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CONNECTED VEHICLE TREND RADAR 3

A car isn’t a smartphone on wheels – yet

EXECUTIVE SUMMARY

For this, the third of our Connected Vehicle Trend Radar reports, Capgemini Invent investigated how far a car can be regarded as a smartphone on wheels, where vehicles fall short of the smartphone model, and what can be done about it. We also looked into the future to see what will be possible once a car takes up a role in our digital lives as central and integrated as that of the smartphone – or more so.

Although the analogy between intelligent vehicles and smartphones has often been drawn, it is not entirely valid because of gaps that still exist between cars and smartphones. These gaps can be analyzed from three main perspectives.

From the perspective of usability and customer experience, one gap lies in the fact that transportation is (and probably will remain) a car's main value proposition and that it otherwise offers a limited range of functionality. The car has yet to be fully integrated into the digital portfolio, and therefore customer experience is not as seamless as it should be. Another gap here is that connected services currently offer relatively low levels of personalization compared with smartphones.

From the second perspective of application landscape and operating system, one major gap concerns the fact that cars offer a much smaller range of apps than smartphones do. A contributory factor is the fragmentation of the automotive industry's OS landscape – a deterrent for many third-party developers.

From the third and final perspective of innovation and updatability, one of the gaps is that vehicles can process relatively limited amounts and types of data. The industry's long development cycles mean that products can seem out of date by the time they reach the market. Over-the-air updates to vehicle software could be a way to address this problem, but they are currently limited too.

When these gaps are fully closed, and as self-driving cars become a reality, the future vehicle will be able not just to equal but often to exceed the role of a smartphone in digital life. It will be able to act as a virtual co-driver, virtual workplace, and much more.

But OEMs will not have to wait for the arrival of fully autonomous driving to realize the benefits. Closing the gaps will arguably make it easier to meet current user expectations as well. That is because the smartphone sets the standard that cars need to match in terms of integrating diverse everyday functionality to provide a seamless, interactive experience that truly meets user expectations.

Capgemini Invent therefore recommends that OEMs take targeted action to close the gaps between smartphone and vehicle functionality relating to each of the three perspectives.

A. Customer perspective: usability & customer interaction

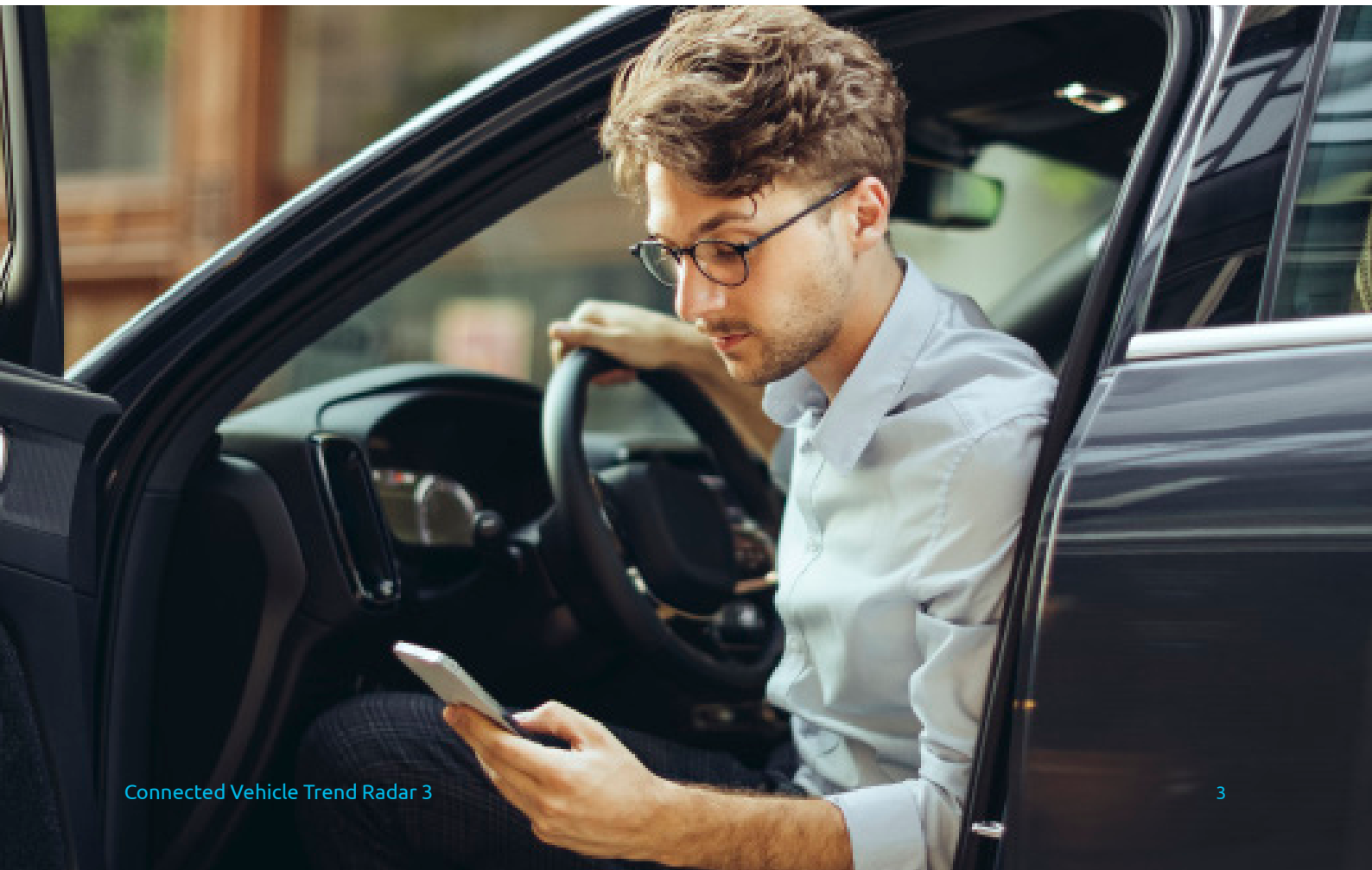
- Re-design the connected services portfolio from a driver-centered experience toward a passenger-centered one – especially for (semi-) autonomous vehicles.
- Integrate commonly used third-party apps and foster seamless synchronization across other devices via centralized account management.

B. Ecosystem perspective: app availability & operating system

- Understand the smart vehicle as an element in customers' digital portfolios and ensure that they can use the same digital services (apps) in the vehicle as on other devices.
- Act immediately and consider strategic cooperation with other OEMs or big tech companies to stay relevant if the OS becomes a decision criterion for vehicle purchase.

C. Technology perspective: innovation & updatability

- Adopt customer-centric product development approaches to better understand and integrate today's and tomorrow's market requirements. Deploy software-based or virtualized techniques to expose customers to the vehicle's user experience during the early stages of development.
- Transform today's hardware-defined cars into software-defined ones by decoupling hardware from software development cycles. Build a cloud-based digital infrastructure to deal effectively with the upcoming data explosion in vehicles.



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INTRODUCTION

We are used to hearing that a car is a smartphone on wheels, and tend to assume the analogy is valid – but is it?

To find out, Capgemini has conducted industry research, including a series of in-depth expert interviews. The results show that several gaps need to be filled before even the most advanced cars are as smart as smartphones. For example, car makers need to combine a comparable range of everyday functions seamlessly into a single platform.

