2 February 2023

Automotive product development: how to become faster and cheaper through digitalization

Smart digitalization can save up to a year of development time and 20 percent of R&D costs.

Executive summary

The automotive industry is changing fast. It is grappling with multiple technical challenges, such as electrification, the software-defined vehicle, the transformation of the electrical/electronic (E/E) architecture and developing autonomous driving. At the same time, incumbent automotive companies need to get closer to their customers to help fend off competition from innovative challengers, including new, pure battery electric vehicle (BEV) players such as Tesla, Rivian, Nio, BYD, and Lucid.

The challenges with emerging technologies call for huge upfront investments, while the pace of change means that development timelines need to be as short as possible to avoid producing an outdated car. It is, therefore, more important than ever to strive for efficiency in product development processes and a reduction in the time it takes to bring

innovation to market. To that end, we analyzed the future BEV development plans of both incumbent (SOP >2024) and challenger original equipment manufacturers (OEMs; latest development) and identified nine essential best practices to lower costs and speed up the development process, while maintaining high quality standards. Two best practices have already been covered in our ongoing article series on product development.

This article is a deep dive into the five best practices, focusing on the series development phase of the vehicle itself. For example, it explains how consequent simulation, parallelization, digital supplier integration, and use of virtual reality (VR) for collaborative design and styling can save OEMs both time and money. By implementing these five cutting-edge practices, an incumbent OEM could save up to a year of development time, as well as reduce R&D-related costs by 20 percent. This accounts for derivative development and used go-with-1 (completion of the final design) as a reference point.

The two remaining best practices focusing on industrialization and certification will be covered in a separate article.

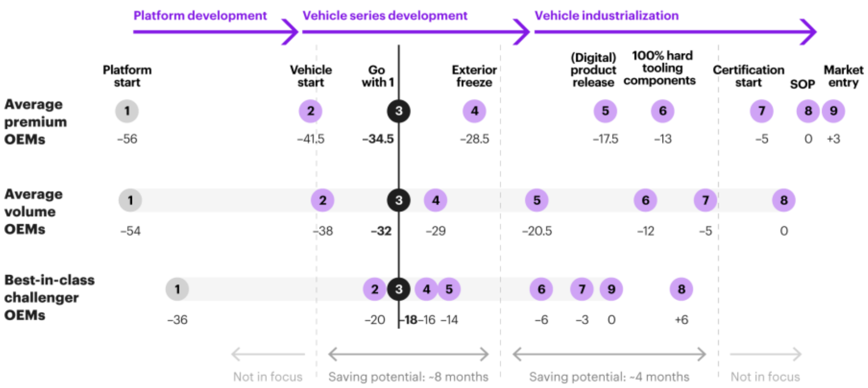
Introduction

The status quo

Today, there is still a huge gap between the product development timelines of incumbent OEMs and challenger OEMs (see figure 1).

BinaryCore

Figure 1
There is a huge gap between the product development time lines of incumbent OEMs and challenger OEMs



Notes: OEM is original equipment manufacturer. SOP is start of production.
Source: Kearney analysis

As premium and volume OEMs have comparable approaches and milestones, we are applying an average time line for these OEMs. However, among challenger OEMs, there are very different approaches to product creation (depending on how they balance quality and speed, buy off-the-shelf or make in-house, and other factors), so we chose to use the most digitized, most time-ambitious challenger OEM as a reference point.

However, the distinctive characteristics of challenger OEMs' approaches, such as their quality aspirations or their market entry strategy, set limits to apply these levers to incumbent OEMs, as they have to ensure they meet the often high expectations of their established customer base.

The digitalization levers incorporated into challengers' development processes and the digital, collaborative mindset within their organizations, however, reveals significant opportunities to save both time and cost. If they were to take a similar approach, we anticipate premium OEMs could achieve a development time of slightly less than 2.5 years for future product developments while respecting their existing quality aspirations. That is one year less than today's plans for the development of future battery-powered electric vehicles. Taking implementation times into account, we anticipate up to 50 percent of the time savings could be realizable for the next vehicle generation.

Note, the total potential cost saving of up to 20 percent is in comparison to current plans. Slightly more than 10 percent can be achieved through direct effects, such as by reducing the cost of hardware. The remaining roughly 10 percent would be achieved indirectly, for example by less reliance on local-bounded development, enabling a further shift of development to best-cost countries.

