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EDITORIAL

Beyond the Roadmap

There are moments when an industry reveals its true standing. Not in strategy documents, bold promises in keynote speeches, or flawlessly crafted roadmaps, but in the questions it asks. Questions directed inward, rather than outward. But why now? Software-defined vehicles, artificial intelligence, centralized computing, zonal E/E architectures, chiplets, and new semiconductor strategies are no longer separate trends. They are interdependent building blocks of a much much larger transformation. It is no secret that electronics and software increasingly define what a vehicle can do, how it evolves over time, and the customer experience. At the same time, these trends force the industry to rethink its responsibilities, development models, and collaboration across the entire ecosystem.

One of the most visible examples of this shift was and still is: Eclipse S-CORE. The initiative was introduced prominently at last year's AUTOMOBIL-ELEKTRONIK Kongress in Ludwigsburg and has since become one of the key reference points in the debate on the software-defined vehicle. The underlying question remains highly relevant: Which parts of the SDV should be developed jointly? Where does differentiation begin? And how can open collaboration be transferred into series-ready automotive platforms? At this year's AEK, S-CORE will present several contributions and discussions on this topic. The focus will be on vehicle architecture, integration, governance, and the industrialization of open software.

This is important because the SDV is not just a software issue. It also affects semiconductor roadmaps, operating systems, middleware, safety concepts, cybersecurity, validation strategies, and the way organizations cooperate. A common software foundation can only create value if it reduces complexity in areas where differentiation is limited and allows enough room for genuine innovation in areas where manufacturers and suppliers want to stand apart.



Dr. Martin Large
Online-CvD

It is no secret that electronics and software increasingly define what a vehicle can do, how it evolves over time, and the customer experience.

Another central topic on this year's agenda is China. Few markets demonstrate the need for speed, user focus, and implementation discipline as clearly as China does. Shorter development cycles, strong vertical integration, and a high willingness to transform ideas into products are changing the global automotive industry's expectations. Rather than simply talking about China, we are bringing the Chinese ecosystem to the stage

to provide first-hand insights into one of the world's most dynamic markets, so the audience can hear directly what is happening there and continue the discussion with them in Ludwigsburg.

All of this makes the 30th International AUTOMOBIL-ELEKTRONIK Kongress especially relevant. On June 16 and 17, 2026, Ludwigsburg will once again become the meeting place – some even call it a 'family reunion' of the automotive industry – for those shaping the next generation of automotive electronics. Further information, including the high-level agenda, can be found on page 16 and beyond.

I hope you enjoy reading this issue and find it helpful for the discussions ahead. See you in Ludwigsburg! ■

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Title page sponsored by ETAS

Picture: ETAS





Technological progress in semiconductors boosts performance, connectivity and comfort while increasing complexity, costs and supply chain vulnerability. Page 38



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On June 16–17, 2026, the AUTOMOBIL-ELEKTRONIK Kongress celebrates its 30th anniversary – bringing together the leading decision-makers in automotive electrical, electronic and software systems. Page 16





Picture: Swarco

Marcus Anders, Managing Director Swarco Traffic Systems, Vice Chair of the ZVEI Traffic Management Systems Division and member of the ZVEI Executive Board.

Every year, around 1.19 million people worldwide lose their lives in road traffic accidents. Most of these accidents, approximately 94 percent, are caused by human error. Traditional safety approaches are reaching their limits.

The technological answer to this challenge has long existed: Cooperative Intelligent Transport Systems (C-ITS) refer to systems in which vehicles, traffic infrastructure, and other road users continuously communicate with one another. Using V2X communication (Vehicle-to-Everything), they exchange safety-relevant information, e.g. about hazardous locations, traffic light signal phases, construction zones, or approaching emergency vehicles.

Visibility Beyond Line-of-Sight

The key added value of C-ITS lies in extending perception. While vehicle sensors such as cameras or LiDAR are limited to their direct field of view, C-ITS enables visibility beyond line-of-sight and sensor boundaries.

This creates a decisive information advantage, particularly at accident-prone junctions, intersections, or poorly visible road sections; seconds that can save lives in critical situations. Whether enabling connected and automated driving or supporting more efficient and climate-friendly mobility, the technology is a central enabler of future transportation systems.

Cooperative communication leads to smoother traffic flows, reduced stop-and-go traffic, and better integration of all road users. At the same time, it opens new opportunities for the automotive and supplier industries to develop data-driven services and digital business models, creating tangible added value for Germany as an industrial location.

C-ITS: How V2X Is Digitizing Road Traffic Today and in the Future

2028 on the Horizon: Rising Urgency

The need for action becomes particularly evident in public transport. In many cities, the prioritization of buses and trams at traffic signals is still based on analog radio systems from the 1980s that are technologically outdated, unencrypted, and pose security risks.

The shutdown of the corresponding radio frequencies has been mandated by the Bundesnetzagentur for December 31, 2028. By that date at the latest, a system transition will be unavoidable.

C-ITS offers a future-proof alternative: digital, standardized, interoperable, and scalable. This not only makes public trans-

port faster and more reliable, but also integrates it more effectively into overall traffic management. Within the C-ITS landscape, two technological approaches have become established: ITS-G5 for direct, low-latency communication, and C-V2X via cellular networks for long-range, network-based services. Modern traffic management requires a hybrid approach, tailored to the specific use case.

core components, standards, communication methods, and security mechanisms are in place and already in real-world operation, for example within the European C-ROADS platform.

The real bottleneck lies in implementation. Responsibilities and operations are distributed across multiple levels, resulting in functional solutions coexisting without leveraging their full collective potential.

This is evident in the area of Public Key Infrastructure (PKI). PKI enables verification, for instance, whether a bus or emergency vehicle is authorised to receive signal priority in a given region.

The technical concepts and European regulatory frameworks are established and robust. What matters now is not treating them in isolation, but integrating them as a fundamental component of a continuously operated, connected traffic infrastructure.

What's Next?

C-ITS has reached a turning point. The technology is deployed in practice, internationally established, and increasingly taken for granted. Vehicles, infrastructure operators, and traffic systems are gradually converging into a shared digital ecosystem.

At the same time, external pressure is rising: the mandatory technology transition in public transport by 2028, increasing demands for road safety, climate targets, and automation.

Like any infrastructure, C-ITS delivers its true value only when widely adopted as a shared system. This shift from *whether* to *how quickly* is already evident in many European neighboring countries and international markets. For decision-makers, this means: those who act now actively shape the future. Those who wait risk having to adapt later to systems defined by others. (na) ■

“Those who act now actively shape the future. Those who wait risk having to adapt later to systems defined by others.”

Marcus Anders, Swarco Traffic Systems / ZVEI

Why Is C-ITS Still Not Deployed at Scale?

The limited large-scale rollout of C-ITS is not due to a lack of technical solutions. The

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Semiconductors for electric mobility

Bosch introduces third generation of SiC chips

Bosch has begun rolling out its third generation of SiC chips and is already supplying samples to global automakers. The silicon carbide semiconductors are designed for use in electric vehicles, where they will control the flow of energy in the power electronics. According to the company, the new generation achieves 20 percent higher performance than the previous version. At the same time, the chips are smaller. This allows more components to be manufactured per wafer, which can improve production cost-effectiveness. SiC power semiconductors switch faster and cause lower energy losses than conventional silicon chips. In the drive electronics of electric vehicles, this helps to increase efficiency and extend range. With the third generation, Bosch aims to further expand these capabilities. The focus is on higher power density, more compact designs, and broader availability of high-performance electronics for electric mobility.

At the same time, the chips are becoming smaller. This allows more components to be manufactured per wafer, which can improve production efficiency.

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croelectronics and communications technology. The development and production of the third generation of SiC chips take place at the Reutlingen plant on 200-millimeter wafers. In addition, the company acquired another plant in Roseville, California, in September 2023. Bosch is investing approximately 1.9 billion euros in expanding production there. The first SiC chips from the U.S. site are scheduled to be delivered to customers as samples before the end of this year. In the future, the SiC semiconductors will come from plants in

Germany and the U.S. In doing so, Bosch is not only expanding its production base but also distributing manufacturing across two locations. Since the start of production of the first generation in 2021, Bosch has, according to its own figures, shipped more than 60 million SiC chips worldwide. In the medium term, production capacity is expected to rise to the mid-three-digit million range. The planned expansion of capacity is part of a long-term strategy to meet the automotive industry's needs in the wake of electrification.

Pre-integrated platform for faster production development

Vector supports the NXP CoreRide platform

The collaboration between Vector and NXP is focused on accelerating the industrialization of software-defined vehicles (SDVs). The joint activities center on software-centric system integration, measurable performance optimization, and secure boot and update architectures. The latest result of this collaboration is the NXP CoreRide Z248 zonal reference system, a ready-to-use, real-time-capable computing platform that can be immediately utilized for series development. The pre-integrated and pre-configured hard-

ware-software platform is based on Microsar embedded software products that are closely aligned with NXP hardware. This tight integration of hardware and software reduces complexity during system startup, lowers integration effort for OEMs, and allows development teams to begin application development sooner. This integrated approach shortens evaluation phases, reduces technical risk, and also accelerates the launch of vehicle programs. The solution package includes Vector products such as Microsar Classic

as a software stack, the DaVinci Configurator for configuring the stack, and PREvision for system design. Vector's base-layer solution improves the critical system performance indicators of NXP CoreRide. This includes optimizing

boot and startup behavior to ensure fast and deterministic availability of the electronic control units (ECUs). The collaboration between Vector and NXP focuses on accelerating the industrialization of software-defined vehicles.

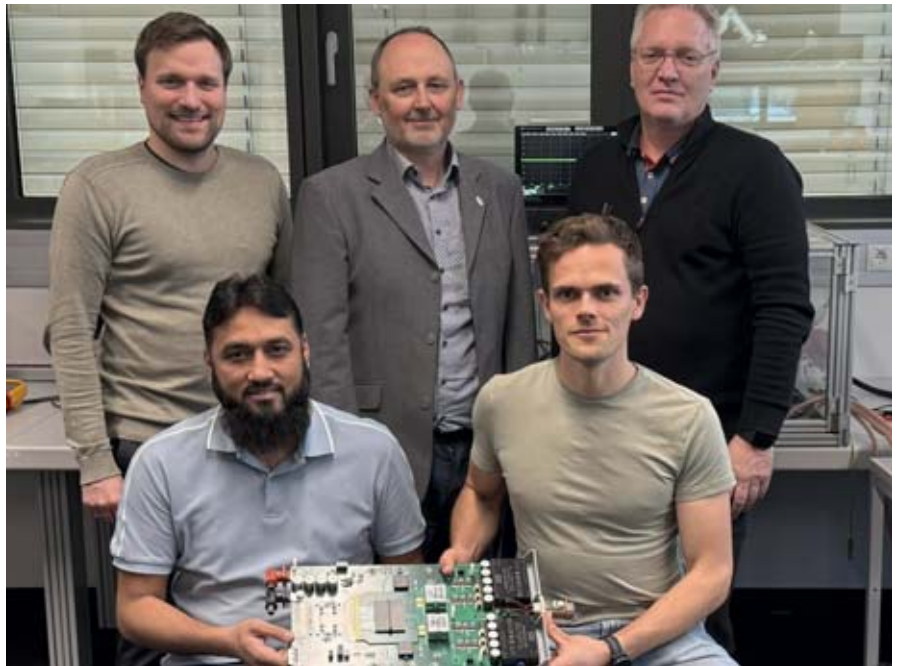


Picture: NXP

Will the 12-volt battery in electric cars become obsolete?

Dual battery: Redundant electrical systems enhance EV safety

The two-year REDSEL research project by Silicon Austria Labs, Infineon Technologies Austria, and AVL List has been successfully completed. The project focused on developing a redundant high-voltage and low-voltage electrical system architecture for electric vehicles. The goal was to create a flexible and fail-safe power supply that could eventually even eliminate the need for traditional low-voltage batteries. At the heart of the solution is a system with two high-voltage batteries and active balancing. This ensures even load distribution and significantly increases operational reliability. In addition, the partners developed a multiport power electronics converter with multiple inputs. A novel magnetic integration concept ensures high power density while reducing the required installation space. On the high-voltage side, 750-V silicon carbide MOSFETs are used, while 30-V components are employed for the first time on the low-voltage side. These offer significant efficiency advantages over previous 40-V solutions. Improved electrical system specifications in current electric vehicles enable the safe use of these new components. Another innovative step is the new safety architecture for switching operations. Mechanical relays are being replaced by semiconductor switches. This increases reliability, reduces weight, and saves space,



Picture: Silicon Austria Labs

while simultaneously improving operational safety.

The technologies developed in the project form the basis for lighter, more robust, and scalable vehicle electrical systems. They support not only the further development of today's electric vehicles but also future applications, including autonomous driv-

ing. The project underscores the importance of close collaboration between research and industry. The developed demonstrator provides a practical demonstration of how new vehicle electrical system architectures can be safely and efficiently integrated into production vehicles in the future.

A new direction in automotive software TTTech Auto becomes TrustMotion

TTTech Auto will operate under the name TrustMotion going forward. The rebranding follows the acquisition by NXP Semiconductors in June 2025. With its new brand identity, the company aims to strengthen its position in the market for software-defined vehicles (SDV). According to the company, TrustMotion will remain a neutral automotive supplier and support OEMs, suppliers, semiconductor manufacturers, and third-party software providers. The focus is on systems, safety, and security for scalable, safe, and secure mobility. The portfolio includes the safety middleware MotionWise, which is considered the company's flagship product. It is designed to simplify the integration of software and hardware in modern vehicle architectures. The offering is complemented by system solutions, safety consulting, hardware design services, and customer-specific system



integration programs. In doing so, TrustMotion addresses a key challenge of software-defined vehicles: functions must interact reliably across different computing platforms, software layers, and safety concepts. Along with the new name, TrustMotion also announced a change in leadership. Chris Greentree has been appointed General Manager. Dr. Stefan Poledna, previously at the helm of TTTech Auto, will assume the role of Chief Technology Officer.

Staying in control while driving Gentex and Antolin develop a dimmable sun visor

Gentex and Antolin plan to jointly bring next-generation dimmable sun visors to the European automotive market. To this end, the two companies have signed a cooperation agreement. The goal is to replace the traditional sun visor with an electrochromic dimmable glass solution. Gentex's technology is based on transparent glass that can be darkened automatically or manually. This is intended to reduce glare from sunlight while allowing the driver to maintain a clear view. Conventional sun visors, by contrast, have so far severely restricted the field of vision. Gentex brings to the partnership its many years of experience with dimmable glass, such as in auto-dimming mirrors and electrochromic aircraft windows. Antolin complements this with expertise in interior systems, industrialization, and the integration of complex vehicle components.



“AI offers immense opportunities—if we combine it with deep automotive expertise.”

Dr. Christof Horn, Accenture
Motto: “Humans remain essential in the automated workflow—for now.”



AI is the new automotive imperative

AI is hungry for data and constantly seeks value creation. Meanwhile, the automotive industry is quietly doing its homework: software is being developed using modern methodologies, IT infrastructure is increasingly automated, documentation has long been digitized, and bridges now connect previously isolated tools and data silos. This creates an ideal breeding ground for artificial intelligence algorithms—now commonly referred to as “agentic AI”—which are becoming ever more capable.

In most individual disciplines—reading texts, recognizing objects, analyzing data—AI now surpasses human capabilities. Knowledge originally generated by humans has largely been absorbed by algorithms; one might even say appropriated without consent. Only the physical 3D world remains challenging, as there is still no comprehensive digital twin that can be readily ingested.

From engineering...

However, further progress no longer depends on ever-increasing volumes of data, which are themselves increasingly contaminated by AI-generated noise. The focus has shifted to making models more efficient, connecting them to factual data sources, and enabling communication between models. The open-

source platform OpenClaw demonstrates what this leads to: the evolution from a chatbot to a network of software agents that interact with our files, tools, emails, and messages in a human-like manner.

This approach has generated significant momentum, pointing to a path toward real value creation and productivity gains beyond AI copilots. The three major concerns—data privacy, IT security, and process governance—are being addressed, as illustrated by rapid adoption within the Nvidia ecosystem under the name “NemoClaw.”

...to prompt engineering

This fundamentally changes the role of the automotive engineer. We are moving from a human-centered, AI-supported development process to an “AI-first” paradigm: humans instruct, guide, and assist AI algorithms, but the process itself is conceived from the perspective of AI. And AI operates differently. A human launches a tool, works on an artifact within it, and exports CAD data. A machine, by contrast, analyzes requirements, writes its own scripts or remotely controls tools, and generates CAD data directly.

Nevertheless, humans remain essential in this automated workflow—for now. Current algorithms still have limited understanding of what they are doing. The term “AI slop” is

gaining traction: rapidly generated artifacts often contain errors, unnecessary complexity, or merely reflect the most probable option rather than the correct one.

New roles

As so often, today’s roles reflect the past. Product owners, project managers, test engineers, and quality managers exist because division of labor and specialization were necessary. This is now changing at scale, and it is not entirely new. Anyone using Word or Photoshop today independently performs work that once required entire teams of specialists.

What will these new roles look like? That remains to be seen. There is, however, a clear sequence: start with customer value and the underlying challenge, then define the solution, followed by the process, and only then the organization and roles. The focus on the customer—the “why”—is therefore critical. And one principle still holds: a bad process automated with AI remains a bad process. When implementing AI, it is therefore useful to orient around value streams: what exactly do we want to produce in the end? And how can we get there most efficiently if all relevant data is available from the outset?

The new automotive imperative: AI offers immense opportunities—if we combine it with deep automotive expertise. (na) ■

Unlocking Edge AI

Architecting the Dynamic, Self-Optimizing Vehicle

Edge AI is shifting the vehicle from a fixed software system to an adaptive platform. Scalable orchestration, efficient deployment, and continuous optimization are becoming central to future automotive architectures.

AI at the edge is reshaping how vehicles are designed, validated, and supported throughout their lifecycle. The real breakthrough isn't running models in the car — it's building an architecture that can deploy, update, and orchestrate intelligence safely and cost-effectively across heterogeneous hardware. That's the shift underway, and it's the direction leading automotive software platforms, including Sonatus, have been built to support.

From Static to Adaptive

Traditional vehicle software has been limited by fixed hardware, rigid update processes, and minimal visibility into real-world behavior. Edge AI changes that. When intelligence runs directly in the vehicle — from physics-based models to machine-learning inference — automakers can detect issues earlier, personalize the driving experience, and continuously refine performance.

This shift requires in-vehicle diagnostics such as battery-health and tire-wear monitoring to reduce recalls and maintenance costs. Platforms like Sonatus make this practical at scale. Pairing AI workloads with dynamic data orchestration is becoming essential for activating context-aware insights without redesigning the underlying architecture.

Engineering for Efficiency, Safety, and Cost

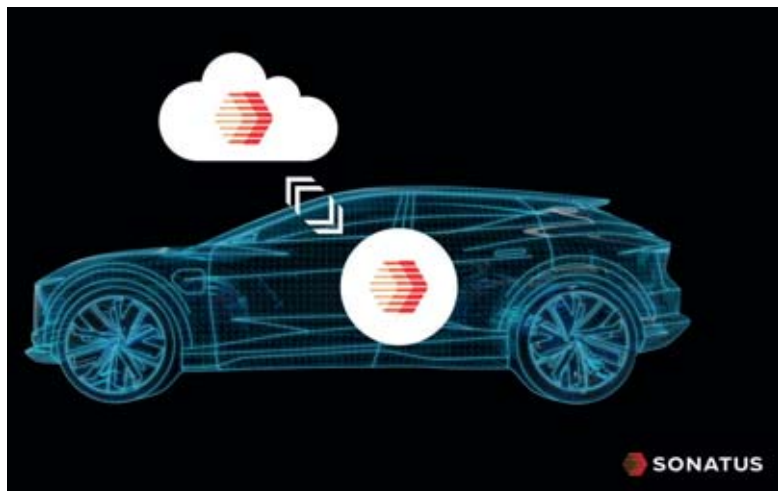
Bringing AI into production vehicles is a systems challenge: automakers must balance AI and non-AI workloads across increasingly consolidated E/E architectures while preserving safety and managing compute budgets.

Across the industry, the goal is to run intelligent



Alexandre Corjon, Senior Vice President, Engineering, Sonatus

Picture: Sonatus



models on general-purpose ECUs rather than on expensive accelerators. Architectures like those developed by Sonatus make this possible while keeping safety and cost in balance. Containerization and virtualization isolate AI workloads into self-contained units, enabling dynamic CPU and memory scaling so non-critical tasks never interfere with safety-critical functions.

Automotive-Grade AI Toolchains

Deploying AI across ECUs, gateways, and domain controllers requires more than a runtime, it requires an automotive-grade toolchain. Sonatus AI Director provides an end-to-end MLOps workflow that standardizes model integration, optimization, and deployment across diverse topologies, whether the target is a single ECU, a zonal controller, or a central gateway.

Complementing this, Sonatus Collector AI captures precise, event-triggered data to feed and refine these models. By orchestrating only the data that matters, OEMs reduce processing overhead and transmission costs.

Built for Continuous Evolution

The future of automotive AI depends on architectures that can evolve as quickly as the intelligence running on them. By unifying data, compute, and software orchestration, Sonatus enables automakers to deploy new capabilities in days instead of months and deliver vehicles that learn and adapt throughout their lifecycle.

This is the shift from software-defined to intelligence-driven, and it's underway now. ■

Author: Alexandre Corjon, Senior Vice President, Engineering, Sonatus

How does Edge AI transform vehicle architectures? Adaptive software platforms enable efficient deployment, orchestration, and continuous optimization.

Picture: Sonatus



Working together with in Eclipse S-CORE on open middleware for the software-defined vehicle: Sven Kappel (left), Vice President – Head of ETAS NeXT mobility innovation & Head of Project S-CORE, and Markus Rettstatt (right), Vice President Software Defined Car at Mercedes-Benz Tech Innovation.





Interview with Sven Kappel, ETAS, and Markus Rettstatt, Mercedes-Benz Tech Innovation

“We do not want to start from scratch with every new vehicle generation”

Eclipse S-CORE aims to put middleware in the software-defined vehicle on a shared open-source foundation. In this interview, Sven Kappel of ETAS and Markus Rettstatt of Mercedes-Benz Tech Innovation explain why shared code can accelerate integration, safety, and industrialization — and why the real transformation is less technical than cultural.

Mr. Rettstatt, Mr. Kappel, what exactly is Eclipse S-CORE — and what problem is the project intended to solve?

Markus Rettstatt: At its core, S-CORE addresses the lack of a shared foundation in middleware. We saw that many companies are working on very similar challenges. If each one develops these basics separately, it creates enormous duplication of effort. By collaborating in an open-source model, we reduce integration effort and avoid redundant foundational work. That allows OEMs and partners to move from idea to vehicle much faster.

Sven Kappel: In addition, the goal is to create a stable foundation that can be used over the long term. We do not want to start from scratch with every new vehicle generation. Instead, we want to establish a platform that can evolve across generations while maintaining a certain degree of backward compatibility. That reduces not only the effort required for integration, but also for development itself.

Mr. Rettstatt, at Mercedes-Benz Tech Innovation you are directly involved in software development for the OEM. When did it become clear to you that vehicle software, without open collaboration and open source, would become slow, expensive or complex?

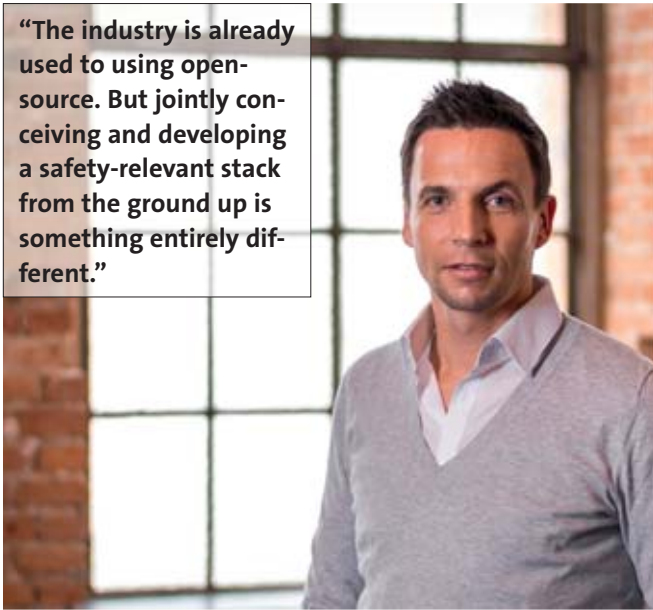
Markus Rettstatt: The key realization was that real differentiation for OEMs happens at the top of the stack — where functions become customer-relevant and define the brand experience. Everything below that is essentially non-differentiating groundwork. Yet that is exactly where we saw many players working on the same problems. In conversations with partners and suppliers, it became increasingly clear that very similar technical challenges were being solved in parallel across many vehicle programs. That is neither efficient nor sustainable. So for us, it became obvious that a common foundation was needed — and open source is a very suitable approach because it enables genuine collaboration on equal terms.

S-CORE is a joint project involving OEMs, suppliers, and software partners. In the early stages, which was more challenging: reaching technical alignment or driving cultural change?

Sven Kappel: Both were challenging, but in different ways. Technically, a solution can almost always be found in the end. Architects discuss, evaluate options, and eventually arrive at a viable decision. From my perspective,

Pictures: Mercedes-Benz/Lilie Schaab, ETAS

“The industry is already used to using open-source. But jointly conceiving and developing a safety-relevant stack from the ground up is something entirely different.”



though, the bigger shift lies in the cultural dimension. The industry is already used to using open-source components in certain areas, such as infotainment. But jointly conceiving and developing a safety-relevant stack from the ground up — including processes, documentation, and quality requirements — is something entirely different. On top of that, in an open community, companies suddenly collaborate that may well be competitors in other areas. The fact that these companies work together to find the best technical solution and share knowledge transparently represents a genuine cultural shift. We have laid the groundwork for that, but the process is far from complete. Ideally, it will grow into a broadly supported community that ultimately involves the entire automotive industry.

In the context of the software-defined vehicle, one key term has come up repeatedly for years: development speed. How can open source actually shorten time to delivery without simply creating new coordination loops?

Markus Rettstatt: Because a shared code base scales far faster than coordination based purely on documents and committees. If you only align through specifications, it often takes a long time before robust results emerge. By contrast, if you look at concrete code artifacts, you can very quickly see what works and what does not. That accelerates decision-making considerably. Of course, we operate in the regulated automotive environment. That means you cannot adopt such a model one-to-one from other software domains. We deliberately adapted our code-first methodology so that it remains architecture-focused and meets the requirements of the automotive industry. And that is precisely the advantage: we combine development speed with industrial-grade reliability.

Sven Kappel: The big difference is that traditional collaboration in this industry is often heavily specification-driven. First, specifications are created over a long period of time. Then implementation follows, then delivery. And only after that can developers of differentiating functions really begin. In an open-source community such as S-CORE, by contrast, a developer can start much earlier. They download the code, work on a stable foundation, and do not have to wait for several sequential stages to be completed. That fundamentally changes the dynamic. Universities and new partners can also get in-

involved much earlier. Development becomes more collaborative, more parallelized, and ultimately faster. And if we succeed in building on that foundation across generations instead of starting over each time, the result is a speed advantage that is hugely relevant for the industry.

So where, in today’s vehicle programs, is the most time being lost?

Markus Rettstatt: The biggest loss of time occurs in integration and validation, not primarily in writing code. That has a lot to do with the fact that numerous proprietary stacks have to be brought together today — stacks that were never really designed to work together. That is exactly what creates friction, rework, and enormous validation effort.

Sven Kappel: And that effect repeats from project to project. If every program starts with a new foundation, the validation effort also starts from scratch every time. If, on the other hand, you build on a stable, jointly developed foundation, then ideally only the deltas have to be validated. That is a crucial lever. On top of that, with S-CORE, our ambition is to make the stack integrable all the way down to the operating-system layer. In other words, the public release does not just exist in theory — it is practically runnable.

You have already mentioned that S-CORE is deliberately focused on the non-differentiating part of the software. Where does that boundary lie in practice?

Sven Kappel: Broadly speaking, between base software, middleware, and application software. Application software is where OEMs create their real differentiation — where the customer experience, brand logic, and vehicle-specific functions take shape. From the perspective of many manufacturers, the layers underneath are not where they need to differentiate strategically. That is exactly why it makes sense to develop this part collaboratively. At the same time, there is still room for differentiation — including for suppliers and distributors. That may take the form of particularly high-performance implementations, supplementary tools, or services around the stack. Our goal is to provide the community with a runnable, robust stack. How that stack is then industrialized, optimized, or enhanced with additional services can still vary.

Markus Rettstatt: Exactly. OEM-specific differentiation will remain in product logic, brand experience, and data-driven functions. Those assets will continue to be clearly separated. But for the non-differentiating foundation, collaborative development simply makes more sense than parallel individual efforts.

Mr. Rettstatt, from Mercedes-Benz’s perspective, is open source already proving to be an accelerator overall — despite the additional governance requirements?

Markus Rettstatt: Yes, very clearly overall. It requires more discipline in middleware governance, no question about that. But in the medium term it reduces friction, and in the long term it is a real scaling lever. What matters is not only developing the stack itself, but also always keeping its adaptability in mind: how can all of this be deployed in real OEM programs? Especially at those friction points, open collaboration helps because architectural decisions can be made earlier and on a more solid basis.

Mr. Kappel, ETAS speaks very openly about actively shaping both architecture and implementation. Where do you currently see the biggest lever: better code, better toolchains, or a new industrialization model?

“S-CORE addresses the lack of a shared foundation in middleware. We saw that many companies are working on similar challenges.”

Markus Rettstatt,
Mercedes-Benz Tech Innovation

Sven Kappel: All three matter, but the biggest lever is probably the industrialization model. Better code is a clear advantage, not least because in an open community more eyes are looking at the same code. That is particularly important when it comes to security. The toolchain is equally central. Anyone who takes safety, compliance, and traceability seriously needs transparent processes all the way from requirements and feature requests to delivery. But the real breakthrough lies in industrializing the same code. That changes the roles in the market. Distributors can focus more on genuine added value instead of differentiating themselves through basic implementation alone. At the same time, OEMs gain more flexibility because they do not have to rebuild their application software every time they switch partners. There is also a different business model emerging: away from purely license-based sales and toward continuous delivery and more service-oriented models. And that is also where we see our role very clearly: not only as an active contributor to the community, but as a reliable partner for production programs. In the end, OEMs do not just need strong open code — they also need partners who can take responsibility for industrialization, integration, compliance, and the path into series production.

What integration problems can a layer such as S-CORE already solve better today than traditional proprietary middleware stacks?

Markus Rettstatt: Above all, it reduces the many project-specific special adaptations that almost inevitably arise with proprietary approaches. If you are involved in developing the stack, integration becomes far more predictable. Interfaces become more robust, and we place strong emphasis on interoperability with established standards, such as those from AUTOSAR or COVESA. The idea is not to ignore standards, but to combine them meaningfully with a code-centric development approach.

Sven Kappel: Middleware's job is to mediate between operating systems and application software. If that layer is open and transparent, it can be integrated cleanly from below just as well as from above. That results in greater reliability, more transparency, and continuous evolution. Compared with proprietary stacks developed in isolation, that is a major difference.

