Capgemini

TECHNOVISION
2022

BEING LIKE WATER

AUTOMOTIVE

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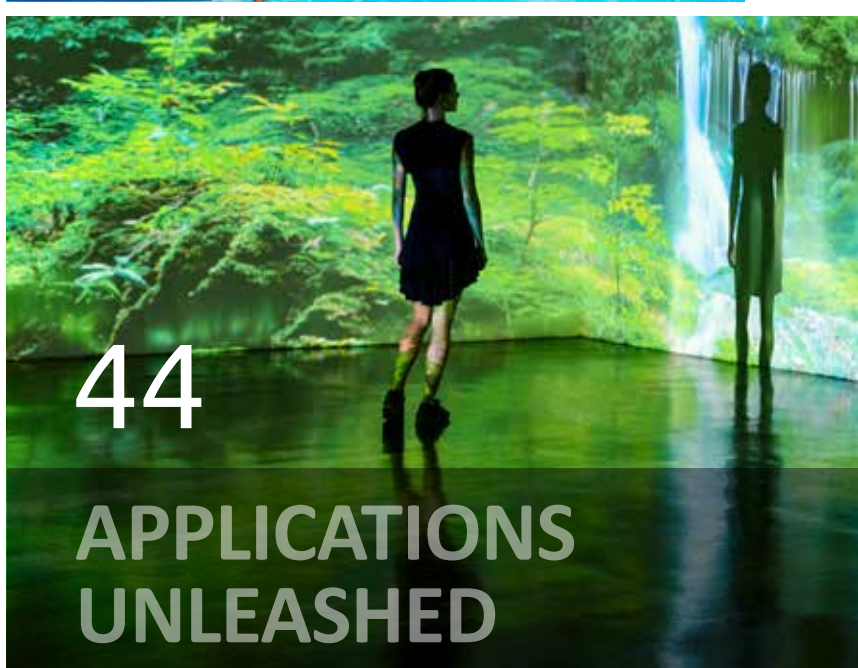
Foreword

Welcome to the first-ever TechnoVision Playbook for Automotive, which discusses how ideas from Capgemini's report TechnoVision 2022: Being Like Water could be applied to handle the disruptions facing the industry.

Now in its 14th year, TechnoVision is a proven source of change-making advice, written by our leading experts with the intention of helping to formulate enterprise strategies and transformation plans that can flow like water – that is, as efficiently, smoothly, and sustainably as possible.

It is probably clear why this theme is so relevant to the automotive world today. The whole industry is experiencing an unprecedented level of transformation, accelerated by customer demand for electric vehicles and by recent resource shortages. At the same time, companies are coming under intense pressure from all of their stakeholders to make their activities and products more sustainable as they work to optimize the industry's footprint.

The 2022 edition of TechnoVision presents ideas that a business could adopt to be able to achieve the flexibility necessary in order to thrive in today's unpredictable environment, and, above all, to become a Technology Business.

Specific examples and ideas are included to help automotive industry players respond to current challenges, astutely leveraging technology trends and keeping the innovation flowing.

So, what are you waiting for? Come on in, the water's fine.

Michael Schulte   **Alexandre Audoin**

Introduction

In a world where "normal" seems to be just a metaphor for something vaguely familiar but by no means permanent, we have come to accept the concept of Uncertainty^{squared}, where uncertainty about tomorrow has become a part of our daily lives today. Recognizing and responding to a rapidly changing environment is paramount for any organization. To thrive, businesses must fluently adjust their strategy to the challenges and opportunities they encounter, transforming both business and technology in a continuous, operational flow.

In India there is a concept called "Jugaad": a flexible and pragmatic way of problem-solving, using limited resources in an innovative way. A similarly frugal innovation approach – a concept that exists in some capacity in every culture around the world – is now more relevant than ever for businesses in the automotive industry.

As demand changes, and technology innovation continues to accelerate, a plethora of opportunities can be utilized by organizations to respond to the vast scale of change. Being fluid – "being like water" – helps organizations plan for the future, whatever it may bring. A "StratOps" enterprise will embody this fluidity. It will use technology to prepare the organization for this dramatically different world, to successfully face whatever challenge or opportunity it comes across. At the same time, it will maintain a powerful, directional flow to fulfill its corporate purpose.

Today, every business is a Technology Business (or as we like to write it, **Technology Ǝ Business**). Once we acknowledge that fact, technology can no longer be kept within the walled garden of centralized IT or R&D. It needs to be internalized, embraced, and utilized throughout the organization, regardless of business unit, activity, or individual role.

To aspire is no longer enough. It is vital for organizations to upskill scarce talent, embrace technology trends, and build on corporate objectives.

Furthermore, corporate objectives are changing. Sustainability has returned to the top of the strategic priority list after taking a backseat during the pandemic. Dealing with scarcity – in terms of not only natural resources, but human resources too – is rapidly turning out to be a determining factor for economic success. And finally, a newly emerging digital playing field has triggered a new wave of innovation initiatives. Leaders still focus on a superior "customer-first" experience and highly effective operations, but must now combine them with talent innovation and an employee-centric experience.

Whatever the business and societal challenges and opportunities are, they all have a common feature: they rely on technology to address them as an integral part of the change equation. Technology and business operations have become so intertwined that it is increasingly unclear where one ends and the other begins. That shows when looking at the TechnoVision trends in 2022, whether the focus is on user experience, collaboration, data, process, applications, or infrastructure.

These ideas are discussed in detail in Capgemini's report: TechnoVision 2022: Being Like Water. Their relevance to the automotive industry is apparent.
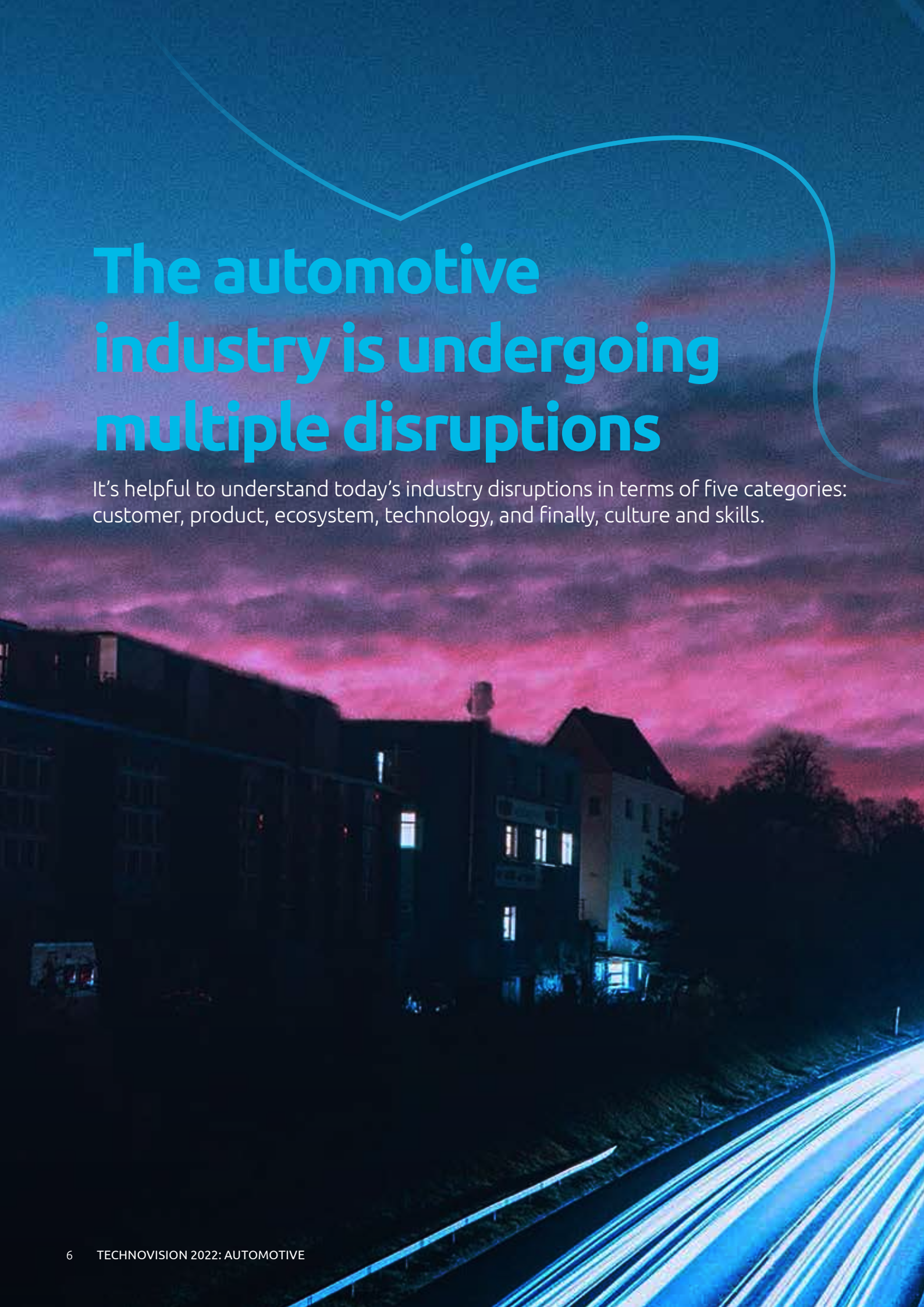
Jean-Marie Lapeyre   **Pascal Brier**   **Manuel Sevilla**

The automotive industry is undergoing multiple disruptions

It's helpful to understand today's industry disruptions in terms of five categories: customer, product, ecosystem, technology, and finally, culture and skills.

Customer disruptions

Digital first purchasing experience, and alternative ownership models

Vehicle buyers increasingly want an end-to-end online purchasing experience, from comparing to buying, to having their vehicle shipped to their door. This trend has been reinforced by the pandemic. Dealer networks still have an important role to play, for example in providing test drives, completing deliveries, and servicing vehicles.

The ownership model also looks to be set to change as alternative options become more popular, including carpooling, ride-hailing services, short-term rentals, and community fleets. Original equipment manufacturers (OEMs) may therefore need to design vehicles specifically for car-sharing (for example, with hygiene features such as air purifiers and ionizers to reduce the need for manual cleaning), alongside services to make sharing easier. In future, rather than paying a set price for their new vehicle, customers may even have the option of paying a per-kilometer or per-mile fee, provided micro-billing can provide a seamless experience.

Extended customer relationships

Traditionally, the customer relationship began with a quick trip to a dealer showroom, but it now starts long before with visiting brand websites, browsing on "MyBrand" smart apps or kiosks, or clicking online ads. Customers will typically use these facilities to gather information, configure the vehicle that they'd like to test, and perhaps even see visualizations of it with them inside.

And similarly, the sales journey does not end when the vehicle leaves the dealer's lot. Historically, interactions after the sale were limited to occasional servicing and, even more rarely, the acquisition of branded accessories. Customers, however, would probably always have preferred a more meaningful relationship throughout the lifecycle, and OEMs are now increasingly providing one – for example, via ownership services, regular over-the-air (OTA) updates, the availability of new apps, and other means.

Extended and diversified drivers' journeys

A typical trip used to start with getting into a car and turning the ignition on and end with stopping at the destination. Soon, the interaction will be extended at both ends.

In the car of the not-too-distant future, before the driver gets in, the extended car system could check the calendar for the intended departure time, and then prepare by loading the destination into the navigation system, tuning to the driver's preferred music stream for a given journey type, and pre-heating the vehicle according to their preferences.

And after the driver gets out of the car, it could park, plug itself into a charging station, and begin drawing power when it is cheapest and most sustainable to do so, while ensuring a full charge in time for the next departure. Alternatively, the vehicle could transfer surplus energy that it has stored into the owner's grid.

Product disruptions

Electrification and the race to sustainability

Electric vehicle (EV) sales are booming, and general expectations in the race to net zero will push several key industry processes beyond the point of compliance with Worldwide Harmonized Light Vehicle Test Procedure (WLTP) standards. Additional concerns include the availability of materials for batteries, the sustainability of the entire supply chain, the need for more charging stations, and recycling capacities.

Sustainability also creates additional opportunities. The already dynamic used car market has been boosted by the unavailability of new vehicles, arising in part from the prolonged shortage of semiconductors. This market could be further complemented by conversion offerings – such as fitting electric engines into old cars – a step beyond traditional refitting and retrofitting.

A new level of personalization and adaptation

Tesla has demonstrated that today's customers may be less focused on historically important features such as exterior trims and want more individualization of their experience. OEM responses range from enabling the customer to choose themes for screens and interior lighting, to dynamically integrating the car with the customer's digital life and providing a seamless experience when and where appropriate.

A topic of major interest is the ability for vehicles to evolve continuously throughout their lifecycle, with new features and functions regularly offered, much like smartphone updates. These will typically be delivered either through OTA updates or by activating new functions to leverage installed hardware.

Maximum ease of use

Even if – despite high expectations – fully autonomous vehicles are still a few years away, Advanced Driver-Assistance Systems (ADAS) are featured in a growing number of new vehicles. For a growing range of driving tasks, we can expect to see more intuitive user interfaces that minimize the

effort and attention required from the driver. Production of these interfaces requires integration between onboard applications, and an onboard user experience that aligns with what users know from their smartphones.

Also, it is no longer enough to have the ability to connect a single phone to the vehicle via Bluetooth: the vehicle needs to become a hyperconnected node, fully integrated in an extended digital ecosystem, interacting both through its built-in interfaces (screen, voice, and other sensors) and via smart devices.

Ecosystem disruptions

From selling vehicles to providing mobility services

Customers are increasingly looking for the ability to select the optimum way to get to a particular destination, potentially combining different modes of transport. To deliver the right experience to customers, OEMs are progressively combining their own products and services with third-party offerings available in the consumer ecosystem in a way that achieves seamless transitions between the various segments of the journey.

This underlines the general shift of emphasis from vehicles to services. To profit from this shift, it is critical to understand what customers really expect, need, and are prepared to pay for; analysis of socio-cultural trends and categories can shed light on the expectations of different customers in different domains.

Changes to ecosystem participation

The automotive industry is already a very open ecosystem with a large network of established companies working together in a mesh with varying degrees of tightness. Today, a growing number of new entrants are starting to reshape the industry's traditional segmentation. These include new pure players (like EV-only startups), as well as established technology companies native to other industries, expanding their portfolios by offering either complete vehicles or key components (such as cockpits or ADAS).

The traditional business model of Tier 1 suppliers is particularly challenged by these changes. It's not just that OEMs are investing to regain control of embedded software – now understood to be key to capturing value; in addition, semiconductor players, historically Tier 2+, are expanding their product stacks upwards to include middleware to directly address OEMs' needs. Also, alternate innovative offerings are coming from the telecom and consumer electronics industries. The role of a system integrator is being redefined in the process, relying increasingly on software expertise.

Compliance, standardization, and "coopetition"

The regulatory pressure on the automotive industry keeps increasing. As well as more stringent safety standards, stricter social and environmental targets, and growing privacy protections, there will be specific cybersecurity requirements. All these pressures force additional expenditures but can also create opportunities – the same way eCall triggered several investments in value-added connected vehicle services.

The shortage of semiconductors during the pandemic highlighted OEMs' dependence on extremely specific components. More generally, the issue stresses the lack of flexibility of existing vehicle electrical and electronic (E/E) architectures and challenges the industry-specific character of automotive technical standards. In contrast, the IT industry has developed numerous standards over the years to support interoperability and flexibility (such as hardware abstraction layers).

Cooperative efforts are ongoing to define standardization or create industry-level components in areas that are not differentiators for brands. Examples include the collaborative definition of detailed test case catalogs that are consumed by virtual simulators used for homologation processes, and the recent creation of the Software-Defined Vehicle Working Group hosted by the Eclipse Foundation – an open source organization well established in the software development community.

Technology disruptions

Software-driven transformation and platform approach

Products, industrial environments, and enterprise processes are progressively being transformed to be primarily defined, designed, and operated around software.

In the near future, vehicle capabilities (other than purely chemico-mechanical ones) will be determined less by the characteristics of a large collection of specialized microcontrollers, and more by software running on increasingly generic and integrated hardware.

