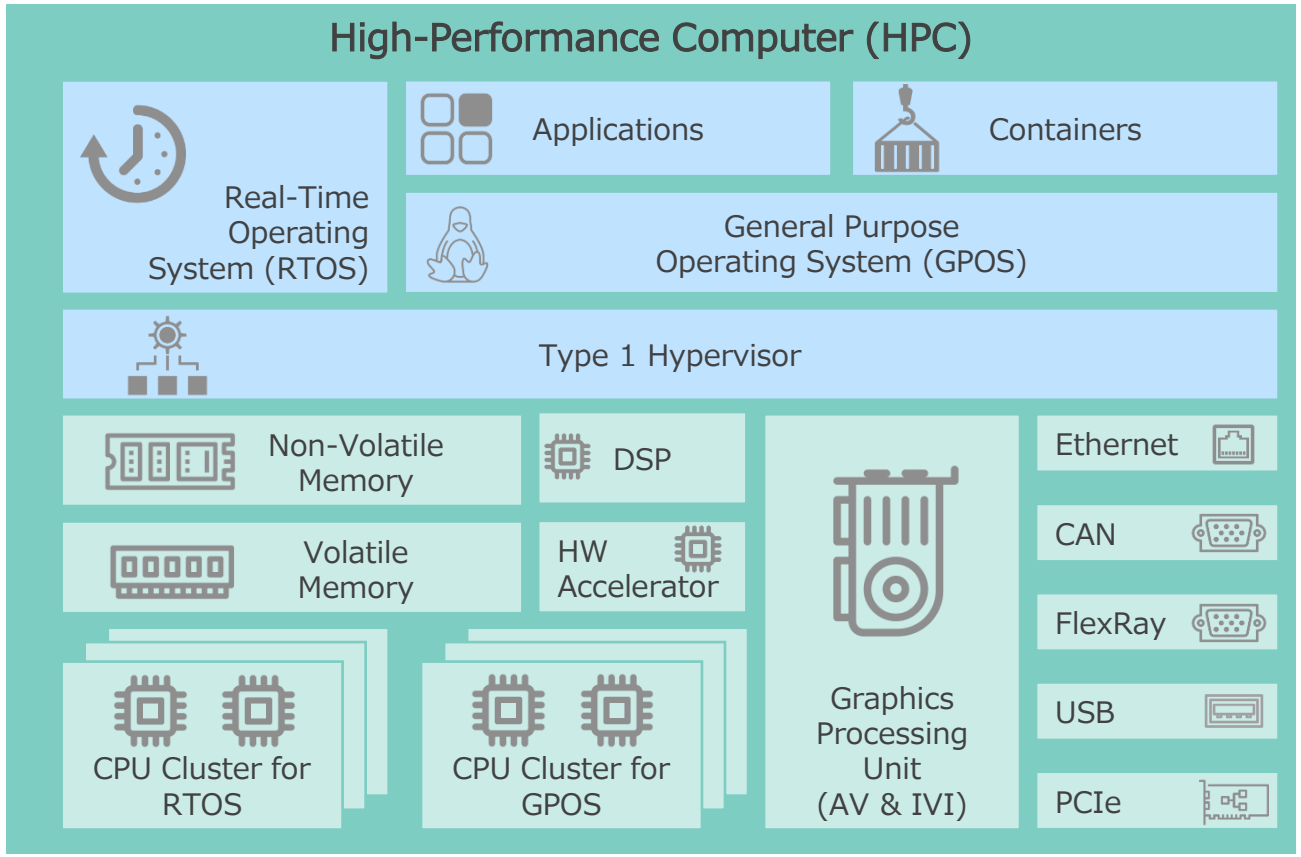
Feature	Head unit display	Instrument Cluster display	Cabin	Connectivity	Sensors	Powertrain
Rich HMI for ADAS visualizations	✓	✓			✓	✓





