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Software-defined vehicles
Global manufacturer readiness study

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Executive summary

The transition to software-defined vehicles (SDVs) is revolutionizing the automotive industry by decoupling software from hardware to enable rapid, ongoing development. At the same time, vehicles are becoming extensions of the digital space, integrating new features and capabilities that align with evolving customer needs. Cloud-based operating platforms and over-the-air (OTA) updates are becoming standard, pushing companies to leverage strategic alliances and robust architectures to manage the growing complexity of mobility data.

Successfully navigating this shift can unlock significant efficiency gains and new data monetization opportunities. Deloitte Global's 2023 SDV study, "Engineering the mobility revolution" highlighted the key trends and strategies defining the SDV revolution. Building on that study, Deloitte Global conducted interviews with more than 160 executives from original equipment manufacturers (OEMs) in Germany, France, Italy, United Kingdom, Spain, the United States, Japan, and South Korea from March to April 2024. The new survey provides valuable insights on the rapidly evolving nature of SDVs and the transformational impact this trend is having on automotive manufacturing organizations around the world.

Key findings

Strategic shift toward SDVs

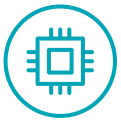
OEMs are increasingly investing in the development of SDVs, with substantial resources allocated to research and development (R&D). Investments in SDVs reached up to US$3 billion per company in the last fiscal year, reflecting the industry's commitment to staying competitive in the digital era. OEMs are also prioritizing investments in artificial intelligence (AI), machine learning, and connectivity. These technologies are important for enhancing vehicle intelligence, personalization, and autonomous driving capabilities.

Centralized decision-making

A majority (69%) of OEMs are adopting a centralized decision-making approach for SDV strategies, driven by the need for consistency, cost efficiency, and faster response times to support robust development. OEMs should balance this strategy with the need to empower regional offices and sub-brands with the flexibility to adapt to local market conditions.

Partnerships and collaboration

Strategic partnerships are becoming increasingly important for addressing complex challenges and driving innovation. OEMs are focusing on partnerships in areas such as cybersecurity, autonomous driving, and advanced operating systems (OS) to leverage external knowledge and gain a competitive edge while reducing overall R&D expenditures.



Disparity in self-perception between technical and business departments

A notable disparity exists between an OEM's technical and business departments when it comes to their perceptions of SDV readiness. Nearly 90% of technical department executives believe their company is a leader in SDV development and implementation. In contrast, 45% of business department executives have the same opinion. This misalignment suggests that some OEMs may face challenges in creating a cohesive strategy, potentially hindering the effective implementation of SDVs. To address the disconnect, OEMs should foster greater collaboration and communication between technical and business departments. Aligning resources on key priorities will be important for developing a cohesive SDV strategy.

Understanding the SDV market

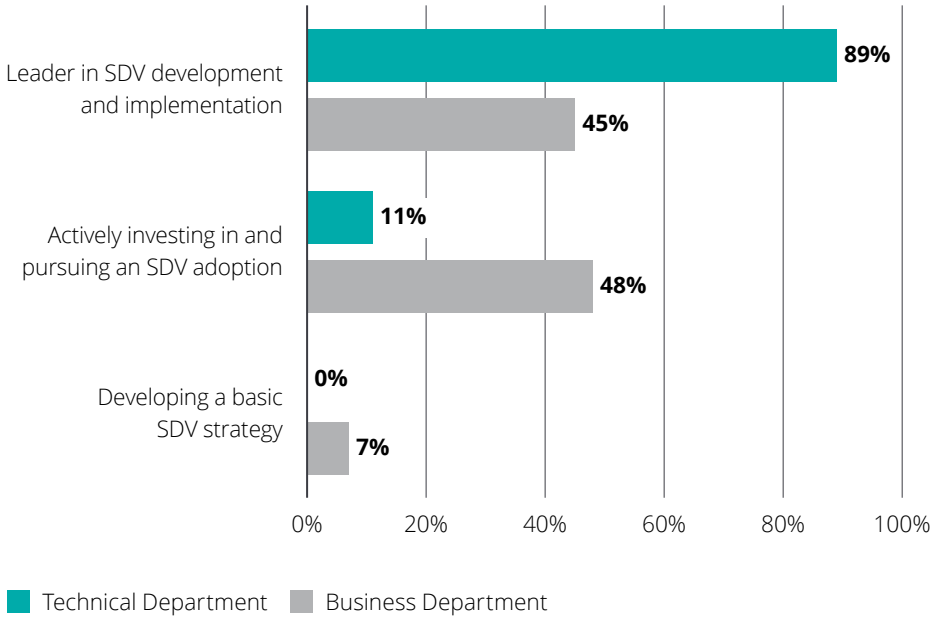
The development of SDVs represents a transformative phase in the global automotive industry. According to a recent forecast, SDVs will represent the vast majority of vehicles sold by the end of the decade.[1] This aligns with the results of the Deloitte Global SDV readiness survey[2] that suggests 81% of the vehicles in an OEM's fleet will be defined by software by 2030. As a result, more than 9 in 10 respondents in the survey confirmed they are actively investing in the adoption of SDVs, demonstrating a firm commitment to this wave of digital transformation.

Perceptions of SDV readiness

One of the most striking discrepancies to emerge from the Deloitte Global survey points to a disconnect in the way technical and business departments view their company's competitive positioning when it comes to SDVs. Nearly 9 in 10 OEM executives in a technical role felt their company was already a leader in SDV development and implementation. In contrast, less than half of survey respondents in a business role said the same. Technical departments like R&D are laser-focused on the development and implementation of their SDVs solutions. On the other hand, business departments like strategy or product management focus on the planning and financial aspects of SDV implementation, potentially affording them a broader perspective on the current state of the competitive landscape. Cross-functional collaboration could be a solution to facilitate the exchange of knowledge and insights, helping to enable a faster transition to new methodologies and tools, thereby enhancing the company's competitive advantage.

This highlights the strategic imperative for OEMs to efficiently align their organizational structures. In addition, current traditional vehicle engineering procedures may not adequately facilitate the incorporation of digital products and solutions, requiring the implementation of new core architectures, agile transformation, strategic relationships, and process restructuring.

Fig. 1 – Disparity in self-perception of leadership in SDV development



Source: Deloitte 2024 Global SDV Readiness Survey.

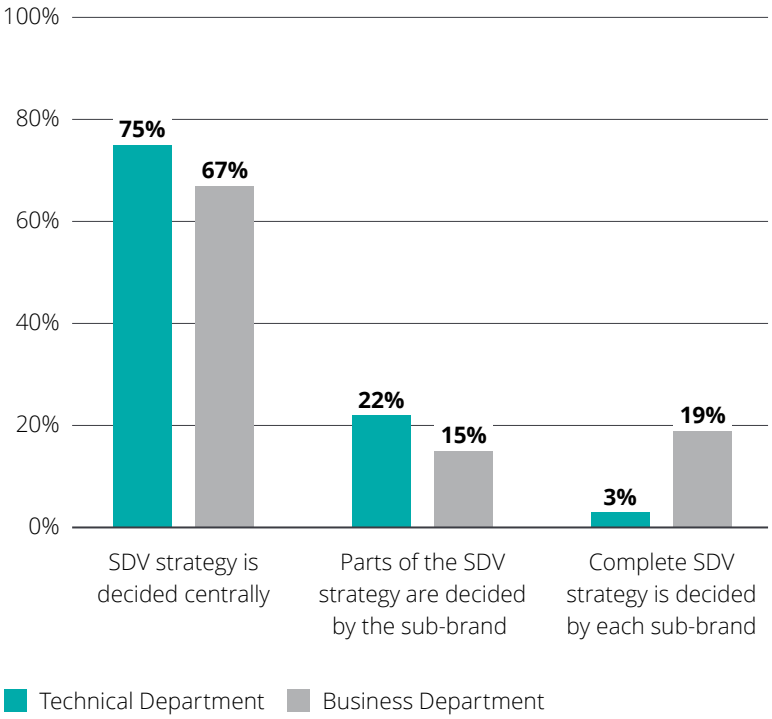
[1] Mike Ramsey, et al., Predicts 2023: Automotive and Smart Mobility, Gartner, December 19, 2022.
[2] Deloitte 2024 Global SDV Readiness Survey.

SDV decision-making processes

Deloitte Global survey results indicate that SDV strategy is predominantly decided centrally, as opposed to hybrid structures where sub-brands have varying levels of influence. This centralized approach allows OEMs to maintain a unified vision and cohesive strategy, which is critical for major changes like adopting SDVs. The following chart illustrates the distribution of centralized versus decentralized decision-making approaches.

On the other hand, decentralized strategies help empower regions and sub-brands to make decisions that are more responsive to local conditions and specific challenges. This flexibility can be particularly beneficial in the fast-paced world of software development, where rapid iteration and adaptation are key to staying competitive. By leveraging both strategies, OEMs can balance the need for overarching coordination with the agility to innovate and adapt at a granular level, thus positioning themselves for success in the evolving automotive landscape.

Fig. 2 – Central vs. decentralized decision-making



Source: Deloitte 2024 Global SDV Readiness Survey.

Importance of cloud-based platforms

The integration of cloud-based operating platforms has become important for the success of SDVs. Deloitte Global survey findings underscore the importance placed on these platforms by both OEM technical and business departments, highlighting the significant progress made in this area.

Notably, two-thirds of respondents from the technical department and 57% from the business department recognize the need for cloud-based platforms to underpin their SDV efforts. The survey also assessed the progress companies have made in implementing cloud-based operating platforms for SDVs, revealing significant advancements. Overall, more than half (56%) of respondents reported that their companies have fully integrated cloud-based platforms. Meanwhile, 36% indicated their companies are currently in the development stage, leaving only 7% of OEMs planning to start the development soon. For their part, 53% of the business department respondents reported having fully integrated cloud-based platforms, while 70% of technical department respondents said they already have fully integrated cloud-based platforms. The higher percentage reported by the technical department can be attributed to their direct involvement with the benefits and challenges of cloud-based platform integration. Technical teams often lead software implementation and integration initiatives, giving them a more intimate understanding of the process requirements.

Adoption pathways

To create the capability required to transition toward SDVs, a significant number of OEMs are actively working on a variety of strategies including business, financial, and operate models in addition to ecosystems. Half of survey respondents stated they are already fully prepared in these areas.

Business Model

A robust business model can help OEMs to create and establish a sturdy framework for operations while outlining their value proposition to successfully deliver new solutions to customers and capture the value successfully. It allows businesses to streamline their operations and gain a competitive advantage while promoting innovation in the rapidly evolving field of SDVs.

Financial Model

Effective financial models for SDVs provide insights into the funding and revenue aspects of the business to capture the quantitative financial performance. This helps to initially determine the economic viability of SDVs, guide pricing strategies, and provide a clear perspective on return on investment. This aids in attracting investment and establishing sustainable growth trajectories.

