NEXT DESTINATION:
SOFTWARE

How automotive OEMs can harness the
potential of software-driven transformation

EXECUTIVE SUMMARY

Software-driven transformation will redefine the global automotive industry. Software-driven transformation is transforming vehicles, organizational structure, processes, methods, and tools to be primarily defined, designed, and operated around software.

Automotive OEMs' software-based revenue is set to more than triple in the next 10 years and drive significant benefits. Software-based features and services will be a $640 billion market by 2031, growing from about 8% of OEMs' current annual revenue ($181 billion) to 22% (more than three times in terms of value). A key driver of this new revenue will be OEMs' share of new vehicles based on a unified/common software platform, which will reach 35% by 2031, up from nearly 7% currently. Overall, software-driven transformation will yield significant benefits. For example, by 2026, OEMs expect to improve their productivity/efficiency by 40% and help leading OEMs garner up to 9% higher market share[1] than their peers.

A majority of OEMs are only at the beginning of their software-driven transformation, with a small cohort of "frontrunners" establishing a strong early lead: 71% of OEMS have only reached the stage of identifying use cases and, overall, only 15% are what we would call highly mature "frontrunners." These frontrunner OEMs have twice the average revenue compared to the rest and stronger ambitions – they expect software to account for 28% of their revenue compared to their peers who expect 20% of their revenue from software-based features and services in 2031.

Frontrunners are establishing a significant lead when it comes to deployment and implementation capability. For example, 93% closely monitor and track the progress and success of their software initiatives by defining software-specific KPIs in various functions, vs just half of the rest. And nearly half (47%) of frontrunner OEMs invest more than $1 billion in their software-driven transformation, compared to 28% of the remaining OEMs.

To catch up with the frontrunners and harness the full potential of software-driven transformation, OEMs need to:

a. Build a software-focused vision and strategy for their organization

b. Leverage software toolchains and agile methodology to foster greater collaboration across organizational units

c. Forge long-term, strategic partnerships with software and technology service providers on key software frontiers

d. Strive for software excellence by building and retaining software talent

e. Tap into the power of data to more quickly enable intelligent vehicles, intelligent operations, and intelligent services, faster

f. Define a clear roadmap for next-generation and standardized vehicle software architecture.

INTRODUCTION

Automotive companies are no strangers to software and technology. Enterprise and industrial control systems already support their complex global operations in the last decades. Computer-aided design (CAD), engineering, and testing, supported by virtual and augmented reality, are industry standards. The amount of code in vehicles has grown steadily and increased significantly with the advent of electric vehicles. Now, the digitization of the industry is accelerating:

- On the vehicle front, the rise of companies such as Tesla show how the heart of a vehicle can be the software itself rather than a collection of specialized hardware. In July this year, Tesla pushed out an over-the-air update of its Full Self-Driving version 9 beta software, which gives drivers access to advanced driver-assist features even on local, non-highway roads.[2]

- On the services front, Renault has carved out a new business unit – called Mobilize – that places heavy emphasis on generating profit pools from data, mobility, and energy-related services. It aims to generate more than 20% of group revenues by 2030.[3] Luca de Meo, CEO Groupe Renault, said, *"We'll move from a car company working with tech to a tech company working with cars, making at least 20% of its revenues from services, data, and energy trading by 2030."*

- On the long-term strategy front, Volkswagen AG has unveiled a new strategy, called NEW AUTO, which is centered around software.[4] *"In the NEW AUTO world, brands will remain a key differentiator,"* said Herbert Diess, chairman of the board of management. *"Customers will still choose a specific design, body style, and brand or service quality. But more than ever, brand differentiation will come from software and services."*

These examples show how software is firmly in the driving seat of the automotive sector – a transformation driven by several factors:

- **Consumers** today view automobiles as more than just a means of transport. They expect more innovative features and services in their cars (such as advanced driver assistance, immersive infotainment, and connectivity, among others) and seamless digital continuity with the increasing number of smart devices they use. To meet or exceed these expectations, OEMs need to become more efficient and agile, delivering new software-based features and services to market at a faster rate, compelling them to achieve software excellence. It also presents an opportunity to OEMs to move away from the model of selling the car once to the model of earning subscription-based revenues over the lifetime of the car.

- OEMs face new **regulatory** demands relating to data privacy, cybersecurity, safety, sustainability, and risk management.

- Software has yielded **significant business and operational benefits.** Our research shows that OEMs have improved productivity/efficiency by 33% and reduced costs (capital and operational expenditure) by 32% overall in the last five years through the use of various software systems and tools.

To assess how well OEMs are progressing on this transformation, we surveyed 570 automotive executives from passenger vehicle and commercial vehicle manufacturers, headquartered in 12 countries globally (see the Appendix for detailed research methodology). We also interviewed 17 automotive industry executives, drawing on their experience of leading software-driven transformation initiatives for their organizations. This research, coupled with our experience in automotive industry transformation, allows us to answer the critical questions:

1. How is software-driven transformation changing automotive revenue streams and how big is this opportunity?
2. How mature is the industry when it comes to software-driven transformation and what advantages do the highly mature enjoy?
3. How can OEMs overcome critical transformation hurdles and harness the full potential of software-driven transformation?

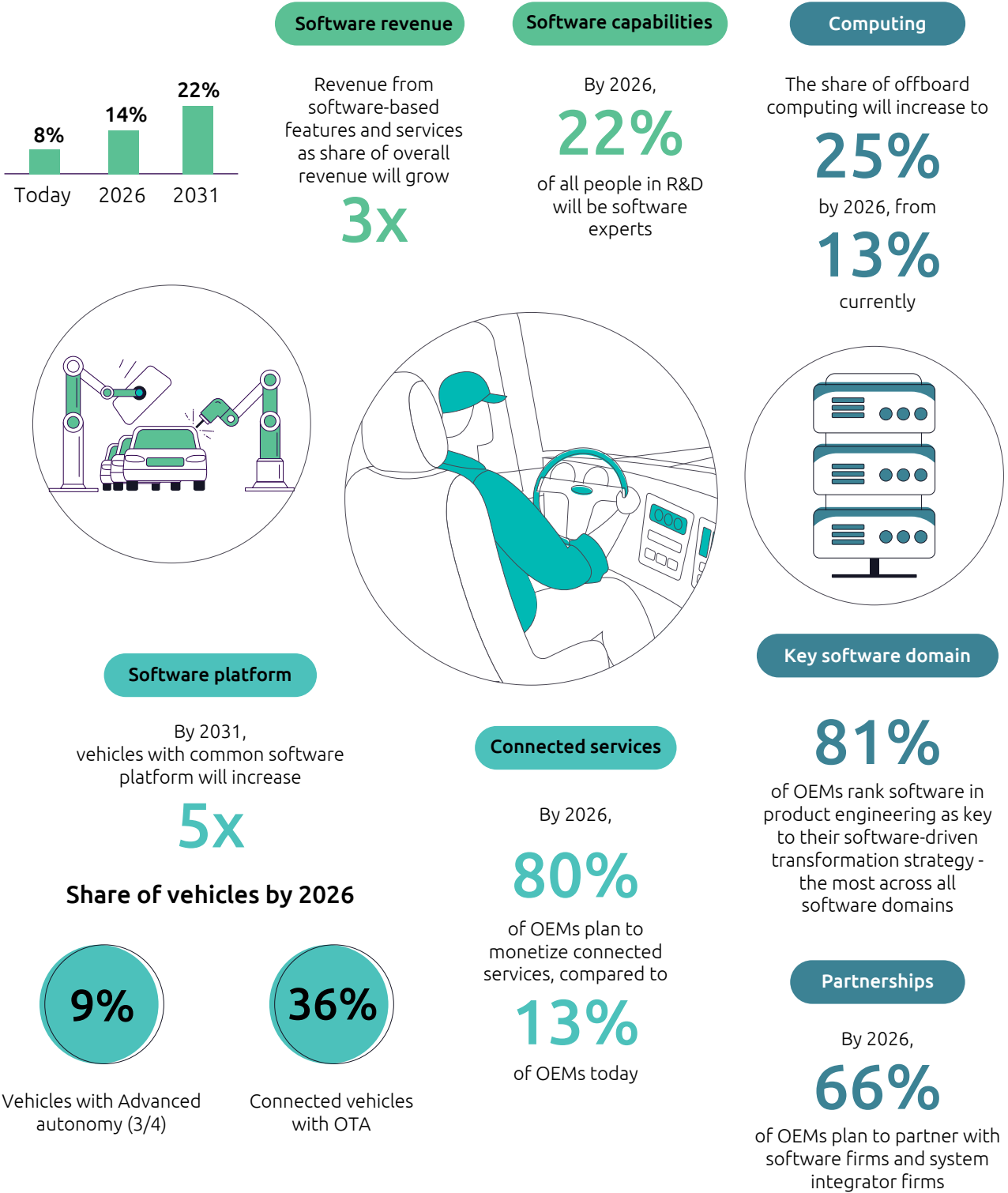# 1–How software is driving the transformation of the automotive sector

As well as redefining the driving and passenger experience, software is bringing about big shifts in how vehicles are conceived, designed, and manufactured. This research examines the impact of software in three broad areas: the vehicle, the processes (internal and external e.g., supply chain), and the OEM organization. Our research reveals several fundamental shifts that this transformation will bring about in the automotive industry in the next five to ten years (see Figure 1).

22%

The share of OEMs' revenue from software-based features and services is expected to nearly triple from **8%** to **22%** in the next ten years.

Figure 1. How software will change the face of the automotive industry over the next ten years

8% Today · **14%** 2026 · **22%** 2031

Software revenue

Revenue from software-based features and services as share of overall revenue will grow

3x

Software capabilities

By 2026,

22%

of all people in R&D will be software experts

Computing

The share of offboard computing will increase to

25%

by 2026, from

13%

currently

Software platform

By 2031, vehicles with common software platform will increase

5x

Share of vehicles by 2026

9%

Vehicles with Advanced autonomy (3/4)

36%

Connected vehicles with OTA

Connected services

By 2026,

80%

of OEMs plan to monetize connected services, compared to

13%

of OEMs today

Key software domain

81%

of OEMs rank software in product engineering as key to their software-driven transformation strategy - the most across all software domains

Partnerships

By 2026,

66%

of OEMs plan to partner with software firms and system integrator firms

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, Capgemini Research Institute Analysis.

Vehicle: From the vehicle standpoint, software-driven transformation involves rethinking the way that OEMs see and build vehicles, along with how the vehicles are driven. Take vehicle autonomy as an example. While full autonomy may still be in the distant future, increasing levels of autonomy (for instance, level 3 and 4, which allow conditional automation and high-level of automation, respectively[5]) powered by software will mean more vehicles on the road can drive with lower levels of human intervention while also saving lives and reducing injuries. The slow development of autonomous driving systems has shown that integrating software into a safety-critical area such as driving systems is fraught with risks and challenges. And automakers have made large investments to ensure that these systems evolve within necessary safeguards.

Likewise, the software embedded within cars is evolving at great speed and is increasingly the key design decision behind today's software-driven vehicle. Today's vehicles increasingly pack more features powered by ever more powerful electronic chips, something that used to be the domain of luxury cars just a few years ago. More software means more functionality inside the car can be controlled by software leading to new features and upgradability without requiring a visit to the workshop. For instance, NVIDIA's latest electronic chip – called Orin – has embedded software capable of running four domains at once.[6] Rather than adding computers to cars, cars can now be built around a computer; and multiple specialized electronic control units, each with its own separate code, will probably be replaced with a reduced set of more generic and powerful units that control even more sensors and actuators, with more centralized software, while connecting to the ecosystem of the driver around the car e.g., smartphone, voice assistants etc.

Processes: OEMs' traditional methods and processes – internal and external e.g., the supply chain – that have led to hardware and manufacturing excellence over the course of decades, are shifting as customer requirements change rapidly and require greater flexibility and agility. These new methods and processes include new services around consumers' changing mobility patterns, for instance the need to be more sustainable in their transport choices while staying abreast of the latest developments in software systems and applications. To meet or exceed these expectations, OEMs must fundamentally change, for instance, their engineering and R&D processes, from a product or hardware standpoint to thinking software first, rather than as a bolt-on. From hardware specifications and manufacturing to after-sales, the entire value chain of vehicles is geared towards making vehicle hardware work smoothly. While this ensures high levels of efficiency, quality, and compliance, it treats software as just another component to be integrated into the vehicle. This approach leaves little room for delivering best-in-class features and services enabled by software, leading to poor customer satisfaction. The need of the hour is a smartphone-like experience that can be updated and adapted at the customer's will. This requires that OEMs change various methodologies, tools, and know-how while retaining efficiency and quality. To effectively transform processes, OEMs will have to increasingly rely on data coming from end consumers, vehicles, plants, R&D, and partners to reimagine how to design, manufacture, and sell vehicles. This will connect OEMs with drivers and passengers in unprecedented ways and lead to greater proximity and trust.
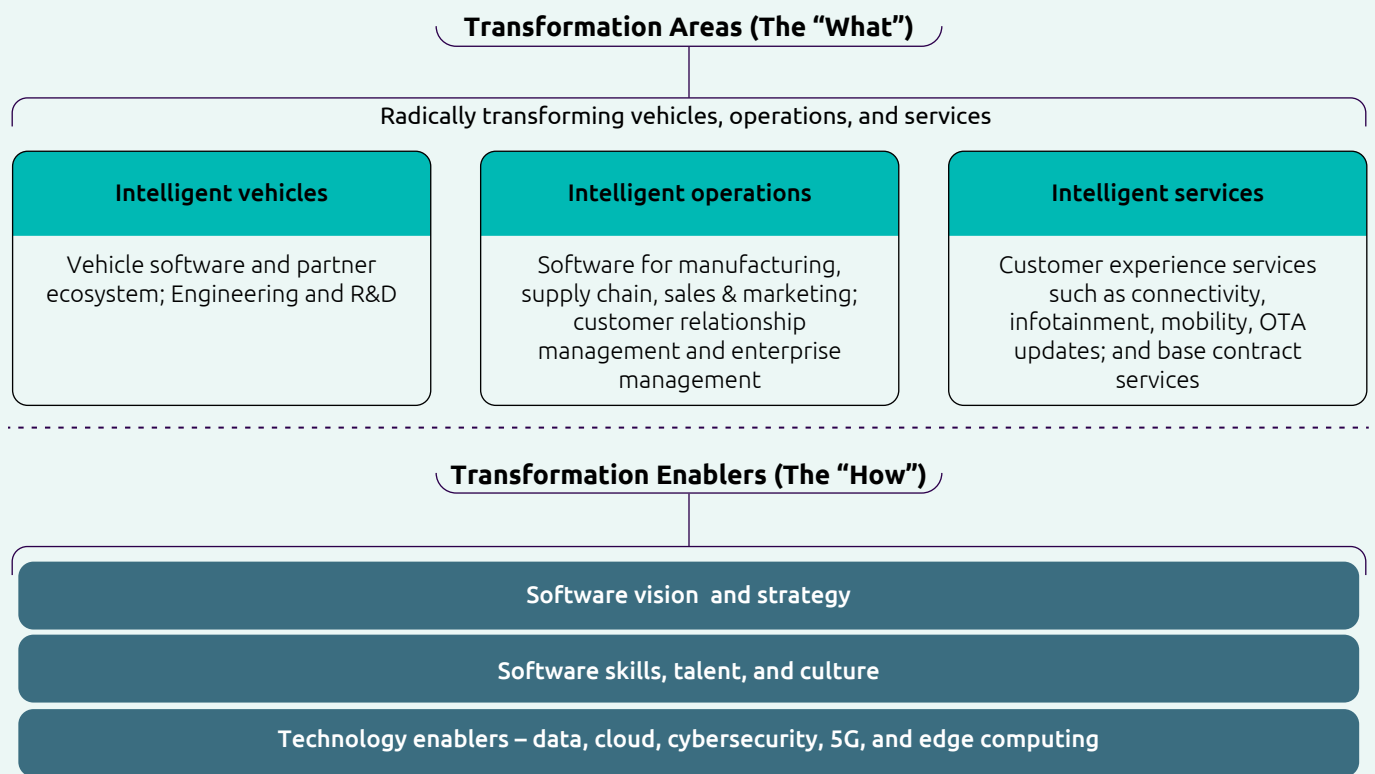
Organization: Automotive OEMs are renowned for manufacturing excellence, employing thousands of mechanical and electronics engineers to design and deliver vehicles that exceed customers' driving expectations. That's bound to change significantly as customer needs evolve and cars are "consumed" by software.[7] In the wake of this massive shift, OEMs are no longer only integrators of software and systems coming from suppliers; they are actively becoming software development companies. To be successful, OEMs will not only need to attract a large numbers of automotive software engineers, architects, test, and validation engineers, but they will also need to upskill a large part of their existing workforce in software skills and new ways of working with software. Large automakers such as Volkswagen and Stellantis have built new software organizations and subsidiaries with the sole purpose of developing software for their vehicles, while Renault has a new business unit tasked with driving revenues from software-driven services.

What do we mean by the "software-driven transformation" of the automotive industry?

For the purpose of this research, we define the software-driven transformation of an automotive OEM as an organization-wide initiative for transforming vehicles, the organizational structure, processes, methods, and tools to the extent that they are primarily defined, designed, and operated around software. One example for processes, for example, would be AI-based quality control in production. Figure 2 shows the key elements.

