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Timing silicon future-proofs SDV performance, says Renesas

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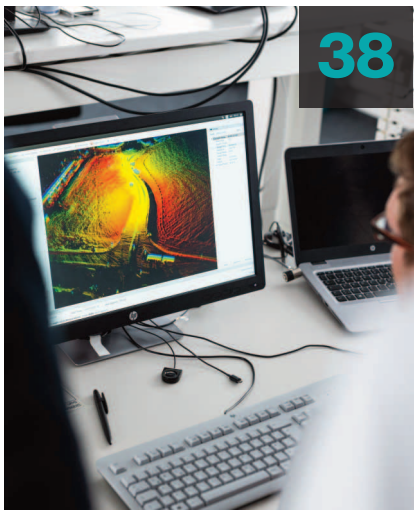

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SOAFEE builds parity across SDV developer environments

As part of the wider SDV Alliance community, SOAFEE aims to provide a common, standards-based compute layer to enable innovation. By Will Girling

At a time when the very definition of a software-defined vehicle (SDV) hasn't reached industry consensus yet, it is unsurprising that the automotive hardware and software ecosystem is highly fragmented. However, the consequence of leaving this rift unrepaired could not only be financially costly for OEMs but dangerous. In 2019, semiconductor and software design company Arm recognised that the software/hardware ecosystem would never be sufficient to comply with vehicle safety standards without harmonisation.

"When automakers switch from one company's system on a chip (SoC) to another, they have to change fundamental aspects of their software like boot, power management, and security," explains Suraj Gajendra, Vice President of Automotive Product and Software Solutions at Arm. "That's not the most streamlined way to do things." As the SDV concept evolved between 2019 and 2020, cloud-native software development and over-the-air updates also came to the fore, requiring even greater consistency between environments.

Gajendra believes the industry needs to aim for parity, cost efficiency, and portability in the auto software space. To set the wheels in motion, Arm developed a standardised firmware layer—Edge Workload Abstraction and Orchestration Layer (EWAOL)—and made this framework available for the open-source developer community. Then, in 2021, the company started gathering industry leaders together to form a consortium—

SOAFEE aims to standardise the non-differentiating compute layer and deliver a new architecture for cloud-native software development

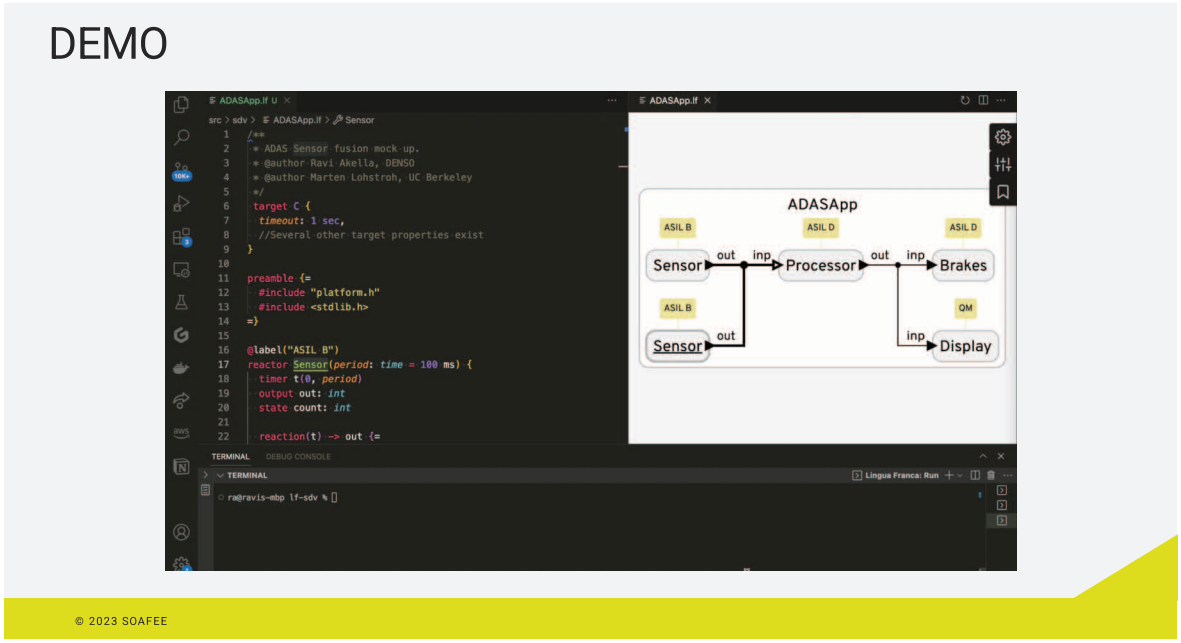
Scalable Open Architecture for Embedded Edge (SOAFEE)—to help spread its message. "SOAFEE is working to bring the SDV idea closer to reality," he tells *Automotive World*.

Targeting SDVs at scale

At the time of writing, SOAFEE has around 130 members, including General Motors, Geely, Tata Motors, AWS, Bosch, and Continental. All are bound by a commitment to three objectives, the accomplishment of which could facilitate the deployment of SDVs at scale. These are as follows: the ability to port software across different hardware platforms, consistency in the cloud and at the edge, and the development of new software before the necessary hardware becomes available. Gajendra acts as Chairperson of the SOAFEE Governing Body.

"We have several active working groups running to look at various aspects of software stack standardisation," he says. Subjects tackled include how the safety-critical and non-safety-critical components of an application can functionally co-exist on a single platform. This is particularly important in advanced driver-assistance systems and autonomous driving software, where constantly evolving road conditions will determine what functions should have priority.

"Cars are complex machines consisting of hundreds of ECUs," Gajendra continues. "Deciding what to consolidate



and how requires really in-depth industry conversations." There are several other consortia–AUTOSAR, COVESA, Eclipse SDV–also considering various issues within the same ecosystem. In January 2024, these came together with SOAFEE to form a "collaboration of collaborations" called the SDV Alliance. "There are some overlaps, but we're not competing; we're generally considering different problems," states Gajendra.

Creating synergy

For its part, SOAFEE is contributing the fundamental or "non-differentiating" compute layer to deliver a standards-based architecture for cloud-native software development. This includes "free-to-reimplement APIs" to help seed solutions in the open-source and commercial developer spaces, which in turn will lead to consistency across the cloud and automotive software edge ecosystem. By doing so, the group hopes to create a shared foundation upon which the industry can innovate and ultimately make SDVs a reality.

"Putting together a sub-system just based on hardware IP building blocks can take nine to 12 months and become very expensive. By providing EWAOL, we bring down the time-to-market for SDVs significantly," says Gajendra. Importantly, the synergy between system safety monitoring and CPUs is also standardised, creating more reliable and complementary hardware/software interactivity. "This enables engineers to direct resources to other aspects: the things that will create brand differentiation and value for their company."

Ultimately, he considers the SDV concept a "backdrop" for the autonomous, connected, and electric mobility technology megatrends currently blooming in the industry. At the same time, these underscore the difficulty of maintaining old ways of working in the auto software space. "Think about the evolution that's happening and how fast things are changing. Waiting months and months for new platform developments as the demand for artificial intelligence (AI) hardware grows is unacceptable." From

> **This is the magic bullet: total parity between all platforms in the vehicle and in the cloud**

September 2024, the consortium's next phase–dubbed 'SOAFEE.next'–has focused on rewriting how AI-enabled SDVs scale.

The magic bullet

In order to keep pace with the latest automotive architectures, SOAFEE.next will bring together new hardware, development platforms, and validation services. "For every piece of new hardware, we're offering a complete suite of matching virtual platforms from our partners like Cadence, Corellium, and Siemens," explains Gajendra. Removing the need to work exclusively on physical silicon, these platforms allow software engineers to accelerate development through virtual prototyping in the cloud.

By combining SOAFEE software solutions with Arm's Reference Design-1 AE hardware, Gajendra states that AI, security, safety, and virtualisation can be aligned to balance SDV functions operating at different levels of mission criticality. "This is the magic bullet: total parity between all platforms in the vehicle and in the cloud. It's a dream situation, because all the environments are based on Arm IP, and the software doesn't need to be reconfigured."

Over the coming years, SOAFEE aims to create a continuous integration and continuous deployment pipeline that allows it to resolve prominent challenges raised by the SDV community. The group will showcase its solutions through 'Blueprints': domain-specific applications with a SOAFEE-compliant implementation and standards-based firmware and hardware. 30 such projects are currently underway, and the group is adamant that communities and an ecosystem approach will be necessary for taking automotive firmly into the SDV era.

In a 4 September press release to mark SOAFEE's three-year anniversary, Dipti Vachani, Senior Vice President and General Manager of Automotive at Arm, reinforced this collaborative message: "No one company can solve the unique software challenges in the automotive industry alone. I firmly believe that it's truly exceptional what we can do together, as proven by the past three years of SOAFEE. Together with all the SOAFEE members, we are dedicated to driving the transformation of the automotive industry that runs on Arm."

Aptiv: telecoms advances spur software-defined mobility

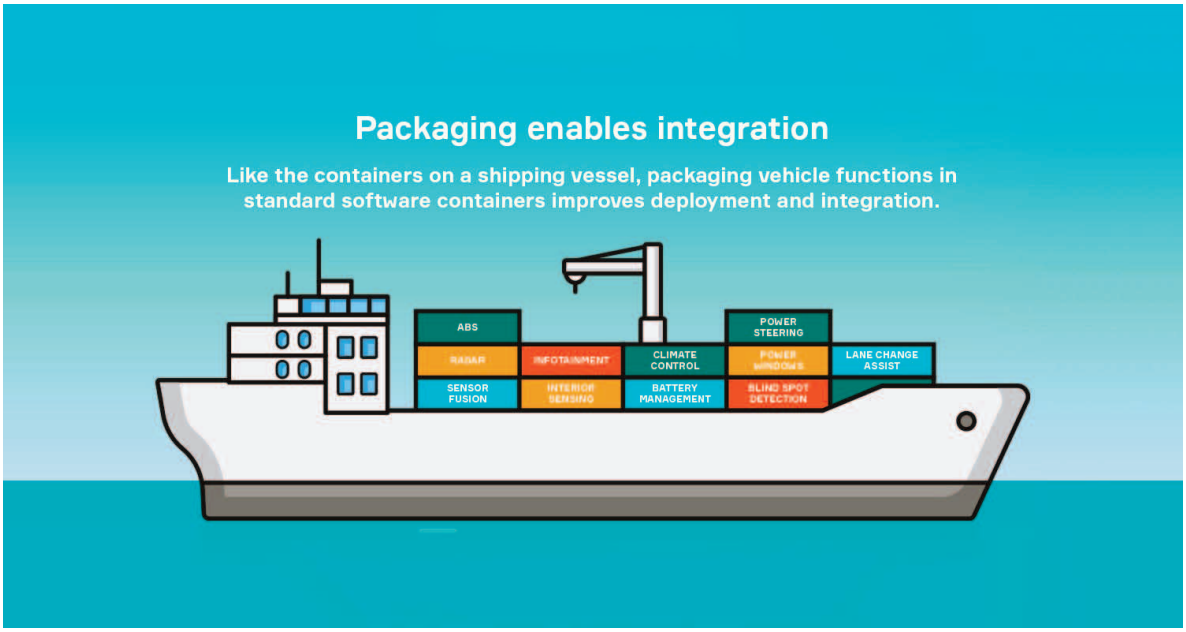
CTO Benjamin Lyon explores how containerised tech and 5G will accelerate OTA updates and the software-defined vehicle. By Megan Lampinen

The software-defined vehicle (SDV) requires a more open software architecture that enables a fresh approach to software development and management. In this new paradigm, automakers need the flexibility to modify individual functions rather than issue updates to entire monolithic code bases and a technology that ensures any changes will not negatively affect adjacent safety-critical software in the vehicle. Could containerisation be the key?

