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Automotive Engineering
Leading the way into the new age of software

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Introduction
The Rise of Software in Automotive Engineering

OEMs and suppliers are facing the biggest shake-up in the industry in more than a century. For decades, the focus of traditional car manufacturers has been on optimizing automotive engineering and building great quality cars. But not even the automotive industry can escape the rapidly growing trend toward interconnected objects and devices. The dominant feature of the vehicle of tomorrow will be software. The number of lines of software code in today's cars has already hit the 100 million mark – with at least five times that amount required for fully autonomous vehicles. To get an idea of the order of magnitude: An airplane only has 14 to 15 million lines of code.

Needless to say, moving the main focus of car manufacturing from steel to software poses major hurdles for traditional OEMs and suppliers.

While new players have the benefit of tailoring their processes to software-dominated products right from the beginning, incumbents are faced with the challenge of adapting and redesigning product development processes that have been extremely successful for decades. And yet it is not a question of "whether" change is necessary, but rather a question of "how" to transform these established product development processes and put automotive engineering on a course for a successful future.

In the automotive industry, software can make or break your ability to compete.

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The automotive industry is facing four major industry developments and "made of steel" is not a sufficient response to any of them. In a world that is moving ever faster, time is becoming more precious, and society is paying more and more attention to environmental awareness and personal safety. It seems that avoiding road congestion, accidents and air pollution is no longer just an infrastructure issue. Instead, we are seeing responsibility shift towards manufacturers, which will ultimately affect suppliers as well. Software has played a key role in triggering this shift. If we take a closer look at the major trends dominating the automotive industry and beyond, it quickly becomes clear that software determines each of them.

Software is a key factor in every major automotive trend.

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New technologies are already being deployed even as automotive players try to transform their business models and adapt their product development to the demands of a market that is increasingly volatile. With more transparency around technical and product development trends, companies will ultimately be in a better position to evaluate their own readiness and identify gaps in their expertise.

To assess the overall software readiness of R&D divisions, we conducted 20 interviews and workshops with the product development experts and industry managers of renowned automotive manufacturers and suppliers. It is crucial for OEMs and suppliers to understand the importance of individual trends in order to determine the right course of action for their enterprise.

Based on these interviews, we first identified ten product development trends that are software-driven and have a strong impact on traditional automotive product development. In the next step, we developed a readiness assessment framework to help automotive players to identify and assess their gaps in expertise, particularly those where action is urgently needed to respond to the trends identified in the first step.

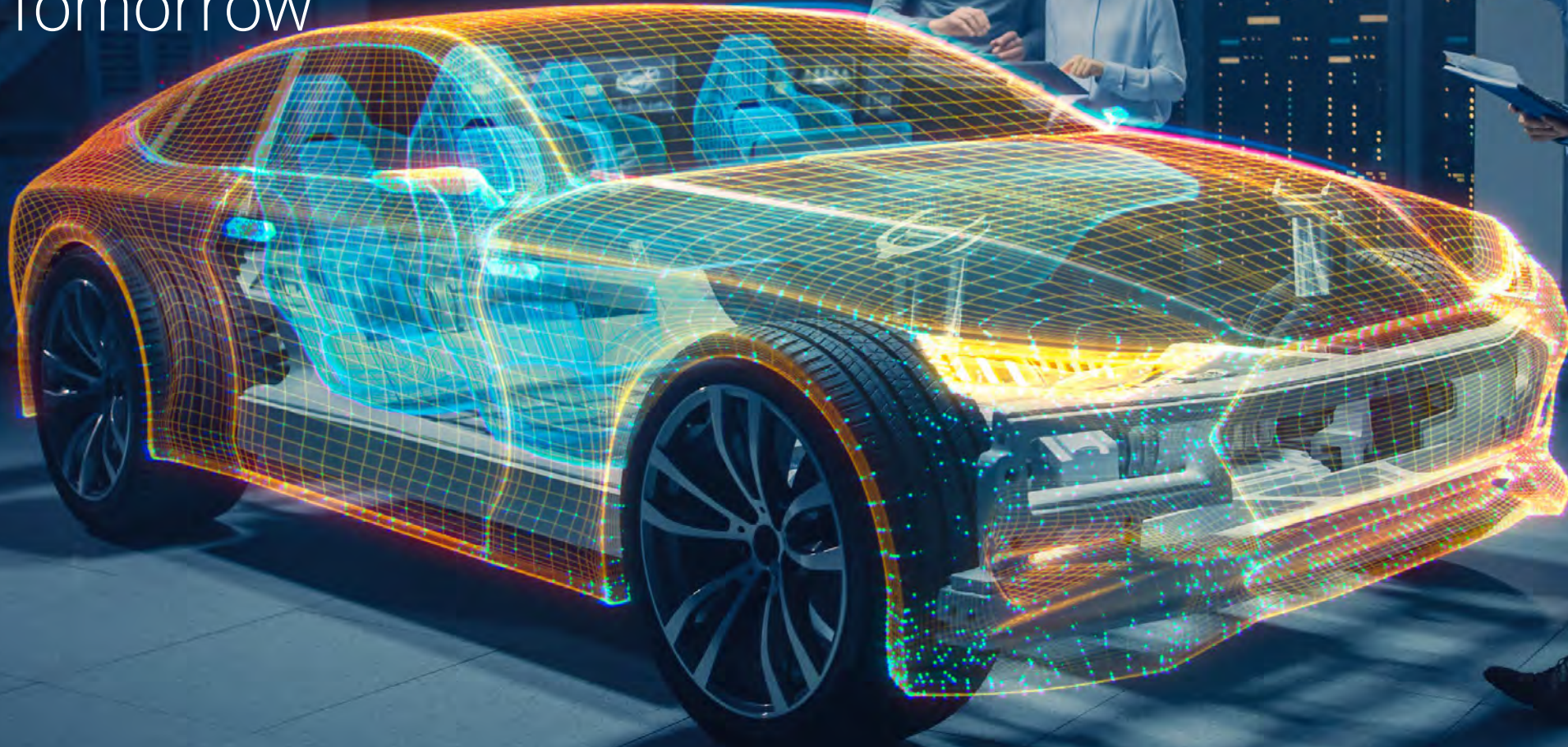We will address both the trends and the findings from our readiness assessment framework in the following.

R&D Software Trends
Software Trends shaping the Product Development of Tomorrow

02 | R&D Software Trends

The innovations emerging in response to CASA (Connectivity, Alternative Drivetrains, Shared Mobility and Autonomous Driving) disruptions pose a threat to the automotive industry's traditional product development paradigm. These R&D processes are not up to the challenge of coping with these threats. Suppliers and OEMs are equally impacted by this development, and both groups are well aware of its potential impact.

Over the last few years, many manufacturers and suppliers have announced or adopted strict measures to counter the disruption in the industry. To be in a position to design a new generation of vehicle computing architecture, several OEMs and suppliers have announced future partnerships or have already joined forces on R&D initiatives, and we are seeing new corporate divisions emerge in many enterprises.

Some companies had already started investing heavily in expertise, hiring thousands of software engineers or announcing plans to establish processes and methods already in use at tech companies. This certainly suggests that they are heading in the right strategic direction, but implementation and operational readiness are still major challenges.

