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Digital automotive R&D

Reduce time and cost to keep transformation on track

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About the authors

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EXECUTIVE SUMMARY

Carmakers' research and development (R&D) costs have risen significantly as they develop electric, connected and autonomous vehicles. The level of R&D spending has outpaced sales growth in Europe and North America even with continuous growth in production volumes and revenues since 2011. Now, as COVID-19 further accelerates the economic downturn which started in 2019, car sales at the 15 largest carmakers (OEMs) worldwide are expected to shrink for the first time in eight years. Both sales volumes and revenues will remain below 2019 levels until 2023, Strategy& estimates show.

Challenging market conditions greatly intensify the pressure to make R&D more efficient. Carmakers that cut investments in electric, autonomous, shared and connected vehicle technologies during the downturn risk falling permanently behind their competitors. The good news is that digital tools exist to bring spending under control, making key stages of the product creation process faster and more cost-effective.

To stay ahead in a rapidly transforming industry, carmakers in Europe spent far more on R&D in the past decade than did their rivals in the US and Asia. European R&D spend increased by 75 percent between 2011 and 2019, to €42 billion. US OEM spending over the same period grew by 30 percent to €13 billion, while Asian carmakers increased their spend by 33 percent to €28 billion. Revenues among the top 15 carmakers in the three regions grew by 55 percent, 18 percent and 40 percent respectively between 2011 and 2019.

To signal how OEMs can make their R&D operations more cost-effective in these leaner times, we have identified five emerging digital technologies in our study that have the most impact on improving efficiency. These are artificial intelligence (AI); virtual, augmented, and mixed reality (VR/AR); blockchain (BC); product lifecycle management (PLM); and additive manufacturing (AM) (*see Exhibit 1, next page*).

Depending on their size, strategy and appetite for risk, OEMs can follow three different pathways to digitalize their R&D processes and quantify efficiency improvements:

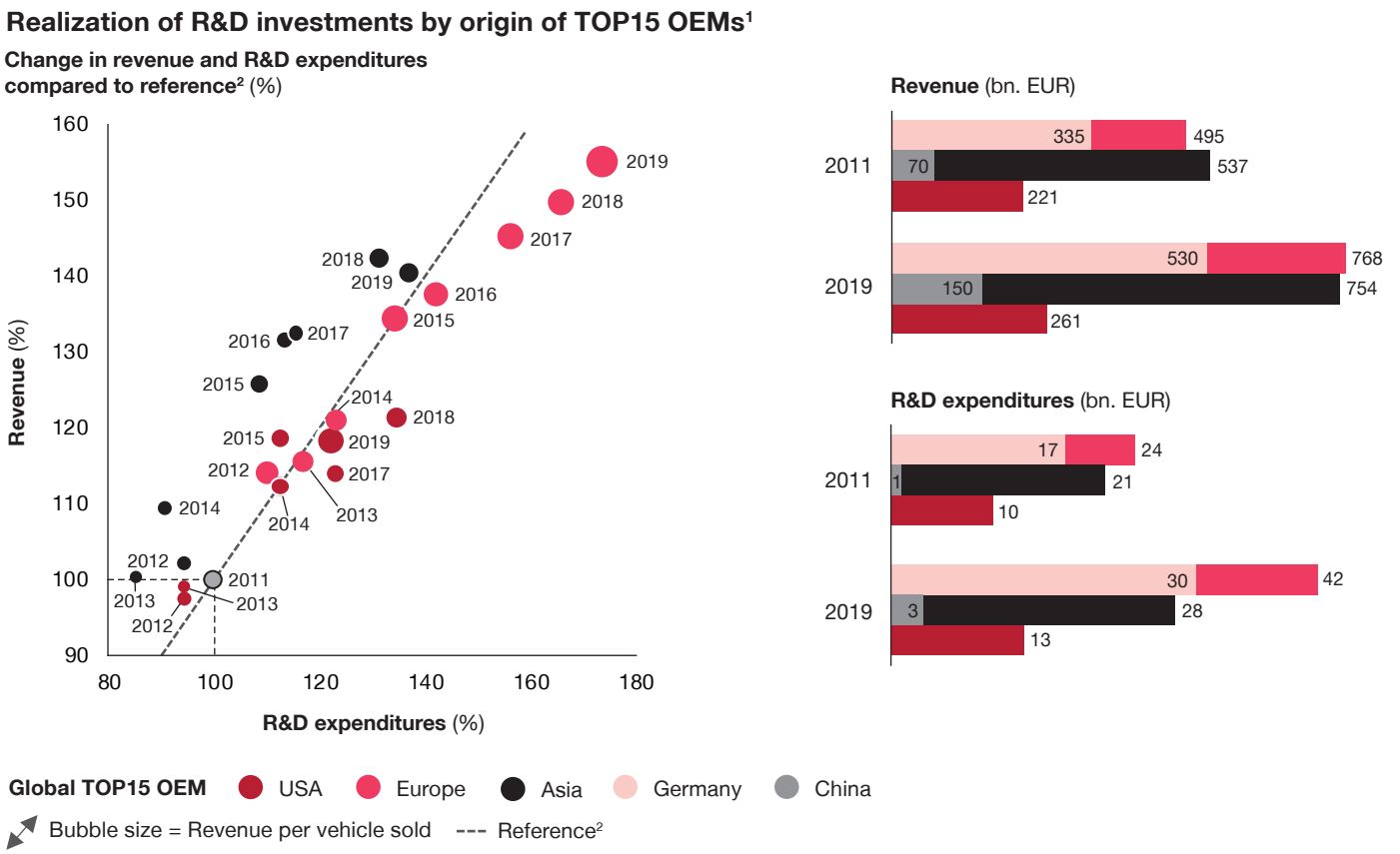
- Digital disrupters can use a number of use cases from all five emerging technologies to improve efficiency by 23 percent by 2025 – defined as a 12 percent cost saving and an 11 percent time saving.