At S-CORE, you describe your approach as iterative, code-driven development rather than a purely specification-driven one. Is that the real cultural break with the traditional automotive industry?

Sven Kappel: Yes, that is certainly one of the defining points. In the past, specifications were developed in committees and then implemented by companies. The problem is that specifications are open to interpretation. Two implementations may refer to the same standard and still behave differently. That problem is significantly reduced when the shared code base becomes the leading artifact. Then we are no longer talking about differently interpreted specifications, but about the same code.

Markus Rettstatt: That does not mean important specifications disappear. But the primary reference point increasingly becomes the developed artifact itself. From there, insights can then flow back into standards and specifications. That changes the logic of collaboration quite significantly.

S-CORE relies on both C++ and Rust. Why this two-track approach?

Markus Rettstatt: Rust shows its strengths where safety-relevant middleware components and concurrency are critical. C++ remains the sensible choice where performance, existing ecosystems, and legacy integration dominate. We cannot and do not want to simply discard proven, production-ready code. In the medium term, Rust



“A shared code base scales far faster than coordination based purely on documents and committees.”

will certainly gain importance, but for now, supporting both languages in parallel is the pragmatic path.

Sven Kappel: Exactly. If we are incorporating existing, production-proven code, it makes no sense to translate it into Rust purely as a matter of principle. But when we develop new concepts entirely from scratch, Rust is often the natural choice.

In automotive, the goal is always safety, security, and production readiness. How do you prevent the speed gained at the beginning from later being lost in compliance and approval processes?

Sven Kappel: By taking those issues into account from the start. It became clear to us very early on that S-CORE would only be viable if safety, security, processes, and documentation were developed alongside it from day one. That is exactly why the S-CORE process is set up so that a distributor can derive a certifiable product from it.

We phrase it very deliberately like this: S-CORE itself is capable of safety certification, and a distributor turns it into a certified product for the OEM. To ensure that, we have our processes audited externally on a regular basis. With Exida, we have a partner on board that has supported us from the outset and reviews both our development processes and our artifacts. That creates the foundation to ensure that industrialization and certification do not later become bottlenecks.

“The real breakthrough lies in industrializing the same code. That changes the roles in the market.”

Sven Kappel,
ETAS

Finally, looking ahead: how would you measure the success of S-CORE three years from now?

Markus Rettstatt: For me, one key indicator of success would be if more production vehicles were using the same core. It would also be a strong signal if fundamental debates about middleware were to decline significantly, and if open source in the vehicle were no longer seen as an exception, but as the norm.

Sven Kappel: I would add two more points. First, a truly thriving community that continues to grow — not only in Europe, but globally. Second, it would be a major success if S-CORE became a place where innovations move quickly toward industrialization. That also applies to AI-driven approaches. If new ideas do not remain stuck in a purely experimental culture, but instead make their way into series production via S-CORE, then we will have done a lot right. ■

Interview by Pascal Nagel



30th International AUTOMOBIL-ELEKTRONIK Kongress

Time to celebrate!

On June 16–17, 2026, the AUTOMOBIL-ELEKTRONIK Kongress celebrates its 30th anniversary – bringing together the leading decision-makers in automotive electrical, electronic and software systems.

For three decades, the AUTOMOBIL-ELEKTRONIK Kongress (AEK) has been the central meeting point for OEMs, suppliers, semiconductor companies and technology players. In 2026, the congress takes place under the anniversary motto: “Disruptive Technologies for Consumer-centric Innovations Powered by AI and Future-proof E/E Architectures.”

The industry is currently undergoing one of its most profound transformations. Software-defined vehicles, AI-driven architectures and new semiconductor ecosystems are no longer future topics – they are shaping real-world platform decisions today. The AEK 2026 reflects exactly this shift. The advisory board and organizers have once again curated a high-level, international program with speakers

from across the entire ecosystem. Key topics of the 2026 edition include: – Software-defined vehicle architectures and their real-world implementation – AI as a system layer across development and vehicle platforms – Zonal and centralized E/E architectures – Semiconductor strategies and chiplet-based approaches – Open ecosystems and new collaboration models such as Eclipse S-CORE

As in previous years, panel discussions remain a core element of the AEK. They provide the opportunity to explore key topics from multiple perspectives and foster open dialogue between OEMs, suppliers and tech companies. These discussions typically continue beyond the stage – in the plenary sessions, networking breaks and the evening event.



Quick Facts

- 30th anniversary edition of the AUTOMOBIL-ELEKTRONIK Kongress
- June 16–17, 2026
- Forum am Schlosspark, Ludwigsburg
- VIP event by invitation on June 15, 2026
- High-level networking at the industry evening event on June 16
- Info & registration: automobil-elektronik-kongress.de
- LinkedIn: #AEK_live

The show must go on! Join us in celebrating the 30th edition of the automotive industry’s family gathering.

Pictures: Matthias Baumgartner



Register for this conference online:
<https://www.automobil-elektronik-kongress.de/tickets/>



30th International Automobil-Elektronik Kongress (AEK) 2026

Day 1: Tuesday, 16 June 2026

08:40 Welcome by Conference Host



Maxi Sarwas
Moderator & Journalist

08:45 Opening Speech by Conference Chair



Ricky Hudi
CEO,
Future Mobility Technologies

09:00 140 Years of Innovation and 30 Years of AEK – The Automotive Industry in the AI Era



Welcome to a year full of jubilees: 140 years ago marked the dawn of the automobile, and today the Automobile-Elektronik Kongress proudly celebrates its thirtieth anniversary.

The keynote outlines how modern vehicle electronics and software have evolved and accelerated innovation, increased speed, and reshaped industry collaboration. It highlights the shift towards software-defined vehicles and AI with continuous updates and scalable software. It sets the stage for a forward-looking discussion on customer-focused innovation, partnering models, and the next chapter of automotive electronics.

Magnus Östberg
CSO,
Mercedes-Benz AG

09:30 Software-Defined Vehicles: On the Road to Realization



The industry has spent years talking about SDVs, but how do we get going? In his keynote, NXP CTO Lars Reger will show what is possible with the silicon that's available today. He'll explain how vehicle architectures are shifting, introduce the "rolling skateboard" as a simple and memorable way to think about a car's foundation, and highlight the practical building blocks—like zonal ECUs, intelligent gateways, efficient networks and safety-focused power systems—that carmakers can use right now. Expect humor, real engineering insight, and a grounded look at how to move from buzzwords to buildable reality.

Lars Reger
Executive Vice President & CTO,
NXP Semiconductors

10:00 The Future of the Automotive Electronics Value Chain



Dr. Florian Weig
Senior Vice President Purchasing & Supplier Network Digital,
BMW Group

10:30 Coffee Break & Networking

11:15 AI Everywhere in Automotive: Architecting Resilient Intelligence for Next-Gen Mobility



Nakul Duggal
EVP & Group GM, Automotive, Industrial, and Embedded IoT & Robotics,
Qualcomm Technologies, Inc.

11:45 Made Simple. Made Personal. Made for Humans. STLA Brain and STLA SmartCockpit – A Leap Forward for Stellantis Customers



Ned Curic
Chief Engineering & Technology Officer,
Stellantis

12:15 Panel Discussion: Chiptlets – Technology & Business Viability



Moderated by Dr. Mathias Pillin, Chief Technology Officer, Robert Bosch GmbH



Dr. Christoph Grote
Senior Vice President AI & Innovation,
BMW Group



Joachim Kahmann
Senior Vice President Purchasing EE & Modules,
Stellantis



Harald Kroeger
Head of Sales & President Automotive,
SiMa.ai



Michael Schaffert
SVP & Head of Chiptlet Program,
Robert Bosch GmbH



Christopher Thomas
President,
TSMC Europe



Dr. Mathias Pillin
Chief Technology Officer,
Robert Bosch GmbH

12:45 Joint Lunch Break & Networking

14:00 Eclipse S-CORE Speed, Efficiency, Community in Open Source: Time to Deliver



Dr. Thomas Irawan
President & Chairman of the ETAS Board of Management,
ETAS GmbH



Dr. Christian Salzmann
Vice President Software and Integration Platforms,
BMW AG

14:30 Scaling Smarter: Chiptlet Architectures for the AI-Driven Vehicle Era



Aish Dubey
VP & GM for Renesas SOC,
Renesas Electronics



15:00 Tier 1 Perspective on E/E Architecture to Enable Next Generation Supply Chain



Today's wiring harnesses are vehicle-specific products with an extreme level of complexity—up to 10³⁰ possible variants. Their production remains highly labor-intensive: approximately 1,500 employees are required, with only ~10% automation, and installation in the vehicle takes around 1 hour and 30 minutes. This model limits scalability, flexibility, and cost efficiency for both Tier 1 and OEMs.

Zonal architecture represents a structural enabler for a new supply chain and significant harness simplification. Since 2019, we have conducted multiple co-design initiatives with key customers and will introduce first automated harness solutions for German and U.S. OEMs in 2026 and 2027. However, current industrialization levels remain insufficient for large-scale automation rollout.

Through our cooperation with Luxshare, we have gained access as system partner to disruptive OEMs in China and California. These players combine in-house electronics and software development, shorter decision cycles, and sprint-based execution—while maintaining structured engineering processes—and consistently target fully automated vehicle assembly by 2030.

To unlock full potential, zonal architecture must align with production modules to optimize total cost of ownership, including assembly time and cost. This requires decentralized features, a robust real-time Ethernet backbone, and redistribution of software monoliths—while acknowledging that current IC readiness in safety, cybersecurity and reliability remains a constraint.

Our approach is to shift the focus of the ecosystem beyond pure SDV alone towards holistic total cost optimization.

Walter Glück
CTO,
Member of the Board of LEONI Wiring Systems GmbH

15:30 Coffee Break & Networking

16:00 From Autonomous Vehicles to Data Factories: The Industrial AI Cloud as a Game Changer



Dr. Julian Raabe
SVP und Head of Automotive and Manufacturing,
T-Systems

16:30 Technologies to Watch



1. **The Brain: The Next Frontier in Vehicle Intelligence** - presented by **Niall Berkery**

2. **Lidar 2.0** - presented by **Glen de Vos**



LIDAR 2.0

Lidar 1.0 was all about the technology and the art of the possible. Lidar would play a key role in enabling compelling autonomous features and user experiences which would drive high levels of adoption, leading to affordable system costs ... this has simply not happened.

Lidar 2.0 is about value. While lidar remains a critical element in autonomous and semi-autonomous systems, Lidar 2.0 is focused on delivering the required performance at a cost level that enables unlocking value for both the OEM and the end consumer. This is the path to scale and mass adoption.

Glen DeVos will share his perspective on what this means for the Lidar industry and the developments that are required to enable Lidar to achieve mass adoption within the automotive industry.

Niall Berkery
CEO & Co-Founder,
Neumo

Glen de Vos
CEO,
MicroVision

17:00 The New Physics of Automotive Software



Dominik Wee
Microsoft

17:30 AI-Defined Vehicles and Mobility: Why Data and AI, will Decide the Automotive Future



Joachim Langenwaller
CEO & Founder,
TMT CoPilots

18:00 End of Conference Day 1

18:30 Drinks being served at Reithaus Ludwigsburg

19:00 Industry Get-together at Reithaus Ludwigsburg

Day 2: Wednesday, 17 June 2026

08:40 Welcome to Conference Day 2



Maxi Sarwas
Moderator & Journalist

08:45 Intelligent Mobility in China: Market Standards and Trends in AI-Powered Vehicles



China has rapidly emerged as the global frontrunner in intelligent and connected vehicle development, driven by strong policy support, high consumer acceptance of digital ecosystems, and intense competition among domestic and international OEMs. The Chinese automotive market is fast-moving and highly transformative, with digitalization and electrification as main tech drivers.

This presentation explores key market trends shaping AI-powered vehicles in China, including advancements in highly assisted driving, in-vehicle AI assistants, data-driven user experiences and state of the art SDV architectures. It further examines how legislation and technology can go hand in hand to achieve enhanced customer experience.

By analyzing industry strategies, technology partnerships, and regulatory developments, the presentation provides insights into how China's unique innovation ecosystem including tech players, authorities and regulation bodies is redefining automotive standards and influencing global mobility transformation.

Ivo Muth
Executive Vice President of Audi China R&D,
Audi (China) Enterprise Management Co., Ltd.

09:15 Re-thinking the Future Vehicle



Dr. Markus Heyn
Member of the Board of Management & Chairman Mobility,
Robert Bosch GmbH

09:45 The Future of Semiconductors in the Software-Defined Vehicle



Peter Schiefer
President & CEO of the Automotive Division,
Infineon Technologies AG

10:15 Transforming Mobility: The Power of Edge AI in Next-Generation Vehicles



Dr. Ahmad Bahai
Senior Vice President & CTO,
Texas Instruments

10:45 Coffee Break & Networking



Register for this conference online:
<https://www.automobil-elektronik-kongress.de/tickets/>



11:15 **Volvo Cars Reinvention for a Software-defined Future. And why it matters.**



An inside look at how the company is reinventing itself for a software-defined future, and why it matters far beyond the automotive industry.

At a time when technology is often used to impress, Volvo Cars is taking a different path: deploying software, AI and advanced computing with a clear purpose - to make people safer and improve quality of life. This philosophy has driven a deep transformation of the company, from its core vehicle architecture to how it builds and scales software.

Thanks to Volvo Cars scalable product architecture (SPA3), next-generation core compute, and a full stack software capabilities, it can improve nearly everything you can think of in the car with software, such as increasing charging speeds or introducing new safety features.

By advancing embodied AI, Volvo Cars enables vehicles to learn from real-world experience and share those insights across the fleet, turning every mile driven into a continuous improvement in safety.

And by investing in in-house software development, AI capabilities and scalable platforms, Volvo Cars is taking greater control over its technology stack, that was developed in Sweden, to ensure resilience, security and long-term innovation in a rapidly changing global landscape.

Join Alwin Bakkenes, Head of Global Software Engineering at Volvo Cars for an inside perspective on the architectural decisions, breakthroughs and cultural changes that are enabling Volvo Cars to lead in the software-defined era.

Alwin Bakkenes
Head of Global Software Engineering,
Volvo Cars

11:45 **Differentiating Experiences at Speed and Scale**

Christian Sobottka
President & CEO of HARMAN & President,
HARMAN Automotive

12:15 **Architecting Semiconductor Sovereignty: China's Disruptive Path to AI-Powered Automotive Electronics**



As the Chinese automotive industry enters its third decade of the 21st century, the sector is transitioning from a period of high-speed expansion into a strategic "slow growth" phase characterized by profound structural transformation. Having witnessed annual sales volumes surpass the 30-million-unit milestone in 2024, and export volumes rise to 7 million, the number 1 of world, it is clear that China has evolved into a primary architect of the global mobility future.

This presentation explores how the convergence of New Energy Vehicles (NEVs) and Autonomous Driving is redefining the industrial core. With NEVs now overtaking 50+% market share in China and consumers exhibiting significantly higher confidence in autonomous driving than their global counterparts, we are accelerating the shift from rule-based engineering to data-driven, AI-powered intelligence.

The true "battle for sovereignty," however, lies within the semiconductor. As EE architectures evolve from distributed ECUs toward central computing platform, the demand for high-performance, high-reliability chips has become a matter of strategic necessity. While significant domestic breakthroughs have been achieved in power electronics, MCUs, and SoCs, we must candidly address the supply chain risks in upstream EDA tools, core IPs, and advanced manufacturing.

The roadmap for China to achieve true semiconductor sovereignty by 2035, targeting computing power exceeding 3000 TOPS and supporting L5 full-scenario integration. To succeed, we must move beyond traditional supplier-buyer relationships and embrace a "Virtual IDM" model—an integrated ecosystem where OEMs and chip designers co-create the silicon that will power the next generation of smart mobility.

Dr. Chengyin Yuan
Secretary-General,
China Automotive Chip Industry Innovation Strategic Alliance

12:45 **Joint Lunch Break & Networking**

13:45 **The Effortless Journey: Unlocking the Full Potential of the Software-Defined Vehicle with Google Maps**



For the past few decades, the automotive industry has steadily advanced E/E architectures, culminating in today's incredibly powerful Software-Defined Vehicles. As we enter the AI era, automakers have an unprecedented opportunity to multiply returns on their hardware investments and deliver highly integrated driving experiences. Today's drivers seek more than a touchscreen; they want an intelligent, conversational partner that understands them and naturally anticipates the real world, seamlessly offloading the complex "math of the drive."

In this keynote, Jørgen Behrens explores how Google is translating its latest consumer innovations into an automotive-grade engineering reality. From natural conversational assistance, to immersive 3D spatial intelligence, to deeply integrated lane-level guidance and energy modeling, Jørgen will demonstrate how the map and the machine now work as one. Underscoring Google's commitment as a long-term partner that prioritizes OEM choice and brand sovereignty, he will share how this collaborative intelligence allows automakers to accelerate SDV innovation, reduce development burdens, and deliver the ultimate luxury: a truly effortless journey.

Jørgen Behrens
Vice President & General Manager Google Maps Automotive,
Google

14:15 **From Smart Vehicles to Embodied AI: Building the 'Silicon-Based Life' Architecture of the Future**



Artificial Intelligence is reshaping the boundaries of the automotive industry. In this presentation, we will share Li Auto's new strategic vision of moving beyond the definition of a traditional automaker to become an "embodied AI enterprise." We believe in "tech equality," and we want to use AI at scale to bring high-quality experiences—like having a private driver or butler—to everyone, not just a select few.

To make this happen, we will show how we are rethinking the smart vehicle from the ground up, turning it into a "silicon-based lifeform." We will explore our latest practices and potential pathways in hardware-software co-design, detailing exactly how we are building a complete life system for this "silicon-based being": a stronger "heart"—the M100 chip; sharper "eyes"—the 3DViT model; a smarter "brain"—the MindVLA 2.0 model; more agile "hands and feet"—the x-by-wire chassis; and a more sophisticated "vascular system"—the Li Auto Halo OS.

Ultimately, all technological evolution serves the human experience. Through a video, we will showcase the latest capabilities of our next-generation Livis, allowing you to witness how our technology is redefining the user experience.

Key Takeaways for the Audience:

- Our Strategic Evolution
- The "Silicon-Based Lifeform" AI Architecture
- Core Technologies
- The Redefined User Experience with Livis

Dr. Liu Qiang
Vice President, Li Auto Inc. General Manager,
Li Auto Germany R&D Center GmbH

14:45 **Integrating Edge AI into Modern E/E Architectures**

Dr. Alexandre Corjon
Senior Vice President, Engineering
Sonatus Inc.

15:15 **Final Remarks & Farewell by Conference Chair**



Ricky Hudi
CEO,
Future Mobility Technologies

15:30 **End of Conference**



With the software-defined vehicle, the importance of secure and transparent software supply chains is growing: SBOMs help manufacturers detect vulnerabilities at an early stage, meet regulatory requirements, and systematically manage cyber risks.

Picture: TechLens - stock.adobe.com

Cybersecurity

Eyes on the software supply chain

Software has become the heart of vehicles and thus also the central entry point for cyber risks. Regulatory requirements such as the Cyber Resilience Act are a response to this. It is high time for manufacturers to make their software supply chains transparent.

In modern vehicles, sometimes more than a hundred control units are at work, and in any case there are millions of lines of code – and the trend is rising. With the transition to the software-defined vehicle, not only functionality grows, but also the attack surface for cyberattacks. At the same time, regulations worldwide are tightening the requirements for the automotive industry. In short: manufacturers have no choice but to make their software supply chains transparent. Software bills of materials (SBOMs) are becoming the key to security, compliance, and competitiveness.

The importance of “software supply chain security” is increasing, above all due to new regulatory requirements that demand systematic management of cyber risks from manufacturers. This includes vulnerability analysis, reporting obligations, and the rapid remediation of critical security gaps. “For the vehicle, the UN EVE WP.29 applies, obligating manufacturers to cybersecurity, while for production the European NIS2 directive and the Cyber Resilience Act apply,” explains Mirko Ross, CEO of Stuttgart-based risk analysis specialist asvin. “All of these regulations require the management of cyber risks.”

In this context, the software bill of materials is gaining in importance. “It makes it possible to search within a piece of software for known vulnerabilities, because it maps the ‘blueprint’ and the ‘ingredient list’ of that software,” Ross explains, making the SBOM an essential building block in cybersecurity management.

Complex supply chains

This is no trivial task, because the automotive industry has one of the most complex supply chains in the world. Vehicles consist of thousands of components and software modules from different suppliers. OEMs often develop only part of the software themselves – large portions come from tier-1 and tier-2 suppliers or from open-source libraries. This structure makes it significantly more difficult to keep track of dependencies and risks. In addition, vehicles are increasingly updated over the air, causing software versions to change continuously.

“Software products are complex constructs with numerous components from suppliers, interfaces to cloud services, and increasingly also AI applications,” Ross emphasizes. “Keeping an overview here and obtaining an up-to-date situational picture is an enormous challenge.” There is also a structural problem: changes to the software must be documented along the entire supply chain. “This only works if OEMs and

suppliers work hand in hand. But automated processes and standardized interfaces are often lacking,” the expert notes.

To address these risks, manufacturers are pursuing a dual-track approach: “Organizationally, OEMs are passing on the obligation for cybersecurity and the provision of SBOMs through delivery and purchasing conditions,” reports Ross. As a result, cybersecurity requirements are increasingly being integrated into supplier contracts. Suppliers must, for example, provide SBOMs or demonstrate how they monitor and remediate vulnerabilities. At the same time, regulatory requirements call for continuous risk analysis over the entire lifecycle of a vehicle. “From a technical perspective, however, it is more complex,” says Ross. The main focus here is on the integration of SBOM standards and automated toolchains. Industry-wide, formats such as SPDX or CycloneDX are common, providing machine-readable information about software components. Ross: “There are several SBOM standards, and these must be converted losslessly between suppliers and OEMs,” explains Ross. “If data is lost in the process, the entire toolchain for scanning vulnerabilities suffers.”

Standardization meets culture

However, the introduction of SBOM-based security processes is not just a technical challenge. It also requires organizational changes in development processes and collaboration. “It is about both standardization and cultural change,” says Ross. “With an SBOM, suppliers disclose the blueprint of their software to the OEM.” In practice, this level of transparency sometimes meets with reservations, for example due to concerns about intellectual property. At the same time, effective SBOM management requires that the documentation be updated with every software change. “This requires a secure software development lifecycle at OEMs and suppliers that is closely interlinked. Product development and software development have to work together more closely here.”

A central role is played by the integration of SBOM creation and vulnerability analysis into DevSecOps and CI/CD pipelines. According to Ross, SBOMs come into play at two points: first, in the quality management of the CI/CD pipeline. Before deployment, the software is automatically checked for known vulnerabilities. Second, SBOMs serve as documentation of the actual software version delivered. This approach enables continuous monitoring of the software supply chain and a faster response to newly discovered vulnerabilities.

What are software bills of materials (SBOMs)?

A software bill of materials, or SBOM for short, is a machine-readable list of all components that make up a piece of software. It documents which components, libraries, and modules are included in a product, who provides them, and how they depend on one another. This creates transparency across the software supply chain – similar to an ingredient list on food products. Typical contents of an SBOM include the name and version of a component, the manufacturer, unique identifiers, cryptographic hashes, licensing information, as well as direct and transitive dependencies. In practice, SBOMs are ideally integrated automatically into development and CI/CD processes and generated in standardized formats such as SPDX or CycloneDX.

Automated SBOM analyses can, for example, detect when an outdated open-source library is included in vehicle software and poses a security risk.

SBOM as a competitive factor

In view of growing regulatory requirements, SBOM management is becoming mandatory for all market participants. However, the maturity level of implementation varies significantly. “Those who achieve the highest level of automation here will have a direct competitive advantage,” says Ross. It is clear that the topic of the supply chain has gained an important new dimension that no one can ignore. (pm) ■

Author: Chris Löwer, freelance journalist

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“A powerful software platform is essential. It influences the cost structure as much as the vehicle’s overall performance,” says Gilles Mabire, CTO of Valeo’s Brain Division.

Picture: Valeo

Interview with Gilles Mabire, CTO Valeo Brain Division

“Software must never be viewed in isolation from hardware”

The software-defined vehicle will not be decided by code alone. In an exclusive interview with Automobil Elektronik, Gilles Mabire, CTO of Valeo’s Brain Division, explains why the interaction between software, hardware and sensors is becoming critical.

Mr Mabire, you have been CTO of Valeo’s Brain Division for a few months. What was at the top of your agenda? First of all, I was fortunate to take over a very well-positioned organisation and a strong team. My predecessor, Joachim Mathes, left me with a solid foundation. For someone stepping into a role like this, that is extremely

valuable. At the same time, it is clear that the Brain Division is now at the centre of the automotive industry’s transformation. On the one hand, there is the software-defined vehicle, which is fundamentally changing the industry. On the other, there is agility: making development, collaboration and decision-making faster and

more flexible. And thirdly, I am focused on the question of what we in Europe need to do to strengthen our competitiveness and technological sovereignty. For me, these three topics belong together: technology, organisation and collaboration.

Let us stay with the software-defined vehicle. The term is everywhere, but in practice the complexity quickly becomes apparent. Where do things most often get stuck today?

First of all, the SDV has long since become more than a buzzword. It is a reality. We are working with several OEMs to bring corresponding solutions into series production this year and next. At its core, this is about continuously developing a vehicle throughout its entire lifecycle. It is no longer enough to deliver a product once. You have to provide updates, improvements and new functions on an ongoing basis. In the long term, that is precisely where great value lies for mobility and for the competitiveness of the automotive industry. But the challenge is enormous. It starts with the system architecture and extends from the integration of hardware and software all the way to validation, testing and assurance. Every additional function and every new software generation increases complexity. The key is therefore not to look at this complexity in isolation, but to master it systemically.

What will be more important in the coming years: the perfect software platform, or the ability to integrate hardware, software and sensors cleanly?

A powerful software platform is essential. It influences the cost structure as much as the overall performance of the vehicle. There can be no compromises in this area. Anyone who wants to remain competitive in the market in future needs a modern and competitive software base. But that is only one part of the equation. Software must never be viewed in isolation from hardware. At the same time, sensors and computing platforms also have to evolve. Ultimately, what really matters is the ability to bring all these layers together in one overall system. Low-speed manoeuvres are a good example: parking functions, automated parking or, in the future, Level 4 parking. For that, you need highly capable software, but also the right hardware architecture and precise sensing based on ultrasonic sensors, cameras and radar. Only when this interaction works properly does real added value emerge for the customer. That is why, in my view, the greater leverage does not lie in an either-or decision, but in integration.

And that is precisely where assurance comes in. Valeo places strong emphasis on virtual validation and digital twins. In a world of continuous updates, is validation becoming the bottleneck?

It is certainly a key factor. For us, virtualising development is a central lever for defining and assessing the architecture and the overall system at a very early stage. Ten years ago, we did not have these possibilities in this form. Back then, it was much more difficult to identify

and manage complexity early on. That is why we have invested heavily in digital development and test environments, also together with partners. Our aim is to digitalise systems as far as possible and to be able to test them largely without physical hardware. This not only accelerates development and assurance, but also improves quality. In addition, we use AI in development itself. We use AI not only in our products, but also in our own software processes. Today, more than a quarter of our software is created with the support of a coding assistant that we use together with Google. As a result, we are seeing clear progress in speed, quality and maturity. We have taken a major step forward, particularly in safety and in dealing with complexity.

“We do not believe in lock-in effects, and open source offers a real advantage in many areas.”

Gilles Mabire,
CTO Valeo Brain Division

The software-defined vehicle is always a collaborative project as well. Where does the boundary between OEM and supplier run today?

That boundary is much less clear today than it was a few years ago. In the past, the relationship between OEMs, Tier 1 and Tier 2 suppliers was organised in a strongly vertical way. Everyone had their clearly defined role. That model has now reached its limits.

Today, we are moving much more within an ecosystem. Carmakers, suppliers, software partners and other tech players are working together more closely and more at eye level. The building blocks can be hardware, software, tools or complete subsystems. Such a model can only succeed if all parties pursue a common goal. From my perspective, the OEM's task is to truly understand the customer's needs and turn them into a compelling user experience. The supplier's task is to translate that understanding into robust technical systems: into platforms, functions, subsystems and integration capabilities.

Let us turn to autonomous driving. GenAI and world models are seen as promising technologies, yet progress in many areas is slower than expected. What, in your view, is genuinely close to series production?

AI is not something fundamentally new for us. We have been using it for years in our products, but also as a tool in the development of those products. That applies to physical systems just as much as to software. Our teams have extensive experience in training models, in synthetic data and in combining synthetic data with real-world data. With these approaches, we are already working today on Level 2 and Level 2+ systems. Together with customers, we are developing programmes that are scheduled to go into series production in 2027 and 2028. Level 3 and Level 4 are still further away in terms of timing. They require additional progress in foundation models, data management and computing architecture. That is exactly what we are working on. And because these challenges cannot be solved in isolation, we are also involved in European projects and collaborations. What is close to series production today is primarily what is already being translated into concrete programmes around Level 2 and Level 2+. The next stage will come, but it clearly needs more time and more collaboration.

Valeo is deliberately pursuing openness when it comes to world models. Why not take a proprietary approach?

Because we do not believe in lock-in effects, and because open source offers a real advantage in many areas. The decisive question is not always: which technology can I completely control myself? Often, the more important question is: how can I adapt existing technology so that it delivers the greatest benefit for my application? If powerful solutions are already available in an open environment, it makes sense to build on them rather than developing everything from scratch in a proprietary way. Openness accelerates development, increases momentum and strengthens competitiveness. Of course, we are not simply relying on external technology. Our contribution lies precisely in adapting such models to concrete requirements: to functionality, safety and the specific application in the vehicle. The real value lies in this translation from an open model into a robust automotive solution.

What does the next step in automated driving need more: better algorithms or better data?

Both. More powerful algorithms are indispensable, but without high-quality and well-orchestrated data, their benefit remains limited. Large volumes of data alone do not help if that data is not properly structured, curated and meaningfully integrated into development processes. That is why this is always about several layers at once: better algorithms, better data, good data management and a consistent system architecture. Added to this are the interfaces to the sensors: cameras, radar, ultrasonic sensors or lidar. Only the interaction of these components enables the next step.

Let us look inside the vehicle. Valeo presented new in-cabin monitoring solutions at CES. Which of these are already real, and which are still demonstrators?

Perhaps I should start by saying this: for us, the software-defined vehicle is not just about technology. It is about using that technology to create a safe and desirable vehicle. What ultimately matters is what the customer experiences and what added value they actually perceive. This is precisely where driver and occupant monitoring play a central role. The first step is clearly a safety use case: the system has to detect whether the driver is attentive or, for example, looking at a smartphone. Solutions like this are already in development or in production in many regions of the world. This is no longer science fiction.

And what is the next step?

In future, it will increasingly be about linking ADAS functions with what is happening inside the cabin. The vehicle has to understand what is going on in the cabin, especially when the driver is not constantly focused on the road at higher levels of automation. The system has to assess whether a person is able to take back control and, if necessary, respond in good time with warnings and information. Beyond that, a new field of interaction and personalisation is emerging. Cameras and algorithms can detect whether someone is tired, how many people are in the vehicle or what the current usage situation is. From this, functions can be derived that make

the vehicle more intuitive and helpful. In combination with generative and agentic AI, we see considerable potential here.

Valeo is also involved in assistance systems for two-wheelers. How much can be transferred from the car to that area?

