


Automotive World Software-Defined Vehicle MAGAZINE

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Setting the mood in
software-defined
sportscars

Elektrobit equips industry for software centrality | **Nio** and **ZF** develop updateable steer-by-wire | **Royal Enfield** plans software-defined two-wheeler | **IBM** helps automakers innovate SDVs faster | **LeddarTech** calls for gradual autonomy ramp-up | What will be the first big SDV market success?

Automotive World

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Contents

3 Editorial summary

4 News in brief

6 Question of the month

What will be the first big market success for SDVs?

11 Elektrobit powers shift to software-first
auto development

15 Software-defined sportscars must support high
performance

19 LeddarTech proposes gradual ramp-up from ADAS
to autonomous

23 IBM: SDV clock speed demands faster innovation

27 Royal Enfield's software-defined motorbike "grows
with you"

30 Nio and ZF label steer-by-wire "cornerstone" of
future SDVs

34 SDV progress: more give-and-take balance on
open source

38 In case you missed it...

Ford pulls plug on FNV4 just as software becomes
imperative

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Editorial summary

While the possibilities of software-defined vehicles (SDVs) seem almost limitless, discussions of promise largely overshadow the near-term commercial reality. As automakers debut concepts and establish release timelines, customers want to know exactly what SDVs are, how the ownership experience differs from older vehicles, and what extra value these products will bring.

To realise SDVs' full potential, automakers must first prepare for a software-centric future. This means breaking away from the primacy of hardware, incorporating the benefits of virtualisation into their workflows, and bridging the gaps between old and new tech in their organisation.

From new in-cabin experiences and advanced driver assistance systems (ADAS) to cyber security and data management, SDV innovation could entail investment in new IT infrastructure, engineering platforms, operating systems, and more.

The scale of the transformation will be significant, requiring automotive to collaborate with open-source software development communities to build an interoperable, industry-wide stack. Differentiation and competition can then spring from this shared foundation.

How fast the SDV transformation occurs will come down to corporate philosophy: some are diving straight into SAE Level 4+ autonomy, while others prefer gradual iterations in artificial intelligence from Level 2 ADAS up.

Personalisation and the ability to keep a vehicle up-to-date years after purchase could be the first big market money makers, though automakers and suppliers must develop supporting business models that do not yet exist. However, upgradeability could ultimately lead the industry down several new avenues for revenue generation.

Near-term options include real-time diagnostics and driving coaching, advanced navigation and customised ride settings. Further ahead, steer-by-wire systems updated over-the-air could redraw cabin layouts and provide the foundation for a whole new generation of ultra-controllable electric and autonomous vehicles.

An SDV offering's success will likely depend on how congruently software can elevate the driver's experience. There is no one-size-fits-all solution for automotive user interfaces, and different brands will invariably need to consider the unique requirements of their vehicle types, target markets, and customers.

News in brief

US softens rules on AVs, including NHTSA crash reports

25/04/2025

After months of speculation, the Trump administration has announced policy changes intended to weaken perceived regulatory barriers around autonomous vehicles. The National Highway Traffic Safety Administration (NHTSA) will now allow domestically-produced autonomous vehicles to qualify for exemptions to safety standards previously available only to imported vehicles, while also softening some of the reporting requirements around crashes and other safety-related incidents.

Mercedes-Benz announces SDV partnership with KPIT

28/04/2025

Mercedes-Benz Research and Development India (MBRDI) has announced a far-reaching collaboration with KPIT Technologies to accelerate the development of Software-Defined Vehicles (SDVs). The partnership aims to renovate the technology stack in the automaker's next-generation vehicles, while also accelerating product launches and lowering costs.

BMW will integrate DeepSeek AI into its Chinese models

28/04/2025

BMW has announced that it will integrate DeepSeek's AI technology into its Chinese vehicle lineup starting in Q3 2025. The first models to feature DeepSeek include the BMW 5 Series Long Wheelbase, the BMW i5, and the all-new BMW X3 Long Wheelbase, all of which are equipped with BMW's 9th-generation operating system.

Toyota picks HarmonyOS for Chinese market EVs

30/04/2025

Toyota has partnered with Huawei to integrate the HarmonyOS operating system in its upcoming e-sedan, the bZ7, marking a significant shift in its strategy for the Chinese market. The car, part of Toyota's new "made for China" range, reflects the automaker's decision to prioritize local innovation, moving from a global-to-local adaptation model to a China-defined approach.

Huawei enlists 11 Chinese OEMs for AV safety pact

01/05/2025

Huawei has partnered with 11 Chinese automakers, including Chery, Audi China, SAIC, BAIC, GAC and Seres, to launch a "smart assisted driving safety initiative". The non-binding agreement aims to improve safety standards for autonomous and assisted driving systems through increased investment, transparent marketing, user education, and clearer functional boundaries.

Ford kills long-planned FNV4 SDV architecture

01/05/2025

Ford has abandoned its FNV4 electrical architecture programme, a project intended to streamline vehicle software and help the automaker better compete with companies

like Tesla. The decision was driven by exorbitant costs, ongoing delays, and the complexity of integrating software from hundreds of suppliers, sources told *Reuters*.

Aurora launches first-ever commercial US robotruck service

02/05/2025

Aurora has launched the first commercial self-driving trucking service in the US, operating driverless Class 8 trucks on public highways in Texas. The company's autonomous trucks began delivering freight between Dallas and Houston for customers Uber Freight and Hirschbach Motor Lines in the week commencing 28 April, and have already completed 1,200 miles without a driver.

Renault imbues next-gen e-LCVs with SDV capabilities

06/05/2025

Renault has unveiled three new battery-electric light commercial vehicles (e-LCVs) – the Trafic, Goëlette, and Estafette E-Tech – featuring 800-volt technology, fast-charging capabilities, and two battery options for varying range requirements. Developed in partnership with Volvo Group and CMA CGM through the Flexis joint venture, the models aim to cater to diverse business needs while integrating Renault's new software-defined vehicle (SDV) architecture.

Waymo, Magna partner to build US robotaxi factory

06/05/2025

Fast-rising robotaxi firm Waymo has announced plans to build autonomous Jaguar I-PACE and Zeekr vehicles at a new factory in Mesa, Arizona, in partnership with Canadian supplier Magna. The facility, which has already created hundreds of jobs,

will play a critical role in scaling Waymo One, the firm's fully autonomous ride-hailing service.

Tesla attempt to trademark 'Robotaxi' rejected by US PTO

09/05/2025

Tesla's attempt to trademark the term "Robotaxi" for its as-yet-unreleased autonomous vehicles has been rejected by the US Patent and Trademark Office (US PTO) for being too generic, according to a new report by TechCrunch. The US PTO deemed the term "merely descriptive," noting that it has been used generically by other companies for more than a decade.

Harman open-sources full connected services platform

12/05/2025

Harman has become one of the first automotive players to open-source a complete connected services platform. The move could prove a game-changer for the realisation and monetisation of software-defined experiences.

GM brings in former Aurora robotruck exec as new CPO

13/05/2025

General Motors has hired Sterling Anderson, co-founder of autonomous trucking company Aurora and former Tesla boss, as its new Executive Vice President of Global Product and Chief Product Officer. Upon assuming the role on 2 June, Anderson will oversee GM's entire product lifecycle, encompassing hardware, software, services, and user experience, as the industry navigates rapid technological change.

All news articles by Stewart Burnett

What will be the first big market success for SDVs?

Industry stakeholders weigh in on what will shape early success in the emerging software-defined vehicle market.
By Will Girling



Software-defined vehicles (SDVs) have the potential to redefine automotive. From enhanced connectivity and compute power to new driving experiences and business models, mobility is undergoing a substantial merger with the tech industry. Year after year, momentum continues to build, and the global value of SDVs could reach US\$1.24tr by 2030—up from US\$213.5bn in 2024, according to MarketsandMarkets.

But while the future possibilities seem almost limitless, discussions of promise and potential largely overshadow the near-term commercial reality. As automakers debut concepts and establish release timelines, customers want to know exactly what SDVs are, how the ownership experience differs from older vehicles, and what extra value these products will bring.

Automotive World spoke to stakeholders from across the industry to determine what early SDV market success might look like, how the technology could generate new revenues, and where the challenges still lie.

Spotlight on personalisation

The phrase ‘a smartphone on wheels’ goes back to at least 2011, when Akio Toyoda used it at that year’s Tokyo Motor Show to describe a vehicle with customisable displays. Konstantin Shirokinskiy, Partner at Roland Berger, believes this industry cliché still indicates where SDV developers should channel their efforts. “When consumer expectations from a vehicle are the same as a smartphone—meaning continuous updateability and access to

novel features—automakers will have achieved their first big market success.”