Based on our findings, today's current measures are clearly insufficient to counter these threats. There are many hurdles still to overcome, chief among them: Transformation is taking too long. Building reliable partnerships in the automotive industry poses well-known challenges. And serious gaps in expertise remain within the enterprises.

For OEMs and suppliers to identify the right course of action, they must first understand the relevance of each individual trend and determine what capabilities they need to address them. With more transparency around technical and product development trends, companies will ultimately be in a better position to evaluate their own readiness and identify gaps in their expertise. For this study, we first conducted expert interviews and workshops with industry mana-gers and technical experts from renowned automotive manufacturers and suppliers. Based on those interviews, we identified ten distinct trends in product development driven by the increasing importance of in-vehicle software.

Traditional OEMs and suppliers must fundamentally rethink their product development processes.

The implications of these product development trends are far reaching and affect organizations from the ground up. In order to develop the right strategy, OEMs and suppliers need a detailed understanding of the trends and their impacts. We ranked these ten trends in terms of their relevance for both sectors.

As CASA becomes more dominant in the vehicle, value contributions will shift. The growing number of software-based applications will make software increasingly relevant in terms of contribution to value-added.

Hardware (HW) and software (SW) development are being decoupled to accommodate different development speeds and processes.

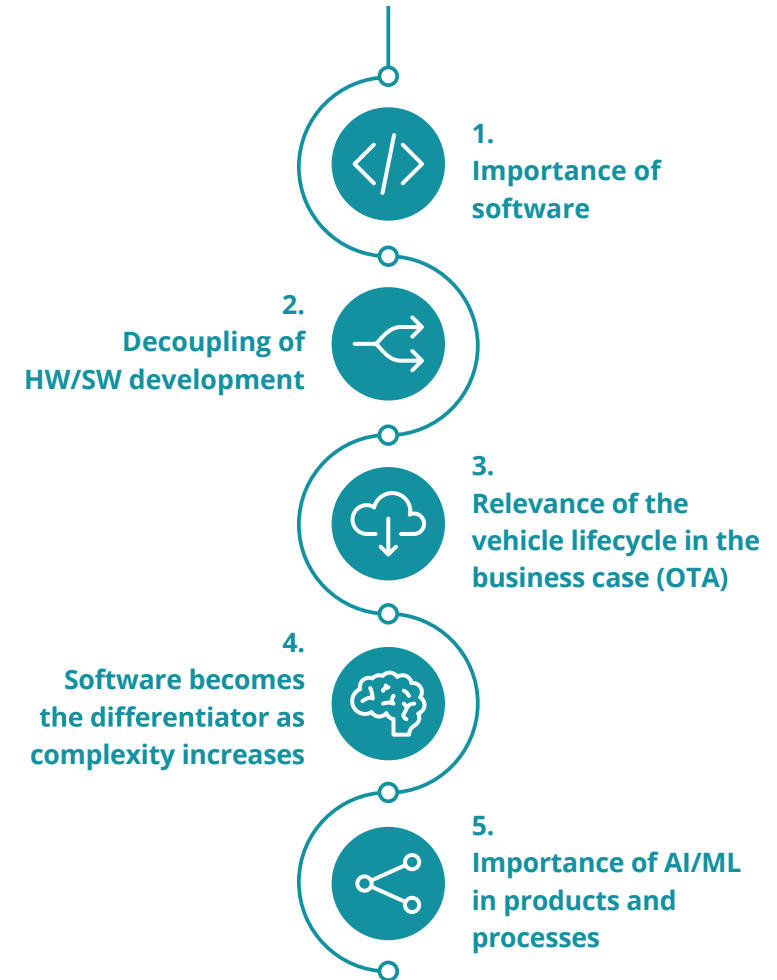Taking the holistic view of the vehicle lifecycle is becoming increasingly important for product development, as manufacturers need to consider over-the-air software (OTA SW) updates right from the start of production (SOP) and make them part of the R&D business case.

As we move from hardware to software-dominated products, software will become the key differentiator in the future. This will inevitably lead to rapid growth in the number of software applications and in their complexity.

We will see an exponential increase in the importance of artificial intelligence (AI) and machine learning (ML), particularly due to autonomous driving.

Product development trends affect organizations from the ground up.

Fig. 1a – Overview of trends sorted by relevance

1. Importance of software

2. Decoupling of HW/SW development

3. Relevance of the vehicle lifecycle in the business case (OTA)

4. Software becomes the differentiator as complexity increases

5. Importance of AI/ML in products and processes

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The more in-vehicle software we have, the more complex the interfaces between hardware and software become. We are seeing hardware variants gradually replaced by modular components to address this complexity.

Vehicle electrical/electronic (E/E) architectures are moving towards a centralized structure in which high performance electronic control units (ECUs) control one entire domain or a set of domains.

Cloud solutions serve as a central, cross-service platform for storing data, running applications and installing updates to enable an ecosystem of connected services.
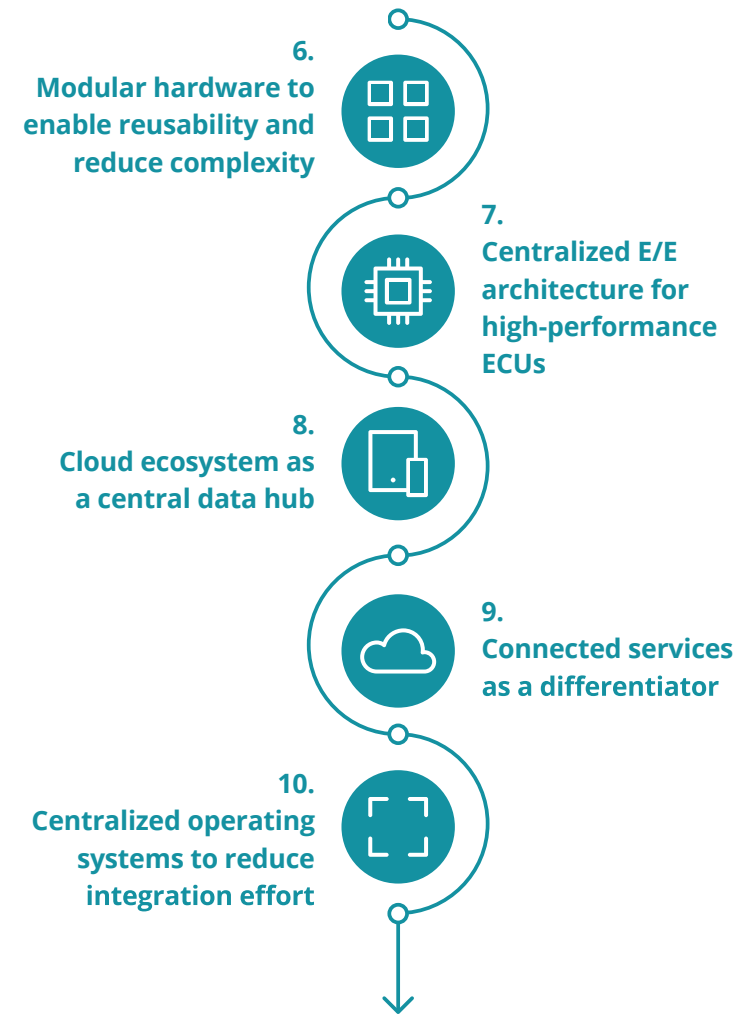
Companies with a range of high-functioning and innovative connected services will have a distinct competitive advantage in years to come.

