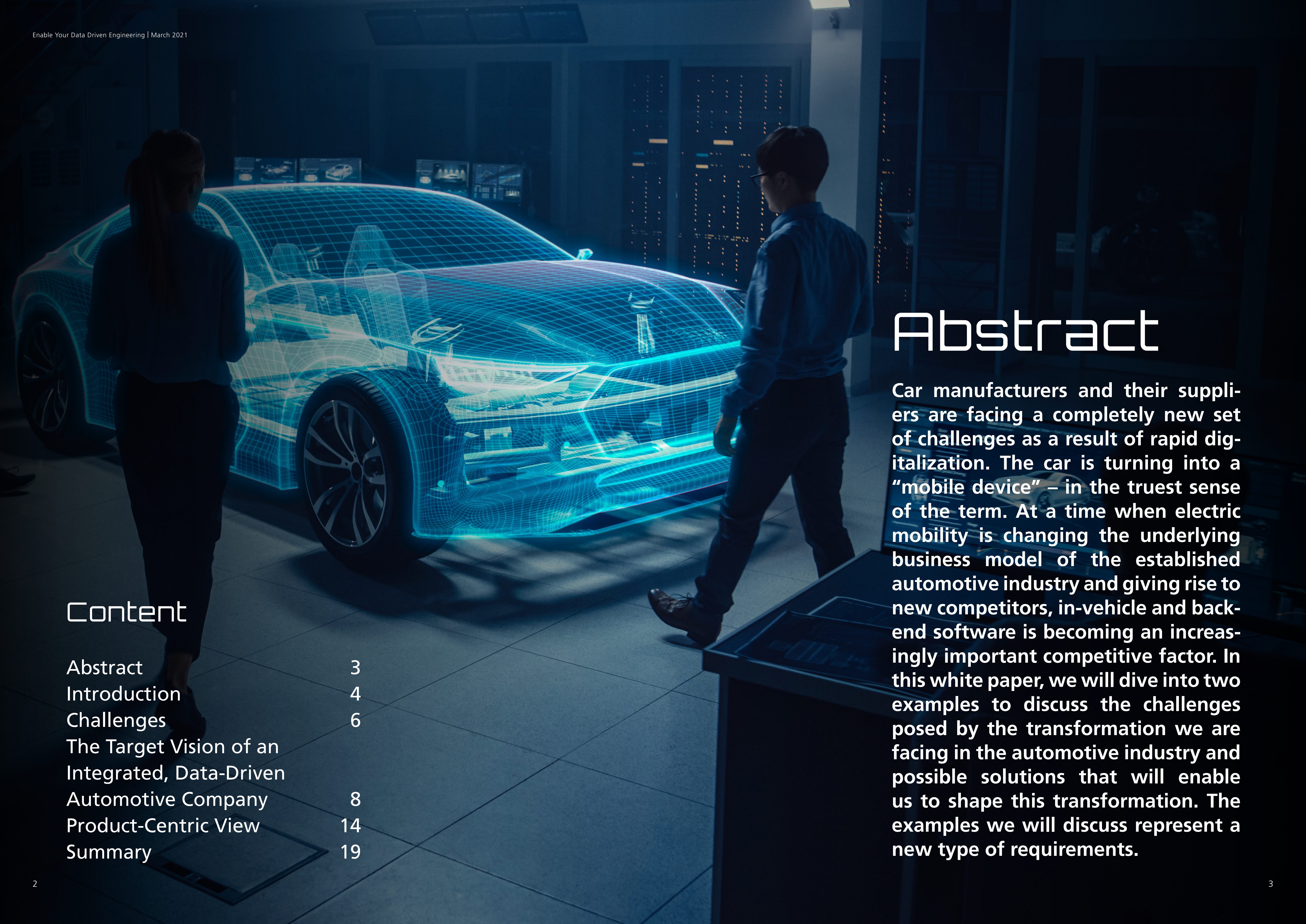
A PORSCHE COMPANY

MHP WHITE PAPER

Enable Your Data Driven Engineering

How engineering processes become more efficient based on data



Content

Abstract

Car manufacturers and their suppliers are facing a completely new set of challenges as a result of rapid digitalization. The car is turning into a "mobile device" – in the truest sense of the term. At a time when electric mobility is changing the underlying business model of the established automotive industry and giving rise to new competitors, in-vehicle and back-end software is becoming an increasingly important competitive factor. In this white paper, we will dive into two examples to discuss the challenges posed by the transformation we are facing in the automotive industry and possible solutions that will enable us to shape this transformation. The examples we will discuss represent a new type of requirements.