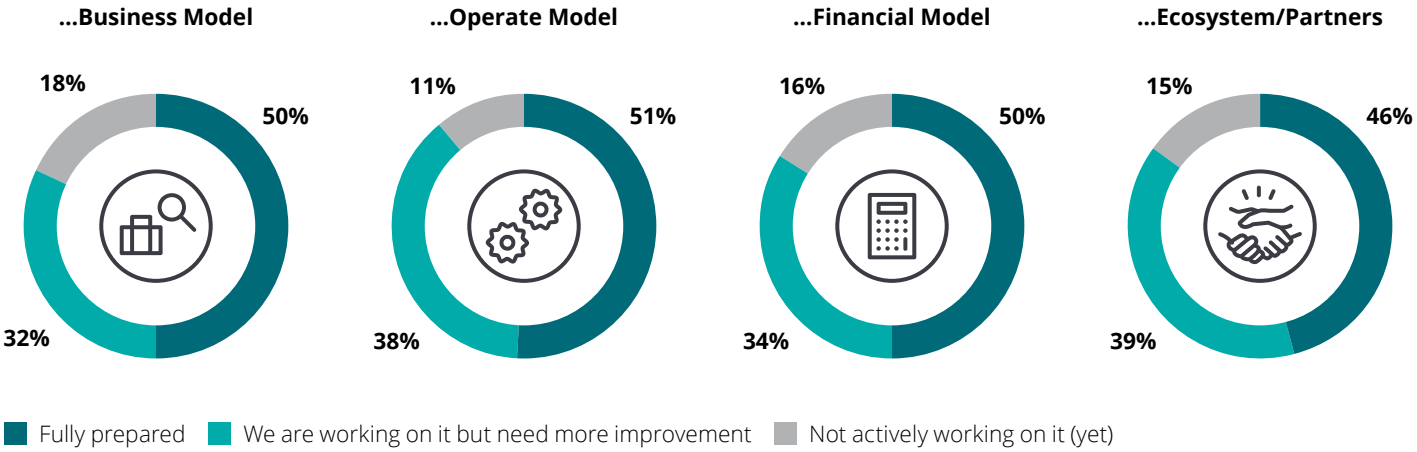
Operate Model

The operate model outlines how the SDV functions and interacts with both its immediate and extended environment. It shapes the organization's approach to advancing its SDV technology while maintaining efficiency, effectiveness, and continual growth. It guides choices surrounding SDV design, manufacture, deployment of updates, maintenance, and overall user experience.

Ecosystem/Partner

The new digital transformation in the vehicle industry is complex and interconnected. An integrated ecosystem ensures seamless interaction between various elements like vehicle technologies, infrastructure, regulations, and helps to share development costs. Partnerships and collaborations accelerate technological advancements and market penetration.

Fig. 3 – OEM preparedness regarding SDV transformation in select strategic areas



Source: Deloitte 2024 Global SDV Readiness Survey.

It is also important to highlight that monetizing SDVs and their data is not just a future possibility, but a present-day reality. Results from the executive survey conducted for this study reveal that 73% of OEMs anticipate achieving a return on investment (ROI) within five years. A strong focus on structural preparedness within these organizations can lay a solid foundation, fostering capability and long-term growth.

Deloitte's independent market analysis supports this ROI projection, estimating the incremental value of SDVs will reach between US$400–US$600 billion by 2030. This market size represents the impact of SDVs across the entire automotive value chain, integrating advanced technologies, data services, and partnerships between suppliers, technology companies, and other stakeholders in the SDV ecosystem. In addition, the market for OTA updates promises significant growth with projections rising from around US$3.3 billion in 2022 to US$14.0 billion by 2030.[3] Harnessing the power of big data and extracting significant efficiency gains play an important role in this growth trajectory. Leveraging software to streamline operations and reduce costs can help significantly enhance corporate profitability and shareholder value, while also enabling reinvestment in innovation and growth.

[3] Global automotive OTA updates market outlook by type, propulsion, vehicle type, application—industry revenue estimation and demand forecast to 2030, Research and Markets, February 2023.

Building the technical foundation

The evolution of SDVs necessitates a paradigm shift in how OEMs approach vehicle design and development, transforming traditional vehicles into dynamic platforms driven by sophisticated software and connectivity.

Innovation brought by cloud-native technologies

Cloud or software native principles are the engine powering the next generation of vehicles. These principles center around leveraging the flexibility, scalability, and resilience of cloud computing environments. These principles are proving critical as vehicles become more dependent on software and connectivity features. Key cloud-native technologies in the automotive industry include:

- **Application programming interfaces (APIs):** Enables communication between vehicle systems and external services, extending vehicle functionality.
- **Containerization:** Offers agility and portability in deploying applications, facilitating efficient management across different vehicle systems.
- **Continuous integration/continuous deployment (CI/CD):** Automates the software release process, allowing for frequent updates and improvements with minimal downtime.
- **DevOps practices:** Improves collaboration between development and operations, speeding up the release of new features and ensuring system reliability.
- **Microservices:** Enhances modularity and allows independent updating of vehicle functions such as infotainment and telematics.

Deloitte Global survey results highlight widespread adoption of cloud-native principles, with 47% of respondents stating they extensively use all cloud-native principles while a further 30% of respondents report using them to a moderate extent. This widespread adoption demonstrates the industry's recognition of the benefits of cloud-native architectures, including scalability, flexibility, and faster development cycles. As organizations gauge their capabilities, a significant majority (72%) of technical survey respondents feel completely capable of handling the demands of SDV technology. This high degree of confidence may be due,

"In contrast to the zero-fault mentality in traditional product design, software isn't free of bugs and may not ever be fully ready. OEMs should reduce complexity and establish an SDV onboard architecture with an SDV operate backend for instant bug fixes and security patches. The most successful OEMs will leverage this platform to create additional value, offering new features and third-party services throughout the vehicle lifecycle."

Elmar Pritsch, Partner, Deloitte Consulting GmbH

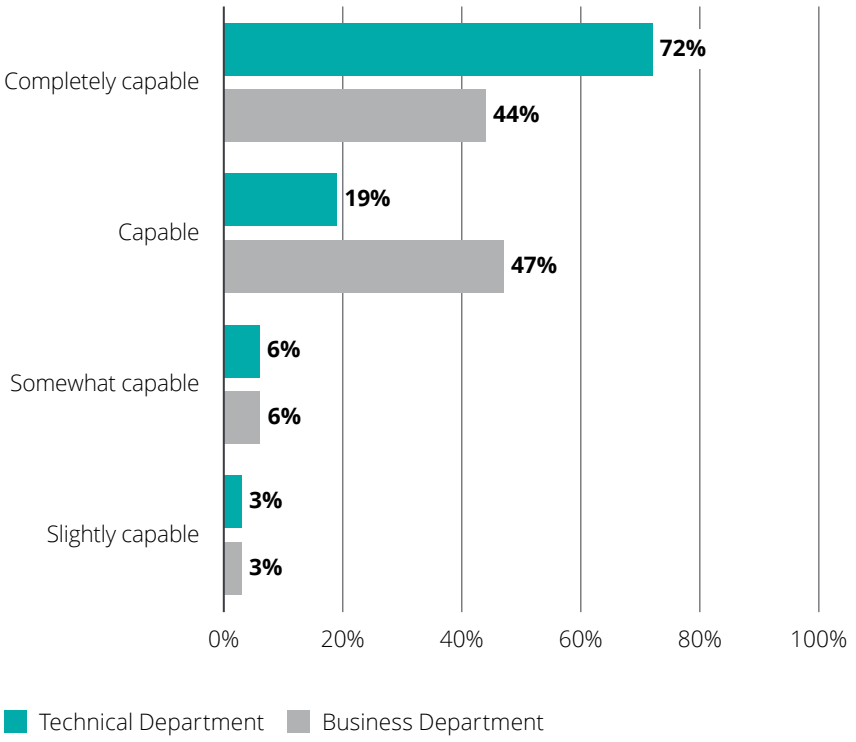
in part, to recent advancements in technology, investments in R&D, and the integration of new systems that enhance vehicle performance and connectivity. In contrast, business department survey respondents feel less confident, with only 44% feeling completely capable. The lower degree of confidence among business department executives suggests potential challenges in market adaptation and strategic alignment.

This disparity suggests that while technical teams have embraced a software-first mindset, business teams may struggle to fully grasp the potential benefits and translate technological opportunities into customer value. Engineers, who work daily with cloud-native technologies and advanced tools, can benefit from continuous training and collaboration within specialized teams, which helps to boost their confidence in the company's SDV readiness. However, business departments may not yet see the financial returns on the significant investments made in software development, instead focusing on the challenges—such as technical concerns and shifting timelines—that come with SDV implementation. As a result, there is a disconnect between the technological advancements and their integration into the broader business models. Bridging this gap is crucial to fully leverage the potential of SDVs and help ensure long-term success.

On the other hand, the lower level of confidence among business representatives could be due to various strategic and market-specific factors. Companies are faced with the challenge of not only understanding these technological advances, but also integrating them into their business models. Aspects such as adapting to market needs, the scalability of technologies, compliance with regulatory requirements and strategic alignment with long-term goals play a significant role in the equation. The fast-moving nature of the market, coupled with unpredictable changes in customer demand and competitive pressures, could lead to uncertainty as to whether the new technologies can deliver the expected business value.

The gap between these two perspectives can lead to significant challenges if no common basis for exchange and understanding is created. Close collaboration may only be effective if both sides establish a shared understanding—technicians should understand the business goals, and business representatives need to grasp the technological potential and implementation processes. Through continuous communication and mutual learning, both sides ensure that technological advances are not only innovative, but also economically viable. The successful integration of cloud-native principles and SDV technologies into the business model therefore require harmonious interaction between technology and business, characterized by shared objectives and a mutual understanding. In this way, the full potential of the technologies can be taken advantage of while simultaneously strengthening the strategic direction of the company.

Fig. 4 – How capable do you believe your current car platform is in supporting the demands of SDV technology?

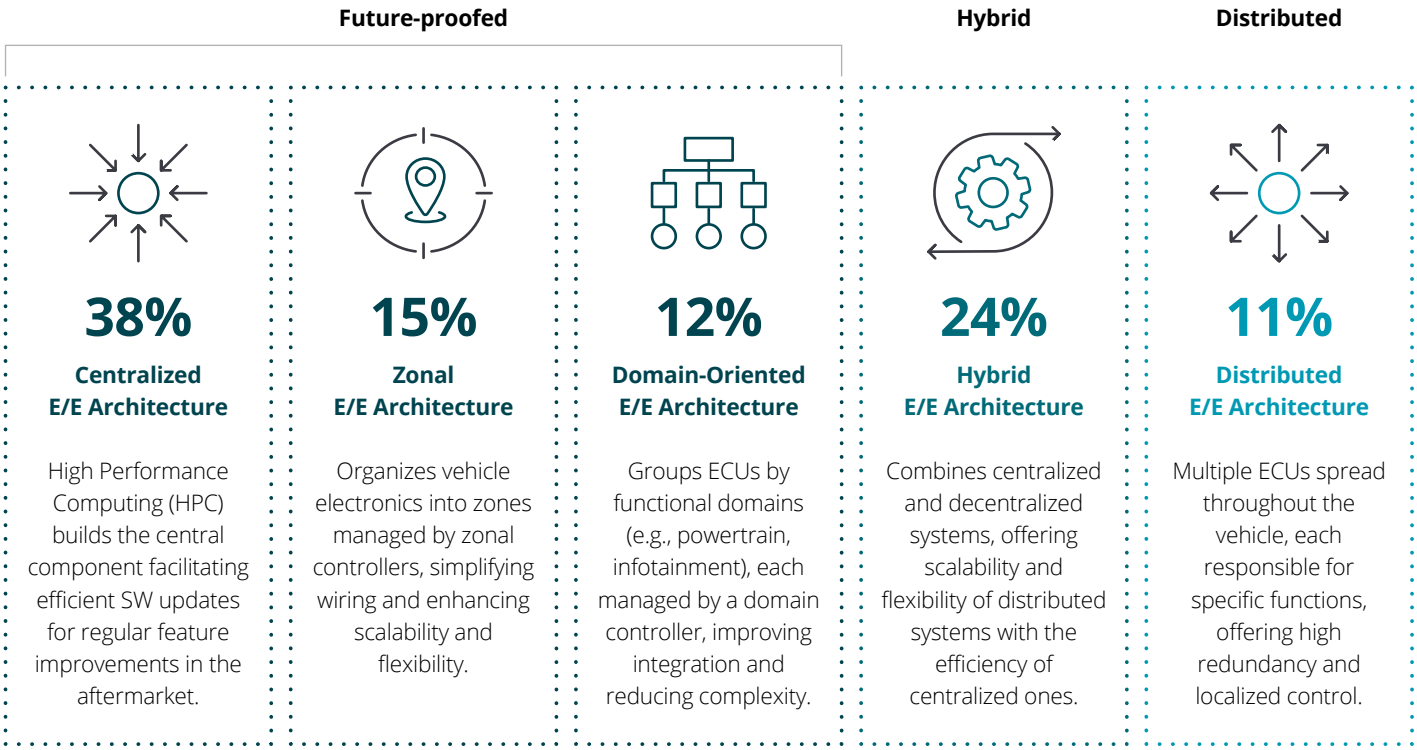


Source: Deloitte 2024 Global SDV Readiness Survey.