One benefit of this emerging transformation will be the displacement of complexity from the physical hardware to the software stacks – which are likely to be easier to manage thanks to well-established design patterns and tools: service-oriented architecture, microservices configuration management, container-based deployments, etc.

Also, more raw information processing power in addition to hardware abstraction opens up the possibility of a flexible platform approach. Software capabilities can be deployed

on standard electronic hardware used across the range, and then configured according to the options desired and bought by an individual customer, with the additional ability to more easily integrate third-party service offerings.

Functioning increasingly as active participants in an extended environment, vehicles will not only be permanently connected, consuming and exposing services, but will soon be routinely interacting with infrastructures (motorways, city systems – V2I), other vehicles (V2V), and – maybe one day – other public road users such as cyclists or pedestrians.

Industrial automation and technological convergence

Industrial processes are also tapping the possibilities of cheap computing power attached to each device, as well as high-speed connections to centralized capabilities that now appear limitless. In this way, operational technology (OT) and information technology (IT) are converging quickly.

Production line automation is going through another wave of improvements to increase efficiency and quality. In particular, a flurry of AI-based systems are being installed, for example, to analyze camera outputs to carry out shop-floor quality checks on the assembly line, to optimize the loading of trucks to reduce space utilization, or to power augmented reality goggles to minimize operators' mistakes.

Safety and cybersecurity

The dark side of using software-defined systems to manage complexity and provide flexibility and value is that it increases the probability that defects will occur and creates a larger cyber-attack surface. It will require significant effort to monitor, prevent, and be prepared to react to these issues, drawing on practices well established in other sectors like banking, aviation, and defense.

In fact, it is expected that legislation will force this additional investment – naturally triggered by safety concerns but also fueled by growing expectations surrounding corporate responsibility (for example, protection of employees in their work environment).

Culture and skills disruptions

The need for agility

Waterfall processes are ill suited to today's dynamic environment because of the tension between the fast-paced development of microservices-based software and much slower vehicle lifecycles. What is needed instead is the water-like fluidity associated with Agile.

Pure EV players have already extensively adopted end-to-end Agile approaches and have shown that they can sustain them for the long haul, releasing product software updates monthly (or even weekly). This is a significant cultural change for the industry – one that will force a rethink of some of the key rules of its traditional operating model.

For example, hardware and software development models are being rethought using relevant abstraction approaches and "service contracts," from which vehicle features can then be derived.

Tackling unprecedented skills shortages

The transformation of the automotive industry requires blending skills from traditional engineering and IT. The new profiles are scarce on the market and are also in demand by other industries that have already set a high bar in hiring, training, and retaining the best talent. Massive recruitment targets already announced across the industry, that have not yet been translated into significant workforce increases, will exacerbate the situation.

New initiatives are appearing to tackle skills shortages in different ways. These include setting up software academies, launching massive reskilling programs, and spinning off dedicated software subsidiaries, often in partnership with tech companies, to create long-term career perspectives for possible candidates.

A more original concomitant approach is to augment the current workforce with AI systems.

HOW CAN THE TECHNOVISION AUTOMOTIVE PLAYBOOK HELP?

Embrace innovation

Innovation helps with tackling all these disruptions – and it is as much a matter of culture as of applied technology. To occur, it needs a meaning and vision that can only be defined within a cultural framework.

Most of the time, innovation can be achieved through a series of clever, inventive ways of making things work, simply and with reasonable effort, without a revolution. This is Jugaad in action.

Innovation does not necessarily mean invention; often, it just consists of reusing a good idea in a different context. Illustrating this fact, software transformation is, to a large
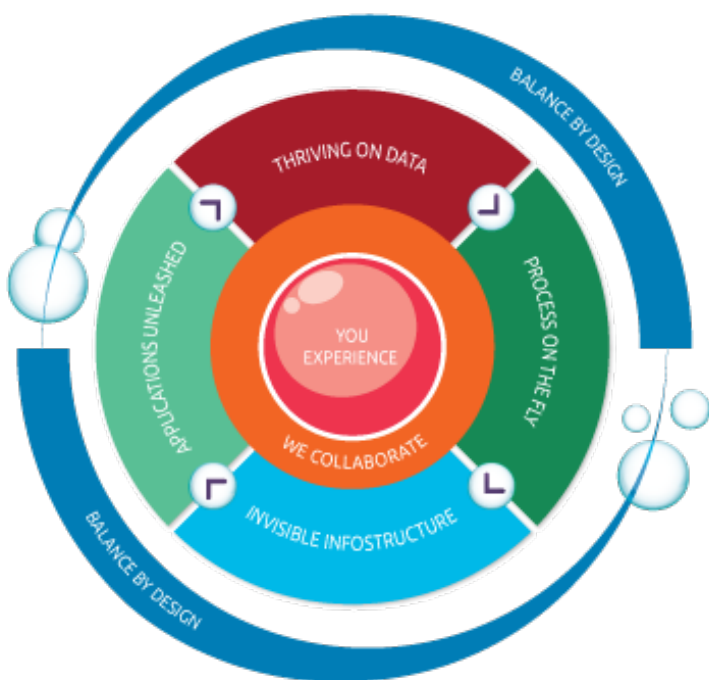
extent, about combining the techniques and practices of engineering and IT. Nothing fundamentally new is invented; rather, existing techniques are applied differently – and typically with a lot of perspiration.

Companies need a measure of water-like flexibility to achieve this type of sustainable innovation amid today's unpredictable conditions.

How to use this playbook

This TechnoVision playbook aims to present some of these ideas, and to illustrate them with real use cases from the automotive industry.

It categorizes technology drivers into six containers that cover the "what" of Technology Business trends, and a seventh container covering overarching design principles – the "how" of creating a balanced Technology Business.

We start with "You Experience," which is about creating seamless, individualized user experiences. Next, "We Collaborate" taps into the power of teams and social connectivity. We then cover trends in the fundamental building areas of data management and processes in "Thriving on Data" and "Process on the Fly," and then infrastructure with "Invisible Infostructure" and applications in "Applications Unleashed."

The final container, "Balance by Design," covers overarching design principles (the "how") that should form part of a Technology Business's mindset – and describes four key transitions that a company will undergo on the journey toward becoming a fully portable, continuously flowing, and balanced Technology Business.

The containers are further subdivided into 37 building blocks.

If you are interested in the longer-term vision of technology trends, the end of the playbook includes a section called "A Few More Things," where we look into the more distant future.

To take full advantage of the TechnoVision Automotive Playbook, 2022 edition, we recommend that you navigate it alongside the original TechnoVision 2022 report. It will provide a helpful reference if you want to explore a specific trend in more detail.

Want to know even more?

If you wish to know more, you can contact our experts in residence, who feature prominently on the container pages. Don't hesitate to reach out to them if you are interested in more cases – they will gladly accommodate your request.

Meanwhile, what are you waiting for? Dive in!

YOU EXPERIENCE

The definition of a highly personalized, seamless user experience – literally, a You Experience – has been included in our TechnoVision dictionary for some time. Yet, as technology entwines itself in our daily lives, the user experience is no longer a separate discipline. It is now an integral part of how we experience life: at home, at work, when shopping, traveling, or even when enjoying leisure time. Organizations can no longer take the well-loved "customer-first" route, but must consider "employee-first," and even "partner-first" routes too, considering user experiences from a holistic, end-to-end perspective. Loyalty, advocacy, and satisfaction remain buzz words, now in the company of talent retention, engagement, and emotional connection to boot. Here, we should take the principles from the School of Positive Computing to heart and apply well-being factors such as self-awareness, mindfulness, empathy, and compassion too. Call it *Us Experience***, if you like.**

More than ever, it's customer first

Customer orientation is not a new trend, but it is more critical than ever because of the rise of direct sales and software transformation, and, above all, growing customer expectations of a highly individualized, seamless experience. And the shift to service orientation means that automakers are trying to satisfy these expectations while maintaining an uninterrupted connection with customers via continuous OTA updates, while still providing safety, reliability, and robustness to fulfill their basic contract with the customer.

The driver's seat is getting more comfortable

You read my mind

Customers expect their cars to learn what they want in the same way their smartphones already do. When they get into a vehicle – even one that they just hired from a car-sharing service – it should know their preferences for infotainment channels, temperature, journey patterns, and more. And it should not retain Bluetooth smartphone registrations for every previous driver – only the current driver's phone should be registered. One way to achieve this level of personalization could be through the use of personalized digital keys to open the vehicle.

Don't interrupt

As the industry's focus shifts from vehicles to transportation services, an important differentiator for OEMs will be the ability to deliver a continuous experience throughout a multi-modal journey. For example, when traveling to a busy city, the driver may decide to park in the suburbs and then take a bus the rest of the way. That transition will be a lot simpler if an app within the initial vehicle helps the driver find the bus and then pay the fare.

Inside the vehicle, too, automakers are aiming to securely – and legally – integrate the customer's digital life with effortless switching between apps. In addition, customers expect to be able to use the same apps and the same account information across their devices.

Immersive, multisensory help along the way

Virtually every new vehicle now has at least one screen, providing a way to communicate with everyone in the car about the temperature, radio channel, desired route, and potentially any aspect of the customer experience. For this reason, something as basic as screen size can determine whether a customer chooses a particular vehicle model.

Increasingly, communication doesn't stop with the screen – drivers can now effectively control vehicles via voice commands and receive spoken responses. The vehicle can also deliver a multisensory experience in other ways, for example by spraying a mood-enhancing perfume into the vehicle's interior. If used judiciously to avoid distraction, immersive technologies can help with driving too. For example, augmented reality (AR) can flag up vulnerable road users ahead.
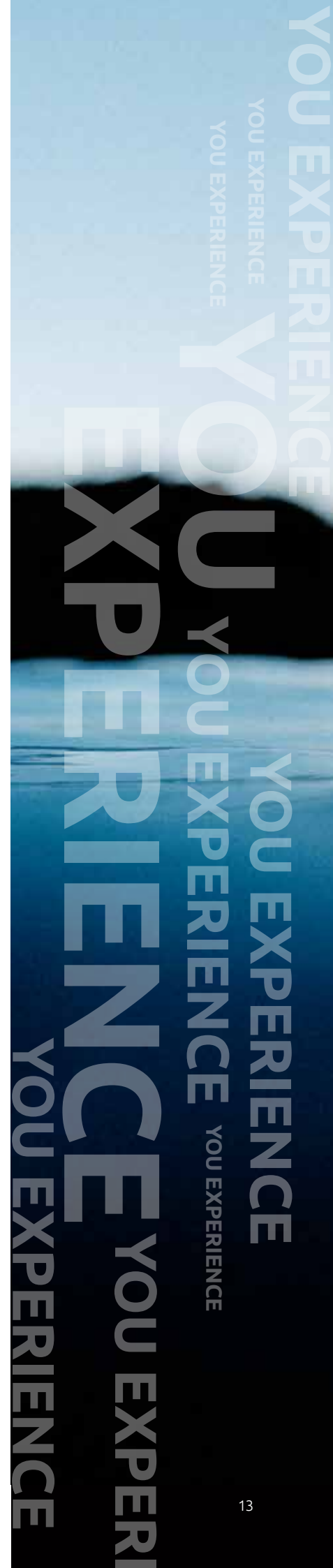
Behind-the-scenes support for customer experience

The move to direct selling and an extended OEM-customer relationship needs suitable back-office support. For instance, it should be easy to pay for services purchased on the fly, perhaps as part of a monthly consolidated charge. Customers could even be billed for their vehicle by the mile or kilometer rather than paying a one-off purchase price.

Employee experience – the new talent magnet

Software transformation is turning more employees into technologists. Once you've recruited talent with those scarce skills – or upskilled existing employees – it's vital to keep them happy and productive. It is also important to help them adapt fast to rapid changes in the environment.

This means providing an excellent employee experience, including through the use of supportive technology. For example, organizations can use virtual reality / augmented reality (VR/AR) goggles in a number of situations: to help warehouse employees locate items faster and more accurately, equip plant floor staff to adapt to changes, or enable highly skilled engineers to evaluate product ideas faster. As well as the right tools, it is vital to provide the right information, which implies breaking down current barriers between information silos. Increasingly, OEMs will want to extend the same type of information sharing and other support to key partners.

Valentina Sanna
Expert in Residence

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Expert in Residence

EXPERIENCE²

Creating a user experience as an integrated whole, seamlessly covering the perspectives of customers, employees, and partners, enabled by all available variants of UX technology

Automakers need to work out how to create signature moments – aspects of experience during the purchase process or ownership cycle that impress customers and are remembered for a long time. For example, if, when you were a child, your family car survived a significant collision with minimal damage, there's a good chance you'll be a customer of that brand for the rest of your life.

The question for automakers is how to build brand loyalty by creating comparable experiences in today's vehicles. Individualization can play an important part here. If a customer feels that their experience is continually becoming more unique to them – ideally to the point where they can imagine that the car was specially created for them or is able to be updated based on their wishes – there's a significant chance they'll remain loyal to that brand.

Audi is creating a universal digital customer experience: integrated user experience

A personalized website, improved myAudi app features, and additional consultation options: Audi is pushing the digitalization of marketing, sales, and aftersales further. Audi believes that interested parties and customers should be offered the possibility of a seamless, emotional, and intuitive brand experience – online as well as offline, across all contact points, from initial interest in a model to the utilization phase. The website is the point of entry into Audi's digital offerings, providing personalized information on all models and services. At its heart is an interactive car configurator with high-end visualizations and detailed information. At any point during the configuration process, the user has the option of saving their selected configuration online using a code, downloading it in the form of a brochure, switching directly to an online consultation, or scheduling a test drive at a local dealership.

With virtual vehicles available, individualization becomes relatively easy. Being offered a new feature displayed on an image of the selected model and color, rather than a generic image, can change the customer's experience completely, and increase the chance of a purchase.

BMW's browser-based AR tool: exploring vehicles with AR and voice

BMW has launched its first AR tool, the BMW Virtual Viewer, in the UK, focusing on BMW's PHEV model. Antiloop built the experience with support from CRAFT, and it is powered by 8th Wall technology. Using smartphones to access the BMW Virtual Viewer in a mobile browser, users can instantly place a new BMW PHEV X5, X1 or 3 Series Touring anywhere in their home, driveway, or garage to see how it looks. They can customize the car, picking a color, choosing the alloys, and tweaking the interior. They can experiment, opening the doors, turning the lights on, even playing the radio. In addition, they can get an x-ray view of the inner workings and see how a PHEV switches between petrol and electric mode. The BMW Virtual Viewer also offers handsfree voice navigation. Simply by talking to the BMW chatbot, users can explore every aspect of the experience, ask questions about the PHEV range or electric/hybrid driving, and even try quizzes.

ME MYSELF AND MY METAVERSE

A new virtual world augments real life, creating a potentially profound impact on the way we live, work, and collaborate

Early in the pandemic, when customers couldn't visit dealers, sales plummeted. Harnessing the metaverse concept means that need not happen again in a similar event. Virtual showrooms have been piloted where customers can walk around looking at different models and colors, get a 360^0 view of a car's interior, see a virtual version of themselves and their families sitting inside, compete in an e-sport tournament, etc. And customers can be given access to a virtual copy of their chosen vehicle, that they can iteratively customize until it matches what they want – speeding up the purchase process with no need for customers to leave home.

This is just one of many examples where concepts like 3D and visualization can help automakers improve customer experience. Of course, these ideas have been around for a while and have helped with R&D tasks, enabling customers in different markets to experience mobility services or autonomous driving. As well as publicizing and promoting future offers, these platforms give automakers a chance to see how customers will react to different features so that they can tune the design.

Hyundai's metaverse space for young consumers: relationship building in virtual worlds

Hyundai has collaborated with online entertainment platform Roblox to step into the metaverse with "Hyundai Mobility Adventure." Featuring Hyundai's advanced products and future mobility solutions, it targets technologically savvy young consumers who are accustomed to exploring virtual worlds beyond physical experiences. Hyundai Mobility Adventure aims to nurture long-lasting relationships with fans, at the same time

familiarizing them with Hyundai Motor's products and solutions. Users can experience future mobility offerings via customizable avatars and communicate with other users by having their avatars interact.