Nine best practices to optimize product development

We have identified nine best practices to lower R&D costs, speed up the development cycle, and maintain quality, five of which are the focus for this article and outlined below in our deep dive analysis.[1]

Deep dive 1: E2E requirement engineering and test automation

End-to-end (E2E) requirement engineering, including test management, can be used to orchestrate product development. This approach can minimize administrative meetings and increase the maturity, freeing up to 5 percent of planned development hours. The OEM will also see a reduction in costs incurred from unplanned changes.

We recommend the following seven design principles:

1. **One single requirement platform** and direct matching to test cases mandatory for 3rd parties
2. **Central management of requirements** (functional, non-functional, and functional safety needs)
3. **Interlinked requirements breakdown** from product to function (product, system, feature, component, and function) based on systems engineering principles
4. **Automated testing and validation** via a connected toolchain and a central orchestration unit
5. **Fully orchestrated** test rig reservation, staging, regression testing, and reporting
6. **Aligned, traceable documentation** from all parties involved in the development process
7. Support from **E2E integration engineers** with full responsibility and ability to devote most of their time to requirement breakdown, rather than bug fixing

These principles provide the foundations for the efficient execution of development milestones. In the long run, the milestones will be superseded by the maturity tracking of the software/hardware loop, which is enabled by the continuous release of digital versions of the product.

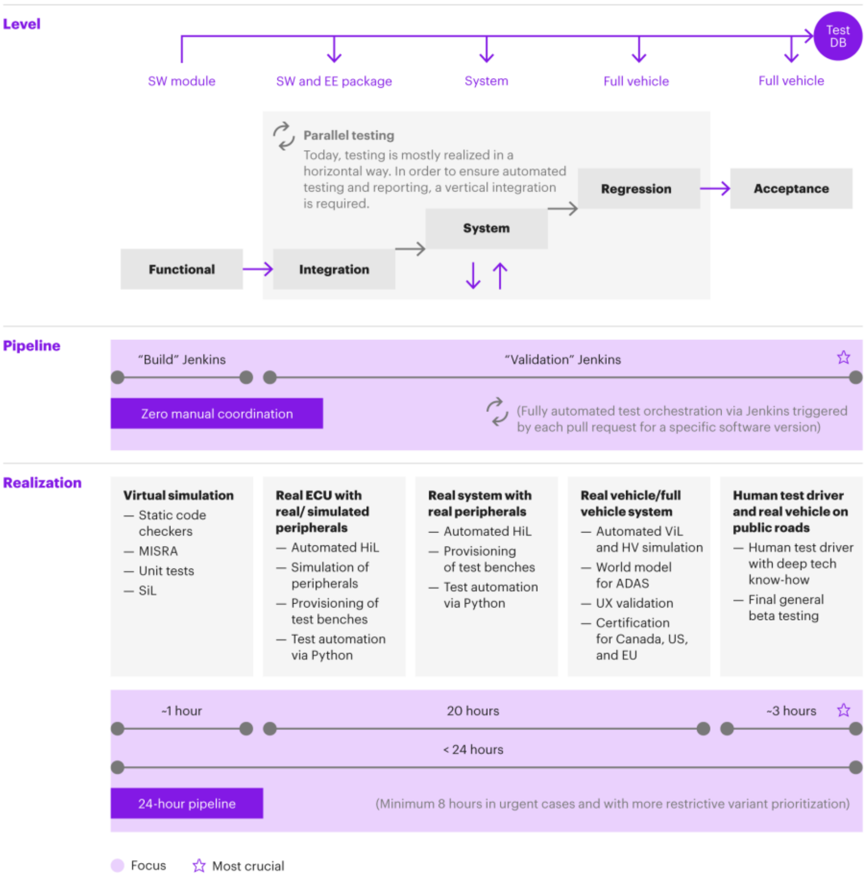
When it comes to execution, bear in mind the following:

- With a software-defined vehicle, the hardware requirements are driven by the software requirements. Overspecification of hardware reduces software integration time and allows flexible deployment of new, post-factory software functions for future revenues and therefore ultimately reduces overall development costs. For more details see [How focusing on hardware today can boost returns in tomorrow's software-driven world].

- Ensure the testing benches are standardized and reachable over the air, as that will enable the developers to test the features themselves. With the right requirement syntax, automated derivation of test cases and test procedure code for the test bench is now possible.