To reduce integration effort, OEMs and Tier 1 suppliers are intensely focused on developing centralized operating systems (OSs). These OSs run all of the relevant applications for one domain or a set of domains and are linked by standardized middleware.

The product development trends differ in the extent to which they are software-focused. It is crucial for both OEMs and suppliers to evaluate each trend in terms of their own readiness and the trend's relevance in order to identify the right strategic measures.

OEMs and suppliers need an in-depth understanding of how product development trends impact their business in order to develop the right strategy.

Fig. 1b – Overview of trends sorted by relevance

6.
Modular hardware to enable reusability and reduce complexity

7.
Centralized E/E architecture for high-performance ECUs

8.
Cloud ecosystem as a central data hub

9.
Connected services as a differentiator

10.
Centralized operating systems to reduce integration effort

Source: Deloitte expert interviews, Deloitte research

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OEM and Supplier Status Quo
Relevance-Readiness Perspective of
R&D Software Trends

In the next step, we asked product development experts from renowned OEMs and suppliers to assess each of the trends we identified based on their strategic relevance and their company's readiness.

Our survey reveals that trends with a strong software focus have particularly high strategic relevance but cannot yet be implemented on an industrial scale.

While the experts we surveyed from OEMs and suppliers were unanimous on the strategic relevance of some product development trends, we also found significant differences in the way OEMs and suppliers perceive other trends.

On average, suppliers were better able to assess their own readiness than OEMs. Our survey also revealed that suppliers were in a better position to judge the strategic relevance of some product development trends and that suppliers were clearly in the lead in terms of their own internal readiness compared to OEMs.

Suppliers are one step ahead of OEMs in responding to product development trends.

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03 | OEM and Supplier Status Quo

When it comes to assessing relevance and readiness regarding certain trends, the biggest difference between OEMs and suppliers is in the area of OTA SW updates, connected services and cloud services.

Suppliers ranked OTA SW updates significantly higher both in strategic relevance and their own internal readiness, which is not surprising when you consider that developing and maintaining software is part of a supplier's core business.

Connected services have a similar strategic relevance for both, while suppliers have more advanced expertise in-house to respond to market demands.

Manufacturers and suppliers have similar views of the strategic relevance of cloud ecosystems, although suppliers are clearly one step ahead in terms of readiness – after all, their clients are already demanding fast delivery of scalable, high-quality software solutions.

Suppliers are likely one step ahead of OEMs in this area also because of their different experiences in recent years. While OEMs mainly outsourced software R&D, suppliers already had a stronger focus on software development, which they could then adapt in response to market requirements.
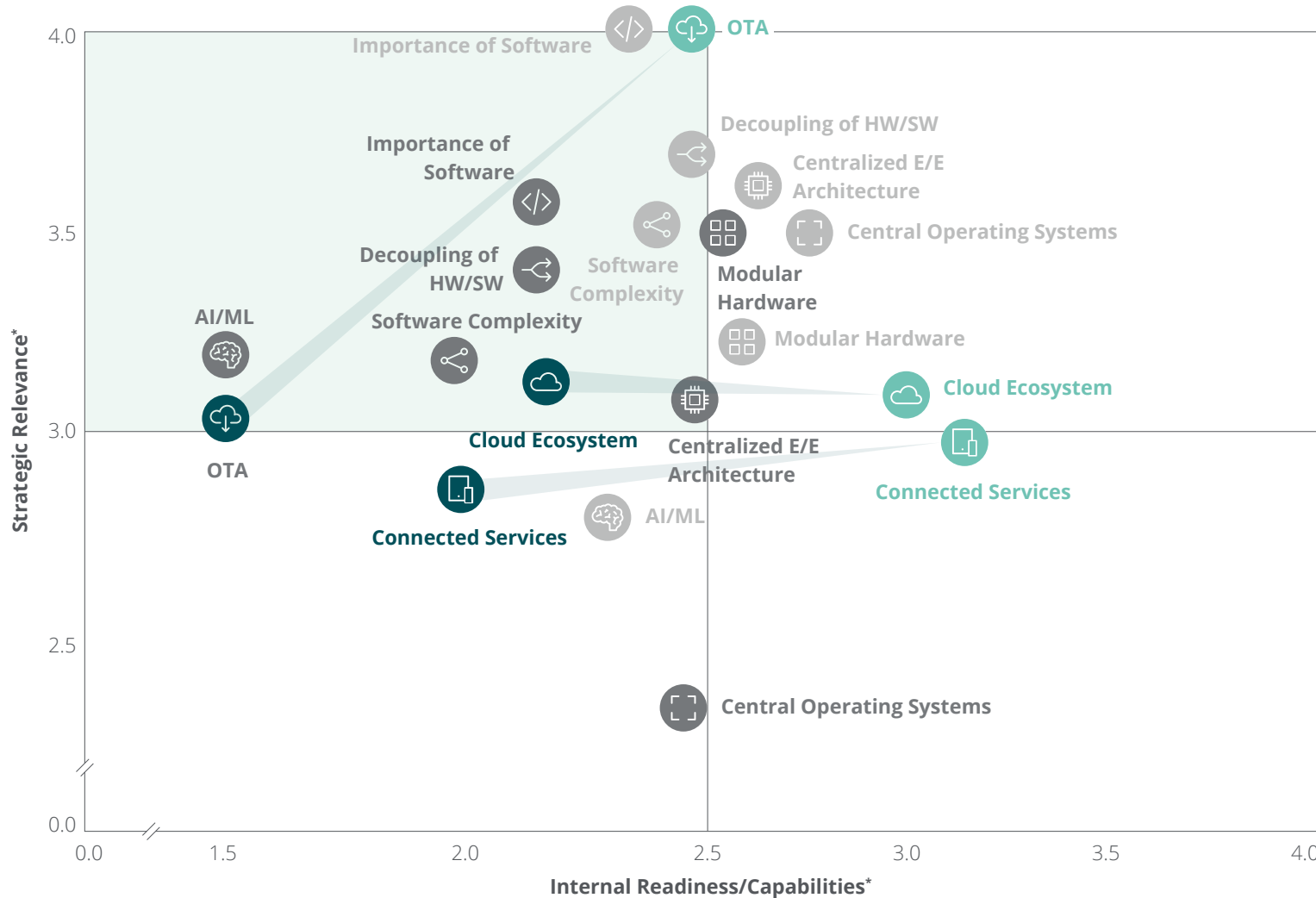
Fig. 2 – Strategic Relevance

Especially in the fields of "OTA", "Cloud Ecosystem" and "Connected Services", OEMs and suppliers show significant differences.