More than one might initially think. The starting point is a clear safety need, because a significant proportion of serious accidents still involve two-wheelers. That is precisely why we need to develop new solutions in this area. The underlying core technologies are quite similar to those used in cars. Of course, there are differences in packaging, integration and validation. But these are not two completely separate worlds. Many technologies and development approaches can be transferred. That is exactly why we also see growth potential in this field. We have already entered into partnerships with various manufacturers, and that shows that the market is there. Our goal is clear: we want to help significantly reduce the number of accidents involving two-wheelers.

Whether on two wheels or four, V2X is a central building block for road safety. It has been discussed for years, but the breakthrough has yet to come. What needs to happen?

From a technological point of view, many of the foundations are already in place. In China, corresponding solutions have already been brought into series production. The technology works and can create significant added value through the interaction of vehicles, infrastructure and other road users. We have also demonstrated its potential in other regions. V2X can make situations visible that conventional sensors alone cannot cover. Especially when it comes to low latency and information beyond the direct line of sight, that is a major advantage. The real open question today, in my view, is less the technology than the business model. Who invests? Who benefits? Who takes on which role in this ecosystem? Many building blocks are already available, for example in smartphones or telematics boxes. What is needed now, above all, is the will to scale. Regulatory impulses could further accelerate this process. I am convinced that V2X can become a real breakthrough for road safety, especially in urban environments.

Finally, looking ahead: if we speak again in three years' time, how would you measure whether Valeo's Brain Division has truly taken a step forward?

A first benchmark would be that our Level 2+ solutions are successfully in series production and are developing into a standard in mobility. Secondly, I would like to be able to show that we are competing on equal terms with very strong competitors, including from China, and that we are bringing products to market much faster with the help of artificial intelligence. Thirdly, it would be a clear signal of success if road safety had noticeably improved through our technologies, meaning cameras, radar and sensing overall. And finally, I would like us to have brought the software-defined vehicle into series production as a safe and desirable product, and for customers to recognise and value that added benefit. (pn) ■

Interview by Pascal Nagel



Unlocking the **AI-defined** vehicle

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Reshaping the in-vehicle safety experience

When Automotive Systems think ahead

Driver monitoring, contextual situational awareness and connected safety functions can create proactive in-vehicle support. By fusing driver state, traffic data and adaptive HMI output, vehicles can respond earlier and more precisely in complex risk scenarios.

Friday, 5:30 p.m. On a city highway, traffic is stop-and-go. Heavy rain is falling, and dusk is setting in. Visibility is poor; brake lights blur across the wet road. The driver is coming off a long workday, is tired and under time pressure. Push notifications on the smartphone add another layer of distraction.

What emerges is not a single risk, but an interconnected risk system: impaired perception, reduced cognitive performance, and a constantly changing traffic environment. Traditional rule-based assistance systems reach their limits in situations like this because they often assess events in isolation.

Here it becomes clear that safety must be understood as a system. Diverse influencing factors, driver condition, environmental conditions, and traffic dynamics, must be captured in real time, evaluated, and combined. This is where the synergy of Harman Ready Care

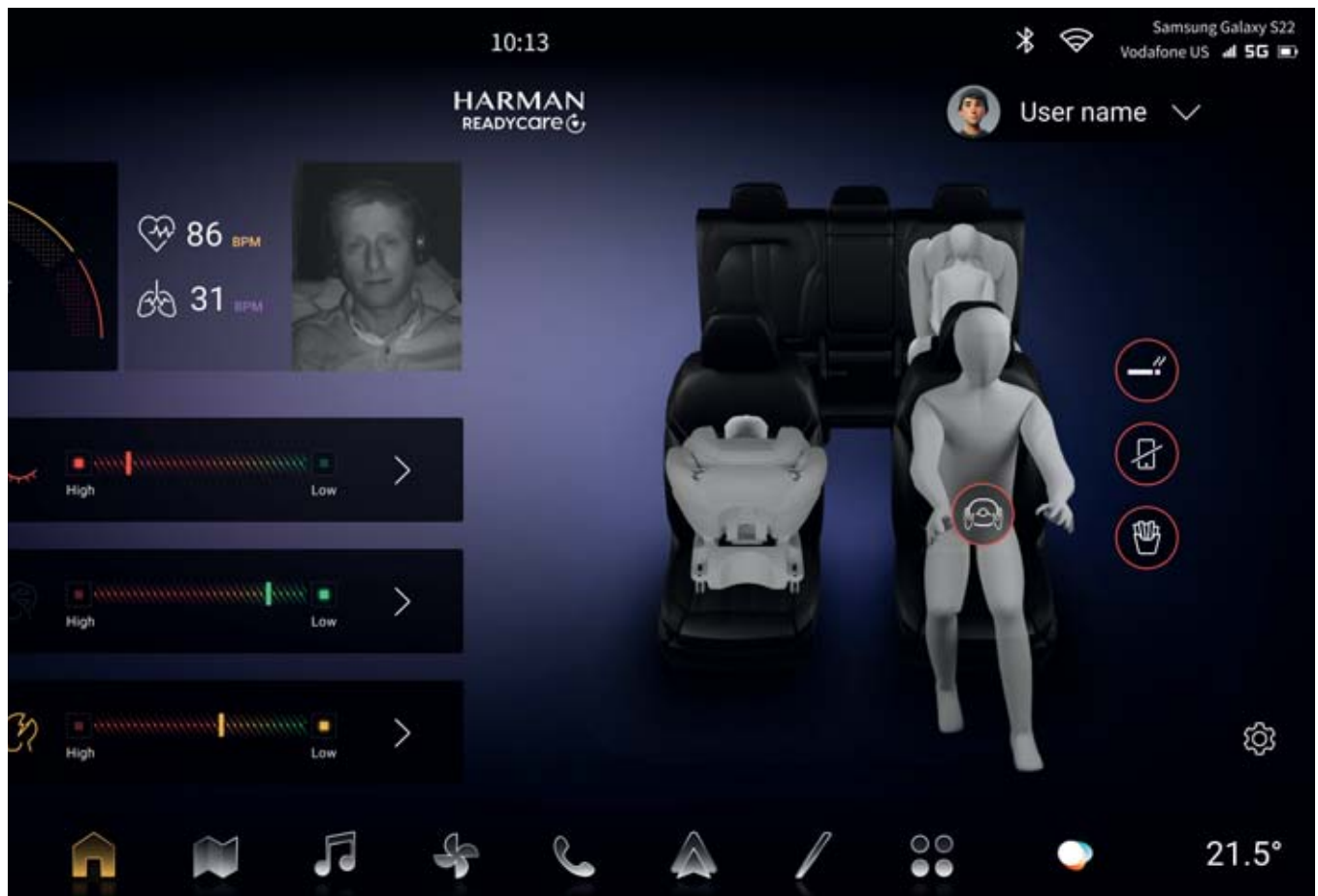
comes into play: through cross-domain data fusion and context-based evaluation models, Harman brings together in-cabin intelligence, connected situational awareness, and robust, adaptive HMI output to create a safety experience that supports proactively rather than merely reacting.

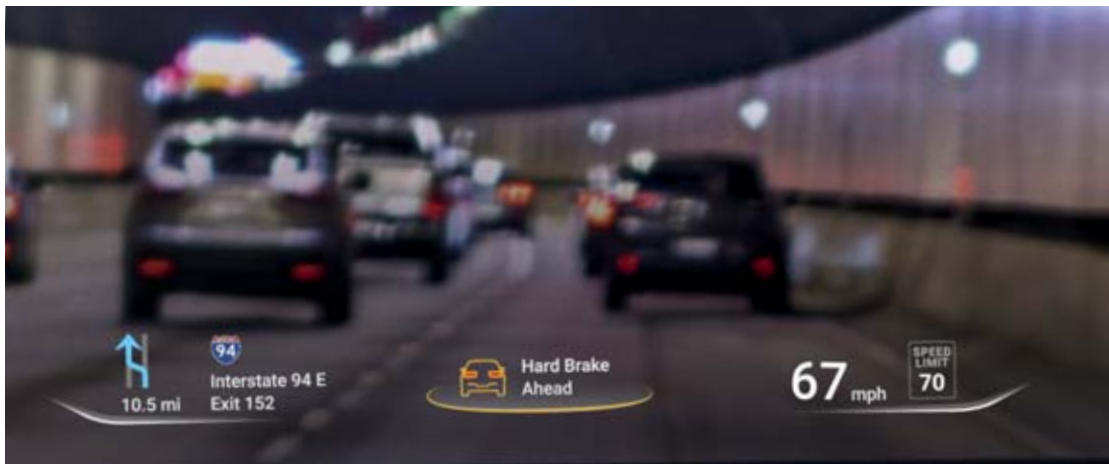
Driver condition as the starting point for safety logic

The critical phase begins inside the vehicle, even before a specific event occurs. Modern driver monitoring systems such as Harman Ready Care continuously analyze the driver's condition. In the scenario described, Ready Care uses contactless, camera-based technology to monitor vital signs such as heart rate and breathing intervals in order to detect stress levels and the onset of fatigue. At the same time, the system evaluates the driver's attention

Sample visualization of data identified by Harman Ready Care on the driver's state with regard to fatigue, distraction, and stress.

Picture: Harman





Harman Ready Aware detects an emerging hazard (heavy braking ahead) and displays a warning in the head-up display.

Picture: Harman

and distraction status (“Eyes & Mind on Road”), distinguishing among visual, manual, and cognitive distractions.

The result is not a binary warning, but a continuous assessment of the driver’s condition, for example, “onset of fatigue and elevated stress; trend: increasing.” This allows the system not only to detect hazards, but also to judge how well the driver is still able to respond in that specific situation. Robust results are achieved through ML models and sensor-data fusion, which deliver stable status parameters even under challenging conditions such as seating position, changing light, eyewear, or partially obscured facial features.

Context-based risk assessment through connected systems

Alongside the driver analysis, the vehicle assesses its surroundings. Harman Ready Aware enhances traditional onboard sensors with Vehicle-to-Network (V2N) data about the vehicle’s environment, extending situational awareness with contextual real-time information beyond the driver’s line of sight. A situational awareness engine processes, filters and prioritizes context-based events, while an analytics/confidence engine evaluates them and assigns a confidence score. The goal is to reduce false alarms and information noise, minimize alarm fatigue, and increase user acceptance.

In this scenario, based on cloud-based V2N data feeds containing traffic and infrastructure events, the system reports a traffic jam 500 meters ahead, along with increased braking activity, early enough to preserve a margin for action.

Data fusion and coordinated system intervention

The key now is to correlate the driver’s condition with the surrounding situation. In state-coupled control, Ready Care transfers the driver’s status to Ready Aware. Ready Aware then switches to a stress- and fatigue-adaptive awareness mode, in which trigger thresholds for critical events, such as a traffic jam, an accident or hazard, or abrupt braking ahead, are adjusted, and onboard sensor data and V2N information are weighted more heavily toward near-term collision risks.

The logic is straightforward: when the driver has fewer cognitive reserves, the system must provide sup-

port earlier and more selectively. Non-safety-related alerts are therefore suppressed, while outputs focus on safety-critical event categories. Information is delivered where it is most likely to reach the driver reliably, for example via the head-up display directly in the driver’s field of view. In addition, directional audio signals can further support rapid, targeted perception of the warning. The result is that the driver can adjust speed and following distance earlier.

The challenge lies in maintaining a consistent, low-latency end-to-end chain: in-vehicle data acquisition, local evaluation and filtering enriched by relevant cloud information, and HMI output coordinated with other content in a way that remains clear and dependable in the moment.

Connectivity as the backbone of the architecture

An escalation chain is in place for emergency scenarios: if an incident occurs despite intervention, the vehicle detects the crash and the Telematics Control Unit automatically initiates the eCall and sends the Minimum Set of Data, such as position and direction of travel. Harman’s Ready Connect TCU supports 4G and 5G connectivity as well as satellite communication (NB-NTN) with text and voice, enabling safety-critical communication such as messaging or emergency SOS functions in regions with limited cellular coverage.

Systemic safety instead of isolated functions

In heavy evening traffic with poor visibility, it is no longer the driver’s reaction time alone that matters, but the quality of system support. This scenario illustrates the shift from isolated functions to a state- and context-aware system for more integrated safety. The identified cognitive driver state (Ready Care) modulates the awareness assessment (Ready Aware), which in turn governs the output and intervention strategy (HMI/display plus cabin signals) and, in exceptional cases, feeds into a robust emergency chain (Ready Connect, eCall). Safety thus becomes proactive, context- and driver-state-based, not as a single warning, but as a coordinated end-to-end function. (bs) ■

Author: Stephan Preuss, Senior Vice President, Division Technology and Product Management, Automotive at Harman



Radar-based solutions increase passenger safety and require reliable and safe embedded software.

Picture: HighTec

Passenger Safety

Implementing In-Cabin Radar Monitoring with Embedded Software Toolchains

With Euro NCAP's 2026 protocol, child presence detection becomes mandatory for top safety ratings. Radar-based solutions such as Novelic's ACAM, developed using optimized embedded software tools from HighTec, demonstrate how these requirements can be met.

When it comes to passenger safety, the Euro NCAP's 2026 safety protocol significantly raises the bar: To achieve top ratings, OEMs and Tier 1 suppliers must implement Child Presence Detection (CPD) into the vehicles. The protocol requires the use of direct sensing technologies such as radar or cameras to detect the presence of children up to six years old within 15 seconds after the vehicle is locked. If a child is detected, the system must trigger exterior alerts such as horn or light activation within 15 seconds, followed by escalating warnings, including smartphone notifications or haptic feedback, if the child remains inside the vehicle.

The Euro NCAP requirements place high demands on sensing technology, signal processing, and system integration. Systems must reliably detect even minimal movements, such as the breathing of a sleeping infant, while operating under strict constraints in terms of power consumption, processing capability, and functional safety.

Radar-Based In-Cabin Monitoring

One approach to addressing these challenges is Novelic's Automotive Cabin Advanced Monitoring (ACAM) solution. Its 60 GHz mmWave in-cabin monitoring radar sensor is designed to monitor the vehicle cabin and detect the presence and movement of occupants, including children and animals. ACAM does not require a line of sight to detect individuals and does not invade passenger privacy.

Compared to camera-based systems, radar offers advantages in low-light or obstructed conditions and enables detection of very small movements. ACAM integrates these capabilities into a compact, power-efficient module and achieves high detection accuracy in line with CPD requirements. In addition to child presence detection, the system supports further features such as seat occupancy detection as well as intrusion and proximity alerts. This allows the same sensing technology to be used for multiple safety and convenience functions.

Challenges in Software Development

The implementation of Novelic's ACAM solution placed high demands on its embedded software as the system requires complex real-time signal processing while maintaining deterministic behavior and meeting strict functional safety requirements. Software development tools therefore had to generate highly efficient and predictable code to meet both performance and safety constraints.

Novelic used the HighTec Development Platform, including an automotive-grade C/C++ compiler to develop and optimize the embedded software of ACAM's radar-based monitoring capabilities. HighTec's toolchain is optimized for the Infineon Aurix TC3x MCU architecture. This MCU family is widely used in automotive safety-critical systems and provides the performance, reliability, and functional safety capabilities required for advanced sensing.

Impact of Development Toolchains

HighTec's multi-architecture compiler support enables developers to target multiple processor platforms and future hardware generations, allowing companies like Novelic to maintain long-term platform flexibility as automotive electronic architectures continue to evolve. As HighTec compilers are based on widely adopted open-source technologies, development teams benefit from a shorter learning curve and reduced vendor lock-in. This enables engineers familiar with open-source toolchains to become productive quickly and integrate the tools easily into existing development environments.

The collaboration between Novelic and HighTec enabled faster development cycles and reduced time-to-market. HighTec's technical support team worked closely with Novelic engineers throughout the development process, helping resolve technical challenges and ensuring that development milestones could be achieved on schedule.

For demanding applications such as in-cabin radar monitoring, systems must process complex signals and detect extremely small movements, e.g. a sleeping infant's breathing, in real time under strict power and performance constraints. HighTec's compilers generate the optimized code required for high-performance embedded software. Furthermore, HighTec compilers are certified according to the ISO 26262 functional safety standard up to ASIL-D, the highest automotive safety integrity level. This gives Novelic confidence that the generated code is trusted and provides their platforms with a solid foundation and a clear path toward potential future safety certification.

In-Cabin Sensing in Future Vehicle Systems

Not only to meet the requirements of the Euro NCAP standard, but to add to their vehicles' safety and convenience features, more and more automotive manufacturers are integrating advanced in-cabin sensing technologies. In addition to child presence detection, in-cabin monitoring systems can enable features such as occupant classification, seat-belt reminders, driver monitoring, and personalized vehicle settings.

As vehicle safety standards evolve and regulatory requirements expand, solutions like Novelic's ACAM are expected to play an increasingly important role in helping automotive manufacturers meet both safety and consumer expectations. Leading tool providers such as HighTec help ensure that their embedded software keeps pace with safety requirements and market developments. (na) ■

Authors: Mario Cupelli, CTO at HighTec EDV-Systeme, and Jure Galic, Marketing Manager at Novelic



Novelic's ACAM is a 60 GHz mmWave in-cabin monitoring radar sensor.

Picture: Novelic



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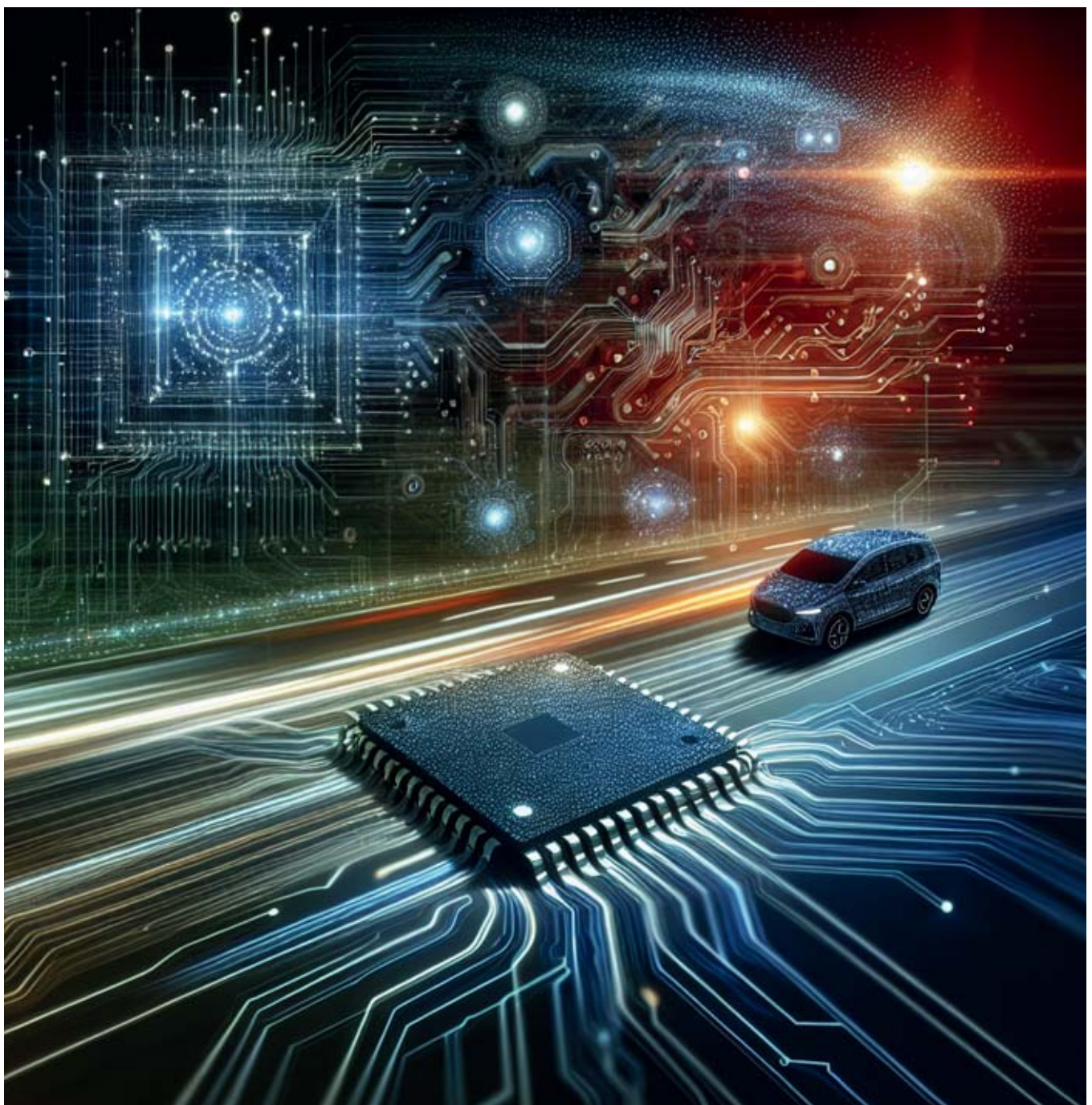
Functional Safety in the Software Era

The Interdependencies of Hardware and Software for Functional Safety

How do hardware and software interact in functional safety? Integrated design, verification, and observability are essential for safe automotive ECUs.

Picture: 2025 Shutterstock AI Generator/Shutterstock

As safety-critical vehicle functions shift from mechanics to code, functional safety depends on more than robust hardware. Reliable integration, verifiable software behavior, and system-level observability become essential.



The automotive industry is innovating in electrification, advanced driver assistance systems, and software-defined vehicle architectures, while trying to align to cost and time-to-market constraints set by the globally competitive supply chain. As vehicles evolve, safety-critical functions that once relied on mechanical systems are increasingly implemented in software alone.

Innovations in vehicle development must comply with ISO 26262 for functional safety and ISO 21434 for cybersecurity assurance, both of which are recognized as state-of-the-art by the automotive industry. This article first establishes what constitutes safe hardware and safe software in the context of safety-critical ECU functions, then examines the challenges of hardware-software integration, and discusses tools and methods that can be used to increase the observability of software behavior during hardware-software integration.

Functional Safety in Hardware Design

When talking about automotive applications FPGAs (field-programmable gate array) play a vital role for emerging technologies and allow the required flexibility until application specific standard products may become available. These applications often result in volumes of several hundred thousand units and hence statistical effects play a significant role. Typical applications for FPGAs are sensor interfacing and providing extracted information to a central ECU. The information provided by these intelligent sensors is part of a safety-critical decision path, i.e., the triggered behavior may lead to an accident or fatality. Algorithms to extract critical information typically are implemented in the FPGA fabric, hence both the underlying technology as well as the specific implementation needs to guarantee that potential hardware failures can be detected.

Most FPGAs are based on SRAM-technology to hold the configuration information defining the functionality. This memory is susceptible to single event upsets (SEU) caused by, e.g., random charged particles and requires on-going health-monitoring and mitigation. Typically, mitigation means a reconfiguration of the FPGA which causes a short interruption of the device operation, which is considered a soft error compared to a hard permanent failure. In contrast, Microchip FPGAs are built for immunity against SEUs and hence will not require any resets or cause interrupted operation. Table 1 compares typical FIT-rates (failure in time) and the resulting number of expected events for SRAM-FPGAs to Microchip:

For the comparison 400 FIT for SRAM-based soft errors is estimated, considering raw FIT rates and calculations for configuration-bits essential for the functionality. To achieve safety compliance, engineers must combine the deterministic, fault-tolerant hardware with safety-certified software that ensures predictable, verifiable performance and design for hard failures which inevitably will happen.

Controlling Failure – Not Eliminating it

Functional safety is about controlling failure, not eliminating it. It accepts that faults are inevitable, but ensures that when they occur, the system reacts in an appropriate way.

For safety certification of hardware designs, the Microchip Functional Safety Package provides documentation, reliability data, and design guidance to support compliance of the implementation tools with SIL 3 (IEC 61508) and ASIL D (ISO 26262) and allows the design using safety decomposition on the hardware for ASIL B(D).

However, hardware determinism alone cannot guarantee system safety. Software is increasingly responsible for control, diagnostics, system update and recovery — making its predictability and verifiability equally critical.

Testing Layers of Functionality in FPGA- and SoC-Based Systems

A key question when designing safety-relevant systems is whether the various layers of functionality can be adequately tested, and whether the device alone is sufficient to achieve the required level of confidence. The answer depends on how each layer is monitored, protected, and verified (Figure 1):

- Power supply integrity: Correct operation of a device depends on a stable and compliant power supply, which must be addressed at system level.
- Hardware configuration: Microchip specifies the FPGA configuration to remain intact for at least 20 years, including immunity against SEUs. This enables permanent operation without the need to account for occasional resets. Only user logic state can be affected by single-event faults and therefore needs protection. For higher safety levels, an independent external watchdog can be added. Single faults can thus be detected and reported to a higher system level (Figure 2).
- Monitoring system components: Ensuring the correct operation of internal system components is one of the main areas where FPGA-based designs differ from MCU-based approaches. In MCUs, diagnostic coverage is usually fixed, while in FPGAs diagnostic mechanisms can often be implemented as needed. Clock integrity is a representative example for this (Figure 3).
- Protecting communication: Safety-related communication is typically protected end-to-end, using mechanisms that often are not implemented in the FPGA alone; End-to-end protection of data payloads is commonly handled by a MCU, where software-based safety mechanisms can react to detected errors and



Figure 1: Required functionality layers for safe FPGA design

Picture: Microchip

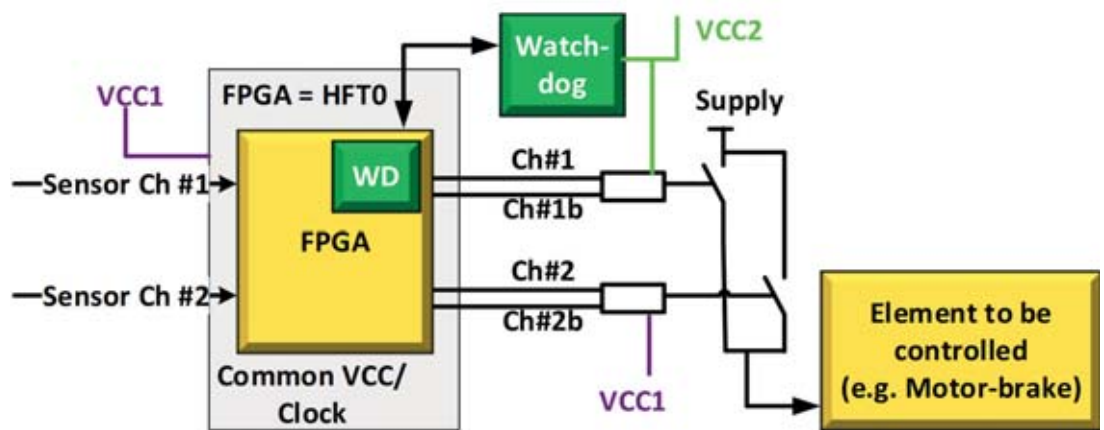


Figure 2: Example setup to achieve HFT=1 with FPGA
Picture: Microchip

transition the system into a safe state. By having both an internal FPGA watchdog and an external watchdog supervising each other, failures in either element can be detected by its counterpart.

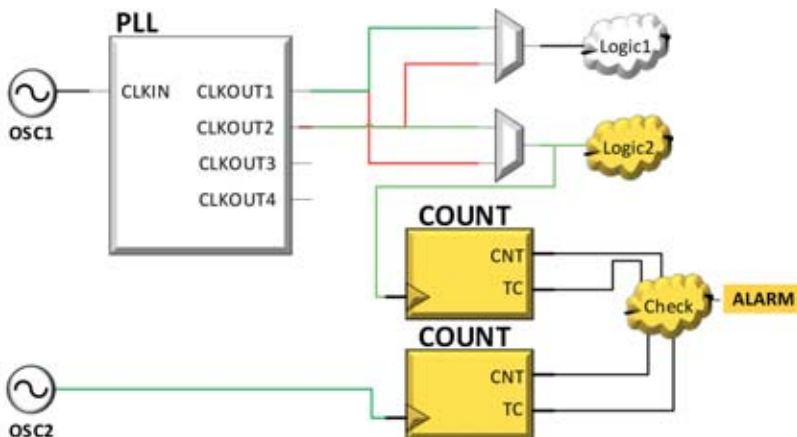
- Proprietary hardware design: The correct functioning of proprietary hardware design elements must be ensured. Independent responsibility for design and testing helps
- Reduce systematic faults and increases overall confidence in the safety of the system. Vendors like Microchip provide functional safety packages for multiple architectures (PolarFire, SmartFusion2, IGLOO2, IGLOO, ProASIC3). FPGAs need help from software to implement critical functions, which will be discussed in the next section.

Developing Safe Software

Safety is not an intrinsic property of the software itself — it is a property shared between the software, the hardware it executes on, and the safety requirements allocated to it. In the context of ISO 26262, software is safe when it demonstrably fulfils its allocated safety requirements at the assigned ASIL (Automotive Safety Integrity Level), without contributing to an unreasonable risk at vehicle level. Therefore, software cannot be verified in isolation: Its safety properties are only fully observable and provable in an integrated system, with all components present and executing on the target hardware.

Figure 3: Frequency monitoring inside FPGA: The clocks for the two independent logic-blocks “Logic 1” and “Logic 2” are defined at design time.

Picture: Microchip



ISO 26262 prescribes a structured development process following a V-cycle, with verification evidence required at each level — unit testing, software integration testing, and system validation. At the component level, static analysis, structural coverage metrics, and requirements-based testing collectively provide evidence that each component behaves correctly against its specification.

However, verification is performed against isolated component specifications, i.e. the behavior of the combined software on shared hardware may be different. ISO 26262 provides two mechanisms to make this integration tractable. The Hardware-Software Interface (HSI) specification formalizes the hardware resource assumptions each software component makes. Freedom from Interference (FFI) governs interference between co-located software components, and its correctness is contingent on HSI validity.

Challenges When Integrating Hardware and Software in Safety ECUs

When multiple software components are integrated on a single ECU, the combined hardware demand can produce failures that do not exist in any individual component, e.g., execution time budget violations, watchdog servicing delays, memory bandwidth saturation, and memory corruption. Some failures surface only under specific combinations of load, timing, and operating conditions that may never be reproduced during validation testing. They can't be reliably induced by a practical test suite, however comprehensive, and they leave no trace under normal integration testing conditions.

However, FFI verification performed against an isolated component HSI produces evidence that does not cover the combined configuration. ISO 26262 also requires a system-level HSI. The challenge is putting it all together in practice: constructing and validating a combined HSI and observing violations of it under the full range of operating conditions.

Tools and Techniques For Observing System and Software Behavior

Observing a system without disturbing it is a fundamental challenge. Non-intrusive hardware trace, implemented on-chip on modern automotive MCUs, is the most



Figure 4: Snapshot of the Green Hills Software History viewer, displaying a recording of a system runs on a multicore processor, integrates multiple OSES, and executes mixed-criticality functions.

Picture: Green Hills

effective method to observe system behavior during integration. Depending on the hardware configuration, the produced trace stream can include information about the activity of peripheral devices and bus transactions within the chip.

Tools that record and analyze such hardware traces provide precise insight into hardware and software interactions during integration testing. Because the trace hardware shares a clock domain with the cores and peripherals it observes, the resulting event timeline is inherently coherent and timestamped. This enables correlating hardware events with software responses. In multicore systems this capability is particularly valuable: a logical software function is frequently decomposed across cores. The execution flow across cores, and the timing violations that arise from inter-core dependencies are only visible if the tool reconstructs execution flow across all cores on a single coherent timeline (Figure 4).