That's the view of Aptiv's Chief Technology Officer Benjamin Lyon. The company, which traces its roots to former General Motors subsidiary Delphi, is one of the few automotive suppliers of both the software and compute behind smart vehicles, as well as the power and data distribution. This expertise positions it as one of the more influential players in SDV architecture.

Can you explain what containerisation technology is and how it relates to automotive?

If you think of software like a puzzle, containerisation enables developers to remove one piece and perform any necessary updates, testing, validation or product enhancements without impacting the other pieces. By using containers, OEMs and suppliers can adopt modern, agile software



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methodologies–small teams continually improving individual functions throughout the life of a vehicle with over-the-air (OTA) updates, with changes integrated quickly and automatically, enabling faster development and deployment cycles across fleets.

The most important way containerisation can benefit OEMs is by making OTA updates faster, easier, and more frequent. This is becoming essential as more consumers expect–and in many cases are willing to pay for–new features throughout the life of the car, just like they do with other products. Containers also make automotive functions portable across vehicle platforms, models, and even vendors. A feature developed for one platform can be deployed throughout an OEM's product line-up with less integration effort.

How has 5G improved OTA updates compared to previous generations of mobile networks?

Think of 5G as the multi-lane, wireless highway of the future. 5G has everything from slow, low priority, cheap lanes to high speed, high priority, high reliability lanes. Previous generations of mobile networks were more like a single-lane road, leading to traffic jams and delays. With 5G, we've expanded the highway, allowing for smoother and faster data transfer, ensuring that critical information can reach its destination quickly and efficiently.

Why is this important for the automotive industry?

Think about software updates. An update may be large, but it can happen during off-peak hours. Just like electricity, the cost of that bandwidth can and will be cheaper. However, time-sensitive information, like the response to a changing streetlight or a pedestrian, are high priority and need to have service level guarantees. The term for this in 5G is network slicing. Network slicing allows for efficient prioritisation of data, ensuring updates occur during off-peak hours and critical information is delivered in real-time.

To take advantage of network slicing, automotive operating systems must be modernised to be 5G aware: the

5G opens up numerous new possibilities within automotive

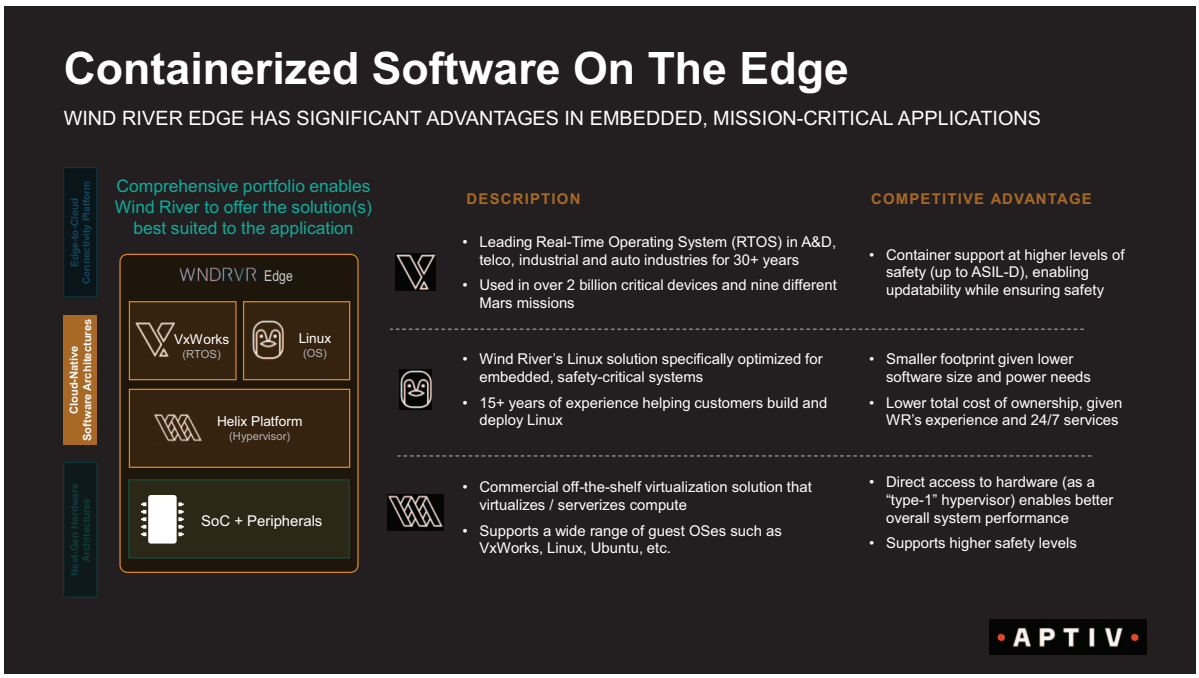
operating system must be able to determine what data to send over what lane on the information superhighway. Aptiv's investments in Wind River VxWorks OS and Helix Hypervisor are enabling our customers to do just that. Ultimately, this will transform the way vehicles communicate and interact with their surroundings. For example, with 5G, vehicles can communicate directly with traffic lights, optimising their speed and reducing energy consumption. As 5G continues to evolve, we can expect even more innovative applications that will enhance safety, efficiency, and the overall driving experience.

Can you provide specific examples of how 5G has impacted Aptiv's approach to OTA and what it means for the future of connected vehicles?

Aptiv's Gen 6 advanced driving assistance system (ADAS) platform is a great example. It leverages 5G's high bandwidth for rapid download and processing of large datasets, resulting in quicker OTA updates for features like lane departure warning, adaptive cruise control, and even autonomous driving capabilities. With Gen 6, an OEM can opt for our most comprehensive ADAS offering designed for SAE Level 3 automation, which allows drivers to take their hands, feet, and even eyes off the road under specific conditions. It's the 5G connectivity and its enablement of better communication between vehicles and infrastructure that can put that level of automation into practice.

What are some of the main challenges associated with implementing continuous OTA updates in vehicles?

This is really where the benefits of Aptiv's use of containerisation comes into play. With any OTA update, security is the top concern at every step in the process. Containerisation improves security by keeping attacks that target one application from spreading to others. Another challenge is compatibility across different vehicle models and hardware configurations. Containerisation technologies allow for modular and flexible software development and deployment, ensuring OTA updates can be tailored to specific vehicle requirements while maintaining compatibility.



When it comes to the evolution of connected cars and OTA capabilities, what role does telecommunications play?

Our acquisition of Wind River gives us a unique view into this aspect, as it is actively supporting the rollout of 5G across multiple carriers globally. Much like the automotive industry, telecommunications is on its way to a software-defined future and experiencing many of the same challenges, including having the right software. Wind River's containerised software is used for OTA updates in both telecommunications and automotive. Whether it's hundreds of thousands of cars or hundreds of thousands of cell towers, the benefits of containerisation in deploying OTA updates across a fleet are the same. The connectivity enabled by the rollout of 5G across the telco landscape will enable a safer, more comfortable and convenient driving experience by connecting cars to the infrastructure all around us. Combining Wind River's telecommunications expertise with Aptiv's mobility background makes me really excited about where the future of the SDV is headed.

What's your outlook for the future of the connected car, especially in terms of integrating more advanced features through OTA updates?

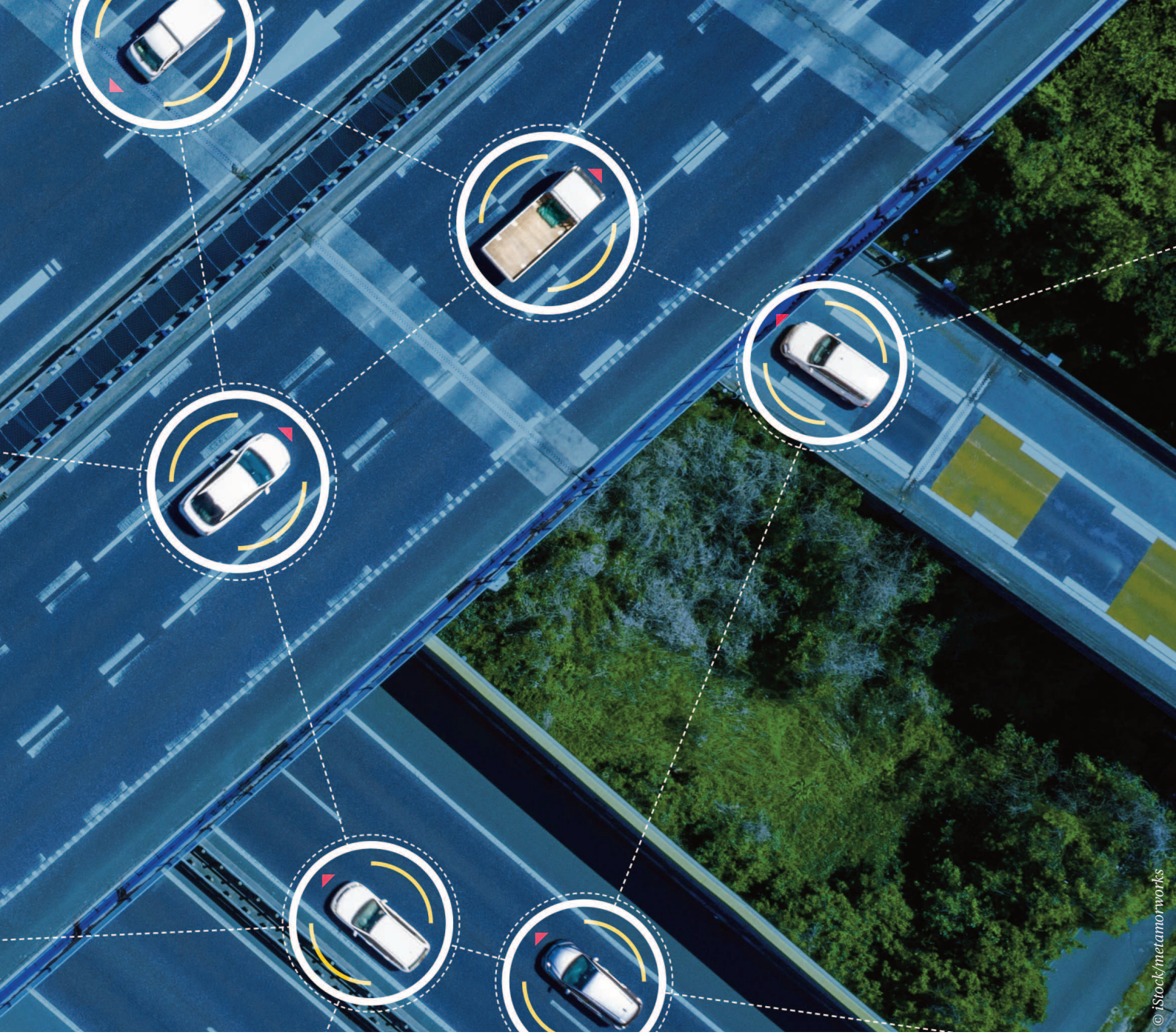
OTA updates offer new ways to increase owner satisfaction and brand loyalty and potentially generate additional revenue. One model might be to offer features through a subscription service, charging for the features through regular billing, or a driver might want to activate a highway driving assist just long enough for a weekend getaway. OTA would allow the features to be downloaded or enabled for only the time that the subscription is active. When a vehicle has enough memory and compute capacity, coupled with an array of radars, cameras and other sensors, all that's needed for new features is the software, delivered through OTA. Much like updates to your phone, the possibilities are truly endless.