Legend:
- ■ ■ OEM
- ■ ■ Supplier

*The scale reflects the experts' assessment of strategic relevance and internal readiness.
0: No/Low strategic relevance or internal readiness/capabilities (i.e. irrelevant, not capable to deliver),
4: High strategic relevance or internal readiness/capabilities (i.e. highest strategic relevance, fully capable to deliver)

Readiness Assessment Framework & Findings
Critical Capabilities to master Automotive Engineering Trends

Being aware of the challenges posed by upcoming trends is not enough to make product development in automotive engineering fit for the future. Leaders at OEMs and suppliers have to acquire the skills they need to meet the challenges posed by the increasing dominance of software. A self-assessment regarding both strategic relevance and internal readiness based on the outlined trends will reveal gaps in expertise and help to identify critical starting points.

In our interviews, we compiled a readiness assessment framework with each participant. The analysis focused on five core areas of R&D expertise to systematically evaluate which capabilities automotive organizations currently have and to understand where both suppliers and OEMs face obstacles to achieving the target state. The data on R&D readiness from the assessment framework was widely scattered across the five main areas of expertise where the companies need to take significant action: the R&D business case and monetization, the required systems architecture, agile development methods, hardware and software decoupling and resource planning. In most categories, there was a moderate need for action. Looking at the individual assessments, however, there is a wide spread across the rating spectrum in all categories. We will assess those findings in more detail on the following pages.

Fig. 3 – Critical Competences and Capabilities

1. R&D Strategy

- **1.1 R&D business case & monetization**
- 1.2 Technology portfolio management
- 1.3 Cooperation management
- 1.4 Sustainability strategy

2. Product & Platform

- 2.1 Customer requirements management
- **2.2 Definition of overall architecture**
- 2.3 Modular product structure
- 2.4 Quality management

3. Development Process

- **3.1 Agile development**
- 3.2 Process standards (ASPICE)
- **3.3 Decoupling of HW/SW**
- 3.4 Uniform toolchain

4. Organization & People

- 4.1 Definition of the organizational structure
- 4.2 Clear role definition
- **4.3 Resource planning**
- 4.4 Quality management

5. Compliance & Regulation

- 5.1 Technical regulation
- 5.2 Sustainability/ environmental regulation
- 5.3 Data protection/data governance
- 5.4 Economic regulation

Average need for action based on expert interviews

1 2 3 4 5

(1 = highest need for action; 5 = lowest need for action)

R&D Strategy

By providing strategic options in response to market developments, R&D strategy helps to shape the overall corporate strategy and drive its implementation. The findings of our readiness assessment show that suppliers, on average, are a bit more advanced in terms of their internal R&D strategy and exhibit greater readiness to respond to software market developments than OEMs.

We see the biggest gap in readiness between OEMs and suppliers in terms of making a business case based on a holistic view of the vehicle lifecycle. OEMs in particular still focus mainly on pure vehicle cost-based business cases without sufficiently considering the opportunity and the demands of new technologies, especially those arising from software features.

OEMs must focus more strongly on adopting a holistic end-to-end lifecycle view that considers post-SOP revenue.

Although suppliers and OEMs have built a well-managed hardware portfolio over the years, both are still lacking a coherent management strategy for the technology portfolio needed to support software development.

OEMS and suppliers have to make software the focus of their technology management strategy, especially in terms of the implications on E/E HW specifications, compatibility and OTA updateability.

"We are good at identifying and selecting partners, but partnering with them is a different story."
—— **OEM**

Automotive companies still find it very challenging to successfully manage software development partnerships. Existing partnerships often struggle to or even fail to become fully operational at all levels. And yet, most relationships are driven mainly by a customer-supplier approach.

To establish successful and strategic development partnerships, OEMs need to take a different role, abandon hubris as well as classical supplier management models, and put partners on equal footing.

Automotive companies are staunchly committed to sustainability, pursuing a broad range of initiatives to advance sustainability goals. In terms of R&D strategy, however, there is room for improvement as we move more towards a circular economy.

To achieve a circular economy, we need a holistic view of the value chain. OEMs and suppliers need to join forces and develop a sustainability strategy that is coherent, comprehensive and compliant with regulations.

Fig. 4 –R&D Strategy Readiness Assessment

OEM Supplier

R&D Strategy Readiness Level

OEM average   Supplier average
Range from 10th to 90th percentile
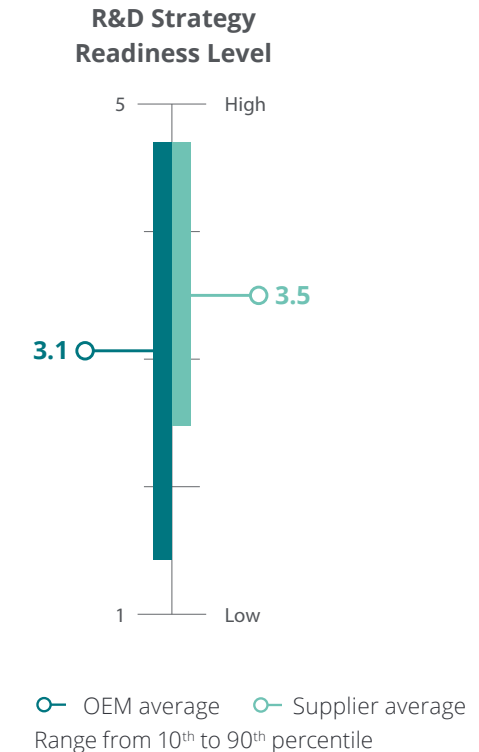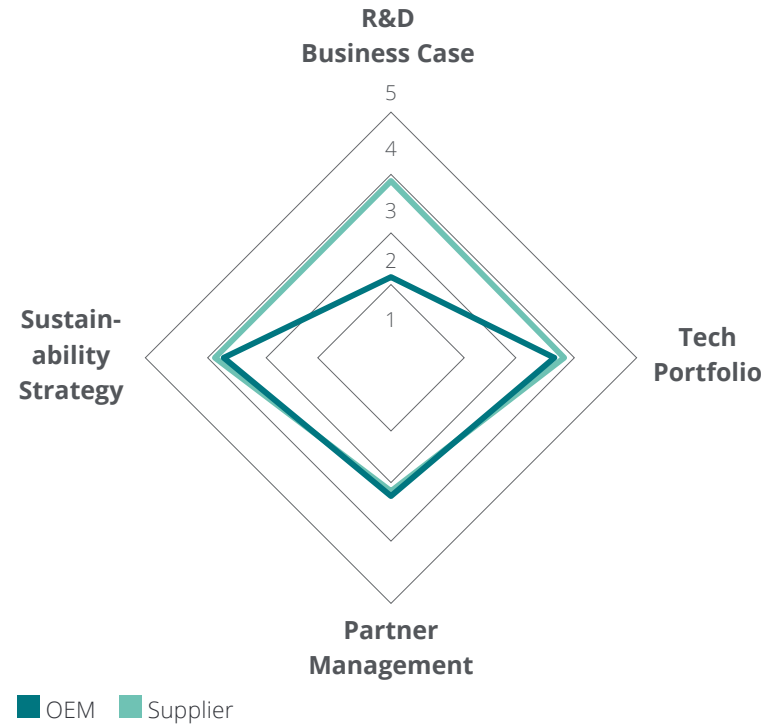
"OEMs constantly switch suppliers depending on the best offer."
——— **Supplier**

Product & Platform

Automotive companies have been largely successful in adapting to the requirements of their customers in recent years and have tailored their products and platforms accordingly for hardware-driven products. However, as software features become more dominant, automotive players and especially OEMs find it hard to adapt and embrace changing product and platform requirements.