The snapshot represents a time window in which the failure of an audio system has been captured. It is visually clear how the regular execution pattern of the software is interrupted. Using the tool to inspect why audio interrupts were not handled by their dedicated core in time, the root cause was determined to be a misconfigured driver for the GPU. Typically, the closer a system gets to its production state, the less hardware trace capabilities are present. To account for this, software trace can be employed. Two important aspects must be accounted for in this case. First, the trace must not be intrusive to the point that it changes system behavior. Second, the enabling and

disabling of software trace must not have a significant impact in on the software configuration.

Integrating tracing tools into continuous development and integration workflows increases the probability that dangerous operating conditions are observed before they reach the field. It also enables a more accurate oversight of the integrated software system as components evolve across the development program.

Summary: Observability is crucial for functional safety

As more vehicle functions start to rely solely on software for their safe operation, the need to achieve functional safety for software-driven systems is becoming critical. To achieve this, a Hardware-Software Interface (HSI) specification is required at both component and system level. However, combining a myriad of individually verified software components together with a hardware platform and proving correct behavior is a challenge that can only be fully addressed during integration.

Using the right tools and processes can significantly help, because they provide observability in the integrated system, allowing for precise verification and failure analysis. Their most valuable application is the detection and remediation of intermittent failures which are difficult to reproduce reliably. Crucially, this observability enables remediation before failures are discovered in the field. (na)

Authors: Martin Kellermann, FPGA Product Marketing Manager at Microchip
Nikola Velinov, Senior Business Development Engineer at Green Hills Software



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Automotive electronic fuses

Implementing intelligent Power Distribution in SDVs

A key enabler of SDV is the power distribution system, which must be configurable, highly available, and capable of rapid fault detection and isolation. Electronic fuses (eFuses) fulfil these requirements by combining switching and protection with integrated sensing and diagnostic intelligence that enable immediate fault isolation at the source.

The term SDV is widely used to describe a paradigm shift in vehicle concept development, where software is increasingly decoupled from hardware. However, discussions often focus solely on the software aspects, such as centralized computing, data processing, in-vehicle networks, and service-oriented software architectures. Yet the hardware side also de-

serves attention, especially when it comes to the equally new electrical/electronic (E/E) architecture, which is currently evolving toward a zonal architecture. A key element of this transformation is the decentralization and electrification of power distribution. This approach reduces the wiring complexity and costs, secures freedom from interference for fail-operational systems, and

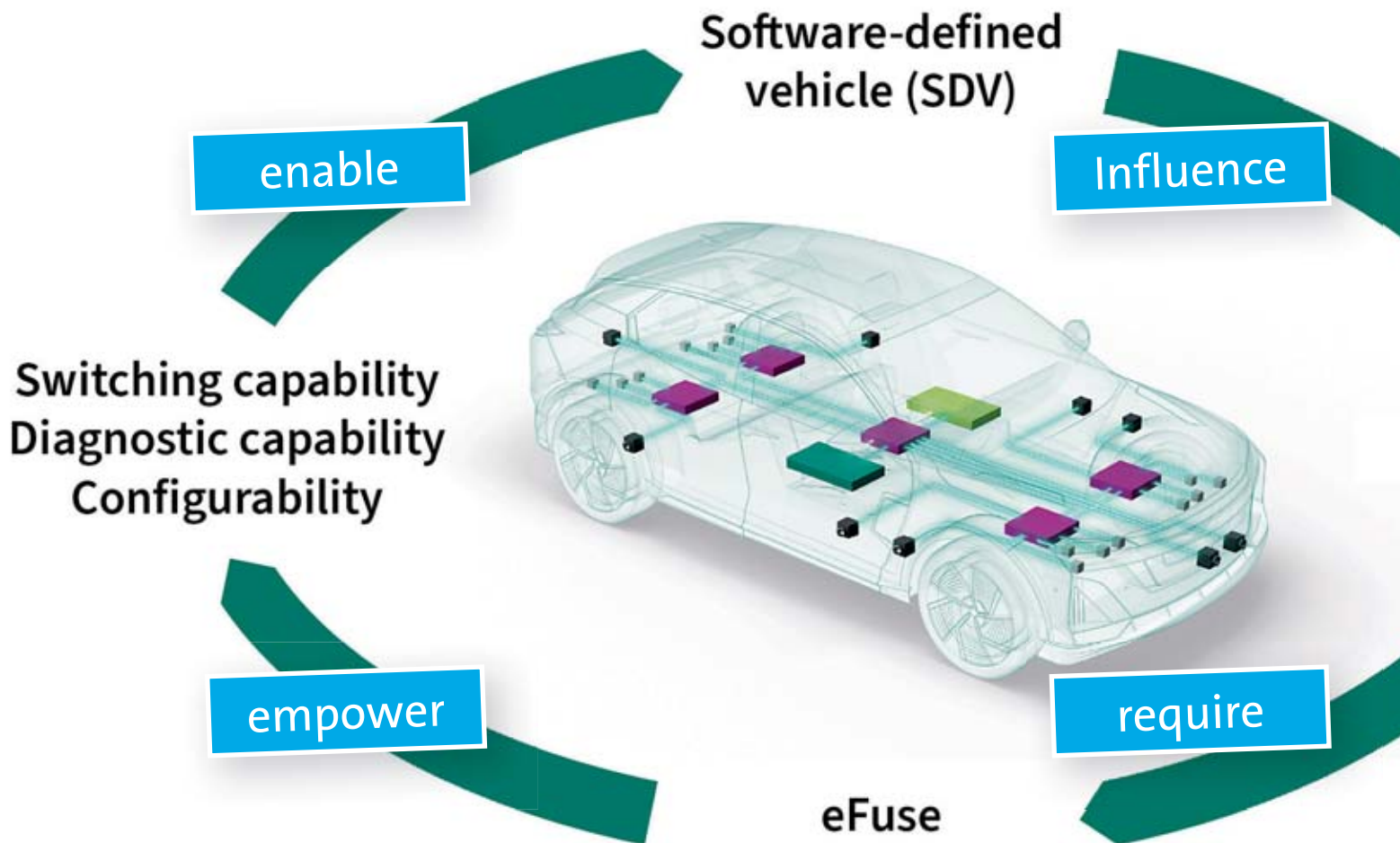


Figure 1: Cause-effect chain linking SDVs and power distribution.

Picture: Infineon

enables more efficient energy management by actively controlling the energy flow while driving and during parking. With the electrification of the power distribution, the eFuse features of switching capability, diagnostic capability, and configurability offer software-based system optimization in SDVs (Fig. 1).

An Overview of the Power Distribution System

Power distribution refers to the controlled transport of energy from the sources to all endpoints in a vehicle via the power distribution system (PDS). The PDS is functionally organized in a high-current primary power distribution close to the source and a subsequent, lower-current, secondary power distribution. The primary power distribution is the first instance to divide electrical power into well-defined supply lines, either directly to high-current applications such as braking, steering, suspension, central computer, or to secondary power distribution. Based on the zonal concept of E/E architecture, the secondary power distribution is decentralized and integrated into the zone controllers.

With new SDV applications, total power consumption may rise from 3 kW up to 9 kW, simultaneously leading to greater power losses in the system. To mitigate these losses and to supply sufficient energy, a 48 V voltage class will be implemented, affecting the entire PDS: the 12 V primary power distribution transitions to 48 V, while the secondary power distribution must supply both 48 V and 12 V endpoints over extended periods. Consequently, zonal 48 V/12 V DC/DC power conversion becomes necessary.

The power distribution system is particularly important for high-availability systems. It enables the power supply of individual safety-relevant vehicle features, including braking, steering, and perception of the environment, and must therefore also be highly available. Due to the safety-relevant vehicle functions, the vehicle power distribution system must meet the increased safety and corresponding development requirements defined in ISO 26262:2018. The functional safety requirements, for example automated driving and X-by-wire, require the total power supply network to be available in ASIL D.

The need for a highly available power supply has a profound impact on the architecture of the vehicle power distribution system. To ensure high availability, especially in safety-critical ASIL D applications, primary and secondary power distribution must be designed with redundant supply paths and fast fault isolation mechanisms.

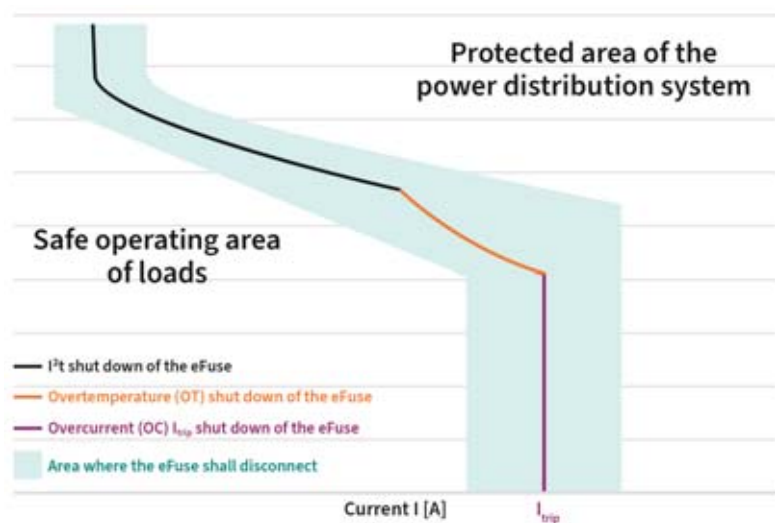


Figure 2: Current-time I_{trip} characteristic of the eFuse to secure a safe operating area of loads and protected area of the power distribution system.

Picture: Infineon

Electronic fuses (eFuses) serve as key safety elements in these architectures. As solid-state, resettable devices, they integrate a high-side driver and DMOS power stage to control the power flow, combined with built-in self-protection and diagnostic intelligence. This enables autonomous, fast fault detection and isolation directly at the point of load, preventing fault propagation and maintaining power availability on redundant paths.

To meet the stringent requirements of safety-critical vehicle systems, the design and development of eFuses must comply with ISO 26262, supporting robust, redundant ASIL D power supply concepts under all operating conditions.

Key eFuse Use Cases in SDVs

As it is used as a safety element in the power distribution system as well as in the context of software defined vehicle, the eFuse needs to perform a number of tasks to support system requirements, leading to specific use cases.

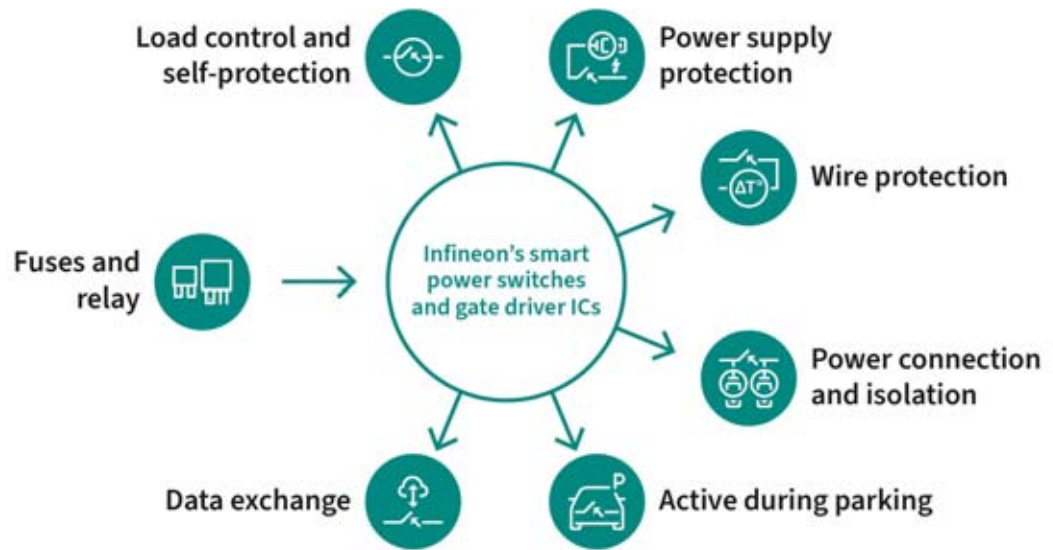
Load Control and Self-Protection: Electronic fuses control loads while protecting themselves. This includes simple on/off switching that requires the capability to charge a capacitor during turn-on, as well as PWM-capable control that meets EMC requirements. The eFuse has to ensure that the load is supplied constantly within a defined current time interval and is not unintentionally disconnected from the power supply system. A so-called “safe operating area” of loads must be ensured (Fig. 2). At the same time, integrated protection mechanisms safeguard the eFuse against overvoltage and thermal stress. To overcome thermal overstress, both overtemperature and overcurrent protection features are integrated. The overcurrent protection is intended to react faster to an overcurrent event like a short circuit in order to reduce the thermal stress in the eFuse during the overcurrent event, but also during demagnetization of the attached wire via the eFuse after the overcurrent disconnection.

Wire Protection: The eFuse must also protect the wiring harness – including connectors and PCB traces – from thermal overstress. This wire protection ensures a protected area of the power distribution sys-

E/E architecture

Figure 3: Use cases of eFuses in the form of smart power switches or gate driver + MOS-FET replacing fuses and relays in an electrified power distribution system.

Picture: Infineon



tem. To prevent wire harness overheating, the eFuse controls the permitted rise in the wire temperature (ΔT) by measuring the current, converting it into an I^2t ratio over time, and transforming it into the thermal domain by using a first-order low-pass filter. Different wire gauges and routing conditions require also different I^2t protection levels per device, and precise protection characteristics allow for optimization of the wire diameter. The eFuse should provide standalone hardware protection that remains active even if the ECU is degraded or is in standby mode, eliminating the need for software support.

Power Supply Protection: These functions are complemented by power supply protection. The eFuse must quickly isolate any kind of electrical fault to protect the power distribution system against voltage drops, thereby ensuring the power supply maintains within the defined voltage range and time interval for all kinds of highly available loads. To enable effective power supply protection in addition to wire protection and integrated over-temperature (OT) and overcurrent (OC) self-protection features, a fast switch-off function is needed. This enables switch-off times of less than 50 μs commanded by an external signal.

Connection and Isolation: One eFuse fail-operational use case is to connect or isolate two power distribution systems. Fast disconnection keeps sub-power distribution systems independent during faults, ensuring freedom from interference between them. Conversely, controlled connection enables power transfer for redundancy, which is particularly important for autonomous driving functions. Independent, bidirectional adjustable protection is required to handle faults regardless of the power flow direction and to prevent back-feeding of a failed sub-power supply system. Special diagnostics, monitoring, and health-check functions support high availability, while software-configurable strategies and fallback settings ensure predictable behaviour even when the controlling ECU is unavailable.

Active During Parking: In addition to the functional safety use cases, SDV features often require remaining partially active even when the vehicle is parked. Such features include telematics, remote services, vehicle ac-

cess, and charging. In this context, eFuses are required to keep selected loads powered during parking while minimizing their own current consumption. The device should consume less than 50 μA in parking mode when the loads are in a low-current state and should avoid unnecessary voltage drops by automatically exiting parking mode when the load requires, e.g., a cyclic wake-up nominal current. Protection mechanisms and their ASIL allocation must also remain available in parking mode, with clear signalling – a flag is set whenever a protection mechanism is triggered or unexpected load over-consumption is detected.

Data Exchange: Finally, eFuses act as distributed sensors. Upon request, they provide reliable and accurate physical data, including voltage, current, temperature, and wire temperature increase (ΔT), as well as system status information. This measurement layer is valuable for SDV functions such as fleet-based calibration improvements, predictive diagnostics, and dynamic adjustment of protection thresholds. Software-defined default and safety behaviour also helps align the power distribution layer to evolving vehicle functions and safety concepts. Moreover, eFuses are configurable via a digital interface, such as SPI, enabling adjustment of integrated features like the aforementioned wiring harness protection, OC protection settings, or fail-safe status via software. In other words, a single hardware component can be used for different applications or installation locations through software configuration. This is another example of how SDVs influence power distribution and how eFuses help enable SDV aspects.

Figure 3 illustrates the described use cases and the multiple benefits of eFuses in the form of smart power switches or gate driver + MOSFET replacing fuses and relays in an electrified power distribution system.

Implementation Examples of eFuse Solutions

The eFuse functions and use cases described are implemented in specialized device families. Infineon offers a range of eFuse solutions designed for circuit protection, load control, and high-availability power distribution in SDV architectures. For instance, the PROFET Wire Guard is an eFuse designed for embed-

ded wire and system protection, featuring integrated I^2t calculation that can be adjusted to match the wire profile and system requirements. It includes an automatic idle mode to maintain full load control and self-protection in parking mode while minimizing power consumption. With an adjustable overcurrent threshold, the device provides deterministic and rapid isolation of faults in the power supply and is developed in compliance with ISO 26262 for safety-relevant applications.

The SPOC Wire Guard provides standalone, hardware-based wiring protection with integrated I^2t functionality and is configurable via a digital interface such as SPI. An idle mode minimizes power consumption during parking. Combined with configurable overcurrent protection, the device enables fast and precise failure isolation and includes a safety manual for integration into automotive safety systems under ISO 26262. Customer-programmable non-volatile memory allows storage of configurations, including safe states, supporting late-stage adjustments in the field. Configurable undervoltage lockout shields load based on priorities, which stabilizes power networks.

For higher-current applications, the combination of EiceDRIVER APD and MOSFET provides a discrete solution. The EiceDRIVER APD incorporates all the functionalities of Wire Guard families. The OptiMOS LinearFET is suitable for disconnect switch applications, offering low on-resistance ($R_{(Dson)}$), a wide safe operating

area, and good paralleling characteristics in linear mode. It supports controlled inrush current into capacitors and improved energy handling during slow switching and short-circuit conditions. In addition, reduction of application complexity and bill of materials is enabled by fewer external protection components and no dedicated pre-charging circuitry.

Summary

A key aspect of SDV functionality is cloud connectivity and the ability to update software, promising continuous optimization of vehicle functions and safety. SDVs generate an incredible amount of vehicle data daily, which is analysed in the cloud and used for predictive maintenance and data-driven development. In this context, intelligent power distribution with eFuses contributes to improved vehicle energy efficiency and energy management by providing continuous and reliable data. In particular, the data exchange delivers precise physical data on demand, which is valuable for SDV features such as fleet-based calibration improvements, predictive diagnostics, and dynamic adjustment of protection thresholds. (bs) ■

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The market's first Automotive Grade 2 SiP, the SAM9X75D5M, drives automotive innovation with a reliable, cost-effective solution. Combining a high-performance MPU and DDR2 SDRAM, it simplifies PCB design and reduces BOM risk. Designed specifically for automotive applications, including digital cockpit clusters, smart clusters for two- and three-wheelers, HVAC control systems, EV chargers and more, it provides OEMs and Tier 1 suppliers with a versatile solution. AEC-Q100 Grade 2 certified, it ensures dependable performance for digital clusters, HMI, EV chargers, diagnostics and asset tracking.

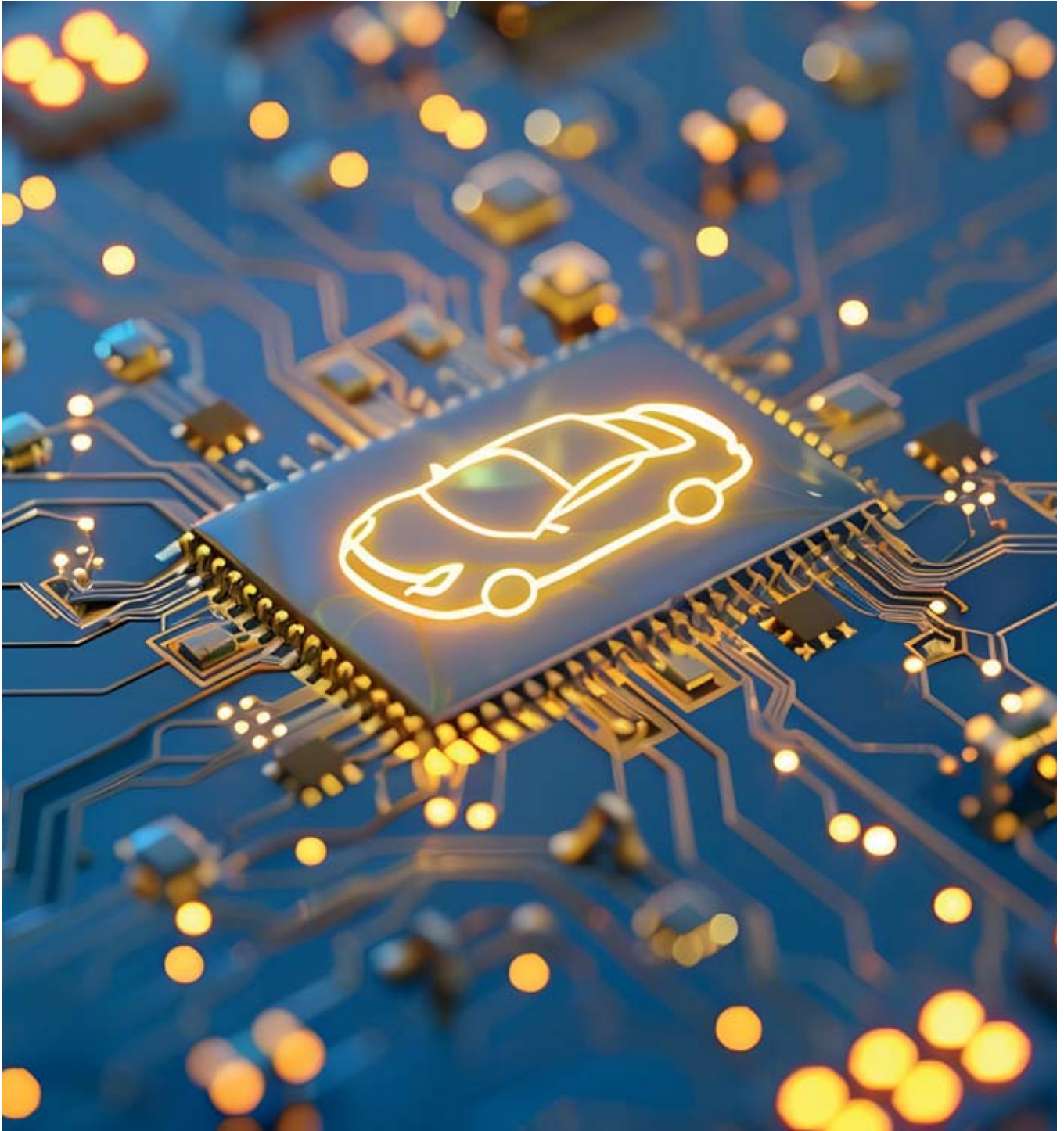
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Why is the semiconductor paradox in today's cars growing? More chips enable innovation, but increase complexity, costs and supply risks.

Picture: sonram - stock.adobe.com

Individually tailored and universal

The semiconductor paradox in today's cars

Modern vehicles depend on more and more semiconductors, yet that is precisely where the paradox lies: technological progress boosts performance, connectivity and comfort while simultaneously increasing complexity, costs and supply chain vulnerability.

Today's vehicles require semiconductors that can be easily assembled like a universal toolkit and deployed across the entire E/E architecture, yet still be configured to such an extent that they meet an OEM's specific software, safety and efficiency requirement. This apparent paradox is resolved when semiconductors are no longer viewed as isolated single-purpose devices but as modular platforms that combine different functional and performance profiles, along with matching safety concepts, on a common technology foundation.

New vehicle E/E architectures

Vehicle E/E architecture is evolving from various narrowly focused applications towards zonal and domain-based concepts with central high-performance computers and powerful zonal nodes featuring edge-AI capabilities. Instead of equipping every function, such as window lifters, seat adjustment, lighting, radar or steering actuators, with a dedicated custom chip, OEMs increasingly rely on broadly applicable MCUs and SoCs that support multiple tasks and are configured via software (Figure 1).

This architecture follows the principle of "central intelligence, distributed compute": central computers handle complex ADAS, infotainment and vehicle functions, while zonal controllers act as gateways, sensor hubs and actuator controllers in each vehicle while also performing initial local processing and evaluation steps. As a result, the number of ECUs and wiring harnesses decreases, while data rates, safety requirements and the number of software functions rise significantly – a combination that is impossible to manage without semiconductors that are both widely deployable and highly adaptable. For semiconductor strategies, this means OEMs and Tier 1 suppliers are moving to chip families that can play different roles – from simple body controllers to safety-critical ECUs. Tailored solutions arise less from a multitude of completely different ASICs and more from scalable platforms offering variants in memory size, compute performance, interfaces, safety level and packaging.

Subscription models, performance headroom and energy demand

With software-first and subscription-based business models, vehicles are turning into a versatile, software-defined platform where hardware-ready features can be unlocked, expanded or adapted via licenses over the entire vehicle lifetime. Even in entry-level segments, this requires semiconductors that offer significantly more performance than initially used. It includes, for example, supporting additional comfort features, higher levels of automation or new diagnostic services that can be rolled out even years after the vehicle has already been shipped. This places considerable demands on the performance and, above all, the reliability of the semiconductors (Figure 2).

This performance headroom must not become a permanent load on the onboard power supply, especially in electric vehicles with long parking and monitoring phases. Always-on functions such as environmental sensing, telematics, OTA connectivity and safety monitoring increase the energy consumption of the electronics, while range

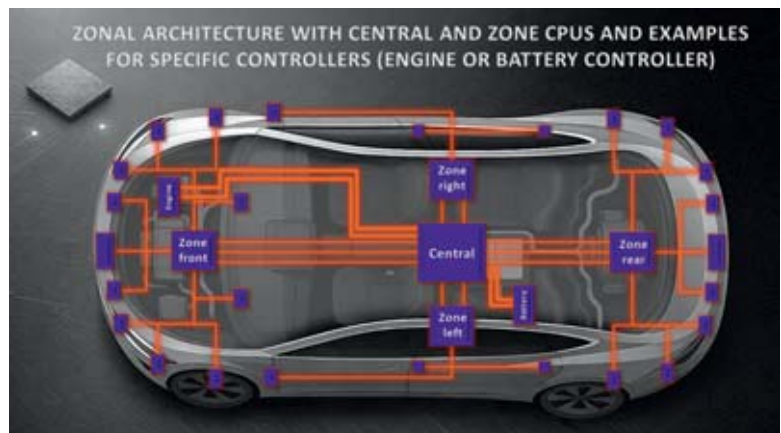


Figure 1: Schematic of a zonal vehicle architecture. Main CPUs controls most of the vehicle electronics with a few specialized controllers e.g. Battery or Engine.

Picture: Globalfoundries

and overall efficiency remain key metrics. Semiconductor platforms therefore need to support advanced energy management concepts – from deep-sleep modes and dynamic voltage and frequency scaling to intelligent workload distribution within the devices, for example between cores and peripheral blocks. On the system level, intelligent strategies are also required: for instance, shifting computationally demanding tasks into short, clearly defined activity windows while allowing large parts of the hardware to remain in highly efficient low-power states most of the time. In addition, mechanisms such as graceful degradation, adaptive quality levels for sensors, and data-driven optimization of energy consumption are gaining importance to continuously improve the interaction between software functions and semiconductor platforms in the field.

At the same time, sustainability pressure is increasing. OEMs expect semiconductor solutions that are not only efficient in operation but also offer high yield, long-term availability and robust reliability to minimize retrofits, spare-part diversity and premature obsolescence. Universal platform chips can contribute to this by driv-



Figure 2: Performance increase of car semiconductors over the last year. The estimation is based on the semiconductor types used during evaluated time frame and is normalized to the performance of 2010. By 2024 the performance increased by about 10x. This trend will keep accelerating.

Picture: Globalfoundries

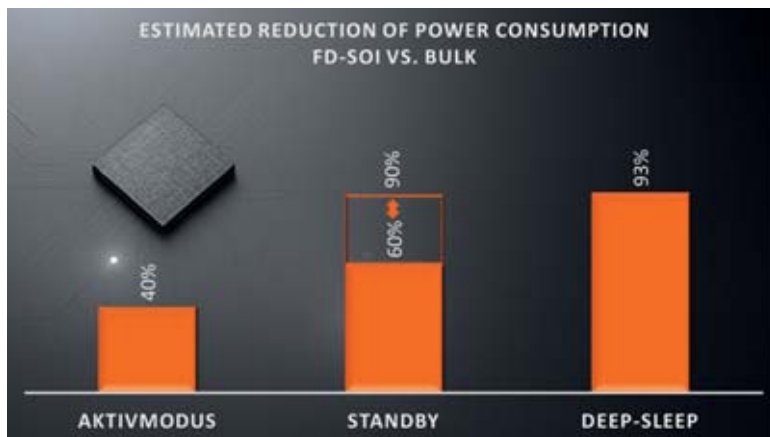


Figure 3: Estimated reduction of power consumption using advanced technologies such as Fully Depleted (FD) – SOI with the benefit of back-bias.

Picture: Globalfoundries

ing higher manufacturing volumes and longer lifecycles, which in turn improve fab efficiency and simplify variant management in the field.

From the semiconductor manufacturer’s perspective, this approach also offers advantages: It reduces product variants while increasing the production volume of platform components which unlocks significant scale effects. Process control in manufacturing relies on statistical evaluation of production data, which becomes more robust at higher volumes, thereby simplifying process control. In practice, this typically translates into higher yields and better quality that can be achieved more cost-effectively and efficiently.

Technology levers for universal chip platforms

To partition software from hardware, balance performance, energy efficiency and scalability, modern automotive semiconductors increasingly rely on process technologies that support digital high-performance logic, mixed-signal, RF, mmWave, NVM and power func-

tionality within a single node. FD-SOI-based processes are particularly relevant here, as the isolating substrate layer and body-bias techniques enable operation at very low voltages and deliver significant advantages in leakage and dynamic power compared to conventional bulk CMOS (Figure 3).

This allows for the development of MCUs that provide high performance in active mode while remaining available for long periods in standby with minimal energy consumption – a crucial capability for zonal controllers or continuous vehicle monitoring. At the same time, these technologies enable integration of embedded non-volatile memories (e.g., eFlash, MRAM, RRAM), robust high-voltage drivers and RF/mmWave blocks for radar or connectivity on a single chip, reducing system complexity, component count and overall cost. Another lever is the systematic use of design platforms: reusable IP libraries for CPU cores, peripheral blocks, security modules, network interfaces and safety mechanisms make it possible to derive multiple device families for different in-vehicle tasks from the same technology. This keeps mask costs and development times under control, while OEM-specific differentiation continues to be achieved via configuration, IP selection and software implementation.

In addition, clearly defined automotive process technologies with guaranteed quality levels, mission-profile-qualified temperature ranges and adapted supply models such as turnkey (wafer manufacturing plus packaging and test) can improve quality, reliability and long-term availability. This significantly reduces product risk already early in the project phase and accelerates industrialization of new derivatives, as qualification, reliability data and supply commitments are aligned with automotive lifecycles and operating conditions.

How “custom” is being redefined

Today, the notion of “custom” is shifting from fixed hardware toward programable flexibility: a semiconductor platform is considered custom-tailored when it offers a modular base architecture that can be precisely adapted to different OEM E/E architectures, vehicle segments and functional scopes via variants and configuration. This includes options for scaling CPU performance, different memory and I/O configurations, safety concepts up to ASIL D, differentiated security features and dedicated IP blocks for radar, motor control or power distribution (Figure 4).