Timing silicon future-proofs SDV performance, says Renesas

As processing systems become more complex, Renesas believes timing silicon holds the key to enhancing SDV bandwidth and latency.
By Stewart Burnett

The success of software-defined vehicles (SDVs) arguably depends on fast response times and higher bandwidth. The control functions handled within a SDV continue to become more complicated due to consolidation around single processing units. A system's responsiveness is crucial for a wide range of features, from infotainment functions like media streaming and navigation to control systems for driver-assist or braking systems. An unexpected lag spike in either of the latter could lead to disastrous consequences for both a vehicle's occupants and other road users. Two key system elements required to ensure systems remain responsive is bandwidth and latency.

Mastering latency—the delay between the start of data processing and transmission to its destination—is essential for SDVs to function as customers expect. For software to be faster and more responsive, there are two key variables to consider: the clock speed for the SoC/CPU and the speed of interconnection between processing systems. Software development is made easier when latency is reduced and becomes predictable.



Yimu Guo, Timing Product Manager at Renesas, believes that SDVs will benefit from a silicon-based clock system that ensures peak system performance with high processing bandwidth and low latency. The clocking solution can determine several key factors including power, speed, and cost. So, how might timing silicon help achieve optimal latency speeds, and how serious could a failure to prioritise this aspect of SDV design be for automakers?

Shrinking the quartz footprint

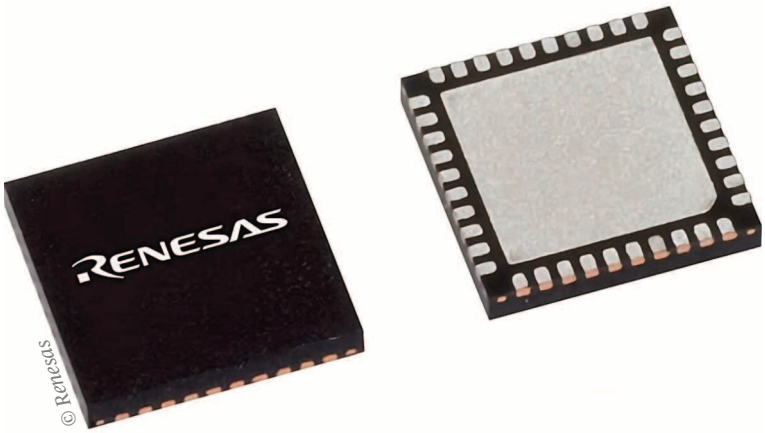
Timing is not a new problem for automotive, but it is becoming more complicated as vehicle functionality and hardware complexity increases. The compute-intensive nature of SDVs will require interconnect speeds an order of magnitude faster than incumbent solutions can offer. “Today, you’re looking at single-digit gigahertz throughput. However, as SDVs evolve in the future, we could reach data-centre class interconnect speeds,” Guo remarks. Silicon-based solutions are better-equipped to handle high performance largely due to their programmability.

Historically, discrete quartz crystal oscillators have been used for automotive timing, but they are now approaching their limitations. Oscillators can only generate a single

output clock frequency, so, as the complexity of SDVs increases, many oscillators are required per vehicle. This results in a larger footprint and can be challenging to integrate, creating unnecessary design hurdles for vehicle engineers to overcome. By contrast, a single silicon-based timing device can be added seamlessly into an SDV control module, allowing for a more compact, integrated system design. “Silicon timing enables the cost optimisation of raw materials, which is a major issue for our customers,” remarks Guo.

quartz devices are limited to a single fixed frequency. This limitation will become increasingly pronounced as SDV development advances. “Purpose-defined functions can include diagnostic and monitoring features to boost the overall reliability and safety in the control unit, improving the overall driver experience,” Guo explains.

However, one of the reasons quartz has endured as a material in automotive is the simple nature of the ECU function. Historically, a low performing MCU with a single clock would perform discrete quartz clocks. However, this scenario is more ideally suited to a silicon timing solution. One single silicon timing device can provide all the disparate clock frequencies within the design while also adding some digital functions for diagnostics and monitoring.



Renesas’ silicon timing solutions allow engineers to program flexible clock speeds depending on the application

Optimal frequency selection

While Renesas and its peers in the timing segment continue to develop silicon-based solutions, Guo emphasises that the trade-off is already worthwhile. “Quartz oscillators are a known quantity and arguably the path of least resistance, but at some point you will need a clock tree that enables flexible frequency selection to meet the range of processing and connectivity features.” This is not an approach familiar to vehicle control unit designs, although it has existed in data centres for decades. To this end, Renesas offers a range of solutions that can generate different clock frequency outputs and direct them towards the appropriate processing and connectivity devices.

Other advantages of silicon for timing applications include the ability to add purpose-defined functions using standard, scalable semiconductor manufacturing processes. Silicon-timing generators can be programmed to provide a wide range of output frequencies, whereas distinct

its task in isolation. With the onset of SDVs, a single processing system must communicate and oversee all these functions. This invariably increases system complexity, resulting in higher speed clocks. The increase in higher frequency clocks would traditionally require many expensive and

Guo highlights the growing perception that cars are becoming “data centres on wheels” but notes a key difference: the consequences of hardware failure in a car are exponentially more severe. “The quality

> **Silicon timing enables the cost optimisation of raw materials, which is a major issue for our customers**

requirements are much higher, and meeting them can be difficult. You need to make sure that your part is fully reliable while running inside the car." Should an electronic braking system experience a communication issue due to a timing failure, for example, the results could be catastrophic. Fast and reliable response times are also crucial in the context of autonomous and driver-assist systems, which process vast amounts of data continuously from a variety of sensors, including LiDAR, radar and cameras. Should latency problems affect the continuous and timely transmission of this data, it could lead to a delayed reaction or failure to perceive an object in the car's environment entirely.

Future-proofing

Guo believes environmental data transmission demands better quality clocking with lower noise levels, improving bit error rate alongside latency and bandwidth. One of SDVs' primary benefits is their allowance for continuous iteration and feature set expansion through over-the-air updates—for example, upgrading from SAE Level 2 to Level 3. Such software advancements using common existing hardware will only place further demand on them, paving the way for more configurable solutions to step in.

While operational reliability is crucial, Guo suggests future-proofing an SDV with timing solutions that can support upcoming standards. This will help ensure the vehicle hardware remains responsive even as its software becomes increasingly complex. He highlights a feature contained within Renesas' Autoclock product family that allows for an increase in system reliability by leveraging redundant input clocks. "If the system reference clock stops working or fails to be within the specification, Autoclock will automatically switch to the back-up if necessary."

Ultimately, Guo believes the relevance of silicon timing will only increase as the automotive industry moves closer to realising SDVs. However, if automakers prioritise clocking during the development process, then they must ensure their vehicle solutions are as responsive in ten years' time as they are at launch. "Hardware requirements are going up, and so is system complexity, even at the subsystem level. You're going to need more and better clocks as a result," he concludes. "As time wears on, the importance and usefulness of silicon timing compared to discrete, quartz-based timing will be realised."

Plus expands from self-driving to software-defined ADAS

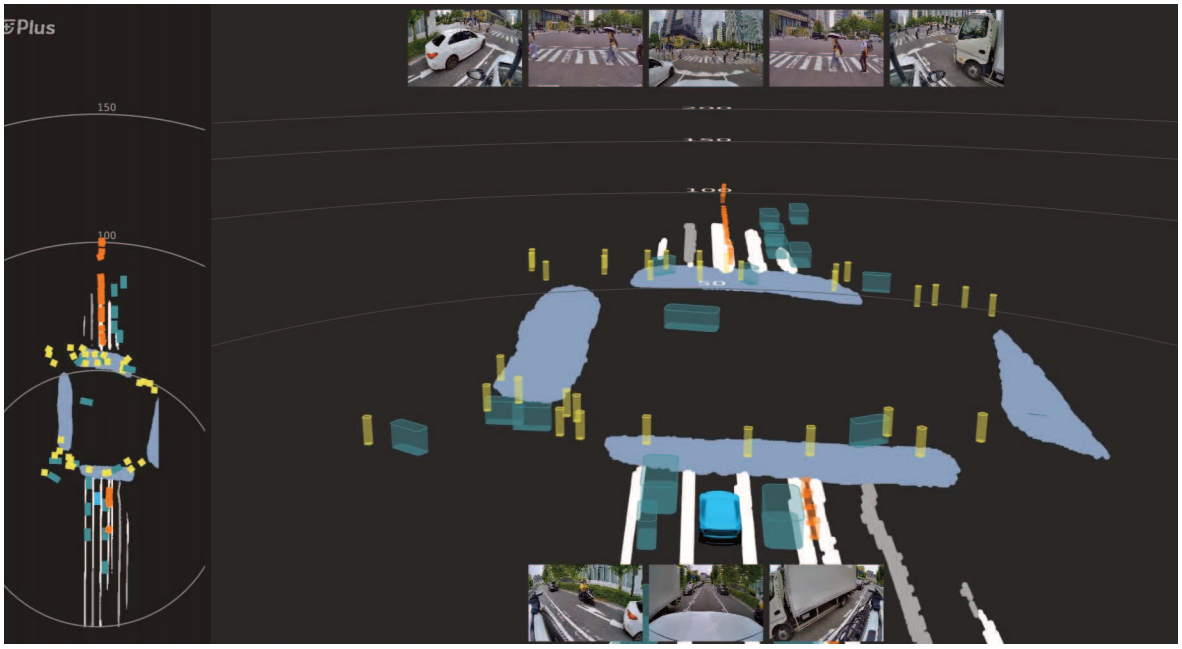
Highly automated driver-in systems will increasingly define automakers in the shift to a software-defined future. By Megan Lampinen

Automated driving is reshaping the mobility industry, putting software at the heart of vehicle design and development. Just as there are different levels of automated driving, so too are there different levels of the software-defined vehicle (SDV). While the industry continues to hammer out an official consensus on these, there appears no doubt that advanced driver assistance systems (ADAS) are among the defining characteristics of early applications.

"Ten years ago, premium vehicles were defined by horsepower and acceleration," says Shawn Kerrigan, Co-Founder and Chief Operating Officer of Silicon Valley start-up Plus. "Today, competition is switching to the ADAS offering: how advanced is it, how much safer or more comfortable does it make your vehicle? These are among the aspects that will define automakers in the move towards SDV."