In this scenario, SDVs will integrate with a wider digital ecosystem that smooths the transitions between life, travel, work, and fun. Smart devices will create the continuity, with cars providing a liminal space that can entertain and enrich the user as they desire. “The move towards customisable and intuitive interfaces will redefine the way users interact with their vehicles, making them more user-friendly and adaptable to personal preferences,” says Chiara Delperto, Vice President of Sales, SDV and North America, at Marelli. “SDV consumers will notice a revolution in their experience, based on evolved human-machine interfaces.”

Henry Bzeih, Chief Software Officer at Renault Group subsidiary Ampere, notes that advanced personalisation and incorporation of “surprise and delight features” will mark a clear division between SDVs and previous-generation vehicles. Beyond passenger models, Ampere also finds a lot of synergy between software-defined mobility and the commercial segment. The first three models built on its SDV architecture—Trafic, Estafette, and Goelette—will be light commercial vehicles, reflecting Renault’s confidence in this early market for the technology.

Ampere’s centralised software architecture and a connected, intelligent operating system will allow operators and drivers to control, analyse, and upgrade vehicle functions quickly and reliably. Greater access to data across the vehicle also allows for optimal maintenance planning and recharge schedules for electric models. Although perhaps not immediately



The flexibility of SDVs enables [fleet managers] to customise exactly how they operate

obvious, Bzeih states that personalisation is still the driving force here: “Every fleet manager has their own rules and way of doing business. The flexibility of SDVs enables them to customise exactly how they operate.”

Is the market ready?

Tesla’s control over in-vehicle hardware and software—particularly its ability to augment system performance using over-the-air updates—indicates what shape a software-defined automotive industry might take. The company’s approach has also generated significant enthusiasm for SDV concepts among other brands—Delperto notes that many OEMs are preparing new software-first vehicle architectures for 2026/27, particularly in China.

But even though automakers have been publicly investing in vehicle software for years, few SDV success stories have materialised so far, according to Mattias Eriksson, President of BlackBerry QNX. “Working out the current share of SDVs on the road today depends on how

you’re qualifying them, but it’s very small when considering expert definitions and significantly behind the industry’s original plan.”

Back in 2021, brands like Stellantis estimated that SDV activities would generate €4bn (US\$4.6bn) in new value by 2026 and €20bn by 2030. However, Shirokinskiy states that expectations of additional recurring revenues associated with SDVs have become increasingly muted among automakers. “I’m not discounting the idea outright, but the unfortunate reality is that we’ve seen a lot of bad examples.” If next-gen personalisation and upgradeability are the segment’s best near-term hope for creating new revenue opportunities, these haven’t been what customers have generally received.

Previously, BMW introduced subscriptions for heated seat functionality and Apple CarPlay, both of which were met by a swift backlash from consumers, who felt they were being charged extra for previously free features. Elsewhere, Shirokinskiy relates that software monetisation



BMW's subscription for heated seats drew criticism from consumers, who didn't see it as customisation but charging extra for standard features

efforts have failed due to lack of a viable business model, protracted development timelines, and poor feature integration and execution that discourages use. These have led many features that were convenient and profitable in concept to become costly, impractical, and unpopular in reality. “For many, the discussion around SDVs has become one of cost mitigation rather than revenue generation.”

Based on his own observations and conversations with industry players around the world, Eriksson concludes that genuine SDVs are at least five to ten years away from reaching the global market. Although no one has fully met the desire for software-driven

personalisation, most companies would agree the opportunity still exists. The challenge is figuring out how to do so in a cost-effective manner while software development, testing, and validation remain expensive. “Customers want new features, but they don’t really want to pay for them beyond free trial periods,” says Shirokinskiy.

Keep it new

So, how can automakers work towards achieving their first big SDV market success? First, Eriksson states, “more work is needed on basic topics like true hardware and software separation,



More work is needed on basic topics

software- and cloud-first principles, truly holistic toolchain integration, and effective orchestration of mixed stacks across the software platform lifecycle.” He notes that the journey will be complex, featuring both technical and non-technical (meaning cultural) aspects, but addressing these foundational issues is necessary for reducing software development costs and delivery timelines.

Delporto agrees, highlighting that the SDV value proposition rests on three elements: zonal architectures to simplify vehicle electronics, decoupled software that isn’t reliant on iterating hardware, and cloud-based digital twin technology for virtual feature development. “From an OEM’s point of view, these innovations allow cost efficiencies and faster time-to-market by reducing the complexity and quantity of hardware required.” Ultimately, increased speed and flexibility from the onset will enable brands to meet consumer expectations more accurately and desirably than before.

In terms of how updateability can then be leveraged most profitably, both Shirokinskiy and Bzeih state that a balance must be struck. A degree of free personalisation must first be standardised to provide a true ‘smartphone on wheels’ experience. Subsequently, a handful of targeted opportunities for monetising novel, differentiating, and impactful features can be explored. Exact strategies for doing so will vary according to brand image and values, such as performance boosts for high-spec models or additional security functions in family cars.

Fundamentally, Shirokinskiy concludes, SDV value should be derived from keeping products new, not narrow considerations of personalisation that restrict access to pre-existing features. “The end goal needs to be a vehicle that’s always up-to-date, even years after it was first purchased. When OEMs can deliver on that expectation, I would consider SDVs to be a market success.”

Elektrobit powers shift to software-first auto development

Elektrobit is equipping the automotive industry with the software-centric solutions it needs to thrive in the SDV revolution. By Will Girling

For many automakers and suppliers, the software-defined vehicle (SDV) remains a disruptive—yet still emerging—concept. While its promise of software-driven value is clear, changing a deeply entrenched hardware-first mindset remains a challenge. Still, as American author William Gibson famously said, “The future is already here—it’s just not evenly distributed.

“The SDV technical disruption has already hit,” asserts Raul Latorre Fortes, Director for SDV Business Development at Elektrobit. Indeed, his colleague, Moritz Neukirchner, has



even developed a taxonomy to clarify the stages of SDV development. Still, many automotive players risk a ‘Nokia moment’ equivalent to when that company failed to anticipate and adapt

to the paradigm shift instigated by Apple's iPhone. The time has come for automakers to decide whether they will lead the transformation or fall behind.



The SDV technical disruption has already hit

Breaking away from hardware

The problem with legacy approaches to automotive software, explains Latorre Fortes, is that development has generally centred on specific hardware platforms only. "When that car line ended, the next platform would start over from scratch." While this wasn't particularly problematic in the old industry paradigm, brands must now incorporate new features quickly, making the shift away from hardware-centrism and legacy workflows necessary.

Latorre Fortes states that OEMs can retain and reuse their existing resources by decoupling software from hardware, saving costs in the first instance but also supercharging SDV development times. To assist this workflow shift, Elektrobit is positioning itself as an industry partner for automotive's transformation through a range of scalable and software-centric

tools. "Our goal is to enhance flexibility, streamline workflows, and accelerate innovation," he says.

Value of virtualisation

Underscoring that the SDV transformation is currently underway, Latorre Fortes states that many of Elektrobit's customers are already reaping the benefit of its solutions. For some, this has meant streamlining and accelerating pre-existing processes to generate operational savings.

Elektrobit's complete virtualisation solution portfolio, including a virtual electronic control unit (ECU) creator and digital high-performance computer (HPC), enables software-in-the-loop testing and validation to improve code quickly and affordably. "A Tier 1 supplying HPCs to several automakers has been using our virtual ECU creator and managed to cut costs by 25-40% and go-to-market times by 30-35%."

The company also offers Virtual In-Vehicle Infotainment (IVI) Development for Android to provide a hardware-agnostic, cloud-to-cockpit digital twin for developing Android automotive operating system (AAOS) projects. "Simulation allows work on software to commence before hardware has even been decided on," adds Latorre Fortes.

Sony Honda Mobility partnered with Elektrobit to develop a complete IVI system for the all-electric Afeela 1, scheduled for production in 2026, which was conceived as a showcase for software-defined design. Elektrobit created an advanced software architecture that allowed unique features from Sony—such as PlayStation gaming content—to permeate the in-



Elektrobit provided software and services for Sony Honda Mobility's Afeela 1, scheduled for production in 2026

cabin experience. The result was an IVI system that “authentically” reflects core brand values. This will be a key design factor in the SDV era, as automakers must learn to differentiate based on both digital offerings and standard customer touchpoints.