- Fast followers can adopt the most mature use cases and improve efficiency by 12 percent – 7 percent in cost and 5 percent in time. Only AI, VR and AM technologies will be at the required level of maturity for this group by 2025, with blockchain and PLM following later.

- Safe drivers focus on the most mature use cases with the greatest potential to increase efficiency, and which can be applied in the most cost-intensive phases of R&D. This improves efficiency by 9 percent – 5 percent in cost and 4 percent in time.

EXHIBIT 1

In most regions R&D expenditures grow faster than sales revenues, resulting into increased pressure on profit margins



1. A: TOP15 OEM based on motor vehicle production 2017 – Asia-based OEMs: Honda, Hyundai-Kia, Mazda, Nissan, Toyota, Geely, Shanghai Auto; China-based OEMs: Geely, Shanghai Auto; EMEA-based OEMs: FCA, Renault, PSA, BMW, Daimler, VW; Germany-based OEMs: BMW, Daimler, VW; NAFTA-based OEMs: Ford, GM
2. 2011 revenues, R&D expenditures and revenues per vehicle sold are set as baseline (100%) for each of the regions – subsequent years are displayed in % of 2011 starting values
Source: Bloomberg, IHS 01/2020, Strategy& analysis

OEMs can move between the three pathways as their confidence in digital processes grows. In this report, we look in detail at which use cases can be used in the various stages of the product creation process for maximum efficiency gains. Some of the use cases described in this study are already being used occasionally by OEMs, but there is still further efficiency potential through an end-to-end rollout along the product creation process.


Transform
Projects
Preferences
Tools
> Part Selector
> Drivetrain
> Suspension
> Hydraulic System
v Batteries
Specifications:
Capacity 54kWh
Range 498 km
> 48v System
> Regenerative Braking
Base Principle
Using electric motors in generator mode allows to use braking energy which usualy dissappears as heat, to charge battery wtich contributes up to 25% of total range.
One pedal Driving
One pedal driving is a way of driving when a driver uses only on pedal for acceleration and breaking. It works by switching electric motors in generator mode when accelerator pedal is not pressed.
Friction Brakes
Conventional friction brakes still are very important part of driving expirience as they needed for quick deceleration and in emergency situations
Model 0.11010-G >Perspective View > Part Selector
Electric powertrain
Regenerative Braking
Range
Power Efficiency
Using Regenerative Braking
290km
Without Regenerative Braking
Efficiency Graph
START SIMULATION
AUTOMOTIVE DESIGN AND SIMULATIONS

SECTION 1

Emerging digital technologies for R&D – making the right choices

Cars are becoming more expensive to make as OEMs respond to changing customer expectations, environmental regulations, and technological disruption. Electric powertrains and automated features could increase the bill of materials by between 20 and 40 percent by 2030, according to Strategy&'s Digital Auto Report. Incorporating a growing share of software also makes development more complex, particularly at the testing and validation stage.

As the chart below shows, the most costly phases of a typical product creation process are conceptualization and series development – the stages between the concept for a new car being approved and the start of production. Together, they account for 77 percent of the cost and 65 percent of the time spent. Our model is based on the current development processes of the 20 largest OEMs worldwide, which includes US, European and Asian carmakers (*see Exhibit 2, next page*).

Based on a series of interviews with industry experts, we identified the five digital technologies with the greatest potential to improve efficiency throughout the product creation process. We then identified three potential use cases for each and mapped those to the 10 product creation milestones above. Finally, we analyzed the maturity of the technologies and their potential to reduce time and cost for automakers.

