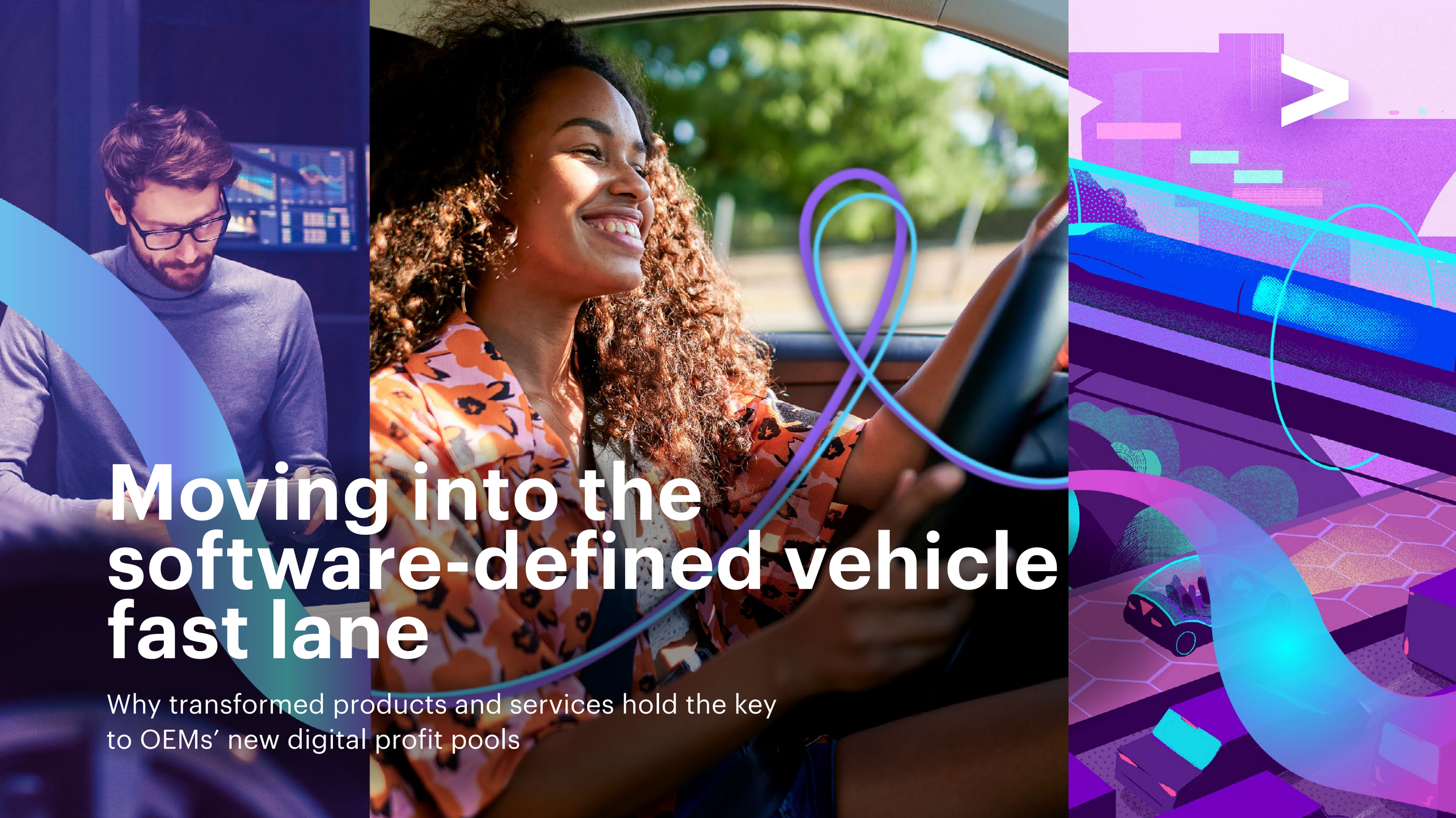
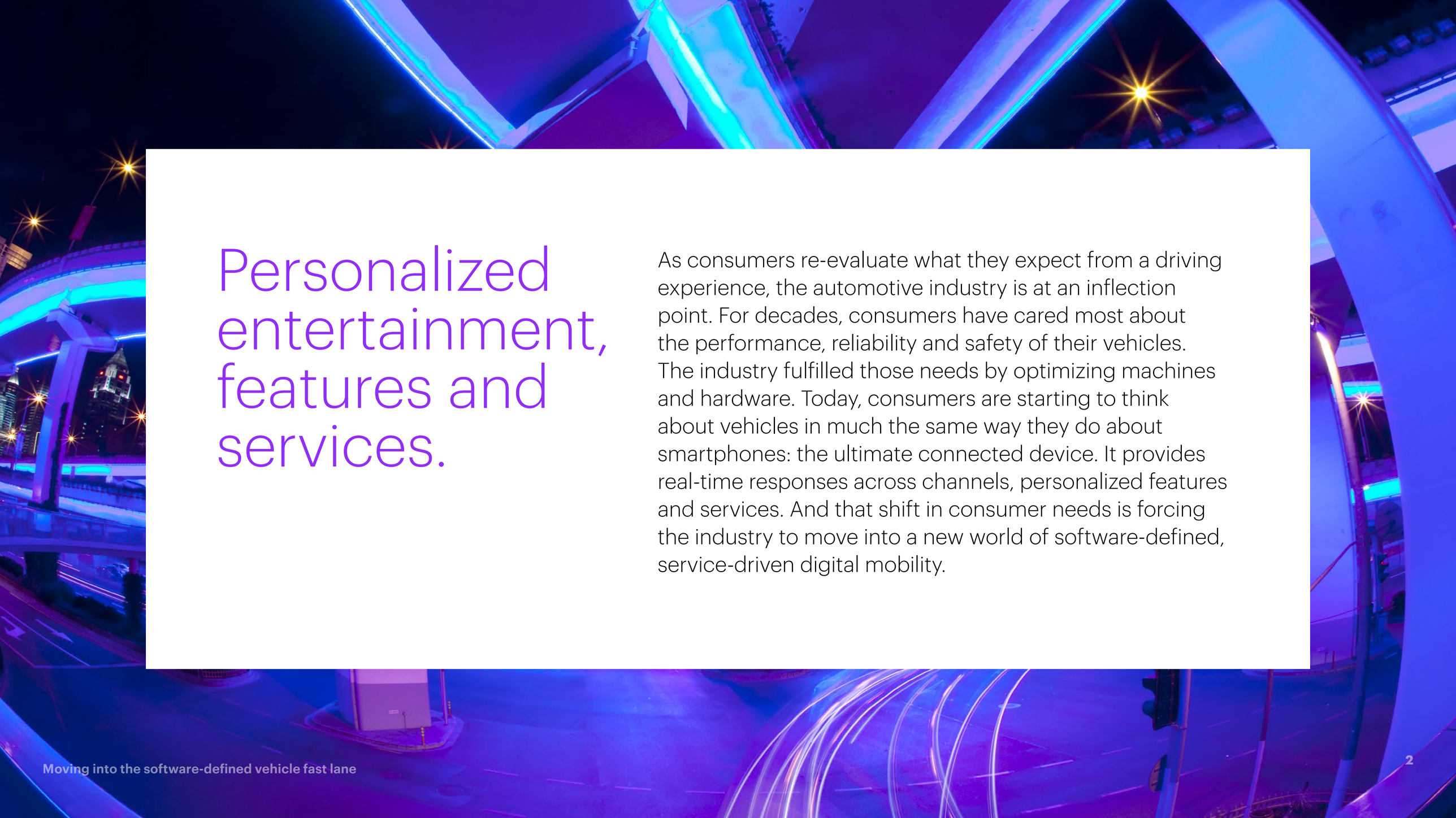