Bridging old and new tech

While SDV innovation is the goal, Latorre Fortes emphasises that safety cannot be sacrificed at any point. EB corbos Linux for Safety Applications enables multiple virtual machines to operate on a single piece of hardware: “We put linux on top of a hypervisor and then add a safety monitor.” This means a vehicle’s OS can be used in HPC domains relating to advanced features like driver-assistance or autonomous driving without interfering with safety functions. Automakers gain system updateability while retaining the same ISO 26262 ASIL B and IEC 61508 SIL 2 certification.

A large part of Elektrobit’s mission is bringing the software development ecosystem together. EB corbos Link provides an off-the-shelf middleware to allow communication between AAOS

and AUTOSAR ecosystems, enabling greater software standardisation, reuse, and interoperability. Latorre Fortes states that this would have previously required complex, customised, and difficult-to-implement solutions. EB zoneo also optimises in-vehicle networking to enable the transition from domain to centralised and zonal architectures. “Putting more computing power in vehicle HPCs is a big trend,” he notes.

As SDVs are brought closer to the mass market, these solutions can lay the foundation for new functionalities. Latorre Fortes relates that an unspecified automaker is currently using EB corbos Link to develop and deploy Android applications that will effectively “futureproof” its vehicles by enabling upgradeability over time. Some commentators consider this the essence of the SDV concept and its primary source of ongoing value.

Although AUTOSAR has been around since the early 2000s, Latorre Fortes believes it remains highly relevant in today’s automotive landscape—especially for enabling technologies like zonal controllers, steer-by-wire, and brake-by-wire systems. For example, EB

tresos Safety Fail-operational is an advanced software solution designed to ensure guaranteed continuous operation in next-generation automated vehicles, SAE Level 3 systems, and x-by-wire applications. It maintains safety and high reliability even in the event of safety-critical electronic system failures.



[Open-source ecosystems] will ultimately enable everyone to innovate faster

In addition, EB tresos, Elektrobit's real-time computing software, is SDV-ready and fully aligned with modern development workflows. "Our goal isn't to reinvent the wheel," Latorre Fortes explains, "but to modernise the toolchain where it makes sense. We want to bridge the old and new worlds by integrating legacy tools that still deliver value in a future-ready architecture."

A software-centric future

Elektrobit gives automakers the ability to sculpt their software-centric futures, but it's also convinced that broad open-source collaboration will be necessary to realise SDVs' full potential. A March 2025 study by

Harvard Business School calculated that open-source software in general represents US\$8.8tr of economic value. Latorre Fortes adds that Elektrobit is participating in several SDV consortiums—including Eclipse, Jasper, and Automotive Grade Linux—and client collaborations to incorporate open-source software development in automotive.

"Many of the things we're doing are in partnership with customers, technology leaders, and industry suppliers," he says. "We think it's key to build an ecosystem that drives progress on topics like modularity and standardisation. This is what will ultimately enable everyone to innovate faster."

Latorre Fortes concedes that industry inertia means some automotive players will be ahead of others during the early stages of SDV development. However, no matter what timescale companies are working to, embracing the change is inevitable. "The shift to software-first processes is no longer an option; it is necessary for automakers to remain competitive."

By facilitating faster and cheaper development of advanced digital products, Elektrobit could help realise an industry in which most vehicles produced are SDV Level 3. This signifies a model with updateable software for customers willing to pay a premium for connectivity and the latest apps and features. Those that do not conform to this new vision for mobility could face market redundancy much sooner than expected. "If OEMs do not start embracing SDV technology and software-centric workflows, they will be left behind," Latorre Fortes cautions.



Images © Ferrari

Software-defined sportscars must support high performance

With the Ferrari F80 UI, DXC makes the case that software must be attuned to the driver's expectations from their chosen vehicle.

By Stewart Burnett

There is no one-size-fits-all solution for the automotive user interface (UI). Different automakers invariably have unique needs based on their vehicle types, target markets, and customer

expectations. While some brands may prioritise deep integration of smart devices—such as Nio and its proprietary smartphone—others will prioritise helping drivers manage their digital fatigue, like Scout Motors.

In the same way, developing a UI for a sportscar poses a unique set of challenges to automotive and software engineers. Rino Ariganello, Automotive & Manufacturing Industry Leader of IT services firm DXC, tells Automotive World that the key to success lies in building a UI that matches the unique performance characteristics and aesthetics of the car. In January 2025, DXC announced it would extend its partnership with Ferrari. The company will now build the software for several of the automaker's next-generation vehicles, including the F80. DXC believes its UI technology will elevate the Ferrari experience, but what does a software-defined sportscar look like?

Setting the mood

"It begins with a dynamic aesthetic," explains Ariganello. "The colours and layout of the screens adapting to the driving style - this creates a next-level driving experience." In the F80's cockpit, a large 21:9 display sits in the instrument cluster, with a second embedded in the dashboard centre. The functionality of these screens is largely the same as standard infotainment systems: while the instrument cluster screen displays critical driving information, the centre screen handles mapping and entertainment options.

By adjusting the UI across these displays—for example, dynamically adapting the colour scheme or adjusting the widget layout to match how the vehicle is used—the user interface matches both the emotional and practical expectations of the driver. Ariganello emphasises that the UI aesthetic must not jar with the aesthetics of the vehicle itself, which is,

according to Ferrari, a "strongly futuristic visual impact with unmistakable references to aerospace."

Balancing this with the more lofty aspects of the F80's UI aesthetic presents a substantial challenge. In addition to more rudimentary elements like dynamic colours and widget layouts, DXC also sees merit in bringing the outside environment into the cockpit. "We've done showcases where, for example, you're out on the California highway and driving towards the sun," explains Mauch. "We take that in as raw data and adapt the interior to match the look and feel of what's going on outside."

This is enabled, in part, by cameras on the vehicle's exterior that function as part of its advanced driver-assist system (ADAS), alongside radars and LiDAR. However, it also requires deep cloud integration to enable the vehicle to receive extensive data analytics, generate real-time insight on its surroundings, and make adjustments on that basis. "Everything in the UI is designed to make you feel connected to the outside elements, the driver will feel seamlessly integrated in its environment" notes Ariganello.

Enabling the driving experience

According to Ferrari, all standard ADAS features will be included free of charge with the F80 when it enters production. These include adaptive cruise control with stop and go function, automatic emergency braking, lane keeping assist, automatic high beam, traffic sign recognition, and driver drowsiness warnings. Ariganello emphasises that these are largely nice-to-haves—the real reason to own a Ferrari is to experience



The Ferrari F80's UI primarily comprises two LCD screens and a series of mechanical buttons on the wheel

the performance directly. An additional function of the cameras feeds their input to the 'rear-view mirror', which shows real-time footage from cameras located on the back of the car. This is done to enhance visibility but also elevate the futuristic aesthetic that the F80 aims to evoke.

The ADAS functions are enabled through physical switches on the wheel UI. Previously, Ferrari used touch-sensitive and haptic feedback buttons, but it has since returned to the more mechanical aesthetic and feel of knobs and buttons. Other software-powered wheel switches include the standard drive modes: wet, sport, race, and traction control off. There are also three powertrain options: Hybrid, which prioritises efficiency; Performance Mode to increase performance while keeping the battery hovering around 70%; and the

maximum-power Qualifying Mode, which eschews power conservation and lets the driver go full-tilt. The F80 is a hybrid, containing a small 2.6kWh battery that recharges while driving.

The touchscreen UI dynamically adapts its functionality depending on whether the driver is on a public road or the track. Besides the addition of 'immersive visuals', which have not yet been revealed by Ferrari, the instrument cluster broadens the scope of information to include g-force, revs, and tyre pressure. In other words, factors that may prove unnecessary or even distracting when commuting but which are of critical importance in high-performance situations. "You have to choose what to include and what to omit," notes Ariganello. "You likely don't need to know about g-force when you're cruising along the Champs-Élysées."



That feeling of immersion in the car's performance is why people buy a Ferrari

He adds that DXC has employed psychological specialists in its organisation to better understand how the driver relates to their restriction within the UI space: “Overloading the driver with too much information at once can lead to distraction, fatigue, and safety-related risks.” For this reason, the company is also working on generative AI voice assistants to help keep drivers’ eyes on the road. However, it remains unclear if this will be featured in the F80 UI. In the performance-oriented nature of the sportscar’s drive modes, a momentary distraction from the road could prove life threatening.

Immersion in performance

Ultimately, everything about the F80’s digital UI is in service of its performance characteristics. “The immersive experience of the car’s performance is what drives people to dream about and buy a Ferrari,” Ariganello remarks. This must be embodied in the latency and overall responsiveness of the UI, and software has to be deeply embedded into various aspects of the vehicle’s hardware for response times to be as low as possible. When the driver accelerates in the F80, they implicitly expect real-time information flow on areas like speed, g-force, and tyre pressure to match what they are

experiencing inside the cockpit. Even a couple milliseconds of perceptible delay will ruin the immersion.