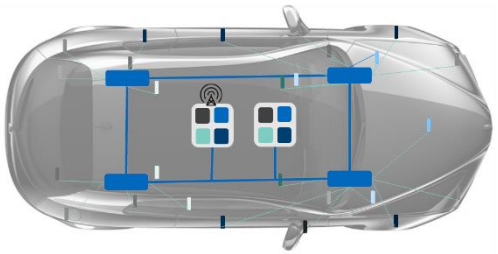
HPCs – Hardware & Software Architecture

High-performance computers are the key to abstraction



- **Applications & containers leverage services on the GPOS** to run portable software integrated with the hardware abstraction services offered by the GPOS or other middleware.
- **The RTOS provides deterministic** computing for safety-critical functions, while the GPOS allows the deployment of more general services, features, and data processing.
- **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 vehicle sub-networks and allow 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.
- **DSPs and hardware accelerators** provide efficient low latency FIR & IIR filter processing for infotainment audio and noise cancellation features.



- **Multiple HPCs** may be deployed to provide **high availability, optimized, redundant AV services,** and/or specialized digital cockpit applications.

Understanding The Profiles – Radar Chart Scoring

Stage	Level	Definition
No Activity	0	Not part of offering or strategy
Research	1	Planned or announced as part of future strategy
Testing	2	Proof of concept / prototype demonstrated
Launch	3	In-market offering available, or expected within 6 months
Refine	4	Competitive offering
Lead	5	Market leadership and continued advancement

Common Scoring System

These are the standard scoring parameters used in the radar chart present in each company profile slide.
These rating criteria have been used for the majority of factors:

- HPC Hardware – Cockpit, Gateway, Connectivity
- HPC Hardware – Body, Motion Control, ADAS
- AI, Machine Learning, Data Management
- Compute Stack
- Virtualization In-car
- Cloud Service

Alternative Scoring

Quantum Computing – A different ranking has been used to take into consideration the complexity and current status of the development of this technology.

Stage	Level	Definition
No Activity	0	No activity
	1	Unproven concept, no public testing has been performed
Research	2	Research announcement
	3	Active investigations with others in either quantum computing or quantum resistance for cryptography
Testing	4	Planned quantum as a service
Launch	5	Offer quantum to others as cloud services

Edge/Near-car Computing – The different scoring reflects C-V2X deployment and involvement in a consortium as indicators of high skill in this space, more than commercial competition with others, as observed in the common ranking.

Stage	Level	Definition
No Activity	0	Not part of offering or strategy
Research	1	Announced targets or research projects
Testing	2	Small scale prototype tested in intended environment
	3	Prototype system tested in intended environment close to expected performance
Launch	4	Edge computing or C-V2X launched
Lead	5	Involvement with consortiums such as AECC

SoC Supplier - Nvidia

Overview

NVIDIA is known primarily for its manufacturing of high-end graphics processing units (GPUs) supporting IVI and SoCs for autonomous vehicles (AV). The latest development aim at covering everything from the car to the data center. With Hyperion, Nvidia provides a complete modular platform for AV development.

Autonomous Vehicles Ecosystem

Nvidia DRIVE powerful computing platforms create an ecosystem for AVs ranging from hardware to software.

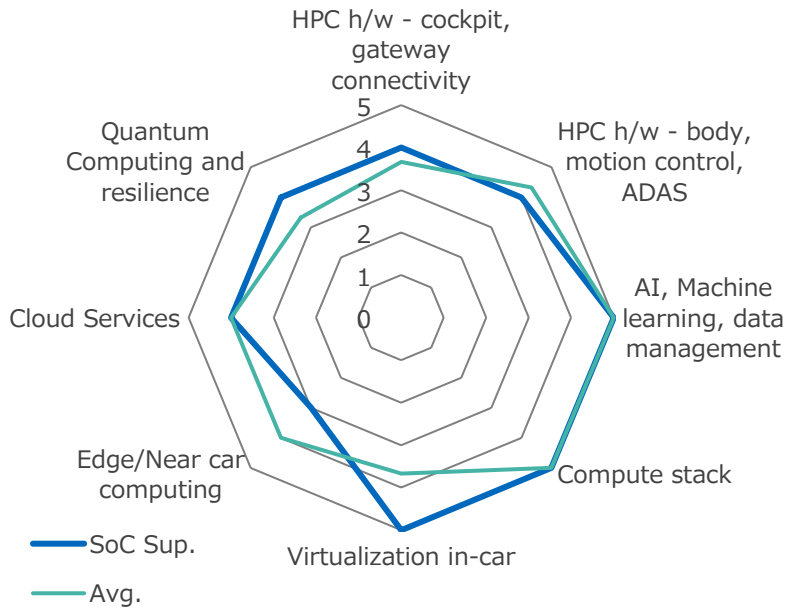
DRIVE Hyperion is an AV platform that integrates Nvidia's SoC Orin-based AI compute with a sensor suite of 12 exterior cameras, three interior cameras, nine radars, 12 ultrasonics, and one front-facing lidar, plus one lidar for ground truth data collection. Also, Hyperion features the full software stack for autonomous driving as well as driver monitoring and visualization, which is ready for OTA updates.