Moving into the software-defined vehicle fast lane

Why transformed products and services hold the key to OEMs' new digital profit pools

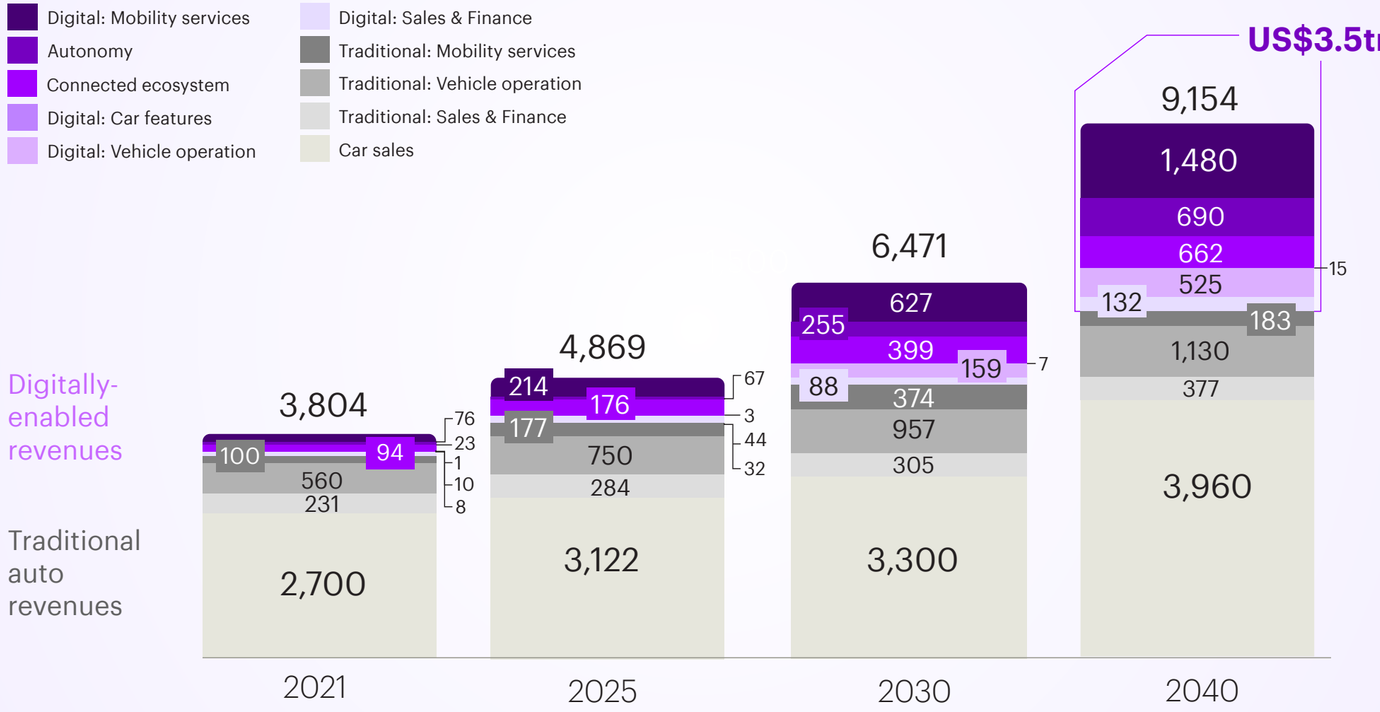


Personalized entertainment, features and services.

As consumers re-evaluate what they expect from a driving experience, the automotive industry is at an inflection point. For decades, consumers have cared most about the performance, reliability and safety of their vehicles. The industry fulfilled those needs by optimizing machines and hardware. Today, consumers are starting to think about vehicles in much the same way they do about smartphones: the ultimate connected device. It provides real-time responses across channels, personalized features and services. And that shift in consumer needs is forcing the industry to move into a new world of software-defined, service-driven digital mobility.

The industry has seen several inflections in the past. So why is this one so critical? With the move to software-defined mobility, a new race for automotive revenue pools is on. The competitors facing established original equipment manufacturers (OEMs)? Tech giants and new automotive players. And the race will be especially intense for new revenue from digitally-enabled services. Analysis by Accenture Research estimates (see page 23 for full workings) these are set to rise more than tenfold by 2040, totaling US$3.5tn or 40% of all revenues in the automotive industry (see figure 1).

Our authors and researchers interviewed senior automotive industry executives with deep experience in software-defined vehicles, totaling 25 hours of interviews between March and April 2022. Extensive secondary research and financial modeling was also conducted. See page 23 for the full methodology.



Source: Accenture Research (2022)

Figure 1: Revenues are increasingly shifting toward digital business models across the entire automotive industry.

Evolving from vehicles into platforms

Established OEMs are at a particularly critical moment. They need to decide how they want to act in this new competitive landscape and how to capitalize on these new profit pools. The key decision they have to make is selecting the control points to secure the position they aspire to. OEMs increasingly understand that the vehicle-centricity of the past is no longer enough to excite consumers. Instead, vehicles will become a part of software and service platforms that span all aspects of consumer mobility. OEMs are clear about the need to transform. But our interviews with senior automotive industry executives show that OEMs see their R&D governance models (the way they drive, qualify and execute product engineering) as ill-prepared to build and deliver services enabled by software. In other words, they are struggling to establish a strong competitive position.

The aim of this paper is to provide guidance and discuss the key steps for OEMs to handle transformation successfully. In analogy to the entry of Apple into the cellphone market in 2007, we believe that — if managed smartly — OEMs don’t need to wait until 2040 to see additional revenue from digitally-enabled services, but can benefit from these new pools earlier.

The big bet

OEMs are investing billions of dollars in software-defined vehicles and new service-oriented architectures.

Such investments come with three major promises:

1 Customer experiences to rival the digital tech giants

Today's consumers compare the experience of a car with its most important digital companion — the smartphone. Seamlessly integrated into all parts of professional and personal life, it entertains us; orders food for us; lets us participate in social communities and it even provides access to our homes.