To date, automotive companies have not had the expertise to anticipate software product demands. The biggest hurdles for OEMs and suppliers seem to be identifying future SW-driven features and developing a sense for the right timing and the right level of detail needed to address future demand.

Automated, regular and early-stage analysis of customer requirements is the key to delivering new features OTA on a regular basis.

Automotive companies often have well-developed, integrated HW/SW architectures for individual product families. However, those solutions lack both the potential for reusability and an overarching view of the systems architecture.

To accommodate different development speeds, OEMs and suppliers must adopt a coherent systems architecture that decouples the HW architecture from the SW platform.

"We often have to set up a task force to solve last-minute problems."
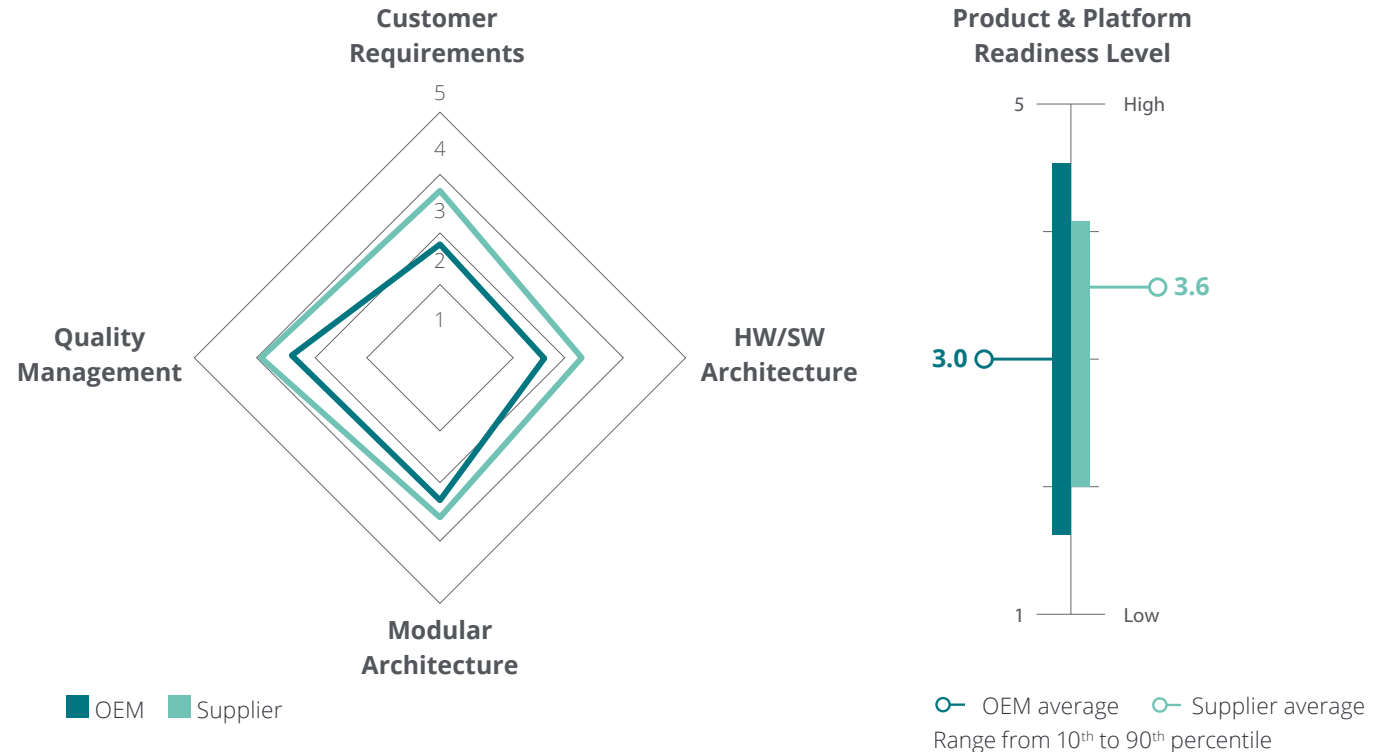——**OEM**

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Automotive companies have broadly embraced the concept of modular hardware parts. Yet, they struggle with reusability and often have little to no downward compatibility with older ECUs, as SW features are often developed from scratch.

To exploit the full benefit of SW functions, automotive companies need to develop them as reusable modules on a uniform platform with downward compatibility across products.

Quality management is a huge factor in hardware-related areas but has not yet been adequately developed for software products. This is especially true for OEMs.

A holistic end-to-end lifecycle view, which also takes post-SOP revenues into account, must also ensure that all SW complies with quality standards and guarantees smooth functionality along the entire vehicle lifecycle.

Fig. 5 – Product & Platform Readiness Assessment

■ OEM ■ Supplier

Product & Platform Readiness Level

OEM average: 3.0
Supplier average: 3.6

○— OEM average   ○— Supplier average
Range from 10th to 90th percentile

"OEMs have major shortcomings in in-house software development."

——**Supplier**

Development Process

Of the five areas of expertise assessed in our framework, the development process is the one where OEMs show the lowest level of internal readiness. They have identified relevant topics that will help increase the SW value-added in development processes, but without a rigorous implementation approach, they end up with a patchwork of "new-meets-old" solutions.

Though automotive companies have been open to agile development in recent years, it has so far been limited to isolated software domains. They face major hurdles in embracing agile methods.

As cars become more and more software-dominated, the market both allows for and demands quick responses. Automotive players must implement agile development on a broader scale to remain viable.

Process and quality assurance standards are crucial to ensure quality in the software development process. Adhering to standards like Automotive SPICE (Software Process Improvement and Capability dEtermination) has become more common among suppliers over the years, but expertise is lacking at OEMs after years of outsourcing the vast majority of their software development activities.

Instead of focusing on compliance with these standards as a supplier management issue, OEMs must adopt these standards themselves for their internal software development.