E/E architecture for tomorrow

The electrical/electronic (E/E) architecture within vehicles is undergoing a renaissance. This intricate web of computing platforms, electronic systems, and networks forms the central nervous system of modern vehicles, dictating their functionality, safety, and overall user experience. As we look at the current landscape and the road ahead, it is clear that E/E architecture is not just adapting but leading the automotive industry's transformation.

Fig. 5 – Predominant E/E architecture in 2030



Source: Deloitte 2024 Global SDV Readiness Survey.

By 2030, future-proofed E/E architectures—such as centralized, zonal, and domain-oriented E/E architectures—are expected to take center stage. These architectures are considered future-proofed because they consolidate computing processes and functionalities into a single or minimal number of powerful domain controllers. This consolidation enhances efficiency, reduces complexity, and improves overall system integration and security. In addition, they offer better scalability to accommodate the increasing demands for data processing and connectivity in modern vehicles. Their design helps facilitate easier updates and maintenance, making them more adaptable to future technological advancements and regulatory requirements.

This approach offers several key advantages:

- **Simplified control unit landscape:** Reduces the number of electronic control units (ECUs), simplifying vehicle electronics and making software updates more manageable.
- **Faster development cycle:** Speeds up development and innovation, reducing reliance and dependency on individual suppliers.
- **Increased vehicle reliability:** Enhances diagnostics and maintenance capabilities to reduce downtime, extending the lifespan of vehicle components through optimized energy management.
- **Enhanced vehicle features:** Offers access to advanced driver assistance systems (ADAS) and autonomous driving functions, with better connectivity and integration of digital services.

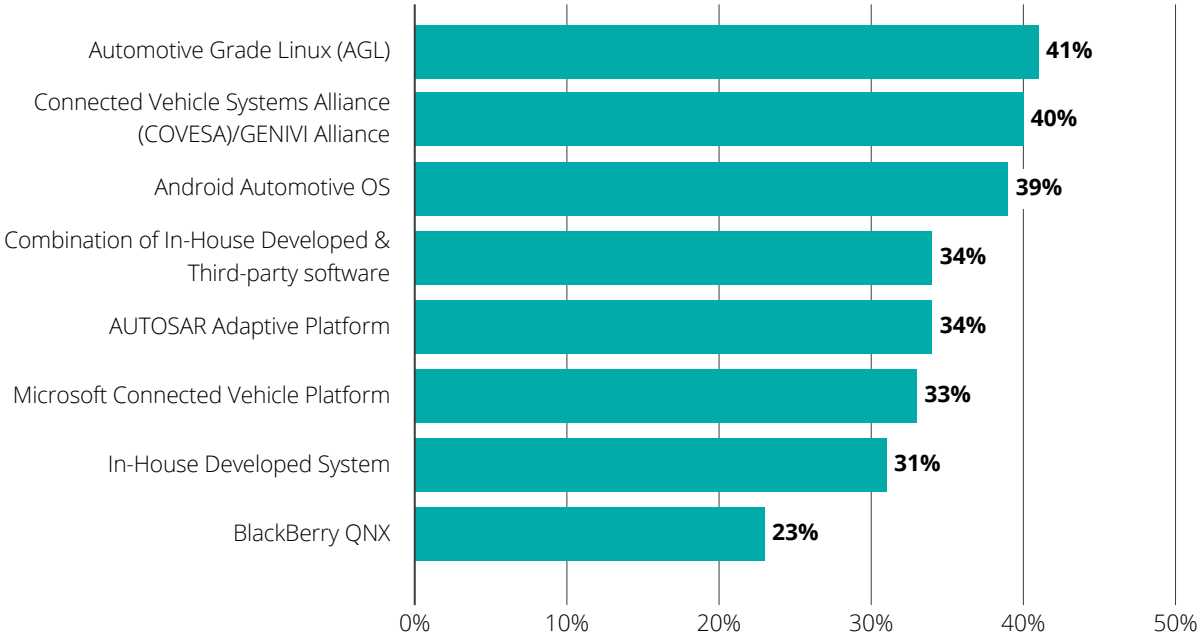
The hybrid E/E architecture (24%) combines the strengths of both centralized and decentralized (or distributed) E/E architectures. It aims to leverage the scalability and flexibility of distributed systems while benefiting from the efficiency and integration of centralized systems, providing a balanced approach to managing the diverse and evolving demands of modern vehicles. However, this approach is not future-proofed, as the increasing complexity and demands for data processing and security in modern vehicles may eventually require a more comprehensive and optimized solution.

Traditional OEMs may lean toward a gradual approach, integrating hybrid E/E architectures over time to ensure stability and manage the risks associated with overhauling legacy systems. This approach allows them to capitalize on the benefits of both centralized and decentralized systems while continuing to develop more advanced technologies. In contrast, emerging players are not weighed down by older infrastructure and can implement fully integrated architectures from the start, enabling faster product launches. While this approach carries higher risks, it allows them to take advantage of cutting-edge technologies and achieve greater efficiency.

Frameworks and operating systems

The adoption of various frameworks and operating systems (OS) in SDVs is driven by the need for robust and reliable platforms that can support a wide range of functionalities. Deloitte Global survey results suggest the most used frameworks/OS in SDV implementation include automotive grade Linux (AGL), connected vehicle systems alliance (COVESA)/GENIVI alliance, and Android Automotive OS (see Figure 6).

Fig. 6 – Frameworks/global operating systems for SDV implementation*



* multiple answers possible

Source: Deloitte 2024 Global SDV Readiness Survey.

These frameworks/OS provide the foundation for developing and deploying various applications and services within the vehicle. OEMs employ multiple frameworks in SDV implementation to leverage the specialized strengths of each platform, ensuring optimal functionality for different vehicle systems. This approach enhances flexibility and customization, allowing manufacturers to differentiate their products and meet diverse market demands. Using multiple frameworks can also increase reliability through redundancy and better integration with various third-party services. However, employing a diversity of systems can lead to increased complexity and higher maintenance costs.

Consolidating OS within an OEM's SDV implementation is challenging, particularly given the need to balance quality management (QM) and safety-critical components. The challenge is compounded by the fact that only a few automotive real-time operating systems (RTOS) are certified as ASIL B or higher which are necessary for safety-critical applications. This limits the options available for consolidation and increases the complexity of maintaining a streamlined system.

Simplifying the number of frameworks/OS can help focus resources on functional development and reduce overall expenses. Reducing the OS count simplifies maintenance while enhancing the ability to provide consistent and reliable vehicle performance. A realistic and achievable approach is to limit the SDV implementation to two OS—one dedicated to safety-critical components and another for QM components—by utilizing containerization or hypervisors on a unified hardware platform, such as high-performance computers. This strategy allows for the segregation of safety-critical and non-safety-critical functions while maintaining system efficiency and minimizing the complexity of the software stack.

Middleware can also play an important role in managing the complexity of multiple OS within SDVs. It acts as a bridge between different OS, ensuring interoperability and scalability. The use of middleware can help promote the standardization and reusability of components across different OEMs. The benefits of in-house developed middleware include:

- **Portability:** Middleware helps ensure that applications can run across different hardware platforms and OS without modification.
- **Hardware abstraction:** It abstracts the underlying hardware, providing a uniform interface for application development.
- **Interoperability:** Middleware facilitates communication and data exchange between different systems and applications.
- **Scalability:** It allows for the integration of new functionalities and services without significant changes to the existing infrastructure.

Developing in-house solutions also presents a series of significant challenges that manufacturers must carefully navigate. These challenges include high development costs while helping to ensure compatibility and maintainability.

High development costs

Creating and maintaining in-house solutions requires significant investment in both specialized talent and resources. The development process involves recruiting highly skilled professionals who possess expertise in various aspects of software development, from system architecture to coding and testing. Moreover, the costs associated with continuous training and development to keep up with the latest technological advancements can be significant. The Deloitte Global survey findings show that over 40% of companies spent more than US$1 billion on software development in the past fiscal year, with some investing as much as US$2.5 billion or more. These substantial financial commitments underscore the heavy burden OEMs face, which can strain budgets and potentially divert resources from other important areas of development.

Compatibility and maintainability

Helping ensure compatibility and maintainability across diverse hardware components and third-party applications is another formidable challenge. Vehicles often comprise a wide array of ECUs and sensors from different manufacturers, each of which has its own specifications and requirements. Developing in-house middleware that can seamlessly interact with this heterogeneous hardware landscape demands meticulous planning and execution. Additionally, maintaining compatibility as new components and applications are introduced necessitates ongoing updates and modifications, adding to the complexity and resource demands.

OEMs should focus on standardizing the software architecture and abstraction layers to create a more unified platform approach. This standardization would enable Tier 1 suppliers and third-party application developers to create solutions that are more widely applicable across different OEM models, rather than custom-building solutions for each specific project. This shift would streamline development processes and reduce costs in the long run.

Agility in software update strategies

As the automotive industry increasingly shifts toward SDVs, the role of software updates has become a critical factor in maintaining and enhancing vehicle functionality. However, updating software within vehicles is not straightforward, particularly when it involves core functionalities that are integral to vehicle operations.

Navigating the complexity of functional software updates

Functional software, which includes essential systems like ADAS and powertrain control, is pivotal to ensure vehicle safety and performance. Due to its critical nature, any updates to functional software must undergo extensive testing and validation before deployment. This is especially true for homologation-relevant software—meaning it must comply with strict regulatory standards and pass rigorous certification processes. The high costs associated with integration testing and homologation make frequent updates impractical, leading OEMs to adopt longer and more stable release cycles for functional software. The industry's approach to software updates reflects a strategic shift toward differentiating between various software types. Functional software, by necessity, follows a more deliberate and prolonged update cycle. Homologation-relevant software undergoes comprehensive testing and certification, helping to ensure compliance with regulatory standards while safeguarding the vehicle. Meanwhile, non-homologation-relevant functional software, although not subject to the same regulatory scrutiny, still requires significant testing to maintain system stability and integrity. Updates in this category can be more flexible, but they are still less frequent compared to updates for third-party applications.

Agile development for third-party applications

In contrast, third-party applications, which are generally non-critical to the vehicle's core functions, benefit from faster release cycles. These applications, such as infotainment systems and various consumer-focused applications, are often updated based on user feedback and technological advancements. The agility in updating third-party applications allows OEMs to stay competitive in the rapidly evolving technology landscape, providing drivers with up-to-date and improved functionality on a regular cadence. This approach enhances the user experience, helping to ensure vehicles remain aligned with consumer expectations and technological trends.