Similar concepts are increasingly used in factories, with smart glasses that tell workers the best order in which to tighten bolts for optimum strength in a vehicle or remind them to screw in a particular bulb. It is already happening, and we'll see much more of it. Additionally, metaverse concepts can help with collaborative design and testing.

Kia Motors' collaborative extended reality (XR) design technology: combining digital and physical prototypes

Kia collaborated with Autodesk, Varjo, and Nvidia to integrate Autodesk VRED and the Varjo XR-1 Developer Edition to merge the best of the virtual and the real worlds. VRED's rendering features combine with Varjo's high-resolution XR technology to enable designers to compare digital and physical prototypes side by side. This capability enhances creativity, enables faster prototyping, and allows collaborative design reviews from anywhere on the planet. Users can review and interact with human-machine interface content from inside the digital car. They can also evaluate materials with intricate patterns and structures or conduct design reviews to understand the final customer experience before building the first physical prototype.

Early adopters are showing that the technical solutions in this area are already feasible, but before they can be industrialized, issues around cost, data interoperability, and scalability must be resolved.

NO FRICTION

The Experience Economy becomes real, enabling businesses to provide truly frictionless and never seen before "phygital" experiences

It is clear that we need to join up the various touchpoints between customer and brand so that the experience is free of friction. If a customer goes to a website or mobile app to find out about a vehicle they may want to buy, they should get exactly the same information as they do if they go to a dealer. This can be hard to achieve, particularly where dealers have historically owned the relationship. Leading automakers are discovering ways to track a customer's journey, to find out when they have visited the website and what information they were given, and to make sure the offers they receive in different channels match one another.

It will be increasingly important to crack this problem because in the future automakers will need to be able to interact continuously with customers, supplying new services and updates, rather than just doing so at the point of sale and occasionally thereafter. One element of this will be to design the back end correctly, so that, for example, customers receive just one invoice monthly rather than multiple invoices for different services they've subscribed to. Another will be to offer frictionless support, perhaps via an in-car virtual assistant. And, of course, the costs must always be justified by the impact on the brand value.

Toyota Driver's Companion: AI virtual assistant to speed learning

In Japan, Toyota Motor Corporation launched its new Driver's Companion and digital owner's manual, which features "Joya," an AI-powered, voice-activated virtual assistant to help drivers learn about the features and controls of their vehicle. Drivers ask questions, and Joya provides a real-time response. Initially offered as a pilot program on specific models, Joya is accessible through

the Toyota App as part of Toyota's Connected Services offerings, a platform that serves as a remote link to Toyota vehicles via a smartphone. The Toyota Driver's Companion also assists drivers with tasks such as defining personal settings, locating buttons and controls, and exploring vehicle features, including safety information. Drivers can explore the vehicle's interior virtually and learn more about how to interact with its functions, such as how to fold down the rear seats or open doors.

For employees, friction can arise from any inconvenience or interruption that causes frustration and impedes productivity. Fortunately, approaches similar to those outlined for customers can remove friction from employee experience and improve collaboration across the whole ecosystem.

Mercedes-Benz's mixed reality support solution: redefining maintenance virtually

Mercedes-Benz USA has collaborated with Microsoft on Virtual Remote Support, a solution intended to redefine the company's automotive maintenance process and the way that its service technicians work. It aims to enhance customer experience and create greater efficiencies in communication and employee safety. Powered by Microsoft's HoloLens 2 device and Dynamics 365 Remote Assist platform, the mixed reality system enables onsite dealership technicians to work handsfree, sharing real-time images and sounds from a vehicle while talking with Mercedes-Benz technical specialists. The specialists' insights and guidance should make it possible to resolve complex maintenance issues more quickly and efficiently.

I FEEL FOR YOU

Boosting both the individual and corporate EQ, by creating a more effective, meaningful, and satisfying symbiosis between people and their technology enablers

The mass of data that companies are going to be collecting needs to be translated into empathy with the customer – a feeling that the brand understands the individual's needs and preferences and is ready to meet them. A driver who is using more fuel than necessary can be offered corrective training or coaching, for example. And sensors together with AI can read the driver's mood and adjust the in-vehicle environment accordingly. All this has to be done judiciously – the driver will still want to feel in control, and not have some Golem-style machine take over from them.

Hyundai's AI-based technology: optimizing vehicle environments based on emotion data

In collaboration with the Massachusetts Institute of Technology (MIT) Media Lab, Hyundai is developing Emotion Adaptive Vehicle Control (EAVC). This technology combines sensor data about an individual's facial expressions, heart rate, respiratory rate, etc. with vehicle data, including measurements of speed, acceleration, noise, and vibration. The combined data is processed using machine learning (ML) to optimize the vehicle environment via vehicle systems that control lighting, climate control, music players, or fragrance dispensers. As part of a bigger project called Little Big e-Motion, the technology has been installed in a special minicar designed to reduce stress in child hospital patients. The vehicle uses information about a child's mood to help them become more comfortable, for example by playing reassuring messages and cheerful tunes.

Where data is not anonymized, customers need to be comfortable with the way it is being used, and to view the related services as empathetic rather than intrusive. This is partly a question of consent – yet asking for that consent may make some customers defensive. It's a problem we need to overcome, in order to both offer customers the right experience and start monetizing data. Order is important here: the customer experience needs to work before the data can be monetized.

Volvo's decision to share its library of (anonymous) accident data was made for altruistic reasons, but it also strengthened the company's image as the safest brand, in a similar way to its historic decision to not patent safety belts. Both decisions convey empathy – and it's always a good idea to play to the strengths of the brand.

Volvo's digital library of safety knowledge: sharing data industry-wide to increase safety

Volvo maintains a library containing the results of its many decades of research into accident data. Since 2019, Volvo has offered this resource to the entire car industry to use freely in the interest of safer roads for all. The library, called Project E.V.A., contains data on tens of thousands of accidents – initially collected to help ensure the safety of Volvo cars. Volvo has used this data in many ways over the years. For example, it created crash dummies to better understand why women are more likely than men to suffer certain injuries in car crashes, which led to the creation of seats with whiplash protection. Some innovations resulting from Volvo's research have become standard across the industry, including side impact protection systems (SIPS), side airbags, and inflatable curtains.

MY OWN PRIVATE AVATAR

Hyper-realistic representations of humans bring unprecedented and unexplored ways to communicate within the context of virtual channels and the Metaverse

Avatars are an essential element of the metaverse concept because they can represent the individual within a virtual world. Today's technology means that these representations can be highly accurate.

In the context of a virtual showroom (or virtual used car lot), creating a realistic avatar for a customer will help them to see how they would look in their new car. And once the vehicle is on the road, avatars can be a compelling way to communicate. Customers brought up on gaming will take to these ideas with enthusiasm. In fact, this could be a way for automakers to get customers to spontaneously promote the brand on social media. A brand's customer demographics will affect the success of this type of initiative.

Porsche's in-car virtual influencers: enhancing experience with avatars

Porsche Ventures has invested in Chinese technology company iMaker, and the two partners are planning to build a new digital ecosystem that will extend and enhance customers' digital experience in Porsche vehicles. In-car applications will communicate and interact with younger customers through virtual influencers: avatars with highly realistic facial expressions and body movements. Virtual influencers are becoming common on social media platforms such as Instagram, often specializing in fashion. In Asia, virtual influencers are increasingly being used by the music industry, at live events, on social media platforms, and in corporate communications.

Avatars can also be a tool for making collaboration between remote workers more rewarding, as well as for training. And they can enhance simulations of industrial processes to help iron out problems – sometimes even before they occur.

BMW's simulated production line: avatars help to pre-empt process issues

BMW has used avatars in a highly detailed and realistic simulation of a production line, powered by Nvidia's Omniverse, to prepare for making EV drivetrains at a factory in Regensburg, Bavaria. Omniverse allows processes to be simulated with photo-realistic details, taking into account physical properties such as gravity. Taking advantage of the avatars' ability to represent human workers grabbing parts and tools and assembling components, these simulations help managers to plan and optimize processes and to prevent ergonomic problems well before the production line opens. As well as making processes as efficient as possible, simulations like this could also be used to train robots to perform increasingly complex tasks.

As always, the costs and benefits will be carefully weighed up before solutions of this kind are industrialized.

WE COLLABORATE

Back to life, back to reality. The world may return to some semblance of what it looked like before the pandemic, but many realities have changed irrevocably – how businesses operate being one of them. Many aspects of value delivery are now entirely independent from location and time. People work together in different ways, in different setups, increasingly at the very edges of what used to be considered the "core organization." Consumers and employees expect integrated experiences, with their latest online endeavors fresh in mind. It requires a new level of cross-organization, cross-sector partnering to meet these expectations. Distribution is the leading design principle, together with mesh-style, loosely coupled collaboration. And with physical and digital worlds fusing, it is no longer clear where the technology network ends, and the business network begins. Oh, it's back to life. But not as we know it.

It's not *what* you know...

The industry already has a functioning and open ecosystem, but right now this is an extremely dynamic space, with new entrants appearing and existing suppliers aiming to extend their offerings. Securing the right partners is critical to success, and so is integration – the assembly of multi-sourced elements into a single offering. This is similar to what OEMs traditionally do when they combine electronics, tires, etc. to make a vehicle, but it becomes orders of magnitude more complex when software has to be assembled too.

Vehicles that work together

Vehicles collaborating to support autonomous driving

V2V communication and collaboration can facilitate autonomous driving. For example, if there's an accident on the road ahead, the vehicle can warn approaching vehicles to avert further accidents. Emergency vehicles can warn others to give way to them as they rush to an emergency.

Collaboration with infrastructure to improve EV use

EVs can be made more economical and sustainable if they can communicate with the grid to agree when to draw energy from the network (and maybe even when to upload it). This is just one example of how V2I collaboration can support both conventional and autonomous driving.

Collaborating on mobility services.

Vehicle to everything (V2X) collaboration can dynamically improve mobility services. Suppose a proposed route involves driving to the station and then taking the train. The vehicle can be warned about delays on the rail system and then advise the customer to continue their car journey instead if that will be faster.

Candidates for collaboration: not just the usual suspects

By collaborating with consenting customers, data about vehicle use can be used to steer continuous improvement. Marketing can use data about the use of current services to identify which new offers should be prioritized. It might even be possible to configure features such as adaptive cruise control to suit individual preferences.

For strategic reasons, OEMs may even decide to collaborate with competitors, for example on operating systems and standards. Models for this coopetition are emerging. OEMs will also want to collaborate with government bodies to provide mobility as a service (MaaS) in cities along the lines laid down in Europe by the MaaS Alliance or the city of Dijon.

And AI should be seen as a potential collaborator within teams: every step of every process should be examined to evaluate if AI could make it cheaper, more sustainable, or otherwise better.

Succeeding with an ever more diverse ecosystem

OEMs and their partners need to develop the standards and APIs needed for effective collaboration. And as data is increasingly shared between partners, success will depend on collaborative approaches to tasks like implementing secure data-sharing processes and guaranteeing data accuracy, integrity, and privacy.

Some aspects of this collaboration will be challenging for automotive companies that are used to carefully guarding their intellectual property and data. They may be able to learn from the IT and telco sectors here. Meanwhile, data exchange is being pioneered by initiatives such as Gaia-X (an EU-sponsored federation of data infrastructure and service providers) and Catena-X (a group of automotive companies aiming at simplifying data exchange along the value chain).

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FLUID WORKFORCE

An agile, adaptive workforce model that boosts organizational resilience and productivity, saves costs, and addresses the shortages of skilled resources

In the US, the "great resignation," as the media have been calling it, is contributing to rapid staff turnover and serious skills shortages. Elsewhere, the resignations may be fewer, but the talent scarcity is real. In some ways, the automotive industry is suffering more than average because of its need to tap into the newest technologies. On the other hand, in these days of rapid change, a fluid workforce can be a good thing provided you have the right ways of managing it.

Companies have a range of tools for tackling this challenge and they need to use all of them. To acquire and retain top talent, they should create an attractive working environment – one that helps their employees feel comfortable with the "new normal." Some are introducing IT tools to help them achieve this.

Software tools to optimize Fisker's working environment: empowering employees with digital admin tools

EV and advanced mobility solutions provider Fisker has chosen ServiceNow's IT Service Management (ITSM) Pro and Software Asset Management (SAM) solutions to create the right environment for its employees. Digital workflows make it easier for employees to get work done, enabling them to spend less time on non-critical tasks and more time on building a reimagined EV experience. SAM helps optimize IT productivity, costs, and resilience, enabling employees to work faster and smarter. Together, these solutions will help Fisker create more meaningful experiences for employees and, in the future, customers.

Because of the pandemic, health & safety is a key consideration for workers and employers alike. Once again, there are software solutions available to take care of some of the legwork.

Volkswagen Group of America's workforce safety solution: streamlining the return to the workplace

Appian's Workforce Safety solution is helping VW to manage the phased return of most of its US workforce to the workplace. Hosted in the cloud, the solution has provided Volkswagen with a fully integrated solution, including a central command center to monitor the health and work status of its employees across all locations in real time. The solution's mobile pass feature uses self-reported employee health screening to automatically and intelligently generate "safe to return" designations that are displayed on an employee's mobile device. Case management capabilities enable contact tracing and the resolution of exceptions and appeals.

To quickly cover the inevitable skills gaps, companies also need to adopt great training techniques – some are using VR to train people in particular aspects of vehicle assembly, for example. Tools are also needed to address knowledge management, ensuring that flexibility is retained even when key employees resign or retire. AR and AI can be used to make new employees productive fast, as well as to reduce dependency on humans through automation (which also reduces failures).

It is often necessary to think outside the box – or outside the company – to solve the talent conundrum. Companies are increasingly ready to collaborate with individuals and organizations anywhere in the world to access talent: the pandemic has shown what is possible. Some may even decide to collaborate with suppliers on talent management.

Experienced IT and engineering professionals can be in particularly short supply, and have expectations of their own about the working environment. Spinning off a separate software company to serve all of a group's brands can make the most of existing talent and attract individuals who might not normally consider working for an OEM.

THE TEAM IS THE CANVAS

Collaborating in teams-oriented workspaces becomes the new natural way to create next-level business results

Virtual canvases help teams work together better. When employees started working remotely at the beginning of the pandemic, teams in many organizations missed their physical whiteboards for sharing ideas and making things happen. That problem was solved by adopting virtual whiteboarding tools. This type of canvas-based interaction is particularly important for today's highly collaborative style of working, in which product teams increasingly own and drive development and associated business functions.

Canvases are not just useful for development teams. On the shop floor, screens above the production line can give teams the ability to view the whole line and halt it if anything goes wrong. And AR can be used to communicate with ecosystem partners too.

Aftermarket AR trial at Daimler Trucks North America: virtual collaboration facilitates repairs

Daimler Trucks North America (DTNA) has piloted Microsoft's HoloLens AR technology as a method of virtual collaboration with dealers and customers. In testing, DTNA leveraged a combination of Microsoft technologies, including the HoloLens 2 platform,

Dynamics 365 Remote Assist, and Teams, to enable service technicians to connect directly to DTNA subject matter experts across the organization who were able to project service manuals, schematics, and other documentation across their field of vision while troubleshooting vehicle repairs.

However we feel about it, interaction with the world increasingly occurs through screens. Younger members of the workforce have grown up learning via YouTube and similar platforms. To help them work and collaborate effectively, they need this type of canvas at work.

TAKEN BY TOKENS

Emergence of a "Token Economy" through the convergence of "real" and digital assets within real and digital business models – converging on themselves

With their ability to bring real and virtual worlds together, tokens can benefit automotive companies in a variety of ways. In a car-sharing scenario, a token could facilitate the process of checking the availability of someone's car and then booking it and arranging pickup. Tokens and distributed ledger technology can also offer a way to collect payment for services purchased on an ad hoc basis. The jury is still out on the value and sustainability of blockchain for the industry, but it could prove useful for verifying the provenance of parts, and recent industry experience suggests that tokens are definitely worth thinking about.