It is almost a truism to call a car a smartphone on wheels. It may have been Toyota president Akio Toyoda who first used the analogy, back in 2011. Subsequently, the same analogy has been repeated by OEMs worldwide (see panel) when they want to emphasize product features such as advanced connectivity, user-friendliness, customizability, and versatility.

"SMARTPHONE ON WHEELS" – AN ANALOGY THAT THE INDUSTRY KEEPS COMING BACK TO

2011 Toyota Motor Corp. President Akio Toyoda unveils a "smartphone on wheels" concept car. [1] With 4G on the rise, this analogy quickly becomes widespread.

2015 Daimler Head Dieter Zetsche says the car is becoming a smartphone on wheels. [2]

2015 Volkswagen brand chief introduces future VW cars as smartphones on wheels. [3]

2016 China's "Internet car" from Alibaba and SAIC is marketed as a smartphone on wheels that can take selfies and pay for your coffee. [4]

2017 Nio's CEO Padmasree Warrior says, "We want to be the first company that builds the next-generation mobile space" – the company wants to build a computer on wheels. [5]

2020 Cars are becoming smartphones on wheels, "Daimler's Chairman of the Board of Management, Ola Källenius told German business newspaper Handelsblatt. "To stay competitive, we will have to control the software. [6]

2022 All the stuff that you can do in your smartphone will be almost inherently native within the vehicle," Volvo's new CEO, Jim Rowan says. [7]

Indeed, the automotive industry's developments around digital and connected services have often followed, or been shaped by, those seen in smartphones. This influence is not surprising. Smartphones have achieved a unique position in our daily lives over the past few years, from the moment when Apple's iPhone first appeared. This success has been due to their groundbreaking combination of functions: phone, camera, music player, browser, calendar, and more, all integrated into a single platform.

In this report, we discuss some ways in which cars fall short of the smartphone model. Building on this analysis, we then define a series of measures and strategies for closing the gaps. Finally, we look into the future to see what will be possible once these gaps are closed, finding that vehicles could, in time, become an even more integral part of our digital lives than smartphones are at present. Our analysis draws on insights from a recent worldwide online survey of more than 2,700 participants from China, the US, and the EU.

VEHICLES VERSUS SMARTPHONES: HOW DO THEY COMPARE?

Of course, a car is never going to be a smartphone, and in many ways it is very much more. Nor do automotive manufacturers lag behind their phone industry counterparts in general. They are already making rapid progress in areas that smartphone makers do not have to worry about, such as drivetrains, autopilot, and predictive collision avoidance.

Yet smartphones do provide a useful model of how technological progress and connected services should be delivered and integrated into a platform, and the automotive industry has benefited from this model. Many major milestones in the smartphone evolution were achieved by vehicles approximately three to five years later.
For example, voice control was provided in smartphones in 2009, but the first voice applications in vehicles did not appear until 2013. Mobile payments were available on phones in 2017/18, but in cars they have only recently been introduced, or have yet to appear [8]. There are several more areas where even the most advanced and intelligent of today's cars still fall short of the smartphone model.

It is useful to understand these gaps, so in this section we'll consider some aspects of smartphones that we believe explain their success and their central role in our lives.
We'll compare those aspects of phones with how cars currently look, using the following three perspectives:

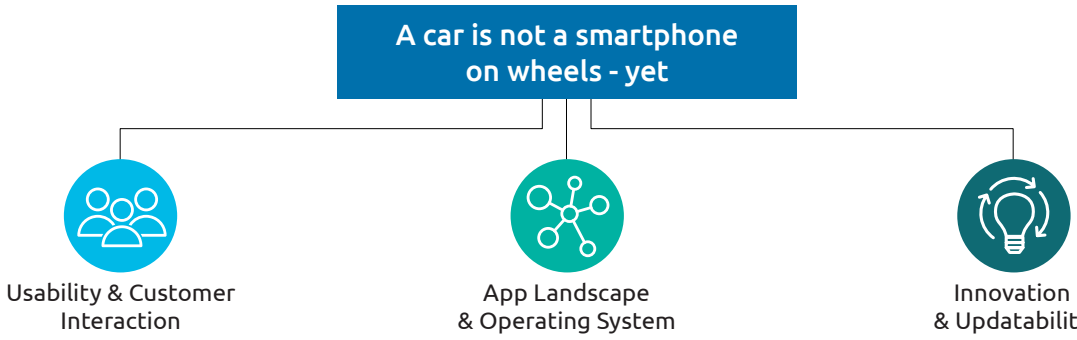


Figure 1: Perspectives
This will help us understand what developments are required before cars' functionality can become as indispensable as that of smartphones.

USABILITY & CUSTOMER INTERACTION

From the customer perspective, there are two major value drivers: usability and customer interaction.

USABILITY

Smartphones score more highly than cars because they can satisfy a wide range of user requirements and everyday purposes. They can serve as cameras or timers, allow the user to watch videos, and so on. This flexible and broad value proposition is a major success factor for smartphones. Indeed, for most users making phone calls is no longer the smartphone's main function – a disruptive change.

Compared to smartphone usage, the driving situation demands significantly more attention, and so the range of tasks that can be safely performed is limited. Hence, transportation remains the major value proposition of today's cars, though this picture could change dramatically as automated and autonomous driving functions mature. In the future, if driving is no longer the main activity while spending time in a vehicle, the driver can become more like a passenger, able to make greater use of in-car services.

As well as having a more limited range of functionality available to them, car drivers miss out on the seamless user experience that smartphone owners enjoy. Thanks to the use of a single account across all devices, if a smartphone user updates a calendar entry or contact, say, that update is instantly visible on the user's tablet, laptop, and so on. With a car, even if the driver logs in to use a connected service, or has a phone app to lock and unlock the vehicle, they cannot expect that updates will get transferred between the car and their other devices, because they probably need to use a separate account for the car. In other words, the car is not yet part of the "digital portfolio."

CUSTOMER INTERACTION

Smartphone producers and app or service providers are good at interacting with customers, and they leverage the customer data they collect to take better care of their customers. People expect to receive personalized offers and recommendations while they are using smartphones, and to be able to engage in direct communication (e.g., via chat).

In vehicles, customers using connected services cannot interact so seamlessly. First steps to improve this situation have already been taken, with in-car voice assistants becoming mainstream in connected cars. Mercedes-Benz's digital companion, MBUX, is widely regarded as the best-in-class user interaction system. It provides intuitive touchscreen control and a navigation display with augmented reality functions. In addition, it continuously learns users' behavior and applies what it learns to make suggestions – regarding destinations or music playlists, for example.

Although features like this help customers to be more engaged with the car, the range of functions supported is still limited compared to voice assistants from Apple, Google, or Amazon. Despite the lead provided by Mercedes-Benz, and Polestar integrating Google Assistant, most OEMs have a long way to go before they achieve real interaction with their users and provide individualized offers and information. Today, connected services are mostly limited to offering information and data to drivers and passengers.

So, while cars resemble phones in that they provide connected services, the way they do so is not generally nearly as convenient.