"So far, backward compatibility is not a given, but we need to ensure it becomes one."
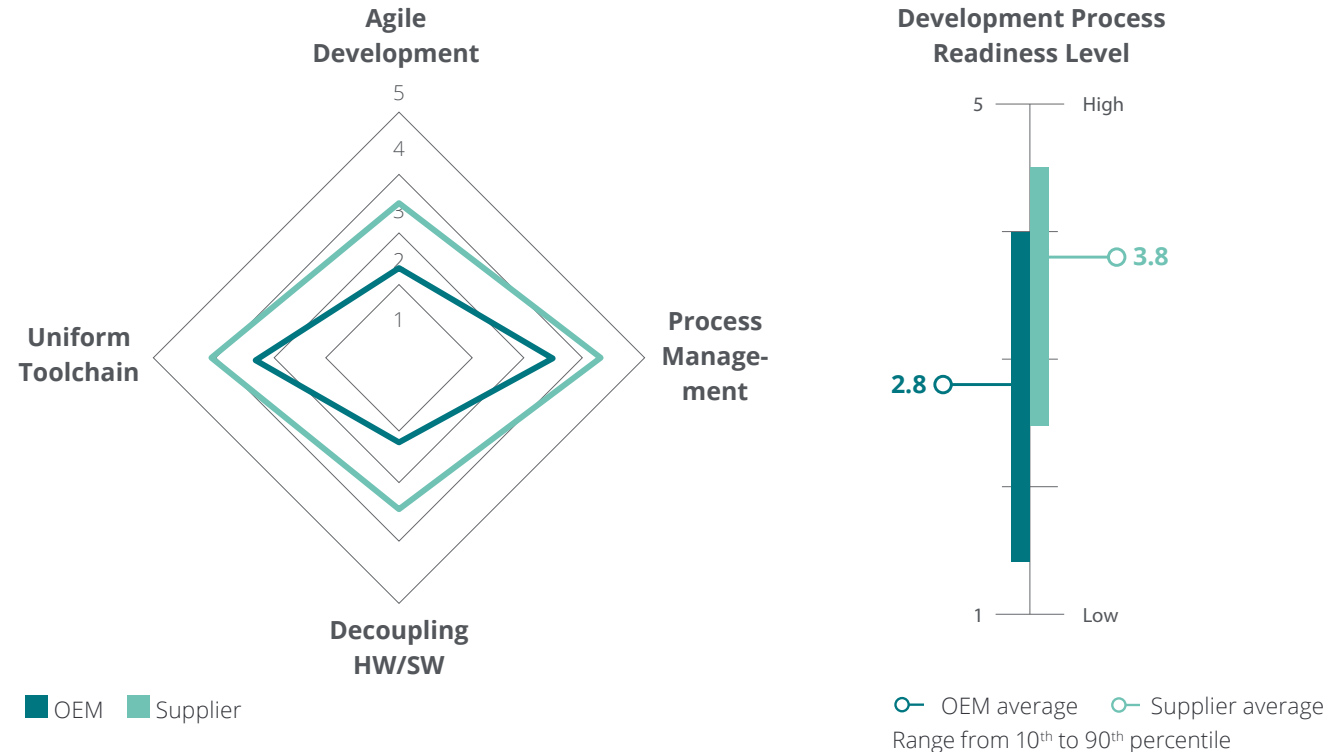——**Supplier**

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One of the biggest challenges OEMs face in the area of software development is moving from a domain-dependent approach to a product development process that closely links HW and SW.

Software is (becoming) the "heart and smarts" of the vehicle. Only a strong decoupling of HW and SW will accommodate differing development speeds and – combined with a modular architecture – allow OEMs to fully exploit the upsides and generate potential post-SOP revenue.

We see a mixed level of maturity in terms of standardized toolchains across the automotive sector. Companies lack a consistent toolchain strategy in most cases, which can lead to a landscape of scattered tool-silos.

For a company to leverage all the benefits of agility, each development team – or, at the very least, each division – must have a unified toolchain.

Fig. 6 – Development Process Readiness Assessment

Agile Development

Process Management

Decoupling HW/SW

Uniform Toolchain

5 4 3 2 1

Development Process Readiness Level

5 — High

3.8

2.8

1 — Low

■ OEM ■ Supplier

○— OEM average   ○— Supplier average
Range from 10th to 90th percentile

"We are changing a lot of things at the moment, but nothing is working optimally yet."
——**OEM**

Organization & People

Automotive companies are facing major resource shortages, but it is more than just a supply chain issue. To cope with staff shortages, they must fight for scarce SW talent and scale in-house training programs at the same time to insulate them from market volatility.

So far, automotive companies have not embraced an organizational structure with the necessary segregation between HW and SW teams. They need to establish a uniform strategy to ensure HW R&D are separated from SW developers in a coherent way.

Without a strict separation between HW and SW development teams, it is impossible to accommodate different development speeds – the basis for regular OTA software updates.

Although traditional roles are well defined, automotive companies have not yet established additional roles for the new responsibilities that come with the increasing software focus – or if they have, they are not yet performing optimally.

OEMs and suppliers need to clearly define their new agile and feature-oriented roles based on new working models and with minimal coordination effort.

"In-house value creation from software is very low at the moment; it will take some time to build up."

——**OEM**

"There isn't enough skilled software talent on the market; we need to train our own experts in-house."

——**Supplier**

The current personnel structure of automotive companies does not yet adequately reflect the structural shifts in value creation. This is especially true for innovative new technologies such as artificial intelligence (AI).

OEMs and suppliers need to embrace a forward-looking HR strategy that also takes market dynamics into account. It is the only way to guarantee that the workforce has the right skills to implement new technologies and enough flexibility to react to changing requirements.

Companies in the automotive industry and beyond are facing a serious shortage of software talent. To date, they have been slow to develop and implement strategic in-house training programs designed to upskill existing employees.

Automotive companies need to be strategic about building re/upskilling programs in order to ensure they have access to skilled labor and to reduce market dependence.

Fig. 7 – Organization & People Readiness Assessment

Source: Deloitte expert interviews
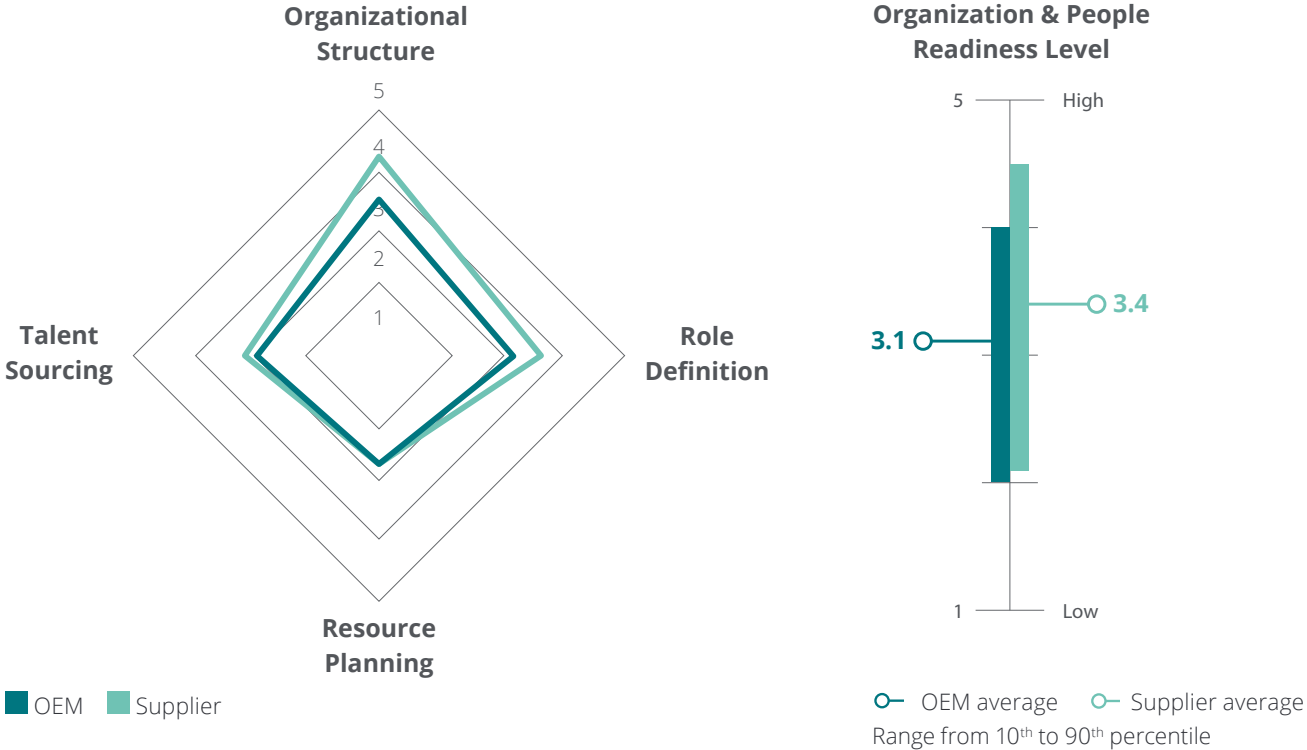
Compliance & Regulation