Software for ADAS and autonomy

Founded by AI experts from Stanford University, Plus started life as an autonomous driving software developer targeting the trucking segment. It quickly gained fame as one of the first companies to test self-driving trucks in California. Since then it has expanded the focus and today provides the core software that underpins not only autonomous driving but also ADAS. "Some people have described it as software-defined ADAS," Kerrigan



© Plus

PlusVision perception software powered by transformer deep neural network models with bird's-eye-view embeddings as output, showing surround vehicle detection (teal), pedestrians (yellow), traffic cones (orange) at a busy intersection. Data from Tokyo, Japan

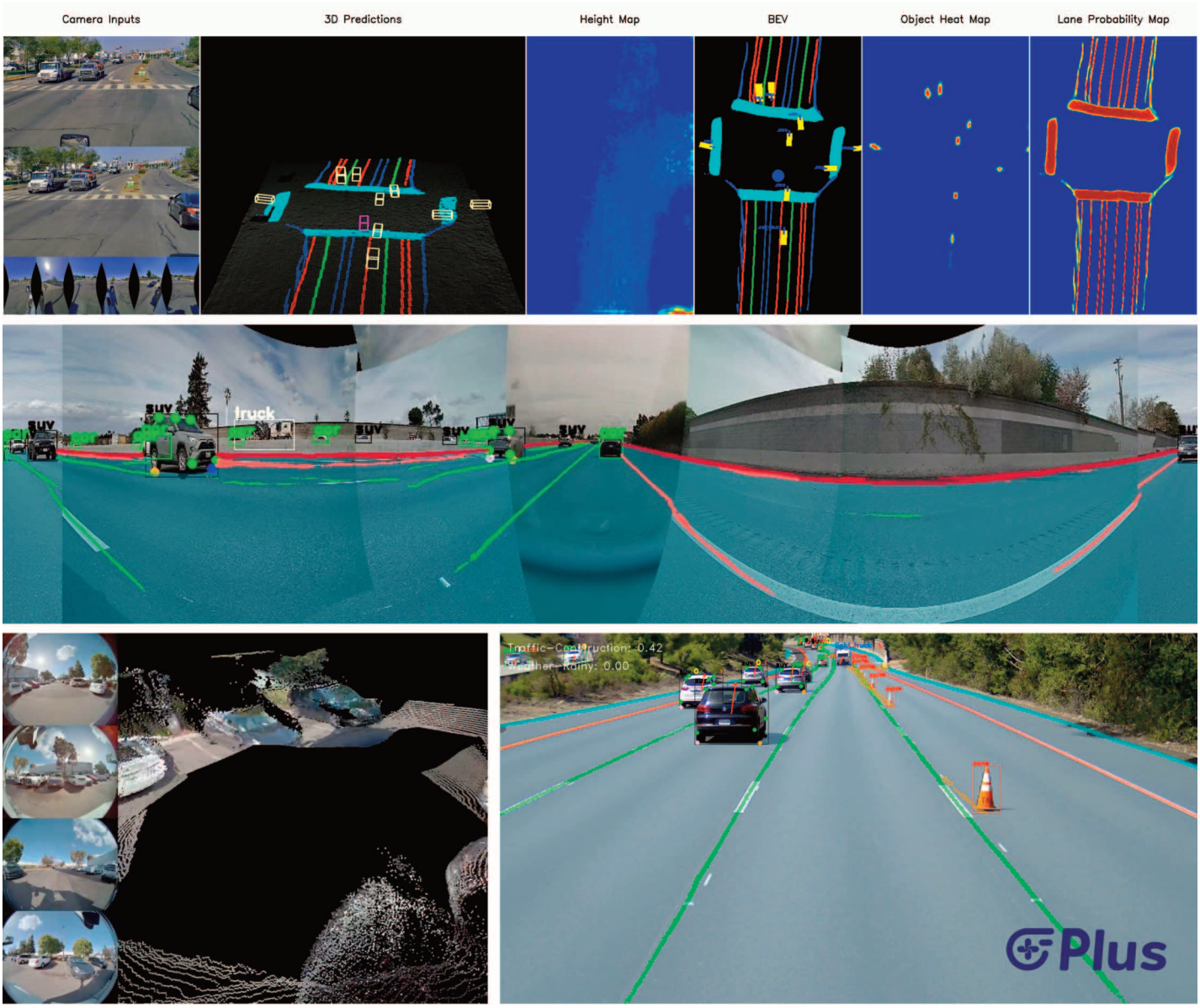
comments. Its Open Platform for Autonomy (OPA) is powered by AI models and supports automated capabilities across different sensors, processors, vehicle platforms, and powertrains. Today the OPA is offered as a suite of software solutions.

"ADAS is one of the most important parts of the overall transition to SDVs, and one of the more challenging aspects of these features is the deep AI required to understand the world around the vehicle," Kerrigan tells *Automotive World*. "That's where we come in with transformer-based neural networks." PlusVision is the company's AI perception software for passenger cars and commercial vehicles with SAE Level 2+ to Level 4 ADAS. "This gives a really robust 3D view of the world around the vehicle."

The idea is that automakers and Tier 1s can integrate these perception capabilities with their own automated driving platforms, tailored however they see fit for different trim levels and price points. The solution was unveiled in April 2024, and Plus is currently in implementation talks with various manufacturers. "The timeline on these programmes tends to be quite long, from selection through to start of production," he points out. "It's usually a couple of years."

Software complexity

PlusVision modules can fuse together data produced by cameras, radars and LiDARs, and are representative of the sort of software and compute requirements of the SDV. Notably, the solution has been designed to run on central ECUs. "In the shift toward SDVs, software is growing more complex and needs to be decoupled from hardware in order to accelerate development efforts and feature over-the-air (OTA) updates," explains Kerrigan. "We developed PlusVision as a flexible



software solution with a future-proof architecture that can adapt to the evolving autonomy needs."

As vehicles advance up the SDV levels, there is widespread agreement that they will require a shift in E/E architecture away from numerous individual ECUs coupled to single functions and towards a zonal approach. Zonal architecture consolidates electronics and functions into centralised zones, dramatically simplifying design and paving the way for OTA updates, more effective data management, and improved cyber security. In fact, some consider zonal architecture the cornerstone of the SDV.

"Vehicles might have 100 different ECUs controlling all the various functions," Kerrigan says. "That makes it hard to reduce cost and complexity, and to update and test new functionality. With the SDV, you want to consolidate that into centralised compute, ideally having one large compute that allows you to do everything. It offers much more potential from a personalisation standpoint, as well as a good way to drive cost reduction. These are among the top reasons for the emergence of SDVs."

While the end game is simplification, the journey is not straightforward. "There have been some high-profile

> **Ten years ago, premium vehicles were defined by horsepower and acceleration. Today, competition is switching to the ADAS offering**

reports in the news about automakers postponing vehicle launches because of delays in software," Kerrigan says. Not only does this new approach introduce a slightly different software coding paradigm, but there are also new challenges around a single computer running software from a number of different providers. "Making this transition is certainly not without complexity," he concedes.

Computing power is also a challenge. "AI that runs in the cloud these days is powered by immense amounts of computing. The computing capabilities on a vehicle have advanced tremendously in recent years but are still relatively limited and constrained compared to the processing power used server side." Power and heat limits are particularly relevant when running such applications on a vehicle. Plus is working with edge AI semiconductor company Ambarella on this front, offering PlusVision on Ambarella's CV3-AD AI domain controller family of systems-on-chip and boasting industry leading AI performance per watt. "Offering our transformer-based deep neural network to OEMs and Tier 1s on really power-efficient computer hardware enables them to build in flexible, high-performance and power efficient models," says Kerrigan.

Up next

Perception systems like Plus' are finding a home in all sorts of software-defined applications, and the company is equally bullish on the prospects for ADAS and autonomy. With roots in Level 4 autonomous systems for trucks, it counts big-name players like Traton and Iveco among its partners. At the same time, it anticipates strong demand for driver-in assistance features as well.

"We started out building end-to-end software for Level 4, in particular for trucking, but since then, we've found applications for that same advanced AI technology in vehicles with human drivers," says Kerrigan. "It's a great opportunity to have a really positive impact in passenger cars as well, given the big drive towards SDV and more advanced perception systems to improve safety and comfort. With solutions like PlusVision, we saw a huge opportunity to help make a positive difference and bring our technology to a broader market."

Plus has expanded its technology offering and partnership network considerably since the company was founded in 2016, but its own journey is far from complete. "We have a bunch of exciting announcements coming up over the next several months," teases Kerrigan.

Can weather data help to differentiate SDVs?

Vaisala believes better weather data integration can enhance the functionality of automotive software while decreasing accident rates. By Stewart Burnett

Images © Vaisala

For software-defined vehicles (SDVs) to be accepted as a clear upgrade over their traditional counterparts, automakers must demonstrate their functional superiority. While software offerings around infotainment and streaming can prove enticing to customers, they are already becoming standard features in most new vehicles. One area that may warrant further attention is the driving experience itself. Work is already underway across numerous fronts to achieve this, including advanced driver assistance systems (ADAS), electronic braking systems (EBS), and software-enabled drive modes that allow drivers to alter the car's centre of gravity and manage energy consumption.

The driving experience can also be augmented through better integration of weather data. Harnessing weather data and analytics can enable automakers to inform customers about road conditions in real-time, create more adaptive routing systems, and improve a range of driving software, including ADAS, autonomous driving (AD), and EBS. Lasse Lumiaho, Product Manager of Road Weather Forecasting at Vaisala Xweather, believes leveraging weather data will necessarily become a core feature of tomorrow's SDVs. "The impact of global warming is increasingly common, and cars will only become more sensitive to weather events as we transition towards being software-driven and electric," he tells *Automotive World*. "Helping drivers navigate this new environment will be key."

Real-time weather tracking

An effective and accurate weather monitoring system for SDVs constitutes two core components: atmospheric data and road condition monitoring.

Atmospheric data is aggregated from a wide variety of sources, both commercial and government. This builds a real-time profile of global weather that can subsequently be integrated with vehicle software to enable better routing and help drivers navigate around potential disruptions. Vaisala offers several solutions for atmospheric monitoring, including autonomous humidity and water vapour trackers and LiDAR-based devices that measure and analyse cloud activity. As part of a wider in-vehicle mapping system, profiles of these metrics can be used to alert drivers of potentially severe conditions and either propose alternative routes or discourage travel entirely.

Road condition monitoring is enabled by an interconnected network of roadside stations that monitor surface conditions. "In practice, this means providing real-time updates on how many millimetres of water, snow, or ice is on the road in a given area and making that information available to all drivers," explains Lumiaho. In the context of vehicle software, this means providing more granular data on how road conditions might materially impact safety and the broader driving experience. Vaisala operates a growing network of stations across the developed world, including much of North America, Europe, Japan, Australia, and New Zealand. He notes that more work needs to be done to expand coverage into developing regions.

Together these two components constitute the bulk of Vaisala's road monitoring platform for automotive applications, which can be integrated into vehicle software to provide drivers with continuous weather data. In November 2024, through a partnership with automotive data and software provider Nira Dynamics, Vaisala added a third component: connected car data. The company now integrates its automotive platform and existing AI and

Drivers could receive real-time updates on metrics including rain, air quality and wind pressure

machine learning-based forecasting models with Nira's billions of connected car data points.

"We're looking at reducing accidents and saving lives when this data is embedded into SDVs," remarks Lumiaho. "You could see areas where accidents occur in real time and issue warnings based on our road condition data–say, for example, due to slippery roads." Data from connected cars could in turn be relayed to road maintenance teams to increase responsiveness and deal with potential issues before they worsen.

Facilitating future mobility

While the integration of up-to-date weather and road condition data promises to make vehicles safer across the board, its most meaningful applications could be found in enhancing the safety and useability of technologies currently reshaping the automotive landscape. Lumiaho previously told *Automotive World* about the potential for weather data to make more accurate and dynamic indications of electric vehicle (EV) range. "A gasoline engine is only about 25% efficient, and diesel is 40%, but an EV can be up to 95%. This means that when environmental conditions affect performance, it's comparatively very noticeable."