Traditionally, cars don't provide a similar experience, which is why the smartphone has taken over as the user interface in the vehicle (for example, Apple CarPlay). With software-defined vehicles, however, vehicles promise to behave more like smartphones. That's either by converging cars with smartphones, as with the "digital key" feature that enables the driver to open and run the vehicle. Or through connected features of the car itself, such as paying at charging spots automatically or streaming games on the screen.

2 Scalable, reusable, efficient and fast software platforms

To survive in the new connected era, it is crucial for OEMs to reduce software development costs and increase software quality. The new era of software-defined vehicles promises software platforms for use across models and generations of vehicles. Platforms offer standardization and over-the-air updates that can help OEMs accelerate development timelines and enhance final product quality.

3 New profit pools and annuity revenue streams

Software also becomes a source of new premium services with potentially high profit margins, comparable to what we have seen in the smartphone industry. OEMs can build those services on the connected ecosystem, as with music streaming, parking or tolling.

Additionally, there is significant potential for monetization from new mobility services such as ride-hailing and autonomous driving (see figure 2 and the full methodology on page 23). OEMs have not yet taken advantage of these. But they offer the chance for monetization — via over-the-air subscriptions — throughout the vehicle's lifecycle.

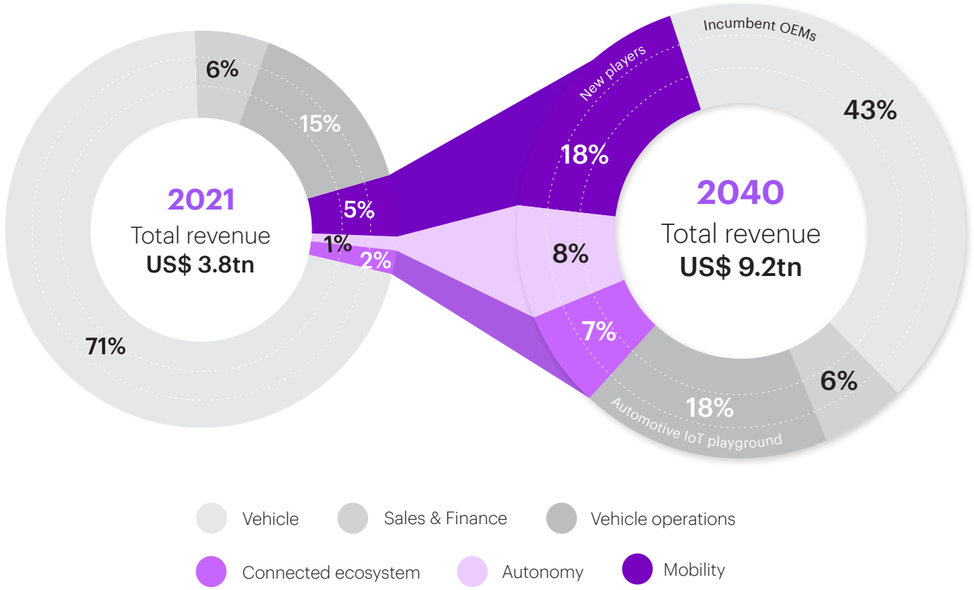
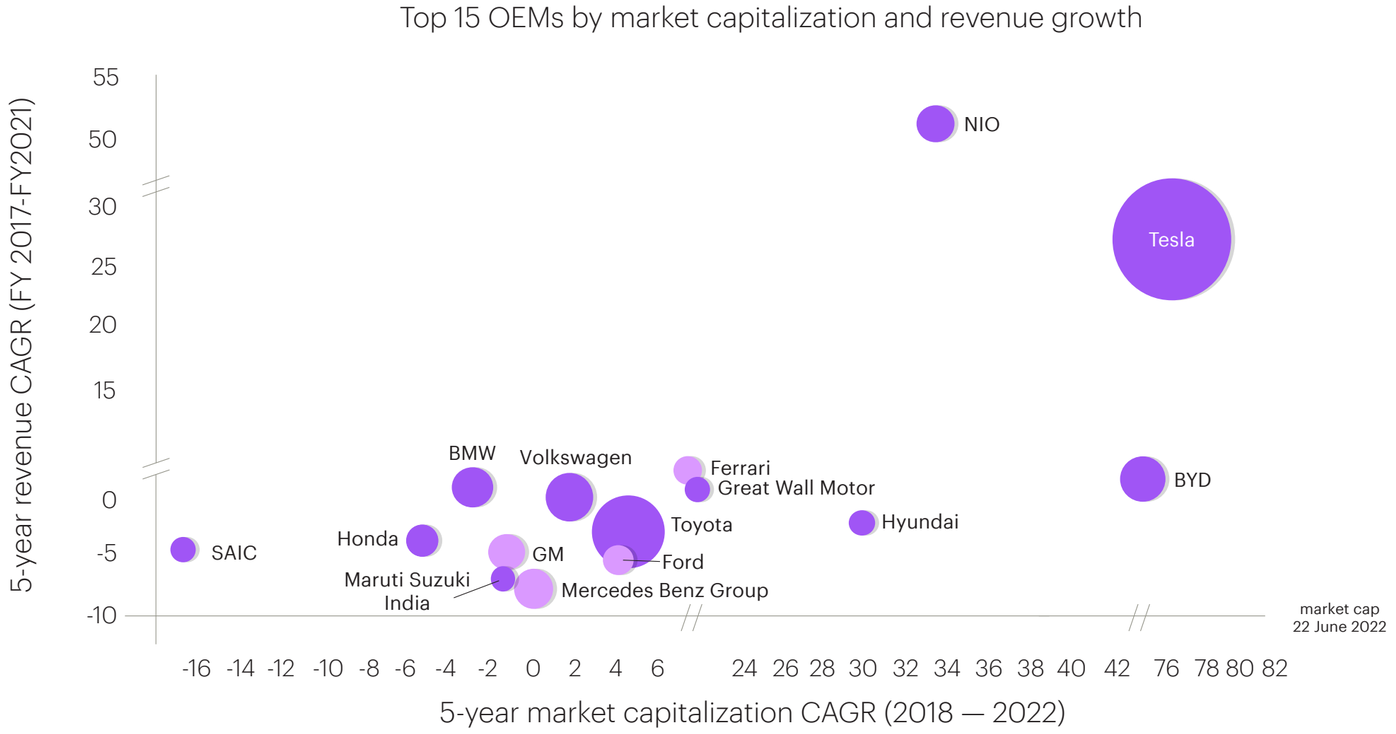


Figure 2: Digital revenue streams projected to rise in mobility/automotive

But how well prepared are OEMs to realize the promises that come with software-defined vehicles? Shareholders' assessments of ambitions and roadmaps reveals a clear picture. Over the last five years, new players such as Tesla, NIO and BYD sustained stronger revenue growth and market capitalization compared to incumbent OEMs (see figure 3). OEMs are finding it hard to match the operational performance and speed of these new players. Our interviews with senior automotive industry executives — along with extensive secondary research — confirm this.