Figure 2. Key elements of automotive's software-driven transformation

Transformation Areas (The "What")

Radically transforming vehicles, operations, and services

Intelligent vehicles	Intelligent operations	Intelligent services
Vehicle software and partner ecosystem; Engineering and R&D	Software for manufacturing, supply chain, sales & marketing; customer relationship management and enterprise management	Customer experience services such as connectivity, infotainment, mobility, OTA updates; and base contract services

Transformation Enablers (The "How")

Software vision and strategy

Software skills, talent, and culture

Technology enablers – data, cloud, cybersecurity, 5G, and edge computing

Vehicle software and ecosystem: Central operating system of the car, common software platform, embedded software, software for global car management, in-car and out-of-the-car software

Software for intelligent operations: Software toolchains for engineering, operations, manufacturing, etc.; Software for specifications, car design, engineering, digital twin, MES, quality, ERP, CRM, digital marketing & sales Customer experience services: Driver and passenger experience enhancement, infotainment, ADAS, powertrain-related services

Base contract services: Safety, robustness, and reliability improvement

Source: Capgemini Research Institute analysis

2–Automotive OEMs' software-based revenue set to more than triple in the next 10 years
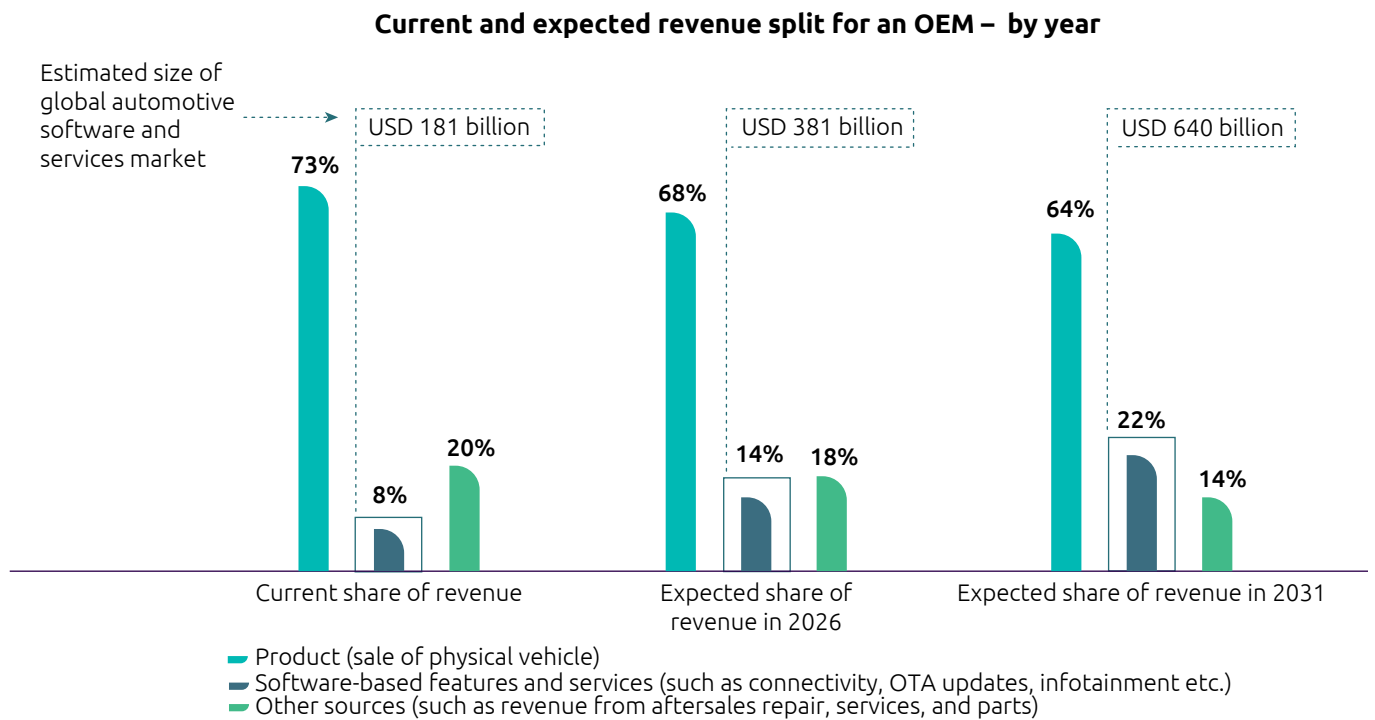
As a $640 billion market in 10 years, more than a fifth of OEMs' revenue could be based on software features and services

The share of OEMs' revenue from software-based features and services is expected to nearly triple from 8% to 22% in the next ten years (see Figure 3). Consequently, the share of revenue from the sale of physical vehicles will decrease over the next ten years. We estimate that out of the total global automotive market (worth $2.37 trillion[8]), the global market for automotive software and services in 2031 will be close to $640 billion.[9]

Figure 3. Revenue share of software-based features and services is expected to increase three-fold in the next 10 years

Current and expected revenue split for an OEM – by year

Estimated size of global automotive software and services market

USD 181 billion USD 381 billion USD 640 billion

73%   8%   20%
68%   14%   18%
64%   22%   14%

Current share of revenue
Expected share of revenue in 2026
Expected share of revenue in 2031

- Product (sale of physical vehicle)
- Software-based features and services (such as connectivity, OTA updates, infotainment etc.)
- Other sources (such as revenue from aftersales repair, services, and parts)

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

Volkswagen estimates that, by 2030, sales of software-based services and subscriptions could add one-third on top of expected electric and internal combustion engine vehicle sales.[10] This estimate from Volkswagen translates to software-based revenue of 25% of overall industry revenue. *"Software is essential for the survival of the automotive industry,"* says a director, Connected car unit at a German automotive manufacturer. *"I strongly believe that the industry and its important role as we know it today, will diminish and perhaps even cease to exist if the industry doesn't care about software."* The SVP, product development at a German automotive manufacturer adds, *"Software has become one of the key differentiators, because the mechanical prowess of the OEMs is now providing diminishing returns in terms of being able to differentiate yourself. So, it's really coming down to software."*

Further, OEMs across all regions expect the share of software revenue to be more than 20% of their total revenue in the next 10 years. For example, OEMs from Japan expect it to be 25% by 2031, those from United Kingdom, and Germany expect it to be 24%, and those from France and China expect it to reach 23% and 22% respectively.

Several automotive manufacturers have provided estimates of revenue they expect from software-based features and services:
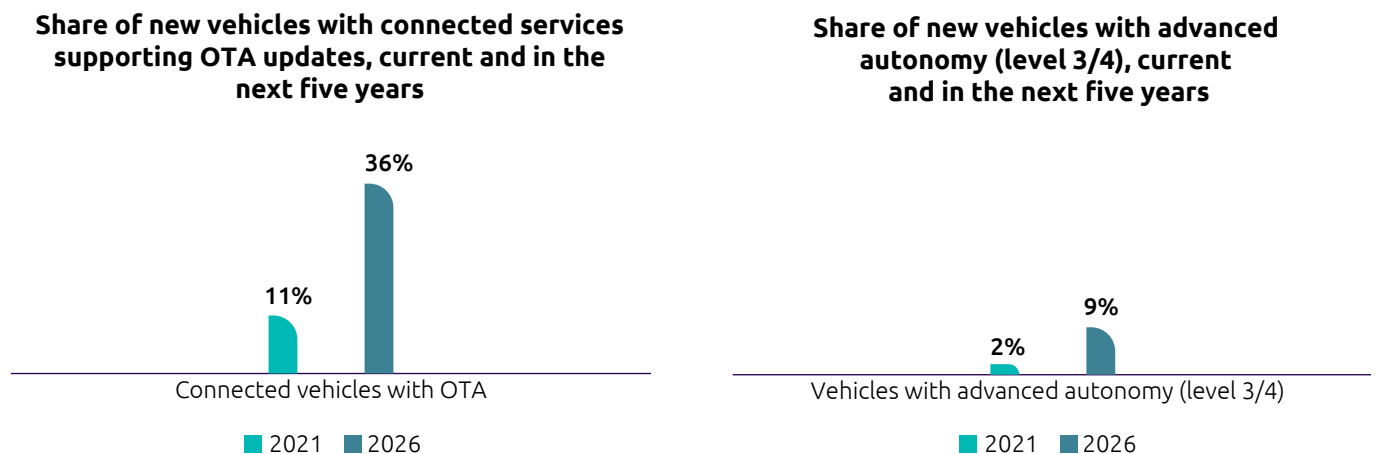
- Revenue from digital services: Mercedes estimates to make €1 billion in operating profit from digital services by 2025.[11]

- Revenue from subscription services: Ford can earn a recurring $9 billion (~8% of its current annual revenue) in revenue only from its data-driven subscription services.[12]

- Revenue from autonomous driving: Tesla expects to double their revenue by developing a network of self-driving robotaxis.[13]

Software revenue will be powered by connected vehicles and advanced autonomy

The growth in software-based revenue discussed above will be enabled by vehicles with connected services and advanced autonomy features. These features will open avenues for revenue growth for OEMs, backed by software. Our survey reveals that, out of all the new vehicles produced, connected vehicles supporting OTA updates (to release new/update existing features) will increase more than three times in the next five years to reach 36%. Further, new vehicles produced with advanced autonomy features (level 3/4) are set to increase nearly five times in the next five years (see Figure 4).

Figure 4. Share of new vehicles with connected services with OTA, and with advanced autonomy expected to significantly rise in the next five years

Share of new vehicles with connected services supporting OTA updates, current and in the next five years

36%

11%

Connected vehicles with OTA

■ 2021 ■ 2026

Share of new vehicles with advanced autonomy (level 3/4), current and in the next five years

9%

2%

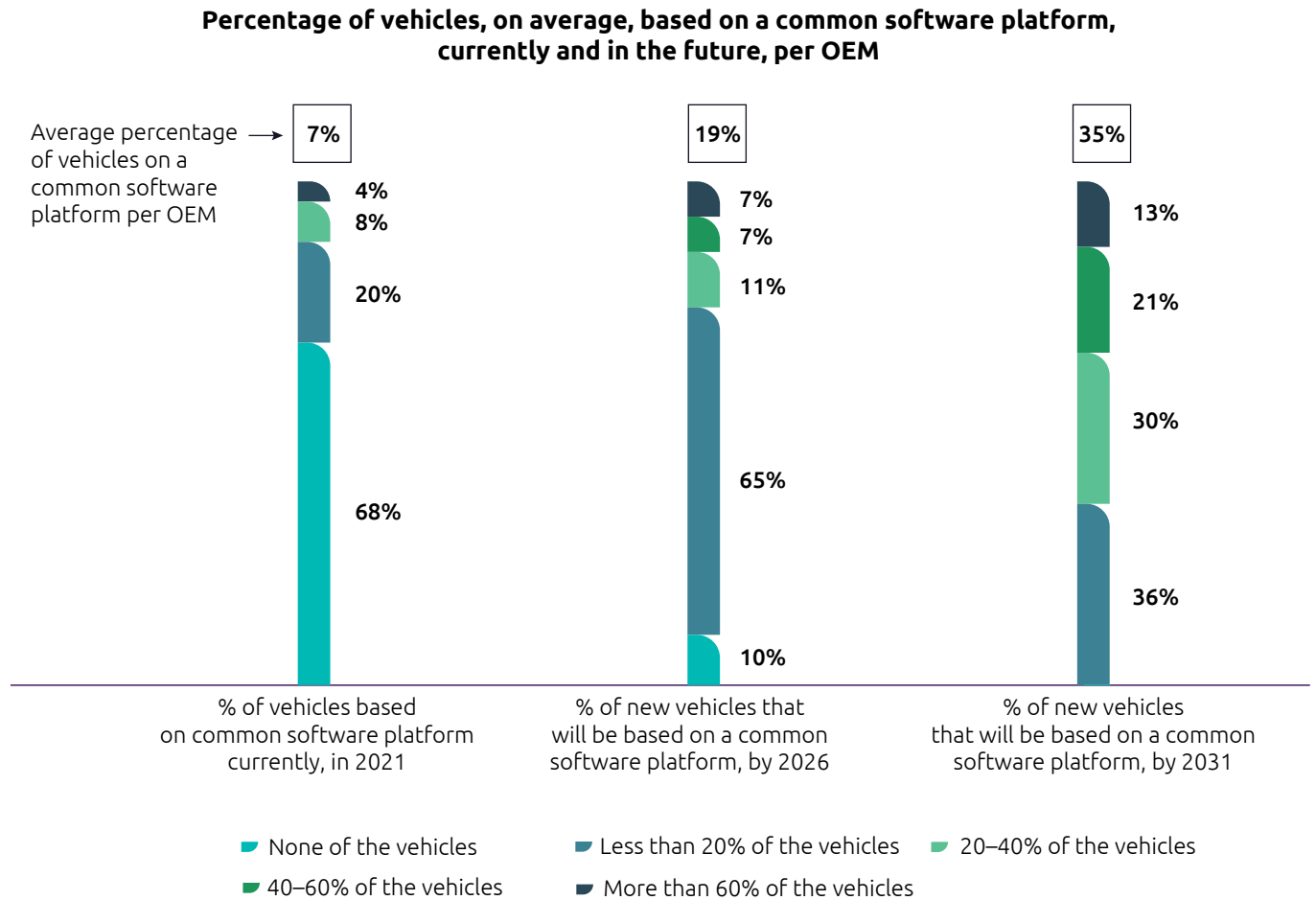Vehicles with advanced autonomy (level 3/4)

■ 2021 ■ 2026

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

To implement connected services and OTA updates, OEMs would require a common software platform across their vehicle lines to push these services and updates across their vehicle fleet and enjoy economies of scale. The integration of various vehicle systems – using a common end-to-end software platform – is essential to unlock new services and updates, and consequently drive software-based revenue. Our findings show that, on average, the percentage of new vehicles based on a common software platform is going to rise in the next five to ten years. More than one in three vehicles (35%) are expected to be based on a single platform by 2031, up from 7% currently (see Figure 5). For example, by 2025, Leading OEMs are working towards transforming themselves into a software-led organization. For example – Volkswagen expects to move most of their vehicles to a single platform and software system in the next five to ten years.[14]

Figure 5. On average, one in three vehicles, per OEM, will be based on a single software platform in the next five to ten years

Percentage of vehicles, on average, based on a common software platform, currently and in the future, per OEM

Average percentage → of vehicles on a common software platform per OEM

7%

- 4%
- 8%
- 20%
- 68%

19%

- 7%
- 7%
- 11%
- 65%
- 10%

35%

- 13%
- 21%
- 30%
- 36%

% of vehicles based on common software platform currently, in 2021

% of new vehicles that will be based on a common software platform, by 2026

% of new vehicles that will be based on a common software platform, by 2031

- None of the vehicles
- Less than 20% of the vehicles
- 20–40% of the vehicles
- 40–60% of the vehicles
- More than 60% of the vehicles

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=84 OEMs (represented by engineering/R&D function) who currently have/plan to have a common software platform in the next five years.

Analyzing further by countries, we find that United States expects to have the largest share of new vehicles (45%), per OEM, that will be based on a common software platform, followed by Japan and China at 41% and 37% respectively.

But aside from large manufacturers such as Volkswagen, BMW, General Motors and others, many traditional OEMs still do not have a common software platform. The research found that 83% indicate that, at present, they do not have a common software platform for their vehicle fleet.

Further, 32% of those OEMs say that they also do not have plans to use a single platform in few of their vehicles in the next five years. This will compromise their ability to deliver the connected car and autonomous services experience that customers will expect.
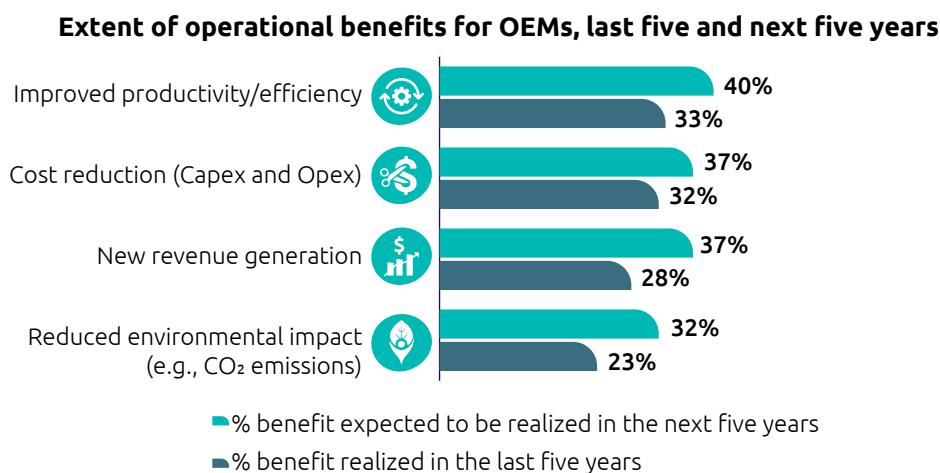
Success of various services and upgrades will also be dependent on the customer demand and usage, which in turn depends on how well OEMs deliver these services to enhance customer experience.

Software-driven transformation will yield significant benefits

Our survey findings point to significant benefits, from an improved environmental footprint to an enhanced customer experience. As Figure 6 shows, the expected benefits of the next five years exceed the benefits that have been realized over the past five years. For example, respondents expect to see a 40% improvement in productivity over the next five years.

Figure 6. The extent of benefits derived from software-driven transformation is expected to be larger in the next five years

Extent of operational benefits for OEMs, last five and next five years

Improved productivity/efficiency
- 40%
- 33%

Cost reduction (Capex and Opex)
- 37%
- 32%

New revenue generation
- 37%
- 28%

Reduced environmental impact (e.g., CO_2 emissions)
- 32%
- 23%

- % benefit expected to be realized in the next five years
- % benefit realized in the last five years

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

Following are a few examples of how OEMs use software to realize benefits:

- Mercedes-Benz Cars Operations (MO360) is equipped with software using real-time networked plants data to support their global vehicle production operations. Owing to comprehensive data availability and fast decisions based on real-time data, estimated increase in production efficiency is more than 15% by 2022.[15]

- BMW deployed smart glasses powered by augmented reality to connect local technicians to experts to service vehicles and deliver it back as quickly as possible. With this, some repairs are being completed up to 75% faster.[16]

- Toyota's uses software-based app to provides contextual coaching based on previous journeys to improve hybrid driving, reduce fuel consumption, and minimize environmental impact.[17]

A director at a Netherlands-based automotive manufacturer, adds, *"We construct complete vehicle virtually, and then drive the vehicle, change parts and components to understand the impact and make decisions for target setting. Previously, we had to wait six months to a year for a physical product to do so. So, the reduction of physical test properties has gone down 30 to 40%, so that's millions of dollars saved. In this process, we have also reduced a ton of inefficiency by increasing productivity."*

A director at a leading German manufacturer says, *"Software-driven product development has helped us considerably reduce our development cycles and make them more agile, leading to faster iterations, releases, and ultimately, a quick response to changing customer needs."* We also found that OEMs expect customer satisfaction to increase by 23% in the next five years. For example, to address customer feedback quickly and improve satisfaction, Volkswagen has implemented a digital agile project that will provide "over-the-air" software updates every 12 weeks. With shorter-update cycles, the customers benefit from continuous performance improvements and new functions.[18] *"Customer demand is changing, and very focused on connectivity inside the vehicle,"* says the SVP, product development at a German automotive manufacturer. *"They want to make their ecosystem fit in their vehicle. Like, in current times they would ask, can my phone be connected to the car seamlessly? Whether that's Alexa in the car or having seamless access to all your profiles and services that are on the smartphone, all of those things are increasingly important."*

A strategy and international program director at a French automotive manufacturer further adds, *"The automotive industry has to shift its revenue pools from generating revenue not only at the time of the sale of the car, but also the revenue generated during the lifetime of the car. The value proposition of software is that software-based features and services are key drivers and enablers of this shift. Ultimately, this shift will be more beneficial for the end-consumer due to higher satisfaction through more appropriate offers and greater resale value of the car, and for the OEMs in terms of customers satisfaction, recurring revenues, with regular touch point with the customer, and lower costs of operation to some extents."*

A global automotive consumer research that we conducted a few months back with more than 3,000 customers worldwide revealed that around 50% of the customers would be willing to switch to another car brand for better connected services, and most of them said they would do this even if the new brand cost more.[19]

Software will differentiate OEMs and provide a competitive advantage

Half of OEMs (51%) expect to be known for providing software features such as ADAS, self-driving, connectivity, and services as much as their automotive engineering excellence in the next five to ten years. They also firmly believe that software will help them achieve a competitive advantage (i.e., an increased market share) over their peers. Leading OEMs expect to get a 9% higher market share over their peers by differentiating themselves with unique software-based features and services.

