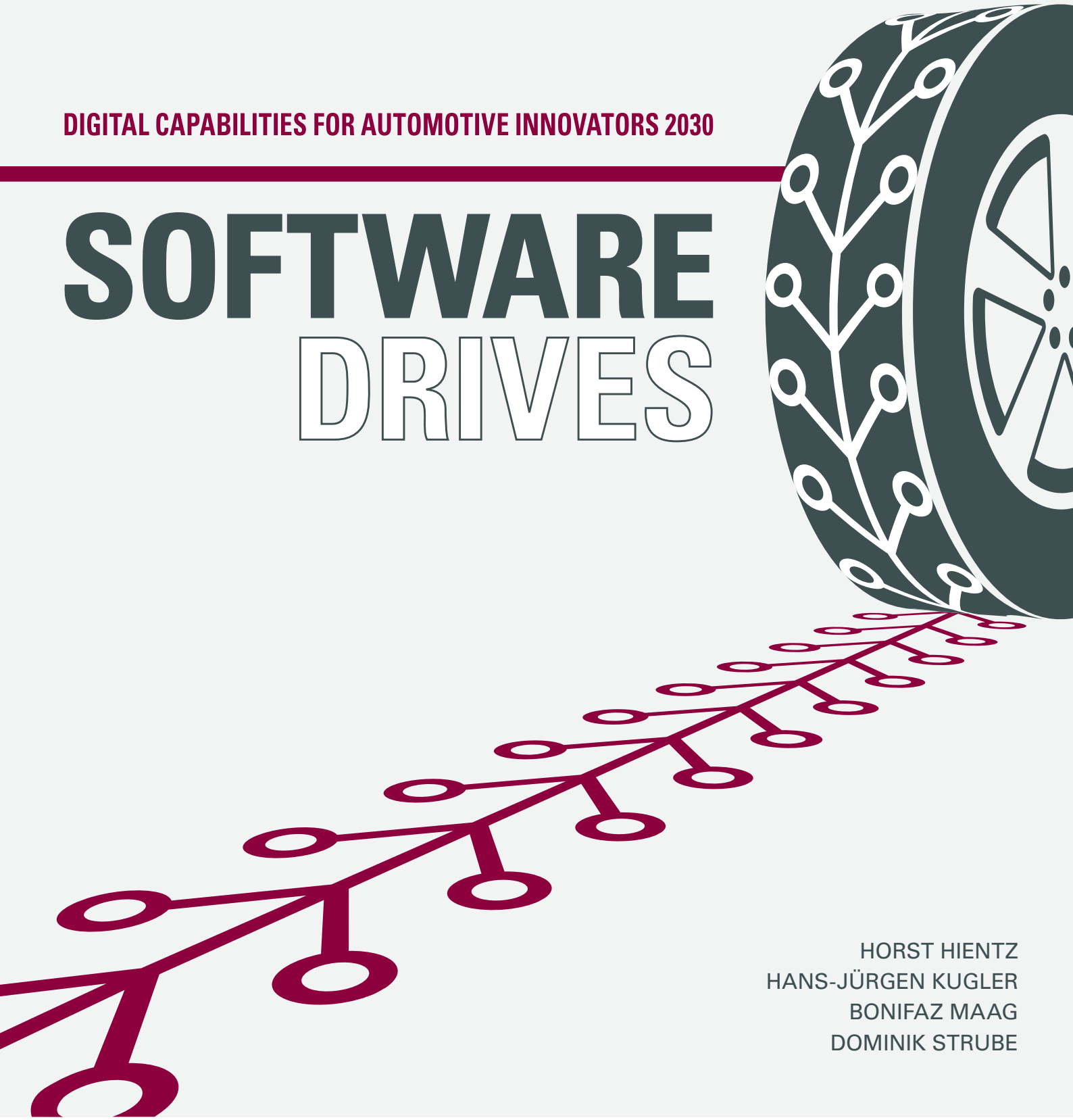
VOLUME 2|2017

DIGITAL CAPABILITIES FOR AUTOMOTIVE INNOVATORS 2030

SOFTWARE DRIVES



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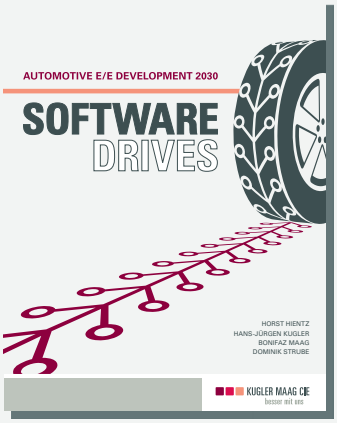
Preface



Software Drives 2030:
Report, Vol. 1,
June 2015

What a difference! When we published Volume 1 of *Software Drives 2030* in June, 2015, there was general acceptance of our conclusions, but there was little evidence of the digital transformation affecting automotive. Now, two years later, we are publishing Volume 2. Two years are considered insignificant in a mature industry, but times have changed. Digitalisation has begun to reshape the automotive sector fundamentally.

Countless studies discussing the impact of this transformation have been published since the release of *Software Drives. Automotive E/E Development 2030.* We are pleased that our initial report contributed to such an important and broad debate.

Talking about the industry's digital future is just the beginning. We want to help the E/E what the digital transformation means to them, and how they can prepare. This is the purpose of the second volume: **Software Drives. Digital Capabilities for Automotive Innovators 2030.**

Digitalisation affects the automotive industry as a whole. It will affect all aspects of every automotive corporation: from business and system architectures, to work-flow and processes to organisational structures and behaviour. Just like the first volume, this report is interview-based. We mapped the participants' insights onto the B/A/P/O model, which stands for Business, Architecture, Process and Organisation. Required behaviours and how to anchor them in an organisation are identified for and across B/A/P/O.

The B/A/P/O model allows us to identify interdependencies between the different business aspects in an existing or future business environment. It helps to find the path to transform an existing organisation into a purposeful digital one.

We hope that this Volume 2 of *Software Drives 2030* will help you to better understand the impact and direction of the digital transformation.

Horst Hientz, Hans-Jürgen Kugler,
Bonifaz Maag, and Dominik Strube

CHAPTER 1

Advisory panel

BMW GROUP

BOSCH

Universität St.Gallen

At a glance.

Executive summary

Once an industry with high-value products in mature markets, the automotive industry faces a business environment where nothing is certain other than that change will accelerate. Technological change is so rapid and far-reaching because it is emerging from hyper-connected technologies and their cross-fertilisation rather than inner-technological innovation.

Many presentations about the forces of this digital transformation do not convey the level of new and extraordinary capabilities organisations will have to acquire.

Even the best of the traditional automotive players will have to change significantly in order to continue to be successful. The connected technologies foster the convergence of domains and industry related value propositions and lead to the emergence of new, potentially disruptive business models. Changes in the business logic and revenue models address all concerns of an enterprise: new business models require appropriate system architectures based on effective processes within an enabling organisation and corporate culture. The changes have to be understood as affecting business, architecture, processes and organisation in parallel.

The B/A/P/O model is at the heart of structuring the research findings. The intent of *Software Drives 2030* is to support enterprises in finding patterns for a coherent fit of these B/A/P/O concerns.

Back to square one

The technological change is exacerbated by a significant shift from products to services. Digital services will be the dominant differentiation criterion. This changes the game of the automotive industry. A service company relies on different capabilities to product-oriented incumbents with capabilities honed in a mature market. The new overall business environment is shaped by VUCA factors – volatility, uncertainty, complexity and ambiguity. The combination of this macro-environment with the advent of a service-dominated industry invites market entrants to succeed with alternative business approaches based on digital services.

The challenge for large corporations will now be to pinpoint and unearth capabilities that correspond with this new overall macro-environment – with a particular focus on service-driven business.

General environment

The new globalised world order is multipolar. This world order consists of a myriad of agents each pursuing their own particular interests. The result is a so-called VUCA world order.

VUCA world order parameters

- Volatility
- Uncertainty
- Complexity
- Ambiguity

Service-driven business

Digital services are turning the automotive industry inside out. The business logic of a service-driven enterprise is unlike the logic of manufacturers.

Service business parameters

- Real-time service fulfilment (24/7)
- Services are retail – but retail is detail.
- Continuous engineering over the intended lifetime – beyond the SOP and vehicle assembly
- Service-shaped value propositions and interfaces

Structure–conduct–performance

The shift to services is across all business dimensions. To map multidimensional transformation we suggest using the B/A/P/O approach. Accordingly, the interviews were based on this model.

The B/A/P/O approach:

- Service-driven **business models**
- require appropriate system **architectures**
- based on purposeful **processes**
- within an enabling **organisation** and **culture.**

The challenge is to design a connected company from the strategy down to the field and vice versa. The B/A/P/O approach makes it possible to implement the structure–conduct–performance paradigm in business.

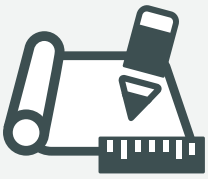
There's also a change dilemma: conceptual bias towards outdated structures. The very structure of an industry incumbent constraints its own ability to transform its business logic.

Business

The shift from product-oriented to service-driven business models requires a rethink regarding value creation and value capturing. Digital services will accelerate business model diversity and fundamentally reshape the automotive industry towards a mobility services sector.

Required capability (example): adding service-driven value

- Customer focus: thinking from the outside in, ignoring which brands and vehicles people drive.
- Defining the value components: value creation, value capturing or both.
- Eco systems: collaborating within cross-industry networks.
- Business realignment: mindset, structures and budgets.



Architecture

System architectures have to anticipate the potential growth of emerging service-driven businesses and related functions.

Required capability (example): developing scalable architectures

- Designing an asynchronous architecture with end-to-end focus.
- Selecting appropriate architectures and automating testing and V&V.
- Priming the system for scaling with surplus capacity.
- Virtualising core and edge nodes.
- Benefiting from blueprints, open source, standardisation, etc.

Process

Continuous Innovation and Engineering connects business functions.

Required capability (example): engineering value continuously

- Continuing Engineering throughout vehicle lifetime, eg by BizDevOps.
- Shifting awareness and resources to operations.
- Accelerating velocity with agile, adaptive and reconfigurable processes.
- Gaining flexibility from third-party infrastructures and dev environments.
- Fostering value and time-to-market simultaneously through experimentation.

Organisation

Making serviceability the core competence of the automotive mobility industry.

Required capability (example): balancing ambiguous requirements

- Opening the company up to cross-industry and ad-hoc co-operations.
- Balancing the needs of both continuous and discontinuous innovation.
- Encouraging more business experimentation and testing, but also failure.
- Hedging between existing product-related and new service-driven businesses.

CHAPTER 2

Introduction: Welcome to a service-driven industry

The report on the first *Software Drives. Automotive E/E Development 2030* management study was published in June 2015. It describes how technological advances and changes in customer needs are having a profound effect on the business principles of the automotive sector, with service-based business models becoming more important than vehicle sales. In the run-up to the study, some interviewees still had the impression that their CEOs were not yet fully aware of the changes stemming from digital transformation.

Since then, the automotive industry has recognised the potential of digitalisation to fundamentally alter the sector. »We have to reinvent Volkswagen« was one reaction (September 2015). Companies like Apple and Google were suddenly seen as serious competitors. Dieter Zetsche described the metamorphosis of Daimler into a service organisation as a ›cultural revolution‹ (July 2016). The digitalisation of the automotive industry is therefore well underway. Change programmes are appearing at every level, from improving work processes and adding value to key digital initiatives and service-centric business models.

Challenges for the industry mindset

In this wide-ranging transformation, one question often remains unanswered: what capabilities will a digital business need in the future? After all, the shift towards service-driven business models will put a question mark over the entire organisation of companies. This is because success in the service business revolves around different principles to those of manufacturing.

The following examples shed light on the consequences that an established player in the automotive sector must deal with when shifting its focus to services:

- **Digital services are delivered in real time** when the customer uses a function. If services are to be an appealing USP, they must be kept up to date throughout the vehicle's entire service life. This makes the ability to keep services up to date hugely important for manufacturers.
- **The never-ending SOP:** During the vehicle's service life, some functions will be modified or even redeveloped entirely. Ensuring development is continuous will become a key challenge for today's project-driven development organisation.

- **Retail is detail:** The margins on digital services are often measured in cents. Significant income can only be made if these services are used en masse. Furthermore, services can only deliver customer benefit if they are adapted to local needs. This makes the retail capability, i.e. scaling and localisation, a fundamental prerequisite for successful services.

Digital transformation is much more radical than any previous innovation in the history of the car. It simultaneously changes not only the technology, but every other aspect

Spotlight
System of systems

Connected vehicles form part of a system of systems (SoS) within their environment. This means they communicate and interact in real time with other systems, which interact on an ad-hoc basis. These include other vehicles, the traffic and telecommunication infrastructures around them, servers and back-end systems. As such, a SoS is always a snapshot.

This represents a fundamental change for vehicle development. Manufacturers are no longer in a position to specify each and every function over the lifetime of a car. The functions have to be based on an open SoS – an entity for which nobody has ultimate responsibility. These are entire systems, developed by different producers with their own product philosophies and the thinking and development cycles of their separate sectors of industry.

This is a revolution, bringing with it new challenges and needs for action:

- **Continuous development:** Error corrections, extra functions or new services can quickly make delivery status obsolete. To keep software up to date, vehicle development must be driven by the individual project and go hand in hand with continuous development that revolves around the entire lifecycle.
- **Continual validation:** Connected functions must be validated throughout the system's defined lifetime. Just carrying out extensive testing before production starts will no longer be sufficient. Constraint-based lifetime validation is one potential solution here.
- **System architecture:** Maintainability, extendibility and flexibility beyond lifecycles are a major challenge for architectures. There will be no more need to link hardware to the kind of function it performs – vehicles will need to hold significant reserves. Connectivity

of the vehicle too. That is why Volkswagen's ›reinvention‹ is no exaggeration. Digital transformation is so far-reaching, it will redefine the ground rules of an entire industry.

This multi-dimensional transformation places high demands on required capabilities. To be effective, skills need to be acquired on a variety of levels. Organisations must be able to implement changes to their business models and technology simultaneously and comprehensively.

This becomes clear when we look at the example of a system of systems (Spotlight below). The autonomous and connected vehicle of the future will form a kind of ad-hoc meta-system with the active surrounding systems. These include other vehicles, infrastructure, servers, IT and telecommunication systems, and requires robust and scalable software architectures similar to service-oriented architectures offered through the internet. This will also entail reference architectures at an SoS level. Keeping things standard will also make it easier to use elements again and manage complexity.

- **The agile organisation –** beyond the internal structures of the company: in the digital economy, being able to react quickly is a major competitive advantage. Companies need to adjust to short development cycles. To achieve the required adaptability, organisations should aim to be agile with decentralised structures.
- **Security:** In a connected world, what's secure today can be perilously insecure tomorrow. Protecting vehicle systems against cyber attack is a never-ending commitment. From conducting risk analyses to updating software, no company can accomplish this alone.
- **Functional safety:** Highly automated driving requires a completely different approach to functional safety, methods that are suitable for the dynamic nature of SoS.
- **New business models:** Not all of these challenges have an immediate impact on the value offered by a company, but they do create extra work. The good news is that different business models, ones that are service-based, are an excellent opportunity to enter new areas of business. Recognising this is the task of senior management, a skill that will have to be developed.

The key to change is not so much the technology, it's more about the company culture. Automotive organisations must learn to lay a foundation for continuous services and not just think in project cycles. The place where new business opportunities are waiting to be unearthed is at the intersection between all the different sectors of industry. So market players must learn how to enter new partnerships and even be open to ad-hoc collaboration, in partnerships of equals. Hierarchical thinking and pecking orders have had their day.

Hans-Georg Frischkorn, Strategy Consultant

of course the vehicle's own subsystems. The composition of the system participants is not known in advance and in fact it changes continuously. Also software versions can vary. Interferences will become the norm. Despite this, the autonomous vehicle must remain stable and reliable.

The whole enterprise is challenged

To answer this challenge, the system of systems capability must come from the entire organisation, ranging from a networked business model to the right product architecture (service and connected system), processes and the organisational structure. This is because creating a vehicle that is compatible with a system of systems requires companies to be much more open – not just from a technological perspective in terms of internal systems, but also with respect to adding value alongside partners from other sectors on an equal basis. This therefore challenges the limitations of both the organisation and its products. Being open on two fronts like this must be reflected in flexible processes and a culture of collaboration. This could be less of a challenge for a development department than a supporting department, eg procurement, as it blurs the closed and hierarchical structure of today's automotive sector.

From business to operations

This report uses the B/A/P/O framework* to illustrate the multi-dimensional challenge for established automotive organisations. The four dimensions of B/A/P/O describe how the resources, assets and capabilities of an organisation can be structured and tapped into, in order to achieve the required business goal.

Each dimension is dependent on the others, so the model is best looked at like a cascade: Service-driven business models require appropriate system architectures based on purposeful processes within an enabling organisation and corporate culture.

- **Business dimension**
  The metamorphosis of the automotive sector into a digital service provider with demand-based business models changes the entire organisation, and thus the ground rules for every other dimension.

- **Architecture dimension**
  In a dynamic and volatile market, the architecture of the vehicle and the mechatronic system must also be highly flexible and inherently variable. Companies in the automotive sector must prepare for an asynchronous base layer that can be scaled easily at any time.

- **Process dimension**
  Processes must be based on speed and flexibility so that the company can quickly recognise and exploit market opportunities in a dynamic environment. Businesses must be able to implement functions even after a vehicle has been delivered.
- **Organisational dimension**
  The organisation and its corporate culture must agree to adapt continuously. In a connected world, this also includes the ability to develop and maintain functions and content in cross-sector partnerships, and to do so at a global level.

This cascading relationship is fundamentally important for two reasons:

1. According to the structure–conduct–performance paradigm,** a business goal can only be achieved if the B/A/P/O concerns are aligned. As business models and the resulting architectures are specific to respective companies, their process-oriented organisation and organisational structure must be focused and tailor-made.
2. The B/A/P/O model and the identified capabilities call for a requirement framework. The requirements must, however, be defined and implemented on an individual basis for the respective company or task.

This requirement becomes more important given the role of a business in the sector. The company's role is a function of its business goal and vice versa, so in turn this has an effect on each B/A/P/O concern.