This feeling of immersion can also be augmented beyond standard UI into other software-enabled cockpit features. One example Ariganello suggests is embedded software that adjusts the seat to make the driver “tighter and more pressed-in” in alignment with high-performance driving behaviour. Similarly, the tension of the wheel can be increased to match driving intensity.

While such functionalities may seem tangential or remote in the context of the wider vehicle market, Ariganello emphasises that the ultimate success of a software-defined vehicle will be determined by how the onboard software both matches and elevates the driver’s expectations. This means performance for the F80 but comfort, leisure, or practicality could be prioritised in other vehicles. “You are always trying to pitch the best ideas for the product you are developing,” he concludes. “Premium segment innovations often set the benchmark for the mass market. Our UI is positioned to lead the way in seamlessly integrating software functionalities and aesthetics with the vehicle, setting a new standard for the industry.”

LeddarTech proposes gradual ramp-up from ADAS to autonomous

Instead of focusing on Level 4 autonomy straight away, LeddarTech believes in scaling up AI functionality iteratively for a better result.

By Will Girling

Competition in the autonomous vehicle (AV) space is heating up: advances in artificial intelligence (AI) could be creating a US\$10tr opportunity, and early pioneers are eager to capitalise. CES 2025 demonstrated that progress in software-defined mobility is accelerating quickly, and automated/autonomous driving could be its most valuable use case.

LeddarTech, which exhibited at the event, certainly thinks so. But there are still substantial challenges for the industry to resolve. Founded in 2007, this global auto software developer

headquartered in Canada believes new approaches to AI, sensor fusion, and vehicle perception can help automakers and suppliers finally bring AVs to market.

However, Chief Executive and President Frantz Saintellemy tells *Automotive World* that the journey will be gradual. Rather than going all in on SAE Level 4+, LeddarTech is building autonomy iteratively, from Level 2 advanced driver assist systems (ADAS) up. Using the LeddarVision Surround-View LVS-2+ stack, he states, yields a safer and better performing AI foundation for progressing to Level 3 and above



Frantz Saintelley,
Chief Executive and President, LeddarTech

What big technical challenges is the automotive industry currently facing while implementing ADAS and autonomous driving systems?

Developing AVs requires substantial capital investment and long-term commitment. In this economically challenging environment, compounded by negative and mixed public sentiment towards AVs, manufacturers are quickly redirecting their focus to short- and medium-term projects, which are easier to realise. ADAS that can scale to higher levels of autonomy and eventually fully autonomous vehicles may ultimately be the winning approach.

However, from a technical perspective, there's a performance delta: existing ADAS systems have constrained operational capabilities. Many struggle in adverse weather conditions such as rain, fog or dirt, and their effectiveness is often reduced at night. Some systems may fail to detect pedestrians or cyclists with the required accuracy. For AVs, these performance deltas extend to control and decision-making technologies. Reports periodically emerge of AVs getting stuck, honking at each other or even driving in circles.

From where do these performance issues stem?

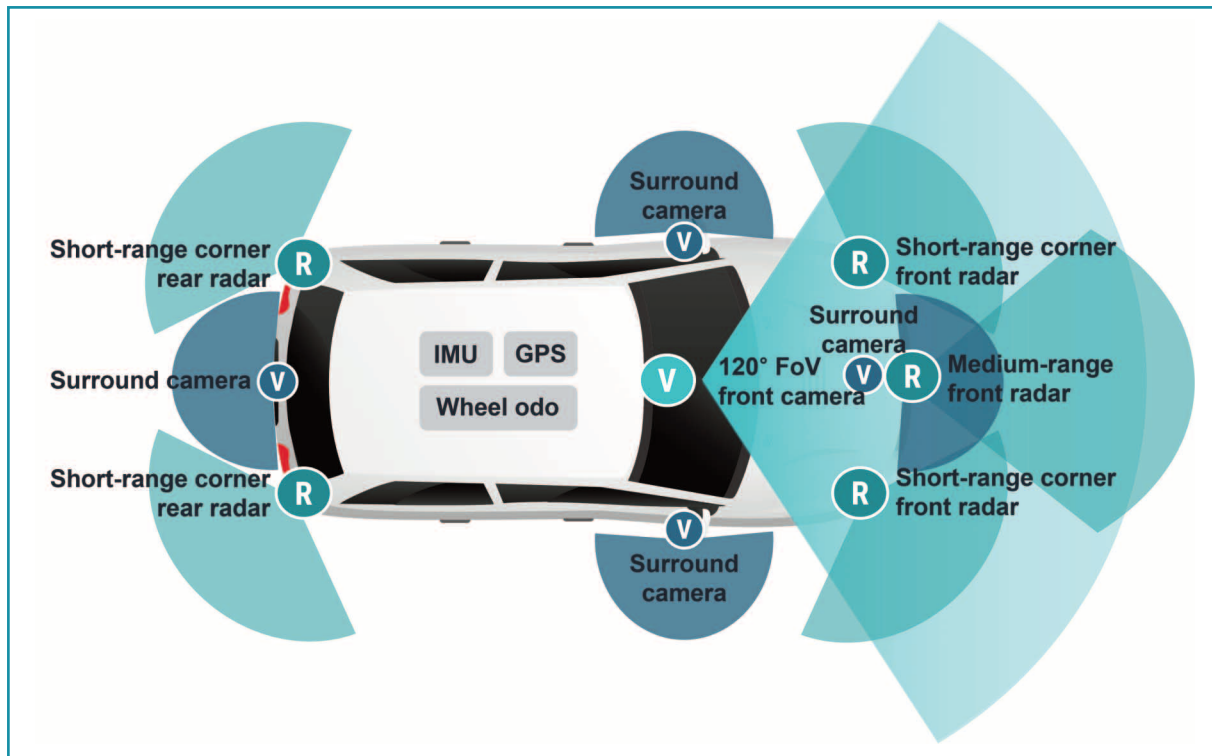
Many environmental perception solutions currently in use are rigid, with software designed to work exclusively with specific sensors. This creates challenges for automakers and Tier 1s, as it limits their ability to improve performance, add new features, or maintain systems in the field. They also face difficulties scaling their systems to higher levels of ADAS and autonomous driving.

Transitioning from Level 2 to Level 3 requires a complete overhaul, leading to increased development time, higher system costs, and added complexity in maintaining production for multiple software versions.

In the end, most of the technical challenges can be traced back to the object-level fusion, which is widely used in today's basic ADAS warning systems. These systems struggle to meet regulatory safety requirements while also addressing consumer demand for convenience features at affordable costs.

How can the LeddarVision Surround-View LVS-2+ stack help automakers?

LeddarVision uses advanced AI and computer vision algorithms to generate precise 3D environmental models that enhance decision making and improve navigation safety. The stack offers centralised and multi-modality sensor-agnostic fusion that can be used to scale from automated driving to highly automated driving. The system can handle an expanding variety of use cases, features, and vehicle sensor configurations. It also addresses many object-level fusion ADAS architecture limitations through



© LeddarTech

Sensor configuration for LeddarVision Surround-View

AI-based, low-level sensor fusion and perception technology, which extends the effective perception range. We can achieve up to twice the effective perception range using the same sensor set.

How does low-level sensor fusion improve perception?

Cars are increasingly equipped with complex sensors—including cameras, LiDARs, radars, and ultrasonic sensors—to gather data about their surroundings. How this data is processed is crucial, and there are two fusing techniques: object-level fusion and low-level fusion.

In the traditional object-level fusion technique, each sensor individually detects an object and runs perception algorithms to identify what it is, as well as determine other properties of the object. This approach processes data from each sensor in isolation.

Meanwhile, the low-level fusion approach pioneered by LeddarTech fuses the raw data from multiple sensors before running perception algorithms on the combined data to identify the object and its properties. AI algorithms process the fused data to detect, identify, classify, and segment objects such as other vehicles, road signs, obstacles, and vulnerable road users like pedestrians. Additionally, AI is used to analyse the vehicle's surroundings to support motion and path planning. Machine learning techniques, particularly deep learning, are employed to train models that can recognise and classify these objects with high accuracy.

AI algorithms, such as convolutional neural networks (CNNs) and vision transformers, are then utilised to process and interpret the data from the vehicle's sensors. Sensor fusion techniques combine this data to provide a comprehensive understanding of the environment,

ensuring redundancy and enhancing accuracy. Deep learning models, particularly those based on CNNs and recurrent neural networks, are trained on extensive datasets to detect and classify objects. This includes identifying other road users, pedestrians, unexpected obstacles, road signs, and lane markings. Techniques like transfer learning improve these models further by fine-tuning pre-trained networks on specific driving datasets.