Mercedes-Benz's easy in-car payments: token-based system enables rapid purchases

Mercedes Pay enables users to conveniently purchase items or services from the car – useful for when you suddenly remember on the way home that it's your wedding anniversary and need to rush to buy flowers for your spouse, or have an urge to download the latest album from your favorite artist that is being played on the radio. Mercedes teamed up with Visa to make the process easier and more widely available. Instead of having to key in a personal identification number (PIN), all that is required for authentication is a fingerprint scan. The payment is then handled via Visa's new Cloud Token Framework, an online payment system where stored authentication data is made secure using individual digital tokens that remove any sensitive payment information by encrypting the data before storing it. This makes payments much easier as users no longer need to enter long card

numbers to complete a purchase. It also makes it possible to pair multiple devices with the car so more than one user can make payments with a fingerprint scan.

Industry standards are starting to emerge for the use of tokens to enable multiple organizations to work together to solve major challenges, such as those around climate and mobility.

MOBI's grid integration standard for EVs: a tokenized credit marketplace for carbon?

The Mobility Open Blockchain Initiative (MOBI)'s member-led Electric Vehicle Grid Integration (EVGI) Working Group created and launched the automotive industry's first global standard for a decentralized vehicle charging system. Tokenized carbon credits (TCC) are one of the use cases covered by the technical specification, along with vehicle to grid (V2G) integration and peer to peer (P2P) applications. The Working Group, chaired by Honda and GM, suggests that a TCC marketplace can enable the direct exchange of credits between surplus and deficit holders, in near real time and without an intermediary such as a broker or aggregator, who could otherwise be a bottleneck. While the standard does not prescribe particular applications or distributed ledger technology (DLT), it aims to define data attributes and functionalities so that organizations can create their own applications with the confidence that they can interact smoothly with one another in a marketplace.

YOUR BUSINESS IS A MESH

Enabled by "water-like" technology, it is easier than ever for organizations to join forces, even if it's just for one day, for one occasion, or for one customer

Organizations can use today's water-like, flexible technology to collaborate on an ad hoc basis to deal with specific situations. A classic example is when, in the absence of a local internet endpoint, a user's device connects to the nearest endpoint via a series of nodes. But here we're using "mesh" to mean any sort of ad hoc collaboration, via cloud-based infrastructure platforms, agile application microservices, data-sharing frameworks, or any other technology enabler. Individual companies are taking steps to create collaborative platforms for their ecosystems.

Volvo Cars' developer portal: encouraging internal and external app and service creators

The portal is designed to help Volvo Cars assemble a range of high-quality apps for its vehicles. It makes a variety of resources and tools available for free, encouraging third-party developers as well as its own employees to create innovative services and in-car apps. Volvo has partnered with Unity, a 3D content platform provider, to develop a high-fidelity, true-to-life, real-time 3D model of the Volvo XC40 Recharge, including both the interior and exterior of the fully electric SUV. The model, together with a 3D environment, will be available on the portal for download as a resource for use in visualization applications, VR, cinematic experiences, and car configurators. Making resources like these publicly available via the portal helps Volvo to collaborate with the best developers in their fields, whether internal or external.

Other collaborative initiatives involve multiple automotive companies working together at a national – or broader – level.

VW/Audi and Germany's Mobility Data Space: a national community for data sharing

The Volkswagen Group is a founding member of the Mobility Data Space established on behalf of the German Federal Government. Comparable with the European Gaia-X initiative that is creating a federated, secure data infrastructure for Europe, the Mobility Data Space is a data-sharing community launched in Germany. Working with Capgemini Invent in a cross-functional project team, Volkswagen and Audi quickly produced impactful use cases to demonstrate the platform's value. One of the first use cases to be delivered was Local Hazard Information, a solution that provides aggregated event data on road traffic hazards collected from vehicle sensors in the Audi fleet. This can be used by various B2B customers with access to the Mobility Data Space, such as a navigation service that warns road users of upcoming danger spots in near real time.

IT'S ALL CONNECTED

In combination with IoT, AI, and Edge computing, 5G connectivity is the catalyst for technology-driven, networked business innovation

5G connectivity has the power to transform the industry in all sorts of ways. Among the most exciting are collaboration and connectivity by vehicles with other vehicles (V2V), with infrastructure (V2I), and with any other element of their environment (V2X). Think about truck platooning, where a group of trucks progress together along a highway. With appropriate connectivity, one driver can control the whole fleet, steering the first truck while the others follow closely. Fuel use is reduced too as most of the trucks are less exposed to the wind.

FPInnovations' truck platooning for forestry: solving labor shortages with connectivity

With Robotic Research, this Canadian non-profit R&D center is working to develop an off-highway platooning system for the forestry industry, enabled by Level 4 autonomous driving. Aims include improving safety and addressing an acute labor shortage. The project will create unmanned convoys of class 8 trucks that follow a driver in a lead vehicle. The technology will be adapted to, and tested against challenging Canadian environmental conditions, such as four-season weather and off-road operations, including those in polar climates. In the future, other sectors such as mining could benefit.

Similar concepts can help improve the driving of other vehicles. When cars are in a traffic jam, the problem is often caused by humans – perhaps trying to change lanes at the wrong moment, or simply not paying attention to the road. It's also possible that the road architecture is causing a bottleneck. Either way, connectivity and automation can help solve this problem by allowing cars to operate in autonomous trains, with a safe distance between vehicles automatically maintained, in a similar way to the truck platoon example.

These potential solutions are still in the future, but automakers are already preparing to take advantage of 5G to support autonomous driving in various ways.

Volvo Cars and Ericsson's real-time mapping: pooling navigational data via 5G

Ericsson and Volvo Cars have trialed the use of 5G connectivity to keep maps constantly updated with real-time information to aid future autonomous driving operations and an understanding of the environment beyond the range of the vehicle and its sensors. As part of the test, Ericsson deployed a 5G mobile radio network while two Volvo cars received a high-definition (HD) map of the route ahead. By updating the maps with information from sensor readings, connected cars were able to detect and distinguish between driving lanes ahead. The trial also successfully tested a handover of connected cars between two national mobile 5G networks, proving that seamless service continuity on 5G networks can be guaranteed across borders – essential for many longer journeys.

Generally, 5G is not widespread enough to support the above scenarios yet, and won't be for the next few years. But on manufacturing sites it is easier to justify the investment, with compelling use cases like VR-enabled training and coaching.

Singtel and Hyundai's smart mobility in the factory: industry 4.0 solutions enabled by 5G

As part of a wider partnership, Singaporean mobile operator Singtel and Hyundai are to develop and pilot a 5G-enabled smart factory use case for a 44,000m² innovation center that Hyundai is creating in Singapore. The aim is to combine Hyundai's manufacturing expertise with Singtel's 5G and IoT capabilities and other technologies to produce Industry 4.0 digital systems.

THRIVING ON DATA

It's no wonder organizations aspire to thrive on data, to be data-powered enterprises. With every business now being a de facto Technology Business, data obviously is at its core. Dare we say, every Business is a Data Business? Look at the facts: data powers superior customer experiences, highly tuned operations, and smart, self-optimizing products and services. Data provides resilience, predictability, and effectiveness, but equally enables organizations to achieve their sustainability ambitions. It also helps their potentially scarce human resources to achieve the best, most satisfying results. With that, it's tempting to declare data to be "just" the new, corporate asset. But assets tend to be stacked, isolated, and safely put away. It's much better to see data as a first-class product; owned, managed, and activated by business domains, and shared in lively exchanges inside and outside the organization.

A challenge worth accepting

Companies face burgeoning volumes of data of growing complexity as a result of connected services, autonomous vehicles, Advanced Driver-Assistance Systems (ADAS – particularly with video), and new sustainability and environmental, social, and governance (ESG) laws and regulations. Autonomous driving systems alone will potentially generate data volumes that are orders of magnitude greater than the total amount companies currently deal with. New IT systems will be deployed and scaled to handle the interaction with cars and drivers that is needed to gather data and permissions in real time and put the data to use to gain invaluable insights.

Data to, from, and in vehicles

Growing data-dependency

With software increasingly determining vehicle characteristics, data from every stage of the design and production processes may be needed during the entire vehicle lifecycle. On the road, vehicle data can be combined with data about driver habits, behavior, and subscriptions, to, for example, determine what options are available or could be added.

The effect of ADAS

The more ADAS features are added, the more data is needed to train and direct the vehicle; often, big data will need to be held in the car, since features must work reliably even without a fast connection to the supporting infrastructure. Even for today's levels of automation, vehicles need contextual information such as local regulations regarding speed, emissions, and passenger entertainment.

Vehicles as servers

As well as generating data, vehicles are already acting as servers or as nodes in a centralized IT solution, handling huge volumes of data locally in real time. As such, they need onboard logic about data distribution, for example to know which data to send off-board routinely and which to make available on demand to avoid explosive growth in vehicle-to-infrastructure telecom costs. Vehicles will also need to keep track of data ownership and consents to avoid the unauthorized transmission of personal (as opposed to anonymized or pseudonymized) data.

The end of silos?

Historically, data generated by designing and building a vehicle was often discarded because one team did not appreciate its value to another team. With software increasingly determining which options an individual vehicle offers, it is vital to retain all potentially valuable data. It should be stored in a meaningful form and made available to everyone who needs it, whether for configuring the vehicle before delivery, integrity checking, or aftersales service.

Rising to the data challenge

As OEMs reinvent themselves as data-powered enterprises, cloud will be increasingly important. It will accommodate data lakes to manage companies' rapidly growing data resources and ensure data continuity. Many smaller data streams will come together to fill a lake.

With vehicles acting as data stores and servers, strong data governance will be more vital than ever to take care of issues such as consent and retention. Contractual definition of ownership and access rights for each data item will require negotiation with stakeholders in areas such as post-sales and insurance, as well as with drivers, fleet managers, etc. Governance bodies can also oversee master data standardization programs, which facilitate successful data sharing within the ecosystem.

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DATA SHARING IS CARING

Participating, collaborating, or even leading in data ecosystems gets more value out of data – creating new connected products, services, and experiences, boosting enterprise performance, and contributing to a better society

Increasingly, value-adding activities depend on the free flow of data to and from a variety of stakeholders, including external ones. Customers might decide to share personal driving behavior data with insurance companies in return for a lower premium. OEMs could share anonymized data with third parties to help them provide additional connected services, e.g. in relation to navigation. This will probably be done using cloud-based data lakes of pooled anonymized data, perhaps stored on platforms such as Gaia-X/Catena-X.

Optimization, especially around objectives like net zero, means close collaboration by a lot of people. Without data sharing, it is impossible to work together effectively on product design. Sharing is also key to providing services such as those that help drivers improve their driving performance – and even more to enabling autonomous driving.

Data sharing is also critical to building trust and working together as a community. It can be something as simple as members of a car-sharing community rating their vehicles, and each other. Ideas like car-sharing can only work if members of the community share – and trust – this type of

data. Incentives can be provided, and some could perhaps come from the ecosystem (for example, discounts on insurance in return for sharing evidence of good driving behavior). Of course, commercial data sharing is also about monetization.

Honda's data monetization initiative: Selling smart vehicle data

Honda has launched a business that sells data generated by smart vehicles. The data is expected to be used in determining consumer demands, gauging the effectiveness of advertising, and planning openings of retail outlets. Offers will include camera and sensor data about driving distances, speeds, etc., information on entertainment content played, and behavioral data generated by a third party. The data will be available by subscription, with monthly subscriptions starting at 200,000 yen.

Companies are keenly aware of the need to be on top of all aspects of their data, and are taking steps to enhance their capabilities, both for sharing and for data management generally.

POWER TO THE PEOPLE

A growing scarcity of specialized skills, the need to activate data as close to the business as possible – plus powerful AI and automation tools – are all driving the unstoppable self-service data revolution

Giving people access to data empowers them to make better decisions and positions them to build their own decision support capabilities, which can be a way around skills shortages. Offering data to employees and partners via self-service platforms is increasingly seen as vital. Third parties are also offering platforms of this kind.

Otonomo's self-service data platform: convenient access to vehicle data for developers and service providers

Otonomo, an Israel-based automotive data services platform provider, offers a self-service platform and API designed to provide hassle-free, online access to aggregated connected car data, both real time and historical. The platform and API are suited to startups and developers looking for easy and quick access to this type of car data, and enable service providers to power traffic management, mapping, parking, smart city, EV management, financial services, and many other solutions. Every day the platform adds more data from millions of cars in over 70 countries. Features include geofencing, dynamic filtering, indexing and search tools, configurable APIs, and visual data report generation capabilities, enabling developers to tailor the car data to their needs.

Giving customers access to their own data has extra benefits. It can be a way to improve the driving experience. For example, contextualized data can coach someone who has recently acquired a hybrid car on the best way to use it.

Michelin's Driving Data to Intelligence: using behavioral data to enhance safety

DDI (Driving Data to Intelligence) is a Michelin solution leveraging the company's expertise in data analysis and driving behavior to contribute to safer mobility. The "Ideal Driver Pro" DDI mobile app provides drivers with detailed data and insights about their way of driving and encourages them to improve their driving behavior over time. The DDI Better Driving Community is available to all car drivers in France. Members enjoy custom-made scoring and coaching programs. They become aware of their risky behaviors and learn how to improve, thereby increasing their safety and the safety of others.

Information about the benefits of mobility services can incentivize people to use them: It could be as simple as telling someone how much money they could make by sharing their car with their neighbors. It's all about making better decisions.

DATA APART TOGETHER

A federated, actively collaborating "mesh" of data producers and data consumers – owned and governed by the business domains themselves – brings data as close as possible to where it is picked up and used, a hallmark of a true Technology Business

Automotive companies will need to find ways to make data reach those who need it, perhaps through the development of a federated, actively collaborating "mesh" of data producers and data consumers. We are already seeing initiatives to make it easier for OEMs and suppliers to pool data.

Surgere's platform for automotive data and analytics: sharing across the supply chain

Surgere's AutoSphere digital environment enables a community of OEMs and suppliers to operate in a single supply chain data ecosystem, sharing data and analytics to move, track, and manage container and part inventory between companies more efficiently. The AutoSphere's backbone is hosted on Microsoft Azure. AutoSphere tackles loss and inefficiency in the automotive supply chain and aims to create seismic improvements in profitability for both OEMs and their suppliers through shared use of highly accurate technology, dynamic data analytics, and massive collaboration.

Currently, access to vehicle-generated data is usually limited to OEMs themselves, but this will change with the likely adoption of an app store model enabling third parties to provide services. Regulatory pressures in response to third-party lobbying will also accentuate the need to make vehicle data more accessible. The vehicle will become part of a complex ecosystem carrying out V2V communication, smart grid usage for energy optimization, connected car services for traffic improvement, and much more. This may increase complexity since multiple data formats will need to be supported at first. In the longer term, however, we can expect cross-industry standardization of the formats.

Here we return to our leitmotif of data democratization. Concepts such as the data mesh move ownership of data to the business domain, where data can best be activated.

GM's integrated telematics solution: simplified mixed-fleet management with vehicle data

GM has adopted the Geotab Integrated Solution, which enables fleet managers to access data collected via an onboard module from compatible Chevrolet, Buick, GMC, and Cadillac vehicles. The solution simplifies the task of mixed-fleet management by providing businesses with the ability to oversee their entire fleet from within a single platform.

ERA OF ALGORITHMS

Challenge everything you've tried so far: the next-generation AI algorithms bring brand-new, awesome ways to solve problems, innovate, and bring out the very best in humans

If vehicles are to make decisions on their own, and ultimately achieve autonomous driving, they need AI algorithms. Given the vast amounts of data generated by sensors and other tools, powerful algorithms are the only way to gain the required information and insights in the time available. One area where AI will be critical to autonomous driving is in making the most of the incoming data.