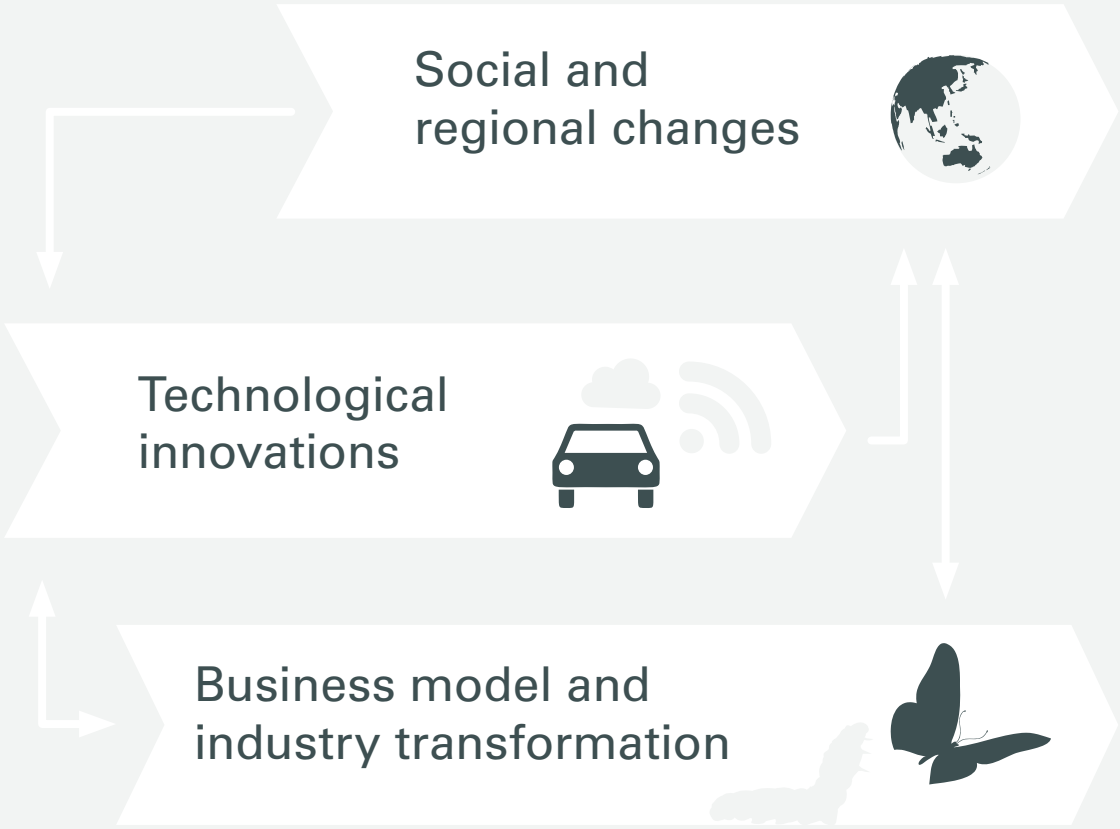
This has implications for business capabilities. Let's take the capability to manage a network partnership as an example. This can look different for the partners involved in a value network, which will be spearheaded by whoever owns the costumer interface. Whether this is the manufacturer or a provider from outside the sector, they must be able to win over the customer by offering unique value. They must also be open and attractive for partners. Only their contribution, be it systems, partial systems or content, makes the overall system possible and delivers appeal.

From manufacturers to suppliers, from established providers to new players in the automotive sector, this report on the *Software Drives 2030* management survey outlines a series of key capabilities based on interviews with experts. These capabilities go across the corporate dimensions of business, architecture, processes and organisation, describing the concerns an automotive organisation must be capable of managing to shape the future of digital solutions successfully.

* van der Linden, Frank, Bosch, Jan, Kamsties, Erik, Känsälä, Kari and Obbink, Henk (2004). Software product family evaluation; in: Proceedings of the 3rd International Conference on Software Product Lines (pp. 110-129). Springer, Berlin and Heidelberg.

** Faccarello, Gilbert, Kurz Heinz D. (ed.) (2016). Handbook on the History of Economic Analysis. Developments in Major Fields of Economics (p. 297). III. Edward Elgar Publishing, Cheltenham.

CHAPTER 3


Social and
regional changes
Technological
innovations
Business model and
industry transformation

Rapid technological changes meet a dynamic environment

Throughout history, the automotive industry has always been about upheaval. But as each challenge came along, manufacturers met the challenge and overcame it. It is remarkable that the number of manufacturers has remained fairly stable over the years. Clearly, the structure of the industry is robust. The question is whether digital transformation will change this.

Until now, virtually all changes have only had an impact on the technology of the vehicle. Change has primarily affected safety systems, car electronics or alternative drives. With each new challenge, engineers succeeded in turning problems into winning technical and commercial solutions and they then integrated each new solution into the existing vehicle architecture. Although each new element only added a sub-system to vehicles, for everyone involved this entailed dealing with even more complexity. Ultimately, however, the changes were one-dimensional, so in actual terms, changes were therefore relatively straightforward. Underlying business fundamentals may have expanded as each change came along, but the fundamentals were never challenged at their core.

The overall business environment

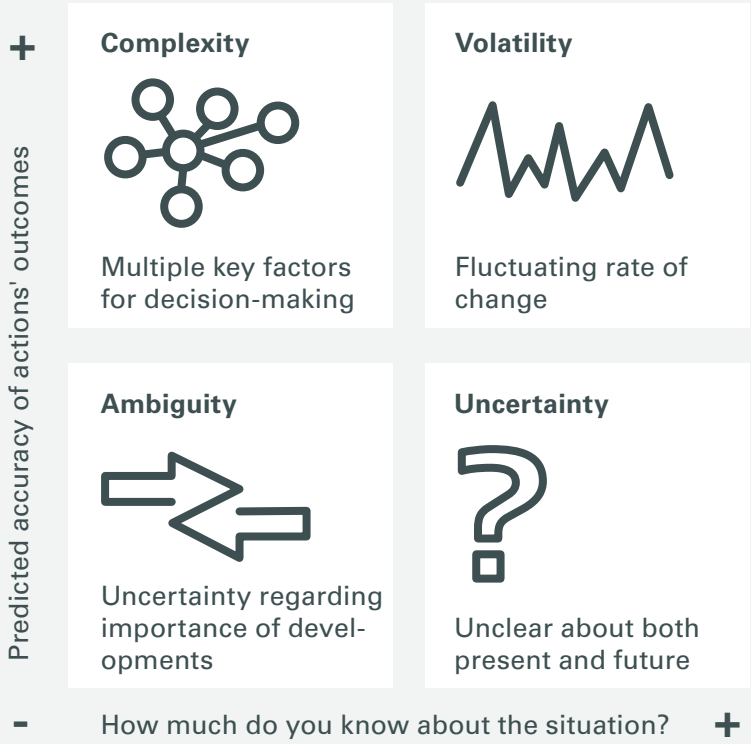
These times of predictability are now over. Digital transformation is rewriting the rule books of an entire industry, because this new wave of disruption resulting from new technology is two-dimensional: changes are also happening in the overall business environment. Transformation is now moving things in almost every direction and everything is happening simultaneously – whether it is technology, business models, the way companies collaborate internally or how they interact with other businesses. Nonetheless, multi-dimensional changes are a trigger and make it necessary to develop completely new business models and business constellations. Also, institutional know-how is rapidly losing relevance. As a result, it will be much easier for players from outside the automotive sector to enter the market.

Unlike the previous business environment in the early phases of digital transformation, as more and more digital solutions are emerging different aspects of the business environment will change. Some changes will be completely new and make predictability all but impossible, including in the automotive and mobility sector. Established and predictable industry structures – a typical reflection of

saturated markets – will be a thing of the past. The transformation of the ICT sector illustrates how established sectors can be completely redefined to the point where the original market players are even forced out. Together with new, connected and potentially disruptive technologies, this creates a new competitive arena, way beyond the boundaries outside of traditional industry.

Challenges of the world of VUCA

These changes are best described with VUCA.* This is a term used by the U.S. Army War College to describe the zeitgeist in the post-cold war era. In politics and economics alike, change is influenced by four key factors: volatility, uncertainty, complexity and ambiguity.



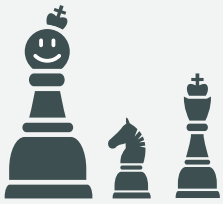
VUCA key factors depend on predictability and analysability.

Uncertainty is the outcome of a new world that can potentially be fully connected. It is a result of the interplay between the high levels of complexity and volatility, a countless number of players in a globalised and multi-polar world (each with their own interests) and the ambiguity of interpreting situations and developments. The VUCA concept is recognised in the field of organisational development and research. It's therefore a useful instrument for describing the conditions in environments of rapid technological and social changes in general, but also the automotive and mobility services industry in particular.

The signposts of development

To work out where everything is heading in the long term, despite ever-changing VUCA factors, we need to step back and look at megatrends. These bring together all the individual trends and developments, providing a crystal ball for long-term transformation. According to the American author and political adviser John Naisbitt, a megatrend must fulfil several criteria. It must be empirically proven and expected to continue for at least 15 years. This is in order to exclude short-term fashions and cycles. A megatrend must have a comprehensive impact as well. It thus influences the whole world, despite regional differences and specific manifestations within social subsystems. Third, a megatrend has profound impacts, changing businesses and the economy all over the planet.

For the automotive industry, we focused on four key developments in the first report on the *Software Drives 2030* survey report:



1. **Individual empowerment:** This trend is the result of the global rise of the middle class, along with rising incomes, rising levels of education and the increasingly networked nature of society. For the automotive industry, this means stronger demand for individual travel solutions. Customers also want ICT solutions to provide better access to information and entertainment options – everywhere. More and more individuals want to be involved in society with transparent information. As a result, citizens and consumers are increasingly becoming the relevant stakeholders. This megatrend is important due to its influence on all other megatrends.

2. **Diffusion of power:** As the individual becomes more important, there is a parallel shift in power towards a multi-polar world. Decision-making can be transferred to networks, especially on a regional level. The current debate regarding drive systems is a reflection of the regulatory power of local and regional authorities and their ability to effectively dictate market access in their area of jurisdiction. The motives of regional regulators stem from different interests, from improving the standard of living to protectionism. Major urban areas can also become economic agents themselves, such as by offering their own mobility solutions.

3. **Demographic patterns:** Increasing urbanisation is augmenting existing megacities and creating new ones. Since 2008, urban agglomerations account for over half of the world's population. The ageing population and involvement of all social groups are also part of this megatrend.

4. **Resource scarcity:** Rapidly rising demand will lead to shortages of resources and goods in the future, from raw materials needed by industry to commodities such as food, water, energy and other life essentials. Increasing complexity will also exacerbate the shortage of skilled workers. The demand for specialists in future technologies such as deep learning, artificial intelligence and big data will far outstrip supply.

Megatrends provide us with signposts for future global developments. For enterprises in the automotive industry, this offers both hazards and opportunities. All of these megatrends have an impact on social groups and regions, resulting in heightened fragmentation. As a result, the needs of citizens and consumers will become more specific and individual. This will pave the way for new market entrants. In contrast, global mass producers will face huge challenges, especially if regional regulators restrict market access or even create monopolies.

Innovations in a service-driven economy

As in the 2015 report for the *Software Drives 2030* survey, we follow the idea that technologies simultaneously drive and trigger innovations. In the digital world, innovations enable users to perform tasks better than in the past. Megatrends act as a catalyst for new solutions, particularly when it comes to globalisation, the emergence of new megacities and urban areas, individualisation and sustainability. Once technology users take advantage of these first-stage innovations, they discover new ways of performing tasks or a way to meet new needs, even though that was not what a technology was originally intended for. When society adopts and reinterprets a technology, it shifts into a second stage of innovation. Smart entrepreneurs recognise a new business opportunity and use this to develop new business models. As a result, even if you were the first to come up with a technology, it can often mean you are not the one who will reap the benefits and enjoy commercial success. A feedback loop develops, leading to more modifications to the technology or adaptations to the business model. By providing technological solutions to needs, businesses therefore form the third and final stage of innovation and the cycle begins again. So innovation is evolutionary.

For evidence of the disruptive power of digital innovation, we need look no further than the interplay between convergence and emergence. As new technology makes it possible to connect up more and more areas of IT, we are witnessing convergence. For example, vehicle electronics now communicate with other vehicles and infrastructure. But the electronic systems also communicate with the communication infrastructure, business applications and their servers. The different areas are becoming increasingly similar and this means that exchange between different systems needs to be smoother, as will be illustrated in Chapter 5 on vehicle architecture. Networks are also resulting in increasing continuity between sectors. Apps and applications in the ICT sector show that networks are capable of gathering information from different industries and this helps create new, integrated services. In technology terms, convergence allows providers to redefine their offering and the benefits they promise to the customer – without being bound by the traditional constraints and conventions of an industry.

As a result of these processes, new offers emerge automatically. Networks help bring together previously isolated, independent systems to form a whole new entity. From a strategic perspective, this significantly expands the room to manoeuvre. New features and structures emerge within a system, appearing suddenly, almost spontaneously.

Such developments are never obvious, as they cannot be foreseen by looking back at the things that came before or by examining each isolated component within a system. Digital innovation processes in the way they were described at the beginning are a phenomenon that runs in parallel with emergence. Technological triggers create impetus and this is jumped on by users who make their own adaptations. Adopting technology in this way lays a foundation for new business opportunities and different ways to translate the social and technological interactions into new products and solutions.

A challenge on two fronts

Technological transformation both within and outside the automotive industry goes hand in hand with significant changes in the business environment – the dynamic and fragmented VUCA world. This technological upheaval also significantly expands the room for manoeuvre of stakeholders and key players within the current industry. New ideas will emerge and these will have the potential to fundamentally change the mobility and automotive industry.

The technological impact of networks is that they result in new kinds of hybrid customer benefits. In the future, customers will no longer purchase vehicles as a physical product; they will buy mobility solutions. These may well be based on the same vehicle, but this will only be part of a service, as the chapter on business models describes. It is here that companies will have an opportunity to differentiate themselves from the competition. Established manufacturers will therefore face a process of metamorphosis and have to evolve into service providers. Alternatively, they could become suppliers to a third party in the industry – the company at the helm when it comes to the customer interface due to its innovative service. The physical entity – in this case the vehicle – will no longer be the only key purchasing criterion. As a result, established rules and roles within the sector will be up for renegotiation.

There is also a technological paradox. As service orientation exacerbates complexity, this will be counteracted by alternative drive trains which will reduce complexity. As a result, the physical components of a vehicle will become less and less significant, with the risk that decades of acquired knowledge will become worthless. No longer will component engineering be a barrier to entry.

The key technologies of the future, like autonomous driving, are so complex that few vehicle manufacturers will be capable of developing effective solutions themselves. Instead, established suppliers and third-party providers from the IT sector are joining forces to develop modular systems. This allows the vehicle manufacturers to implement solutions in their vehicles without having to carry out the task of development themselves. As the technology is no longer exclusive, it lowers the barrier to entry for new providers. The same applies to ICT platforms, including the available content. The combination of reduced product complexity and licensing of plug-in systems places enormous pressure on the previously stable industry structure.

New providers are therefore in a comfortable position and able to occupy a market niche with clear cutting-edge benefits – without the dead wood. By contrast, established players will face challenges on several fronts. First, they will now have to earn money with their existing business models, but at the same time, they will also have to take a number of gambles and develop a variety of alternative technologies like different drive systems.

While their acquired knowledge is losing value, vehicle manufacturers are faced with a double threat:

1. **Through a combination of path dependency** (continuing to do what is easiest and most cost effective), old ways of thinking and sunk costs, they underestimate the impact of digital transformation and in particular its velocity.
2. **There are countless areas of innovation,** so manufacturers run the risk of having to fight fires on too many fronts when allocating resources.

The double challenge posed by the interplay between technological innovation and the emergence of new business models means that businesses in the automotive sector will have to fundamentally reposition themselves. They will need new competences and the ability to manage digital transformation.

Digital capabilities

Changes in the fundamentals of business will also bring about sweeping change in the automotive sector. New strategies will be needed with a sharper focus on service provision and this will result in radical changes to organisations. Surviving the onslaught of digital transformation and working out the best way to develop new business models will require certain kinds of capabilities – competences that traditionally the automotive sector does not possess.

From an organisational standpoint, the term ›capabilities‹ usually refers to the basic abilities of a business or unit to fulfil its business purpose. It is these capabilities that enable a company to implement its strategy and the business models it derived from the strategy. Capabilities therefore combine knowledge, experience, expertise, skills and relevant procedures. As different businesses pursue different goals, capabilities always depend on the context. As a result, capabilities are only developed according to the specific business, its strategy, and the role that it plays in the value network. Important in this respect are factors such as whether a company maintains the customer interface and leads the network, or whether it controls a specific aspect of value creation.

This report describes the requirements a business must meet in order to possess the right capabilities.

From business to implementation: the B/A/P/O approach

A company or business unit is like an instrument, the means by which goals are achieved within the context of industrial enterprise. As form follows function, such an instrument must be developed and structured in keeping with the desired result. The various ›concerns‹ of a digital business can be represented by layers, like a kind of model. The uppermost layer represents the foundation of the business and requirements for the next layer. This produces a cascading model which helps ensure the organisation maintains the required focus on its goals.

Major concerns of a technology-driven business:

- **Business**
  How can the expanded R&D organisation recognise business opportunities and contribute immediately to solutions?

- **Architecture of Products and Services**
  How do these opportunities affect the future product and service architecture, i.e. services made possible by using physical products?

- **Processes**
  How do processes need to be designed to effectively support digital business models and contribute to integrated product and service architectures?

- **Organisation and Culture**
  How must the automotive organisation of the future be structured to generate digital business models and support services, while also creating space for targeted processes? What type of management and what cultural change does this require?

The questions in the expert interviews and in this report are based on these concerns, which are based on a model called B/A/P/O. We match the necessary capabilities to each concern, based on the information gained from the interviews.

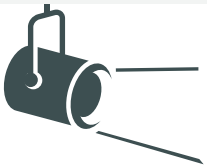
Directions of change

So, there are two opposing directions of change. Primarily, technical innovations trigger social adaptations and create customer demand. Companies operate as the interpreter – they develop business models to fit these needs and they provide means for their fulfilment.

Once the business approach has been defined, the direction of change alters. A structure–conduct–performance paradigm clicks into effect within the corporation, guiding transformation based on the original purpose of the business to develop new organisational structures – B/A/P/O.

As a result, it is possible for a recently founded business or a new organisation to structure itself around the new business model. By contrast, established players will often become ensnared by B/A/P/O traps. Even if they change their business model, the underlying organisation basically remains unchanged.

* Stiehm, Judith Hicks and Townsend, Nicholas W. (2010). The U.S. Army War College. Military Education in a Democracy. (p. 6) Temple University Press, Philadelphia.



Spotlight
Value at stake

The digital revolution that is taking place in our cars and trucks and on our roads and highways has the potential to reduce emissions, save a million lives, create tens of millions of jobs and drive net economic benefits worth more than $5 trillion globally over the coming decade.

According to a study by consultancy ecomo.world, that's just the beginning: by integrating 450 effects of the transformation of road transportation identified in various academic and industry studies into a single comprehensive financial model, we were able to identify significant economic, financial and societal changes resulting from digitalisation.