Can you share any use cases or partnerships that demonstrate your product's efficacy?

We have conducted more than 80 in-vehicle, on-the-road demonstrations and engaged with more than 200 different industry professionals. The feedback has been overwhelmingly positive: OEMs and Tier 1 suppliers have expressed significant interest in our solution.

One of our current collaborations is with Arm. By optimising critical performance-defining algorithms within the ADAS perception and fusion stack for the company's central processing units (CPUs), we have successfully minimised computational bottlenecks and enhanced overall system efficiency using the Arm Cortex-A720AE CPU. This partnership is key as the industry shifts towards a software-defined vehicle era with centralised and zonal E/E architectures.

How will you continue to iterate and develop LVS-2+ for higher levels of autonomy?

The transition from Level 2 to Level 3 autonomy marks a significant evolution, shifting system operation

from a fail-safe model to a fail-operational one. This progression introduces numerous new requirements and challenges, including updates to the safety concept, enhanced sensor redundancy architecture, enriched environmental perception features, and increased computing capabilities.

LeddarTech has already begun to define these critical concepts and develop the foundational building blocks needed to support Level 3. In collaboration with our industry partners, we have successfully developed an initial safety concept to address the unique challenges of fail-operational systems. This concept serves as a cornerstone for our ongoing advancements, ensuring that LVS-2+ continues to meet the rigorous demands of higher autonomy levels.

So, what role could LeddarTech play in taking automated/autonomous driving fully into the mainstream?

We are delivering scalable, cost-effective solutions that provide Level 3 performance at Level 2 costs, making ADAS more accessible. By processing raw data from multiple sensors, LeddarVision enhances safety and reliability in complex scenarios, strengthening consumer trust in automated driving. Collaborating with OEMs, Tier 1s and other major industry players, LeddarTech fosters industry-wide innovation and accelerates the deployment of autonomous features. This approach reduces development complexity and time-to-market, enabling automakers to bring cutting-edge technologies to a broader audience with less risk.

IBM: SDV clock speed demands faster innovation

From IT infrastructure to engineering platforms and a new operating system, IBM is helping automakers innovate more efficiently. By Megan Lampinen

The automotive industry is shifting from a hardware-centric model to a software-centric one. This emerging paradigm calls for increasingly rapid development cycles from automakers. From new in-cabin experiences and advanced driver assistance systems (ADAS) to cyber

security and data management, the journey towards the software-defined vehicle (SDV) is rewriting the rulebook on automotive innovation.

IBM is building on its roots in computing to help automakers modernise their operations in response to the new industry clock speed.



IBM X-Force Red

Drawing on more than a century of technology expertise, it now finds itself on the vanguard of new mobility development. “In some cases we are providing the IT infrastructure for automotive projects—a very traditional IBM play. In others, we directly supply something that goes into the vehicle, like our Red Hat In-Vehicle Operating System,” says Hans Windpassinger, Principal Client Engagement within IBM’s Global Manufacturing Industries team. “Whether it’s technology, consulting or support services, we are helping automotive customers on their journey towards SDV.”

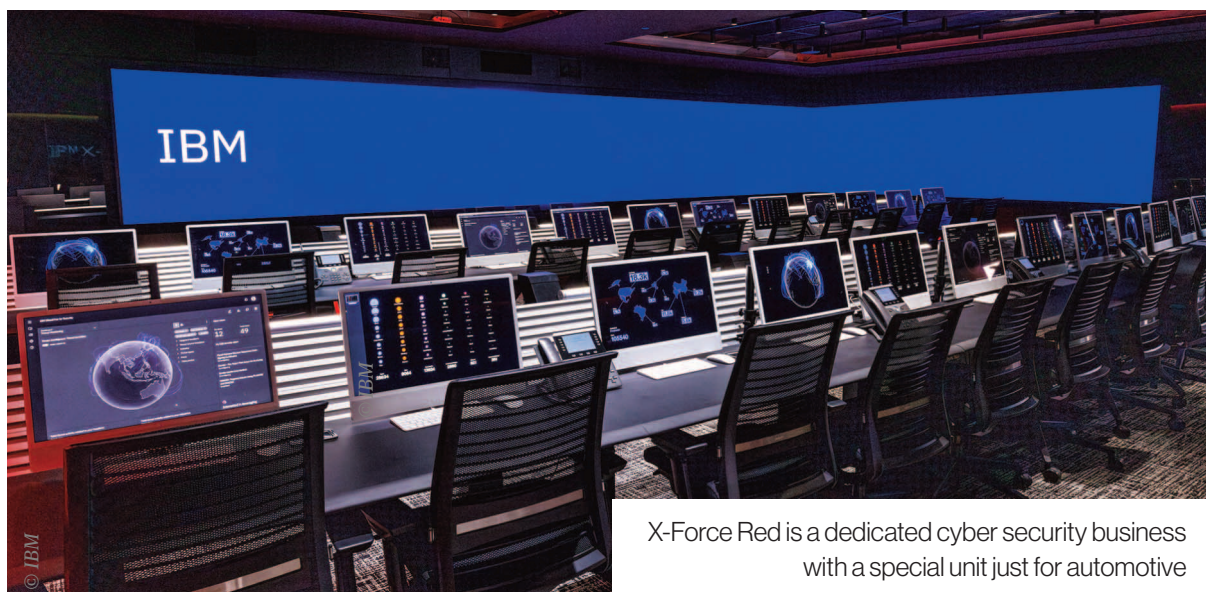
IT infrastructure lags AI and compute

ADAS is growing increasingly clever thanks to progress within artificial intelligence (AI), but training AI models requires vast amounts of data. Many developers find themselves confronted with petabytes of data spread across various regions, and managing that data is a huge challenge. “It’s not unusual for OEMs to collect up to 40 or even 50 petabytes of data,” he says. “They cannot simply make a copy or put it

somewhere. You have to manage it effectively, and managing huge amounts of data has always been a strength of IBM.”

Continental served as a case study on the effectiveness of IBM’s IT infrastructure. The supplier was regularly receiving more than 100 terabytes of data from a test fleet of automated vehicles. With the help of Nvidia GPU computing, this data was ingested, processed, selected, annotated, and used for training and validation of the system. “Continental invested in these very data-hungry GPUs from Nvidia and then realised that its existing infrastructure cannot really feed them,” notes Windpassinger.

What the supplier needed was something faster that could provide the necessary bandwidth and random access. For this it turned to BMW’s Elastic Storage Server (ESS) and found that it could enable more AI experiments within the same time compared to the legacy system. “It could get 14 times more out of the Nvidia DGX systems with our ESS,” emphasises Windpassinger. “This is an incredible factor, which shows how



X-Force Red is a dedicated cyber security business with a special unit just for automotive

important IT infrastructure is for enabling efficient work from data scientists and leveraging the GPU power available today.”

The open source SDV

With the move towards SDV, the in-vehicle operating system (OS) becomes increasingly important. It acts as the vehicle’s brain, serving as the core software platform and coordinating multiple electronic control units and functions. The global automotive OS market is poised to grow in value from US\$11.83bn in 2023 to US\$30bn by 2030, according to Grand View Research. There are a number of solutions on the market today, but IBM is hopeful that its new Linux-based offering could propel the industry towards the open source SDV.

The Red Hat In-Vehicle Operating System comes from IBM’s Red Hat subsidiary and applies Linux to safety-critical automotive systems. In theory, it accelerates development time, reduces costs, and opens the door to new services and revenue streams.

The idea is that the huge existing talent pool of developers competent in Linux will make it easier for automakers to find the necessary talent and innovate faster. “More talent means faster innovation,” suggests Red Hat.

Automotive certification remains a work in progress. So far, the Linux math library, a key part of the Red Hat In-Vehicle OS, has achieved ISO 26262 ASIL-B functional safety certification. It has also demonstrated that the required mixed criticality configuration can reliably meet ASIL-B requirements. “By pairing edge computing with the proven reliability of Linux, we’re building a foundation that not only meets critical safety standards but also enables automakers to deliver personalised, connected, and adaptive driving experiences at scale,” comments Francis Chow, Vice President and General Manager, In-Vehicle Operating System and Edge, Red Hat.

While Windpassinger isn’t able to share specific timelines, he adds: “We really look forward to the time when

we have the Red Hat In-Vehicle OS completely certified.”

Security

Software is extending into almost every aspect of the vehicle and the development process, meaning cyber security needs to do the same.

Guidehouse Insights expects the global automotive cyber security solutions market to see revenue of more than US\$445bn by 2031.