Nvidia also offers a broad variety of SoCs and GPUs through the developer kits DRIVE Orin, AGX Pegasus, and AGX Xavier, and looks ahead already with upcoming ones like Atlan. The SoCs offered also as integrations of its Hyperion platform are designed to enable level 2 to level 5 autonomy, as well as robotaxis. Their AI-focused processors like H100 Hopper allow the training of advanced AI models.

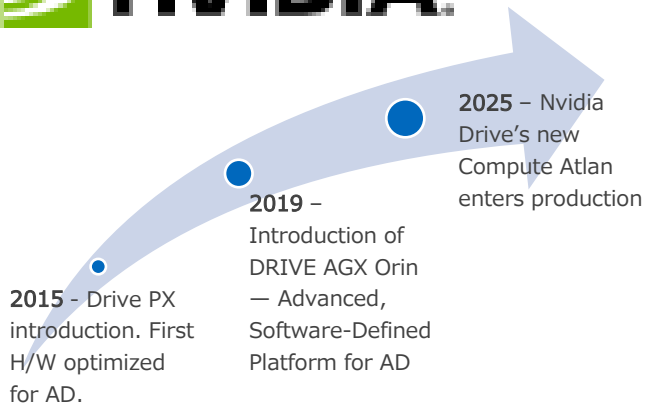
Strengths

- Nvidia enjoys already a strong presence in automotive with numerous partnerships with the largest OEMs in the world in different market segments.