Already digitalisation is impacting nearly every facet of the freight and passenger driving experience. Vehicle manufacturers are joining forces with technology partners to deliver such services as remote vehicle diagnostics, real-time traffic reports, over-the-air software updates, fleet and supply chain management tools and a wide array of location-based services.

For passenger vehicles, the highest value will be created by advanced driving assistance systems and new shared mobility services. Greater connectivity is enabling insurance companies to better align driver risk with the premiums it charges its customers, while also reducing the cost associated with accidents and claims management. Supply chain management exchanges are enabling shipping companies to reduce the number of empty trucks – approximately 25%! – that add unnecessary congestion to already busy roadways.

Who benefits from the digitalisation of road transportation?

Interestingly, half of the value at stake is societal, as these new technologies prevent an estimated 19 million road accidents, saving a million lives and eliminating 12 million injuries.

But as with all revolutions, this transformation will create both winners and losers, as industries and technologies cross traditional market boundaries and create entirely new rules of competition. The biggest winners of this transformation are fleet owners, vehicle insurers and vehicle manufacturers. Drivers of hire vehicles and trucks, rental companies, but also the health industry and lawyers are likely losers, as autonomous technology reduces accidents, injuries and lawsuits.

The above estimates are based on conservative technology penetration rates – the real value at stake could be significantly higher. For each percentage point increase in vehicle market penetration, the global value at stake increases by $1.7 trillion or 33% overall, with the value of mobility-as-a service and self-driven vehicles nearly doubling.

Self-driven vehicle
$790 billion

Connected vehicle
$884 billion

Mobility-as-a-service
$**895 billion**

Intell. transportation system
$1,251 billion

Advanced driving assistance system
$1,254 billion

The model makes a compelling case for shared, electric self-driven vehicle services like Uber or Lyft and against personal car ownership. For each percentage point increase in personally owned self-driven vehicles, fuel consumption increases 60 billion litres, due to more empty vehicle miles travelled, thereby erasing 30% of overall fuel savings of the digitalisation of road transportation.

These trends have significant implications for businesses and policymakers as they consider how best to invest, partner and regulate in this brave new world of transportation.

Progressive public agencies and officials around the world are investing in intelligent transportation infrastructure to ready their cities for when autonomous vehicles converge with other modes of public transportation, replacing underperforming or unprofitable segments of their public transportation systems with entirely new mobility solutions.

Likewise, major players from the automotive, mobile service provider, insurance, fleet/telematics, intelligent transportation and mobility-as-a-service industries are working to figure out how this transformation of road transportation will play out for them.

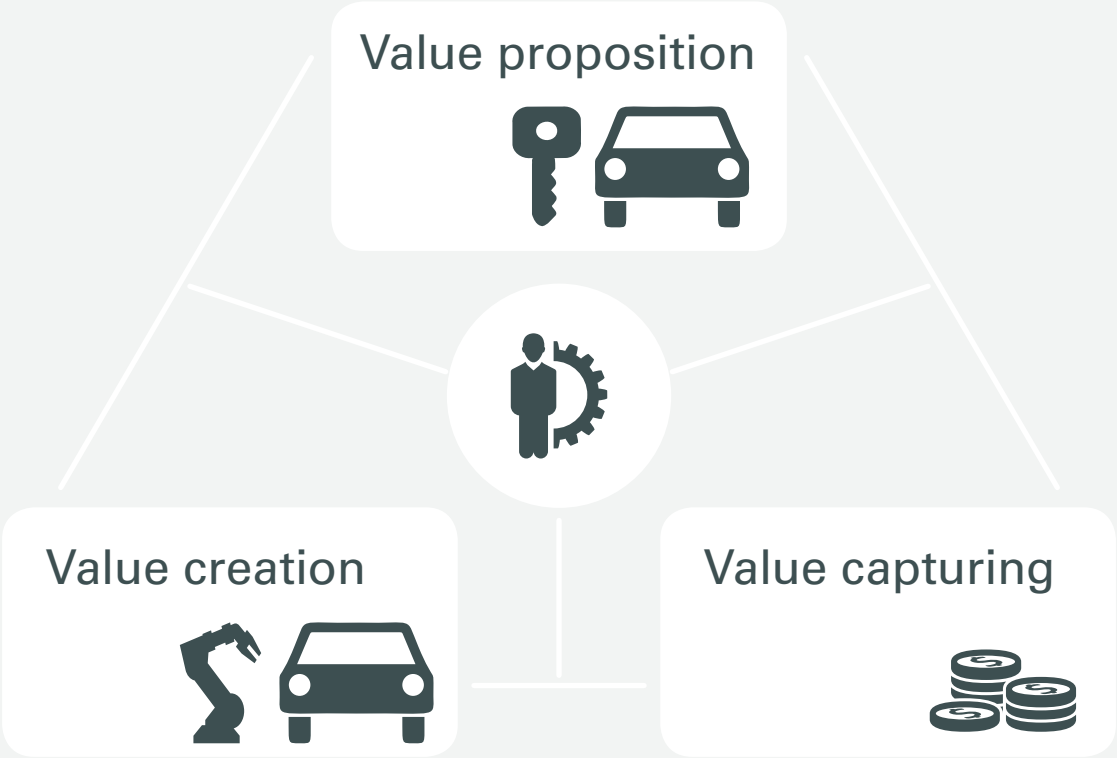
New alliances and partnerships across industries and often disjoined government agencies will be necessary to fully realise the potential value of the opportunities that lie ahead. It's up to us to work together to unlock the tremendous value the digitalisation of road transportation holds for all of us.

Andreas Mai, ecomo

The ›V@S model‹ by ecomo identifies the value at stake 2017 – 2026 within the global digitalisation of transportation: value at stake by mobility concerns (left) and by industry stakeholders (right). | ecomo.world, 2017

	Stakeholder	Value creation	Value migration	V@S
↗	Society	3,547	(980)	2,567
↗	Fleet owners	4,869	(3,741)	1,128
↗	Vehicle insurers	716	(78)	638
↗	Vehicle manufacturers	956	(391)	566
↗	IT Security	324	0	324
↗	Start-ups	235	0	235
↗	ICT	206	0	206
↗	Oil	241	(89)	152
↘	Legal	0	(24)	(24)
↘	Medical	0	(54)	(54)
↘	Rental	0	(65)	(65)
↘	Drivers / chauffeurs	347	(946)	(599)
	Total [$ billion]	**11,442**	**(6,369)**	**5,074**

CHAPTER 4



Automotive shifts to service-driven business models

A business pursues a common goal. And all aspects of the business must be geared towards achieving this goal. The starting point for this is the strategy. The strategy empowers the business to differentiate itself from the competition. How the strategy is implemented is determined by business models. These describe a series of logical relationships between the company's resources, capabilities, partners, etc. And these add value for both the customer and the business itself.

The automotive industry is changing. New technologies, combined with digital and on-demand mobility services, are fundamentally changing the way companies generate revenue. Vehicle manufacturers must therefore rethink their business models, some of which may have been in place for generations. Traditionally, business models were based on a single transaction in which a consumer, leasing firm or dealership assumed ownership of the vehicle. The return on the vehicle manufacturer's investment stemmed from a similar process to that of an industrial goods producer. A vehicle would leave the factory and was purchased by a customer via an intermediary. This business model was therefore product-oriented and the development organisation was product- and project-driven.

»Our business model over many years has been about how many of the vehicles did we sell. Now, we are looking at the ecosystem around that and essentially it's looking at services and revenue, it's looking beyond just the sale of the vehicle.«

Mark Fields, CEO, Ford Motor Company

Game changer digital services

The rise of digital services, including on-demand mobility, is based on a wholly different view of business. In a business that deals in digital services, the return on investment is similar to that of a retailer, in which tiny margins are generated millions of times. The single transaction of the macro-solution – the vehicle – morphs into countless micro-transactions: the total number of uses of fee-based services. The provider of these services, who may not necessarily be the manufacturer in all strategies, now controls aspects dictating customer interactions.

This business model is similar in nature to that of a digital B2C provider, with direct customer contact in real time.

This contrasts to digital services, which make it possible to answer specific demands with unique value propositions. Subsequently, a variety of digital business models will emerge and drive diversity in the industry. Established product-oriented business models may be enhanced or even replaced by service-driven models.

Value creation, the instrument that allows a vendor to provide value, doesn't have to be the same thing as capturing value, which is when the vendor delivers and gets paid.

Consequently, services are becoming the new paradigm of the automotive industry:

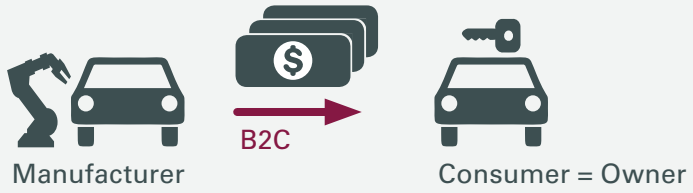
- Services shape the value proposition.
- Services drive brand differentiation.
- Services define the customer interface.

Furthermore, digital services allow companies to offer customers a more sophisticated customer benefit. On-demand mobility services are a good example of this. The provider of these services at the customer interface no longer needs to be the vehicle manufacturer, or even a company from the automotive sector. Services can be offered by fleet operators, insurance providers or even local authorities. For example, mega-cities in growth markets can become providers of innovative travel services. This potential is reinforced by their regulatory remit, which allows them to set the rules of use for the transport infrastructure.

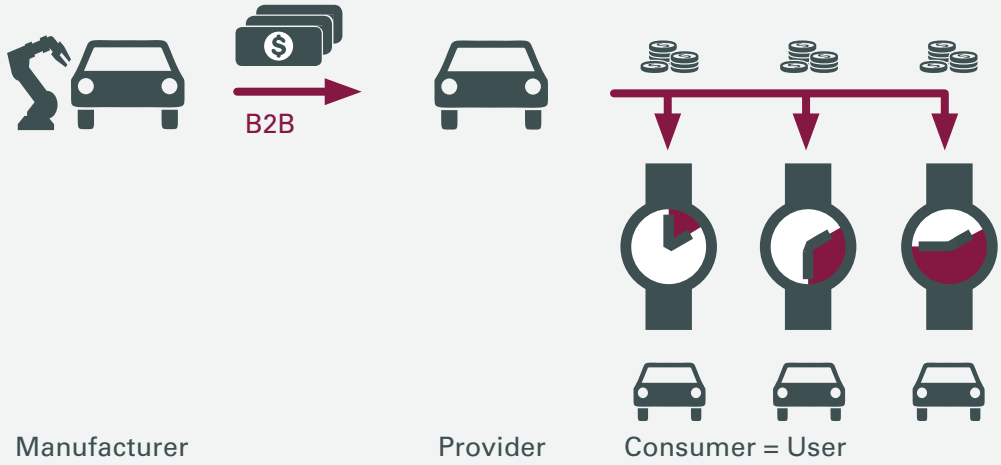
The range of potential agents increases the variety of potential business models. These offer a variety of benefits to the customer, meaning they are based on different methods for adding value. This will have major consequences for today's automotive industry. Established factors such as the roles occupied by each company, their value chains, even the tier hierarchy, will become obsolete. The entrenched industry structure with its defined market will become a kind of blue ocean, in which innovative companies can create their own market and gain customers by offering value.

These innovations revolve around disruptive business models with the potential to transform an entire industry. Disruption happens when a business model combines new technologies with a new customer need. This is extremely likely in the travel and transport sector due to a number of interacting factors that will dictate the future success of an industry – personalised services, shared assets, value-based pricing, and cooperation in ecosystems beyond industry boundaries, to name but a few.

Today's product-driven profit model: The single transaction

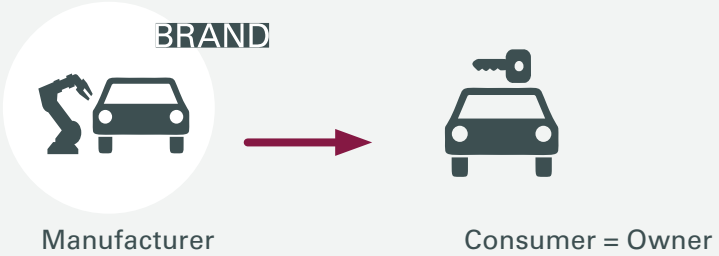


Tomorrow's service-driven profit model: A multitude of micro-transactions



From consumer ownership to mobility-on-demand: in the future a mobility service will occasionally be used.

Today the brand is driven by the car manufacturer.



Tomorrow the service provider will drive the brand.

The shift to services allows market entrants to control the customer interface by redefining value. The manufacturer's leading role might be jeopardised.

Despite the dominance of services in future business models, sales from services will not necessarily become the primary source of revenue, provided there is no availability of mobility-as-a-service solutions. Several CEOs have stated that revenues from services will constitute a significant portion of their overall revenue. Such statements could not be confirmed in the interviews, however. We also supported this view in the first *Software Drives 2030* report, but despite the industry's best efforts, none of the services currently available are capable of generating significant revenues – yet. Nevertheless, services will form the backbone of future business models. They will be an essential prerequisite for vehicle sales and market differentiation.

The next question is: what will the parameters be for the automotive business models of the future?

The parameters of future business models

Service-orientation

The ability of products to deliver services will become a decisive factor in future business, not just for manufacturers, but also for car makers. For both, success has traditionally been defined by vehicle sales. Digital transformation is enabling customers, suppliers and competitors to interact in a variety of new value networks:

- A unique customer benefit is often found at the point where the different sectors of industry meet. Digital services therefore combine each contribution to value to form a new service. As a result, business models have to reflect the fact that each provider involved in the process comes from a different sector of industry.
- As services are, by definition, delivered on demand in real time, the customer relationship with vehicle users also develops live – through mutual interaction. Business models must also take co-creation into account.

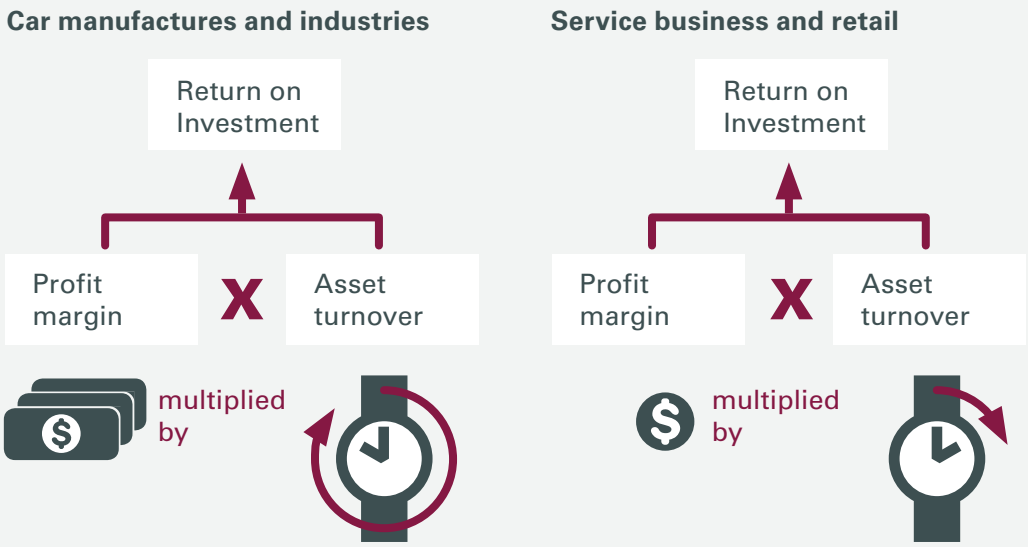
Customers will expect smart products in the future. The combination of constant connectivity and the internet of things makes it possible to add additional digital benefits to physical products. This means that sophisticated product-related services are seen as natural in certain customer segments, such as automated parking or finding parking spaces. By 2030, (additional) digital services will be just as important for the car as software-oriented functions are today. This is because they enhance comfort and convenience. Rather than being priced separately, they will be seen as a basic condition of sale for the vehicle.

This means that car manufacturers need to radically rethink the basis of their costings and calculations, as operations aimed at managing and developing services will take up a considerable portion of budgets. Spending on services will become a significant factor for digital business models and this must be taken into account. Therefore, in addition to remaining competitive through operational excellence, efficiency and continual product cost optimisation, modern vehicle and component manufacturers will also have to stay on top of service costs – despite the relatively low margins. But in turn, digital transformation offers new possibilities such as predictive maintenance. For example: without help, vehicle manufacturers will no longer be able to continue offering services and keep them up to date throughout the entire service life of a vehicle. They will need to create and control ecosystems as value creation networks. They must ensure that these ecosystems remain attractive to both kinds of customer (with appealing services and up-to-date content) plus their business partners (so they can continue to contribute to service provision). In this scenario, innovations (and therefore brand differentiation) are primarily the result of the digital service. No longer will these factors revolve around vehicles' software-related functions.

If it's the services that are making the contribution to revenue, this changes the Return on Investment (ROI) for today's vehicle manufacturers and suppliers.

- Traditionally, a manufacturer would generate ROI by selling high volumes of products with higher profit margins. Investment costs and assets did not lead to much annual turnover.
- With services, the return on investment follows a different logic. It corresponds more to ROI models in retailing. Profit margins are minute – as low as a few cents in the case of digital services. These margins stem from each fee-based service transaction, potentially thousands of times a day. There is a corresponding operating result, as turnover rates are higher. This fundamentally changes the way manufacturers need to view investments and budgets.

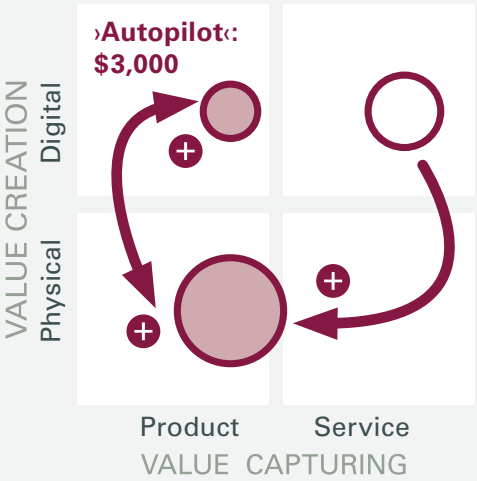
The mechanic of returns depends on the business logic: in manufacturing, margins are high, the asset turnover is slow. In digital business, micro-margins are turned over rapidly.



We would like to emphasise that, despite manufacturers' best efforts, there are currently no services for which customers are prepared to pay to any significant degree. We therefore do not expect a wholesale shift to service-based business models in the immediate future.

Nonetheless, autonomous driving in combination with mobility-as-a-service solutions has the potential to turn this prognosis on its head. This would make autonomous driving a game-changer, as on-demand mobility would drastically reduce the appeal of vehicle ownership. Established vehicle manufacturers must be aware of this and develop suitable business models to safeguard their business. Developing such alternative business models is one thing, but actually implementing these models will require firms to become fully fledged service providers. If man-

How car2go creates value: hardware as a service. Consumers pay to use a fleet of cars.