APP LANDSCAPE & OPERATING SYSTEM

The smartness of a device depends on the variety of ways in which it can deliver value to the user – which in practice means the variety of third-party apps – and on how well these services or apps are integrated to support different aspects of the user's driving experience and wider lifestyle.

App landscape

A vast number of third-party apps – perhaps 2–3 million in total – have been designed and developed for smart devices. Cars fall short of smartphones in this area, with far fewer apps. Smartphone users can find apps to address virtually every purpose you can think of, in both B2B and B2C segments. For cars, the connected services apps are mostly focused on infotainment, telematics, safety & security, and vehicle-to-everything (V2X) connectivity. Examples of V2X functionality include traffic lights alerting vehicles to adjust their speed to take account of an impending change from green to red, and vehicles warning each other of hazards to prevent collisions.

There are several reasons for the difference in the size of the application landscapes for phones and for cars. One is the smaller user base. There are almost 4 billion smartphone users worldwide, but probably only around 120 million connected cars on the roads[9]. That small user base, coupled with the fact that people do not use the connected services in their cars as intensively as those on their phones, makes connected cars a less appealing market for third-party app developers.

Operating system

The way services are supplied and integrated is another major area of difference between cars and phones, and one that further explains the difference in the app landscape. The phone app market is centralized around two players, Google/Android (with around 72% of the market) and Apple/iOS. These two have massive negotiating power, can define guidelines and standards, and run app stores via which the vast majority of apps are offered to customers. This structure has led to the growth of a huge ecosystem of third-party developers, who can take much of the credit for the richness of functionality available to smartphone users.

For cars, the ecosystem is far more fragmented. Regarding operating systems, some OEMs want to offer their own: For example, Daimler is aiming to launch MB.OS by 2025. Volkswagen has bundled its software competencies into a newly formed entity, CARIAD, to develop the VW.OS operating system. However, more and more OEMs – including Polestar and Ford – are adopting Android Automotive. Clearly, this fragmented landscape is less open, and less attractive to app developers, than that presented by smartphones. Smartphone app developers need to consider just two operating platforms, but anyone launching an app for cars is likely to have to create – and, worse, to support, update, and maintain – multiple versions.

OPENING UP THE CAR

In addition, OEMs have tended to limit the range of apps that get integrated into their cars – often for good reasons such as safety considerations – and this has made it a difficult market for developers to access. This represents another major gap between phones and cars, and one that the industry needs to close. In fact, the gap may start to close very soon whether we like it or not, because regulations such as the EU's Digital Markets Act are likely to enforce the availability of third-party app stores within cars, and will limit OEMs' ability to act as gatekeepers to their platforms.

On balance, this opening up of the market is good news for OEMs. The creation of an ecosystem that encourages third-party apps will be crucial for the industry's ability to combine diverse valuable functionality into a single platform in the way that has been achieved with smartphones. Furthermore, OEMs can start to earn money from software as well as hardware. There is more than one way to do this. One approach is through revenue sharing models like those from which smartphone vendors such as Apple already benefit. Another approach is for OEMs to develop operating systems and license them to other OEMs, perhaps on an as-a-service basis. There will also be opportunities for exploiting the wealth of data generated by connected services. OEMs can derive insights that help them (and their ecosystem members) to offer the individualized services that customers really value.

INNOVATION & UPDATABILITY

At present, cars do not keep up with technological innovation anywhere as successfully as phones do. Here we will discuss two of the main reasons. One is about the rate at which manufacturers and their ecosystem partners can innovate. The other reason is to do with the way innovation is distributed to customers using the finished products.

INNOVATION

It is relatively easy to ensure that most smartphones are equipped with the latest technology. Development cycles are short (around one year), and users tend to replace their phones around every two to three years. This rapid innovation results in a sophisticated device, with very fast processing and response times, and advanced use of many different types of data; for example, interpretation of sensor and image data. This is supported by mobile cloud services that smartphones often use to offload heavy data processing and storage outside the device.

Vehicles have a much longer development cycle of up to five years – so much so that hardware can already seem outdated when it is launched. In addition, cars tend to have a longer lifespan of around seven years (or two to three years for commercial vehicles). It is one reason why a car is currently a less streamlined device than a phone, and more limited as to the amount and type of data it can work with, and what it can do with it.

It is not possible – or desirable from the sustainability viewpoint – to make people change their cars more often. So the main way to bridge this gap is for OEMs to adopt a more customer-centric development process that reduces time to market and ensures that evolving customer expectations (and technological possibilities) are reflected in the models they deliver.

UPDATABILITY

Another way to keep cars up to date is to add innovative features once they are on the road. That brings us to a second key differentiator between cars and phones in the technology area: the ability to distribute innovation in the form of software updates to an existing device. Smartphones are usually permanently online and can receive regular updates, processed in the background. By contrast, smart cars tend to be offline a lot of the time, even if they can be remotely activated, for example for climate control purposes. Even when they are online, this does not mean that they can necessarily receive over-the-air (OTA) software updates the way a smartphone can; this depends on the car's architecture, plus the availability of updates and of the infrastructure necessary to enable those updates.

Progress is already happening here, with Tesla's lead being followed by the likes of Mercedes-Benz, Audi, and BMW. But at present, only the newest models in a range tend to have these capabilities, so there is still a way to go before cars have the updatability of phones.

CLOSING THE GAPS

In the previous section, we identified a number of gaps that will need to be filled before even the most advanced cars can be as smart as smartphones. Now we will discuss some approaches to filling the gaps, tackling each of the three perspectives in turn.