A best practice test execution procedure is shown in figure 2.

Figure 2
A central end-to-end software test and reporting setup enables a zero manual execution in less than 24 hours



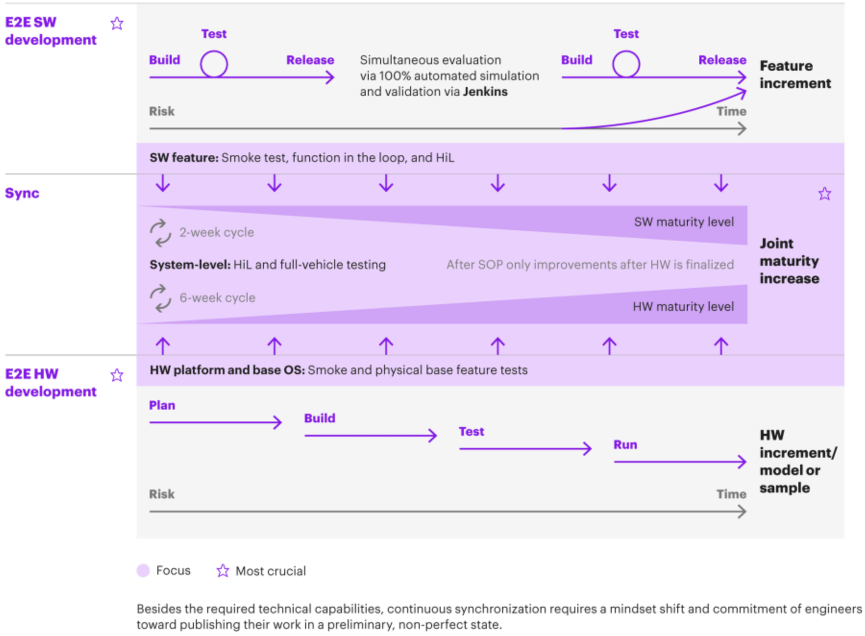
Notes: SW is software. EE is electrical/electronic. SiL is software in the loop. ECU is electronic control unit. HiL is hardware in the loop. ViL is vehicle in the loop. HV is ?. ADAD is advanced driver assistance system. UX is user experience.
Source: Kearney analysis

Deep dive 2: stringent synchronization of the V-model and software loop

The synchronization of software and hardware development is the foundation for an agile, quality-focused development or integration. By jointly verifying and validating the software and the associated hardware, you can prevent late integration issues. In our experience, this approach dramatically increases software and E/E maturity, ultimately preventing delays in the start of production.

In our engagements with OEMs, we have often found a six-week synchronization cycle (a six-week sprint for hardware development parallel to 3x two-week sprints for software development) to be the best choice, balancing administrative efforts and fast iterations (see figure 3). The release train should not wait and should always depart on time—if features are not release ready, they can be considered for the next release. Every three months, a major planning meeting should be convened to review the software backlog plan and enable sufficient planning horizons for hardware development.

Figure 3
A six-week synchronization schedule is often the best approach



Notes: E2E is end-to-end. SW is software. HW is hardware. HiL is hardware in the loop. SOP is start of production. OS is operating system.
Source: Kearney analysis

Note, while synchronization is required for all hardware that interacts with E/E and software, for other hardware, other cycles are feasible.

For more details see Unlocking speed, quality, and cost: how to optimize hardware development in an embedded software environment.

Deep dive 3: virtual, collaborative design and styling

Employing virtual, collaborative design and styling can optimize the design and technical alignment phase. A switch from modeling in clay to using AR/VR (augmented or virtual reality) systems can reduce this phase by up to 10 months, if you also involve suppliers (see figure 4). This phase offers the highest potential for time savings, since the time it takes to create tooling defines the timeline for the remaining steps and offers only limited scope for improvements.