How Tesla creates value: the offer combines free digital services, eg digital maintenance, with high-end digital add-ons. | University of St. Gallen*

ufacturers want to maintain control of customer interactions, they must be capable of developing digital services through service-oriented business models. They must also be able to manage these models throughout the entire service life of the vehicle.

Adding value, deriving value and cash flow

Vehicle manufacturers add value for their customers just like any other manufacturer: by selling them a product that offers benefits (in this case a car). In service-based business models, however, it is best to make a distinction between adding value and deriving value. Examples of hardware-as-a-service or digital add-ons reflect this.

Services become a key success factor in competitiveness if customers no longer own the vehicle or if vehicles become interchangeable. This will require busi-

Spotlight

Transformation of business models

The relevance of information technology as a key element of new business models has increased continuously since the 1990s. Specifically the internet has facilitated numerous new business models with impressive economic success records. Digital business models significantly deviate from traditional business models along several dimensions such as value proposition, value generation or value capturing (revenue model). Offering digital solutions, corporations can benefit for instance from negligible marginal costs, reduced transaction fees or the exploitation of network effects.

Many such digital offerings share three overarching characteristics:

- **Value chain integration.** IT enables a close integration of users, customers and suppliers over the entire solution lifecycle.
- **Service-orientation.** IT allows corporations to maintain post-sales relationships with customers through digital services.
- **Analytics as core competence.** IT-based collection and analysis of usage data become central elements of digital offerings and key drivers of digital business models.

Today, new innovative technologies, including sensors and actuators, data analytics or artificial intelligence lead to an even stronger merger of the physical and digital worlds, often referred to as the Internet of Things (IoT). The IoT entails the vision that almost any physical object will be connected to the internet enabling new digital services. This goes far beyond improving internal efficiency or leveraging online media for cross-channel sales, but also refers to digital servitisation, i.e. the transition from offering physical products and digital services to hybrid solutions. With this ongoing transition, digital business models can now diffuse into the physical word.

In light of these developments, companies across industries are challenged to innovate their business models considering the novel characteristics of digital business model patterns. Hence, also traditionally hardware-oriented corporations will become more digital and service-oriented. In order to be successful, these innovation activities have to go hand in hand with ongoing product innovation, process innovation and servitisation initiatives.

Prof. Dr. Elgar Fleisch, ETH Zurich & University of St. Gallen

nesses to anticipate customer functions that add value and incorporate them into their business model. Regardless of whether functions or services generate immediate revenue or only create revenue indirectly (by enabling value derivation), they will be key to business success.

For service-based business models, constant revenue streams – generated when services or functions are actually used – will be more important than the actual level of revenue stemming from wise investments, the capital expenditures. Continuous revenue streams provide a constant cash flow based on operating expenditures over the intended lifetime of the vehicle and services.

Spotlight
Megacities

Probably the most fundamental change to the major automakers' current business model is that their most important customers may no longer be consumers, but megacities – cities with 10 million plus people, where roughly 70% of humanity is expected to live by 2025.

The popularity of new mobility services brings its own set of issues, and has the potential to put even more pressure on already highly stressed transportation systems. Uber and Lyft, for example, are putting more cars on already congested roads. In New York City, it is estimated that these services account for a 14% increase in the number of vehicles on the street.

These new services take market share from traditional taxis, car rental services and public transit, creating new market pressures and policy issues. New entrants into the market will naturally focus on more profitable areas and routes, leaving unprofitable ones to public transit authorities. On behalf of this year's World Economic Forum, the Boston Consulting Group and MIT provided simulations of the impact of self-driven, shared taxis and shuttles for the city of Boston: such services have the potential to reduce public transit ridership by 10 to 39%.

Public authorities would be ill advised to try and stop the march of progress by implementing rules and regulations that would stifle innovation in order to unfairly protect inefficient and antiquated systems.

Instead, they must develop new strategies that will:

- Balance the commercial and social bottom-line of public and new personal mobility modes.
- Efficiently balance supply and demand across all systems.
- Deliver integrated multi-modal transportation services.

Setting up and positioning ecosystems

To offer customers value through service-based business models, these models must be adapted to local customer needs. The salesman's formula ›retail is detail‹ also applies to services. Local needs comprise more than local information or other content of interest.

Services must always offer excellent quality and up-to-date content, from restaurant recommendations to traffic information. They must also match the culture of the customer. Factors such as regulatory constraints or provisions vary between regions so they are subject to different changes due to the different stakeholders.

Key questions for policymakers to consider include:

- Should cities make data sharing a cost of doing business for private transportation companies?
- Should taxis and ehailing operators be taxed at a higher rate for trips with underutilised 4- to 6-passenger vehicles?
- How can cities ensure that automakers or mobility as a service startups operate reliable and safe (self-driven) taxis?
- What type of vehicles should a city authorise for future personal transportation services, eg, electric, self-driven, traditional vehicles, ultra-small vehicles, etc.?
- Should a city dedicate a precinct or a segment of a road exclusively to self-driven vehicles to accelerate deployment?
- Should cities outsource the entire operation of multi-modal transportation systems or manage it in existing or new agencies?
- Should cities outsource their transit services to public transport operators or consider new entrants into the industry, such as automakers or startups?
- Should cities work exclusively with one automaker or one mobility provider as a service startup for (self-driven) personal vehicle modes?
- How can cities ensure there will be an array of choices of personal vehicle brands and personal transportation services?
- And last, but certainly not least, will automakers and public transit authorities be able to make the leap of faith to align traditionally opposing objectives to create a joint solution that is better than its individual parts?

This challenge will require new forms of collaboration between currently stove-piped government entities and across currently disjointed industries. Even more importantly, we will need strong, visionary leaders capable of driving us to a bright future of smart city transportation. **Andreas Mai,** ecomo

Megacities: the new power

Increasing urbanisation is making city and regional authorities more powerful. Demand will increasingly revolve around the cities in the future and urban areas will influence markets in two ways (See the *Megacities* Spotlight).

- From a regulatory perspective, it is here that vehicle registrations are coordinated. So cities can favour or even exclude certain parameters such as drive systems or levels of automation.
- Megacities can also become active market participants in their own right, for example by operating fleets for mobility-as-a-service.

Algorithms and BizOps

Real-time data and usage profiles are important business assets for product and service providers. If decisions can be taken in real time using algorithms, this paves the way for elastic pricing – a wholly foreseeable development. We also expect technological developments like artificial intelligence (deep learning) and blockchain to be reflected in future ecosystems. As a result, they will be central to business models. We say this even despite the fact that interviewees were unsure how such aspects will develop in the sector by 2030.

Technology use will probably not have a direct impact on functions in and around the vehicle. With blockchain methods, intermediaries could become obsolete as transactions are recorded and secured automatically. This provides a reliable foundation for closer cooperation in value networks.

Strategic focus and governance

The challenge of running a competitive service-based business model lies not so much in R&D as in the strategic focus and governance of the entire company. Businesses must base their strategy entirely on service as the important USP.

Successful business models require businesses to take several decisions at the same time and each decision must work hand in hand with all others. These can include developing or expanding the areas in which firms do business. Alternatively, firms can focus more on products, service-based business, or both. It will also include functions that add or derive value, how a company is positioned in an (open or closed) ecosystem, the handling of sensitive customer data, etc.

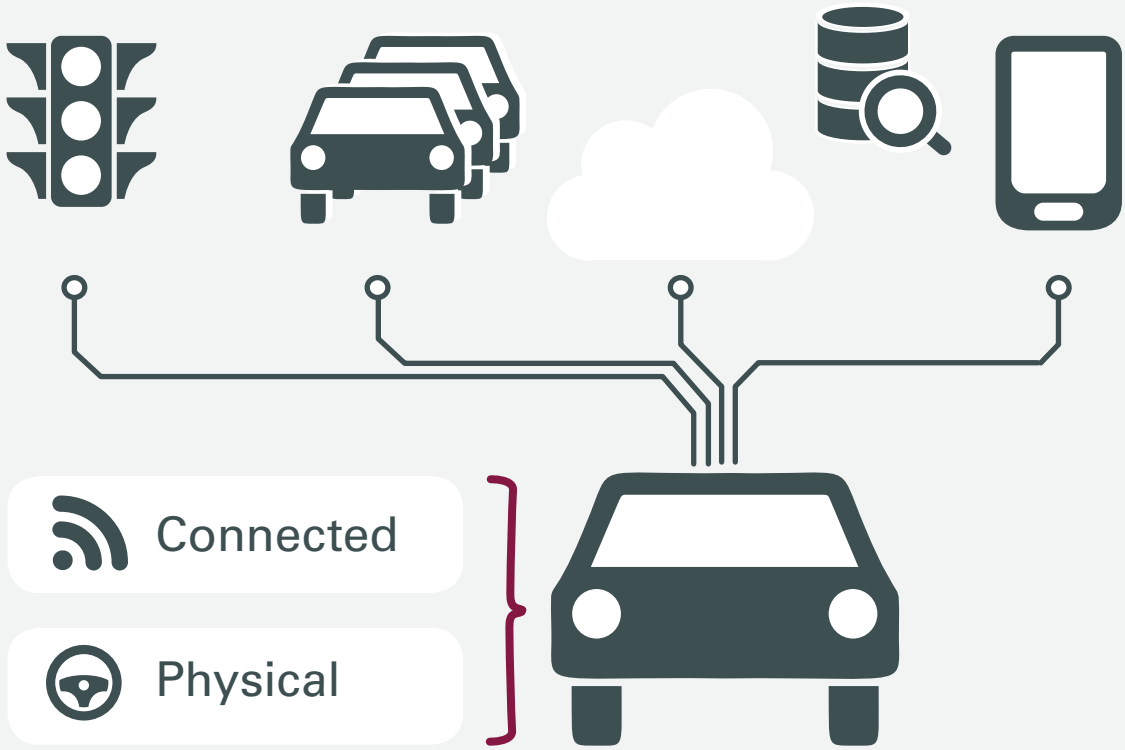
From product to service

Established players in the automotive sector tend to have entrenched, product-focused business models. As a result, they face two challenges. On the one hand, they will need to keep their existing (and to date successful) business model going. This is, after all, how they generate the revenue they require for future investments in the here and now, as well as in the foreseeable future. But on the other hand, they will need to be the ones that create and shape the future. To adapt and shift towards service-centric business models, they will have to experiment with new business scenarios; they must gather experience, inside and outside the organisation. The trick will be to manage both sides of this business model equation at the same time. So they will need to keep existing business and develop it, but simultaneously they will have to devote sufficient time and energy (i.e., investment, resources and especially managerial capacity and commitment) to new projects.

The interviews point to spin-offs as one way to experiment with new business opportunities. Manufacturers have already founded spin-offs to secure the development of new technologies. In future, there will be greater emphasis on business model innovation with a general focus on digital services. These businesses will be purpose-built and they will be strictly driven by service thinking. And service and product architecture, as well as processes and structural organisation, will have to be geared to this new thinking and the business purpose. Without the constraints of the original organisation, spin-offs will be free to focus solely on pursuing the new business model.

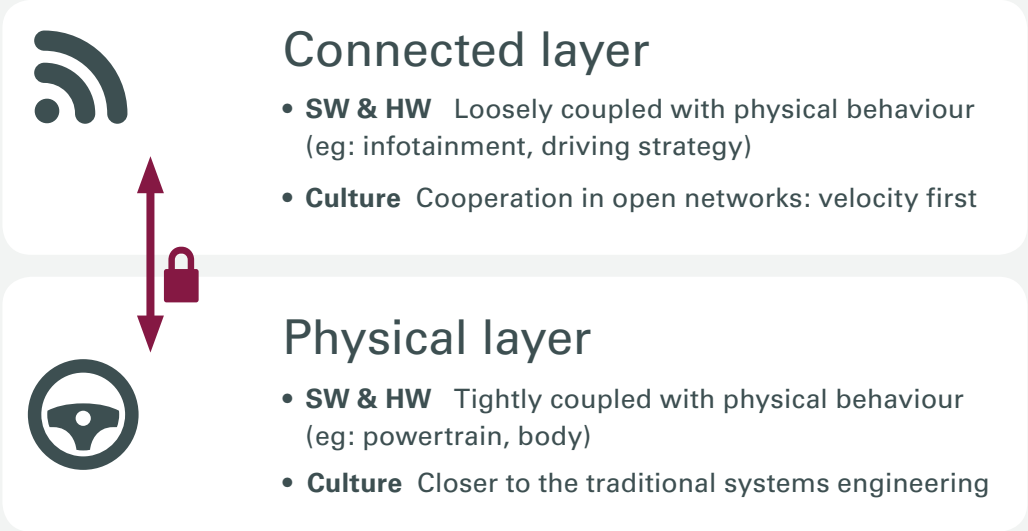
* Wortmann, Felix, Bilgeri, Dominik, Weinberger, Markus, & Fleisch, Elgar (2017). Ertragsmodelle im Internet der Dinge. In: Betriebswirtschaftliche Aspekte von Industrie 4.0 (pp. 1-28). Springer Gabler, Wiesbaden.

CHAPTER 5



Architecture: The car becomes a part of the world wide web

As demonstrated in the previous chapter, service-oriented business models will bring about fundamental change in the automotive industry. Only radically different vehicle architectures can reflect the vehicle's new role as a data node in the internet of things. Such architectures must on the one hand take openness and networks into account, but on the other they must also safeguard cyber-security and functional safety. The previous *Software Drives 2030* took a close look at this challenge in 2015. One solution with the potential to address both of these somewhat contradictory requirements comes in the form of dual - layered architecture. With this approach, the physical layer addresses the need for safety and security, while the comfort and convenience functions are located in the connected layer along with functions delivering highly autonomous driving and cyber-security.



A horizontal architectural model: Two loosely coupled layers address different functionalities. The business culture in the responsible R&D units will be different.

In contrast to traditional function-oriented architectures, the service-oriented Connected Layer will consist of three independent tiers. This structure supports the service focus of business models.

This chapter centres on the needs of connected layers and the implications in terms of required capabilities.

Rethinking E/E architectures

The following key drivers will be essential:

- **Speed matters:** Being able to make adjustments to existing functions (even after delivery) or deploy new functions within a vehicle fleet means that it will be important to have the right digital business models in place.
- **System of systems:** The vehicles of the future will be part of a system that interacts within an overarching 'system of systems'. From a design perspective, a key aspect of this will be that systems are robust and able to cope with changes in their environment.
- **Services over functions:** Running services requires different architecture partitioning. This begins with simple adaptability but also includes ensuring there are things like distinctions from other services. Service-oriented architecture will gain in importance in terms of a functional asynchronous architecture.
- **Fewer control units:** Adding value through digital services, and focussing on the connected software this involves, mean that fundamentally different architectures are needed due both to scaling and the reduction of complexity. Non-functional requirements will play a significant role in defining these, and there will be a trend towards a reduced number of electronic control units.
- **Artificial intelligence (AI):** AI has an important role to play – incorporating AI into systems will make it necessary to devote more attention to overall architectures. This report provides an architectural outline that differentiates between remote, core, edge and local computing.
  Another question to be answered is which parties or agents will be in charge of decision-making.
- **Commoditisation of physical layers:** Electric vehicles are already resulting in much simpler power trains. This is lowering the barriers to market entry and drive and chassis hardware now play less of a role in brand differentiation. Expertise is shifting towards software and connected layers.

The trend appears to be heading towards car manufacturers expanding and running their original software development ecosystems in the future. More than ever, software architectures will play a decisive role in competitiveness. Functional requirements are increasingly taking a back seat, becoming secondary to non-functional needs. The ecosystems of the future will have overlaps that can only be managed through standardisation.

Fields of action

This implies the following key areas of focus:

- **Hardware standardisation**
  especially in terms of commoditisation
- **Software standardisation**
  by creating a reference architecture for the internet of things, also through interfaces
- **Non-functional requirements**
  will dominate future architectures.
- **Artificial intelligence (AI)**
  has its place, although it will probably not be as dominant as currently expected when it comes to delivering services for automated driving.
- **Servers will act as the third node**
  not only in data centres but also in the vehicle.
- **Robust architectures –**
  constraint-based engineering
- **Centrally coordinated service catalogues**
  for efficient implementation of service-oriented architectures
- **Striking the right balance**
  between deep and flat integration, which will have to be discussed and agreed. Points of variance in architectures must be clear and support the business models within the new ecosystem.

How non-functional requirements will shape architectures

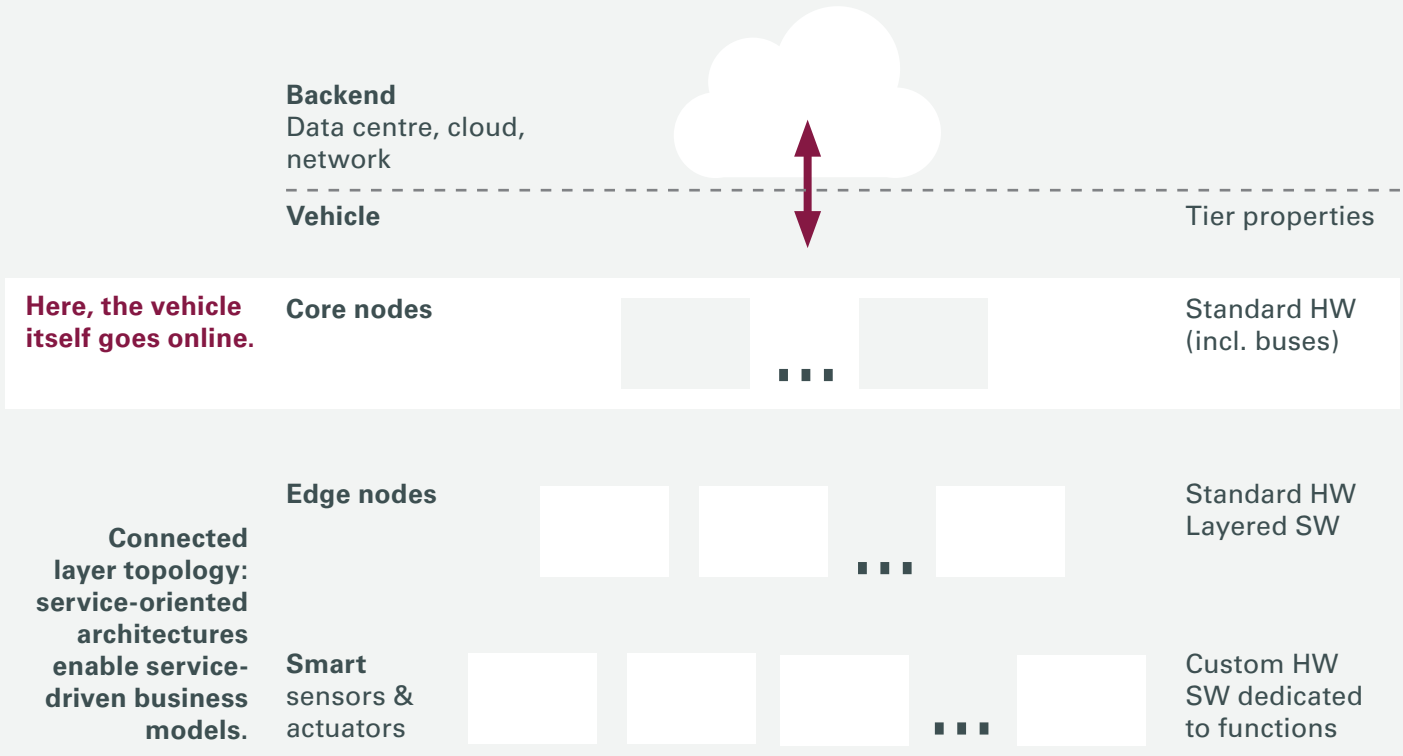
Functional requirements continue to shape the topologies of modern connected layer architectures. This will affect the generation of vehicles for which production is due to start between 2020 and 2023. Examples of the functional perspective are ECUs responsible for a particular section in the vehicle. Both the location and the area of responsibility of the ECU are defined by the section's tasks. Also, partitions on effective platforms can be defined by the functional tasks they perform. To still enable stable and flexible architectures in the long term, however, according to several respondents it will be important to clearly separate topology aspects from functional factors. Also, non-functional requirements should have a significant influence on topological architecture.