> "The readiness of the engineering functions within OEMs right now to adjust to the business model associated with software-defined vehicles, is quite low. They are just not used to it."
>
> VP, Autonomous Driving MaaS strategy division, a leading European OEM

In particular, incumbent OEMs are struggling to forge the connection between R&D decisions and value creation with software-driven vehicles. These executives see plenty of room for improvement, especially in their R&D governance models.



Sources: Accenture Research (2022), CapitalIQ (2022)

Figure 3: New automotive players' revenue and market capitalization outpacing incumbent OEMs

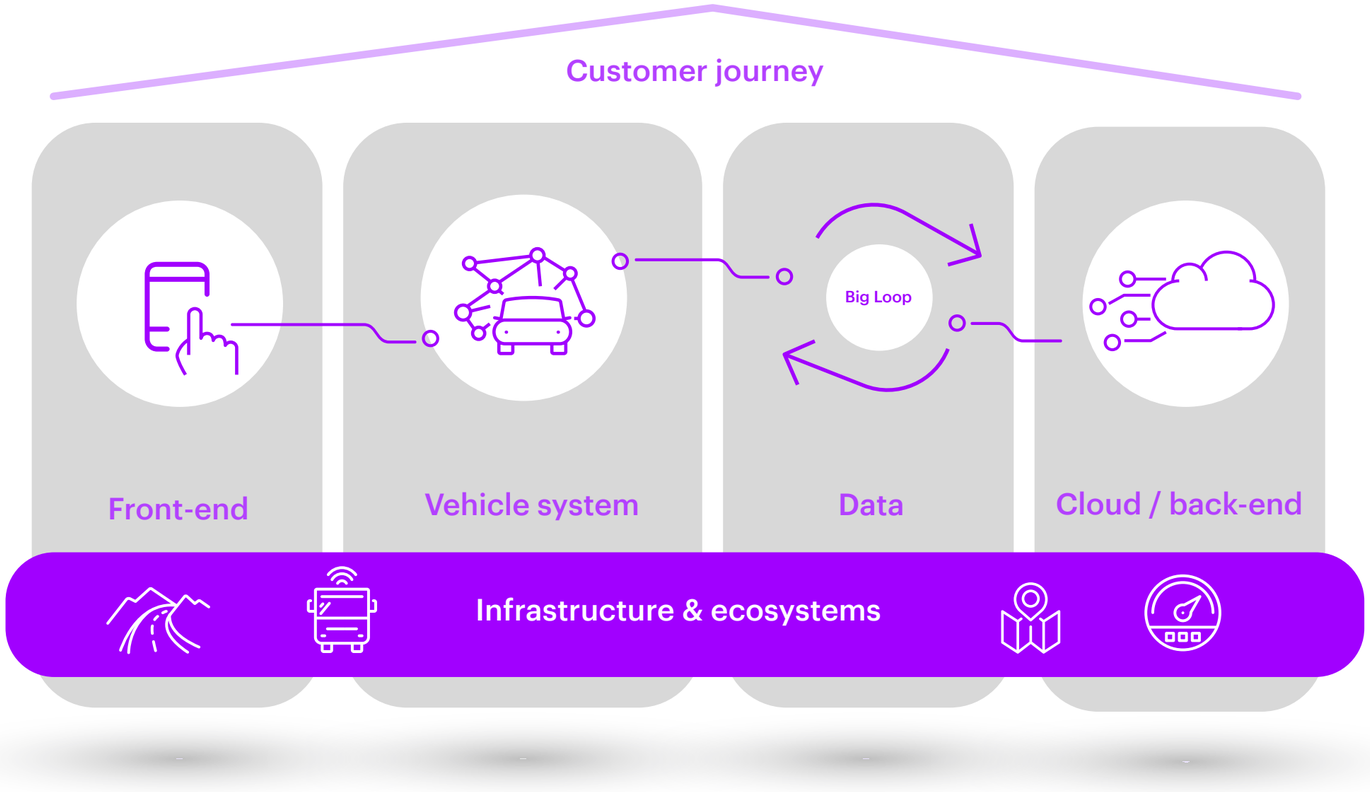
Redefining the product

So, what should OEMs do? A key task to handle the software-defined vehicle involves the vehicle itself. On this point, it is worth taking a look at China's auto market, where connected features and digital services have become essential for local consumers. The winner is no longer who offers the "best car", but who delivers the best total experience to a target group. Achieving that requires a perfect fit between the business model and a performant technology stack. Together, these create an exciting customer journey — something that Chinese brands like NIO have successfully pursued.

To achieve the same outcomes, OEMs need to think beyond the car as simply “the vehicle plus x”, where the software is fitted to the vehicle. Instead, they need to think along the lines of a system of systems, i.e., an interplay of standalone systems that, as a collection, enable new and unique capabilities. These systems include the front-end, cloud back-end, interfaces to infrastructure and ecosystems — and the vehicle platform (see figure 4). In essence, it needs a service-platform, an approach thought through end-to-end, reaching beyond the vehicle.

"Customer expectations are changing, as today’s vehicle users are much more digitally-native and accustomed to making software updates to enhance the experience of a product or service.”

Director of connected car services,
a leading OEM in Asia



Source: Accenture (2022)

Figure 4: A system of systems enabling new and unique capabilities

Spotlight #1

NIO builds its fan base

NIO is a great example of a new player in auto that is combining a customer-first mindset with that of a software company. The Chinese startup launched a new series of vehicles with an emphasis on creating a unique user experience.[1] It begins with the sense of a community where people connect through the app and then meet in NIO Spaces and NIO houses, destinations where some have even sought to get married.[2]

Customers are targeted as fans, not simply as buyers, with a special focus on user feedback, which includes direct communication to NIO executives and rapid implementation of product upgrades. Inside the vehicle, the personal assistant, NOMI, is designed to add an emotional and personal character to the vehicle.[3] And during ownership, the company addresses very real customer pain-points, such as long waiting times for the vehicle to recharge or even finding an available charging station by swapping the entire battery[4] or addressing parking headaches with a valet service[5] that can be directly ordered from the vehicle. Future vehicles will join AR/VR glasses, sound and a cutting-edge motion technology to create an immersive, 3D cinema experience in the vehicle[6] — providing an even better experience for their fans and help ensure new revenue streams for NIO.