Mercedes-Benz's project to improve visibility: safe driving in poor conditions thanks to sensor data and AI

Vision software specialist Algolux is one of about 20 participants in AI-SEE, a project led by Mercedes-Benz AG to ensure safe driving in poor visibility conditions. Over a period of three years, the project aims to enable Level 4 autonomy for mass-market vehicles. The intent is to build a novel robust sensor system supported by AI-enhanced vehicle vision for low visibility conditions. Algolux will provide technology and domain expertise in the areas of deep learning AI algorithms, fusion of data from distinct sensor types, long-range stereo sensing, and radar signal processing. A critical objective of advanced driving systems is the recognition of all road users in challenging weather conditions. Algolux relies on a smart fusion approach which represents the control center or "brain" of the system, thereby enabling a more robust perception platform that can be used in any lighting or weather conditions.

Algorithms are the key to managing otherwise intractable volumes of data in numerous other areas, such as sustainability, where automakers need to keep track of not just their own activities but those of their suppliers.

Audi's AI tool to assess supply chain sustainability: analyzing data to prevent ESG violations

Audi has been piloting an AI tool that analyzes information about suppliers to assess their sustainability in terms of environmental pollution, human rights, and corruption. It also monitors information about potential cybercrimes. The project has been running since October 2020 and Audi is using intelligent algorithms to analyze news about suppliers from publicly available online media sources and social networks across 150 countries. The system alerts Audi to any potential violations of its sustainability criteria so that it can take prompt corrective action. AI startup Prewave has developed the tool, which uses automotive speech recognition in 50 languages to check for potential violations of Audi's sustainability criteria and alerts the carmaker to them. The algorithms are constantly learning, and therefore the system is increasing its ability to recognize developing risks.

Building those algorithms, of course, is no easy matter. Huge volumes of data are needed to create and test them. And when the algorithms go live, they have to operate at the edge – i.e. in the vehicle, rather than in the cloud, since safety cannot depend on connectivity, posing additional challenges.

All that could add unmanageable complexity unless vehicles are adapted in other ways. Volvo, for example, is reducing the number of configurations it offers. To do that, automakers need yet more algorithms to deliver insights from another type of data – sales data about take-up of current models – so that they can understand which configurations need to be available in each of their markets.

CREATIVE MACHINE

Unleashing the generative capabilities of AI to enable individuals and organizations to express themselves better in different creative ways, even if they lacked the capabilities or manpower for it in the past

Increasingly, data will be combined with the power of technology to come up with revolutionary design propositions or new design elements for use by a human designer. For example, by feeding data about people's driving behavior and preferences into a computer-aided design process, it is possible to create a design that starts with the interior instead of the exterior – something that's extremely difficult for a human designer to do.

Given the right sales data, AI-enabled processes can also help with the process of rationalizing the choice of vehicle configurations available while ensuring the needs of a given market are met. And in a related use, AI can recognize patterns in data in order to select the best solutions from a large number of candidates put forward by creative humans.

GM's AI-enabled pattern recognition: accelerating advanced driver assistance systems design

General Motors is assessing the potential of an AI-enabled pattern recognition technology to accelerate the design of ADAS. Developed at the US Department of Energy's Oak Ridge National Laboratory, Multinode Evolutionary Neural Networks for Deep Learning (MENNDL) uses evolutionary approaches to optimizing convolutional neural networks – algorithms used by computers to recognize patterns in datasets of text, images, or sounds. MENNDL can evaluate thousands of neural networks in a matter of hours, depending on the power of the computer used. In this way, MENNDL could help automakers find ways for cars to quickly and accurately assess their surroundings in order to navigate safely through them.

But AI is not limited to recognizing and analyzing patterns: it turns out that generative AI systems can produce increasingly spectacular results in art creation.

BMW's virtual art installation: an AI-generated "masterpiece"

BMW has created a virtual art installation that projects AI-generated artwork onto a virtual rendition of the automaker's 8 Series Gran Coupé. Dubbed "The Ultimate AI Masterpiece," the installation harnessed Nvidia StyleGAN – a generative model for high-resolution images – to create original artwork projection-mapped onto the virtual vehicle. The project debuted in 2021 in conjunction with the contemporary art festival Frieze New York, marking the 50th year of cultural engagement by the BMW Group.

PROCESS ON THE FLY

Strategy tends to be eaten for breakfast, by culture – but also by a lack of operational execution. Organizational aspirations simply "blah blah blah" without any ability to turn insight into action, quickly respond to events, overcome business silos, or go with whatever flow the corporate purpose supposes. And all that goodness must be delivered against a scarcity of skilled human resources and a need to reduce travel and energy consumption. This is where Process on the Fly comes to the fore and shines ever brighter. Having been consistently less in the spotlight than its complementary container, Thriving on Data (ever heard of "Big Process"?), breakthroughs within intelligent automation and a taste of touchless execution have firmly placed this container center stage. Quit talking and *start doing*.

Your vehicle is now served

With OEMs' margins on vehicle sales reducing, services are now among the most promising revenue sources, bringing rain to what otherwise might become a parched desert. To offer customers the right services at the right time, OEMs are looking for agile, fluid processes. In addition, new business models such as mobility services will necessitate totally new processes, with a car journey becoming a sub-process of the overall process of getting from point A to B.

A fluid and reliable assistant

Increased focus on ADAS

Mobility services will work better once a car can pick up a customer and drive them wherever they want, with no need to park, offering an easy connection to other transportation methods. Therefore, it makes sense to start designing mobility-related processes to take advantage of ADAS and ultimately fully autonomous driving.

Dealing with cybersecurity threats

When the process of using a vehicle becomes part of a wider transportation process, cybersecurity threats multiply. The need to protect customers against these threats, which historically was an afterthought, must be a core design objective.

Rationalizing vehicle software development and deployment

A platform approach to software has many advantages, from reduced dependency on specific electronic chips to improved upgradability of vehicles on the road. But clearly it requires completely new processes for developing, building, and managing vehicles.

Industrial optimization along the digital continuum

AI is already analyzing camera outputs to carry out shop-floor quality checks, and smart devices attached to robots are reporting detailed production information automatically.

In the future, automation of production processes can be expected to gather pace. AI is providing additional opportunities to optimize and automate industrial processes, limiting the need for human intervention to situations where higher expertise is needed.

Given the increasing complexity of the business, automakers need efficient ways to manage the end-to-end product lifecycle, from design to logistics. For this, they need digital continuity, with a virtual view of their operation that lets them monitor processes in their entirety.

Process integration in the back office

During the sales process, customers expect to be able to migrate between channels seamlessly. They want to test-drive a vehicle that is as similar as possible to the one they built on the online configurator. They then expect to complete the purchase online, with any modifications that they have made with the dealer already known to the system.

The aftersales relationship, too, needs to be informed by the choices already made: for example, customers should only be offered accessories that fit the vehicle they own. This seamlessness can only be achieved with digital, and fully integrated, customer relationship management (CRM) systems behind the scenes.

Adapting to Agile

Waterfall processes will cope less and less easily with today's needs, such as accelerating the delivery cycle and updating vehicle operating systems and applications OTA. The shift to Agile processes will affect hardware as well as software design. To adopt new processes rapidly yet with minimal risk, OEMs will need to emulate startups by applying Agile to process management, and adopting fail-fast techniques. The goal is a style of process management that's constantly on the move, like water.

PLM without frontiers

In a world where processes often span multiple organizations and platforms, automakers will want to work with their industry associations to define standards for product lifecycle management (PLM) and for supply chain interactions such as purchase orders and invoices. Doing this at industry level will keep down the costs of interactions between partners.
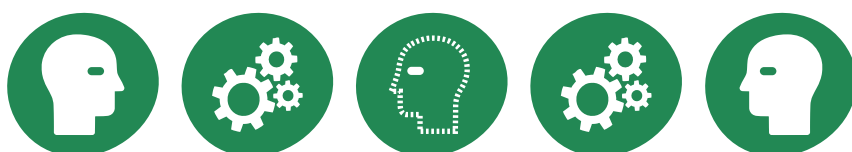
in **Fabienne Lefever**
Expert in Residence

in **Roshan Batheri**
Expert in Residence

PROCESS IS MINE MINE MINE

Using Digital Twins to inject continuous process innovation, making it the envy of the entire flock

The greater the rate of change, the greater the need to ensure that a tweak in one process does not cause problems elsewhere. The answer is to use digital twins and other forms of simulation to test proposed changes before they are implemented.

OEMs are already introducing these tools for the development of new vehicles.

Hyundai's digital twins for the design function: simulation in a real-world context

At Hyundai, digital twin technology is being used to make a digital replica of a real car for simulation not only in a virtual space but also in the physical world with related equipment. The technology will be used within the design function of the Hyundai Mobility Global Innovation Center in Singapore (HMGICS). Hyundai has been building this open mobility innovation base by combining AI, IoT, robotics, and other leading-edge technologies. The company is looking to expand digital twin technology to the development of all models. It has recently unveiled a plan to design and build a new metaverse roadmap and platform for Meta-Factory, a digital twin of a factory for testing and the optimization of operations.

Once digital twins are in place for R&D use, they can usually be readily adapted for testing changes and new services. Emerging approaches to testing onboard software will also help with ensuring that process changes have no unintended consequences. For example, OEMs will increasingly develop software independently of hardware using simulated or virtual vehicles to test it. This technique means that target quality is reached earlier, and the finished product can go live faster. The same technique can be used to test updates that will be delivered OTA. Similar approaches are already in use on standalone software projects and will increasingly be applied to embedded software.

Digital twins can also help with optimizing industrial processes and with understanding the wider environment, such as the supply chain.

BMW's virtual factory planning: faster, more efficient processes for new vehicles

BMW has adopted Omniverse, Nvidia's digital twin tool for factory planning in the R&D phase of creating new vehicles, in order to plan processes with greater speed and efficiency.

Renault's supply chain simulation: a holistic view of suppliers and inventories

Renault has chosen Google Cloud's Supply Chain Twin, which provides the ability to create digital twins that can simulate physical supply. By aggregating inventory data from suppliers and leveraging Google Cloud's strength in organizing and orchestrating data, Renault is expecting to achieve a holistic view of its suppliers and inventories.

ROCK ROBOT ROCK

Robots become a dependable, digital companion, giving us the time and freedom to think, plan, and focus

Process automation whenever possible should be the aim: it's the way to stop failures and to reduce effort and complexity.

As automakers increasingly interact directly with end consumers rather than through dealers, they need to ensure the quality of the relationship without saturating the organization.

Ford optimizes marketing campaigns with Pega: a transformed customer engagement

Ford drove a "Communications Optimization" using Pega's Self-Optimizing Campaigns. Backed by adaptive models, the system learned how to best engage customers: after messages are sent, the customer actions are collected and automatically feed the robotic model. Were messages opened? Clicked-through? Did the customer go to the web? What did they do there? How engaged were they? Just three weeks after launching the "FordPass Mobile App" campaign, Ford engaged over 300,000 customers and saw a 26% increase in conversion.

This will be particularly important with the move toward promoting new services to customers on an ongoing basis. Purchasing a subscription to a new connected service should trigger an automatic process that delivers the service to the car and takes care of the billing. Manual processes in the background should be avoided because they can't scale affordably to deal with a rapidly growing transaction volume.

SILO BUSTERS

Busting corporate silos by adding flexible process layers on top of them, rather than breaking or rebuilding already established structures

Within automotive companies, there has always been full interdependency between the various technical teams working on vehicle development. Many companies have now reoriented themselves even more strongly around products, bringing in people from back-office functions such as purchasing and IT to product teams, and increasing flexibility as a result.

In addition, established techniques like Agile and DevOps, applied beyond IT, are further improving project delivery across the natural organizational boundaries.

One risk here is that making the product the new king may create new silos. This should be borne in mind when creating product-centric teams. It's important to make sure that while these teams have autonomy around the product, their efforts and decisions are aligned with wider company goals. The jury is still out on the best way of achieving this.

Silo-busting may extend beyond the organization if OEMs decide to tighten their relationships with suppliers and,

for example, engage the supply chain in future process design. Dealerships, too, need to be brought into the fold, and encouraged to focus strongly on customer experience. Modern CRM systems should help, both inside and outside the organization.

Ferrari's CRM solution: enhancing customer experience to encourage repeat business

A custom-built, Oracle-based CRM solution, rolled out across Ferrari's entire global dealership network, is helping Ferrari stay in touch with high-profile, high-net-worth customers worldwide, and with the dealerships that serve them. The company is able to reach approximately three times as many users as with its previous approaches to CRM. That reach and engagement is critical since Ferrari derives much of its revenue from repeat customers. The system also feeds data to the MyFerrari app used by supercar owners. Ferrari used Oracle CX Cloud and Oracle Cloud Platform as a Service (PaaS) to build the platform, which ensures that data is comprehensive and up to date, and that the complex demographics of Ferrari owners are properly managed.

CAN'T TOUCH THIS

A process seamlessly adapting to its environment, optimizing itself without human intervention or support – is that even a process anymore?

In the car, the need for customers to control processes through conventional interactions, even with touch screens, will diminish. Many in-vehicle functions can potentially be controlled by voice, from opening the window to activating music players. Google and Amazon have pioneered this idea, and most automakers and other technology partners will emulate their initiative and take it further, perhaps to the point where all relevant vehicle functions are fully voice controlled.

Sensors such as cameras can further streamline interactions with processes, and as we progress toward autonomous driving more and more of them will be available. Gestures may be preferable to voice control for some users or situations.

Jaguar Land Rover's no-touch touchscreens: controlling onboard systems through gestures

Jaguar Land Rover and the University of Cambridge have shared a vision of an AI-powered "no-touch" touchscreen that lets users operate their infotainment displays from a short distance, potentially improving usability while in motion and also reducing the risk of transferring pathogens. Cambridge engineers developed a solution that combines machine learning with vision-based sensors to detect user gestures and quickly predict the item they intend to use or touch, so that they just need to point. Lab

tests found a reduction in screen interaction effort of up to 50%, thanks to the technology's ability to predict user actions with high accuracy. Implementation of this feature could lead to safer, distraction-free driving.

Perhaps even better, it may increasingly be possible to better interpret a human's intention and predict what they are going to want to do, so that an action can be suggested in advance. For both customers and employees, this should result in more effective processes and an improved experience.

Toyota's behavior prediction initiative: using AI to understand decision-making

An initiative to develop artificial intelligence tools is being launched by the Toyota Research Institute. The initiative, Machine-Assisted Cognition (MAC), is intended to create and demonstrate AI tools that can understand and predict human behavior in the context of decision-making.

There is a wide range of possibilities, inside and outside the car. As the customer approaches their vehicle, a sensor-driven process could recognize them and unlock the car without the need to use a phone or other device, while increasing the level of security. Already, sensors can warn if the vehicle is too close to another vehicle. With the vehicle driving itself, an alarm could be set off or a message pushed to a human operator's screen.

AUGMENTED ME

Adding AI to business operations to accelerate decision-making, create a symbiotic relationship, and bring harmony to both human and machine

At least until all driving is completely automated, processes should maximize the use of AI to support human decision-making and reduce the scope for human error. If a customer will reach their destination earlier than planned because of a lack of traffic, they can receive suggestions about where to pass the spare half-hour pleasantly. Customers can be advised to take a break when they show signs of stress – whether by digital assistant, vehicle-specific software, or some combination of the two. ML and deep learning (DL) are starting to be used to analyze driver behavior and physical signs to find out what they need or want and respond accordingly.

Mercedes-Benz's AI-powered user experience: harnessing DL to understand drivers' needs

Mercedes-Benz is using DL and natural language processing (NLP) technologies to improve the driving experience and make drivers more effective, for example by automatically gauging their needs and moods. The company's AI-powered operating system (OS), Mercedes-Benz User Experience (MBUX), responds to conversational commands from drivers and adapts to their habits over time. Other features integrated into MBUX include the ability to receive and pass on messages about road conditions, petrol prices, weather, and vehicle location. Everything is controlled by either natural-speech voice commands or an advanced user interface (UI). This AI-powered digital assistant has been compared with a butler because of the way it learns and adapts to the customer's preferences.

AI can also be used to improve the quality of the information that drivers use to make decisions – for example, their view through the windshield.