Under this new definition, ‘custom’ means the hardware remains constant while the vehicle’s identity evolves through software. By moving away from bespoke, one-off chips in favor of a standardized technology platform, semiconductor suppliers offer a versatile ‘silicon backbone’ for the E/E architecture. This approach eliminates supply chain headaches, as fewer distinct part numbers need to be managed and qualified over the long term. (na)

Author: Dr. Oliver Aubel, Corporate Lead Automotive Solutions at GlobalFoundries Fab1 in Dresden

Vehicle Function	Multipurpose Integration
Radar (77–81 GHz): MMIC front-end, LNA, PLL, ADC, Radar DSP/MCU	ADAS SoCs consolidate radar processing; zones fuse multiple sensors
Window lifter, power window system, central locking / door actuators, windshield wiper, ...	Body controllers + smart motor drivers
Airbag, seatbelt pretensioners, pyro-disconnect (battery), pedestrian protection, ...	Safety MCU + generic squib driver arrays
Lidar: Laser driver, SPAD/APD receiver, TDC/ADC, MCU/DSP	Sensor fusion SoCs & generic HV drivers replace dedicated ASICs
Lighting: LED drivers, diagnostics	Universal LED driver family + central controller
Ultrasonic parking: Driver, AFE, ADC, MCU	Zone controllers with integrated AFEs

Figure 4: Examples for multi-purpose semiconductors combining several activities into one Chip / Controller.

Picture: Globalfoundries

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How does SOVD improve diagnostics in software-defined vehicles? Dynamic services, scalable diagnostics, and OTA-ready architectures extend classic OBD.

Picture: The Little Hut - stock.adobe.com

From OBD to SOVD

How to Successfully Implement Diagnostics for the SDV

Diagnostics are mandatory, and based on the ASAM SOVD standard, implementing diagnostics in the software-defined vehicle (SDV) is more than just a breeze. SOVD also opens up entirely new possibilities. An overview.

To ensure that vehicles function reliably, comply with emission limits, and can be operated safely, they must continuously monitor themselves. This continuous self-monitoring is known as diagnostics, or more specifically, On-Board Diagnostics (OBD): In modern vehicles, OBD detects faults in electronic systems, evaluates their impact, and stores them using standardized diagnostic codes, while also alerting the driver when necessary – for example, via the Malfunction Indicator Light (MIL). The DTCs (Diagnostic Trouble Codes) can be read via the diagnostic interface, which is fully standardized.

Classic Diagnostics from a Technical Perspective

Classic vehicle diagnostics is based on an architectural model in which each function is assigned to a clearly defined ECU. Diagnostics thus refers to the physical ECU, its implemented software versions, and its defined measured values and error codes. Each ECU has hard-coded UDS services and logs errors in the form of DTCs. UDS stands for Unified Diagnostic Services and represents a standardized diagnostic service protocol.

The corresponding data structures are static and must be fully specified during development. If new func-

tions are added or existing ones expanded, this requires a change to the diagnostic description, which in turn leads to significant additional effort and dependencies between suppliers and OEMs. Furthermore, a software update of the vehicle will have to be made.

These analyses are primarily based on local data from individual ECUs. As a result, the ability to perform cross-system root cause analysis is quite limited. With the shift from a distributed architecture—featuring over 100 ECUs per vehicle—to a zonal architecture that relies primarily on HPCs (high-performance computers), traditional diagnostics via UDS and OBD are clearly reaching their limits. SOVD will at least significantly simplify and accelerate the diagnostics.

Service-Oriented Diagnostics

Service-oriented diagnostic systems move away from this ECU-centric focus and treat diagnostics as a dynamic system function that can be distributed across multiple software and hardware nodes. Software modules offer diagnostic functions as services that can be discovered, orchestrated, and executed within the vehicle network during operation.

SOVD (Software-oriented vehicle diagnostics), a standard from ASAM (and ISO 17978) for vehicle diagnostics, is an approach that directly adapts diagnostic mechanisms to the principles of service-oriented architecture models, which have been well-known in computer technology for many years.

At the heart of this approach is the fundamental idea of no longer viewing diagnostics solely as a local function of individual ECUs, but rather as a distributed, dynamically instantiable capability. Each individual software component relevant to the diagnostic system makes its diagnostic functions available as standalone services that can be discovered and integrated via standardized interfaces within the vehicle; diagnostics thus become flexible and evolvable. Crucially, unlike traditional OBD, SOVD no longer relies on statically defined data sets but is generated at runtime from the diagnostic options available at any given moment and appropriate to the situation.

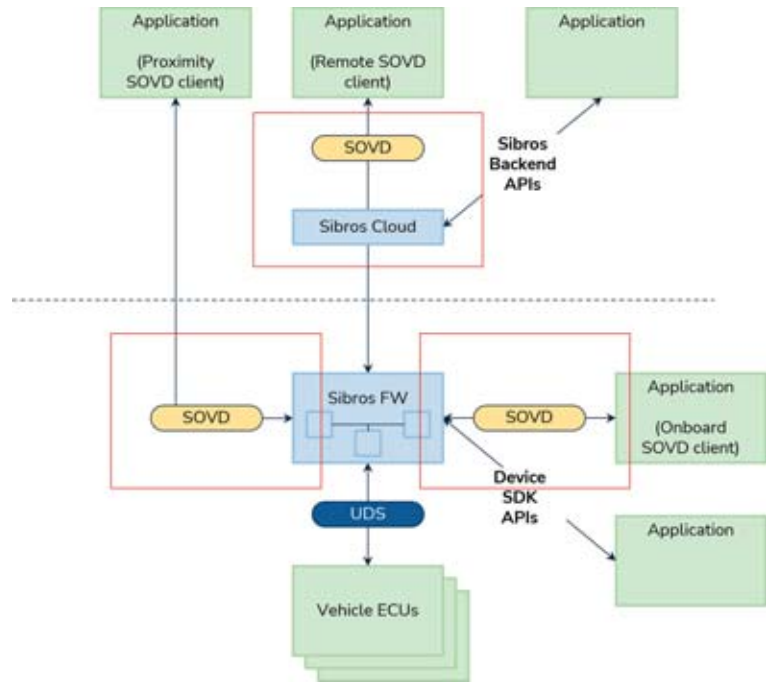
New software services then immediately bring their own diagnostic capabilities with them and no longer need to be integrated into a static diagnostic scheme. The execution itself can be distributed among ECUs, central high-performance computers (HPCs), and cloud infrastructures, making significantly more computing power and contextual data available. In addition, OTA updates can be performed much easier.

Service and Communication Diagnostics

Service-oriented diagnostics take into account not only local error states but also communication-related contexts, dependencies between services, temporal patterns, and series of historical measurement values. This creates a holistic view of the system that identifies chains of causes rather than merely presenting symptoms.

SOVD: From Reactive to Proactive

While traditional diagnostic systems operate primarily in a reactive manner and report threshold violations after an issue has occurred, SOVD enables proactive eval-



uation. SOVD makes it possible to identify anomalies even before a defined fault condition is reached. This is particularly important given the increasing complexity of software and the growing number of distributed functions in the vehicle. The ability to dynamically bind services allows the system to establish diagnostic paths only when they are actually needed. This feature makes diagnostic tools faster, scalable and adaptable, which is crucial for vehicles such as SDVs that receive continuous software updates and functional retrofits.

Thanks to the Sibros software extension, the migration to SOVD is completely seamless.

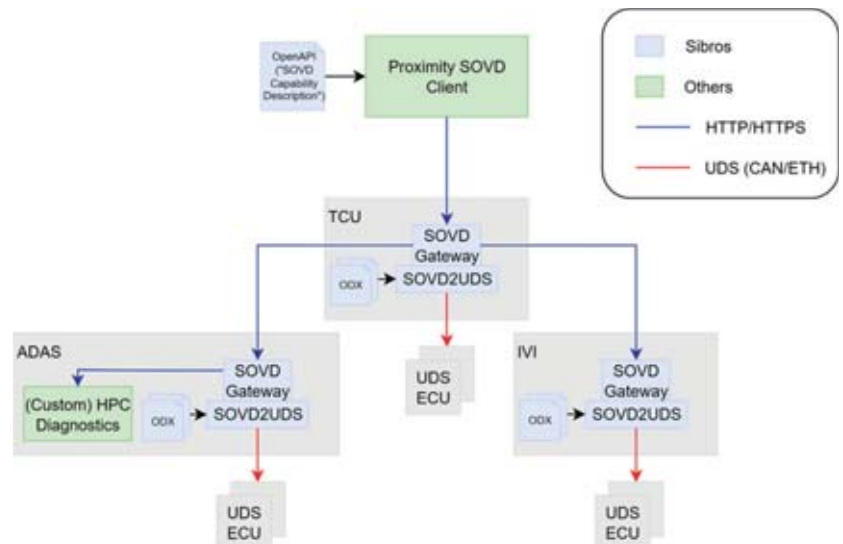
Picture: Sibros Technologies

SOVD is a perfect fit for the SDV and highly flexible

In summary, traditional diagnostics primarily address the behavior of individual ECUs and their static fault maps. SOVD, on the other hand, implements a distributed, flexible diagnostic system based on dynamic software services, thereby enabling a level of diagnostic quality that matches the reality of service-oriented vehicle architectures. When we speak of a software-defined

A typical SOVD architecture within a vehicle.

Picture: Sibros Technologies





proaches primarily detect local fault symptoms, service-oriented diagnostic systems enable access to extensive data sets. These include time series of physical measurement values, service dependency graphs, metrics related to communication quality within vehicle networks, and software-side status data that provide insight

The advantages of SOVD in a nutshell.

Picture: Sibros Technologies

vehicle (SDV) in everyday language, we mean “service-oriented vehicle architecture.” In short: SOVD and SDV are a perfect match.

A key feature of SOVD is the dynamic discovery of the required diagnostic functions. Instead of defining fixed diagnostic paths, the system automatically determines which services are available and suitable for a specific analysis. Thus, during operation, the vehicle maps out a diagnostic path that results from the interaction of the involved services. This flexibility is particularly relevant in vehicles whose software scope changes over their lifetime due to OTA (Over-the-Air) updates or service extensions. New functions can immediately provide diagnostic capabilities without requiring any adaptation of the previously implemented diagnostic architecture.

Distributed Diagnostic Tasks

Equally important is the ability to distribute diagnostic tasks across the vehicle network. Vehicles with SDV architectures feature powerful central computers capable of performing extensive analyses. At the same time, edge control units continue to exist, performing local status checks and rapid self-tests. Service-oriented diagnostic systems make targeted use of this structure and adapt the execution of a diagnosis to the available service structures. Computationally intensive evaluations can also be performed quickly in backend infrastructures as needed, provided that functional and regulatory conditions permit this. Diagnosis is thus no longer limited to the physical capabilities of a single control unit but instead utilizes the entire available hardware network.

Another advantage lies in the expanded use of contextual information. While traditional diagnostic ap-

proaches primarily detect local fault symptoms, service-oriented diagnostic systems enable access to extensive data sets. These include time series of physical measurement values, service dependency graphs, metrics related to communication quality within vehicle networks, and software-side status data that provide insight into different configuration states or the latency of critical function paths. By linking this information, fault scenarios can be identified that would have remained hidden in traditional systems.

SOVD in Practice – Including Legacy Systems

To use SOVD in a vehicle, an OEM needs the appropriate firmware. Sibros’ firmware fully leverages the potential of SOVD and also helps simplify diagnostics per se. A good example of this is OTA updates. With Sibros firmware, the OEM no longer has to worry about each individual ECU, because the firmware delivers the appropriate software package to the respective ECU and performs the update.

Sibros has actively participated in the ASAM committee, which developed ISO 17978, the first standard for diagnostics. ISO 17978 builds upon traditional UDS diagnostics, and communication via UDS will still be possible within the SOVD framework. This means that traditional ECUs, such as an ABS control unit, can continue to be used, updated and diagnosed within the SOVD framework. An HPC with the appropriate firmware installed fully manages its downstream ECUs—including legacy ECUs such as an ABS control unit.

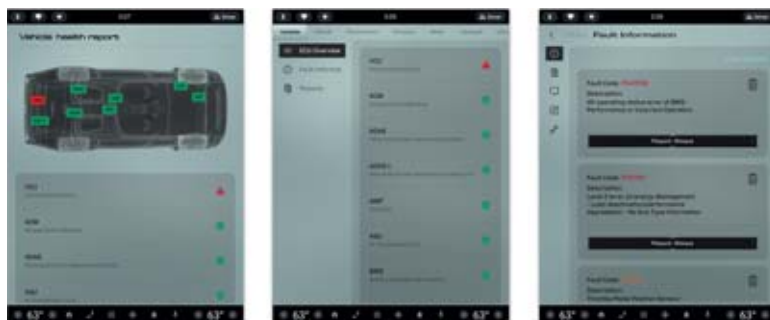
The HPCs act as service providers for all lower-level ECUs connected to them; hence the term “service-oriented.” SOVD uses JSON as its standard protocol, and JSON operates according to Internet guidelines (using REST APIs and HTTP), meaning that Internet developers are now also in demand for automotive software development.

SOVD is good for security

By using standard Internet security mechanisms within the SOVD framework, OEMs can also manage the entire security landscape in the vehicle much more easily and comprehensively. When an OEM uses the Sibros platform, it can simultaneously utilize its own proprietary communication logic within the vehicle, which can provide additional security.

By using the Sibros firmware, OEMs can already enjoy all the benefits of SOVD, with the OEM providing the hardware and data; the firmware handles the rest, acting as a framework for the standards-compliant handling of data within the SOVD framework. All parameterization, the framework conditions, and the data itself originate from and remain with the OEM. Thus, SOVD based on Sibros firmware forms a central component of the technical foundation upon which true software-defined vehicles will be built. (na)

Author: Hemant Sikaria, CEO of Sibros Technologies



While UDS primarily displays raw error codes, SOVD offers many options for visually appealing and complex data presentation. Here is an example of a SOVD diagnostic client based on the IVI (In-Vehicle Infotainment).

Picture: Sibros Technologies



The software-defined vehicle

**Software defines what a vehicle can do.
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As the global market leader in automotive semiconductors, Infineon helps accelerate the market introduction of software-defined vehicles (SDVs).

Complexity rises as E/E architectures shaped by SDVs evolve from domain-based to zonal. The right choice of semiconductors enables the transition from domain-based to zonal architectures, reduces complexity and aligns real-time computing, fast connectivity, intelligent power distribution, and strong cybersecurity.

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- Fast time-to-market with low integration risk
- Software reuse across platforms
- Seamless over-the-air updates
- Improved economy and energy efficiency

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The AudioAnalyzer is available in various models depending on requirements.

Picture: MCD

How Does the Car Sound?

Audio analysis of in-vehicle infotainment systems

Reliable audio analysis is essential for modern in-vehicle infotainment systems. Objective testing of voice output, control functions, music and component noise helps ensure clear sound, robust communication and reproducible quality in development and production.

At a time when infotainment systems are becoming increasingly important in vehicles — often jokingly referred to as “smartphones on wheels” — the testing of these systems is becoming more critical as well. Voice output and voice control, in particular, can provide valuable support for increasingly complex vehicle functions, making driving easier and safer for the driver. This is because modern infotainment systems integrate car radios, navigation systems, hands-free systems, driver assistance systems and other functions. In addition to audio signals, digital information is constantly exchanged with the vehicle, often via modern cellular communication standards.

In Search of “Pure Sound”

An important aspect is the audio quality itself, but also how it integrates into the vehicle’s environment. After all, real-world driving conditions typically don’t match the controlled conditions of a living room or concert hall. However, important information must always reach the user clearly and reliably. Even when it comes to purely entertainment-based functions like music or audiobooks/podcasts, listeners’ expectations are higher

today than they were in the days of crackling and static-filled FM radios. Vehicle manufacturers and their suppliers therefore require test equipment capable of objectively and reproducibly verifying and calibrating the quality of audio transmission. Such testers must be able to capture, analyze and display analog and digital audio signals with the highest possible integrity. This gives rise to various requirements. Among other things, high-quality, precise audio A/D converters are essential. The number of channels can also be critical for capturing as many signals as possible at once. In addition to frequency and various signal level measurements, total harmonic distortion (THD) and FFT spectrum measurements are often required for analyzing audio signals. An integrated signal generator can also be useful in practice, as it allows for the generation of various signal waveforms and modulation types as test signals.

The MCD AudioAnalyzer Toolmonitor

A proven audio analyzer for this application is the AudioAnalyzer from MCD Elektronik in Birkenfeld, which is available directly from MCD Elektronik or through distribution partners such as Meilhaus Electronic. It is

available in various models depending on requirements. At the heart of all variants is the "AudioAnalyzer" software, which centrally bundles all monitoring and analysis functions. This control software operates as a standalone application for controlling the hardware variants. It offers the ability to remotely control or query all functions and measured values from other programs. This remote control can be implemented using various software interfaces such as .Net SDK, Socket, WebAPI, or Command Line. The AudioAnalyzer Toolmonitor features an intuitive graphical user interface and includes functions such as an oscilloscope, FFT spectrum, and measurements of AC, DC, RMS value, THD, FREQ, SINAD, and more. Captured signals, their frequency/phase response, and other results can be visualized directly within the software. The generation of test signals and modulations (AM, FM, PM) is also supported.

AudioAnalyzer Hardware

In terms of hardware, the MCD AudioAnalyzer is available in four configurations designed to meet a variety of audio analysis needs. The Compact USB Edition is a compact, USB 2.0-compatible variant for direct connection to a PC and is ideal for space-saving workstations and quick measurements.

The Rack Edition is designed for installation in standard 19-inch systems and can be conveniently controlled via USB from a host PC. The Standalone Pro Edition operates completely independently with an integrated PC and enables measurements without external control. The SmartModuleS Edition is a flexible module for the MCD SmartModuleS system. In this configuration, up to two balanced stereo inputs and outputs can be configured and additional modules can be integrated into larger enclosures such as an 84 HP SmartModuleS enclosure. All variants are available as standard from MCD Elektronik and offer maximum flexibility for professional audio analysis in research, development and production. All models feature an analog, balanced stereo input (1 mV–50 V rms, two XLR jacks) and an analog, balanced stereo output (1 mV–15 V rms, two XLR connectors). In addition, there is a digital/optical S/PDIF input and output with sample rates of up to 192 kHz (two TOSLINK-compatible connectors) and a digital coaxial S/PDIF input and output (depending on the model, two RCA jacks or two BNC connectors). The sample rates are 44.1 kHz, 48 kHz, 96 kHz, or 192 kHz with 24-bit resolution. The models differ in form factor and whether they include an integrated PC; the core features themselves are identical. In addition to classic audio measurement of signals from sound systems such as amplifiers, radios, TVs and infotainment systems, the AudioAnalyzer also enables noise measurements on a wide variety of components such as switches, gearboxes, mechanical devices, signal generators, switching power supplies, distance sensors or RF modulators, extending to the calibration of tuners, transmission testing of various types of converters of various designs or noise analysis of speed measurements.

While audio analysis in infotainment systems is clearly indispensable, particularly for voice, music and multimedia functions, its applications extend far be-



yond these areas. For example, the MCD AudioAnalyzer can be used for structure-borne noise measurements, such as analyzing engine and transmission noises from electrically driven components like automotive mirrors, windshield wipers, valves or central locking systems. Through this analysis, users can identify and evaluate issues related to gear ratios, runout, concentricity, or unwanted noise generation. Such noises can be perceived by the driver as both annoying and safety-related - such as the clicking sound of a turn signal - and are therefore examined very closely by manufacturers.

Modular with the MCD SmartModuleS

The MCD SmartModuleS is a 19-inch module system that condenses an entire test bench into a compact format. The device was specifically designed for small-batch testing, incoming inspections or test station development. Thanks to its standalone design (the base unit contains a fully integrated industrial PC) and compact size, it is also suitable for use as a laboratory or test station device. The currently available module types include a 2-channel oscilloscope featuring the technology of the proven PicoScopes, an industrial, switchable USB hub, a digital control module and the audio analyzer described above. The advantages of the MCD AudioAnalyzer in the SmartModuleS variant lie in the fact that a system with two analyzers can be configured with minimal effort, enabling a total of four mono or two stereoinputs and outputs. This allows even extensive measurement setups to be implemented costeffectively while maintaining the flexibility and precision of audio analysis. This system is available as a preconfigured solution. However, an 8-channel PicoScope or "mixed" configurations can also be implemented in a SmartModuleS system housing.

Summary

Audio analysis is a key factor in vehicle infotainment systems, but also in many other fields when it comes to testing and analyzing sound events. The MCD AudioAnalyzer offers interesting and proven solutions in this area, both in terms of hardware and software. The modular design of the MCD SmartModuleS allows for the cost-effective configuration of an audio analyzer with multiple channels. (bs)

Authors: Ernst Bratz, Meilhaus Electronic
Dr. Thomas Däubler, MCD Elektronik

The Compact USB Edition is a compact, USB 2.0-compatible variant for direct connection to a PC and is ideal for space-saving workstations and quick measurements.

Picture: MCD



How can SDV architectures scale efficiently? Central compute, chiplets, and open toolchains support performance, flexibility, and long-term development.

Picture: Catsby_Art - stock.adobe.com

Scaling Compute for the Software-Defined Vehicle Era

How Central Compute, Chiplets, and Toolchains Enable SDVs

Software-defined vehicles are increasing demands on automotive computing. Central compute, chiplet-based scalability, and open toolchains provide a practical foundation for performance growth, software reuse, and long-term platform development.

Software-defined vehicles (SDVs) are fundamentally changing how automotive electronic systems are designed, developed, and evolved over a vehicle's lifetime. Advanced driver assistance systems, AI-based perception and decision-making, increasingly complex cockpit functions, and the expectation of continuous over-the-air updates are driving compute requirements well beyond what traditional, highly distributed ECU architectures can efficiently support. At the same time, the semiconductor industry is experiencing diminishing returns from classical process-node scaling. Each new node delivers smaller performance and efficiency gains, while cost, design complexity, and qualification effort increase significantly.

For OEMs and Tier-1 suppliers, this creates a structural mismatch: software complexity and performance demands are accelerating rapidly, while the traditional approach of relying on ever-larger monolithic SoCs on the latest process nodes is becoming economically and technically constrained. As a result, vehicle electronics architectures are shifting toward centralized compute platforms combined with software-first development models. In this context, Renesas' R-Car Gen5 serves as a central compute platform for SDVs, which combines the integration advantages of a monolithic SoC with chiplet-based scalability and an open SDK and toolchain to address automotive system-level requirements.

Central Compute as the Backbone

Centralized computing is a key enabler for SDVs because it allows multiple vehicle domains to be consolidated onto a shared hardware and software foundation. Instead of maintaining numerous dedicated ECUs with isolated software stacks, a central compute platform can host ADAS, cockpit, gateway, and body functions on one system, provided that mixed-criticality requirements are handled correctly. This consolidation reduces system complexity, wiring effort, and integration overhead, while enabling a more coherent software architecture across the vehicle.

R-Car Gen5 is designed to serve as such a central compute backbone. It combines high-performance application processors with real-time and safety-oriented cores, allowing workloads with very different timing, safety, and availability requirements to coexist on a single platform. The architectural focus is not only on peak compute performance, but on predictable behavior, long-term availability, and the ability to support software evolution over many years. For SDVs, this is critical: software is no longer static at SOP but continues to evolve throughout the vehicle lifecycle.

From a system perspective, central compute also enables OEMs to define a common hardware and software baseline across multiple vehicle lines. This reduces fragmentation and allows software components, tools, and processes to be reused more effectively. The result is not only lower development cost, but also improved quality and faster rollout of new features.

Chiplet-Based Scalability

While central compute simplifies architecture, it does not eliminate the need for performance scaling. ADAS and AI workloads in particular continue to grow rapidly, driven by higher sensor counts, increased resolution, the rise of on-board in-cabin AI, and more sophisticated models. However, scaling performance by continuously increasing the size and complexity of monolithic SoCs faces practical limits. Reticle size constraints, yield degradation for large dies, and power density challenges make this approach increasingly unattractive, especially for automotive applications with strict reliability and qualification requirements.

Chiplet architectures offer an alternative path. By decomposing a system into multiple silicon dies within a single package, performance can be scaled more flexibly and cost-effectively. For automotive use, the key benefit is not maximum modularity for its own sake, but the ability to add compute capability where it is needed without redesigning the entire SoC. R-Car Gen5 adopts this philosophy by

combining a powerful base SoC with the option to extend performance through additional chiplets, particularly for AI acceleration. This approach enables OEMs and Tier-1s to deploy a common hardware platform across different vehicle classes and trim levels, while differentiating performance through optional extensions. Entry-level vehicles can rely on the base configuration, while higher-end variants or later lifecycle updates can integrate additional compute resources. Importantly, this scalability is designed to respect automotive constraints such as functional safety, long-term reliability, and predictable behavior. Rather than tightly coupling all dies through shared memory, the architecture emphasizes controlled communication and clear fault-containment boundaries.

Maintaining a Unified Software Model

Hardware modularity only creates value if it does not fragment the software environment. For SDVs, software reuse and portability are essential, as validation and certification effort grow rapidly with system complexity. A core requirement is therefore that scaling the hardware—whether through additional cores or chiplets—does not force fundamental changes to the software architecture.

R-Car Gen5 and its chiplet extensions are designed to present a unified logical system to software. Standardized interfaces, virtualization, and abstraction layers ensure that accelerators are accessed in a consistent way, regardless of whether they are integrated on the base SoC or provided via a chiplet. From the perspective of the operating system and applications, additional compute resources appear as part of the same system, rather than as special-case devices.

This unified software model reduces integration effort and limits the need for variant-specific software branches. It also simplifies long-term maintenance, as software updates and new features can be developed and validated against a consistent platform abstraction, even as the underlying hardware evolves.

SDK and Toolchain as a Time-to-Market Lever

As software content grows, development efficiency becomes a decisive factor for competitiveness. Hardware capability alone is insufficient if bringing up platforms and integrating software takes too long. Renesas addresses this through an open SDK and toolchain, known as the R-Car Open Access (RoX) platform, with the Whitebox SDK as its baseline configuration. The emphasis is on providing a coherent, production-oriented development environment rather than a collection of disconnected tools. Linux and Android form the foundation for high-level software, complemented by virtualization support and

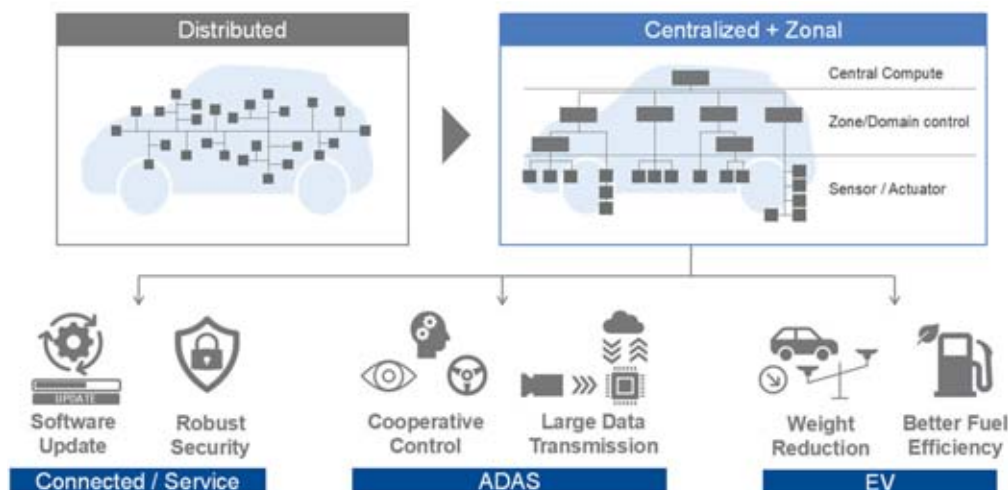


Figure 1: Transition to Centralized E/E Architectures

Picture: Renesas

options for real-time operating systems where required. Standard APIs and open interfaces are used to minimize lock-in and to ease portability across projects and hardware generations. A particularly important aspect is the ability to start software development early. Virtual platforms and cloud-based development environments allow teams to begin integration, testing, and CI/CD workflows before final hardware is available. This shift-left approach reduces late integration risk and shortens overall development timelines.

System-Level Implications for OEMs and Tier-1s

The combination of central compute, chiplet-based scalability, and an open toolchain has significant system-level implications. OEMs gain the ability to define stable compute and software platforms that span multiple vehicle generations, preserving software investments and reducing architectural churn. Tier-1 suppliers benefit from clearer integration targets and a shared development environment that reduces duplication of effort and accelerates collaboration. From a lifecycle perspective, this approach supports incremental performance scaling and feature growth without disruptive hardware changes late in a program. It also aligns well with OTA-driven feature deployment, where new functionality may be introduced years after SOP, provided sufficient compute headroom or modular upgrade paths exist. (na)

Author: Peter Bechberger Bechberger, Director, SoC Product Marketing, Renesas

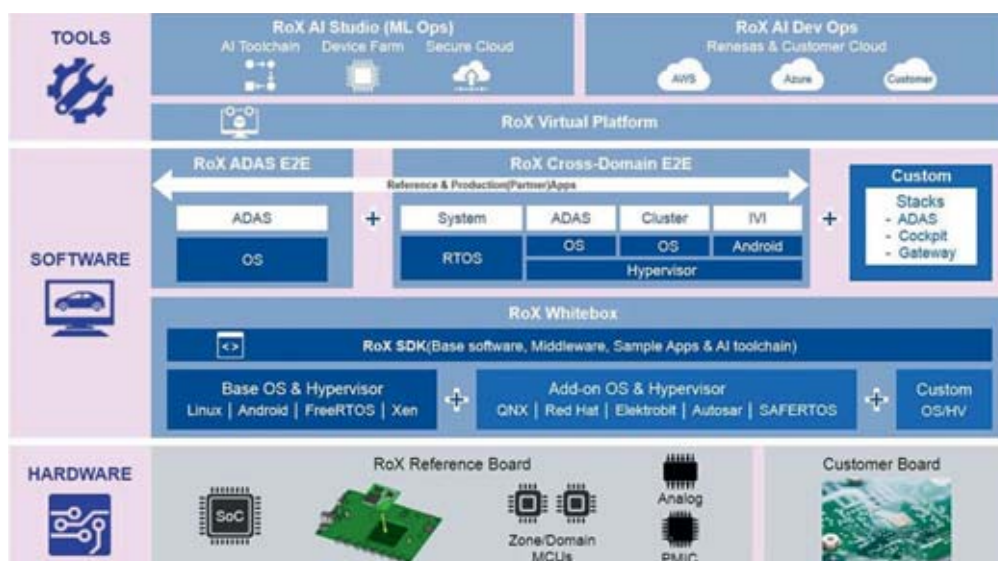


Figure 2: RoX Open SDV Platform

Picture: Renesas



SDV – Complexity out. Speed in.

The quantum leap for software-defined vehicles

Contrary to the Industry's focus on Software optimization over the last decade, Secor is presenting the SDV PoC 2.0 at the AEK – a holistic, open-source approach, 50% shorter time-to-market, 30% lower development and production costs.

