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Validation of SDVs Begins with the First Line of Code

Interview with Dr. Matthias Traub and Jan Linnebacher, Vector



Translation of a German publication in [Automobil Elektronik](#) issue 04/2026

Software-defined vehicles are transforming not only vehicle architectures but also the way they are developed, tested, and validated. The evolution of CANoe reflects this transformation over the past three decades: from a bus simulation tool to a comprehensive validation platform for software-defined vehicles. Dr. Matthias Traub and Jan Linnebacher of Vector explain why validation starts earlier today, what role Shift Left, virtualization, and AI play, and why open ecosystems are becoming a decisive competitive factor.

CANoe has been an established development tool for 30 years and is considered an industry standard for testing, simulation, and validation in many areas. At the same time, vehicle development has changed fundamentally during this period. Dr. Traub, in your view, what is the principle that allows a tool to remain relevant for such a long time?

Dr. Matthias Traub: The key is that we do not remain static but continuously innovate. This applies to CANoe as well as to our other products and solutions. For many years, we have pursued a clear technology strategy: starting with CAN, then LIN, FlexRay, and Ethernet, and today focusing on topics such as virtualization, cloud connectivity, and AI.

The key is to anticipate technological developments early rather than waiting until the market starts demanding them. Equally important is our close relationship with customers. We need to

understand what is actually required in development, where existing processes no longer fit, and which requirements need to be reflected in our roadmaps. Long-term strength emerges from this combination of technology leadership, customer collaboration, and adaptability.

How do you recognize when a product like CANoe needs to evolve?

Dr. Matthias Traub: Primarily through close dialogue with customers. Vector is not only a provider of tools but also a development partner. A good example is our collaboration with Mercedes-Benz. There, we serve as the lead development partner for MB.OS and work in integrated teams on the software platform itself. Tools such as CANoe are used directly in these projects. Our employees experience firsthand, together with the customer,

what works, where limitations arise, and where we need to adapt or accelerate solutions. This close collaboration shapes the way we develop products. It is also a key success factor on the path toward agentic workflows, meaning AI-supported processes that independently execute recurring engineering tasks and provide targeted support to developers. Our goal is to provide agentic workflows across the entire DevOps chain.

That sounds like a continuous reality check. Is this close connection to day-to-day development the real success factor?

Dr. Matthias Traub: Yes – but not in the sense of merely listening. For us, being close to the customer means working together on real-world development challenges and deriving robust, scalable solutions from them. I worked at OEMs for over twenty years and am well acquainted with these expectations from that perspective. You want to work with partners who don't just provide a product, but who understand the system interdependencies. We continue to develop our solutions together with our customers and adapt them to their requirements.



"Software is evolving from a component into the defining factor of vehicle development. This inevitably changes organizational roles."
Dr. Matthias Traub, Vector

Looking at today's development environment, the role of software above all has changed significantly. In your view, what is the most fundamental shift in the development and validation of software-defined systems?

Jan Linnebacher: Validation is no longer a phase-specific activity. The traditional approach of specifying, implementing, deploying to hardware, and then testing no longer works for software-defined systems. Some customers develop new releases daily. Validation has therefore become an integral part of the development process. And it does not end with SOP. Software updates continuously introduce new functions into vehicles, which must be validated throughout the entire lifecycle. In addition, we are no longer testing individual functions in isolation. Cross-domain systems and continuous deployments continue to increase complexity.

Dr. Matthias Traub: For me, the change goes even deeper. Software is evolving from a component into the defining factor of vehicle development. This inevitably changes organizational roles as well. In the past, the focus was on individual ECUs. Today, we are dealing with highly networked systems in which software takes center stage. As a result, OEMs are taking on greater responsibility.

The Shift Left approach describes this shift perfectly. Validation begins earlier in the development process, for example in Software-in-the-Loop environments, with virtual ECUs, or directly at the developer's workstation. This makes it possible to detect defects earlier, isolate them more precisely, and make subsequent system integration faster and more efficient.