Owning the right control points

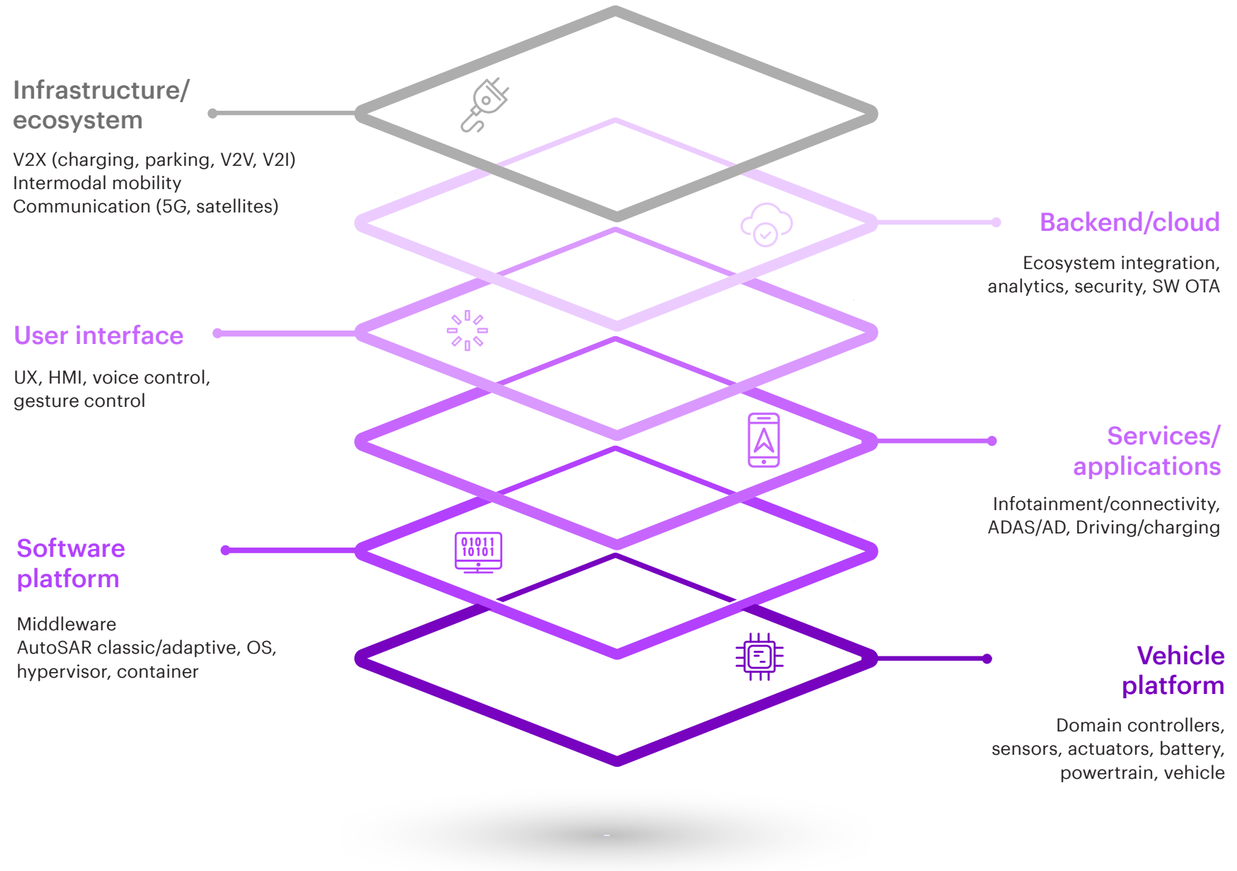
A service platform needs to be understood as an enabler for the business model(s) that an OEM has identified to realize future revenues. But not all elements are equally important or differentiating. The key is to pick the right ones in which it makes most sense to invest scare resources, time and money.

Take, for instance, Amazon and its intention to be the number one marketplace in the world,[7] with the best customer experience. Through events like Black Friday, Amazon very quickly realized that just offering the best selection of goods was not enough; they also needed to offer it 24/7 through every peak demand period.

The most critical element to achieving this was the backbone of the marketplace. And what better way than to control it directly. With their business model in mind, Amazon identified the control points — the critical layers of the technology stack — that they needed to own.

Automotive OEMs need to ask the same question: which control points do they need to own in order to create a user experience that fits their targeted business model? This question is complex because today's automotive technology stacks are comprehensive, extending beyond the vehicle itself to encompass everything that's required to deliver connected, digital experiences and services (see figure 5).

In this context, Tesla has pursued the path of owning and controlling many more layers than the industry has traditionally dealt with. Established OEMs will follow. For instance, many are creating their own operating systems (OS): Volkswagen with its vw.os, planned for launch in 2025[8] and Toyota with Arene[9] also in 2025. Each follows the same narrative of scalability beyond the OEM.



Legend: vehicle-to-everything (V2X); vehicle-to-vehicle (V2V); vehicle-to-infrastructure (V2I); user experience (UX); human machine interface (HMI); automotive open system architecture (AutoSAR); software over-the-air (SW OTA); advanced driver assistance systems & autonomous driving (ADAS/AD).