The strategic shift toward software differentiation

OEMs increasingly recognize the need to differentiate between functional software and third-party applications. By distinguishing between these software types, OEMs can optimize operational efficiency and the consumer experience. Functional software updates, though less frequent, help ensure the reliability and safety of the vehicle, while agile updates to third-party applications keep the vehicle's user-facing features fresh and competitive. This strategic differentiation reflects the evolving nature of the automotive industry, where the integration of advanced software solutions is becoming increasingly important. OEMs that successfully navigate this complex software ecosystem will be better positioned to leverage the full potential of SDVs, enhancing their market position and driving innovation.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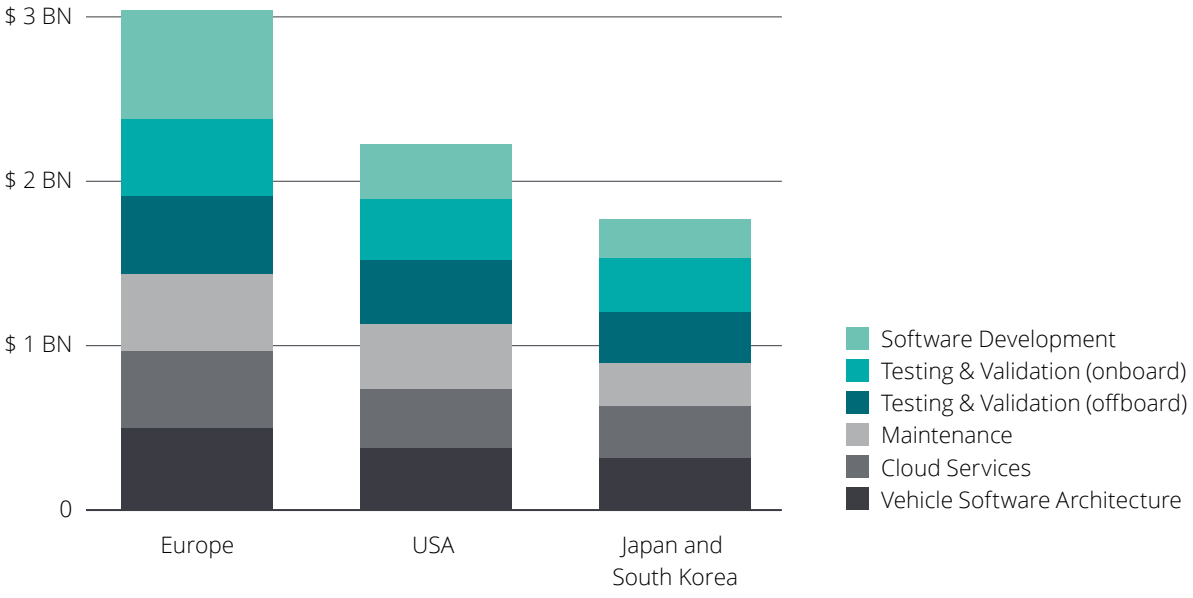
Maximizing efficiency

According to the Deloitte Global 2024 Global Automotive Consumer Study (GACS), consumers in emerging markets such as India, China, and Southeast Asia are more willing to pay for connected vehicle services, viewing these technologies as valuable enhancements. They are more likely to prioritize advanced vehicle features, connectivity, and customization. In contrast, consumers in established markets like the United States, Japan, and Germany often see these features as "nice-to-have" or standard, rather than something they are eager to invest in. For them, price remains the most important factor in vehicle brand choice. To stay competitive and meet these diverse demands, OEMs should transition to software-defined vehicles. This transition is not just a trend but a strategic imperative for the future of mobility, enabling OEMs to deliver tailored solutions that cater to varying consumer preferences across different global markets.

SDV spend and financial forecasts

At the heart of the transformation from hardware to software as the key determinant of vehicle functionality and performance, OEMs are making substantial investments in the transition to SDVs. Results from Deloitte Global SDV readiness survey suggest that OEMs are committing significant resources to this transition, with investments reaching US$3 billion, or up to one-third of their total R&D budget. Traditional OEMs from Europe and the United States are at the forefront of this transition, driven by the challenge of keeping pace with new market entrants.

Fig. 7 – Total annual R&D expenditure for SDV transition by region and category



Source: Deloitte 2024 Global SDV Readiness Survey.

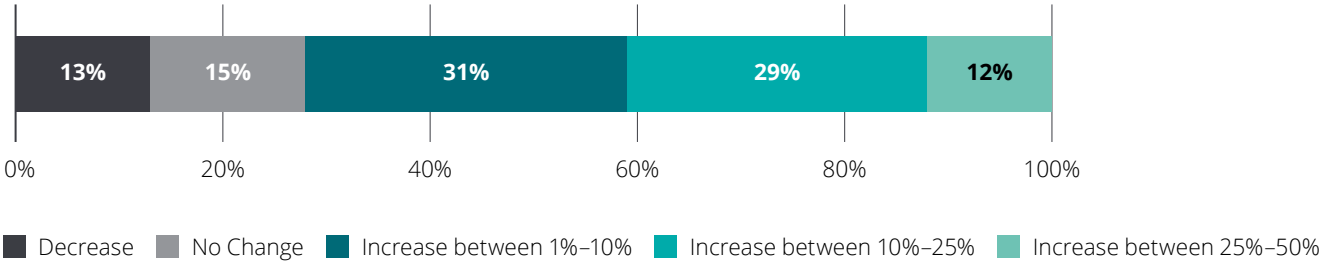
The shift to SDVs is propelled by several key factors:

- **In-house development:** OEMs are building large software engineering teams to develop proprietary OS and applications, to help ensure they retain in control of important aspects of vehicle functionality and user experience.
- **Data management:** With vehicles generating vast amounts of data, OEMs are investing in cloud infrastructure to handle real-time data processing and OTA updates, which are important for maintaining vehicle performance and security.
- **Edge computing:** To enhance the efficiency and speed of data processing, OEMs are investing in edge computing solutions that bring computational power closer to the vehicle, reducing latency and improving responsiveness.
- **Virtual environments:** Advanced simulation tools are being utilized to create virtual environments that mimic real-world driving conditions, allowing extensive testing of software features such as autonomous driving algorithms in a controlled and repeatable manner.
- **Digital twins:** This technology helps enable OEMs to create exact digital replicas of vehicles, facilitating real-time monitoring and testing. This approach helps identify potential challenges before they manifest in the physical vehicle, reducing development time and costs.
- **OTA updates:** Continuous validation processes and automated testing frameworks are employed to help ensure that new software updates do not introduce bugs or compromise safety, maintaining the integrity of the vehicle's systems.
- **Personalization and customer-centric services:** SDVs provide the flexibility to deliver customized, on-demand experiences. OEMs must now design business models that focus on offering tailored services that customers are willing to pay for, from real-time updates to feature enhancements.

In parallel, global R&D spending in the automotive sector reached US$160 billion in 2022[4], driven by advancements in electric vehicle (EV) technology and digital transformation efforts. This trend has continued into 2024, with a significant focus on electrification. As OEMs prepare for the future, Deloitte Global survey results indicate that 60% of respondents expect a slight to moderate increase in their annual R&D expenditure by 2030, potentially adding up to US$600 million in additional costs annually. Only 13% of respondents anticipate their R&D expenditure to decline over this period.

This increased spending, while necessary, puts substantial financial pressure on OEMs, impacting profitability and cash flow. Investing heavily in new technologies like electrification, autonomous driving, and connectivity requires significant upfront capital. As OEMs race to develop advanced SDVs, competition intensifies. Those who can innovate quickly and efficiently will gain a competitive edge, while others might struggle to keep pace. This competitive pressure can lead to a consolidation in the market, where only the strongest players survive. This financial burden may drive OEMs to explore various strategies for sustainability and growth, helping to ensure they can continue to innovate and coAmpete in the evolving automotive landscape.

Fig. 8 – Projected change in R&D expenditure toward 2030



Source: Deloitte 2024 Global SDV Readiness Survey.

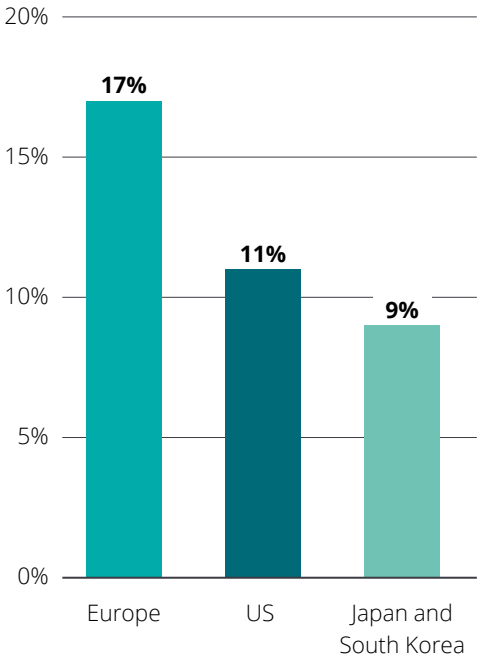
[4] European Commission: Joint Research Centre, Nindl, E., Confraria, H., Rentocchini, F., Napolitano, L. et al., The 2023 EU industrial R&D investment scoreboard, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2760/506189.

Potential for efficiency gains

Surveyed OEMs anticipate up to 20% efficiency gains in the transition to SDVs. European OEMs see the highest potential for improvements. Respondents highlight gains in software development, testing and validation, maintenance and integration, cloud services, vehicle software architecture, and reuse of software.

- **Software development:** Streamlined processes and modular architectures help enable faster and more efficient software development.
- **Testing and validation:** Virtual environments and automated testing frameworks can reduce the need for extensive physical testing.
- **Maintenance and integration:** Improved data management and OTA updates can simplify maintenance and integration processes.
- **Cloud services:** Enhanced cloud infrastructure supports real-time data processing, improving decision-making and performance.
- **Vehicle software architecture:** Modular designs and standardization reduce complexity and facilitate the reuse of software components across different models and brands.

Fig. 9 – Potential efficiency gains through the adoption of SDVs



Source: Deloitte 2024 Global SDV Readiness Survey.

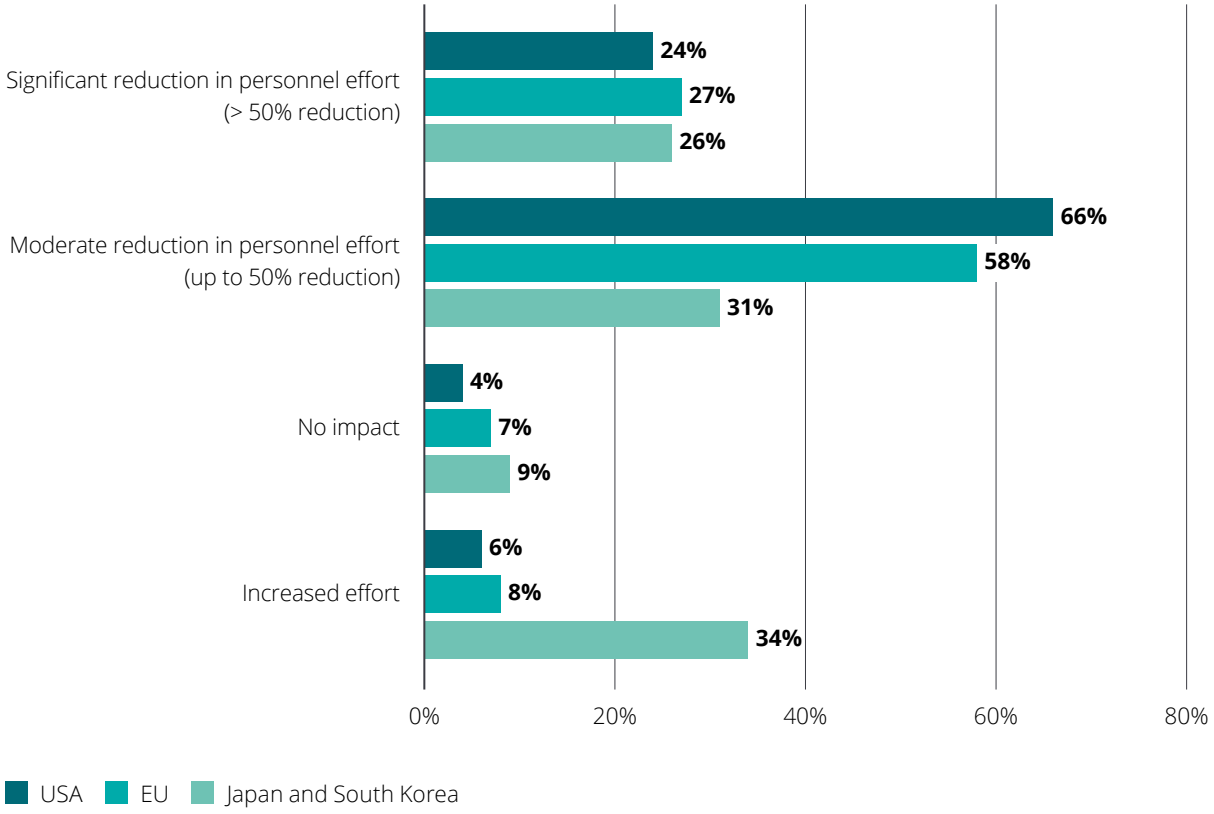
Workforce impact

The transition to SDVs is expected to lead to workforce reductions in Europe and the United States, with 80% of surveyed respondents from these regions anticipating moderate staffing cuts. This is because these regions have already completed the necessary hiring to support the transition and are now shifting focus to optimizing operations, which may decrease personnel needs in existing departments. In contrast, Japanese and South Korean OEMs are still increasing their SDV-related workforce to manage both current and future vehicle generations. These regions are investing heavily in R&D areas such as AD/ADAS, AI/ML, and software maintenance, reflecting different stages of progress in the SDV transition. Effectively managing this transition will be important for OEMs to leverage the advantages of SDVs while ensuring their workforce is upskilled and reskilled for the future.