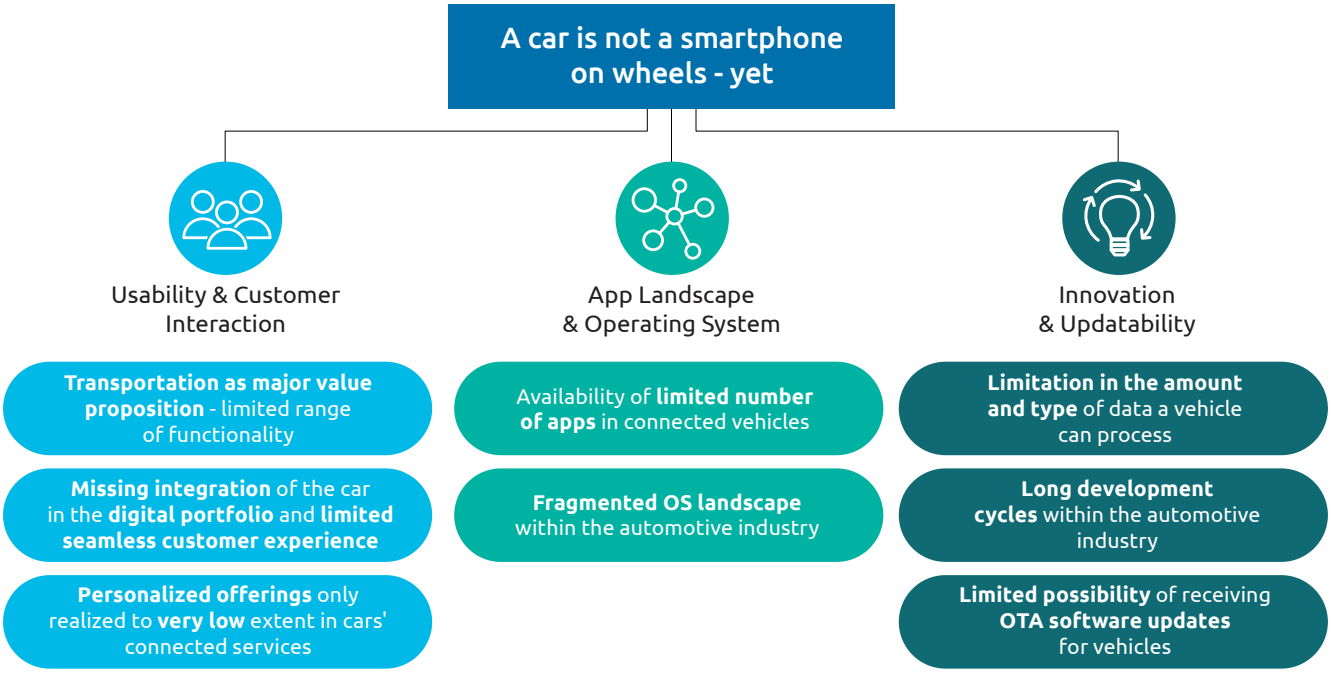


Figure 2: Perspectives
This will help us understand what developments are required before cars' functionality can become as indispensable as that of smartphones.

CUSTOMER PERSPECTIVE: USABILITY & CUSTOMER INTERACTION

VALUE PROPOSITION

Transportation is still the major value proposition for today's cars. This relatively narrow focus means there is a gap between the range of functionality available to customers via their vehicles and via their smartphones.

Transportation is likely to remain the vehicle's main value proposition, even in the era of autonomous driving, but OEMs can narrow this gap by broadening the vehicle's value proposition through augmented applications and connected services.

Once fully autonomous driving is possible – and this is no longer a fantasy since level 3 approvals are already being obtained by OEMs – the car-smartphone gap can be narrowed much further. The key will be to transform periods that are currently spent purely on driving/ transportation into immersive customer experiences, and thereby broaden the value proposition as far as possible.

Current research in the field of autonomous driving mainly focuses on its technical feasibility and enablement, and neglects the customer's role, and especially that of the driver. Progress toward autonomous driving will gradually turn drivers into passengers, so that more and more of their attention can be transferred to other activities. Therefore, the role of connected services must be reconsidered: They will no longer be limited to assisting the driver during the journey, but will be able to address a much wider range of areas and functionalities, transforming the vehicle into an "experience device."

More than 50% of our survey participants state that once autonomous driving becomes possible, they want to use entertainment features (e.g. online games, videos, music), social media, and web browsing features during the time gained. These new opportunities are not limited to fully autonomous driving cars, but are also applicable to preliminary stages such as highway pilots or other level 3 autonomous driving functions.

OEMs should therefore reconsider how different people will use their products. Given that drivers will become more like passengers, and that customers in general know exactly how they want to use their spare time, great opportunities for OEMs will emerge. Thus, we recommend transforming a journey into an experience using connected services.

This can be achieved by developing new applications based on technology such as AR – for example, games where you compete against other passengers and cars, or virtual tours through cities and landscapes. Displayed content is no longer limited to the on-board computer or heads-up displays. Potentially, the entire vehicle can now be used for entertainment and interaction. Handled this way, the autonomous vehicle can not only become a "living room on wheels," but also open up new business opportunities in the automotive sector (e.g. creating offices or meeting rooms on wheels).

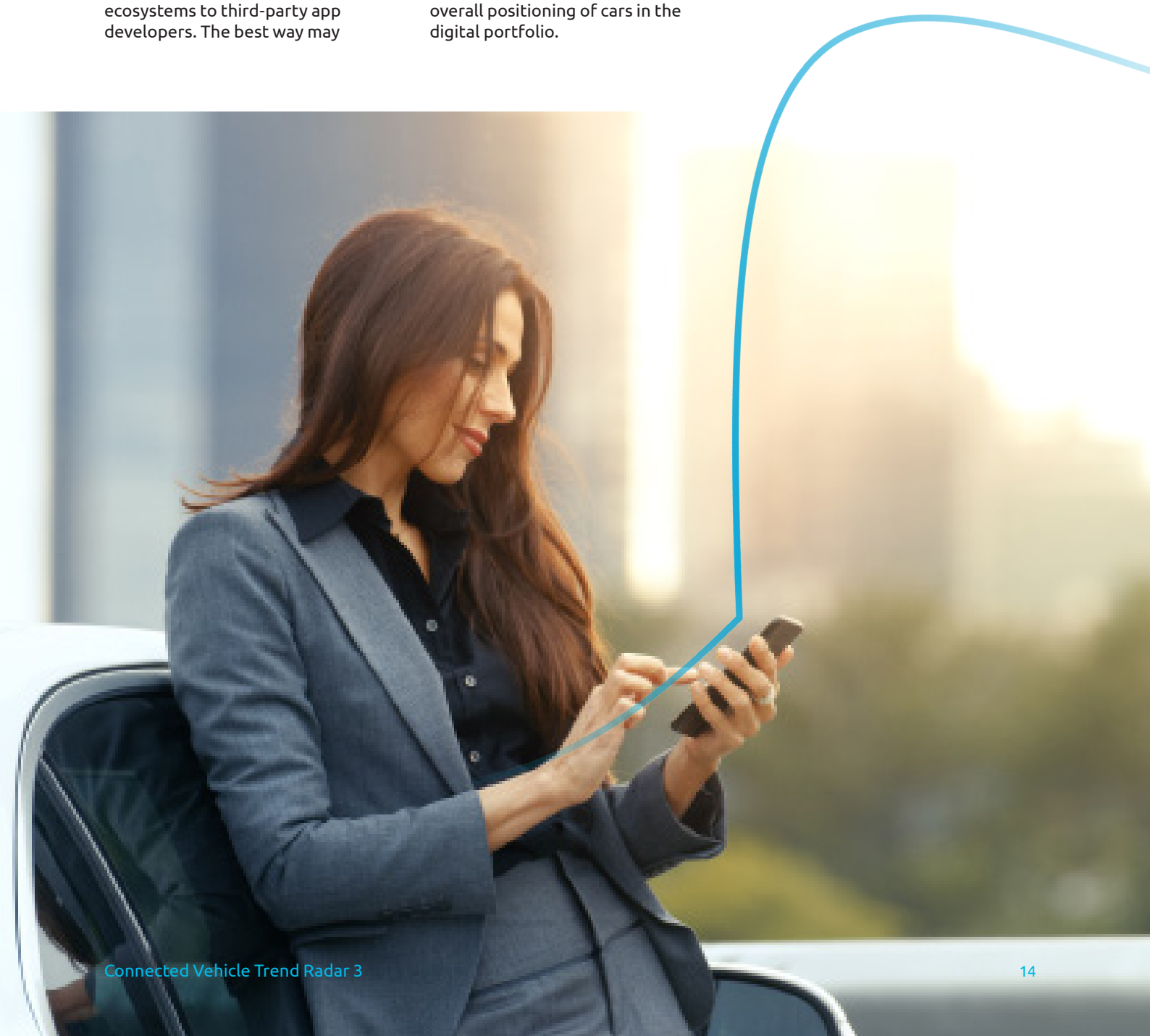
With this extended value proposition, OEMs can enhance their brands with new offers and differentiating features in the market.