How can you tell whether Shift Left has truly been understood and is more than simply testing earlier?

Dr. Matthias Traub: By whether roles, processes, and toolchains actually change. In traditional vehicle development, work was strongly aligned with the V-model: specification, implementation, testing, and integration. Today, these activities increasingly converge. Software application developers already execute tests in the background, partly with AI support, and identify defects much earlier. Equally important is platform thinking. In the past, vehicle projects at OEMs were often reimaged from scratch. Today, the focus is increasingly on platforms, much like in the mobile communications industry. You have an operating system, a software platform, and continuously evolve both over time.

If this development logic changes, CANoe inevitably changes as well. What does the current state of CANoe reveal about the challenges customers are facing today?

Jan Linnebacher: CANoe originated in an era when bus communication was the primary focus: CAN, later LIN, FlexRay, and Ethernet. Customers needed visibility into what was happening between connected ECUs. If an ECU was not yet available, it had to be simulated. That core principle remains unchanged to this day. The real transformation lies in what CANoe has become. We have systematically evolved CANoe from a simulation tool into a validation platform that integrates seamlessly into our customers' development workflows. Today, customers are less interested in individual features. They want to use CANoe as a testing platform and as an enabler for their development processes. That is why we have embraced as-code paradigms. Configurations exist as text files, allowing teams to collaborate, version them, and integrate them into modern development environments. CANoe runs in CI/CT environments, in the cloud, on Linux, and in the near future also on ARM architectures.

Dr. Matthias Traub: And of course, AI plays a central role today. One key feature we are delivering with the current CANoe 20 release is the MCP interface, the Model Context Protocol. This creates a connection that enables AI systems to interact with

CANoe. At the same time, we are gradually introducing our own AI assistants and agents. Within CANoe, these include an assistant for CAPL and an assistant for automated test generation. These capabilities align perfectly with the new roles Jan has described.

The industry talks a great deal about “China Speed.” Development cycles are becoming shorter while technical complexity continues to increase. What determines whether development teams can keep pace?

Jan Linnebacher: The decisive factor is how consistently validation is applied, and when. If a defect is discovered very late, in the worst case in the vehicle itself, the development cycle has effectively already been lost. Shift Left goes hand in hand with virtualization. Those who can identify defects in a virtual environment, in a VECU, or directly in the code gain valuable time. One customer in the brake control systems domain lost around fifteen weeks because a software defect only became visible during HIL testing. A lengthy investigation subsequently revealed that the root cause was a faulty control loop in the software that caused pressure spikes. In a virtual environment, the issue could have been identified much earlier. This level of discipline in validation is exactly what we need to keep pace with the short development cycles of Asian competitors without compromising quality.

Dr. Matthias Traub: Discussions about China Speed are often reduced to development velocity alone. From my perspective, it is really about the ability to master speed, quality, and scalability simultaneously. That is where competitiveness is determined. There must be an appropriate organizational setup with adapted roles, both at OEMs and in collaboration with partners. In addition, the right technological foundation is required: CI/CT, end-to-end continuity, and as-code approaches are essential elements. Automated processes are increasingly managed through scripts and agentic workflows. As a result, the developer's role is shifting more toward design and supervision. At the same time, approval according to the four-eyes principle remains essential. Many Chinese and Asian manufacturers had the advantage of starting from a clean slate and adopting modern development processes from the outset. At the same time, we still see room for improvement in safety and security standards that are already well established in Europe. That also creates an opportunity to leverage European quality standards once again as a competitive advantage.

As development cycles become faster and validation needs to start earlier, AI naturally comes into focus. Where do you already see concrete applications in simulation, testing, and validation today, and how is this changing the role of the test engineer?