Christoph Hartung, ETAS GmbH – a Bosch subsidiary and a provider of systems, tools, and solutions for the auto industry – says, *"Although brand and design will continue to drive differentiation for OEMs in the near future, software is defining how mobility will evolve. Software is already disrupting the entire value chain of programming to deploying automotive components. Add to this the paradigms of new E/E architecture, new capabilities of connected devices, 4G/5G, and cloud, we are starting to unlock new differentiators in data-driven development, and business model innovation. All these key pieces are now coming together which was not possible until recently."* A director, Connected car unit at a German automotive manufacturer, adds, *"Engaging the users of our cars with a highly digital and seamless experience is one of the most important aspects of our transformation. We believe that this overall vehicle experience is one of the biggest opportunities that software enables, since there are few other areas that have a continuous, one-to-two-hour interaction with clients, nearly every day that we as the automakers enjoy."*

According to 60% of respondents, tackling the environmental footprint will be key to building that advantage and driving growth, given how important sustainability issues are to consumers today. Validating this, one of our consumer research from 2020 revealed that:

- Purchasing decision for 56% of customers will be influenced by connected services with a positive influence on the environment
- 53% of them are willing to change car brands if the other brand offers sustainable connected services.[20]

Leading OEMs have sustainable initiatives in place, for example, BMW's Plug-in Hybrid car automatically recognizes when it enters a low emission zone and switches to emission free, purely electric operation.

Dr. James Kuffner, chief digital officer of Toyota Motor Corporation and CEO of the Woven Planet Group says, *"Our dream is to provide a world-class software platform developed by the Toyota Group. I believe this project we call Arene together with connected mobility services will be the platform that will improve Toyota's competitive advantage."*[21]

In the following section, we have identified a cohort of OEMs (who we call the frontrunners) who are better placed to drive differentiation and achieve this competitive advantage over their peers.

3—How mature is the industry when it comes to software-driven transformation and what advantages do the highly mature enjoy?

The software-driven transformation agenda is being backed by substantial investments

To implement a software-driven transformation, OEMs, on average, plan to invest ~2.2% of their annual revenue, every year for the next five years. This translates to nearly 50% of an average OEM's annual R&D budget.[22] Out of the total investment in software initiatives, 46% will go towards the following three areas:
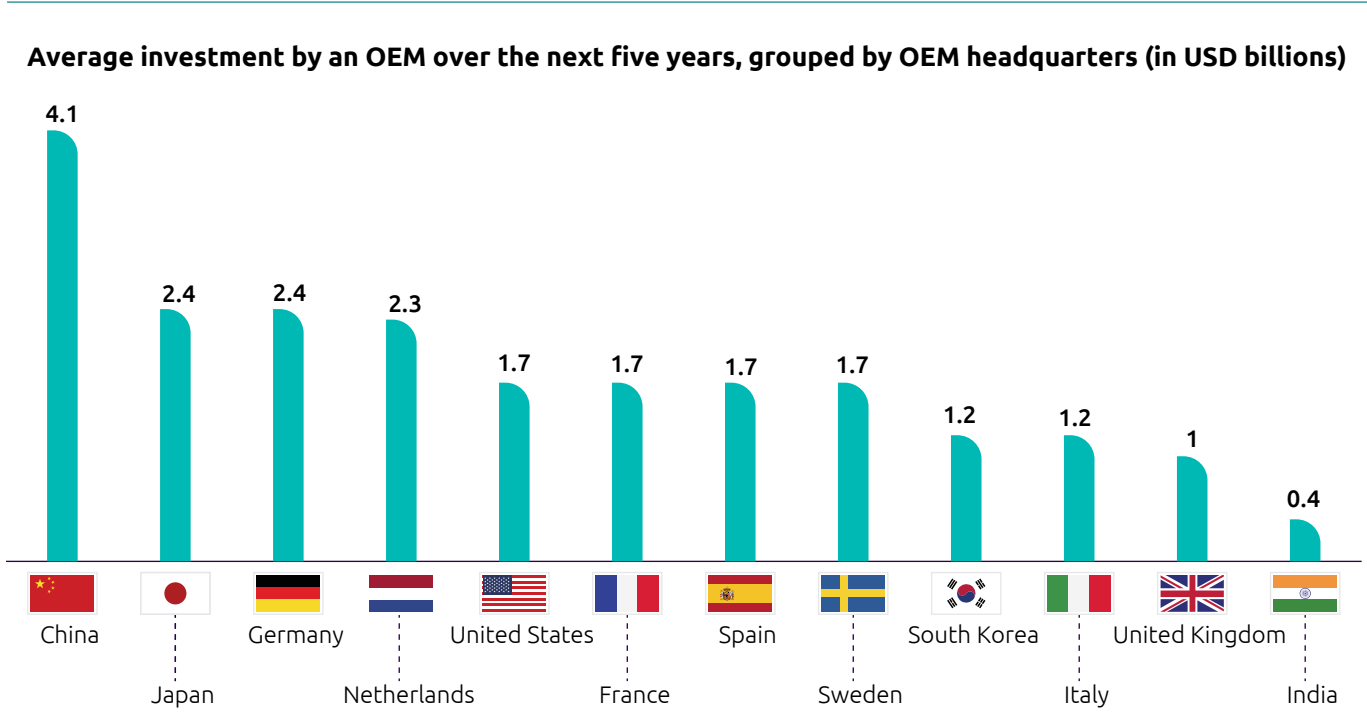
- Software architecture (e.g., software platform of the vehicle, operating system/middleware, software for code generation)

- Software platform for cockpit experience (e.g., infotainment, connected services)

- Security and safety (advanced driver assistance systems and autonomous drive, cybersecurity).

The rest of the investment is divided between other areas such as software for vehicle electronics, powertrain systems, manufacturing/production, and enterprise software. As we can see from Figure 7, OEMs from China are placing the biggest investment bets, significantly exceeding other countries.

Figure 7. OEMs from China invest the most towards their software-driven transformation strategy

Average investment by an OEM over the next five years, grouped by OEM headquarters (in USD billions)

Country	Value
China	4.1
Japan	2.4
Germany	2.4
Netherlands	2.3
United States	1.7
France	1.7
Spain	1.7
Sweden	1.7
South Korea	1.2
Italy	1.2
United Kingdom	1
India	0.4

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

50%

of annual R&D budget will be spent on software by OEMs, on average, every year for the next five years.

Furthermore, more than half (52%) of OEMs believe that they will break even within their investment period (i.e., within 5 years). These OEMs, on average, intend to invest 3% of their revenue annually for the next five years (compared to 2% for the rest of the OEMs).

Over three-quarters (79%) of OEMs are focusing on software in operations, with 74% of OEMs focused on software for product engineering. The top functions receiving significant budget include engineering/R&D and IT (see Figure 8).

Figure 8. Software investments are broadly spread across functions, with a stronger focus on Engineering/ R&D and IT

Investment split for an average OEM, by functional area
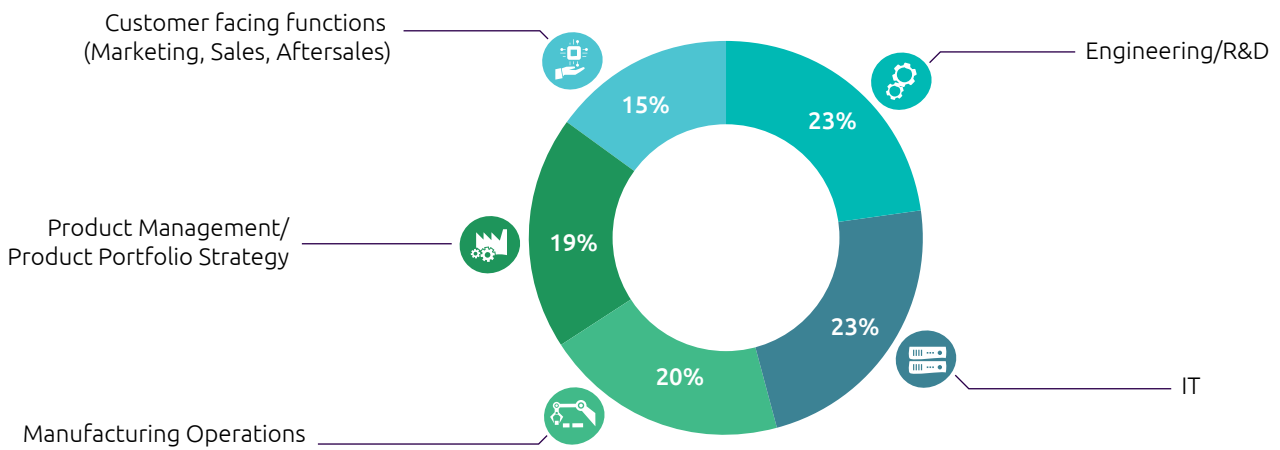
Customer facing functions (Marketing, Sales, Aftersales) — 15%

Engineering/R&D — 23%

IT — 23%

Manufacturing Operations — 20%

Product Management/ Product Portfolio Strategy — 19%

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=572 executives from all functional units.

Only 15%

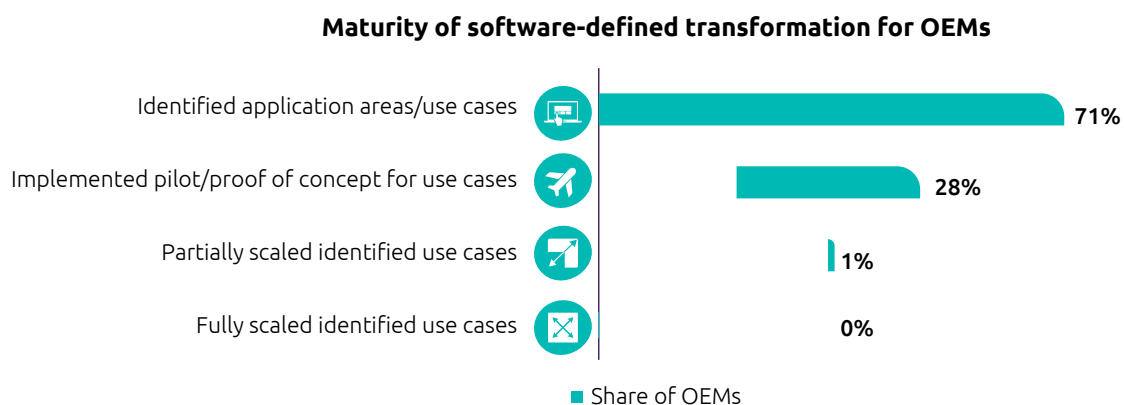of OEMs are mature frontrunners in software-driven transformation.

However, a vast majority of OEMs are only at an initial stage of their transformation journey and only 15% are mature frontrunners

While the automotive industry has begun its transformation journey, it is still at a very early stage:

- 71% have only identified application areas/use cases

- Just 28% have graduated to a pilot/proof of concept based on the use cases

- No OEM has fully scaled the identified use cases based on their software-driven transformation for at least one model/production facility (see Figure 9).

Figure 9. Most OEMs are at the nascent stage of this software-driven transformation

Maturity of software-defined transformation for OEMs

Identified application areas/use cases	71%
Implemented pilot/proof of concept for use cases	28%
Partially scaled identified use cases	1%
Fully scaled identified use cases	0%

■ Share of OEMs

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

Partial scale: Partially scaled the identified use cases for at least one model/production facility
Full scale: Fully scaled the identified use cases for at least one model/production facility
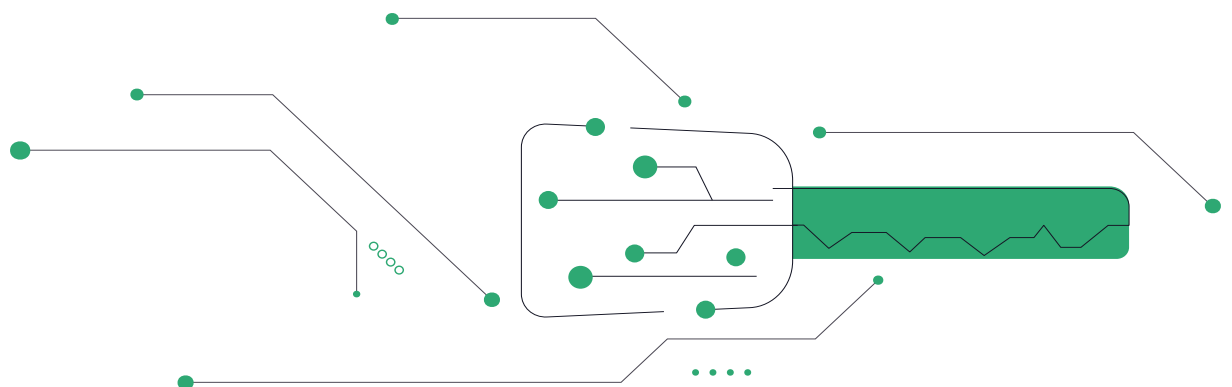
When it comes to partial scaling of use cases for at least one model/production facility, China's OEMs are ahead of the rest, with 63% having implemented a pilot based on software use cases. This perhaps reflects the significant demand seen from customers in the country. *"Customer expectations drive market trends – for instance in China, we see people requesting very advanced features that we do not see in other parts of the world,"* says a senior manager of autonomous driving at an automotive manufacturer based in the United Kingdom. *"So, I think it really depends on consumers and their social-economic factors, cultural factors, and also how much the car will mean to them – will it be a status symbol or an icon or just a car."*

While most organizations, as we have seen, are trying to leverage software, far fewer have successfully delivered against their ambition. Success requires a special set of skills, and capabilities backed with vision and the command of their operational areas. The former makes it possible to deliver the transformation and the latter ensures that they can cohesively deliver a strong outcome. Our research shows that only 15% of automotive OEMs have been able to attain

maturity on both these fronts (see Figure 10). A large share of OEMs who are not as mature are grappling with a range of issues, such as breaking away from legacy architecture and processes, lack of collaboration, and skills shortage (more on the challenges in the next section).

In order to understand the maturity of OEMs, we analyzed their current maturity in terms of two criteria:

- The enablers or intrinsic capabilities to develop, create and leverage software (called transformation enablers)
- The extent to which software is transforming the various operational areas like manufacturing, the vehicles, internal admin systems (see insert: What makes an OEM a software-driven transformation frontrunner).

As Figure 10 shows, only 15% emerged as highly mature frontrunners. On average, frontrunners tend to be twice the size of their peers in terms of annual revenue.