Introduction

The shift toward electric mobility presents enormous challenges for the established automotive industry. This applies in equal measure to manufacturers and their suppliers. The shift away from internal combustion engines, which have been powering vehicles for over a century, is hitting car manufacturers (OEMs) extremely hard because the knowledge and expertise they have developed regarding the production of economical and clean engines has become irrelevant practically overnight. In the past, the complex thermodynamic processes involved in the combustion of fuel in the engine and chemical processes involved in the treatment and cleaning of exhaust gases has enabled established automotive groups to dominate the market for decades – while making it difficult for new competitors to gain a foothold. Electric mobility shifts this focus to entirely new areas such as battery technology or charging infrastructure.

The rapid digitalization of vehicles is a very similar situation. Previously, clearance dimensions in the vehicle or the manufacturing quality of the interior were the crucial factors, but today customers are increasingly more interested in having a diverse range of digital services and driver assistance systems. With this trend, vehicles are becoming a type of "mobile device," providing highly innovative infotainment systems while also making the driver's job easier with a wide range of assistance systems, which are becoming increasingly advanced. The software and sensor technology that facilitate these systems are therefore becoming an increasingly important competitive factor and are initiating the transformation of a world previously dominated by mechanical engineering.

The digital transformation of vehicles, which is constantly becoming more complex due to the use of numerous control units and driver assistance systems, has not gone unnoticed by legislators. For example, engine and exhaust electronics determine emission behavior, and driver assistance systems are increasingly influencing driving behavior, which in turn affects road safety. In addition, after a vehicle has been produced, software updates can be used to modify vehicle features that affect the vehicle's homologation. Therefore, it is only logical that the legal requirements regarding product compliance have increased significantly. Manufacturers and suppliers of vehicles and/or vehicle parts must ensure a high level of transparency and traceability from development through the entire life cycle in order to obtain and maintain the approval of their products. It is this consistent transparency required across entire process chains that poses significant problems for manufacturers and suppliers, since system landscapes have historically developed to reflect the organizational units of the respective company

"The increasing software complexity in vehicles intensifies the requirements of product compliance."

Challenges

The automotive industry has always been strongly influenced by the innovative spirit of engineers and mechanical engineering experts. This has led to significant improvements in production quality, comfort, and active and passive safety features . As a result, today's vehicles offer excellent protection in the event of an accident. However, even though the market share of SUVs continues to increase, the consumption of fuel and amount of pollution caused by exhaust gases has also been significantly reduced using sophisticated engine electronics. To make this possible, the development processes relating to the interaction of different components have been continuously improved. Manufacturers and suppliers have invested heavily in building a high level of expertise in thermodynamics and exhaust gas aftertreatment and have continuously optimized production and logistics processes in terms of time, quality and costs.

The technological shift toward electric mobility is further diminishing the importance of mechanical components and is quickly devaluing the expertise in the area of combustion engines that has been developed over many years. Since electric vehicles are significantly less complex as products, many components have been rendered obsolete, putting entire areas of the supplier industry at risk. Established OEMs, on the other hand, risk losing their positions as pioneers in the industry and becoming easily replaced vehicle manufacturers if they are unable to adapt to the new market conditions and continue to offer attractive products.

In contrast, the increasing digitalization of vehicles has proven to be a significant complexity driver and poses a real challenge to everyone involved. For a long time, digitalization played a minor role and was not seen as a significant competitive factor, meaning that OEMs outsourced the development and production of sensor technology and the necessary software to suppliers. This strategy continued for as long as these components could operate independently of each other. However, this is often no longer possible when implementing a function-oriented development approach, since the interaction of modules and control units from different suppliers can ultimately only be coordinated by the OEMs themselves. However, the considerable amount of work involved in the quality assurance and integration of such solutions increasingly results in the otherwise sacrosanct Start of Production (SOP) being postponed, and therefore to significant losses in profitability. The situation is likely to be exacerbated by the rapidly growing complexity of the in-vehicle and back-end software.

However, simply handing this task over to the central IT department is easier said than done. A brief look at the history of the central IT department and of the specialist departments provides a useful insight into the reasons for this:

Previously, the primary task of the central IT department was to run the IT solutions specified and paid for by the specialist department as cheaply as possible. For example, the most important requirement for the central IT department was to use as low a share of the company's turnover as possible and to optimize itself as a cost center. As a result, it has been almost impossible for the IT department to distinguish itself as a driver of innovation. Its limited and often unattractive tasks have resulted in the IT department keeping a low profile without the ability to exert any significant influence over the emerging IT landscape. This is particularly evident when you look at how IT is incorporated into companies at an organizational level: As an organizational unit, IT has often been integrated into the Finance division.

In contrast, the main task of the specialist departments was to develop and produce good-quality products quickly and at a low cost. The necessary software components and IT systems were developed independently or in close coordination with suppliers. Only when the level of complexity increased and interdependencies arose as a result of technical requirements were the various departments forced to cooperate more closely. The IT systems were then networked with each other in order to enable them all to access the necessary central data. The need to consolidate and modernize application landscapes at regular intervals, thereby keeping them up to date with the latest technology, has been repeatedly postponed in favor of new developments and interfaces.