SEAMLESS INTEGRATION

Another gap identified in the previous section is that the car is not integrated into a customer's digital portfolio. Currently, switching between different devices is not the flexible, seamless experience that customers expect and want. Our survey results show the importance customers place on closing this gap. For 42% of our participants (57% in China), integration of smartphone apps into the vehicle is a determinant of willingness to pay for connected services.

To satisfy this requirement, OEMs should now open up their ecosystems to third-party app developers. The best way may be for OEMs to establish an app store containing the full range of (externally developed) apps that customers already use on their smartphones alongside its own apps. By including these third-party apps, the customer experience is optimized since the switch between smartphone, tablet, and car is more convenient and seamless. This move to an open ecosystem has the additional advantage of offering OEMs new revenue potential; one option is a revenue-share model where a per-transaction commission is collected – a similar model to that used by the Apple App Store and Airbnb. Since the car will then be perceived as an additional sales channel by external providers (e.g. Amazon), this will strengthen the overall positioning of cars in the digital portfolio.

To support and enable this seamlessness, centralized account management should be established, either within the car or – even more conveniently – via the smartphone app associated with the car. This feature will enable customers to store the credentials needed to log into the different app accounts once and then automatically synchronize their different devices and app data with the car. As a result, data consistency is ensured. Already, the latest BMW models allow the user to log into their Spotify account by scanning a QR code. Centralized account management would enhance ease of use even further.

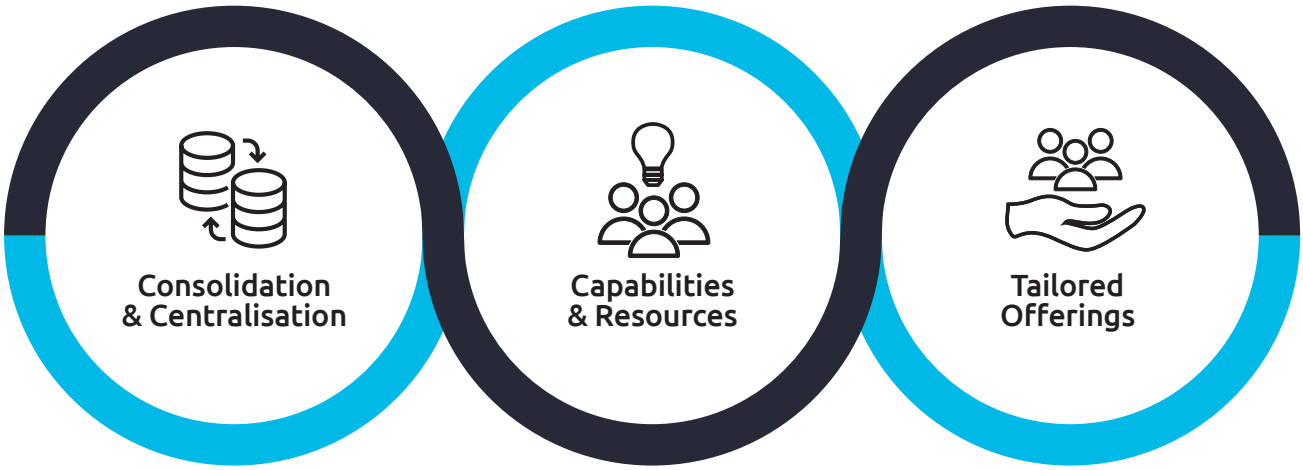


PERSONALIZED OFFERINGS BASED ON DATA

Smartphone customers take it for granted that the phone will provide a wide range of personalized offers and services (e.g. identifying a customer's preferred restaurants on Google maps when they perform a general search for restaurants). Currently, OEMs include personalized offerings within their strategy and are taking their first steps in this field, but the full potential of personalization is not yet realized in cars' connected services.

Our survey shows that over 50% of customers are aware of this gap, and that it bothers them. This is especially true of younger customer groups and of Chinese customers, who expect cars' connected services to reflect their habits (e.g. driving style, regular routes, or stops along the way) and preferences (brands, vehicle types, etc).

Combining the insights of the value proposition and seamless user experience sections with this survey result, it is clear that simply adding new digital services is not sufficient – there is a need for personalization too. OEMs should therefore aim to narrow this personalization gap by establishing offerings tailored to customers' needs. This requires a number of steps, shown in Figure 3.



- Consolidate and centralize customer data
- Maximized personalization potential by combining customer, vehivle data and third party (weather, mapping, etc.)

- Develop capabilities and resources for generating insights from customer data (internally or externally through partnering)
- Insight related to customer preferences (brands, vehicle types, etc.) and customer behavior/habits (driving style, regular routes or stops along the way)

Use the insights to tailor compelling offers like:

- Promote certain features based on driving behavior (offering function on demant laser light if the customer is always driving by night)
- Proactively offer a test drive based on customer preferences (detected when the customer often browses the OEMs website for certain vehicle models)

Figure 3: Narrowing the personalization gapas that of smartphones.

CONSOLIDATE AND CENTRALIZE DATA.

Personalization potential can be maximized by combining customer data, vehicle data, and third-party data (weather, mapping, etc).

Develop capabilities and resources for generating insights from customer data, either internally or through collaboration with partners owning these capabilities. These insights can relate to both customer preferences and customer behavior or habits.

USE THE INSIGHTS TO TAILOR COMPELLING OFFERS.