We see the main requirements for topologies as follows:

- **Security**
- **Quick and simple deployment** of new functions
- **Design** based on standard architecture patterns (eg, REST)
- **Updateability**
- **Balance** between deep and flat integration
- **Scalability**
- **Easy adaptation** to different markets and functions
- **An architecture model** that takes an integral view of the backend and the vehicle
- **Constraint-based engineering**
- **Distinctions** between operational platforms and basic functions within a service level

To meet these requirements, we have transferred the information from the interviews into a topological schematic for a connected layer. This is a sketch of further architectural aspects considered in this report. It is not a blueprint or the architecture itself.

The idea behind the topology is a tiered architecture based on generic nodes. Each computer node within an edge or core layer is symmetrical, so each is essentially capable of

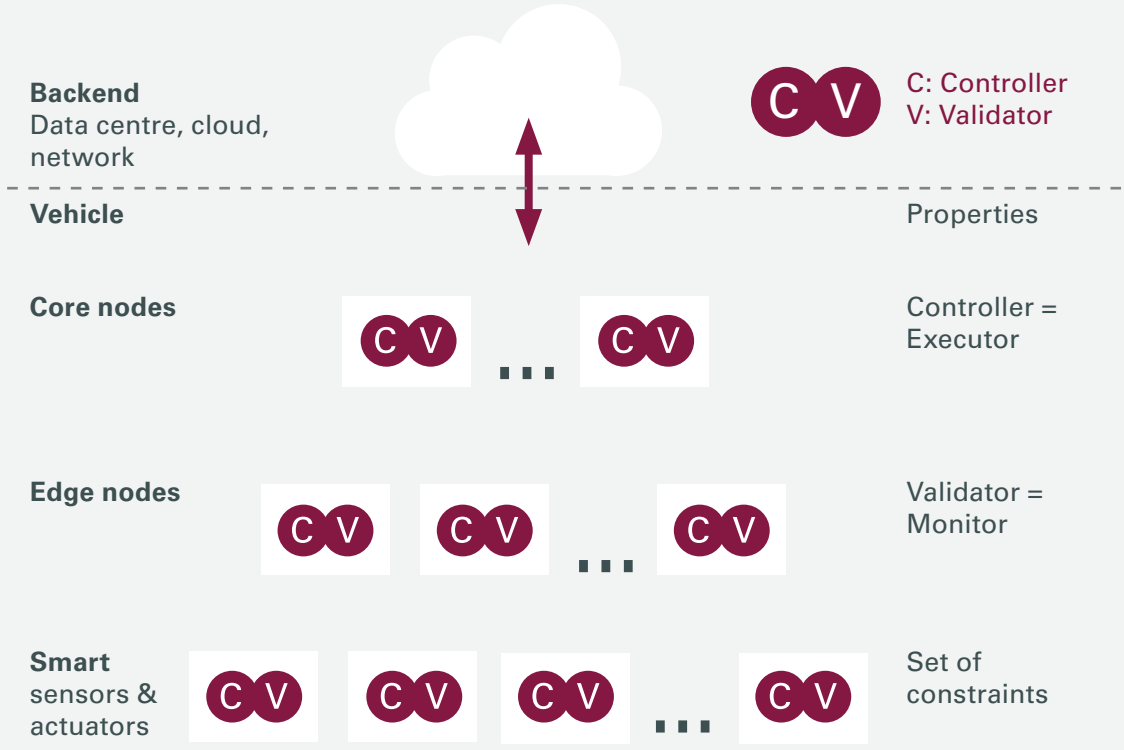


performing the functions of others. This makes it possible to deploy functions in a simple manner and address redundancy requirements. Necessary functions and features can be introduced relatively flexibly. In a market that is dynamic and changes quickly, this is essential. Another factor will be software scalability, even if it's impossible to predict the scope of scalability required. When it comes to sensors and actuators, software and hardware can be tailored to the respective task. The illustration on the bottom left-hand corner demonstrates the topology of a connected layer.

Non-functional requirements

Constraint-based engineering is a central non-functional requirement. It refers to the process of defining a problem and the conditions to be adhered to (constraints) separately from the solution. This makes it possible to assess solutions to the problem through, amongst other things, observing adherence to constraints. Especially in fields like a system of systems, this makes it possible to actually observe whether individual components are working within defined constraints during operation. This has a major impact on the architecture design on which this survey is based. In our opinion, it also significantly influences actual implementation due to the coming system of systems environment.

As illustrated in the *System of systems* Spotlight, the development of future vehicles and their related functions will be based on the fact that the overall environment with which they're connected cannot be specified, at least not cohesively or as a whole. Individual IoT components (such as backend systems, telecommunication networks, traffic management systems or the functions of other vehicles) will develop independently; the process will not necessarily be coordinated, so individual components will change. Given this, there's a need to specify



Validator–controller model within the connected layer's topology.

the non-functional constraints a system must adhere to within this system of systems. This must be done clearly, regardless of the actual implementation scenarios. Typical constraints will include performance criteria and other conditions like response times. This makes it possible to develop the various components relatively independently from each other based on interface specifications.

To do this, one controller and one validator can be used per node. The controller will execute the intended function and while it's being developed, the constraints it will need to adhere to within the given configuration have to be incorporated in the deployment package. The validator will then use this information and monitor the controller's compliance with these constraints. If a controller fails to adhere to constraints, the validator will perform a number of defined actions in the deployment package. This is illustrated on the previous page.

Another essential feature of layered architectures is that the basic functions of nodes can be very different from those encountered in application layers. Thus, there will be major differences in development cycles, and a number of concepts relating to this factor are already in place in the automotive industry.

The third node in the vehicle

These vehicle architectures for the connected layer will appear in future vehicle generations after the year 2023. Basic structures will be shaped less by traditional functional requirements and more by non-functional needs. The current component, zone and domain architectures will therefore be replaced by a 3-tier structure of physical nodes within the vehicles' connected layers.

These tiers combine:

- **Core nodes**
  from high-performance servers
- **Edge nodes**
  with data and decision-making aggregators
- **Devices**
  such as sensors and actuators

Apart from the devices, the nodes also form generic platforms based on standard hardware and layered software structures. Terms like middleware will be commonplace.

The first step in this direction is a powerful third node. We believe that this third node will complement the two standard computers that are used to integrate the man-machine interface (MMI) and autonomous driving. The node should

have a tier structure. In terms of internet connection, it should be similar to servers used in processing centres and thus be in a position to enable seamless integration in DevOps structures and processes.

Rather than simply connecting vehicles to the internet, this third node will bring the internet into the vehicle. So it may also include functions that are integrated more closely with the backend (ie, with the vehicle manufacturer's server farm). If the MMI can seamlessly integrate functions on this third node into its structures and processes, this will also help solve the issue of deep and flat integration. Striking the right balance is a challenge. Flat integration makes it relatively simple to change functions independently, as there is less dependence on other functions. The downside to this is that integration in the user interface is often difficult. Context-sensitive menus are often not possible, images and commands do not appear as required, text wrapping is often awkward, etc. With deep integration, functional implementation is adapted clearly to the overall architecture and the MMI. This avoids the aforementioned disadvantages, although this comes at the price of reduced reactivity and flexibility.

The MMI computer will allow for smooth integration of functions in the vehicle. The server node can also be used to easily update and change functions.

Standardisation: the key to coping with growth

Functional growth will continue to accelerate. The complexity of algorithms will also increase. Keeping things standard already makes it easier to respond to the rapid growth in demand for software, and it will also make complexity and expanding workforces more manageable. One example of this is the specifications of service-oriented architectures. Currently, several functions introduced by suppliers make little difference. Again, they were implemented due to specifications of the vehicle manufacturers. This wastes resources which could otherwise be used for alternative activities that add genuine value.

There are also higher-level overlaps between the various vehicle manufacturers – the system of systems or through interfaces to the Internet of Things. Using the same interfaces can significantly reduce design and integration outlays. Despite this, there is no competitive advantage in doing so, as all manufacturers use systems the same way.

Virtualisation is coming, but how?

When it comes to the aspect of virtualisation, the managers we surveyed now overwhelmingly believe that this will become a part of future architectures. The previous survey report provided no clear picture on this issue. Another open question is whether to assign static or dynamic resources and whether to use completely virtual machines or container solutions. The respondents recognised the benefit of separating partitions and functional areas, especially when it comes to freedom from interference, but some deliberation is still needed to define exactly how. Options under discussion include container solutions, static virtual machines and dynamic virtual machines. All three help to modify functional scopes without needing to take the dependencies of others into account. All of the study participants who were questioned on this issue pointed to virtual machines as part of the long-term solution. By long term, we mean beyond 2025, by which point we expect a significant increase in the number of virtual machines in vehicles.

From today's perspective, the first step (SOP 2021–2023) will probably be based on existing operating systems. Autosar Adaptive Platform is one option. Others are hypervisor-based solutions from the various semiconductor manufacturers. Container solutions were also mentioned. One thing all approaches have in common is that the assumed resources will initially be allocated statically. This means no changes can be made to the allocated volume of memory, communication channels, communication capacities, cores or CPU utilisation while systems are running or once a system is in use in the field.

We see dynamic virtualisation in many areas of vehicle functions as fundamental to future success. Vehicle manufacturers will only be able to quickly add functions and safeguard security if they're in a position to introduce new or modified functions quickly, securely and across all series. This support will be vital for the future of business models. Virtualisation will also be of help when it comes to resolving issues relating to the balance of deep and flat integration. By implication however, this means model view controller principles will need to be applied rigorously. If layers can be kept separate and this is supported by a separation from the virtual machines, this will also make it easier to substitute functions. This is because the presentation layer runs independently of functions in a separate virtual machine.

Currently, the biggest stumbling block is how to virtualise communication channels. By contrast, virtualising memory and CPU capacity is less problematic, especially with static allocation.

Artificial intelligence will have a role to play, but maybe not as we expect

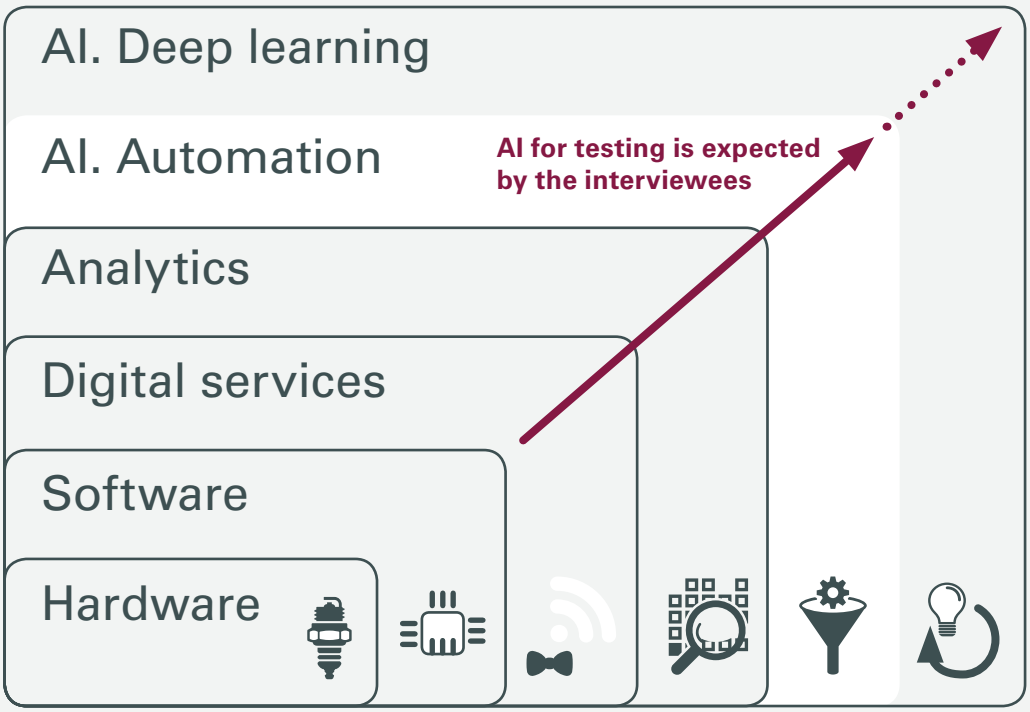
According to the respondents, artificial intelligence (AI) will be a key success factor for the future of automated driving. Applications are only just beginning to appear, especially in the field of deep learning. This makes AI's actual usefulness difficult to gauge at present. In our view, which was mirrored by many of the more critical responses in the survey, a lot of important questions remain unanswered. The following points are currently unresolved.

Each has the potential to put a significant damper on the current hype around AI:

- **Decision-making authority** in multi-agent systems is unclear.
- **AI systems' ability** to handle erratic human behaviour is limited.
- **AI's judgement capacity** must be extensive enough to make billions of decisions every day.

Enormous investments are needed in both development and operation. It will not be possible to finance features such as autonomous driving via service charges.

Using AI in autonomous driving creates a multi-agent system involving countless agents, which more or less stand shoulder to shoulder in terms of hierarchy. These communicate with each other to solve problems and take decisions together. Here is a simple example: when two autonomous vehicles approach each other, both agents must react appropriately to avoid a collision. Any decision-making process is aided by communication, which raises two important questions. First, how is the decision made and second, which agent drives the decision under any one of the many possible scenarios. This is not just complex



Deep learning, a high-level stage of artificial intelligence, is to be pushed as the next driver of both technology and business models (right).

The majority of our interviewees, however, point to a mismatch in the high-level AI cost-benefit ratio.

because of the sheer scope of potential scenarios; latencies play an important role. Agents involved in a decision must be informed quickly to ensure that two agents don't contradict each other. This concern is not related to ethical debates regarding which decision should be made based on algorithms. Rather, it's about the random interaction of dynamic agents. Currently, multi-agent systems are not being used under demanding, real-time conditions. Resolving this issue is therefore of central importance for the future of AI and deep learning in autonomous driving.

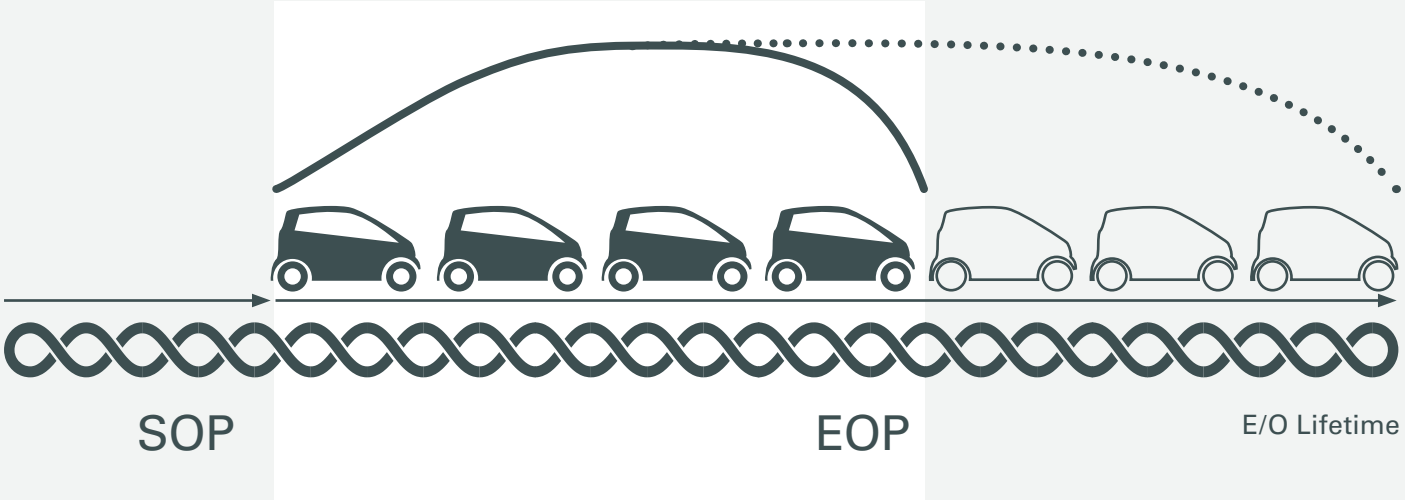
Using AI will make the traffic of the future a mixture of rational and less rational agents. Whether drivers or pedestrians, human beings make erratic decisions based on impulse or intuition. This leads to new scenarios. To a certain extent, AI systems can compensate for human error but there will still be many situations, even trivial ones, in which AI systems react inappropriately. This makes it harder for customers to accept and trust these systems. Short-cycle learning is certainly one way that this system can be weakened. This then poses the next question: how much learning is actually tolerable during live operation?

The current figures on decision-making accuracy in AI systems do not meet the requirements of normal traffic. If millions of vehicles take thousands of decisions every day in the future, a handful of these decisions will result in ambiguous situations. Currently, society won't tolerate wrong decisions made by machines. There is also perceptual bias regarding the number of potentially lethal decisions that can be made – and this will not change, even if there are reductions in road deaths due to automated decision-making. Furthermore, the cost implications of running and continuously validating AI systems are staggering. Manufacturers will need to determine whether their business models actually allow for them to pass on any such costs to customers as they accrue over the vehicle's service life. Overall then, the aptitude of AI and deep learning for autonomous driving is currently questionable.

One thing all of the interviewees did agree upon is that development tasks such as verification and validation will benefit hugely from the use of AI. This is especially the case for managing the vast volumes of test data, which without AI would be impossible.