Bosch's Virtual Visor: using AI to improve visibility

Bosch has debuted a concept sun visor designed to protect drivers from sun glare. The Virtual Visor relies on AI to map the driver's face in order to project a transparent, dark-shaded mask onto the eyes, allowing for an unrestricted view of the road. The AI camera technology shades the driver's eyes, allowing them to operate their vehicle without being impaired by bright light or physical sun visors. The creative use of liquid crystal technology to block a specific light source decreases dangerous sun glare, improving visibility, comfort, and safety.

Equally, AR can be used internally, for example to help warehouse staff find and pick the right items. Virtually any back-office process is a candidate for AI-human collaboration to increase accuracy and efficiency and improve resource usage. Process orders, say, could be routinely handled by AI, and escalated to human colleagues only when there is some exception that the AI cannot deal with. As before, it all depends on having the right data available in the right place and at the right time.

APPLICATIONS UNLEASHED

At the heart of any Technology Business is its applications portfolio. A thriving heartbeat of the organization – part of the business, responsive to every demand. These applications mirror the new business dynamics, built and continuously changed at high speed, to a high quality, and in whatever incarnation necessary. Yet, changes are afoot, dear Watson. Many applications no longer look like the ones we used to know, as they morph into a connected mesh of microservices. And where is that old-fashioned user interface again? With agility and minimum viable products no longer the "new normal," but the "well and truly established," the quality of application services needs to be at enterprise level – with the trust balance of the organization secured by design, and a continuous, flawless deployment throughout all business operations.

The core of customer experience

Perhaps more than in any other industry, apps are vital to customers as well as behind the scenes. Given the advent of software-defined vehicles and increasing customer-centricity, the quality of applications will increasingly shape customer experience, adding "smart" to a vehicle by flowing like water through every nook and cranny.

The way apps are designed and implemented will strongly affect the vehicle's ability to provide a seamless customer experience, and to fit equally seamlessly into the customer's overall digital lifestyle. So will API-ization, which enables internal and external systems to connect to services. Together with AI, API-ization allows systems to have smart conversations with one another, with no need for human intervention.

Many features will be implemented as microservices, as opposed to the type of apps found on smartphones. Service architecture will be key to ensuring the integrity of the vehicle.

The power of apps in the car

Realizing the full range of potential services

The apps currently available are roadside assistance, multi-modal transportation services, including vehicle booking, and EV range management, including booking charging slots to complete a long trip. Apps can interact with the vehicle to automate tasks, such as locking/unlocking doors, or starting the car remotely where that's legal. But much more seems possible as internal functions increasingly become software-defined: for example, adjusting engine behavior based on external information to optimize energy use, or interacting with other entities for collaborative mobility.

Boosting intelligence

AI will be an essential element of many in-car apps. ADAS is the most obvious AI-dependent area, but it is worth considering how AI could improve any given app. Often it will make the difference between a copycat app and a highly individualized one that really fits the customer's needs.

Defining and redefining the car

When a vehicle is software-defined, most functions are upgradable over time and not stuck in their initial state. Apps are also crucial to the vehicle's ability to adapt to different requirements throughout its lifecycle. When it changes hands or is shared between multiple drivers, it should adjust to individual preferences and budgets with regard to user interface, personal assistance features, driving characteristics, and so on.

Smarter factories and enterprise functions

AI can inject welcome intelligence into industrial software. For example, AI-enhanced cameras can detect defects such as cracks or paintwork flaws in completed vehicles. And AI can collaborate in this way throughout the vehicle lifecycle – for example, it could be used to find extra dents and other defects in a hire car that has just been returned. Automakers are starting to take advantage of the ability to upgrade legacy robots at reasonable costs. In addition, today's greater network capacity and speed makes it possible to link information technology and operational technology (IT/OT) environments. Each vehicle can have its own

IP address and technical configuration, facilitating IT/OT interaction.

Meanwhile, back-office systems such as enterprise resource planning (ERP) and CRM are being rethought to provide the fluidity necessary to meet current and evolving customer needs. Back-office applications need to ensure customers get the information they need pre-sales (e.g. can a UK customer buy a left-hand drive version of a German-produced car?). Customers also expect a fluid experience as they deal with different OEM departments, and maybe dealerships and finance companies, across the customer journey. AI will be as important here as on the factory floor and inside the vehicle, and so will concepts such as cloud architecture, embedded analytics, DevSecOps, APIs, and microservices.

Adjusting to the "app age"

To make sure they invest in the right apps, automakers will keep coming back to the customer. Analysis of socio-cultural trends and categories can shed light on the expectations of different customers in different domains, now and in the future. If automation makes "the ultimate driving machine" obsolete, what will customers want instead?

The customer environment for choosing apps needs to be convenient for customers and attractive to third-party developers. If it is an app store, it may be modeled more on Apple's tightly monitored and controlled one than on the more open Android version, since OEMs will want to retain some control. In the future, a brand's value could even be linked to the size of its app store.

OEMs are thinking carefully about how they develop and/or obtain apps. Agile is essential to provide the frequent OTA updates that drivers will increasingly expect. Techniques like DevSecOps offer useful ways to roll out bug fixes fast with controlled risk.

In a world where processes often span multiple organizations and platforms, public service APIs will enable mobility services to be delivered smoothly, at minimal cost, and with maximum quality. Collaborating with industry associations to define these APIs will reduce costs and speed up the process.

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KONDO MY PORTFOLIO

Tidying up the applications portfolio in a systematic, decisive way to make room for innovation, agility, and the next generation of powerful application services

Most OEMs are getting to the point where they can connect with the customer via a cool front end but behind the scenes it's a very different picture. Some companies are operating with a dated legacy application landscape, especially in the manufacturing area, with applications that date back to the 1980s in some cases.

Before they can get to where they need to be – agile and fluid as water – companies face the painful process of rationalizing and modernizing their legacy environment. Only with total control of their IT landscape can they make changes as fast as they need to. A move to cloud is a common trigger for reviewing the landscape.

Mercedes-Benz's accelerated software development: modernization through cloud and microservice

Mercedes-Benz selected Capgemini for the development and maintenance of its core Electric/Electronic Product Data Management (EE-PDM) application in an R&D environment. The application is used for the development and documentation of electronic vehicle components. The manufacturer aims to establish a more flexible and efficient deployment process, which requires further innovation to ensure minimal time between application updates and a faster time to market of electronic product components. In order to achieve this goal and support the client's #TwiceAsFast strategy aimed at streamlining its IT processes, Capgemini will leverage its deep expertise in cloud technology, microservices architecture, and DevOps.

Reducing the number of applications is key. In some companies, making a change in one system requires testing another 50. Even with the best test tools, that is going to make it impossible to continually deploy new features at the necessary rate, and with the necessary confidence. If you can get the 50 down to three, releasing those new features gets a lot easier, faster, and safer.

In the back office, legacy apps need to be modernized and rationalized, at least to the point where they do not prevent the company from using new technologies to transform the business and deliver the services customers want.

HONEY, I SHRUNK THE APPLICATIONS
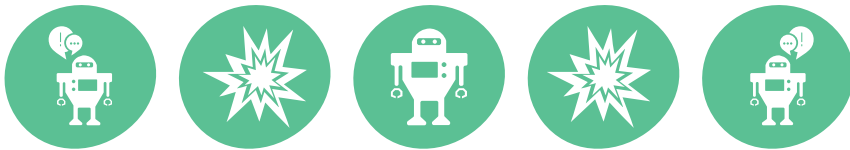
Next-generation agile and response "light" application services are built on the concepts of Microservices, API-first, Cloud-native, and Headless

Complexity is not only about the number of applications but is also hidden in applications' design. The limitations of traditional, fully integrated, all-in-one apps, unable to adapt to waves of changing requirements over the years, are now crippling software budgets.

Wherever possible, it is best to keep applications' technical structure as clean as possible and for design functions to be as generic as feasible. This makes it easier to leverage today's multitude of software abstractions in order to implement microservices, cloud-native architecture, model-view-controllers, and model-driven designs.

The "keep it simple" mantra, which enabled the undeniable success of smart apps, is now extending to E/E hardware vehicle platforms. Mature OEMs are developing single hardware platforms to support, with minimal variations, all models and brands; differentiating capabilities could be modular add-ons and/or software-driven capabilities. The next stop will be containerized applications on highly standardized vehicle hardware. These applications will conform to cloud standards and provide functionality that is significantly more sophisticated than the traditional ECU-driven capability set.

And today's cloud platforms can help with the process of downsizing and optimizing applications.

Daimler's intelligent cloud solution: driving innovation with modern microservices architecture

Daimler has opted for an intelligent cloud solution, migrating its global aftersales portal to IBM's secure public cloud. The platform, based on the IBM Cloud Kubernetes Service, is designed to allow the client to transform the application into a modern and scalable microservices architecture that helps it drive innovation. Use of cloud also makes it easier to scale as needed and quickly introduce new offerings to meet the needs of users.

WHEN CODE GOES LOW

Low-code and no-code platforms make building next-generation application services a high-productivity matter, for both IT and business specialists

Offering powerful AI-enabled tools leveraging API catalogs and pre-built templates, today's low-code and no-code platforms equip IT and engineering teams to achieve the lightning-fast development needed to keep pace with customer expectations and with changes in the business and technical environment. They extend existing Model-Based Systems Engineering (MBSE) techniques.

Visteon's off-the-shelf process automation: low-code engine accelerates complex processes

Visteon chose Creatio's low-code solution to orchestrate its IT environment and align client and partner international data. An off-the-shelf process automation and CRM solution for custom workflows was implemented using the low-code business process management (BPM) engine, and it accelerated multiple complex processes. This includes quote lifecycle management, document management, vehicle lifecycle management, and marketing automation.

Similar platforms can also be used in the back office, perhaps enabling users to create and amend their own small applications without the maintenance and operations headaches associated in the past with "shadow IT."

Continental's drive for digitization: low-code engine slashes development time

In just a few weeks, instead of a year, automotive technology company Continental built an electronic capital request (eCR) system. IT can integrate the app with ERP systems such as SAP Finance to check each capital request against the accounting budget. Mendix's low-code platform has also been used to build a range of solutions that have helped streamline processes in finance, HR, and purchasing. Not only are these new solutions built on a platform that makes updates and evolutions possible, but they are also delivered to Continental employees much faster and are easy for IT to maintain and update. The tool is made available to citizen developers as well as IT professionals.

As well as low-code platforms, packages such as ERP and CRM applications will increasingly make it possible – and safe – for users to define their own functionality by configuring pre-written software. It all helps to free up scarce IT skills, hopefully without creating technical debt, while ensuring that the back office is as responsive to changing requirements as the vehicle's onboard software.

MESH UP YOUR APPS

A "mesh" of highly accessible, secure, and agile application services that are ultra-easy to connect with and combine, both inside and outside the organization

As connected capabilities become more and more common, it is becoming frustrating to have a completely different experience on a smartphone versus the one you get in the vehicle when you attempt to do the same thing. It's even worse if you must enter the same information separately after switching from one device to the other.

It ought to be possible now to use the same accounts on both devices to drive common personalization and allow transparent access to protected resources. The in-car system also needs to know about choices already made by the user on their other devices. The entire process should add up to a seamless experience inside and outside the car. And this experience depends on the implementation and maintenance of a customer-centric information architecture.

GM's software platform for ensuring a consistent experience: connecting customers digital lives using cloud technology

GM Ultifi is an end-to-end software platform designed to streamline customers' digital lives using cloud-based connectivity. For example, vehicles could communicate with a smart home en route to deactivate the security system and adjust the thermostat. The platform also unlocks new vehicle experiences: in the future, for example, internal cameras could be used for facial recognition to start the vehicle's engine. Or, based on route planning and GPS, teen driver settings could be adjusted for extra caution in a school zone.

APPS ♥ AI

Systematically infusing new and existing applications with AI capabilities, making them smarter, autonomous, valuable, with a positive impact on society and the environment

AI and ML provide a way to make apps – and vehicles – really smart, by contextualizing the apps and the data they use to a specific situation. If you've just set out from home, you don't want a recommendation for a nice coffee bar, but if you've been driving for two hours that recommendation will be welcome because you probably want a break.

AI and ML will open up a whole world of seamless driver interactions. They can range from learning that the driver would like the window automatically opened as they approach their workplace's parking lot barrier to a whole range of driver assistance functions. Customers will especially value AI/ML features designed to support safety, reliability, and robustness.

As well as in-car apps, AI-enabled apps on other devices can support vehicle customers and help to integrate the brand and the vehicle into their digital life.

ŠKODA AUTO's tailored customer offers: AI-driven app "hand-picks" services that appeal to drivers

Using AI technology from Anagog, ŠKODA AUTO Digilab has developed Citymove, an app that helps it make the right offers to customers. Before they go on a journey, the app helps them choose whether to use their car or go for other mobility options such as buses, trams, the metro, rental bikes, taxis, and ride-hailing cars – all of which can be chosen, booked, and paid for via the app. The app also proposes personalized offers via notifications pushed to smartphones. Tailored to the location, the chosen means of transport, and the individual's behavior, offers may include deals on drinks, snacks, or services in the vicinity, discounts on fuel or car washes, and much more.

With multiple sensors in the car to support edge computing, even more contextual information is available. For example, if the driver's eyes show signs of tiredness, then recommending a place to rest would be appropriate even if they have only just left home. Information about heart rate from a smart watch could be used the same way, with permission, to help detect the driver's mood or state of health.

It's not just driver-related intelligence that's important. If an EV's battery will soon need charging, an app could modify the engine and environment parameters to save energy so that the driver can reach a more distant charging station with reduced queuing time and less impact on the environment. This would be done to reflect stored user characteristics and/or a choice made on the fly. AI-enabled apps could be used widely to guide or nudge users toward more sustainable choices.

INVISIBLE INFOSTRUCTURE

O Infrastructure, Where Art Thou? The odyssey towards a truly invisible IT infrastructure may still be ongoing, but progress is made. For many organizations, the pandemic era accelerated a move towards the public cloud; a signpost of increasing "invisibility." It is now the default choice amid a diverse range of cloud deployment options. To keep up with the pace of a Technology Business – or rather, being its pacemaker – IT infrastructure needs to fluently adjust to changing needs and the whimsical ways of the time. A software- and AI-driven, nearly autonomous supply chain – with reliability engineered within – is key to that. It also deals with the scarcity of skilled experts and excess energy consumption. But IT infrastructure also expands its reach, integrating Operational Technology and "things" at the edges of central IT, showing yet again that "Infostructure" is not a spelling mistake.

Industry trends affecting automotive

The automotive industry makes additional demands on infrastructure, in that the infostructure must provide a continuum between the vehicle and the off-board world. The following points should be read with this end-to-end infostructure, including the vehicle, in mind.

Despite pricing issues, cloud is ever more popular: for data lakes and enterprise systems, in industrial environments, and to support the delivery of connected services. Increasingly the first choice for new value creation, cloud must still coexist with the legacy landscape.

Meanwhile, trends such as **edge and IoT**, fueled by the wide availability of cheap systems on chips (SoCs) and single board computers able to run a full Linux stack, are transforming the environment into a continuum of data issuers, data consumers, and data consolidators along which information flows as freely as water.

Rapid, persistent, and resilient communications are being realized via high bandwidth / low latency networks. Data and processes can reside wherever is most effective, economical, and sustainable – vehicle, cloud, or elsewhere. Communication between vehicles and other entities is another aspect of this trend.

Pervasive connectivity contributes to **increasing cybersecurity risks**, but there are other contributing factors, such as the proliferation of connected objects such as vehicles and industrial robots, juxtaposition of multiple technologies, and sometimes a lack of focus on asset protection.

Keep calm and make a datacenter out of your car

Adding onboard computing power

OEMs are investing heavily in this key enabler of software-defined transformation and connected service provision. Traditional electric/electronic (E/E) architecture is moving away from multiple specialized electronic control units (ECUs) toward a consolidated, service-oriented high-performance computing (HPC) platform – a disruptive change, but one that will reduce complexity and enable a wide range of services. High-speed networks can connect the vehicle to other entities in the mobility ecosystem, from other vehicles and road users to roadside telemetry systems. Flexible communication with off-board systems will lead to a seamless experience that shifts focus from the vehicle toward customer mobility.