Software-defined vehicles (SDVs) are the next evolutionary stage of the car, putting the customer at the center. They must also address rising SW complexity, industrial requirements and fragile supply chains. Most SDV concepts only solve a piece of the puzzle; the structural challenges remain intertwined across technical, economic and geopolitical dimensions. A holistic approach is required.

Customer expectations: Smartphone-like usability and the ability to personalize one's own vehicle through SW - this expectation has been articulated in the industry for over a decade. It has yet to be fulfilled. Further-

more, today's customers also expect SW updates without a service center visit.

Software complexity and no reuse: Over-the-Air (OTA) updates have been a persistent challenge for years. Updating SW across multiple ECUs (electronic control units) without a service center visit is complex, because neither the SW architecture nor the vehicle network is designed for it. ECUs also require a secure fallback to remain operational in the event of update failures. As a result, OTA updates remain largely confined to a few non-critical control units. With each new vehicle development, ECUs are re-tendered and implement-

ed with new MCUs (micro control units), as their production cycles are limited. This means existing SW must be recompiled and, to a large extent re-coded (up to 80%). This lengthens development, increases the risk of errors and prevents reusability, while new market entrants continue to intensify time-to-market pressure.

Industrial requirements: OEMs and Tier-1 suppliers must maintain vehicle SW over the full lifecycle, yet face limitations due to different hardware (HW) revisions, complex wiring harnesses and the absence of standards. At the same time, the shift to zonal E/E architecture demands far-reaching changes in development and supply chain qualification. Open-source middleware such as Eclipse SDV aims interoperability, but adds governance, security and integration risks. Furthermore, the OEM-specific app stores currently in use are proprietary and fail to generate cross-brand economies of scale.

Volatile supply chains and geopolitical dependency: Unstable supply chains put production at risk, as cost considerations have led to single-source dependencies for many critical components. The wiring harness illustrates this best: nearly every unit is a custom build, and a single missing harness is enough to halt the entire production line. The same applies to ECUs, MCUs and other non-substitutable components. A future-proof SDV must build resilience into the system, rather than treating it as an emergency response. All of the requirements above are met by the Secor SDV Ecosystem described below.

SDV Ecosystem - Introduction

Many SDV concepts address individual problems. But what if the goal is to shape a future vision rather than optimize one issue at a time?

That is precisely the step Secor has taken. The starting point were the challenges described above. These cannot be resolved incrementally - they are far too deeply intertwined for that. The solution can only be a holistic approach: an ecosystem specifically designed for these requirements and flexible enough to meet the demands of the future. Drawing on extensive automotive expertise, Secor has developed exactly that - and will be presenting the Secor SDV PoC 2.0 at the 30th AUTO-MOBIL-ELEKTRONIK Kongress.

The essence is standardization:

The patent-pending Secor SDV Concept is the only offering on the market that relies on standardized SW and HW. Since its presentation at embedded world 25, it has accordingly been de-

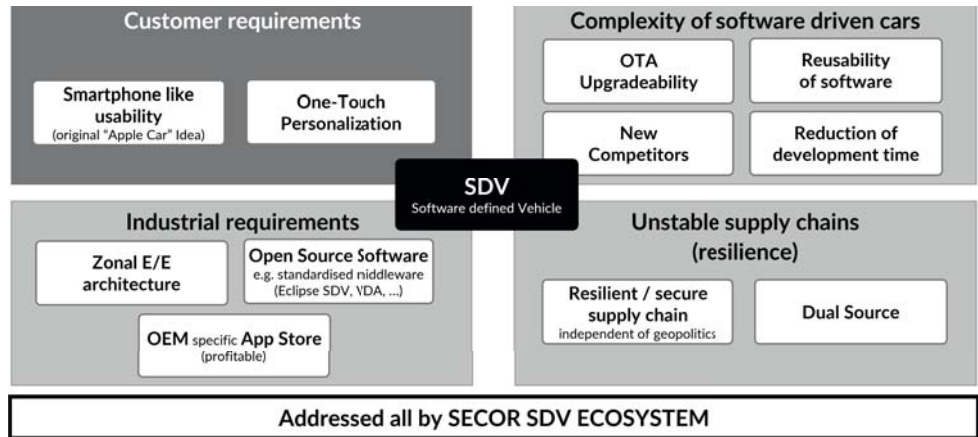


Figure 1: The four main challenges for the SDV. A holistic approach is required. Picture: Secor

scribed by experts as a game changer and a paradigm shift for the automotive industry.

Resilient HW: Thanks to its function-compatible design, the HW is interchangeable - both at SOP and even twenty years later. At the same time, the HW is multifunctional and built for resilience. Its architecture uses chiplets to create a scalable RISC-V MCU family, making it easier to adapt and port to new manufacturing processes. Because of this design, the HW will be produced simultaneously at three fabrication facilities across different continents, helping ensure a stable supply even during geopolitical disruptions.

Software reuse: The SW is modular and can be reused across multiple vehicle generations. It is provided through a certified SDV library, ensuring it matches the maturity level of the previous vehicle and is reliable and error-free as the previous generation of vehicles.

In addition, it supports 3rd-party SW integration, allowing applications to be distributed through an SDV app store for both B2B and B2C use.

The Secor SDV delivers the following benefits:

- Interchangeable semiconductors from development through after-sales, across vehicle generations - enabling the refurbishment of both newer and classic vehicles
 - Resilient, multifunctional semiconductors supported by secure multi-sourcing at competitive costs
 - Modular, error-free SW with certified interfaces as error-free as the previous generation of vehicles
 - Shorter development cycles, improving competitiveness in time, cost, quality and environmental impact
- These advantages for OEMs and Tier-1 suppliers are measurable (cf. AEL 05/2025, p. 48):

Figure 2: Secor is a holistic SDV Ecosystem with a robust core consisting of standardized HW, SW, APIs and an app store. Picture: Secor

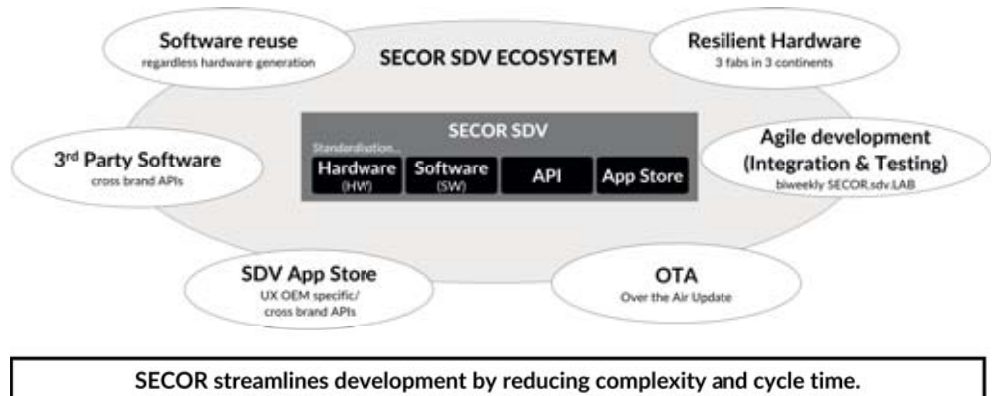




Figure 3: The Secor SDV Ecosystem serves as the foundation for significant technical innovation that goes beyond the status quo.

Picture: Secor

- 50% shorter time-to-market through standardized SW modules
- 30% lower development and production costs through reusability
- Resilient supply chains through pin- and function-compatible alternatives
- Longer service life and resource-efficient production

Secor SDV – In a nutshell

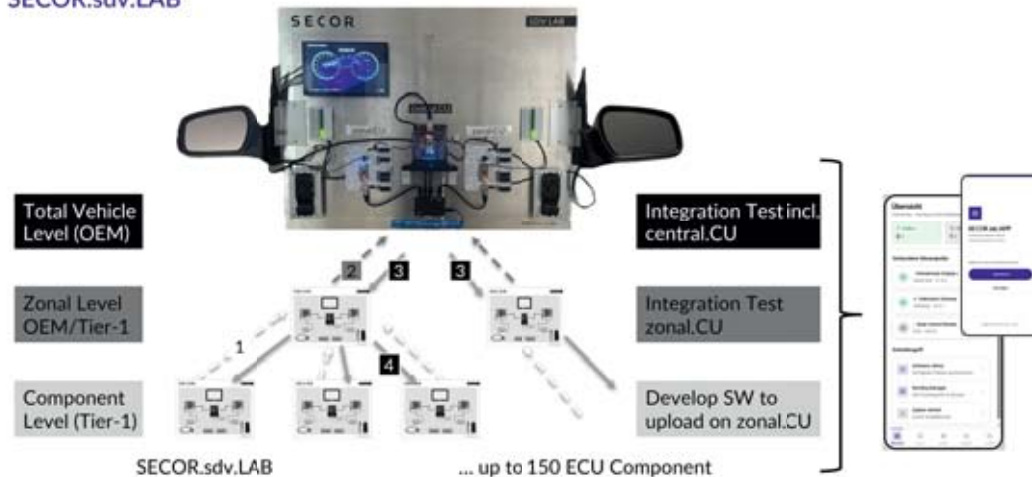
To overcome the MCU dilemma, Secor - together with Fraunhofer IIS – is developing a flexible and powerful MCU designed to remain functionally compatible for decades. This approach is inspired by the x86 processor, which has been used in standard PCs for over 40 years. Similarly, the new RISC-V-based MCU is built for long-term consistency and scalability. To ensure supply resilience, the MCU is designed to be manufactured at three fabrication facilities (fabs) across different continents, reducing the risk of disruption. Because the HW interfaces remain stable, the SW changes typically required with each new MCU are no longer needed. Existing SW can be reused, significantly reducing development time. Fewer changes mean fewer newly introduced errors – reducing the need for time-consuming debugging and resulting in substantial savings in both time and cost.

The SW architecture is structured so that the base level realizes the HW abstraction down to the compo-

Figure 4: Secor.sdv.LAB and the Secor.lab.APP are a continuous integration and continuous deployment (CI/CD) solution that will accelerate the development process by at least six months.

Picture: Secor

Consistent software versions, regular integration tests and error logs organized by SECOR.sdv.LAB



nent level (Level 3). The next SW level handles functional logic (Level 2), previously delivered by suppliers alongside their ECUs. In the new zonal/central E/E architecture, SW is decoupled from HW. Therefore, the functional logic can now come from the supplier, the OEM, a third party, or an open-source project such as Eclipse S-Core. On top sits the user interface with the OEM’s brand identity (Level 1). These SW layers are connected via multiple

APIs (Application Programming Interfaces) based on the COVESA VSS (Vehicle Signal Specification), drawing on an established industry standard. Thanks to the standardized APIs, the SW modules of the functional logic (Level 2) can be traded in the B2B SDV app store - including to new customers. Since this does not affect the UX level, no OEM-specific brand interests are compromised. Through API-based abstraction, the modules are vehicle- and brand-independent. An OEM can therefore equip its prototype or technology demonstrator with functional SW modules from the SDV app store for direct use or further adaptation.

End customers can buy apps for their vehicle through a brand-specific B2C app store or replace existing apps with new ones. OEMs can also offer subscription-based services, such as access to exclusive SW features or modules.

Agile development (Integration & Testing biweekly with SECOR.sdv.LAB)

In the SDV context, “integration is the supreme discipline” from a technical standpoint (cf. AEL 01/2026, pp. 26–27).

With SDVs, integration becomes the key challenge. It largely determines how long the product development process (PDP) takes and how quickly SW and HW are ready for SOP. All SW modules must be combined into a single, type-approval-ready system. In the Secor SDV Ecosystem, standardized HW removes the need for SIL (SW-in-the-Loop) testing. The SECOR.sdv.LAB provides all Tier-1 suppliers and partners with the same HW setup - one central control unit and two zonal control units - allowing integration work to be distributed across development sprints.

Early integration results are then brought together at the OEM level for full system integration. This process is supported by the SECOR.lab.APP, which connects all partners in a project and ensures everyone is working on the same

SW version, with OTA updates every 14 days.

Additional tools like user management and shared defect tracking improve efficiency across companies involved in the PDP. Simulations and regression testing help identify errors earlier, reduce complexity and speed up development.

Discussions with homologation service providers suggest further efficiency gains are possible. Overall, this leads to a consistent "shift-left" approach, where issues are addressed earlier in the development cycle.

SDV SOP dates are often delayed, mainly due to the complexity of integrating K-matrices / communication matrices.

In the Secor SDV Ecosystem, this complexity is removed. A flexible E/E architecture, combined with a patent-pending Message Broker, manages communication between the central control unit (central.CU) and multiple zonal control units (zonal.CUs).

Similar to how the internet works, each SDV component is assigned to its own IP address. These addresses are managed by the Secor directory service, simplifying communication and reducing integration effort.

OTA updates are available at any time, allowing new features and improvements to be rolled out rapidly. This enables continuous development, integration and testing, as well as the ongoing deployment of SW into vehicles. This results in SW living on beyond the individual vehicle into its successors.

The ecosystem supports both central and zonal E/E architectures, though Secor favours the zonal variant due to its clear advantages for the wiring harness. By dividing the vehicle into zones, wiring harnesses can be standardized and variants significantly reduced. At the same time, the quantity and length of cables decrease, reducing both weight and cost. This lower variance and also increases efficiency in the supply chain and OEM assembly.

A further advantage of the zonal architecture is that SW for uninterrupted applications can be distributed into the zonal CUs. This reduces the power demand – and the resulting heat dissipation – at the central.CU.

SDV Ecosystem – Further R&D roadmap

The in-vehicle communication networks are being shifted toward full Ethernet. As a transmission technology, Ethernet supports a wide range of protocols, including well-known ones like Internet Protocol (IP) and Time-Sensitive Networking (TSN).

It can run over different media, such as twisted pair, coaxial cables and plastic or glass fiber. Available bandwidths range from

10 and 100 Mbit/s up to 1–10 Gbit/s, which is more than sufficient for future vehicle requirements.

In the Secor SDV PoC 2.0, 10 and 100 Mbit/s bandwidths are currently used.

Plug-and-play

In the current (patent-pending) development, every component becomes plug-and-play. As soon as it connects to the vehicle network, it automatically receives a local address. The component then provides metadata – such as manufacturer, product code, capabilities and control details – which is stored in a directory service. Based on this information, the required SW modules are automatically downloaded, allowing the component to be used immediately. This enables rapid prototyping with flexible combinations of components. In production, components can be replaced without requiring new development. In after-sales, the directory service allows precise identification of installed parts and compatible alternatives, even if they are not identical. Any changes to control parameters can be delivered OTA, similar to driver updates.

Data usage is managed through a central API that handles and distributes all events and data. This data can be logged and sent to the cloud for use in applications like predictive maintenance. During development, it is also possible to record driving cycles with precise timing, which can then be used as input for simulations in development and system integration.

Take an active role in the SDV transformation

The next PoC will be the Bavaria+ SDV 1.0 FPGA at IAA Mobility 2027. Secor is already actively working with a handful of companies on its implementation. You have the opportunity to become part of the new SDV Ecosystem and contribute your components or a concept vehicle. Due to the higher material unit costs for an FPGA-based central.CU and zonal.CU, the Bavaria+ SDV 1.0 targets small-series production.

These vehicles could become the first automobiles of the 21st century that future generations will still cherish as classics. Work is already underway on a silicon-based central.CU and zonal.CU designed for high-volume production, with market readiness planned for IAA Mobility 2029 (Bavaria+ SDV 2.0). (na) ■

Authors: Dr. Hartwig Schwerdtle, CEO Secor Group
Klaus Jungbauer, CTO and Founder Secor Group

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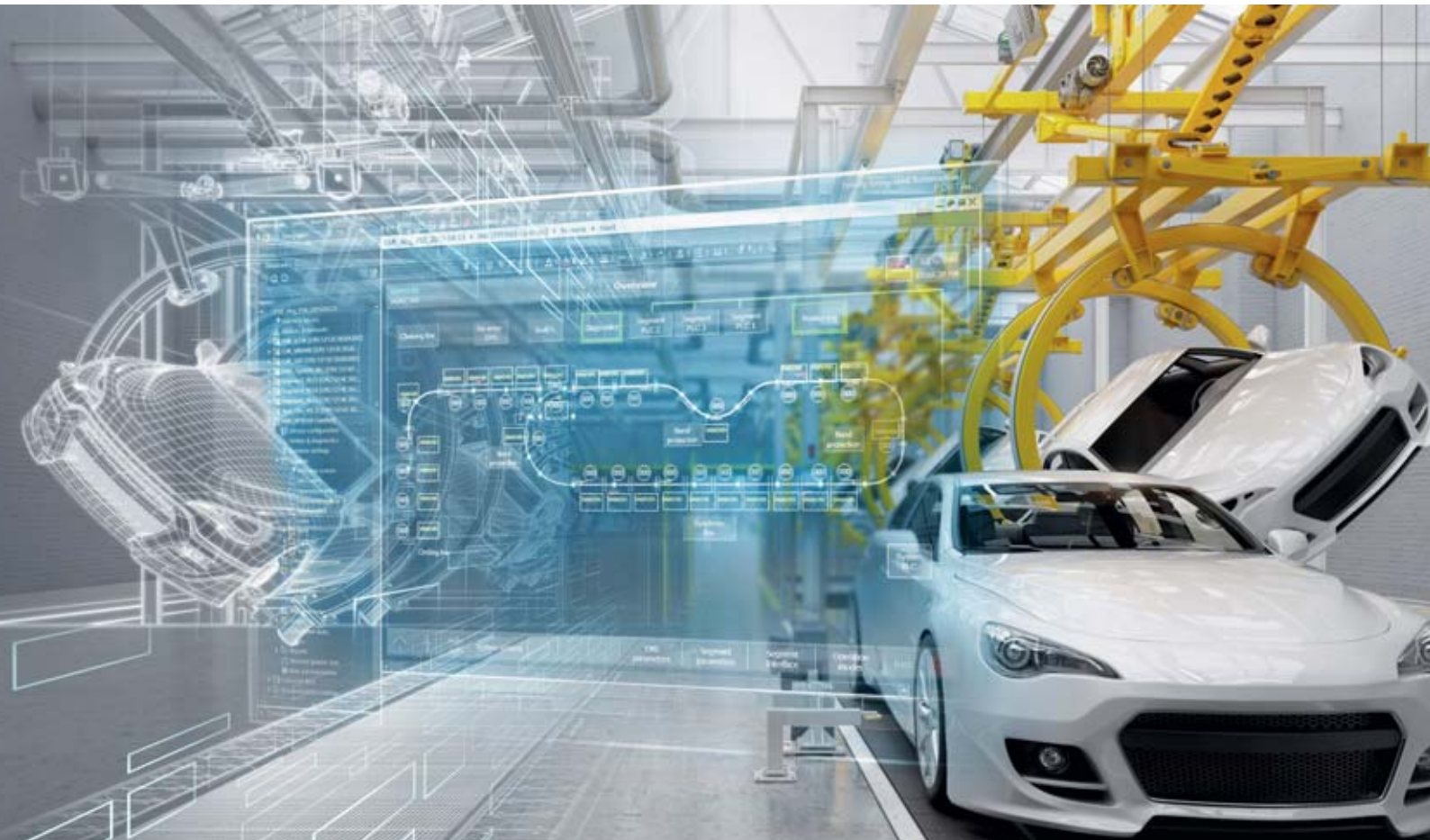
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**CUSTOMIZED TEST SYSTEMS
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How can digital twins help to reshape the design methodology of automotive semi-conductors and systems, enabling truly software-defined vehicles?

Picture: Siemens

Software-defined Systems

Reshaping the future of modern cars

Digital twins are becoming central to software-defined vehicle development. By enabling early validation of software workloads, chip architectures and full vehicle systems, they help reduce risk, accelerate development and support continuous feature evolution.

Today's vehicles are no longer defined by horsepower or torque. Instead of this, they are now characterized by the intelligence and adaptability of the software that runs them, along with consumer expectations of continuously evolving driving experiences.

To meet these expectations, automakers are now realizing that they need to adopt a software-first mindset rather than designing fixed hardware architectures and layering software on top. In this way, the rise of the software-defined vehicle (SDV) represents a paradigm shift in automotive engineering.

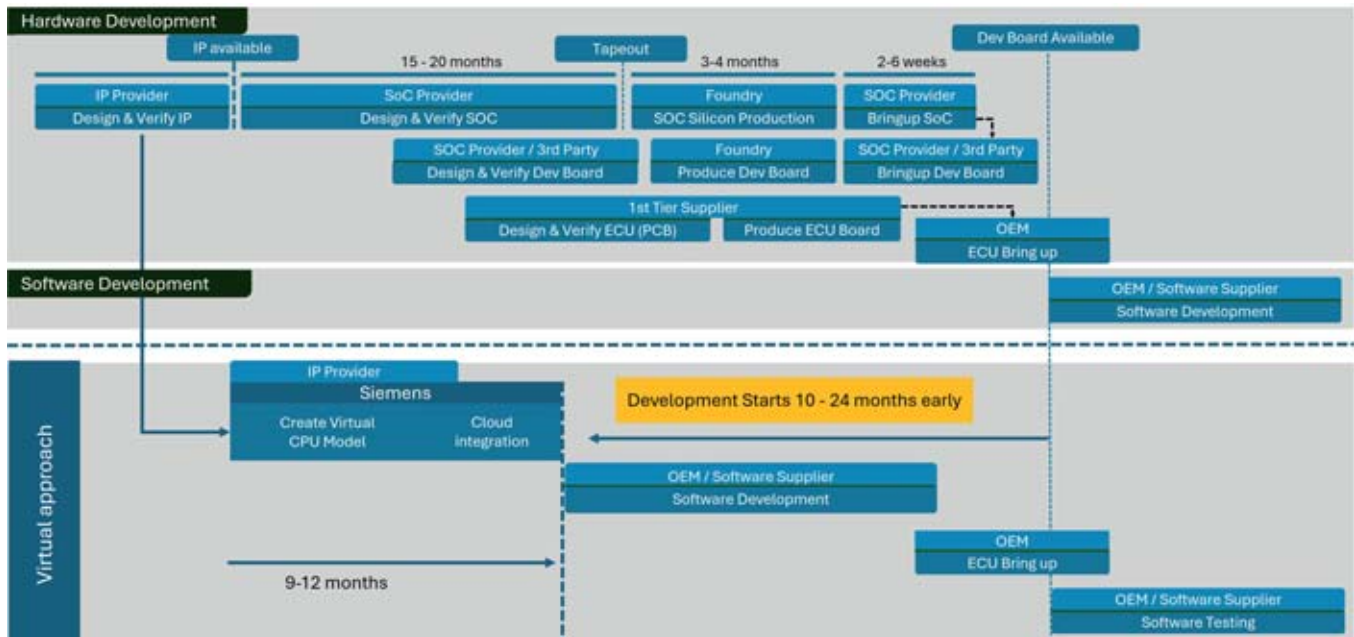
Limitations of Vehicle Development

Traditionally, the automotive industry has followed a hardware-first development model. In this model,

vehicle architecture is finalized long before software development begins. This is inefficient and prone to delays.

For example, when new safety or infotainment features emerge mid-development, manufacturers struggle to integrate them because the vehicle's electronic architecture and electronic control units (ECUs) are already locked down. This often leads to delays to vehicle launch or the postponement of innovative next-generation features, damaging brand competitiveness and consumer perception.

As cars evolve into connected, intelligent systems, the complexity of integrating hundreds of sensors, ECUs, and AI-driven functions is exposing the inflexibility of hardware-first design. A simple software change, like adding a new driver-assistance function, can cascade



into months of revalidation and hardware retesting. Consumer electronics and mobility services iterate every few months, making the slow, siloed model of development no longer sustainable.

These issues, coupled with the need to accelerate time-to-market and to offer differentiation that excites consumers, mean that software development can no longer just be an afterthought. It needs to be embedded into the hardware design process from the beginning. Using a shift-left approach, engineers/architects can start with software workloads and validate them on a digital twin of the vehicle and its electronics much earlier in the development cycle. System architects can now continuously develop and test AI-driven applications, such as:

- Autonomous driving perception stacks.
- Decision-making capabilities.
- Advanced driver assistance systems (ADAS).
- Connectivity.
- Infotainment systems.

Development using virtual ECUs and semiconductor models allows the hardware to be optimized around actual software demands.

Early Digital Twin Deployment Saves Time and Money

The traditional flow for development is shown in the top half of Figure 1. The bottom half of the figure shows a digital development flow where co-development can be started much earlier. Using this approach, software development can be started at least six months earlier and tested with the hardware without affecting the delivery schedule.

Tier 1s and OEMs want to move away from the conventional hardware and software development cycle. By deploying digital twins early in the design process, engineers can test how different hardware architectures respond to software workloads, such as AI-based perception or real-time navigation. This reduces the risk of costly redesigns. It can also ensure timely delivery or even accelerate time-to-market.

AI Workloads are Significantly Influencing Chipset Feature Optimization

Artificial intelligence is now an integral part of today's cars. Many features are fueled by AI models, including:

- Advanced driver assistance systems.
- Lane-keeping.
- Adaptive cruise control.
- Highway pilot.
- Collision avoidance.

These features require massive data processing capabilities, fast calculations, and continued learning from real-world driving scenarios.

Unlike traditional automotive control units designed for deterministic tasks (for example, engine control or braking), AI-driven workloads demand specialized semiconductor hardware with immense computational throughput, low-latency data transfer, and high energy efficiency. Examples include:

High-performance systems-on-chips (SoCs) such as NVIDIA Drive or Qualcomm Snapdragon Ride that integrate CPUs, GPUs, and neural processing units (NPU) for perception and decision-making.

Memory subsystems like LPDDR5 and high-bandwidth memory that enable faster data movement between sensors and processors.

Networks-on-chips (NoCs) that handle parallel AI inference and communication among distributed ECUs.

The next generation of autonomous vehicle features will be even more complex, requiring more dynamic, high-bandwidth computational resources. Once this occurs, digital twins will be used to quickly evaluate multiple potential chipset configurations that would be far too expensive and time-consuming to achieve using real SoCs.

For even more realistic results, semiconductor suppliers should be able to simulate the workloads taken from current real-world driving data. By validating silicon architectures in virtual car environments, chipmakers can anticipate bottlenecks early, optimize performance, and deliver AI-ready semiconductors that enable better and more adaptive vehicles.

Figure 1: Top: conventional hardware and software development cycle. Bottom: a more efficient approach using virtual hardware.

Picture: Siemens

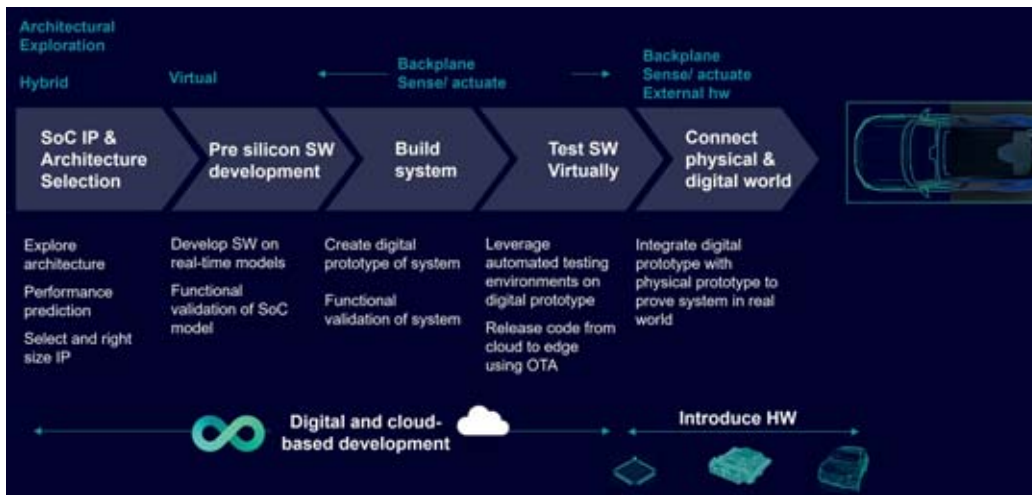


Figure 2: The end-to-end digital approach using Siemens PAVE360 integrated development workflow for software-defined vehicles.

Picture: Siemens

SDV Development Cannot Happen in Silos

One of the significant issues in current vehicle design methodology is that much of the development happens in silos. After the definition phase, parallel teams develop their systems in isolation with little to no interaction until the full system integration.

Efficient code cannot be developed in isolation from the rest of the system, but that's not the only problem. More significantly, when full system validation is only possible after hardware is delivered, any significant issues can cause immediate and potentially catastrophic schedule delays.

To address these issues, a digital twin platform can be used to simulate full systems-of-systems. For the results to be as accurate as possible, real-world inputs and hardware should also be integrated.

SDV Feature Set Evolution Needs Continuous Validation and Testing

Software-defined vehicles are not static products that become obsolete after a few years. Rather, they are evolving platforms. These cars can receive continuous updates, unlocking new features long after purchase.

For owners, this means enhanced safety, an improved driving experience, and a longer vehicle lifespan. For automakers, software-defined vehicles create new revenue streams through subscriptions and feature-on-demand services.

In this scenario, a system designer can't simply choose a chipset without a futuristic outlook, nor can they write efficient code in isolation. A stable, adaptable simulation environment capable of evaluating full systems throughout the entire SDV development flow is also required.

Ultimately, realizing a full software-defined vehicle concept is not possible without using digital-twin technology. Even then, it can't be achieved using a piecemeal approach. Instead, it needs a holistic environment that integrates all the models, tools, and hardware into one platform with synchronized communication. It should also be scalable, growing with designs to cover each phase of the development cycle.

Figure 2 illustrates how an integrated development workflow for SDVs enables an end-to-end digital twin approach. It's an open solution based on automotive standards that can be used to build a platform that provides a 360-degree view of how chips, ECUs, software stacks, and vehicle networks interact.

How to Use a Digital-Twin Platform to Design and Test SDVs

A multi-fidelity digital twin should be able to scale across vehicle design, creating a sole source of truth within an organization. A digital twin environment can be used by system architects for architecture selection to test multiple SoCs in the same loop by deploying similar software architecture onto various models of

the SoC and analyzing their performance for the given scenario. Then they can select the best SoC for their use cases using simulation, rather than relying completely on the datasheets provided by the chip makers.

By using native acceleration in the cloud, pre-silicon software development is now also possible. For example, Innexis Architecture Native Acceleration (ANA) offers near real-time performance, thus overcoming the issues commonly associated with slow virtual models. It is available for leading next-generation automotive IP such as Arm Zena-CSS.

Now, OEMs can develop their software early and IP partners can create software ecosystems before the hardware becomes available. System architects can then use the digital-twin platform to build a simulation of their full system through the VSI tool, test the developed software, and validate the system performance under multiple scenarios using inputs from both the real and virtual world.

Tools such as CARLA allow system engineers to run and validate using multiple real-world scenarios. This ensures that the hardware and the software perform under millions of kilometers of simulated scenarios. These efforts also ease subsequent certification to technical, safety, and legal standards.

Similarly, system architects can assess their mechanical models by integrating the Amesim/PyBamm/FMU3.0 models into their simulation or the network. System testing can always be traced back to the requirements in the same loop, and design iterations can be done in a timely manner to achieve the required maturity. Once the system architects are confident enough with their design, they can start bringing the actual hardware in the loop.