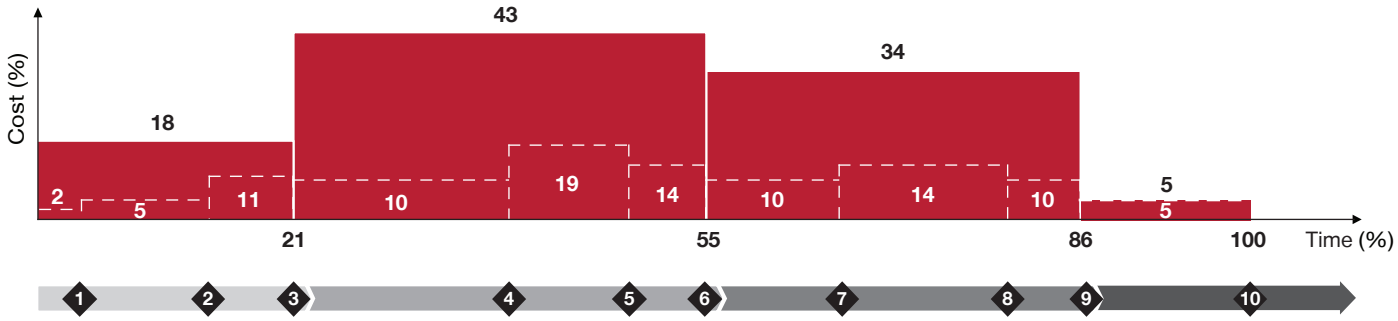
> "The experience of COVID-19 has made us think even more intensively about the use of digital tools. Our vision is to develop and test a vehicle mainly in a virtual space and simulate the production."
>
> **Board member in charge of R&D, German OEM**

EXHIBIT 2

Highest cost along the product creation process are incurred in the conceptualization and series development phases

Cost and time distribution

% of total cost and time



Initialization

1. Kick-off
- Strategy, pricing and volume targets defined
- Innovations and trends screened

2. Project scoping
- Technical, financial and sales targets described
- Project costs scoped

3. Project feasibility
- Feasibility approved
- Powertrain concept defined
- Production sites identified

Conceptualization

4. Concept approval
- Specification book completed, TCO defined
- Basic design and packaging determined
- Key suppliers identified

5. Design freeze
- Interior and exterior surface design finalized
- Manufacturability confirmed, tooling started
- Design-prototype available

6. Sourcing release
- Series tool production started
- Digital vehicle available
- All suppliers nominated

Series development

7. Launch confirmation
- Safety concept approved
- Production-concept approved
- Deviations between supplier and OEM resolved

8. 0-series production
- Series parts manufactured on interlinked systems
- Workforce qualified
- JIS-process started
- Complete vehicle approved

9. Start of production
- Marketing vehicles produced
- Environmental certificates available

Ramp up

10. Model launch
- New cars available for customer presentation
- Full capacity production achieved
- Spare parts catalogue available
- Demand capacity management started

Note: PCP – Product creation process, TCO – Total cost of ownership
Source: Basis cost derived from analysis of 20 PCPs of largest OEMs, validated through Strategy& expert survey

Five emerging digital technologies and 15 exemplary use cases

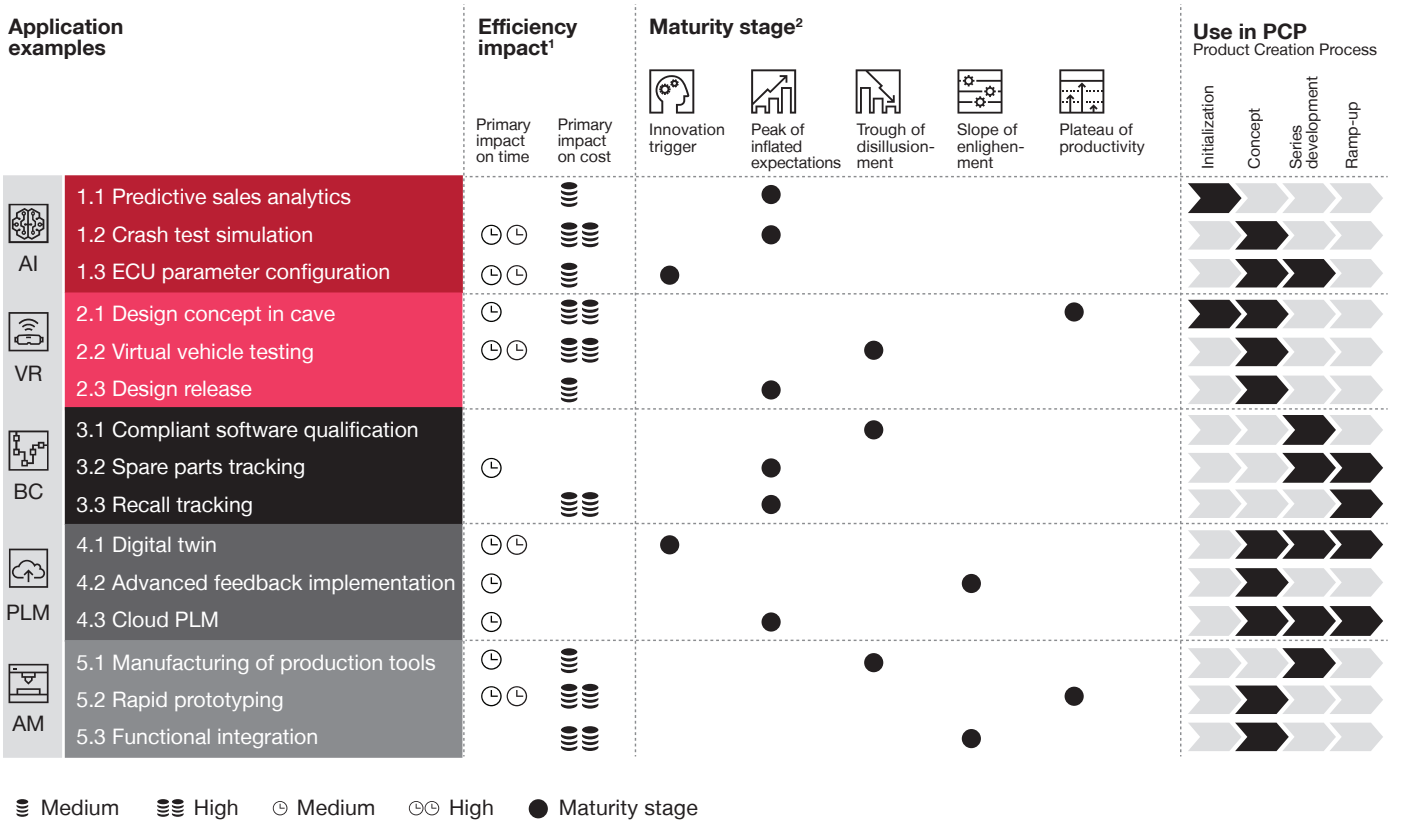
Artificial intelligence (AI) 	• Predictive sales analytics: enables accurate forecasts of sales and 'take rates' (the proportion of cars sold with particular features e.g. panoramic sunroofs) based on historical trends • Crash test simulation: calculates optimal component design and packaging • Electronic control unit (ECU) parameter configuration: setting automated parameters for ECUs reduces the number of physical tests required
Virtual, augmented and mixed reality (VR) 	• Design concept in CAVE[1]: virtual vehicle concepts replace drawings and clay models in the early phase of development, using immersive virtual reality • Virtual vehicle testing: allows component testing and verification on a 'holodeck' – a room where designers and engineers can walk around and assess virtual models of new cars • Parts design evaluation: enables optical evaluation of interior and tools using a mixed-reality concept to assess parts before producing a physical component
Blockchain (BC) 	• Software qualification for compliance: ensures data used for advanced driver-assistance systems (ADAS) and software validation is genuine • Spare parts tracking: verifies the origin of spare parts • Recall tracking: identifies vehicles containing defective parts or software
Product lifecycle management (PLM) 	• Digital twin: creates a digital replica of the vehicle to provide real-time access to the current stage of development to teams around the globe during product creation • Advanced feedback implementation: consistent use of existing and new test and field data • Cloud PLM: integrated cloud-based development platform for efficient collaboration and task automation
Additive manufacturing (AM) 	• Production tool manufacturing: 3D printing of tools, jigs, and fixtures for (pre) series production • Rapid prototyping: AM quickly generates physical prototypes of components • Functional integration: AM enables the development of individual components with multiple integrated functions