The lack of consolidation of the IT landscape is becoming an increasingly significant burden for several reasons. As the number of applications grows, their operating costs increase accordingly and further restrict the freedom of the specialist department due to high annual fixed costs. However, the costs are also unnecessarily increased when developing new IT systems, since these systems often must connect to different systems to acquire data, which means that appropriate interfaces need to be implemented. This is not only very cost-intensive, but also time-consuming, since the data management systems – which are often still running on mainframe computers – have limited interface capabilities. Moreover, all efforts to improve data governance and achieve the traceability required by law are unnecessarily complicated.

In addition to the high costs, the expanded IT landscape also hinders the innovation and performance potential of new IT systems. Consequently, the performance of new IT systems often falls short of expectations due to the new systems' dependence on data from their predecessors. Often, the IT landscape is also unable to provide appropriate solutions to handle the increasing complexity and significantly increased non-functional requirements such as safety, scalability and latency. Furthermore, the architectures of new IT systems must adapt to the realities of existing systems and lose some of their potential and flexibility. Lastly, over time it becomes increasingly difficult to gradually consolidate the expanded system landscape, since the increasingly interconnected, heterogeneous design and the age of the systems make it practically impossible to modernize them. This often involves the same amount of work as developing a completely new system, which would entail high investment costs and complex migrations.

In summary, due to the strict cost discipline it has had to exercise, the central IT division has not fulfilled its potential regarding the design of innovative solutions and well-grounded system architectures and has not been able to develop the expertise that is now urgently needed. In turn, the specialist department has created a "shadow IT" landscape by designing additional IT systems and has neglected the necessary consolidation tasks for reasons of speed and cost. Consequently, this IT system landscape now increasingly acts as a cost driver that stifles innovation. At the same time, the decreasing level of vertical integration and the undervaluing of IT have led to a considerable loss of the crucial software expertise that is needed to evaluate and develop modern IT landscapes.

The Target Vision of an Integrated, Data-Driven Automotive Company

In the following section, two examples of different challenges caused by digitalization will be presented and compared to strategic corporate objectives. This will provide an initial insight into this network of relationships and the associated effects. The corporate vision serves as an essential anchor for defining and quantifying the challenges. To avoid going into too much detail here, we will limit ourselves to the following strategic objectives:

- **Very attractive and competitive product**
- **Satisfied customers**
- **Decent returns**
- **Motivated employees**
- **Sustainability**

"These objectives are always associated with optimizing the triangle made up of time, cost and quality."

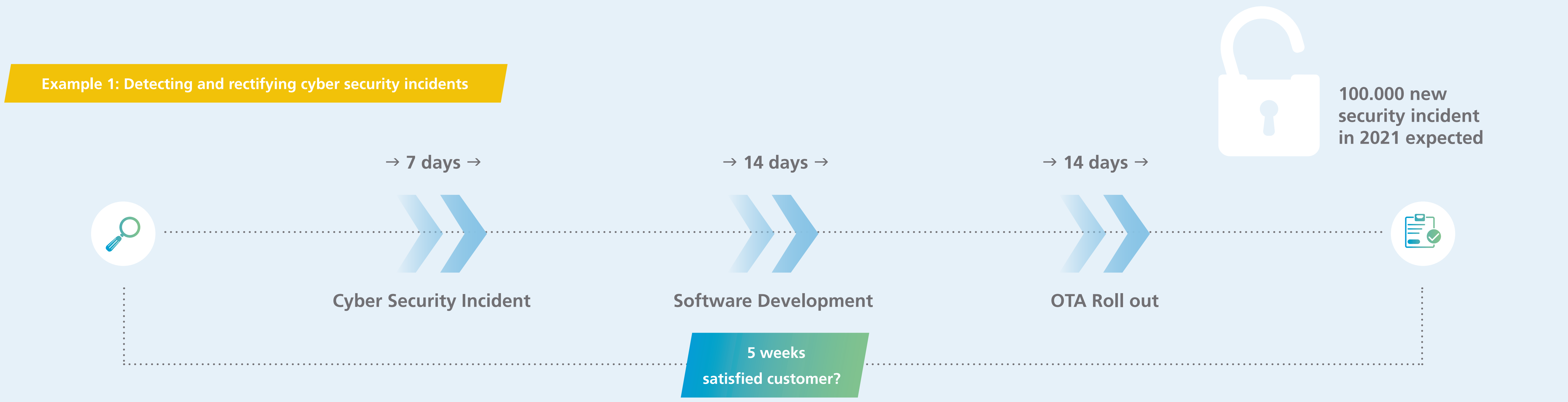


Figure 1: Cyber Security Incident Process

Within the framework of WP.29 GRVA, UNECE adopted new regulations on cyber security management and software update management. Compliance with these regulations is absolutely necessary in order to obtain type approval – and must be maintained over the entire product life cycle.