Figure 10. Very few OEMs have the maturity to successfully implement software-driven transformation
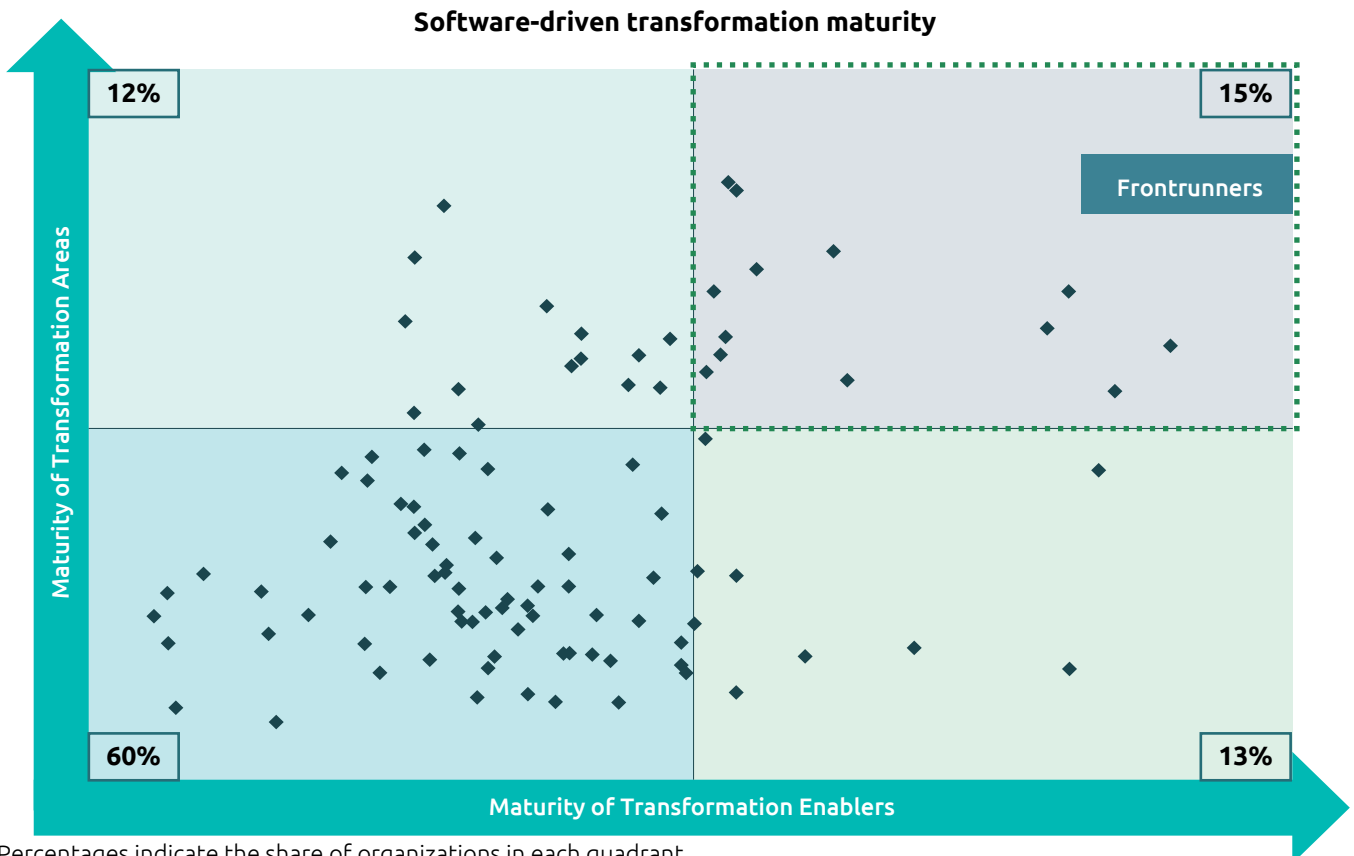
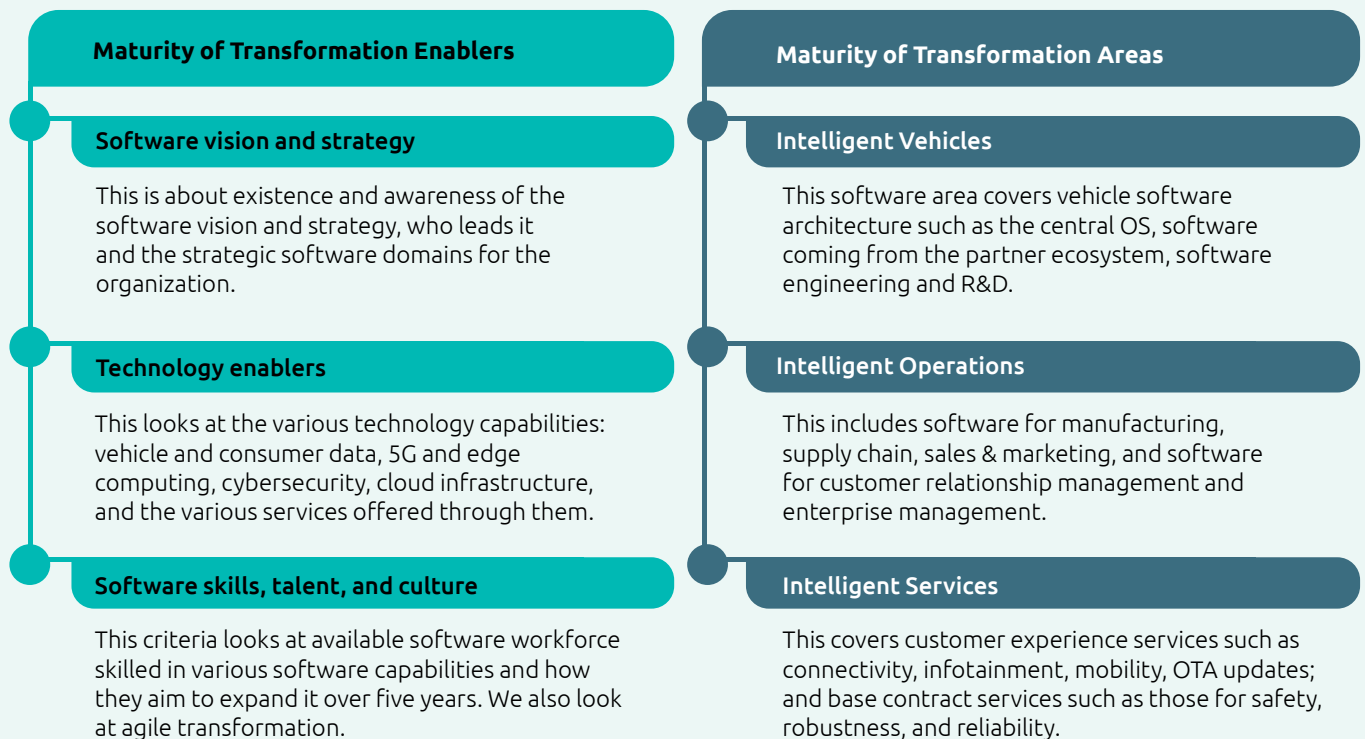Percentages indicate the share of organizations in each quadrant

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=100 OEMs with both General Manager and Engineering representative roles.

Per our survey findings, compared to the rest, the German automotive OEM industry, on average, has built a relatively higher level of maturity in terms of vision, skills, and technology. However, they are in line among their peers in their command of their transformation areas.

What makes an OEM a software-driven transformation frontrunner?

A successful software-driven transformation requires OEMs to build upon two dimensions:

Maturity of Transformation Enablers

Software vision and strategy

This is about existence and awareness of the software vision and strategy, who leads it and the strategic software domains for the organization.

Technology enablers

This looks at the various technology capabilities: vehicle and consumer data, 5G and edge computing, cybersecurity, cloud infrastructure, and the various services offered through them.

Software skills, talent, and culture

This criteria looks at available software workforce skilled in various software capabilities and how they aim to expand it over five years. We also look at agile transformation.

Maturity of Transformation Areas

Intelligent Vehicles

This software area covers vehicle software architecture such as the central OS, software coming from the partner ecosystem, software engineering and R&D.

Intelligent Operations

This includes software for manufacturing, supply chain, sales & marketing, and software for customer relationship management and enterprise management.

Intelligent Services

This covers customer experience services such as connectivity, infotainment, mobility, OTA updates; and base contract services such as those for safety, robustness, and reliability.
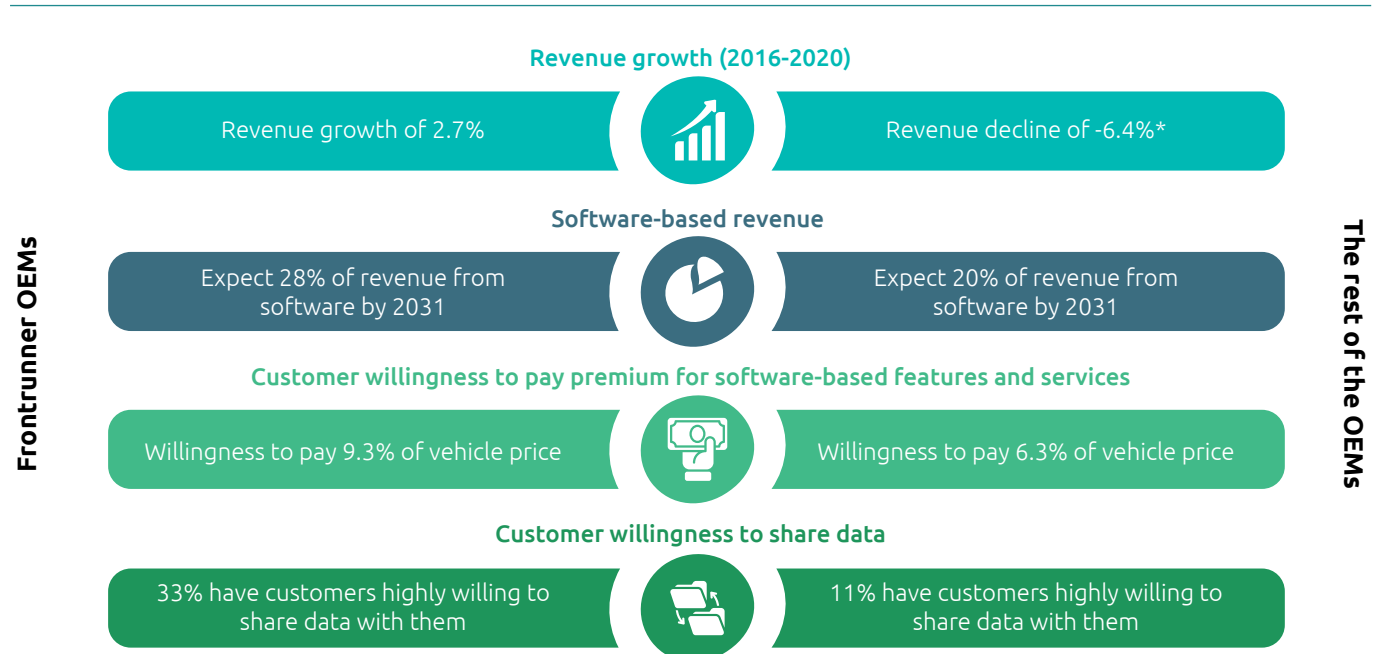
Source: Capgemini Research Institute analysis.

Software-driven transformation frontrunners are likely to achieve better results than their peers

Frontrunners have achieved considerable gains compared to their peers, as Figure 11 shows. For example, they have outpaced the automotive industry in terms of growth, attaining revenue growth of 2.7% compared to a -6.4% revenue decline for the automotive industry during the last five years.

Figure 11. Frontrunners are likely to achieve better results from their transformation initiatives compared to their peers

Revenue growth (2016-2020)

Frontrunner OEMs		The rest of the OEMs
Revenue growth of 2.7%		Revenue decline of -6.4%*

Software-based revenue

| Expect 28% of revenue from software by 2031 | | Expect 20% of revenue from software by 2031 |

Customer willingness to pay premium for software-based features and services

| Willingness to pay 9.3% of vehicle price | | Willingness to pay 6.3% of vehicle price |

Customer willingness to share data

| 33% have customers highly willing to share data with them | | 11% have customers highly willing to share data with them |

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=100 OEMs with at least both General Manager and Engineering representative roles. *Global automotive data from MarketLine.[23]

93%

Share of frontrunner OEMs closely monitoring and tracking the progress and success of their software initiatives by defining software-specific KPIs in various functions, vs just half of the rest of the OEMs.

Frontrunners organize, measure, and invest better in software-driven transformation compared to the rest

At the same time, frontrunners excel at organizing, measuring, and investing in software-driven transformation compared to the others (see Figure 12). Frontrunners:

- Use a centralized transformation approach, which allows them to have a coherent, unified view of the changes. Additionally, this central governance system needs to be backed by reformed processes and methods to successfully move forward on transformation agenda. For example, Volkswagen set up a whole software unit called CARIAD that consolidates software expertise from across the Group under one umbrella.

- Monitor the progress and success of their software initiatives within various functional groups to ensure that they are on track. Compared to the rest, frontrunners understand how critical it is to know exactly what to measure and how to measure it. This way manufacturers can monitor or measure the success rate of their software actions in near-real time and take corrective actions.

- Align their spend according to the customer needs. Compared to the rest, they plan to spend more on

in-vehicle software (such as cockpit experience features, navigation, voice assistants) to improve the overall experience of the customer. As vehicles become more about the digital experience and less about a means of transportation, it is vital for OEMs to provide a superior and personalized experience for consumers and integrate their in-vehicle and exterior vehicle experiences.

- Back their software implementation plans with significant investment. Compared to the rest, they plan to invest more in the next five years to further their software-driven transformation.

- Are better prepared in handling issues related to passenger safety, i.e., reliability, availability, and serviceability (RAS) measures. As more features and updates are enabled by software, passenger safety is paramount. Frontrunners are more adept at providing consistent performance, including detecting in advance which component or system needs repair/maintenance. This helps earn customer trust, as safety- and security-related services are particularly valued by customers (see insert on Connected services maturity and monetization plans for more details).

Figure 12. Frontrunners organize, measure, and invest better in software-driven transformation

Internal restructuring
67% vs 35%
Two in three (67%) frontrunner OEMs have a centralized unit or team to have a coherent, singular view of the software-driven transformation, compared to 35% of the rest of the OEMs.

KPIs to measure benefits
93% vs 50%
93% of frontrunner OEMs, on average, have KPIs to measure benefits in engineering, operations and customer-facing functions; vs 50% of the rest of the OEMs.

Software vs hardware spend to enhance customer UX
29% vs 18%
Compared to hardware features, frontrunner OEMs plan to spend more on software features in the next five years to enhance customer experience (29% for frontrunners vs 18% for the rest of the OEMs).

Investment in software
47% vs 28%
Nearly half (47%) of frontrunner OEMs invest more than $1 billion in their software-driven transformation, compared to 28% of the rest of the OEMs.

Preparedness to implement passenger safety measures
33% vs 2%
One in 3 (33%) frontrunner OEMs are prepared in implementing reliability engineering software and electronic systems (reliability, availability, and serviceability (RAS)), as compared to only 2% of the rest of the OEMs.
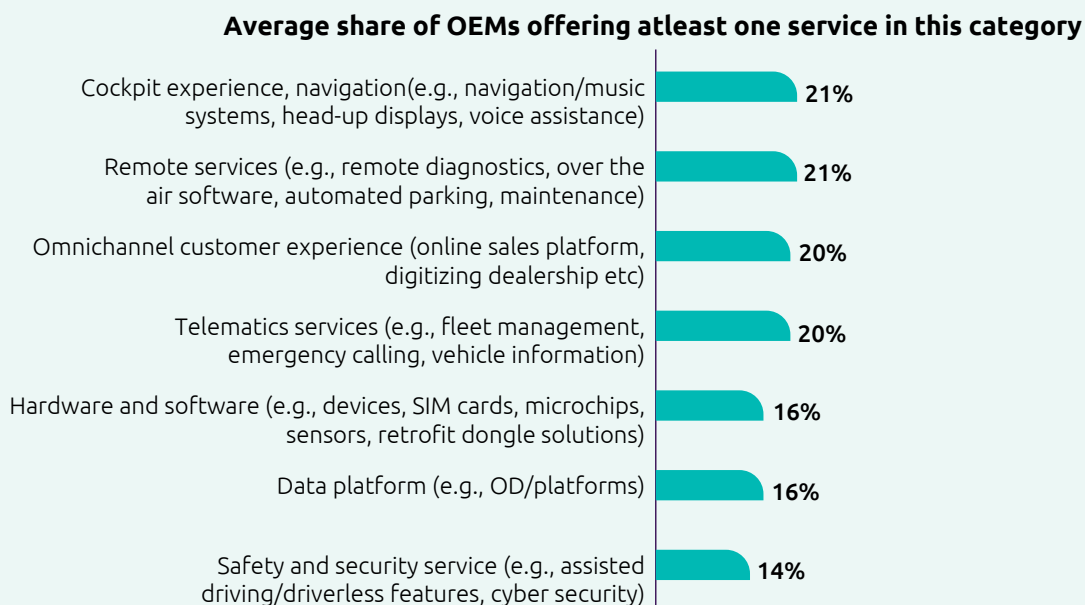
Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=100 OEMs with at least both General Manager and Engineering representative roles.

Connected services maturity and monetization plans

The research shows that OEMs' connected service offerings are not very advanced. Figure 13 outlines a number of service categories, and we can see that only a minority have at least one solution in each area. For example, only around one in five (21%) offer a cockpit experience solution.

Figure 13. OEMs are not advanced in terms of their connected services offerings as only a few offer at least one service in each category

Average share of OEMs offering atleast one service in this category

Category	Share
Cockpit experience, navigation(e.g., navigation/music systems, head-up displays, voice assistance)	21%
Remote services (e.g., remote diagnostics, over the air software, automated parking, maintenance)	21%
Omnichannel customer experience (online sales platform, digitizing dealership etc)	20%
Telematics services (e.g., fleet management, emergency calling, vehicle information)	20%
Hardware and software (e.g., devices, SIM cards, microchips, sensors, retrofit dongle solutions)	16%
Data platform (e.g., OD/platforms)	16%
Safety and security service (e.g., assisted driving/driverless features, cyber security)	14%

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

Maturity is particularly low for safety and security services, which is concerning as several of these services are already mandated by law or will be in the future. Also, due to COVID, OEMs need to focus on developing remote services for the vehicle, as customers will increasingly prefer using them.