1. Original source: A Cave Automatic Virtual Environment (CAVE) is an immersive virtual-reality environment created by projecting images onto three to six walls of a room-sized cube, creating a 3D image for the user.
For reference see Cruz-Neira et al., 1992. The CAVE audio visual experience automatic virtual environment. Communications of the ACM, 64-74

As with all technologies, there is a risk-reward trade-off when it comes to maturity: the more mature an application, the less risky, costly and time-consuming it is to implement. Other users have tried it out and the application has been improved over time. The downside is that adopting a mature technology means the company is a late follower rather than a first mover – unlike the first company to use the application, there is no advantage over competitors (*see Exhibit 3*).

EXHIBIT 3

AI, VR and AM promise highest efficiency impact, while AM use cases are most mature



1. Based on Strategy& and SME evaluation
2. According to Gartner analysis

Note: I – Initialization, C – Concept, S – Series development, R – Ramp-up, ECU – Electronic control unit, ADAS – Advanced driver-assistance systems, PCP – Product creation process, AI – Artificial intelligence, VR – Virtual, augmented and mixed reality, BC – Blockchain, PLM – Product lifecycle management, AM – Additive manufacturing

Source: Strategy& analysis

CASE STUDY

End-to-end development platform

Using a cloud-based development platform to reduce the time spent to develop automated driving functions

In a recent study, we were asked by a premium OEM to evaluate the impact a cloud-based development platform, including a cloud-based product lifecycle management (PLM) system, would have on the efficiency of developing advanced driver assistance systems (ADAS). Such a digital development platform enables an end-to-end workflow for developers and allows for simultaneous working, real-time feedback and continuous integration and testing. Our evaluation showed there was a considerable opportunity to save development costs and time in testing and validation, software development and compliance.

The highest potential for savings was identified in testing and validation. The development platform, including the cloud-based PLM, can be used to: optimize test and training data collection and scenario generation; make data management more efficient; automate and carry out various simulations; and leverage real-time feedback from tests. It ensures end-to-end traceability with a direct link between system requirements (the 'what') and implementation and test cases (the 'how'). OEMs can then check automatically if the requirements are being implemented and significantly decrease the lead time for bug fixes.

Significant saving potentials were also identified for software development. The development platform enables the use of modern agile methods such as 'DevOps' throughout the development process, which reduces doubling up on work and inconsistencies, and allows for the automation of manual processes. The aim of the DevOps (development and operations) methodology is to speed up development, lower failure rates and shorten the time it takes to fix bugs by continually integrating and deploying the software in the vehicle fleet, which further reduces cycle times.