An OEM is monitoring developments regarding the potential vulnerabilities of its in-vehicle software to cyber attacks. These can be caused by faulty or unsafe software libraries and can potentially endanger the vehicle and its occupants, but also the environment. Firstly, the OEM must know which software libraries – including updates – have been installed in the vehicle by the OEM itself and by its software suppliers. This will enable it to compare them with the known vulnerabilities. Most of the vulnerabilities are available from publicly available sources such as the NIST database and are constantly updated. If a vulnerable software library is installed, the potential consequences of this in the worst-case scenario must be investigated. Depending on the result, an appropriate corrective action must be taken and the affected vehicles must be supplied with the new software. The following diagram illustrates this process. The given periods are optimistic, and experience dictates that they tend to last a little longer.

In this example, **the first step** takes seven days. During this step, the vehicle classes or models that are affected by a vulnerability are identified. To do this, the installed software versions of all vehicle classes must be checked against newly listed vulnerability entries from the above-mentioned NIST database – including the software created by the supplier. In this way, the vulnerability is analyzed in terms of its relevance and severity and an adequate corrective action is defined.

The second step is to fix the vulnerability. This may involve creating a software element known as a "bug fix" and testing it for effectiveness and side effects in various test scenarios. In our example, this takes another two weeks.

In **the third and final step,** the specific vehicles for which the bug fix has to be rolled out are determined. This step, which consists of compiling the corresponding software packages, locating the vehicles with the vulnerable software version and performing the update, takes a further two weeks in our example.

In addition, it should be noted that there are several hundred thousand new entries in the NIST database each year that affect part of the software used in the vehicle. This means that this process must be repeated regularly and relatively frequently.

The OEM therefore has the following tasks:

- The entries in the vulnerability databases and the installed software components of all model variants must be continually compared; the software suppliers must also be well integrated into this process so that they can work efficiently with the OEM on rectifying the fault, if necessary
- The potential of the vulnerability (one vulnerability can trigger a cascade of other vulnerabilities) and the requirements of an adequate troubleshooting process must be assessed quickly
- In a two-week sprint, the corresponding software modification is developed and tested at various levels; the integration of a software supplier must be factored into this
- In addition, the vehicles that will be provided with an Over-The-Air (OTA) update must be selected accurately and quickly, and this selection must take country-specific circumstances into account; logging of the vehicles supplied with the update is mandatory – this requires an efficient and high-performance OTA interface that is capable of ensuring that software packages are transferred between the manufacturer and the vehicle – regardless of geolocation – in compliance with high security standards

The ability to successfully complete these tasks is contingent on several conditions:

- Is constant, fast access to the necessary data management systems available, allowing a continuous, automated comparison of entries in the vulnerability databases with the software installed in the vehicle fleet?
- What is the process for integrating a supplier who created the installed software? Can this be achieved within the given period?
- Are agile teams of experts available for impact evaluation and development teams available for implementation at short notice, and do they have the necessary equipment? Are the necessary, highly automated toolchains available?
- Is a sufficiently efficient OTA environment that can provide updates to a variety of vehicles in a short time available?
- Can the associated product compliance requirements be met?

Therefore, the speed and quality with which the necessary update can be installed in a vehicle are crucial here. Processes, methods and tools must be able to achieve this objective in principle and must be adjusted if necessary. It may also be necessary to increase vertical integration by bringing software development that has been outsourced to suppliers back into the company.