Figure 4
A switch from modeling in clay to using AR/VR systems can reduce the design and technical alignment phase by up to 10 months, if you also involve suppliers

		Narrow down to 1	Go-with-1 decision	Fitting design and components	Supplier involvement
Executive summary		**Many OEMs already use VR to narrow down to 1 design**	**Final decision mostly still on clay**	**Parallelization mostly seen for speed-focused OEMs with (partly) close supplier relations**	
Volume	1	**Exterior: Clay-led** (3 models; size ratio 1:4) **Interior:** VR-led	**Exterior: Clay-led** (GW1 clay size ratio 1:1) **Interior:** VR-led	**In parallel** to design process	**Parallel**/involved from design start
Volume	2	**Clay-led** (3 models; size-ratio 1:6) **VR supportive** for exterior and interior	**Clay-led** (GW1 clay size ratio 1:1)	Mostly **sequential** post go-with-1	**Sequential**/ mostly post fitting
Premium	1	**VR-led** (including glasses/gloves)	**Exterior: Clay validation** (GW1 clay size ratio 1:1 without changes in review) **Interior: 3D printing** validation **Next step: Clay-free**	Mostly **sequential** post go-with-1	**Sequential**/ mostly post fitting
Premium	2	**VR-led**	**Clay validation** (GW1 clay size ratio 1:1 without changes in review) Shift **empowered by leadership and training**	Mostly **sequential** post go-with-1	**Sequential**/ mostly post fitting
Challengers	1	**Clay-led** (Funnel: clay 1:6, then VR)	**Clay-led** (GW1 clay size ratio 1:1 without changes in review)	Mostly **sequential** post go-with-1	**Sequential**/ mostly post fitting
Challengers	2	**VR-led** (including glasses/ gloves and mockups) **In-field feedback** as **foundation** for design start	**Clay iteration**	**In parallel** to design process	**Parallel**/involved from design start
Challengers	3	**Exterior: Clay-led** (only 1 design proposal) **Interior: VR-led**	**Exterior: Clay iteration** **Interior: VR-led**	**In parallel** to design process	**Parallel**/involved from design start

VR-driven VR-supported Clay-driven Clay-supported

Notes: AR is augmented reality. VR is virtual reality. OEM is original equipment manufacturer.
Source: Kearney analysis

The **vehicle start through series model data phase** can be divided into the **design phase** (until exterior freeze) and the **data-derivation and supplier alignment phase**. In the **design phase** there is the potential to save seven months, as premium OEMs typically spend 13 months on this phase today versus six months for the best-in-class challenger.

The **data-derivation and supplier alignment phase** offers the potential to save a further three months, mostly by aligning suppliers in parallel with the **design phase.**

Through the use of AR/VR, the process becomes less location-dependent, which gives rise to a potential cost savings of about 3 to 4 percent, in addition to the potential savings through time reduction.

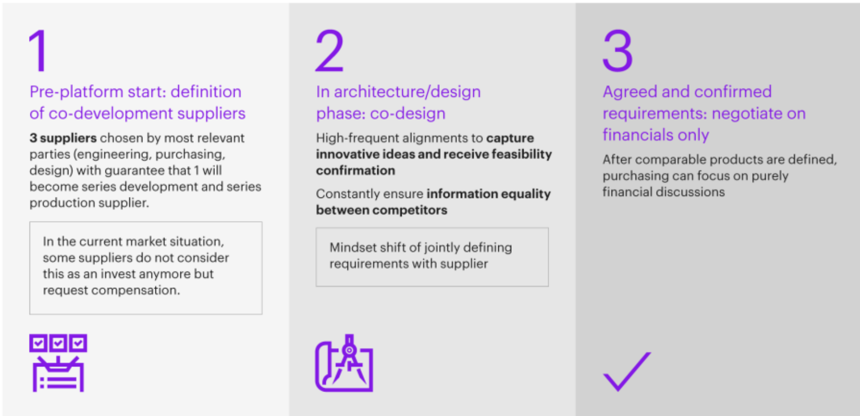
To achieve best practice in this phase, OEMs need to adopt parallelization and end-to-end virtual reality and involve suppliers from vehicle start (or already in advanced engineering).

Parallelization calls for simultaneous design and technical concept development/validation, including fitting, to maximize efficiency and effectiveness. You also need an agile project house setup (including design, development, finance, operations) instead of line functions. That will enable fast iterations, including target convergence for all functions. Employing expert assessment (rather than time-consuming and expensive simulations or hardware tests) from an early stage further increases speed.

Both end-to-end toolchains (for example, Autodesk) and the latest hardware setup (Powerwalls, VR glasses, gloves, smelling options) should harness VR. To maximize the benefits, all former clay-related processes (such as aerodynamics, color, and trim) also have to switch to VR. An interim step is to employ VR to narrow down options and then go to a final, unedited, clay-based confirmation. Using VR end to end will have a direct cost benefit in terms of design capacity. However, the biggest impact is indirect, as VR enables location-independent early-stage development. For example, the OEM can make greater use of expertise in best-cost countries, saving up to 4 percent in development costs.