The third area in which costs can be significantly lowered using a cloud-based development platform is compliance. Our evaluation showed that time spent on ensuring compliance can be reduced because tedious manual processes such as compliance report generation for functional safety can be automated. Also, data quality checks for AI model testing and training data – which are expected to become mandatory with upcoming regulations – can be automated and performed directly during data collection.

Overall, we estimated that the OEM would have saved a significant share of the development cost on its last camera-based ADAS project by using such a platform.

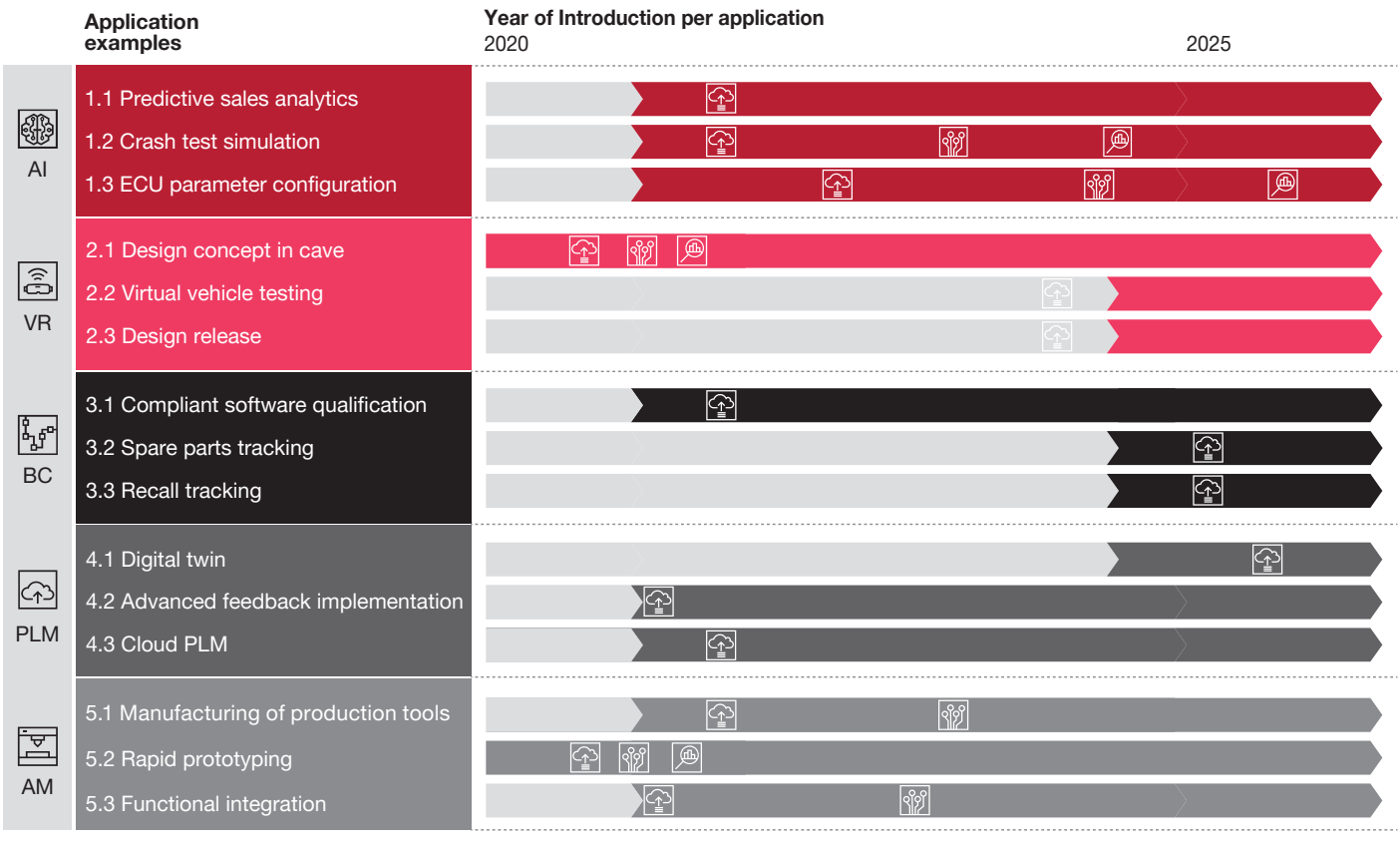
SECTION 2

How to get there – which path is right for your organization?

The ‘right’ level of digitalization in R&D will depend on each OEM’s need to reduce costs and save time, as well as their appetite for technology risk and the level of support at the top of the organization. We broadly expect OEMs to introduce the digital R&D use cases described above over the following time frame (*see Exhibit 4*).

OEMs should therefore select the digital technologies and use cases they need based on their maturity (*see Exhibit 3, page 7*), efficiency gain and impact on the product creation process.