Example 2: Highly automated driving

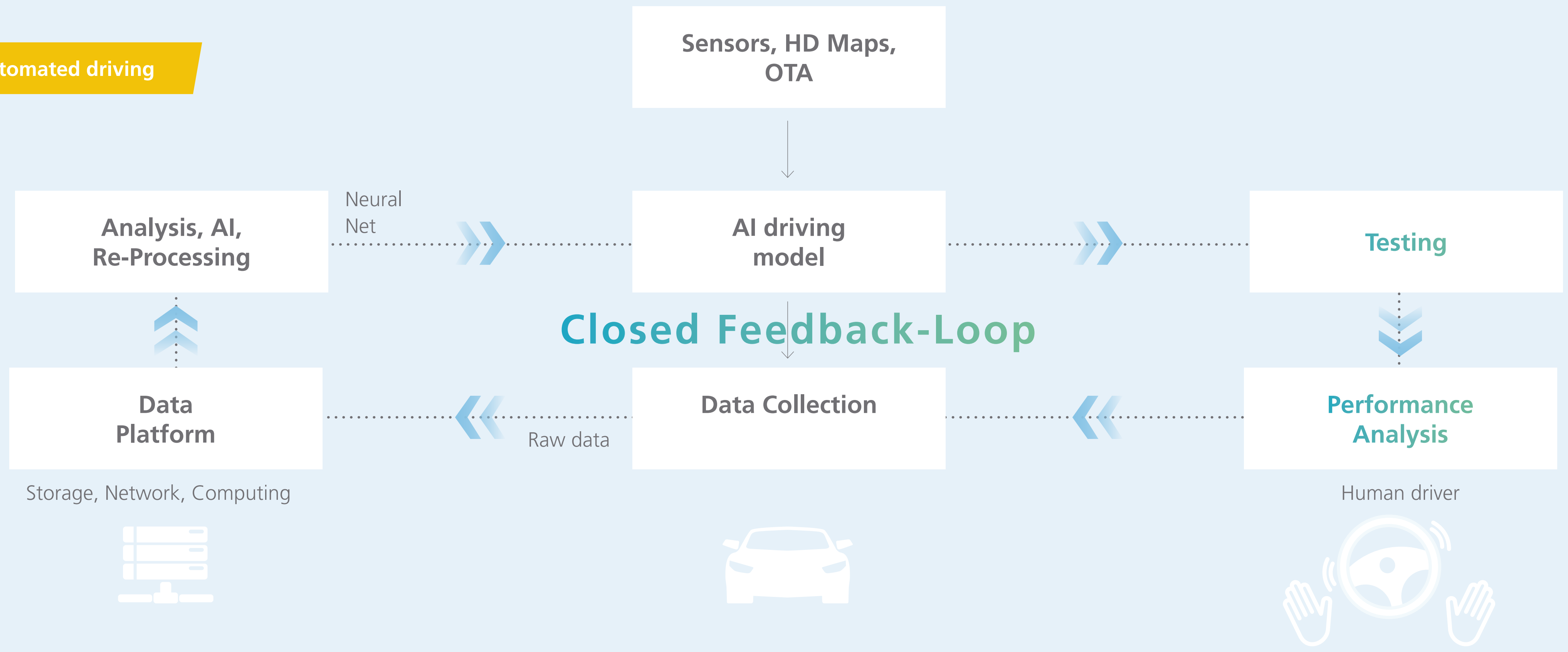


Figure 2: Closed Feedback Loop for highly automated driving

A large number of driver assistance systems are now available to assist drivers and improve their safety. Until now, all systems only supported the driver and did not take over the actual driving of the vehicle. In vehicles with SAE automation level 3, the vehicle takes over driving intermittently, while in vehicles with SAE automation level 4 and above, the vehicle drives completely autonomously. This involves a software that is based on artificial intelligence and is comparable to the human brain in the way it works. What makes this type of software so special is that it can handle situations that it has never encountered before. This is achieved through "neural networks," which are trained using a variety of different test data or test scenarios and are not deterministic – in contrast to conventionally developed software. There is always only a certain probability that neural networks will achieve the task they are asked to do. Therefore, the aim is to drive this probability toward 100 per cent . The main feature of this software is that the results get progressively better as the software completes more training scenarios. The training can be done both in the physical world and virtually using a simulator. The training data consists mainly of images and image sequences – and millions of them have to be collected, processed and run through for the training. This process is visualized in the graphic 2.

In constantly repeating iterations, the software is improved and trained within one run based on the collected feedback and analysis results in the backend (left side). The improved software is then installed in the test vehicle (test mule) and tested in various situations. Raw data from the journey as well as the difference between the behavior of the human driver and of the software are recorded (right part). This information is fed back into the development backend. The subsequent analysis and data evaluation triggers the next improvement loop and the process begins anew. Since this is a closed cycle, it is also referred to as a closed feedback loop.

This example clearly shows that traditional development needs to evolve in terms of its processes, methods and tools in the future. In this case, development is not complete once the SOP is reached. Rather, it is a continuous process that builds on the V-model-based approach from the field of systems engineering. Secondly, customer driving situations should be included in the development process to expand the range of scenarios accordingly and to supplement the test drives performed during development. This means that the development process is not limited to the use of test mules in the product development process. Experience from customer use is also included in the development process.

The large number of video cameras and lidar and radar sensors installed in autonomous vehicles are complementary sensors that act as the vehicles' "senses," which enable the vehicles to perceive the surrounding environment and other road users. Complex and rapidly changing traffic situations place high demands on the frequency and resolution of the sensors used. It is therefore hardly surprising that an enormous amount of data is generated during test drives, and that this then needs to be analyzed. For example, each hour spent driving a test vehicle generates several terabytes of video or lidar data. Usually, several test mules are operated simultaneously across different phases of vehicle development in two shifts. This results in a gigantic amount of data being recorded in a short time, which then needs to be analyzed very quickly at a later stage.