Further, those OEMs that currently offer these services have limited success in monetizing them: only 13% currently monetize connected services in some form today with the majority (80%) making it part of future plans. Talking about some challenges in monetizing services, The head of design and development for energy recovery systems at an Italian automotive manufacturer says, *"It is difficult to get the end customer to pay significantly more for software. A customer can see and feel hardware and is relatively happy to pay for a piece of hardware that they see as better than the previous one. This mindset of reluctance to pay more for software in the mass market is not easy to break."*

A director at a Netherlands-based automotive manufacturer adds *"We may experience subscription service fatigue from the customer as they might say that they can't pay for another service because they already pay for 30 of them."* And a SVP, product development at a German

automotive manufacturerobserves, *"If you're hoping that all customers are going to subscribe on day one and stay on, that's not the model, at least not one we're seeing. Also, because customers might have multiple subscriptions, and are billed separately for them, it is difficult for them to keep track. So, this is something that the customer is definitely reacting to, and it needs to be managed better."*

OEMs should focus on maturing and monetizing safety and security services (e.g., theft detection systems, hazard, and collision warning) as customers want these solutions and are willing to pay for them.[24] It is also worthwhile to note that the degree of willingness to pay for various services could vary by geography.
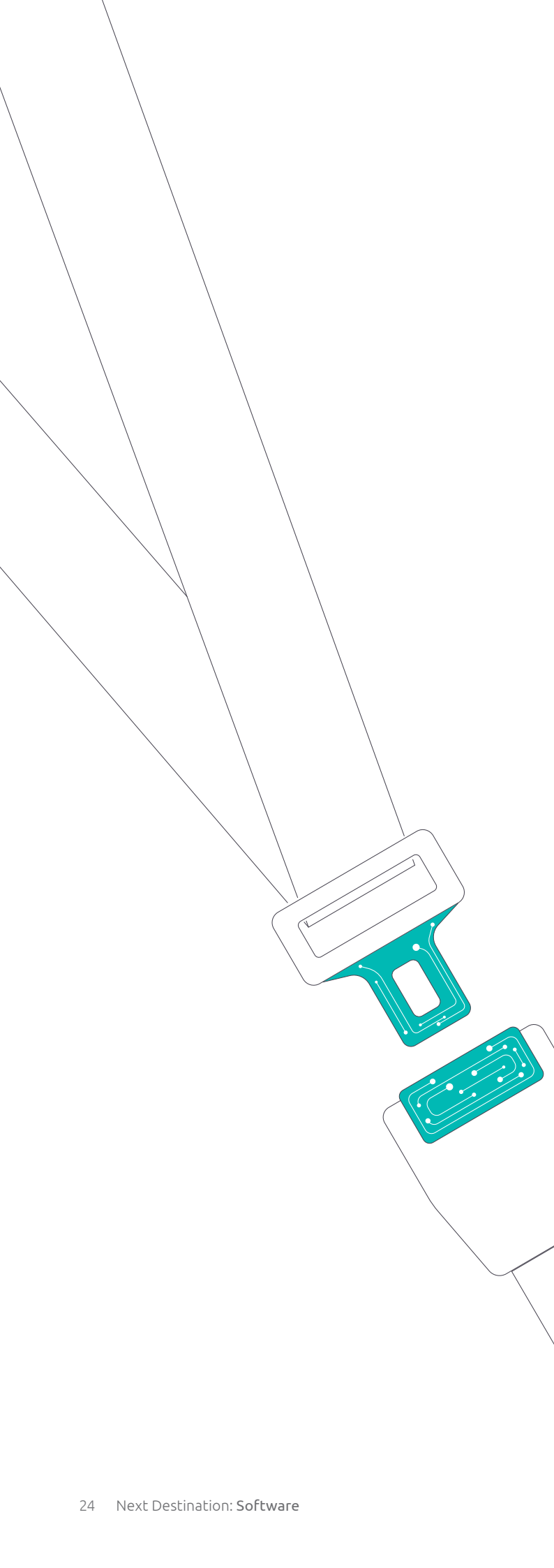
To purchase these services, OEMs should offer flexible options, as 61% of customers want to purchase connected services at any time, 71% would like to decide on individual services or packages, and 69% would like to choose between different versions, e.g., basic, or

premium connected services. Fee-based service bundle subscription renewal rates (after free trial periods) have not always proved successful for OEMs.[25] For example, BMW canceled the annual fee for the in-car use of Apple's CarPlay, acknowledging that customers prefer their phone's interface.[26]

Additionally, to put their monetization plans into action, OEMs need a strong, holistic connected vehicle and OTA strategy. A senior engineering manager from a Chinese electric vehicle manufacturer says, *"To successfully roll out features and updates, the infrastructure needs to be really strong, robust, and reliable. We cannot have incorrect information about any car or its previous updates. As all of this in done through the cloud; while rolling out new software, we keep the service team ready on the field, just in case something goes wrong."*

47% vs 28%

47% of frontrunner OEMs invest more than $1 billion in their software-driven transformation, compared to 28% of the rest of the OEMs.

4—How can OEMs overcome transformation hurdles and harness the full potential of software-driven transformation?

Drawing on our experience of working with leading OEMs globally, as well as insights from this research, we have identified a number of critical success factors for software-driven transformation. These are outlined in Figure 14 and this section looks at each in more detail.

Figure 14. A six-point framework to assist OEMs make the best of their software-driven transformation

Transformation Enablers

1 **Build a software-focused vision and strategy**
- Create a vision for the next five to ten years and rally the organization around it
- Take a broader view of the transformation beyond the vehicle, to include processes and organization

2 **Leverage software toolchains and agile to foster collaboration across organizational units**
- Foster collaboration across the organization and share expertise across silos
- Infuse key elements of agile transformation in your strategy

3 **Forge strategic partnerships on key software frontiers**
- Identify key software frontiers where you need partners' support
- Ensure compliance with cybersecurity and data regulations

4 **Strive for excellence by building and retaining software talent**
- Build a clear strategy for sourcing and retaining software talent
- Create a culture of software excellence on par with engineering excellence

Transformation Areas

5 **Define a clear roadmap for the next-generation software architecture**
- Accelerate the transition to a service-oriented architecture as part of the overall E/E transformation
- Decouple hardware and software development lifecycles

6 **Tap into the power of data to enable intelligent vehicles, operations, and services, faster**
- Aim for end-to-end transformation of vehicles, operations, as well as services through the power of data

Source: Capgemini Research Institute analysis.

"Volkswagen has been a frontrunner in software-driven transformation for many years. Our transformation vision and strategy that encompasses not only the transformation of the vehicle to cater to customer demand, but also the transformation of internal methods or processes and tools; alongside carving out new units such as CARIAD for the transformation of the entire organization. No one element of this transformation is complete without the other two."

Christian Eckert
Head of EER Resource Management & Services, Volkswagen

1. Build a software-focused vision and strategy for your organization

I. Create a compelling software-focused vision for the next five to ten years and rally the organization around it

Leaders must build a clear and compelling vision for what the organization wants to achieve with the software-driven transformation in the next five to ten years. With software increasingly becoming the heart of modern vehicles, OEMs' strategy must be software-focused. By that we mean:

- Vehicles developed around software

- Processes (and associated methods and tools) reimagined with software

- An organization with the right software-related skills and talent.

However, not all are embracing this imperative. While all frontrunners believe that automotive organizations will become software organizations, only 28% of the rest believe this to be the case.

A number of leaders are embracing this shift. Volkswagen, for example, is focused on its "NEW AUTO" strategy. It is currently undergoing a transition from combustion engine to e-mobility and is convinced that its next, more radical change over the next ten years is going to be towards safer, smarter, and finally autonomous cars.[27] This transition will be largely powered by software, creating numerous opportunities. The key aspects of this vision are summarized in Figure 15.

Figure 15. Volkswagen's "NEW AUTO" strategy is clearly focused on software

1. Software excellence and common software platform

- Targeting 60% of its sales and up to 40 million cars based on software stacks developed on its own – the CARIAD group that is developing the software backbone for all group cars

2. Future of Mobility

- Developing systems capabilities for robotaxi fleets, Mobility-as-a-Service (MaaS), and fully autonomous driving

- Expects the market for (MaaS) to grow from <$10 billion today to >$100 billion by 2030, propelled by driverless robotaxis.

3. New vehicle architecture

- Improving and speeding up its Mechatronics platform competencies by investing around 800 million euros into a new research and development facility.

- Achieving margin parity between electric vehicles and IC engine vehicles in two to three years.

4. Business model and recurring revenues

- Establish a business model for a unified software and scale it to 10 million cars p.a.

- Develop a relevant mobility platform and tap into recurring revenue opportunities e.g., autonomous driving

Source: Volkswagen Group website, Volkswagen Group Strategy Day presentations published on, July 13, 2021.

A unifying vision like this, endorsed and promoted by leaders inside and outside the organization, would go a long way in rallying the organization around software as a common cause. It would also ensure that there is broad alignment on goals and objectives among various stakeholders and foster collaboration.

Making software-driven transformation work is going to require a new style of leadership, more agile and adaptive than before. Bringing in a corporate leader with specific experience leading a software organization or an automotive software division is one option to accelerate progress. *"Hiring someone with experience in corporate strategy and leading a software organization can bring valuable outside-in perspective as large OEMs can be hard to disrupt from within,"* says Melissa Sawicke, director at Mahindra Automotive North America, a subsidiary of Indian automotive manufacturer Mahindra & Mahindra. *"An external stakeholder can bring fresh thinking and innovative ideas. He or she can also bring valuable partnerships and help build a partnership ecosystem and alliances. You could then start to analyze what to bring in-house vis-à-vis what to partner for."*

II. Take a broader view of the transformation beyond the vehicle, to include transformation of processes and organizational structure

To achieve the full benefits of software-driven transformation, it is critical to create an end-to-end view of the transformation beyond the vehicle itself to processes and organization. Our survey found that only 18% have a strategy that prioritizes all three key aspects of software-driven transformation. Christian Eckert, head of EER Resource Management & Services, Volkswagen told us, *"Volkswagen has been a frontrunner in software-driven transformation for many years. Our transformation vision and strategy that encompasses not only the transformation of the vehicle to cater to customer demand, but also the transformation of internal methods or processes and tools; alongside carving out new units such as CARIAD for the transformation of the entire organization. No one element of this transformation is complete without the other two."*

2. Leverage software toolchains and the agile methodology to foster greater collaboration across organizational units

I. Foster collaboration across the organization and beyond – sharing expertise across silos through software toolchains

Collaboration with internal stakeholders (internal units and functions) and external stakeholders (suppliers, dealers, software players) is going to be a key enabler of the software-driven transformation as software toolchains and applications cut across organizational boundaries and silos. Software development methodologies, such as DevOps and DevSecOps (which stands for development, security, and operations and integrates security as a shared responsibility throughout the software development lifecycle), that inherently require creation of cross-functional teams of software architects, developers, testers, business users, and in some cases clients/customers. One of the ways DevOps makes the collaboration to work seamlessly is through toolchains which are an integrated set of commonly used tools for code development, management, testing, automation, and monitoring. Having a toolchain made accessible to users across the organization – from hardware and software engineering, production, and business users shortens improves the quality of software while reducing the time to rollout new features.

Some OEMs are making significant investments in unified customer relationship management systems in order which aid multiple teams build a common view of the customer. By combining vehicle data (such as vehicle performance

indicators) with customer data across domains (such as service preferences, willingness to pay, etc.), OEMs will be able to apply advanced analytics and AI to make intelligent decisions about next-best actions such as offering new services or assistance.

Traditionally, expertise can be siloed in OEMs, reflecting the need for teams to develop specialist expertise. OEMs will have to find ways of unlocking this expertise by bringing specialists onto one common "playground" to exchange ideas and best practices freely and seamlessly. For instance, this can be done either at an organizational level (for instance, by creating an organization-wide program headed by a taskforce of experts), or at business unit level impacting a subset of brands or vehicle models rather than all of them.

Fostering collaboration will be a critical exercise as the research shows that many organizations are not aligned and working together with a common purpose, either internally or externally:

- In terms of internal collaboration, 62% feel that objectives for functional groups are not aligned with leadership strategies of software-driven transformation.

- In terms of external collaboration, nearly half (49%) believe that collaborating and combining applications sourced from various suppliers – and then building them into a single and standard platform – is going to be challenging.

"It's always difficult to change people's ways of working but it is absolutely critical with software-driven transformation. Breaking silos will not only help make faster progress on transforming the organization, but software will itself help bring internal units and functions closer together by allowing them to work on a single toolchain."

Melissa Sawicke
Mahindra Automotive North America, a subsidiary of Indian automotive manufacturer Mahindra & Mahindra

"I believe the legacy of every unit dealing with suppliers independently, and then integrating various components and applications, is not more optimal anymore," says director of product development at a leading German manufacturer. *"It has to give way to a new working model of a more seamless collaboration between various units and also with suppliers."*

Software tools and applications can themselves serve as a bridge to improve collaboration internally and externally. *"It's always difficult to change people's ways of working but it is absolutely critical with software-driven transformation,"* says Melissa Sawicke, director at Mahindra Automotive North America. *"Breaking silos will not only help make faster progress on transforming the organization, but software will itself help bring internal units and functions closer together by allowing them to work on a single toolchain."*

She adds, *"For instance, once you have an enterprise data lake, it is no longer Sales or Marketing data, it will be all departments working off the same system and seeing all the same things depending on their access and security protocols. A single chain of tools like this can align KPIs, enable end-to-end traceability, align stakeholders with a common language, and lead to faster decision-making."*

II. Infuse key elements of agile transformation into your software-driven transformation strategy without disregarding vehicle quality and regulatory requirements

So far, only 8% of OEMs have included agile transformation as a key ingredient in their software-driven transformation strategy today (with 43% planning on doing so in the next three years). Frontrunner OEMs are significantly ahead of the rest in adopting key agile transformation practices (see Figure 16), which is a critical capability. While the automotive industry is no stranger to monthly sales action plans, special launch of new models every quarter, agile principles can not only bring speed of delivery, but also clearer prioritization of customer value, and greater cross-functional collaboration. Christian Eckert, head of EER Resource Management & Services, Volkswagen told us, *"We need to cater to fast-changing demands of not only end consumers but our B2B partners such as dealerships and fleet operators, globally. To do this effectively, we need to adapt the timeline of development of various software features in line with organizational priorities. So, some updates need to be shipped every week, while some can take a few weeks. Agile tools and processes help us achieve that."*

The agile methodology has proven to be extremely beneficial not only in the context of software development but also across wider organizational transformation. Adopting agile principles has particular challenges for the automotive industry in two broad areas – the need to adhere to strict regulations, and incompatibility with conventional development and quality processes. However, our discussions with clients and industry experts confirm that the potential benefits of agile methodology – such as customer-centricity, promoting collaborative work, faster value delivery, and better clarity on priorities and value streams – outweigh any difficulties faced during its implementation. The implementation of Agile methodologies will also require some changes to adapt to the vehicle design, quality, and regulatory constraints.

Figure 16.Frontrunners are ahead of the rest of the organizations in adopting key agile transformation practices

Key agile practices that OEMs are planning to inculcate in the next five years
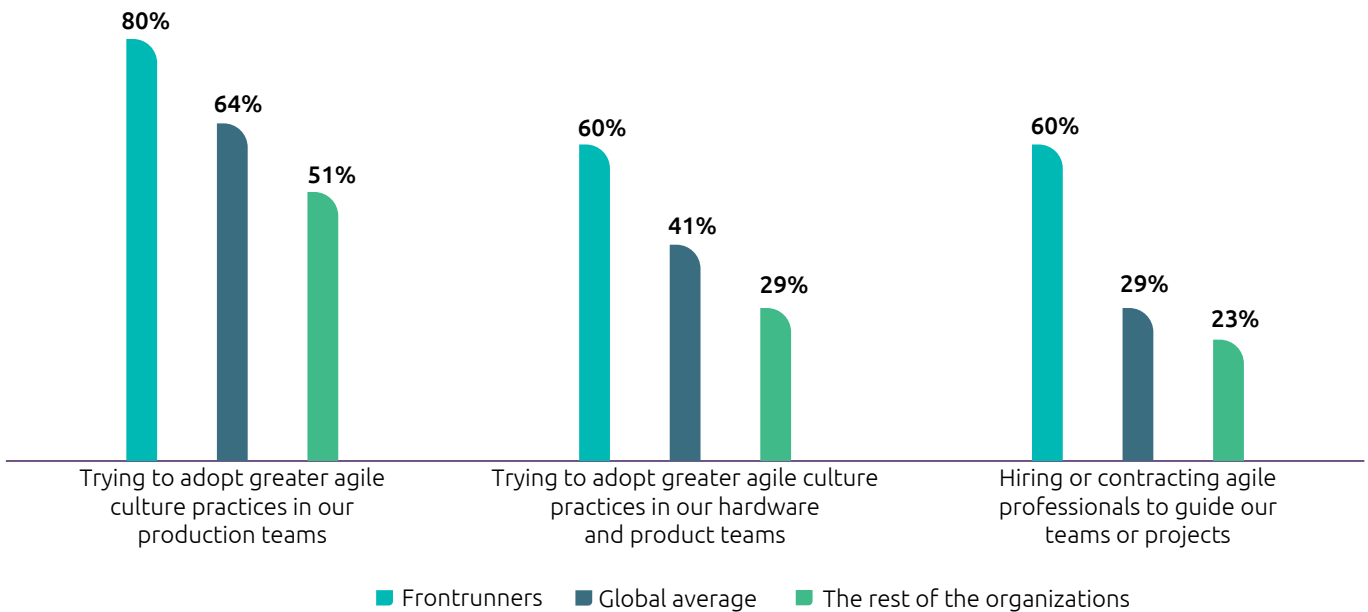
	Frontrunners	Global average	The rest of the organizations
Trying to adopt greater agile culture practices in our production teams	80%	64%	51%
Trying to adopt greater agile culture practices in our hardware and product teams	60%	41%	29%
Hiring or contracting agile professionals to guide our teams or projects	60%	29%	23%

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

Only 10%

of OEMs, on average, believe that they are well prepared to implement various cybersecurity measures.

3. Forge long-term, strategic partnerships with software and technology service providers on key software frontiers

Delivering software-driven transformation requires new, deeper, and more long-term partnerships and joint ventures with software, technology, and service partners that can help OEMs scale, such as providers that can offer capabilities in chipset and semiconductor manufacturing, embedded and application software development, cloud, and AI, for instance. OEMs need a robust ecosystem strategy to effectively strike and scale these partnerships. *"OEMs still procure software products and services in much the same way as they purchase any other automotive component,"* says Christoph Hartung of ETAS GmbH. *"Moreover, the purchase cycle is also very short, up to two to three years. That will have to change with software taking centerstage. OEMs will need to strike strategic partnerships with software providers and work hand-in-hand with these partners to co-innovate, co-develop, and co-deliver products and services over much longer time horizons."*

I. Identify your key software frontiers where you need partners' support

In the next three to five years, half of OEMs plan to create joint ventures with software/tech vendors or service providers to to create new software organizations, and 44% plan to partner with system integrator firms for end-to-end capabilities and software services from consulting, technology to process outsourcing. Sharing of generated value is going to be key for collaborations to prosper. *"With greater collaboration in delivering new services to the end-consumer, OEMs and tier-1 suppliers will have to agree on revenue share in line with the value that they bring to the table,"* says a senior manager of autonomous driving at an automotive manufacturer based in the United Kingdom. *"Although it depends on the business model of the services sold to the customer, there is a lot of potential for a win-win agreement between the two parties."*

Multiple areas in the automotive software value chain require external collaboration and partnerships. Take as just one example the vehicle's software architecture. This ecosystem partnership typically involves collaboration and integration across the vehicle hardware (embedded systems, chips, sensors, networking systems, etc.) and software systems stack (the operating platform of the car, infotainment, ADAS/ autonomous system). This type of partnership allows OEMs

to tap into the latest innovations in hardware abstraction and service-oriented architecture. Currently, nearly half (45%) of the OEMs collaborate with traditional automotive suppliers, such as Bosch and Continental. However, this sourcing strategy is bound to change in the next five years as some (10%) OEMs will move towards technology players such as Nvidia, Intel, and Huawei for specialized hardware and their tightly coupled and end-to-end software. Although this approach will require OEMs to lose some of the control over their vehicle architecture, which will hard to accept for most OEMs. More on this is discussed in more detail in one of the following sub-sections on vehicle software architecture.

II. Ensure compliance with cybersecurity and data regulations.

Most OEMs facing growing compliance and cybersecurity challenges as the industry moves to highly connected and software-driven vehicles and systems:

- 71% believe that the GDPR and other regulations have created unique challenges with regards to customer and vehicle data.