EXHIBIT 4
Automotive OEMs implement digital applications at different speeds



Source: Strategy& analysis

Based on these criteria, we have set out three distinct routes to digitize R&D. OEMs can switch between them as they become more comfortable with digital processes. Once they have chosen a path, automakers must then review their overall innovation strategy and their collaborations with technology suppliers to ensure all the strands work together.

The three ways-to-play are

1

Digital Disrupters

OEM pushes the frontiers of technology at an earlier stage of maturity by introducing technologies as part of its own research. Uses a number of use cases from all five technologies.

2

Fast Followers

OEM extends the use of use cases from all five technologies right along the product creation process, accepts smaller efficiency increases than Digital Disrupters.

3

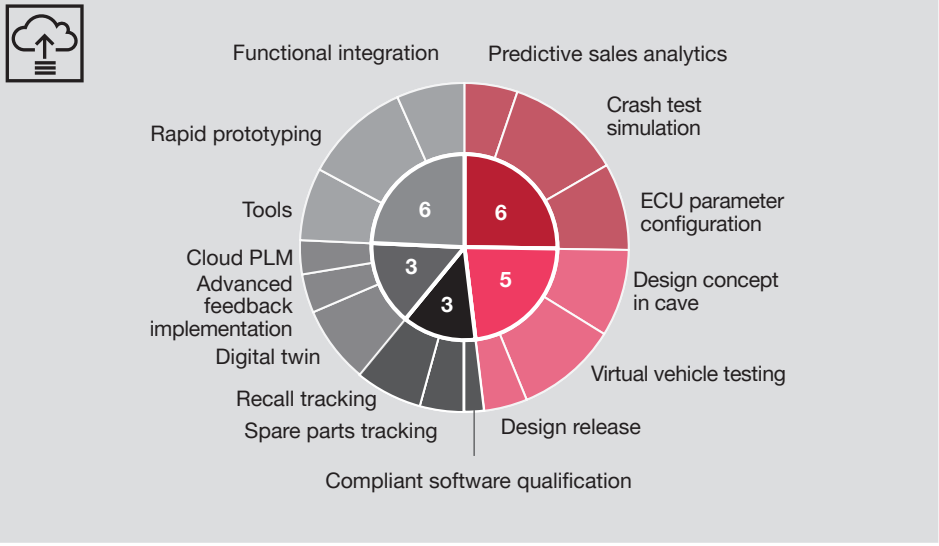
Safe Drivers

OEM focuses on AI, VR and AM technologies with proven high efficiency improvements, and which are mature.

EXHIBIT 5

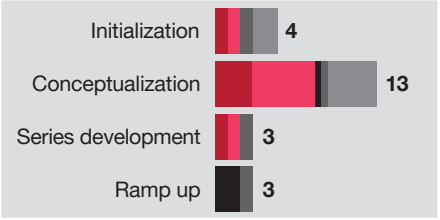
Digital Disrupters leverage all 5 digital technologies to improve efficiency by 23 percent at an accelerated pace

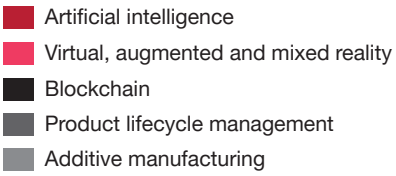
Savings by enabler and application in 2025 (%)



Savings by efficiency type (%)

Savings by PCP phase (%)



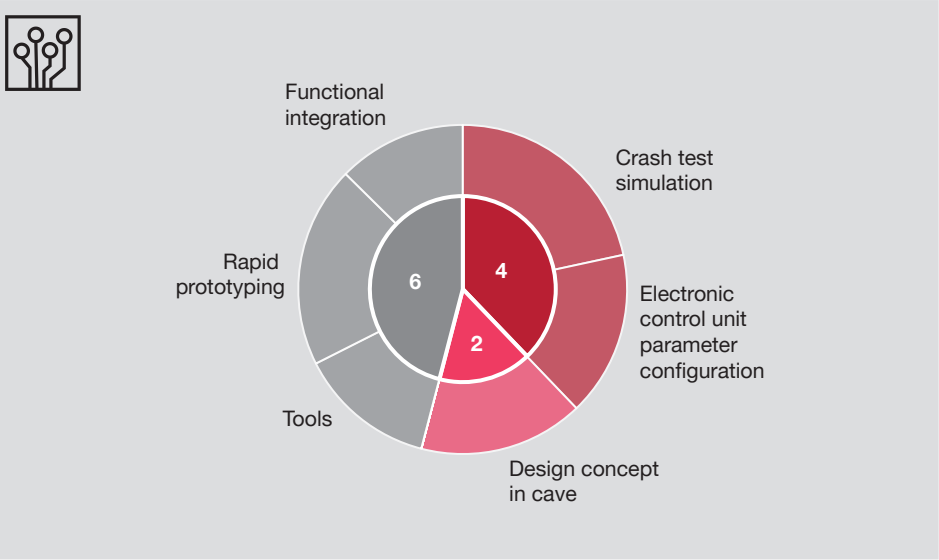


Note: PCP – Product creation process, ECU – Electronic Control Unit
Source: Strategy& analysis