As in the previous example, there are some problem areas to highlight here:

- The current established procedure following the systems engineering V-model is not adequate for this use case
- The predominantly client-based toolset of engineers is no longer sufficient because neither the developer's computer nor its network bandwidth are able to handle this huge amount of data; there are hardly any providers on the market that provide the necessary toolchain for server-based development
- Few employees possess the know-how needed to develop AI-based algorithms
- The product development process must be able to coordinate the different life cycles of mechanics, sensors and software and allow continuous development
- Due to the huge amount of data and processing power required for development, a highly optimized hosting environment is a competitive factor

Product-Centric View

These two examples clearly demonstrate that we need to rethink the form of development that is prevalent today. The time-tested and successful form of mechanical development needs to be expanded to include sensor and software development. As shown in the examples above, software development often uses an iterative approach with short cycles. This approach is intended to enable companies to respond quickly to market demands such as updates at short notice, new digital services, V2X functions, etc. A close coupling of mechanical development and software development is neither possible nor sensible and is replaced by a loose coupling, which gives both sides the freedom they need. The loose coupling also offers the advantage that the in-vehicle and back-end software, which is costly and time-consuming to develop, can be used for various vehicle models.

This results in a shift from a phase-centric view to a product-centric view, with several take outs of major DevOps patterns (Figure 3).

The left side of this graphic shows the product development process. There is a smooth transition between development and placing the product on the market. The right side illustrates the use of the product by the customers. The experiences of the customers, together with the events experienced and the usage behavior, provide valuable information that flows back into the further product development. This closes the loop and the next iteration can begin. This loop is very similar to the procedure in our example of autonomous driving and reflects a key pattern regarding processes.

The basis for this is the Digital Twin (DT), as shown in the graphic 3. It serves as a link between the product and the manufacturer, acting as a kind of avatar of the physical vehicle. The DT can perform various tasks: On the one hand, it acts as an intermediary between the manufacturer and the product, serving as an interface that is available to both sides for communication. The DT can provide detailed information about the current construction status of its physical counterpart, help with the geolocation of the vehicle or assist with the adaptation of the vehicle to country-specific conditions. It also serves as an intermediary for software updates and can collect data from the physical vehicle, thus providing valuable feedback for development. In addition, it is connected to the IT back-end and can support interactions between in-vehicle software, back-end software, and services. The overall concept of the DT opens up completely new opportunities for car manufacturers to obtain comprehensive information about the use or utilization of their products.

Process Automation

In order to achieve this product-centric target vision and become more competitive on the market, digitalization efforts should be increased or kept at a high level. A key subsidiary objective on the path to this target vision is to advance process automation. For example, it is still often the case that the data used to determine product development maturity is collected manually from the relevant specialist departments and also consolidated manually. This process is prone to errors, slow, and makes it difficult to achieve effective control of the development process. Achieving automated pro-