Key areas of decreased workforce include:

- **Standardization and modularity:** Standardized hardware platforms and modular designs help reduce the complexity of development and maintenance.
- **Reduced development cycles:** Advanced simulation tools and virtual environments allow for faster and more efficient testing and validation.
- **Digital twin technology:** Real-time monitoring and testing in digital environments reduce the need for extensive physical prototypes.
- **OTA updates:** The ability to update and manage vehicles remotely reduces the need for frequent physical interventions.

Fig. 10 – Quantifying savings in personnel through the adoption of SDVs



Source: Deloitte 2024 Global SDV Readiness Survey.

Realizing efficiency through key drivers

In the shift to SDVs, achieving efficiency is critical for OEMs looking to stay competitive. Deloitte Global survey findings identified three key drivers that OEMs are leveraging to realize efficiency gains. These drivers—centralized decision-making, software simplification, and strategic partnerships—are crucial in optimizing the SDV transition journey.

Streamlining costs with centralized decision-making

In the survey, respondents were asked whether their company's SDV strategy is determined centrally by the overall group headquarters or if individual sub-brands and regions have the autonomy to make their own strategic decisions. The results showed that 69% of respondents reported using a centralized decision-making approach, where the overall group headquarters sets the SDV strategy.

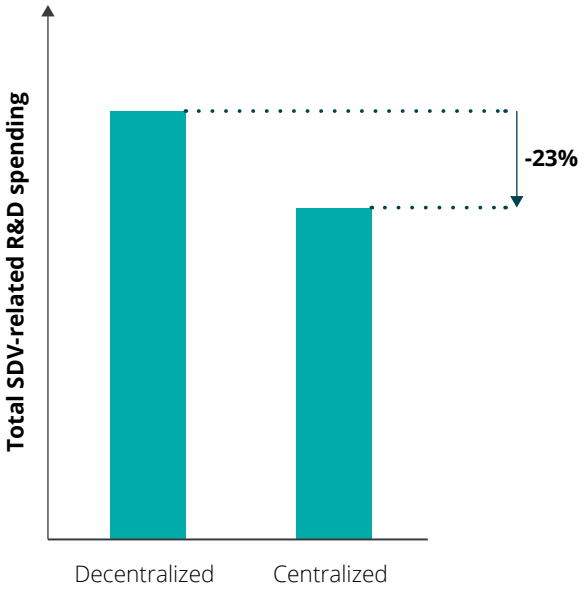
Centralized decision-making also has a significant impact on cost efficiency, with OEMs saving an average of 23% (up to US$700 million) in R&D-related costs compared to decentralized strategies. This approach can allow for streamlined strategy implementation, faster response times to market changes, and more consistent alignment with corporate goals. By adopting a centralized strategy, departments and sub-brands can work toward a common objective, minimizing duplication of efforts and maximizing resource utilization.

However, transitioning to a centralized decision-making model can pose significant challenges. It requires substantial organizational changes, including aligning various brands and regions under a unified strategy, which can be complex and resource intensive. However, a recent announcement of cross-OEM SDV collaboration highlights the industry's recognition that a unified approach is essential to remain cost-competitive in the rapidly evolving SDV landscape.[5]

Benefits of centralized decision-making:

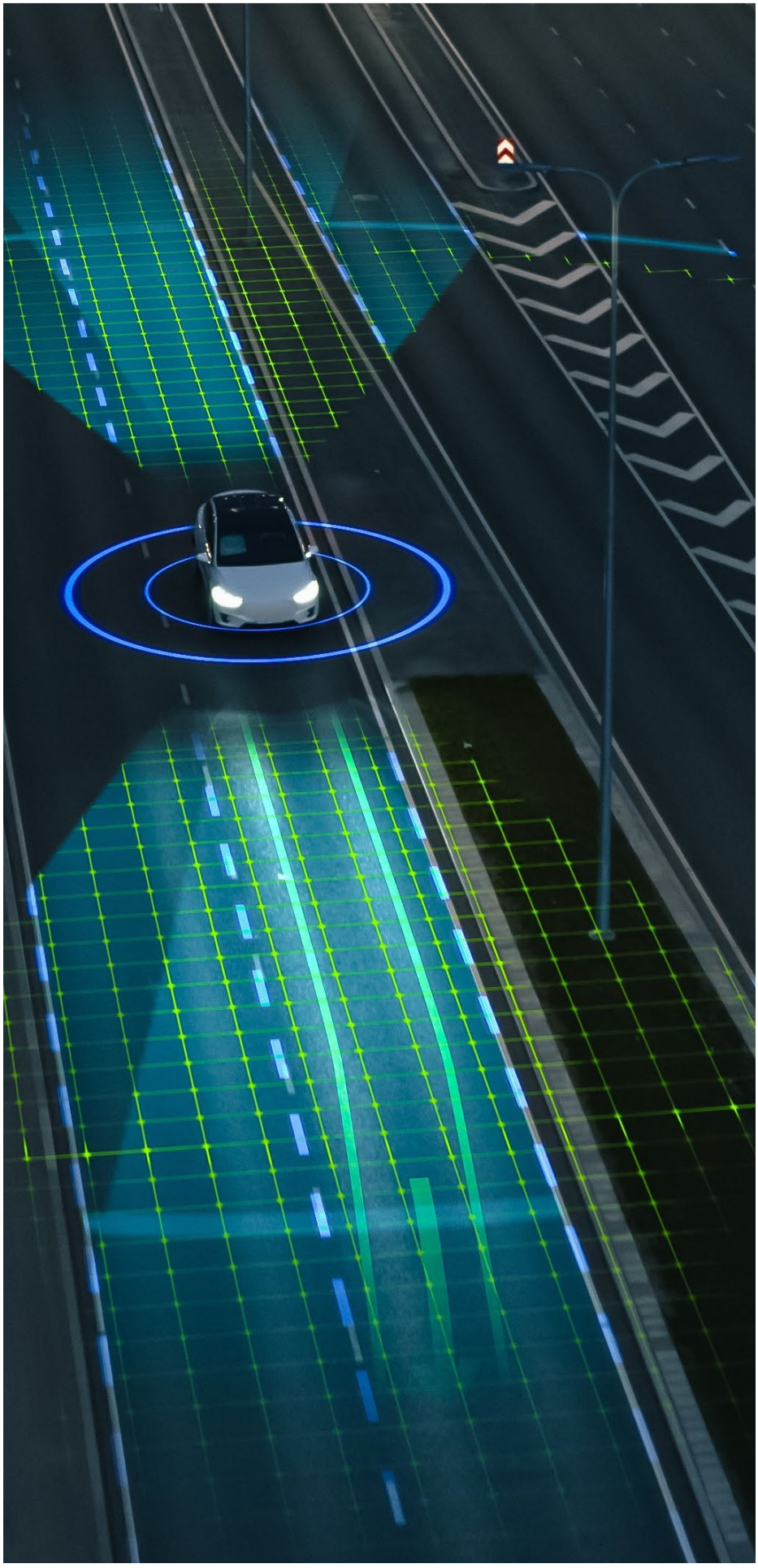
- **Strategic alignment:** Helps ensure the organization, including sub-brands and regional offices, are aligned with the overall corporate strategy, leading to more coherent and effective decision-making.
- **Cost efficiency:** Can reduces the likelihood of redundant projects and initiatives, leading to significant cost savings.
- **Speed and agility:** Helps OEMs respond more quickly to market changes and technological advancements, maintaining a competitive edge.
- **Consistency:** Provides a uniform approach to strategy and implementation across different regions and departments, helping to ensure consistency in execution and outcomes.

Fig. 11 – Impact of centralized vs. decentralized decision-making on SDV R&D spending



Source: Deloitte 2024 Global SDV Readiness Survey.

[5] EMegan Lampinen, Competition, cost drive Nissan-Honda-Mitsubishi coalition, Automotive World, August 5, 2024.



Balancing centralization with local flexibility

While centralized decision-making offers numerous benefits, it also presents challenges, such as potential delays in localized decision-making and a need for flexibility. To navigate these complexities and help ensure both strategic coherence and operational flexibility, OEMs should implement a structure that balances centralization with local autonomy. The following key success elements should be preserved within a centralized strategy:

- **Scalability and adaptability:** The central strategy should be flexible and adaptable to different regional markets, considering their unique characteristics and demands.
- **Implementing efficient communication channels:** To help ensure that information flows smoothly across the organization.
- **Defined decision-making framework:** A well-defined decision-making framework should guide both central and local decisions, delineating responsibilities and ensuring that local entities have the autonomy to act within set parameters.
- **Empowerment within a framework:** Sub-brands and regional plants should be empowered to make decisions that cater to local conditions and challenges while adhering to the central strategy.
- **Regular reviews and updates:** Conducting regular reviews of the decision-making process and updating it to address emerging challenges and opportunities.

By balancing centralized decision-making with localized empowerment, OEMs can effectively navigate the complexities of the SDV landscape, resulting in strategic coherence and operational flexibility across regions and sub-brands.

Simplifying software for operational efficiency

Reducing software versions represents another way to generate substantial efficiencies and cost savings. Deloitte Global survey results suggest that OEMs with fewer software versions (i.e., less than five) have significantly less SDV-related R&D expenditure, which can translate into savings of up to US$1 billion. However, it is important for OEMs that these savings do not come at the expense of innovation, flexibility, or overall market competitiveness.

Benefits of reducing software versions:

- **Simplified maintenance:** Fewer software versions mean less complexity in maintaining and updating the software, leading to more efficient operations.
- **Enhanced quality control:** Focusing on fewer versions allows for more rigorous testing and validation, improving overall software quality.
- **Streamlined integration:** Easier integration of new features and updates across different vehicle models and brands.

Strategies to help reduce software versions:

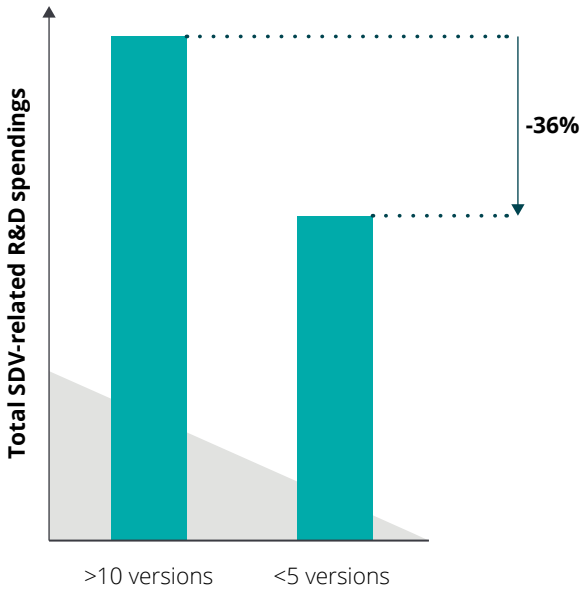
- **Standardization:** Implementing standardized software platforms across different models to reduce variability.
- **Modularity:** Developing modular software architectures that allow for easy updates and integration of new functionalities without the need for multiple versions.
- **Centralized control:** Maintaining centralized control over software development for consistency and to avoid unnecessary proliferation of versions.