Jan Linnebacher: Primarily in tasks that are highly time-consuming for developers and test engineers. One example is deriving

test cases from requirements. AI can already support this effectively, quickly, and with increasing precision. Another area is log file analysis. We are talking about hours spent evaluating log and measurement data, identifying patterns, and assessing relationships. AI can structure this data much faster, highlight anomalies, and generate hypotheses. However, evaluating and approving the results remains a human responsibility. That said, there is already significant potential in using AI to accelerate time-consuming testing activities.



“The best toolchain is of little value if virtualization, test automation, and AI support are applied only selectively rather than consistently throughout the development process.”
Jan Linnebacher, Vector

Dr. Matthias Traub: For me, the key is not to view AI as an isolated feature. The real leverage comes from embedding AI throughout the entire DevOps loop and using it to automate recurring tasks. This not only increases speed but also improves robustness. Defects are identified earlier and localized more precisely, allowing teams to focus on the most critical aspects of overall system integration.

Many tasks traditionally performed by test engineers will increasingly run in the background within automated CI/CT pipelines, supported by AI agents. Nevertheless, the Human-in-the-Loop remains essential. AI can reduce workload and accelerate processes, but responsibility, judgment, and final approval remain with the engineer.

So far, we have focused heavily on speed. But continuous validation is not only about shortening development cycles. Why is the ability to validate software at scale becoming a differentiating factor beyond speed alone?

Dr. Matthias Traub: It is ultimately about maintainability and robustness. From an end customer's perspective, what matters is that a system used in the vehicle, or delivered through an OTA update, works reliably and without errors. The first value is speed: delivering new features or bug fixes quickly, much like users have come to expect from the smartphone world. The second value is reliability. Especially for the German automotive industry, the challenge is to maintain the high-quality standards

customers expect in an increasingly software-driven world and, ideally, raise the bar even further.

Software is now developed in connected environments that span departments, companies, and toolchains. What determines whether such ecosystems succeed or fail?

Jan Linnebacher: Openness. Open tools are a critical success factor. The reality of the SDV world is built on partnerships between OEMs, Tier 1 suppliers, software companies, and technology partners. This requires open, scalable products that can be deployed quickly and integrated easily. It also requires collaborative models that we actively drive forward together with our customers. Everyone must see themselves as bridge builders. Those who focus only on optimizing their own area without looking beyond it will struggle in these environments.

Dr. Matthias Traub: To me, openness does not mean that one provider must cover everything. Openness means bringing together the best capabilities from different partners to create a solution that works as a whole. That is why we collaborate with technology partners such as Synopsys in virtualization and QNX in software platforms.

In the automotive industry, collaboration often breaks down because of differing levels of expertise. Companies build large software organizations only to discover that many employees have primarily worked on specifications and do not yet possess the required software engineering capabilities. That is why a strong focus on skills is essential.

Equally important is working as equals. In the past, relationships between OEMs and partners were more hierarchical. Today, teams must develop solutions together across company boundaries.

Considering all these developments, what will determine over the next five years which companies succeed and which do not?

Jan Linnebacher: It will depend on how consistently companies align themselves around software. Organizations that fail to take software and AI-supported workflows seriously and embed them throughout their operations will struggle. The best toolchain is of little value if virtualization, test automation, and AI support are applied only selectively rather than consistently throughout the development process. Openness, collaboration, and transparency across domains and organizational boundaries will become essential prerequisites. We can already see how rapidly the industry has evolved over the past three or four years. I do not believe this development will continue linearly. It is likely to accelerate even further.

Dr. Matthias Traub: From my perspective, the priority now is creating the right conditions. We contribute by establishing collaborative ways of working, both in project setups and at

technological interfaces. A key guiding principle is modularity. Our solutions must integrate not only with our own portfolio but also with third-party solutions.

On top of that come agentic workflows. Here, we aim to provide a robust foundation built on our domain expertise and ecosystem, one that customers can rely on. For Vector, it is important to contribute to Germany as a technology hub through speed, robustness, and technological expertise in global competition.

Interview conducted by Pascal Nagel, Editor-in-Chief of AUTOMOBIL-ELEKTRONIK, Ultima Media Germany

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