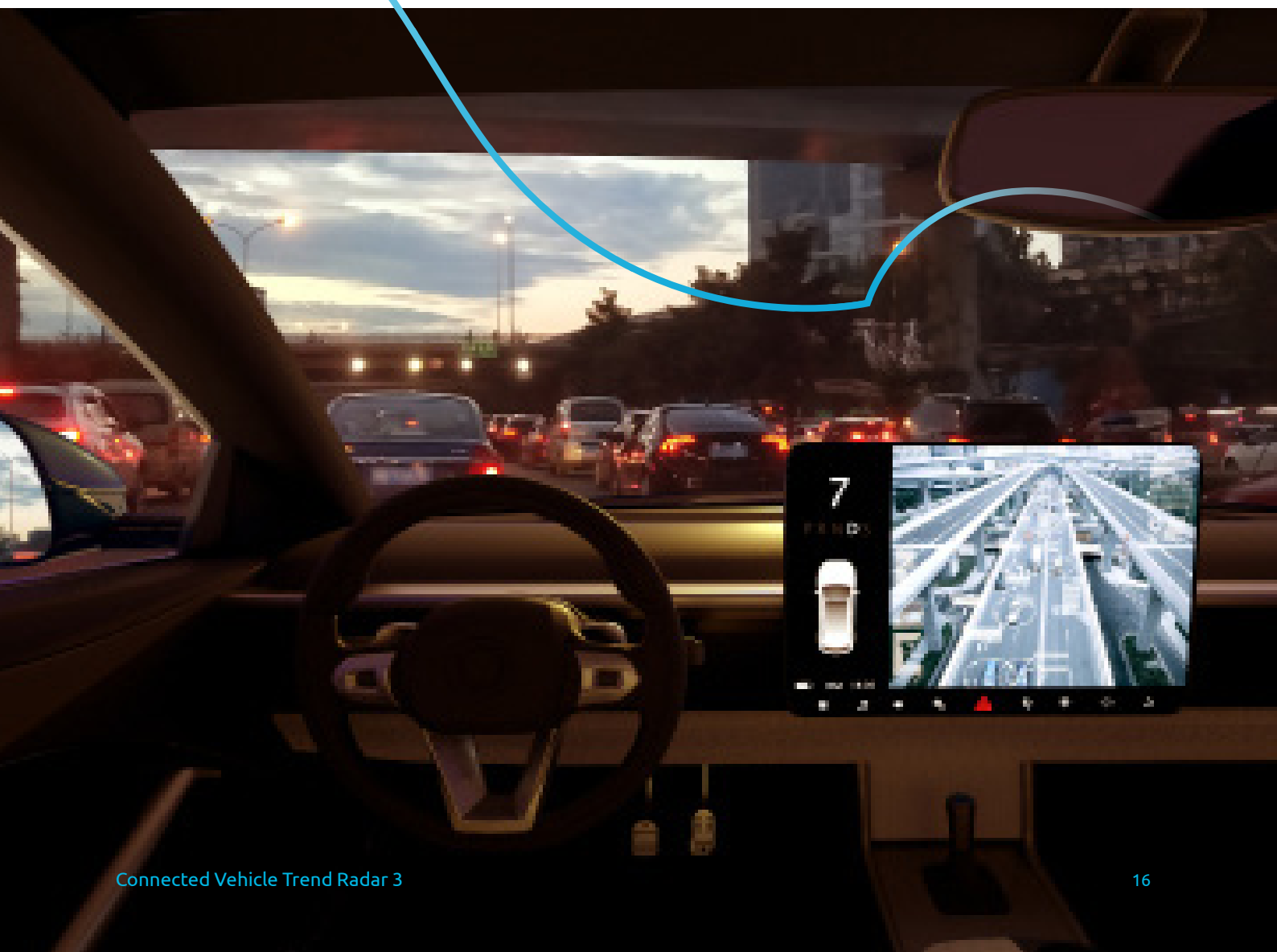
Certain functions could be promoted based on driving behavior, such as offering an on-demand light function whenever the customer is driving by night. Or a test drive could be proactively offered based on customer preferences and insights indicating interest in specific models or characteristics. With the aid of remote diagnostics, notifications could be pushed to the customer offering maintenance appointments at a preferred location and time.

One way of enabling and supporting these personalized offerings – while also developing the car as a channel for interaction between customer and OEM – is with an in-car voice assistant (VA).

The necessary technology could be delivered in various ways.

OEMs could either enhance the VAs that they have developed in-house, or incorporate third-party offerings, especially those that customers already know and like, such as Amazon Alexa, Google Assistant, or Apple Siri. At present, our survey suggests that 75% of customers prefer third-party options.

If OEMs decide to invest in evolving their own VAs, they should treat the popular third-party VAs as role models in terms of functionality and quality, otherwise it will be hard to compete. Our survey found that the main reason for dissatisfaction with current VAs is functionality, with 46% complaining that the assistant often fails to understand them properly.



ECOSYSTEM PERSPECTIVE: APP AVAILABILITY & OPERATING SYSTEM

APP AVAILABILITY

Relatively few apps are available in connected vehicles compared with the wide choice available to smartphone users. More than half of survey participants have 20-30 apps on their smartphones in addition to the pre-installed ones, and some people have even more.

Naturally, cars and phones feature different types of apps: The most popular ones on the smartphone tend to relate to social media, email, messaging, and games, whereas vehicles tend to run apps such as navigation, infotainment etc. However, that looks set to change. Nearly 60% of our participants say they would like to have the same variety of apps in their vehicles as on their smartphones and would use them as intensively. This feeling is strongest in China, where 82% favor that answer.

According to the survey results, more than 65% of participants would like their cars to offer the same navigation and music or video streaming apps that they use on their phones. Around 45% would like to have in-car access to their smartphones' news and social media apps; 35% would like apps for mobile banking, payment, email, and charging electric vehicles; and 33% for online shopping.

Customers' desire to use smartphone apps in their cars reinforces our earlier point that partnerships with third parties will be critical to success in expanding the app landscape. So what sort of incentives and enablers should OEMs offer to tempt developers into their ecosystem? Possibilities include:

- Access to data: For example, an OEM could offer to support an online provider of repair and maintenance workshop services by sharing car status information to help create personalized offerings.
- Developer platforms to facilitate app development for the OEM's ranges: Mercedes-Benz /developers is an example.
- Adoption of open-source policies as standard to make it easier for app developers to provide end-to-end support for apps in vehicles, from development to maintenance and updates.

CENTRALIZATION AROUND A LIMITED NUMBER OF OSS

The smartphone app market is centralized around Google/Android and Apple/iOS whereas, the automotive industry's OS landscape is much more fragmented, making it unattractive for third-party providers. We foresee that, as has already happened in the smartphone OS landscape, the automotive OS market will become consolidated, though not to quite the same extent. More insights regarding operating systems and ecosystems are discussed in Connected Vehicle Trend Radar 2.

Meanwhile, individual OEMs urgently need to review their OS strategy. They have a choice of three options:

- Use an existing OS, probably Android Automotive
- Build their own OS
- Take a hybrid approach, using Android Automotive and the Android Open-Source Project (AOSP) as a starting point and later building a comprehensive OS landscape

In deciding between these options, an OEM needs to keep in mind several strategic questions. How well do standard solutions fit the business's needs? What are the key drivers of the OS for customers? (Premium and volume OEMs may answer that last question differently.) And how much budget is available for OS development?

Option 1: Use an existing OS, probably Android Automotive

Advantages include lower costs and effort, the fact that the OS is designed to support multiple OEMs, and Google's expertise and continuous innovation in areas like software, data, AI, and machine learning.

Disadvantages include dependence on a third party: Arguably, long-term competitiveness is only possible when the OEM has control of the entire vehicle architecture, including electronics. It may also be hard to realize any special requirements that the OEM has and to integrate these extra features into the main OS. Other disadvantages include dependency on the modules offered by Android Automotive, and lack of support for iOS apps.

Option 2: Build an OEM-specific OS

This option clearly avoids the disadvantages of option 1. The OEM has the flexibility to focus on its own requirements, and preserves its independence from third-party OS suppliers. The OEM is also free to form strategic partnerships with Tier 1 and Tier 2 suppliers, tech companies, and other OEMs. It can monetize data in line with its own strategy and pricing models.

The option has its own disadvantages, however. The OEM faces high development costs for a relatively small number of output units (there are far fewer cars of a single brand than there are PCs, smartphones, etc.). It might also be difficult to justify the considerable expense of building a customized, scalable OS can be justified, unless the OS can afterwards be licensed to other OEMs. An OEM may also lack the technical knowhow and resources to develop complex software within a realistic timescale.

Option 3: Hybrid approach

This approach involves using Android Automotive and the AOSP as a starting point for building an OEM-specific OS.