EXHIBIT 6

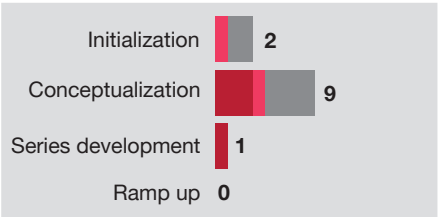
Fast Followers focus on most mature use cases within 5 digital technologies, resulting in 12 percent efficiency improvement

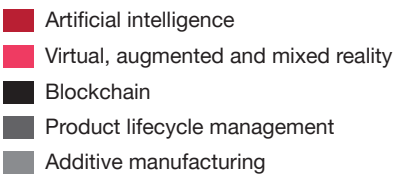
Savings by enabler and application in 2025 (%)



Savings by efficiency type (%)

Savings by PCP phase (%)



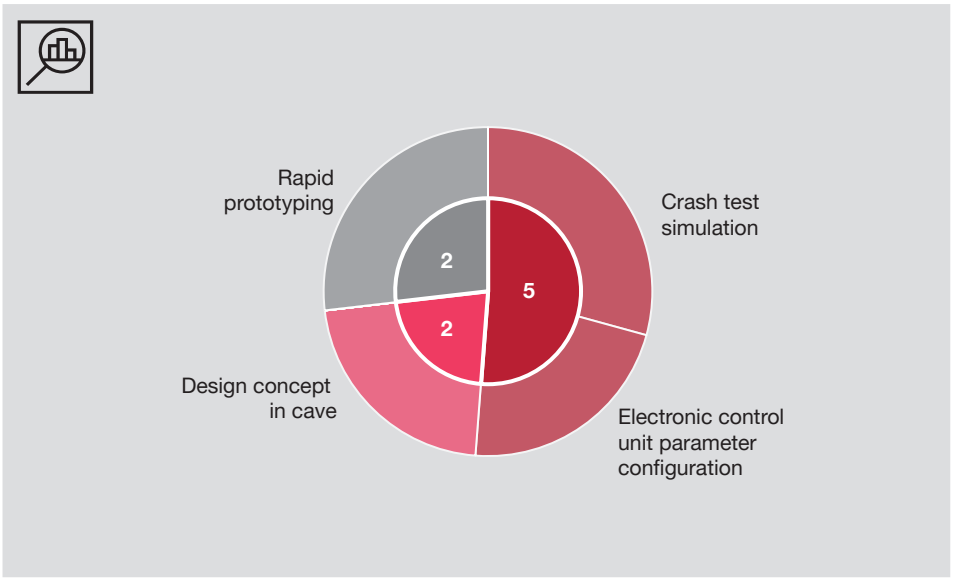


Note: First application to be implemented in 2021, thus, no efficiency improvement in 2020, PCP – Product creation process
Source: Strategy& analysis

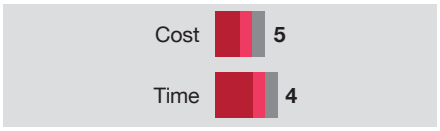
EXHIBIT 7

Safe Drivers improve efficiency by 9 percent by 2025, leveraging only mature AI, VR and AM use cases

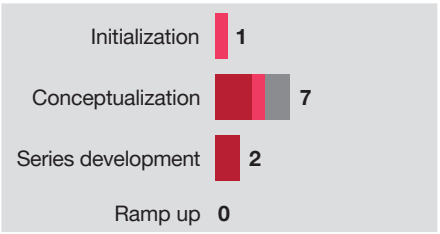
Savings by enabler and application in 2025 (%)

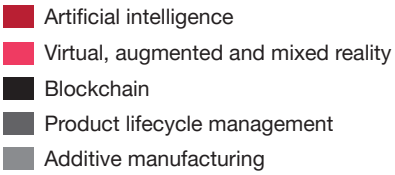


Savings by efficiency type (%)



Savings by PCP phase (%)