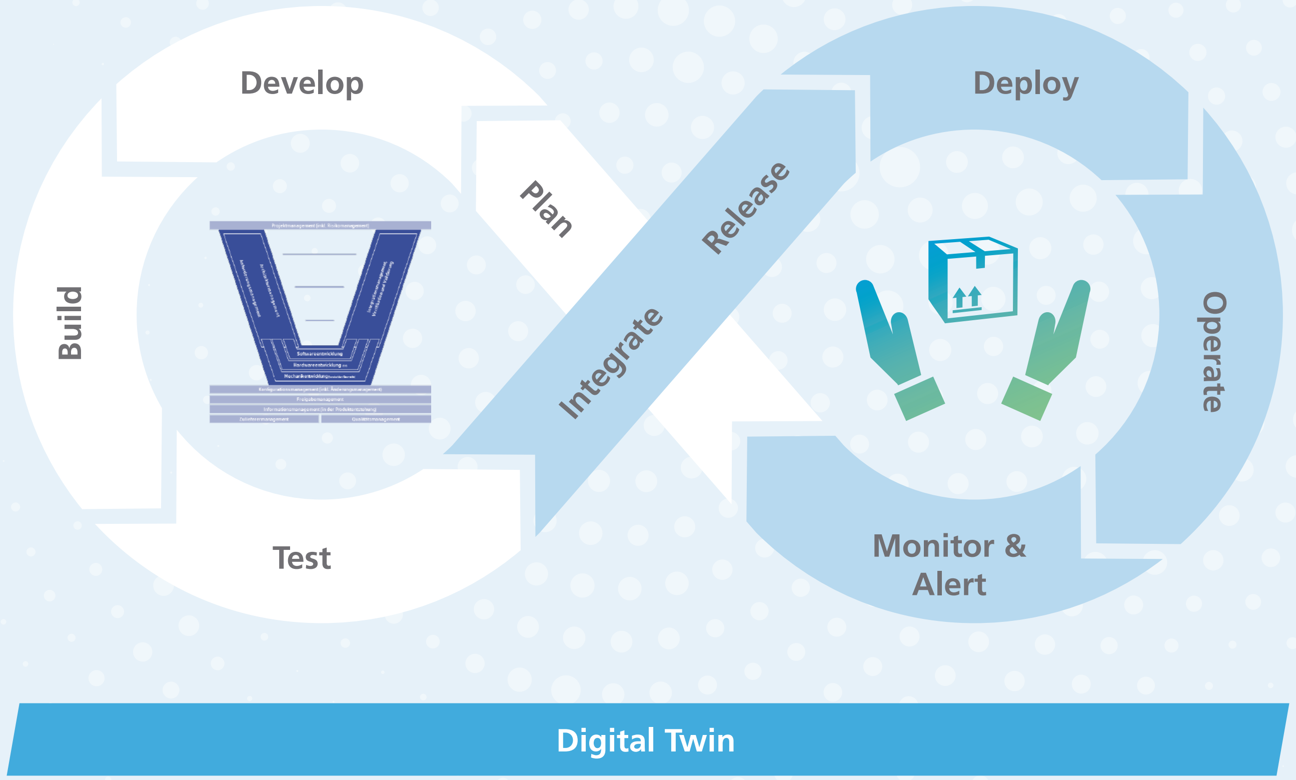


Figure 3: Product centric perspective with feedback loop

cesses and workflows not only saves costs, but also has the added advantage that automatically produced log file entries fulfill many of the requirements relating to product compliance or approval processes with regard to transparency and traceability. Using BPMN-2.0-compatible processes and implementing RPA allows OEMs to speed up processes and improve quality levels significantly. The automation of processes defined in this way can be supported by appropriate engines. This frees up the engineers' time, which would otherwise be spent performing laborious tasks. In addition, automated processes are a necessary prerequisite for real-time monitoring of important information in dashboards. A Role Based Access Control (RBAC) also ensures that the privacy of employees can be protected and that essential requirements of the workers' council can be met.

Data Hub

To improve the speed and responsiveness of processes, methods and tools and achieve a high degree of automation, quick, role based access to all of the necessary information and data must be ensured. This is only possible if a uniform and integrated data model is available and all core company processes are supplied with the necessary information. Most importantly, the IT implementation of the data model must meet the non-functional requirements. Therefore, regardless of the number of users, a short latency, a very high level of availability, and excellent performance must be guaranteed for all read and write accesses by human and machine. The uniform and integrated data model is also a necessary basis for any efforts to consolidate the IT landscape, since it maps all the essential properties of the product and describes its origin and use, thus providing a solid basis for the subsequent IT development.

KPIs for Digital Systems

Just as the corporate vision is broken down into detailed objectives in the various divisions and departments, the KPIs must also be defined with same level of precision in order to be able to quantify the achievement of objectives in detail. Since the development of processes, methods and tools for a wide range of digital services is still a relatively new area, an iterative process for the definition of KPIs should be implemented here to accompany the successive optimization of Processes, Methods and Tools (PMT). The KPIs serve as guidelines in this case and determine the minimum requirements that must be met in order to achieve the set objectives. This may also occasionally lead to fundamental changes being made in order to achieve the objectives.

Vertical Integration

However, it is not only the technical and operational issues listed here that are critical to the success of the business. One of the key strategic issues for company management is achieving the right level of vertical integration in different areas: Which competencies can be outsourced and which must remain or be built up in the company for strategic and competitive reasons? Asking this question introduces new perspectives that generally lead to changes in the organization of the company or the way it works – for example, the matter of whether the software should be built into the vehicle or whether the vehicle should be built around the software.

Tesla is now seen as a role model by some car manufacturers, since the company has kept important areas such as battery development, charging station infrastructure, software and sensor technology in house and can make decisions relating to these areas quickly and without the need to discuss these decisions with third parties. Tesla is also involved in chip development. This is not widely known. The driver assistance systems of the future, which will enable partly or fully autonomous driving according to SAE level 3 or 4, can only be developed using high-performance chips in combination with very low energy consumption.

A final note: It is important for companies to focus not only on "what" they plan to do but also on "how" they plan to do it. It is crucial that companies do not spend too long focusing on theory and writing specifications. Instead, it is important for them to start quickly, to build prototypes in order to improve their own understanding of problems and to be able to identify and lessen the impact of roadblocks more quickly, and in doing so, to follow a straight path toward their set objectives. Because as the writer Ernst Ferstl so beautifully puts it: "The difference between theory and practice is far greater in practice than in theory"