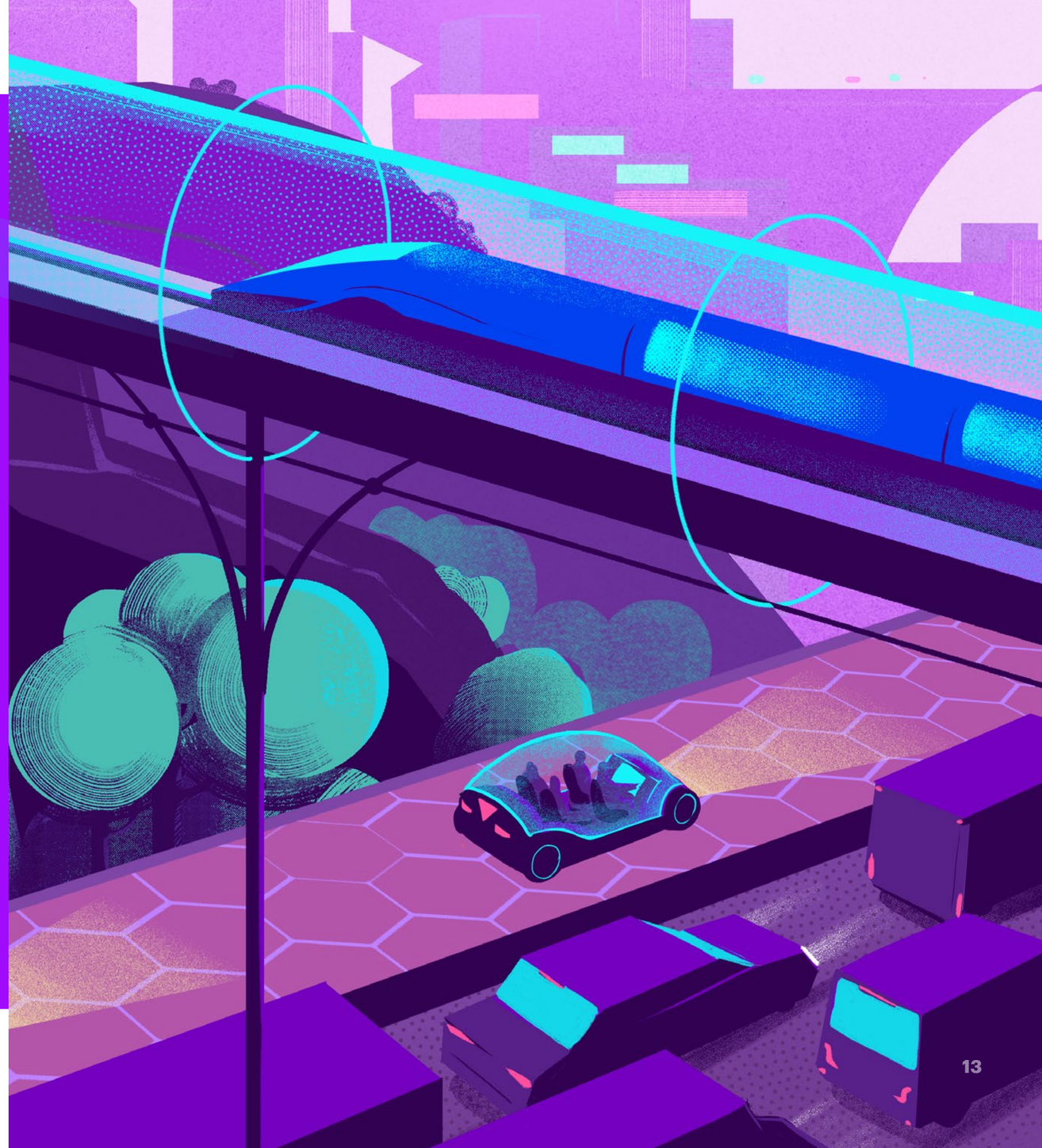
Figure 5: Today's automotive technology stack encompasses everything needed to deliver digital experiences and services

Spotlight #2

Tesla is going for the full-stack approach

Tesla, with no prior footprint in automotive manufacturing and R&D, has nonetheless brought striking innovation into the core domains of automotive excellence, such as battery cooling[10] and its own sensors.[11] But much of Tesla's significantly higher market capitalization is based on the promise of future digital services, and the profits that will flow from them — a promise that capital markets trust Tesla will be able to fulfill.

Much like its technology counterparts, Tesla has quickly diversified its revenue streams not only beyond the core automotive value chain but has created and monetized a whole ecosystem around the electric vehicle, with much upside for future growth. Tesla now offers its own insurance[12] and is working toward converting the vehicle interiors to an entertainment platform.[13] Manufacturing and selling home chargers or solar panels[14] sounds like a good add-on for any homeowner, yet once those homes and vehicles connect to the electric grid, generate, buffer and broker energy, Tesla has the potential to create a whole new (and widely anticipated[15]) parallel energy market.



So, will we see a future with twenty OEM operating systems co-existing in the market? Probably not. The content required to keep each platform engaging, combined with a very limited number of customers, will not be attractive enough to create a sustainable developer community. And the OS is only one example. Each OEM has its own culture, processes, R&D traditions and expertise that have evolved over many years — and been very successful in doing so. There is no merit in dismantling all this to try and imitate Tesla's model. Instead, it's important that OEMs use their heritage to their advantage and play to their core R&D strengths, to build customer-centric and competitive software-defined vehicles.

Moreover, the competitive landscape is more fragmented. New players from the tech industry have entered the market trying to dominate and own specific areas of the technology stack. For example, with Android Automotive OS, Google's operating system has been optimized for use in automotive infotainment systems and has already been integrated in vehicles such as those from Volvo and Polestar. Huawei positions its OS as an alternative to Android. The company and its partners have launched a vehicle with Huawei's Harmony Cockpit operating system. Multiple other open-source initiatives, such as the Eclipse Foundation, are aiming to join forces and create software assets for reuse by OEMs and suppliers.

In this new landscape, OEMs need to get to the bottom of some key questions that include:

- **What are the R&D layers now involved in making software-defined vehicles?**
- **Should they develop an operating system in-house or collaborate with others?**
- **What proprietary technologies do they need to own, and which can they buy?**

These considerations introduce an option beyond the traditional binary of make or buy. OEMs now need to think about how they can collaborate, compose, configure and contribute to platforms that could be open-source, alliance-driven or offered by tech players. Four distinct and valid archetypes arise from these considerations (see figure 6). Each requires specific capabilities, and each has its clear advantages and disadvantages.