Partnerships



NVIDIA



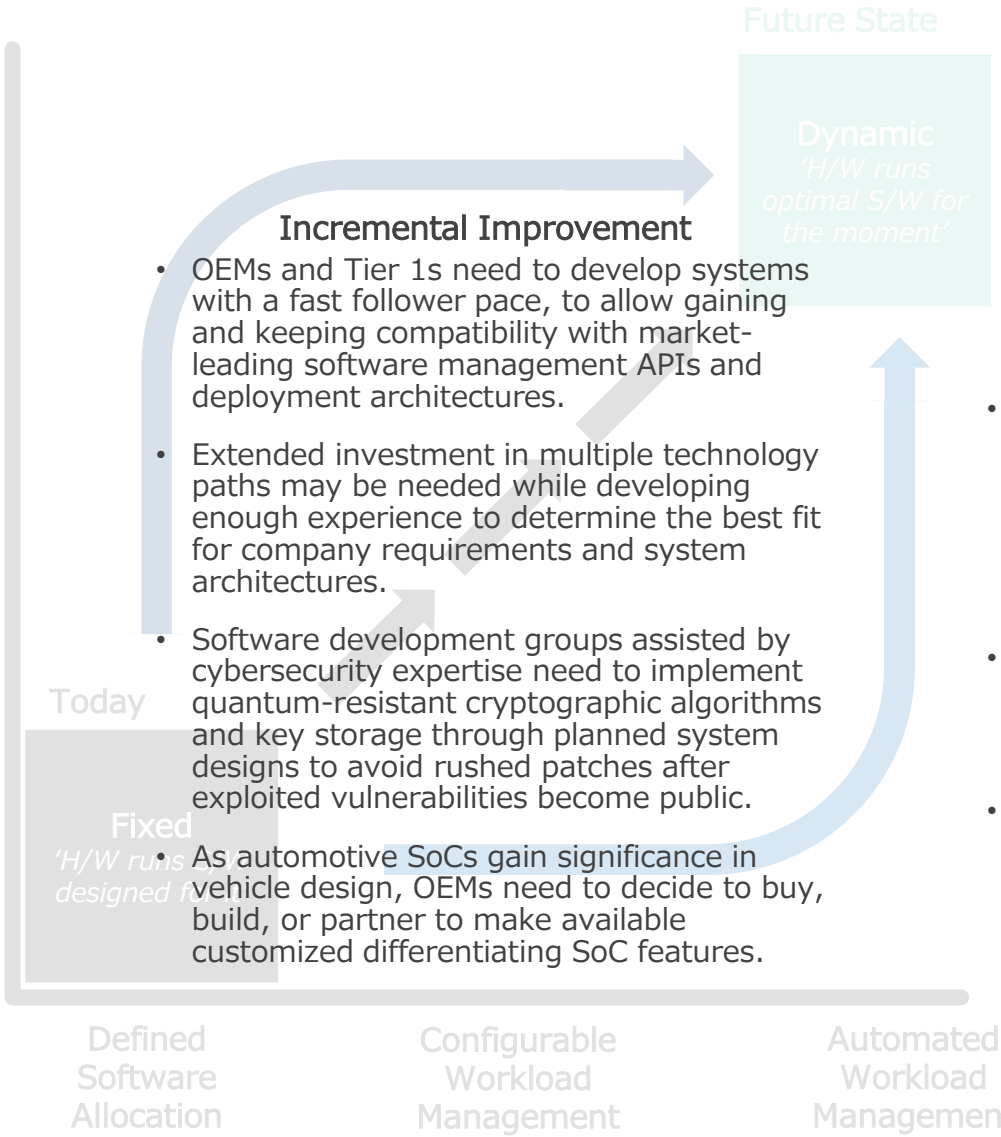
Acquisitions & Investments

- **2022** – Acquisition of Excelero. The high-performance block storage provider will have its technology integrated into Nvidia's enterprise software stack.
- **2022** – Acquisition of Bright Computing, a leader in HPC cluster management solutions. Amsterdam-based Bright Computing spun out of HPC firm ClusterVision and automates administration for clusters.
- **2021** – Acquisition of Oski Technology, a company developing comprehensive formal verification methodologies to identify and sign-off high-risk blocks, achieve system-level architecture sign-off, and quickly resolve post-silicon bugs.
- **2021** – Acquisition of DeepMap, a start-up dedicated to building high-definition maps for autonomous vehicles. The HD mapping solution combines digital camera images with lidar to build 3D maps that represent real-time road data.

Obstacles to Dynamic Workload Management

Disruptive OEMs & Hardware Suppliers

- OEMs will need to reorient processes and cost performance metrics away from focusing narrowly on single-vehicle models or single fiscal years. Cost engineering and purchasing groups will need to see the long-term gains possible with an initial investment
- HPC designers need to focus on generalized hardware, allowing use as cross-domain H/W to offer in-vehicle redundancy for critical workloads and parallel computing speed increases. If designers specialize in custom hardware to specific input/outputs and workloads, flexibility will be limited.
- Network Edge computing is initially limited by narrow use-case deployments such as 5G positioning services and low latency applications.



Incremental Improvement

- OEMs and Tier 1s need to develop systems with a fast follower pace, to allow gaining and keeping compatibility with market-leading software management APIs and deployment architectures.
- Extended investment in multiple technology paths may be needed while developing enough experience to determine the best fit for company requirements and system architectures.
- Software development groups assisted by cybersecurity expertise need to implement quantum-resistant cryptographic algorithms and key storage through planned system designs to avoid rushed patches after exploited vulnerabilities become public.
- As automotive SoCs gain significance in vehicle design, OEMs need to decide to buy, build, or partner to make available customized differentiating SoC features.

Disruptive Software Suppliers

- System architects need to discover methods to interface with legacy protocols during transition periods. Compatibility with hardware and software should be done so that new beneficial changes can quickly proceed without abandoning commitments to existing products.
- Containers' greater benefit will need organization and cross-organization standardization leading to reuse and hardware portability.
- Machine Learning (ML) needs acceptance as functionally safe through the development of explainable ML or a determination of a sufficient amount of testing.

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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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