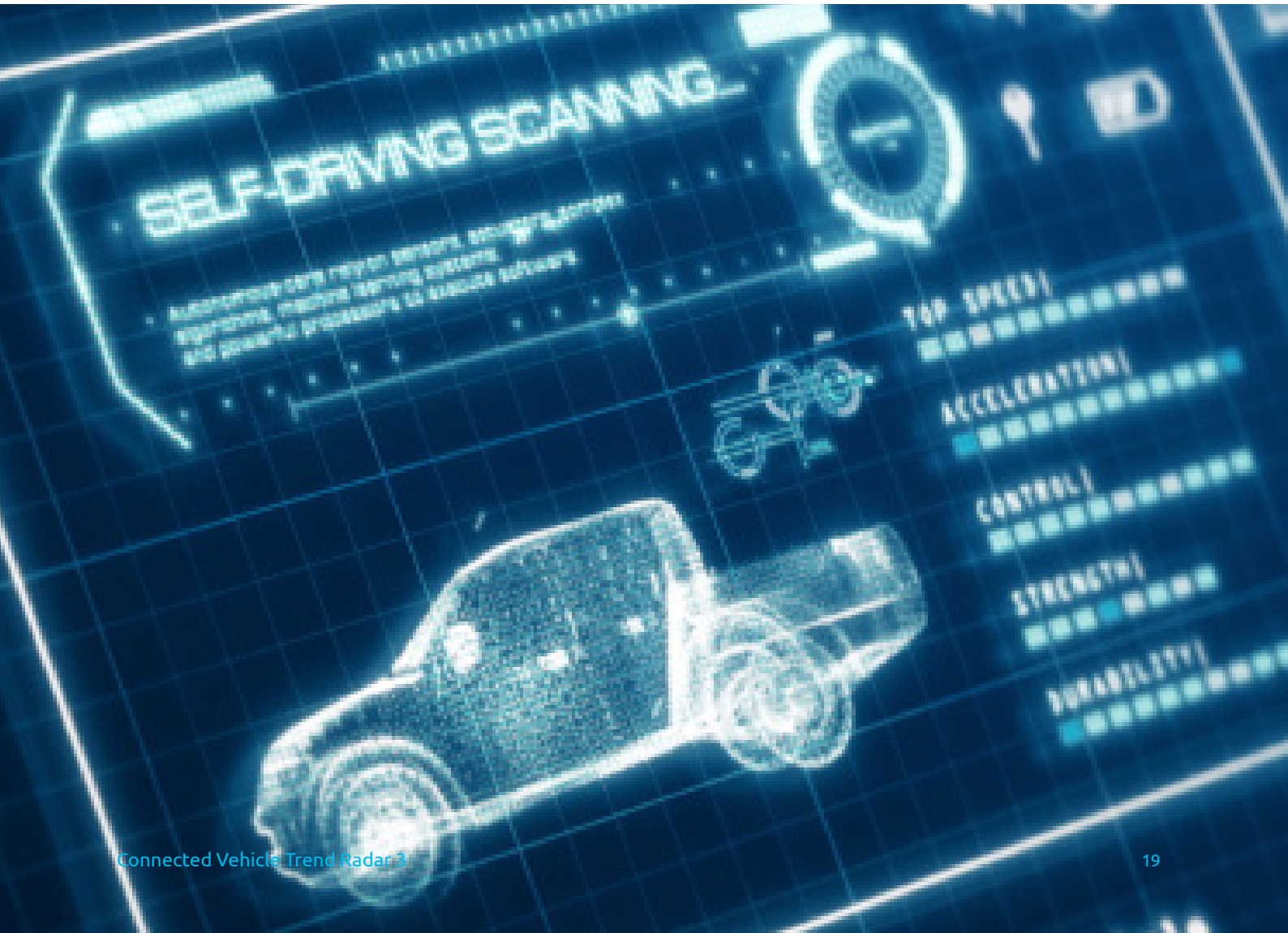
The approach provides a modular basis for development of an OS based on Android, combining customization with openness (through open source) and scalability. Other advantages include a huge ecosystem of developers and applications, and the fact that, as in Option 1, the OEM retains the ability to pursue its own strategy for data monetization, with its preferred pricing models. The hybrid approach also retains some of the disadvantages of Option 1, such as dependency on Android Automotive modules.

Whichever of the three options an OEM selects, we recommend pursuing it in collaboration with suitable partners. OEMs should think strategically about how best to cooperate with other OEMs, IT companies, or even companies in other industries.

Collaborations between OEMs were already under discussion (e.g. the intention to build a common OS for electric cars by BMW, Daimler, and VW). Such collaborations may take various forms: For example, an OEM with its own OS could license it to others as a service. We strongly recommend that OEMs aim to match the high standards of functionality and reliability set by IT companies to safeguard their competitiveness if they decide to keep OS development within the automotive industry.

In fact, partnering with IT companies, and capitalizing on their strengths in the OS area, is essential. These companies have not been slow to enter the automotive industry themselves. Google announced Android Automotive in 2017, and by 2022 it will feature in more than 15 vehicle models, from brands including Polestar, General Motors, Ford, Renault, Nissan, and Stellantis. Seven years after the launch of Apple CarPlay, Apple plans to add climate control, speedometer, and seat adjustment to CarPlay via cooperation with OEMs. In the future, Apple will possibly also implement its CarPlay innovations in electric cars of its own.

When collaborating with IT companies, OEMs should not underestimate these companies' own ambitions. They are attempting to use OSs as an entry point to help them gain intelligence about all scenarios affecting customers, from mobility to home to office. Already, Huawei's Harmony OS is designed to deliver a "smooth experience" across all devices in all scenarios; platforms include smartphone, TV, tablet, PC, and automotive infotainment systems.



TECHNOLOGY PERSPECTIVE: INNOVATION & UPDATABILITY

DEVELOPMENT TIME

Vehicles have a much longer development cycle than smartphones do. Cars typically take at least five to six years to develop, compared with one or two years for smartphones. Partly because of this long cycle, a vehicle can already seem outdated when it is launched.

OEMs have two main ways to close this gap. The first is to adopt customer-centric product development approaches, which can help to ensure that customer needs are met by the finished product. By involving the customer as early as possible in development, and maintaining that dialogue throughout the development cycle, OEMs can better understand current requirements and pain points, and predict future ones.

The second way to close this gap is to deploy software-based or virtualized techniques to further speed up development.
One advantage of this approach is that vehicle designers and testers can evaluate new vehicles before they are built by using virtual solutions such as AI-powered simulations, together with augmented and virtual reality.
This can reduce development time significantly and the resultant product is likely to be better because more configurations can be evaluated and tested, with fewer physical prototypes (which means less cost).

Another advantage of software-based or virtualized techniques is that they make it possible for customers to try out the vehicle's user experience during the early stages of development. That way, customers can provide early feedback to vehicle designers to inform development iteration.
Techniques like this are already being used by industry leaders as they can reduce time to market; physical testing with customers can be completely omitted in most cases.

OTA SOFTWARE UPDATES

Unlike most smartphones, cars cannot necessarily receive OTA software updates – only the newest models tend to have these capabilities. In addition, cars tend to be offline much of the time, even if they can be remotely activated. This is already an issue for many customers. Almost 70% of survey participants consider regular software updates to be important, and almost half of Chinese participants see them as very important. It is important for OEMs too. Effective software updates are critical to any strategic plans that require fast deployment of innovations and new features after a vehicle is built and sold. Updates are also the key to future revenue streams from digital business models.