“Security is a really important element within SDV. As the attack surface grows, we also see the number of vulnerabilities—and incidents—growing,” Windpassinger observes. Securing both hardware and software while conforming to regulatory requirements and maintaining customer expectations has put traditional ways of working under pressure. In many cases, automakers are turning to outside expertise.

IBM has a dedicated security unit, X-Force Red, with the stated mission of “hacking anything to secure everything”. One year after its 2016 launch X-Force Red added a division specifically focused on automotive. Here, security experts test vehicles and components for vulnerabilities and work with manufacturers to fix them. “These guys are the good hackers. They hack systems based on an order from a customer, and they always find something. Nothing’s perfect.”

Looking ahead, Windpassinger sees considerable scope to improve automotive cyber security with greater use of AI. Within the vehicle security operation centre, AI can be used to find patterns and to better identify potential incidents. He also flags threat analysis risk assessments

and penetration testing as areas that could be improved with AI.

Growing in importance

The rise of software’s role within automotive is blurring the lines of industry players and relationships. While IBM didn’t start off as an automotive company, its expertise is becoming increasingly relevant to the industry. As well as the areas touched on above, the company also offers automotive players its expertise on large language models (LLMs), algorithms that are particularly good with human language. “Our own LLMs, called Granite, are small, effective and powerful. They are perfect candidates for embedding into vehicles,” he says. The latest addition to the line-up, Granite Family Version 3.0, is currently provided on the Qualcomm AI Hub, meaning it can be executed and deployed on the ubiquitous Snapdragon platform.

The company’s connected vehicle platform, IBM IoT Connected Vehicle Insights, helps automakers analyse data from connected vehicles and turn it into actionable insights. It has already been adopted by big names such as Suzuki in Japan and its Indian unit Maruti Suzuki. The SDV portfolio also includes the IBM Engineering Lifecycle Management platform for engineers, helping with modelling and compliance.

“With the rise of SDV, automotive is definitely growing in importance for us and our customers,” concludes Windpassinger. “Despite the current challenges, OEMs and Tier 1s are pushing ahead with their R&D.” And with advances like these, IBM is becoming increasingly efficient and responsive to the needs of software-defined mobility.

Royal Enfield's software-defined motorbike “grows with you”

The Flying Flea shows how software-defined experiences can be delivered on a two-wheeler.
By Megan Lampinen

The software-defined vehicle (SDV) promises an ever-evolving user experience. From safety and efficiency to infotainment and comfort, the possibility of constant upgrades and updates opens the door to a new mobility paradigm. So far, both headline space and market applications have focussed on passenger cars and commercial trucking, but SDV is certainly not limited to these segments.

“SDV as a concept applies to any vehicle,” says Sudhakar Bhagavatula, Chief Information Officer at motorcycle manufacturer Royal Enfield. “Passenger vehicles represent a closed environment—very different to what is found on a two-wheeler. Rendering software-defined experiences on two wheels is more complex but offers a real

opportunity to build a special kind of connection between bike, rider, and terrain.”

And that’s exactly what the company has done with the new Flying Flea.

A bike that grows with you

With more than 125 years behind it, Royal Enfield is the world’s oldest global motorcycle brand in continuous production. Its latest model draws on that rich heritage. The original Flying Flea (officially the Royal Enfield WD/RE) was created in 1941 for the British War Office. Lightweight and agile, it was designed to be dropped into high risk areas by parachute to help soldiers carry messages.



The Flying Flea will launch in 2026

Images © Royal Enfield

The name is now being revived as Royal Enfield's new electric vehicle (EV) brand, starting with the FF-C6 electric motorcycle. Pivotal, this is also the range that introduces its vision for connected motorcycling, offering smartphone digital keys, customisable ride modes and over-the-air (OTA) updates. "This is a bike that grows with you," says Mario Alvisi, Chief Growth Officer, EVs, at Royal Enfield.

Much of the SDV capability is underpinned by Qualcomm expertise. At the heart of the FF-C6 ride experience is Royal Enfield's in-house-developed operating system, powered by the Qualcomm Snapdragon QWM2290 system-on-chip. This enables the motorcycle to manage all aspects of the vehicle and ride experience through an interactive instrument cluster, securing multi-modal interaction with 4G, Bluetooth, and Wi-Fi connectivity. "This is a fully connected, fully updatable bike, offering a continuous evolution of features OTA," says Nimish Shrivastava, Senior Director, Product Management at Qualcomm.

Riders can interact through touch screen, voice control, joystick, smartphone, and smartwatch. Integration with the Snapdragon Car-to-Cloud platform—in this case serving as

bike-to-cloud—allows users to connect to their bike, monitor its status, and change their preferences remotely. "To render all these experiences, we've adopted the software-defined approach," Bhagavatula states. "It's the same inspiration and methodology seen with the software-defined car."

From four wheels to two

The inspiration may be the same, but the deployment environment on a two-wheeler is more complex in terms of safety and security than that of an enclosed car or truck cabin. In some cases, these challenges open up new opportunities for software-defined experiences. Situational awareness is a case in point. "You can put cameras around the bike, and they detect potential hazards outside of the rider's peripheral vision," says Qualcomm's Nakul Duggal, Group General Manager of Automotive, Industrial & Embedded IoT, and Cloud Computing.

Real-time diagnostics, advanced navigation, and personalised ride settings are just the start. The Royal Enfield team is particularly enthusiastic about the bike's ability to offer driving coaching for improved efficiency based on observed driver behaviour and the specific terrain. While not every driver will necessarily welcome this feedback, others may find it invaluable. "Technology has a lot to offer if you're open to it," Duggal tells *Automotive World*. "You can always shut it off if you're not."

Royal Enfield is a big believer in co-creation and took in considerable feedback from riders while developing the bike and its specific features. "We put a lot of effort into talking with people," Alvisi explains. "The initial idea

of building a software-defined EV came from these conversations. People didn't tell us, 'I want an EV or an SDV,' but they were telling us they wanted specific traits. We could identify clear trends."

Above all, the aim is to have software features support a close rider-bike relationship that fits in with the user's digital lifestyle. "The technology enhances the sense of freedom you have on a bike, taking it to the next level," he adds. "It's not an obstacle to freedom but rather allows you to connect with the bike in a new way. The aim is to make your life easier without the technology becoming invasive."

The key to providing these freedom-enhancing digital experiences is a microservices architecture. With this approach, each application is composed of numerous smaller, loosely coupled and independently deployable services. "How do you put the right services on the device? What do you take it to the cloud? How do you bring updates at the right time? All those are more complex because of constraints within the bike, and microservices is the right way to do that," Shrivastava claims.

An appreciating asset

A vehicle defined by software is one that can evolve over time, and that capability will soon become the ticket to play in any segment. "The whole idea is to make the bike an appreciating asset," says Qualcomm's Manmeet Singh, Senior Director of Business Development.

In terms of what that looks like on two-wheels, the future is wide open. Royal Enfield is currently considering offering users the option of downloading premium features, potentially at an extra cost but not necessarily. Down the line



Flying Flea is one of the first two-wheeler platforms to incorporate connected services technology through the Snapdragon Car-to-Cloud Platform

there could even be new forms of vehicle ownership made possible by digital advances. "There will be quite a lot of developments here," says Alvisi.

As Bhagavatula adds: "What's important, especially in the EV world, is not just the launch of the motorcycle, but that we can offer new experiences OTA over a period of time afterwards, all done through the platform."

Despite the promised benefits, Royal Enfield is aware that not every rider will immediately embrace the move towards an electric, software-defined motorcycle. In many ways the two-wheeler segment is very traditional, but the company is willing to wait for its consumer base to come round in their own time. "Over the course of human history, whenever there is a big change, there are people that resist and others that immediately embrace it," Alvisi points out. "It's the latter that become the trendsetters, and gradually, if the change makes sense for the majority of people, then adoption starts."

The first Flying Flea model will be the classic-styled FF-C6, followed by the scrambler-styled FF-S6. Both are scheduled to arrive on the global market by early 2026.

Nio and ZF label steer-by-wire “cornerstone” of future SDVs

Steer-by-wire systems updateable over-the-air could usher in a new era of electric, autonomous, and software-defined mobility. By Will Girling

Although it has previously been implemented in some limited-run or concept vehicles, steer-by-wire (SbW) is only now starting to gain significant momentum. The technology removes the traditional steering column that turns a vehicle's wheels mechanically and replaces it with a digital system of electronic control units (ECUs) and cable networks. Electric models already featuring SbW include the Lotus Eletre, Tesla Cybertruck, and Nio ET9.