- Only 10%, on average, believe that they are well prepared to implement various cybersecurity measures (see Figure 17).

- 60% find it challenging to ensure that suppliers' products meet regulatory requirements around cybersecurity risks.

OEMs must therefore create a strong technology foundation of data privacy, security, and cybersecurity requirements. However, over a third (37%) do not collect any data related to vehicle cybersecurity and out of those who do collect data, 25% do not analyze it to uncover patterns and insights. Specialized software providers for cybersecurity and data privacy and security can help OEMs not only collect relevant data, but also help maintain and analyze it to understand threat patterns to prevent vulnerabilities in the future while adhering to data protection standards.

OEMs now need to conform to the UNECE regulations[28] for automotive cybersecurity, which clearly define performance and audit requirements for IT security and software updates

Figure 17. OEMs are facing growing compliance and cybersecurity challenges

How prepared are OEMs to implement cybersecurity measures in the following areas, share of OEMs

	Well prepared	Average preparation	Not well prepared
Providing secure OTA software updates and ensuring vehicle safety is not compromised	9%	15%	76%
Detecting and addressing security threats across vehicle fleet in the field	8%	14%	78%
Reliability engineering software and electronic systems - reliability, availability, and serviceability (RAS)	8%	11%	81%
Securing vehicles by design to mitigate cyber risks	6%	11%	83%
GDPR and other consumer data protection acts	4%	23%	73%

■ Well prepared   ■ Average preparation   ■ Not well prepared

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs, respondents primarily from general management function.

for vehicles. It requires specific actions by manufacturers in four key areas:

- Management of cyber risks for vehicles

- Security by design during vehicle development to minimize risks along the value chain

- Intrusion detection and protection for the entire vehicle fleet

- Provision of secure software updates and establishment of a legal basis for over-the-air updates.

Further, upcoming ISO/SAE 21434 standard aims to ensure that vehicles are secure throughout their lifecycle, with a particular focus on risk management. It also makes specific reference to the need for a strong cyber security culture at an organizational level for manufacturers.[29]

"OEMs still procure software products and services in much the same way as they purchase any other automotive component. Moreover, the purchase cycle is also very short, up to two to three years. That will have to change with software taking centerstage. OEMs will need to strike strategic partnerships with software providers and work hand-in-hand with these partners to co-innovate, co-develop, and co-deliver products and services over much longer time horizons."

Christoph Hartung
ETAS GmbH – a Bosch subsidiary and a provider of systems, tools, and solutions for the auto industry

4. Strive for software excellence by building and retaining software talent

I. Build a clear strategy for sourcing and retaining software talent

There is a growing need for software capabilities and expertise in the automotive industry: 97% of executives say that in the next five years as much as 40% of their talent will need to possess the necessary skills in-house to deliver software-driven transformation. The largest and most critical talent gap is for software/IT architects, followed by cloud management professionals and cybersecurity and compliance

experts. There will also be a need for experts with a good mix of both industry and technology expertise (see Figure 18). Christian Eckert, head of EER resource management & services, Volkswagen, says, *"CARIAD is one of our biggest bets on software transformation as we've grown the unit from modest beginnings about five years ago to over 11,000 now. And yet, we are constantly on the lookout for software talent. We need software experts globally in all our major countries and locations. And hiring them is just one part of the strategy. We have our own university to upskill internal talent on software skills."*

Figure 18. Software skills to deliver software-driven transformation are in short supply, making hiring and retaining these skills among the top talent management challenges

Most critical talent gaps for OEMs

Software/IT architects	56%
Cloud management professionals	45%
Cybersecurity and compliance experts	44%
Developers with AI, machine learning, deep learning expertise	39%
Embedded software engineer/product development experts with a mix of industry and technology expertise	36%

■ Share of executives
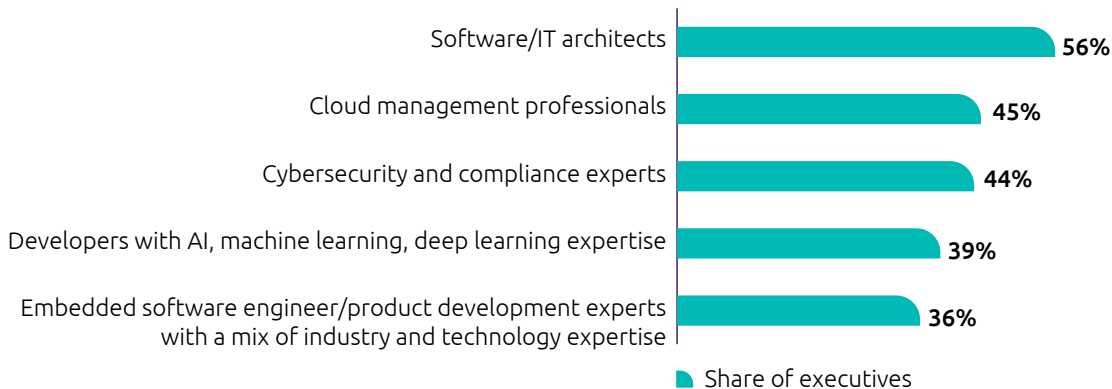
Top challenges OEMs face with respect to talent management

Retaining the talent after recruiting is difficult	60%
Sourcing the right talent is difficult to find due to high demand from other manufacturers and non-automotive organizations	55%
Creating awareness about the need for the right talent is challenging	48%
Getting the right talent and skillset is expensive	38%

■ Share of executives

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=572 executives from all functional units.

As well as the issue of a short supply of talent, retaining talent (60%) and sourcing the right talent (55%) are two of the top challenges that OEMs face with regards to software skills. OEMs need to be an employer of choice for software professionals by investing in specific programs for hiring, retaining, and upskilling experts with software know-how.

In hiring, OEMs will compete with not only their peers in the industry, but also BigTech companies, pure-play, and generic software products, and services providers. These tech organizations hold a strong positioning in the market owing to the higher than average pay packages and employee-friendly policies. But more than that, these tech players offer a particular culture, where there is a mindset of innovation and experimentation based on a test and learn, agile, and nimble approach that avoids bureaucracy and quickly pivots if a solution is not working. OEMs' unique talent proposition instead is to offer complex and unique problems that are challenging yet compelling to solve. For instance, making roads and driving safer for all, making transportation sustainable, and mobility within everyone's reach. Earlier this year, Daimler announced its plans to hire 1,000 software engineers in Germany to develop its planned operating system for electric vehicles.[30] This is part of Daimler's broader drive to recruit a total of 3,000 programmers worldwide to strengthen Daimler's global software hubs in India, Germany, the US, China, and Israel. *"To gain expertise, our hiring practices are changing as well,"* says a director at a Netherlands-based automotive manufacturer, talking about the hiring software skills and its related challenges, *"because the skill sets we are now looking for are different than what they used to be. We also find that it is difficult for people to transition from non-automotive to automotive environment, because the requirements are just so much different and so much more stringent."*

To keep software professionals engaged, OEMs will need to cultivate their intellectual curiosity and technological acumen. This can be done by bringing software professionals from across various parts of the organization together in one community to solve challenges beyond their immediate function:

• This can be done formally, by establishing a software excellence academy or council of experts with well-defined levels where professionals progress as they develop their skills and knowledge. Additionally, career models/frameworks, and incentive structures need to be created instead of relying on legacy frameworks that may not be in line with the aspirations of software experts.

• Informally, organizations can create hackathons and challenges that give software professionals a chance to collaborate and compete with similar professionals from inside and outside the organization – providing opportunities to learn and grow.

To reduce the pressure of hiring new talents, OEMs must strive to upskill their existing engineers with software knowledge and expertise.

Traditionally the industry has not been very flexible and fast. So, shifting into a new culture with less hierarchies & embracing the change will be vital. But you also need to combine this with capabilities, i.e., attracting talents and building competence."

Petter Hörling,
Director research at Volvo Cars

II. Create a culture of software excellence on a par with mechanical excellence.

A big challenge for OEMs will be integrating a culture that attracts and retains software developers – a culture of programmers and code developers – into one of automotive engineers. The process of bringing these two cultures together in an effective way will require an ongoing plan of action. And not only a cultural one, with hardware and software development cycles running to very different time scales, aligning them in an effective way, to deliver a great product, is going to be a challenging task. *"Traditionally the industry has not been very flexible and fast. So, shifting into a new culture with less hierarchies & embracing the change will be vital"* says Petter Hörling, director research at Volvo Cars. He adds, *"But you also need to combine this with capabilities, i.e., attracting talents and building competence."*

Software engineers will come to the automotive industry with a belief that they can influence the car of the future. If they are empowered to make key decisions related to vehicle design and development in an environment of trust, they will find the culture to be conducive to their individual and collective growth. *"Automotive organizations not only need to hire good software talent but also create an environment that nurtures this talent,"* says Shawn Sehy, senior director at Nissan. He adds, *"Software experts would need senior management's trust and a level of freedom to experiment and apply what they know. Only then will the new culture prosper and deliver."*

5. Define a clear roadmap for next-generation and standardized vehicle software architecture

The transformation of software architecture has to be part of the overall vehicle E/E (electrical and electronics) architecture transformation, including infrastructure such as high-performance computing or domain controllers as well as in-vehicle network architecture. For the scope of this research, we discuss the transformation required in the vehicle software architecture which involves virtualization towards a service-oriented architecture to aid:

a. Accelerated development of a common software platform

b. Decoupling of hardware and software development lifecycles.

"With increasing reliance on software and electronics, managing the complexity of vehicle architecture is going to be extremely difficult and mastering it is going to be even more challenging," says Christoph Hartung of ETAS GmbH. *"It is a good sign that the OEMs are investing and have invested in the development of service-oriented architecture. The best practices developed by the software/IT industry can further help OEMs, as they have mastered service-oriented architecture for over a decade. Together they can promote open standards (such as AUTOSAR) and open tools that will benefit the entire industry."*

AUTOSAR – a global partnership of leading automotive and software firms – develops and establishes a standardized software framework and open E/E system architecture.[31] The AUTOSAR standards enable development of hardware and software independent of each other, and enhances quality and efficiency through software reuse. They also establish distributed development among suppliers, enabling design flexibility, innovation, simplified system integration, and reduced software development costs.

I. Accelerate the transition towards a service-oriented architecture to aid the development of a common software platform

Cars have, in the past, been dominated by microcontrollers that control very specific parts of the vehicle. All of these act independently and may amount to millions of lines of code. Currently, 93% OEMs have a traditional vehicle architecture with independent controls for each vehicle function. Discussing the drawbacks of traditional architecture, a director at Netherlands-based automotive manufacturer, says, *"We decide on a system architecture, and then it takes two to three years to get to the launch of the vehicle. By then, the choices that we had locked in are now obsolete. The need to develop a new electrical architecture used to be every seven to 10 years in the past, but now it's reduced drastically. New architecture needs to be developed to enable new features with greater computing power."*

Recent research from the Volvo Car Group revealed that an average Volvo vehicle in 2020 had 100 million lines of code – equivalent to over 60,000 books of 300 pages of average length.[32] Volvo expects this complexity to grow tenfold in the next ten years. With the additional complexity of functions such as ADAS, edge computing, and vehicle safety, we are fast moving to an automotive world where the growing complexity of vehicle architecture is likely to massively increase vehicle development costs (and time) for hardware and associated software, let alone increasing warranty and recall costs if not managed well. This complexity will need to be managed and brought under control, even as the utility of vehicle electronics will be defined by the services that it enables. This is true since traditional vehicle architecture cannot cope with this additional complexity.

"Automotive organizations not only need to hire good software talent but also create an environment that nurtures this talent. Software experts would need senior management's trust and a level of freedom to experiment and apply what they know. Only then will the new culture prosper and deliver."

Shawn Sehy
Senior director at Nissan

A service-oriented architecture is therefore paramount to the success of a software-driven transformation of the vehicle.

In the service-oriented approach, every module – for instance, electronic control units that help operate various components of the car (such as windscreen wipers, windows, air conditioning, etc.) – offer their functionality by means of a service that can be invoked via application programming interfaces (or APIs). It allows for a more granular and simplified operation of various electronics units of the car by means of software. This approach can be further simplified if various electronic control units within each domain (such as body, chassis, cockpit experience) can collaborate with each other as well as with other domains via a central computing unit. However, only 18% of OEMs state that the transition from independent, siloed architecture to more centralized, consolidated software and E/E is important. Highlighting the importance of a more centralized structure, The head of design and development for energy recovery systems at an Italian automotive manufacturer says, *"The onboard computing is exploding in terms of the number of individual devices which have processes in them which are scattered around the vehicle and doing different functions. But this is not very sustainable because you end up with a lot of over specified processes. Like, many devices that are maybe working at 10% of their capability because they don't need to do anymore."* A step further is the introduction of domain control units (DCUs) that would further simplify control of various domains and standardization of software and hardware to handle each domain.

This transformation will accelerate the trend of a vehicle running on a single platform for the operation of the car (compared to today's situation, where you have multiple and independently working pieces of software). Mercedes-Benz has partnered with Nvidia to develop a next generation computing platform that it would begin rolling out to its fleet in 2024.[33] The AI platform allows the development of advanced autonomous functions, new in-cabin features, driver monitoring, and other safety features, along with over-the-air software updates.

The head of design and development for energy recovery systems at an Italian automotive manufacturer explains why a non-standard and disparate software systems in the car create problems, saying, *"OEMs have too many software systems that don't communicate with each other. Teams working on those systems individually continue to develop their own pieces of software packages where they see an edge in their domain as they don't want to risk falling behind developments in other parts of the vehicle. This creates an overhead to build custom integrator systems that pull data using APIs from each individual system to create an end-to-end view of the vehicle operation."* He adds, *"Instead, OEMs need a strategic partner with a long-term approach to guide them in adopting a suite of integrated tools that allow seamless software development for all departments with pre-built connectors between various domains."*

The service-oriented architecture will significantly reduce this complexity and ease the engineering process by moving the complexity in a "middleware" layer that can be developed per industry standards. OEMs must pursue this standardization of architecture at a fast pace as it is critical to harnessing the full potential of software and has numerous advantages. For instance:

c. **Shorter design cycles and scalability:** The current cycle of design to market is on the long side as it takes a significant amount of time for a design change to be rolled out into production. With more vehicle functions being controlled by software, which is in turn easier to update and ship, it is now possible to handle more changes in the design of a vehicle. It also aids scalability of functions across vehicle lines and brands due to simpler portability of software packages, processes, and best practices.

d. **Support for 5G/edge computing as well as offboard functionality via cloud:** The evolution of software and hardware architecture will have to seamlessly incorporate the evolution of 5G/edge computing and cloud technologies as well. In that respect, the vehicle architecture must be considered from chip to cloud,

rather than each in isolation or as separate, "onboard" vs "offboard" silos. An end-to-end architecture is needed that fulfills the needs of superior performance at the vehicle level without compromising vehicle safety, data privacy, or cybersecurity (see Figure 19). As the architecture evolves, several computing requirements of the vehicle (such as infotainment, and non-safety critical services) will be offloaded to cloud to take advantage of virtually unlimited storage and computing resources – either "on premises at the OEM's site or on private/public cloud operated by cloud service providers. Whereas more safety-critical elements, edge computing use cases and autonomous/ADAS system software will continue to be served by the compute onboard the vehicle. Seamless connectivity via 5G will enable new use cases such as augmented reality enabled displays, and direct

delivery of consumer goods to the boot of the vehicle, among others. The collective intelligence of vehicles fleet or cars in traffic (enabled by real-time or near-real-time analysis of aggregate fleet data on cloud) will also enable innovative use cases such as dynamic routing and proactive detection of traffic congestion.

Only 18% of OEMs have currently employed 5G use cases in their vehicles as part of their software-driven transformation strategy, but 55% plan to do so over the next five years. This exponential growth in the use of cloud and edge computing must be matched with the right investments in the technology infrastructure to build an end-to-end architecture for the vehicle. Finally, OEMs and technology partners will have to find ways to bundle and price access to cloud services appropriately to not ward off unwilling customers.

Figure 19. Evolution of end-to-end vehicle system architecture
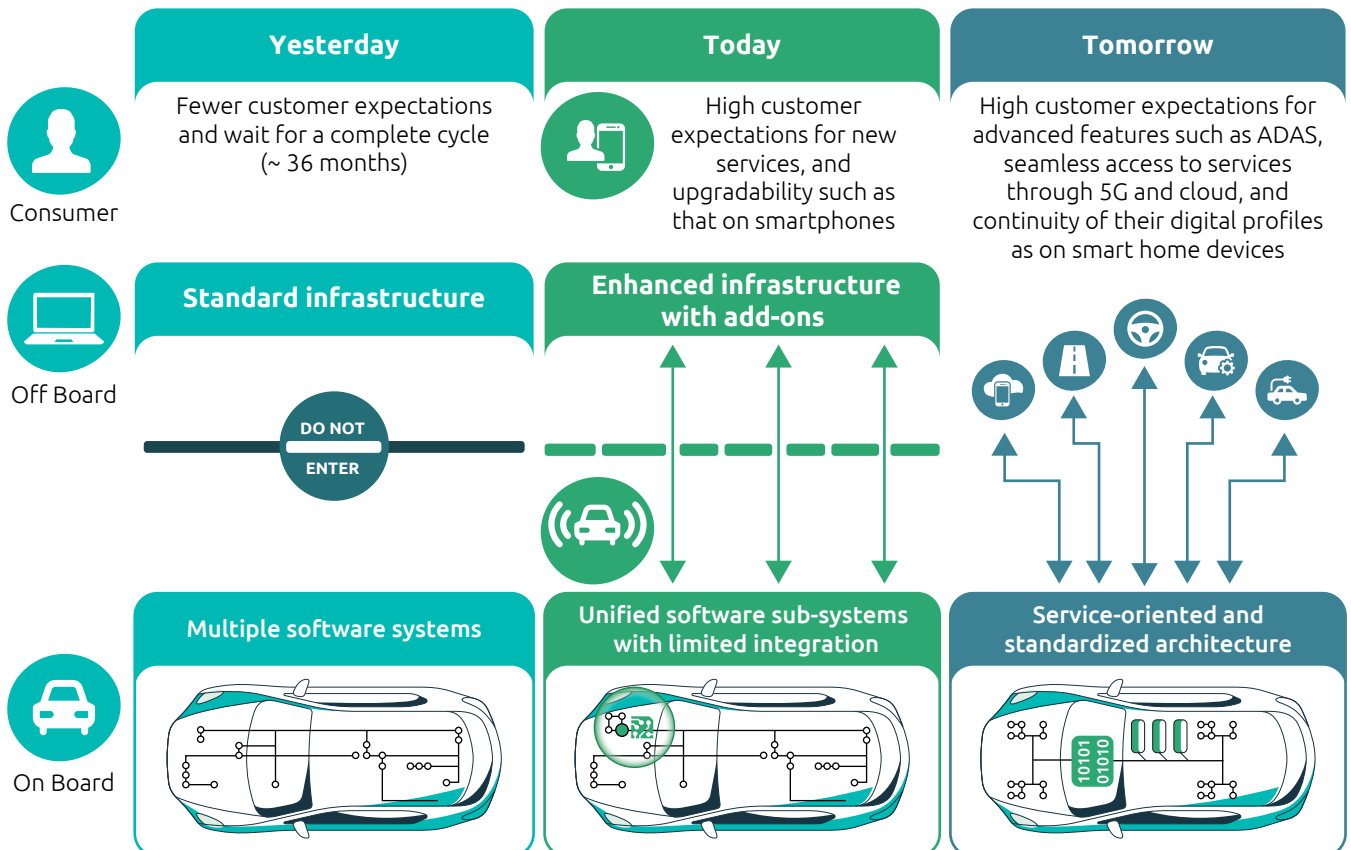
Source: Capgemini Research Institute analysis.