Air temperature alone can diminish an EV's basic range by up to 40%, rising to 75% if roads are covered in snow or experiencing high winds. Supplying such information through the infotainment system, particularly when providing route options to drivers, could help them

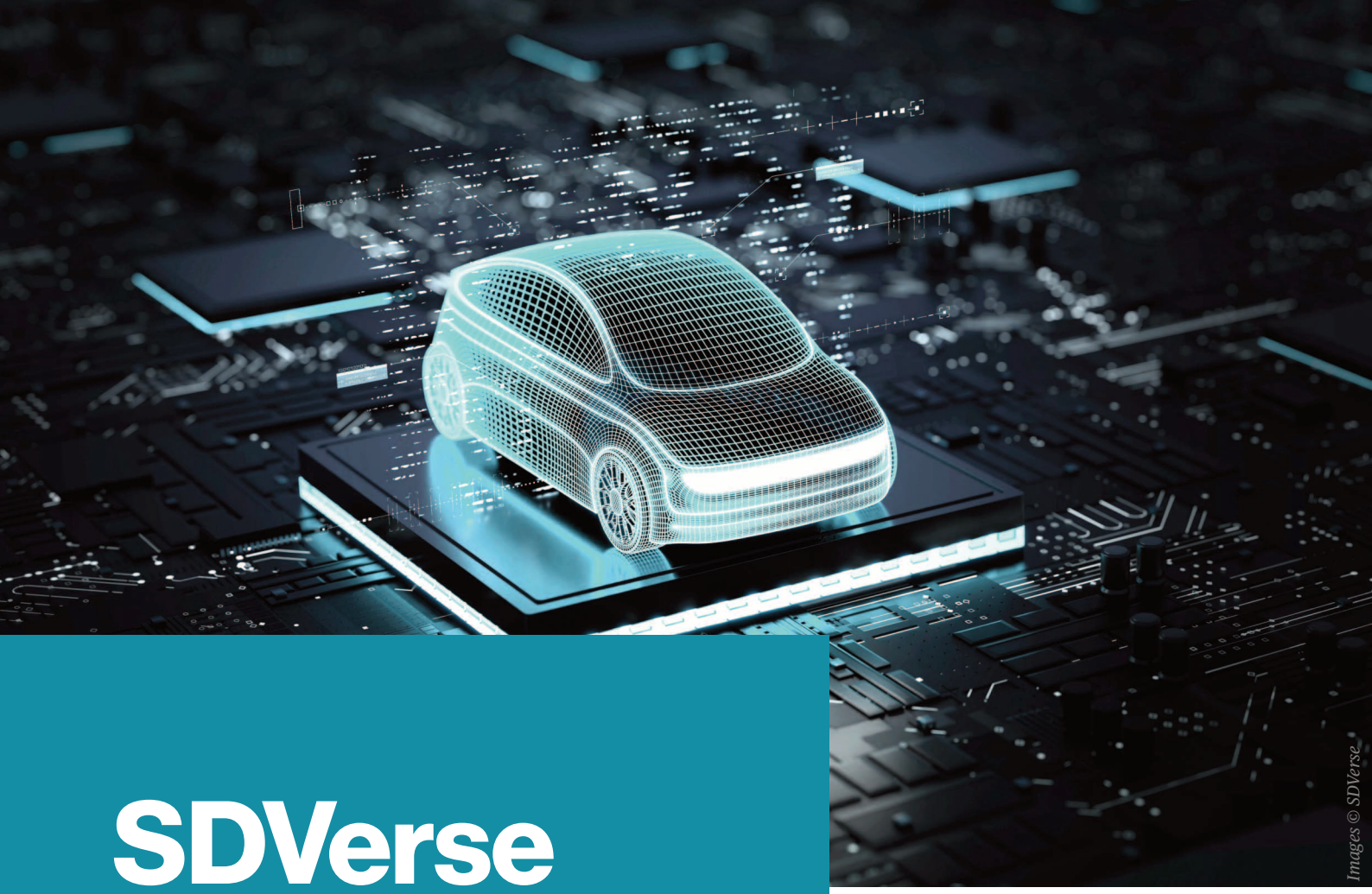
> **If you want to make the most of the data, you're going to need a live connection**

save time and money, or prevent the car from running out of energy in a charging dead zone. Beyond determining EV range, this data can be used to make recommendations on software-enabled driving modes—for example, suggesting a switch to eco-mode when driving in inclement weather. In addition, EBS can be dynamically reconfigured to help drivers navigate slippery conditions or severe winds.

Better integration of weather and road conditions data sets would also facilitate the rollout of more advanced software offerings like ADAS and AD. Lumiaho opines that such data could prove essential for facilitating these features on a number of fronts, including reliability, safety, and consumer trust. "If you use this data, the vehicle can better understand the friction of the road surface and thereby help to increase the availability and safety of these features." AD could be disabled in conditions it is inadequately trained to navigate, while ADAS could be activated to hit the emergency brakes and prevent an accident. Beyond in-vehicle applications, Vaisala's data sets could also be used to better train ADAS and AD systems, improving their performance in extreme weather conditions.

Ultimately, Lumiaho believes that deeper integration of weather and road condition data will facilitate the realisation of SDVs across several fronts, demonstrating clear advantages over their more traditional counterparts. However, uneven connectivity—particularly in more remote locations—may impact the reliability of its real-time predictions. "If you want to make the most of the data, you're going to need a live connection," he states. "This also extends to ADAS and AD use-cases. Today's sensors might be able to see what's happening 200m ahead, but they can't see around corners or what lies beyond an incline."

With time, he believes that the usage of such data will become commonplace in automotive software, in part due to the increasingly common nature of extreme weather events. Consumers will see it not as an add-on or subscription option but a core SDV feature included as standard at purchase. "It's definitely more of an add-on today, but safety should not be compromised because somebody did not subscribe for a service. We are already seeing software features from high-end vehicles trickling down into cheaper models, and I expect that the same will happen here."



Images © SDVerse

SDVerse provides an 'Amazon' for automotive software

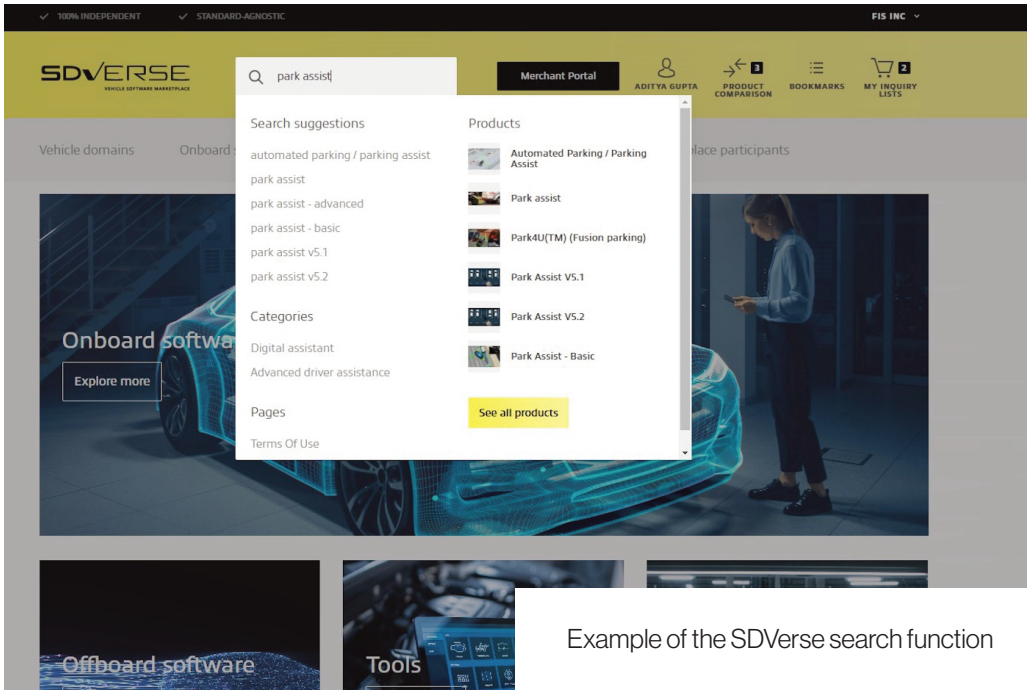
Through its e-commerce platform for auto software, SDVerse hopes to save automakers time and money and accelerate SDV adoption. By Will Girling

Developing software-defined vehicles (SDVs) promises to unlock significant new value and monetisation opportunities for automakers. However, they must currently account for two deficiencies: lack of native software talent and an organisational culture that isn't as conducive for software development as Big Tech's. With even well-resourced brands like Volkswagen struggling to manage the transition, an in-house approach may not be optimal.

Over the last three years, automakers have spent almost US$100bn on automotive software. "The industry recognises that the future will be defined by software, and in-house sourcing is one of the big and costly experiments happening right now. But a lot of

OEMs are now realising that there isn't enough talent for them to do everything by themselves," says Prashant Gulati, Chief Executive of SDVerse. The idea for his company, a global B2B market for buying and selling auto software, began to gestate in 2023.

Founded from a collaboration between General Motors, Canadian Tier-1 Magna and Indian IT solutions provider Wipro, SDVerse aims to unify what Gulati calls a "fragmented" ecosystem. "We've created a platform to help OEMs and suppliers can find the companies selling the software they need and integrate it." The goal is to let the marketplace provide a foundation that will enable automakers to channel their resources to differentiation instead.



Example of the SDVerse search function

Amazon for auto software

The problem with moving away from in-house software development is that the alternative is not necessarily much easier to navigate. Streamlining SDVs depends on knowing exactly what the market can already offer so companies don't constantly reinvent the wheel. However, as the importance of software accelerates, the industry has no common overview.

Gulati highlights that auto software discovery often lacks cohesion: procurement staff must piece together what they need to know through "analogue" channels, which could range from conversations with suppliers to attending in-person conferences. "It's difficult even for people moving from the tech industry to automotive. Finding out whether the software they need already exists could take months."

Officially launched on 30 September 2024, the SDVerse marketplace aims to enhance auto software discovery and thereby accelerate commercialisation by up to 80%, according to Gulati. "The user experience is similar to an e-commerce platform like Amazon. Customers log in and search and compare different products." At the time of writing, there is no community rating mechanism for the results.

Designed for maximum efficiency, SDVerse allows sellers to list the precise features and attributes of their software, making it easy for buyers to find them. By inputting search terms like 'parking software for a chipset with AUTOSAR compatibility on a Linux operating system', the marketplace will provide applicable options. Buyers can then ask sellers questions live to ensure software compatibility.

The importance of feedback

For many in the industry, Tesla's success is proof that focusing on vehicle software can provide significant new value for the industry. However, not every automaker is starting from the same position. "It's far easier

for companies with a 'clean sheet architecture' to make the transition," says Gulati. "The challenge is greater for players with established supply chains, especially large automakers."

SDVerse is also guided by a wider advisory council of industry executives from a wide variety of partners, including NXP, FEV, Forvia, and Valeo. From this feedback, companies within the ecosystem can ascertain how best to meet the evolving needs of automotive software. "This isn't just a passive marketplace for buying and selling," Gulati emphasises. "With these learning opportunities, we can more successfully monetise SDVs." This is particularly important given software's shorter product cycles relative to hardware, with which industry players have more prior experience.

He hopes that more OEMs and suppliers from every major global market will join and enrich SDVerse as the venture develops. In the short term, monitoring engagement and activity on the platform will be Gulati's main focus, but expanding the range of products available is also a priority. Currently, the platform provides a range of foundational offerings–including cloud services, battery management software and tyre pressure monitoring solutions–with 180 comparable attributes. In the near future, he anticipates a surge of new artificial intelligence features.

For the industry, by the industry

Making automotive software independent from hardware has become a common rallying cry in the SDV community. By doing so, advocates such as Gulati believe more features and faster time-to-market can be unlocked. He points to Microsoft as representative of a similar inflection point for personal computers decades earlier: "It was the first company to develop software that could work on all hardware platforms." For SDVs to flourish, automakers and suppliers must pursue a similar agenda.

"A lot of companies are exploring the shift from domain to zonal architectures. That work is important, but it's also costly and time consuming, and the return on investment is uncertain." Gulati positions SDVerse as a market force to instigate change even among legacy manufactures not yet exploring the possibilities of new architectures. As the automotive industry enters what former Stellantis Chief Executive Carlos Tavares called a "Darwinian" phase of big wins and losses, Gulati believes conserving resources will be paramount. "If an OEM can save six months of effort by purchasing some software that it was going to develop in-house, is that not valuable?"