Safe Updates Through Digital Twins

One of the hallmarks of SDVs is the ability to evolve via over-the-air updates. Using digital twin technology, system architects can develop software upgrades while the cars are running on the road. Architects can simulate any software releases against the digital twin of the hardware and ensure that updates won't compromise safety or performance. After rigorous testing, the software can be deployed to millions of vehicles on the road without endangering any human lives in the real world. (bs)

Author: Conhas Thakkar, leading Technical Solution Architect at Siemens EDA

SPECIAL: Electrification

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Wide Bandgap

The EU project FastLane brings together industrial and scientific expertise in Silicon Carbide Semiconductors.

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Batteries

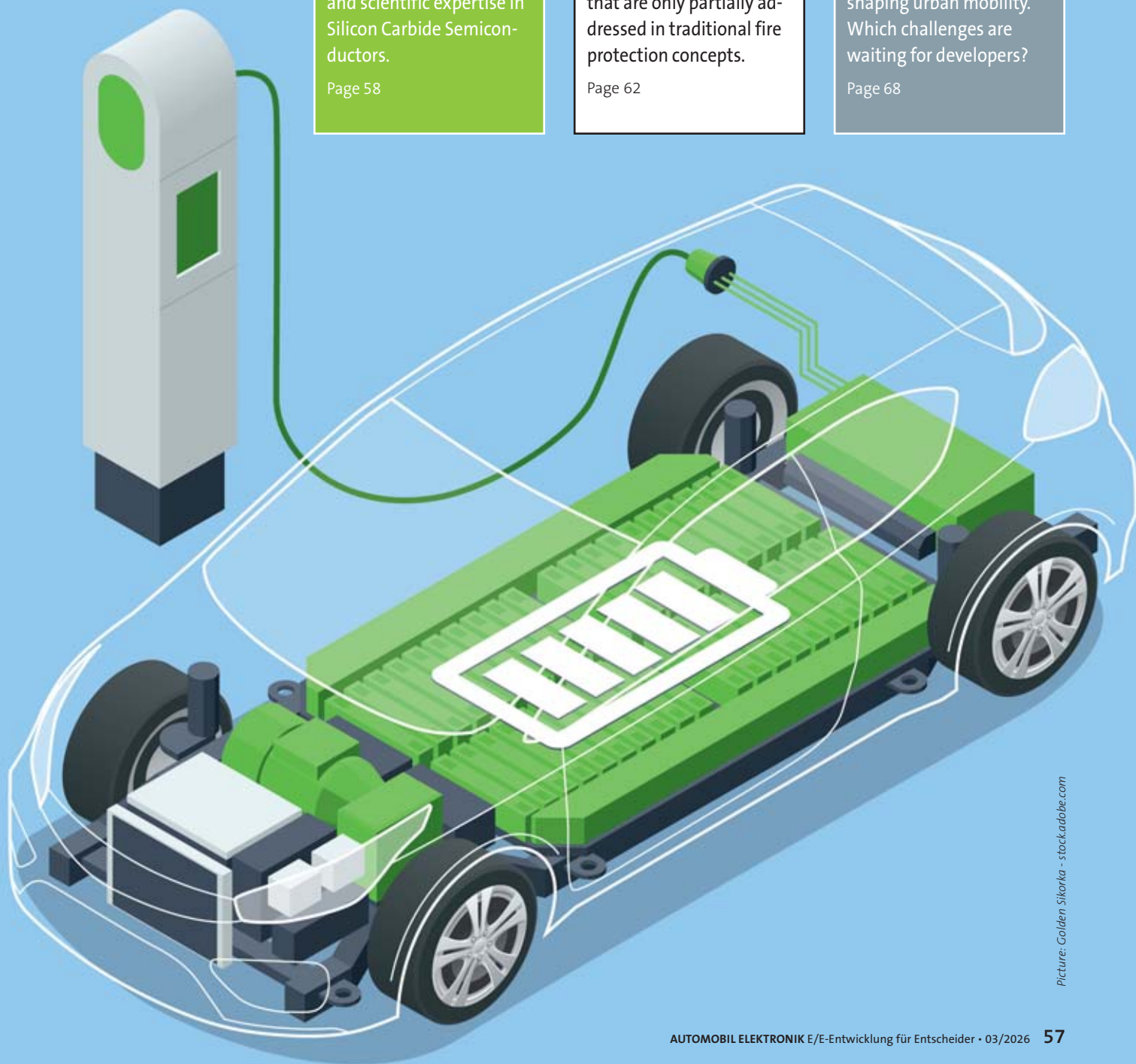
LiB manufacturing involves specific fire risks that are only partially addressed in traditional fire protection concepts.

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Urban Mobility

Electric two- and three-wheelers are re-shaping urban mobility. Which challenges are waiting for developers?

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Picture: Golden Slianka - stockadobe.com



Picture: Adobe Stocks, edited by Heraeus Electronics

SiC Improves the Efficiency of Power Electronics

EU Project FastLane Boosts SiC Value Creation

Silicon carbide is emerging as a cornerstone of next-generation power electronics. The EU project FastLane brings together industrial and scientific expertise to drive material innovations and sustainably improve efficiency, cost structures, and supply security.

The global electronics industry is undergoing a profound transformation, driven by the demand for higher efficiency, environmental sustainability, and strategic autonomy. In this evolving landscape, Silicon Carbide (SiC) has emerged as a key enabler of next-generation power applications. To harness its full potential, the European FastLane project, launched in 2024, supports EU independence in critical raw materials while developing an independent Silicon Carbide raw material and device supply chain

and broadening SiC functionalities to overcome current limitations

A Pan-European Effort to Reshape Power Electronics

FastLane is a three-year initiative co-funded by the European Union, bringing together 29 partners from seven countries, including leading research institutions, specialized SMEs, and major industrial players. Under the coordination of Valeo, the consortium aims to enhance

energy efficiency and reduce the carbon footprint of power electronics by developing a robust, independent SiC supply chain—from raw materials to system-level demonstrators. By leveraging economies of scale, FastLane drives cost-efficient energy conversion applications, strengthening Europe’s technological and economic resilience in power electronics.

The project’s comprehensive structure spans multiple work packages and collaborative efforts, covering the entire SiC power electronics value chain. This includes material development, device fabrication, packaging innovations, and final system integration.

Materials Innovation

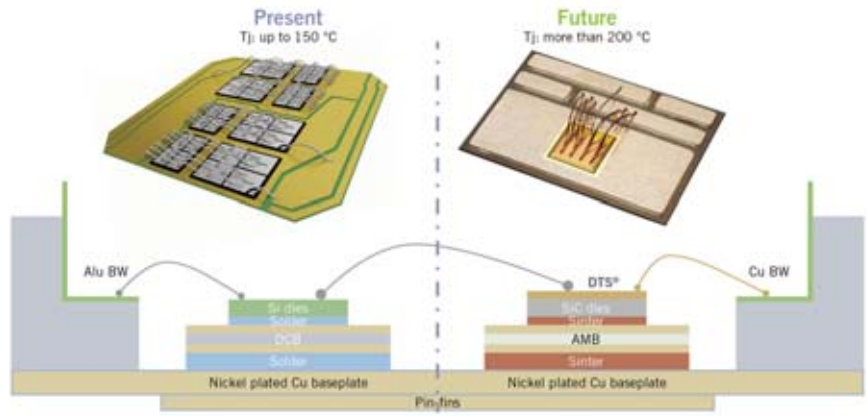
Within the FastLane consortium, materials development plays a central role in enabling the assembly and performance of advanced SiC power modules. Among the contributors, Heraeus Electronics supports the integration of six distinct SiC module designs through three specialized packaging technologies. These innovations address key challenges in thermal management, electrical performance, and reliability—critical factors for next-generation power electronics.

The company’s focus lies in developing environmentally responsible materials that facilitate miniaturization, forward integration, and high-efficiency energy conversion. In response to industry-wide shifts—such as the rise of e-mobility, AI, and next-generation communication technologies—collaborative innovation across the value chain has become essential. Heraeus Electronics engages in joint research efforts with academic institutions, start-ups, equipment providers, and end users, contributing to broader ecosystem development through EU funded initiatives and industry associations.

Technical Innovations

To achieve the FastLane project goal for higher efficiency of power modules SiC dies enable them to operate at >175 °C, with higher switching frequencies and increased power densities. Their effective implementation requires advanced packaging materials. Heraeus contributes within FastLane with this key innovations:

- Ag sinter pastes enabling attachment of Active metal brazed (AMB) substrates without noble metal surfaces



- Ag-free AMB substrates with designs reducing parasitic inductance and
- Die-Top System (DTS©) enabling reliable Cu bonding to SiC dies.

Silver Sintering for AMB Substrate Attachment on Aluminum Baseplates

To reduce both cost and weight in SiC power module packaging, Heraeus has developed the PE 360P silver sinter paste, enabling the attachment of Active Metal Brazed (AMB) substrates to aluminum baseplates without the need for precious metal surfaces.

- This innovation offers significant advantages:
- Up to 70 % weight reduction
- Cost savings of up to 91 % compared to copper baseplates

Initial results with PE 360P show robust AMB adhesion and minimal delamination (<5 %) already with Cu-coated Al baseplates after 1500 temperature cycles (-55 °C/+150 °C), comparable to similar Ag-coated baseplates. In contrast, Ni-coated Al baseplates fail to ensure sufficient adhesion. Ongoing work focuses further on optimizing Ag sintering directly on non-precious metals coated Al.

This approach supports scalable, cost-efficient packaging for high-performance SiC modules.

Silver-Free, Low-Inductance AMB Substrates

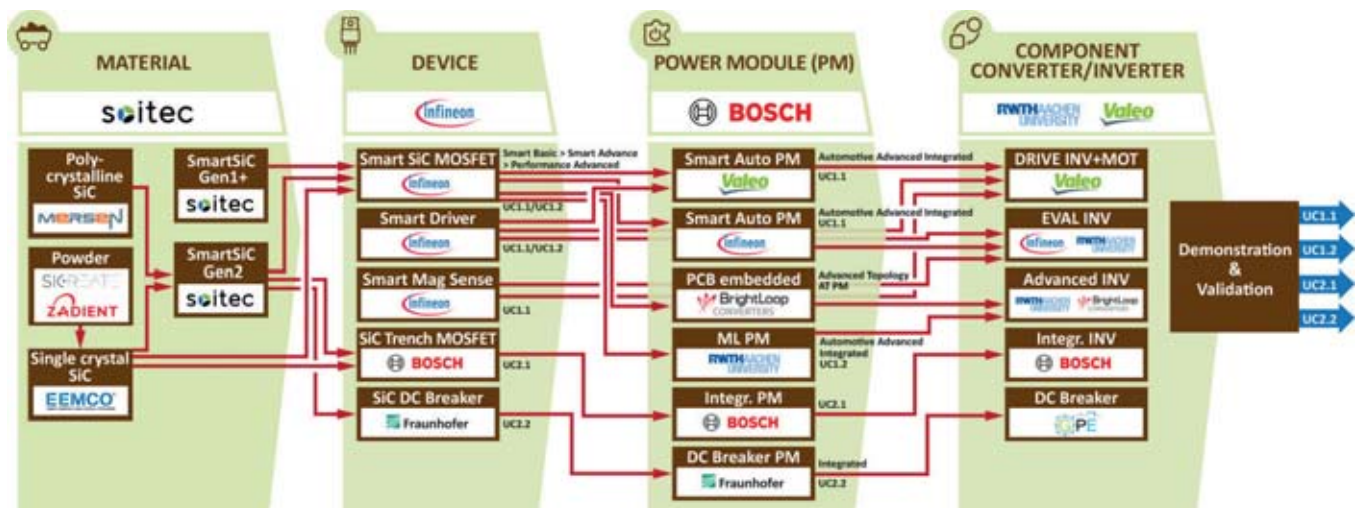
The second major innovation centers on the development of silver-free, low-inductance AMB substrates using Si₃N₄ ceramics, designed to reduce parasitic inductance and improve cost efficiency. The key benefits include:

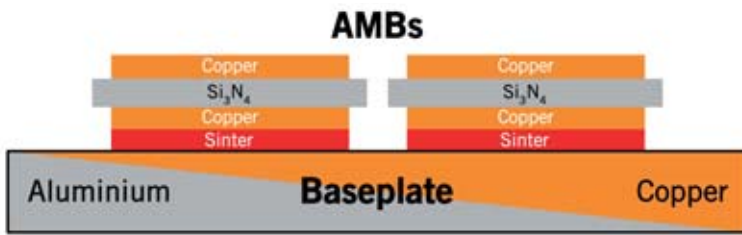
Material innovations in power electronic modules addressing key challenges in thermal management, electrical performance, and reliability.

Picture: Heraeus Electronics

Overview Project Partners in the Consortium

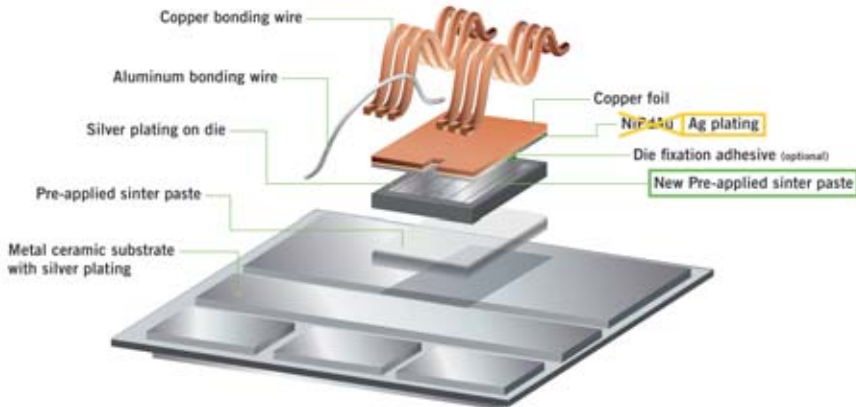
Picture: FastLane Project





Schematic drawing of AMBs sintered to baseplates.

Picture: Heraeus Electronics



Schematic drawing of die top system DTS.

Picture: Heraeus Electronics

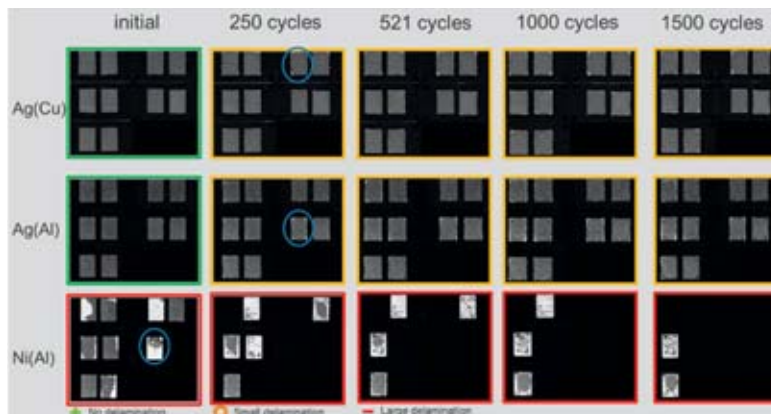
- Reduced cost through elimination of silver (Ag content >60 wt % in conventional AMB pastes)
- Reduced Ag migration for enhanced reliability
- Superior performance compared to traditional Direct Copper Bonded (DCB) substrates

Scanning acoustic microscopy confirmed the reliability of these AMB 2.0 substrates after thermal shock testing (-65 °C to +150 °C). Their performance rivals Ag-containing AMB, surpasses DCB substrates, and meets all customer specifications. Their integration into Valeo's low-inductance power modules is planned as the next step.

This innovation also strengthens the European AMB supply chain, with all key manufacturing partners—including metal and ceramic suppliers and Heraeus Electronics' technology and production site—located within Europe. This supports risk mitigation, improves supply chain stability, reduces CO₂ emissions, and enhances the EU's market position. To ensure secure global delivery

Scanning acoustic microscope results after thermal cycling of AMBs attached to three different baseplate types.

Picture: Heraeus Electronics



capability, Heraeus Electronics also maintains a dual-source strategy in Asia.

Die Top System for Copper Wire Bonding

The third building block addresses top-side interconnection, a critical factor for achieving high reliability in SiC modules. Heraeus has developed the Die Top System (DTS) in collaboration with European partners. This system features a copper foil with pre-applied sinter material, enabling copper wire bonding with over 10× reliability improvement compared to aluminum bonding.

- The industrialized DTS Silver replaces NiPdAu metallization with Ag plating, ensuring:
 - Simplified sintering
 - Reliable copper bonding to SiC dies
- Future development includes laser-structured DTS[®] Silver for finer wire bonding geometries (down to 0.5 × 0.5 mm²). These advanced interconnects will be evaluated in FastLane power modules for performance and reliability.

First-Year Deliverables and Ongoing Integration

In the first year of FastLane, Heraeus Electronics and its partners successfully delivered three core packaging innovations:

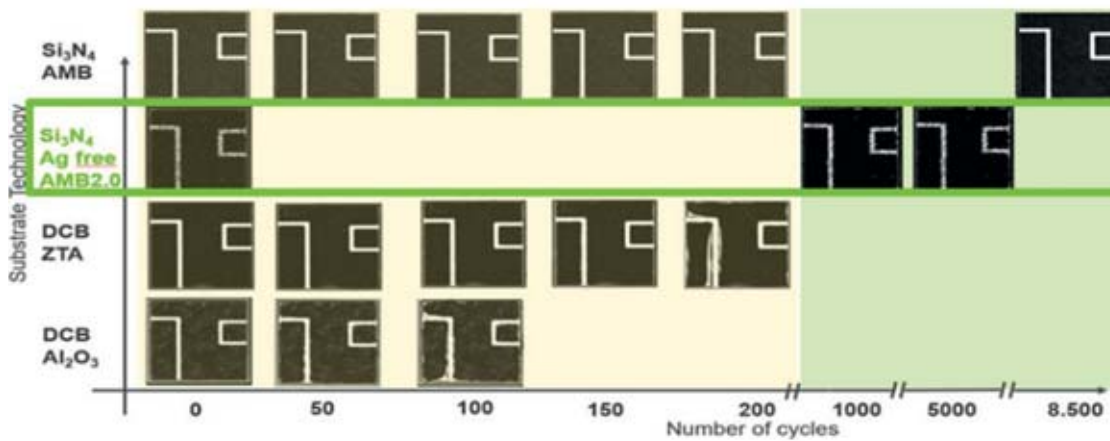
- Development of an Ag sinter paste for AMB attachment on Ag-metallized aluminum baseplates, replacing conventional copper
 - Design of silver-free AMB substrates using Si₃N₄ ceramics for reduced cost and inductance
 - Development of DTS[®] systems enabling reliable and cost-efficient copper wire bonding to SiC dies
- These technologies are now undergoing integration and reliability testing across multiple power module use cases. This work will continue through June 2027, with the goal of enhancing SiC performance, efficiency, and resilience throughout Europe's power electronics value chain.

Conclusion and Outlook: Tailored SiC Demonstrators for Strategic Applications

By integrating advanced SiC technologies into tailored demonstrators across mobility and energy domains, FastLane delivers on five major objectives:

It aims to reduce the environmental impact of power electronics by improving energy efficiency and lowering the carbon footprint of materials and processes. At the same time, it contributes to strengthening European sovereignty over critical raw materials by establishing a more independent and resilient SiC supply chain.

The project also focuses on unlocking new functionalities in SiC devices and packaging, enabling operation under higher temperatures, switching frequencies, and power densities. Cost optimization is pursued through innovations in materials and scalable manufacturing techniques. Finally, FastLane supports accelerated innovation in next-generation power electronics by fostering collaboration across research institutions, industrial partners, and technology developers. Ultimately improving usability and affordability for end users.



Scanning acoustic microscope results after thermal cycling of AMB and DCB substrates.

Picture: Heraeus Electronics

The contributions from all FastLane partners are enabling the development of silicon carbide power module demonstrators tailored to specific end-user applications.

E-mobility:

- Light commercial vehicles (UCs 1.1 & 1.2a) for high-volume applications
- Ultra-class haul trucks (UC 1.2b) for high-power, heavy-duty environments

Energy systems:

- Power inverters for electrolyzers (UC 2.1) to support green hydrogen production

- Solid-state circuit breakers (UC 2.2) for grid protection and advanced battery storage

These demonstrators will validate the technical feasibility and performance of SiC modules under real-world conditions. Together, these efforts aim to position Europe at the forefront of sustainable, high-performance power electronics—powered by Silicon Carbide. (bs)

Authors:

Dr. Sebastian Fritzsche, Manager Technology Scouting at Heraeus Electronics,
Dirk Brauer, Research & Innovation Director at Valeo eAutomotive Germany



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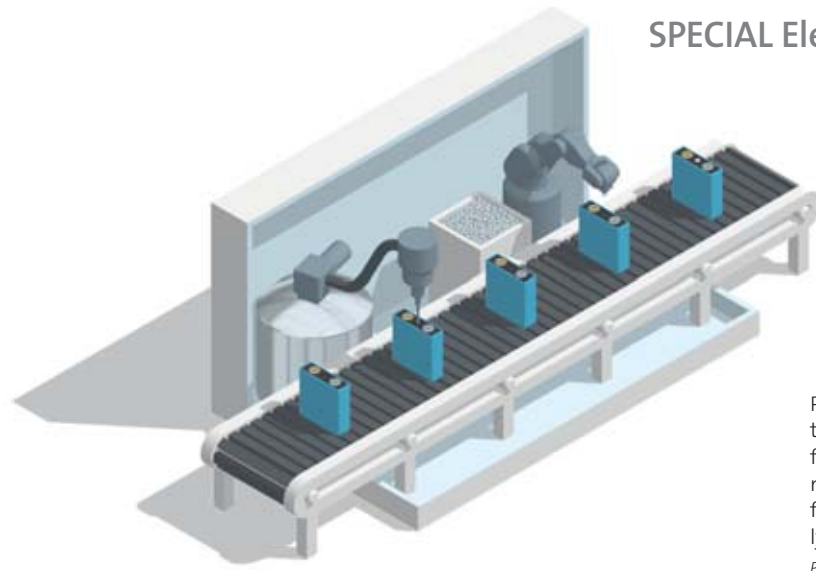
Fire Protection in LIB Manufacturing

Why Fire Suppression alone is not sufficient

Lithium-ion batteries (LIB) manufacturing involves specific fire risks that are only partially addressed in traditional, building-related fire protection concepts. TÜV SÜD supports both manufacturers and operators in developing an individual, risk-based strategy.

LIB cells are at risk of thermal runaway – not only during critical stages of the manufacturing process, but also during use.

Picture: Siemens



Process step: electrolyte filling. The fire risk here stems mainly from the flammable electrolyte

Picture: Siemens

Fire protection in battery cell manufacturing does not start with the suppression system. It begins with stable processes, clearly defined quality criteria, and a production environment that detects, analyses and if necessary, removes critical deviations at an early stage. For manufacturers, this represents the greatest leverage in risk reduction.

In battery cell manufacturing, fire risks arise wherever high-energy materials, tight tolerances, solvents, heat input, manual processes (“human factor”) and automated systems interact. Because these risks rarely occur in isolation, localized measures limited to structural aspects cannot provide adequate protection. Defects or faults often tend to propagate across multiple process steps. Minor defects that remain undetected at an early stage can lead to severe consequences at later stages. A robust risk-based fire protection strategy therefore evaluates not only individual plant components but the entire process chain. This leads to specific design criteria, tailored fire protection measures, defined inspection requirements, and a sound deviation and escalation management system. Manufacturers are therefore advised to extend the conventional fire protection concept with process and machine safety, and to develop an integrated, risk-based strategy. Particular attention must be paid to the specific characteristics of the three main areas in LIB cell manufacturing: electrode manufacturing, cell assembly, and cell finishing.

Early risks in electrode manufacturing

In the initial production stages — such as mixing, coating, drying, and calendaring — organic solvents, high temperatures, mechanical stress, and electrostatic discharge play a key role. Sensitive and raw materials encounter potential ignition sources. Reducing ignition sources contributes to safety, as does the use of qualified raw materials with clearly defined handling and storage procedures. Equally important are appropriate exhaust and ventilation concepts, as well as continuous quality assurance that identifies deviations early and eliminates them when necessary. This reduces the risk of defects propagating into downstream steps and compromising the safety of the finished LIB cell.

Cell assembly: keeping the electrolyte under control

During cell assembly, cells are filled with electrolyte for the first time. A key risk here lies in handling the liquid, highly flammable electrolyte. This involves risks associated with handling liquid, highly flammable electrolytes. Even small leaks or incorrect filling can significantly increase this risk. The situation becomes particularly critical when additional heat input — for example during welding or contacting — occurs. The filling process should therefore be continuously monitored — for instance by measuring the degree of wetting — and strict approval procedures for parameter changes must be observed. Process steps such as, stacking and packaging of filled cells are susceptible to mechanical stress and technical malfunctions that can lead to sparking and damage.

Cell finishing I: Formation — preventing thermal runaway

When cells are charged for the first time during the formation process, fire risk increases significantly. Any defect — such as damaged separators or incorrect electrolyte filling — can trigger thermal runaway at this stage. This uncontrolled, self-reinforcing chain reaction within the cell, triggered for example by short circuits or thermal stress, can lead to fire, explosions, or the release of toxic substances and gases. Thermal runaway is particularly critical because, once initiated, it cannot be stopped as a self-sustaining exothermic reaction. Protection concepts must therefore focus primarily on early detection, spatial containment of the process, prevention of propagation to adjacent areas, and clearly defined emergency measures. All sensor and alarm systems must be fully functional and available at all times. Gradual contamination and the aging of all components can also affect safety.

Cell finishing II: Aging — planning for monitoring

The aging step likewise requires special attention. In this step, many already-charged cells are stored in different temperature zones. A battery management system (BMS) covering or continuously monitoring this phase is not always in place. The decisive factors here are early detection, clearly

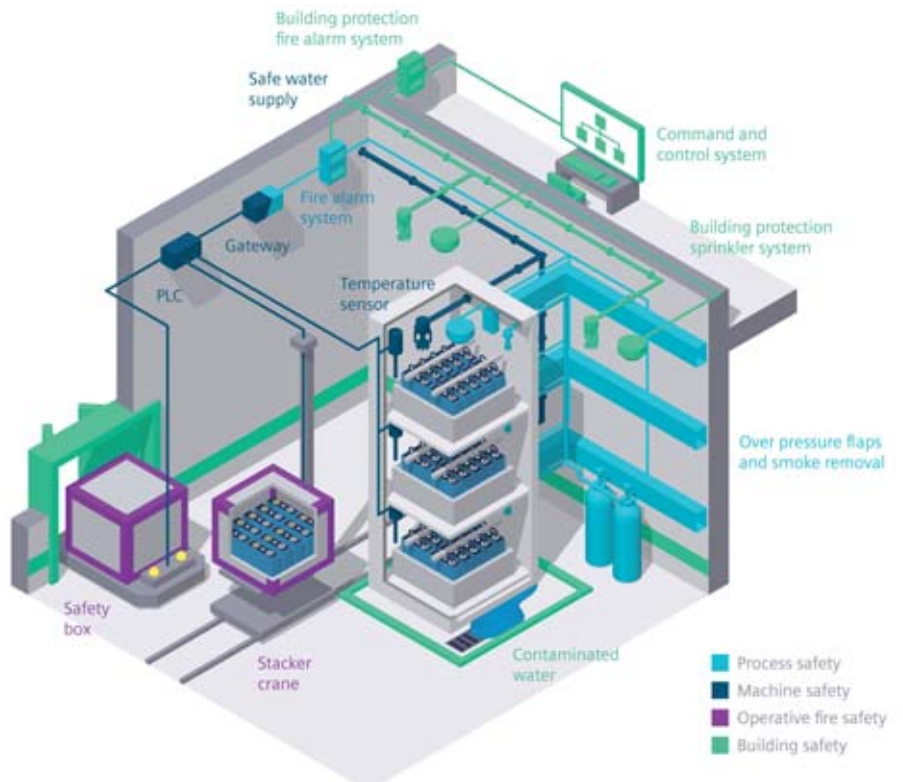


Process step: formation. The cells are charged and discharged several times over a period of several days. Errors from previous steps can very easily lead to fires at this stage.

Picture: Siemens

To safeguard the high-risk formation process, tailored measures are required in the areas of building, process and machinery safety, as well as operational fire safety.

Picture: Siemens



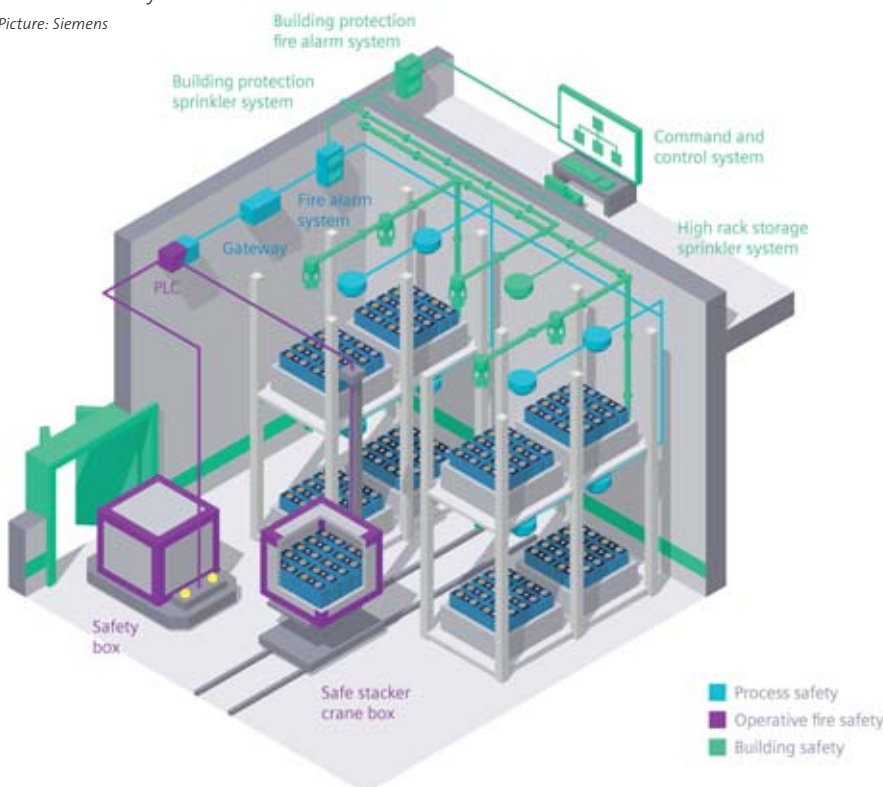
defined alarm pathways, and effective measures to limit and control fire and smoke propagation. Combining monitoring systems with emergency organization allows the specific risks of this process step to be reduced to an acceptable level.

A risk-based fire protection strategy can serve as the basis for close monitoring of both steps and defines approval thresholds and quality criteria for a production

stop or emergency scenario. Complete traceability of the entire batch and all processes forms the basis for effective risk containment. Clear rules should be defined for handling all deviations.

Aging is one of the most high-risk stages of the process. Measures must be taken across all areas of fire safety to ensure this stage is carried out safely.

Picture: Siemens



The regulatory framework: supplementing legal requirements with a risk-based strategy

From a building law perspective in Germany, LIB cell manufacturing is primarily governed by the Model Building Code (Musterbauordnung, MBO) and the respective state building regulations, the Model Administrative Regulation on Technical Building Rules (MVV TB), and special building regulations such as the Model Industrial Buildings Guideline (Muster-Industriebaurichtlinie).