These fundamentally changing architectures, perspectives and ways of developing functions will have a major impact on how processes and structures are organised. The next two chapters look at this in more detail.

CHAPTER 6



Continuous processes are an everday challenge

In a dynamic market, all structural factors affecting a business must be designed to be adaptable. This is also true of processes in businesses and organisations. According to the B/A/P/O principle, processes need to take into account the product architectures associated with a volatile business environment.

Two factors have a significant influence on processes:

- **Business trigger**
  Added value and business models become digital
- **Architecture trigger**
  Connected vehicles become part of a system of systems

This means that functions delivered via software become a USP. Software is already becoming more and more widespread in vehicles and this will accelerate significantly. Also, it must be easy to update and expand software in vehicles that have already been sold. This has a significant impact on development and servicing processes.

Key areas dominating the future of the automotive industry:

Flexibility and velocity

- The market will be dominated by the provider who is first to offer software-based functions. It will therefore become increasingly important to react quickly. Culture, processes, infrastructure and data storage must all be geared accordingly.
- Velocity will become more important than perfection.
- Velocity also affects the mechatronic systems in general, as new carmakers will drive the product development process.

Continuous development

- Service-based functions must be kept attractive – without interruption.
- Product development does not end at SOP. The focus on continuously developing a product during its entire service life will therefore become more important than the limited time perspective of a development project ending with SOP.

- To react quickly, continuous development means businesses will need to aim to remain robust and ensure everything around them is easy to maintain. This means system architectures and processes will need to be simplified and adapted.
- Although cyber-security is one of the major challenges for industry, it is still viewed from a technical perspective. In future, however, it will become more important to monitor security on a continual basis, across entire businesses. The same applies to the ability to react quickly to corresponding threats. There is also the fact that vehicles now have very long service lives. This means data and system configurations will need to remain available for a very long time.

Safeguards

- Testing increasingly revolves around virtual integration, joint verification and validation across the entire business.
- Ongoing validation is needed in a system of systems, to maintain a vehicle's core functions as part of contractually binding service level agreements.
- Artificial intelligence will help with testing as a means of automating tests and this will partially compensate for the massive rise in testing costs.

Flexibility and velocity

The ability of organisations to react quickly to changes or exploit new opportunities will become more important as we move towards digital business models. Aside from the cultural implications, this also influences processes, infrastructures and data storage.

For processes, this means that organisations will need to be able to reconfigure themselves and take decisions as quickly as possible. To leverage the benefits, service-oriented units will be needed which are small and flexible enough to allowing for a corresponding degree of freedom in process design. End-to-end responsibility will also help. As well as fulfilling the right conditions in terms of product architecture, this will have to go hand-in-hand with the right kinds of organisations and processes. This is because the differences between services can be substantial. Differences are dictated by the type of service, geography and culture. A service that works well in Germany may be of no interest in the United States or China and vice versa.

This means that the global success of a service depends on getting the details right. To get to market quickly and be as global as possible, however, it will be less important to try to provide perfect services. What will be more important is that organisations learn from a market and are able to adapt their services quickly to local conditions. Decision-making processes therefore need to be kept short. And the people with the authority to make decisions should be lower down the hierarchy. To make sure the process of agreeing on changes does not take too long, implementation should not be in different business silos. The ideal solution for quick and focused implementation is to pool expertise in a cross-functional team. This calls not only for the freedom to take the required decisions, but also enough leeway to take responsibility for all aspects of implementation and continuity.

This requires the team to:

- Stay close to the customer and understand their needs.
- Benefit from the corresponding freedom from a contractual perspective.
- Ensure the product architecture offers the right freedom from interference, in order to minimise dependence on other services.

In the case of a notional service, this could mean that teams define the service levels a vehicle manufacturer offers to its customers. They could also continuously develop the service's geographical coverage and local configuration (which attributes are relevant in which region), and manage the service in the market. As and when required, they could coordinate with other teams offering related services, as well as the higher-level HMI or the fundamental architecture. The aim should always be to improve market acceptance and relevance, aspects they would be responsible for alongside generating the right revenues.

In this example, flexibility is achieved above all through decentralised decision-making and end-to-end responsibility for a specific service. This brings the two factors under one umbrella: high velocity with high flexibility, in keeping with achieving the concept of continuous development.

Another factor here is that teams also work with external partners. These can include software developers, data suppliers and infrastructure providers. Such partnerships would be totally unlike current relationships between customers and suppliers.

- Services on the world wide web (and therefore also in the internet of things) often arise through a combination of complementary services from various sectors. This means that in future, collaboration partners may come from outside the automotive sector. They want a partnership of equals, and are therefore not prepared to bow to the manufacturer.
- Certain requirements may call for specific skills that can only be obtained through ad-hoc partnerships. Businesses must therefore be prepared to enter spontaneous partnerships.
- At the same time, vehicle functions need to be maintained for the entire service life of a vehicle. This calls for structural measures to compensate for any potential loss of strategic partners.

Some partners may only work at a local level, while others may only cover certain functional aspects. This ecosystem for continuous service provision will therefore change and expand more or less rapidly depending on how advanced or mature a service is. If services are only offered to customers in certain regions in the early phases, this may only require a single partner to provide data. Additional partners can then come on board as further regions are added. Such an ecosystem will change continuously. Allowing this to happen in a controlled manner – whilst ensuring that service quality does not suffer – is one of the most important tasks for the team. But first, an infrastructure is required that facilitates efficient and flexible collaboration.

This has a massive impact on processes and infrastructures. It must be possible to quickly adapt processes to changing circumstances. Changing customer needs may call for changing infrastructure requirements (eg, streaming vs. download). New partners in the ecosystem introduce new aspects that will influence this (eg, new tools and interfaces), while new service functions or ranges may need different operating arrangements (eg, local infrastructures for safeguarding latencies). New team structures may also be needed quickly as services are combined or separated.

Organising effective collaboration often takes a complete rethink. Given the way services are currently signed on to and commissioned, being in a position to enter into partnerships of equals at the drop of a hat requires a culture shift across all areas.

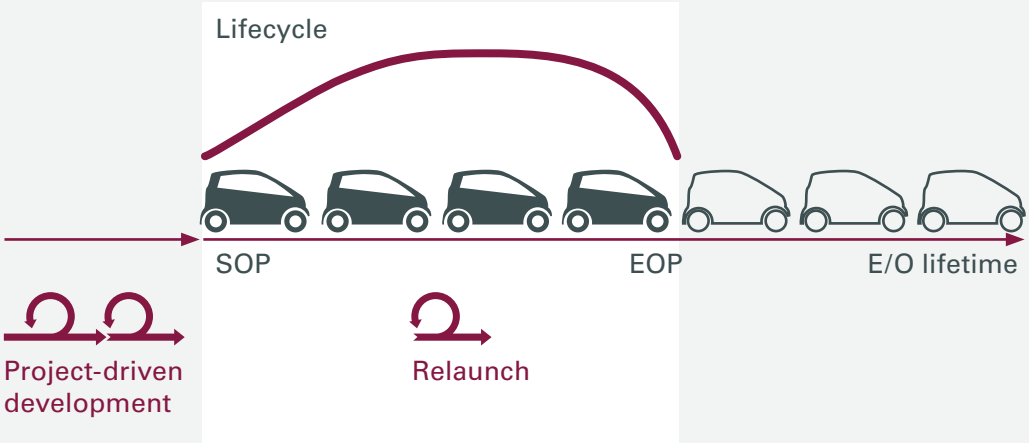
Development within networks

Today, vehicles are developed within networks which are typically spearheaded by a manufacturer. The network's hierarchies are relatively clear and a vehicle is then specified and divided into its components. These are then developed by the partners within the network as part of a collaboration arrangement that can vary in terms of complexity. If everything goes to plan, all components will be ready for series production by SOP and ramp-up for production can start. This raises the question of how different development will be in the future.

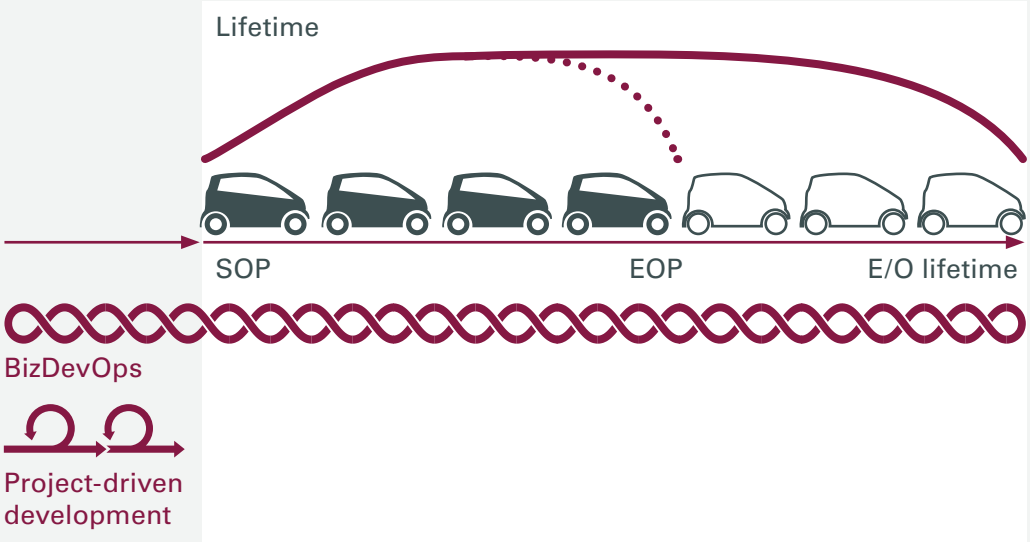
Differences will result from the following:

- More and more functions will be modified over the vehicle's entire lifetime, becoming a central part of complex services. These services will then be offered to vehicle owners by the manufacturer or third parties, probably based on different business models.

Today: SOP-oriented development



Tomorrow: Continuous Engineering



An end-to-end approach characterises Continuous Engineering.

BizDevOps, for example, provide service continuity throughout the vehicle's intended lifetime.

- Both performing functions within cars and these functions' existence will depend on connectivity.
- Services will emerge in all corners of the world and providers will have to react quickly to retain the appeal of their products.

This all leads to the prospect that functional development in particular will no longer be dominated in the medium term (after 2022) by the SOP. Instead, there will be continuous, short-cycle upgrades to product functions and this will also be the case with the services that are based on these functions. Development will increasingly occur within an ecosystem of businesses. This corresponds to the technical nature of the system of systems in that vehicles represent a system of data nodes.

This ecosystem will have to address these concerns:

- Flexibility and velocity for service development. This is about ensuring there is convergence between the development partners involved in engineering. So they should work according to the same schedules and cycles and share the same common overall processes, ideally as a cross-functional team with end-to-end responsibility. This covers continuous development of the business model, deliveries, integration, deployment and operation, all seamlessly coordinated as *BizDevOps* (see Spotlight).
- Component and system development will continue on a top-down basis, especially when it comes to hardware. Explicitly specifying constraints, however, will become an important factor for creating a solid basis in the system of systems.
- BizDevOps will require source code for services.
- Concerning the migration of processes and tools to the cloud, development platforms will be operated in the cloud so they can be reconfigured quickly and easily through third-party development teams and partnerships.
- Data will be stored in a way that enables quick, easy and secure access to all those with authorisation.

The aspects of flexibility and velocity have already been addressed above.

Turning to the development of components, one of the main differences compared to current development processes is how constraints are determined. These will mostly be specified in a system of systems, before being broken down into individual component systems by the various carmakers. Being able to break things down like this can be compared to today's specification work. The important new aspect is that the various vehicle manufacturers and other companies involved in the system of systems will have to clearly specify and agree on the constraints affecting individual systems. This will probably happen through international committees.

Providing source codes will be a major prerequisite for function development through teams. This will allow teams to quickly develop services together. Intellectual property will probably play a secondary role here.

In future, service development teams and different parties working on component and system development will find themselves working within fast-changing collaboration structures. There will be significant differences between the teams within these ecosystems. This means that ac-

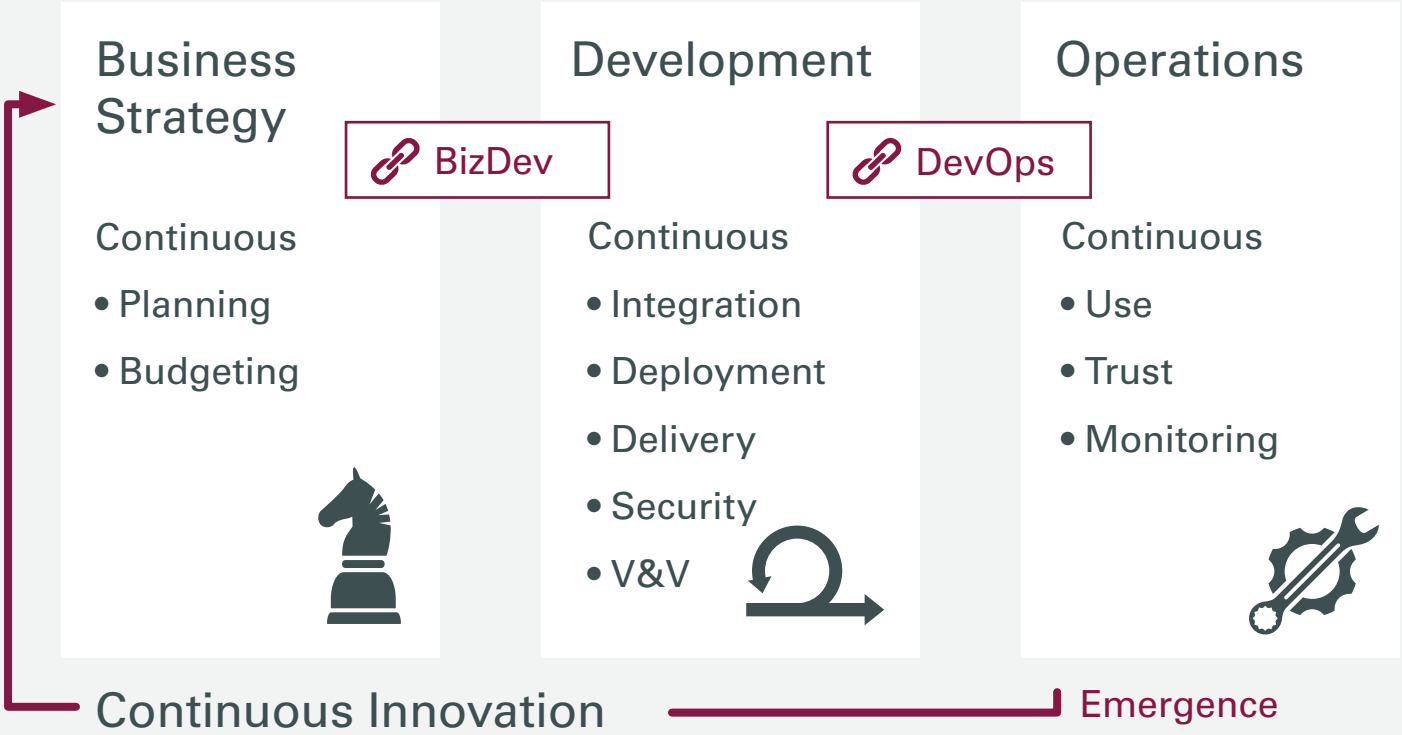
cess to tools and data must be quick, easy and secure. The easiest way to achieve this is put a corresponding development infrastructure in place through a third party in the cloud.

Continuous development

Continuous development of the infrastructure layer will require cross-functional teams consisting of experts on the embedded systems in a vehicle, perhaps also tier 1 experts, security experts and IT experts for the IT backend. Together, the job of these teams will be to define architectures and implement them in the software. Updates will be developed and tested continuously, but with less frequency, particularly with respect to security and compliance with the constraints. The infrastructure layer will probably be identical for all vehicles made by a company. At the core layer, the architecture of the nodes will be very similar to that of a backend server. The aim should be to provide app and service developers with an environment that is similar to ones used in IT development. Of course this therefore means important real-time requirements must be addressed.

By contrast, there will be more regular ongoing development of services and apps. There will also be local or regional interpretations or versions. The focus here will be on implementing business models quickly and coherently. It will also be important to run services in the field. Again, the key idea here is BizDevOps. The quality requirements when it comes to services and apps will not be as high as they will be for the infrastructure teams. A/B testing and other methods of gathering quick and meaningful user feedback will be useful mechanisms for accelerating development in keeping with each target group. For this to work properly, it will be essential that key players understand customers and know their profiles, so they can deploy and operate functions effectively and offer service variants. Smart data can play a major role here.

Continuous Innovation aligns Continuous Engineering with business concerns – continuously. | Iero, University of Limerick*



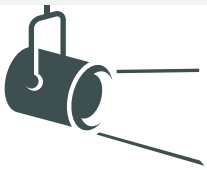
Safeguarding

Another factor that will become more important in the coming years is safeguarding.

This is due to three main factors:

- Increasing product complexity
- Product development across the entire service life
- Continuous changes in the system of systems

Increasing product complexity is mainly being driven by driverless vehicles. This requires software on a scale that is far beyond anything ever developed for any product in any industry. The total number of lines of code for the sensors, components and backend functions these vehicles require – not forgetting involved input from data providers for the necessary functions – will certainly total several hundred million. There could possibly be over a billion lines of code. Some time ago, we estimated a company's development requirements in the run-up to 2025, only focusing on its anticipated product portfolio in the field of embedded software: 75 million lines of code. Just the testing required for such massive volumes would take over 20,000 man-years, so automated testing will be essential. Tests will have to be performed at all levels and coordinated between the different partners. The focus will have



Spotlight
BizDevOps

BizDevOps is an organisational pattern that emphasises the concurrency and integration of the development of the business (Biz), the development of products or services (Dev) and their operation (Ops) over their lifetime. Traditional corporations generally have three separate divisions, which, reflecting the individual BizDevOps components, split the responsibilities more or less sequentially. BizDevOps can be seen as a shift left extension of DevOps. BizDevOps integrates these functions for continuous collaboration with each other and for close interaction with the customer. It is a holistic approach that delivers value in short cycles while retaining room for experimentation. The IT infrastructure extends what is required for DevOps to facilitate business modelling with automated traceability. The most important precondition for BizDevOps is that the culture of the organisation can embrace agility and flexibility. This foundation facilitates a tighter connection between strategic planning and execution, thereby enhancing open innovation and continuous experimentation.

Prof. Brian Fitzgerald, Iero, University of Limerick

to be on pinpointing errors as efficiently as possible. Highly automating testing should therefore be incorporated in the development cycle as early as possible. Established testing methods and approaches used at the moment (such as simulations, reviews, back-to-back testing of models and software, MIL, SIL and HIL) will remain important, but the degree of automation will need to increase. In future, each software change will have to be tested automatically, as intensively as possible, all the way to vehicle level. This is the only way to ensure the enormous growth in functions is also dealt with when it comes to testing. There will need to be a systematic shift away from manual tasks, to focus more on developing automated procedures and move away from performing tests.