If or when the transition to zonal architectures is complete, he posits that SDVerse will become more valuable still. "It will become even easier to find the right software, because then issues around hardware compatibility fade away." Citing Warren Buffet's creed that resource allocation should be a business leader's number one priority, Gulati concludes that automakers must move away from the idea of becoming one-stop-shops in the SDV era. "There are plenty of consortiums looking to standardise the underlying technology; we're interested in driving adoption by making the value of SDVs apparent. SDVerse is for the industry, by the industry; individual efforts will not work anymore."

SDV ecosystems transform product development and ownership

Software-defined vehicles will create new value but also change the OEM-supplier dynamic and redefine product economics. By Will Girling

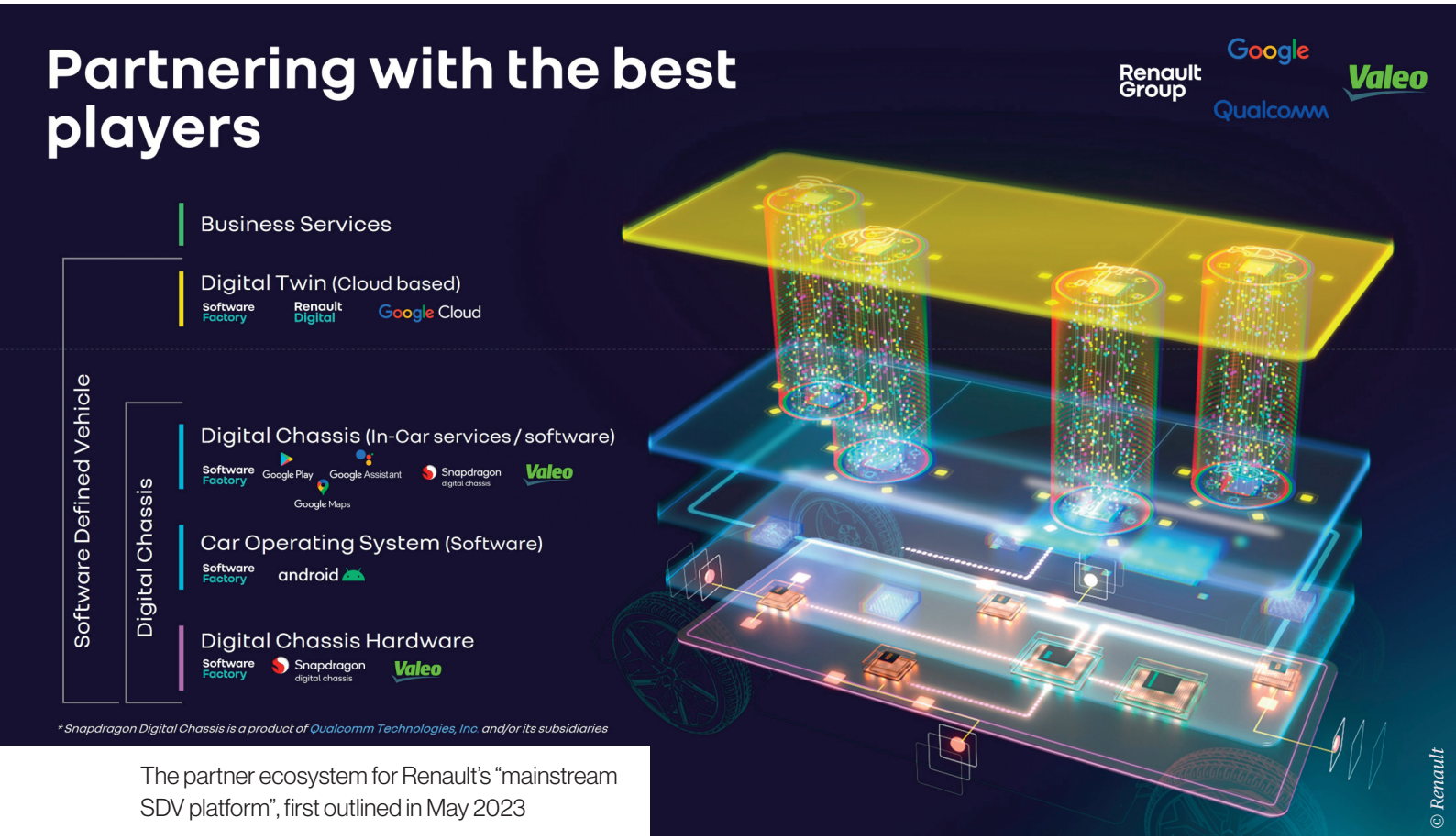
Although the transition to software-defined vehicles (SDVs) is challenging for all automakers, start-ups at least have the advantage of a 'clean slate' on which to develop their products. Incumbents, meanwhile, must find competitive and cost-effective methods to design new architectures while simultaneously maintaining their legacy technology.

However, the challenge isn't just technological: SDVs also require a new mindset. Instead of producing finished vehicles that will not significantly change once they leave the factory, OEMs will be expected to create adaptable products that can continuously evolve for years. From management philosophy to supplier ecosystems, SDVs represent the dawn of a new way of working for automotive players.

The challenge and the opportunity go hand-in-hand. Derek de Bono, Head of SDV at Valeo, believes the immediate focus should be on finding a way to manage unchanging hardware and constantly updating software. "The industry has always dreamed of a car that could evolve with the customer, but hardware needs to provide a solid enough foundation for that dream to come true."

SDVs require ecosystems

De Bono states that the complexity of SDV central compute units and their integrated software layers is such that no company can manage the transition alone. "An ecosystem of partners is necessary, each bringing their own expertise on a range of subjects–from AUTOSAR to system-on-



The partner ecosystem for Renault's "mainstream SDV platform", first outlined in May 2023

chips and in-vehicle infotainment." Success, he continues, will depend on agile, collaborative, and fast-paced work environments.

Both the projects and the associated challenges will be bigger than ever before, and automakers must accept that SDV development will redistribute their previously consolidated ownership of delivery to partners across the ecosystem. "Everyone will be invested in ensuring a vehicle goes to market in time and meets the same quality standards a brand's customers expect."

As a diverse smart tech supplier and partner, de Bono states that Valeo's role in each SDV project could vary significantly. Although some might primarily consider it a hardware supplier, the company has also been involved in software for around 30 years. As SDVs gain industry momentum, Valeo is undergoing a "slight transition" to "shine a light" on what it can do in the software realm, too.

Co-developing, co-owning

There is an emerging consensus in the SDV space that hardware must be decoupled from software to maximise value. "Product lifecycles not only will be different, they have to be different," says de Bono. "If the industry wants to ensure the safety and stability of a vehicle for 15-20 years, there needs to be a new understanding about how the changing (software) and unchanging (hardware) elements come together."

On a practical level, this will impact how partner ecosystems collaborate: he emphasises that participating in the creation of an SDV requires an ability to adapt as the project evolves. At any time,

Valeo might start by supplying hardware and then switch to integrating and validating its own or a third party's software stack. The level of input each partner contributes will be determined by its ability to meet the needs of a highly diverse product.

Valeo's portfolio of offerings—called 'Valeo anSWer' and based on three pillars: applications, middleware, and services—give it a wide range of competencies in the SDV ecosystem. This also means it can collaborate with automakers working towards important industry milestones, such as Renault's pursuit of a mainstream SDV platform. "It's important that SDV architectures don't just stay in the premium vehicle market," adds de Bono. Joining Google and Qualcomm, Valeo will supply Renault with a high-performance computer, as well as other electrical/electronic components, software packages, and testing and validation services.

SDVs, he continues, promise to change the concept of value in the OEM-partner ecosystem. Working with BMW, for example, Valeo is delivering a new domain controller in partnership with Qualcomm, a sensor set, and a parking stack. Meanwhile, it has also been helping to develop SAE Level 4 valet parking over the last two years. To do this, Valeo uses an aggregated cloud of data from in-built vehicle sensors to produce crowdsourced maps.

The more collaborative nature of this product development subsequently changes the traditional ownership paradigm. Once BMW's L4 functionality has been achieved, de Bono states that the resulting maps can then be sold to other interested OEMs and service providers. "That's a completely new way of working. It's not suppliers delivering for BMW; it's everyone co-developing and co-owning the resulting IP."

Economics of SDVs

New ways of working in the SDV era might ultimately be a matter of economic necessity. De Bono recognises that initial investment costs will be high: "A vehicle today has between 50 and 150 ECUs, and with those comes complex and expensive wiring harnesses. However, once installed, the architecture can be simplified over time to reduce the number of ECUs." This not only generates savings in the first instance but also creates space for more hardware and functions down the line, an essential component of the SDV ethos.

"A truly successful SDV means evolving the vehicle with the buyer." He uses the example of someone purchasing a vehicle while living in an urban environment. While the "basic lighting package" might be sufficient at the time, if that person later moved to the suburbs, where late-night driving in darkness became necessary, enhanced lighting would become desirable. "That could be achieved through an over-the-air software update. But the point is you need that hardware already present in the vehicle." In electric vehicles, De Bono suggests the same principle could also apply to powertrain upgrades for vacations.

If the challenge of SDVs is how to make them financially viable for manufacturers, de Bono believes this 'pay to unlock' business model will create enough long-term value to justify automakers' high initial investment. By saving money on what the customer doesn't see—the architecture—OEMs can invest in more hardware that can be enriched through software. In the next 18-24 months, he expects to see the first wave of SDV products that capture this opportunity come to market.

Cyber security strategy: SDVs raise the stakes

With functions and features increasingly defined by software, how can automakers ensure their products are secure? By Megan Lampinen

Cyber security has been a growing concern within the automotive industry, particularly as cars become more connected. Formal hackathon events and independent white hat exploits by researchers have demonstrated that it's technically possible for a remote actor to access all sort of vehicle systems. From hijacking driving controls and causing sensor hallucinations to capturing the wireless modem that receives over-the-air (OTA) updates, playing video games on the infotainment system and interfering with the windshield wipers, no system is fully secure from intrusion. But in terms of documented, in-the-wild, on-the-road cyber attacks on connected vehicles, these are few and far between.

"Given some of the well-publicised vulnerabilities, one would expect to have seen numerous attacks," notes Dante Stella, a cyber security lawyer with Dykema. "Several things could explain why we haven't."

To start with, there doesn't seem to be an easy way to monetise these vulnerabilities, and Stella notes that many potential cyber criminals remain unmotivated by vehicles. At the same time, the lack of software uniformity across manufacturers makes it more difficult for malicious actors to create economies of scale when developing attack techniques. Stella also suggests that the number of connected vehicles in operation is probably "still too small to excite state actors bent on paralysing infrastructure or inspiring

OTA updates open up new attack vectors

other terror." That said, attackers with sufficient incentives could still cause damage to a targeted vehicle.

So far, most of the cyber attacks within the mobility sector have involved stealing customer data from customer service departments, ransoming production systems, and pranking electric vehicle (EV) charging stations. "None of that is good, but we are not in the 'robotaxi revolt' phase," Stella tells *Automotive World*. "Well, not yet."

Software is in everything

While a fully autonomous ecosystem remains a distant prospect, the age of the software-defined vehicle (SDV) has arguably arrived. The industry has begun to position for a future in which vehicle functionality and the customer experience are shaped by software. With OTA updates, both of these can continually evolve over a vehicle's lifetime.