However, reducing complexity is not without its challenges. Various factors contribute to the persistence of numerous software versions:

- **Diverse requirements:** Different markets and regulatory environments often require specific functionalities and compliance features, leading to the need for multiple software versions.
- **Legacy systems:** Many OEMs have to support a range of legacy systems and older vehicle models, which complicates efforts to standardize and reduce software versions.
- **Customization:** Consumers increasingly demand personalized features and customization options, necessitating a variety of software versions to cater to different preferences and specifications.
- **Innovation and competition:** Rapid technological advancements and competitive pressures push OEMs to frequently update and diversify their software offerings to stay ahead in the market.

Understanding these challenges is important for OEMs as they strive to balance the benefits of reducing software versions with the realities of a dynamic and varied market environment. By addressing these complexities through strategic planning and innovative approaches, OEMs can work toward achieving greater efficiency and cost savings while meeting diverse market demands.

Fig. 12 – Impact of software version reduction on SDV-related R&D expenditure



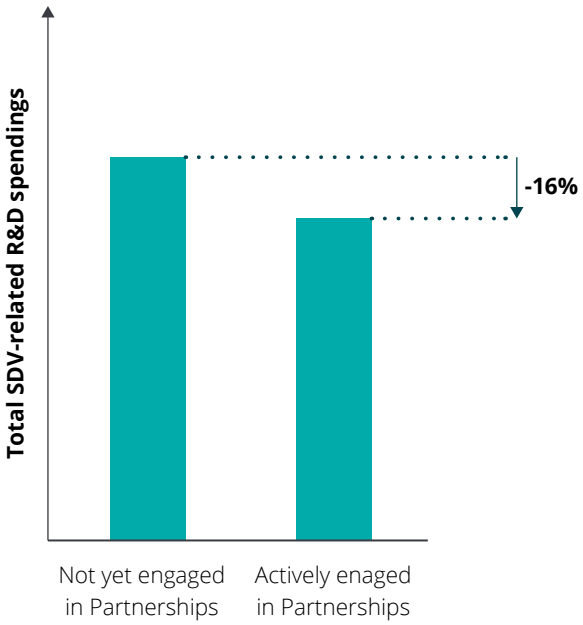
Source: Deloitte 2024 Global SDV Readiness Survey.

Leveraging strategic partnerships
Partnerships play an important role in accelerating the transition to SDVs. Deloitte Global survey results indicate that more than 80% of self-proclaimed SDV leaders are actively engaged in partnerships today. There is a noticeable trend where OEMs are collaborating with other OEMs to build and establish a broader ecosystem for SDVs. Some Japanese and South Korean OEMs are already actively engaged in partnerships with other OEMs, and US and European OEMs are following this trend. OEMs increasingly recognize that they may not be able to navigate the complexities of SDV development alone. The scale of investment, rapid pace of technological advancements, and the need for specialized skills make it difficult for any single company to maintain a competitive edge independently. Partnerships provide access to a broader range of expertise and resources, making them essential for staying at the forefront of innovation.

Benefits of partnerships:

- **Access to expertise and technology:** Collaborating with tech companies allows OEMs to leverage cutting-edge technologies and specialized knowledge, which may be challenging to develop independently.
- **Cost sharing and risk mitigation:** Partnerships help OEMs share the financial burden and risks associated with high R&D expenditures. The survey results suggest OEMs estimate the potential total savings from partnerships at around 16%. Given that investments in the transition to SDVs can reach up to US$3 billion, this saving can be substantial, amounting to as much as US$500 million.
- **Accelerated innovation and time-to-market:** Joint ventures can speed up development cycles, allowing OEMs to bring new technologies to market more quickly.
- **Enhanced consumer experience:** Partnerships can enhance the consumer experience by integrating various services and continuously improving vehicles through OTA updates and new feature additions.

Fig. 13 – Impact of strategic partnerships on SDV-related R&D expenditure



Source: Deloitte 2024 Global SDV Readiness Survey.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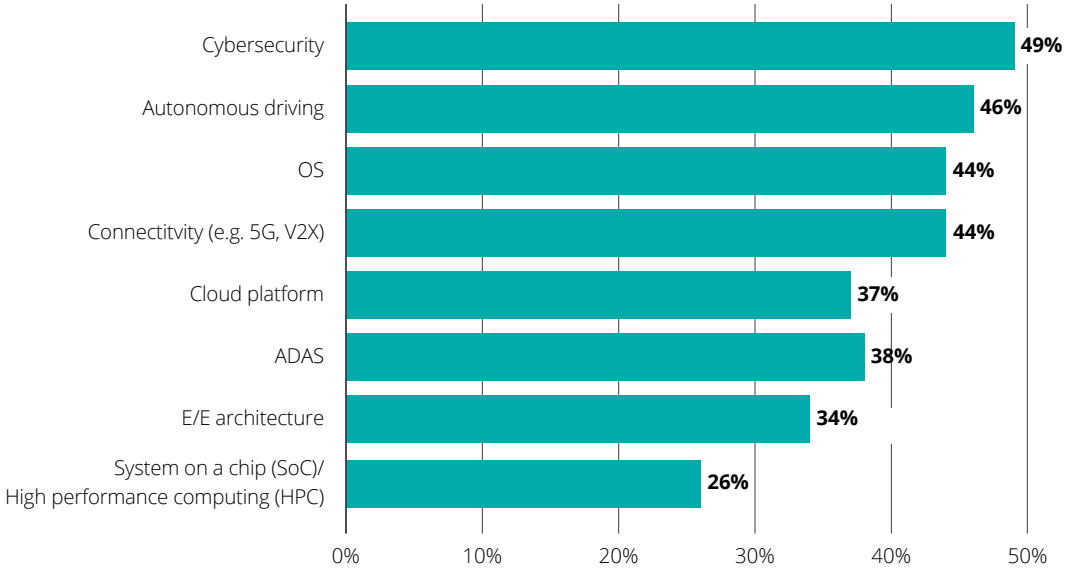
However, it is important to consider whether these cost savings from partnerships outweigh the potential loss from splitting profits with partners. While partnerships provide significant cost benefits and risk mitigation, the profits generated from new technologies and innovations may also be shared with the partner. OEMs must weigh these financial considerations against the strategic advantages that partnerships offer.

Despite this trade-off, strategic partnerships are increasingly seen as important for tackling complex challenges and driving innovation. According to Deloitte Global survey results, OEMs are currently focusing their strategic partnerships on three key areas: cybersecurity, autonomous driving, and OS. These areas represent the most critical domains where collaboration is already happening. By partnering with specialized companies in these fields, OEMs are gaining the necessary expertise and technological edge to excel in the SDV market.

Ultimately, the decision to engage in partnerships should be guided by a comprehensive evaluation of both immediate financial impacts and long-term strategic benefits. By balancing the cost savings and profit-sharing dynamics, OEMs can make informed decisions that support their growth and competitiveness in the evolving automotive landscape.

Fig. 14 – Key areas where OEMs choose strategic partnerships in SDV transformation*



* multiple answers possible

Source: Deloitte 2024 Global SDV Readiness Survey.

Deep dive:
Increasing importance of cybersecurity

According to the results of the executive survey conducted for this study, cybersecurity has emerged as one of the most critical concerns for automotive manufacturers due to the increasing "software-ization" of vehicles. OEMs should now consider themselves as software developers, adhering to regulatory requirements like UNECE R155 and R156.[6] The complexity of achieving comprehensive cybersecurity has increased, making it difficult even for large OEMs to keep up with evolving threats. The scarcity of qualified cybersecurity professionals further complicates this challenge. Collaborations with external experienced leaders and specialized service providers help OEMs bridge this talent gap.

"Partnerships in cybersecurity are important for OEMs to leverage external expertise, meet evolving regulatory requirements, and manage risk. By sharing resources and intelligence, OEMs can transform cybersecurity into a strategic advantage."

Ingo Dassow, partner, Deloitte Consulting GmbH

Examples of strategic collaborations in cybersecurity:

- **Automotive Information Sharing and Analysis Center (ISAC):** Pools cyber intelligence from various OEMs and suppliers, despite limitations due to antitrust regulations and business secrecy concerns. This organization plays an important role in threat intelligence and fleet monitoring (virtual security operations center).

- **Managed service providers:** Collaborating with managed service providers helps enable OEMs to outsource comprehensive Security Operations Center (SOC) and Security Incident and Event Management (SIEM) operations. This approach allows OEMs to operate a holistic SOC/SIEM for the vehicle, production, and supply chain, as well as enterprise IT domains externally, making cyber protection significantly more effective.

[6] Ingo Dassow and Thilo Bebber, Cybersecurity trends in different industries, Deloitte, April 2024.

The role of OTA updates in reducing vehicle recalls

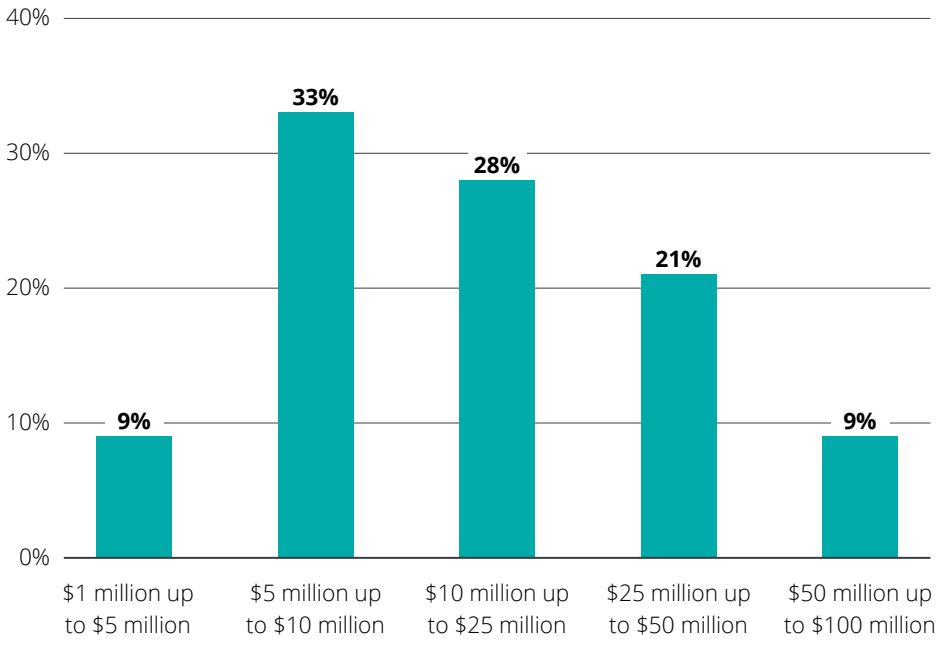
One of the most promising solutions to address vehicle recalls is the implementation of OTA updates. These updates allow manufacturers to remotely fix software issues without requiring the vehicle to be taken to a service facility. This capability helps to enhance the user experience by minimizing disruptions and provides significant advantages in recall avoidance and cost savings.

In June 2024, an OEM "recalled" 1.85 million vehicles in the United States due to software that failed to detect improperly closed hoods, increasing the risk of accidents. Instead of physically recalling affected vehicles to service facilities, the OEM deployed an OTA update that modified the software to recognize an open hood and promptly alert the driver.[7] This approach clearly demonstrates the effectiveness of OTA updates to swiftly address obvious safety concerns in a cost-efficient manner.

Deloitte Global survey results indicate a strong consensus on the effectiveness of OTA updates in mitigating recalls as 60% of respondents believe that regular OTA updates can prevent between 50% and 75% of potential recalls. A further 9% of survey respondents felt that OTA updates could prevent more than 75% of potential recalls.

Avoiding recalls through OTA updates not only enhances vehicle reliability and customer satisfaction but also offers considerable cost savings. Traditional recalls involve significant expenses, including logistics, labor, replacement parts, and the inconvenience caused to vehicle owners. In contrast, OTA updates can be deployed swiftly and efficiently, reducing the financial burden on manufacturers and the inconvenience to customers.

Fig. 15 – Cost savings if faulty software could be rectified via OTA updates.



Source: Deloitte 2024 Global SDV Readiness Survey.