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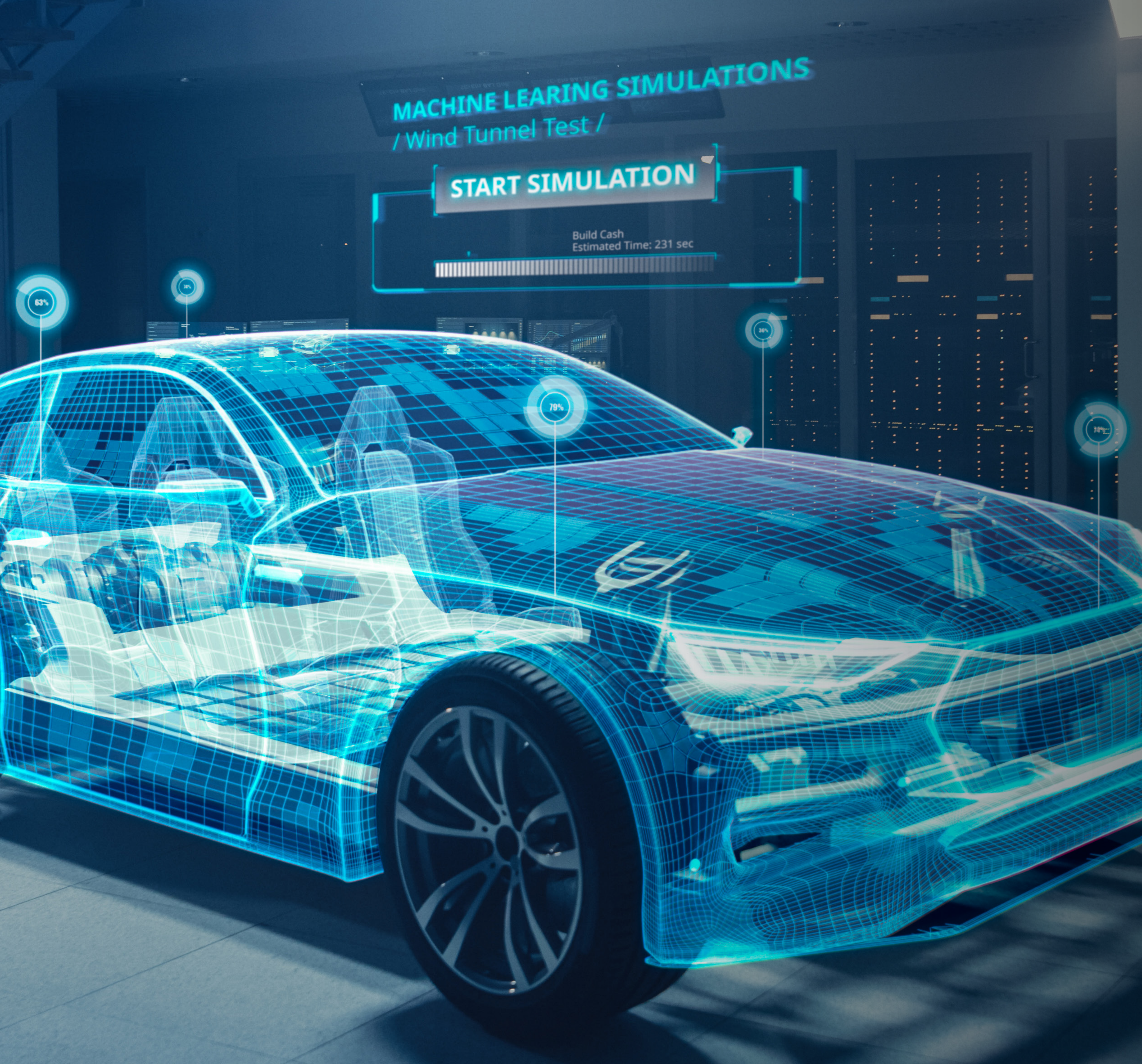
Ernst Ferstl
Writer



Summary

The digital transformation shows no sign of slowing down, even for established car manufacturers, and is forcing the entire industry to face a new set of challenges. The ability of companies to keep up with the pace of this change in a world driven by software is crucial to their ability to remain competitive.

A prerequisite for this is the ability to make fact-based decisions at any time based on quickly available and high-quality data.

Seamless and tool-supported process architecture with a high degree of automation enables high quality and speed and ensures the necessary transparency and traceability with regard to compliance requirements.

Publisher

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Contact persons

Sponsor
Dr. Markus Junginger
Partner
Customer Product & Services
markus.junginger@mhp.com

Authors

Raphael Müller
Associated Partner
Digital Engineering Solutions
raphael.mueller@mhp.com

Dr. Jörg Saße
Associated Partner
Connected Vehicle & Services
joerg.sasse@mhp.com

Contact persons international

USA:
Tobias Hoffmeister
CEO MHP Americas
tobias.hoffmeister@mhp.com

Greg Reynolds
Sales Director
greg.reynolds@mhp.com

UK:
Guy Williamson
CEO MHP UK
guy.williamson@mhp.com

CHINA:
Markus Müssig
CEO MHP China
markus.muessig@mhp.com

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