"Software is in everything," asserts Brian Irwin, Managing Director with Alvarez & Marsal's Automotive and Industrials group. The firm's Global Cyber Risk and Incident Response Services practice advises on cyber resilience and assists with cyber threat hunting, code reviews and penetration testing as well as red teaming. "Software runs throughout the entire vehicle—it's even in the rear-view mirror." Some modern vehicles have upwards of 150 million lines of code. In comparison, an A737 airplane has 75 million lines of code. This new paradigm raises several new potential security concerns.

"SDVs accumulate vulnerabilities by an increasing reliance on a stack of software components—some purchased as commodities, some open-source, some custom-developed," Stella explains. "Every component of the stack can have its own vulnerabilities, including 'inherited' ones." For example, if a car leverages a version of an operating system that has a particular vulnerability, the car could have that same vulnerability as well. This puts the focus on supply chain management and the use of software bills of material (SBOMs) to know exactly what goes into a vehicle.

Stella notes that this software stack offers multiple points of entry for compromise in the SDV's manufacturing or software update process through supply-chain attacks. "Should a threat actor compromise the systems of a supplier that provides one of the software components, a fleetwide vehicle software update could effortlessly proliferate a vulnerability or malware to hundreds of thousands of cars simultaneously."

Ruediger Ostermann, Vice President and Chief Technology Officer of Global Automotive for TE Connectivity, similarly flags the supply chain as a key security focus within the rise of SDVs. "GM and Ford don't build things like high-performance computers themselves," he notes. "They rely on suppliers to provide them and ensure their development processes contain an element of cyber security validation."

Standards and best practice

This is where regulations and guidance on best practice play an important role. The UNECE World Forum for Harmonization of Vehicle Regulations' (UNECE WP.29) regulation on cyber security (R155) requires all new car lines launched from existing electronic architectures to obtain cyber security system type approval as part of the whole vehicle type approval process. R156 issues similar requirements for OTA updates.

At the same time, the industry is establishing SBOM standards and procedures to ensure that software is sourced and deployed in such a way as to ensure the integrity of the stack, identify vulnerabilities, correct or compensate for them, and trace any apparent issues. Auto-ISAC (the Automotive Information Sharing and Analysis Center) is one of the groups leading the push for industry-wide standards, practices, and procedures for SBOMs.

While Stella observes that SBOMs could help curb risks with 'buy' versus 'make' software, he cautions that "automakers will always run into a tension between effectiveness and economic reality. The most secure systems would be built in-house using principles of security by design and least access."

In practice, that's not terribly realistic, at least at the moment. As he elaborates, tremendous cost pressures serve as a powerful incentive to use commodity or lightly customised software components rather than reinventing them. On top of that, automakers are not typically vertically integrated, and some systems are designed by suppliers that may provide the same hardware/software components to numerous OEMs. Similar base hardware and software could create shared vulnerabilities, and "the desire to accommodate future software changes could lead to systems that are more flexible—and vulnerable—than they need to be," he warns.

Playing with fire

The challenge of securing SDVs is made more difficult by the growing industry pressure to innovate at an accelerating rate, and for automakers to be the first to market with new features. "Technology in vehicles is increasing exponentially. Consumers want artificial intelligence (AI), electrification and new customer experiences," says Rocco Grillo, Managing Director and Head of the Global Cyber Risk and Incident Response Services at Alvarez & Marsal. "If you don't bring your idea to market first, 100 other companies could grab it, make it better and bring it to market themselves."

> **A fleetwide vehicle software update could effortlessly proliferate a vulnerability or malware to hundreds of thousands of cars simultaneously**

The trouble, as he sees it, is that some players may overlook something or fail to test sufficiently. “That race can’t be at the expense of security,” Grillo emphasises. “You can’t just tack it on at the end. Technology is like fire: it’s good, but if you don’t manage it, it could result in a crisis or even become catastrophic.”

AI in particular has prompted concerns among consumers, but it’s impact on cyber security is currently unclear. “It is difficult to predict the extent to which AI will pose a threat unique to SDVs,” says Stella. “We know already that threat actors use AI for social engineering–tricking people into giving up credentials–and for writing malicious code and defeating endpoint protection. As vehicles lean more heavily into AI for delivering driving dynamics or entertainment, we can expect to see attempts to influence those systems or cause them to fail.”

His advice to developers within the SDV ecosystem is pragmatic: incorporate security, privacy, and data minimisation consistent with emerging data protection laws and DevSecOps principles; explore layered defences, so a single vulnerability does not hand an attacker the keys to every system in an SDV; carefully consider the cost/risk trade-offs in software sourcing choices; and aggressively manage the software supply chain, using SBOMs and other methods, to enhance verification, auditing, traceability, and accountability.

These steps should provide a practical foundation for secure vehicles, though nothing can ensure complete protection. “As technology evolves, cyber risk will evolve too, without question,” says Grillo. “The threat actors will find ways to circumvent controls. It doesn’t mean that we unplug the internet–that’s the only way you’d really be 100% secure.”

Irwin points to the phrase “with great power comes great responsibility”, a sentiment found in various wordings across historic texts but popularised by the Spider Man series. “As we embed greater and greater feature functionality, the opportunity for disruption increases. Those responsible need to up their game and make sure that we’re protected.”

Qualcomm: SDV is "redefining" modern vehicles

Qualcomm's technology underpins the evolution from a hardware-based industry to one defined by software.

By Megan Lampinen

Images © Qualcomm

Qualcomm's push into automotive is gaining momentum as the industry revs up its digital journey. The company's Snapdragon Digital Chassis cloud-connected automotive platforms power hundreds of millions of vehicles on the road today, rapidly establishing themselves as the industry standard. Serving as the building blocks for connected and automated features, they are designed to address the evolution of vehicles from products defined by hardware to those defined by software.

"This is truly redefining the modern automobile," says Nakul Duggal, Qualcomm's General Manager of the Automotive Business.

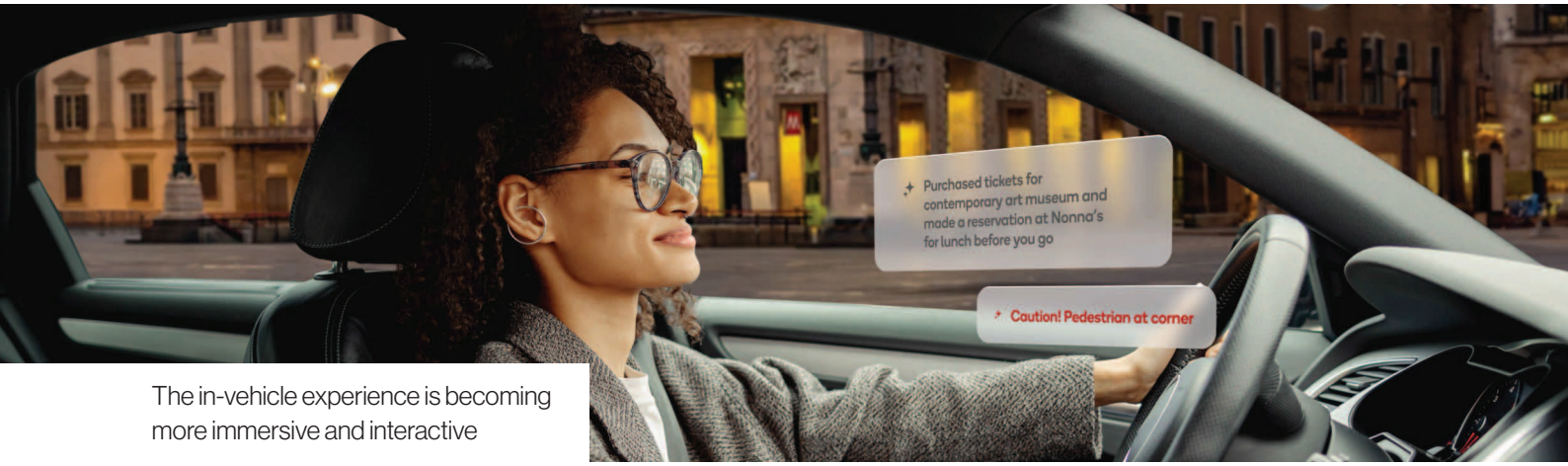
The digital lifestyle

Duggal has been with Qualcomm since the 1990s and helped guide its evolution into automotive. The company, best known for its mobile chipsets, is also active in computing and IoT. With the move towards software-defined vehicles (SDVs), automotive is poised to play an increasingly important role. Qualcomm currently has a US$45bn automotive order pipeline and expects its automotive business to generate US$8bn in revenues by 2029.

As Duggal tells *Automotive World*, it's all about anticipating industry trends: "We build platforms that meet the needs of our customers and end consumers. With more complex technology integrated into the vehicle, cars are moving towards centralised compute architecture, which means greater integration. Vehicles are increasingly defined through software. The beauty with this is that design is continually updated over the vehicle's lifetime."

Driving this trend is the move to incorporate the vehicle into the consumer's digital lifestyle. Seamless integration with smartphones, wearable devices, and connected home technology is becoming not just desired in a new vehicle but expected. "From a consumer perspective, the car is an extension of their digital life," Duggal observes. "We spend a considerable amount of time in the car. People want to carry out their usual activities there, get work done, make memories. They want it to be an asset that has value. Because of this, the digital aspect is becoming increasingly important."

A big part of Qualcomm's focus is on understanding exactly what digital lifestyle experiences consumers want in the car and enabling them. The company is currently working closely with automotive partners on this. "Part of the challenge is that auto industry hasn't traditionally thought about cars in this way," he says. "The product is starting to evolve, and everyone is trying to figure out what that means. Some automakers are adapting very rapidly, others are on a more incremental path, but the change is happening."



The in-vehicle experience is becoming more immersive and interactive

AI excitement builds

Qualcomm doesn't provide the digital experiences but rather the foundations on which automakers can build their brand-specific UX offering. Snapdragon Digital Chassis includes the Cockpit platform, Car-to-Cloud, Auto Connectivity and the Ride platform, as well as the recently added Cockpit Elite and Ride Elite. These two most recent additions target advanced digital experiences and automated driving capabilities, respectively, and are designed to facilitate the industry transition towards SDVs.

"We are building software that we can develop in the cloud and deploy at the edge in a continuous manner," Duggal explains. "If somebody thinks of a new feature, they will test it out in the cloud and push an update, similar to what happens on a laptop computer."

Google is just one of the technology partners with which Qualcomm is working to make it easier for automakers to meet SDV requirements. In October 2024, the two companies announced a new collaboration, bringing together technologies from the Snapdragon Digital Chassis, Android Automotive OS, and Google Cloud to produce a new standardised reference platform for AI-powered cockpit solutions.

Qualcomm is positioning itself as a connected computing company for the emerging era of AI processing. The partnership with Google specifically looks to deploy Google AI to create in-car experiences based on generative AI (GenAI), a form of AI that can produce content based on inputs. That could take the form of an intuitive voice assistant, an immersive map experience, real-time updates that anticipate driver needs, etc. All of these will be powered by Snapdragon heterogeneous edge AI system-on-chips.

"I'm very excited about AI," enthuses Duggal. "It is such a valuable tool. Over the last year and a half, developments within GenAI have allowed humans to consume information that a machine produces." As an example, he points to how a user can provide a simple command to the car such as 'tell me how to change a tyre.' The AI takes into account context and knows what sort of car to which the person refers. It then searches the car's user manual and can intelligently provide the exact information requested. Such functionality represents a huge step up from simply supplying a list of search results.

Snapdragon Cockpit Elite and Snapdragon Ride Elite

Connecting data to action

This is just the tip of the iceberg with AI capabilities within the vehicle. “It comes down to connecting data to information to action,” says Duggal.