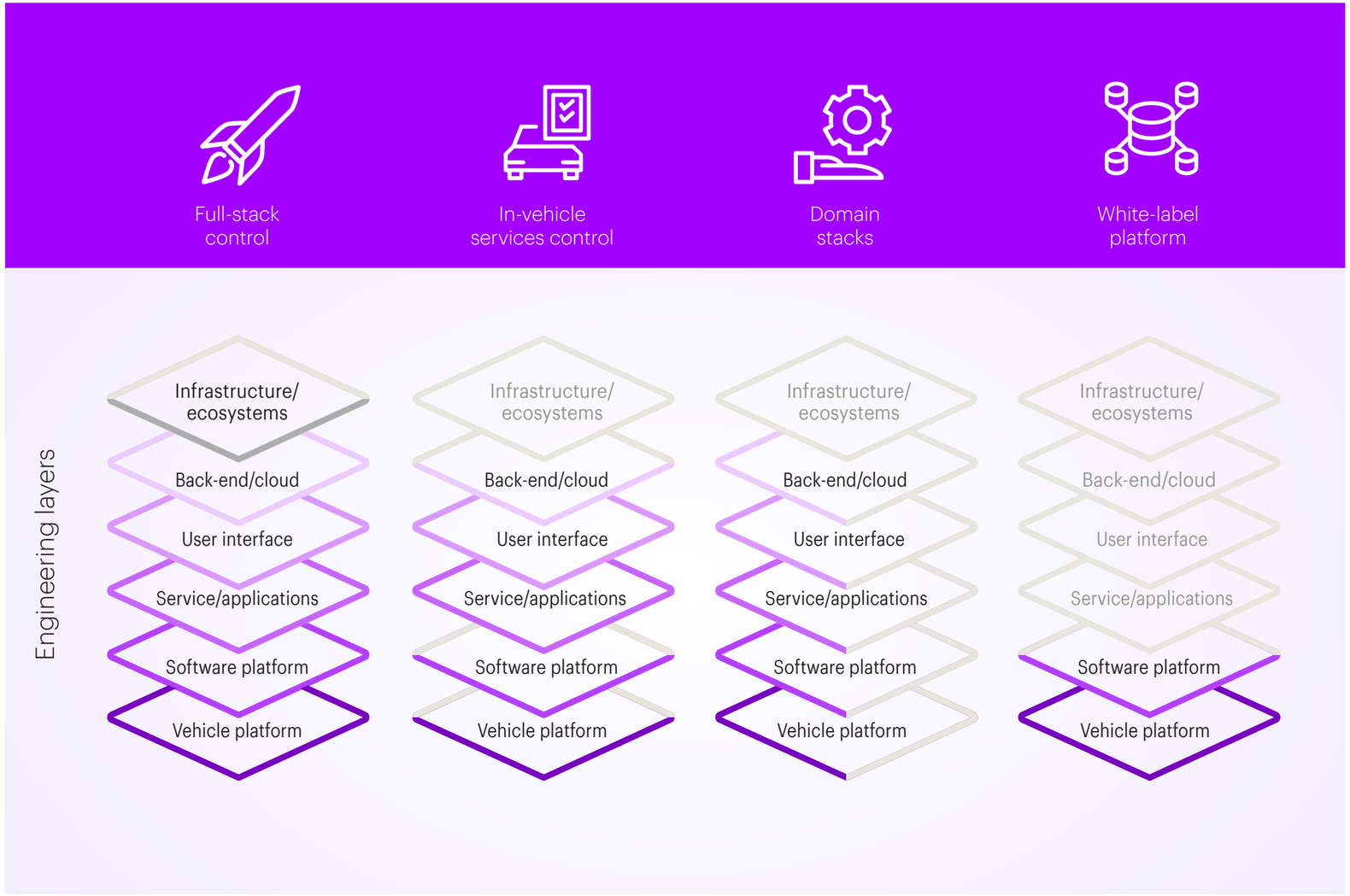
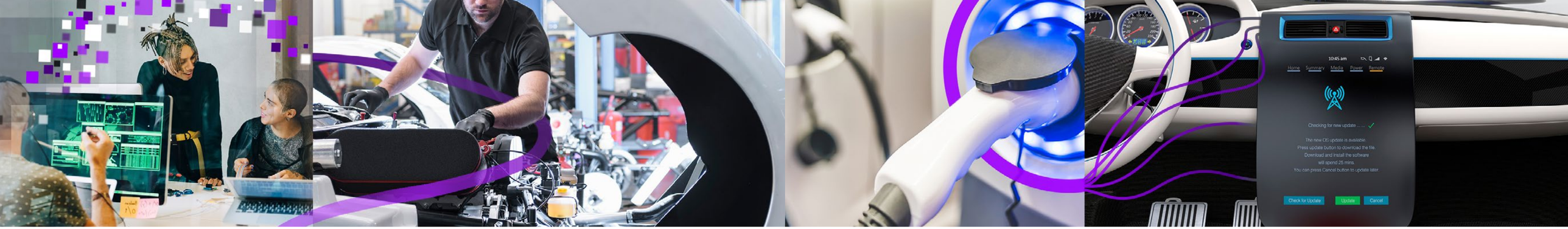


Figure 6: Each archetype comprises different elements of the automotive technology stack



Full-stack control

Advantages:

Full-stack control offers the highest potential revenues and significant customer loyalty, as well as total ownership of customer data. It does this by building and owning everything. That means the complete product, services and experience, as well as everything that delivers it, from hardware to the cloud back-end.

Disadvantages:

At the same time, this approach — exemplified today by Tesla, — requires major investment in infrastructure and technology capabilities. There are considerable challenges, too, such as managing a complex ecosystem over lifetime — e.g., if the charging infrastructure is also part of the stack, as is the case with Tesla — or limiting the addressable market to only the vehicles in operation of the own brand.[16]

In-vehicle services control

Advantages:

It does not have to be the all-or-nothing play. In-vehicle services control means that a few layers are addressed through partnerships and outsourcing, while the OEM remains in control of most. OEMs like Mercedes-Benz and BMW are pursuing this route.[17] For them, there is no value in building their own operating system or cloud framework (e.g. for scaling reasons). Instead, they are partnering with external providers like Google for Android Automotive or relying completely on open source.

Disadvantages:

Of course, use of open-source software may be liable to misuse, which could create security issues. And this is a model that requires extensive supporting infrastructure. If they choose to participate in new alliances and ecosystems, companies need to carefully consider trade-offs between complete control and the costs and capabilities required to develop and operate a specific layer.

Domain stacks

Advantages:

This model targets engineering efforts toward developing highly specialized services that can also operate with hardware and near-hardware software from a third-party manufacturer. Processing and analyzing the data that drivers need requires advanced data management capabilities, as well as artificial intelligence (AI) and machine learning. Waymo and Pony.AI are examples of this approach. Each offers an advanced software stack using AI and machine learning to enable autonomous driving.[18] As does Baidu's Apollo, which aims to become the equivalent of a device OS such as Android, but for software-defined vehicles.[19] This model offers ownership of the customer experience and therefore enables access to valuable end-consumer data.

Disadvantages:

But it may also limit control over hardware quality and the experience that it provides. Core services experience providers may also run the risk of becoming de facto software suppliers to other industry players. Traditional OEMs that choose to become customers of such a platform would restrict their potential to create value. They would be left with shaping the brand, design and user interaction as well as integrating the complete experience.

White-label platforms

Advantages:

Providing a platform for others to build on is another distinct archetype approach we see emerging. The platform could be hardware or software or, indeed, a combination of the two. Unbranded "white-label" offerings are sold to others, who, in turn, market them under their own label. There are many different variants of this archetype, including those from providers such as Flextronics[20] and Qualcomm[21] to self-driving stacks. And some OEMs may even extend their own platforms to others.

Disadvantages:

However, while bi- or trilateral vehicle projects have enjoyed significant success in the past, the long-term platform play will require new capabilities. Success here rests on managing the complexities of architecture alignment, process governance and providing extensive maintenance and support to third parties.

OEMs must now chart their own course and identify the right archetype for their business — a strategic decision that will determine the services it can own and monetize in the future. Making that decision needs an evaluation of how well the respective option aligns with:

1 The targeted profit pools and business models

The choice of whether to self-develop stacks depends on which business model the OEM targets. Brand identity, customer base, price positions and other factors are affecting the according OEM strategy. To monetize services, features and data, OEMs need to first create value for the customer — which requires them to control the customer experience. Our research highlights the complexity of integrating external solutions without losing the customer interface and access to data. From the tech players' perspective, it is essential to gain access to relevant data of the vehicle, driver, other passengers and infrastructure. Giving access to those data streams needs to be balanced with the aspired positioning of the OEM and a realistic view on the feasibility. Most OEMs will have to combine a mix of self-developed elements with close partnering and use of external tech stacks, but always with a clear strategy on how to share data and customer access.