There is also a completely new area of testing. There are now some highly complex sensors like camera and radar arrays, or multi-technology sensor configurations, and these are being trained by using huge volumes of data. These need to be tested to ensure they deliver the right detection and hit rates, and this requires intensive use of artificial intelligence to manage the test data. Without this, it will not be possible to properly assess either the sensor systems or the more valuable automation functions. There are such huge financial and time implications in terms of moving things forward in development in this area, that such a task is virtually unaffordable.

Big bracket

Retail is detail: until now, this was not a core competence of carmakers, but for a service-based business model to succeed, it is important to know and take into account the needs of individual customers.

In general, this means that carmakers will have to become much more service-oriented and more regional in their outlook. They will also have to act quickly based on the analysis of large volumes of data. Are they ready for this? Time will tell. Reprogramming the strong DNA of a product and developing a new DNA in services is difficult. Not only does this require end-to-end responsibility and decentralised decision-making, above all it takes an ability to think and act locally. Services must always be up to date. Project-based development must therefore also include the aforementioned aspects relating to continuous development. This is a Herculean task, especially with respect to culture, processes and structures.

* Fitzgerald, Brian and Stol, Klaas-Jan (2015). Continuous Software Engineering. A Roadmap and Agenda; in: Journal of Systems and Software (pp. 176 – 189). Elsevier, Amsterdam.

CHAPTER 7

The organisational foundation of serviceability

People work together in groups because they have a common purpose. This common purpose is part of the strategy which defines their business models, services and products for a given market. A common set of structural and behavioural patterns – relationships and roles – makes group collaboration effective. An organisation forms the foundation of collaboration to create value together. It includes the people and the structures.

Every organisation has its own identity and behaviours, its corporate culture. This is determined by the common purpose (why do we work together?) and common values and beliefs (how do we deal with each other?). This culture is more important for success than efficient structures. The task of the structures and patterns is to facilitate the development of a desired culture.

The term *organisation* refers to long-established companies, business units, departments, as well as temporary project consortia and partnerships.

To breathe life into its structures the organisation needs the right kind of people and it needs to keep them. This applies to internal employees just as much as partnerships. Digital transformation must therefore involve all business functions, including supporting functions such as HR and procurement.

In the following, we consider the behaviour of successful organisations resulting from the interactions of people and structures. We then discuss required core competences and possible organisational forms. We conclude with comments on the digital transformation of entire organisations.

The behavioural patterns of digital organisations

Digital organisations operate within a VUCA world order. Success in the long term necessitates an ability to adapt incrementally to fluid environments plus the right know-how to innovate discontinuously whenever required. The organisational behaviour has to correspond to these complex and sometimes contradictory market forces. The following patterns each describe different aspects of this behaviour. The concurrence and interaction of these patterns differ from organisation to organisation. Their characteristics drive the organisational behaviour of a particular company. Depending on the situation, a company may need more emphasis on one aspect than another.

The ability of organisations to adapt

The VUCA world order works in conjunction with rapid technological change to trigger constant, even transformational change in business models. Architectures, platforms, services, products and the processes all change in response to VUCA. Digital organisations provide a platform to support cooperative and continual development. The structure–conduct–performance paradigm tells us that these changes need to affect the overall organisation. Most modern organisations place emphasis on standardising behaviour and try to avoid exceptional circumstances. For instance, they try to shield the inner organisation from the outside by establishing elaborate procedural structures. Many are so reliant on standardising their operations that they try to make behavioural patterns cover all potential fluctuations in behaviour. Such organisations can deal with quite diverse situations, but only if such situations were predicted. Behaviours are needed that do not rely on organisations predicting possible scenarios – they need behaviours that adapt.

Adaptation may affect the

- People involved (roles and responsibilities etc.),
- Operational structure,
- Structural organisation.

Going through the above aspects from top to bottom, each factor becomes increasingly difficult. Each can imply significant modification – at the very foundation of the organisation.

In all cases, adapting may mean

- Adding or removing dedicated resources, including personnel – more of the same will stretch HR (alignment).
- Changing positions within the value creation network – based on existing roles: business process impact, behavioural adjustment within a consortium.
- Dissembling and reassembling structural and behavioural patterns: structural and behavioural elements must be simple and modular; the corporate culture must embrace change as an opportunity, not see it as a sign of failure.

The agile organisation (see Spotlight) has generally been positioned as a model organisations should aspire to. The

Spotlight

Agile organisation

Many companies in the automotive industry face a highly dynamic business environment which can best be described with the VUCA model. Tomorrow's customers will probably be different from today's customers; technologies change quickly, as do established roles in an industry. The same applies to the complexity of system of systems drive technology and changes in collaboration models. This challenges modern organisations – including their structure, processes and culture.

As nobody knows what the industry will look like even five years from now, nobody is in a position to design or set up an organisation that will fully meet future needs. Therefore, increased flexibility and an ability to respond quickly to upcoming needs are key success factors for all organisations. Many large and small organisations have understood this and launched corresponding initiatives.

The common terms used to describe the objectives of such initiatives are *agile organisation* or simply *agility*. The key objective is to make organisations ready for the VUCA world order. To do so, certain values and principles are emphasised as part of a company's DNA.

Values like transparency, openness, trust, embracing change or interaction gain more attention in a connected business environment. The purpose is to establish an organisation which facilitates and encourages team orientation, customer focus and decision-making. Concepts like self-organising teams, continuous learning, servant leadership, pull principle and frequent integration, improve flexibility and velocity over time. In addition to these values and principles, organisations now also use different processes, methods, practices and tools.

By design, agile organisations:

- Can respond to rapid market changes
- Become a learning organisation with feedback loops
- Offer an attractive workplace for knowledgeable workers
- Can work effectively in complex ecosystems and adopt various roles as value contributors.

Agility is a proven way to deal with VUCA world order because it provides stability as the organisation learns to adapt to new and dynamic business environments.

Dr. Harald Naunheimer, ZF Friedrichshafen

implication of a VUCA environment is that significant emphasis should be placed on the adaptability of organisations and the speed at which they are able to adapt. This means that organisational structures and patterns also change themselves, as they adapt effectively in order to adapt to address new requirements. Adaptability goes beyond the benefits of agile organisation. However, agile organisations provide a better starting point for becoming adaptable in the first place.

The importance of adaptability is underscored by the need for organisations to understand local customers. New business opportunities often arise locally and these must be quickly converted into viable offers. Developing and producing components and systems calls for organisations that are capable of adapting quickly and reliably to the changing nature of expandable architectures' needs. Also, change requests need to be adressed quickly.

The ability to organise

Adaptability must be paired with an ability to organise. When an adaptable organisation is also capable of organising itself, it can proactively and innovatively change itself. Self-organisation is an ability that is required at all levels. Adaptability overcomes path dependencies stemming from internal procedures and it helps organisations break with existing thought patterns. Embracing discontinuity is a necessary counterpart to adaptability: it helps organisations recognise when breakthrough innovations look promising with respect to business models or products. Continuous or discontinuous change within an organisation must result in systems and processes that are equally effective. The ability to self-organise is required in every part of the organisation. Task responsibility and organising tasks should remain within the remit with the same people.

Self-organisation extends adaptability through

Operational behaviour patterns

- Identifying tasks from requirements and priorities
- Roles, responsibilities and authority

Governance behaviour patterns

- Where are we going?
- Are we using the right approaches?

With self-organisation, a foundation needs to be built and maintained in order to put the right business models in place and implement architectures or processes. People also have to believe in these concepts and feel like they are part of self-organisation. They need the right experience and expertise, so they know which structures to select in order to set up the appropriate business processes. In the past, structures were usually determined by the size of the organisation and driven by the pursuit of efficiency. They were often inherited. Efficient processes and rigid hierarchies served their purpose and in a stable and mature market, both delivered competitive advantage.

VUCA necessitates organisations with structures and processes that act as building blocks. These can be mixed and matched as required and, if necessary, disassembled. People who are required to work under new set-ups should also be empowered to build those structures themselves. Organisations cannot be created on a drawing board any more and expected to operate without changing. Today's organisations must have the ability to transform and reorganise themselves. And self-organisation is one of the essential aspects of the skills and scope of an organisation.

The ability to lead

Organisational ability gives the organisation the tools for an adequate set-up. Utilising this setup the organisation must be able to empower people to develop and expand their creative potential and to contribute to the added value in an agreed targeted way.

The ability to lead includes the ability to integrate different cultures and orchestrate ecosystems. Tapping the human potential requires being able to relate an exciting vision and inspire people to align with the vision and forge teams. The teams need the space to experiment, to find themselves and their own way of providing value.

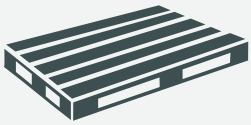
Solid knowledge and experience in digital and service-driven business models based on networked software, big data analysis, artificial intelligence, deep learning and more is needed. This knowledge must permeate the organisation. It must be paired with the ability to quickly identify digital trends to align interdisciplinary teams accordingly. The potential implications of software for its own activities and the ecosystem must be recognised at an early stage. This background of knowledge and experience must not only be present in one designated area of the organisation. Regardless of a chosen organisational structure, this background is required in every area and at every level of the organisation. The close interaction between software and other disciplines requires thinking and acting across domains in engineering and management.

Moreover, especially in knowledge-intensive sectors, a new generation of employees is looking for more than just a job. Earlier generations of employees were attracted by technology and products. The interest now is in an underlying purpose, reasons for creating the products and services they are working on.

This new generation expects more degrees of freedom for own initiative from the organisation's management, as well as opportunities for growth and the possibility to shape customer services directly. Transparent and fair decision-making and reduced hierarchies are receiving greater importance in deciding where to work. These statements also apply to leading organisations as well as to the leading consortia.

For incumbents of the automotive industry it is an additional challenge to protect the business of the future from being starved by the daily business. As a rule, an established vehicle manufacturer is a highly path-dependent organisation with a significant interest in current components, systems or products. This is clearly demonstrated by the internal combustion engine. This organisation tends to allocate resources where profits are generated. This pays off directly in the quarterly report and creates security. Adaptive innovation can easily matched using cost of capital calculation.

Investing in uncertainty is crucial for digital transformation. It is a strategic management task and it is especially important to reserve management resources for future areas. The portfolio of present and future perspectives needs to be actively managed. This can include radical action – such as withdrawing from formerly strategic business areas. Such action facilitates the focus on new technologies.

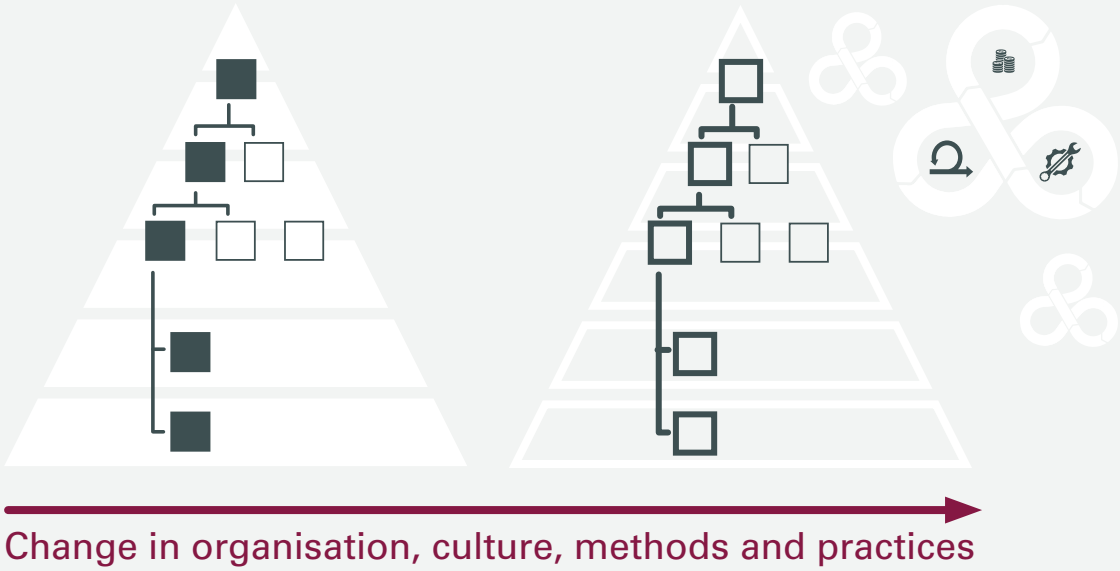


Platform and ecosystem alignment

Value-added networks and ecosystems will behave differently from today. They operate in a network economy. The organisation must recognise the importance of this economic change and promote network behaviour through its structures and patterns.

For organisations that implement services, BizDevOps (see Spotlight) – the consistent, team-driven deployment of a service from business model to continual operation – can be a flexible way to respond to changing needs. The more independent services are, the easier it is to offer them flexibility adapted to the customers' needs. The team would have to have all the necessary abilities and authorities from the business model to the development, and on to operation. If partners are involved in the provision of the service, they need to be integrated into the team.

Even in a network economy exclusive focus on individual customers carries the risk of narrowing innovation to adapting improvements, because of quick revenue return. Opportunities for radical changes in the market may be overlooked. The ability to influence the future of the ecosystem requires that discontinuity is incorporated in the strategy by design. It is helpful to think in platforms rather than in individual services or products. Ecosystems, in which a variety of services are offered around the customer, are to be built around such platforms. Whether these services contribute as value creation or value capturing directly or indirectly to sales, and whether these relate to owning a vehicle, is of secondary importance. The service offering today is limited, and only the future will show which services will prosper, which will terminate, and which new ones will arise.



From traditional hierarchy (left) **to Continuous Innovation** (right): **Serviceability and a customer end-to-end focus challenge the organisational structure.**

Who will dominate the customer interface in the future is not predictable and depends on the business model. A product-dominated business model, such as a vehicle manufacturer might operate, requires much stronger competences in achieving customer loyalty – in order for the ecosystem to evolve around the offerings of this manufacturer. The attractiveness of a product, such as a vehicle, will be determined by the ease of integration into the digital lifestyle of customers. This customer experience is the ultimate differentiation potential.

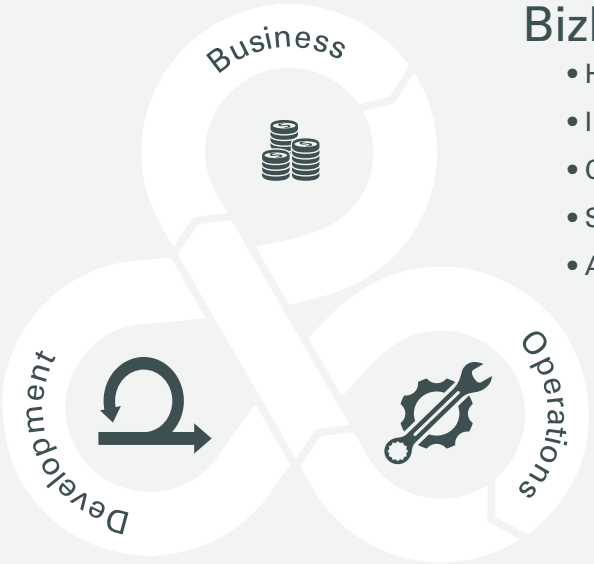
The ability to orchestrate ecosystems and the ability to influence ecosystems through platforms will prove significant for the success of organisations.

The ability of organisations to innovate

In a dynamic business environment time for detailed analytical decision preparation is limited to few very fundamental decisions. Trends in the digital world change frequently. In dealing with VUCA a central strength is a culture that fosters experimentation and accepts failures. Associated to this mindset is the acceptance of creative destruction. At the same time this is also another argument for organisational structures that can be built quickly and reconfigured. When the dynamic appearance and disappearance of the team is part of the culture, the dissolution of a team is no longer seen as a failure, but just as a possible and acceptable result of an experiment. Essential for this is that many experiments are risky. Consequently, an experiment-based culture is defined by a dynamic equilibrium: high-level experiments will result in business alignment; this will require new organisational structures and so the dissolutions of teams. The latter, distant from failure, will reset the innovation cycle: new ideas will arise. New teams will be built to test these ideas as well.

These learning loops must be run continuously and kept as short as possible. We have thus further demands for independence and empowerment of the teams. The lessons learned from the experiments have to be made available as a background experience for all areas through the organisational patterns. This ability of the organisation can only develop when a certain level of slack is maintained.

A digital services team (BizDevOps) is a cross-functional team empowered by decision-making responsibility. Acting as a mini company, the BizDevOps team is its services' PO & CEO.



BizDevOps teams

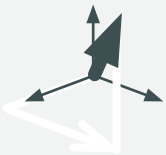
- Holistic approach
- Intrapreneurship
- Customer tie
- Short decision-making
- Accountability
  - Well-defined scope
  - Cross-competences
  - Quick feedback from experiments and failures

Achieving velocity and having the space for experiments require appropriate resources. This paradigm shift from the focus on efficient processes in the saturated market is necessary in a dynamic market with rapid technological changes.

Continuous improvement and discontinuous innovation

In a volatile and ambiguous world management needs to adapt and improve continuously and to innovate discontinuously. So it has to address paradoxical concerns:

- **Continuous, incremental improvements**
  The adaptability to changing customer requirements as a prerequisite for continuous improvement has already been presented. There are three dominant aspects: An agile organisation with short and frequent learning loops. Continuous engineering extending the adaptiveness to changes in the business environment (BizDevOps). And openness for emerging business opportunities. These strengths allow the adaptive and agile organisation to survive in the Red Ocean.



- **Discontinuous, transformative innovations**
  Other innovative capabilities need to include the ability to both interrupt path dependency and actively shape markets. Transformational innovations provide unique and possibly radically different solutions to customer needs.

  Creating a customer is the central strategic capability and allows the Blue Ocean to differ from the competition. This approach relies on evolution directed by strategy: business experiments are intended to foster creative destructions – inside and outside the company. Whilst the nature of an agile organisation is evolutionary by definition, the concept of transformation innovations applies business experiments and evolutionary methods to explore business opportunities different from today.

The organisation must provide structural and cultural conditions for the continuity of both continuous adaptation and discontinuous, transformational innovations. This concerns patterns of thinking regarding the customer and market perspective, as well as the inner perspective of how the market is to be handled.

Global is the new local

Service-oriented business models based on networked software are becoming the central growth factor for the automotive industry. The demand for software developers, and for analysts in the field of big data as well as specialists for artificial intelligence and deep learning, will continue to grow rapidly. Development departments of all the companies involved are forced to strengthen their attractiveness as an employer and to address their relevant target groups all over the world due to the enormous need. Western Europe and North America are not able to satisfy their needs due to the comparatively scarce availability of adequately trained developers. This problem is amplified by having to develop software at relevant levels close to the customer in order to implement their needs and constraints as optimally as possible. This means that Central Eastern Europe (CEE) and Asia are moving into the focus.