Ideally, an OEM will involve suppliers from day one to fully harness their know-how (see figure 5). This approach will also enable suppliers to input data into the digital twin and access data to enable continuous feasibility approvals. Best practice is to select two to three suppliers based on the platform requirements (for example, one by design, one by engineering, one by purchasing) for the design and concept phase. If you guarantee that one of this group will ultimately become the development and series supplier, they typically provide between three and six months as investment.

Figure 5
Ideally, OEMs will involve suppliers from day one to fully harness their know-how



Note: OEM is original equipment manufacturer.
Source: Kearney analysis

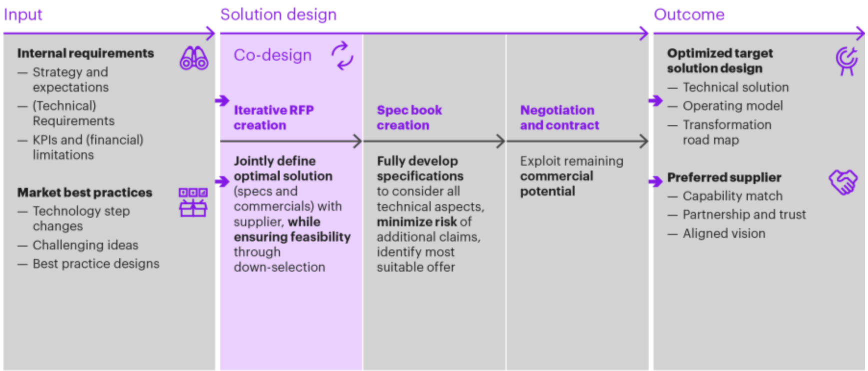
Deep dive 4: digital supplier integration and collaboration

Building on the practice of involving suppliers from day one (see previous section), suppliers should participate in the solution design as well as execution. If you co-design the RFP with suppliers, you could save up to two months of development time.

To co-design the RFP, follow an iterative process in a joint setup with suppliers, designed to identify the optimal solution within a short time frame while ensuring ongoing feasibility approvals in parallel (see figure 6).

Figure 6

A co-design approach follows an iterative process in a joint setup with suppliers



Notes: KPI is key performance indicator. RFP is request for proposal.
Source: Kearney analysis

It is also important to take a collaborative approach to software sourcing to prevent unplanned delays through mismatches that occur with an OEM-internal development approach. This approach could reduce development costs by about 2 percent. We have identified eight key collaboration criteria:

1. Fully decouple hardware from software to allow execution of separate sourcing strategies.
2. Define domain-specific supplier nomination timelines. The goal should be early long-term sourcing of base and middleware, while sourcing customer features (infotainment, ADAS, body, and comfort) as late as possible to gain access to the latest trends.
3. Align on an agile six-week synchronization cycle and data needs.
4. Jointly detail user stories and then adapt your requirement sheet accordingly.
5. Define your required level of code insights (in the knowledge that transparency increases costs). But be aware that full transparency is legally required for safety-relevant functions.

6. Define the IP rights, especially in collaborative development and strategic partnerships. Joint IP rights further tighten the relationship.
7. Provide access to the one software repository and testing orchestration tool.
8. Include termination clauses if agile approach is not met.

Deep dive 5: consequent simulation for hardware prototype reduction

Consequent simulation is one of the biggest challenges for incumbent OEMs. Removing hardware phases from the development process and absolutely minimizing component testing requires a true mindset change as engineers are used to physical validation. Nonetheless, taking this step can save up to 10 percent of development costs and up to three months of development time. The key is to develop the right strategy to determine when to skip hardware testing and build confidence in simulations.

To optimize your simulation setup, follow these four principles:

1. Simulation capability frontloading

Begin by building a structured definition of the required simulation models and methods. Then identify the most hardware-demanding model method combination and focus improvement efforts on these. Make model method availability a prerequisite for the transition from the innovation step to the vehicle development step, while harnessing in-field data to optimize the model and method.