II. Decouple hardware and software development lifecycles.

Only 13% of OEMs say that they have a plan to de-couple and separate the currently tightly integrated hardware and software architecture and development. This shows that OEMs are not yet ready to deploy software in vehicles with greater speed and frequency. This in turn translates into an ineffective mechanism for over-the-air (OTA) updates. Just 4% of OEMs say that they currently provide some kind of an OTA update.

The software development, testing/validation, and release approach is fundamentally faster with respect to the hardware development in the vehicle. This creates a functional disconnect between the two domains when it comes to developing and maintaining them over the lifetime of the vehicle. While the hardware, once it leaves the factory, can mostly be upgraded when the vehicle arrives for maintenance or servicing at a dealer, the software system has no such constraint and can be handled via over-the-air upgrades delivered via cloud and mobile networks. Consequently, it makes sense to delink the software development from the evolution of hardware. This allows you to deliver improvements in software in smaller releases pushed frequently to the vehicles, much like we update our smartphones and apps at regular intervals.

Decoupling hardware and software development, while preserving the departments' collaboration and alignment, can accelerate the pace at which OEMs can innovate. This new model is the best way to start to drive change, to embrace agile development models while maintaining necessary collaborations.

6. Tap into the power of data to more quickly enable intelligent vehicles, operations, and services

As Figure 20 shows, there are various data domains enabled by software that have the potential to add "intelligence" to the automotive value chain. However, organizations that do not have a mature approach to using data analytics across the value chain – vehicles, systems, operations, and services – are in the majority.

Across vehicles, operations and services, the picture is mixed:

- "Intelligent products & systems": More than half (52%) use data related to vehicle performance, usage, vehicle electronics, and body either historically or in real-time through AI-powered algorithms and machine learning.

- "Intelligent operations" – this area is relatively weak. For example, less than a third (30%) use operations data for predictive decision-making and supply chain management.

- "Intelligent services" also require more effort – nearly half (45%) do not offer any connected services and our previous research with automotive consumers has found that 44% of customers do not yet have any connected services in their cars, and only about half of those who do have them are frequent users.[34]
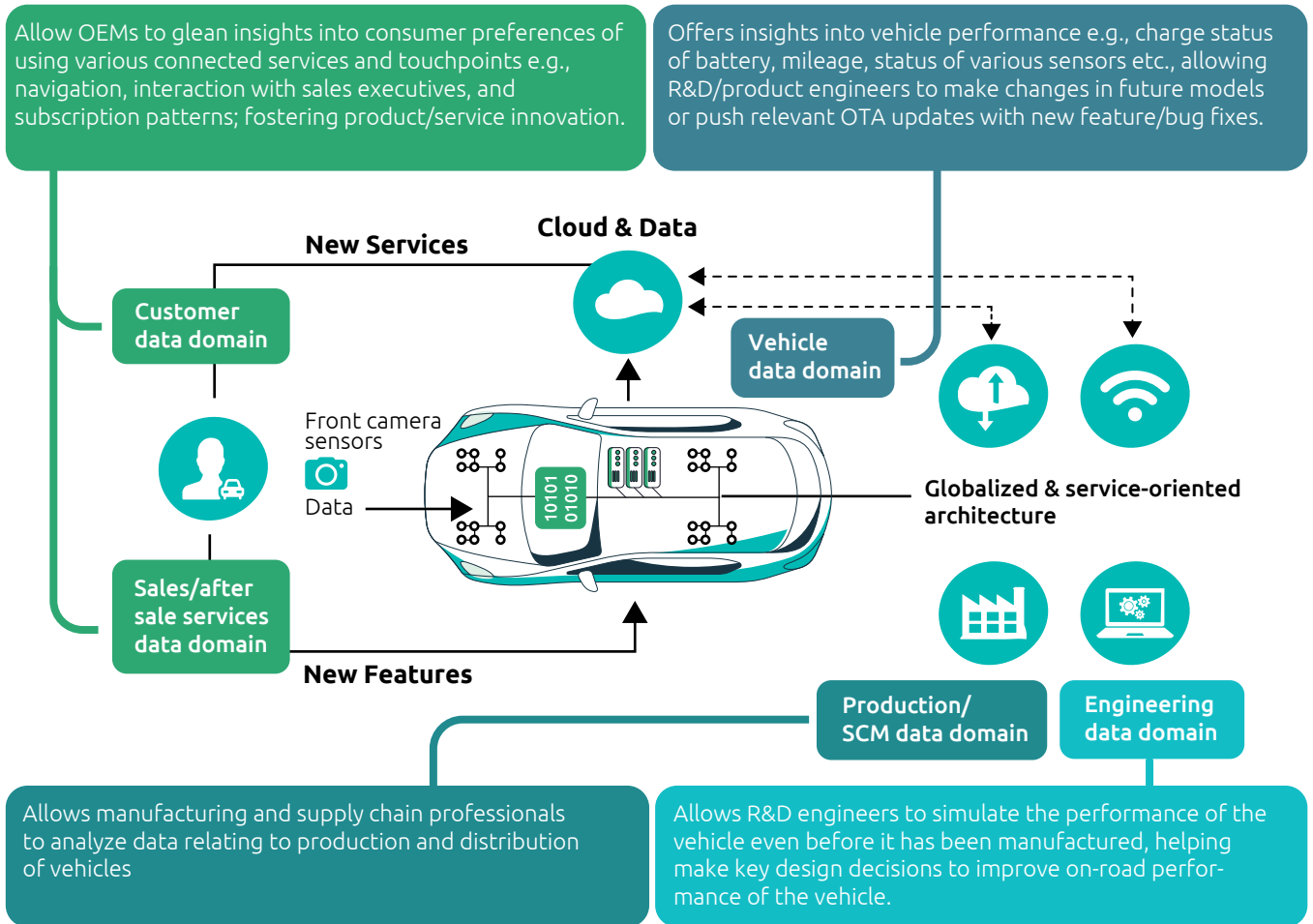
The legacy IT architecture, coupled with data silos, presents a significant data challenge, as many OEMs do not collect and analyze data from various disconnected systems. According to our survey, nearly half (47%) of the OEMs do not either collect or analyze the data coming from vehicles.

Further, automation in collection and analysis of data, for instance in modeling and testing, can help identify potential issues and improvement areas much faster and earlier in the process, saving valuable time and cost of development, and avoiding recalls.

Only **13%**

of OEMs plan to de-couple and separate the currently tightly integrated hardware and software architecture and development.

Figure 20. Software and data enable transformation of OEMs' vehicles, systems, operations, and consumer-facing services

Allow OEMs to glean insights into consumer preferences of using various connected services and touchpoints e.g., navigation, interaction with sales executives, and subscription patterns; fostering product/service innovation.

Offers insights into vehicle performance e.g., charge status of battery, mileage, status of various sensors etc., allowing R&D/product engineers to make changes in future models or push relevant OTA updates with new feature/bug fixes.

Cloud & Data

New Services

Customer data domain

Front camera sensors

Data

Vehicle data domain

Globalized & service-oriented architecture

Sales/after sale services data domain

New Features

Production/ SCM data domain

Engineering data domain

Allows manufacturing and supply chain professionals to analyze data relating to production and distribution of vehicles

Allows R&D engineers to simulate the performance of the vehicle even before it has been manufactured, helping make key design decisions to improve on-road performance of the vehicle.

Source: Capgemini Research Institute analysis.

CONCLUSION

Software promises to be a potent driving force with vast opportunities, albeit with some challenges. This means that the automotive players must fundamentally change business, operations, and customer and partner relationships. If OEMs' experience with software excellence so far is an indicator, they face an uphill battle to win over customers, generate new revenue from software-based features and services, and drive efficiencies in internal processes and organizational structure. Turning this situation around will mean learning from high performers and leaders in this field. Frontrunners – who make concerted efforts to consolidate their software expertise, have strong governance practices, and invest heavily compared to their peers – are guiding others in confidently driving towards the next destination of innovation and growth for the industry: software.
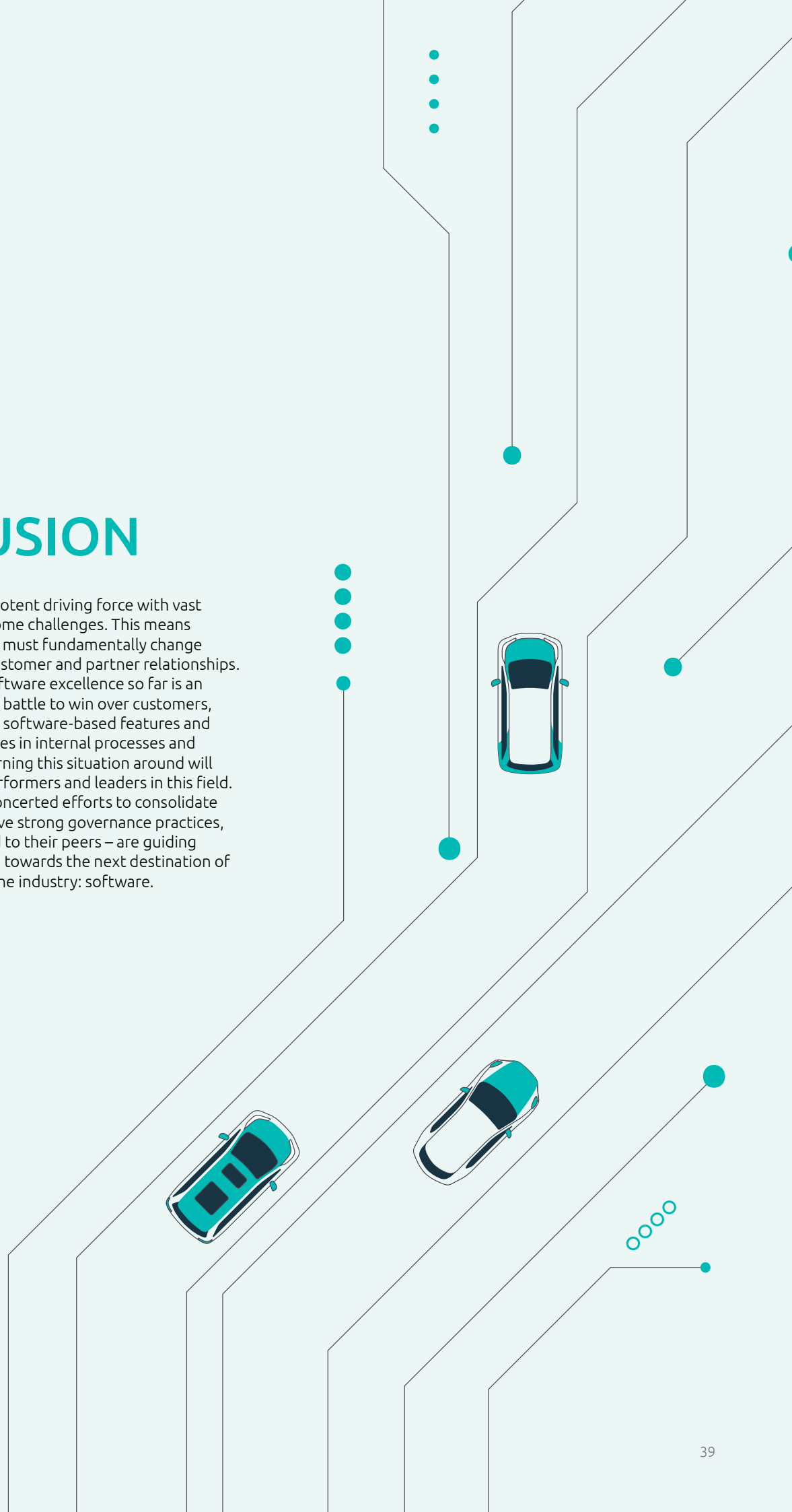
RESEARCH METHODOLOGY

For this research, we surveyed 572 executives working for automotive OEMs, who have been either associated with or lead a software-driven transformation project. Along with this, we interviewed 17 industry experts covering various aspects of the software-driven transformation. The survey and interviews were conducted during July–August 2021.

In our research we count an organization to be a standalone OEM if they follow the criteria:

a. Companies that have separate balance sheets for brands are considered separate OEMs (Volvo Cars, Volvo Trucks)

b. Companies that are an equity JV are considered separate (GAC Toyota in China is separate from parent companies)

c. Acquisitions with independent operations are considered separate. e.g., Jaguar Land Rover is considered separate from Tata Motors.

d. Country subsidiaries (e.g., Audi US, Audi UK) are not considered separate OEMs.

We have conducted our analysis based on two categories:

Overall respondent view: This covers all the 572 executives at director-level or above, who participated in our survey. Each OEM contributes three to four executives, belonging to different functions.

OEM view: This covers 148 OEMs combining responses from 572 executives. To get a unified view for each OEM, we have considered the responses from executives from different functions based on their relevant expertise on the question in consideration.

Respondent view; N=572 executives of different function per represented OEM
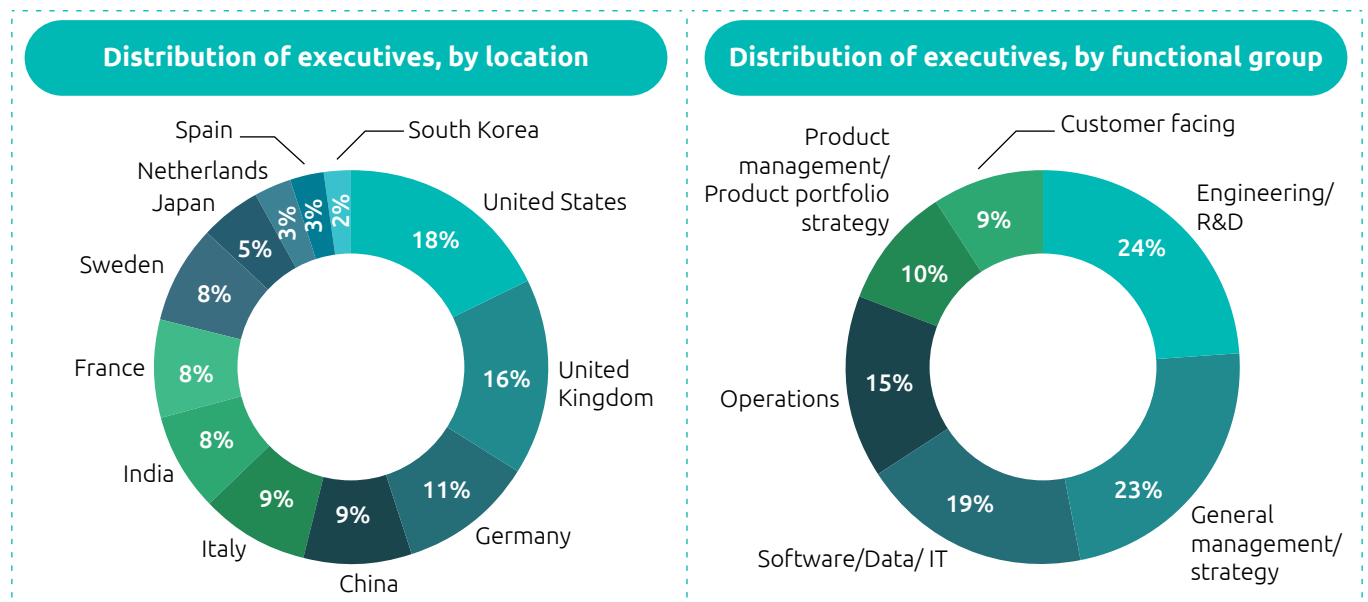
Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=572 executives.