Mobile edge computing

Vehicles should in the future be able to construct data objects using IT-standard formats, decide what information to push to the cloud depending on connectivity conditions, log and store events, and make services available via APIs (service-oriented architecture or SOA). Strong security mechanisms will be required to maximize safety, reliability, and robustness. Otherwise, customers will not accept the innovations.

OTA software updates

These will enable corrective, preventive, or adaptative maintenance of embedded software. They will also deliver new capabilities to vehicles on the road: for example, enhancements to engine modes, assisted braking, ADAS capabilities, or infotainment.

Virtualization/containerization

Functions traditionally performed by specialized microcontrollers can be coded in software and can – still logically isolated – run on standard hardware. This hardware abstraction increases OEMs' flexibility if the electronic component supply chain is disrupted. Virtualization also enables Agile development approaches to be applied to embedded software, reducing time to market and increasing confidence in OTA updates. An entire vehicle can be simulated as a digital twin in the cloud, making it much easier to test new or enhanced software.

Location-independent processing in the factory

Successful use of robots and sensors on the shop floor depends on processes being executed wherever is most efficient – often in the cloud. That requires fast communications as well as powerful cloud infrastructure. In addition, inexpensive single board computers (SBCs), exemplified by the Raspberry Pi with its numerous hardware extension modules, will be available for deployment in "dirty" industrial environments. With the right infrastructure – and the right edge and IoT capabilities – ML and AI can become integral to the industrial environment.

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Expert in Residence

LORD OF THE CLOUDS

Cloud adoption moves far beyond the middle-earth realm of cloud migration, now also driven by sustainability, distribution, sovereignty, "FinOps" and multi-cloud forces – all for that precious, better business flow

To move toward objectives like autonomous driving, you need to be able to continuously deploy individual smart features such as adaptive cruise control, collecting and managing large volumes of different data types.

That means becoming Lord of the Clouds, as most data is stored and managed in cloud-based data lakes. Cloud is key to offering apps on demand, so that the car becomes a sort of app store – for example, if I didn't choose to have cruise control in my car when I bought it, I should be able to install the software whenever I need it and get billed on a periodic basis. Cloud can also reduce a company's carbon footprint due to its ability to scale dynamically.

Automotive companies, while well advanced on their cloud journey, often still struggle with legacy systems. Cloudifying their app landscape before building new services will help them reap more benefits from invisible infostructure.

Of course, not everything needs to be run in the cloud, even if it comes from a cloud vendor.

Volkswagen Passenger Cars' on-premises implementation of AWS' NICE DCV: high-performance remote display solution runs on VW's own infrastructure

Volkswagen Passenger Cars has implemented NICE DCV, a technology from AWS, on its own high-performance computing cluster. It is a high-performance remote display solution for securely delivering remote desktops and application streaming from a data center or the cloud to any device. More than 1,000

computer-aided engineering (CAE) engineers at VW run 3D CAE software remotely and stream the user interface to client machines, eliminating the need for dedicated office-based workstations. VW is enhancing its security capabilities by using NICE DCV encryption features along with its internal enterprise virtual private network (VPN) solution. Additionally, NICE DCV streams pixels instead of geometries, ensuring customer data privacy. The solution secures both pixels and end-user inputs by using TLS protocol, so customer data is highly protected.

In fact, to get the best out of cloud, companies need to find ways to combine it optimally with other infrastructure elements.

Hyundai's next step in software-defined cars: virtualization using cloud plus in-vehicle commodity chips

To bring the connected car even closer to the world of business IT, Hyundai has allied with US software house Sonatus. The Sonatus program code runs partly on platforms in the vehicle and partly in the cloud and dovetails the functionalities of both worlds with each other. While it benefits from a virtualized environment, it does not require extremely powerful computer platforms like those recently introduced by some Tier 1s. Instead, it can run on commodity microprocessors such as those from NXP and Arm.

CROUCHING TIGER, HIDDEN CONTAINER

All the complex infrastructure an application needs, nothing to see but next-generation, energy-saving containers that will run anywhere, delivering multiple critical consumer-facing business services

To handle deployment complexities, companies need to avoid being locked into hosting technologies that are proprietary and not interoperable. Containers and associated technology were designed to standardize integration and deploy and run across various environments.

Mercedes-Benz R&D's "container-driven cars": testing applications as independent microservices

Mercedes-Benz is building container-driven connected vehicle software by leveraging Kubernetes, a distribution system for containerized software that was originated by Google and is now open source. In this way, the Mercedes-Benz development team can build applications that can be tested as independent microservices. Microsoft's Azure Kubernetes Service (AKS) was used as the managed Kubernetes platform for distributing the microservice-based application development platform to reduce complexities and build new solutions faster.

Porsche Informatik's private cloud container environment: speeding up application delivery

Porsche Informatik, an IT service provider for the Volkswagen Automotive Group, used Red Hat OpenShift to create a private cloud container environment to speed up application development and delivery to stay competitive in a fast-paced global market. Porsche Informatik's developers can take advantage of self-service capabilities, and teams across the organization can work together more effectively with a DevOps approach supporting continuous integration and delivery (CI/CD) workflows. As a result, Porsche Informatik has cut development time from weeks to hours and created a solid foundation to stay ahead of competition.

SIMPLY THE EDGE

Intelligent devices, at the "edge" of central IT and close to operations, add a powerful dimension to the existing IT infrastructure

Although major processing and data management will happen off-board and often in the cloud, critical functions need to remain onboard. If an autonomous vehicle identifies a situation such as an accident ahead that makes it necessary to recalculate its path, it must be able to do this recalculation instantly, even when no connectivity is available. This means that decision-making capability will need to be brought to the edge, i.e. into the vehicle.

Toyota, big data, and edge: a joint initiative for delivering data to connected cars

Toyota, Intel and Denso are among the companies that have formed the Automotive Edge Computing Consortium, which aims to develop the infrastructure needed to support the skyrocketing data demand from connected vehicles. The objective is to develop an ecosystem to support emerging services such as intelligent driving, creation of maps with real-time data, and driving assistance based on cloud computing. The consortium estimates that data volume between vehicles and the cloud will balloon to 10 exabytes per month by 2025 – approximately 10,000 times larger than today's volume. It plans to focus on increasing network capacity to accommodate automotive big data by means of edge computing and more efficient network design.

In the same way, time-critical applications, such as those in a smart factory, need to have decision-making capability available at the edge – following the "4-walls principle" of keeping all critical resources of a process local to the production site.

Audi's factory automation POC: edge technology to enhance quality control

Audi partnered with Intel on a proof of concept (POC) experiment focused on improving the quality control process for the welds on its vehicles. Intel integrated its Edge Machine Learning with Nebbiolo's Edge Software to automate and enhance Audi's critical quality control processes in its factories. The POC took place at Audi's factory in Neckarsulm, Germany, one of the company's two principal assembly plants. The new infrastructure based on Nebbiolo's Edge Software supports a hierarchical data analytics and machine learning architecture, with edge models iteratively refined by Audi's and Intel's data science teams, which enables the inspection of all the 5,000 welds per car, yielding accurate quality results for each weld within 18 milliseconds. This helped Audi meet its goal of inline quality control and significantly reduced labor cost.

OPS, AI DID IT AGAIN

AI renders IT operations fluid, proactive, and resilient, improving efficiency and reliability while it learns – on its way to full, handsfree autonomy

The automotive world is tending to move to no-touch operations, with automatic monitoring of production lines, as well as predictive maintenance where problems are worked on before they turn into incidents, and automatic recovery from any incidents that do occur.

This is already happening on the manufacturing side. However, further investment will likely add AI to the applications and infrastructure that design or control their operations, in the quest for "no car lost on the line" – that is, no interruptions to production from errors or incidents.

BMW's virtual factory: AI-powered simulation to optimize assembly lines

BMW started making drivetrains for electric vehicles at a vast factory in Regensburg, Bavaria. Well before any new parts rolled off the production line, the entire manufacturing process was able to be run in realistic detail inside a virtual version of the factory. The simulation allowed managers to plan the production process in greater detail than was previously possible. Over time, BMW wants to use this simulation to have robots learn how to perform increasingly complex jobs. BMW used a software platform called Omniverse, developed by Nvidia, to recreate the Regensburg production line with photo-realistic details, accounting for physical properties like gravity and different materials. The simulation can include avatars of human workers grabbing parts and tools and assembling components to find the best procedure and minimize ergonomic problems.

SILENCE OF
THE SERVERS

Building a highly automated, self-optimizing IT infrastructure that is so entwined with business operations, that it is no longer distinctly noticeable

The trend toward maximum automation makes heavy infrastructure demands. In the automotive world, these demands may be noticed first on the shop floor or in warehouses.

You can already see manufacturing robots capturing production data for storage in global data lakes to support real-time global analysis of assembly plant key performance indicators (KPIs); mobile robots (such as Automated Guided Vehicles or AGVs) re-flashing firmware on new vehicles in a parking lot rather than halting the production process while waiting for a major software update; cameras attached to units with AI-enabled application-specific integrated circuits (ASICs – specifically tensor processing units or TPUs) that perform image recognition to automate visual quality control; AR goggles improving operators' productivity via training, easy access to documentation, and quick identification of objects in visually crowded environments. There are more examples every day.

That said, engineering departments have traditionally been the heavy lifters in terms of computing complexity.

Nissan's cloud migration of off-premise HPC workloads: speeding up engineering processes and reducing cost with cloud power

Oracle announced that Nissan Motor is migrating its on-premises, HPC workloads to Oracle Cloud Infrastructure. By moving its performance and latency sensitive-engineering simulation workloads to Oracle Cloud, Nissan will be able to speed up the design and testing of new cars. Oracle Cloud Infrastructure's

compute, networking, and storage services optimized for HPC applications will allow Nissan to benefit from the HPC solution with RDMA networking as it innovates cars. Nissan anticipates higher performance and lower costs with the ability to easily run engineering simulation workloads in the cloud.

Another new trend, as automotive companies rapidly evolve into software houses, is the adoption of the advanced automation techniques available for software development.

Bosch's initiative to speed up and improve software delivery: faster software innovation through cloud-based continuous integration

About 40,000 Bosch employees work in R&D for the company's mobility solutions sector, and about one-third of them are software engineers. For example, Bosch's automotive division, one of its main areas of business, provides software for engine control in passenger vehicles. As part of an initiative to help its software engineers deliver higher-quality software faster, the Diesel Gasoline Systems – Electronic Controls (DGS-EC) division is adopting continuous integration (CI) practices with CloudBees, a cloud platform for delivering CI at scale. Reflecting on this shift, Bosch CEO Volkmar Denner has even noted, "Bosch is a software company."

BALANCE BY DESIGN

The essence of designing a Technology Business is to find and preserve several balances in parallel: balance between the interests of stakeholders, between short and long term, centralized and decentralized, friendly and authoritative, purposeful and spontaneous. Besides the WHAT of technology trends, TechnoVision offers a view of HOW to shape these balances within the organization – by purposeful design. The principles within this container aim to provide control questions for executives, a bouquet of perspectives for architects, and a systematic checklist for anybody involved in a Technology Business portfolio, program, project, or initiative.

Transition 1: Preparing for service provision

As the automotive industry transforms into the mobility service industry, it needs to re-evaluate its mission. Products should now be seen in the context of getting the customer from A to B in the best and most sustainable way and at the best price – and that, rather than the vehicle itself, should be the focus of innovation.

To tackle this transformation, some companies are acquiring startups specializing in hourly or conventional rental. Some are launching mobility services offering bikes and scooters – and cars – on a monthly subscription basis. Some are investing in ride-sharing services.

Success in the mobility world depends on tearing down silos, or at least bridging the boundaries between them with holistic hardware and software approaches, always with a focus on the customer.

Transition 2: Managing complexity through standardization

The technology landscape should be rethought for a future where OEMs and customers constantly interact, with real-time, event-driven processing, and platforms constantly pushing up-to-date, individualized offers toward customers. Many new data flows (e.g. vehicle data to support ML around product design) must be securely supported, requiring powerful networks and secure communication methods.

Behind the scenes, this highly innovative future might seem to imply a level of complexity that is hard to manage. The solution lies in standardization – in the sense of alignment and streamlining – so that elements can be assembled with reduced efforts and managed as a seamless whole. Part of the standardization is likely to happen through the use of open-source solutions, which can enable industry actors to transparently cooperate in order to cope with the cost of non-differentiating investments in the ongoing transformation.

Another solution to the complexity will be a blurring of boundaries between the IT and engineering disciplines, reflecting the integration of software into vehicles. This will help to tackle one of the issues facing the industry: namely, that as vehicles become software-defined, onboard computing systems provided by Tier 1 suppliers can no longer be treated as black boxes. OEMs need to build a detailed internal understanding of their functions and effectively reinvent themselves as software companies.

Transition 3: Making electrification work

To ensure a successful future for EVs, it is important to look beyond the vehicle itself. For example, the charging network will be a major determinant of success. Companies can influence the future both by taking steps to improve that network and by innovating to ensure that vehicle architecture and services can work with whatever is available.

When assessing investments in charging stations, OEMs will be influenced by their potential as a source of business revenue and an enabler of communication with drivers. While so far only Tesla has built its own charging infrastructure, others are expected to be investing in this area, though early initiatives such as Ionity are limited at present.
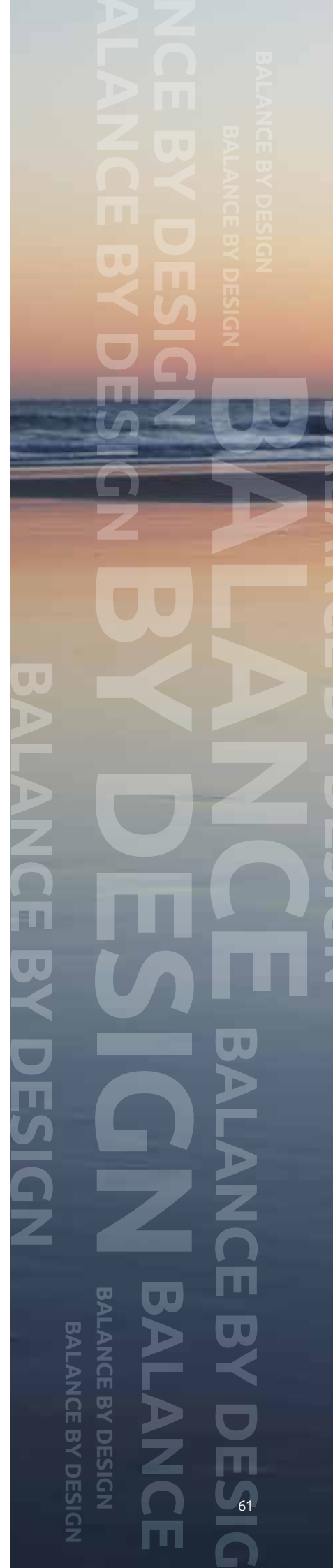
Careful design will be needed to ensure that vehicles use the charging network as efficiently as possible. For the most economical, sustainable results, V2X interaction with the smart grid is needed to decide when and how fast to charge, and when to upload electricity.

Companies will also need to consider the entire lifecycle of the EV, and not just the immediate future. For instance, a vehicle could last 15 years, but its battery will not. OEMs will therefore want to plan for affordable, convenient battery replacement.

Transition 4: Building a comprehensive view of ESG

Automakers are keenly aware of the importance of sustainability. Not only are they under pressure from regulators and governments, but they know that for customers sustainability can be a criterion for choosing a vehicle, just as it is for consumer goods. Clearly, sustainability is becoming a focus of innovation.

However, laws and regulations, as well as customer and public expectations, mean we're going to need a more holistic picture of the vehicle's impact on the world. Intensifying stakeholder scrutiny extends to social responsibility and governance, as well as sustainability. Human rights and modern slavery, along with corruption and sanctions, need to be considered: for example, companies are expected to avoid procuring cobalt in countries where child labor is prevalent. Data governance is another key dimension to operating as an ethical business.