CEE countries such as Poland and Romania have been established development locations for some time. Comparatively new are countries like Bulgaria. Overall, European firms in particular are going to strengthen their commitment in this region. Advantages include the generally very good skill level of the developers as well as the comparatively easy accessibility (maximum two time zones).

In Asia, India has been an established location for a long time, but new ones such as Malaysia and Vietnam are now emerging. In addition to its importance as a sales market, China is also becoming a significant R&D location for companies.

The consistent globalisation of product development encompasses more than just more extensive off-shoring. Rather, it places demands on product architecture as well as on the processes and structures. Building a globally active development organisation and combining the strengths of the various regions must be a cornerstone of any software-focused R&D strategy.

Success factors for good implementation are:

- Architectures which support such a distributed development.
- Establishing R&D sites, which will become peers rather than hierarchies in the mid term.
- Defining clear profiles for tasks, competences and authorities, utilising the relevant cultural strengths.
- Creating processes, organisations and infrastructures that really support distributed development at peer level.

Managing employees from different cultures is an enormous challenge. On the other hand, increased diversity also increases the potential for innovation.

Competences needed

The dynamic business environment and the reorientation on service-driven business models require different organisational skills compared to today. These capabilities of a digital organisation ensure that the structures and the actual culture keep the organisational behaviour on the straight and narrow as defined by strategy.

Core competences for digital organisations

- **IT becomes core competence on all levels**
  Organisations that want to dominate the customer interface, eg the vehicle manufacturers, must integrate IT expertise into the teams that design, implement and operate these services. The underlying paradigm could be BizDevOps.
- **Quick launch of services**
  When services are essentially the competitive differentiating element, any new services must be implemented quickly and globally brought to the market and managed globally. This requires a malleable organisational structure that facilitates fast formation of such teams and an organisational culture supportive of experiments.
- **Orchestration of ecosystems**
  In the future companies will have to react quicker to changes happening in the value-creation network, or swiftly execute changes they want to trigger themselves. To this end it is becoming increasingly important to build platforms that can be reconfigured quickly and flexibly and contain all the essential solution components, which are then used by the value-creating partners.
- **Service is retail, retail is detail**
  Companies that want to change from a product provider to a service provider have to learn that the service business depends on each individual customer and that this customer wants to be valued and understood. This includes being prepared to modify the mechanics of how to create and capture value. In addition, the service provider must be aware of its customers and their true needs. He must develop an understanding of the environment in the respective region and offer suitable services for this market.

- **Software competence in management**
  Software already dominates the functionality of products (about 80%). The increase in services and their growing complexity will strengthen this dominance. It is, however, still the case that own understanding and hands-on experience with software are rare in the automotive industry. The number of such software-experienced managers is in the low single-digit percentage range.
- **Leadership as a servant leadership**
  Things can be managed, people can only be led. In order to be able to build on the skills of organisation, leadership and innovation, servant leadership must become a key component of organisational culture, although this may seem revolutionary for traditional management. Servant leadership is also important for the effective deployment of cross-functional teams.
- **Global engineering management**
  Coordinating the local competences globally and turning the challenge of leading different cultures into advantages of ability to react or innovate requires a broad vision in the design of global development organisation structures, procedures and infrastructures. To this end, alternatives to top-down enforced solutions must be developed.

Again, there will be a move away from command and control to delegation of responsibility, cross-functional teams and a stronger focus on value creation from the customer's point of view.

Organisational forms and -building blocks

Until now, we have mostly used the abstract term *organisation*. This can take many forms: physical or virtual, central or distributed, matrix or network, or a hybrid organisation composed of parts of these. However, the ideal organisation can not exist. The variety of business models can not be replaced by a generic blueprint. Instead, organisational forms will be developed according to the respective business models.

Organisational forms will change as the ecosystems in which the want to exert influence by utilising the various strengths of their structures and patterns.

Organisational building blocks are the elements from which organisational forms are built. The organisational units must be able to describe and support a self-created and independent self-organisation.

In line with the understanding of *living systems,* this essentially means a common understanding of all parties involved concerning:

- A common purpose
- Objectives and objectives tasks
- Criteria for the achievement of objectives
- Rules for dealing with each other
  (which does it mean to be responsible for something?)
- Roles and assignments (who must communicate with whom, for what?)
- Rules for improving cooperation (governance)
- Mechanisms for synchronisation

These are basic building blocks for teams, and applied fractally, for entire organisations. Here, teams of teams are formed. This creates hierarchies, but these are based on a common understanding of tasks and thus are dynamic.

How these building blocks are woven in organisational patterns depends on what approach is chosen. Inner source as part of the development approach fits the above considerations every well. It is not without reason that models such as *Holacracy* or *Sociocracy* attract increasing interest, especially in software companies. Committing to such an approach means this for these companies turning away from command and control down to self-organisation and team and individual responsibility.

Many companies take these issues seriously and prepare for their long trek to adapt their corporate cultures accordingly. In addition to large vehicle manufacturers, such as Daimler, VW or Ford, there are other companies, such as Bosch, Continental and ZF, which consistently transform that way. Some, such as Zenuity, are in the potentially favourable position to build their organisation right now as a greenfield approach.

We have already stressed that consortia and their projects are organisations, too. The approaches discussed here are also applicable to these types of organisations. They can, for instance, be combined with the big brother of inner source: open source is firmly established in automotive and will grow in importance. The fact that open source can also be a path to disrupting an ecosystem, especially in the context of platform considerations, has not yet been widely understood.

In the future, blockchain technologies will shape platforms for partnership-based joint development. Blockchain allows trust-based multi-agent systems to complete and implement development contracts with defined delivery performance and acceptance.

Organisational development and digital transformation

Organisational forms and patterns of organisations will continue to change over time. Growth (more of) and diversification (new markets, products or services) are the motives. The transformation to a digital organisation will be hampered by

- The size of the original organisation is, and
- how different the new business model is from the old one.

Both properties increase the difficulties in delineating separate areas for behaviour change without addressing the whole of the organisation. To achieve this and established way is that of founding a subsidiary in order to circumvent this problem. This may not only help to avoid obstacles to change the organisation, but also to potentially help bilateral negative impact on business performance in the short term. However, for the digital transformation of a current organisation, the greenfield scenario with a subsidiary companies may be of limited use, depending on the constraints:

- The organisation wants to replace today's core business in the medium term by a new business. The approach of establishing a subsidiary would make the relationship to the customer more indirect and potentially weaken it.
- It is uncertain which services will be implemented. The approach of establishing a complete organisation for each experiment does not appear effective.
- The coming 15 years will be more and more dominated by velocity rather than efficiency. The model of the subsidiary organisations appears too lengthy and involved for this case.

Setting up a new digital organisation with an own new brand and portfolio, represent a full green field situation. Here it is important to secure the advantage of not having to undo a long and powerful legacy of behavioural patterns. Separation into a new business with the task and the authority to self-organise is the only sure way to loose unwanted legacy.

The transformation into a digital organisation does not have to take place in one step for the whole organisation. Different business areas could be selected over time and combined. Important is to develop overarching common goals. Each of the sub-transformations should be aiming at transforming a part of the old business into an end-to-end digital business, with its own market access and its own market positioning operating its own BizDevOps. The organisation needs to be established, such that both continuous and disruptive evolution are possible without endangering the very existence of the organisation in question.

CHAPTER 8

Summary

B/A/P/O for digital enterprises

Digital transformation will fundamentally change the rules of the game in the automotive sector. The rise of service-oriented business models will change the entire logic of doing business for manufacturers and suppliers alike. For this reason, change must not just address such individual concerns as technology. Transformation in businesses will be directed by the structure–conduct–performance paradigm. B/A/P/O factors that will ensue as a result will help synchronise business affairs.

Business: Thinking back to front

This realignment begins with the business model. The role of business models is to provide a coherent idea of how to implement the strategy and how to add value for the customer through an offering with appeal. Following on from strategy, business models must consider both the macro-factors of the VUCA world and the internal logic of digital, service-centric business: This is a prompt for us to think back to front, beginning with the customer benefit. Such business models ignore industry conventions and established ways of thinking. Indeed, this is what makes them so revolutionary. Putting the customer benefit at the centre of our thinking often leads to a convergence of sectors and offerings. A smartphone, for example, pulls together the value propositions of several industries, offering a common point of access. This in turn leads to new ideas for new offers. Digital business models therefore have wide-ranging potential to combine existing offerings and spawn new ones.

At the same time, they also open the door to a much greater range of offerings in ways that are far more sophisticated, going beyond the product and service ranges provided by today's automotive industry. Low marginal costs make it easy to offer tailored value propositions to smaller customer segments. Furthermore, by combining value creation and value capturing, countless customised combinations can be offered, hand in hand with correspondingly diverse business models. Established players in the automotive industry will need to know how they want to position themselves in the service-driven mobility sector of the future. The starting point for their realignment will be the strategic direction they want to go in. There will be a wide variety of business models in the future and as a result, we will also see many different forms of process-centric organisations and different organisational structures. The one size fits all approach of hierarchical companies will become a thing of the past.

Architecture: Space for new ideas

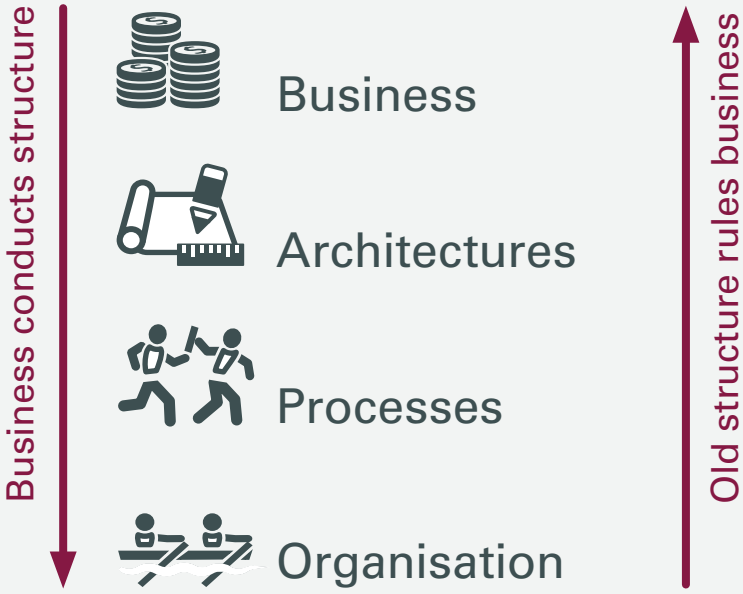
The infinitely scalable nature of digital services means that system architectures will need to be designed deliberately with expansion and extendibility in mind. Software/hardware constellations whereby each element fits like a glove and everything matches within an encapsulated environment reflect a concept that is running into a dead end.

This need for scalability requires a whole package of measures, with architectures based on generic blueprints. Such blueprints will need to be focused on non-functional requirements. Additional elements will include standard software and hardware, with the appropriate bus systems, large reserve capacity, virtualisation and standardised interfaces. The architectural elements that will interact with the internet will have to correspond with internet architecture in terms of the underlying structure. As such, these elements will no longer be simply connected to the internet – they will be part of it.

This report develops an architectural schematic for such requirements, continuing the separation between the physical layer and the connected layer, as suggested in the first volume of *Software Drives 2030*. This architectural schematic provides a foundation for service-based business models throughout the vehicle's lifetime.

Processes: Continuous engineering

Fundamental changes will also be required in process-oriented organisations. With services, it is smooth implementation and delivery that count. This requires a continuous flow of information and decisions that cannot be limited by



The structure of an industry incumbent constraints the ability to transform the business logic of the company.

departmental boundaries. This continuity across all functional areas will therefore break down previous functional separations. The focus in organisations that currently revolve around E/E systems will shift, as services are delivered in real time and need to retain their appeal. SOP-centric development will become less relevant. Instead of thinking in terms of separate projects, developers will increasingly take a broader view of operations, shifting the focus to continuous service engineering. This report advocates that BizDevOps is a way to synchronise development and service provision as part of the business model. Service teams with responsibility for defined BizDevOps will ensure the emphasis lies in customer orientation. Accordingly, work processes will need to have inbuilt flexibility so they can be quickly configured to respond to changes in market needs.

Organisation and culture: Enabling collaboration

It will be the organisational structure that lays the right foundations for this new focus on service provision. The all-important factor within organisations will be *serviceability*. Above all, this will entail finding constructive ways to compensate for conflicting interests. For example, companies will need to develop templates for expanding company boundaries. This is because digital services based on outside-in thinking will often merge value propositions from a number of sectors. Being in a position to develop superior services will require ad-hoc collaboration with specialists from complementary industries. The templates for collaboration will have to make it possible for all partners to achieve win-win and work in partnership without complication. Another key factor for making businesses fit for the dynamic market of the future is innovation. Agile organisations that can adapt will quickly enjoy the fruits of success by being closer to customers. They will be able to respond to market reactions by quickly incorporating feedback into new offers. But short-term innovation will not be the only key issue; long-term success will also be a vital factor. Digital services have the potential to offer radical and disruptive innovations. Focused evolution and experimenting with business models will help businesses attract new customers.

In the end: The change dilemma

Given factors such as B/A/P/O and the structure–conduct–performance paradigm, everything points towards the need to base system architectures, process-oriented organisations and organisational structure themselves on new business missions and new business models. In the automotive sector, this will mean creating digital organisations to put service-based models into practice. Industry incumbents face a problem that is already the other way round – they have established organisational structures, processes, methods and ways of thinking. And now, radical technological development and the dominance of digital business models are turning these structures and certain aspects of this know-how into a burden.

Again, the structure–conduct–performance paradigm is relevant in this regard. Change often goes wrong because it was based on outdated structures. Far from being a shortcut to the future, an existing organisation can soon send firms down the road to nowhere. This is where being willing to break with continuity comes back into play. Transformation will also require businesses to think back to front, taking the desired result for the customer as their starting point. Once that has been defined, B/A/P/O clicks into place. By using the cascade model, digital transformation can be given a structure and companies can focus clearly on the right goals.

CHAPTER 9

Survey design

The survey **Software Drives. Digital Capabilities for Automotive Innovators 2030** was conducted by Kugler Maag Cie from February to May 2017. Two main research activities were performed and afterwards were followed by an analysis phase using various approaches to derive findings:

- Desk research
- Expert interviews

Desk research

The task was to identify and analyse research results which were externally produced and might be related to the objective of this survey. The desk research provided important input on how to develop the expert interview framework. This research is based on the performance–conduct–structure paradigm – the assumption that there is a VUCA world order and use is being made of megatrends and the B/A/P/O model.

Expert interviews

More than 40 interviews with experts from the automotive industry were conducted. The interview duration averaged about 90 minutes. The interview framework described above allowed interviewers to start with open questions without directing the interview partner. This allowed the interviewers to use the expert interviews themselves to also validate the content framework.

The interviewers all have a significant assessment background. Only a few interviewers were used. This simplified the interpretation of the results and the derivation of findings.

CHAPTER 10

Glossary, survey participants and acknowledgements

AI Artificial Intelligence comprises three stages of machine learning. First stage (1950 – 1980): smaller subsets of machine learning. Second stage (1980 – 2010): automation of processes and workflows. Third stage (since 2010): deep learning.

APAC Asia Pacific – the part of the world in or near the western Pacific Ocean.

Asynchronous architecture An architecture is called asynchronous if it is undocked from the intended functionality.

B/A/P/O This model brings together aspects of business, system architecture, the process-oriented organisation and the organisational structure.

Big data A broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualisation and information privacy.

BizDevOps The organisational principle of synchronising the business with its process-oriented organisation and its structure. BizDevOps provides a template for implementing B/A/P/O.

CapEx Investment or business improvement costs.

CE Consumer electronics.

CERT Computer emergency response team.

Deep and flat integration The depth to which applications and features are integrated into an overall system, indicating the degree of adaptation and dependency.

Deep learning The third stage of AI. Deep learning brings together big data analytics and self-learning algorithms with the aim of detecting patterns and learning from them.

DevOps Improvement of the development and delivery process, pulling the functions of development and operations into one team.

E/E Electrics and electronics as a subset of mechatronic systems.

End-to-end A professional mindset for planning the delivery of value. Working outside-in places the intended customer value first, with the secondary benefit of streamlining supporting activities.

EOP End of production.

HW Hardware.

Industry 4.0 IoT applied to industrial processes, including manufacturing and logistics.

IoT The internet of things is the network of physical devices (›things‹) embedded with electronics, software, sensors and connectivity enabling data exchange with the manufacturer, operator and/or other connected devices.

Lifecycle A phase model describing sales stages.

Lifetime The service life of a vehicle or product.

MMI Man-machine interface.

MVC Model-view-controller.

OEM Original equipment manufacturer; here vehicle manufacturer or brand.

OpEx Operational expenditures are expenses for running a business or service.

OTA Software updates over the air.

PO Product owner (role).

Privacy The ability of an individual or group to seclude themselves, or information about themselves, and thereby express themselves selectively. Of particular relevance for the data communication of cars to OEM and third parties.

REST Representational state transfer is a paradigm of providing interoperability between computer systems on the internet.

R&D Research and development.

ROI Return on Investment is a business metric originally developed by DuPont as a means of breaking down return on equity into three parts. ROI is gauged by asset turnover and profit margin.

Reuse Development cycles can be accelerated and made less expensive by using modules that have already been developed. It is important to strike a healthy balance between legacy and new systems.

Safety Generally more as functional safety: the control of recognised hazards to achieve an acceptable level of risk.

Security The security is the degree of resistance to, or protection from, harm. It applies to any vulnerable and valuable asset, such as a person, accommodation, community, nation, or organisation. Applied here to vehicles and its passengers.

SOA Service-oriented architecture.

SOP Start of production.

SW Software.

Tier-1/-2 Suppliers to carmakers at the first level and their sub-suppliers.

TTM Time-to-market.

Value proposition Part of the business strategy, a value proposition promises benefits to the customer.

Value capturing Mode of generating revenue in a digital business model.

Value creation Mode of providing benefits for the customer.

VUCA A world order model coined in US military research. A VUCA world order is influenced by volatility, uncertainty, complexity and ambiguity.

Survey participants (extract)

More than 30 interviews with decision-makers from vehicle manufactures and major suppliers were conducted. Our thanks go to our respondents for their valuable input and inspiring suggestions.

Kai L. Barbehön, BMW Group
Aine Denari, ZF TRW
Dr. Rolf Dubitzky, Valeo
Dr. Stefan Ferber, Bosch Software Innovations
Lars Fiechtner, VMware
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Thank you very much indeed.

Kornwestheim, September 2017

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