Danilo Teobaldi, Principal Chief Engineer at Nio, tells *Automotive World* that SbW is primarily valuable for addressing basic issues like unwanted vibrations, delayed response, and wear



Danilo Teobaldi,
Principal Chief Engineer, Nio

and tear; but it also marks a step forward in other aspects like safety, comfort, and adaptability. “SbW provides a variable steering ratio that optimises handling, offering maximum manoeuvrability at low speeds and superior stability at high speeds, and thereby providing both comfort and an uncompromised driving experience.”

Importantly, SbW is highly complementary with software-defined vehicle (SDV) concepts under development today. Removing mechanical linkages creates more interior space for infotainment experiences, while fully digital steering opens the door for next-generation automated and autonomous driving systems. “It paves the way for delivering a more personalised and dynamic driving experience,” states Teobaldi.

Safe and scalable

The Nio ET9, deliveries of which commenced in March 2025, integrates SbW from ZF into its SkyRide intelligent chassis. Jake Morris, SbW Portfolio Director at ZF, explains that his company’s technology is a scalable and modular system that provides OEMs with a simple and adaptable conversion process.

“This is particularly important for existing and future vehicle architectures—it is conceivable that a single central high-performance computer will control the SbW system in concert with all other driving dynamics functions.” ZF is demonstrating what this could look like with its cubiX software platform and Chassis 2.0 concept, an all-in-one vehicle system combining smart actuators with software applications and intelligent chassis architectures.



Nio's ET9 is among the new production models to incorporate steer-by-wire technology

“Steering becomes electric, intelligent, software-based and interconnected, just like the cars of the future,” says Morris. Through this highly configurable concept, the characteristics of a specific model or an entire brand can be controlled entirely through software.

In terms of safety, SbW systems eliminate mechanical connections that could fail and replace them with ECUs for redundancy, ensuring the vehicle remains controllable even if part of the system fails. “This intrinsic safety is vital for the reliability of SDVs, which must operate flawlessly under all conditions,” he states. Compared to legacy systems, Nio claims the ET9’s digital steering has more precise control and reduced delay, minimising the risk of skidding or loss of traction.

Morris notes that SbW systems can also be scaled across different vehicle models and platforms, making them a versatile solution for various types of vehicles, from compact urban cars to luxury SUVs. By removing mechanical complexity, SDVs subsequently become easier and more cost effective to produce. For example, manufacturing

right-hand-drive variants for markets like the UK, Australia, Japan, and India would simply require installing a steering wheel actuator on the other side of the cockpit.

Updateable steering

Over-the-air (OTA) updates are increasingly touted as the core benefit and most important attribute of SDVs. Teobaldi states that SbW intersects neatly with this trend in the Nio ET9: “The whole base-function calibrations can be updated OTA, improving the low-speed manoeuvrability, mid-speed agility, and the high-speed stability.”

Instead of relying solely on automatic brake systems, the ET9 uses both front and rear steering adjustments to maintain control—for example, to stabilise the car if a tyre blows out. “This smart steering system can be

continuously improved and updated, allowing new safety features to be developed, validated, and eventually provided to the user without physical changes.” OTA could also be used to deliver value-add functions like adaptive steering settings that automatically adjust based on driving style, road conditions, or environmental factors to ensure optimal performance in a variety of scenarios.

“SbW and OTA combine with Nio’s SDV architecture to provide the digital foundation that enables continuous evolution and allows for real-time customisation and improvement,” says Teobaldi. Morris agrees, calling updateable SbW the “cornerstone” of next-generation vehicles that will facilitate enhanced customisation, deeper ADAS integration, improved diagnostics, and enhanced safety.

A digital representation of the components in ZF’s steer-by-wire system



Going forward, the effectiveness of SbW could beget fully interconnected vehicle control systems, incorporating brake-by-wire and throttle-by-wire. This would result in a fully software-controlled vehicle. This new paradigm will be a substantial boost for both electric vehicle manufacturers and SDV developers seeking energy conservation through greater system efficiency. “This evolution will not only enhance the driving experience but also pave the way for more advanced, safe, and efficient vehicles,” says Morris.

Foundation for next-gen vehicles

Perhaps the most exciting consequence of SbW could be the realisation of fully autonomous vehicles (AVs). Competition in both the private vehicle and robotaxi markets is heating up, but while sensor tech receives a lot of attention, updateable digital steering systems could prove to be the unsung hero. Morris considers the technology an integral to any system SAE Level 2 and above, meaning one in which the computer must have full control over the vehicle’s dynamics.

Teobaldi calls updateable SbW wire systems nothing less than “crucial” for the future of AVs. “SbW can incorporate the latest sensor technologies, control algorithms and safety enhancements, ensuring that autonomous functionalities continue to improve and adapt to emerging standards.” This flexibility will be vital for maintaining high safety and performance levels in a rapidly advancing field. Morris is even more expansive: while calling a SbW a “pivotal component” that will be key enabler for specific applications like robotaxis, he believes it might ultimately reshape vehicles themselves.

“SbW systems free up valuable space within the vehicle. This allows for more innovative interior designs and better utilisation of space, which is especially important for electric vehicles and AVs, where every inch of space can be optimised for passenger comfort and additional technology,” says Morris. In the cabin of highly automated vehicles, the steering wheel could even retract into the dashboard to create an effective ‘living room on wheels’.



SDVs [...] must operate flawlessly under all conditions

By setting a new benchmark in precision and adaptability, Teobaldi positions SbW as a core pillar in Nio’s strategy to be at the forefront of smart, software-defined electric mobility. Morris, taking a broader perspective, calls SbW more than just an innovation in vehicle steering: “It is a foundational element for the next generation of SDVs. By enhancing integration with software control, offering customisation and flexibility, optimising space, improving safety and supporting advanced mobility solutions, SbW systems are set to revolutionise the automotive industry and drive the future of mobility,” he concludes.

SDV progress: more give-and-take balance on open source

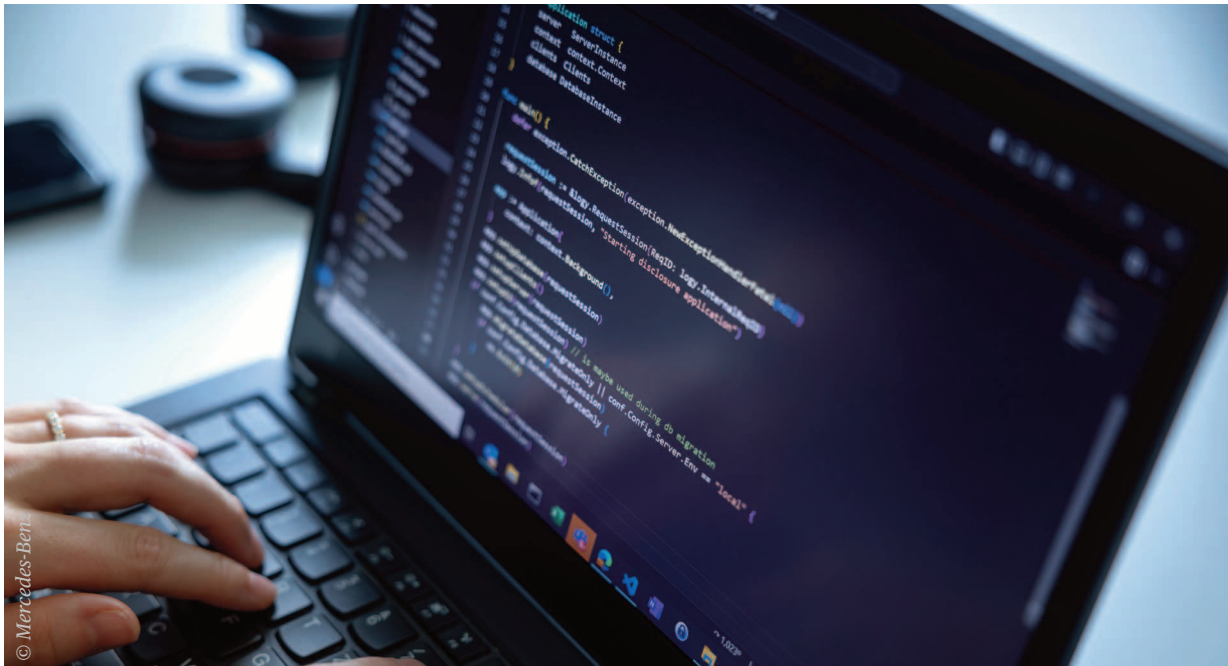
Enthusiasm for open source software contribution is not yet matched by adoption. By Megan Lampinen

In the move towards new mobility, software has become more than just a means to an end. It is a valuable asset in its own right and needs to be recognised as such. This shift represents a radical change from traditional automotive industry approaches, and one that is posing headwinds for incumbents.