Methodologically, the risk-based fire protection strategy is based on EN ISO 19353:2019 (Safety of machinery – Fire prevention and fire protection) and DIN EN ISO 12100:2011 (Safety of machinery – General principles for design – Risk assessment and risk reduction).

In addition to the above mentioned process, machinery and fire safety regulations, testing standards such as IEC 62660 (Lithium-ion secondary cells for the propulsion of electric road vehicles) and its Parts 1–3 must also be considered for LIBs used in electric vehicles:

- IEC 62660-1 Performance and endurance tests,
- IEC 62660-2 Tests for reliability and abuse behaviour of cells and
- IEC 62660-3 Safety requirements for lithium-ion cells and cell packs.

In addition, ISO 14001 (regarding environmental management systems), ISO 45001

The majority of battery storage systems currently in use incorporate LIB cells. Risk-based fire safety measures during the manufacturing process also protect the systems from the serious consequences of thermal runaway.

Picture: Braillegrenate/Shutterstock

(regarding occupational health and safety management systems) and the EU Battery Regulation (EU) 2023/1541 (regarding information and sustainability requirements as well as the placing of LIBs on the European market) are also relevant to cell manufacturing.

However, no currently applicable standards fully addresses, at the process and machine level, the specific fire risks associated with LIB cells. These risks arise from the interaction of machine, process, and end product. This underlines the need for a risk-based strategy that takes into account potential damage severity, likelihood of occurrence, and the ability to prevent propagation.

Clear separation, early detection and targeted fire suppression

Another important lever is the structural separation of critical areas. Fire compartments limit incidents spatially and help to ensure the availability and redundancy of the overall plant or individual critical production areas. Equally important is detection and suppression technology tailored to the specific process. Only then can sensors be positioned at the right location and meaningful trigger thresholds defined. This must be complemented by calibration and inspection schedules, a reliable spare parts supply chain, and a structured deviation management. The storage and packaging of charged cells also require particular care. Where large number of cells are stored together over extended periods, spatial separation should be provided alongside appropriate monitoring.

Conclusion

To meet the demand for LIB cells safely, one should go beyond conventional building-focused fire protection concepts. A risk-based strategy incorporates machine and process safety and specifically addresses the risks of each individual manufacturing step. Such an approach protects employees and the environment, safeguards investments, and ensures compliance with safety requirements. TÜV SÜD supports companies in developing and implementing an integrated, risk-based fire protection strategy. (bs) ■

Author: Manuel Obert, Senior Project and Business Development Manager at TÜV SÜD Industrie Service



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How can DC charging systems support high-power charging anywhere? Integrated storage, PV, and a shared DC bus improve flexibility and efficiency.

Picture: XCharge

Charging with Integrated Energy Storage

High-Power Charging Infrastructure for Any Location

High-power charging no longer depends solely on large grid connections. Integrated DC systems that combine photovoltaics, battery storage, and fast charging create a more efficient and flexible foundation for future EV infrastructure.

Nearly three million electric vehicles are currently in operation across Germany, supported by roughly 50,000 fast-charging points. However, the expected growth in passenger EVs—driven, for example, by new subsidy schemes—will require a substantial expansion of fast-charging infrastructure. This expansion is constrained by limited grid capacity and high electricity prices. One promising solution is the direct use of solar power for fast charging.

While the combination of solar generation and fast charging is an obvious approach, only a limited num-

ber of providers have adopted it so far. Early adopters already combine PV modules with DC fast chargers but fail to fully exploit the potential, as they typically do not store the generated energy. Instead, surplus electricity is fed into the grid whenever no vehicle is charging.

Where a storage solution is integrated to enable local use of PV energy, it is usually implemented as a separate system, because PV systems, battery storage, and charging stations are often treated as distinct entities from both a regulatory and technical perspective, typically



This new solution integrates PV generation, battery storage, and high-power charging (HPC) technology into a single system based on a shared DC bus.

Picture: XCharge

connected via an AC coupling point. Such AC-coupled architectures require multiple energy conversions—from the PV inverter to the storage inverter and finally to the fast charger—resulting in significant losses. In addition, system separation complicates coordinated control of energy flows.

A New Approach: DC Charging Systems with Integrated Battery Storage

To address these challenges, new solutions integrate PV generation, battery storage, and high-power charging (HPC) technology into a single system based on a shared DC bus. All components operate directly on the DC level, eliminating conversion losses associated with AC coupling.

This is achieved, for example, through onboard maximum power point tracking modules (MPPT modules), which process solar energy directly and feed it into the DC bus. Separate inverters or external power conversion systems are no longer required. In addition to reducing conversion losses, this approach also lowers space requirements as well as integration and maintenance effort.

The Right Mix: Fast Charging from Solar and Grid

This charging architecture is not merely theoretical but already in operation. Fast-charging systems with integrated storage are deployed, for example, in Pendleton (Oregon, USA). A photovoltaic system with a capacity of 10 kWp continuously supplies energy to the storage system, which has sufficient capacity to charge a vehicle for several hundred kilometers during a typical coffee break. In the absence of sufficient solar irradiation, the storage system can also draw energy from the grid, typically at night or during periods of low electricity prices. Subject to appropriate regulatory frameworks, feeding energy back into the grid is also possible.

How the DC Bus Architecture Works

One example of such a system is GridLink by XCharge. It integrates grid connection, photovoltaic generation, battery storage, and the fast-charging unit on a shared DC bus. This architecture enables direct coordination of all

energy flows within the power electronics. The AC grid connection primarily serves as a supplementary energy source and typically provides a connection capacity of around 44 kW. Higher charging power is delivered by the integrated battery storage, which buffers peak loads and enables high-power charging even with limited grid capacity. As a result, a high-capacity grid connection in the range of several hundred kilowatts is not required.

The system architecture is based on three module types: bidirectional AC/DC modules for grid and microgrid connection, bidirectional DC/DC modules for battery integration, and MPPT modules for direct PV integration. A central charger controller coordinates all power modules and manages energy flows in real time. Power modules communicate via CAN (Controller Area Network), the battery management system via Modbus, and backend connectivity is provided through OCPP (Open Charge Point Protocol).

Integration of Small and Large PV Systems

Two integration pathways are available for PV systems. Smaller PV capacities can be connected directly via integrated MPPT modules (typically up to approximately 30 kW). Larger PV installations are coupled to the DC bus via external power electronics, enabling higher capacities but requiring more precise coordination of bus voltage, interfaces, and protection mechanisms.

The system operates in a grid-following mode and does not provide grid-forming capabilities. Microgrid operation is therefore only possible if an external grid-forming energy source is available. However, the modular architecture allows for scalability of power modules as well as firmware-based extensions of a lot of the operating functions.

Grid-Independent Deployment of New Charging Sites

With the ongoing solar boom—more than one million new PV systems were installed worldwide in 2024 alone—and the increasing number of electric vehicles, the intelligent coupling of fast charging, photovoltaics, and battery storage is becoming increasingly important.

Fully integrated DC architectures enable, for the first time, the systematic use of locally generated solar energy for high-power charging without requiring the costly and time consuming installation of new high-capacity grid connections. Fast-charging sites are thus evolving from passive electricity consumers into active nodes within the energy system. (na)

Author: Albina Iljasov, Head of Europe at XCharge

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How can electric two- and three-wheelers overcome design challenges? Efficient motor control improves range, thermal performance, noise control, and cost.

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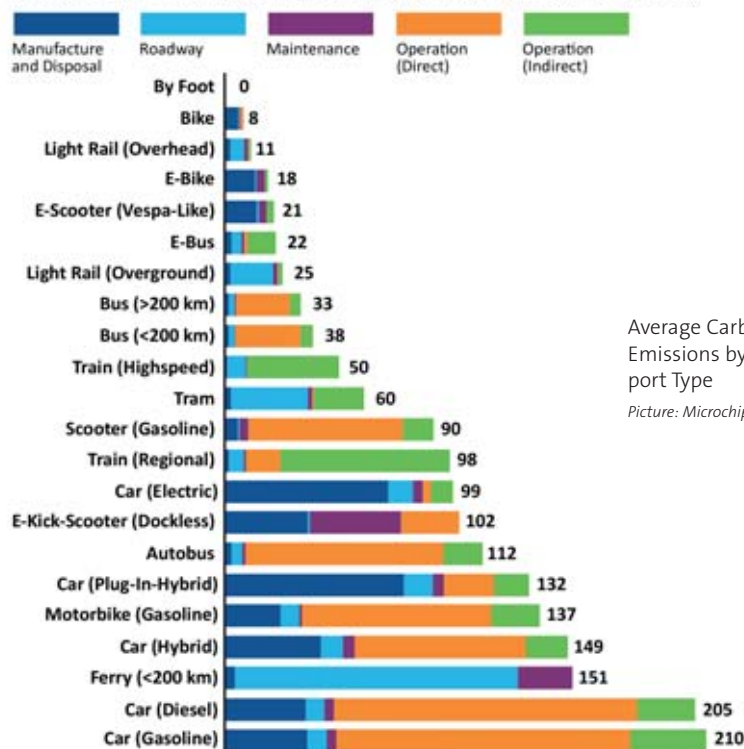
Advancing Electric Micro-Mobility

Designing Efficient Electric Two- and Three-Wheelers

Electric two- and three-wheelers are reshaping urban mobility. Efficient motor control, thermal management, and scalable reference designs are helping improve range, reliability, and affordability across vehicle classes.



Average Carbon Emissions by Transport Type (in Gram per pkm)



Average Carbon Emissions by Transport Type

Picture: Microchip

The global movement towards sustainable transportation is accelerating, and e-mobility solutions—such as e-kick scooters, e-bikes, e-scooters and electric rickshaws—are at the forefront of this transformation. These innovative vehicles are not only reducing pollution but also providing a more efficient and convenient way to navigate increasingly crowded urban environments. According to a report in Travel and Mobility Tech (TNMT), e-bikes and e-scooters have a significantly lower per-capita carbon footprint compared to other modes of transportation.

The electric scooter market is booming. Meticulous Research projects it will surpass \$405 billion by 2031, with nearly 300 million units in circulation. This remarkable growth is fueled by localizing production in emerging economies, shifting consumer preferences and strong government initiatives aimed at easing congestion and cutting emissions. Supported by government incentives and improved infrastructure, cities across Europe, North America and Asia are embracing e-kick scooters, e-bikes and e-scooters to reduce traffic and fossil fuel use. In these regions, micro-mobility options are increasingly integrated into urban transport networks, with app-based rentals and dedicated lanes making them even more accessible. On the other hand, the Asia-Pacific region is expected to dominate the sector, accounting for over 80% of global electric two- and three-wheelers sales. In South Asia, electric two- and three-wheelers are quickly replacing traditional two-wheelers like mopeds, motorcycles and three-wheelers also known as rickshaws. In countries like India, the Philippines, Vietnam and Thailand, this shift is driven by rising fuel costs, supportive policies,





and growing environmental awareness, offering cleaner and more efficient urban transport.

Environmental and Economic Benefits

E-mobility solutions offer significant advantages by reducing air pollution, promoting sustainability and providing economic benefits. Unlike traditional vehicles that emit harmful pollutants such as carbon dioxide (CO₂), nitrogen oxides (NO_x) and particulate matter (PM), full electric vehicles produce zero tailpipe emissions, resulting in cleaner air and a healthier environment. They also promote sustainability by reducing dependence on fossil fuels and utilizing renewable energy sources like solar, wind and hydroelectric power which help mitigate climate change by lowering greenhouse gas emissions. Additionally, electric vehicles are economically advantageous, with lower operating and maintenance costs compared to traditional vehicles, as electricity is cheaper than gasoline or diesel, and they require less service due to fewer moving parts. For businesses, adopting e-mobility solutions can lead to cost savings and improved operational efficiency, making them a smart choice for a greener and more cost-effective future.

Motor Control for Electric Two- and Three-Wheelers

Motor control is the core technology in electric two- and three-wheelers, precisely managing how battery power is delivered to the motor. The controller processes throttle and sensor signals, dynamically adjusting voltage and current to control speed, torque and direction. Most vehicles in this segment use brushless

 <p>Range Anxiety System efficiency improvement Managing switching losses</p>	 <p>Thermal Management Motor, inverter and battery High power charging</p>	 <p>Noise Reduction Reducing acoustic and mechanical noise Managing electromagnetic interference (EMI)</p>	 <p>Size, Weight and Cost Compact and light weight High power/weight ratio Cost effective for affordability</p>
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Design challenges in micro mobility vehicles

Picture: Microchip

DC (BLDC) or permanent magnet synchronous motors (PMSM), paired with advanced algorithms like Field-Oriented Control (FOC) for smooth, efficient and responsive performance. Modern motor controllers go beyond basic power delivery. They integrate seamlessly with battery management and connectivity systems, enabling real-time diagnostics, remote updates and enhanced safety features. As electrification accelerates, the complexity of these systems increases, presenting new design challenges in efficiency, thermal management and system integration. Addressing these challenges is essential to ensure optimal performance, safety and reliability for the next generation of electric two- and three-wheelers.

Design Challenges

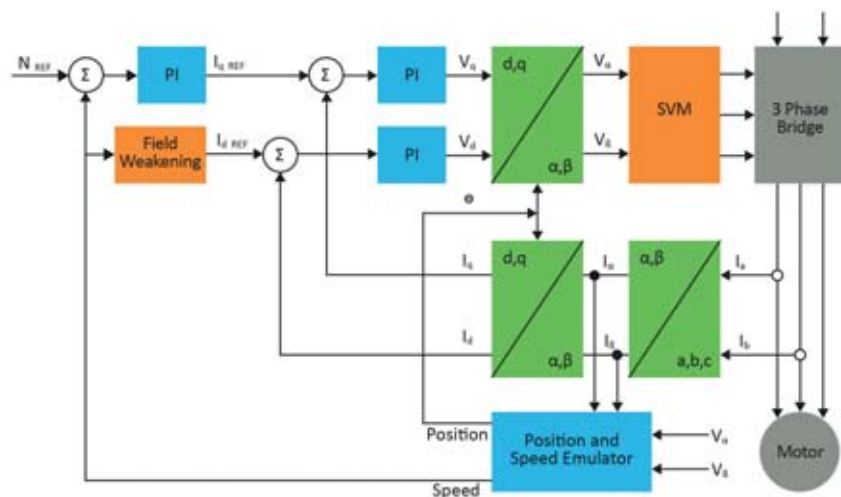
Despite their promise, electric two- and three-wheelers face several design hurdles. Range anxiety remains a top concern, requiring improvements in system efficiency and better management of switching losses. Effective thermal management is essential, especially with the rise of high-power charging. Noise reduction, both acoustic and electromagnetic, is increasingly important for user comfort and regulatory compliance. Finally, balancing size, weight and cost is critical to making these vehicles compact, lightweight and affordable for a broad range of consumers.

FOC ensures consistent performance and longer battery life.

Picture: Microchip

Range Anxiety

Advanced motor control techniques play a crucial role in overcoming range anxiety for electric two-wheelers.

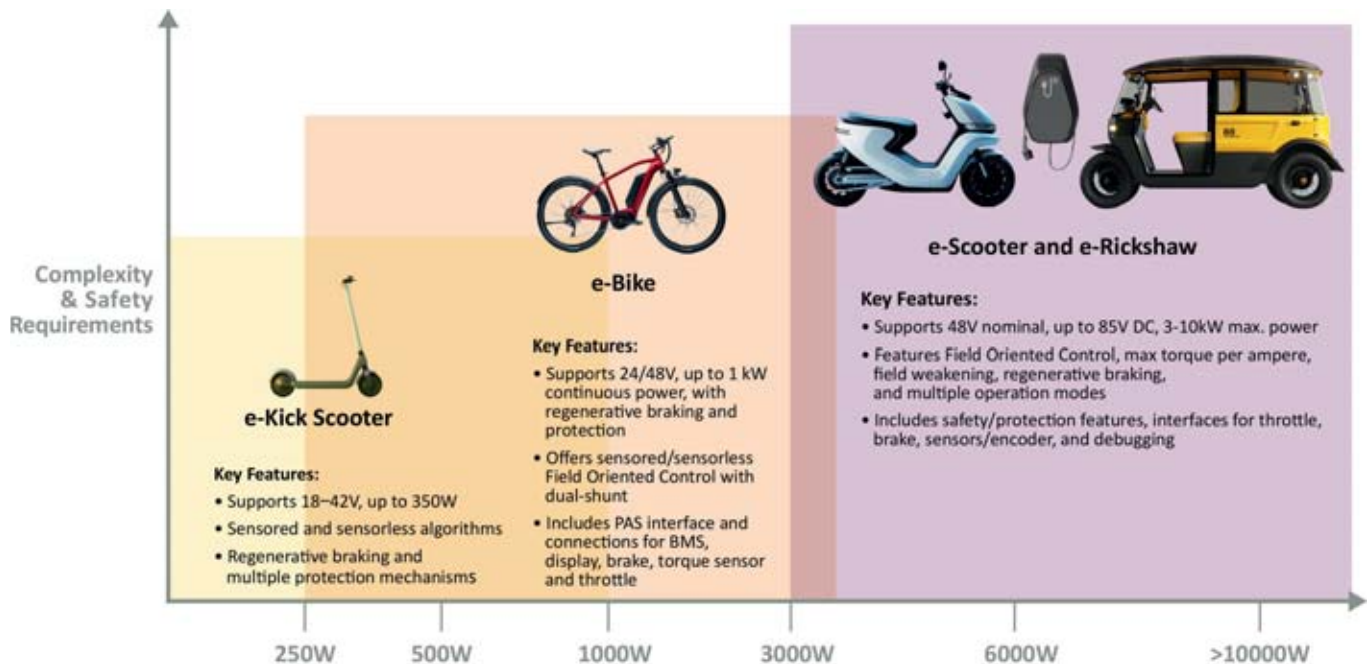


Alongside improvements in battery technology and the adoption of high-efficiency motors like BLDC and PMSM, featuring advanced materials such as rare-earth magnets and high-grade silicon steel, as well as algorithms such as FOC are key to maximizing performance. FOC enables precise, independent management of motor torque and magnetic flux, resulting in smoother acceleration, enhanced responsiveness and greater overall efficiency. It also supports energy-saving features like regenerative braking and optimized riding modes, both of which help extend vehicle range. When combined with effective thermal management and regular maintenance, FOC ensures consistent performance and longer battery life.

Building on the foundation of FOC, Maximum Torque Per Ampere (MTPA) takes efficiency a step further by optimizing the motor's current to deliver the highest possible torque for the least amount of energy. MTPA dynamically adjusts the d-axis and q-axis currents, allowing the motor to operate at its most efficient point under varying load conditions. In Eco-mode, MTPA maximizes range by minimizing energy losses, while in Sports Mode, it enables strong acceleration and dynamic performance. By integrating MTPA with FOC, electric two-wheelers achieve superior energy efficiency, reduced battery consumption and a more reliable, range-optimized riding experience.

Thermal Management

Thermal management is a critical aspect of any electric vehicle design, as the motor, inverter and battery generate significant heat during both operation and charging, which can negatively impact performance, safety and component longevity if not properly controlled. Overheating, especially under high loads or during high-power charging, can reduce efficiency and even cause damage. To address these challenges, manufacturers employ advanced cooling techniques such as liquid cooling which is highly effective but more complex, and forced air cooling which is simpler but less efficient. Additionally, smart thermal management algorithms, including those integrated with Field-Oriented Control, help optimize motor performance and prevent overheating by actively managing thermal loads. During high-power charging, active cooling systems and optimized charging algorithms further help dissipate excess heat and ensure safe, efficient charging. By combining these advanced cooling methods and intelligent control strategies, electric two-wheelers can achieve greater reliability, safety and long-term durability.



Noise Reduction

Reducing noise and managing electromagnetic interference (EMI) are two critical aspects of motor control systems in electric vehicles. Advanced algorithms such as Field-Oriented Control (FOC) help minimize torque ripple and acoustic noise, while precise manufacturing of motor components addresses mechanical imbalances and misalignments for quieter operation. On the EMI front, high-precision current sensing and active EMI filtering in the circuitry dynamically reduce high-frequency noise. Flux concentrators, made from high-permeability materials like ferrite, play a vital role by enhancing magnetic field accuracy for current sensing, reducing stray electromagnetic emissions and shielding the system from external interference. Optimizing the design of these components—including material selection, geometry and air gap size—further improves their effectiveness. By integrating advanced control algorithms, meticulous manufacturing, and innovative components like flux concentrators, motor control systems achieve superior noise reduction and EMI management.

Size, Weight and Cost Management

Electric two- and three-wheelers face significant challenges related to size, weight and cost, all of which influence their performance, usability and market adoption. To address these challenges, manufacturers are using lightweight materials such as aluminum, carbon fiber and magnesium, along with compact motors and batteries for more streamlined and portable designs. Achieving a high power-to-weight ratio is also crucial, with efficient motors and optimized powertrain configurations (such as 48V, 72V or 96V systems) delivering strong performance without unnecessary bulk. Cost-effective solutions, including mass production, standardized components, affordable lithium-ion batteries and government incentives, help make electric two-wheelers more accessible. From a motor control perspective, advanced algorithms like Field-Oriented Control help maximize efficiency, while integrated motor-control

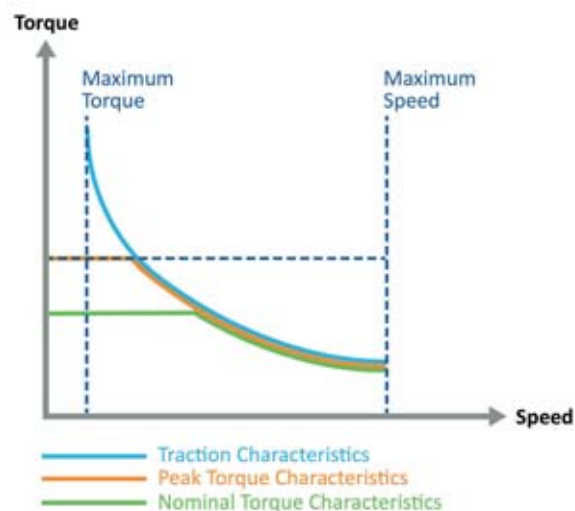
units and robust thermal management systems further reduce size and weight and ensure reliable operation. By addressing these factors, the industry can drive innovation, enhance usability and accelerate the widespread adoption of e-mobility solutions.

Reference designs

Microchip addresses these challenges with a suite of scalable reference designs for electric two- and three-wheelers, spanning applications from compact e-kick scooters (18–42V, up to 350W) and e-bikes (24/48V, up to 1 kW) to high-power e-scooters and e-rickshaws (48V nominal, up to 85V DC, 3–10 kW). These designs feature sensored and sensorless motor control, advanced FOC, MTPA, field weakening, regenerative braking and multiple operation modes. Comprehensive safety and protection mechanisms are built in, along with flexible interfaces for throttle, brake, sensors, encoders and debugging, making the platform adaptable for a wide range of electric mobility applications. (na) ■
 Author: Prमित Nandy, Product Marketing Manager, Microchip Technology

Microchip provides a suite of scalable reference designs for electric two- and three-wheelers.

Picture: Microchip



Speed and torque characteristic

Picture: Microchip



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- Technological and economic challenges of cell manufacturing in Europe
- Changes in EU regulations – Battery Pass & sustainability requirements
- Recycling strategies and second-life concepts
- Solid-state batteries and new battery materials
- Safety aspects: thermal propagation & cooling technologies

- Battery trends for heavy-duty commercial vehicles

The focus of the 8th Automotive Battery further is on fast charging, stationary storage, recycling & second life, market topics, presentations from China/ASEAN, military battery applications compared to passenger cars, warranties, charging infrastructure, the global market, energy generation & marketing, as well as train and commercial vehicle batteries. With practical case studies, international perspectives, and interactive discussions, we provide a comprehensive overview of materials and cells, system integration, safety and warranties, regulation, and market processes. We look forward to exciting presentations, best practices, and inspiration for the next generation of mobility batteries.

You can register for the conference using the QR code on the left.

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Data rate of 1.16 Mbps
Ultrasonic Chipsets

Bosch has introduced its new TB193 and TB293 ultrasonic chipsets for AI-based near-field perception in vehicles. Designed for parking and driver assistance systems, the chipsets capture raw ultrasonic sensor data directly at the source, enabling more precise object detection and distance measurement. The TB293 sensor chip is mounted at the ultrasonic transducer and records the raw signals, while the TB193 control chip coordinates multiple sensor chips and prepares the data for further processing. With a data rate of 1.16 Mbps, the solution supports real-time



transfer of large data volumes for AI algorithms and sensor fusion with camera and radar data. Bosch also introduces the open VASI bus, which transfers both data and power and gives OEMs more flexibility in sensor selection. The chipsets consume up to 50 % less energy, require fewer peripheral components and pins, and can reduce component weight by up to 50 %. They operate reliably at temperatures up to 150 °C.

Up to 98.3 Mbps
Automotive Audio Bus

Analog Devices has released A²B 2.0, the latest generation of its Automotive Audio Bus technology, to full production. The new version offers four times higher full-duplex bandwidth, up to 98.3 Mbps, and supports up to 119 upstream and 119 downstream audio channels. It also enables Ethernet data tunneling via the Open Alliance SPI (OASPI) interface, supporting

integration into modern in-vehicle and software-defined vehicle architectures. A²B 2.0 is designed for applications requiring low, deterministic latency, including road-noise cancellation, in-car communication, premium audio and infotainment systems. Analog Devices specifies a latency of 62 µs and expects system cost reductions of up to 30 % through higher functional integration and fewer external components. The technology remains compatible with existing A²B 1.0 cabling and connector infrastructure, offering OEMs and Tier 1 suppliers a straightforward upgrade path.



10GBASE-T1S to 10GBASE-T1
Test Solutions for Automotive Ethernet

Keysight Technologies has introduced two test solutions for automotive Ethernet receiver compliance, covering 10GBASE-T1S to 10GBASE-T1. They address the need to validate receiver robustness as zonal architectures, software-defined vehicle functions and higher data rates increase physical-layer requirements. The 10GBASE-T1S solution, developed with BitifEye Digital Test Solutions, targets multi-drop Ethernet networks for zonal and edge-controller applications. It automates receiver compliance tests according to Open Alliance TC14 PMA Test Suite 5.2.1 and verifies bit error rate under



impaired channel and coupled noise conditions. For optical in-vehicle links, Keysight adds an nGBASE-AU physical-layer testbed. It supports IEEE 802.3cz Amendment 7, 2023 and Open Alliance TC7 specifications, including TDFOM measurements such as OMA, extinction ratio, average optical power and optical amplitude ratio. FlexDCA provides test automation for compliance and development setups.

-40 °C to +180 °C
Flat-wire inductors

Under the designation WE-SFIA, Würth Elektronik is introducing a new series of flat-wire inductors in the 2010, 2013 and 2016 package sizes. The inductors stand out thanks to an exceptionally low DC resistance and an extended operating temperature range from -40 °C to +180 °C. WE-SFIA is available as a catalogue component, but can also be adapted as a basis for customer-specific requirements. The WE-SFIA inductors are designed for highly efficient DC/DC converters in automotive environments, such as single-phase and multiphase converters, as well as buck and boost converters with high sat-



uration currents of up to 150 A. Further applications as filter chokes include battery management, motor, audio and infotainment systems. The flat-wire technology used in these inductors offers a number of advantages: it is mechanically more robust and enables tighter, more uniform winding as well as improved heat dissipation. Flat-wire windings also provide a larger cross-sectional area, reducing electrical resist-

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Caricature: Heinrich Schwarze-Blanke

Organization is the AI brake



Dr. Dieter Lederer
Change thought
leader, author,
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musician
His latest book: *Der
Change Code*

The CTO proudly presented the new AI-powered development system to his fellow board members: autonomous agentic AI, automated test generation, code reviews in seconds. Everyone is thrilled. This must be the breakthrough – applause! Six months later, the program is behind schedule, the budget has been blown, and the teams are frustrated. The technology was excellent, the organization surrounding it was not. A good intention turned into a poor implementation.

This story is not an isolated case. Billions are currently being poured into AI systems that hold great promise: ultra-fast development, elimination of non-creative work, and continuous optimization through self-learning. Yet the impact often fizzles out. Not because the technology fails to deliver, but because the organization isn't ready for it. Experience shows that organization beats technology. Even the most advanced AI system only creates value if it is embedded within the organization.

That may sound trite, but it isn't. Most companies pour all their energy into technology and hope that people will figure out how to use it on their own. But that doesn't work. Without further developing the organization, results will only come about by chance.

Speed requires structure

While this is a truism and nearly every company can attest to it, learning from it remains unpopular. The following suggestions may help.

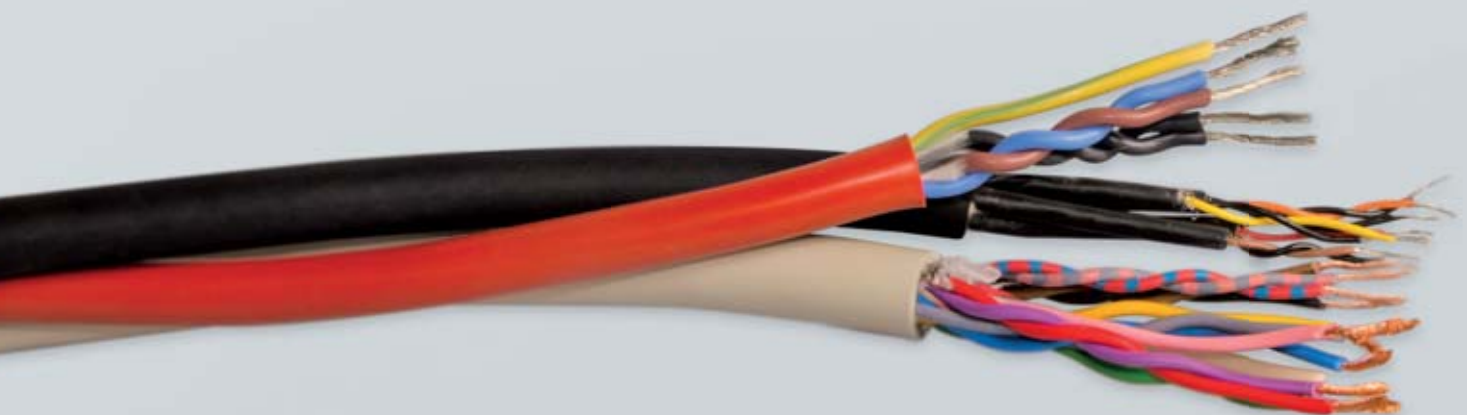
- **AI requires a data culture:** AI systems are only as good as the data they operate on. Organizations that have hoarded data in proprietary silos for years will find that their AI investments lead to costly frustration.
- **AI requires throughput:** AI systems can reduce development time to minutes for tasks that used to take weeks. That sounds like a breakthrough, but it's only half the story if bottlenecks occur afterwards. The solution lies in scalable integration and validation processes that enable high throughput.
- **AI requires upskilling:** Simply purchasing AI systems and handing them over to teams that don't know how to use them is not a transformative approach. It is an investment without a strategy. Real progress can only be achieved when the deployment of technology and upskilling go hand in hand.

AI systems are redefining what is technically possible. But it is the organization's capabilities that will determine what actually makes it onto the road. Anyone who focuses on just one of these levers is wasting money – even with the most advanced technology. (na) ■



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