Unless commitment to these issues is demonstrated, the industry's mixed regulatory history may lead to heavy regulation around vehicles' social impact as well as their sustainability. And the need to satisfy all these requirements strengthens the case already made for designing effective, secure data-sharing platforms.

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TECHNOLOGY ⧓ BUSINESS

Move from alignment to unity of business and IT, creating a seamless Technology Business strategy and operations

Gone are the days when the talk was about aligning technology with the business (meaning that one must catch up with the other). Now technology and business have converged to the point where they are effectively the same thing. The vehicle is no longer just chemico-electro-mechanical, but will soon be defined by software. With continuous OTA updates, the vehicle will rarely need to go to the garage, the way services are sold will be transformed, and the experience within the vehicle will be completely different.

Among other implications, this means that IT practice is going to pervade a much bigger portion of automakers' business.

The winners will be the companies that successfully combine IT effectiveness with excellent engineering approaches – something that can be difficult because of the very different cultures and ways of working that characterize these two disciplines. However difficult it is, technology and business need to come together as never before.

With "software eating the world," as Marc Andreessen put it a decade ago, it's only to be expected that some automotive companies are setting up their own software subsidiaries. As well as appealing to the talent they need, these startup-style organizations can excel at innovation.

ADAPT FIRST

Move adaptability from afterthought to prime time

There are two aspects to keeping up with rapid changes to the business and technological environment. The first is organizational readiness. A clear strategy is needed – does the company want to be the first mover, leading the market with all the risk that entails, or does it want to be the one that is fastest at jumping on trends successfully pioneered by others and quickly implementing them?

Either way, the company needs the flexibility to cope with continuous change. As we know, approaches like model-based design, Agile, or DevOps can help, but it is also necessary to invest in the right supporting infrastructure:

one that integrates the front end and the back office. For example, when services are sold to customers and delivered OTA to the vehicle, it's vital to be able to invoice for them efficiently.

This integration is critical. Rather than simply moving existing applications to the cloud, companies should look at modernizing them.

Finally, companies should be ready to move far away from their core business and traditional processes if it can make them more adaptable.

WITH OPEN ARMS

Upgrade your technology platform to the ultimate Technology Business platform: a superior, open set of attractive services, acting as a magnet for active collaboration, internally and externally

Competitive pressure and the need for brand differentiation have often led the automotive industry to build in-house solutions: the "make or buy" question is recurrent, and sometimes occurs alongside the "not invented here" syndrome.

But with the move to services, the size and completeness of the ecosystem may become the real differentiator. We should expect automakers to start allowing, or even welcoming, third-party software inside the vehicle to get a particular offer to market quickly; the door has already been opened by Google Auto.

Therefore, the emphasis shifts from functional specification of ECUs to writing software to providing APIs facilitating integration of third-party apps.

Porsche's open source software initiative: encouraging employees to add to open source resources

Porsche created a process for submitting and publishing code on the GitHub development platform. This process is specifically aimed at software developers, and subsidiaries such as Porsche Digital, and makes it even easier for employees to contribute to open source resources and publish code. Porsche is also broadening its online presence; the sports car manufacturer now has an official profile on GitHub – the world's leading developer platform for software, used by more than 50 million people. The focus of the strategy is on in-house developments and new initiatives, as well as participation in or contribution to existing third-party projects. Every employee is encouraged to play an active role in GitHub projects and advance the worldwide community as a contributor.

DO WELL, DO GOOD

Boost the organization's societal purposes by saying "Yes" to technology that boosts sustainability and say "No" to what is energy-wasting or non-essential

Automakers know they need to overcome a difficult reputation when it comes to making a positive contribution to the planet, and they have been quick to shift their attention to EVs.

In addition, while making sure that EVs are available as widely as possible with minimal environmental impact, companies recognize that they may not be the right solution for some regions; in parts of Africa, for example, the infrastructure necessary for EV adoption won't realistically be available for some time. So, automakers may need to continue evolving conventional vehicles to be as sustainable as possible. To this end, could AI be used to help drivers lower emissions and fuel consumption through better driving behavior?

As the automotive industry is an unrecognized leader in product recycling, it's important to view the overall picture of the vehicle's sustainability: from the choice of sustainable material to the environmental cost of the long inbound and outbound supply chain (including the effects of shipping materials across the world), and the refitting of electric motors into used vehicles.

Aside from sustainability, there are other aspects where "who cares wins."

Toyota and MIT's safety training for autonomous vehicles: accident avoidance through simulation

In collaboration with the Toyota Research Institute, MIT invented a data-driven simulation system to train driverless cars to avoid accidents. The simulator uses a small dataset captured by humans driving on a road to synthesize a practically infinite number of new viewpoints from trajectories that the vehicle could take. The controller is rewarded for the distance it travels without crashing, "motivating" it to learn how to reach a destination safely. This might involve regaining control after swerving between lanes or recovering from near-crashes. In tests, a controller trained within the simulator and deployed onto a full-scale driverless car could navigate through previously unseen streets. With the car positioned to mimic various near-crash situations, the controller was able to successfully recover the car back into a safe driving trajectory within a few seconds.

TRUST THRUST

Power up the entire *trust* ecosystem – from the organization's core to its edges – securing your existing business and pushing forward to its next permutation

Although cybersecurity practices are mature and readily available in the industry for enterprise environments, it is much less true for industrial settings and for products.

With software soon to become dominant in the vehicle, the attack surface will increase massively. Customers must fully trust the manufacturer's cybersecurity measures to prevent hackers from taking control of the vehicle.

Automakers are well aware of the importance of cybersecurity and are taking steps to tighten it up.

GM's cybersecurity partnership with the military: collaborative penetration testing and risk analysis for the common good

General Motors has formed a research and development agreement with the US Army CCDC Ground Vehicle Systems Center with a focus on conducting penetration testing and cybersecurity risk analysis to improve cybersecurity for both GM and the army. Cybersecurity experts from the two parties can share best practices, methodologies, tools, and approaches, and embed or co-locate in each other's organizations. Key learnings are to be shared with the Society of Automotive Engineers for the development of common standards.

BMW's collaboration with a blockchain startup: joint development of a security platform for vehicle data

VeChain, a China-based blockchain company, has partnered with German carmaker BMW to develop an auto security platform that keeps vehicles free from forgery. The two companies plan to roll out the blockchain-based Decentralized Application (dApp) VerifyCar, which will collect vehicle data such as mileage, repairs, and additional services. The dApp will run on the VeChainThor blockchain to keep the data secure and tamper-proof. By accessing the app, the user can decide what data they want to share with whom. The recipients can compare the data with the "digital fingerprints" or reference stamps on the VeChain blockchain. If the user-provided data and the reference on the blockchain match, the recipient knows that the data is authentic. Data such as mileage is collected in real time and stored on VeChain with the assistance of hardware provided by BMW. VerifyCar protects consumers from sellers who intentionally manipulate vehicle data such as mileage to fetch a better price.

IQ CQ EQ UP

Ensure a properly measured and monitored balance between three – sometimes conflicting – assets: the corporate Intelligence Quotient, Creativity Quotient, and Emotional Quotient

It is not enough to leverage the power of AI. We need to do it in a way that adds to the experience by building empathy – the emotional quotient (EQ). We have already noted that using sensors to detect indications that the driver is getting tired (such as frequent blinking) and suggesting a break can be valuable to the customer. The value will be so much greater if the vehicle has learned how much blinking is normal for the individual customer. The ideal is to enrich the experience to the point where the customer feels that they are being treated as a "segment of one" and receiving a service that's unique to them.

In a similar way, AI can be used to build more intelligence into the organization. Success still depends on the creativity quotient (CQ) of humans. Gaining access to the right people, and keeping them happy and productive, will remain vital. AI has a key role to play in providing the best employee experience, as well as in making the most of human creativity – for example, by helping evaluate and compare multiple solutions put forward by humans or, indeed, other AI.

NO HANDS ON DECK

Assume full, handsfree automation as the default for all new Technology Business processes

We have talked about the importance of automation in different parts of the business, but we also need to go a step further and consider how to make the whole business autonomous, so that it runs itself in a real sense. When more capacity is needed to ensure continuity, it should be the system that spins up more servers – not a human operator. Factories should be automated to the point where downtime is a thing of the past. And, looking into the longer-term future, instead of having humans make decisions about lowering the price, AI will be able to do it.

Volkswagen's plan to digitalize global production: AI and cobots at the heart of supply network upgrade

Volkswagen intends to completely overhaul its manufacturing capacity through a strategy of digitalization across North America. Industrial software based on AWS's cloud, new intelligent robotics, and other AI elements are set to be rolled out in factories across the region. Using artificial intelligence, cobots (collaborative robots), and integrated in-house cloud systems, the company is laying the basis for a planned total upgrade of the global supply network. The explicit aim of this project is to achieve a 30% increase in productivity and lay the foundations for digital manufacturing jobs in the future.

This isn't to say that people will be obsolete. For one thing, they will be needed to ensure that machines deliver what's really wanted. To take just one example, we should guard against bias getting into autonomous systems. It is easy for recruitment processes to build in gender or racial biases when they learn from the status quo, so humans must monitor to ensure that nothing like this happens.

But we should aim to use AI to eliminate failures caused by humans (whether through operational errors or programming faults in legacy systems) from all processes, whether in factories or in vehicles.

Volvo's collection of customer data to refine driver assistance features: AI plus real-time sensor data speeds up progress toward autonomous driving

Together with its in-house self-driving technology arm Zenseact, Volvo will enable owners of its next-generation vehicles to supply real-time data gathered from sensors to help in the development of electronic driver assistance features, including future fully self-driving systems. Volvo owners will be able to choose whether this data is collected, and much of it will be kept anonymous. The data will be stored in a data center with some 225 million gigabytes of capacity and processed by fast AI systems. The AI looks for patterns in the data and then predicts outcomes that driver assistance and self-driving systems rely on to take actions. Volvo will then be able to design driver assistance and self-driving systems for specific geographic locations much more quickly than with a limited number of prototypes going out all over the globe.

A Few More Things

If Marty McFly traveled back from the future with a TechnoVision report in his back pocket rather than a sporting almanac – what would it say? Unfortunately, no one has a DeLorean time machine, so it's impossible to envisage the future accurately. Yet, what we can see is the emergence of key trends we believe will further shape our technological horizon. Maybe not this year, but soon. Very soon.

Autonomous, probably; hovering, possibly…

We've been talking about it for a while, but SAE Level 5 (fully autonomous) vehicles are still a few years away. Eventually, however, they will become a reality, after successive improvements of ADAS systems.

Also, the massive development of drones over the last decade will certainly drive some applications in the automotive industry – from attached flying companions to fully floating vehicles. These applications are likely, of course, to be highly regulated, and initially limited.

Both trends will probably take hold in the professional fleets segment first.

…but all electric

As a result of social expectations and associated legislation and incentives, recently exacerbated by the soaring prices of fossil fuels, the biggest changes can be expected on the energy front, which is already seeing sustained investments and cross-sector alliances.

First, the density of EV charging infrastructure is set to increase steeply, following the recent hike in EV sales. This is already reflected in overall energy consumption forecasts as total demand increases, in part due to the transfer of transportation applications from fossil fuels to the power grid.

Second, significant improvements in battery technology, including the move to solid-state electrolytes, will make them cheaper, safer, more durable, and faster to recharge.

Finally, we are also keeping an eye on complementary solutions, such as vehicle energy distribution alternatives including the long-envisioned battery-swapping service, or the highly anticipated hydrogen fuel cells – assuming technical and economic challenges to implementing both can be overcome.

These are not new ideas, but since the conditions that need to be met to make them largely available are excruciatingly difficult, they will appear slowly. And don't hold your breath about seeing a "Mr Fusion" reactor sitting on top of a car anytime soon!

Multisensory AR cockpits

In parallel with the increased sophistication of driving aids, the nature of interactions between occupants and the vehicles will evolve.

To start with, expect any surface to potentially become a touchscreen, with transparent ones providing an AR experience, coupled with anti-dazzle capabilities, all supported by immersive 3D projectors.

Interactions will go beyond touch on physical or virtual buttons: voice assistants have made tremendous progress in the last few years and are being integrated in vehicles today; gesture recognition is being adopted rapidly and will soon extend – with a heavy dose of AI – to reading head and eye movements, body language, facial expressions, and metabolism.

Progress in noise cancellation technologies could deliver sound bubbles that completely or selectively filter out external noise, or even isolate passengers in separate environments. One person could be putting a confidential call through to the office, another enjoying music without any road noise, and the last one listening to chirping birds during the ride through the countryside.

Some of these capabilities could be implemented initially with optional wearables (for example, smart glasses to deal with parallax for AR), but smart implants may even come into play at some point.

Software-defined, inside and out

Even if it is still a difficult problem, the evolution of technologies that gave birth to cloud, smartphones, or drones, will progressively adapt to address "hard real-time" needs and safety considerations that are paramount for automotive applications.

Software-defined vehicles, though almost nonexistent on today's roads, are on course to become the dominant type, marking a real disruption of the E/E technical standards that have dominated the industry for nearly 40 years.

This opens up the path to realizing the benefits of virtualization, continuous value delivery, and innovative integration of an exponential number of digital resources and services. Think about what this same evolution did to your phone over the last 20 years. Then ask yourself when you last got lost on a trip and had to stop to open a paper map to find out where you were. Now, which of the issues that you face today will be removed in the next 20 years?

Virtual Companions will be a visible element of this evolution: they are digital versions of vehicles and their environments, living in the cloud, equipped with the most advanced inference engines, and integrated with all the usual components of the occupants' digital life: social networks, entertainment channels, business productivity tools, and so on. They will constantly compute what the occupants may want or need, naturally leveraging information coming from digital cockpits.

Think of them as descendants of today's navigation systems, trying to find better routes based on real-time traffic information. Soon, they will start proposing changes to engine modes, braking and suspension strategies, or air conditioning settings, to optimize range. They will also select alternative charging stations to reduce waiting time on a long journey. The potential is huge, so expect to see a lot of innovative ideas popping up.

Flexible industrial environments

EV and software transformation and the related trend toward E/E standardization are shifting the source of the automotive product's complexity. So, while advanced software configuration management is becoming indispensable to handle the significant increase of logical complexity, the industrial production environment is likely to be simplified, or at least further streamlined with a stronger scaling effect.

To blockchain or not to blockchain

Current blockchain techniques are controversial in the industry, particularly because of their massive resource usage requirements, and their use has so far been limited.

But blockchain-type architecture could be used to develop immutable records of vehicle lifecycle information – something that could help streamline the used vehicles market. It could also address end-to-end supply chain data certification, for example with projected sustainability scores.

Quantum computing

Quantum computing is already a key consideration when thinking about the future of cybersecurity and encryption, but it could also provide specific solutions to some combinatorial optimization problems, numerical simulations, machine learning, or sensing at nano scales. Major automotive companies are already researching and preparing for that future.

Further research

Technovision 2022: Being Like Water

Circular Economy for a Sustainable Future
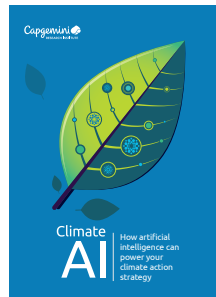

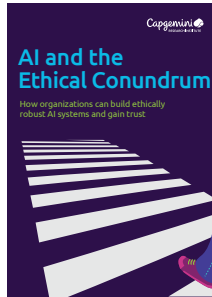**Data Mastery**

The Data-powered Enterprise
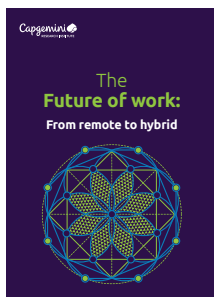

Sustainable IT
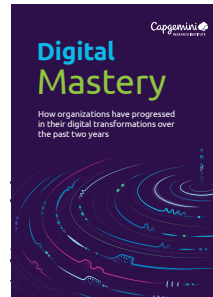

Climate AI

AI and the Ethical Conundrum

Sustainable Operations

The Future of Work

Next Destination: Software

Digital Mastery

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