“There has been a massive explosion in the number of new players over the past few decades,” says Michael Plagge, Vice President of Ecosystem Development at the Eclipse Foundation, an open-source software non-profit. “If 30 years ago someone predicted there would be 100 new OEMs on the market by 2025, nobody would have believed them.” Pivotal, these start-ups are coming to market in a new way, with a new sort of product. “Their key value-add has

totally changed,” he tells *Automotive World*. “Fifteen years ago it was safety, which has since become foundational to all cars. Now it’s all about services and the customer experience. It’s a completely new development paradigm, and the established players are under pressure.”

A pivotal difference between the newer players and the traditional automakers stems from the point at which they begin their design journey. “The traditional OEMs plan a car from the hardware side, then consider software as something required to make the hardware do what they want it to,” suggests Ansgar Linwedel, Director of Software-Defined Vehicle (SDV) Ecosystem Development at Eclipse. “It’s a completely different approach to the challengers—the BYDs and Teslas—which start by considering the customer



experience they want to provide, the features, and the lifecycle of the car. That makes them come into software from a completely different angle.”

Changing strategies also poses challenges for traditional cost models. As Plagge explains: “OEMs have a very good way of forecasting hardware costs for ECUs. They know exactly what the supplier needs to spend.” Anecdotally, one major German OEM can forecast the price of an ECU’s hardware parts with a precision of 99%. Software is another matter. “OEMs still struggle with the cost model for generating software and don’t have a precise way of estimating how much effort something requires,” adds Plagge. “With the current focus on the bill of materials, they regard software as a means to an end and not an asset in itself.”

100 brands, 100 software stacks

Within the software stack there are layers that contribute to brand differentiation and more fundamental

layers that enable the vehicle to be software-defined. The trouble is that suppliers and automakers have been developing their own bespoke systems. “If we have roughly 100 automakers on the market, we could end up with 100 different SDV stacks,” observes Linwedel. “BMW is building its stack into all BMWs, Mercedes is building its version into all Mercedes models, and so on. Where will it end?”

The Eclipse SDV Working Group believes interoperability could go far in realising a truly software-defined ecosystem. Described as a code-first initiative, it aims to build open-source software stacks and associated tooling for SDVs’ core functionality. “Each player has been building underlying software where there is no competitive edge,” Linwedel states. “Everyone needs it, but there’s no need for everyone to develop it individually. Let’s develop that stack once and deploy it in all the different brands, then everybody can work on the functions where they believe they can stand out in the market.”



It's a completely new development paradigm, and the established players are under pressure

The SDV Working Group intends to offer open-source solutions, starting with the Safe Open Vehicle Core project's software stack. A growing number of automakers and Tier 1s have been publishing open-source manifestos, but that doesn't mean the industry has fully embraced the approach yet.

"Most of these companies are happy to share their source code, but that's not enough," says Lindwedel. "They also need the willingness to change themselves and adapt what has been generated by the community. Organisations are proud of the architecture they spent years developing, but nobody can survive with such a specific architecture. For collaboration to work, there needs to be willingness to change internally." On this front he sees gradual progress and expects the wider transition to take time.

A community where OEMs meet Big Tech

The automotive sector has already proven it can embrace collaboration, and has been doing so successfully on the hardware side for decades. Pretty much all of the incumbents have

platform sharing agreements with at least one other partner, with many more recent arrangements springing up around shared battery technology. "The industry is already used to collaborating on hardware, and organisations are slowly adapting to do the same with software," Lindwedel notes. He specifically flags AUTOSAR (Automotive Open System Architecture) as a case in point. "We have examples where the car industry started collaborating on software, but in those instances, the OEMs are not part of the development yet."

Ford Chief Executive Jim Farley noted in a 2023 episode of the Fully Charged Show podcast that most of a vehicle's software comes from a vast number of different suppliers—150 in Ford's case—that don't talk to each other. "If an OEM wants to change the software, it's hell," adds Lindwedel. It also puts all the software competency in the hands of the suppliers.

The Eclipse SDV Working Group is promoting collaboration at the code level, bringing together a wide range of automakers, Tier 1 and 2 suppliers, and Big Tech. Microsoft was one of its founding members. For Plagge, Big Tech's involvement is particularly valuable. "In the SDV Working Group



New arrivals are taking a software-first approach

framework, every member has the same rights and obligations, but that does not mean we replace the traditional strong dependency across the different tier levels. These tech players not only have technology capabilities that the traditional automotive industry lacks, they are also much more independent.” Saying ‘no’ to an automaker could be difficult for a supplier that relies heavily on that company as a source of revenue. Microsoft won’t be so dependent on BMW for business as Bosch or Continental would be, for example. “We see more independent thinking and a more experienced approach when it comes to software-based systems,” emphasises Plagge.

Big Tech also brings experience in developing an open-source ecosystem and fostering community. “Around 30% of what we do is about technology, with

70% about people and bringing them together,” notes Lindwedel. “We are really focusing on how to overcome big egos, habits of tradition, and the ‘not invented here’ mentality. These guys don’t just have the hard skills like coding but also the soft skills like how to build governance and develop communities.”

Plagge echoes this sentiment, adding that the success of the SDV Working Group will not be decided by technology alone: “We can have amazing technology and still fail. We try to support our community with a change of mindset. Companies are coming together because of the external pressure; they see the need to collaborate to reduce costs and increase efficiency. Those challenges will not be solved by brilliant technology alone. We need to have a management community, and that’s what we are building.”

IN CASE YOU MISSED IT...

Ford pulls plug on FNV4 just as software becomes imperative

Ford reportedly ended FNV4 because it was costing too much money, but the problem it was addressing hasn't disappeared.
By Will Girling

Legacy automakers are at a disadvantage in the shift to software-defined vehicles (SDVs) compared to start-ups. While newer players start with a 'blank sheet' that enables vertical integration across both hardware and software, incumbents often lack in-house expertise and rely on extensive supplier networks to assemble finished products. The latter doesn't always produce desirable results.

Aware that its electric vehicle (EV) architectures were behind industry pioneers like Tesla, Ford initiated its Fully Networked Vehicle (FNV4)

programme. Its goal was to decentralise ECUs into modular zones controlled by a central ‘brain’. The move away from domain architectures is a prevalent SDV trend, as it can save money, streamline vehicle functionality, and enable advanced features.

However, in Ford’s case, the journey hasn’t been worthwhile. According to an article by *Reuters*, the automaker has shelved FNV4 owing to slow progress, fast-rising costs, and the overcomplexity of integrating software from hundreds of suppliers. In total, Ford’s software and EV activities incurred losses of US\$5bn in 2024, and numerous issues with these technologies have occurred for years. Most recently, more than 24,000 US vehicles were recalled in April due to powertrain control module software problems.

It should be noted that no SDV implementation strategy has been smooth, even for Tesla, the poster child of the digital revolution. During 2024 alone, 5.1 million of its cars were recalled in the US, though these were primarily fixed with over-the-air (OTA) updates. In its own way, Ford has managed to reduce the frequency of recalls: between 2022 and 2024, incidents fell from 8.7 million to 4.1 million. The issue is that the nature of automotive recalls is moving away from hardware to software, and these will likely be ongoing and require constant OTA attention.

By spiking FNV4, Ford might not only be postponing a transition that’s necessary to remain competitive but also impeding the release of new products. Perhaps most notably, BlueCruise, the automaker’s advanced driver assist system (ADAS), might fall

behind just as the technology reaches an industry inflection point elsewhere. Chief Executive Jim Farley stated in June 2024 that BlueCruise could unlock SAE Level 3 in production vehicles from 2026 but would likely not be included in cheaper models. This contrasts with BYD’s decision to make ADAS available across its product range as a standard feature.

For legacy players stuck in the transition to software-centric products, creating ecosystems has never been more important. Brands like Toyota and BMW are collaborating with tech companies like Waymo and DeepSeek to bridge the knowledge gaps in their autonomous vehicle plans. Volkswagen is also leveraging partnerships—both old (Carizon) and new (Rivian, Uber)—to accelerate its automated/autonomous driving in China and the US. Meanwhile, Renault Group and its subsidiary Ampere have launched their first SDV platforms. Ampere’s goal—to create a single platform with a centralised software architecture and a connected, intelligent operating system—bears a striking similarity to Ford’s FNV4.

Shannon Johnston, Knowledge Expert at McKinsey, observed in a recent webinar that design complexity in modern vehicle platforms is growing at 42% per year—an unsustainable rate. A good E/E architecture will make or break a product’s success in the SDV era: providing a better user experience, shortening development times, reducing defects, and improving automaker productivity. If FNV4 was too inefficient, Ford will need to create something better. One thing it can’t do is turn back the clock and ignore the issue entirely.