2. Validation-only, innovation-based component testing

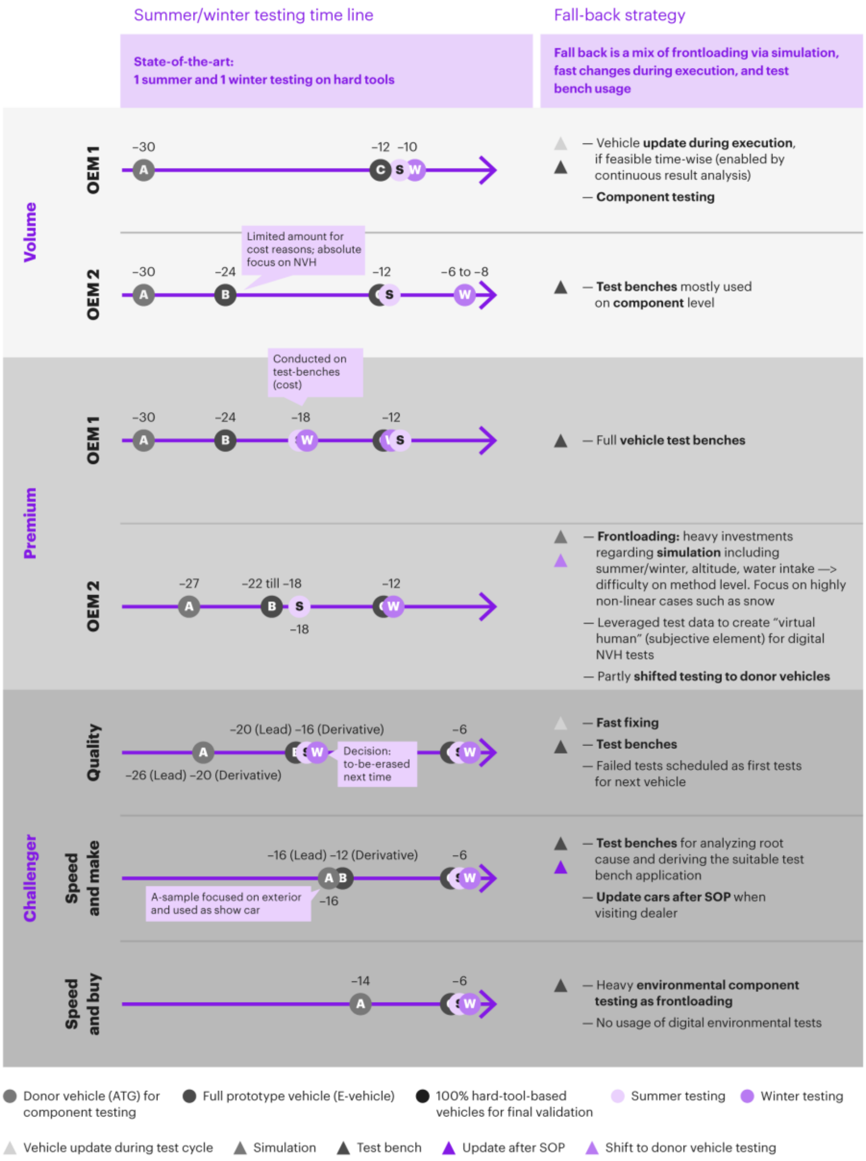
The innovation level of a prototype component or subsystem and the historic success rate of the proposed validation method can be used to determine the necessity of a hardware test. If such a test is required, try to reduce the hardware testing to a single round by using simulation to identify the most vital product variant and production inaccuracy combination.

3. Elimination and reduction of hardware phases

By maximizing component validation, you can reduce the number of testing cycles for (later) derivatives to just two (one with donor vehicle and one at the turn of soft to hard tooling). Summer and winter testing can be combined in a single testing cycle, conducted in parallel by using worldwide test locations, together with fallback strategies involving on-the-spot fixing and test benches (see figure 7). You can also reduce the number of crash tests to one or two per use case, by conducting the tests with the most crucial vehicle. However, you may need to conduct more tests for side crashes, as this is the most important use case.

BinaryCore

Figure 7
Summer and winter testing can be combined in one testing cycle



Notes: OEM is original equipment manufacturer. NVH is noise, vibration, and harshness. SOP is start of production.
Source: Kearney analysis

4. A get-it-done mentality

Be sure to actually follow through on the hardware test reductions. We have seen many incumbent OEMs increase their simulation know-how, but not reduce the hardware tests. Hardware test reduction on a component and vehicle level has the potential to reduce hardware costs by up to 50 percent and save up to three months development time.