2 The maturity of standard solutions in the market

Modular approaches of modern software architectures and the progressive decoupling of hardware and software are facilitating the integration of external software building blocks. To safeguard their software development resources, OEMs must shift their focus from self-developed architectural elements to customer differentiation and business models. The integration of mature standard solutions like Android, in all its different flavors, can boost time-to-market and efficiency, but needs a reversal of mindset: the OEM must adopt the standard solution to realize the benefits. As scalability can be hindered easily, the R&D function needs to find new ways of working with alliances, standard solutions and open source. However, where external solutions are not yet ready to implement or where differentiation is key, proprietary innovations will win the day.

3 Realistic future capabilities

In-house development of software requires significant engineering capacity and capabilities. Should OEMs foresee constraints here, they will need to evaluate the criticality of control points. If the importance of a technology layer prevents outsourcing, partnering via joint ventures could be an option to maintain ownership of the respective control points.

4 The financial resources and willingness for long-term investment

Developing and maintaining in-house technology stacks also requires enormous financial investments. We estimate for instance, the development of a car operating system can cost an OEM around US$4bn and its lifetime maintenance another US$6bn.[22] Looking at potential sales volumes, only a few OEMs appear to have the financial backing to establish a full-stack approach themselves.

Changing the corporate culture and architecture

Along with the transformation to software-defined vehicles, OEMs also need to transform their organizations. Today, they are perfectly built to deliver vehicle projects at a predefined start of production (SOP) date. However, they need to become organizations that continuously deliver hardware and software platforms — no longer halting development once production starts.

To continuously improve the driving experience for the end-consumer, a step-change is needed to enable the regular deployment of software updates and upgrades to vehicles over-the-air, throughout their lifetime. In addition, OEMs need to address three main imperatives to future-proof their business:

1. Manage the ownership of business models and market access. At the business layer, OEMs need to have clear ownership of their business models (i.e., vehicle sales, digital sales, B2B) including budgets and bundling requirements, guiding the technology development. This is especially important as new types of digital business models don't easily integrate with vehicle lifecycles, calculation schemes and technology domains.

2. Deliver innovation roadmaps by scalable technology building blocks. To ensure the speed and quality required in a software business at scale with much shorter cycle times, OEMs need to orchestrate decoupled and scalable building blocks. Systems Engineering and Model-Based development (MBSE) approaches will help provide greater organizational agility, as will adopting consistent processes and tool chains including integration, testing and operations.

3. Bring the business and technology views to an optimum by managed end-to-end architectures. Prioritize architecture over everything else and reduce silos by adopting an integrated framework that brings together end-to-end functional architecture, software architecture, vehicle architectures and ecosystem interfaces. Aligning the functional portfolio with architecture generations and vehicular project roadmaps will allow for greater innovation.

At most OEMs, these organizational layers require an overhaul to fit to future product roadmaps and to overcome historical restrictions and legacy requirements. However, the increased complexity of vehicle software makes it difficult for OEMs on their own to fully implement quicker development cycles. Instead, they need to work with partners in an ecosystem approach that brings together software and automotive know-how. Partnerships like these create common standards using open source and task allocation (via tools, interfaces, etc.) that ensure a high level of agility and innovation. Both of which are essential in creating a superior customer experience through continuously released features and services.

To foster agility, management philosophies at OEMs also need reorganization. Traditionally, R&D defines the vehicle, IT defines the backend, and marketing and sales defines the user services. The only way to guarantee a unique and seamless user experience is by integrating all of these core areas. Doing so requires executive leadership skills to lead multi-disciplinary and diverse teams, including analytics and customer experience talent, as well as teams for cloud, edge and on-board.

Finally, OEMs need to increase their attractiveness to software and computer engineering talent. Becoming a magnet to talent will become more important as the transition to software-defined vehicles gains momentum. It is therefore essential to drive the cultural changes that will enable OEMs to compete against tech companies that benefit from a better perceived image among young IT professionals. Achieving this will require dedicated career paths and offices in vibrant, modern urban locations.

Conclusion: the road ahead.

Automotive OEMs are at a crossroads. They must carefully consider their next move and the strategic control points they want to own within the SDV platform technology stack. This is mission-critical to creating new business models that will enable OEMs to monetize new digital opportunities and future-proof their businesses.

OEMs are under no illusion that they face bumps in the road ahead, but now is not the time to standstill. Success will be rewarded to OEMs who drive change—not only in the products they make, but throughout their entire organization—and become agile, digital enterprises, steely focused on creating and delivering unique user experiences, ready for the imminent future.

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Research methodology

We interviewed 15 senior automotive industry executives from companies with deep experience in the area of software-defined vehicles. Interviews took place between March and April 2022.

The executives we interviewed belonged to one of the following four categories...

Incumbent OEMs

... with revenue of over US$1bn: Executives we interviewed represented some of the biggest incumbent OEMs headquartered in China, Germany, Japan and the US.

Tier-1 suppliers

... with revenue of over US$1bn: Our executives pool included some of the largest Tier-1 automotive suppliers from Europe.

New-age suppliers

... with revenue of over US$1bn: We interviewed some of the largest new automotive suppliers from the US, involved in supplying advanced computing platforms to the OEMs.

New auto players

... with valuations of over US$500m: We interviewed new auto players based out of China.

We also interviewed 10 client-facing Managing Directors from Accenture's Automotive practice working closely with OEMs in China, Europe and North America between January and February 2022. We asked the executives to share their point of view on the ongoing transition towards software-defined vehicles and what it means for the engineering and manufacturing functions of incumbent OEMs. They also shared their views on the challenges incumbent OEMs are facing and what is holding them back on their journey to building value with software-defined vehicles. We combined these discussions with our extensive secondary research to help shape the research narrative. We also used the discussion with external senior executives to validate our hypotheses in the realm of software defined vehicles..

Our projections on current and future Automotive revenue pool values (as shown in figure 1) are estimations based on economic modeling compiled by experienced analysts within our in-house Accenture Research team. The model is underpinned by quantitative secondary data from more than 40 sources (including investor reports, auto intelligence etc.) that provide information on sales development, market financial performance, feature-level market forecasts and price estimations. All compiled data was validated, categorized, and duplicative entries suppressed (e.g., ensuring features are only accounted for under a single category and do not appear across multiple categories) and our assumptions were verified based on discussions with automotive industry experts and Accenture leadership. To identify the size of current and future digital revenue streams (as shown in figure 2), we aggregated the projected values of features within each respective category.

Lastly, we used publicly-available financial data to validate our findings about the incumbent OEMs. We collated revenue and market capitalization figures for the top 15 OEMs globally for the period 2017 to 2021 and calculated the 5-year compounded annual growth rate (CAGR) for each of the players. The CAGR, along with the size of the market capitalization (as on 31 March 2022) were then mapped as shown in figure 3 of this report.

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