Note: PCP – Product creation process
Source: Strategy& analysis

SECTION 3

Making digital R&D a reality

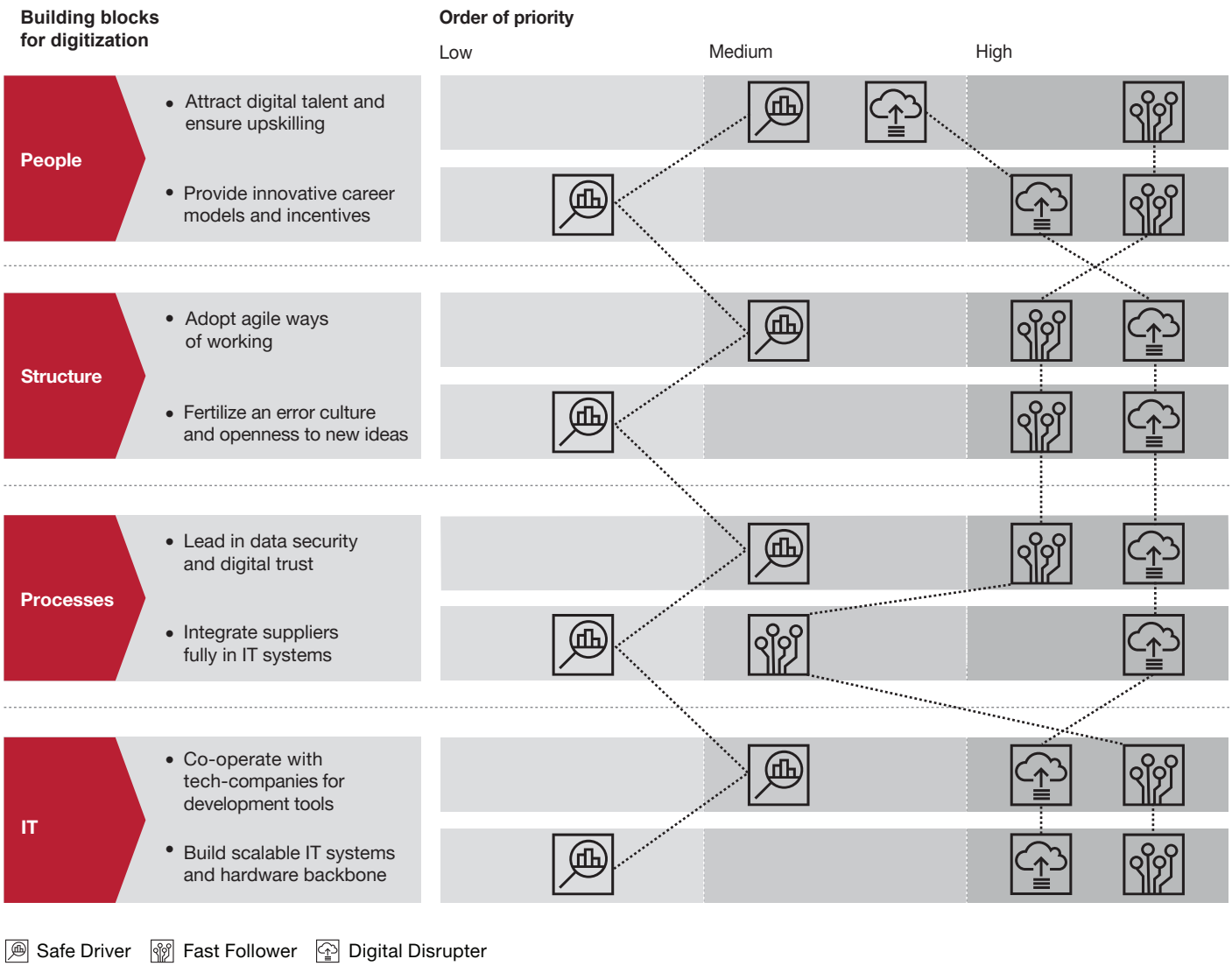
Once they have chosen which path to start on, automakers must take action in four key areas: people, structure, processes and IT.

People	OEMs must ensure upskilling of their existing workforce while working on attracting digital talent, because digitalizing R&D will increase the number of technology-driven projects in the business, with cross-functional teams from diverse backgrounds working on them. Innovative career models and incentives will enable OEMs to compete with software firms for the best employees.
Structure	To get the most out of their new digital R&D tools, OEMs need to adopt some of the agile ways of working used by software developers, developing a culture where employees are not afraid to try and fail, then learn from their mistakes in new iterations.
Processes	OEMs should aim to become leaders in data security to build up digital trust. Moreover, suppliers need to be more integrated into the OEMs' IT systems to fully exploit the potential of the R&D efficiency improvements described above.
IT	OEMs should consider co-operating with technology companies to develop their digital toolkit. Companies that focus on implementing only the most fully-developed use cases should look at strategic co-operation with external partners, while those that plan to implement the full set of use cases should also aim to build the capabilities for the development of the digital tools internally. Moreover, these OEMs should strive to build scalable IT systems and hardware support.

Regarding IT and Tech companies, prominent co-operations can already be found: Automotive cloud (Volkswagen and Microsoft), production cloud (Volkswagen and Amazon Web Services), data driven marketing (Daimler and Salesforce), software-defined computing architecture for automated driving (Mercedes and Nvidia), and digital transformation (BMW and Alibaba). Of course, these co-operations require proper structures and new or revised processes. Moreover, the workforce needs to embark on the transformation journey, also adapting the own way of working, e.g. with cloud based collaboration tools and supporting aids like robot process automation (RPA) to speed up manual procedures.

EXHIBIT 8

Actions to take to excel in digitalizing R&D



Source: Strategy& analysis

Priorities by degree of digitalization

Digital Disrupters

- Push frontiers of digital enabler in all PCP phases by research and lead in digital trust
- Fully integrate suppliers in IT systems to utilise complete potential of digital technologies
- Keep an eye on cost, don’t follow an idea without an indication it will pay off

Fast Followers

- Partner with tech companies to implement digital application over all PCP phases
- Review organization and capabilities tofully evolve potential of digital enablers
- Become place-to-be for digital elite and thoroughly drive upskilling of workforce

Safe Drivers

- Start with mature digital technologies in concept and series development phase to cover gaps in expertise
- Attract and hire the right people and upskill current workforce
- Build scalable IT systems

Strategy&

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