Automotive players are under massive pressure to showcase rapid advancements in new technology, but the slow compliance process within the current regulatory framework often holds them back. Of the five areas of expertise assessed in our framework, compliance and regulation is the one area in which OEMs exhibit the highest level of internal readiness.

With the uncertainty surrounding software regulations, compliance often requires huge effort from automotive companies. This becomes even more onerous where regulations are still under development, particularly when companies are forced to acquire technology and compliance expertise at same time, e.g., ISO 21448, SOTIF.

Product development teams have to constantly monitor the progress of the regulatory framework and build a systems architecture that is flexible enough to allow for adjustments.

The automotive industry is committed to complying with environmental regulations and operating sustainably, yet this remains one of the biggest challenges, especially from the supplier perspective.

Automotive companies need to leverage the power of software and Big Data analytics to better understand and optimize the company's environmental footprint.

"There are still so many unknown challenges. I think we'll see a flood of IP lawsuits in the future."
—— **OEM**

"Patent research sometimes works very well, and sometimes it doesn't."
—— **Supplier**

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Both OEMs and suppliers are still managing quite well with data governance. However, as the sheer volume of data increases in years to come, data governance will become more challenging. Both groups will face greater challenges due to the uncertainty surrounding UNECE/WP29 standards.

Data protection and data security are critical for regulatory compliance and consumer confidence. To accommodate increasingly complex demands, OEMs and suppliers need dedicated members of staff working on this issue.

Overall, the automotive industry has so far managed corporate legal issues very well (e.g., antitrust, patents). We believe automotive players will need to focus more attention on intellectual property infringements in the medium term.

Automotive companies will have to have rigorous processes in place to ensure that no one infringes on their IP, particularly as partnerships, mergers and acquisitions, joint ventures, etc. become more prevalent.

Fig. 8 – Compliance & Regulation Readiness Assessment

OEM   Supplier

OEM average   Supplier average
Range from 10th to 90th percentile

Source: Deloitte expert interviews

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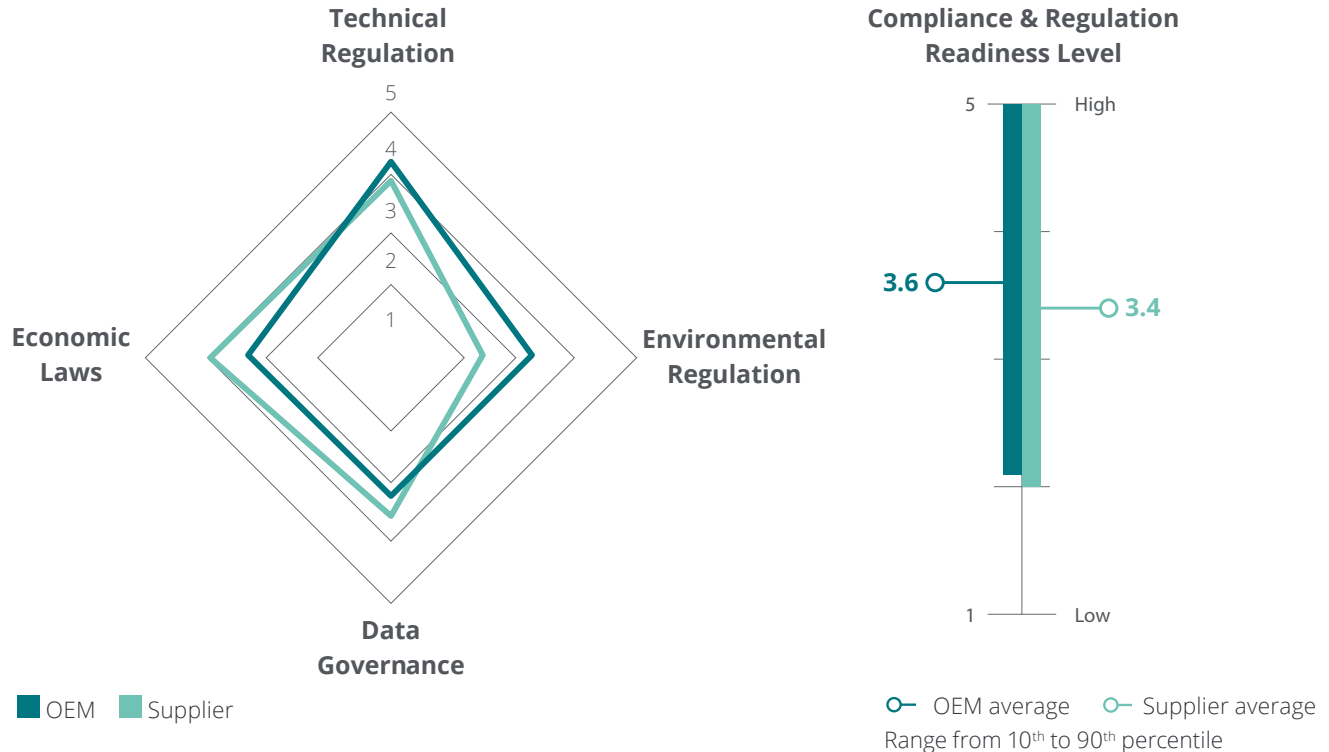
Setting the Course
Ten no-regret Moves to make Automotive
Engineering ready for Future

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OEMs and suppliers alike have a long way to go to achieve a best-practice R&D organization fit for the future. To stay at the top of their game, they must act smart and act fast.

We have developed ten no-regret moves that will help incumbents set automotive engineering on the course for future success.

OEMs and suppliers must act fast to stay at the top of their game.