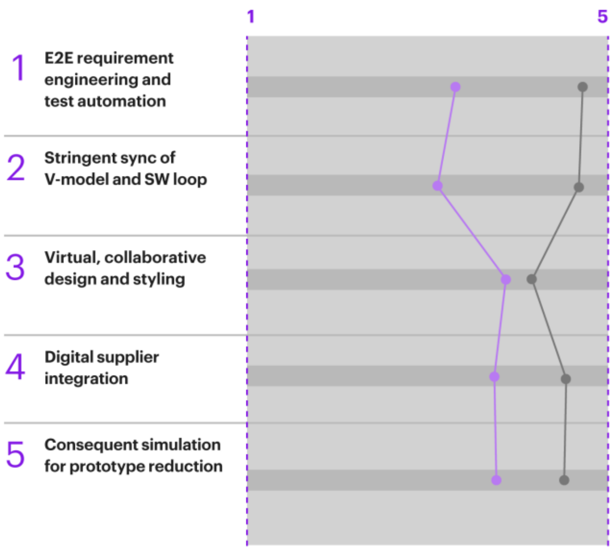
BinaryCore

Final assessment

The biggest challenges in realizing the benefits from the outlined digital levers are those where incumbent OEMs must manage the transition from hardware-based processes and mindsets to software-style approaches and mindsets.

Today, incumbent OEMs typically struggle to reconcile the software and hardware worlds, often resulting in a failure to create a holistic requirement approach (to the extent where they are using different tools for requirement and testing internally and with different suppliers) and a lack of synchronization. By contrast, challenger OEMs benefit from a greenfield setup with many tech-experienced employees—the perfect starting point. Therefore, the benchmark in our deep dives 1 and 2 shows significant scope for improvement (see figure 8).

Figure 8
The benchmark in our deep dives 1 and 2 shows significant scope for improvement



Premium/volume competition (best-in-class)
Challenger competition (best-in-class)

Notes: E2E is end-to-end. SW is software.
Source: Kearney analysis

Some incumbent OEMs are already utilizing AR/VR, parallelization, and the supplier involvement approaches described in the section on "virtual, collaborative design and styling." For these OEMs, the gap to the challengers is small, particularly given that especially premium OEMs need to spend more resources on design to maintain their position in the market. However, other incumbent OEMs lag far behind in this area.

In terms of supplier integration, incumbent OEMs' purchasing departments are fast closing the gap. Nonetheless, the methods described in this article are not fully rolled out. In particular, the engineering process and tool requirements for suppliers are typically not fully transparent and not included in requirement sheets, while hardware and software decoupling has not yet fully been achieved.

Setting aside software, batteries, and E/E, incumbent OEMs' long experience of simulations is a huge asset, often exceeding challenger OEM know-how. Nonetheless, a lack of trust in the results of simulation and a risk-averse approach often prevent them from taking advantage of these skills.

Conclusions

The best practices set out in this article represent clear levers incumbent OEMs can pull to close the speed and cost gaps to challengers. Their implementation is, however, challenging. And as it can take time to change mindsets, it is important to start now. OEMs that fail to act risk seeing their products slowly become non-competitive, as they will become too expensive and might be considered "not state-of-art," especially compared to models from challenger OEMs.

We recommend a stepwise implementation intended to tap most of the benefits for the vehicles already in development. Ideally, an OEM should work toward a true north star via planned intermediate releases. Establishing a digitalization project organization and governance model can help bring about the necessary shift in mindset, risk appetite, and ways of working. Once this shift is complete, the digital organization will have served its purpose and can be disbanded.

In the process of designing or optimizing your next development process?

By benchmarking your current plans or jointly deriving a digitization target picture for your development approach we can help you to accelerate your development process. To discuss exactly how in more detail, please contact the authors below.

The authors wish to thank Tobias Paul, Andreas Foitzik, and Sebastian Werner for their valuable contributions to this paper.

[1] *For more on the four remaining best practices contact the author team or visit https://www.kearney.com/digital/automotive-software-every-day-a-new-car*

Authors:

Felix Kreichgauer

Stephan Krubasik

Michael Roemer

Christine Sachseneder