Imagine a hot day in which two individuals are sitting inside a vehicle for a certain length of time. The car can detect their presence, the high temperature inside and outside, and the fact that they have been sitting there for several minutes. “It should ask itself, ‘What potential actions could I offer to the people sitting inside?’” The obvious one is to suggest lowering the cabin temperature.

“These are all things that are very possible as you start to connect the dots, but it is not how a car has traditionally been designed,” Duggal says. Compounding this is the level of fundamental complexity within the automotive sector, particularly compared to other software-defined products like phones and computers: “A phone is either Android or Apple. A computer could be a Mac or a PC. However, there are hundreds of car platforms, and because every automaker wants to make their own brand imprint, you need a variety of players to come together over time.”

The industry is also facing a skills shortage. “There is not enough of the right type of skillset within automakers, which shapes what a company does in-house and what it relies on others to do,” says Duggal. Many have been turning to Qualcomm in their journey towards greater automotive intelligence and the SDV. In fact, Chief Executive Christiano Amon claims that the Digital Chassis can be found in vehicles from “virtually every automaker.”

As Duggal concludes, “Given the pace at which technology is changing and automakers are thinking of new experiences, this platform sets things up for what’s to come both for automated driving and the digital car.” If all goes to plan, the coming years will see Snapdragon ignite new digital experiences and capabilities in the transition to a software-defined future.

Accenture: SDV requires transformational software mindset

Accenture's acquisition of AOX aims to provide embedded software architecture expertise while also encouraging digital native mindsets. By Stewart Burnett

Automakers have not experienced equal success in transitioning to software-defined vehicles (SDVs). Legacy automakers have generally faced setbacks that their newer counterparts successfully evaded. This has led to some older brands reaching out to start-ups for collaboration.

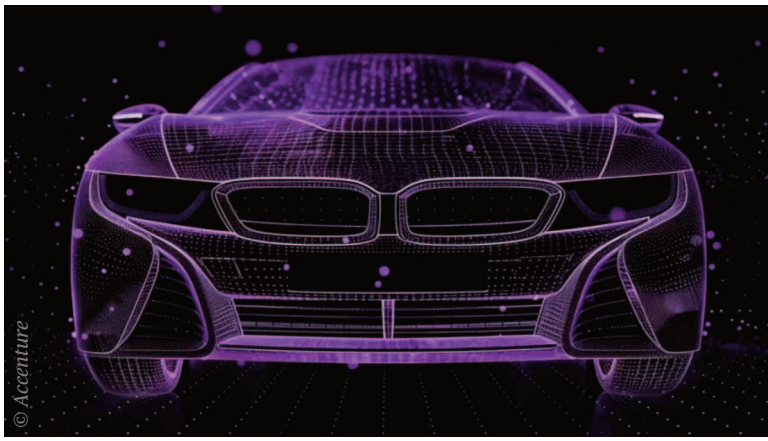
However, these partnerships will not be a feasible option for all brands. For some time, strategy and consultancy firm Accenture has maintained that a fundamental shift in organisational mindsets will be crucial for everyone to succeed in their SDV ambitions. In March 2024, it launched the LearnVantage Academy, an educational platform intended to instil this message, while also building core competencies and coaching leadership.

Then, in December 2024, Accenture announced it would acquire automotive digital technologies firm AOX. According to Christof Horn, Global Head of SDV at Accenture, this will bolster the consultancy's ability to help its clients excel across the entire software development process. "Software expertise is becoming the dominating factor in the market. The AOX team will become another pillar of the automotive technology powerhouse Accenture has been building over the past few years."

Capacity for hire

Taking cues from the amenability of major automakers to external partnerships, AOX is intended to act as both a support player and a strategic partner in software development for Accenture. The firm's expertise spans from ideation and architecture R&D through to maintenance and firmware updates across the entire vehicle lifecycle.

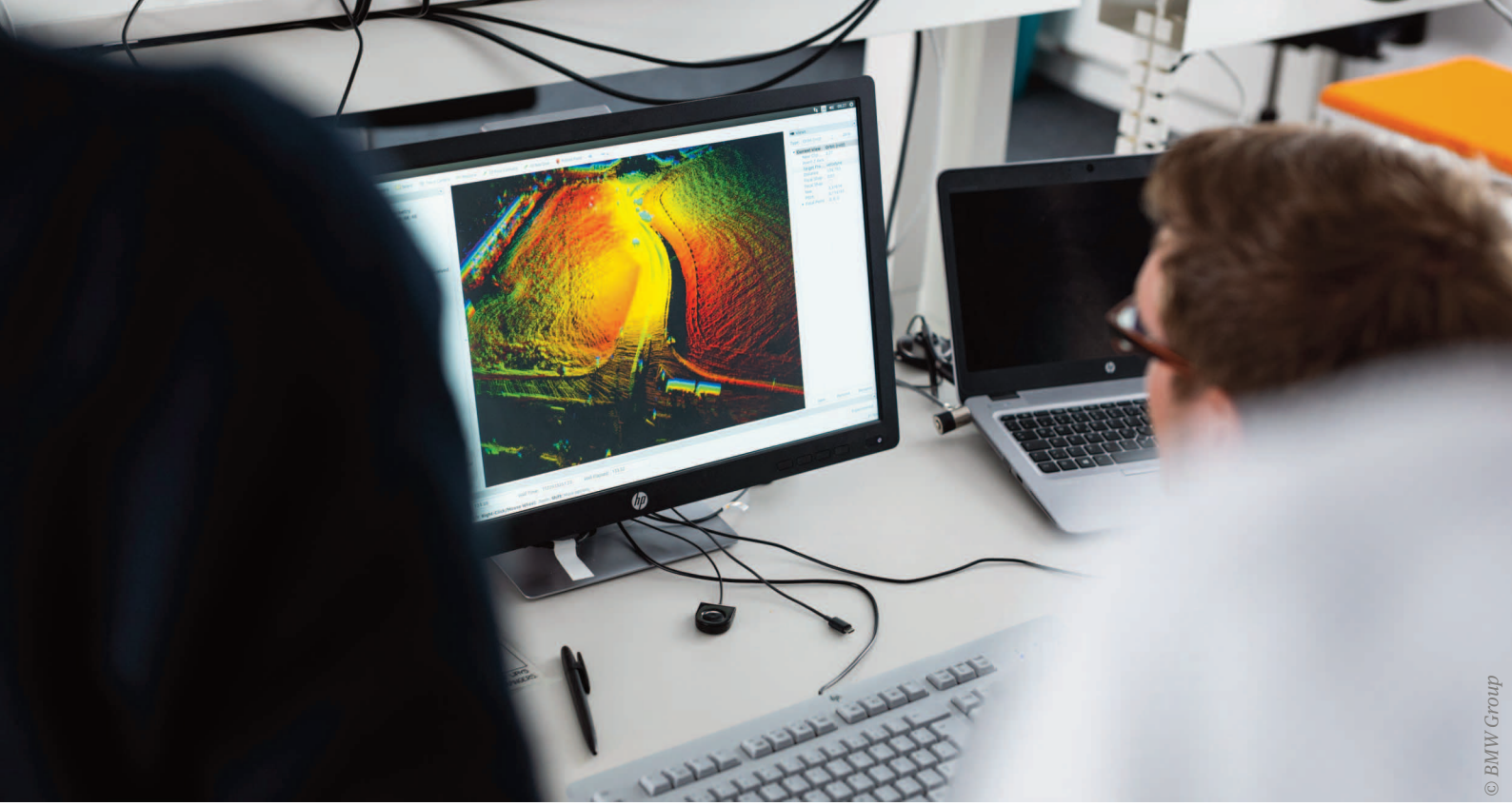
"The acquisition of AOX is another strategic move in further growing our SDV capabilities Juergen Reers, Global Automotive and Mobility Lead at Accenture, tells *Automotive World*. "There's a reason for that: it's strongly focussed on in-vehicle software architecture, model-based system engineering, providing consultancy work, and enabling the overall transformation." By bringing AOX into its wider SDV operation, Accenture hopes to build upon its existing offerings with direct software development capacity.



AOX can help automakers with direct software development support on their SDV journey

While fostering 'digital native' mindsets and a transformational approach to automotive design—hallmarks of the LearnVantage platform—remain crucial to the wider SDV mission, these may not address the more pressing realities automakers face meeting software development deadlines. "Transitioning to software development isn't easy. It changes not only the vehicle itself, but also its integration within the wider digital infrastructure," says Reers.

AOX will provide automakers with software architectures and written lines of code while also bolstering Accenture's consultancy effort. In doing so, Reers explains, automakers are



empowered to continue their transition towards SDVs unabated, while still transitioning away from hardware-oriented legacy mindsets. Accenture can also plug gaps in an automaker's current software development capacity and help it facilitate the transition. This, in turn, helps prevent increasingly common occurrences such as vehicle launch delays due to software development issues, keeping automakers on track with their product release schedules.

Frameworks for success

While AOX can undertake a range of software development and support capacities–from high-performance controllers to specific areas like in-vehicle sound–its primary expertise is in building architectures that serve as a foundation for the entire vehicle design strategy. "If you want to build a house, you need to get the architecture right at the start," remarks Horn. In practice, this means "solid" and "seamless" processes and standard operating procedures that can be iterated throughout the vehicle's design cycle and subsequently in maintenance.

For automakers still getting to grips with the fundamentals, Accenture can support how to deliver and iterate software. For example, in October 2024, the company released a major update of in-vehicle software–a layer that translates communications between the vehicle's hardware components and the applications running on top - as open source, making it available for OEMs, tier ones and silicon vendors. Accenture states that this software is now running in some five to six million vehicles currently on roads. Given the demanding timelines in which automakers aim to realise their software ambitions and the relative lack of industry experience, Reers believes having third parties step in, do the work, and provide guidance on how to achieve similar results could prove highly advantageous.

Accenture and AOX make recommendations based on automakers unique SDV goals, but also offer software components and deep technical expertise. One of AOX's particular areas of expertise is QNX and other real-time operating systems– software platforms

> **If you want to build a house, you need to get the architecture right at the start**

currently gaining traction in the automotive industry and used in applications where low latency and safety are crucial. Reers notes that demand in such technologies will likely increase as automated driving continues to gain traction.

Lifecycle awareness

Another area in which AOX can assist automakers is code optimisation. This is a universal theme across all software development: the leaner the code and the better it suits the unique capabilities of the hardware on which it is running, the faster and more efficiently the resulting software will perform. “You need to understand that this is a very restricted environment in terms of memory and compute power,” Horn emphasises. Using the bulk of available processing power and memory at the outset with little consideration for optimisation will inevitably make the addition of new features and updates later in the vehicle’s lifecycle more difficult.

He adds that the “managing” process of maintaining and iterating vehicle software and its interfaces (APIs) is currently “heavily underestimated”. If a third-party provider updates its software, this may require small tweaks to the vehicle’s operating system or other embedded software to prevent unexpected glitches. “It used to be that a car was built and then more or less left as it was, but now someone needs to take care of these interfaces for a decade.” AOX can provide guidance on how to manage these lifetime processes or take a more hands-on approach, depending on how far along an automaker is on their journey with software development.

Reers states that, ultimately, Accenture’s focus remains on higher-level strategic guidance, organisational transformation, and architecture development. While the acquisition of AOX represents a strategic addition to its SDV offerings to date, it is a single part of a wider effort to transition the automotive industry away from traditional hardware-based mindsets to a more agile and software-oriented paradigm.

“Beyond the minutiae of individual processes and lines of codes, that’s the big challenge we’re looking to address,” he concludes. “The old model of vehicle design was very successful, but it’s no longer relevant. You need to think and act like a tech company, and that means shifting towards a sprint mindset in which new features don’t come with model updates every year but continuously. That will be difficult without the right expertise on hand.”