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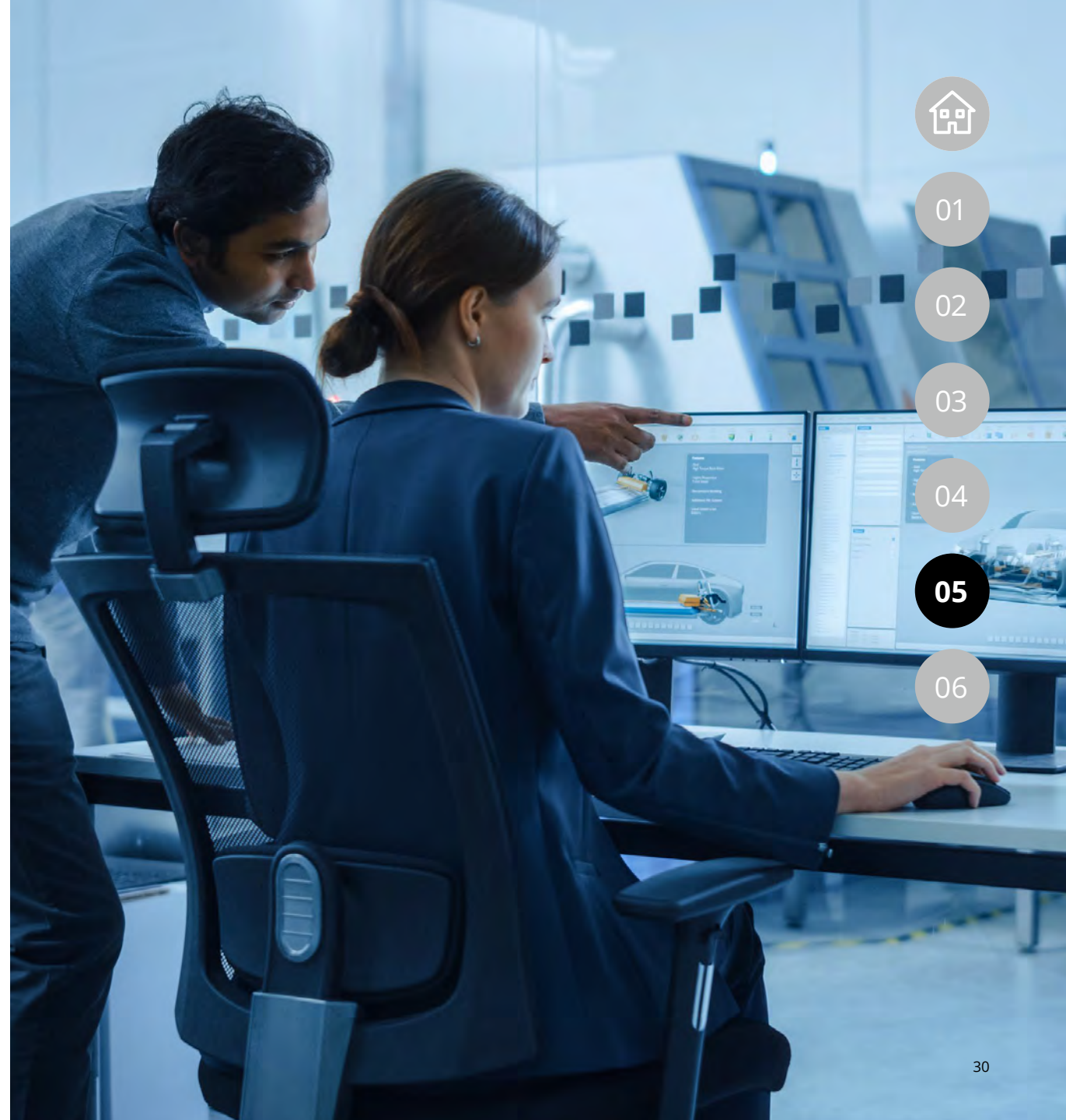
1. Create a board-level position (CXO) for software development to demonstrate the importance of SW to the enterprise. The role needs decision power on par with HW executives.

2. Adjust vehicle business cases and purchasing structures to support SW-driven technology decisions and enable long-term development partnerships on equal footing.

3. Update and adapt the product development process (PDP) to reflect the requirements of the digital age, taking into account agile development, increased SW content and HW/SW decoupling.

4. Put more focus on functionality as a design imperative for products, processes and organizational structures, replacing outdated single-domain silos with feature-oriented, cross-domain architecture.

5. Design architectures to be flexible and modular, allowing for easy component substitutions, e.g., to avoid non-tariff trade barriers or upgrade E/E components.

6. Implement a uniform SW platform with service-oriented architectures that will support the SW ecosystem in terms of updateability, downward compatibility and reusability.

7. Ramp-up digital product development capabilities such as digital twins and threads for scaled, virtual prototyping, real-time fleet monitoring and product upgrades.

8. Unify development toolchains across the organization, standardize tools and establish open, cloud-based development infrastructures with a "plug-and-play" type connection for partners.

9. Adopt cultural change initiatives to break down the HW/SW silo mentality and push an end-to-end approach to systems engineering that combines both worlds instead.

10. Make life-long learning a part of your company's DNA, especially for SW, and develop in-house training programs to continuously educate and upskill your workforce (e.g., corporate university).

Conclusion
Paving the way to a software-driven
R&D enterprise

Software is the accelerator that will enable players to gain ground in the automotive industry. Four key industry trends – connectivity, autonomy, sharing and alternative drivetrains – are shaking up the automotive industry and beyond, even when it comes to software engineering. Product development in the automotive industry is traditionally focused on refining hardware to perfection, but that is no longer sufficient to keep up with these emerging trends. Though automotive players have seen the writing on the wall and made strategic course corrections, it is quite clear that both suppliers and automotive manufacturers still have a lot of work to do. Software developers and systems engineers have recognized the strategic relevance of these trends, but so far they have not found an adequate response. And although making software the focus of automotive product development won't be an easy ride, there is no way around it for R&D development organizations looking to cruise into a brighter future.

Even though OEMs and suppliers still have a long way to go, the future is bright for software-driven automotive R&D.

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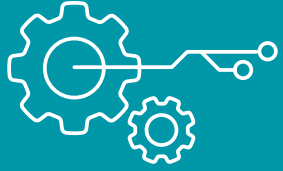
1. We need to fundamentally change the way we organize and conduct product development, driven by the demands of new tech, incl. digitalization, autonomy and electric drivetrains.

2. Ultimately, we will have to create product platforms and architectures based on the entire vehicle lifecycle to guarantee updateability, downward compatibility and reusability of SW.

3. Value creation in vehicle development – and therefore the focus of automotive R&D – is shifting from hardware (HW) to software (SW), which will require more comprehensive digital transformation.

4. As this trend progresses, electrical and electronic (E/E) architectures will become more centralized, requiring more powerful in-car computers as well as standardized interfaces.

5. To keep SW up to date on an ongoing basis and to enhance vehicle value over its lifetime, we have to guarantee over-the-air (OTA) SW updates for all vehicles and processes as well as potentially HW upgrades.

6. We need to further decouple HW and SW development to allow for different development speeds, i.e., faster, agile SW development that is more independent from vehicle development cycles.

7. Agile, cross-functional development processes are key for iterative product advancement, rapid prototyping and regular releases of product increments, primarily for SW, but increasingly also for HW.

8. Cloud-based services are the logical extension of the physical product into the digital world. They provide a seamless extension of other digital services.

9. As new monetization channels become available, we need to extend the business case calculations to the entire vehicle lifecycle and demand novel approaches to purchasing and financial control.

10. Suppliers aspire to provide platforms and modular components, thereby standardizing specifications across OEMs and shifting the onus of defining those specifications from OEMs to suppliers.

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