For instance, the "function on demand" model will give customers the ability to add features to their car on an ad hoc basis, so that a traveler could temporarily install an app for cashless tollbooth payments when driving into a country with toll roads, for example. OTAs are a key enabler for functions like these, and in any situation where customers need a new function fast, whether it is an intelligent search for a parking space or finding an alternative route in abnormal traffic conditions. Therefore, OEMs need to make the ability to receive OTA software updates into a standard for all their models, also ensuring that cars are online as necessary to receive these updates. To achieve this change successfully, OEMs must shape enabling operational processes by following the continuous integration (CI) and continuous delivery (CD) principle; that is, including processes for identifying the need for an update, for designing and building software in short release cycles, for rapidly but thoroughly testing new software, for timing updates appropriately, and so on.

Once again, progress is already being made here: BMW released an OTA upgrade to over a million of its vehicles across more than 20 models globally. This was the largest campaign of its kind ever carried out by a European manufacturer.

PROCESSING AND RESPONSE TIME

A car is more limited than a phone as to the amount and type of data it can work with, and how it can use this data. To bridge this gap, OEMs need to transform today's hardware-defined cars into tomorrow's software-defined ones. Today's development approach cannot support software-designed vehicles because of the way software is created. Although OEMs build some software elements in-house or in close collaboration with strategic partners, they buy others in from various suppliers, then integrate them as best they can. The result is that the typical car relies on a wide range of development languages and software structures, leading to incompatibilities and inconsistencies that tend to drive up complexity.

This approach is increasingly problematic because the "softwarization" of today's cars demands seamless integration of subsystems and components. OEMs therefore need to put great emphasis on decoupling their hardware development cycles from those for software, to be able to develop software faster and deploy it more frequently. They must also streamline the development approach, and align development languages and software architecture, regardless of who is developing each element. OEMs should also think about their ability to process and analyze data efficiently; the proliferation of applications and sensors in vehicles will soon create a "data explosion" for which OEMs need to prepare if they are to achieve a satisfactory response time.

If done correctly, offloading heavy processing to the cloud is another way to improve the responsiveness of connected services. OEMs should therefore work with their partners to create a cloud-based digital infrastructure that provides a smart, scalable foundation for delivering connected experiences to customers.

Some of these changes are already starting to happen, as part of a shift in the automotive industry's rationale. Rather than adding computers to cars, OEMs will in the future build cars around computers.

IMAGINING LIFE AFTER THE GAPS ARE CLOSED

We have argued that cars cannot yet be regarded as smartphones on wheels, and looked at what needs to be done to close the gaps. In this section, we consider the role that a car could play in our lives in the future, once those gaps are closed.

VIRTUAL CO-DRIVER

Let's take a quick trip into the near future: to 2032, say. Even if vehicles are not yet fully autonomous, there's plenty of scope for drivers to benefit from technologies such as virtual reality (VR) and artificial intelligence (AI). So for example, you probably now have a virtual human agent (VHA) in your car: a lifelike character generated by AI and capable of a wide range of human behavior, and presented via VR or as a hologram.

Sometimes the VHA acts as a driving instructor, helping a customer to learn about a new vehicle or a recently added feature. In addition, the VHA can make spoken safety recommendations when a hazard is detected, or when human driving behavior is suboptimal. With the driver's permission, it can even take over the car and demonstrate better (for example, more sustainable) ways to drive.

The VHA can also take charge of entertainment, by controlling infotainment systems in accordance with the driver's known preferences, or even by making conversation. Entertainment is pitched at just the right level to keep the driver awake but not distracted from driving tasks.

VIRTUAL WORKPLACE

By 2032, autonomous vehicles are likely to have reached the point where they can drive themselves on the freeway, if not yet in towns. What can drivers do with the time and attention that has been freed up?

Imagine an architect having a 360-degree view of the building to be constructed projected on the windscreen, she can confidently direct her team so that they can perform the detailed construction work.

For others, working in the car may be as simple as having the windshield transform into an interactive whiteboard that enables them to brainstorm with colleagues – and, of course, have their work stored safely in the cloud.

CONCIERGE

Once fully autonomous cars arrive – perhaps a bit after 2032 – they will be able to perform a wide range of tasks on behalf of customers. Picture a family party at your home. You are busy looking after the first guests when you hear that other visitors have arrived at the airport.

Fortunately, you can simply send your self-driving car to pick them up. On the way back to your home, the car provides personalized entertainment to help your guests relax after their flight. Or, if they are new to the area, the vehicle can help them get oriented by flagging up landmarks along the route using augmented reality techniques.

RECOMMENDATIONS FOR CLOSING THE GAPS BETWEEN CARS AND SMARTPHONES

In this third Connected Vehicle Trend Radar, we have explored the gaps between smart vehicles and smartphones that exist today. Once those gaps are closed, vehicles could in the not-too-distant future become at least as central to our digital lives as our smartphones are. We have given some examples of the benefits that customers could be enjoying a few years ahead.

However, while tackling the gaps between vehicles and smartphones, we should be aware that we are dealing with a moving target. If it takes two to five years to close a gap and we start now, there a risk that when we get to 2025 the car will be comparable with a smartphone from 2022 rather than one in 2025. To catch up with smartphones, we need to anticipate what future phones will be like.

Whether or not OEMs believe in this vision of the future, we consider it essential that they start closing some of the gaps we have identified. Without doing so, it will be hard for them to meet the expectations of today's customers.

A. Customer perspective: usability & customer interaction

As they work to close the gaps, OEMs should take the opportunity to improve flexibility and usability. The rise of automated and autonomous driving brings many opportunities for smartphone-like user interaction. It is, however, crucial that OEMs identify the applications that will really be used.

Specifically, we at Capgemini Invent recommend that OEMs re-design their connected services portfolios to move from a driver-centered experience toward a passenger-centered one – especially for autonomous and semi-autonomous vehicles. At the same time, they should work to integrate commonly used third-party apps into the vehicle and foster seamless synchronization across other devices via centralized account management.

B. ecosystem perspective: app availability & operating system

The app landscape needs to catch up with these ideas, particularly in terms of the way functionality is created, delivered, and integrated. The emergence of app stores for third-party apps may improve matters and offer OEMs additional revenue streams from revenue sharing and as-a-service OS delivery, as well as opportunities for data utilization and monetization.

We recommend that OEMs strive to understand the smart vehicle as an element in customers' digital portfolios and ensure that they can use the same digital services (apps) in the vehicle as on other devices. They should start tackling this area now, considering the possibility of strategic cooperation with other OEMs or big tech companies. This will help OEMs to stay relevant if the OS becomes a decision criterion for vehicle purchase.

C. Technology perspective: innovation & updatability

The key to closing the gaps in the technological field is faster, more customer-centric processes, and finding a way to deliver innovation more effectively to cars on the road – which depends on making OTA software updates pervasive and effective, and providing the necessary infrastructure.

We recommend that OEMs adopt customer-centric product development approaches to better understand and integrate today's and tomorrow's market requirements. Software-based or virtualized techniques should be deployed to expose customers to the vehicle's user experience during the early stages of development. OEMs should also work to transform today's hardware-defined cars into software-defined ones by decoupling hardware from software development cycles. They should look to build a cloud-based digital infrastructure that will deal effectively with the upcoming data explosion in vehicles.

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