[7] David Shepardson and Disha Mishra, Tesla recalls 1.85 million US vehicles over unlatched hood issue, Reuters, July 30, 2024.

Unlocking the value of SDVs

The evolution of software has helped enable new opportunities for data monetization, prompting OEMs to reassess their strategies and form relationships to leverage external experience. OEMs should balance offering personalized services with addressing consumer concerns about data privacy, particularly as willingness to pay for connected services varies significantly between developing and developed markets.

Capitalizing on data to redefine business models

Each leap forward in connected car technology produces a wealth of data, enabling services that add value for consumers and create monetization opportunities for manufacturers. The seamless integration of vehicles with cloud platforms allows for thorough data analysis, leading to personalized pricing for services and a deeper understanding of vehicle usage patterns. This integration enhances the ability to tailor services to individual needs and preferences, thereby improving customer service.

Deloitte Global survey results indicate that companies plan to monetize data produced by SDVs through several key strategies. The most popular approach, chosen by 30% of survey respondents, is to use data to offer enhanced services, providing advanced and personalized features to customers. By leveraging the data to provide advanced and personalized features, companies can significantly improve the customer experience, tailoring services to meet individual needs.

The second most widely favored method, preferred by 26% of survey respondents, is forming partnership models. This strategy involves collaborating with other businesses to maximize the value derived from SDV data. Partnerships could enable the sharing of data insights, co-development of new services, or the creation of integrated solutions that combine strengths from multiple companies. Such collaborations can enhance innovation and expand market reach, benefiting the parties involved.

Direct sales of data remain the least popular approach. Deloitte Global's 2024 Global Automotive Consumer Study (GACS) found that consumers, especially in developed markets, are hesitant to share personal information with third parties. This hesitancy is also reflected in the results of the Deloitte Global SDV readiness survey conducted for this study, as companies focus on customer satisfaction through enhanced services and in-house data use.

Regional differences in consumer willingness and trust

To align with the findings of the GACS, it is important to acknowledge that while consumers value personalized and enhanced services, their concerns about data privacy should be addressed. The study shows that consumers in developing markets such as India, China, and Southeast Asia are more willing to pay for connected vehicle services compared to those in developed markets like the United States, Japan, and Germany. This willingness presents a significant opportunity for OEMs to introduce monetized connected services in these regions while maintaining a focus on data security and transparency to build trust globally.

In addition, the study reveals that consumers in developing markets are very interested in connected vehicle features, even if it means sharing their personal identifiable information. Features like maintenance updates, traffic congestion updates, and safer route suggestions are among the most desired. Conversely, in developed markets like Germany and the United States, a significant portion of survey respondents do not trust anyone with their data, presenting a challenge for OEMs aiming to monetize connected services. OEMs can help address these trust concerns by ensuring robust data protection and transparent data usage policies.

Differentiation in a standardized market

As data monetization practices become standard across the industry, OEMs will need to differentiate themselves from competitors. This can be achieved through:

- **Unique service offerings:** Developing exclusive features or services that set them apart from other OEMs.
- **Superior data security:** Offering unparalleled data protection to build consumer trust and loyalty.
- **Innovative collaborations:** Forming strategic alliances that provide advantages and expand service capabilities.
- **Customer-centric approaches:** Continuously focusing on enhancing customer satisfaction and addressing their evolving needs.

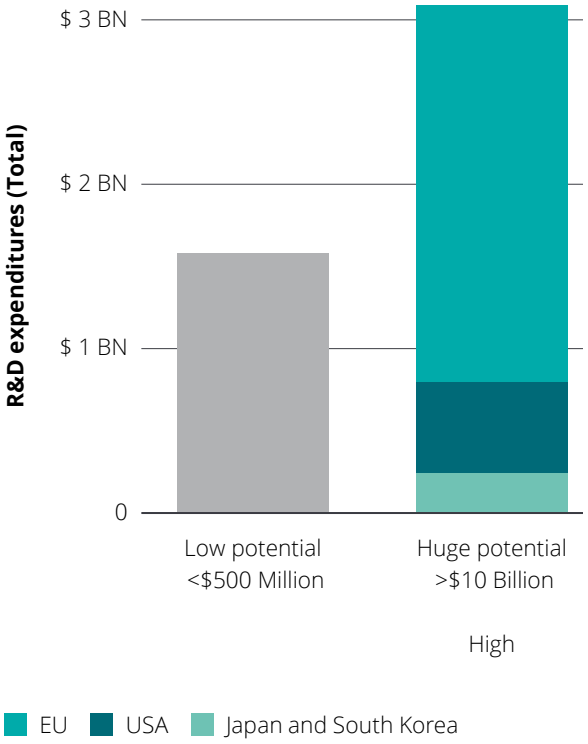
By focusing on these strategies, OEMs can stand out in a market where data monetization practices are commonplace, ensuring they remain competitive and continue to add value for their customers.

Harnessing digital services to drive profit

The potential for digital services exceeding US$10 billion continues to drive substantial R&D investments in the automotive industry. Both European and US OEMs recognize significant opportunities in digital and connected services, driven by the competitive nature of their markets. To stay ahead, these OEMs prioritize innovation, constantly introducing new digital features to attract and retain customers.

The adoption of connected features facilitates continuous interaction with customers, offering opportunities to upsell services and cultivate long-term relationships. Moreover, the capability to collect and analyze extensive data from connected vehicles provides OEMs with valuable insights into consumer behavior, preferences, and vehicle performance. This data-driven approach helps OEMs tailor their offerings more precisely, delivering features that are more appealing and relevant to their customer base.

Fig. 16 – Regional R&D investments driven by potential revenue from digital services



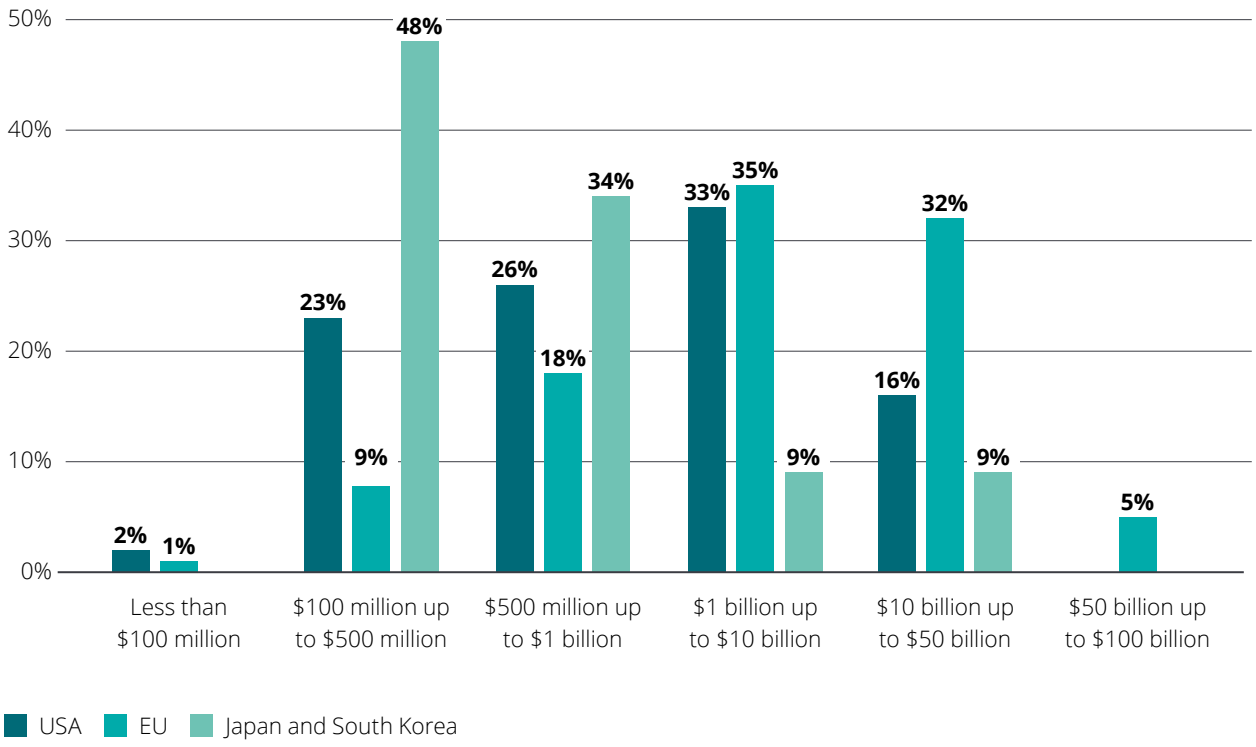
Source: Deloitte 2024 Global SDV Readiness Survey.

Adopting adequate pricing models

Most OEMs have high expectations for the profitability of digital services, with nearly a third of survey respondents projecting profits in the US$1 billion to US$10 billion range. On average, OEMs see potential profits of around US$775 million. Increased functionality and customization offered by SDVs allow for greater personalization of features and services, tailored to individual user preferences. This personalization can lead to higher customer satisfaction and loyalty, driving up revenue.

Most OEMs (81%) expect to generate significant revenue from data monetization, indicating broad confidence in the financial potential of data-driven services. The average expected revenue is around US$720 million over the next five years.

Fig. 17 – Projected revenue from data monetization in SDVs over the next five years



Source: Deloitte 2024 Global SDV Readiness Survey.

One strategy for data monetization involves licensing vehicle data to third-party developers and service providers. This collaboration benefits both parties: developers gain access to crucial data on vehicle performance and driver behavior, which helps them create innovative automotive solutions, while OEMs receive ready-made products that enhance customer experience. The key is to distinguish between creating value from data and realizing that value as financial gain.[8] Companies should consider packaging insights like targeted consumer behavior analytics and selling them as high-value products. Failing to leverage the full potential of data is similar to underutilizing a company's talent, facilities, or equipment. This perspective emphasizes the importance of a strategic approach to data monetization, ensuring that value is not only created but also realized.

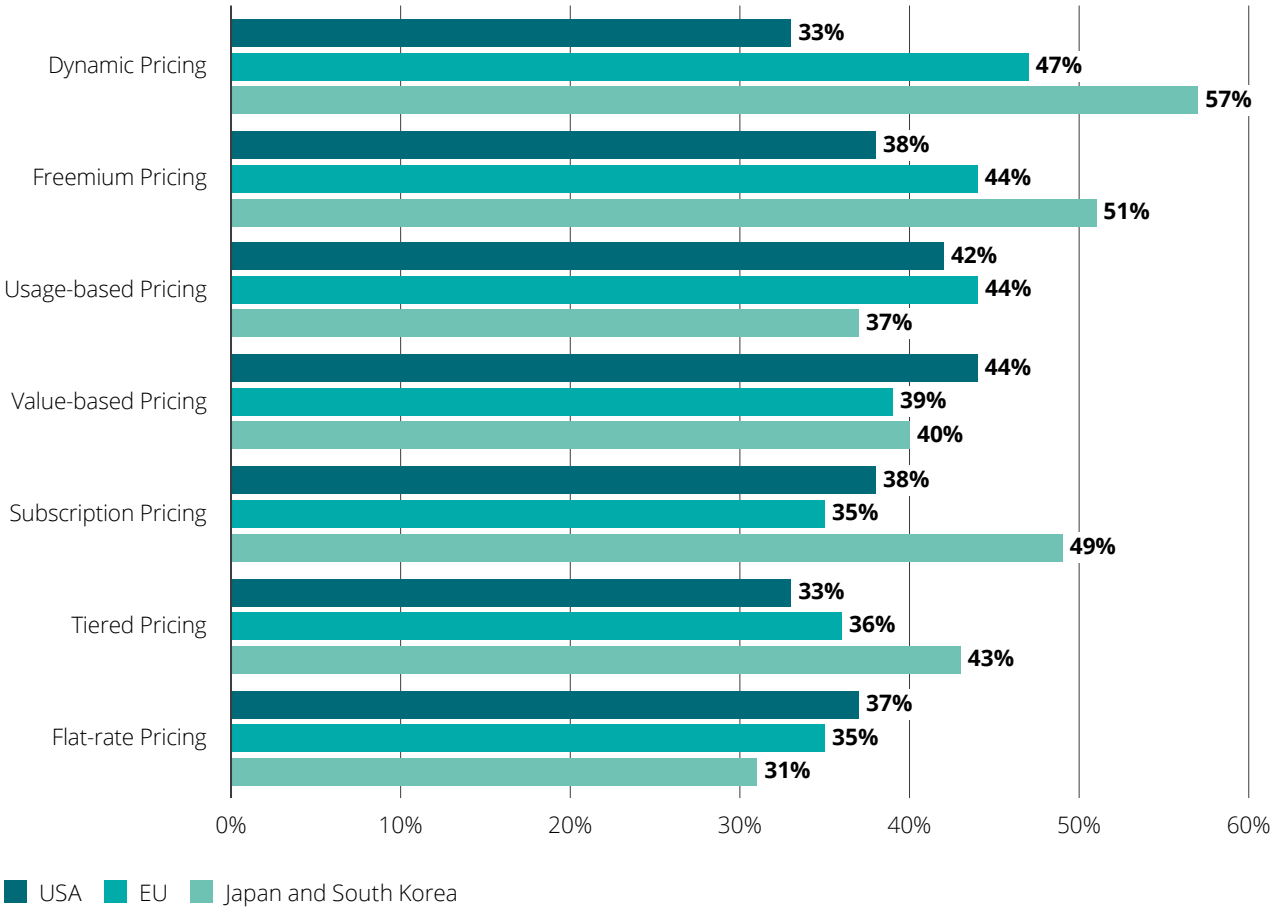
Furthermore, OEMs are experimenting with various pricing strategies for their digital services and features. These include:

- **Value-based pricing:** Pricing based upon the perceived value to the customer.
- **Usage-based pricing:** Charges based on the frequency of updates applied.
- **Tiered pricing:** Different charges for basic, premium, etc., updates.
- **Dynamic pricing:** Prices fluctuate based on demand, time, and other factors.
- **Flat rate pricing:** A standard charge for all updates.
- **Freemium pricing:** Basic updates for free, with charges for advanced features.
- **Subscription pricing:** Regular (monthly/yearly) fees covering all updates.

- **Tiered pricing:** Different charges for basic, premium, etc., updates.
- **Usage-based pricing:** Charges based on the frequency of updates applied.
- **Value-based pricing:** Pricing based upon the perceived value to the customer.

Among these strategies, dynamic pricing emerges as the most favored by survey respondents. The preference for dynamic pricing likely stems from its flexibility and responsiveness to market conditions. By adjusting prices in real-time based on customer behavior, demand fluctuations, and competitive actions, companies can potentially maximize revenue and customer satisfaction.

Fig. 18 – Pricing strategies for digital services and features in SDVs



Source: Deloitte 2024 Global SDV Readiness Survey.

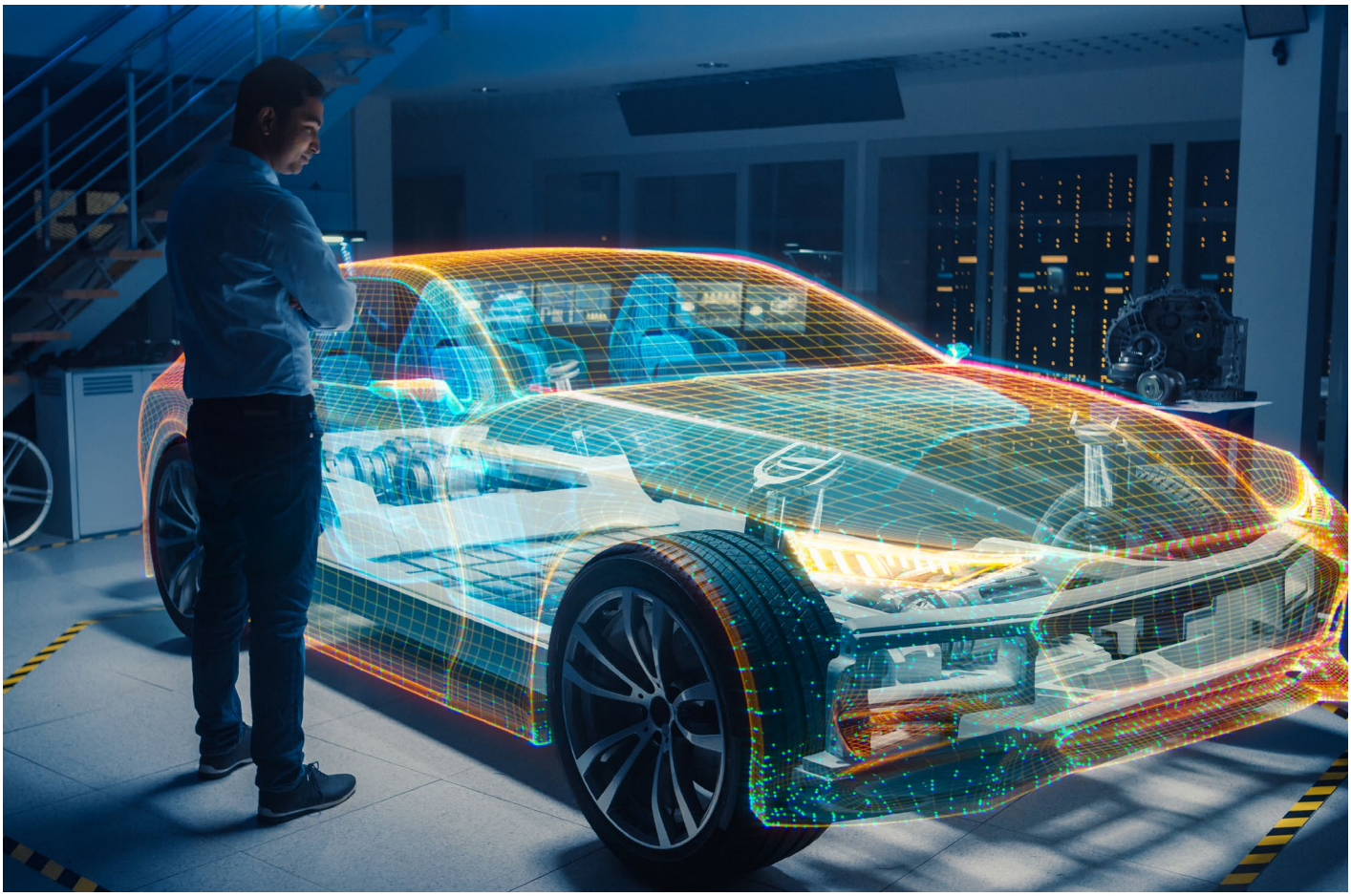
[8] Dr. Milan Kumar, Four proven data monetization strategies in the age of AI, Forbes, August 8, 2024.

Regional analysis reveals a strong inclination toward dynamic pricing for SDV data monetization in Japan and South Korea. This preference is likely driven by consumers in these regions who highly value personalized and flexible services, which dynamic pricing provides by adjusting costs based on real-time data and usage patterns. However, a survey by the Japanese Consumer Affairs Agency on consumer awareness and behavior on digital platforms conducted in Japan[9] shows that approximately half of the respondents surveyed were concerned about personalized pricing, with only 27% aware of its use. This contradiction suggests that while consumers may appreciate this pricing strategy for personalized services, their views could differ when it comes to larger purchases like vehicles. This highlights the need for further exploration to understand how consumer attitudes toward personalized pricing might vary globally across different industries and markets.

Respondents based in Europe also show a preference for dynamic pricing options, albeit with less variation across strategies compared to Japan and South Korea. This could be due to the slower pace of innovation indicated by the Deloitte Global survey results, leading to a less pronounced emphasis on a specific pricing strategy.

In contrast, the United States is leaning toward a more stable pricing model, with value-based pricing emerging as the most popular strategy. This approach allows OEMs operating in the United States to adapt to consumer trends while maintaining more consistent pricing versus the variability of dynamic pricing.

Overall, consumers in more developed markets exhibit a reluctance to pay higher prices. However, it is noteworthy that a greater percentage of consumers in developing markets show a keen interest in connected car features, even if it means sharing their personal information with third parties. This trend underscores the popularity of dynamic pricing among many OEMs. Currently, many of these OEMs are still in the experimental phase with SDVs, as dynamic pricing stands out for its flexibility and responsiveness to market demands. The Deloitte Global survey also highlighted price as one of the most critical factors for consumers when purchasing a service.



[9] The survey of user awareness and behavior on digital platforms, Japanese Consumer Affairs Agency, May 20, 2020.

Conclusion

The shift to SDVs is revolutionizing the automotive industry, transforming vehicles into software-driven platforms that evolve throughout their lifecycle. This transformation offers significant opportunities for efficiency gains, new revenue streams, and innovative business models. However, the journey requires more than just technological advancement; it demands strategic foresight, robust digital infrastructure, and strong organizational alignment.

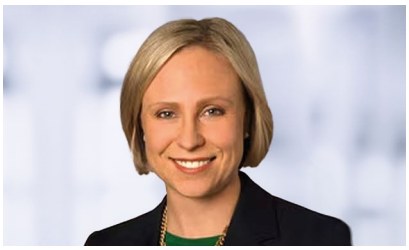
OEMs should prioritize the integration of advanced digital infrastructures, embrace the agility of cloud-based platforms, and help ensure their organizations are structurally ready to navigate this transition. Aligning technical and business strategies is important for driving a cohesive approach that can meet the diverse demands of global markets. The survey conducted for this study also highlights the importance of centralizing decision-making processes to drive consistency and efficiency while allowing for localized flexibility.

Moreover, the growing importance of cybersecurity and the ability to quickly adapt through OTA updates are critical to maintaining competitiveness and consumer trust. Strategic collaborations play a vital role in this transition, as it is unlikely that any company can effectively navigate the complexities of SDV development alone. Collaborations in areas like cybersecurity, autonomous driving, and OS are important to accelerate innovation and share the costs and risks involved. OEMs must act decisively and swiftly to embrace the SDV revolution. This means not only investing in the necessary technologies but also fostering a culture of continuous innovation, collaboration, and adaptability. The automotive industry stands at a crossroads, where the choices made today will determine the leaders of tomorrow.

Contacts

Dr. Elmar Pritsch
Partner | Deloitte Consulting GmbH
Global SDV Lead
epritsch@deloitte.com

Stavros Stefanis
Partner | Deloitte Consulting LLP
US SDV Lead
sstefanis@deloitte.com



Lisa Walker
Partner | Deloitte Consulting LLP
US Automotive leader
lisawalker@deloitte.com

Masato Shoji
Partner | Deloitte Touche Tohmatsu LLC
Japan Automotive leader
masato.shoji@tohmatsu.co.jp

Tae Hwan Kim
Partner | Deloitte Consulting LLP
Korea Automotive leader
taehwankim@deloitte.com

Erik Thorwirth
Partner | Deloitte Consulting GmbH
Germany SDV Lead
ethorwirth@deloitte.de

Key contributors

Friedemann Döring
Manager
Deloitte Consulting GmbH
fdoering@deloitte.de

Corina Cruceru
Manager
Deloitte Consulting GmbH
ccruceru@deloitte.de

Anastasia Gerbel
Consultant
Deloitte Consulting GmbH
agerbel@deloitte.de

Ryan Robinson
Director
Deloitte Canada
ryanrobinson@deloitte.com

Christopher Ahn
Principal
Deloitte Consulting LLP
chriahn@deloitte.com

Chris Barber
Senior Manager
Deloitte Services LP
chrbarber@deloitte.com

Yuichi Murakami
Director
Deloitte Tohmatsu Consulting LLC
ymurakami@tohmatsu.co.jp

Kei Kano
Manager
Deloitte Tohmatsu Consulting LLC
kei.kano@tohmatsu.co.jp

Emiri Kono
Associate
Deloitte Tohmatsu Consulting LLC
emiri.kono@tohmatsu.co.jp

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