OEM view; N=148 OEMs
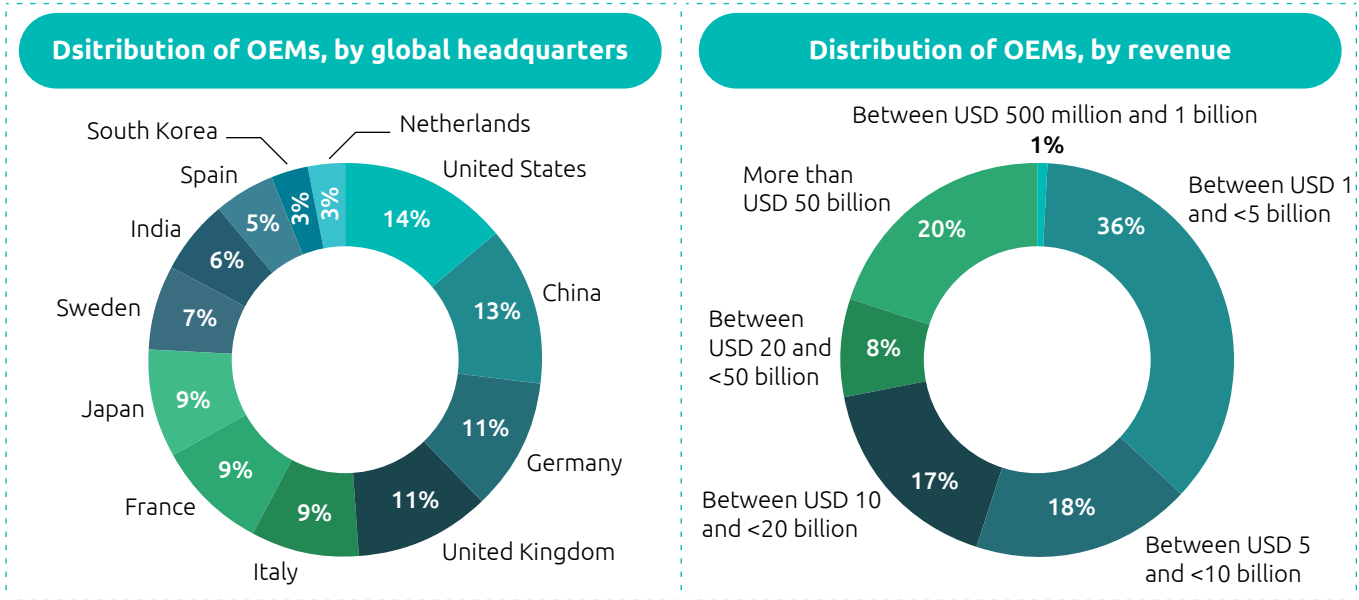
Dsitribution of OEMs, by global headquarters

South Korea
Netherlands
Spain
United States
India 14%
Sweden China 13%
Japan Germany
France United Kingdom
Italy

5% 3% 3%
6%
7%
9%
9% 9% 11% 11%

Distribution of OEMs, by revenue

Between USD 500 million and 1 billion
1%
More than USD 50 billion
Between USD 1 and <5 billion
20% 36%
Between USD 20 and <50 billion 8%
Between USD 10 and <20 billion 17% 18%
Between USD 5 and <10 billion

Source: Capgemini Research Institute, Software in Automotive Industry survey, July 2021; N=148 OEMs.

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OUR OFFER

WE ENABLE AGILE SOFTWARE-DRIVEN TRANSFORMATION IN AUTOMOTIVE

Driving up value to get the future you want

Information technology (IT) and digital are in Capgemini's DNA – and so, now, is engineering. We have unrivaled expertise in designing, building, and maintaining complex systems. More importantly, we understand how software can integrate into an automotive company to increase business value and cost efficiency.

We are experts in all the leading-edge technologies needed for Intelligent Industry. Leveraging key partnerships as necessary, we cover everything from 5G and connectivity, advanced driver assistance systems (ADAS), and the development of embedded technologies, to mobility services. In addition, we are the leading provider of engineering services and systems via Agile methodologies. With our transformational consulting skills, we can create the future you want.

Building on this range of capabilities, we can help clients achieve software-driven transformation in whatever way they require in order to drive up business value for themselves and their customers.

Keeping complex vehicles functional and secure

Our services are designed to make sure that tomorrow's complex vehicle is fully functional, and fully secure, throughout its lifecycle. Naturally, all the software must remain safe, stable, fast, and upgradable at all times. This means it needs to be continually enhanced with new

functionality, and kept secure and up to date, via over-the-air (OTA) updates.

These ongoing updates are vital to ensure that connectivity and usability functions keep working throughout the full lifecycle of the vehicle. They also satisfy the growing need for cybersecurity as vehicles become more automated, and customer and sustainability requirements more sophisticated.

The new vehicle architecture involves multiple layers – hardware, software, connectivity, data, and cloud – all of which have to be orchestrated. As integration specialists, we know how to ensure that software transformation enhances the overall architecture.

How we partner with clients

At Capgemini, we believe we have a major role to play in building the future of the sustainable mobility industry. The world is changing continuously, and so are customers' expectations. They want more and more services, delivered ever more safely and with less environmental impact.

We can partner with you in this software revolution as an end-to-end solution and services provider, and if required as a transformational partner in the realization of strategic value.

Today, IT and engineering need to be more closely linked than ever before. Our software-driven transformation approach makes sure that happens.

OUR OFFER

Customer First › Helping our clients deliver exceptional personalized experiences and continually reinvent their business and offerings.

Intelligent Industry › Harnessing the potential of technology and data to transform and digitize products, industrial operations and connected services of different industries

Enterprise Management › Delivering, transforming and operating the core IT systems, processes and business applications of enterprises for greater agility and operational efficiency

Outer ring labels: ENERGY & UTILITIES, CONSUMER GOODS & RETAIL, SERVICES, TELECOMMUNICATIONS, MEDIA & TECHNOLOGY, PUBLIC SECTOR, MANUFACTURING, FINANCIAL SERVICES

Middle ring labels: OPERATIONS, STRATEGY & TRANSFORMATION, APPLICATIONS & TECHNOLOGY, ENGINEERING

Inner labels: CYBERSECURITY, SUSTAINABILITY, CLOUD, DATA

€15,848m revenue

As a responsible company, we leverage technology to serve our clients and society, working for useful, accessible, and sustainable innovation. Our aim is to unleash human energy through technology for an inclusive and sustainable future.

Our offers around software-driven transformation fall into three main areas: Customer First, Intelligent Industry, and Enterprise Management.

Customer First

Our Smart Mobility Connect offering empowers automotive players to create the mobility ecosystem of the future, designed with people at its heart. We construct this mobility ecosystem of the future with three core pillars:

- Connected Customer: cutting-edge technology to reimagine customer mobility experiences across sales, marketing, and aftersales

- Connected Services and Products: new connectivity capabilities that extend business success

- Connected Ecosystem: a strategic vision to create the mobility business of the future

The technological framework that helps us deliver on our approach is the Customer Engine platform. It connects these pillars and integrates intelligence into each stage of the new mobility journey.

Intelligent Industry

Intelligent Industry supports major shifts in processes towards a more Agile and flexible design approach and business model. It offers automotive players the opportunity to take the lead in the race to a data- and software-defined automotive world. With the help of key technologies such as

AI, cloud, and IoT, automotive players have the potential to address the topic of Intelligent Industry in a targeted manner.

We focus on the following areas: end-to-end software-driven transformation, validation & verification of ADAS, digital continuity enabled by end-to-end digital twins and product lifecycle management (PLM), connectivity & services experience on- and off-board, sustainable mobility products, and Intelligent Industry operations.

Enterprise Management

With Capgemini's guidance, you can optimize your whole system and cloud landscape for ultimate operational efficiency and sustainability.

Success stories here include the use of cloud-based software in ERP operations, such as our work with SAP S/4 HANA and our unique collaboration with SAP® on cloud for automotive suppliers and the industry cloud. This helps our clients to build a flexible and future-proof digital enterprise core.

We also have a major footprint in marketing, sales, and aftersales (e.g. customer and CRM solutions). By taking advantage of cloud's configurability, adaptability, and scalability, and the pay-as-you-go commercial model, we know how to help automotive players to reduce upfront investment and ongoing operating expenditure while improving performance and resilience.

By applying all these disciplines, together with our recognized capabilities in integration, collaboration, and Agile, we can give you the software transformation you want.

WHY PARTNER WITH CAPGEMINI ON SOFTWARE-DRIVEN TRANSFORMATION?

We uniquely combine IT and engineering capabilities

As a leading service provider in both IT and engineering, we are in an unrivaled position to help clients combine these capabilities. Our Intelligent Industry program is designed specifically for this purpose. It merges our engineering and IT practices seamlessly, enabling us to offer everything clients need to succeed with software-driven transformation.

We are a catalyst in the talent war

Software is becoming a key capability for automotive clients, and the workforce has to be reshaped accordingly. Filling the talent gap is made harder by the fact that the skills needed for software transformation are also required by a range of other industries including telecommunications and semiconductors.

We are devoting a lot of energy to hiring people who can supply both software and automotive engineering expertise, and also to training new and existing staff to do so. Here we leverage certification and training courses, including our renowned Capgemini University. We also use our partner ecosystem to meet our clients' needs.

We are uniquely positioned to address the market's skills shortage thanks to our long heritage of adapting our workforce to deal with successive waves of disruptive business change. This policy is reflected in our continued rapid growth.

We know how to develop strategy for software-driven transformation

As well as our engineering and IT capabilities, we have the consultancy expertise to address process and organizational issues from a strategic standpoint. We know not just how to tackle a client's immediate challenges but also how to anticipate those that may arise later on in a transformation: for example, Incident Management and Correlation in an extended vehicle environment.

We can support clients as they define their ambition and align on strategic goals based on Core Context analysis. We can also help them to set up governance, adapt business models, establish their partnership strategy, and design a transformation roadmap.

We facilitate business transformation by assessing the maturity of the building blocks in the value chain, and adapting operating models and engineering processes for the new paradigm. This may involve anything from deploying Agile@Scale frameworks to supporting change management and communication.

Our portfolio has all the ingredients of success, and we know how to use them

Capgemini's comprehensive portfolio contains offers for the three pillars discussed above – Customer First, Intelligent Industry, and Enterprise Management. But, more than that, we are uniquely placed to combine those offers into solutions to address real business requirements, such as delivering a new connected service to a vehicle on the road. This is because, as experts on fundamentals such as cloud infrastructure, AI, and data, we know how to leverage back-end architecture to implement the front-end services that customers want.

Capgemini is the right partner for any automotive enterprise's long-term journey through software-driven transformation. Software and engineering excellence are both core competencies for Capgemini, as is comprehensive Agile transformation. We bring all these competencies together using efficient, scalable development and maintenance processes, leading to sustainable products and an experience that is truly valued by drivers. And that's the way to get the future you want.

ABOUT THE AUTHORS

Alexandre Audoin
Head of Global Automotive Capgemini Group
& Head of Automotive Capgemini Engineering
alexandre.a.audoin@capgemini.com

Alexandre is Capgemini Group's global leader for the automotive industry, and head of automotive within Capgemini Engineering (formerly Altran). After joining Altran in 2012, he worked on numerous projects with different OEMs, accumulating a wide range of expertise, particularly around Intelligent Industry. Before that, Alexandre gained in-depth engineering experience at Renault and PSA Group in areas including hybrid systems, powertrains and SW. Now, Alexandre is shaping Capgemini's position within the industry, and helping our clients to master end-to-end software-driven transformation.

Markus Winkler
Executive Vice President, Global Automotive, Capgemini Group
markus.winkler@capgemini.com

Markus Winkler is Executive Vice President and in the leadership team of the Global Automotive Industry. Markus works with teams across the world, helping Automotive clients shape their mobility strategies and implement what's next in the rapidly changing automotive industry. Markus is a recognized expert in digital transformation and has gained wide ranging experience in delivering major international business and technology transformation programs in the automotive industry. His experience has a key focus on customer first, connected services, and digital excellence gained by working with some of the world's most innovative and recognizable brands, helping to define the future of the automotive industry.

Jean-Marie Lapyere
Chief Technology & Innovation Officer, Global Automotive Industry
jean-marie.lapyere@capgemini.com

Mathematician and Computer Scientist by training, Jean-Marie initiated his executive career in the industry in 2002 as CTO of the French Tax Authority. He started in the automotive industry early 2007 and, until joining Capgemini in spring 2021, held various senior positions with GM for 10 years, then PSA, driving global enterprise technology and security programmes. Now he is an architect of Capgemini's Software-Defined Transformation in the Automotive Industry.

Jiani Zhang
Executive Vice President, Chief Software Officer, Capgemini Engineering
jianiz.zhang@capgemini.com

Jiani is the Chief Software Officer of the Capgemini Engineering Group where she leads the strategy and mission of software transformation for our clients. With extensive experience in product development, strategy consulting and go-to-market, she has led many businesses to growth from pure-play software services companies to software solutions at IBM. Jiani has a passion for technology and enjoys working with clients to grow and scale their business with the power of software and technology.

Pascal Feillard
Senior Director, Automotive Business Transformation, Capgemini Engineering
pascal.feillard@capgemini.com

Pascal spent 22 years with the PSA Group, rising from research engineer to managing recycling and end-of-life vehicle policy in PSA's Strategy Directorate, followed by financial controller, director of strategic marketing and foresight for the PSA Group, and project director for the PSA Group's Supply Chain Department. In 2018, he joined Altran, which Capgemini acquired in 2020. Pascal received an engineering degree from the Polytech Paris-Sud, a doctorate from the National Institute of Applied Sciences (INSA) in Lyon, France, and a post doctorate from the University of Cambridge, England.

Sandhya Sule
Vice President - Technology & Initiatives, Capgemini Engineering
sandhya.sule@capgemini.com

Sandhya has over 30 years of experience in different stages of R&D, technology evangelization, business development, solution development, and delivery management. With Capgemini for last 17 years, she has worked in various functions including technology R&D and as business delivery head for Automotive Engineering. In Automotive sector, she is instrumental in developing and driving solutions in next generation and emerging areas like autonomous vehicles, connected cars and urban mobility. As CTIO for Connected Futures, she works with the technical experts within and outside, to identify, adopt and design solutions for clients around connectivity, 5G, IOT edge and connected enterprise. She is currently part of a strategic initiative in Capgemini, focusing on Next Generation Software for Automotive.

Sebastian Tschödrich
Global Head of Automotive at
Capgemini Invent
sebastian.tschoedrich@capgemini.com

Sebastian leads the global automotive
practice of Capgemini Invent. He is working
as an automotive consultant for more than
14 years, with experience in Europe, China
and APAC. He is specialized in advising and
supporting automotive organizations in
significant transformations, mainly in the
domains digital business, customer centricity
and performance improvement.

Peter FINTL
Director of Technology & Innovation,
Capgemini Engineering
peter.fintl@capgemini.com

Peter Fintl is an electronics engineer and
business economist. He has been in the
automotive industry for more than 20 years.
Peter currently works as Director Technology
and Innovation at Capgemini Engineering.
There he is particularly engaged in the
topics of automated, connected driving, and
sustainable mobility.

Subrahmanyam KVJ
Senior Director, Capgemini Research Institute
subrahmanyam.kvj@capgemini.com

Subrahmanyam is a senior director at the
Capgemini Research Institute. He loves
exploring the impact of technology on
business and consumer behavior across
industries in a world being eaten by software.

Hiral Shah
Senior Consultant, Capgemini Research
Institute
hiral.shah@capgemini.com

Hiral is a Senior Consultant at Capgemini
Research Institute. She works closely with
industry/business leaders to help them
leverage digital technologies to transform
their organization and business operations.

Caroline Segerstéen Runervik
Executive Vice President,
Head of Market Sweden
caroline.segersteen-runervik@capgemini.
com

Caroline Segerstéen Runervik is Head of
Market Unit Industries and Public in Sweden
and since January 2021 Head of Market
Sweden, overseeing the overall business.
With more than 20 years of experience
from international IT and Management
Consulting business, both from start-ups and
global companies in management, strategic
sales and business development roles, her
passion is to serve clients and add value to
their transformation journeys. She also has
been the head of the Manufacturing and
Automotive sector in Sweden, and is part of
Capgemini's Global Automotive leadership
team. Caroline is committed to sustainable
growth - to be achieved through a constant
focus on cultivating the organization
with values of trust, inclusiveness and
sustainability.

Jerome Buvat
Global Head of Research and Head of
Capgemini Research Institute
jerome.buvat@capgemini.com

Jerome is head of the Capgemini Research
Institute. He works closely with industry
leaders and academics to help organizations
understand the nature and impact of digital
disruption.

Amol Khadikar
Senior Manager, Capgemini Research Institute
amol.khadikar@capgemini.com

Amol is a senior manager at the Capgemini
Research Institute. He leads research projects
on key frontiers such as artificial intelligence,
sustainability, and the future of work, to help
clients devise and implement data-driven
strategies.

Shahul Nath
Senior Consultant, Capgemini Research
Institute
shahul.nath@capgemini.com

Shahul is a senior consultant at the Capgemini
Research Institute. He keenly follows
disruptive technologies and its impact on
industries and society.

For more information, please contact:

Global Capgemini Group

Alexandre Audoin
alexandre.a.audoin@capgemini.com

Markus Winkler
markus.winkler@capgemini.com

Jean-Marie Lapeyre
jean-marie.lapeyre@capgemini.com

Sebastian Tschödrich
Capgemini Invent
sebastian.tschoedrich@capgemini.com

Pascal Feillard
Capgemini Engineering
pascal.feillard@capgemini.com

Ruth Peters
Global Marketing - Automotive
ruth.peters@capgemini.com

France

Arnaud Bouchard
arnaud.bouchard@capgemini.com

Germany

Ralf Blessmann
ralf.blessmann@capgemini.com

North America

Andy Howard
andy.howard@capgemini.com

UK

Rob Pears
robert.pears@capgemini.com

India

Roshan Batheri
roshan.batheri@capgemini.com

Nordics

Caroline Segerstéen Runervik
caroline.sergersteen-runervik@
capgemini.com

China

Chu Yan
yan.chu@capgemini.com

Japan

Hiroyasu Hozumi
hiroyasu.hozumi@capgemini.com

Italy

Eraldo Federici
eraldo.federici@capgemini.com

Spain

Yoan Groleau
yoann.groleau@capgemini.com

Belgium

Evy Nerinckx
evy.nerinckx@capgemini.com

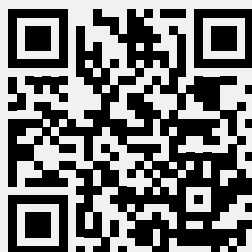# Subscribe to latest research from Cpgemini Research Institute

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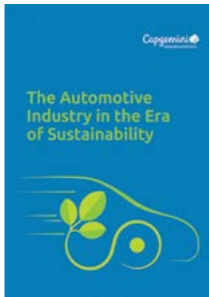
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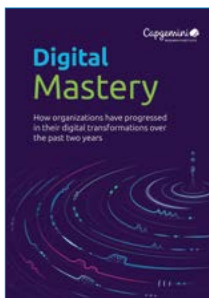

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About
Capgemini

Capgemini is a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided everyday by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 290,000 team members in nearly 50 countries. With its strong 50 year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. The Group reported in 2020 global revenues of €16 billion.

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About
the Capgemini Research Institute

The Capgemini Research Institute is Capgemini's in-house think tank on all things digital. The Institute publishes research on the impact of digital technologies on large traditional businesses. The team draws on the worldwide network of Capgemini experts and works closely with academic and technology partners. The Institute has dedicated research centers in India, Singapore, the United Kingdom, and the United States. It was recently ranked number one in the world for the quality of its research by independent analysts.

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